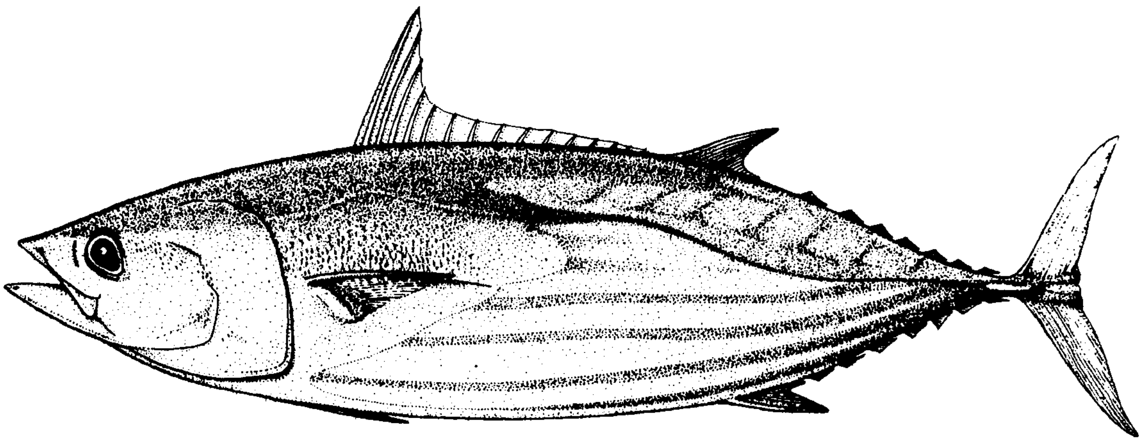
AN ASSESSMENT OF THE SKIPJACK AND BAITFISH RESOURCES OF NEW CALEDONIA



Skipjack Survey and Assessment Programme
Final Country Report No. 20

South Pacific Commission
Noumea, New Caledonia
March 1985

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PREFACE

The Skipjack Survey and Assessment Programme was an externally funded part of the work programme of the South Pacific Commission. Governments which provided funding for the Programme were Australia, France, Japan, New Zealand, United Kingdom and the United States of America, and the generosity of these governments is gratefully acknowledged.

The Skipjack Programme has been succeeded by the Tuna and Billfish Assessment Programme which is receiving funding from Australia, France, New Zealand and the United States of America. The Tuna Programme is designed to improve understanding of the status of the stocks of commercially important tuna and billfish species in the region. Publication of final results from the Skipjack Programme, including results from the Programme's investigation of yellowfin tuna resources of the region, is continuing under the Tuna Programme. Reports for each of the countries and territories for which the South Pacific Commission works have been prepared in a final country report series. Most of these reports have been co-operative efforts involving all members of the Tuna Programme staff in some way.

The staff of the Programme at the time of preparation of this report comprised the Programme Co-ordinator, R.E. Kearney; Research Scientists, A.W. Argue, C.P. Ellway, R.S. Farman, R.D. Gillett, J.P. Hallier, L.S. Hammond, P. Kleiber, J.R. Sibert, W.A. Smith and M.J. Williams; Research Assistants, Susan Van Lopik and Veronica van Kouwen; and Programme Secretary, Carol Moulin.

Throughout the survey, the French Administration and local authorities, particularly members of the Territorial Assembly and local Gendarmerie, were most generous in their co-operation with the Programme, for which we are indeed grateful.

Tuna Programme
South Pacific Commission

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AN ASSESSMENT OF THE SKIPJACK AND BAITFISH RESOURCES OF NEW CALEDONIA

1.0 INTRODUCTION

The Skipjack Survey and Assessment Programme was created in response to rapid expansion of surface fisheries for skipjack (*Katsuwonus pelamis*) during the 1970s in the waters of the central and western Pacific. The objectives of the Skipjack Programme were to survey the skipjack and baitfish resources within the area of the South Pacific Commission, and to assess the status of skipjack stocks and the degree of interaction between fisheries for skipjack within the Commission region and beyond. These assessments provide a basis for rational development of skipjack fisheries throughout the region and sound management of the resource.

The Programme's field research spanned almost three years between October 1977 and August 1980, and included 847 days of tagging and survey operations. Visits were made to all countries and territories in the area of the South Pacific Commission (Figure A, inside front cover) as well as New Zealand and Australia. Thirty-eight days were spent in the waters of New Caledonia in late 1977 and early 1978, with an additional day spent between Matthew and Hunter Islands in March 1980, while in transit between Norfolk Island and Fiji. Preliminary results from the 1977-78 visit were given by Kearney & Hallier (1978). This report presents the final analyses of the work by the Programme in the waters of New Caledonia, compares them to previous data and to results from elsewhere in the Programme's study area, and considers their implications for skipjack and baitfish resource management.

1.1 History of the Fishery

Traditionally, most local fishing activity in New Caledonia has focused on reef and lagoon species, with little interest in pelagic resources. However, since the late 1960s there has been artisanal fishing for skipjack, using small Tahitian-style, pole-and-line boats (bonitiers). The fleet is based in Noumea and fishes areas off the south west coast from October to May or June each year (Loubens 1977). Between 1970 and 1979, it caught an estimated 60 tonnes per year (Marcille & Bour 1981) with a catch per unit effort higher than that of the Tahitian fleet based in Papeete (Loubens 1977). This activity has since declined, with only two vessels now fishing during the favourable season.

Locally based industrial operations commenced in 1981 with the establishment of a pole-and-line fishery by the Transpêche Company, using Japanese-built vessels. Catches between 1981 and 1983 were insufficient to support commercial operations (Hallier 1984) under market conditions then prevailing, and the company is no longer active. Another company, Polypêche, has announced plans for longline activities in joint venture with Japanese interests, seeking to enter the high quality "sashimi" market (Hallier 1983).[1] There are 1 000-tonne capacity fish freezing facilities in Noumea, which in future might offer transhipment services to foreign fishing vessels operating in the south-western Pacific. A much smaller facility in Thio, operated by Polypêche, is designed to cater for sashimi-quality products.

There are records of fishing by Japanese pole-and-line vessels in New Caledonian waters since 1974 (Skipjack Programme 1980), but effort and catches have varied greatly between years. The largest catch, in the summer of 1979-1980, was 3 236 tonnes of tuna, mostly skipjack. Longline vessels from Japan and Taiwan made large catches around New Caledonia between 1962 and 1977 (Skipjack Programme 1981a). Further data are available for 1972-1976 (Klawe 1978), when Asian longlining fleets caught an average of about 2 500 tonnes annually. Most of this comprised species other than skipjack, which represented only a very small proportion of the catch. Since the declaration of the 200-mile Exclusive Economic Zone in 1979, only the Japanese longliners have been licensed to fish, catching a few hundred tonnes per year (Services des Affaires Maritimes unpublished data). Purse-seiners are not yet operating in New Caledonian waters, although exploratory fishing by American vessels in 1980 and 1981 yielded an average of 45 tonnes per set (Boely & Conand 1980; Muyard 1980; Hoffschir 1981; Rosenberg 1981).

1.2 Previous Research Activities

Early surveys of the skipjack and baitfish resources of New Caledonia were made by the Japan Marine Fishery Resource Research Center (JAMARC). This work identified seasonal variations in abundance of baitfish and skipjack (Anon. 1972, 1973, 1974), with both sufficiently abundant in summer to support a viable pole-and-line fishery for skipjack. Later survey work in August 1980 by the Manus Star, a pole-and-line vessel owned by the Starkist company, suggested that skipjack might be sufficiently abundant in winter to support commercial operations (Boely undated). Surveys were subsequently undertaken by the Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM) (Anon. 1982; Petit & Hazane 1983), to further characterise both the baitfish and tuna resources. They provided evidence of winter presence of yellowfin (*Thunnus albacares*) to complement the occurrence of skipjack in summer. Some of this work has utilised remote-survey techniques including aerial spotting and infra-red radiometry (Petit & Hazane 1983). At present, ORSTOM conducts research into remote sensing of environmental variables, seeking correlations between them and skipjack distribution and abundance throughout the South Pacific.

2.0 METHODS

2.1 Vessels and Crew

Two Japanese commercial fishing vessels, the Hatsutori Maru No.1 and

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1 Operations commenced in November 1983 (Service des Affaires Maritimes pers. comm.).

the Hatsutori Maru No.5, were chartered at different times by the Skipjack Programme from Hokoku Marine Products Company Limited, Tokyo, Japan. Details of both vessels are given in Kearney (1982). The 192-gross tonne Hatsutori Maru No.1 was used during the survey of New Caledonia in December 1977 and January 1978. The waters of Matthew and Hunter Islands were briefly surveyed on 31 March 1980 using the 254-gross tonne Hatsutori Maru No.5.

The Hatsutori Maru No.1 was operated with at least three Skipjack Programme scientists, nine Japanese officers and twelve Fijian crew. For the Hatsutori Maru No.5, an additional two Fijian crew were employed. Observers from the Japan Fisheries Agency, the New Zealand Ministry of Agriculture and Fisheries and the New Caledonia fishing community were on board at various times during the surveys. Names of all personnel and details of the times scientists and observers spent on board are given in Appendix A.

2.2 Baitfishing

Most baitfishing activity was carried out at night using a "bouki-ami" net set around bait attraction lights. In some countries, beach seining during daylight hours supplemented night catches, but it was not attempted in New Caledonia. Details of both techniques and all modifications employed by the Skipjack Programme are given in Hallier, Kearney & Gillett (1982).

2.3 Fishing, Tagging and Biological Sampling

Both vessels used by the Skipjack Programme were designed for commercial, live-bait pole-and-line fishing, and the basic strategy of approaching and chumming schools normally employed by such vessels was not changed. As in commercial fishing, minor variations in technique were tried from day to day depending upon the behaviour of skipjack schools and the quantity and quality of live bait carried.

The numbers of crew on the Hatsutori Maru No.1 and No.5 were fewer than either of these vessels carry when fishing commercially. The effective number of fishermen was further reduced because at least one crew member was required to assist each scientist in the tagging procedures. Moreover, the need to pole tuna accurately into the tagging cradles reduced the speed of individual fishermen. Clearly, these factors decreased the fishing power of the research vessel. During the first survey in the waters of Fiji (26 January to 10 April 1978), the relative fishing power of the Hatsutori Maru No.1 was calibrated by comparing its catches with those of the commercial fleet operating in the same area, and with catches achieved during a period of one month when the vessel fished commercially under the same captain while using an enlarged crew complement. From these comparisons, it was estimated that the fishing power of the Hatsutori Maru No.1 under survey conditions was 29 per cent of its commercial fishing power (Kearney 1978). It was assumed that the same ratio of 3.47 applied to the operations of the Hatsutori Maru No.5.

Since tagging was the primary research tool, attempts to tag large numbers of skipjack usually dominated the fishing strategy. The tagging techniques and alterations to commercial fishing procedures were described in detail by Kearney & Gillett (1982).

Specimens of tuna and other pelagic species which were poled or trolled, but not tagged and released, were routinely analysed. Data collected included length, weight, sex, gonad weight, stage of sexual maturity, and a record of stomach contents. In addition, a log was maintained of all fish schools sighted throughout the Programme. Where possible, the species composition of each school was determined. Records were kept of the chumming response and catch by species from each school. Argue (1982) described methods used for the collection of these data.

Skipjack blood samples for genetic analysis were collected according to the methods described by Fujino (1966) and Sharp (1969), and were frozen and packed on dry ice for air freighting to the Australian National University, Canberra, Australia, where they were electrophoretically analysed (Richardson 1983).

Beginning in December 1979, body cavities of skipjack were examined for the presence of macro-parasites. Complete sets of gills and viscera were taken from five fish from each school (up to a maximum of three schools per day), frozen, and subsequently air freighted to the University of Queensland, St Lucia, Australia, for detailed examination.

2.4 Data Compilation and Analysis

Five separate logbooks were used for compiling data accumulated during the fieldwork outlined in Sections 2.2 and 2.3. The techniques used to enter data from these logs into computer files and to process data were discussed by Kleiber & Maynard (1982). Electrophoretic data from blood samples and parasite identifications from skipjack viscera were also coded and entered into computer files. Data processing was carried out on the Programme's Hewlett Packard 1000 computer in Noumea.

Assessment of the skipjack resource and possible interactions among skipjack fisheries required several different approaches. Records of the migration of tagged skipjack formed the basis of the investigations of movement patterns and fishery interactions, using analytic techniques described in Skipjack Programme (1981b) and Kleiber et al. (1984). Evaluation of the magnitude of the skipjack resource and its dynamics, based on tag recapture data, were described by Kleiber, Argue & Kearney (1983). Methods employed in studies of growth were described by Lawson, Kearney & Sibert (1984) and Sibert, Kearney & Lawson (1983), and of juvenile abundance, in Argue, Conand & Whyman (1983). Procedures used to compare fishing effectiveness of different baitfish families are described in Argue, Williams & Hallier (ms.). Evaluation of population structuring across the whole of the western and central Pacific was based on a comparison of the tagging results with the blood genetics analyses (Anon. 1980, 1981; Skipjack Programme 1981c) and analyses of the occurrence and distribution of skipjack parasites (Lester, Barnes & Habib ms.).

3.0 SUMMARY OF FIELD ACTIVITIES

Figure 1 shows that surveys for tuna and baitfish during the first visit were conducted around the southern two thirds of the Grande Terre and the northern islands of the Loyalty group. There was no subsequent attempt to cover the north of the main island, because few recoveries of tagged fish were expected from the low fishing effort in that area. The second visit consisted of only one day spent around Matthew and Hunter Islands, not shown in Figure 1.

FIGURE 1. AREAS SURVEYED FOR SKIPJACK AND LOCALITIES FISHED FOR BAIT BY THE SKIPJACK PROGRAMME IN THE WATERS OF NEW CALEDONIA DURING 1977-1978

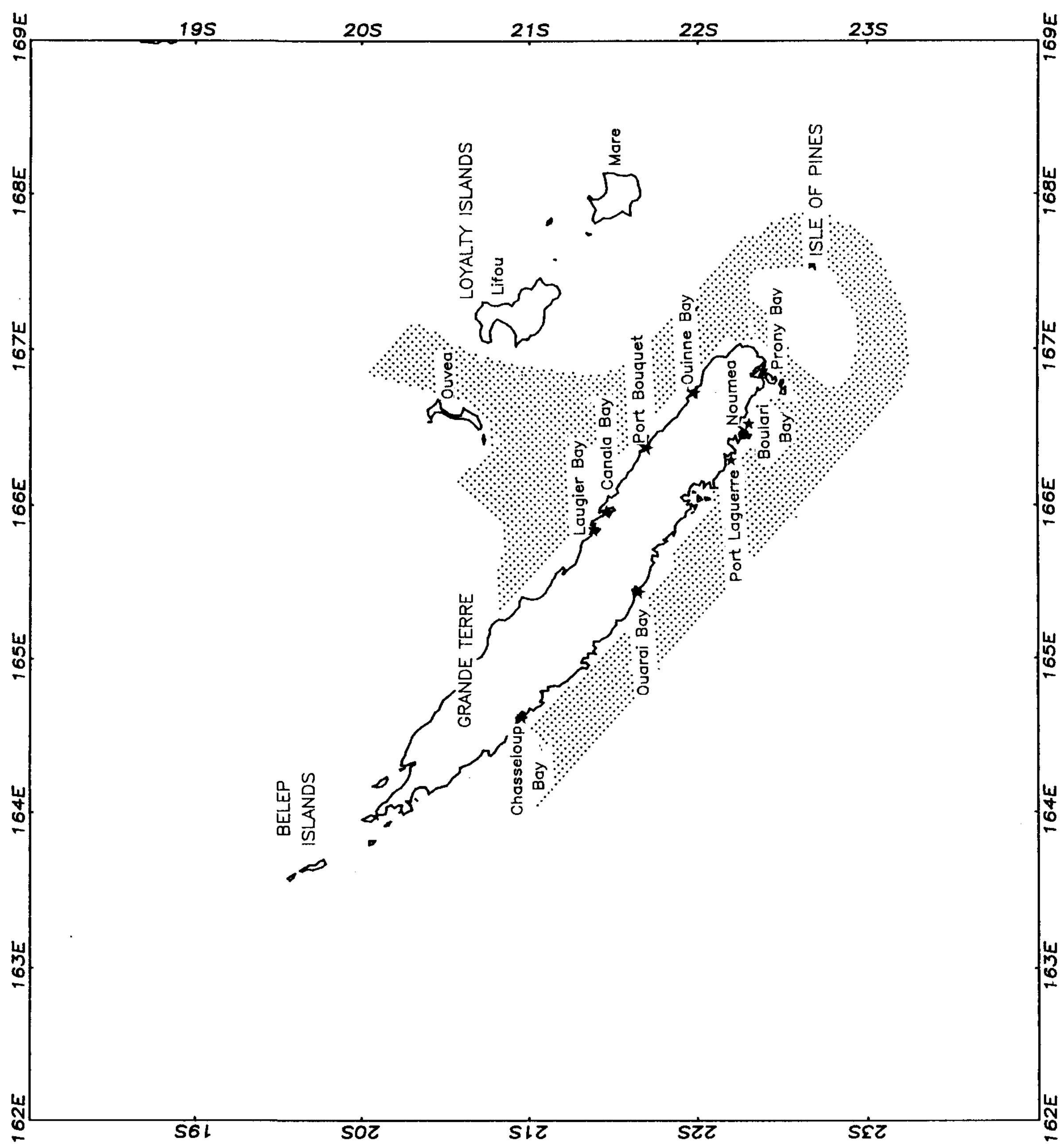


Table 1 summarises skipjack field activities during 39 days in New Caledonian waters, of which 24 days were spent fishing and 15 were divided equally between baiting, steaming or stays in port. Two hundred and forty-one hours were spent either searching or fishing for skipjack, for an average of 8.9 hours per day. A total of 10 219 skipjack were tagged in New Caledonian waters, all but 25 during the first visit.

Baitfishing activities carried out on 24 nights are summarised in Table 2. Forty hauls were made at nine different locations between December 1977 and January 1978. Bait was carried from New Zealand during the visit to Matthew and Hunter Islands, as no baitfishing could be carried out there, through lack of suitable conditions.

TABLE 1. SUMMARY OF DAILY FIELD ACTIVITIES BY THE SKIPJACK PROGRAMME IN THE WATERS OF NEW CALEDONIA. Schools sighted are identified by species: SJ = skipjack or skipjack with other species except yellowfin, YF = yellowfin or yellowfin with other species except skipjack, S+Y = skipjack with yellowfin or skipjack with yellowfin and other species, OT = other species without skipjack or yellowfin, UN = unidentified, but most likely schools with tuna.

Date	General Area	Principal Activity	Bait Carried (kg)	Hours Fishing and Sighting	Schools Sighted (numbers) SJ	YF	S+Y	OT	UN	Fish Tagged (numbers) SJ	YF	OT	Fish Caught (kg) SJ	YF	Total Catch (kg)
13/12/77	NE New Caledonia	Steaming	0	13	4	0	0	0	5	-	-	-	-	-	-
14/12/77	Laugier Bay	Steaming	0	3	0	0	0	0	2	-	-	-	-	-	-
15/12/77	East Coast	Fishing	255	14	4	1	1	0	2	1559	11	0	6694	268	6962
16/12/77	East Coast	Fishing	218	13	9	0	0	0	0	535	0	0	2599	0	2599
17/12/77	East Coast	Fishing	230	13	8	0	0	0	0	1249	0	0	5070	0	5070
18/12/77	East Coast	Fishing	200	11	5	0	0	0	4	654	0	0	2707	0	2707
19/12/77	East Coast	Fishing	68	10	5	0	0	0	0	105	0	0	407	0	409
20/12/77	East Coast	Fishing	210	4	0	1	1	0	0	922	0	0	3950	11	3961
21/12/77	East Coast	Fishing	174	6	3	0	0	0	2	279	0	0	1208	0	1224
22/12/77	East Coast	Fishing	185	7	6	0	3	0	4	818	33	0	2470	157	2630
23/12/77	S New Caledonia	Fishing	8	7	6	0	0	0	1	0	0	0	0	0	0
24/12/77	Noumea	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
25/12/77	Noumea	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
26/12/77	Noumea	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
27/12/77	S New Caledonia	Steaming	0	0	-	-	-	-	-	-	-	-	-	-	-
28/12/77	W of Noumea	Fishing	60	6	2	0	0	0	3	426	0	0	969	0	969
29/12/77	S New Caledonia	Baiting	6	0	-	-	-	-	-	-	-	-	-	-	-
30/12/77	Prony Bay	Baiting	6	0	-	-	-	-	-	-	-	-	-	-	-
31/12/77	Noumea	Fishing	63	7	1	0	0	0	5	25	0	0	46	0	46
01/01/78	Noumea	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
02/01/78	S New Caledonia	Steaming	0	0	-	-	-	-	-	-	-	-	-	-	-
03/01/78	Ouvea	Fishing	446	12	9	0	0	1	4	607	0	0	2104	0	2114
04/01/78	East Coast	Fishing	165	10	1	0	1	0	0	235	1	0	819	27	853
05/01/78	East Coast	Fishing	171	9	6	0	0	0	1	448	0	0	1469	0	1473
06/01/78	Laugier Bay	Baiting	479	0	-	-	-	-	-	-	-	-	-	-	-
07/01/78	East Coast	Fishing	471	4	1	0	1	0	1	268	8	0	775	68	845
08/01/78	East Coast	Fishing	392	8	4	0	1	0	0	376	3	0	1427	95	1524
09/01/78	Port Bouquet	Fishing	450	8	2	1	1	0	2	71	0	0	202	7	209
10/01/78	SW New Caledonia	Fishing	368	12	3	0	0	0	0	224	0	0	476	0	478
11/01/78	Noumea	Fishing	345	7	5	0	0	0	0	92	0	0	234	0	234
12/01/78	SW New Caledonia	Fishing	269	10	3	0	0	0	0	38	0	0	77	0	77
13/01/78	Bourail	Fishing	245	11	9	2	0	0	1	413	0	0	1153	0	1153
14/01/78	Chasseloup Bay	Fishing	159	12	5	1	0	0	1	3	0	0	19	0	19
15/01/78	West Coast	Fishing	249	4	4	0	0	0	0	847	0	0	2449	0	2449
16/01/78	Noumea	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
17/01/78	S New Caledonia	Steaming	0	0	-	-	-	-	-	-	-	-	-	-	-
18/01/78	Port Bouquet	Baiting	480	0	-	-	-	-	-	-	-	-	-	-	-
19/01/78	NE New Caledonia	Baiting	563	8	0	0	0	0	6	0	0	0	0	0	0
31/03/80	Hunter Island	Fishing	125	12	1	0	1	0	4	25	27	0	77	99	176
TOTALS	Days 39			241	106	6	10	1	48	10219	83	0	37401	732	38181

TABLE 2. SUMMARY OF BAITFISHING EFFORT AND CATCH BY THE SKIPJACK PROGRAMME IN THE WATERS OF NEW CALEDONIA

Anchorage	Time of Hauls	Number of Hauls	Species*	Estimated Average Catch per Haul (kg)	Mean Length (mm)	Other Common Species*
Laugier Bay			*Stolephorus heterolobus*	109	55	*Spratelloides delicatulus*
21°22′S	Night	11	*Herklotsichthys quadrimaculatus*	8	53	*Priacanthus* sp.
165°52′E			*Dipterygonotus leucogrammicus*	2	58	*Leiognathus bindus*
Canala Bay			*Stolephorus indicus*	46	42	*Pranesus endrachtensis*
21°27′S	Night	2	*Stolephorus devisi*	46	42	*Atherinomorus lacunosus*
165°58′E			*Herklotsichthys quadrimaculatus*	2		*Hypoatherina ovalaua*
Prony Bay			*Spratelloides gracilis*	15		Sp. of Carangidae
22°22′S	Night	4	*Spratelloides* (new species)	8	35	Sp. of Synodontidae
166°54′E			*Stolephorus heterolobus*	7	61	Sp. of Acanthuridae
Prony Bay			*Stolephorus heterolobus*	3		*Atherinomorus lacunosus*
22°23′S	Night	1	*Spratelloides gracilis*	3		*Rastrelliger kanagurta*
166°54′E			*Apogon(Rhabdamia) gracilis*			*Decapterus* sp.
Prony Bay			*Decapterus* sp.	5		*Spratelloides gracilis*
22°19′S	Night	1	*Thrissina baelama*			*Stolephorus heterolobus*
166°49′E			*Rastrelliger kanagurta*			*Bregmaceros* sp.
Port Bouquet			*Stolephorus heterolobus*	100	58	*Herklotsichthys quadrimaculatus*
21°40′S	Night	6	*Gymnocaesio gymnopterus*	49	50	Sp. of Sphyraenidae
166°22′E			*Spratelloides gracilis*	15	31	*Apogon(Rhabdamia) gracilis*
Laugier Bay			*Herklotsichthys quadrimaculatus*	72	107	*Gymnocaesio gymnopterus*
21°22′S	Night	4	*Stolephorus heterolobus*	57	47	*Amblygaster clupeiodes*
165°51′E			*Decapterus russelli*	29	116	*Gazza minuta*
Port Bouquet			*Decapterus russelli*	51	109	*Hypoatherina ovalaua*
21°40′S	Night	3	*Gymnocaesio gymnopterus*	23	59	*Amblygaster clupeiodes*
166°21′E			*Herklotsichthys quadrimaculatus*	21	58	*Lutjanus kasmirii*
Port Laguerre			*Decapterus russelli*	120	157	*Leiognathus bindus*
22°12′S	Night	2	*Stolephorus heterolobus*	44	71	*Gazza minuta*
166°18′E			*Selar crumenophthalmus*			*Rastrelliger kanagurta*
Ouarai Bay			*Stolephorus devisi*	357	49	*Leiognathus bindus*
21°49′S	Night	1	*Herklotsichthys quadrimaculatus*	185	52	*Apogon(Rhabdamia) gracilis*
165°46′E			*Scomberoides* sp.			*Stolephorus insularis*
Boulari Bay			*Stolephorus heterolobus*	90	53	*Gazza minuta*
22°15′S	Night	1	*Decapterus russelli*	6	57	*Scomberomorus commersonii*
166°31′E			*Rastrelliger kanagurta*			*Herklotsichthys quadrimaculatus*
Ouarai Bay			*Stolephorus devisi*	84	52	*Stolephorus insularis*
21°49′S	Night	2	*Herklotsichthys quadrimaculatus*	9	53	*Decapterus russelli*
165°45′E			*Gazza minuta*			*Stolephorus indicus*
Chasseloup Bay			*Stolephorus heterolobus*	87	71	*Amblygaster sirm*
20°52′S	Night	2	*Herklotsichthys quadrimaculatus*	11	63	*Spratelloides gracilis*
164°39′E			*Stolephorus devisi*	7	53	*Caesio coerulaureus*

* Until recently, *Herklotsichthys quadrimaculatus* was known as *Herklotsichthys punctatus* (Wongratana 1983) and *Atherinomorus lacunosus* was known as *Pranesus pinguis* (Whitehead and Ivantsoff 1983).

Explanatory Notes

Anchorage	: Recorded positions are truncated to the nearest minute. For large bays there may be more than one position tabulated.
Time of Hauls	: Day hauls - 0600-1759 hrs inclusive Night hauls - 1800-0559 hrs inclusive
Number of Hauls	: Number of hauls at the anchorage position, either day or night as specified. A haul is defined as any time the net was placed in the water.
Species	: Those species that made up at least one per cent of the numbers caught from one or more bait hauls at a particular location.
Average Catch (species)	: Total catch includes bait loaded, bait discarded alive and bait discarded dead at the location. The average catch in kilograms per haul is the product of total catch in kilograms and weighted numerical percentage of the catch for a particular species, divided by the total number of hauls at the location. The weighted numerical percentage is the product of numerical percentage, a constant, and the cube of the species′ average standard length. (In the absence of a mean SL for the species, the numerical percentage itself is used.) The sum of the weighted percentages equals the sum of the total of the numerical percentages. In this way the smaller (numerically abundant) fish are suppressed in their contribution to the catch while the less common, larger fish are proportionally enhanced in their representation. Catches are expressed in kilograms for the dominant three species; thus, the sum of the average species catches will often be less than the average location catch.
Mean Length	: Weighted by numerical abundance when there were multiple hauls at the same location.

A summary of numbers of fish sampled for biological data is given in Table 3. The fork length of tagged skipjack ranged from 30 to 74 cm (Figure 2), with a mean of 52.1 cm, slightly higher than the Skipjack Programme's overall average of 50.4 cm. Maturity data are summarised in Figure 3, the incidence of tuna juveniles in the stomachs of sampled skipjack and other species in Table 4, and diet items in Table 5. Blood samples were taken from 105 skipjack from a school on the east coast of New Caledonia on 8 January 1978 and from 109 skipjack from a school on the west coast on 15 January 1978; results of blood genetics analyses are included in Figure 4 (Section 4.3.4). No samples were taken to be examined for parasites.

TABLE 3. NUMBERS OF FISH FROM THE WATERS OF NEW CALEDONIA SAMPLED FOR BIOLOGICAL DATA

Species	Number Measured	Number Weighed	Number Examined for Sex	Number Examined for Stomach Contents	Number Examined for Tuna Juveniles	Number Sampled for Blood Analyses
Skipjack *Katsuwonus pelamis*	1437	500	719	277	477	214
Yellowfin *Thunnus albacares*	59	30	48	26	26	
Mackerel Tuna *Euthynnus affinis*	5	0	5	5	5	
Frigate Tuna *Auxis thazard*	5	3	5	4	4	
Rainbow Runner *Elagatis bipinnulatus*	4	0	4	4	4	
Dolphinfish *Coryphaena hippurus*	5	4	5	5	5	
Totals	1515	537	786	321	521	214

4.0 RESULTS AND DISCUSSION

4.1 Bait Availability

The physiography of the Grande Terre, with deep bays along the coast and abundant fresh water runoff, suggests numerous locations favourable to baitfish. On the small islands there are fewer suitable sites. However, many areas which might support good bait resources are exposed to prevailing winds or currents, or are too shallow for deploying a net the size and/or type of the bouki-ami. Therefore, the assessment of the baitfish resource by the Skipjack Programme is conservative, as the use of alternative baitfishing techniques in these areas may allow access to a larger resource.

FIGURE 2. LENGTH FREQUENCY DISTRIBUTIONS OF SKIPJACK TAGGED OR SAMPLED BY THE SKIPJACK PROGRAMME IN NEW CALEDONIA

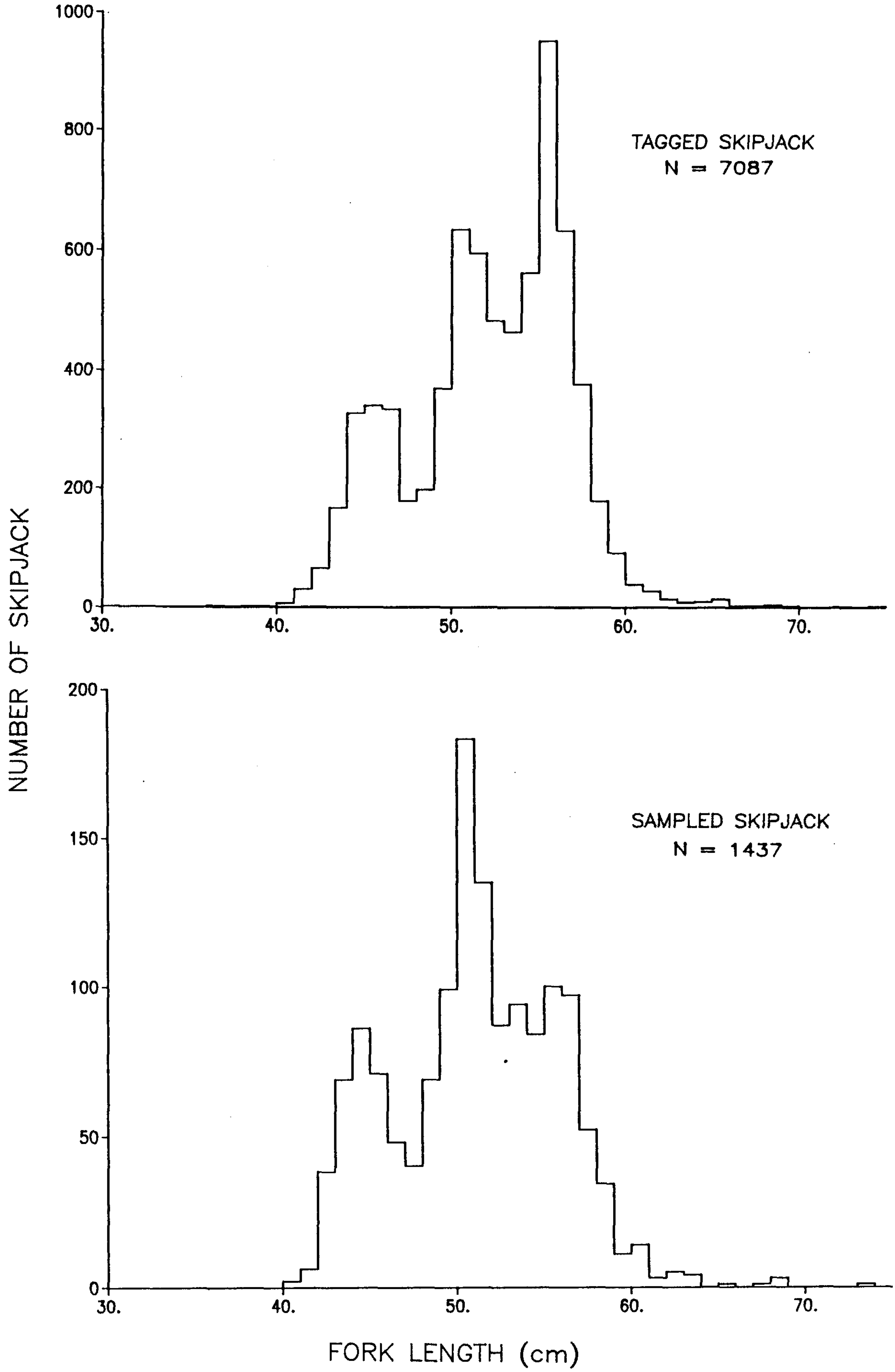


FIGURE 3. DISTRIBUTION OF FEMALE SKIPJACK BY MATURITY STAGE FOR SAMPLES FROM (a) NEW CALEDONIA AND (b) FROM THE ENTIRE SKIPJACK PROGRAMME STUDY AREA

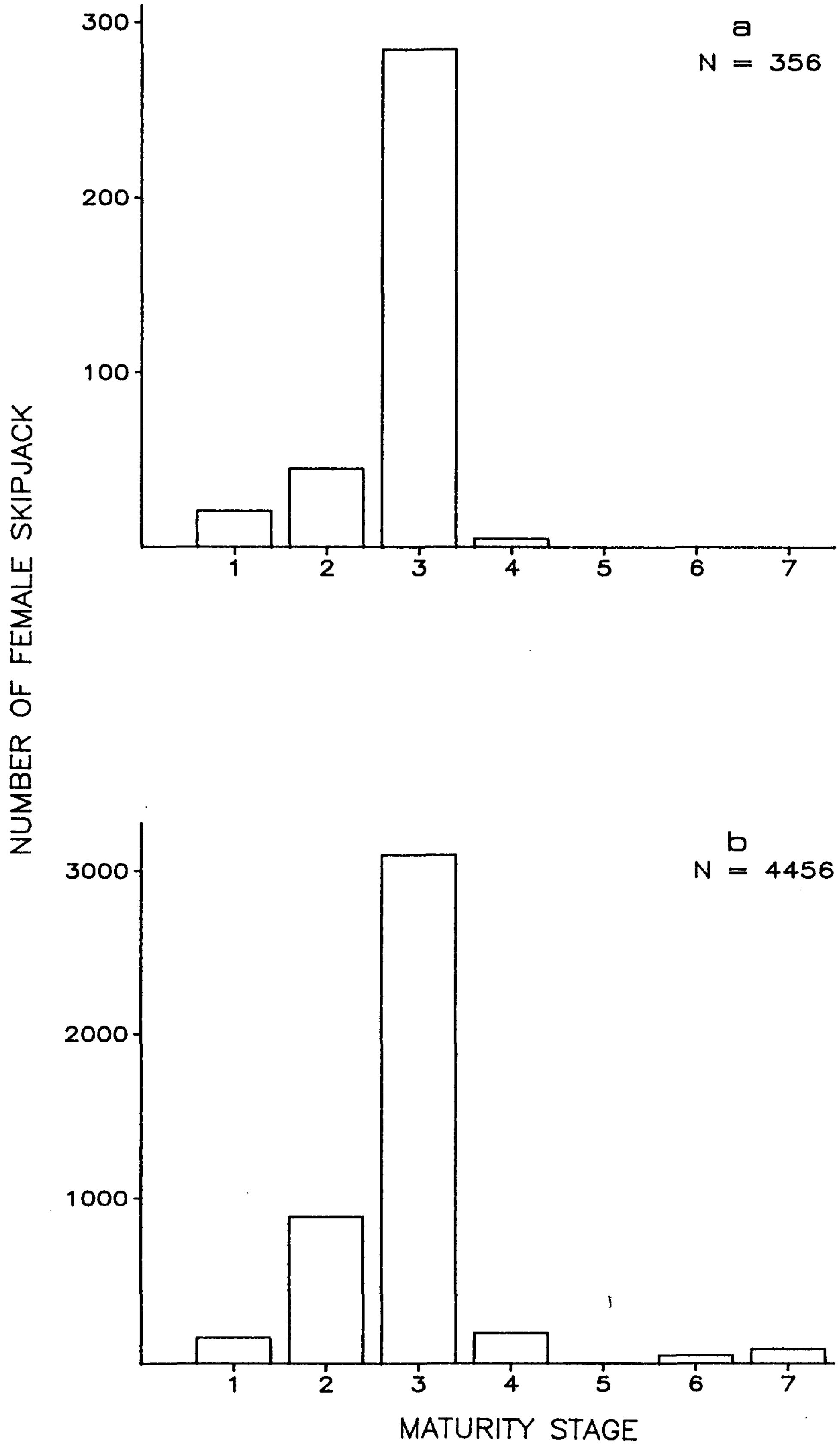


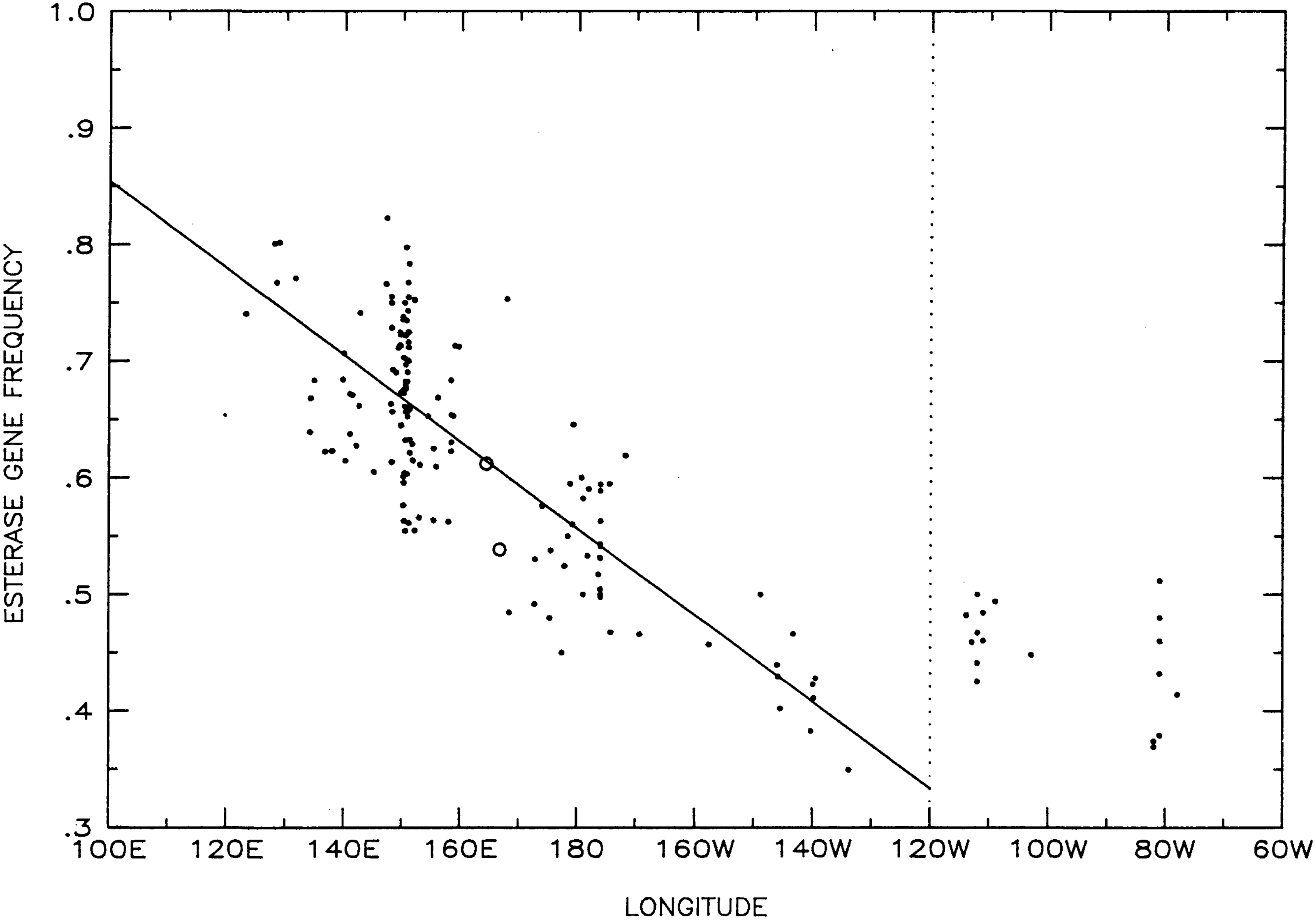
TABLE 4. INCIDENCE OF TUNA JUVENILES IN STOMACHS OF PREDATOR TUNA SAMPLED IN NEW CALEDONIA

Predator	Predators Examined	Prey Species	No. of Prey	No. of Predators with Prey	Prey per 100 Predators	Percentage of Predators with Prey
Skipjack	477	Skipjack	48	26	10.06	5.45
		Mackerel Tuna	4	3	0.84	0.63
		Frigate Tuna	5	4	1.05	0.84
Yellowfin	26					
Rainbow Runner	4					
Mackerel Tuna	5					
Frigate Tuna	4					
Dolphinfish	5					
Total	521		57			

TABLE 5. ITEMS FOUND IN STOMACHS OF SKIPJACK SAMPLED IN NEW CALEDONIA

Item No.	Diet Item	Number of Stomachs	Percentage Occurrence
1	Chum from _Hatsutori Maru_	208	75.09
2	Cephalopoda (squid)	115	41.52
3	Fish remains (not chum)	85	30.69
4	Acanthuridae	65	23.47
5	Decapoda (shrimp)	49	17.69
6	Siganidae	42	15.16
7	Scombridae (j)	30	10.83
8	_Coryphaena hippurus_ (Coryphaenidae)	26	9.39
9	Stomatopoda (alima stage)	25	9.03
10	_Decapterus_ sp. (Carangidae)	21	7.58
11	Unidentified fish	17	6.14
12	Chaetodontidae	14	5.05
13	Empty stomach	13	4.69
14	Exocoetidae	11	3.97
15	Euphausiacea	9	3.25
16	Gempylidae	8	2.89
17	Aluteridae	8	2.89
18	_Anthias_ sp. (Scolopsidae)	5	1.81
19	Synodontidae	5	1.81
20	_Pterycombus peterii_ (Bramidae)	5	1.81
21	Priacanthidae	4	1.44
22	Decapoda (carid shrimp)	4	1.44
23	Decapoda (megalopa stage)	4	1.44
24	Balistidae	4	1.44
25	Stomatopoda	3	1.08
26	Bramidae	3	1.08
27	Tetrodontidae	3	1.08
28	Pteropoda	2	0.72
29	Coelenterata	2	0.72
30	Fistulariidae	2	0.72
31	_Dactylopterus orientalis_ (Dacylopteridae)	2	0.72
32	_Xiphasia_ sp. (Xiphasiidae)	2	0.72
33	Decapoda (penaeid shrimp)	2	0.72
34	Cirrhitidae	1	0.36
35	Holocentridae	1	0.36
36	Paralepidae	1	0.36
37	Syngnathidae	1	0.36
38	Amphipoda (Hyperiidae)	1	0.36
39	Scaridae	1	0.36
40	Carangidae	1	0.36
41	Sternoptychidae	1	0.36
42	Trichiuridae	1	0.36
43	Ascidiacea	1	0.36
	Total Stomachs Examined	277	

FIGURE 4. SKIPJACK SERUM ESTERASE GENE FREQUENCY FOR 163 SAMPLES VERSUS THE LONGITUDE OF THE SAMPLE LOCATION. Each point is the average of approximately 100 specimens sampled from a single school on the same day. New Caledonia samples are shown as circles.



Good baitfish concentrations were detected in numerous areas and many excellent catches were made during the first visit (Tables 1 and 6). The total catch was 5 212.5 kg of bait, of which 4 783.5 kg were loaded alive in the bait wells, including 444 kg transported live to Vanuatu to supplement insufficient local catches during the Programme's visit to that country. On average, 119 kg of bait were loaded per haul, one of the highest results achieved during the entire Programme (Skipjack Programme 1981d). Baitfishing was satisfactory in Laugier Bay and around Port Bouquet, but disappointing in Prony Bay, corroborating earlier Japanese results (Anon. 1972, 1973, 1974). In comparison, during ORSTOM surveys from 1980 to 1982, 28 327 kg of bait were caught in 342 hauls at 19 different sites in all areas of New Caledonia including the Belep and Loyalty Islands (Anon. 1982), averaging 83 kg per haul or about one-third less than the Skipjack Programme's results from the main island. However, the net used by ORSTOM was smaller than that used by the Skipjack Programme and areas which are known as poor baitfishing grounds were visited for scientific purposes. The local Transpêche fleet averaged 96 kg of bait per haul at 19 different locations during 1981-1983 (Hallier 1984). The data from ORSTOM and the local fleet included catches taken at all times of the year, and the low averages reflect poorer catches in the colder months (Anon. 1982). Highest catch rates were obtained between February and May. In contrast with the Hatsutori Maru No.1, which made better catches on the east coast and in the south, both the ORSTOM vessel and the Transpêche fleet found the west coast more productive (Anon. 1982; Hallier 1984).

TABLE 6. CATCH OF THE 10 DOMINANT BAITFISH SPECIES IN BOUKI-AMI HAULS MADE BY THE SKIPJACK PROGRAMME IN NEW CALEDONIA

	Catch (kg)	% of Total
Stolephorus heterolobus	2396	46
Herklotsichthys quadrimaculatus	735	14
Stolephorus devisi	625	12
Decapterus russelli	514	10
Gymnocaesio gymnopterus	359	7
Spratelloides gracilis	152	3
Stolephorus indicus	91	2
Spratelloides (new species)	30	0.5
Dipterygonotus leucogrammicus	20	0.4
Hypoatherina ovalaua	19	0.4
		95.3
Number of bouki-ami hauls		40
Total bait caught		5212.5 kg
Total bait catch loaded		4783.5 kg
Total bait discarded alive		22.5 kg
Total bait discarded dead		406.5 kg
Average catch per haul		130.3 kg
Average catch loaded per haul		119.6 kg

Anchovies, principally Stolephorus heterolobus and to a lesser extent Stolephorus devisi, comprised 58 per cent by weight of the Programme's catch. The herring Herklotsichthys quadrimaculatus accounted for 14 per cent, while sprats, most Spratelloides gracilis, contributed 5 per cent of the catch (Table 6). The relatively high contribution of mackerel scad (Decapterus russelli) to the catch resulted from several large hauls on the west coast (Table 1); the specimens were too large to be good quality bait.

Catches by the ORSTOM vessel and the local fleet showed a similar dominance by anchovies in 1981 and early 1983, whereas in 1980 and 1982, herrings and sardines (especially Amblygaster spp.) were the main species (Anon. 1982; Hallier 1984; ORSTOM unpublished data). Winter catches contained higher proportions of species which are not preferred as live bait, and of larger individuals which are less effective bait (Anon. 1982). Fluctuations in abundance have been reported for various baitfish species, including H. quadrimaculatus in Vanuatu (Grandperrin et al. 1982), Marshall Islands (Hida & Uchiyama 1977) and Kiribati (Kleiber & Kearney 1983), and Stolephorus spp. and Spratelloides spp. in Papua New Guinea (Tuna Programme 1984). Some fluctuations may have been in response to fishing pressure (Wankowski 1980; Johannes 1981) emphasising the vulnerability of baitfish stocks and the need for management regimes.

4.2 Skipjack Fishing

One hundred and seventy-one schools of tuna and tuna-like species were sighted during the 241 hours spent searching in New Caledonian waters (Table 1), at an average of 0.71 schools per hour, similar to the rate of 0.75/hour for the entire Programme. Skipjack were present in 94 per cent and yellowfin in 13 per cent of the identified schools; most (86%) were pure skipjack schools. Only one school, of mackerel tuna (Euthynnus affinis), did not contain either skipjack or yellowfin. Other species, including rainbow runner (Elagatis bipinnulatus), frigate tuna (Auxis thazard) and dolphinfish (Coryphaena hippurus), occurred only infrequently, in mixed schools with either skipjack or yellowfin (Kearney & Hallier 1978).

The 38 tonnes of skipjack poled or trolled on board the research vessels in New Caledonian waters corresponds to an equivalent estimated commercial catch of 5.5 tonnes per day, based on a conversion factor of 3.47 (Section 2.3). This is higher than the average daily catch rate of 3.4 tonnes per day achieved during the entire Skipjack Programme. The locally based Transpêche fleet averaged 3.3 tonnes per boat-day between late 1981 and early 1983, but their catch showed strong seasonal variation (Hallier 1984). Daily catches of about 11 tonnes were taken in the summer of 1981-1982, while winter catches were about one tonne or less per day. Since 1974, Japanese pole-and-line vessels, fishing only in summer, have made daily catches averaging 5-7 tonnes, with a high of 9.6 tonnes per day in the 1979-1980 season (Skipjack Programme 1980; Service des Affaires Maritimes unpublished data).

4.3 Biological Observations

4.3.1 Maturity and recruitment

Female gonad maturity stages for skipjack samples from New Caledonia are shown in Figure 3. Seven stages of gonad maturity were recognised using criteria in Argue (1982), representing a progression of reproductive condition from immature (stage 1) to post-spawning (stages 6 and 7).

Maturing gonads were classified as stages 2 and 3, mature gonads as stage 4 and ripe gonads as stage 5. On both visits, stage 2 and 3 gonads were predominant, with few mature fish. This distribution of maturity stages is similar to that found for 5 225 female skipjack examined by the Programme between 1977 and 1980 (Figure 3), except that no stage 6 or 7 fish were found in New Caledonia. The absence of running ripe female gonads (stage 5) is not unusual, as only two were sampled during the entire Programme.

Seasonal changes in female gonad index[3] for all Skipjack Programme samples from tropical waters suggest that skipjack spawning is most intense south of the Equator between October and March (Figure 5). This trend is very similar to the that presented by Naganuma (1979) for samples collected from a wide area of the tropical south Pacific waters, and by Lewis (1981) for samples from the Papua New Guinea fishery, a few degrees south of the Equator. Skipjack sampled from New Caledonia in December 1977 and January 1978 had gonad index values (30.6 for 40-49.9 cm skipjack and 64.4 for 50-59.9 cm skipjack) similar to summer averages in Figure 5 for skipjack of these sizes. Three skipjack sampled from Hunter Island on 31 March 1980 had gonad indices less than 20, comparable to overall averages for March and April. These results suggest that skipjack spawning in the waters of New Caledonia exhibits seasonal periodicity similar to that observed in the larger data set from the entire study area.

A further index of breeding is the incidence of skipjack juveniles in the stomachs of predators. Only 26 of the 477 skipjack predators (5.5%) examined from New Caledonia had skipjack juveniles in their stomachs, a frequency of 10.06 skipjack prey per 100 predators (Table 4). This is less than the 25 to 50 juveniles per 100 stomachs found in Vanuatu, Wallis and Futuna or the Marquesas Islands, but is similar to the overall Programme average of 10.8 for tropical waters. Argue et al. (1983) presented detailed analyses of the tuna juvenile data, taking into account size-selective predation by adults, time of day, distance from land and sampling season. Skipjack juveniles occurred most frequently in the stomachs of skipjack captured by the Programme between October and March in tropical waters south of the Equator, coinciding with the period of maximum gonad development in skipjack in these waters. The data also indicate that during the 1977 to 1980 survey period, abundance of juvenile skipjack within this region was highest in two areas, one centred approximately on Solomon Islands - Papua New Guinea - Vanuatu, and the other on the Marquesas and Tuamotu Islands. As virtually nothing is known about the movements of juvenile skipjack, the relative contributions of spawning in these areas or in local waters to recruitment in New Caledonia cannot be established.

4.3.2 Diet

Table 5 lists 42 food items found in the 277 skipjack stomachs examined by the Skipjack Programme in New Caledonia. The stomach contents were typical of those from skipjack from other tropical waters in the South Pacific Commission region. Apart from chum from the research vessel, squid (Cephalopoda), fish remains, surgeonfish (Acanthuridae), rabbitfish

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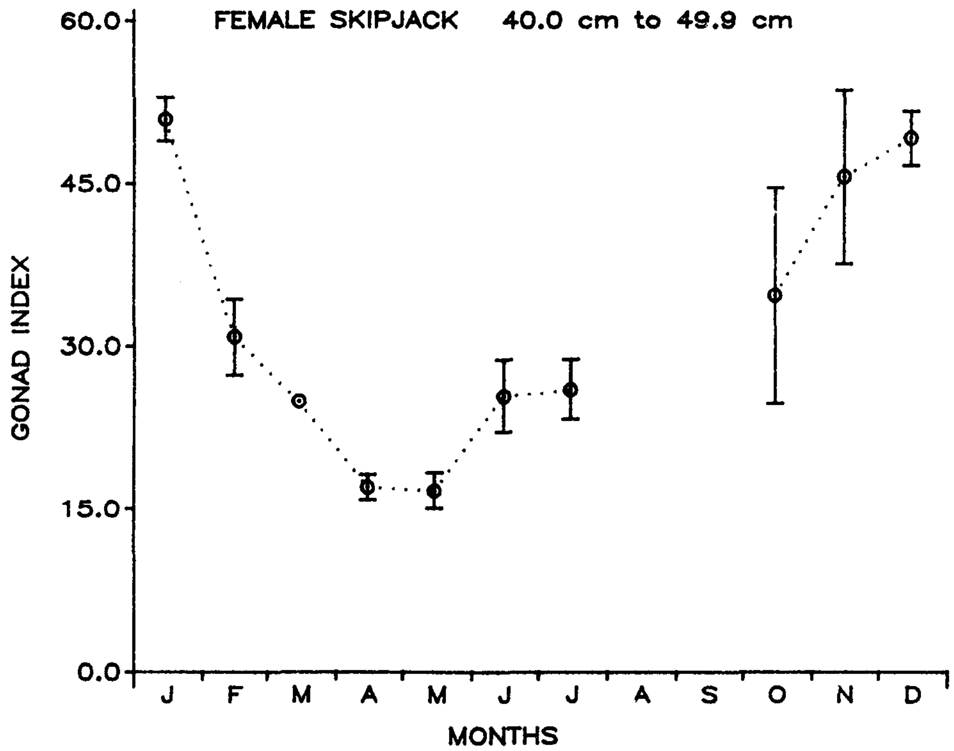
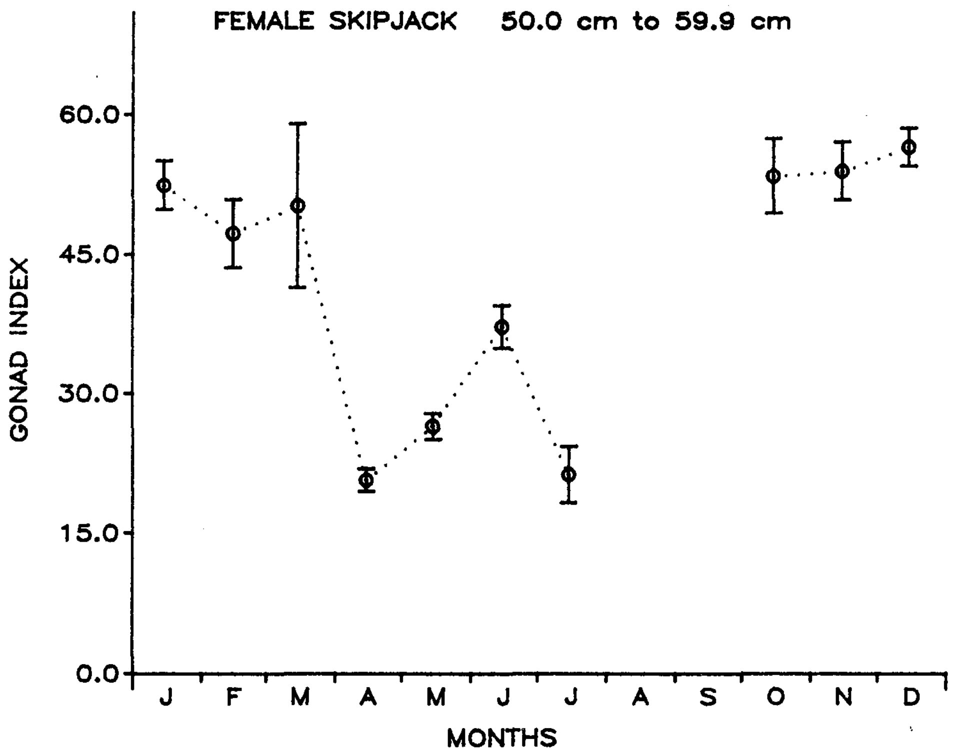
3 Gonad index=10^7(gonad weight gm/(fish length mm)^3) (Schaefer & Orange 1956). High index values, particularly over 50, are associated with skipjack whose gonads have a high percentage of eggs that are ready to be spawned (Raju 1964).

FIGURE 5. AVERAGE GONAD INDICES (± two standard errors), BY MONTH, FOR FEMALE SKIPJACK SAMPLED BY THE SKIPJACK PROGRAMME FROM TROPICAL WATERS SOUTH OF THE EQUATOR. Standard errors omitted for one small (<5) sample (top graph, March); other sample sizes were at least 8 and most exceeded 100. No samples for August and September.





(Siganidae) and tuna juveniles (Scombridae) were the most common food items, occurring in over 10 per cent of the stomachs examined. The different frequency of tuna juveniles from that given in Section 4.3.1 was due to the different sample size. The results in Table 5 indicate the importance of fish to the diet, but also emphasise the opportunistic nature of skipjack feeding. Analyses based on contents of all skipjack stomachs sampled throughout the entire region are currently in progress.

4.3.3 Growth

The growth of skipjack, as in other tunas, is a function of size. Larger fish increase in length more slowly than smaller fish (Joseph & Calkins 1969). Therefore, when a tagged fish is recovered, its increase in size depends on not only the length of time it was at liberty, but also its size when released. These considerations complicate the evaluation of growth by the analysis of tagging data. Table 7 presents a summary of size and growth information for skipjack tagged and released in the Skipjack Programme study area for each size class for which there were sufficient data. Mean size-at-release varied from 41 to 55 cm, time-at-liberty from 0 to over 300 days, and growth increments from -0.3 to 12 cm. The effects of time-at-liberty can be seen by noting the difference in growth increment between FIJ1 and FIJ2 data sets, in which the fish were released at approximately the same size but the mean times-at-liberty were different. The effects of size-at-release can be seen in the different growth increments in the PAL3 and PNG0 data, in which the fish were at liberty for approximately the same period of time but the mean sizes-at-release were different. Growth increments were in most instances quite small, and the proportion of fish which did not show any measurable growth was high (40%). There are several possible reasons for this apparent lack of growth. Firstly, the time-at-liberty may have been too short for much growth to have occurred. Secondly, skipjack may have been near their maximum size when tagged and released. Thirdly, they may have encountered conditions unfavorable for growth. Fourthly, errors in length measurement at both release and recovery may have obscured what little growth occurred.

It is possible to calculate corrections for the effects of size-at-release and time-at-liberty on the observed growth increment. These calculations used analysis of covariance and a linearised version of the von Bertalanffy growth equation, to produce a standard growth increment for an arbitrary size-at-release and time-at-liberty (Sibert et al. 1983). Standardised growth increments are presented in Table 8. Growth varied considerably from country to country, and differed significantly between visits to a country and between fish recovered inside or outside the country of release (Sibert et al. 1983). Thus, skipjack growth seems to be highly variable in time and space. The growth observed in tagged skipjack was a function of where and when the fish were tagged, and where they were recovered. It may be closely coupled to environmental conditions such as temperature and the oceanographic variables that are thought to regulate the abundance of food.

Only 15 of the skipjack released in New Caledonia were recovered with reliable information on time-at-liberty and size-at-release and -recapture. The data are too few and too variable to provide an accurate assessment of the growth of these fish.

TABLE 7. SUMMARY OF LENGTH INCREMENTS FOR SKIPJACK TAGGED BY THE SKIPJACK PROGRAMME IN VARIOUS COUNTRIES AND TERRITORIES IN THE SKIPJACK PROGRAMME STUDY AREA. Fish were at large for periods between 10 and 365 days. Country abbreviations are explained in Appendix C.

	RECAPTURES WITHIN COUNTRY OF RELEASE						RECAPTURES OUTSIDE COUNTRY OF RELEASE					
Country and Visit	Sample Size	Mean Size at Release	Mean Size at Recapture	Mean Days at Liberty	Increment Mean	Increment Standard Deviation	Sample Size	Mean Size at Release	Mean Size at Recapture	Mean Days at Liberty	Increment Mean	Increment Standard Deviation
FIJ1	431	48.0	48.6	23.9	0.65	2.29	3	51.3	55.3	68.7	4.00	2.65
FIJ2	208	51.2	55.3	108.7	4.09	5.34	9	51.7	61.3	237.8	9.67	11.86
KIR1	279	48.4	49.8	56.0	1.43	2.18	15	51.0	55.2	137.3	4.20	3.43
MAQ2	26	48.3	48.0	18.9	-0.27	1.31	3	48.0	60.0	273.7	12.00	3.00
PAL1	0						14	59.0	63.1	113.6	4.14	4.59
PAL3	14	40.8	47.8	85.3	7.00	5.55	143	40.6	49.3	171.0	8.71	6.49
PNG0 *	290	54.6	56.4	87.6	1.78	2.46	16	53.4	57.6	229.7	4.25	3.86
PNG2	609	54.6	55.2	51.5	0.63	3.17	37	51.5	56.8	197.8	5.32	4.58
PON1	7	53.9	57.7	84.7	3.86	2.67	12	53.9	57.6	152.4	3.67	3.37
PON3	13	51.4	57.2	168.0	5.77	2.31	43	55.4	59.9	186.0	4.47	4.30
SOL1	38	51.8	54.3	192.5	2.45	4.28	2	52.5	57.5	199.0	5.00	0.00
TRK1	1	50.0	56.0	121.0	6.00	-	10	49.7	56.7	152.6	7.00	2.79
TRK2	1	53.0	54.0	21.0	1.00	-	6	53.5	60.0	186.2	6.50	4.04
VAN1	1	52.0	52.0	0.0	0.00	-	3	50.7	57.3	261.0	6.67	2.89
WAL1	0						22	53.0	54.4	198.5	1.36	2.77
WAL2	0						7	52.9	57.1	242.7	4.29	5.22
WAL1+WAL2	0						29	53.0	55.0	209.2	2.07	3.63
ZEA1	213	45.8	46.4	37.9	0.64	2.30	11	47.5	54.2	305.7	6.64	3.41
ZEA2	1	54.0	54.0	76.0	0.00	-	3	50.3	57.7	323.7	7.33	4.51

* Results for skipjack tagged and released in Papua New Guinea from 1972 to 1974 (see Kearney, Lewis and Smith 1972; Lewis, Smith and Kearney 1974).

TABLE 8. STANDARDISED INCREMENT (cm) OF LENGTH FOR FISH 50 CM LONG AT RELEASE AND AT LIBERTY FOR 90 DAYS. The 95 per cent confidence interval of each increment is given in parentheses. Country abbreviations are explained in Appendix C.

Country	Increment	Visits Included
FIJ	4.5 ($\pm$1.2)	FIJ1, FIJ2
KIR	1.4 ($\pm$1.2)	KIR1
PAL	8.5 ($\pm$6.4)	PAL3
PNG	3.6 ($\pm$1.9)	PNG2
PON	4.1 ($\pm$4.1)	PON3
SOL	2.5 ($\pm$1.4)	SOL1
ZEA	1.5 ($\pm$5.2)	ZEA1

4.3.4 Population structure

There is movement of some skipjack adults over much of the western and central Pacific (Figure B, inside back cover), suggesting that genetic exchange is possible among all parts of the Programme's study area. However, detailed examination of tag recapture data (Section 5.0) and preliminary analyses of fishery interactions (Section 5.3) indicate that the actual level of exchange of skipjack, at least of the size caught by pole-and-line gear, may be quite low. Analyses of the genetic variation in skipjack throughout the central and western Pacific were undertaken by the Skipjack Programme to provide additional information on migration, population structure and, ultimately, potential interactions between fisheries.

Electrophoretic analyses of skipjack blood samples reveal a gradient in esterase gene frequency, a genetic marker used to infer population structure, across the tropical Pacific between approximately 120°E and 130°W (Figure 4). The esterase gene frequencies for both of the samples taken in the waters of New Caledonia were within the 95 per cent prediction limits for the regression line of average gene frequency on longitude. There was considerable variation in individual esterase gene frequency values along this average line, although the cause of this variability was unclear (Anon. 1981).

Several models of population structure of skipjack in the Pacific Ocean have been proposed (Fujino 1970, 1976; Sharp 1978; Anon. 1981). One of these models, suggested by the Programme's tagging and blood genetics data, is called the clinal population structure model (Anon. 1981). It has the basic premise that the probability of breeding between skipjack is inversely proportional to the distance between them. Acceptance of this model implies that there are no genetically isolated skipjack subpopulations in the study area, separated by geographical boundaries, which is contrary to hypotheses advanced by Fujino (1970, 1976) and Sharp (1978).

The gradient in esterase gene frequency is consistent with several possible distributions of skipjack spawning, one being a relatively even distribution of skipjack spawning in tropical waters across the study area. Alternatively, it may be considered a product of "overlap" of skipjack from two or more centres of higher spawner density at the approximate extremes of the study area or beyond. The similarity between eastern Pacific esterase gene frequencies (east of 130°W) and those from French Polynesia suggests that skipjack from these areas may have the same genetic origin, and collectively may represent a spawning group at the eastern extreme of the study area. The geographic pattern of occurrence of juvenile skipjack in predator stomachs (Section 4.3.1) tentatively supports the latter view of skipjack spawning.

Parasite samples were taken over a wide range of tropical waters and from subtropical and temperate waters of Norfolk Island and New Zealand, but not from New Caledonia. A multivariate analysis presented by Lester et al. (ms.) showed that the parasite faunas from widely separated tropical areas were similar, and that skipjack caught in New Zealand carried many tropical parasites. The parasite studies did not improve definition of skipjack population structure, nor offer a means of clarifying fishery interactions.

After two workshops hosted by the South Pacific Commission to examine the question of skipjack population structure, it was concluded (Anon. 1980, 1981) that it is difficult to choose between the various population structure hypotheses, due to limitations of the extant blood genetics, tagging and ancillary data. However, the genetics data supported the conclusions that there should be minimal short-term interactions between fisheries at the extremes of the Programme's study area, and that interaction should increase as the distance between fisheries decreases.

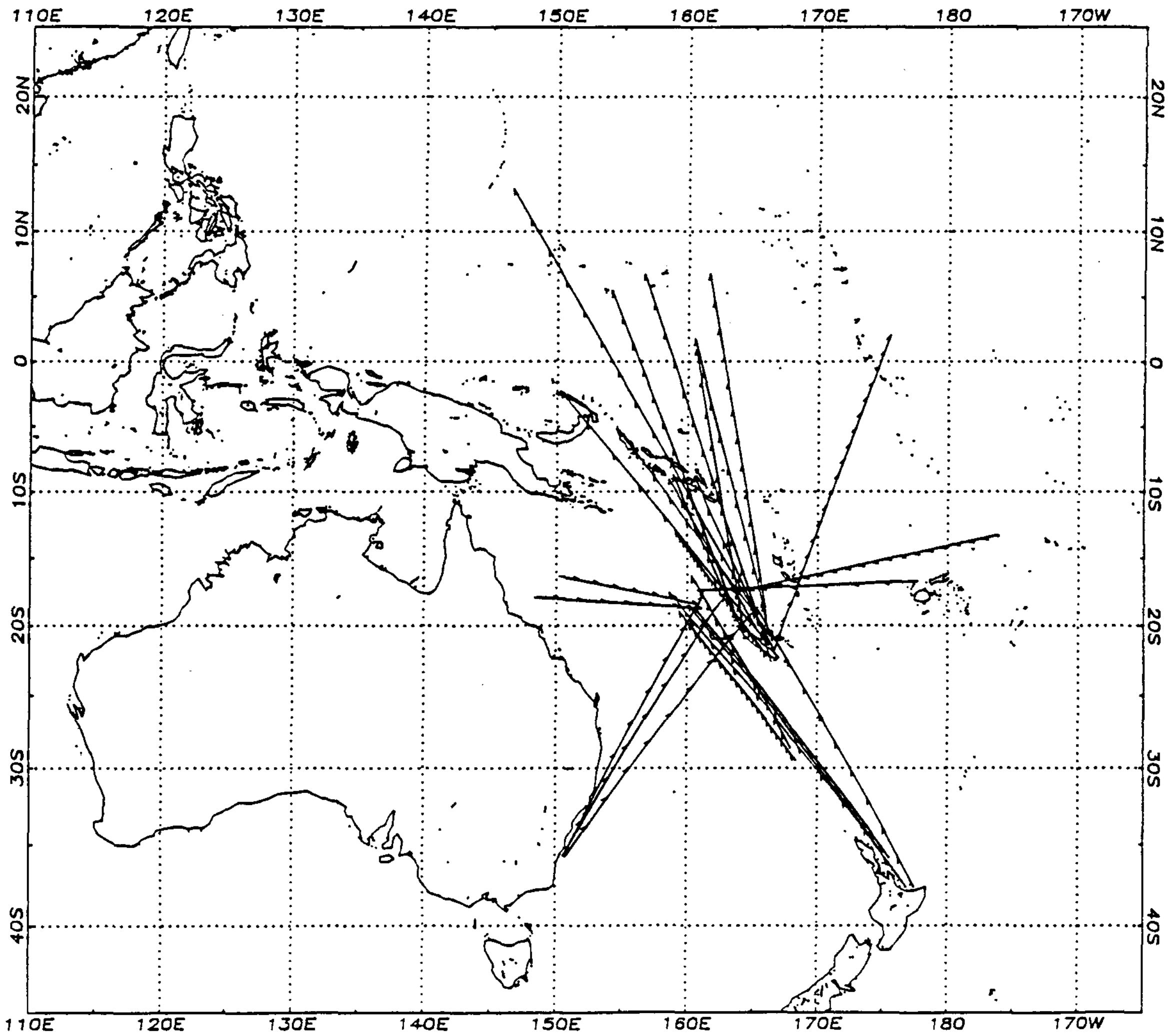
5.0 TAG RECAPTURE DATA

As of April 1983, 39 recoveries of the 10 219 tagged skipjack released in the waters of New Caledonia had been notified to the Skipjack Programme. Thirteen recoveries were from New Caledonian waters by the Skipjack Programme vessel, immediately after the fish were released or a few days later. Five other fish were recaptured in New Caledonian waters within 60 days of release, all but one by bonitiers. The low recovery rate (< 1%) is indicative of the low level of local fishing effort at the time of the releases and precludes any evaluation of the resource or of local movement patterns using tag recapture data.

5.1 Skipjack Migration

Nineteen skipjack tagged in New Caledonia were recaptured in waters external to New Caledonia's EEZ, after periods of up to two years at liberty. Straight line representations of movement of a selection of these skipjack are shown in Figure 6. Most (10) were recovered in Solomon Islands; other areas of recapture included Kiribati, Northern Marianas, Papua New Guinea, Ponape, Truk and international waters south of the Federated States of Micronesia. Two other recoveries were from indeterminate locations. While all known recovery locations are to the north of New Caledonia, movement in other directions cannot be precluded. There are very large fisheries for skipjack to the north of New Caledonia, while those to the east, south and west (Fiji, French Polynesia, New Zealand locally based fisheries, and Japanese pole-and-line fishery to the

FIGURE 6. STRAIGHT-LINE REPRESENTATIONS OF MOVEMENTS OUT OF NEW CALEDONIAN WATERS OF SKIPJACK TAGGED IN NEW CALEDONIA, AND INTO NEW CALEDONIAN WATERS OF SKIPJACK TAGGED ELSEWHERE BY THE SKIPJACK PROGRAMME. Only 26 of the 37 recorded migrations are plotted, by choosing only one example of movement in each direction between any pair of five degree squares. Tick marks on the arrows represent 30-day periods at large.



west) are small and/or seasonal. Thus, the apparent tendency of skipjack to migrate north from New Caledonia may be a reflection of only the relative intensities of fishing effort. The seasonal decline in surface sea temperature in the months following tagging in New Caledonia may also have been involved, since southward migrations probably occur in spring and early summer (Argue & Kearney 1983) with movements in a northerly direction after summer.

Also represented in Figure 6 are movements into New Caledonian waters of skipjack tagged elsewhere by the Skipjack Programme. Eighteen fish, variously from Wallis and Futuna, Fiji, Norfolk Island, New Zealand and Australia, were recaptured by Japanese pole-and-line vessels operating in New Caledonian waters. Full details of each release and recovery of fish which moved into or out of New Caledonian waters are given in Appendix B.

Figure B (inside back cover) presents a selection of Skipjack Programme tag returns from throughout the central and western Pacific. Returns were selected by plotting no more than one example of a migration in each direction between any pair of ten degree squares and no more than one example of a migration wholly within any ten degree square. The impression from this figure is one of considerable mixing of skipjack, with little evidence of barriers to movement within the study area. The lack of apparent movement beyond the area surveyed reflects poor chances for recovery as a result of low fishing effort, and the presence of unsuitable habitats at the latitudinal extremes (skipjack are seldom encountered polewards of 40 degrees latitude or in waters less than 16°C).

However, the impression of many wide-ranging international migrations gained from Figure B does not accurately reflect the average over all the tag recoveries. The figure overemphasises long distance, relatively rare migrations, due to the procedure used to select recoveries for the figure. The majority (86%) of tag recoveries were made less than 250 nautical miles from their release site and within 180 days of tagging (Figure 7). Long-distance migrations are prevalent only within the group of skipjack that were at large for more than 180 days.

5.2 Resource Assessment

The Programme's tag recapture data provide a basis for assessing the magnitude of the skipjack resource and its resilience to fishing pressure. A model formulated by Kleiber et al. (1983) was used to analyse tag attrition rates (the frequency of tag returns as a function of time) to derive estimates of various parameters of skipjack stock dynamics. Separate analyses were performed for the whole study area covered by the Programme and for the 200-mile zones of Papua New Guinea, Solomon Islands, the Gilbert Group of Kiribati, Fiji, New Zealand, and the Society Islands of French Polynesia, for each of which there were sufficient tag recapture statistics, as well as data on either catch or effort by fishing fleets. There were insufficient local tag recoveries (due to low fishing effort) to perform such an assessment of New Caledonia's skipjack stock. Figure 8 shows the numbers of tag returns for the whole Skipjack Programme study area versus the numbers of months these tags were at large after release. The straight line in the figure depicts the average number of tag recoveries one would predict per month from fitting the mathematical model of Kleiber et al. (1983) to the catch and tag return data.

The data points (stars) in Figure 8 deviate little from the line predicting the average number of tag returns per month. The instantaneous

FIGURE 7. NUMBERS OF SKIPJACK TAG RECOVERIES, BY DISTANCE TRAVELLED AND TIME-AT-LARGE, FOR THE ENTIRE SKIPJACK PROGRAMME DATA SET. Data are for tag returns received by 10 October 1983. Recaptures for 103 fish which travelled more than 1,500 nautical miles are included in the sample sizes, but are not shown in the figure.

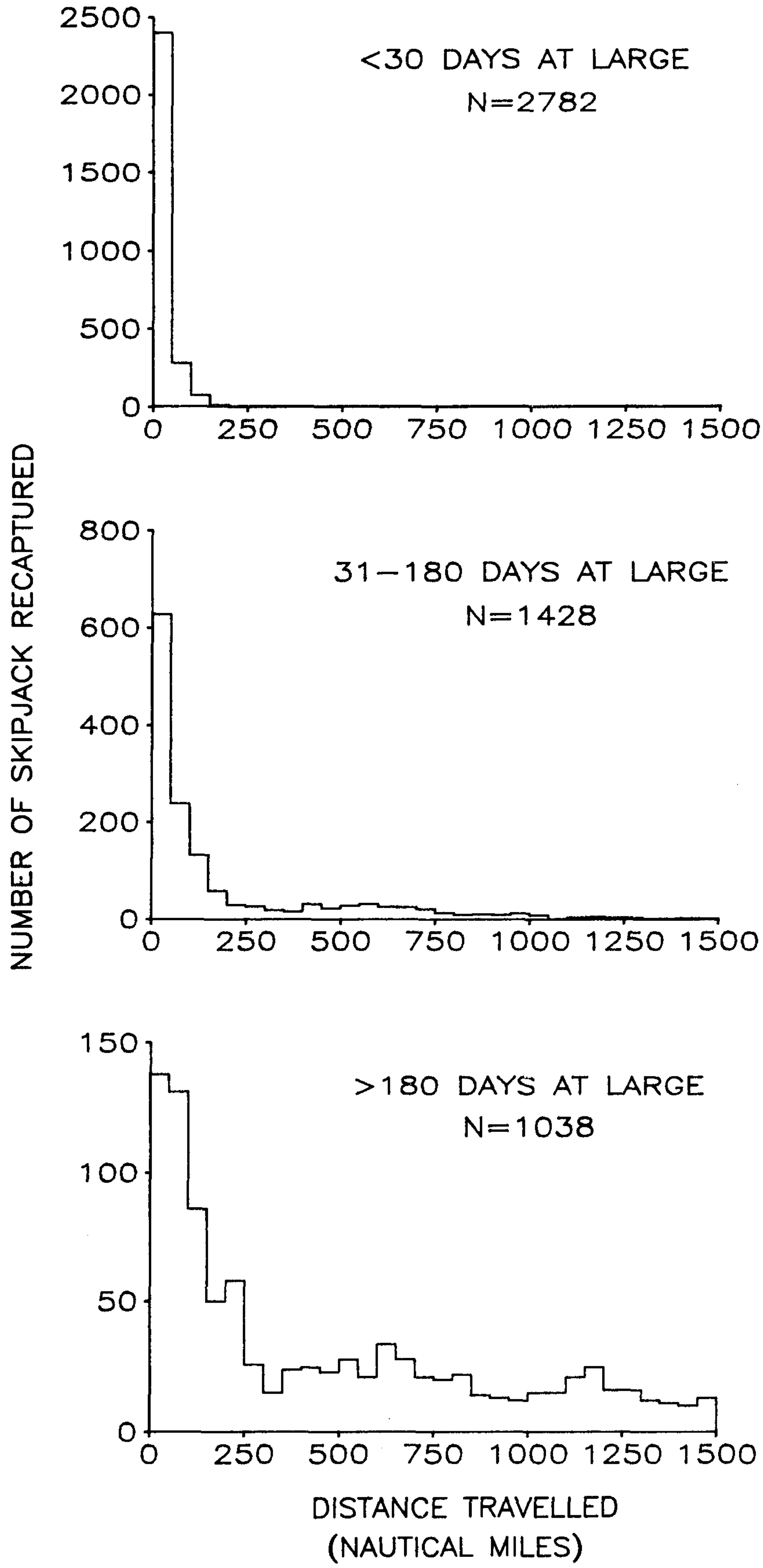
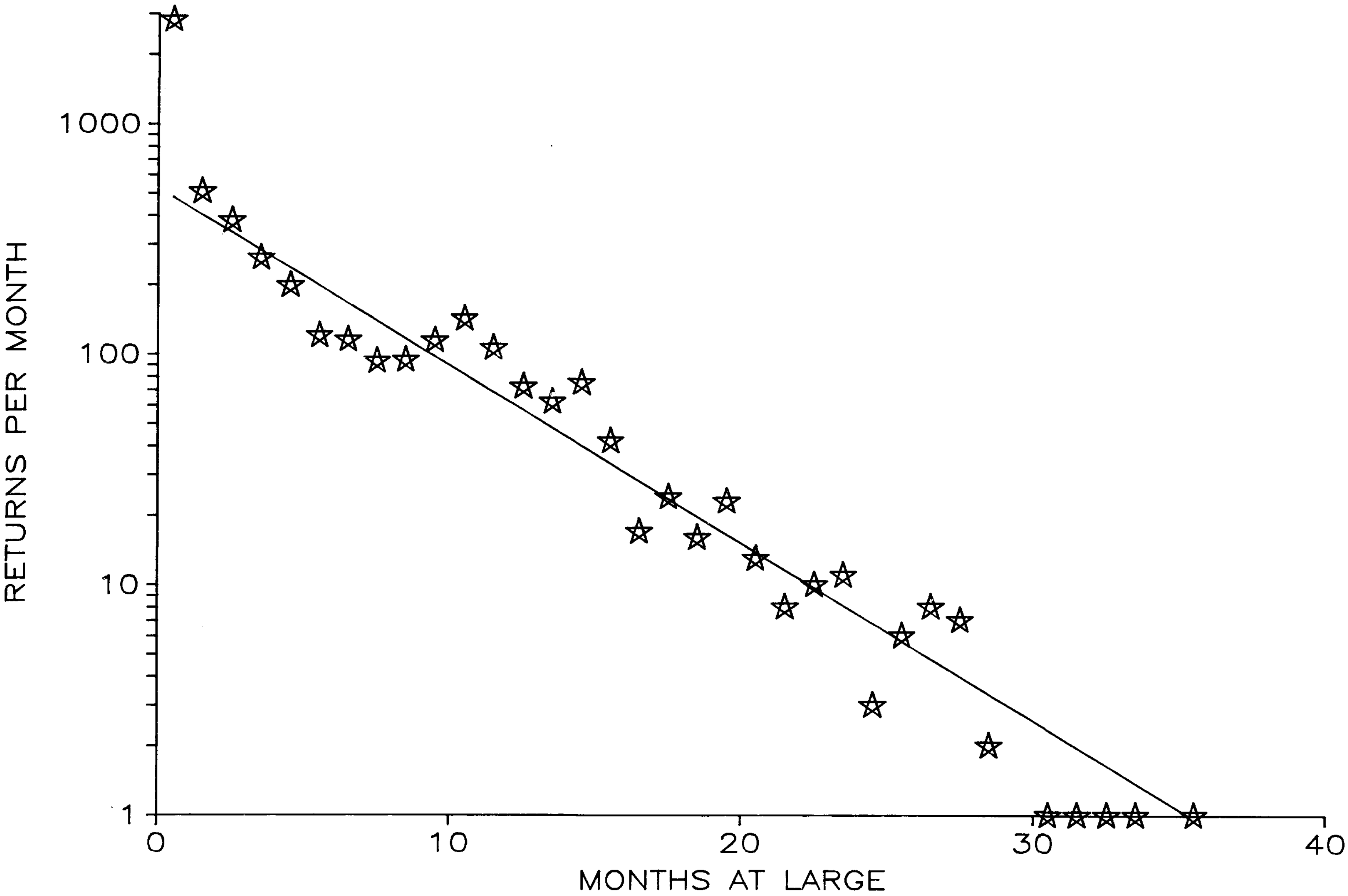


FIGURE 8. NUMBERS OF SKIPJACK TAG RECOVERIES VERSUS MONTHS AT LARGE, FOR THE ENTIRE SKIPJACK PROGRAMME DATA SET. The Y axis has a logarithmic scale.



rate of decrease of tag returns estimated from the fitting procedure is called the tag attrition rate, which results from natural and fishing mortality, changes in vulnerability, and emigration. An additional component, presumably small, includes both continual shedding of tags and continual mortality from the effects of tagging. The estimate of attrition rate was 0.17 per month (Kleiber et al. 1983), which is similar to the rate of 0.23 estimated for skipjack stocks from the large fished area north of the Equator in the eastern tropical Pacific (Joseph & Calkins 1969). Thus, after six months at large, close to 70 per cent of the tag releases by the Skipjack Programme were unavailable for recapture, for one or another of the reasons above, and after a year this had increased to 90 per cent. Assuming steady-state conditions in the stock, these fish were replaced by new recruits through reproduction, growth and immigration.

The model also provided estimates of several other parameters of the skipjack stock, but in doing so a correction factor was applied to account for non-return of recaptured tags, return of tags without sufficient or accurate recapture data, and loss of tags immediately after application through shedding or mortality. In the entire study area, the population size or "standing stock" which was vulnerable to surface fisheries was estimated to be approximately three million tonnes during the 1977 to 1980 study period (95% confidence range of 2.5 million to 3.7 million tonnes). Average monthly catch, in the Programme's study area, 19 000 tonnes, divided by population size, provided an estimate of average monthly fishing mortality of approximately 0.006, which is only a small proportion of the monthly attrition rate. Other losses, through natural death, decreased vulnerability to fishing and emigration are difficult to partition, but because the study area was vast and covered much of the area of skipjack distribution in central and western Pacific waters, it has been assumed that emigration is the smallest of the three.

The product of standing stock and monthly attrition rate provides an estimate of monthly "throughput" - the biomass (tonnes) of skipjack recruited to the standing stock each month. This is assumed for the duration of the tagging experiment to be matched by an equal amount leaving each month (i.e. steady-state conditions prevail). From Skipjack Programme data, throughput was estimated to be 0.46-0.59 million tonnes per month. Average monthly loss due to catch represents approximately four per cent of the estimated monthly throughput. Hence, there appears to be potential for greatly increased catches from the region as a whole before recruitment would be affected (Kleiber et al. 1983). The experience with much more mature skipjack fisheries off the coast of Japan and in the eastern Pacific, where there has been no relationship between catch per unit effort and effort over a period of 20 or more years (Joseph & Calkins 1969; Kearney 1979), supports this view.

The resource of skipjack in the waters of New Caledonia is obviously some small fraction of the total standing stock in the study area. Although the data for New Caledonia are insufficient to estimate quantitatively the size of the local skipjack resource, it is likely that the fishery for skipjack in the waters of New Caledonia could increase greatly without significantly impairing recruitment. However, a large increase in skipjack fisheries in neighbouring countries could have a detrimental impact on the quantity of skipjack available in New Caledonia (see Section 5.3).

5.3 Fishery Interactions

With increasing fishing activity and changing gear technology, catches from the area served by the South Pacific Commission have grown remarkably in recent years, leading inevitably to greater interaction between fisheries (Kearney 1983). These may occur, for example, between various types of fishery within a particular country (e.g. artisanal *vs* industrial), between fisheries based on different gear types (e.g. purse-seine *vs* longline for yellowfin) or between fisheries operating in different countries. The data of the Skipjack Programme provide a measure of the last type of interaction.

Tag recapture data enable assessment of interaction only within one generation of fish. However, within-generation assessments are most appropriate for skipjack, since the absence of any relationship between catch per unit effort and effort, even within intense fisheries (Joseph & Calkins 1969; Kearney 1979), suggests that between-generation interactions are not significant. Within-generation interactions between fisheries may be construed in various ways, such as the change in catch in one fishery resulting from catches in another, or the fraction of recruitment in a fishery attributable to migration from another fishery. The methods developed by the Skipjack Programme measure interaction in the latter way, that is, as a function of throughput.

A parameter, the "immigration coefficient" I, was derived to express interaction as the percentage of the throughput in a "receiver" country which could be ascribed to migration from another, "donor" country (Kleiber et al. 1984). An earlier version of I expressed interaction as the contribution of migrants to standing stock of the receiver country (Skipjack Programme 1981b). The present coefficent is computed from the number of tag releases in the donor country and the number of recoveries of those tags in the receiver country, together with various parameters of the two stocks, estimated by the tag attrition model of Kleiber et al. (1983). Two values of I exist for any pair of fisheries, one for each of the directions in which interaction may occur. It should be remembered that, as with the parameters derived from the tag attrition model, the immigration coefficient measures only the interaction between particular fisheries operating in defined areas. It does not provide a measure of migration of fish from all parts of a country's fishery zone to the whole fishery zone of another country, and is therefore a minimum estimate of interaction.

Table 9 summarises the recoveries from skipjack released throughout the total study area, by country/territory of release and recovery and offers a simple index of the degree of interaction between fisheries. However, this form of presentation takes no account of tag recovery effort, that is, the catch from which the tags were recovered. Reliable catch data are necessary for quantifying the interactions. These were available to the Programme from some of the locally based fisheries during the period tags were at large, but not for catches between 1979 and 1982 by the large United States and Japanese distant-water purse-seine fisheries and the Japanese distant-water pole-and-line fishery. These fisheries operate in much of the western Pacific and over the period of tag recoveries they accounted for a significant percentage (~20%) of Skipjack Programme tag returns. Until the Programme receives catch data from these fisheries, accurate estimates of interaction between distant-water and locally based fisheries cannot be made.

TABLE 9. SUMMARY OF SKIPJACK RELEASE AND RECOVERY DATA FOR THE ENTIRE SKIPJACK PROGRAMME, AS OF 10 OCTOBER 1983. See Appendix C for abbreviations.

COUNTRY OF RECAPTURE

NUMBER OF RELEASES BY COUNTRY

		AMS	CAL	FIJ	GIL	GUM	HAW	HOW	IND	INT	JAP	KOS	LIN	MAQ	MAR	MAS	MTS	NAU	NCK	NOR	NSW	PAL	PAM	PHL	PHO	PNG	PON	QLD	SOC	SOL	TOK	TON	TRK	TUA	TUV	VAN	WAK	WAL	WES	YAP	ZEA	TOT
775	AMS	3																																					1			4
10219	CAL		18		1					2					1											2	2			10			1									37
20094	FIJ		1	1948	1					5								1							4				1			2			6		1	2	2		3	1977
174	GAM																																									
4569	GIL	1			385			24		32		1	1			14		1					2		1		1															463
108	JAP				1				2	3	7				1	1																										15
297	KOS									3						2																										5
20282	MAQ				1			1		4				42											1				1													50
195	MAR									2	1				2		1										1						2									9
327	MAS									2						1		1																								4
1229	NCK																		1																							1
91	NIU																																									
1113	NOR		2	1																										1												4
4322	NSW	1	6	2						1											2								1	8									1		9	31
7233	PAL				3				28	69		3			1	6						108		6		77	9			2			23							31		366
367	PHO				1																																					1
59	PIT																																									
8550	PNG				1	1		5	7	18		1				7						2	2			958	3	1		26			11							3		1046
5518	PON				1			2		17	2	23			1	30								1		1	113			1			13							10		215
2651	QLD		3																									2		25			1			2						33
48	SCK																																									
1725	SOC																												36													36
6221	SOL			1	1				1	2																16				526												547
64	TOK																														1											1
1969	TON																								1				1			10							1			13
1054	TRK									4		5				5											19						16							2		51
5528	TUA																												5					25								30
2904	TUV			2	2		1	1		7		1				4		1					1		1	1				2					2				1	1		28
1254	VAN																									1				4						2						7
16065	WAL		1	14	5			5		11						3									24	2			3				1		1			66	11		6	153
1926	WES	1																											1	1									19		1	23
778	YAP				2				3	7	1				3							1					1						3							5		26
12734	ZEA		5	31						3										1	2								5		1	1			1	1			5		1003	1059
140443	TOT	6	36	1999	405	1	1	38	41	192	11	34	1	42	9	73	1	4	1	1	4	111	5	7	32	1058	149	3	54	606	2	13	71	25	10	5	1	68	41	52	1022	6235

TABLE 10. COEFFICIENTS OF INTERACTION BETWEEN FISHERIES OPERATING IN VARIOUS COUNTRIES AND TERRITORIES IN THE CENTRAL AND WESTERN PACIFIC (from Kleiber et al. 1984). See Appendix C for abbreviations for countries and territories. The numerals following country codes indicate tag release data sets from separate visits to the same country.

Donor Country	Receiver Country									
	PNG[c]	SOL[c]	PAL[c]	FSM[d]	MAS[d]	MAR[d]	FIJ[c]	ZEA[e]	WES[f]	SOC[f]
PNG	-	2.6	0.8	1.4	0.5					
SOL 77	1.1	-								
SOL 80	3.7	-								
PAL 78			-	8.6	2.2					
PAL 80	1.6	0.4	-	3.5	1.3	0.7				
FSM	0.7	0.9		-	37.0	10.8				
MAS					-					
MAR				17.4		-				
FIJ 78							-	0.6[a]		
FIJ 80							-			
ZEA							6.5	-	2.1[b]	3.6
KIR[c]				<0.1	0.1					

a assuming β_r=0.76 and T_d=7300

b assuming β_r=0.76

c local pole-and-line fishery

d Japanese pole-and-line fishery

e local purse-seine fishery

f local artisanal and subsistence fishery

The Skipjack Programme has calculated coefficients of interaction in at least one direction for as many pairs of countries and territories in the South Pacific Commission region as possible with the available data. A selection of the results is shown in Table 10. Most coefficients are small, with over half of them less than 2 per cent, but they span a wide range, from less than 0.1 per cent for movements from Kiribati to the Federated States of Micronesia to 37 per cent for movements from the Federated States of Micronesia to the Marshall Islands. Most of those omitted from the selection in Table 10 were also very low, from 0.1 to 1.0 per cent (e.g. Argue & Kearney 1982; Tuna Programme 1984). Thus, with very few exceptions, interactions at the time of tagging were quite low, at least between the particular fisheries listed in Table 10. Developments in these areas since then may have already altered the levels of interaction. It should also be noted that these results apply only to skipjack of the size tagged by the Programme (mostly >45 cm). Skipjack smaller than this could very well move large distances and contribute significantly to interactions between stocks in the fished areas.

Fishery interactions increase as the distance between fisheries decreases. If fisheries in neighbouring countries expand their areas of operation to include waters adjacent to common borderlines, the degree of interaction may increase. Furthermore, if different gear types were to operate in the same area, such as purse-seine and pole-and-line fleets working in the same or nearby fishing grounds of a country, then the degree of interaction would be much higher than present figures indicate. Since the few tagging data indicate some exchange of fish between New Caledonia and its neighbours, there exists the possibility of interactions between fisheries in the future. At the present low levels of exploitation, there probably are only very small interactions between fisheries operating in New Caledonian waters and those operating elsewhere.

6.0 CONCLUSIONS

6.1 Baitfish Resources

The Skipjack Programme's surveys indicate that, at least during summer, the baitfish resource around the southern two-thirds of the island is large and dominated by species which are most effective as live bait for tuna. There are numerous, extensive baiting locations, and if gear other than the bouki-ami nets used by the Programme is deployed, many other localities would be accessible to baitfishing. Other surveys by JAMARC, ORSTOM and the Starkist Company, and commercial operations by locally based pole-and-line vessels also indicate that there is a baitfish resource sufficiently large to support a commercial fishing fleet. They also have shown the baitfish to be abundant in northern areas not visited by the Skipjack Programme.

The availability of baitfish varies seasonally, with lower catches in winter. Changes in the species composition and size distribution in winter catches also may lead to insufficient baitfish supplies during these months, thus limiting the activities of a pole-and-line fishery. However, the abundance of tuna is also low during the cold months, reducing the requirement for live bait.

There is no evidence of overexploitation of baitfish stocks in New Caledonia, but in other parts of the central and western Pacific the abundance of species that are common in New Caledonia has been found to fluctuate, in some instances apparently in response to heavy fishing pressure. Therefore, if the baitfish resources are to be heavily exploited, the stocks should be closely monitored.

6.2 Skipjack Resources

The few recoveries of tags from skipjack released in New Caledonian waters did not permit an estimate of the size and dynamics of the skipjack resource. However, the assessments made by the Skipjack Programme for its entire study area in the central and western Pacific may be used to infer that the skipjack resource in the waters of New Caledonia is large. Turnover should be similar to that calculated for the region as a whole, but would be expected to display much greater variation between summer and winter. Daily catches and the rate of school sightings by the Programme confirm that, in summer, skipjack are as abundant as they are in several other areas which presently support commercial fisheries. However, catch data from foreign and locally based vessels generally indicate that abundance is seasonal and variable, and that fishing operations in the colder months are probably not commercially viable in New Caledonia.

Purse-seining, which is by several criteria a more efficient harvesting method than pole-and-line fishing, in future may prove desirable, but little exploratory purse-seine fishing has been conducted in New Caledonian waters. The few trials conducted to date have achieved variable results.

No estimates of interaction between skipjack stocks in New Caledonian waters and those in other areas could be made, but tag recaptures confirm that there is some exchange with adjacent areas. If large-scale commercial fisheries for skipjack are established in New Caledonia and in adjacent regions, they should be closely monitored, perhaps by further tagging studies, for evidence of interaction.

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APPENDIX A. SCIENTISTS, OBSERVERS AND CREW ON BOARD THE RESEARCH VESSELS

South Pacific Commission Scientists

Jean-Pierre Hallier	13-31 December 1977 16-19 January 1978 31 March 1980
Antony Lewis	2-16 January 1978
Robert Gillett	13 December 1977-16 January 1978
James Prescott	2-16 January 1978
Lionel Haefner	16-19 January 1978
Des Whyman	31 March 1980

Observers

Rene Grandperrin SPC Fisheries Adviser	11-14 December 1977
Masakazu Yao Fisheries Biologist Far Seas Fisheries Division Japan Fisheries Agency	13-29 December 1977 20-24 January 1978
Francois Liuvea New Caledonian fisherman	11-14 December 1977
Masao Hashizume Fisheries Biologist Far Seas Fisheries Division Japan Fisheries Agency	5-12 December 1977 20-24 January 1978
Gary Voss Fisheries Technician New Zealand Ministry of Agriculture and Fisheries	31 March 1980
Gwiedo Kucerans Fisheries Technician New Zealand Ministry of Agriculture and Fisheries	31 March 1980

Japanese Crew
Cruise One

Masahiro Matsumotu, Captain
Ryoichi Eda
Sakae Hyuga
Yoshihiro Kondoh
Yoshio Kozuka
Yoshikatsu Oikawa
Akio Okumura
Kohji Wakasaki
Mikio Yamashita

Japanese Crew
Cruise Two

Mitsutoyo Kaneda, Captain
Kenji Arima
Seima Kobayashi
Yoshihiro Kondoh
Yoshikatsu Oikawa
Tsunetaka Ono
Yukio Sasaya
Kohji Wakasaki
Mikio Yamashita

Fijian Crew
Cruise One

Eroni Marawa
Lui Andrews
Vonitiese Bainimoli
Mosese Cakau
Kitione Koroi
Jone Manuku
Isola Rodan
Jeke Savirio
Ravaele Tikovakaca
Samuela Ue

Fijian Crew
Cruise Two

Eroni Marawa
Lui Andrews
Samuela Delana
Eroni Dolodai
Kitione Koroi
Metuisela Koroi
Aminisasi Kuruyawa
Josua Raguru
Jona Ravasakula
Napolioni Ravitu
Ravaele Tikovakaca
Samuela Ue

APPENDIX B. TAG AND RECOVERY INFORMATION FOR EACH TAGGED SKIPJACK WHICH MADE A MIGRATION OUT OF OR INTO NEW CALEDONIA'S 200-MILE EXCLUSIVE ECONOMIC ZONE. A list at the end of this appendix gives the meanings of the codes used. The inset lines present release data as follows: country abbreviation (see Appendix C); school number; year/month/day of release; time of release; latitude of release; longitude of release; numbers of tagged skipjack released; numbers of tagged yellowfin released; numbers of species other than skipjack and yellowfin that were tagged and released. Line(s) following that for release data present the following data for each tag recovery: species, S for skipjack, Y for yellowfin; recovery country abbreviation (see list); year/month/day of recovery; days at large; recovery latitude; recovery longitude; great circle distance in nautical miles between release and recovery location; fork length in millimetres at time of tagging and length credibility code (see list); fork length at recovery and credibility code (see list); tag number; nationality of recapture vessel (or country chartering vessel), and tag recovery gear (see list). Date or position of recovery was excluded if the range of possible values was more than half the span from the release date or release position to the midpoint of the range of possible recovery dates or positions. If the range was less than half of this span, the information was included and the date or position of recovery was taken to be the midpoint of the range.

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          WAL 222 780520 0850 1317S 17623W  350    0    0
S CAL 791206 565 1732S 16330E 1190 510M 645W SK15753 JAPPOL

          ZEA 438 790302 1045 3526S 17453E  709    0    0
S CAL 791202 275 1829S 16007E 1284 500M 625W SK00931 JAPPOL

          ZEA 450 790306 1000 3553S 17534E  292    0    0
S CAL 801222 657 1839S 16034E 1304 445M 542W SH08732 JAPPOL

          ZEA 456 790308 0920 3741S 17726E  556    0    0
S CAL 800108 306 1843S 16515E 1305 580M 682W SH09044 JAPPOL

          ZEA 463 790314 1605 3741S 17651E  210    0    0
S CAL 800209 332 1749S 16043E 1463 595B 735W SK03707 JAPPOL
S CAL 800217 340 1734S 15835E 1543 595B 695W SK03390 JAPPOL

          NSW 489 790406 0735 3543S 15038E   61    0    0
S CAL 791121 229 1749S 16113E 1212 630M    U SK06288 JAPPOL

          NSW 492 790406 0955 3544S 15046E  100    0    0
S CAL 800108 277 1843S 16515E 1277 570M 682J SK06624 JAPPOL

          NSW 498 790406 1600 3510S 15105E   70    0    0
S CAL 791201 239 1815S 16053E 1141 610M 666J SK06881 JAPPOL

          NSW 506 790408 0840 3508S 15104E  194    0    0
S CAL 800214 312 1800S 16152E 1178 570M 710W SK07256 JAPPOL

          NSW 515 790409 1605 3458S 15105E  764    0    0
S CAL 791206 241 1737S 16259E 1220 460M 700W SK09223 JAPPOL

          NSW 516 790410 0925 3456S 15105E   68    0    0
S CAL 791206 240 1750S 16042E 1147 610M 710J SK09448 JAPPOL

          QLD 523 790501 0800 1756S 14822E  457    0    0
S CAL 791127 210 1846S 16106E 0727 660M 676J SK32265 JAPPOL
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        QLD 531 790503 1105 1622S 15012E  725    3    0
S CAL 791204 215 1827S 16047E 0619 480B 600W SK34752 JAPPOL

        QLD 534 790503 1310 1620S 15007E  171    0    0
S CAL 791210 221 1716S 16258E 0740 490M 490W SK35049 JAPPOL

        NOR 797 800326 1520 2928S 16820E  239    0    0
S CAL 820218 694 1855S 15922E 0800 640M 816W 1B19650 JAPPOL

        NOR 798 800327 1425 2837S 16757E  456  123    0
S CAL 810317 355 1621S 16019E 0848 500M 620W 2B22461 JAPPOL

        FIJ 841 800418 1230 1644S 17721E  130    1    0
S CAL 801112 208 1724S 16046E 0952 570M 750W 2C25933 JAPPOL

        CAL  51 771215 1340 2051S 16541E  901    0    0
S CAL 771218 003 2100S 16537E 0010 550M 535A SA00725 SPCPOL
S CAL 780212 059 2113S 16555E 0026 541B 570E SA01499 CALREC

        CAL  53 771215 1840 2114S 16602E  275   11    0
S CAL 780104 020 2125S 16614E 0016 548B 540A SA00995 SPCPOL
S PNG 780729 226 0220S 15017E 1460 540M 610W SA01516 PNGPOL

        CAL  56 771216 1235 2100S 16545E  184    0    0
S SOL 780725 221 0900S 15830E 0833 540M 610B SA03036 SOLPOL

        CAL  62 771217 1825 2053S 16537E  209    0    0
S CAL 771217 000 2053S 16537E 0000 540M 548A SA04617 SPCPOL

        CAL  68 771220 0730 2115S 16558E  922    0    0
S CAL 780108 019 2146S 16642E 0051 550M 465A AY04669 SPCPOL
S CAL 780211 053 2228S 16715E 0102 580M 580D AY05386 CALSHE

        CAL  72 771222 1102 2130S 16628E  231    0    0
S CAL 780107 016 2127S 16618E 0010 490M 540A AY05960 SPCPOL

        CAL  78 771222 1510 2142S 16638E   17    0    0
S MAR 790305 438 1314N 14636E 2405 490M 640W AY06564 JAPPOL

        CAL  79 771222 1605 2145S 16640E  182    0    0
S CAL 780104 013 2125S 16614E 0031 478B 535A AY06525 SPCPOL

        CAL  80 771228 1325 2212S 16603E  152    0    0
S SOL 800127 760 1258S 15902E 0684 430M 581W SA05113 JAPPOL

        CAL  83 780103 1445 2043S 16618E  130    0    0
S PNG 780924 264 0520S 15445E 1142 510M    U SA05626 PNGSUB
S INT 781006 276 0144N 16032E 1389 530M 609C SA05652 JAPPOL

        CAL  84 780103 1610 2035S 16612E   56    0    0
S PON 790207 400 0645N 16140E 1662 511B 616J SA05501 JAPPOL

        CAL  86 780103 1710 2036S 16612E   58    0    0
S CAL 780103 000 2036S 16612E 0000 500M 500A SA05541 SPCPOL

        CAL  88 780103 1745 2035S 16609E  260    0    0
S CAL 780103 000 2035S 16609E 0000 530M    U SA06140 SPCPOL
S SOL 780902 242 0905S 15945E 0783 480M 520B SA06311 SOLPOL

        CAL  89 780104 1210 2125S 16614E  235    1    0
S SOL 780616 163 0845S 16030E 0829 526B 570E SA06473 SOLSUB

        CAL  92 780105 1456 2053S 16534E  257    0    0
S CAL 780105 000 2053S 16534E 0000 520M 520A SA06590 SPCPOL

        CAL  94 780107 1810 2127S 16618E  231    8    0
S SOL 780828 233 0950S 15830E 0829 440M 510W SA06918 SOLPOL

        CAL 95  780108 1230 2142S 16640E  115    0    0
S SOL 781011 276 0725S 15715E 1016 410M 520W SA07123 SOLPOL

        CAL  96 780108 1545 2146S 16642E  261    3    0
S KIR 790817 586 0200N 17530E 1517 480M 638W SA07402 JAPPOL

        CAL  97 780109 1635 2237S 16737E   71    0    0
S SOL 780930 264 0910S 15910E 0942 500M 560W SA07548 SOLPOL

        CAL  99 780110 1430 2235S 16624E   49    0    0
S PON 790208 394 0643N 15638E 1849 420M 601W SA07682 JAPPOL

        CAL 108 780113 1505 2148S 16528E  228    0    0
S CAL 780126 013 2256S 16634E 0091 470M    U SA08452 CALSHE
S CAL 780127 014 2256S 16634E 0091 500M    U SA08430 CALSHE
S CAL 780127 014 2256S 16634E 0091 490M    U SA08409 CALSHE
S SOL 780420 097 0850S 16030E 0829 498B    U SA08209 SOLPOL

        CAL 110 780115 0840 2058S 16424E  842    0    0
S CAL 780115 000 2058S 16424E 0000 510M 497A SA08548 SPCPOL
S CAL 780115 000 2058S 16424E 0000 440M 435A SA08571 SPCPOL
S CAL 780115 000 2058S 16424E 0000 530M 528A SA08794 SPCPOL
S CAL 780115 000 2058S 16424E 0000 440M 442A SA08535 SPCPOL
S SOL 780721 187 0845S 15852E 0800 510M 598W SA08479 SOLPOL
S INT 781008 266 0056N 16036E 1333 505M 630W SA08968 JAPPOL
S SOL 781123 312 0915S 15938E 0755 450M 520B SA08635 SOLPOL
S TRK 790131 381 0525N 15409E 1694 505M 612W SA07964 JAPPOL
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CODES FOR LENGTH MEASUREMENTS, RECAPTURE GEARS AND COUNTRY ABBREVIATIONS

Release Length Credibility

M	Measured
B	Estimated from Biological Data
T	Estimated from Tagging Data
G	Guessed
U	Unknown
Q	Length Questionable

Recapture Length Credibility

A	Measured by research vessel staff
B	Measured by local joint ventures
C	Measured by Japanese long-range boats, or long-liners of other nationalities
D	Measured by other supposedly reliable sources
E	Measured by unreliable sources
W	Measured length verified by weight
J	Estimated from weight
K	Estimated from other sources (string, etc.)
U	Unknown

Nationality of Recapture Vessel (Country Abbreviations)

AMS	American Samoa
CAL	New Caledonia
FIJ	Fiji
IND	Indonesia
INT	International waters
JAP	Japan
KIR	Kiribati
KOR	Korea
NOR	Norfolk Island
NSW	New South Wales (Australia)
PAL	Palau
PHL	Philippines
PNG	Papua New Guinea
POL	French Polynesia
PON	Ponape (Federated States of Micronesia)
QLD	Queensland (Australia)
SOC	Society Islands (French Polynesia)
SOL	Solomon Islands
TAW	Taiwan
TOK	Tokelau
TON	Tonga
TUV	Tuvalu
USA	United States
VAN	Vanuatu
WAL	Wallis and Futuna
WES	Western Samoa
ZEA	New Zealand

Type of Recapture Vessel

SEN	Purse-seine
POL	Pole-and-line
LON	Longline
SHE	Pearl-shell trolling
ART	Artisanal
GIL	Gill net
REC	Recreational (sport fishing)
SUB	Subsistence (village)
UUU	Unknown

APPENDIX C. ABBREVIATIONS USED FOR COUNTRIES AND TERRITORIES IN THE CENTRAL AND WESTERN PACIFIC

AMS - American Samoa
CAL - New Caledonia
COK - Cook Islands
FIJ - Fiji
GAM - Gambier Islands (French Polynesia)
GIL - Gilbert Islands (Kiribati)
GUM - Guam
HAW - Hawaii
HOW - Howland and Baker Islands (U.S. Territory)
IND - Indonesia
INT - International waters
JAP - Japan
JAR - Jarvis (U.S. Territory)
KIR - Kiribati
KOS - Kosrae (Federated States of Micronesia)
LIN - Line Islands (Kiribati)
MAQ - Marquesas Islands (French Polynesia)
MAR - Northern Mariana Islands
MAS - Marshall Islands
MTS - Minami-tori shima (Japan)
NAU - Nauru
NCK - Northern Cook Islands
NIU - Niue
NOR - Norfolk Island
NSW - New South Wales (Australia)
PAL - Palau
PAM - Palmyra (U.S. Territory)
PHL - Philippines
PHO - Phoenix Islands (Kiribati)
PIT - Pitcairn Islands
PNG - Papua New Guinea
POL - French Polynesia
PON - Ponape (Federated States of Micronesia)
QLD - Queensland (Australia)
SCK - Southern Cook Islands
SOC - Society Islands (French Polynesia)
SOL - Solomon Islands
TOK - Tokelau
TON - Tonga
TRK - Truk (Federated States of Micronesia)
TUA - Tuamotu Islands (French Polynesia)
TUV - Tuvalu
VAN - Vanuatu
WAK - Wake Island (U.S. Territory)
WAL - Wallis and Futuna
WES - Western Samoa
YAP - Yap (Federated States of Micronesia)
ZEA - New Zealand