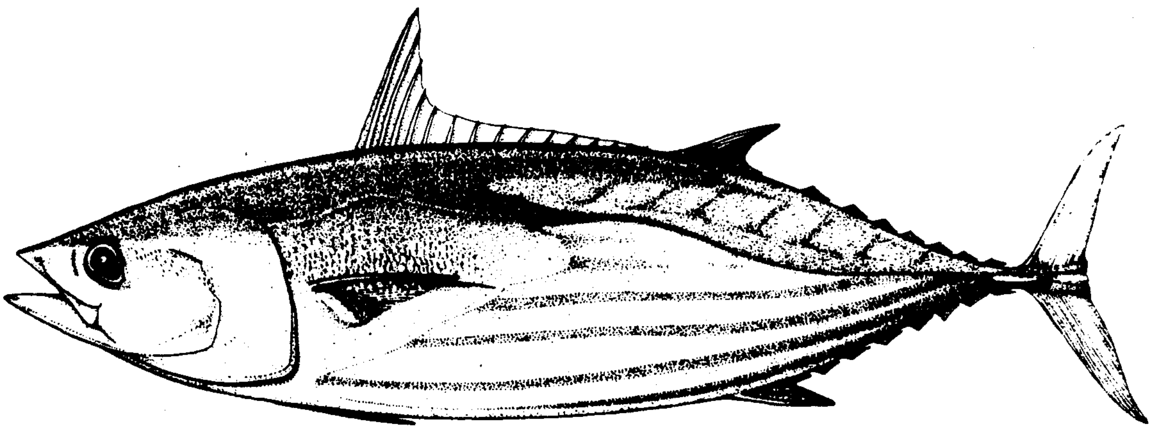
AN ASSESSMENT OF THE SKIPJACK AND BAITFISH RESOURCES OF WALLIS AND FUTUNA



Skipjack Survey and Assessment Programme
Final Country Report No. 19

South Pacific Commission
Noumea, New Caledonia
October 1984

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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 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 Skipjack Programme's investigation of yellowfin tuna resources of the region, is continuing under the Tuna Programme. Reports have been prepared in a final country report series for each of the countries and territories for which the South Pacific Commission works. Most of these reports have been co-operative efforts involving all members of the Tuna Programme staff in some way.

The staff of the Tuna 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, 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 WALLIS AND FUTUNA

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 Skipjack Programme carried out 847 days of tagging and survey operations in the central and western Pacific between October 1977 and August 1980. The total study area included all of the countries and territories in the area of the South Pacific Commission and also New Zealand and Australia (Figure A, inside front cover). The Programme surveyed the waters of Wallis and Futuna between 4 and 31 May 1978 (Kearney & Hallier 1978), and again between 10 and 22 May 1980. This report assesses skipjack[1] and baitfish resources of Wallis and Futuna on the basis of results of surveys from Wallis and Futuna, and those from the region as a whole.

1.1 Fisheries in Wallis and Futuna

There is a large demand for fish in Wallis and Futuna, where, as in other areas inhabited by Polynesians, fish is a highly esteemed commodity. However, local fisheries predominantly focus on coastal species, even though the accessible reef and lagoon resources are considered heavily exploited. Overfishing was reported as early as 1932 at Futuna Island (Burrows 1936), and in 1969 the South Pacific Commission fisheries officer reported that lagoon fish stocks were decreasing at Wallis Island (Hinds 1969). Despite this, there is only occasional fishing for tuna by a few residents (Gatel pers. comm.), and the local tuna catch is presently less than two tonnes per year.

There are indications that tuna fisheries could become more important in the future. A long-range development plan (Dijoud undated) was adopted by the Territorial Assembly of Wallis and Futuna in 1979. The plan takes into consideration the state of reef and lagoon fisheries and the demand for fish, and states that the utilisation of resources outside the reef is a major objective.

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1. Skipjack are known in Wallis and Futuna by the local name "atu".

1.2 History of Tuna Fishing and Tuna Development Activities

The literature contains descriptions of traditional skipjack fishing techniques used in Wallis Island (Burrows 1937) and Futuna Island (Burrows 1936). These techniques, similar to those of other Polynesian areas, involve the use of specialised canoes and pearl-shell lures by skilled master fishermen. Up to 100 skipjack per day were caught by the three- or four-man crew of a canoe. The decline of tuna fishing by this method began in the late 1800s and has been attributed by various authors to the influence of the church, which restricted canoe movements (Anon. 1976; Fusimalohi & Grandperrin 1980), the danger involved (Phillipps 1953), the strenuous activity necessary (Burrows 1936), and the poor manoeuvring qualities of the traditional outrigger canoes (Hinds 1969). Interest in tuna fishing revived about the time of the first World War, when Tokelauan and Chinese fishermen, assisted by Wallisians, ventured outside the reef and caught up to 80 skipjack per canoe per day (Hinds 1969). By the 1930s, however, tuna fishing had again almost ceased in Wallis and Futuna (Burrows 1936, 1937). Venturing beyond the reef for any sort of activity came to a virtual halt in the 1950s when a large portion of the population, including most of the fishermen, emigrated to New Caledonia for employment in the nickel industry (Anon. 1976). In 1970, the Department of Rural Economy set up a boat building centre in an attempt to revive interest in the ocean and to provide an independent means of obtaining fresh fish for the villages (Anon. 1976). In 10 years approximately 200 boats were constructed by the project (Fusimalohi & Grandperrin 1980). Only a few of these were used for tuna fishing, which remains an occasional pursuit by a handful of fishermen.

Tuna fishing has been carried out in the 271,000 square kilometres Extended Economic Zone of Wallis and Futuna by Japanese, Korean, Taiwanese, and United States vessels using longline, pole-and-line, and purse-seine gear. Data presented in Klawe (1978) shows that longline vessels from Korea, Taiwan and Japan reported combined catches of 189 tonnes and 386 tonnes in 1975 and 1976 respectively. This catch included 399 kg of skipjack. In the period 1972-1978 Japanese pole-and-line vessels spent 61 boat days between the months of October and April in Wallis and Futuna's economic zone. These vessels, which make use of live bait transported from Japan, caught 257 tonnes of tuna of which 98 per cent were skipjack (Skipjack Programme 1980). American purse-seiners frequently cross the Wallis and Futuna zone in transit between the cannery in Pago Pago and the purse-seining grounds north of Papua New Guinea. Souter & Broadhead (1978) report that the United States vessel Jeanette C made four sets in the waters of Wallis and Futuna in March 1978 and caught 228 tonnes of tuna. The operators of two other American purse-seiners, the Pacific Princess and the Tifaimoana, have shown considerable interest in the Wallis and Futuna area and have submitted proposals for access to the 200-mile zone that include the deployment of numerous fish aggregating devices (Gatel pers. comm.).

Appendix A lists the exploratory fishing, fisheries development and baitfishing activities known to have been carried out in Wallis and Futuna. Those surveys that concentrated on evaluating the abundance of tuna have generally recorded very favourable results. Similarly, exploratory baitfishing surveys have reported good to excellent catches.

2.0 METHODS

2.1 Vessels and Crew

Two Japanese commercial fishing vessels, the *Hatsutori Maru No.1* and 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 (1982c). The 192-tonne *Hatsutori Maru No.1* was used during the first survey of Wallis and Futuna in May 1978 and the 254-tonne *Hatsutori Maru No.5* was used during the second, in May 1980.

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 three Fijian crew were employed. Appendix B lists scientists, observers and crew who were on board during the two surveys in the waters of Wallis and Futuna.

2.2 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 with 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 vessels under research conditions. During the first survey in the waters of Fiji (26 January to 10 April 1978), the *Hatsutori Maru No.1* fished commercially for approximately one month, as part of the charter agreement between the Programme and the vessel's owner. From comparison of survey and commercial catches at this time, it was estimated that the fishing power of the *Hatsutori Maru No.1* under survey conditions, such as in Wallis and Futuna, was 28.8 per cent of its fishing power during commercial fishing (Kearney 1978). It was assumed that the same ratio applied to the *Hatsutori Maru No.5*.

Since tagging was the primary research tool, attempts to tag large numbers of skipjack and, secondarily, yellowfin (*Thunnus albacares*) usually dominated the fishing strategy. The tagging techniques and alterations to commercial fishing procedures have been 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 records 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 captured on board the Programme's vessels 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.

2.3 Baitfishing

Baitfishing carried out by the Programme in the lagoon at Wallis Island employed a "bouki-ami" net set at night around bait attraction lights. Procedures were similar to those used by commercial vessels, but were modified where necessary to meet the Programme's special requirements. In some countries beach seining during daylight was used as an alternative bait catching technique. Beach seining was not attempted in Wallis and Futuna. Details of both techniques and all modifications employed by the Skipjack Programme are given in Hallier, Kearney & Gillett (1982).

2.4 Data Compilation and Analysis

Five separate logbooks (Kearney 1982b) formed the basis 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 are discussed in Kleiber & Maynard (1982). Electrophoretic data from blood samples and identifications of parasite 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 was approached from several viewpoints. Data from skipjack tag releases and recoveries have formed the basis of investigation of movement patterns, fishery interactions and population dynamics, using analytic techniques described in Skipjack Programme (1981b) and Kleiber, Argue & Kearney (1983). Methods employed in biological studies of growth are described in 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 Skipjack Programme (1981f) and Argue, Williams & Hallier (ms.). Evaluation of population structuring across the whole of the western and central Pacific has centred on a comparison of the tagging results with results from blood genetics analyses (Anon. 1980, 1981a; Skipjack Programme 1981c). Occurrence and distribution of skipjack parasites have also been evaluated (Lester 1981; Lester, Barnes & Habib ms.).

3.0 SUMMARY OF FIELD ACTIVITIES

The area surveyed for tuna and baitfish while in the waters of Wallis and Futuna is shown in Figure 1 and a summary of the field activities is presented in Table 1. A feature of the period of both surveys was the poor weather. Tuna fishing ceased for eight days due to either very rough seas or prevention of baitfishing the previous night because of strong southeast winds.

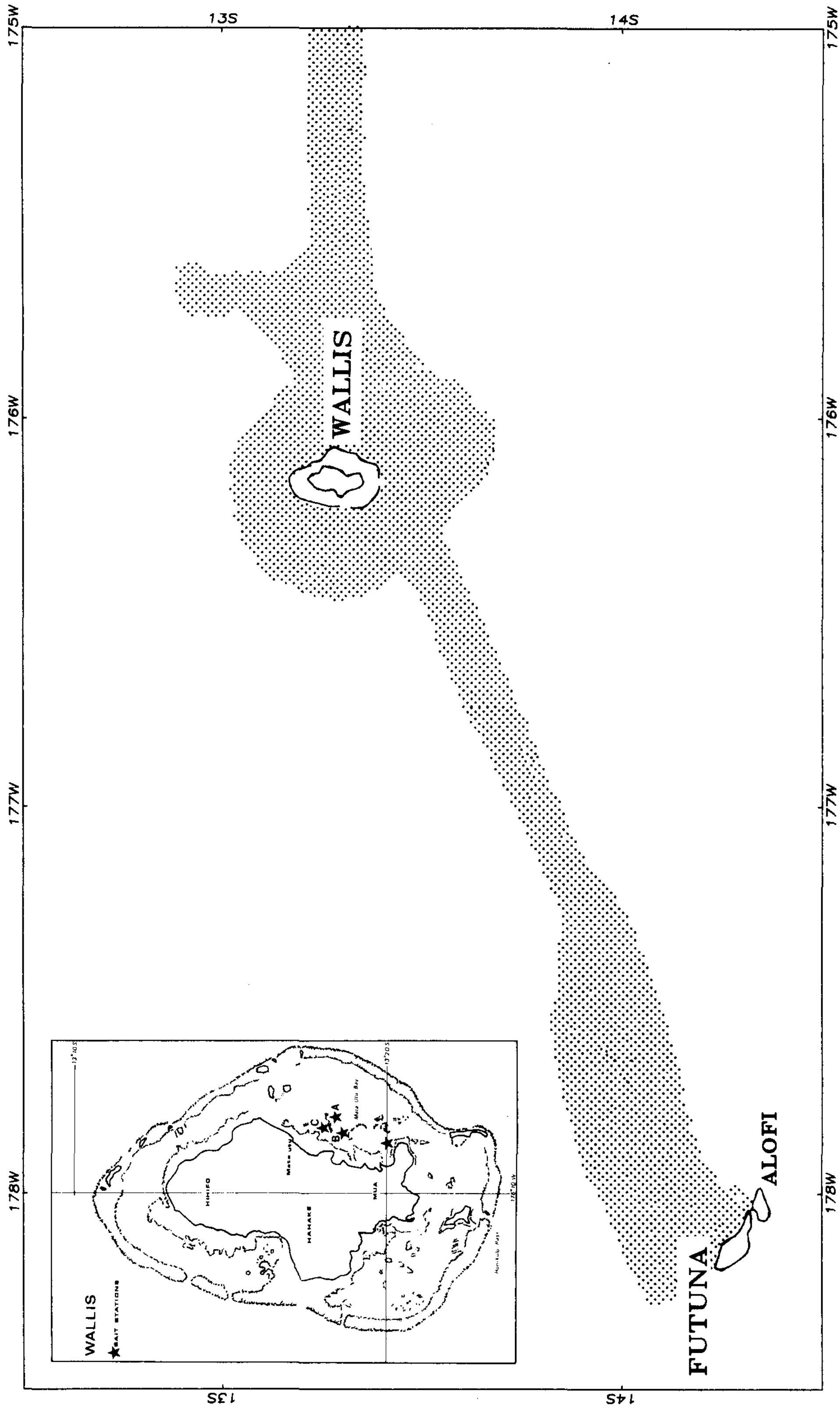

FIGURE 1. SURVEY AREA AND BAITFISHING LOCALITIES FOR THE SKIPJACK PROGRAMME SURVEY IN THE WATERS OF WALLIS AND FUTUNA

TABLE 1. SUMMARY OF DAILY FIELD ACTIVITIES IN THE WATERS OF WALLIS AND FUTUNA. Schools sighted are given 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)
04/05/78	Mata Utu	Steaming	0	0	-	-	-	-	-	-	-	-	-	-	-
05/05/78	Mata Utu	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
06/05/78	SE of Wallis Is	Fishing	795	8	3	0	1	0	2	1258	105	0	6465	373	6837
07/05/78	Matu Utu	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
08/05/78	Mata Utu	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
09/05/78	NW of Wallis Is	Steaming	0	7	1	1	0	0	7	0	0	0	0	5	5
10/05/78	Mata Utu	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
11/05/78	NE of Wallis Is	Steaming	0	10	0	0	0	0	11	-	-	-	-	-	-
12/05/78	NE of Wallis Is	Fishing	731	9	5	0	0	0	3	661	0	0	2130	0	2132
13/05/78	W of Wallis Is	Fishing	623	10	3	0	1	0	3	766	0	0	3059	4	3066
14/05/78	W of Wallis Is	Fishing	113	7	2	0	0	0	1	191	0	0	1150	0	1150
15/05/78	NW of Wallis Is	Fishing	641	10	7	0	0	0	1	882	0	0	4022	0	4022
16/05/78	SE of Wallis Is	Fishing	335	4	2	0	0	0	0	1031	0	0	3425	0	3425
17/05/78	S of Wallis Is	Fishing	147	8	2	0	0	0	2	1053	0	0	3484	0	3484
18/05/78	S of Wallis Is	Fishing	455	5	3	0	0	0	0	1035	0	0	3324	0	3324
19/05/78	S of Wallis Is	Fishing	593	9	4	0	1	0	0	1962	26	0	6308	129	6450
20/05/78	W of Wallis Is	Fishing	648	8	3	0	0	0	0	2921	0	0	9082	0	9082
21/05/78	S of Wallis Is	Fishing	122	2	1	0	0	0	2	417	0	0	1546	0	1546
22/05/78	Mata Utu	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
23/05/78	Mata Utu	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
24/05/78	S of Wallis Is	Fishing	120	5	4	0	1	0	1	137	7	0	423	33	456
25/05/78	SE of Wallis Is	Fishing	93	5	2	0	0	0	1	146	0	0	419	0	419
26/05/78	W of Wallis Is	Fishing	167	4	1	0	1	0	0	203	75	0	444	265	767
27/05/78	W of Wallis Is	Fishing	117	7	1	0	0	0	3	27	0	0	26	0	26
28/05/78	Wallis Is - Futuna Is	Fishing	489	9	0	0	0	0	8	0	0	0	0	0	0
29/05/78	Futuna Is	Fishing	258	5	4	0	0	0	1	486	0	0	2621	0	2621
30/05/78	Mata Utu	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
31/05/78	E of Wallis Is	Fishing	131	4	5	0	0	0	22	337	0	0	1200	0	1200
10/05/80	W of Wallis Is	Steaming	129	0	-	-	-	-	-	-	-	-	-	-	-
11/05/80	Mata Utu	In Port	107	0	-	-	-	-	-	-	-	-	-	-	-
12/05/80	S of Wallis Is	Fishing	99	6	1	1	0	0	2	0	0	0	0	0	0
13/05/80	Mata Utu	Baiting	60	0	-	-	-	-	-	-	-	-	-	-	-
14/05/80	Mata Utu	Baiting	266	0	-	-	-	-	-	-	-	-	-	-	-
15/05/80	NW of Wallis Is	Fishing	450	8	0	2	1	0	0	1604	206	2	6020	1047	7071
16/05/80	Mata Utu	Baiting	690	0	-	-	-	-	-	-	-	-	-	-	-
17/05/80	W of Wallis Is	Fishing	962	7	0	1	2	0	3	10	271	0	39	1561	1600
18/05/80	W of Wallis Is	Fishing	591	8	0	1	0	0	5	0	2	0	0	140	140
19/05/80	E of Wallis Is	Fishing	687	4	0	0	0	0	1	0	0	0	0	0	0
20/05/80	W of Wallis Is	Fishing	693	5	0	0	0	0	2	0	0	0	0	0	0
21/05/80	Mata Utu	Baiting	851	0	-	-	-	-	-	-	-	-	-	-	-
22/05/80	Futuna Is	Fishing	761	5	4	2	1	0	1	938	42	0	2970	174	3148
TOTALS				179	58	8	9	0	82	16065	734	2	58157	3732	61971

A total of 41 days were spent in the territory's 200-mile zone during the two cruises, but only three of these days were in the vicinity of Futuna Island. The research vessels steamed approximately 2,700 nautical miles and spent 179 hours searching and fishing for tuna, 136 hours during the first visit and 43 hours during the second visit. The vessels caught a total of 61,971 kg of skipjack and other tunas and tagged and released 16,065 skipjack, 734 yellowfin and 2 bigeye tuna.

A summary of numbers of fish sampled for biological data is given in Table 2. The size distribution of tagged skipjack (Figure 2) shows a range of 26-76 cm. The average length was 51.7 cm, slightly larger than the Skipjack Programme's overall average length of 50.4 cm. Maturity data are summarised in Figure 3, skipjack diet items in Table 3 and incidence of tuna juveniles in the stomachs of predator tuna in Table 4. Seven blood samples, each of approximately 100 skipjack, were taken from separate schools; results of genetic analyses are included in Figure 4.

TABLE 2. SUMMARY OF NUMBERS OF FISH SAMPLED FOR BIOLOGICAL DATA IN THE WATERS OF WALLIS AND FUTUNA

Species	Number Measured	Number Weighed	Number Examined for Sex	Number Examined for Stomach Content	Number Examined for Tuna Juveniles
Skipjack *Katsuwonus pelamis*	2114	799	852	268	445
Yellowfin *Thunnus albacares*	159	112	112	48	92
Mackerel Tuna *Euthynnus affinis*	1	1	0	0	1
Frigate Tuna *Auxis thazard*	3	3	3	3	3
Rainbow Runner *Elagatis bipinnulatus*	29	21	19	5	6
Dolphinfish *Coryphaena hippurus*	1	1	1	1	1
TOTALS	2307	937	987	325	548

Baitfishing activities are summarised in Table 5. The bouki-ami was hauled 36 times at four different locations, catching a total of 10,501 kg of bait.

FIGURE 2. LENGTH FREQUENCY DISTRIBUTIONS FOR TAGGED SKIPJACK (upper graph) AND FOR SAMPLED SKIPJACK (lower graph) FOR BOTH SKIPJACK PROGRAMME SURVEYS IN THE WATERS OF WALLIS AND FUTUNA. N is the sample size.

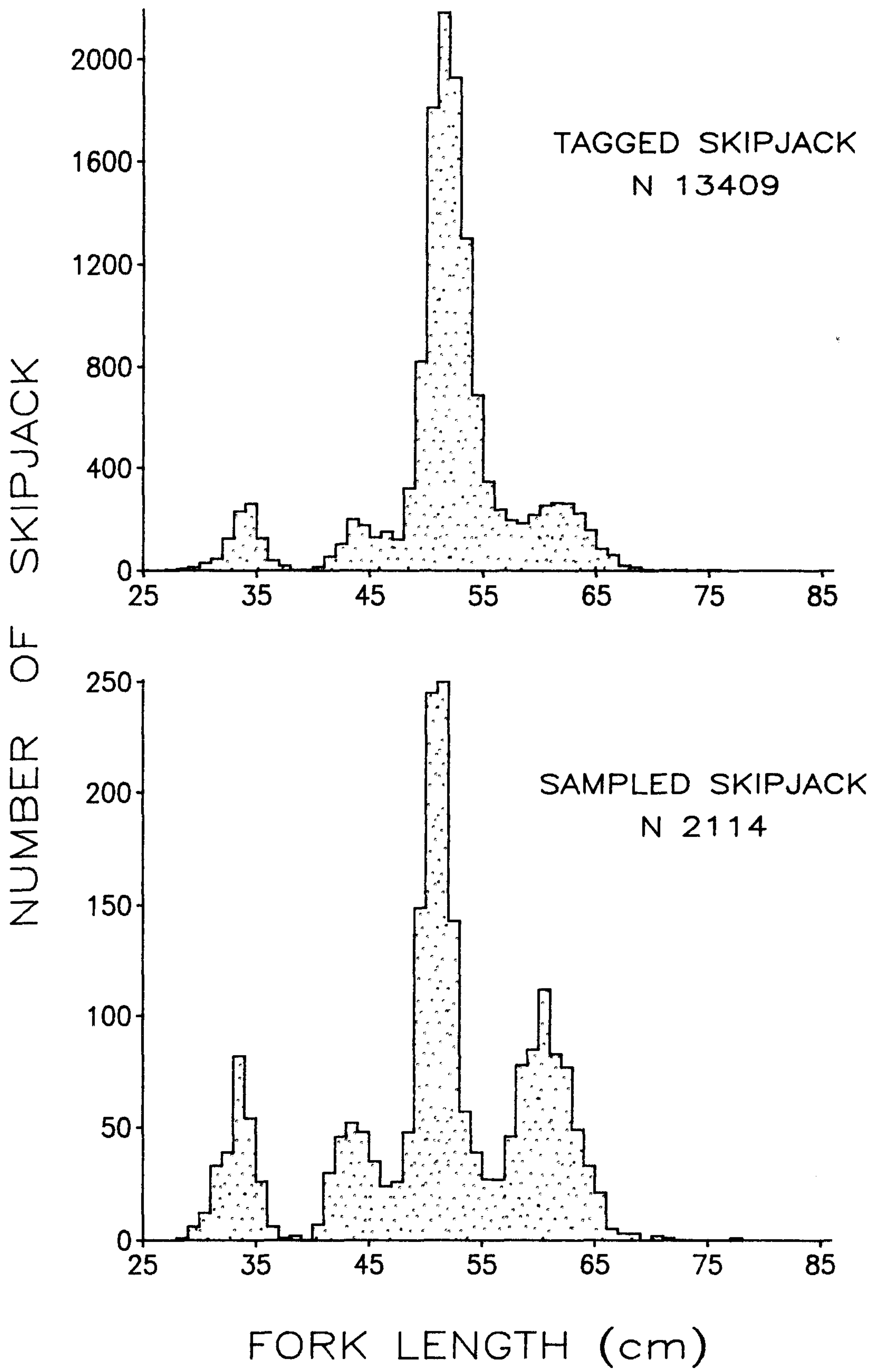

FIGURE 3. DISTRIBUTION OF FEMALE SKIPJACK BY MATURITY STAGE FOR SAMPLES FROM BOTH SURVEYS IN THE WATERS OF WALLIS AND FUTUNA (upper graph) AND FOR ALL SKIPJACK SAMPLED FROM TROPICAL WATERS BY THE SKIPJACK PROGRAMME (lower graph). N is the sample size.

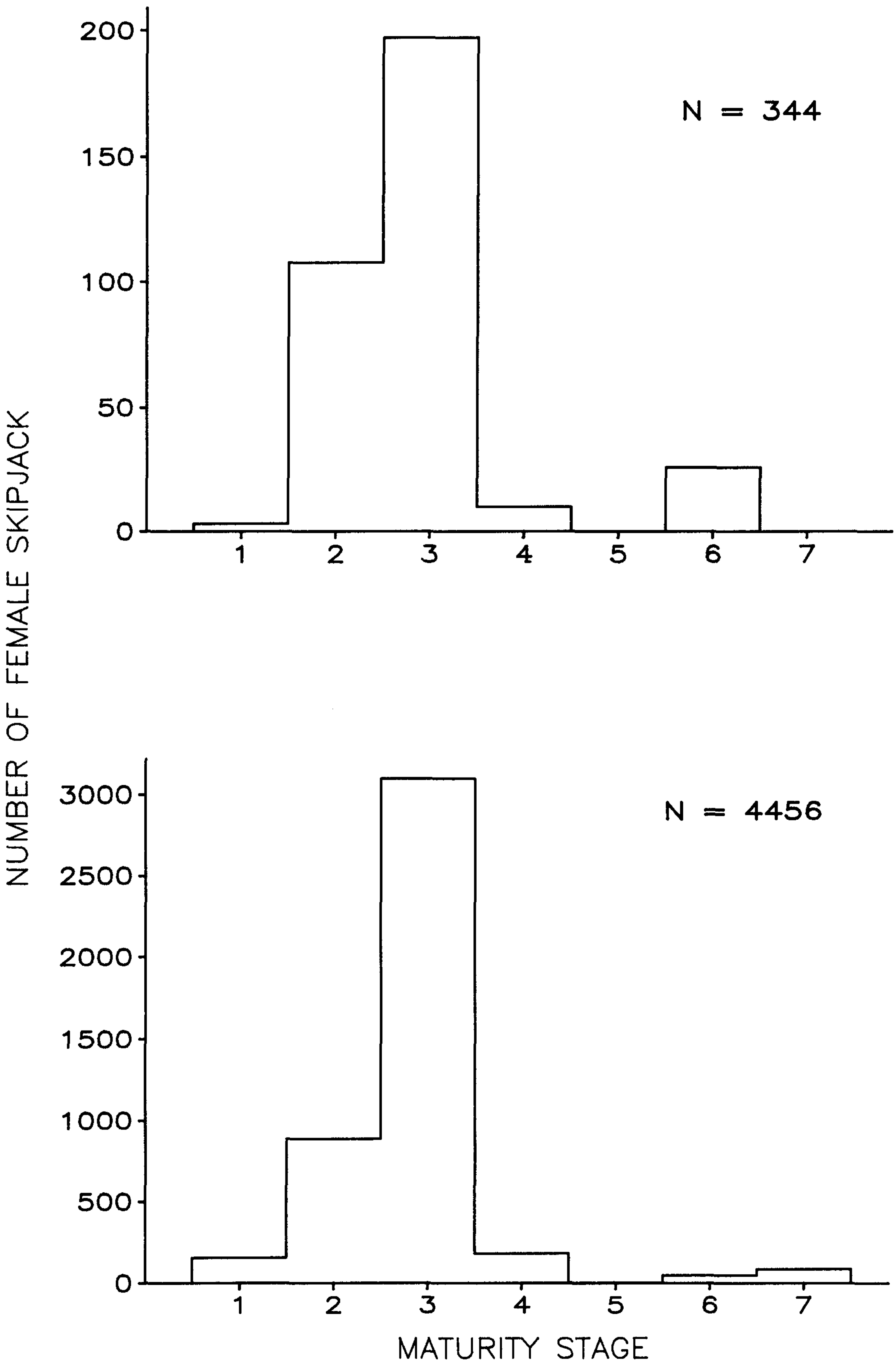

TABLE 3. DIET ITEMS FOUND IN THE STOMACHS OF SKIPJACK SAMPLED IN THE WATERS OF WALLIS AND FUTUNA

Item No.	Diet Item Fish and Invertebrates	Number of Stomachs	Percentage Occurrence
1	Chum from Hatsutori Maru	240	89.55
2	Fish remains (not chum)	95	35.45
3	Squid (Cephalopoda)	35	13.06
4	Alima stage (Stomatopoda)	25	9.33
5	Acanthuridae	25	9.33
6	Anchovy juvenile (Engraulidae)	21	7.84
7	Copepoda	17	6.34
8	Gempylidae	15	5.60
9	Tuna juvenile (Scombridae)	14	5.22
10	Aluteridae	12	4.48
11	Gastropoda	12	4.48
12	Holocentridae	7	2.61
13	Megalopa stage (Decapoda)	6	2.24
14	Chaetodontidae	5	1.87
15	Empty stomach	5	1.87
16	Fistulariidae	4	1.49
17	Balistidae	4	1.49
18	Siganidae	4	1.49
19	Stomatopoda	3	1.12
20	Ostraciidae	3	1.12
21	Unidentified fish	3	1.12
22	Dactylopterus orientalis (Dacylopteridae)	2	0.75
23	Phyllosoma stage (Decapoda)	2	0.75
24	Blue goatfish (Mullidae)	2	0.75
25	Prawn (Decapoda)	2	0.75
26	Priacanthidae	2	0.75
27	Crustacea	2	0.75
28	Mollusca	2	0.75
29	Paralepidae	1	0.37
30	Stolephorus buccaneeri (Engraulidae)	1	0.37
31	Heteropoda (Gastropoda)	1	0.37
32	Leptocephalus (Anguilliformes)	1	0.37
33	Synodontidae	1	0.37
34	Skipjack dart tag	1	0.37
35	Decapoda	1	0.37
36	Billfish juvenile (Istiophoridae)	1	0.37
37	Sphyraenidae	1	0.37
	Total Stomachs Examined	268	

TABLE 4. INCIDENCE OF TUNA JUVENILES IN THE STOMACHS OF SKIPJACK AND YELLOWFIN SAMPLED IN THE WATERS OF WALLIS AND FUTUNA

Predator	Predators Examined	Prey Species (tuna) juveniles)	No. of Prey	Predators with Prey	Prey per 100 Predators	Percentage of Predators with Prey
		May 1978				
Skipjack	324	Skipjack	169	37	50.16	11.42
		Yellowfin	1	1	0.31	0.31
		Albacore	15	12	4.63	3.70
Yellowfin	20	-				
		May 1980				
Skipjack	121	-				
Yellowfin	72	Skipjack	1	1	1.39	1.39
		1978 and 1980 combined				
Skipjack	445	Skipjack	169	37	37.98	8.31
		Yellowfin	1	1	0.22	0.22
		Albacore	15	12	3.37	2.70
Yellowfin	92	Skipjack	1	1	1.09	1.09

FIGURE 4. SKIPJACK SCHOOL SERUM ESTERASE GENE FREQUENCY VERSUS LONGITUDE OF THE SAMPLE LOCATION. The circles represent the esterase gene frequencies for the six samples from Wallis and Futuna. The regression line on the left of the dotted line includes 145 samples collected between Indonesia and Pitcairn Island (correlation coefficient -0.81). Esterase gene frequencies for 18 eastern Pacific samples are shown to the right of the dotted line.

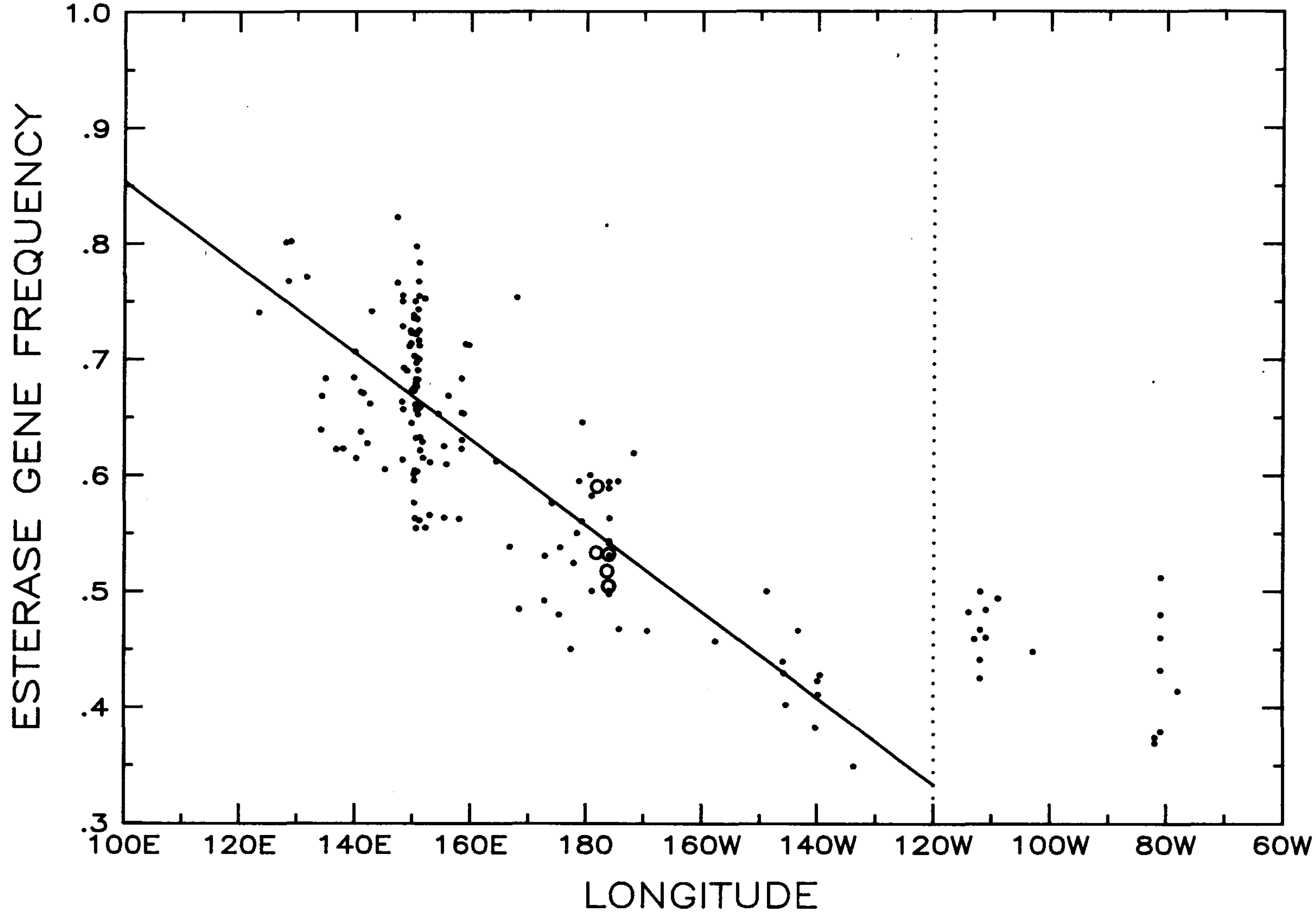

TABLE 5. SUMMARY OF BAITFISHING EFFORT AND CATCH IN THE WATERS OF WALLIS AND FUTUNA*

Anchorage	Time of Hauls	Number of Hauls	Dominant Species	Est. Av. Catch per Haul (kg)	Mean Length (mm)	Other Common Species
Mata Utu Bay (Site A) 13°18′S 176°07′W	Night	32	Stolephorus devisi	238	59	Selar crumenophthalmus
			Sardinella sirm	24	115	Spratelloides delicatulus
			Herklotsichthys quadrimaculatus	22	83	Siphamia sp.
Mata Utu Bay (Site B) 13°17′S 176°07′W	Night	1	Stolephorus devisi	641	63	Siphamia sp.
			Sardinella sirm			Leiognathus elongatus
			Spratelloides delicatulus			Herklotsichthys quadrimatulatus
Mata Utu Bay (Site C) 13°18′S 176°06′W	Night	2	Sardinella sirm	46	126	Spratelloides delicatulus
			Stolephorus devisi	9	60	Hypoatherina ovalaua
			Cheilodipterus macrodon			Archamia lineolata
Matalaa Bay 13°20′S 176°08′W	Night	1	Stolephorus devisi	118	52	Sardinella sirm
			Spratelloides delicatulus	3	51	Herklotsichthys quadrimaculatus
			Dussumieria acuta			Archamia lineolata

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

4.0 RESULTS AND DISCUSSION

4.1 Baitfish Availability

The bouki-ami is a very effective method of netting live bait for pole-and-line fishing; however, for best results it must be operated in waters of suitable depth, protected from excessive wind, current and wave action. Inspection of navigation charts prior to the first visit indicated that the eastern part of the lagoon around Wallis Island was suitable for vessels of the size of the Hatsutori Maru No.1. The uncharted western side of the lagoon could not be explored for baitfishing potential. At Futuna Island, the reef is very close to shore so baitfishing was not feasible. Baitfishing was carried out at four sites in Wallis lagoon (Figure 1) - three in Mata Utu Bay (sites A,B,C) and the fourth in Mataala Bay. All four sites were fished during the first visit. Only site A in Mata Utu Bay, which provided good catches during the first visit, was fished during the second visit. Other locations in the lagoon were not fished since they were near the pass and barrier reef where strong currents made them unsuitable for bouki-ami baitfishing.

The gold anchovy, Stolephorus devisi, comprised 82 per cent by weight of all bait captured from both visits (Table 6). This species dominated most bait hauls in Wallis lagoon (Table 5) and occurred in 97 per cent of them. It is a delicate species requiring careful handling to prolong survival in the baitwells, but is considered to be very effective for pole-and-line fishing (Skipjack Programme 1981f). During both visits, strong winds and choppy water conditions made bait handling difficult and resulted in higher than normal bait mortality. Two other bait species, the spotted pilchard, Sardinella sirm, and the gold spot herring, Herklotsichthys quadrimaculatus, together constituted 15 per cent by weight of the total catch; each occurred in more than 70 per cent of hauls. Both are regarded as good bait species. Juveniles of reef-associated fish species (Acanthuridae, Scaridae) were caught in extremely low numbers and occurred in less than six per cent of bait hauls at Wallis Island.

The average catch of 291 kg of bait per bouki-ami haul was the highest achieved for any of the countries surveyed by the Skipjack Programme (Skipjack Programme 1981e). In good weather conditions, usually two hauls could be made per night, but at Wallis Island strong wind often prevented a second haul, with the result that the net was hauled only 36 times in 33 nights. Baitfish catches by the Programme's research vessel were much higher than those of the Japanese Marine Fishery Resource Research Center (JAMARC) vessel Akitsu Maru in 1973 (Anon. 1974), which caught an average of only 75 kg per night (mostly anchovy) using a "standard" dipnet, and 60 kg per night (mostly anchovy) using bouki-ami gear. In September 1982, the Natacha, a pole-and-line vessel operated by a New Caledonian fishing company, Transpêche, averaged 75 kg per bouki-ami haul (mostly gold spot herring) in three nights' fishing under poor weather conditions (P. Petiniaud pers. comm.).

Catches from four sites fished by the Skipjack Programme in the eastern portion of the lagoon are shown in Table 5. At the site most frequently fished in Mata Utu Bay (site A), catches averaged 276 kg (98 per cent gold anchovy) during the first visit and 305 kg (57 per cent gold anchovy) during the second visit. Although extremely high average catches

TABLE 6. BAIT SPECIES, OCCURRENCE AND ESTIMATED CATCH IN COMBINED BOUKI AMI HAULS OF THE SKIPJACK PROGRAMME IN THE WATERS OF WALLIS AND FUTUNA*

Species	Percentage Occurrence	Estimated Catch (kg)
Stolephorus devisi	97	8389
Sardinella sirm	86	860
Herklotsichthys quadrimaculatus	72	691
Selar crumenophthalmus	44	142
Spratelloides delicatulus	92	113
Sp. of Atherinidae	6	3
Hypoatherina ovalaua	39	1
Rastrelliger kanagurta	11	1
Leiognathus elongatus	39	0
Apogon (Rhabdamia) gracilis	36	0
Dussumieria sp.	36	0
Cheilodipterus macrodon	33	0
Bregmaceros sp.	31	0
Archamia lineolata	25	0
Sp. of Apogonidae	22	0
Siphamia sp.	22	0
Sp. of Sphyraenidae	17	0
Pterocaesio diagramma	14	0
Apogon fragilis	8	0
Sp. of Acanthuridae	6	0
Sp. of Priacanthidae	6	0
Atherinomorus lacunosa	6	0
Fistularia sp.	6	0
Scomberomorus commerson	6	0
Sp. of Holocentridae	6	0
Sp. of Leiognathidae	6	0
Pseudamia polystigma	6	0
Sp. of Soleidae	6	0
Sp. of Lutjanidae	6	0
Sp. of Syngnathidae	6	0
Sardinella clupeoides	6	0
Sp. of Chaetodontidae	6	0
Sp. of Pomacentridae	3	0
Mullodichthys samoensis	3	0
Sp. of Bothidae	3	0
Sardinella sp.	3	0
Sp. of Squid	3	0
Sp. of Polychaete	3	0
Hypoatherina cylindrica	3	0
Sp. of Serranidae	3	0
Caranx sp.	3	0
Scomberoides sp.	3	0
Sp. of Crustacea	3	0
Sp. of Mullidae	3	0

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

were achieved during both visits, catches from hauls at this site varied greatly, from 66 to 652 kg per haul. At the time of full moon, catches dropped sharply as a result of the reduced effectiveness of the bait attraction lights.

One night was spent baiting at each of the other sites for catches of 641, 121 and 55 kg per haul. At sites B and C, catches were dominated by gold anchovy S. devisi (100 per cent and 98 per cent, respectively, by weight of the catch) and at the site in Mataala Bay, spotted pilchard dominated the catch (84 per cent by weight).

Overall, Wallis Island bait catches were high but variable and were dominated by a single species, the gold anchovy. Good catches of effective bait species at Wallis Island indicate some potential for the establishment of a baitfishery. However, due to the small size of the lagoon, the total bait resource is unlikely to be large.

4.2 Skipjack Fishing

The survey vessels visited the waters of Wallis and Futuna in May 1978 and May 1980. The Hatsutori Maru No.1 fished only 18 of 28 days during the first visit due to poor weather conditions in early May. In that time, 127 schools were sighted for an average of 0.93 schools sighted per hour spent searching or fishing. The average daily tuna catch under research conditions during the first visit converts to an estimated commercial catch of 9.6 tonnes per day, using the factor of 3.47 given by Kearney (1978). In May 1980, the Hatsutori Maru No.5 sighted 30 schools in 4.3 hours for an average of 0.70 schools sighted per hour spent fishing or searching. The estimated average commercial catch in 1980 was 5.9 tonnes per fishing day. In comparison, the overall results for the Programme show an average of 0.75 schools sighted per hour and 3.4 tonnes of skipjack and other species caught per day. A JAMARC research vessel surveyed the waters of Wallis Island for three days in December 1973, averaging about 3.5 tonnes of tuna per day (Anon. 1974). Japanese commercial pole-and-line boats fishing in Wallis and Futuna between 1975 and 1977 averaged between 3.6 and 6.0 tonnes of skipjack per day (Skipjack Programme 1980). In 1982, a commercial pole-and-line boat from New Caledonia fished for eight days in the Wallis and Futuna economic zone averaging 3.4 tonnes of tuna per day. These results suggest that the availability of skipjack and other surface tunas is quite high in the waters of Wallis and Futuna.

4.3 Skipjack Population Biology

4.3.1 Sexual maturity

Figure 3 presents female skipjack maturity data for Wallis and Futuna (upper graph) and for all Skipjack Programme samples from tropical central and western Pacific waters (lower graph). In both graphs maturing skipjack (stage 3) dominate, as they do most samples from pole-and-line catches in the tropical western Pacific. The presence of skipjack females with mature gonads (stage 4) and spent gonads (stage 6) in the samples from the Wallis and Futuna surveys implies that at least some skipjack spawning took place during the May survey period.

Seasonal changes in female gonad index[2] for all Skipjack Programme samples from tropical waters suggest that skipjack spawning is most frequent south of the Equator during spring-summer months (October to March) (Figure 5). This trend is very similar to that presented by Naganuma (1979) for samples collected from a wide area of the tropical south Pacific, and by Lewis (1981) for samples from the Papua New Guinea fishery, just a few degrees south of the Equator. Skipjack sampled from Wallis and Futuna in May 1978 and May 1980 had low gonad index values (16.1 for 40-49.9 cm skipjack and 23.6 for 50-59.9 cm skipjack), similar to May averages in Figure 5 for skipjack in the same size intervals from the total Programme sample.

4.3.2 Juvenile recruitment

Another index of spawning activity is the incidence of skipjack juveniles observed in the stomachs of predators.

An average of 50.2 skipjack juveniles per 100 skipjack predator stomachs was observed in Wallis and Futuna during the first survey in May 1978 (Table 4). This was the highest level observed in the Programme study area; however, over 75 per cent of these juveniles occurred in stomachs of only 24 large (>60 cm) skipjack sampled from three schools on the morning of 29 May 1978. This result suggests that there was some recruitment of skipjack in May 1978 to Wallis and Futuna waters. However, during the second survey, two years later, skipjack juveniles were absent from the stomachs of all 121 adult skipjack examined.

Argue, Conand & Whyman (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 between October and March in the Programme's samples from tropical waters south of the Equator, which is roughly the period of maximum skipjack gonad development in these waters. The data also indicated that during the 1977 to 1980 survey period, abundance of juvenile skipjack within the study area was highest in two areas, one roughly bounded by Solomon Islands, Papua New Guinea and Vanuatu, and the other including 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 Wallis and Futuna cannot be established.

4.3.3 Diet

Thirty-six diet items were recorded from 268 skipjack sampled from Wallis and Futuna (Table 3). A similarly wide variety of diet items has also been observed in skipjack from other tropical waters, indicating that skipjack are highly opportunistic feeders.

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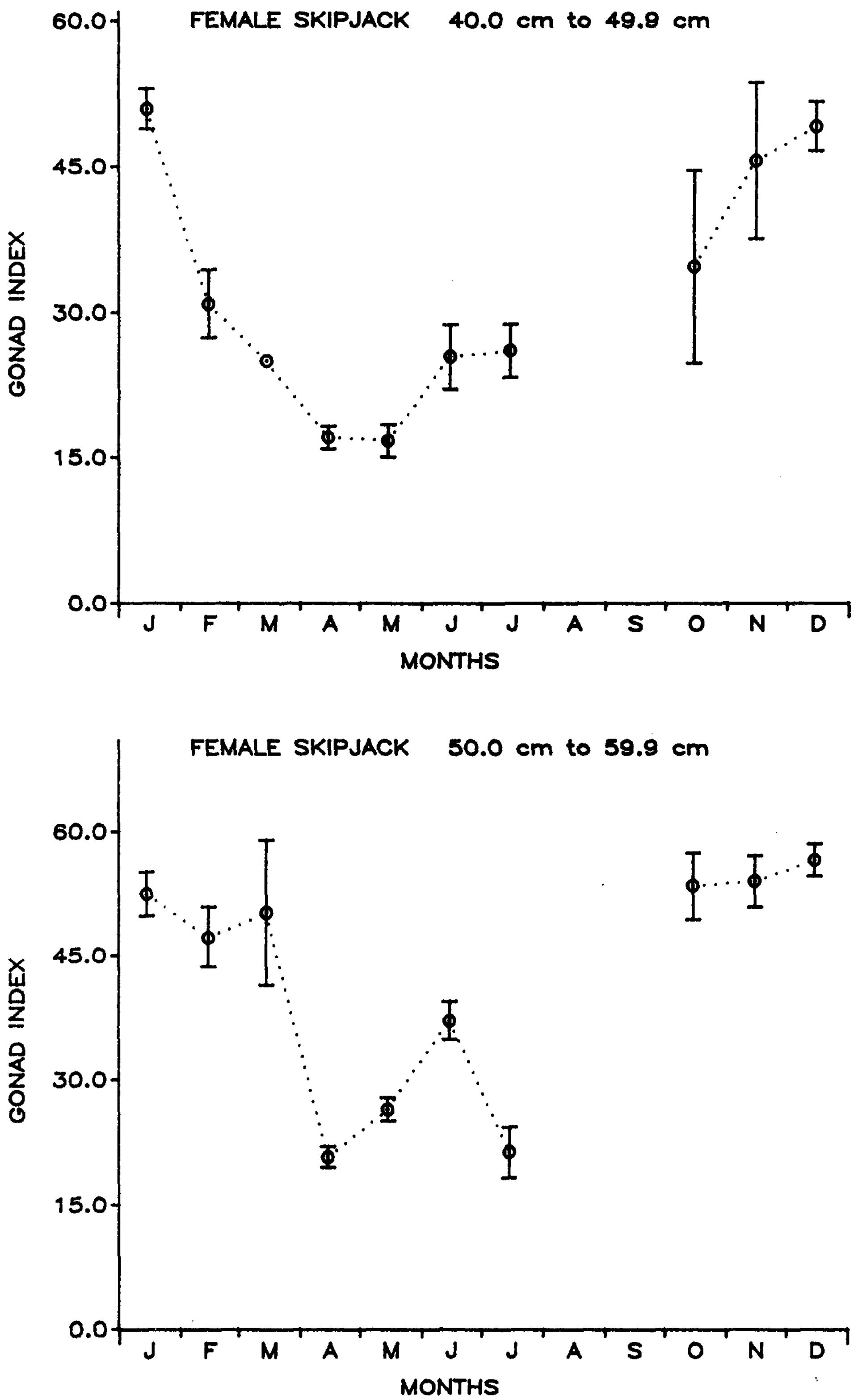
2. Gonad index=10^7(gonad weight gm/(fish length mm)^3) (Schaefer & Orange 1956). High index values, particularly over 50, are associated with skipjack whose gonads have a high percentage of eggs that are ready to be spawned (Raju 1964).

FIGURE 5. AVERAGE FEMALE SKIPJACK GONAD INDICES (circles) AND TWO STANDARD ERRORS ON EITHER SIDE OF THE AVERAGES (vertical lines), BY MONTH, FOR SKIPJACK SAMPLED FROM TROPICAL WATERS SOUTH OF THE EQUATOR. Standard errors omitted for one small sample (<5); other sample sizes were at least 9 and most exceeded 100. No samples for August and September.



Common diet items of skipjack from Wallis and Futuna, other than chum, were fish remains, squid (Cephalopoda), the alima stage of stomatopods, surgeon fish (Acanthuridae) and juvenile anchovies (Engraulidae) (Table 3). Each of these items occurred in over seven per cent of stomachs examined.

4.3.4 Growth

The growth of skipjack, as in other tunas, is a function of size. The growth of larger fish, as measured by the rate of change in length, is slower than that of smaller fish (Skipjack Programme 1981d). 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. For a given time at liberty, a small fish will have a greater increase in length than a larger fish. 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 study area, for each size class for which there were adequate data. Mean size at release varied from 41 cm to 59 cm; time-at-liberty varied from less than one to over 300 days; growth increments varied from -0.3 cm to over 12 cm. The effects of time-at-liberty can be seen by noting the difference in growth increments calculated from tag release and recovery data generated by the two visits to Fiji (FIJ1 and FIJ2) where the fish were released at approximately the same size, but the mean times-at-liberty were quite different. Similarly, the effects of size-at-release can be seen by noting the difference in growth increments between the first visit to Kiribati (KIR1) and the second visit to Papua New Guinea (PNG2) where the fish were at liberty for approximately the same period of time, but the mean sizes-at-release were quite different. On the whole, growth increments were quite small and the percentage of fish which did not show any measurable growth was quite high (40.1%). There are several 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 be near their maximum size when tagged and released. Thirdly, skipjack may have encountered conditions unfavourable for growth. Fourthly, errors in length measurement at both release and recovery may have obscured what little growth there was.

Corrections for the effects of size-at-release and time-at-liberty on the observed growth increment were calculated using analysis of covariance and a linearised version of the von Bertalanffy growth equation. The corrections have been used to calculate a standard growth increment for an arbitrary size-at-release and time-at-liberty (Sibert, Kearney & Lawson 1983). Standardised growth increments are presented in Table 8. It can be seen that the amount of growth varied considerably from country to country. Further analysis shows that growth increments also differed significantly between visits to a country and between fish recovered inside and outside of the country of release (Sibert, Kearney & Lawson 1983). Skipjack growth is therefore seen to be highly variable in time and space. The observed growth in tagged skipjack was a function of where and when the fish were tagged, and where they were recovered. Thus, growth of skipjack may be closely coupled to environmental conditions such as temperature and other oceanographic variables that are thought to regulate the abundance of food.

It is not possible to assess growth of skipjack in Wallis and Futuna waters since all of the fish released and recaptured there were at liberty for less than 10 days (see Table 7).

TABLE 7. SUMMARY OF SKIPJACK GROWTH INCREMENTS BY VISIT FOR FISH AT LIBERTY FROM 10 TO 365 DAYS. Country abbreviations are explained in Appendix D.

	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.

TABLE 8. CALCULATED GROWTH INCREMENTS (cm) FOR FISH RECAPTURED WITHIN COUNTRY OF RELEASE. Calculations for fish 50 cm in length at release and at liberty for 90 days. The 95 per cent confidence interval of each increment given in parentheses. See Sibert, Kearney & Lawson (1983) for details. See Appendix D for abbreviations.

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

4.3.5 Population structure

4.3.5.1 Blood genetics and tagging

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 countries within the Programme's study area. However, detailed examination of tag recapture data (Section 4.4.1) and preliminary analyses of fishery interactions (Section 4.4.3) 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 and population structure.

Results from electrophoretic analysis of skipjack blood samples show a gradient in esterase gene frequency, a genetic marker used to infer population structure, from west to east across the Pacific between approximately 120°E and 120°W (Figure 4). The esterase gene frequencies for samples taken in the waters of Wallis and Futuna were all within the 95 per cent prediction limits for the regression of gene frequency on longitude. These were among the first samples obtained from tropical waters between 160°E and 160°W longitude and their gene frequency values helped to substantiate the presence of a longitudinal gradient in esterase gene frequency. There was considerable variation in individual esterase gene frequency values along this average line, although the cause of this variability was unclear (Anon. 1981a).

Several models of population structure of skipjack in the Ocean have been proposed (Fujino 1972, 1976; Sharp 1978; Anon. 1. One of these models, suggested by the Programme's tagging and b. genetics data, is called the clinal population structure model (Ano. 1981a). 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 (1972, 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 spawning in tropical waters across the study area. Alternatively, one could view the gradient as the result 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 (to the right of the dotted line in Figure 4) and those from French Polynesia suggests that eastern Pacific skipjack have the same genetic origin as skipjack in French Polynesia and thus could collectively represent the group at one extreme. Occurrence of skipjack juveniles also appeared highest at the longitudinal extremes of the Programme study area, including waters just to the west of Wallis and Futuna (Argue, Conand & Whyman 1983), thus lending some support to the latter view of the distribution of skipjack spawning.

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

4.3.5.2 The occurrence of parasites

Parasite samples were taken over a wide range of tropical waters, including those of Wallis and Futuna during the second visit and subtropical waters of New Zealand and Norfolk Island. Preliminary results from a multivariate analysis presented by Lester (1981) show that the parasite faunas from widely separated tropical areas are quite similar, and that skipjack caught in New Zealand carried many tropical, as well as subtropical parasites. Analyses of parasite data are continuing; however, preliminary results do not suggest a way of clarifying fishery interactions in tropical waters using parasite fauna, nor is it likely that definition of skipjack population structure will be greatly improved by further analysis of the existing parasite data.

4.4 Resource Assessment from Tagging Data

Of the 16,065 tags released in Wallis and Futuna during the two visits in May 1978 and May 1980, 153 have been returned. All recoveries in Wallis and Futuna waters (66) were by the Programme's tagging vessel. Complete details of all recaptured tags from Wallis and Futuna releases are presented in Appendix C. The lack of recaptures by any other vessels in Wallis and Futuna reflects the very small local skipjack catch.

4.4.1 International migrations

Figure B presents a selection of Skipjack Programme tag returns plotted as straight line arrows between tagging and recovery location. 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 two examples 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 oceanographic barriers to movement of skipjack 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 environmental barriers to migration at the latitudinal extremes (skipjack are seldom encountered polewards of 40 degrees latitude or in waters less than 16°C).

It should be noted, however, that the overall impression of many wide-ranging international migrations depicted by Figure B does not accurately reflect the average case for all the tag recoveries. This figure overemphasises long-distance, relatively rare migrations, due to the procedure used to select recoveries for the figure. In fact, the majority (86%) of tag recoveries were made less than 250 nautical miles from their release site and within 180 days of tagging (top and middle graphs in Figure 6). Long-distance migrations are prevalent only within the group of skipjack that were at large for more than 180 days (bottom graph in Figure 6).

Eighty-seven skipjack released in Wallis and Futuna waters were recaptured in other countries. These migrations are shown schematically in Figure 7. These fish appear to have migrated in all directions and were recovered by fisheries in the waters of countries surrounding Wallis and Futuna. Sixty-seven (44%) of these recoveries were by pole-and-line fisheries (excluding the Programme's research vessel). There is a suggestion in this figure of an appreciable degree of international movement; however, as discussed later, in Section 4.4.3, such apparent movement cannot be quantified without complete catch statistics for the period tags were at large.

4.4.2 Mortality and production

The distribution of tagging throughout the study area was such that large numbers of skipjack were tagged in the vicinity of important fisheries with similarly large numbers tagged in waters quite remote from these fisheries. The decline in numbers of tag recoveries with increasing time-at-large can be assumed to be due to the following factors: death of tagged fish from fishing and natural causes; changes in vulnerability to fishing gears; and, to a lesser extent, emigration away from the study area as a whole, for example, into unfished central Pacific waters. These principles have been discussed by Kleiber, Argue & Kearney (1983) who developed an analytical model for the analysis of tag release and recovery data. Figure 8 shows the numbers of tag returns versus the numbers of months these tags were at large after release. This is what would be

FIGURE 6. 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.

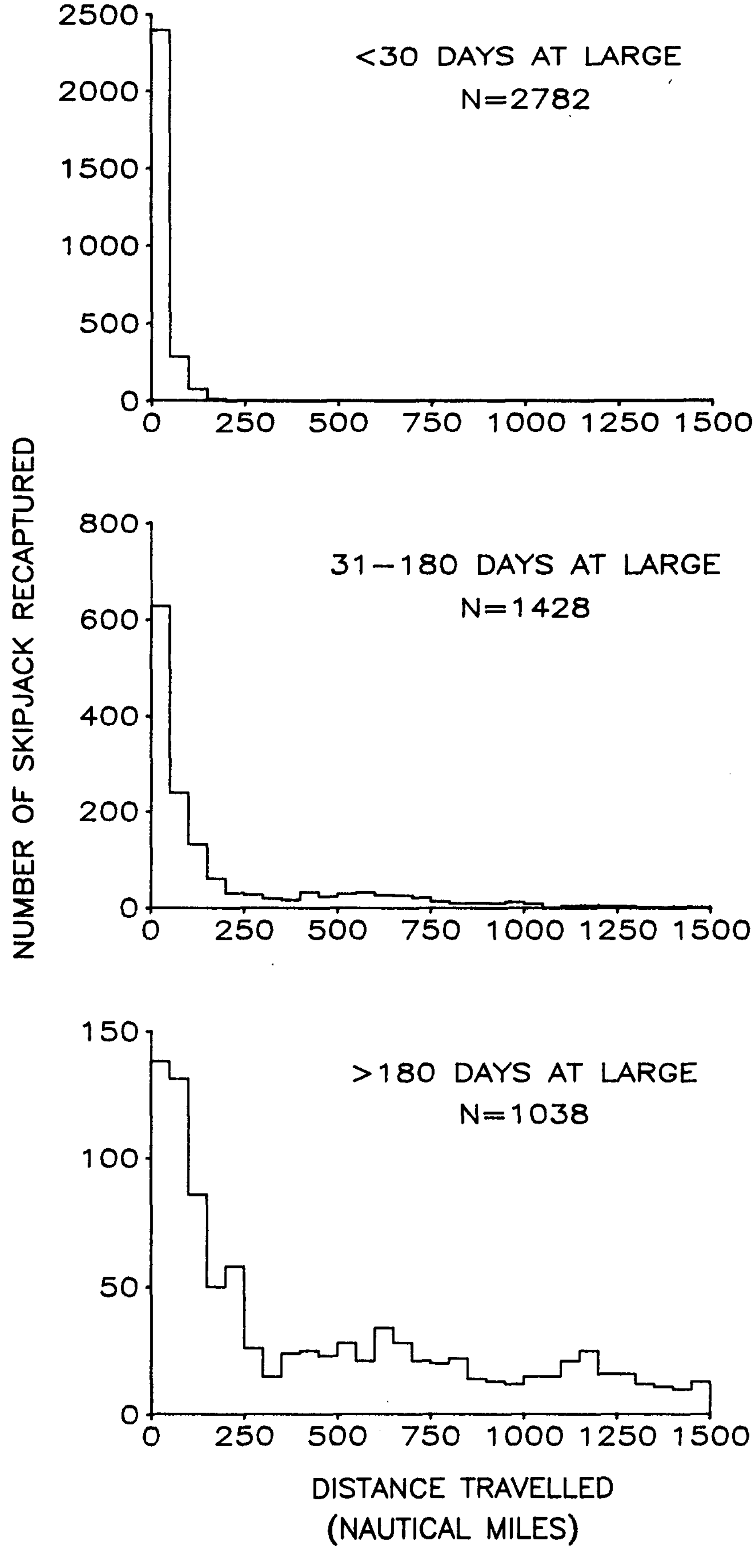


FIGURE 7. MOVEMENTS OF SKIPJACK TAGGED IN THE WATERS OF WALLIS AND FUTUNA AND SUBSEQUENTLY RECOVERED, AND MOVEMENTS OF SKIPJACK TAGGED IN OTHER COUNTRIES AND SUBSEQUENTLY RECOVERED IN THE WATERS OF WALLIS AND FUTUNA. No more than one arrow between any pair of one degree squares of longitude and latitude is shown. Tick marks on arrows represent 30-day intervals of time at liberty.

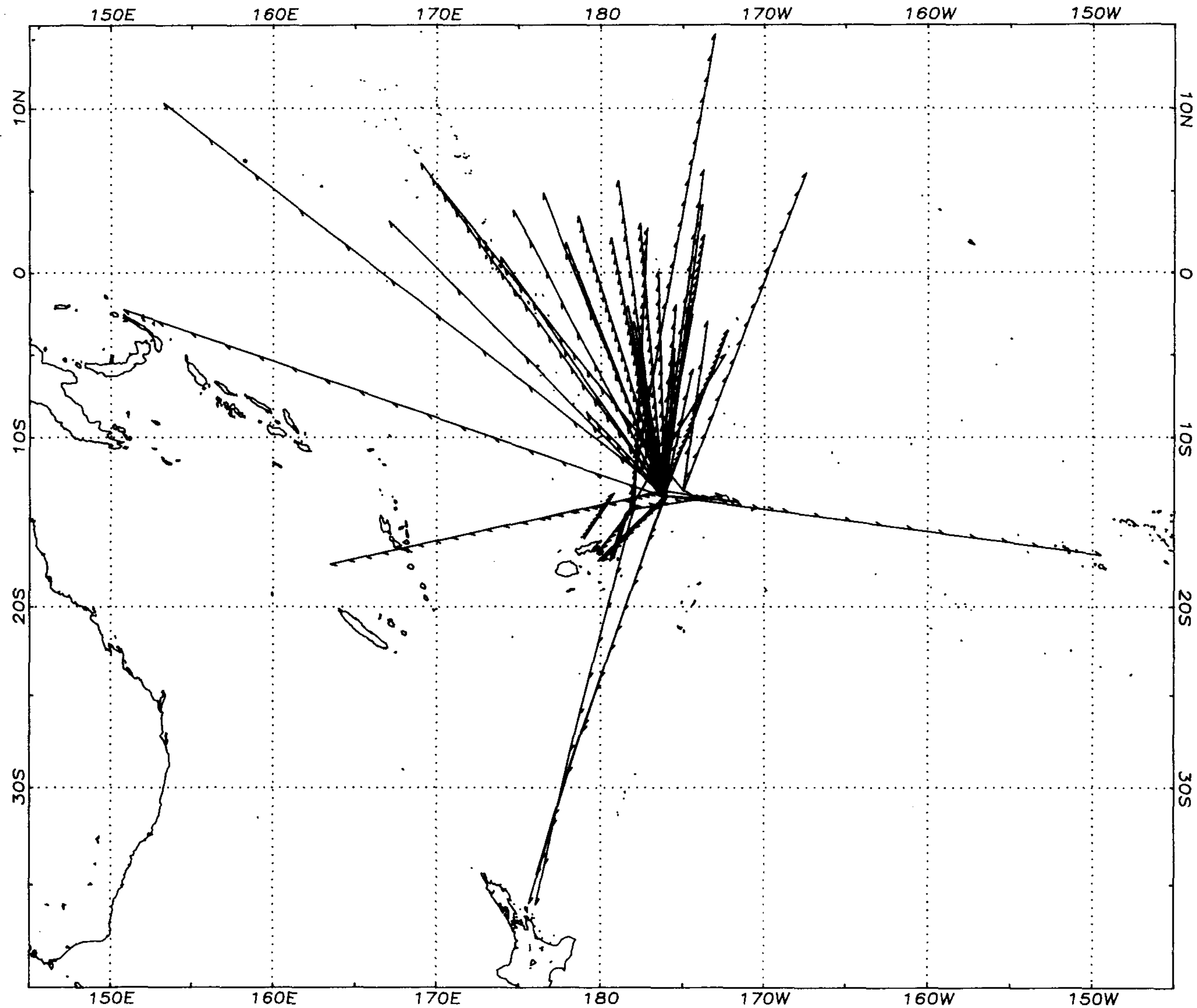
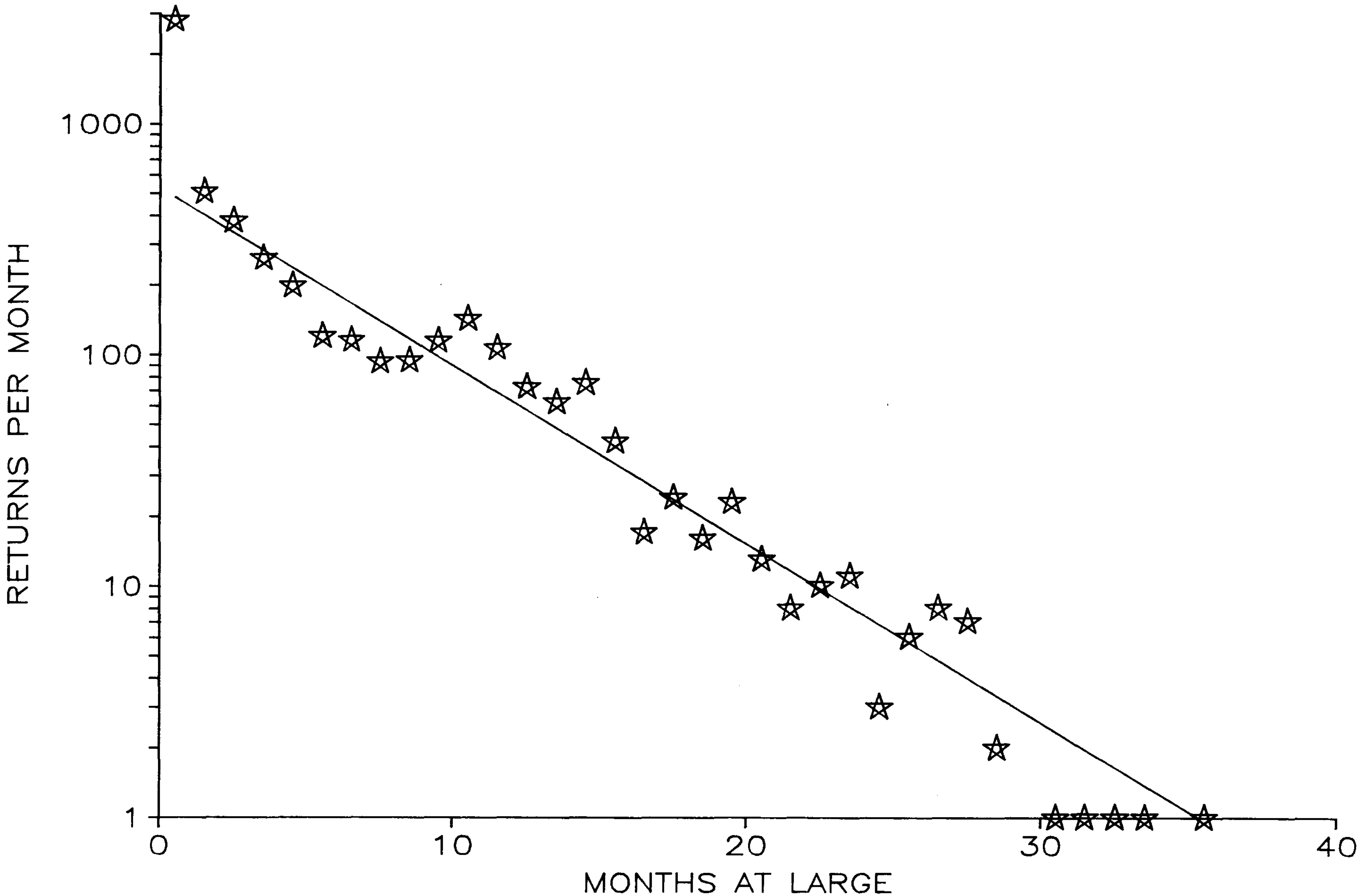


FIGURE 8. NUMBERS OF SKIPJACK TAG RECOVERIES VERSUS MONTHS AT LARGE. The Y-axis is in log scale.



expected with time if all tags were released simultaneously in the different areas. 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, Argue & Kearney (1983) to the catch and resulting tag returns.

The data points (stars) deviate little from the line predicting the average number of tag returns per month. The instantaneous rate of decrease of tag returns estimated from the fitting procedure is called the tag attrition rate, which represents the decline in the number of tagged skipjack due to the above causes. An additional component, presumably small, includes both the continual shedding of tags and continual mortality from the effects of tagging (Skipjack Programme 1981a). The estimate of attrition rate less the effects of tag shedding and tag mortality was 0.17 per month (Kleiber, Argue & Kearney 1983). 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 reason or another, and after a year this had increased to 90 per cent.

The model also provided estimates of several other parameters of the skipjack stock, but to do 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 slippage or mortality. The population size or standing stock in the study area which was vulnerable to surface fisheries was estimated to be approximately three million tonnes during the 1977 to 1981 study period (confidence range - 2.5 million to 3.7 million tonnes). Average monthly catch, 19,000 tonnes, divided by population size provided an estimate of average monthly fishing mortality of 0.006, which is a small proportion of the monthly attrition rate. This leaves losses through natural death, decreased vulnerability to fishing and emigration. It is difficult to partition the last three loss factors, although considering that the study area was vast and covered much of the area of skipjack distribution in tropical waters, it has been assumed that emigration is the smallest of the three.

The product of standing stock (population size) and monthly attrition rate provides an estimate of monthly throughput for the study area. In this context, throughput measures the tonnes of skipjack being recruited to the standing stock each month, which is assumed for the duration of the tagging experiment to be matched by an equal amount leaving each month. From Skipjack Programme data, recruitment was estimated to fall between 0.46 and 0.59 million tonnes per month. Average monthly loss due to catch represents approximately four per cent of the estimated monthly recruitment. Hence there would appear to be potential for greatly increased catches from the region as a whole before recruitment would be affected (Kleiber, Argue & Kearney 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) also suggests that fisheries could be expanded.

4.4.3 Fishery interactions

One of the principal reasons for tagging skipjack was to investigate the degree of interaction among skipjack fisheries throughout the western and central Pacific. Table 9 summarises the recoveries from skipjack released throughout the total study area, by country/territory of release and recovery. This form of presentation, however, 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 and these were available to the Programme for locally based fisheries during the period tags were at large, but not for catches, 1979-1982, by the large and growing United States and Japanese distant-water purse-seine fisheries, nor for recent catches by the Japanese distant-water pole-and-line fishery. These fisheries operate in much of the central and western Pacific. Over the period of tag recoveries they accounted for a significant percentage (~20%) of Skipjack Programme tag returns. Until the Programme receives monthly catch data from these fisheries, estimates of interaction between distant-water and locally based fisheries cannot be made.

Using the available catch statistics and tag recoveries, several measures of fishery interactions are possible: the change in catch in one fishery resulting from increased catches in other fisheries, within a generation or between generations; the fraction of recruitment (or standing stock) that arises from immigration from neighbouring fished areas; the change in yield per recruit resulting from different fishing strategies. The absence of any demonstrable relationship between catch per unit effort and effort for mature skipjack fisheries suggested that between-generation fishery interactions were negligible for skipjack fisheries in the western and central Pacific. Therefore evaluation of interactions within one generation was considered more urgent.

The initial approach followed by the Skipjack Programme was to use tagging data plus catch statistics to estimate coefficients of migration between particular fisheries (Skipjack Programme 1981b). The product of population size in the donor fishery and migration coefficient gave an estimate of the tonnes of skipjack migrating between fishing areas. Comparison of these estimates with estimates of population size in the recipient country, or in the donor country, illustrated stock interactions within one skipjack generation, since they measured the fraction of the standing stock that migrated to or from a particular area.

A simpler expression of interaction is the percentage of throughput in the destination country that is due to immigration from the donor country (Kleiber, Sibert & Hammond ms.). There were four pairs of countries and territories in the Skipjack Programme study area for which it was possible to obtain quantitative estimates of this interaction (Table 10). These were Papua New Guinea - Solomon Islands, New Zealand - Fiji, New Zealand - Society Islands, and New Zealand - Western Samoa (Kearney 1982a; Argue & Kearney 1982, 1983; Gillett and Kearney 1983). As shown in column 4 of the table, skipjack immigrants from the fished area in a particular donor country were generally a small fraction (<10%) of throughput in the destination country's fished area, which implies that interactions among locally based fisheries in these countries are minor. It should be noted that this applies only to skipjack of the size tagged by the Programme (most were between 40 and 60 cm). Skipjack smaller than this could very well move large distances and contribute significantly to interactions between stocks in the fished areas. However, as fisheries in the study area are not yet exploiting fish less than 40 cm to any great degree, it

TABLE 9. SKIPJACK TAG RELEASE/TAG RECOVERY MATRIX FOR ALL TAG RELEASES AND FOR ALL TAG RECOVERIES RECEIVED BY THE PROGRAMME AS OF 10 OCTOBER 1983. Releases and recoveries are arrayed by tagging or recovery location, usually a country or territory except in cases where small geographical divisions were more informative; abbreviations are explained in Appendix D. Not included in the table are returns for which the country or area was unknown.

COUNTRY OF RECAPTURE (columns); NUMBER OF RELEASES BY COUNTRY (rows)

		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, Sibert & Hammond ms.) See Appendix D 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 can be reasonably assumed that fishery interactions resulting from movement of small fish are presently negligible.

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 would be expected to increase. Furthermore, if different gear types were to operate in the same area, such as purse-seine and pole-and-line fleets operating on the same or nearby fishing grounds within a country, then the degree of interaction would be much higher than that among present locally based fisheries. The tagging data in Section 4.4.1 indicated some interchange of fish between Wallis and Futuna and neighbouring countries, thus showing the need to monitor developing fisheries near Wallis and Futuna.

5.0 CONCLUSIONS

Results from the two Skipjack Programme surveys suggest that harvestable baitfish resources of Wallis Island are large in relation to the relatively small amount of lagoon habitat. However, Programme catches were dominated by a single species, the gold anchovy (Stolephorus devisi). Fisheries based on a single species of tropical baitfish often suffer from wide fluctuations in bait abundance; thus, a cautious approach is recommended for development of a baitfishery in Wallis and Futuna. Baitfishing in the lagoon should not significantly interact with local fisheries for adults of reef-associated species since few juvenile reef fishes were caught with bouki-ami gear, and adults of these species do not respond to the attraction lights used for tuna bait.

Both surveys of Wallis and Futuna took place in May and achieved daily skipjack catch rates that were generally higher than those reported for other countries and territories surveyed by the Programme. These results and those from previous exploratory fishing surveys at other times of the year imply that skipjack are abundant in the waters of Wallis and Futuna.

Skipjack exploitation in Wallis and Futuna was low during the period of the tagging experiment. There were no local recoveries of tagged skipjack other than those by the survey vessel, thus there were no data for local resource assessment or for quantifying fishery interactions. The pattern of international tag recoveries from tag releases in the waters of Wallis and Futuna and neighbouring countries, suggests that there is potential for fishery interactions between Wallis and Futuna and all countries close by.

The resource of skipjack in the waters of Wallis and Futuna is obviously some small fraction of the total standing stock in the study area. Although the size of the local skipjack resource could not be quantified, the Programme's catch results suggest that skipjack are abundant in Wallis and Futuna. Skipjack appear to represent a potential resource for development of local fisheries, and/or for deriving benefits from the licensing of distant-water purse-seine and pole-and-line vessels. There is, however, cause for concern that any great increase in skipjack fisheries in neighbouring countries, such as the recent large build-up in the purse-seine fishery to the west of Wallis and Futuna, could have serious, detrimental impact on the quantity of skipjack available in the waters of Wallis and Futuna. Accordingly, it is recommended that development or expansion of neighbouring fisheries, particularly purse-seine fisheries, be closely monitored.

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APPENDIX A. SUMMARY OF EXPLORATORY FISHING AND FISHERIES RESEARCH IN WALLIS AND FUTUNA

1950-1972	U.S. National Fisheries Service (various vessels)	During 22-year period 177 research cruises to explore distribution and abundance of tuna in central Pacific. 35 hours of spotting carried out in Wallis and Futuna. 13 bird flocks seen in Wallis and Futuna zone.	Anon. 1972
July-Aug. 1969	V.T. Hinds - SPC Fisheries Officer	Two-week visit to investigate the possibility of establishing an offshore fishery. Numerous recommendations made.	Hinds 1969
June-July 1970	ORSTOM Research Project "Danaides 1" - R/V Coriolis	Research cruise for collection of basic oceanographic data along 177°W meridean. Information on tuna ecology and thermocline collected in addition to numerous other data.	Cremoux 1980
Dec. 1973	Japan Marine Fishery Research Resource Center - Akitsu Maru No.20	Seven-day skipjack and baitfish survey using 192-tonne vessel.	Anon. 1974
Jan.-Feb. 1977	ORSTOM Research Project "Danaides 2" - R/V Coriolis	Research cruise for collection of basic oceanographic data along 177°W meridean. Information on tuna ecology and thermocline collected in addition to numerous other data.	Cremoux 1980
June-July 1977	ORSTOM Research Project "Ecoton" - R/V Coriolis	Research cruise for collection of basic oceanographic data along 177°W meridean. Information on tuna ecology and thermocline collected in addition to numerous other data.	Cremoux 1980
March 1978	U.S. purse-seine vessel Jeannette C	Four sets of the net on four consecutive days catching, 0, 123, 47 and 58 tonnes of skipjack (80%) and yellowfin (20%).	Souter & Broadhead 1978 Marcille & Bour 1981
May 1978	SPC Skipjack Programme Hatsutori Maru No.1	Exploratory baitfishing and pole-and-line fishing during 28-day period. 13,768 tuna tagged.	Kearney & Hallier 1978
Oct. 1979	U.S. National Marine Fisheries Service - R/V Townsend Cromwell	Trolling for pelagic species on Pasco Bank.	Anon. 1979
March, June, July, Sept., Oct. 1979, Jan. 1981	ORSTOM Research Project - tuna exploration by aerial observation	91 hours of flight in Britten Norman aircraft during 4 missions; favourable concentration of surface schooling tuna observed.	Marsac 1981
Feb.-July 1980	SPC Deep Sea Fishery Development Project	39 days spent primarily bottom fishing; however, exploratory trolling for pelagic species carried out on several occasions.	Fusimalohi & Grandperrin 1980
May 1980	SPC Skipjack Programme - Hatsutori Maru No.5	Exploratory baitfishing and pole-and-line fishing during 13-day period. 3,033 tuna tagged.	Skipjack Programme unpublished data
Oct.-Nov. 1980	Ecole pratique des hautes études : mission Wallis and Futuna	Team of 7 French scientists carrying out "pre-development research" on the reefs and lagoons of Wallis and Futuna. Report of mission has implications for baitfish development.	Richard et al. 1980 Richard et al. 1982
April 1981	CNEXO - Aquaculture Potential Evaluation Mission	15-day mission by Director of the CNEXO Aquaculture installation in New Caledonia. Report stated there is potential for raising milkfish and mollies for use as live bait.	Anon 1981b
Sept. 1982	Transpêche Fishing Co. - F/V Vaea	11-day visit to Wallis. 6 hauls of bouki-ami net in shallow water in extremely rough conditions. Yielded approx. 175 buckets of mostly sardines. Caught about 13 tonnes of tuna, some around payao; very favourable concentrations of tuna seen.	Petiniaud pers. comm.

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

South Pacific Commission Scientists

Jean-Pierre Hallier	5-31 May 1978 14-23 May 1980
Robert Gillett	4-12 May 1978 10-20 May 1980
Des Whyman	4-31 May 1978
Charles Ellway	5-31 May 1978 9-15 May 1980
A.W. Argue	14-23 May 1980
James Ianelli	10-23 May 1980

Observers

Gaston Lutui Secrétaire de l'Assemblée Territoriale	5-7 May 1978
Atonio Sako Ministre coutumier de Wallis	5-7 May 1978
Patelise Manufeka Ministre de la police du Roi de Wallis	5-7 May 1978
Keleto Lakalaka Président de la Commission Permanente	7-8 May 1978
Leone Muliakaaka Chef du village de Malaefoou	9-11 May 1978
Ludovic Katena Secrétaire du district de Hihifo	9-11 May 1978
Raymond Ruff Représentant du Vice-Rectorat	14-15 May 1978
Jean-Marie Bonnette Chargé des relations publiques auprés du Gouverneur	18 May 1978
M. Basset Chef du Service des postes	18 May 1978
Enelio Felomaki Pêcheur	14, 15 May 1980
Pesamino Taputai Greffier du Tribunal de Mata Utu	18 May 1980
Simione Vakauliafa Restaurateur à Mata Utu	18 May 1980
Auni Lagikula Infirmière	19, 20 May 1980
Gedeon Jessop Conseiller territorial (Futuna)	22 May 1980
Talila Jessop Futuna	22 May 1980

Observers (cont.)

Sioli Masei Conseiller territorial (Futuna)	22 May 1980
Feleki Masei Futuna	22 May 1980
Sovita Tokotuu Futuna	22 May 1980
Soane Maituku Futuna	22 May 1980
Gerard Mayrand Conseiller pédagogique	22 May 1980
Pierre-Yves Huet Chef de secteur - Economie Rurale	22 May 1980

Vessel Crew

Kenji Arima
Ryoichi Eda
Sakae Hyuga
Mitsutoyo Kaneda, Captain, Hatsutori Maru No.5
Seima Kobayashi
Koshihiro Kondoh*
Yoshio Kosuka
Masahiro Matsumoto, Captain, Hatsutori Maru No.1
Akio Okumura
Yoshikatsu Oikawa*
Tsunetaka Ono
Yukio Sasaya
Kohji Wakasaki*
Mikio Yamashita*

Fishing Crew

Lui Andrews*
Vonitiese Bainamoli
Jovesa Buarua
Mosese Cakau
Samuela Delana*
Lui Diva
Eroni Dolodai
Luke Kaidrokai
Veremalua Kaliseiwaga
Kitione Koroi
Metuisela Koroi
Aminiasi Kuruyawa
Sovita Lequeta
Jone Manuka
Eroni Marawa*
Joshua Raguru
Jona Ravasakula*
Napolioni Ravitu
Ravaele Tikorakaca*
Tuimasi Tuilekutua
Samuela Ue*
Taniela Verekila

* Crewed on board both the Hatsutori Maru No.1 and No.5.

APPENDIX C. RELEASE AND RECOVERY DATA FOR ALL FISH TAGGED IN WALLIS AND FUTUNA. 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 D); 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.

WAL 189 780506 0840 1327S 17607W 85 0 0

WAL 190 780506 0930 1326S 17602W 602 105 0
S WAL 780506 000 1326S 17602W 0000 540M 550A SK10271 SPCPOL
S WAL 780506 000 1326S 17602W 0000 535M 540A SK10572 SPCPOL
S WAL 780506 000 1326S 17602W 0000 500M 540A SK10254 SPCPOL
S WAL 780516 010 1330S 17605W 0005 480M U SK10465 SPCPOL
S PHO 781002 149 0438S 17531W 0529 530M 551C SK10222 JAPPOL
S PHO 781003 150 0432S 17649W 0536 490M 551J SK10283 JAPPOL

WAL 191 780506 1250 1321S 17602W 509 0 0
S TRK 790331 329 1020N 15315E 2316 630M 705W SK11429 JAPPOL

WAL 192 780506 1500 1322S 17603W 62 0 0

WAL 193 780512 0755 1325S 17611W 96 0 0
S WAL 780516 004 1325S 17609W 0002 520M 502A SK11611 SPCPOL

WAL 194 780512 1120 1307S 17607W 332 0 0

WAL 195 780512 1250 1308S 17613W 137 0 0

WAL 196 780512 1500 1321S 17615W 23 0 0

WAL 197 780512 1630 1325S 17614W 73 0 0

WAL 198 780513 0930 1328S 17613W 332 0 0

WAL 199 780513 1200 1314S 17616W 6 0 0

WAL 200 780513 1220 1313S 17615W 128 0 0
S WAL 780513 000 1313S 17615W 0000 640M 640A SK12147 SPCPOL
S WAL 780513 000 1313S 17615W 0000 650M 650A SK12125 SPCPOL

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S WAL 780513 000 1328S 17620W 0002 610M 610A SK12361 SPCPOL
S MAS 780909 119 0310N 16705E 1405 620M 620B SK12042 JAPPOL

WAL 202 780514 0910 1320S 17624W 75 0 0

WAL 203 780514 1110 1308S 17622W 116 0 0

WAL 204 780515 0710 1323S 17613W 200 0 0
S HOW 800428 714 0301N 17737W 0988 520M 605J SK12530 JAPPOL

WAL 205 780515 0800 1324S 17612W 59 0 0
S WAL 780515 000 1309S 17622W 0018 600M 580A SK12538 SPCPOL
S PHO 780930 138 0410S 17609W 0554 530M 548W SK12543 JAPPOL

WAL 206 780515 1000 1310S 17618W 4 0 0

WAL 207 780515 1035 1309S 17622W 410 0 0
S WAL 780515 000 1309S 17622W 0000 630M 630A SK13010 SPCPOL
S WAL 780515 000 1309S 17622W 0000 640M 640A SK13260 SPCPOL
S FIJ 780716 062 600M U SK13011 FIJPOL
S WES 780722 068 1347S 17237W 0222 600M 680J SK12564 WESSUB
S KIR 790202 263 0350N 17440E 1151 594B 665J SK12915 JAPPOL

WAL 208 780515 1300 1308S 17622W 194 0 0
S PHO 781012 150 0233S 17425W 0645 600M 658W SK13603 JAPPOL

WAL 209 780515 1350 1309S 17615W 10 0 0

WAL 210 780515 1615 1327S 17611W 5 0 0

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S WES 780814 090 1330S 17250W 0194 500M 500K SK13686 WESSUB

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S WAL 780516 000 1330S 17605W 0000 520M 520A SK14146 SPCPOL
S WAL 780516 000 1330S 17605W 0000 505M 505A SK14279 SPCPOL
S WAL 780519 003 1328S 17607W 0003 520M 522A SK13783 SPCPOL
S WES 780726 071 1350S 17137W 0261 490M 520E SK14204 WESSUB
S 780929 136 513B 560W SK14340 JAPPOL
S PHO 781126 194 0307S 17610W 0623 510M 556J SK13944 JAPPOL
S SOC 790723 433 1700S 14930W 1552 510M 580D SK14489 POLPOL
S FIJ 800720 796 1720S 17950E 0330 520M U SK14184 FIJPOL

WAL 213 780517 1030 1337S 17604W 19 0 0

WAL 214 780517 1150 1329S 17607W 1034 0 0
S WAL 780517 000 1329S 17607W 0000 510M 505A SK14910 SPCPOL
S WAL 780517 000 1329S 17607W 0000 520M 520A SK15328 SPCPOL
S WAL 780518 001 1331S 17605W 0003 530M U SK15449 SPCPOL
S WAL 780518 001 1331S 17605W 0003 530M 520A SK15276 SPCPOL
S WAL 780518 001 1331S 17605W 0003 510M 515A SK15420 SPCPOL
S WES 780712 056 1350S 17205W 0236 500M U SK15048 WESSUB
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S PHO 781002 138 0442S 17702W 0530 530M 485J SK14873 JAPPOL

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S INT 781002 138 0452N 17628E 1186 530M 530W SK15288 JAPPOL
S ZEA 790314 302 3556S 17535E 1419 530M    U SE01223 USASEN
S KIR 800117 610 0321N 17332E 1183 520M 555W SK15430 JAPPOL
S MAS 800213 637 0641N 16900E 1500 520M 650W SK15081 JAPPOL
S PHO 800922 859 0331S 17214W 0641 540M 670W SK15545 JAPPOL

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S WAL 780518 000 1331S 17605W 0000 530M 530A SE01984 SPCPOL
S WAL 780518 000 1331S 17605W 0000 520M 520A SE02075 SPCPOL
S WAL 780518 000 1331S 17605W 0000 530M 530A SE02238 SPCPOL
S WAL 780518 000 1331S 17605W 0000 510M 510A SE02043 SPCPOL
S WAL 780518 000 1331S 17605W 0000 560M 560A SE02035 SPCPOL
S WAL 780518 000 1331S 17605W 0000 505M 505A SE01835 SPCPOL
S WAL 780518 000 1331S 17605W 0000 500M 500A SE01720 SPCPOL
S WAL 780518 000 1331S 17605W 0000 540M 540A SE01710 SPCPOL
S WAL 780518 000 1331S 17605W 0000 500M 500A SE01703 SPCPOL
S WAL 780518 000 1331S 17605W 0000 500M 500A SE01756 SPCPOL
S WAL 780518 000 1331S 17605W 0000 520M 520A SE01736 SPCPOL
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S PHO 781001 136  407S 17660W 0567 530M 508W SE02003 JAPPOL
S PHO 781016 151 0348S 17529W 0584 520M 530W SE02294 JAPPOL
S ZEA 790119 246 3429S 17603E 1329 540M 541D SE01940 USASEN
S FIJ 790320 306 1720S 17956W 0319 550M 543B SE02257 FIJPOL
S HOW 790830 470  005N 17630W 0816 510M 488W SE02111 JAPPOL
S INT 800822 827 0327N 17840E 1065 540M 410C SE02099 JAPPOL

        WAL 216 780518 1105 1334S 17612W  293    0    0
S WAL 780518 000 1334S 17612W 0000 510M 510A SE02680 SPCPOL
S WAL 780519 001 1324S 17610W 0010 495M 510A SE02796 SPCPOL
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S PHO 780930 135 0410S 17609W 0564 540M 519W SE02471 JAPPOL
S PNG 790905 475 0215S 15049E 2071 550M 620W SE02658 PNGPOL

        WAL 217 780519 0735 1324S 17610W  363   26    0
S WAL 780519 000 1330S 17605W 0008 514B    U SE02587 SPCPOL
S WAL 780519 000 1330S 17605W 0008 514B    U SE02503 SPCPOL
Y WAL 780526 007 1310S 17618W 0016 580M    U SE02869 SPCPOL
S WES 780829 102 1403S 17137W 0268 514B    U SE02530 WESSUB
Y WAL 800314 665 1325S 17605W 0005 595M 760J SE02871 WALART

        WAL 218 780519 0915 1328S 17607W  194    0    0
S PHO 781009 143 0211S 17432W 0683 504B 520W SE03334 JAPPOL

        WAL 219 780519 1030 1330S 17605W 1028    0    0
S WAL 780519 000 1331S 17608W 0003 520B 500A SE04345 SPCPOL
S WAL 780526 007 1310S 17618W 0024 500M    U SE03517 SPCPOL
S WES 780824 097 1405S 17140W 0260 500M 525E SE03722 WESSUB
S PHO 780926 130 0320S 17630W 0611 490M 485J SE03796 JAPPOL
S KIR 780928 132 0312N 17400E 1163 520M    U SE03553 JAPPOL
S PHO 781002 136 0554S 17424W 0467 530M 496J SE03284 JAPPOL
S INT 781002 136 0452N 17628E 1188 520B 530W SE03488 JAPPOL
S PHO 781013 147 0230S 17353W 0673 520M 515W SE04056 JAPPOL
S PHO 781016 150 0331S 17344W 0615 480M 620J SE03648 JAPPOL
S WES 781024 158 1405S 17142W 0258 520B 540E SE03446 WESSUB
S INT 781115 181 0300S 17800W 0640 500M 490J SE04032 JAPPOL
S TUV 790122 248 0834S 17913E 0405 520M    U SE03884 TUVSUB
S ZEA 790304 289 3530S 17501E 1405 490M 540D SE03518 USASEN
S FIJ 790324 309 1616S 17940W 0266 520M 536B SE03605 FIJPOL

        WAL 220 780519 1150 1331S 17608W  317    0    0
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        WAL 221 780519 1320 1329S 17614W   60    0    0
S PHO 780816 089 0300S 17200W 0677 482T 525J SE04759 JAPPOL

        WAL 222 780520 0850 1317S 17623W  350    0    0
S PHO 781005 138 0521S 17425W 0490 510M 545B SK15805 JAPPOL
S SOC 790201 257 1700S 14940W 1562 510M 560W SE04412 POLSHE
S ZEA 790304 288 3612S 17530E 1443 480M 515W SE04967 USASEN
S SOC 790801 438 1705S 14930W 1572 530M 600E SK15813 POLPOL
S CAL 791206 565 1732S 16330E 1190 510M 645W SK15753 JAPPOL
S HOW 800621 763 0208N 17922W 0942 510M 590W SE04987 JAPPOL

        WAL 223 780520 1030 1315S 17620W 1565    0    0
S WES 780728 069 1327S 17242W 0212 510M    U SK16143 WESSUB
S PHO 780916 119 0426S 17336W 0553 505B 400K SK17079 JAPPOL
S KIR 780928 131 0312N 17400E 1143 505B    U SK15611 JAPPOL
S PHO 781008 141 0346S 17317W 0597 505B 505W SK16659 JAPPOL
S KIR 781013 146 0057N 17356E 1030 500M 450C SK15869 JAPPOL
S FIJ 790226 282 1448S 17635E 0423 505B    U SK17603 JAPPOL
S ZEA 790304 288 3612S 17530E 1446 505B 560W SK16687 USASEN
S FIJ 790725 431 1610S 17910E 0314 510M 560B SK16101 FIJPOL
S INT 791019 517 0537N 17858W 1143 510M 695W SK16283 JAPPOL

        WAL 224 780520 1230 1317S 17616W 1006    0    0
S WAL 780520 000 1317S 17616W 0000 500M 506A SK17997 SPCPOL
S WAL 780520 000 1317S 17616W 0000 510M 510A SK17848 SPCPOL
S WAL 780520 000 1317S 17616W 0000 520M 523A SK18412 SPCPOL
S WAL 780520 000 1317S 17616W 0000 510M 510A SK18482 SPCPOL
S WAL 780520 000 1317S 17616W 0000 510M 513A SK17841 SPCPOL
S WAL 780520 000 1317S 17616W 0000 470M    U SK17578 SPCPOL
S WAL 780520 000 1317S 17616W 0000 500M 504A SK17789 SPCPOL
S WAL 780520 000 1317S 17616W 0000 530M 530A SK17797 SPCPOL
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S WAL 780521 001 1332S 17610W 0016 510M    U SK18265 SPCPOL
S FIJ 790131 256 1710S 17855E 0363 490M 500W SK17392 FIJPOL
S     790306 290                   520M 630J SK18019
S FIJ            1610S 17910E 0316 520M    U SK18090 FIJPOL
S INT 810209 996 0218N 17342W 0947 510M 710C SK17478 JAPPOL

        WAL 225 780521 0815 1332S 17610W  417    0    0
S WAL 780521 000 1332S 17610W 0000 500M 500A SK18342 SPCPOL
S PNG            0600S 15600E 1705 520M 563D SK18696 UUUUUU
S PHO 781003 135 0447S 17605W 0525 520M 485J SK18628 JAPPOL
S INT 791005 502 0410N 17350W 1071 510M 554C SK18110 JAPPOL
S INT 800419 699 0150N 17755E 0987 530M 350E SK18903 JAPPOL

        WAL 226 780524 0730 1329S 17609W   49    7    0

        WAL 227 780524 0850 1330S 17601W   50    0    0

        WAL 228 780524 1200 1326S 17614W   38    0    0

        WAL 229 780525 0945 1336S 17601W  137    0    0

        WAL 230 780525 1050 1338S 17600W    9    0    0

        WAL 231 780526 0815 1319S 17617W  122    0    0

        WAL 232 780526 0945 1310S 17618W   81   75    0

        WAL 233 780527 1220 1313S 17615W   27    0    0

        WAL 234 780529 0730 1411S 17754W  140    0    0
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        WAL 235 780529 0830 1405S 17758W  308    0    0
S FIJ 790224 271 1655S 17946E 0215 500M 535W SK19392 FIJPOL
S ZEA 790411 317 3600S 17600E 1354 510M 560J SK19390 USAPOL
S HOW 800730 793 0242N 17710W 1008 500M 640W SK19722 JAPPOL

        WAL 236 780529 1045 1413S 17803W   38    0    0

        WAL 237 780531 1500 1313S 17458W  337    0    0
S PHO 781010 132 0300S 17330W 0619 520M 501W SK19502 JAPPOL
S INT 791018 505 0605N 16724W 1243 490M    U SK19914 JAPPOL
S MAS 791125 543 0524N 17001E 1431 515M 613W SK19955 JAPPOL

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S WAL 800515 000 1304S 17621W 0000 528T 530A 1E15234 SPCPOL
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S WAL 800515 000 1304S 17621W 0000 520M 580A 1E15181 SPCPOL
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S WAL 800515 000 1304S 17621W 0000 528T 528A 1E15243 SPCPOL
S HOW 801008 147  202S 17822W 0673 490M 566W 1E15768 JAPPOL
S FIJ 810212 273 1730S 17900E 0378 610M 550B 1E15898 FIJPOL
S FIJ 810214 275 1650S 17910E 0344 540M 580E 1E16100 FIJPOL
S FIJ 810224 285 1544S 17959E 0266 550M 610W 1E15093 FIJPOL
S INT 810224 285 0615N 17345W 1169 535M 550C 1E16983 JAPPOL
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        WAL 865 800517 1215 1319S 17616W    9   58    0

        WAL 866 800517 1235 1321S 17615W    0    4    0

        WAL 867 800517 1325 1317S 17617W    1  209    0
Y INT 820511 724 0225S 16530W 0914 570M 250C 1E17028 KORLON

        WAL 868 800518 1410 1330S 17610W    0    2    0

        WAL 869 800522 1210 1419S 17810W   97    0    0

        WAL 870 800522 1230 1421S 17808W  212    0    0
S FIJ 810212 266 1710S 17935E 0214 410M 560E 1E17477 FIJPOL

        WAL 871 800522 1435 1417S 17814W   88    0    0

        WAL 872 800522 1525 1421S 17817W   64    0    0

        WAL 873 800522 1545 1420S 17816W  477   42    0
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S WES 801203 195 1329S 17241W 0329 450M 565E 1E10095 WESSUB
S INT 820404 682 1425N 17304W 1752 430M 680J 1E10503 USASEN
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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 Hatsutori Maru No.1 (SPC staff)
B	Measured by joint local 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 D. ABBREVIATIONS FOR COUNTRIES, TERRITORIES AND SUBDIVISIONS THEREOF

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