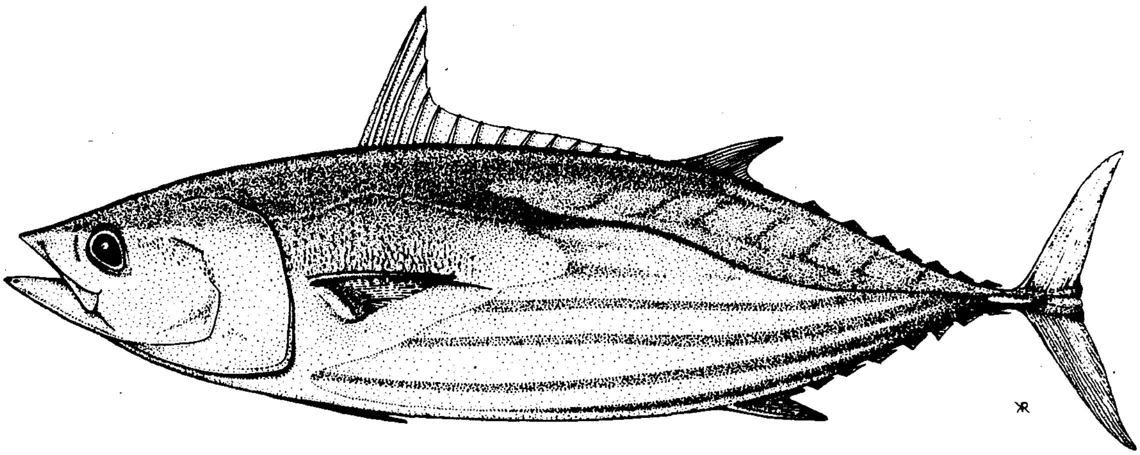
SPC

AN ASSESSMENT OF THE SKIPJACK AND BAITFISH RESOURCES OF FRENCH POLYNESIA

R.D. Gillett
and
R.E. Kearney



Skipjack Survey and Assessment Programme
Final Country Report No. 7

South Pacific Commission
Noumea, New Caledonia
July 1983

AN ASSESSMENT OF THE SKIPJACK AND BAITFISH RESOURCES OF FRENCH POLYNESIA

R.D. Gillett
and
R.E. Kearney

Skipjack Survey and Assessment Programme
Final Country Report No.7

South Pacific Commission,
Noumea, New Caledonia
July 1983

PREFACE

The Skipjack Survey and Assessment Programme, which commenced in August 1977 and concluded in September 1981, was an externally funded part of the work programme of the South Pacific Commission. The governments of Australia, France, Japan, New Zealand, United Kingdom and the United States of America provided funding for the Programme.

The Programme worked in the waters of all of the countries and territories within the area of the South Pacific Commission and in New Zealand and Australia. This report is one of a series covering the assessment of the skipjack and baitfish resources of each country. Interim reports detailing the field results for each country have previously been published by the South Pacific Commission in a Preliminary Country Report series.

As the fieldwork and analysis phases of the Skipjack Programme have only recently been completed, many reports resulting from the Programme have not yet been published. Many are at present in draft form and therefore constant reference is given to reports in manuscript (MS). Papers referred to as manuscripts in this final country report will be released over the duration of the Tuna Programme.

Even though the Programme investigated the yellowfin tuna resources of the region, detailed discussion on this species is not included. It will be presented later in the results of the Tuna and Billfish Assessment Programme which succeeded the Skipjack Programme as of October 1, 1981.

The staff of the Skipjack and Tuna Programmes 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.D. Gillett, J.-P. Hallier, P. Kleiber, T.A. Lawson, W.A. Smith and M.J. Williams; Research Assistants, Susan Van Lopik and Veronica van Kouwen; and Programme Secretary, Carol Moulin. Most staff were involved to some extent in the fieldwork from which this report resulted and/or in the analysis of the data and preparation of the manuscript.

The Skipjack Survey and Assessment Programme is grateful for the co-operation of the Inter-American Tropical Tuna Commission (IATTC) which jointly sponsored the second visit to French Polynesia. The Director of Investigations, Dr J. Joseph, is to be thanked for his long-standing support of the Skipjack Programme. The diligent fieldwork of IATTC research scientists, Dr W.H. Bayliff and Mr T. Foreman was important to the success of the survey. Service de la pêche de Polynesie francaise (SPPF), Office de la recherche scientifique et technique outre-mer (ORSTOM), and Centre national pour l'exploitation des oceans (CNEXO) provided valuable assistance while the research vessel operated in French Polynesia and during the subsequent period of tag recoveries and data analysis.

Tuna Programme
South Pacific Commission

CONTENTS

LIST OF TABLES

LIST OF FIGURES

AN ASSESSMENT OF THE SKIPJACK AND BAITFISH RESOURCES OF FRENCH POLYNESIA

1.0 INTRODUCTION

This report presents the results of the Skipjack Survey and Assessment Programme in the waters of French Polynesia and considers the implications of these findings to skipjack and baitfish development and management. It covers two visits of the Programme to the area, from 6 December 1978 to 3 February 1979 and from 13 December 1979 to 17 February 1980, and reviews results from these visits in the light of available catch and biological data from other sources. The second of the two cruises was funded jointly with the Inter-American Tropical Tuna Commission (IATTC).

2.0 BACKGROUND

French Polynesia encompasses an extended fisheries zone of over five million square kilometres. In this vast area skipjack fishing is carried out almost exclusively for domestic consumption. Although the territory presently ranks fourth in the total domestic skipjack catch for countries in the South Pacific Commission region, the catch is less than one skipjack per 10 square kilometres of ocean surface per year. In 1978 French Polynesia's fish exports represented less than 0.03 per cent of total exports (Anon 1980e) while in 1979 and 1980, no fish were exported (Anon 1981b; Anon 1982c). French Polynesia has an annual negative balance of trade of approximately 39,690,464,000 CFP[1] (Anon 1982a). Understandably, there is considerable interest in French Polynesia in expanding the skipjack fishery.

2.1 History of the Fishery

Fishing for skipjack has always been an important facet of life in French Polynesia. In ancient times a prominent feature of the calendar year was the "Tetai" or months of November and December when the skipjack fishing season commenced (Handy 1932). At present, and in former years, skipjack has been the largest component of the fish catch, a subject of everyday conversation, and an important part of the diet of the residents of French Polynesia.

Traditionally, fishing for skipjack and other surface tunas was often done from large double canoes equipped with floating baskets from which live bait was thrown to attract fish (Nordhoff 1930). This was a much-cherished communal activity as well as the most enjoyed pastime of chiefs (Handy 1932). About 1920, changes in the local economic system in Tahiti encouraged individual efforts, and the subsequently reduced capacity for group co-operation eventually led to the termination of live-bait

---

1. Under the average exchange rate for 1980, 77.19 CFP=US$1.00, this was equal to US$444,877,363.

fishing. At this time there was an expansion of the fishery which made use of relatively small canoes and pearl-shell lures.

In the early 1950s skipjack fishermen began to use small motorised launches, called "bonitiers", from which pearl-shell lures were trolled. Through the years, competition among these boats has encouraged an increase in propulsion power from the original 9-to-18 hp to the present average of over 200 hp. The typical "bonitier" of today is 10 metres long, 9 tonnes in weight, and is capable of speeds up to 20 knots. Tables 1 and 2 show, respectively, catches by these vessels in recent years and the deployment of the bonitier fleet. The vast majority of the catch is for local consumption; however, on rare occasions production in excess of local demand is frozen and shipped overseas. This is done by Tahiti Tuna Ventures which is jointly operated by the American companies Starkist and Bumble Bee (Kent 1980). Although there is no tuna canning now in French Polynesia a small cannery did operate in Papeete from 1939 to 1947. It was initiated largely due to food shortages in Europe. The cannery had a throughput capacity of about two tonnes of tuna per day and produced about two to three thousand cases per year (Van Pel and Devambez 1957; Van Campen 1953).

TABLE 1. TUNA CATCHES BY BONITIER VESSELS BASED IN FRENCH POLYNESIA

Year	Skipjack (tonnes)	Yellowfin (tonnes)
1976	1400-1700	100-300
1977	1400-1700	100-300
1978	2700	100-300
1979	900-1000	100-300
1980	950	300
1981	839	573

Estimated from: Marcille *et al.* (1979)
Chabanne (1980)
Chabanne and Marcille (1980)
Chabanne, Marec and Asine (1982)
Chabanne and Gallet (1982).

TABLE 2. LOCATION OF FRENCH POLYNESIA SKIPJACK BONITIER VESSELS IN 1981

Fishing Localities	Number of Bonitier Fishing Vessels
Papeete	51
Other areas of Tahiti	15
Leeward Islands	23
Moorea	3
Tuamotu	3
Marquesas	3

Source: Chabanne and Gallet (1982).

Within the 200-mile economic zone of French Polynesia, longline vessels from Asian countries have made incidental catches of skipjack while concentrating on albacore, bigeye and yellowfin. Japanese, Taiwanese and Korean longliners in 1975 and 1976 (latest date for which complete catch data are available) captured 14.0 and 22.3 tonnes of skipjack respectively, in a total tuna and billfish catch of 7,044 and 7,264 tonnes (Klawe 1978). This longline catch was less than two per cent of all skipjack caught in French Polynesia for these two years.

In 1979 the exploitation of deep-water tuna in French Polynesia was limited by the introduction of fishing licences. Only Japanese longliners were licensed from October 1979 to April 1980 during which time they made a total tuna catch of 3,305 tonnes, almost all from the Marquesas area (Chabanne 1980). Two hundred and ninety Japanese vessels were permitted to catch 5,600 tonnes of tuna between July 1981 and August 1982 for a fee of 32,578,560 CFP (Chabanne and James 1980; Anon 1981d). The most recent agreement with the Japanese allows the capture of 3,600 tonnes between August 1982 and April 1983 for a fee of 21,000,000 CFP (Anon 1982b). Additionally, 280 Korean vessels are licensed to catch 5,200 tonnes between December 1981 and January 1983 for 28,363,630 CFP (Ugolini 1982).

French Polynesia is outside the usual range of present distant-water surface tuna fleets. Only twice since 1972 has fishing by a commercial Japanese pole-and-line vessel been reported in these waters (Skipjack Programme 1980a; R. Robert, personal communication) and American purse-seining has been confined to exploratory fishing, usually while vessels were en route to New Zealand.

A few attempts have been made to use anchored fish aggregation devices (FAD) for tuna fishing. IATTC deployed three rafts in 1978 and 1979 in the Marquesas and SPPF[2] installed six FADs in 1981 and 1982 in the Society Islands.

2.2 History of Skipjack Research in French Polynesia

Studies on the commercial tunas of French Polynesia had their beginning in 1954 when sales of these fish were first recorded at the municipal market in Papeete (Bard 1974). Bessineton (1976) and Anon (1974) report that in July 1973 the Centre National pour l'Exploitation des Océans (CNEXO), in collaboration with SPPF, began a systematic tuna sampling programme. Since that date about 1,000 fish per month have been measured to the nearest centimetre (rounded body length) at Papeete with complementary sampling of 300 additional fish at other locations in Tahiti. Also begun in 1973 was a biological sampling programme in which stomachs and gonads were examined.

SPPF and CNEXO initiated the collection of catch statistics in 1974. Since September 1978 ORSTOM has also been involved in this work.

---

2. Service de la pêche has recently been administratively reorganised to form the Office de recherche et d'exploitation des ressources océaniques (ORERO).

A programme to study live-bait fishing potential was begun by SPPF and CNEXO in 1974 and was completed five years later (Anon 1980b). After 1976 this project used the 21-metre research vessel Tainui for the fishing trials.

Numerous research and exploratory fishing expeditions for surface tunas have been carried out in French Polynesia (Appendix A). In addition to assessing local fishery potential, the goal of many of the fishing/research endeavours was to ascertain if there was any relation between tuna stocks of French Polynesia, especially the Marquesas Islands, and those of the eastern Pacific fishery.

3.0 THE SKIPJACK PROGRAMME SURVEY

The objectives of the Skipjack Survey and Assessment Programme were to survey the skipjack and baitfish resources within the area of the South Pacific Commission and to assist with the assessment of the status of the stocks and the degree of interaction between individual fisheries within the region and beyond. These assessments were planned to provide a basis for rational development of skipjack fisheries and sound management of the resources throughout the region.

The Programme's research schedule spanned almost three years, from October 1977 to August 1980 inclusive, and incorporated visits to all of the countries in the area of the South Pacific Commission and also New Zealand and Australia (Figure A, inside front cover). During this period, over 150,000 tuna, including 140,443 skipjack, were tagged and released. Programme research vessels spent 127 days in French Polynesia divided into the two periods described in Section 1.0. During these two periods the vessels travelled approximately 14,700 nautical miles and visited the Marquesas, Tuamotu, Society and Gambier Islands. Fishing activities for skipjack and bait are summarised in Tables 3 and 4 respectively. The areas surveyed and the baitfishing locations are shown in Figure 1.

Visual scanning and exploratory fishing for tunas and baitfish were the primary survey techniques. Tagging and biological sampling, including blood and parasite studies, were the basic tools used to study the skipjack and yellowfin tuna resources. Comparison of results from other areas in the central and western Pacific visited by the Skipjack Programme to those obtained in French Polynesia, analysis of previous work, and trends in the local fishery, form the basis for resource assessment.

4.0 MATERIALS AND METHODS

4.1 Vessels and Crew

Two modified Japanese commercial live-bait pole-and-line vessels were used for the skipjack and baitfish survey of French Polynesia. The Hatsutori Maru No.1 of 192 gross tonnes was used for the first visit and the Hatsutori Maru No.5 of 254 gross tonnes was used for the second. Both vessels were chartered from Hokoku Marine Products Limited of Tokyo, Japan. Details of each are given by Kearney and Hallier (1980). The Hatsutori Maru No.1 was operated with three Skipjack Programme scientists, nine

TABLE 3. SUMMARY OF DAILY FIELD ACTIVITIES IN THE WATERS OF FRENCH POLYNESIA. Date, area, main activity, bait carried (kg), hours fishing, schools sighted, numbers of skipjack, yellowfin, and other species tagged, catch (kg) of skipjack and yellowfin, and catch (kg) of all species combined are shown. 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).

Date	General Area	Principal Activity	Bait Carried (kg)	Hours Fishing	Schools Sighted (numbers) SJ	YF	S+Y	OT	UN	Fish Tagged (numbers) SJ	YF	OT	Fish Caught (kg) SJ	YF	Total Catch (kg)
06/12/78	NW Society Is	Fishing	18	12	0	0	0	0	11	0	0	0	0	0	0
07/12/78	NW of Tahiti	Steaming	3	6	0	0	0	0	6	0	0	0	0	0	0
08/12/78	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
09/12/78	Vairao	Baiting	0	5	0	0	0	0	4	-	-	-	-	-	-
10/12/78	Tahiti - Moorea	Fishing	314	8	3	0	0	0	6	76	0	0	278	0	278
11/12/78	Tahiti - Moorea	Fishing	401	11	4	0	0	0	5	0	0	0	7	0	7
12/12/78	Moorea - Tahaa	Fishing	348	12	1	0	0	0	4	11	0	0	43	0	43
13/12/78	Tahaa - BoraBora	Fishing	377	4	2	0	0	0	1	45	0	0	171	0	171
14/12/78	Raiatea	Fishing	350	12	2	0	0	0	0	187	0	0	684	0	684
15/12/78	Rangiroa	Fishing	303	13	4	0	1	0	3	255	4	0	856	10	866
16/12/78	Tikehau	Fishing	204	8	4	0	1	0	2	55	0	0	206	0	206
17/12/78	Apataki	Fishing	212	11	5	0	2	0	1	399	0	0	1405	12	1419
18/12/78	Fakarava	Fishing	95	10	2	0	0	0	1	54	0	0	189	0	189
19/12/78	Fakarava	Fishing	221	10	3	1	0	0	1	976	0	0	4140	0	4140
20/12/78	Fakarava	Fishing	41	11	4	0	0	0	7	254	0	0	964	0	964
21/12/78	Fakarava	Fishing	68	10	1	0	0	0	5	85	0	0	277	0	277
22/12/78	Fakarava	Fishing	62	11	2	0	1	0	15	226	58	0	753	176	938
23/12/78	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
24/12/78	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
25/12/78	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
26/12/78	Vairao	Steaming	0	3	0	0	0	0	8	-	-	-	-	-	-
27/12/78	Tahiti - Moorea	Fishing	74	12	2	0	1	0	5	34	0	0	121	0	121
28/12/78	Huahine	Fishing	62	12	1	1	0	0	3	325	0	0	1141	6	1147
29/12/78	Huahine	Fishing	27	6	1	0	0	0	1	0	0	0	9	0	9
30/12/78	Tahaa	Fishing	26	11	1	0	0	0	9	61	0	0	197	0	197
31/12/78	Moorea	Fishing	48	6	2	2	0	0	1	89	0	0	256	3	259
01/01/79	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
02/01/79	NE of Tahiti	Steaming	38	5	0	0	0	0	2	0	0	0	0	0	0
03/01/79	Rangiroa	Baiting	311	3	0	0	0	0	3	0	0	0	0	0	0
04/01/79	Ahe	Fishing	347	12	1	0	1	0	6	132	12	0	547	35	582
05/01/79	NE of Tuamotu	Steaming	300	12	0	0	0	0	12	0	0	0	0	0	0
06/01/79	Nuku Hiva	Fishing	275	12	3	0	2	0	9	400	0	0	1271	0	1271
07/01/79	Nuku Hiva	Fishing	113	11	3	1	0	0	1	117	0	0	478	11	488
08/01/79	Nuku Hiva	Fishing	11	5	0	0	0	0	7	0	0	0	0	0	0
09/01/79	Nuku Hiva	Fishing	113	12	6	1	0	0	2	478	0	0	1449	0	1449
10/01/79	Nuku Hiva	Fishing	84	8	6	0	1	0	0	106	0	0	329	10	339
11/01/79	Nuku Hiva	Fishing	84	8	8	0	0	0	0	322	0	0	1156	0	1156
12/01/79	Nuku Hiva	Fishing	146	9	1	0	1	0	8	266	0	0	878	0	878
13/01/79	SW Marquesas Is	Fishing	66	10	2	0	0	0	5	256	0	0	762	0	762
14/01/79	NE of Tuamotu	Fishing	12	11	1	0	0	0	9	16	0	0	89	0	89
15/01/79	NE of Tahiti	Steaming	0	6	0	0	0	0	4	-	-	-	-	-	-
16/01/79	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
17/01/79	Tahiti	Steaming	0	0	-	-	-	-	-	-	-	-	-	-	-
18/01/79	Tahiti	Baiting	168	4	1	0	0	0	1	0	0	0	4	0	4
19/01/79	Rangiroa	Fishing	153	10	1	1	0	0	2	31	0	0	282	2	284
20/01/79	Fakarava	Fishing	192	11	2	0	1	0	2	446	2	0	1664	17	1681
21/01/79	Fakarava	Fishing	125	10	3	1	0	0	1	317	0	0	1283	3	1287
22/01/79	Fakarava	Fishing	233	10	4	0	0	0	1	499	0	0	2131	0	2131
23/01/79	Fakarava	Fishing	69	7	2	0	1	0	2	244	0	0	1001	4	1006
24/01/79	Fakarava	Fishing	63	3	0	0	1	0	0	299	18	0	1400	95	1496
25/01/79	Fakarava	Fishing	80	11	1	0	0	0	13	39	0	0	156	0	156
26/01/79	Rangiroa	Baiting	38	2	0	0	0	0	0	0	0	0	0	0	0
27/01/79	Rangiroa	Fishing	222	11	4	0	0	0	1	130	0	0	689	0	689
28/01/79	Huahine	Fishing	168	11	3	0	1	0	3	586	4	0	2220	51	2271
29/01/79	Huahine	Fishing	135	5	3	0	0	0	0	219	0	0	830	0	830
30/01/79	Huahine	Fishing	44	5	1	0	0	0	0	91	0	0	176	0	182
31/01/79	Tahaa	Fishing	38	3	0	0	0	0	3	0	0	0	0	0	0
01/02/79	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
02/02/79	Tahiti	Steaming	0	0	-	-	-	-	-	-	-	-	-	-	-
03/02/79	SW of Tahiti	Baiting	90	12	0	0	0	0	10	0	0	0	0	0	0
04/02/79	SW of Tahiti	Fishing	75	7	0	0	0	0	1	0	0	0	0	0	0
12/12/79	NW Society Is	Steaming	0	10	0	0	0	0	0	-	-	-	-	-	-
13/12/79	NW of Tahiti	Steaming	0	9	1	0	0	0	11	-	-	-	-	-	-

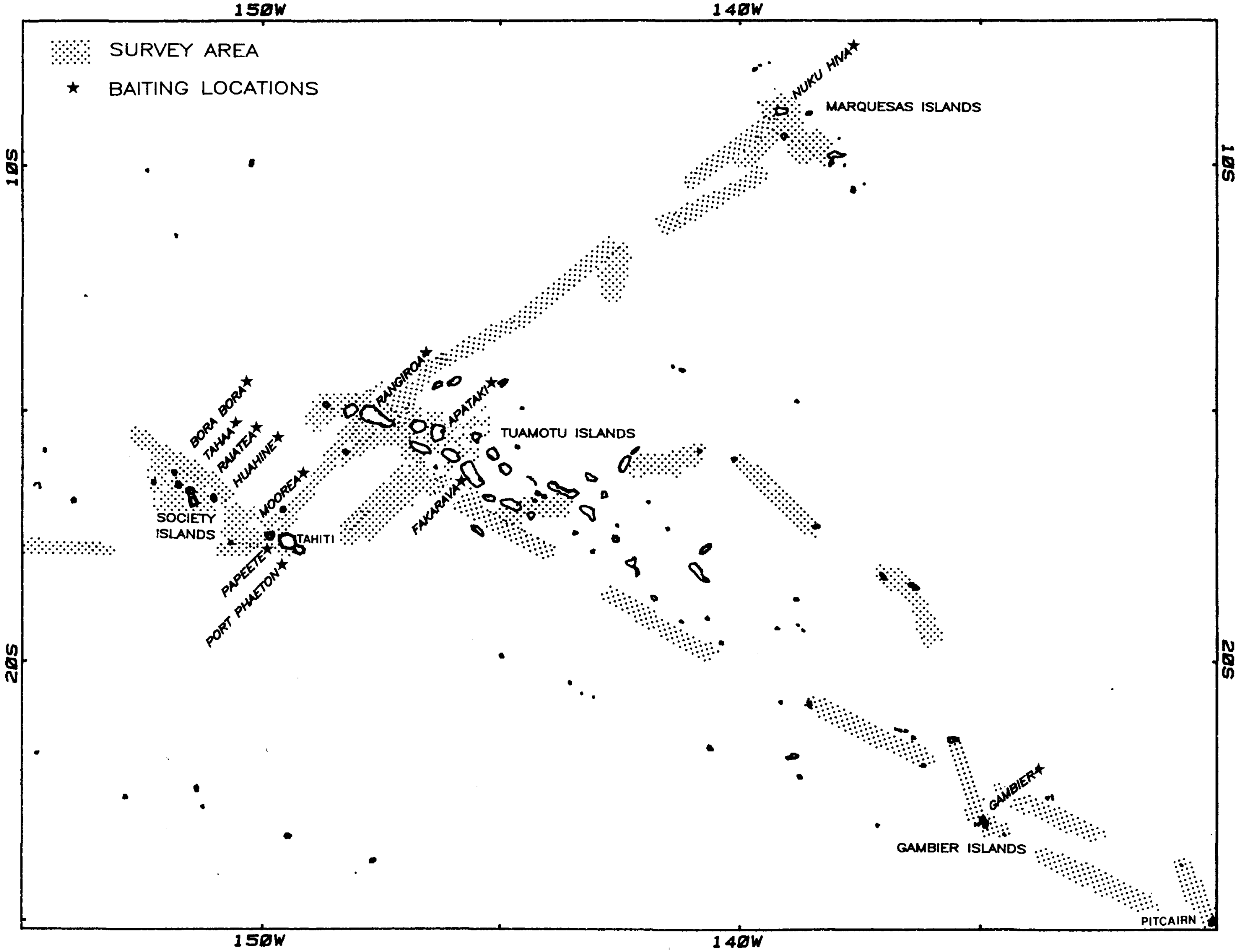
Date	General Area	Principal Activity	Bait Carried (kg)	Hours Fishing	Schools Sighted (numbers) SJ	YF	S+Y	OT	UN	Fish Tagged (numbers) SJ	YF	OT	Fish Caught (kg) SJ	YF	Total Catch (kg)
14/12/79	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
15/12/79	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
16/12/79	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
17/12/79	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
18/12/79	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
19/12/79	NE of Tahiti	Steaming	0	0	-	-	-	-	-	-	-	-	-	-	-
20/12/79	Rangiroa	Baiting	0	0	-	-	-	-	-	-	-	-	-	-	-
21/12/79	NE of Tuamotu	Steaming	678	11	0	0	0	0	7	0	0	0	0	0	0
22/12/79	SW Marquesas Is	Fishing	674	12	3	0	7	0	4	203	110	1	601	411	1014
23/12/79	Marquesas Is	Fishing	545	6	7	0	2	0	0	1032	47	0	3105	319	3424
24/12/79	Nuku Hiva	Fishing	365	9	7	0	0	0	0	1443	0	0	3525	0	3525
25/12/79	Nuku Hiva	Fishing	848	10	11	0	1	0	0	1826	1	0	4755	5	4760
26/12/79	Nuku Hiva	Fishing	801	9	10	0	0	0	0	699	0	0	1908	0	1908
27/12/79	Nuku Hiva	Fishing	423	8	7	1	1	0	1	1752	1	0	4578	9	4587
28/12/79	Nuku Hiva	Fishing	146	7	5	0	0	0	0	1040	0	0	2659	0	2659
29/12/79	Tai-O-Hae	Baiting	87	0	-	-	-	-	-	-	-	-	-	-	-
30/12/79	Nuku Hiva	Fishing	114	6	3	0	1	0	0	33	4	0	81	7	89
31/12/79	Nuku Hiva	Fishing	120	5	4	0	0	0	0	109	0	0	286	0	286
01/01/80	Tai-O-Hae	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
02/01/80	Tahuata	Baiting	0	0	-	-	-	-	-	-	-	-	-	-	-
03/01/80	Ua Pou	Baiting	0	0	-	-	-	-	-	-	-	-	-	-	-
04/01/80	Nuku Hiva	Fishing	90	3	3	0	0	0	0	468	0	0	1131	0	1131
05/01/80	Nuku Hiva	Fishing	416	6	8	0	0	0	0	1553	0	0	4008	0	4008
06/01/80	Nuku Hiva	Fishing	246	6	3	1	0	0	0	705	0	0	1873	0	1873
07/01/80	Nuku Hiva	Fishing	519	7	8	0	1	0	0	643	0	0	1664	0	1664
08/01/80	Nuku Hiva	Fishing	453	10	8	0	0	0	0	857	0	0	2066	0	2066
09/01/80	Nuku Hiva	Fishing	114	4	0	0	1	0	0	449	3	1	1188	16	1206
10/01/80	Nuku Hiva	Fishing	368	3	1	0	0	0	0	70	0	0	163	0	163
11/01/80	Nuku Hiva	Fishing	350	6	5	0	0	0	0	765	0	0	1975	0	1975
12/01/80	Nuku Hiva	Fishing	303	4	4	0	0	0	0	745	0	0	2031	0	2031
13/01/80	Nuku Hiva	Fishing	272	4	4	0	0	0	0	287	0	0	683	0	683
14/01/80	Nuku Hiva	Fishing	225	4	3	0	0	0	0	769	0	0	1796	0	1796
15/01/80	Nuku Hiva	Fishing	261	9	10	0	0	0	0	500	0	0	1106	0	1106
16/01/80	Nuku Hiva	Fishing	338	7	7	0	1	0	0	1018	0	0	2803	0	2805
17/01/80	Nuku Hiva	Fishing	117	4	1	0	1	0	0	789	22	0	1442	61	1504
18/01/80	Nuku Hiva	Fishing	203	3	5	0	0	0	1	146	0	0	360	0	360
19/01/80	Nuku Hiva	Fishing	72	2	3	0	0	0	1	237	0	0	558	0	558
20/01/80	Nuku Hiva	Fishing	162	7	7	1	0	0	0	223	0	0	562	0	562
21/01/80	SW Marquesas Is	Fishing	41	12	3	1	0	0	4	232	0	0	562	0	562
22/01/80	NE of Tuamotu	Steaming	0	11	8	0	0	0	6	-	-	-	-	-	-
23/01/80	Tuamotu	Steaming	0	7	0	0	0	0	16	-	-	-	-	-	-
24/01/80	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
25/01/80	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
26/01/80	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
27/01/80	Papeete	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
28/01/80	Tahiti	Steaming	0	6	1	0	0	0	3	-	-	-	-	-	-
29/01/80	Rangiroa	Baiting	756	1	0	0	0	0	5	0	0	0	0	0	0
30/01/80	Central Tuamotu	Steaming	756	12	0	0	0	0	11	0	0	0	0	0	0
31/01/80	SE Tuamotu	Steaming	755	12	0	0	0	0	10	0	0	0	0	0	0
01/02/80	SE Tuamotu	Fishing	752	11	0	0	0	0	1	0	0	0	0	0	0
02/02/80	NE of Gambier Is	Fishing	749	12	0	0	0	0	0	0	0	0	0	0	0
05/02/80	Gambier Is	Fishing	633	12	0	0	1	0	0	174	302	34	476	1230	1794
06/02/80	Gambier Is	Fishing	597	7	0	0	0	0	5	0	0	0	0	0	0
07/02/80	Marutea Sud	Fishing	570	12	0	0	0	0	2	0	0	0	0	0	0
08/02/80	Puka Puka	Fishing	552	10	0	2	0	0	0	0	0	0	0	0	0
09/02/80	Central Tuamotu	Steaming	543	0	-	-	-	-	-	-	-	-	-	-	-
10/02/80	Raroia	Fishing	536	8	2	0	0	0	0	191	0	0	695	0	695
11/02/80	Tahanea	Fishing	441	11	2	1	0	0	6	157	31	0	661	296	956
12/02/80	Kaukura	Fishing	351	9	3	0	2	0	5	402	255	0	1247	1741	2988
13/02/80	Rangiroa	Fishing	174	3	0	2	4	0	2	65	362	0	250	1199	1449
14/02/80	Rangiroa	Fishing	153	12	0	0	0	0	10	0	0	0	0	0	0
15/02/80	Tahiti	Baiting	81	0	-	-	-	-	-	-	-	-	-	-	-
16/02/80	W of Tahiti	Fishing	278	12	0	1	1	0	2	1	33	0	8	458	466
17/02/80	W of Society Is	Fishing	224	13	0	0	0	0	1	0	0	0	0	0	0
TOTALS				834	257	18	39	0	321	27709	1269	36	81298	6187	87597

TABLE 4. SUMMARY OF BAITFISHING ACTIVITIES IN THE WATERS OF FRENCH POLYNESIA

Anchorage	Time of Hauls	Number of Hauls	Dominant Species	Est. Av. Catch per Haul (kg)	Mean Length (mm)	Other Common Species
			Marquesas Islands Jan. 1979			
Tai-o-hae Bay			*Sardinella marquesensis*	7	71	*Gymnocaesio* sp.
08°55'S	Night	4	Sp. of Myctophidae	1	60	Sp. of Fistulariidae
140°05'W			*Decapterus maruadsi*			*Apogon(Rhabdamia) cypselurus*
Tai-o-hae Bay			*Sardinella marquesensis*	101	91	Sp. of Carangidae
08°54'S	Day	1	*Albula vulpes*			*Gnathodon speciosus*
140°05'W			*Trachinotus bailloni*			*Polynemis sexfilis*
Tai-o-hae Bay			*Sardinella marquesensis*	66	98	*Trachinotus bailloni*
08°54'S	Day	6	*Upeneus vittatus*	2		*Alectis ciliaris*
140°06'W			*Albula vulpes*			*Scomberoides tol*
			Marquesas Islands Dec. 1979 - Jan. 1980			
Tai-o-hae Bay			*Sardinella marquesensis*	152	70	*Caranx sexfasciatus*
08°55'S	Night	8	*Kuhlia marginata*	24	138	*Mullodichthys* sp.
140°06'W			*Selar crumenophthalmus*	17	120	*Upeneus vittatus*
Tai-o-hae Bay			*Sardinella marquesensis*	16		*Upeneus vittatus*
08°54'S	Day	6	*Polynemis* sp.			Sp. of Carangidae
140°06'W			*Zanclus canescens*			*Chanos chanos*
Tai-o-hae Bay			*Sardinella marquesensis*	15		Sp. of Pempheridae
08°55'S	Day	17	Sp. of Carangidae	2		Sp. of Apogonidae
140°06'W			Sp. of Mugilidae			*Trachinotus bailloni*
Tai-pi-vai/Haka Paa			*Sardinella marquesensis*	135	71	Sp. of Kuhliidae
08°53'S	Night	21	Sp. of Myctophidae	7		Sp. of Sphyraenidae
140°02'W			*Selar crumenophthalmus*	6	120	Sp. of Squid
Houmi			*Sardinella marquesensis*	108	74	Sp. of Belonidae
08°54'S	Night	4	Sp. of Polynemidae			Sp. of Chaetodontidae
140°01'W			Sp. of Mullidae			*Caranx* sp.
Tai-o-hae Bay			*Sardinella marquesensis*	33	70	*Upeneus vittatus*
08°54'S	Day	4	Sp. of Bothidae			Sp. of Carcharhinidae
140°05'W			Sp. of Carangidae			*Chanos chanos*
Tai-pi-vai			*Sardinella marquesensis*	5		
08°53'S	Day	1	*Upeneus vittatus*			
140°02'W			Sp. of Carangidae			
Anaho Bay			*Sardinella marquesensis*	21	64	Sp. of Myctophidae
08°53'S	Night	4	Sp. of Lutjanidae			*Selar crumenophthalmus*
140°03'W			Sp. of Fistulariidae			*Scomberoides* sp.
Anaho Bay			*Sardinella marquesensis*	82	72	*Selar crumenophthalmus*
08°49'S	Night	2	Sp. of Balistidae			Sp. of Apogonidae
140°03'W			*Scomberoides* sp.			Sp. of Fistulariidae
			Tuamotu Islands Dec. 1979 - Jan. 1980			
Rangiroa Atoll			*Spratelloides gracilis*	27	35	Sp. of Squid
14°58'S	Night	8	Sp. of Anguillidae (j)			Sp. of Sphyraenidae
147°38'W			Sp. of Hemirhamphidae			Sp. of Lutjanidae

Anchorage	Time of Hauls	Number of Hauls	Dominant Species	Est. Av. Catch per Haul (kg)	Mean Length (mm)	Other Common Species
Apataki Atoll			*Spratelloides gracilis*	2	34	Sp. of Mullidae
15°18'S	Night	1	Sp. of Pomacentridae			Sp. of Lutjanidae
146°22'W			*Bregmaceros* sp.			Sp. of Apogonidae
Fakarava Atoll			*Spratelloides gracilis*	56	38	Sp. of Squid
16°03'S	Night	16	Sp. of Belonidae			*Cheilodipterus macrodon*
145°37'W			Sp. of Mullidae			Sp. of Pomacentridae
			Tuamotu Islands Feb. 1980			
Rangiroa Atoll			*Spratelloides gracilis*	38	36	Sp. of Belonidae
14°58'S	Night	2	Sp. of Pomacentridae			Sp. of Crustacea
147°38'W			Sp. of Chaetodontidae			*Pseudamia polystigma*
			Society Islands Dec. 1978, Jan. - Feb. 1979			
Port Phaeton			*Selar crumenophthalmus*	33	143	*Spratelloides gracilis*
17°45'S	Night	5	Sp. of Myctophidae	2	44	Sp. of Chaetodontidae
149°19'W			*Stolephorus indicus*	1	92	Sp. of Apogonidae
Vairao			*Spratelloides gracilis*	6	47	Sp. of Chaetodontidae
17°48'S	Night	1	Sp. of Acanthuridae			*Siphamia* sp.
149°17'W			Sp. of Apogonidae			
Opunohu Bay			*Spratelloides gracilis*	12	40	*Stolephorus indicus*
17°30'S	Night	7	*Sardinella melanura*	6	91	*Selar crumenophthalmus*
149°51'W			Sp. of Siganidae	3	54	Sp. of Holocentridae
Haamene Bay			*Selar crumenophthalmus*	11	124	*Stolephorus buccaneeri* (juvenile)
16°38'S	Night	5	*Stolephorus indicus*	3	64	*Sardinella melanura*
151°27'W			*Stolephorus buccaneeri*	2	55	Sp. of Holocentridae
Bora Bora			*Albula vulpes*	6		*Chanos chanos*
16°28'S	Day	4	*Mullodichthys samoensis*	1		*Mugil vaigiensis*
151°43'W			Sp. of Carangidae			*Crenimugil crenilabrus*
Bora Bora			*Stolephorus buccaneeri*	2	40	
16°28'S	Night	1	Sp. of Holocentridae			
151°44'W						
Maroe Bay			Sp. of Holocentridae	3	34	Sp. of Chaetodontidae
16°45'S	Night	2	*Stolephorus indicus*	2		Sp. of Fistulariidae
150°59'W			Sp. of Apogonidae			*Mullodichthys* sp.
Faie Bay			*Spratelloides gracilis*	5		
16°43'S	Day	2				
150°59'W						
Fare Bay			*Spratelloides gracilis*	14	40	Sp. of Acanthuridae
16°43'S	Night	4	Sp. of Holocentridae	3		Sp. of Aluteridae
151°02'W			Sp. of Myctophidae	3		Sp. of Chaetodontidae
Fare Bay			*Spratelloides gracilis*	3	32	Sp. of Chaetodontidae
16°42'S	Day	2	Sp. of Scorpaenidae			*Bregmaceros* sp.
151°01'W			Sp. of Syngnathidae			Sp. of Balistidae
			Society Islands Feb. 1980			
Port Phaeton			*Mullodichthys samoensis*	73	90	*Sardinella melanura*
17°45'S	Night	2	Sp. of Myctophidae	46	41	Sp. of Chromidae
149°19'W			Sp. of Acanthuridae	28	40	*Caranx* sp.

FIGURE 1. SURVEY AREA AND BAITFISHING LOCALITIES FOR THE SKIPJACK PROGRAMME SURVEYS IN THE WATERS OF FRENCH POLYNESIA



Japanese officers, and twelve Fijian crew. In addition to the above staff, the larger *Hatsutori Maru No.5* carried three extra Fijian crew members, and while in French Polynesia, two IATTC scientists. Numerous observers from various organisations were accommodated aboard the vessels and local residents were encouraged to participate in the fishing activities. Details concerning staff, crew, and observers are listed Appendix B.

4.2 Skipjack Fishing and Tagging

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

The number of crew on the *Hatsutori Maru No.1* and *Hatsutori Maru No.5* was less than either of these vessels would carry under commercial fishing conditions. As at least one crew member was required to assist each scientist in the tagging procedures, the effective number of fishermen was further reduced. Additionally, the need to pole skipjack accurately into the tagging cradles reduced the speed of the individual fishermen. In 1978, during the Skipjack Programme's survey of the waters of Fiji, it was possible to calibrate the relative fishing power of the *Hatsutori Maru No.1* while engaged in tagging. This was done by comparing the vessel's catches while tagging to those of the commercial fleet operating in the same area, and further comparing them to the vessel's own performance in the one-month period during which it fished under commercial conditions with the same captain and enlarged crew. It was determined that the survey catch to commercial catch conversion factor was 3.47 for the *Hatsutori Maru No.1* (Kearney 1978). A conversion factor of the same order is thought applicable for the *Hatsutori Maru No.5*.

As tagging was a primary tuna research tool, attempts to tag large numbers of fish most often dominated the fishing strategy. At other times purely exploratory fishing (e.g. in the southeastern Tuamotu Islands, Gambier Islands) was the primary concern. The tagging techniques and alterations to normal fishing procedures are described in detail in Kearney and Gillett (1982). Evidence is presented in Skipjack Programme (1981b) which supports the contention that tagging skipjack by these techniques does not greatly alter their behaviour.

4.3 Biological Sampling

Specimens of tuna and other pelagic species which were poled or trolled, but not tagged and released, were routinely analysed. Data collected included length frequency distributions, length/weight relationships, sex ratios, gonad weights and stages of maturity and stomach contents (Table 5). In addition, a record of all fish schools sighted throughout the survey was maintained. Where possible, the species composition of each school was determined and records were kept of schools chummed and the subsequent biting response. Argue (1982) describes the methods used for collection of this information.

TABLE 5. SUMMARY OF NUMBERS OF FISH SAMPLED FOR BIOLOGICAL DATA FROM THE WATERS OF FRENCH POLYNESIA

Species	Total No. Measured	Total No. Weighted	Total No. Examined for Sex	Total No. Examined for Stomach Content	Total No. Examined for Tuna Juveniles
Skipjack <u>Katsuwonus pelamis</u>	4354	2342	2389	944	2359
Yellowfin <u>Thunnus albacares</u>	334	234	211	105	220
Frigate Tuna <u>Auxis thazard</u>	5	2	2	2	2
Bigeye Tuna <u>Thunnus obesus</u>	9	9	9	5	9
Rainbow Runner <u>Elagatis bipinnulatus</u>	9	7	6	1	1
TOTALS	4711	2594	2617	1057	2591

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

During the second French Polynesia survey, skipjack body cavities were examined for the presence of macro-parasites which could possibly be used in evaluating stock structure. Five complete sets of gills and viscera from each school were frozen and subsequently air freighted to the University of Queensland, St Lucia, Australia, for detailed examination for the presence of parasites.

4.4 Baitfishing

Baitfishing was carried out by the Programme using bouki-ami gear set at night around a bait attraction light or by using a beach seine during the day. Night baiting procedures were similar to those used by commercial vessels operating in Papua New Guinea, Solomon Islands, and Fiji, but were modified where necessary to meet the Programme's special requirements. The beach seining method was modified from that used by commercial vessels in

Hawaii. Details of both techniques and all modifications employed are given by Hallier and Gillett (1982).

In addition to natural bait, the Programme made use of two different species of cultured bait in French Polynesia. CNEXO at Vairao and the Service de la pêche at Rangiroa provided 532.5 kg of mollies (Poecilia mexicana) and 1,951.5 kg of milkfish (Chanos chanos) respectively. Results of comparative studies on these two cultured bait species are given in Skipjack Programme (1980b, 1981a) and Kearney and Rivkin (1981).

4.5 Data Compilation and Processing

Five separate log book systems formed the basis for compiling data accumulated during the fieldwork outlined in Sections 4.1, 4.2 and 4.3. The techniques used in computerising and processing the data are discussed by Kleiber and Maynard (1982). Data processing was carried out on the Programme's Hewlett Packard 1000 computer. Electrophoretic characteristics of all blood samples collected and analysed at the Australian National University, and parasite identifications on all viscera specimens taken and analysed at Queensland University, were also coded and computerised.

4.6 Data Analysis

Assessment of the status of the stocks and possible interactions between the French Polynesian fishery and those in other countries was approached from many viewpoints. Intensive studies of the migration of tagged skipjack have formed the basis of investigations on the behaviour of skipjack and the movement of stocks. Analytical methods for investigating migratory patterns are described in Skipjack Programme (1981c) and Kleiber, Argue and Kearney (1983). Evaluations of population structuring across the whole of the western and central Pacific have centred on a comparison of the tagging data with the blood genetics results (Anon 1980f, 1981a). Occurrence and distribution of skipjack parasites have also been evaluated for their value in determining stock structuring (Lester 1981).

5.0 RESULTS AND DISCUSSION

5.1 Baitfish Assessment

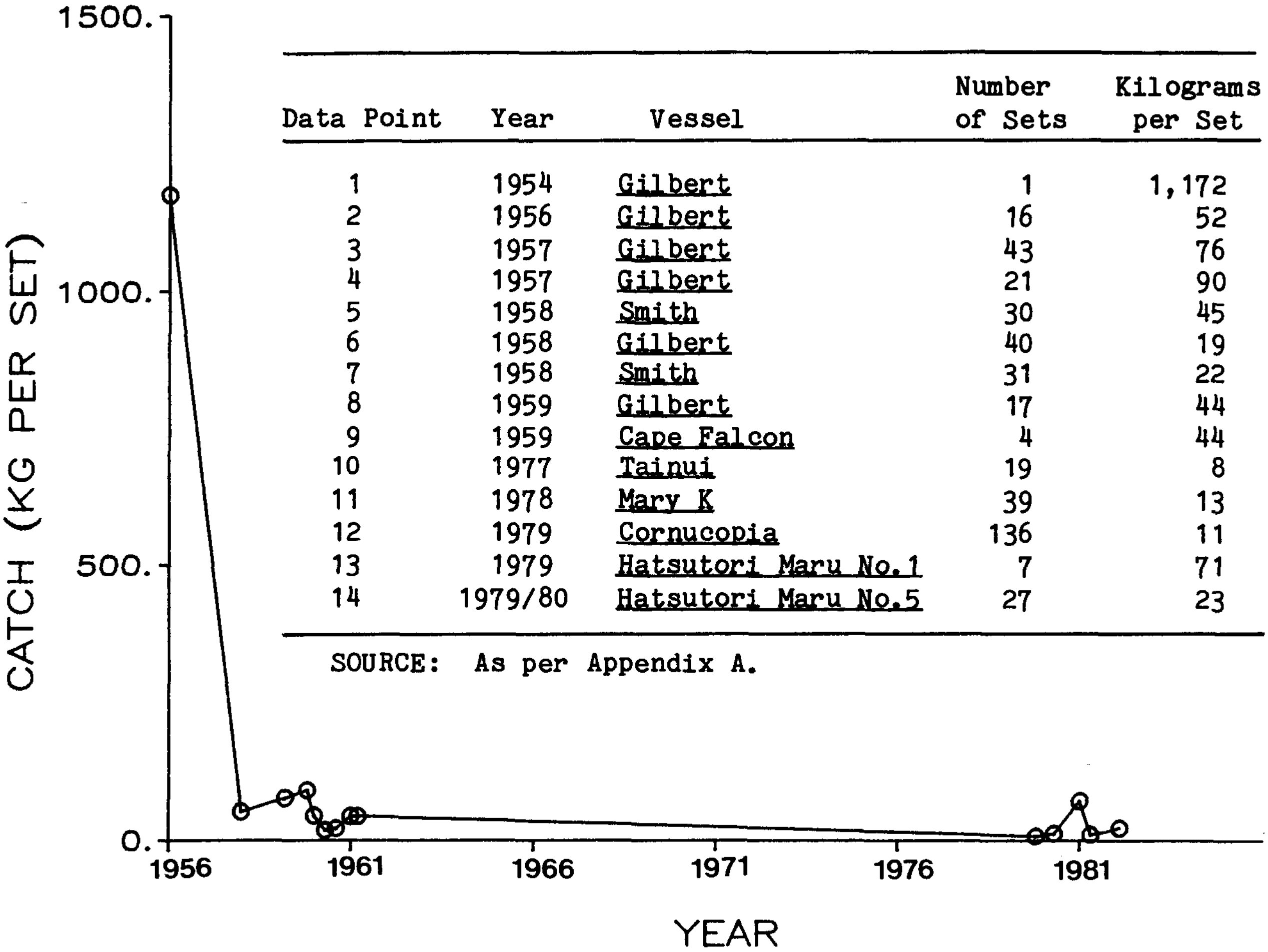
5.1.1 Marquesas Islands

The Marquesan sardine, Sardinella marquesensis, occurs naturally only in the Marquesas Islands. The overwhelming majority of bait captured in these islands has been the Marquesan sardine and any attempts to establish a live-bait fishery using wild baitfish would be based on this one species. Several authors (Royce 1954; Baldwin 1977; Kearney, Hallier and Gillett 1979; Gillett and Kearney 1980), have noted the desirable qualities of this species as a tuna baitfish.

Baitfish supplies adequate for the Programme's immediate needs were taken during both visits to the Marquesas. The crucial point for future development is the stability of the baitfish resource under constant fishing pressure. Historical trends, catch records of the two Skipjack Programme visits, characteristics of similar species, and the geography of the Marquesas, are used here to comment on the degree of stability which might be expected.

Figure 2 shows the average catch of the Marquesan sardine per beach net set in Tai-o-hae Bay for 14 expeditions covering 26 years. Although the units of effort varied between the cruises, the basic netting techniques were derived from the Hawaiian method and in many cases the same personnel were involved in the surveys. Furthermore, most of the nets were constructed by the same group of fishermen in Hawaii. It is therefore believed that the catching efficiency has not varied greatly and the results are comparable. It should be pointed out, however, that the high catch rate for the Hatsutori Maru No.1 is an expected result for a short survey of the best baiting areas.

FIGURE 2. AVERAGE CATCHES OF MARQUESAN SARDINE PER BEACH NET SET IN TAI-O-HAE BAY, NUKU HIVA



Data Point	Year	Vessel	Number of Sets	Kilograms per Set
1	1954	Gilbert	1	1,172
2	1956	Gilbert	16	52
3	1957	Gilbert	43	76
4	1957	Gilbert	21	90
5	1958	Smith	30	45
6	1958	Gilbert	40	19
7	1958	Smith	31	22
8	1959	Gilbert	17	44
9	1959	Cape Falcon	4	44
10	1977	Tainui	19	8
11	1978	Mary K	39	13
12	1979	Cornucopia	136	11
13	1979	Hatsutori Maru No.1	7	71
14	1979/80	Hatsutori Maru No.5	27	23

SOURCE: As per Appendix A.

Figure 2 shows fairly wide fluctuations in catch and even possibly a long-term decline in catch per unit effort (CPUE), especially if the Hatsutori Maru No.1 results are excluded. In addition, an area is scouted before a decision is made to set the net and, if no bait is observed, it is rarely set. Because of this, the unit of effort in Figure 2, the beach seine set, tends to overestimate stock size at low levels of abundance. Therefore, the apparent long-term population decline in Tai-o-hae Bay, whether natural or fishery induced, is probably underestimated in the figure which is based on catch per set.

On a shorter time scale, more dramatic declines in availability have been noted. Nakamura and Wilson (1970) estimated the population of sardines in Tai-o-hae Bay to be approximately 4,200 kg in January 1957. After 17 months and 164 sets of the beach seine, this quantity was reduced to an estimated 32 kg. They felt that the apparent reduction in the population resulted from their baitfish catches in the bay. These estimates, however, were based on visual inspection of the beaches and did not consider any portion of the population which may have been in deep water.

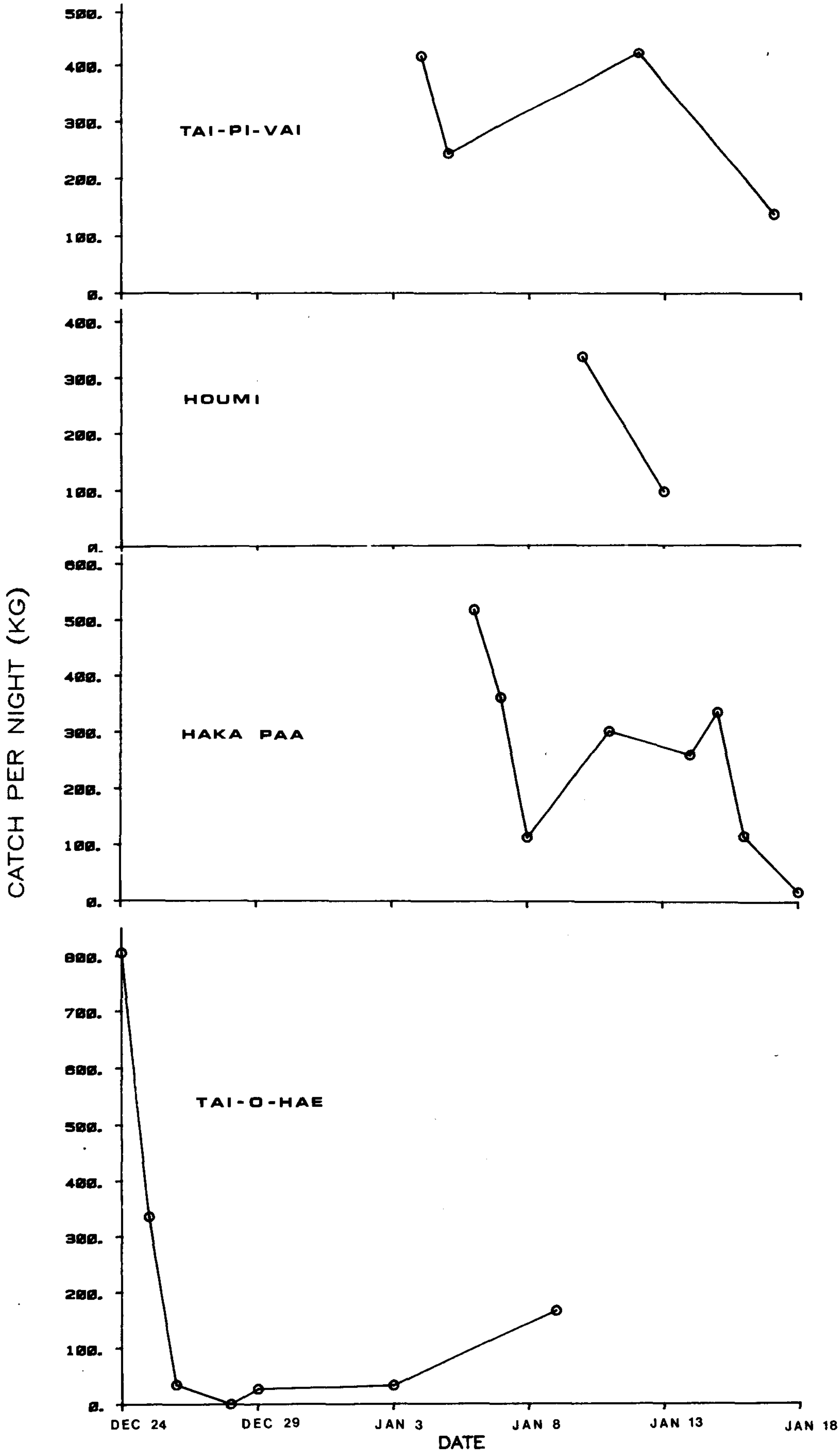
Information on the capture of sardines in deep water was obtained by the Skipjack Programme. Figure 3 gives the catch per night for the "bouki-ami" net by the Skipjack Programme in four different bays on the south coast of Nuku Hiva. These were among the few cases in which bait has been caught at night in the Marquesas. The graphs show that the catch of sardines in deep water was also subject to a marked decline with time. The combined quantity of bait taken in the first set at each of the four locations was 1,803 kg. For the last set made at each location the combined amount was only 111 kg.

For live-bait tuna fishing, the consistency of supply is almost as important as total quantity of baitfish. In none of the established bait fisheries in the tropical central and western Pacific does one species so overwhelmingly dominate the bait catch as does the Marquesan sardine in the Marquesas Islands. Any fishery established on such a narrow resource base is subject to the fluctuations in abundance (whether natural or fishery induced) of the single species, without the buffering effect of other baitfish populations.

In addition to the previously noted changes of abundance at Nuku Hiva, extreme fluctuations have been noted at Hiva Oa and Tahuata. Royce (1954) and Sprague (1961) mention that these islands have produced sizeable quantities of baitfish in the past; however, a lack of any bait in these areas was noted during Skipjack Programme surveys.

A similar clupeoid species, *Herklotsichthys punctatus*, has been shown to undergo large population fluctuations in Majuro (Hida and Uchiyama 1977) and in the Gilbert group (Hallier and Kearney 1980). In Palau, the abundance of this species has been reported to have declined markedly in apparent response to fishing pressure (Johannes 1981). In Fiji, where a considerable portion of the baitfishing is dependent on various sardine species, there have been large changes in availability with serious consequences for the skipjack fishing industry. Ellway and Kearney (1981) suggested that sardines, predominantly *Sardinella sirm*, having longer life-cycles than many other tropical baitfish species, are more vulnerable to fishing pressure. Historically, sardine resources from many parts of the world have tended to be susceptible to depletion by fishing. Murphy (1977) cites fishing for the Pacific sardine, the Far Eastern sardine, and

FIGURE 3. BAIT CATCHES BY THE SKIPJACK PROGRAMME AT FOUR BAYS ON THE SOUTH COAST OF NUKU HIVA (DECEMBER 1979 AND JANUARY 1980)



the South African sardine as examples of fisheries that have completely collapsed under intense exploitation.

Of considerable importance for projecting the stability of any bait fishery which might be established in the Marquesas Islands is the extent of the areas where fishing would be feasible. Table 6 presents the results of a close inspection of nautical charts of the area and shows all the locations where night baiting could possibly be carried out.

TABLE 6. NIGHT BAITING LOCATIONS IN THE MARQUESAS ISLANDS

Island	No. of locations where baiting is possible under most conditions and where area is charted	No. of locations where baiting is possible under most conditions but uncharted	Baiting Possible only under favourable wind and swell conditions	Total
Nuku Hiva	5	3	4	12
Ua Huka	1	0	8	9
Ua Pou	0	0	3	3
Eiao	0	0	1	1
Tahuata	1	0	2	3
Hiva Oa	2	0	3	5
Fatu Hiva	1	0	1	2
TOTAL	10	3	22	35

Although Table 6 shows a number of localities, the results of the Skipjack Programme surveys, in conjunction with previous work in the area, suggest that the only places where sardines can consistently be caught by any method are Tai-o-hae, Contrôleur, and possibly Anaho and Tai-oa Bays, all on Nuku Hiva. Bayliff and Hunt (1981), taking into account the Skipjack Programme surveys, reached the same conclusion.

Considering that successful baiting areas within the Marquesas are few and small in size; that the baitfish resource is comprised almost exclusively of a single species and that this species is related to several which have proven to be unreliable in other areas; that the catches per unit effort for most of the expeditions to the Marquesas fluctuated widely; and that rapid short-term declines in availability have been noted; it is most unlikely that the good catches of bait taken by the Skipjack Programme could be sustained over a lengthy period.

5.1.2 Tuamotu Islands

Table 7 lists the known results of previous baitfish surveys to the atolls in the Tuamotu Group. With the exception of the similarity between the two Skipjack Programme visits, the results are not comparable between surveys as there were probably large differences in the efficiency of the various gears used.

TABLE 7. EXPLORATORY BAITFISHING IN THE TUAMOTU ISLANDS

Vessel	Date	Atoll	Results
Gilbert No.15	April 1954	Raroia, Makemo, Fakarava	Negligible quantities (night) Some day bait possible
Sasayama Maru No.1	April 1976	Arutua	Caught 47 kg Chanos chanos (beach seine) Bought 30 kg Selar
Tainui	Oct. 1980	Fakarava	20 sets, 14 kg average catch per set - S. gracilis and S. crumenopthalmus
	May 1981	Rangiroa	7 sets, 7.5 kg " "
		Apataki	8 sets, 5 kg " "
		Toau	2 sets, 0.4 kg " "
		Ahe	2 sets, 4 kg " "
		Kauehi	-
		Tahanea	-
Tainui	Nov. 1978	Toau	Only large Kuhlidae, no bait)
	April 1980	Rangiroa	Insignificant quantities) night of juvenile sprats) bait
		Fakarava	Only large fish, no sprats)
Mary K	March, April 1980	Rangiroa	No bait, night
Hatsutori Maru No.1	Dec. 1978-Jan. 1979	Rangiroa	216 kg (8 sets) Spratelloides gracilis) night
		Apataki	2 kg (1 set) " ") bait
		Fakarava	896 kg (16 sets) " ")
Moetu IV	Only data for April 1979 available	Fakarava	35 buckets mullets and goatfish (beach seine) Good concentrations at night but not fished
Hatsutori Maru No.5	Feb. 1980	Rangiroa	76 kg (2 sets) Spratelloides gracilis) night bait

Source: As per Appendix A.

Ninety-nine per cent of the bait captured by the Skipjack Programme in this area were identified as the silver sprat, Spratelloides gracilis,3 a species which comprised 30 per cent of all bait catches in the large Papua New Guinea baitfish fishery in the years 1976 through 1979 (Dalzell and Wankowski 1980; Wankowski and Dalzell, undated). This species has been subjected to considerable fishing pressure in Papua New Guinea (about 180 tonnes per year from a limited number of baiting grounds) and has been somewhat resilient to this exploitation. There are, however, a number of important differences between the situation in Papua New Guinea and that in the Tuamotu Islands. There are two other major baitfish species in Papua New Guinea, Stolephorus heterolobus and Stolephorus devisi which, together with Spratelloides gracilis, tend to buffer large fluctuations in total baitfish catches by changes in population levels of individual species. In the Tuamotu Archipelago no such accompanying baitfish species have ever been captured in commercial quantities. In addition, the Tuamotu Islands, unlike those in Papua New Guinea, are almost all atolls. The productivity in the lagoons of these atolls would probably be far less than in the major baitfishing anchorages of Papua New Guinea. In other central Pacific atolls visited by the Skipjack Programme research vessels, large fluctuations in the availability of baitfish were observed. In June 1978 at Funafuti Atoll in Tuvalu, catches of another species of sprat, Spratelloides delicatulus, were 266 kg per night haul (two nights), but were only 32 kg per haul in June 1980 (seven nights). Catches at Penrhyn Atoll in the northern Cook Islands averaged 48 kg per night haul in December 1978 (5 nights) and dropped to virtually zero in December 1979 (3 nights). Similar examples for other bait species could be cited from the atolls in the Gilbert Group in Kiribati and in the Marshall Islands. It would therefore not be surprising to have major fluctuations in baitfish availability in the Tuamotu Islands.

One positive feature of this island group with respect to baitfishing is that there are many areas in the Tuamotu Islands where baitfishing is possible; some of the largest atolls in the world are in the Tuamotu Group. Rangiroa, Fakarava, Hao, Apataki, Makemo, Mururoa, Toau, Tahanea, Kauehi and Raroia all have relatively deep lagoons with adequate access for a vessel the size of the Hatsutori Maru No.5. Possible problems include a lack of good charts for all areas of the lagoons and the strong winds which are frequent in this area.

Table 8 compares the results of the Skipjack Programme baitfish survey in Tuamotu Islands with results from other countries visited by the Programme. The average catch per bouki-ami haul in the Tuamotu area was less than half of that obtained from areas with established skipjack live-bait fisheries. The modest quantities obtained could conceivably be supplemented by day baiting (suitable areas are reported by Anon 1976 and Royce 1954), or by cultured baitfish from the milkfish project on Rangiroa.

---

3. There has been some speculation that the Spratelloides species of French Polynesia is different from that of S. gracilis of the western Pacific. However, recent examination by taxonomic authorities of sprat samples collected by the Skipjack Programme in French Polynesia confirm that they are indeed the same species (Thosaporn, personal communication).

TABLE 8. BAITFISHING EFFORT AND CATCH RESULTS FOR THE SKIPJACK PROGRAMME

	BOUKI-AMI					BEACH SEINE				
	No. of Baiting Localities Fished	No. of Hauls	Total Catch (kg)	Loaded Catch (kg)	Average Catch per Haul (kg)	No. of Baiting Localities Fished	No. of Hauls	Total Catch (kg)	Loaded Catch (kg)	Average Catch per Haul (kg)
* Papua New Guinea	26	57	6,840	5,323	120	2	4	99	96	24
* Solomon Islands	24	60	8,965	8,406	148	0	0	0	0	-
New Caledonia	14	40	5,207	4,778	130	0	0	0	0	-
* Fiji	26	71	12,821	12,134	180	1	1	0	0	-
Vanuatu	3	5	177	177	35	0	0	0	0	-
Western Samoa	5	14	1,130	1,067	80	0	0	0	0	-
Society Islands	7	27	893	767	33	3	8	44	44	5
Marquesas Islands	6	44	5,601	5,367	127	4	34	1,062	952	31
Tuamotu Islands	3	27	1,196	1,051	44	0	0	0	0	-
Kiribati	5	21	1,198	1,155	57	3	7	1,782	907	254
Tonga	6	32	1,097	1,085	34	3	12	190	190	15
* Palau	9	34	3,310	2,996	97	0	0	0	0	-
Ponape	3	36	5,056	4,534	140	0	0	0	0	-
Niue	0	0	0	0	-	0	0	0	0	-
Cook Islands	3	15	585	489	39	0	0	0	0	-
American Samoa	4	5	180	138	36	0	0	0	0	-
Marshall Islands	5	8	609	567	76	2	4	89	87	22
Yap Islands	1	2	258	255	129	0	0	0	0	-
Wallis and Futuna	4	36	10,501	9,134	291	0	0	0	0	-
Truk Island	4	8	690	672	86	1	1	50	50	50
Kosrae	2	10	807	598	80	0	0	0	0	-
Norfolk Island	0	0	0	-	-	0	0	0	0	-
Tuvalu	6	15	1,508	905	100	0	0	0	0	-
Nauru	0	0	0	-	-	0	0	0	0	-
Tokelau	0	0	0	-	-	1	3	41	41	13
Pitcairn Islands	0	0	0	-	-	0	0	0	0	-

* Areas with established large-scale bait fisheries.

Source: Skipjack Programme (1981d).

Skipjack Programme (1980b, 1981a) suggest that milkfish, such as those cultured in Rangiroa, are an especially effective tuna bait. On the other hand, Kearney and Rivkin (1981) discuss possible economic constraints on such a development.

Although it is suspected that total baitfish abundance is not great, it is difficult to assess the baitfish potential of the Tuamotu Archipelago fully without replicate surveys of the areas. However, as all of the Tuamotu Islands where baiting is possible are atolls, the resources are unlikely to be particularly plentiful and are likely to exhibit wide fluctuations in abundance

5.1.3 Society Islands

The baitfish resources of the Society Islands have been surveyed by the vessels *Anela*, *Redonda*, *Tainui*, *Mary K*, *Hatsutori Maru No.1* and *Hatsutori Maru No.5*. The *Tainui* surveys were the most comprehensive, visiting all of the larger islands at least once and many of them on several occasions at different times of the year. Results from these surveys were not encouraging; over a three-year period baitfish catches were poor in quantity and seasonal in abundance (Anon 1978b-e, 1978j, 1980b).

The Skipjack Programme captured an average of 33 kg per haul (27 hauls) during the visits to the Society Islands using bouki-ami gear. Table 8 compares these results to other countries surveyed by the Programme. Table 9 lists the baiting results from the three best locations sampled by the Programme in the Society Islands. Not only were the catches meagre at even these locations, but the quantities of effective bait captured were further reduced due to the fact that a considerable portion was composed of undesirable species (e.g. *Stolephorus indicus*, species of Acanthuridae).

TABLE 9. BAITFISH CATCH DETAILS FOR THREE LOCATIONS IN THE SOCIETY ISLANDS

Port Phaeton-Tahiti	(kg)	Opunohu Bay-Moorea	(kg)	Haamene Bay-Tahaa	(kg)
Selar crumenopthalmus	165	*Spratelloides gracilis*	84	*Selar crumenophalmus*	55
Myctophidae	102	*Sardinella melanura*	42	*Stolephorus indicus*	15
Stolephorus indicus	5	*Siganidae*	21	*Stolephorus bucaneeri*	10
Mulloidichthys samoensis	146				
Acanthuridae	56				
Total Bait Catch - All Sets	474	Total Bait Catch - All Sets	147	Total Bait Catch - All Sets	80
Good Bait	146	Good Bait	84	Good Bait	10
Total Acceptable Bait	311	Total Acceptable Bait	126	Total Acceptable Bait	65
% of Total Bait Acceptable	66	% of Total Bait Acceptable	86	% of Total Bait Acceptable	81

Annual variation in baitfish abundance in Tahiti has been documented by various authors. Handy (1932) and Nordhoff (1930) discuss the seasonality of *Mulloidichthys samoensis* ("ouma") and Ottino (1965) describes annual fluctuation of *Selar* sp. ("ature"). These species, which have demonstrated variable availability, constituted 95 per cent of the acceptable bait catch at Port Phaeton, considered to be the best night baiting location in the area. *Mulloidichthys* also makes up most of the beach seine catch in the leeward Society Islands. Any live-bait fishery in the Society Islands would have to cope with the problem of periodically reduced availability of bait due to the seasonality of the major baitfish species.

An additional problem associated with baitfish capture in this island group, as contrasted with the Tuamotu or Marquesas areas, is the possible conflict with small-scale fishermen. Both *Selar crumenopthalmus* and *Decapterus* sp. ("operu") are frequently caught and prized as food by local residents. These two species are usually in most baitfish hauls, sometimes in considerable quantities. Additionally, *Mulloidichthys* are widely sought by Tahitian fishermen as live bait for small-scale fishing. A further consideration is that Port Phaeton and Opunohu Bay are especially affected by heavy rainfall. The murky water resulting from a heavy downpour reduced bait catches by the Skipjack Programme at these locations.

The modest live-bait catches by previous surveys, the high proportion of non-bait species in these catches, the demonstrated seasonality of the resources, the competition with traditional use of some species, and the effects of heavy rainfall, all suggest that the regular capture of commercial quantities of baitfish in the Society Islands would be difficult, if not impossible.

It has been stated that the introduction of the Marquesan sardine into the Society Islands could lead to the establishment of a viable baitfish fishery (Powell 1963). However, in view of the questionable ability of Marquesan sardines to support a viable fishery in its native Marquesas Islands, and the negative results when the species was introduced into Hawaii (Randall and Kanayama 1972), this could not be recommended as a solution to the baitfish problem.

5.1.4 Gambier Islands

The only baitfish exploration carried out in the Gambier Islands was by the Skipjack Programme. Scouting for bait near some of the beaches in this area revealed virtually nothing. No bait was caught in the one attempt with the bouki-ami net and it is suspected that the baitfish resources are minimal in this area.

5.2 Fishing Success/Skipjack Abundance

There is a need to be cautious when quantifying the fishing success of survey and tagging operations, such as those conducted by the *Hatsutori Maru No.1* and *Hatsutori Maru No.5*. The reduction in fishing efficiency due to tagging, together with the need to survey areas where little is known, or where it is suspected that there are reduced quantities of tuna, complicate evaluation.

Pole-and-line fishing success is influenced by many factors including the amount of tuna present in an area and their vulnerability, searching efficiency of the crew, bait availability, skill of the fishermen, etc. Three factors - catch, school sightings, and chumming success - are probably the most relevant in evaluating the quality of fishing at the time of the survey and are discussed below.

5.2.1 Catch estimates

Estimates of possible commercial catches of tuna by the Skipjack Programme based on the previously discussed conversion factor of 3.47 (Section 4.1) are given in Table 10.

Some of these catch rates are higher than in some of the areas surveyed by the Skipjack Programme in which there is a viable commercial fishery. The *Hatsutori Maru* vessels did, however, have access to more bait (Table 3) in French Polynesia (cultured bait plus the advantage of a short baiting period on an unexploited stock in the Marquesas - see Section 5.1.1), than a long-term commercial operation would be expected to have.

TABLE 10. ESTIMATES OF POSSIBLE COMMERCIAL CATCHES OF TUNA BY THE SKIPJACK PROGRAMME

	Hatsutori Maru No.1		Hatsutori Maru No.5	
	No. of fishing days	Tonnes/ fishing day	No. of fishing days	Tonnes/ fishing day
Marquesas	8	3.0	27	5.7
Society Islands	12	1.6	1	0.5
N.W. Tuamotu	17	3.3	4	5.1
S.E. Tuamotu	-	-	2	No catch, poor weather
Gambier	-	-	1	3.6

5.2.2 Sightings of tuna schools

For the entire three years of the Skipjack Programme an average of 0.76 schools were sighted per hour (Table 11). The favourable result obtained in the Marquesas (Table 12) is in agreement with that of Waldron (1964) who evaluated fish school and bird flock sightings from 177 research cruises and 29,204 hours of searching in the area bounded by 30°N, 20°S, 180°W, 110°W. He found that within this general area the number of bird flocks and skipjack schools sighted for each quarter year unit was greatest in the Marquesas.

TABLE 11. NUMBER OF SCHOOLS SIGHTED PER HOUR BY THE SKIPJACK PROGRAMME

Country		Number of Schools Sighted per Hour				Total No. of Schools	Positive Response to Chumming (%)
		Skipjack	Yellowfin	Skipjack+ Yellowfin	Others		
Papua New Guinea	(1)	0.19	0.29	0.04	0.10	0.62	42.62
	(2)	0.15	0.06	0.10	0.50	0.81	43.96
Solomon Islands	(1)	0.15	0.09	0.06	0.16	0.46	30.99
	(2)	0.09	0.01	0	0.65	0.75	54.92
Vanuatu		0.30	0	0.07	0.21	0.58	66.67
New Caledonia		0.46	0.02	0.03	0.22	0.73	49.61
Fiji	(1)	0.22	0.07	0.11	0.45	0.85	50.00
	(2)	0.16	0.12	0.20	0.31	0.79	55.86
Tonga	(1)	0.14	0	0.08	0.27	0.49	50.00
	(2)	0.22	0.14	0	0.04	0.40	34.78
Wallis and Futuna	(1)	0.37	0.01	0.02	0.47	0.87	70.00
	(2)	0.09	0.12	0.05	0.39	0.65	43.48
Western Samoa	(1)	0.38	0.02	0.04	1.71	2.15	60.00
	(2)	0.29	0.18	0	0.35	0.82	41.67
American Samoa	(1)	0.19	0	0	0.81	1.00	16.67
	(2)	0.27	0.18	0	0.27	0.72	60.00
Tuvalu	(1)	0.40	0.01	0.06	0.63	1.10	43.55
	(2)	0.22	0	0	0.96	1.18	57.14
Kiribati	(1)	0.48	0.03	0.03	0.70	1.24	55.93
	(2)	0.22	0.02	0.03	0.76	1.03	56.52
Trust Territory	(1)	0.05	0.02	0.03	0.34	0.44	24.24
of the Pacific	(2)	0.09	0.02	0.03	0.42	0.56	30.43
Islands	(3)	0.15	0.06	0.05	0.68	0.94	48.15
Tokelau		0.04	0	0.02	2.02	2.08	42.86
Cook Islands	(1)	0.17	0	0.02	0.78	0.97	37.50
	(2)	0.12	0.10	0	0.42	0.64	11.11
French Polynesia	(1)	0.22	0.02	0.03	0.49	0.76	52.83
	(2)	0.43	0.03	0.06	0.33	0.85	59.90
New Zealand	(1)	0.32	0	0	0.28	0.60	42.59
	(2)	0.48	0.01	0	0.11	0.60	9.09
Australia		0.35	0.02	0.05	0.17	0.59	45.73
Pitcairn Island		0	0.08	0.16	0.31	0.55	46.15
Niue		0.17	0.11	0.06	0.74	1.08	40.00
Norfolk Island		0.07	0.02	0.05	0.18	0.32	50.00
Nauru		0.09	0.03	0	1.15	1.27	0
Weighted Average for Entire Survey		0.23	0.04	0.05	0.44	0.76	46.47

Note: (1) and (2) specify first and second visit respectively to an area.

Source: Skipjack Programme Preliminary Country Reports

TABLE 12. SIGHTINGS OF SURFACE TUNA SCHOOLS PER HOUR IN FRENCH POLYNESIA

	Hatsutori Maru No.1	*Hatsutori Maru No.5*	Other Vessels
Marquesas	0.92	0.99	0.29(1)
Society Islands	0.67	0.42	0.27(2)
N.W. Tuamotu	0.72	1.17	0.25(2)
S.E. Tuamotu	-	0.50	-
Gambier	-	0.32	-

(1) Average during nine months for *Mary K* and *Cornucopia* (Bayliff and Hunt 1981).

(2) Average during two months for *Mary K* (Bayliff and Hunt 1981).

5.2.3 Chumming success

Information on the chumming success in French Polynesia is given in Table 13. The average chumming response for all countries visited by the Skipjack Programme was 46 per cent and there was surprisingly little variation between countries. The apparently poor results obtained in southeast Tuamotu Islands were probably due to very poor weather and a small sample size.

TABLE 13. PERCENTAGE OF SCHOOLS CHUMMED FROM WHICH AT LEAST ONE FISH WAS POLED

	Hatsutori Maru No.1	*Hatsutori Maru No.5*
Marquesas	58	64
Society Islands	30	-
N.W. Tuamotu	73	48
S.E. Tuamotu	-	17
Gambier	-	33

TABLE 14. CATCH DATA FOR VARIOUS LIVE-BAIT VESSELS IN FRENCH POLYNESIA

Vessel	Area	Total Tuna Catch (tonnes)	Catch per Day (tonnes)	Source
Moetu II	Society Islands/ Tuamotu	29	0.13	
Anela	Society Islands/Tuamotu/ Marquesas	149	1.19	
Redonda	Society Islands/Marquesas/ Austral	5	0.17	Anon (1978a)
Sasaya Maru	Society Islands/Tuamotu/ Marquesas	46	0.85	
Tainui	Society Islands	74	0.44	
Moeta IV(3)	Tuamotu	6.6	2.20	Anon (1979a)
Japanese pole-and-line (unknown name)	Society Islands	86	10.75	Skipjack Programme (1980a)
Taisei Maru No.24	Tuamotu	16.3	5.43	R. Robert (personal communication)

Mary K and Cornucopia not included because these vessels were involved in tagging and conversion factors are unavailable.
For period 4/3/76 to 1/9/77.
Fished for longer period but data only available for three fishing days.

5.2.4 Fishing success of other pole-and-line vessels

Available catch data for other live-bait vessels is given in Table 14. The five best performing vessels based on catch per day (*Hatsutori Maru No.5*, *Hatsutori Maru No.1*, *Moeta IV*, Japanese pole/line vessel, *Taisei Maru No.24*), had access to considerable quantities of bait other than local, naturally occurring species. The experience of the Skipjack Programme, together with this catch information, suggest that the quantity of bait available, not the amount of tuna, is the major limiting factor for live-bait pole-and-line fishing in French Polynesia.

5.2.5 Purse-seining

Appendix A shows 11 trips by purse-seine vessels to French Polynesia. Detailed information is available for only four of these expeditions (Table 15).

TABLE 15. CATCH DATA FOR PURSE-SEINE FISHING IN FRENCH POLYNESIA

Purse-seine Vessel	No. of sets	Successful Sets	Tuna Catch (short tons)
Zapata Discoverer (1972)	3	2	45
Kerri M (1972)	37	9	87
Kerri M (1971)	32	9	160
Sea Treasure (1974)	5	3	17.5
TOTAL	77	23	309.5

All of the above fishing took place in the Marquesas where these and other purse-seine vessels usually reported good quantities of tuna which were difficult to catch. Failures were attributed to the following factors:

- net too shallow
- shifty, erratic movement of fish
- tendency of fish to sound
- water too clear
- poor weather
- deep thermocline
- little phosphoresence for night-time sets.

Since the time in which purse-seining in the Marquesas took place, there have been a number of technical innovations to overcome some of the above-mentioned problems. Some operators of the larger purse-seine vessels have expressed the opinion that, with time, seining could be productive almost anywhere in the tropical Pacific, particularly if carried out in association with fish aggregation devices.

Aerial surveys conducted by ORSTOM, in collaboration with the American Tuna Company, Starkist Inc., from February to December 1981, showed that large schools of skipjack were at times present in the Marquesas during the survey period and that at least some schools were thought to be vulnerable to purse-seining (G. Bell, personal communication). Although schools were more numerous in the Marquesas than in the Society Islands, a higher proportion of those schools observed in the aerial survey appeared "seinable" in the Society Islands (Marcille and Bour 1981). Marcille (1979) states that on the basis of oceanographic conditions, the Marquesas and Austral Islands are the most favourable areas in French Polynesia for purse-seining.

5.3 Observations from Biological Sampling

5.3.1 Stomach contents

Table 16 lists the items found in the 944 skipjack stomachs examined by the Skipjack Programme in French Polynesia. The number of skipjack with goatfish in their stomachs, especially in the Tuamotu and Society Islands, is noteworthy. In these two areas goatfish were found in 28 per cent of the skipjack stomachs examined, much higher than in any other area surveyed by the Programme. The presence of a wide variety of items in skipjack stomachs, including non-food objects, highlights their opportunistic feeding habits. Community groups of prey species are thought to vary across the central and western Pacific and identification of these is the subject of ongoing analysis.

The examination of stomach contents, specifically for the presence of tuna juveniles, was undertaken by the Skipjack Programme to give information on early life history, spawning activity and skipjack feeding behaviour. Table 17 gives the results for the Marquesas, Tuamotu, and Society Islands. Tuna juveniles per 100 predators is used as an indicator of the relative abundance of tuna juveniles in a particular area. Argue, Conand and Whyman (1983) show that the incidence of tuna juveniles, predominantly skipjack, was higher in the Marquesas than in any other island part of the study area. This high concentration has been noted previously by Nakamura and Matsumotu (1965). The relatively high incidence of tuna juveniles in the waters of French Polynesia endorses the contention that there is considerable skipjack spawning here or at least nearby.

Also of interest were the albacore juveniles found in the samples taken in the Tuamotu Islands. Their number per 100 skipjack, 4.10, was the highest for any area surveyed by the Skipjack Programme. Over half of the albacore juveniles found during the entire three-year survey were found during the survey of the Tuamotu Islands.

5.3.2 Skipjack size frequency and gonad maturity data

Length frequency data from the two surveys is presented in Appendix C and information on female gonad maturity data in Figure 4. Most of the female skipjack gonads sampled were late maturing (stage 3). The absence of ripe female gonads is not considered unusual. Examination of 10,926 skipjack gonads in 25 countries and territories of the central and western Pacific by the Skipjack Programme revealed only two females with ripe gonads.

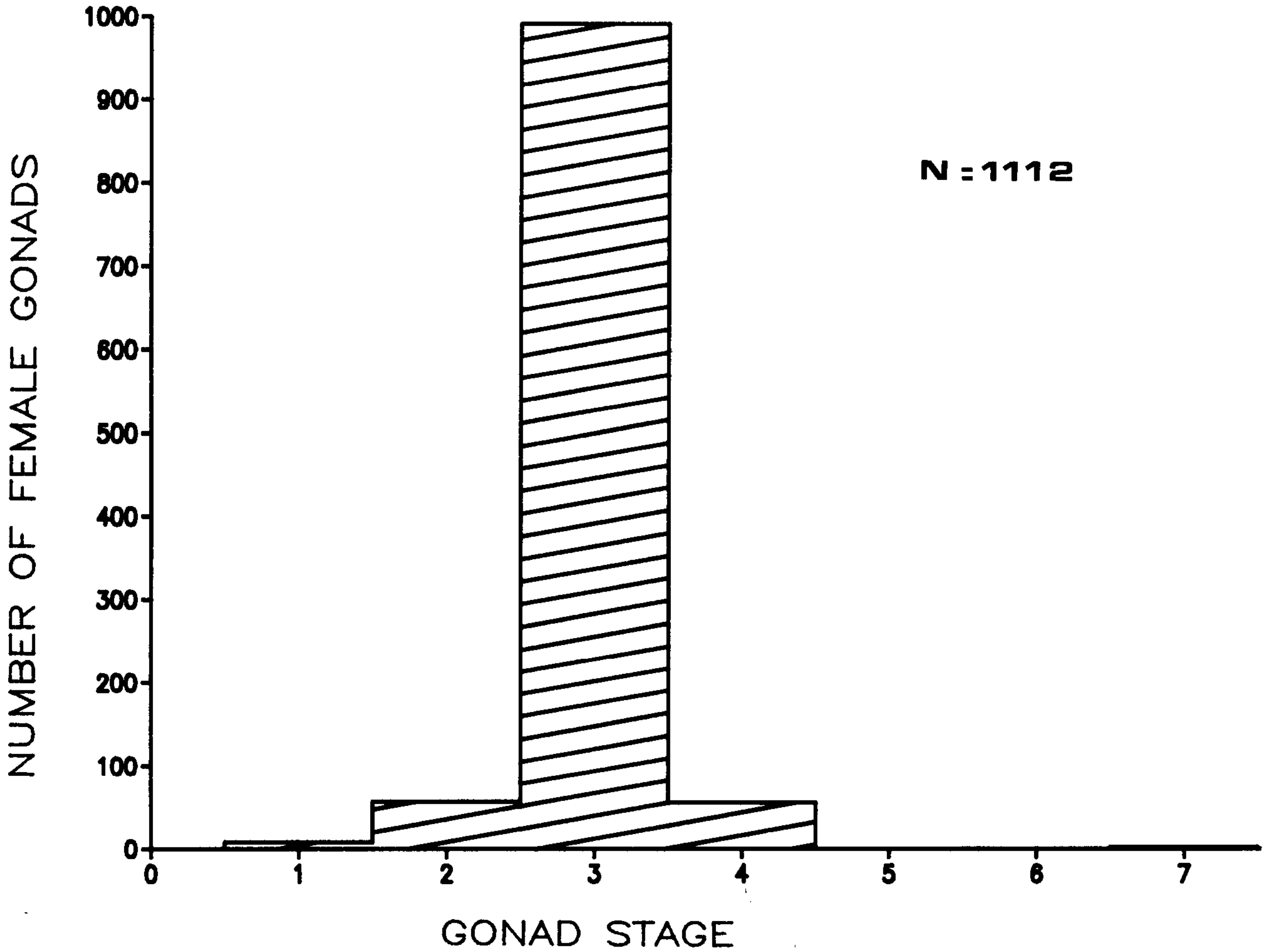
TABLE 16. DIET ITEMS FOUND IN THE STOMACHS OF SKIPJACK SAMPLED IN THE WATERS OF FRENCH POLYNESIA

Item No.	Diet Item Fish and Invertebrates	Number of Stomachs	Percentage Occurrence
1	Chum from _Hatsutori Maru_	609	64.51
2	Fish remains (not chum)	502	53.18
3	Alima stage (Stomatopoda)	212	22.46
4	Squid (Cephalopoda)	193	20.44
5	Blue goatfish (Mullidae)	137	14.51
6	Holocentridae	136	14.41
7	Acanthuridae	100	10.59
8	Tuna juvenile (Scombridae)	91	9.64
9	Shrimp (Decapoda)	70	7.42
10	Gempylidae	57	6.04
11	Unidentified fish	57	6.04
12	Empty stomach	56	5.93
13	Synodontidae	54	5.72
14	Juvenile fish	51	5.40
15	Balistidae	41	4.34
16	Megalopa stage (Decapoda)	39	4.13
17	Chaetodontidae	32	3.39
18	Carangidae	31	3.28
19	Stomatopoda	28	2.97
20	_Decapterus_ sp. (Carangidae)	25	2.65
21	Aluteridae	24	2.54
22	Fistulariidae	20	2.12
23	Siganidae	18	1.91
24	Clupeidae	12	1.27
25	Blenniidae	12	1.27
26	Lutjanidae	11	1.17
27	Exocoetidae	10	1.06
28	Argonauta (Cephalopoda)	10	1.06
29	Bramidae	9	0.95
30	Phyllosoma stage (Decapoda)	9	0.95
31	Ostraciidae	8	0.85
32	Gastropoda	8	0.85
33	_Selar_ sp. (Carangidae)	8	0.85
34	Unidentified invertebrate	7	0.74
35	Pteropoda (Gasteropoda)	5	0.53
36	Paralepidae	5	0.53
37	_Dactylopterus orientalis_ (Dacylopteridae)	5	0.53
38	Euphausiid (Euphausiacea)	5	0.53
39	Serranidae	4	0.42
40	Priacanthidae	3	0.32
41	Diodontidae	3	0.32
42	_Ranzania_ sp. (Molidae)	2	0.21
43	Sphyraenidae	2	0.21
44	Crustacean remains	2	0.21
45	_Chiasmodon_ sp. (Chiasmodontidae)	2	0.21
46	Nomeidae	2	0.21
47	Stomiatidae	2	0.21
48	Octopus (Cephalopoda)	2	0.21
49	_Mola mola_ (Molidae)	2	0.21
50	Billfish juvenile (Istiophoridae)	2	0.21
51	Scaridae	2	0.21
52	Bark (wood) material	1	0.11
53	Leptocephalus (Anguilliformes)	1	0.11
54	Mollusc egg case	1	0.11
55	Scombrid juvenile (Scombridae)	1	0.11
56	_Xiphasia_ sp. (Xiphasiidae)	1	0.11
57	Tetrodontidae	1	0.11
58	Coryphaena hippurus (Coryphaenidae)	1	0.11
59	Paint material	1	0.11
60	Cigarette material	1	0.11
61	Amphipoda	1	0.11
62	_Cypselurus_ sp. (Exocoetidae)	1	0.11
63	Mollusca	1	0.11
64	Copepoda	1	0.11
	Total Stomachs Examined	944	

TABLE 17. INCIDENCE OF TUNA JUVENILES IN THE STOMACHS OF SKIPJACK AND YELLOWFIN FROM THE WATERS OF FRENCH POLYNESIA

Predator	Predators Examined	Prey Species	No. of Prey	Predators with Prey	Prey per 100 Predators	of Predators with Prey
		Marquesas Islands				
Skipjack	1476	Skipjack	327	121	22.15	8.20
		Yellowfin	5	4	0.34	0.27
		Mackerel Tuna	18	8	1.22	0.54
		Frigate Tuna	43	19	2.91	1.29
		Albacore	1	1	0.07	0.07
		Dogtooth Tuna	1	1	0.07	0.07
Yellowfin	57	Skipjack	55	12	96.49	21.05
		Mackerel Tuna	29	1	50.88	1.75
		Frigate Tuna	18	1	31.58	1.75
Frigate Tuna	1	-				
TOTAL	1534		497			
		Tuamotu Islands				
Skipjack	683	Skipjack	62	35	9.08	5.12
		Albacore	28	20	4.10	2.93
Yellowfin	130	Skipjack	6	4	4.62	3.08
Rainbow Runner	1	-				
TOTAL	814		96			
		Society Islands				
Skipjack	181	Skipjack	1	1	0.55	0.55
Yellowfin	13	-				
TOTAL	194		1			

FIGURE 4. MATURITY STAGES OF FEMALE SKIPJACK SAMPLED IN FRENCH POLYNESIA BY THE SKIPJACK PROGRAMME



Yoshida (1966) examined 402 female skipjack gonads from the Marquesas and Tuamotu Islands between August 1956 and June 1958 and concluded that the minimum skipjack length at first spawning was 43 cm and that major spawning occurs from November to April, although some spawning may occur all year. Yoshida states that one female skipjack with running ripe ovaries was encountered.

5.3.3 Parasite studies

Gills and viscera from 150 skipjack from French Polynesia waters were collected by the Skipjack Programme, and scientists at the University of Queensland examined them for the presence of parasites which could possibly be used as population markers. Results were compared with those from other countries in the study area. Analyses of these results and collection of samples from other areas are continuing, therefore only preliminary results are available. These have been discussed by Lester (1981). Lester concluded that "within the limits of our small number of samples, there is no parasitological evidence for more than one stock of skipjack in the SPC area."

5.4 Growth

Growth studies on fish are undertaken to learn more about the basic biology of the animal, to assist in yield modelling and, in some cases, to give information on stock structuring. A study on skipjack growth was an integral part of the Skipjack Programme. Almost all tagged fish were measured upon release and over 80 per cent of the returned tags were accompanied by length information. Detailed results of the growth investigation appear in Skipjack Programme (1980c, 1981e), and Lawson and Kearney (MS). Table 18 from Lawson and Kearney is a brief summary of the results of the study. Listed are the annual growth rates for the four countries with the most complete data: Papua New Guinea, Solomon Islands, Kiribati and Fiji. Adequate data was not available to study growth rates in French Polynesia.

TABLE 18. ESTIMATES OF SKIPJACK GROWTH RATES FOR SEVERAL COUNTRIES IN THE SPC REGION, BY SIZE AT RELEASE AND TIME-AT-LARGE. Average growth rates with standard errors greater than 3 cm or for samples of less than six skipjack are considered unreliable, and are given in brackets.

Area of Release	Size At Release (cm)	Days At Large	Sample Size	Growth Rate (cm/yr)	Standard Deviation (cm)
Fiji	40-49	31-180	38	17.23	14.89
Fiji	50-59	31-180	12	(11.95)	20.79
Fiji	40-49	181-450	20	16.6	3.91
Fiji	50-59	181-450	10	7.01	6.10
Kiribati (Gilbert Is)	40-49	31-180	180	9.46	9.96
Kiribati (Gilbert Is)	50-59	31-180	39	1.42	12.78
Kiribati (Gilbert Is)	40-49	181-450	1	(5.43)	-
Kiribati (Gilbert Is)	50-59	181-450	0	-	-
Papua New Guinea	40-49	31-180	16	(20.85)	14.47
Papua New Guinea	50-59	31-180	292	5.40	11.75
Papua New Guinea	40-49	181-450	3	(19.38)	7.70
Papua New Guinea	50-59	181-450	15	8.23	2.45
Solomon Islands	40-49	31-180	87	12.72	11.23
Solomon Islands	50-59	31-180	42	5.75	18.43
Solomon Islands	40-49	181-450	77	11.37	7.90
Solomon Islands	50-59	181-450	50	4.08	6.35

Growth rates appear to vary considerably between areas. Temporal variation was also observed in growth rates estimated from data from several years of tagging in Papua New Guinea by both the Skipjack Programme and the Department of Primary Industry of Papua New Guinea. Geographic and temporal variability of skipjack growth is thought to reflect environmental conditions, but, as yet, neither the degree of environmental heterogeneity nor the precise effects of the environment on skipjack growth are well understood.

The Society and Tuamotu Islands are of special interest with respect to growth of skipjack due to the presence of very large fish. Skipjack as large as 45 kg have been reported from this area (Nordoff 1930, Anderson 1963). Length frequency data from Tahiti (Marcille et al. 1979, Chabanne and Marcille 1980) confirm that large fish (greater than 10 kg) are common in the catches. Very large skipjack are also reported from the Hawaiian area, but individuals with extensive experience in both fisheries claim that the skipjack from Tahiti achieve greater size (W. Paulo, R. Kinney, personal communication). The maximum size of skipjack caught in the Society Islands is markedly different from that of some of the other areas of the South Pacific Commission region. Kearney (1973) states that in Papua New Guinea fish above 6 kg are rare, far less than one per cent of the pole-and-line catch, and skipjack above 7 kg are almost never taken.

5.5 Recruitment

Examination of 91 months of length frequency data (Marcille et al 1979, Chabanne and Marcille 1980, Chabanne, personal communication), shows that skipjack are caught by the Society Island's fishery at a size as small as 27 cm length to caudal fork (LCF). Three and a half per cent of all the fish sampled were less than 40 cm. Although the availability of young skipjack varies from month to month, there appears to be no pronounced seasonal pattern to the appearance of small skipjack in the fishery.

Studies by IATTC suggest a significant correlation between oceanographic conditions in the central tropical Pacific and recruitment in the eastern Pacific (Anon 1980d). It is quite possible that a similar relationship exists for recruitment into the French Polynesia fishery.

Marcille et al. (1979) report two modes in the catch at Tahiti; these modes vary but are most commonly centred on 47 and 62 cm. An examination of tagging data is informative of the relationship between these two modes and of recruitment to the Tahitian fishery (Table 19). From Table 19 it can be seen that the larger mode observed by Marcille was at least partially made up by recruitment to the Tahitian fishery of fairly large fish from outside the area. The lack of recoveries of large fish in the Society Islands from locally tagged small fish suggests local recruitment to the larger mode from the smaller mode is minimal.

As can be seen from previous sections, both gonad and tuna juvenile studies suggest that spawning takes place in or near French Polynesia. How much this local spawning actually contributes to recruitment in French Polynesia is unknown.

5.6 Genetic Analysis of Skipjack Blood Samples

The Skipjack Programme sought to clarify the issue of skipjack population structuring by tagging skipjack and simultaneously collecting blood samples from selected schools. During the fieldwork, blood samples were obtained from approximately 100 individuals from each of 58 schools throughout the study area. Ten of these 58 schools were from French

Polynesia. To assist in the analysis and interpretation of this data, the Skipjack Programme hosted two workshops during which experts in the fields of fishery genetics, population genetics, and fishery population biology met with the Programme's scientists. The results of those workshops appear in Anon (1980f, 1981a).

TABLE 19. REPORTED SIZES OF TAGGED SKIPJACK RECOVERED IN THE SOCIETY ISLANDS FROM RELEASES IN OTHER COUNTRIES

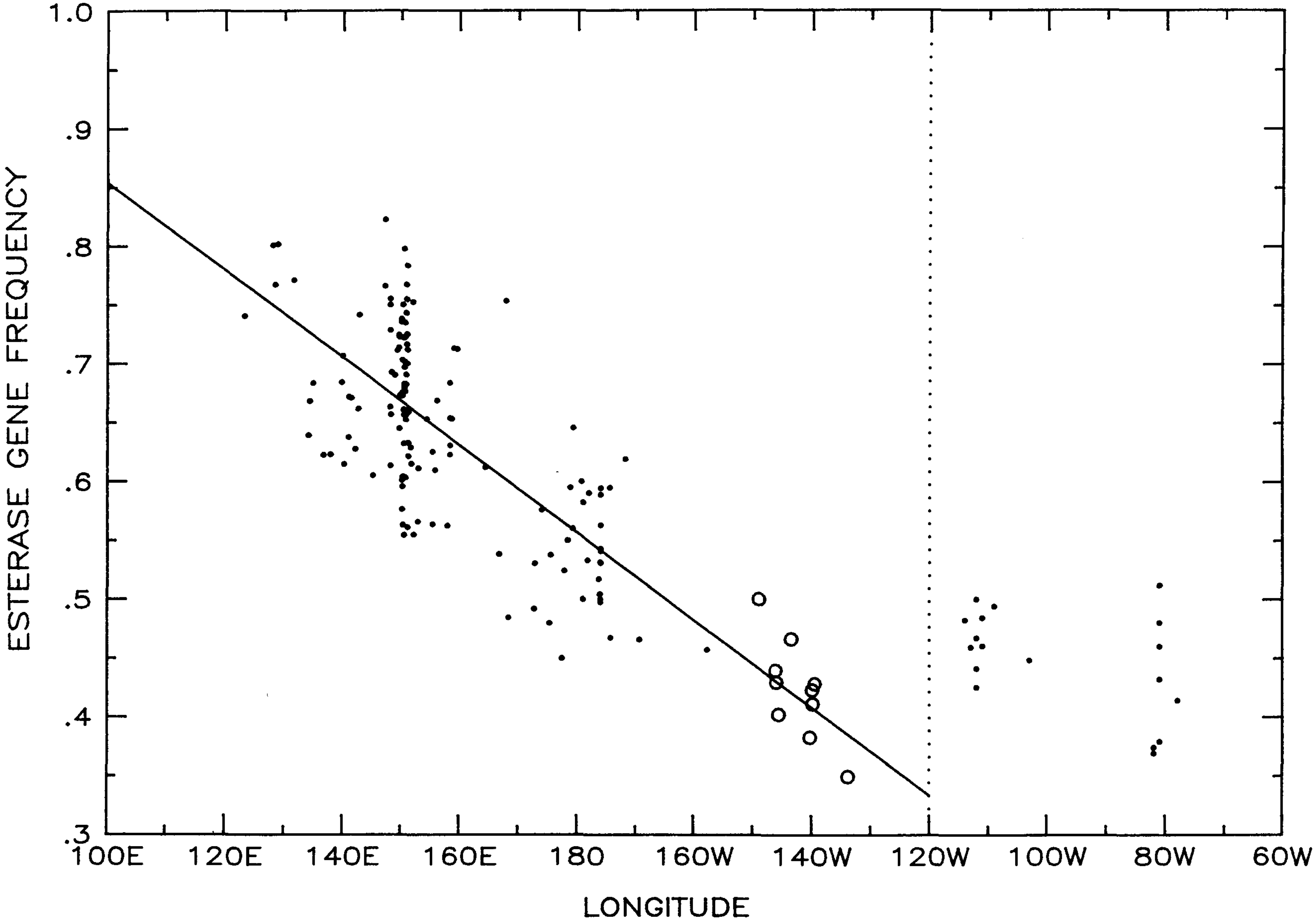
Size at release outside French Polynesia (cm)	Size at recapture in French Polynesia (cm)
57	65
54	65
51	58
51	56
53	60
46	57
47	65
45	49.6
46	unknown
47.6	51
46	59
62	65

Forty-two loci were surveyed for electrophoretically detectable polymorphisms. Serum esterase was considered most suitable for detailed consideration. Esterase gene frequencies (Figure 5) showed a pronounced longitudinal gradient across the study area with a flattening of the gradient between French Polynesia and the eastern Pacific. The samples from French Polynesia (open circles on Figure 5) had gene frequencies that were consistent with the longitude of the area and its position on the gradient.

Existence of the esterase gradient was considered to be strong evidence that there is some form of population structuring, i.e. Pacific skipjack do not comprise a single panmictic population in which all adults of a single generation have an equal chance of mating. Similarly, the flattening of the esterase gradient between French Polynesia and the eastern Pacific suggests a common genetic origin for skipjack in the central and eastern Pacific.

Genetically isolated skipjack subgroups separated by stable geographic boundaries were not identified from the data. Furthermore, there did not appear to be any genetically isolated breeding populations as previous researchers using more limited data have suggested. However, the genetics data supports the conclusion that there should be minimal short-term interactions between the fisheries at the extremes of the Programme's study area (Anon 1981a).

FIGURE 5. SKIPJACK SCHOOL SERUM ESTERASE GENE FREQUENCY BY LONGITUDE OF THE SAMPLE LOCATION. Gene frequencies for a total of 163 samples from numerous schools are plotted with the samples from French Polynesia given as open circles. The regression line was fitted to data for 145 samples west of 120°W (dotted line); the correlation co-efficient was -0.81.



5.7 Skipjack Migration

The analysis of skipjack migrations is restricted by both limited fishing operations in and around French Polynesia and by the lack of information for some of the existing fisheries. The small skipjack fishery in French Polynesia is centralised near Tahiti and covers only a very small portion of the total French Polynesian 200-mile zone. In addition, it is well over 1,000 nautical miles from this centre of activity to any other significant skipjack fishery. Despite these limitations, the data does enable some interesting inferences of skipjack movement relevant to French Polynesia.

5.7.1 General migration

Figure B (inside back cover) is a straight-line migration map summarising the Skipjack Programme data for the entire survey area. Only a portion of all tag returns are illustrated (one arrow in each direction between any two ten degree squares). Table 20 is a movement matrix which shows the number of fish tagged in any country and recaptured in another country and Appendix D gives additional information on fish tagged in French Polynesia. A general feature of the overall migration data is that there appear to be no oceanic barriers to the movement of skipjack in the study area. Also apparent is the trend for most recoveries to occur within one month of tagging and close to the point of release, but there is a tendency for at least a part of the population to migrate. Seventeen per cent of 5,339 tag recoveries were made at a distance of more than 200 nautical miles from where they were tagged. Fifty-eight per cent of the fish that were at liberty for more than 99 days were recaptured more than 200 nautical miles from the point of release.

5.7.2 French Polynesia international recoveries

Figure 6 is a straight line migration map showing only those tagged skipjack making international migrations that were released or recaptured in French Polynesia. Appendix E lists detailed release and recapture data for all of the international recaptures either into or out of French Polynesia.

There have been 12 tag returns from French Polynesia of skipjack tagged in other countries and seven skipjack tagged in French Polynesia were recovered elsewhere. Salient aspects of this data are the high proportion of recoveries in the Society Islands which came from releases outside this island group, and the absence of tag recoveries from the eastern Pacific fishery.

International tag returns in French Polynesia were from fish tagged in the waters of six different countries: Fiji, Tonga, Western Samoa, Australia, Wallis and Futuna (3 tags), and New Zealand (5 tags). These fish were recaptured in French Polynesia in the fishing season immediately after they were tagged. As most skipjack fishing in French Polynesia takes place in the Society Islands, it is not surprising that all of the international tag returns were from this area. It is interesting to note that all parts of the total Programme study area in which considerable numbers of skipjack (over 2,000) were tagged between mid-February and

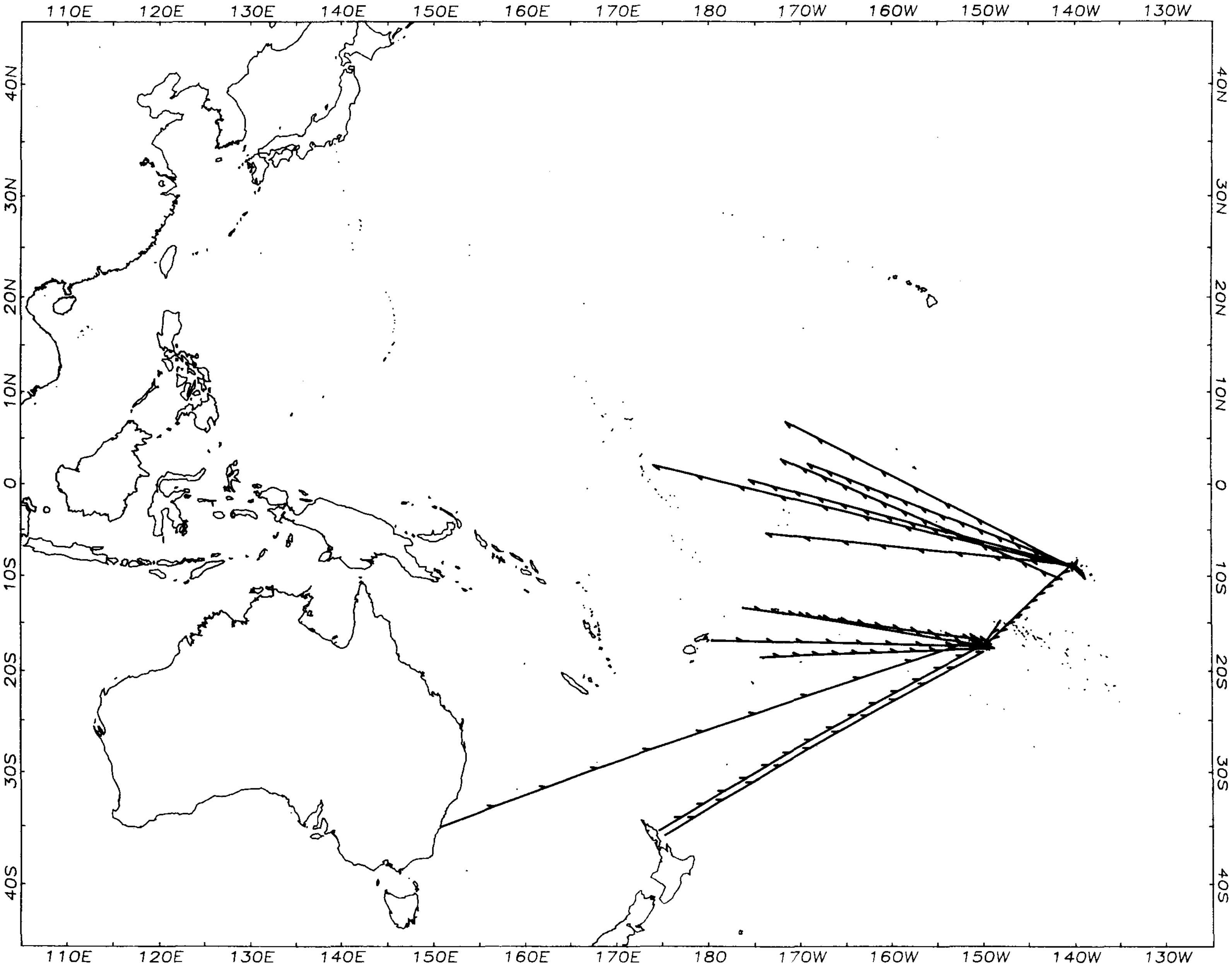
TABLE 20. RELEASE AND RECAPTURE SUMMARY FOR ALL TAGGED SKIPJACK RELEASED BY THE SKIPJACK PROGRAMME IN OTHER COUNTRIES. Data for returns up to 16 December 1982. For explanation of country abbreviation see Appendix F.

COUNTRY OF RECAPTURE

NUMBER OF RELEASES BY COUNTRY

		AMS	CAL	FIJ	GIL	GUM	HAW	HOW	IND	INT	JAP	KOS	LIN	MAQ	MAR	MAS	NTS	NAU	NCK	NOR	NSW	PAL	PAM	PHL	PHO	PNG	PON	QLD	SOC	SOL	TOK	TON	TRK	TUA	TUV	VAN	WAK	WAL	WES	YAP	ZEA	TOTAL
775	AMS	3																																					1			4
10219	CAL		18		1					2					1											2	2			10			1									37
20094	FIJ		1	1949	1					5								1							4				1			2			6		1	2	2		3	1978
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	67		3			1	6						104		5		77	7			2			23							30		356
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	29								1		1	58			1			13							10		159
2651	QLD		3																									2		25			1			2						33
48	SCK																																									
1725	SOC																												36													36
6221	SOL			1	1				1	2																15				525												545
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		10						3									24	2			3				1		1			66	11		6	152
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	2000	405	1	1	38	41	189	11	34	1	42	9	72	1	4	1	1	4	107	5	6	32	1057	92	3	54	605	2	13	71	25	10	5	1	68	41	51	1022	6167

FIGURE 6. FRENCH POLYNESIA INTERNATIONAL SKIPJACK MIGRATION ARROWS. Tick marks represent 30-day periods between release and recapture. Movements plotted have been selected to show no more than two examples between any pair of 10 degree squares.



mid-May contributed to Society Islands tag returns. This is more surprising when one considers the relatively low level of skipjack catches in the Society Islands.

Considering that there were 1,725 tags released in the Society Islands by the Programme, the high proportion of tag returns that came from other areas is notable; 18 (47 per cent) of the 38 tagged fish recaptured here came from releases outside the Society Islands, and 12 (32 per cent) were international returns originating from outside French Polynesia (average straight line migration distance: 1,926 nautical miles).

Fish tagged in French Polynesia were recovered in four other areas: the Gilbert Group (1 tag), international waters between Howland Island and the Line Islands (4), Phoenix Islands (1), and Howland Island (1). These fish were at liberty from 254 to 434 days. All were tagged in the Marquesas. None of the 7,427 skipjack released by the Skipjack Programme in other parts of French Polynesia have been recovered outside the country.

Although the skipjack stock in the Marquesas during December 1979-January 1980 seemed quite homogeneous, as indicated by the length frequency histogram (Appendix C), tagged skipjack did not migrate into other areas as a unit. For example, eight months after its release in the Marquesas area a 47 cm skipjack was recaptured in the Marquesas. A similar size skipjack tagged the previous day in the same general area was recaptured 2,000 miles away two days after the first skipjack was recaptured in the Marquesas.

5.7.3 Local movements within French Polynesia

Observed movements of tagged skipjack within the Society and Tuamotu Islands exhibit the expected apparent movement into areas where there is fishing effort (Figure 7). There have been four groups of tags released in the Tuamotu Islands: 464 by IATTC in March and April 1978, 4,713 by the Skipjack Programme in December 1978-January 1979, and 815 by the Skipjack Programme in January 1980. From these releases there have been 3, 2 and 2 returns respectively in the Society Islands. These skipjack were at liberty from 45 to 291 days.

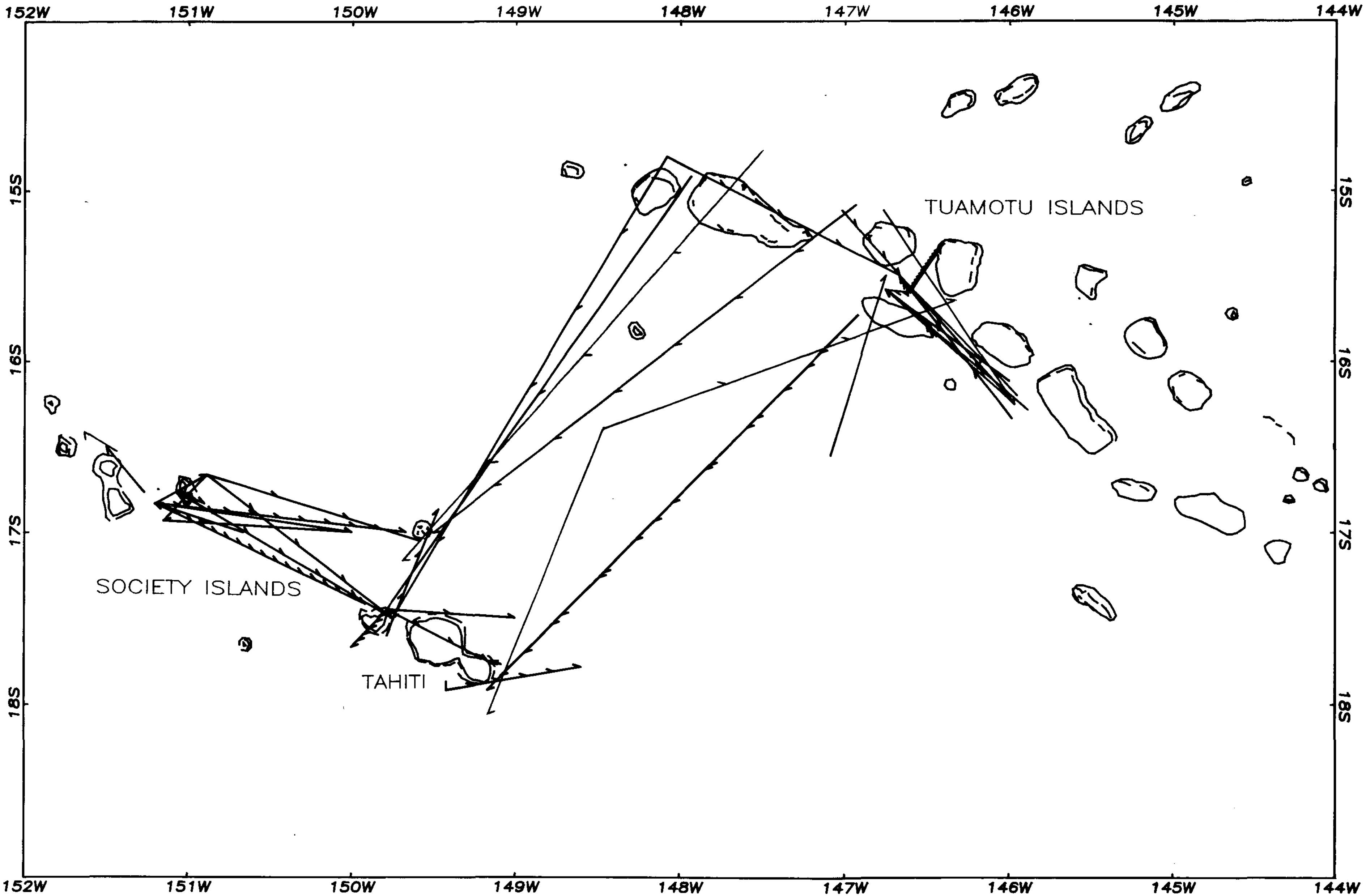
The small number of returns in the Society Islands from the large number of fish tagged in the Marquesas is notable. The one tag return was from a skipjack which was at liberty 323 days.

Society Islands fishermen recovered 20 tagged fish which were released in the Society Islands. These were at liberty from 10 to 522 days (average 115 days). Only one recovery was reported more than a year after release. There have been no recoveries from the release of 174 skipjack near the Gambier Islands in February 1980.

5.7.4 Possible patterns in migratory behaviour

Migration trends are not obvious from the straight line migration map (Figure B). Although the skipjack movements might initially appear to be diffusive, simple random motion does not seem to explain adequately the observed skipjack movements into and out of French Polynesia. Six skipjack tagged in the Marquesas were recovered from the Japanese pole-and-line

FIGURE 7. STRAIGHT LINE REPRESENTATIONS OF MOVEMENTS OF SKIPJACK WITHIN THE TUAMOTU AND SOCIETY ISLANDS. All tag returns (66 SPC and 4 IATTC) are plotted. Tick marks represent 30-day periods.



fishery located about 2,000 nautical miles from the Marquesas, in the Phoenix Islands/equatorial area. In 1980 this fishery caught about 15,000-20,000 tonnes of skipjack (extrapolating from previous year's catch data and inspection of data in Tanaka (1980)). In the same year about 1,200 miles to the north of the Marquesas the eastern Pacific fishery outside the CYRA[4] took 17,600 tonnes (Anon 1981c), yet there were no tag recoveries reported from this area. It therefore appears that during the time in which six tagged fish were recovered in the Japanese fishery to the west of the Marquesas, no fish were recovered from a catch of approximately equal magnitude taken even closer to the Marquesas, but to the north.

Evidence from the release of tagged skipjack in the central regions of the study area suggests that, during the years of the study, skipjack in these regions showed more tendency to move towards the Society Islands than to the west. The Skipjack Programme tagged 40,920 skipjack in the Tonga/Niue/Wallis and Futuna/American Samoa/Western Samoa area. Six of these tags were returned from the small Tahitian fishery while only one was returned from the much larger Solomon Islands fishery, approximately an equal distance to the west. Skipjack catches during the years in which tagged fish were returned from the two areas are:

	Society Islands	Solomon Islands
1979	approx. 950*	23,806***
1980	950**	21,935***
TOTALS	1,900 tonnes	45,741 tonnes

Sources: * Chabanne (1980)
** Chabanne, Marec and Asine (1982)
*** Solomon Islands Ministry of Natural Resources (unpublished data)

It can be seen that the Solomon Islands had over 20 times the skipjack catch of the Society Islands, but fewer tag recoveries. If we assume approximately equal harvest rates in the two areas, as indicated by Skipjack Programme (1981c), more movement towards the Society Islands is suggested. However, because of the small number of tag returns, this suggestion must be considered with caution.

5.8 Fishery Interaction

5.8.1 Observed fishery interaction within the central and western Pacific

As demonstrated by tag returns, there is at least some interaction between the fishery in French Polynesia and those in several other countries. The data also show that skipjack have the ability to undergo

---

4. The CYRA is the yellowfin regulatory area of the IATTC. Here, the area in question lies outside this zone at about 10°N between 120° and 140° west longitude.

vast migrations. Genetic data from the blood studies suggest that there are no genetically isolated subpopulations separated by geographical barriers in the study area. Therefore, there is potential for at least some interaction between areas.

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 skipjack fisheries suggests that between generation fishery interactions would be negligible for present or even greatly expanded fisheries in the western and central Pacific. Therefore, evaluation of interactions within one generation is 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 1981c). 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. Results demonstrated a generally low level of stock interaction for existing locally based fisheries.

A simpler expression of interaction is the percentage of recruitment (throughput) in the destination country that is due to immigration from the donor country (Kleiber, Argue and Kearney 1983). This estimate of interaction is independent of p[5], assuming that p is the same in the donor and destination countries.

There were four pairs of countries and territories in the Skipjack Programme study area for which it was possible to obtain quantitative estimates of interaction due to skipjack movement (Table 21). These were Papua New Guinea and Solomon Islands, New Zealand and Fiji, New Zealand and the Society Islands, and finally, New Zealand and Western Samoa. As shown in column 4 of the table, skipjack immigrants from the fished area in the donor countries were generally a small fraction of recruitment (throughput) in the destination countries' fished area (less than 10 per cent), which implies that interactions between fisheries in these countries are generally minor. It should be noted that this situation applies only to skipjack of the size tagged by the Programme (most were between 40 and 60 cm). Skipjack smaller than this range could very well move large distances and contribute significantly to interactions between stocks in the fished areas. However, as fisheries of the SPC region are not yet

---

5. p is a factor which corrects for tag shedding, non-reporting, and mortality due to tagging. It is a value from zero to one (ideally close to one).

exploiting fish less than 40 cm to any great degree, it can be reasonably assumed that fishery interactions resulting from movement of these small fish are presently negligible.

TABLE 21. SUMMARY OF FISHERY INTERACTION RESULTS BETWEEN SIX FISHERIES IN THE REGION

Country of Origin	Country of Destination	Average Annual Catch of Country of Destination in Tonnes (years)	Range of Estimated Percentages of Throughput of Migrants from Country of Origin to Country of Destination
Solomon Islands	Papua New Guinea	38400 (1978,1979)	1% to 5%
Papua New Guinea	Solomon Islands	22100 (1979-1981)	1% to 2%
New Zealand	Fiji	3800 (1979-1981)	8% to 12%
New Zealand	Western Samoa	700 (1976-1978)	14%
New Zealand	French Polynesia (Society Islands)	1500 (1978-1980)	9%
Fiji	New Zealand	8800 (1980-1981)	<1%

It has been pointed out (Skipjack Programme 1981c) that fishery interactions increase as the distance between fisheries decreases. Thus, if fisheries in neighbouring countries were to expand their areas of operation to include waters adjacent to their common borderlines, the degree of interaction could be expected to increase. Furthermore, if substantial fisheries were to develop in overlapping areas, such as purse-seine and pole-and-line fleets operating in the same waters of a country, then the degree of interaction would be much higher than that between present locally based fisheries which are all relatively isolated. Interactions affecting the skipjack resource in the waters of French Polynesia should be expected to remain small until fisheries develop much closer than the nearly 2,000 nautical miles presently separating the fishery in the Society Islands from major skipjack fisheries.

5.8.2 Interaction with the eastern Pacific

French Polynesia is an area of special interest to skipjack research because it lies between the major fisheries of the western and eastern Pacific. It has been shown (Matsumoto 1958, 1966; Klawe 1963) that larval skipjack are rare in waters east of 130°W and that skipjack with fully developed gonads are similarly not common in the eastern Pacific (Orange 1961; Klawe 1963). These larval, juvenile and gonad studies strongly suggest that there is limited skipjack spawning in the eastern Pacific, and that skipjack taken there have resulted from spawning in other regions, possibly including French Polynesia. Furthermore, as skipjack migration from the eastern Pacific to west of 140°W has been confirmed by tagging

(Anon 1979c), it has been the goal of many research expeditions (Appendix A) to determine if skipjack present in French Polynesia, at a size large enough to tag, contribute directly to the eastern Pacific fishery.

Rothschild (1965) discussed three central Pacific areas where eastern Pacific tuna might originate: the Hawaiian zone, equatorial zone, and Marquesan zone. He proposed that large numbers of skipjack from the Marquesan zone do not enter the eastern Pacific area. His supporting data included the zone's location in the southern hemisphere, size differences between Tahitian tuna and those in Hawaii, and immunogenetic data. Williams (1972) discussed three hypotheses on migration of young skipjack into the eastern Pacific based on oceanographic conditions. Unlike Rothschild's model, none of the models proposed by Williams exclude the Marquesas area as a contributor of fish to the eastern Pacific.

In the late 1950s when the eastern Pacific fishery was less developed, 4,584 skipjack were tagged in the Marquesas and Tuamotu Islands by the United States Fish and Wildlife Service (Wilson and Austin 1959). The Skipjack Programme tagged 20,282 skipjack on the two trips to the Marquesas and an additional 7,427 skipjack in the adjacent Tuamotu, Society and Gambier Islands. Prior to, and simultaneously with, these fish being tagged, IATTC tagged 2,346 skipjack in the Marquesas and 885 in the Society and Tuamotu areas (Bayliff and Hunt 1981). Table 22 summarises this tag release information. None of these 35,524 tagged skipjack have ever been recovered in the eastern Pacific fishery. Only seven have been recovered outside of French Polynesia (all towards the west, as discussed in Section 5.7.2), while 120 have been recovered locally. The very large number of skipjack tagged in the Marquesas in December 1979 and January 1980, and the relatively good catches and large geographical extent of the eastern Pacific fishery in the period after the tagging (Figures 8 and 9a), created a favourable situation for the recapture of tagged fish which migrated eastwards, yet none were recovered to the east.

A consideration of migration speeds and growth of skipjack offers one explanation of why fish tagged near the Marquesas have not been recaptured in the eastern Pacific. An examination of tag returns from areas directly to the west of the Marquesas, of skipjack that migrated eastwards, reveals an average speed of 7.6 miles per day. Similarly, the four skipjack that were tagged by the Skipjack Programme in the Marquesas, and recaptured outside French Polynesia, moved at 7.9, 7.7, 7.8 and 9.4 miles per day respectively. Therefore, if a tagged fish moved between the Marquesas and the eastern Pacific and behaved in the same manner as fish tagged by the Skipjack Programme in areas farther west, it would be expected to take between 300 to 350 days to reach the eastern Pacific.

The results of the Programme's growth studies show considerable variability (Skipjack Programme 1981e). Fish in the size range of 40 to 49 cm and at liberty from 181 to 450 days were shown to have an average annual growth rate of approximately 12 cm. It follows then that, if it takes between 300 to 350 days for migration from the Marquesas to the eastern Pacific, the average size of fish tagged in December 1979 and January 1980 would be about 59 cm upon entry into the eastern Pacific fishery. An inspection of the length frequency histograms for the eastern Pacific for 1967 to 1980 (Anon 1981c) shows that fish greater than 59 cm were a minor component of the eastern Pacific catch (less than 10 per cent

TABLE 22. SUMMARY OF TUNA TAGGING IN FRENCH POLYNESIA

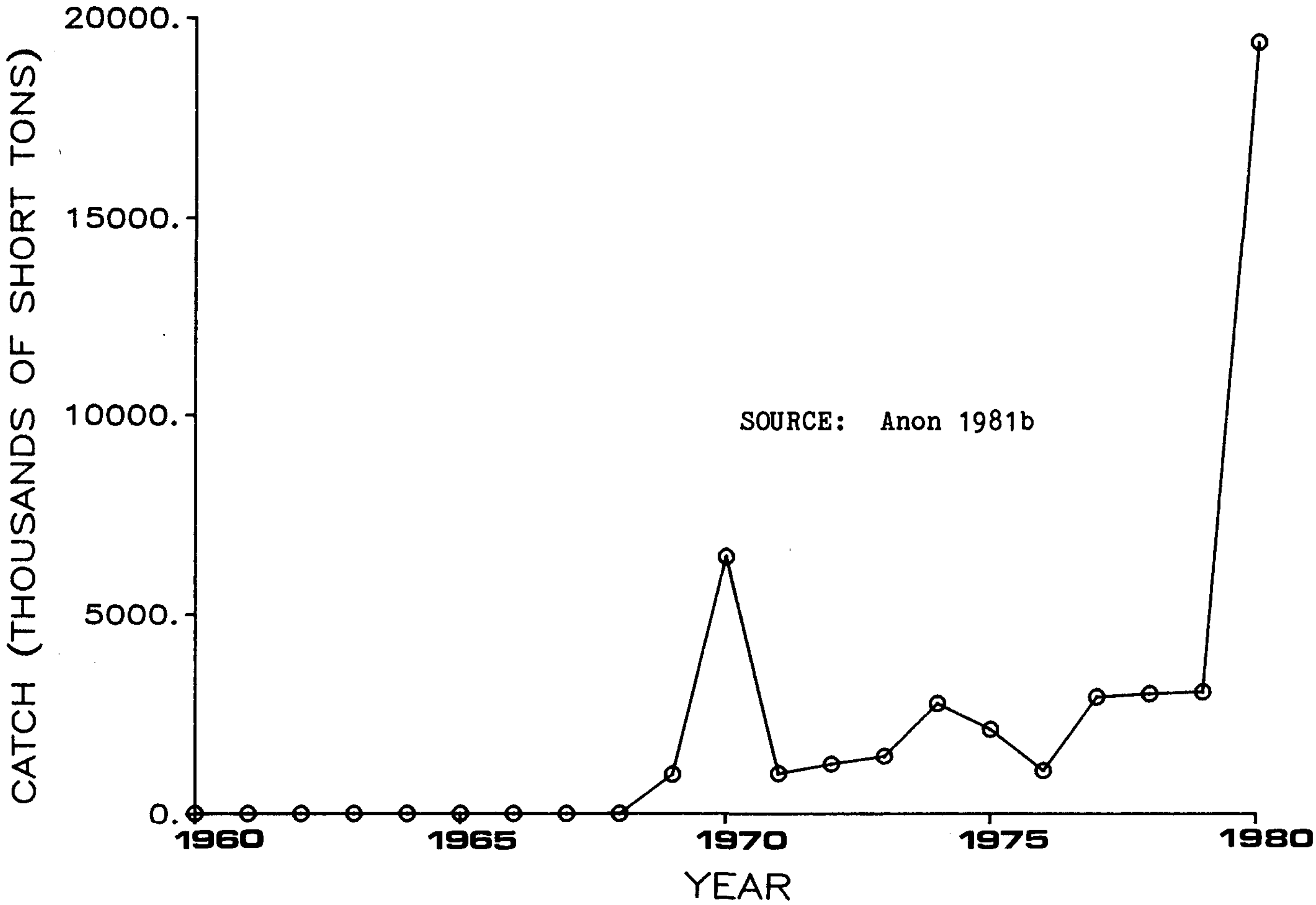
			Skipjack		Yellowfin		Tuna Species	
Vessel	Year	Location	Released	Recaptured	Released	Recaptured	Released	Recaptured
Hatsutori Maru No.5	1979/80	Marquesas	18,593	49	188	0	2	0
		Tuamotu	815	2	648	4	0	0
		Society	1	0	33	2	0	0
		Gambier	174	0	302	0	34	0
Hatsutori Maru No.1	1978/79	Marquesas	1,689	1	0	0	0	0
		Tuamotu	4,713	28	94	1	0	0
		Society	1,724	36	4	0	0	0
Cornucopia	1978/79	Marquesas	1,874	0	72	0	0	0
Mary K	1978	Marquesas	112	0	281	1	0	0
		Tuamotu	464	3	72	0	0	0
		Society	421	1	258	0	0	0
Tainui	1977	Marquesas	360	0	47	1	0	0
Charles H. Gilbert/ Hugh H. Smith	1957/58	Marquesas) Tuamotu)	4,584	0	196	0	0	0
		TOTAL	35,524	120	2,195	9	36	0

Details of fish known to have made international migrations are listed in Appendix E.

Source: As per Appendix A.

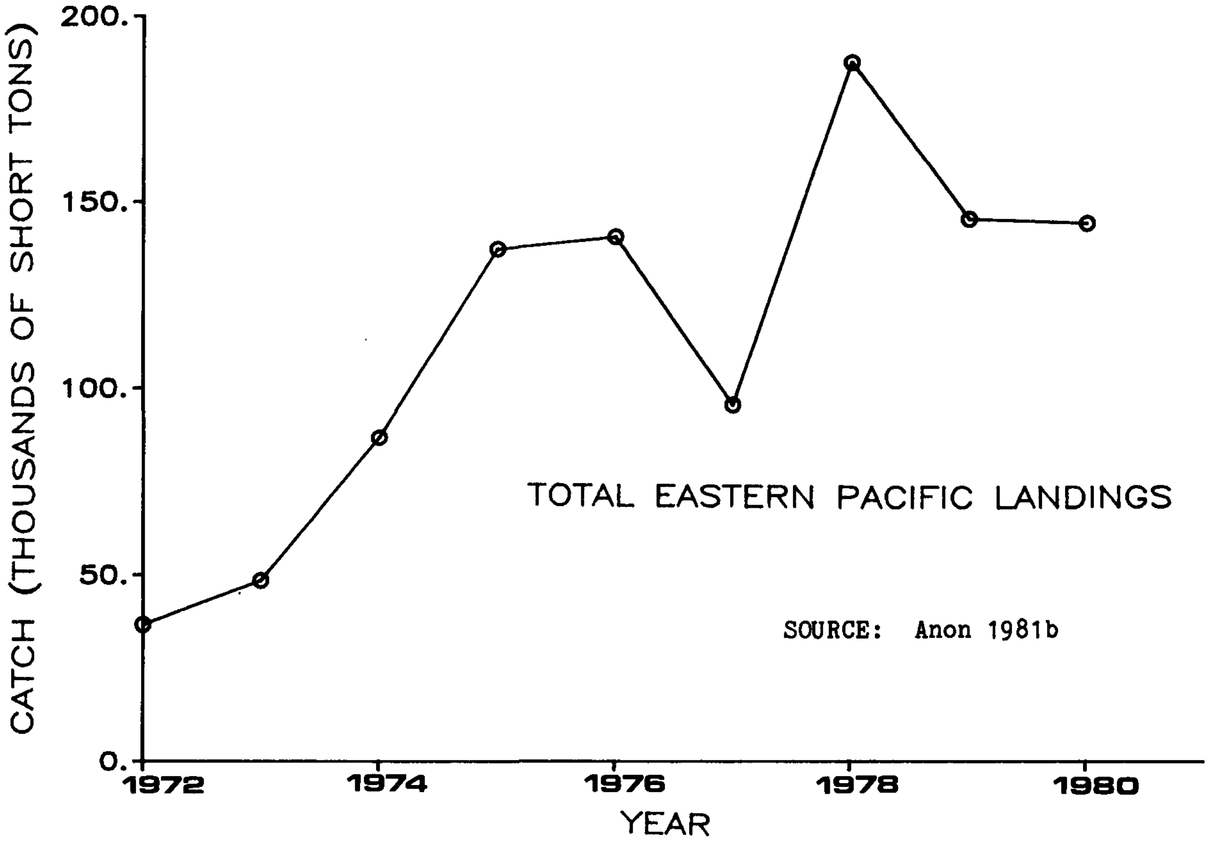
for the 12 months following tagging). Furthermore, there is evidence (Bayliff 1977; Bayliff, personal communication) from tagging and growth studies that at least part of the larger mode in the eastern Pacific skipjack catches is comprised of individuals recruited the previous year that stayed in the fishery an additional year. It is possible that most of these larger fish in the eastern Pacific are layovers, in which case fish of post-recruit size from the Marquesas could only account for a very small portion of the eastern Pacific catch.

FIGURE 8. CATCHES OF SKIPJACK IN THE EASTERN PACIFIC OUTSIDE THE YELLOWFIN REGULATORY AREA (OFFSHORE EASTERN PACIFIC FISHERY) OF IATTC



The above discussion suggests that movement of adult skipjack from the Marquesas to the eastern Pacific is limited, but does not exclude the possibility that larvae and juvenile skipjack drift or migrate in this direction. There is little skipjack spawning in the eastern Pacific, but the large numbers of tuna juveniles present in the Marquesas, as judged by the number of such specimens found in tuna stomachs (see Section 5.3.1), suggest that spawning is intense in this area. Such spawning could contribute significantly to recruitment in the eastern Pacific.

FIGURE 9a. TOTAL SKIPJACK CATCH IN THE EASTERN PACIFIC



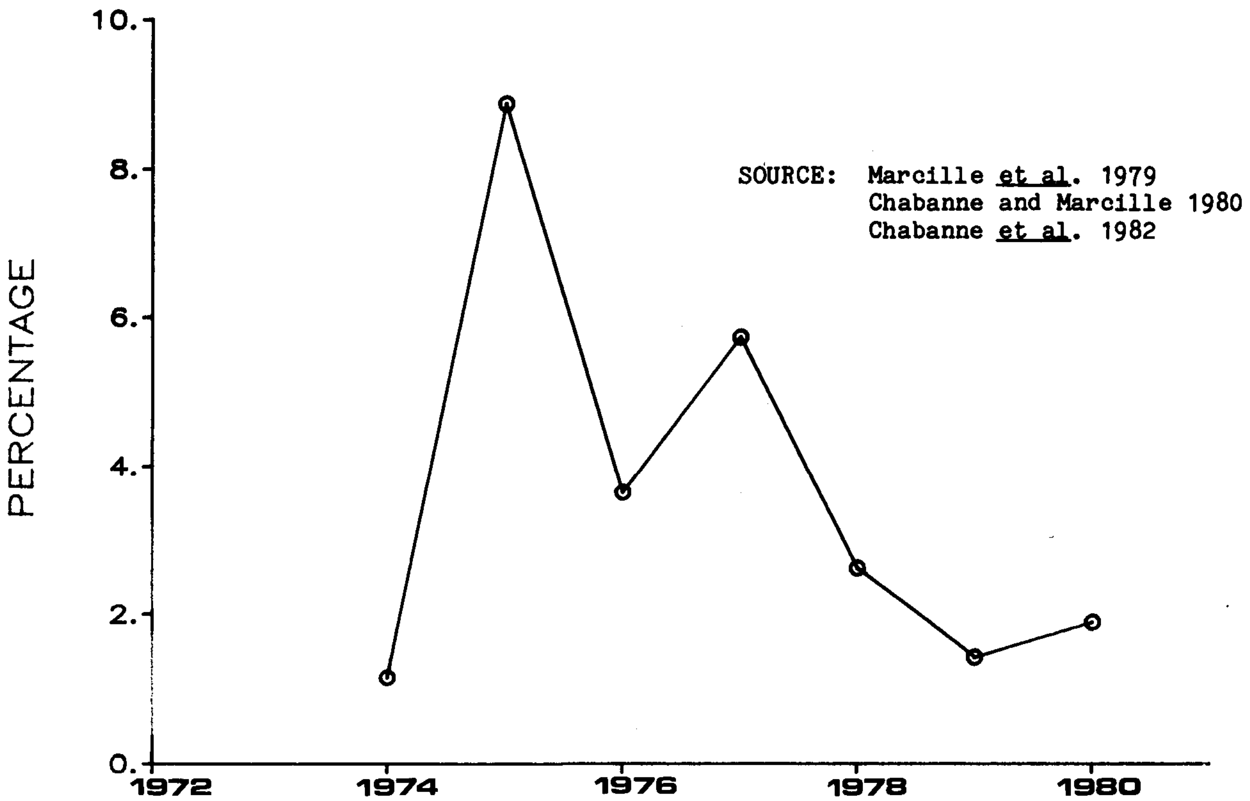


FIGURE 9b. PERCENTAGE OF SKIPJACK GREATER THAN 76 CM (LCF) IN THE TAHITIAN CATCH. Length frequency information collected by French research organisations in French Polynesia is expressed in rounded body length. In this report the lengths have been converted to LCF (length to caudal fork) by the use of Table 13 in Marcille *et al*. (1979).

Correlations have been found between indices of skipjack abundance in the eastern Pacific and sea surface temperatures in the spawning areas of the central tropical Pacific, approximately one and a half years earlier (Forsbergh 1980).

If the average-sized tuna juvenile encountered by the Skipjack Programme in the Marquesas (49.3 mm) was to drift passively, actively migrate, or a combination of the two, at a net rate of five nautical miles per day towards the centre of the eastern Pacific fishing grounds, and grow at the rate that Uchiyama and Struhsaker (1981) calculated for juvenile skipjack, it could arrive at a size similar to what Williams (1972) gives as the size at entry of small fish. Unfortunately, such movement is difficult to confirm as tuna juveniles are rarely captured by fishing gear, and studying the movements of these very small fish by conventional tagging techniques is not feasible at the present time.

One possibility of ascertaining if the eastern Pacific fishery is interacting with the fishery in French Polynesia is to study the size composition of skipjack in the French Polynesia fishery, and try to relate this to any increases in catch of the eastern Pacific skipjack fishery (Figures 9a and 9b). The time span of the present series of size frequency data is inadequate for this purpose; however, continuation of the existing size sampling programme in Tahiti could enable monitoring of this relationship, and should be encouraged.

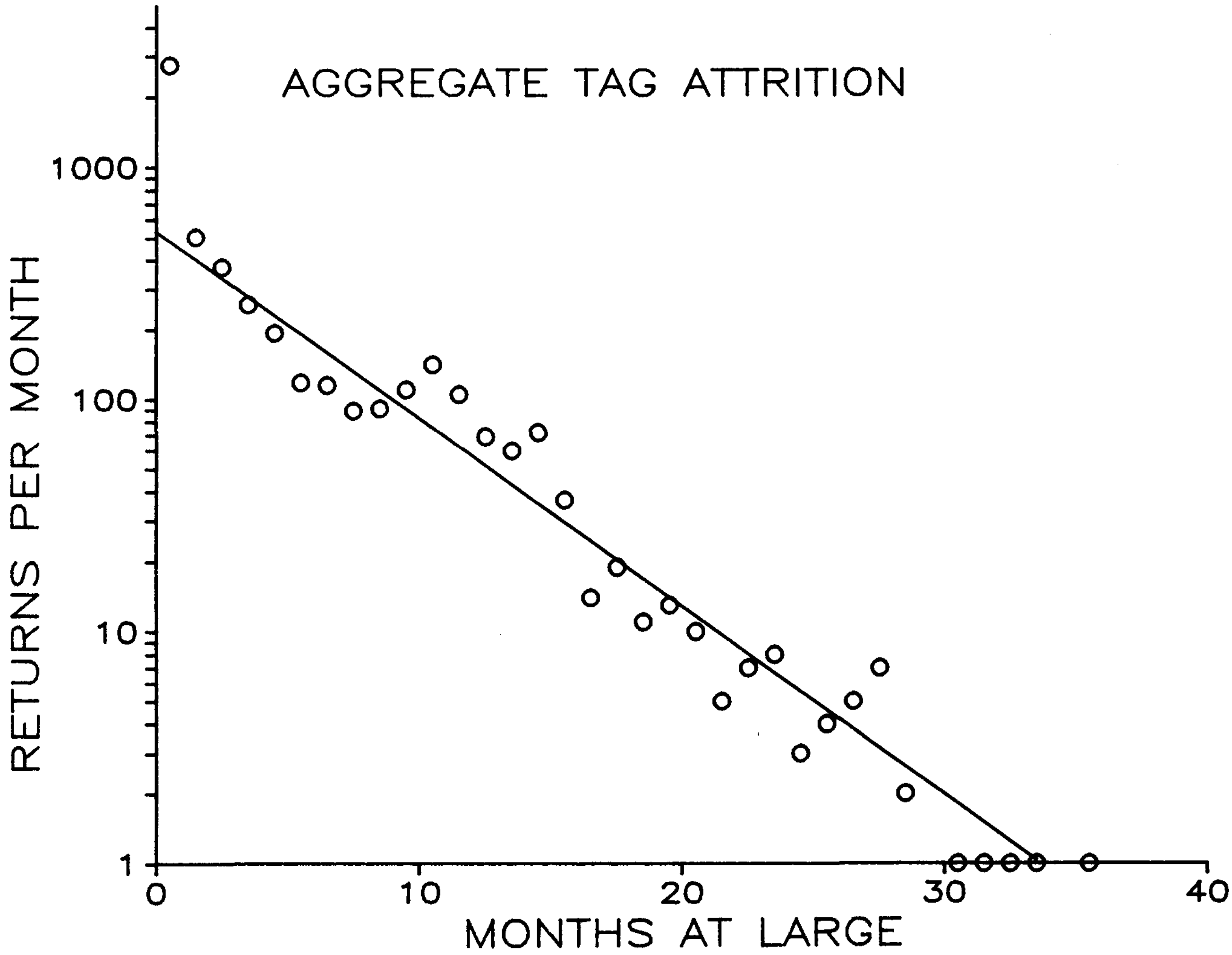
In summary, the tagging of large numbers of post-recruit skipjack over the years in French Polynesia suggests that there is little migration of these fish to the eastern Pacific, but for different reasons from those given by previous workers (e.g. Rothschild 1965).

5.9 Skipjack Resource Estimates

One of the major reasons for tagging skipjack was to estimate various parameters of population dynamics considered necessary for assessing the magnitude and resilience to fishing pressure of the skipjack resource. Important parameters considered were: (1) the population, which is the standing stock of fish which are vulnerable to the fishery; (2) the attrition rate, which in steady state conditions is the population turnover rate, or in other words the proportion of the population cycling through the area in a period of time due to immigration, emigration, local productivity and mortality; (3) the throughput; population size times the turnover rate, which is the tonnes of fish cycling through the area per unit time; and (4) the exploitation rate, which is the proportion of the population which is harvested. Of the four parameters, throughput is the most useful measure of the skipjack resource because it is a rate against which catch (also a rate) can be compared. A high throughput relative to catch is evidence (though not proof) that the fishing pressure is not having a serious impact on the fish stocks. on the fish stocks.

Some analyses of skipjack mortalities based on the whole of the Programme's data set have been completed (Skipjack Programme 1981c; Kleiber, Argue and Kearney 1983). In order to evaluate the skipjack resources of the whole region, these studies examined the Skipjack Programme's tag release and recovery data in aggregate. Figure 10 shows the returns received per monthly period at liberty plotted against time at large, exclusive of returns with imprecise date of recapture and recaptures by the Programme's tagging vessel. The values plotted represent the returns per month which would have resulted had all the tags been released on the same day. As expected, the return rate declines with time at an approximately logarithmic rate.

FIGURE 10. AGGREGATE SKIPJACK TAG RETURNS PER MONTH



In order to obtain parameter estimates and confidence ranges for the estimates, a tag recapture and attrition model (Kleiber, Argue and Kearney 1983) was fitted by an iterative regression technique (Conway, Glass and Wilcox 1970) to the recovery data in Figure 10. The best fitting values for these parameters and the 95 per cent confidence limits are given in Table 23.

The average catch for the whole of the study area during the years that the tags were at large, approximately 19,000 tonnes per month, is very low compared to the throughput of 520,000 tonnes per month.

These parameter estimates were derived from aggregate tag recovery rates over the whole of the study area. As such they represent average

TABLE 23. SKIPJACK POPULATION PARAMETERS ESTIMATED FROM TWO SETS OF TAG RETURNS. The aggregate set includes skipjack returns from anywhere from all releases by the Skipjack Programme. The Society Islands set is from tags released in December 1978 and January 1979. The factor, p, corrects for the recaptured tags that are not returned or retained with insufficient data, for mortality due to tagging, and for tag shedding. It is a value between 0 and 1 (ideally close to 1). Numbers in brackets give the 95 per cent confidence ranges.

	Turnover ($months^{-1}$)	Population/p (tonnes)	Throughput/p (tonnes/month)	Approximate Average Catch During Recovery Period (tonnes/month)	Average Exploitation·p ($months^{-1}$)
Total study area returns	0.17 (0.15-0.20)	3.0 (2.5-3.7) ($X10^6$)	520 (460-590) ($X10^3$)	$19X10^3$	0.0063(0.0051-0.0077)
Society Islands	0.59 (0.20-1.3)	9.7 (1.8-67.1) ($X10^3$)	5.7 (2.1-20.1) ($X10^3$)	100	0.010(0.001-0.055)

values for a large region and the values for particular countries could vary considerably.

The model can also be applied to tag return data from releases in the waters of individual countries. To do so, it is necessary to have a considerable number of tagged fish recovered in the area and a record of the fishing effort and/or catch. The lack of these data for the Marquesas, Tuamotu or Gambier Islands meant that it was not possible to estimate skipjack population parameters in these areas. Although the number of tag returns in the Society Islands was not great, it does allow some insight into skipjack population dynamics in the area.

Catch and tag return data for the Society Islands (Table 24) were used in the tag attrition model discussed above. Figure 11 compares the actual number of tag returns to expected values as predicted from the model. The population parameters which minimise the difference between the observed and expected are given in Table 23.

TABLE 24. SOCIETY ISLANDS TAG RETURN AND CATCH DATA[1]

Month Recapture	No. of Tag Returns	Catch	
12/78	0	18.3	(84.4)[2]
01/79	1	49.2	
02/79	4	54.8	
03/79	4	78.3	
04/79	1	95.4	
05/79	3	149.4	
06/79	2	110.8	
07/79	0	81.6	
08/79	0	77.0	
09/79	0	41.1	
10/79	0	53.2	
11/79	0	87.5	
12/79	0	47.0	
01/80	0	160.0	

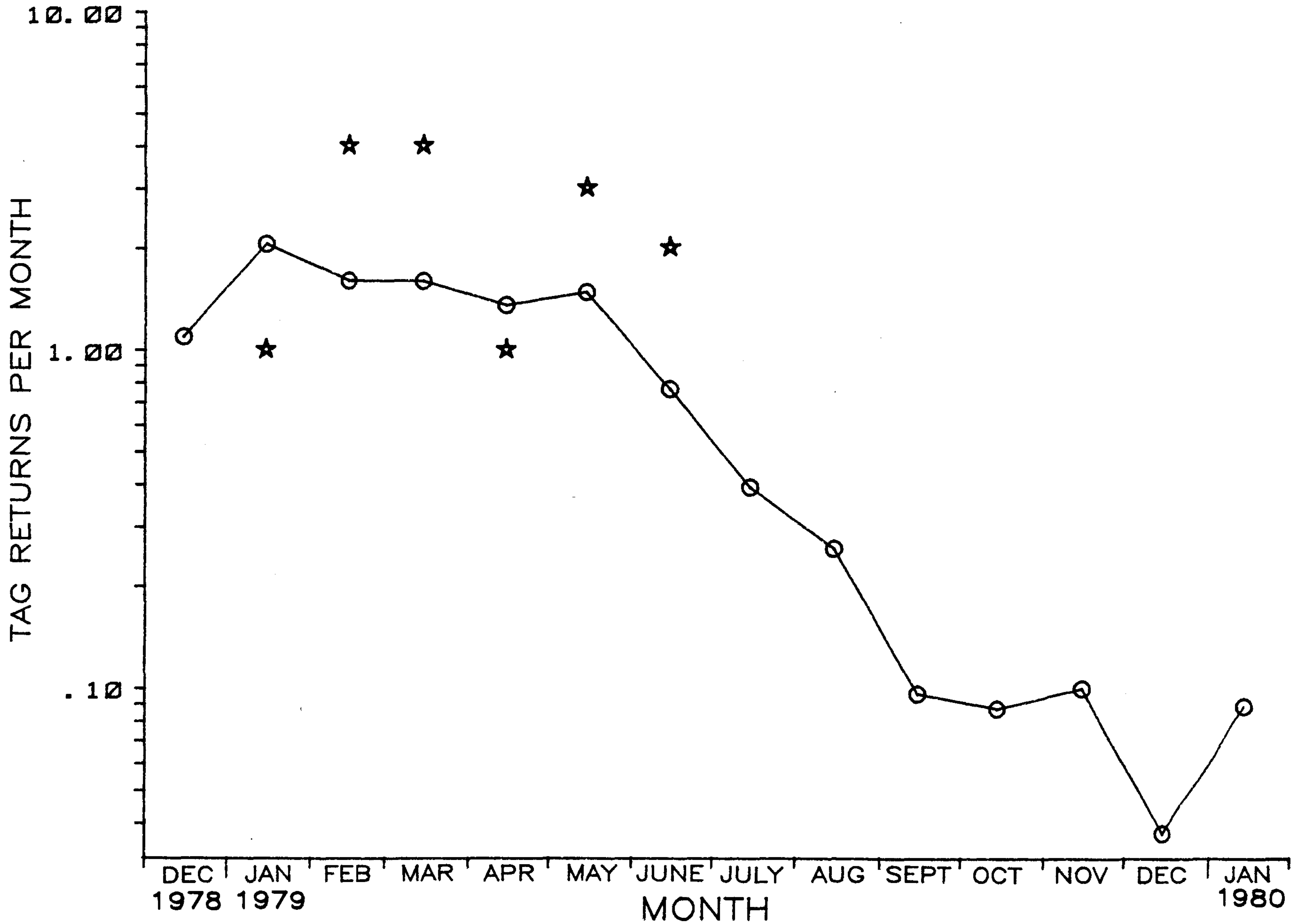
Average Catch = 83.5 tonnes/month

1 Estimated from: Marcille *et al*. (1979)
Chabanne and Marcille (1980)
Chabanne, personal communication.

2 Catch in December 1978 prorated for portion of month for which tagged fish were at large.

The exploitation rate for the Society Islands from Table 23 lies between the average for the whole study area, which includes vast areas where there is currently no fishery (e.g. the Marquesas Islands), and the exploitation rate for particular countries where there is an active fishery (i.e. Fiji, Solomon Islands). As for the overall data set discussed above, the small size of the present Society Islands catch compared to the

FIGURE 11. ACTUAL AND PREDICTED NUMBER OF TAG RETURNS FROM TAG RELEASES IN THE SOCIETY ISLANDS IN DECEMBER 1978 AND JANUARY 1979. Stars represent actual tag returns and circles represent values predicted from the tag recapture and attrition model.



throughput (about two per cent) leads to the conclusion that the local fishery in the Society Islands is not having a sizeable impact on the skipjack stocks. In fact, on the basis of these population studies, a great deal more effort can be exerted by the fishery without detrimental effects on the overall population.

5.10 Yellowfin Tuna

Although the Skipjack Programme concentrated on studies of skipjack, other tuna species, primarily yellowfin tuna, were studied on an opportunistic basis. These investigations included tagging, examination of stomach contents, inspection of gonads, and collection of length frequency data.

Details on the occurrence of tuna juveniles in the stomachs of yellowfin, and the occurrence of juvenile yellowfin in the stomachs of other predators, are given in Section 5.3.1. Yellowfin length frequency data for the surveys of French Polynesia are presented in Appendix C.

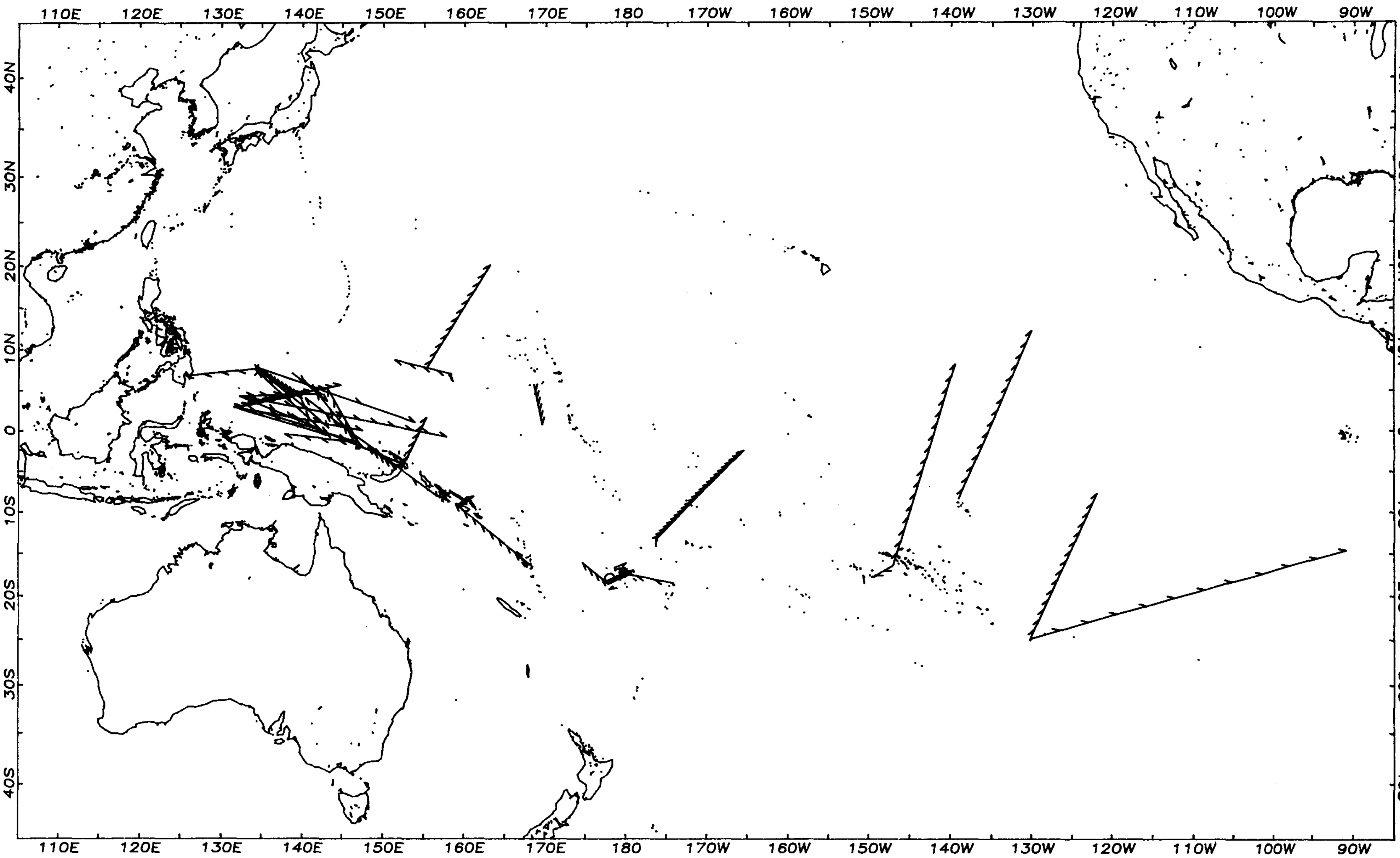
Figure 12 gives straight line migration arrows for tag recoveries from yellowfin for the entire study area. In addition to the Skipjack Programme's yellowfin tag returns, also plotted are two yellowfin recaptures released by IATTC in French Polynesia. A characteristic of yellowfin migrations in general is that they tend to be more limited than those of skipjack. From Figure 12 it can be seen that the movements of yellowfin in French Polynesia and the adjoining Pitcairn Islands area appear to be more extensive than for yellowfin in areas farther west. Four yellowfin from this central Pacific area were recaptured in the offshore eastern Pacific fishery, two by purse-seine vessels and two by longline vessels. This is especially interesting as few yellowfin tagged in the inshore eastern Pacific fishery have been recaptured in the offshore area (Schaefer, Milner and Broadhead 1961; Joseph et al. 1964). This may indicate that offshore eastern Pacific yellowfin stocks are more closely related to central Pacific stocks than to those of the inshore eastern Pacific areas. Considering the importance of the eastern Pacific yellowfin fishery and the stock management presently in effect, it is quite possible that this subject will receive additional attention in the future.

Yellowfin return rates for the entire study area are approximately half of the return rates for skipjack. However, in French Polynesia a similar percentage of each species was recovered; 1,269 yellowfin were tagged by the Skipjack Programme and 7 tags were returned (0.55%), compared to 116 recoveries out of 27,709 skipjack releases (0.42%). This relatively high recovery rate for yellowfin in French Polynesia is probably a result of proportionally more yellowfin having been tagged in areas with greater fishing effort (Table 3).

6.0 CONCLUSIONS

It is appreciated that there are limitations to resource assessments that are based largely on data from two short visits to a country. However, the data generated by the Skipjack Programme throughout the central and western Pacific are relevant to the overall evaluation of the resources of French Polynesia. Therefore, these data, in combination with

FIGURE 12. YELLOWFIN MIGRATION ARROWS (INCLUDING TWO IATTC RECAPTURES RELEASED IN THE MARQUESAS ISLANDS). Tick marks represent 30-day periods between release and recapture. Movements have been selected to show no more than one example of movement between any pair of five degree squares; 44 arrows plotted out of a total of 200.



other documents referenced, provide assessments that were not previously possible and which are submitted as being the best available at the present time.

Although the Skipjack Programme made reasonably good baitfish catches around the Marquesas Islands, there are numerous indications that the favourable catches in this area probably could not be sustained over a long period. There is insufficient reliable data to evaluate fully the potential for baitfishing in the Tuamotu Islands, but indications are that the resources are not great. The Society Islands, which have been the subject of numerous baitfish surveys, have been shown to be lacking in sizeable baitfish resources. Therefore, it appears that if a live-bait fishery is to be established in French Polynesia making use of naturally occurring species, it would necessarily be of small scale.

The overall migration study reveals that skipjack is a truly regional resource. Tagging data demonstrate some interaction between fisheries in French Polynesia and those at considerable distance, but due to the small size and scattered distribution of the fisheries, this interaction is at present thought to be slight. Interaction with the major skipjack fishery in the eastern Pacific is unlikely to be large for fish of post-recruit size.

Stomach content and gonad data suggest that intensive skipjack spawning occurs in French Polynesia. This spawning could very well contribute to recruitment to the eastern Pacific fisheries, a notion supported by the blood genetics data.

Genetic analysis of blood samples shows that skipjack present in French Polynesia, together with the other locations in the study area, do not constitute a Pacific-wide panmictic stock, although genetically isolated subgroups could not be identified. The flattening of the skipjack esterase gradient between French Polynesia and the eastern Pacific suggests a common origin for skipjack in both areas. Data on the occurrence of skipjack parasites also suggest that there are no discrete subpopulations of skipjack in the central and western Pacific.

Tagging studies suggest that skipjack growth rates are variable and likely to be influenced by environmental conditions.

On the basis of available data, it appears as though skipjack are abundant in French Polynesia, especially in the Marquesas and Tuamotu Islands. Past attempts to develop large-scale commercial skipjack fisheries have failed due to factors other than skipjack abundance. Even though previous purse-seining trials in French Polynesia have not been very encouraging, recent innovations in seining technology offer promise for this area.

The available data indicate that the present fishery is having a minimal impact on the skipjack population and that catches could increase considerably without detrimental effects. Restrictions on the future expansion of the skipjack fishery in French Polynesia above present levels are not likely to be biological in nature.

REFERENCES

ANDERSON, E. (1963). Tahitian bonito fishing. Kroeber Anthropological Society Papers No.28.

ANON (undated a). Cruise report M/V Kerri M, Marquesas Island area, 15 October-8 November 1972. Living Marine Resources Inc., San Diego, California.

ANON (undated b). Sea Treasure cruise, October 15-December 10, 1974.

ANON (1954). Tuna and live bait plentiful near Marquesas Islands Charles H. Gilbert (Cruise 15). Commercial Fisheries Review 16(6):6.

ANON (1956). Narrative report Hugh M. Smith, Cruise No.31. United States Department of the Interior, Fish and Wildlife Service, Pacific Oceanic Fishery Investigations, Honolulu.

ANON (1957). POFI activities. Pan American Fisherman 11(9):16.

ANON (1958). Skipjack tuna and live-bait sardines found abundant in Marquesas Islands area (M/V Hugh M. Smith, Cruise 42). Commercial Fisheries Review 20(4):34-35.

ANON (1974). Situation des recherches entreprises sur la bonite (Katsuwonus pelamis) en Polynésie française. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vairao, Tahiti.

ANON (1976). Rapport de mission. Campagne expérimentale du Sasayama Maru No.1, 17 avril-7 mai 1976. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vairao, Tahiti.

ANON (1978a). Navire expérimental Tainui fiche résultats années 1976 et 1977. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vairao, Tahiti.

ANON (1978b). Compte-rendu d'activité No.4/78. Campagne de pêche effectuée par le Tainui du jeudi 30 mars 1978 au jeudi 20 avril 1978, aux Iles Sous-le-Vent. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vairao, Tahiti.

ANON (1978c). Compte-rendu d'activité de la campagne de pêche effectuée par le Tainui du 28 octobre 1978 au 11 novembre 1978. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vairao, Tahiti.

ANON (1978d). Compte-rendu d'activité No.8/78. Mission au profit du Service de la pêche à Scilly effectuée par le Tainui du vendredi 13 au 21 octobre 1978. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vairao, Tahiti.

ANON (1978e). Compte-rendu d'activité No.3/78 de la campagne de pêche effectuée par le Tainui du vendredi 10 mars 1978 au mardi 21 mars 1978 aux Iles Sous-le-Vent. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vàirao, Tahiti.

ANON (1978f). Compte-rendu d'activité de la campagne de pêche effectuée par le Tainui du lundi 19 septembre au 16 novembre 1977 au profit de l'IATTC aux Tuamotu et Iles Marquises. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vairao, Tahiti.

ANON (1978g). Report on tuna tagging activities in the Marquesas Islands, September-November 1977. Inter-American Tropical Tuna Commission, La Jolla, California.

ANON (1978h). Report on tuna tagging activities in the Marquesas, Tuamotu and Society Islands, February-April 1978. Inter-American Tropical Tuna Commission, La Jolla, California.

ANON (1978i). Compte-rendu sur la mission de marquage de thonidés entreprise par le Mary K aux Iles Marquises au profit de l'IATTC du 22 février au 19 mars 1978. Centre national pour l'exploitation des océans, Délégation du CNEXO pour l'océan Pacifique.

ANON (1978j). Compte-rendu sur la mission de marquage de thonidés entreprise par le Mary K aux Iles Sous-le-Vent au profit de l'IATTC du 25 mars au 12 avril 1978. Centre national pour l'exploitation des océans, Délégation du CNEXO pour l'océan Pacifique.

ANON (1979a). Rapport de pêche à l'appât vivant. Société de commercialisation et d'exploitation du poisson, Tahiti.

ANON (1979b). Report on tuna tagging activities in the Marquesas Islands, December 1978-May 1979. Inter-American Tropical Tuna Commission, La Jolla, California.

ANON (1979c). 1978 Annual Report of the Inter-American Tropical Tuna Commission. Inter-American Tropical Tuna Commission, La Jolla, California.

ANON (1980a). Rapport de mission No.391. Service de la pêche, Papeete, Tahiti.

ANON (1980b). Opération thon Pacifique. Compte-rendu semestriel - juin 1980. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vairao, Tahiti.

ANON (1980c). Report on tuna tagging activities in the Marquesas, Pitcairn, Gambier and Tuamotu Islands, December 1979-February 1980. Inter-American Tropical Tuna Commission, La Jolla, California.

ANON (1980d). 1979 Annual Report of the Inter-American Tropical Tuna Commission. Inter-American Tropical Tuna Commission, La Jolla, California.

ANON (1980e). South Pacific economies 1978: statistical summary (Edition No.4). South Pacific Commission, Noumea, New Caledonia.

ANON (1980f). Review of preliminary results from genetic analysis of skipjack blood samples collected by the Skipjack Survey and Assessment Programme. Skipjack Survey and Assessment Programme Technical Report No.1, South Pacific Commission, Noumea, New Caledonia.

ANON (1981a). Report of the second Skipjack Survey and Assessment Programme workshop to review results from genetic analysis of skipjack blood samples. Skipjack Survey and Assessment Programme Technical Report No.6, South Pacific Commission, Noumea, New Caledonia.

ANON (1981b). South Pacific economies 1979: statistical summary (Edition No.5). South Pacific Commission, Noumea New Caledonia.

ANON (1981c). 1980 Annual Report of the Inter-American Tropical Tuna Commission. Inter-American Tropical Tuna Commission, La Jolla, California.

ANON (1981d). Forum Fisheries Agency Weekly News Telex for week ending 2 July 1981, Forum Fisheries Agency, Honiara, Solomon Islands.

ANON (1982a). Un canneur japonais dans nos eaux. La Dépêche de Tahiti, 9 septembre 1982. p 14.

ANON (1982b). Les accords de pêche 82-83. La Dépêche de Tahiti, 31 août 1982.

ANON (1982c). South Pacific economies 1980: statistical summary (Edition No.6). South Pacific Commission, Noumea, New Caledonia.

ARGUE, A.W. (1982). Methods used by the Skipjack Survey and Assessment Programme for collecting biological, tuna school and ancillary data from a pole-and-line fishing vessel. In Kearney, R.E. (ed.). Methods used by the South Pacific Commission for the survey and assessment of skipjack and baitfish resources. Tuna and Billfish Assessment Programme, Technical Report No.7, South Pacific Commission, Noumea, New Caledonia.

ARGUE, A.W., F. CONAND and D. WHYMAN (1983). Juvenile tunas from stomachs of skipjack and other surface tunas caught by pole-and-line gear in the Pacific Ocean. Tuna and Billfish Assessment Programme, Technical Report No.9, South Pacific Commission, Noumea, New Caledonia.

AUSTIN, T.S. (1957). Summary, oceanographic and fishery data, Marquesas Islands area, August-September, 1956 (EQUAPAC). United States Fish and Wildlife Service Special Scientific Report - Fisheries No.217.

AUSTIN, T.S. (1962). Report on tuna surveys in the Marquesas Islands. United States Bureau of Commercial Fisheries.

BALDWIN, W.J. (1977). A review on the use of live baitfishes to capture skipjack tuna, Katsuwonus pelamis, in the tropical Pacific Ocean with emphasis on their behaviour, survival and availability. In Shomura, R.S. (ed.). Collection of tuna baitfish papers. United States Department of Commerce, National Oceanic and Atmospheric Administration Technical Report, National Marine Fisheries Service Circular 408:8-35.

BARD, F.X. (1974). Preliminary research on skipjack through the Tahitian fishery. Paper presented at the 21st Tuna Conference, Lake Arrowhead, U.S.A., September-October 1974. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vàirao, Tahiti.

BAYLIFF, W.H. (1977). Estimates of the rates of mortality of skipjack tuna in the eastern Pacific Ocean derived from tagging experiments. Inter-American Tropical Tuna Commission Internal Report No.10, Inter-American Tropical Tuna Commission, La Jolla, California.

BAYLIFF, W.H. and G.A. HUNT (1981). Exploratory fishing for tunas and tuna tagging in the Marquesas, Tuamotu, Society, Pitcairn, and Gambier Islands. Inter-American Tropical Tuna Commission Special Report No.3, Inter-American Tropical Tuna Commission, La Jolla, California.

BESSINETON C. (1976). La pêche des bonitiers à Tahiti. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vàirao, Tahiti.

CHABANNE, J. (1980). Tuna fishing in the exclusive economic zone of French Polynesia in 1979. Regional Technical Meeting on Fisheries 1980, 12 : Working Paper No.22, South Pacific Commission, Noumea, New Caledonia.

CHABANNE, J. and F. GALLETT (1982). La pêche bonitière en Polynésie française en 1981. Notes et documents d'océanographie No.17. Office de la recherche scientifique et technique outre-mer, Centre ORSTOM de Papeete.

CHABANNE, J. and P. JAMES (1980). La pêche des navires palangriers japonais dans la zone économique exclusive de Polynésie française, octobre 1979-avril 1980. Notes et documents d'océanographie No.21. Office de la recherche scientifique et technique outre-mer, Centre ORSTOM de Papeete.

CHABANNE, J. and J. MARCILLE (1980). La pêche bonitière en Polynésie française en 1979. Office de la recherche scientifique et technique outre-mer, Centre ORSTOM de Papeete. No.13.

CHABANNE, J., L. MAREC and A. ASINE (1982). La pêche bonitière en Polynésie française en 1980. Notes et documents d'océanographie No.15. Office de la recherche scientifique et technique outre-mer, Centre ORSTOM de Papeete.

CONWAY, G.R., N.R. GLASS and J.C. WILCOX (1970). Fitting nonlinear models to biological data by Marquardt's algorithm. Ecology 51(3):503-507.

DALZELL, P.J. and J.W.J. WANKOWSKI (1980). The biology population dynamics and fisheries dynamics of exploited stocks of three baitfish species, Stolephorus heterolobus, S. devisi, and Spratelloides gracilis in Ysabel Passage, New Ireland Province. Papua New Guinea, Department of Primary Industry Research Bulletin 22.

DOUMENGE, F. (1973). The development of tuna and skipjack fishing in French Polynesia and experience in live-bait techniques. South Pacific Islands Fisheries Newsletter 10:27-30.

ELLWAY, C.P. and R.E. KEARNEY (1981). Changes in the Fijian baitfishery 1974-1980. Skipjack Survey and Assessment Programme Technical Report No.5, South Pacific Commission, Noumea, New Caledonia.

FORSBERGH, E. (1980). Synopsis of biological data on the skipjack tuna, *Katsuwonus pelamis* (Linnaeus, 1758), in the Pacific Ocean. In Bayliff, W.H. (ed.). Inter-American Tropical Tuna Commission Special Report No.2. Inter-American Tropical Tuna Commission, La Jolla, California.

FRANCK, N. (1982). La pêche au thon de nuit donne des résultats très intéressants. La Dépêche de Tahiti, 5 janvier 1982. No.4,797.

FUJINO, K. (1966). Instructions for collecting blood and serum samples from tuna fishes. FAO Circular 26, Food and Agriculture Organization, Rome, Italy.

GILLETT, R.D. and R.E. KEARNEY (1980). Second interim report of the activities of the Skipjack Survey and Assessment Programme in the waters of French Polynesia (13 December 1979-2 February 1980, 5-17 February 1980). Skipjack Survey and Assessment Programme Preliminary Country Report No.21, South Pacific Commission, Noumea, New Caledonia.

HALLIER, J.-P. (1980). Compte-rendu de la mission effectuée à Tahiti et aux Tuamotu de l'ouest du 8 au 25 avril 1980. Centre national pour l'exploitation des océans, Centre océanologique du Pacifique, Vairao, Tahiti.

HALLIER, J.-P. and R.D. GILLETT (1982). Baitfishing methods used by the Skipjack Survey and Assessment Programme and their comparison with those used by commercial Japanese pole-and-line vessels. In Kearney, R.E. (ed.). Methods used by the South Pacific Commission for the survey and assessment of skipjack and baitfish resources. Tuna and Billfish Assessment Programme Technical Report No.7, South Pacific Commission, Noumea, New Caledonia.

HALLIER, J.-P. and R.E. KEARNEY (1980). Second interim report of the activities of the Skipjack Survey and Assessment Programme in the waters of Kiribati (22 November-5 December 1979). Skipjack Survey and Assessment Programme Preliminary Country Report No.20, South Pacific Commission, Noumea, New Caledonia.

HANDY, E.S.C. (1932). Houses, boats, and fishing in the Society Islands. Bernice P. Bishop Museum Bulletin No.90, Honolulu, Hawaii.

HENIN, C., B. CALVEZ, F. CONAND, C. HOFFSCHIR, E. JOSSE and P. WAIGNA (1980). Rapport de la "Campagne du Thon Austral 01" à bord du N.O. Coriolis, 1er février-1er avril 1978. Rapport scientifique et technique No.9, Office de la recherche scientifique et technique outre-mer, Centre ORSTOM de Nouméa.

HIDA, T.S. and R.A. MORRIS (1963). Preliminary report on the Marquesan sardine, Harengula vittata, in Hawaii. Pacific Science 17(4):431-437.

HIDA, T.S. and J.H. UCHIYAMA (1977). Biology of the baitfishes Herklotsichthys punctatus and Pranesus pinguis in Majuro, Marshall Islands. In Shomura, R.S. (ed.). Collection of tuna baitfish papers. United States Department of Commerce, National Oceanic and Atmospheric Administration Technical Report, National Marine Fisheries Service Circular 408:8-35.

JAMES, P. (1982). L'appât vivant dans les Tuamotu du nord-ouest. Notes et documents d'océanographie No.14. Office de la recherche scientifique et technique outre-mer, Centre ORSTOM de Papeete.

JOHANNES, R.E. (1981). Words of the lagoon: fishing and marine lore in the Palau district of Micronesia. University of California Press, Berkeley.

JOSEPH, J., F. ALVERSON, B. FINK and E. DAVIDOFF (1964). A review of the population structure of yellowfin tuna, Thunnus albacares, in the eastern Pacific Ocean. Inter-American Tropical Tuna Commission Bulletin 9(2), Inter-American Tropical Tuna Commission, La Jolla, California.

KEARNEY, R.E. (1973). A brief outline of the first year of the Papua New Guinea skipjack fishery. South Pacific Islands Fisheries Newsletter No.9.

KEARNEY R.E. (1978). Interim report of the activities of the Skipjack Survey and Assessment Programme in the waters of Fiji (26 January-18 February, 28 March-10 April 1978). Skipjack Survey and Assessment Programme Preliminary Country Report No.5, South Pacific Commission, Noumea, New Caledonia.

KEARNEY, R.E. and R.D. GILLETT (1982). Methods used by the Skipjack Survey and Assessment Programme for tagging skipjack and other tuna. In Kearney, R.E. (ed.). Methods used by the South Pacific Commission for the survey and assessment of skipjack and baitfish resources. Tuna and Billfish Assessment Programme Technical Report No.7, South Pacific Commission, Noumea, New Caledonia.

KEARNEY, R.E. and J.-P. HALLIER (1980). Second interim report on the activities of the Skipjack Survey and Assessment Programme in the waters of the Trust Territory of the Pacific Islands (2-21 November 1979). Skipjack Survey and Assessment Programme Preliminary Country Report No.19, South Pacific Commission, Noumea, New Caledonia.

KEARNEY, R.E., J.-P. HALLIER and R.D. GILLETT (1979). Interim report on the activities of the Skipjack Survey and Assessment Programme in the waters of French Polynesia (6 December 1978-3 February 1979). Skipjack Survey and Assessment Programme Preliminary Country Report No.14, South Pacific Commission, Noumea, New Caledonia.

KEARNEY R.E. and M.L. RIVKIN (1981). An examination of the feasibility of baitfish culture for skipjack pole-and-line fishing in the South

Pacific Commission area. *Skipjack Survey and Assessment Programme Technical Report* No.4, South Pacific Commission, Noumea, New Caledonia.

KENT, J. (1980). The politics of Pacific Island fisheries. Westview Press, Boulder, Colorado.

KLAWE, L. (1963). Observations of the spawning of four species of Tuna (*Neothunnus macropternus, Katsuwonus pelamis, Auxis thazard, Euthynnus lineatus*) in the eastern tropical Pacific based on distribution of their larvae and juveniles. *Inter-American Tropical Tuna Commission Bulletin* No.6:447-540, Inter-American Tropical Tuna Commission, La Jolla, California.

KLAWE, W.L. (1978). Estimates of catches of tunas and billfishes by the Japanese, Korean and Tawainese longliners from within the 200 mile economic zone of the member countries of the South Pacific Commission. *South Pacific Commission Occasional Paper* No.10, South Pacific Commission, Noumea, New Caledonia.

KLEIBER, P., A.W. ARGUE and R.E. KEARNEY (1983). Assessment of skipjack resources in the central and western Pacific by estimating standing stock and components of population turnover from tagging data. *Tuna and Billfish Assessment Programme Technical Report* No.8, South Pacific Commission, Noumea, New Caledonia.

KLEIBER, P.M. and C.A. MAYNARD (1982). Data processing procedures of the Skipjack Survey and Assessment Programme. *In* Kearney, R.E. (ed.). Methods used by the South Pacific Commission for the survey and assessment of skipjack and baitfish resources. *Tuna and Billfish Assessment Programme Technical Report* No.7, South Pacific Commission, Noumea, New Caledonia.

LAWSON, T.A. and R.E. KEARNEY (Manuscript). Estimates of growth rates and length measurement errors for skipjack (*Katsuwonus pelamis*) from the western Pacific Ocean based on tagging data. *Tuna and Billfish Assessment Programme Technical Report*, South Pacific Commission, Noumea, New Caledonia.

LESTER, R. (1981). Preliminary results of observations on the parasites of Pacific skipjack tuna. *Regional Technical Meeting on Fisheries 1981*, 13: Information Paper, South Pacific Commission, Noumea, New Caledonia.

MARCILLE, J. (1979). Nouvelles techniques pour développer la pêche thonière à partir des territoires français du Pacifique Sud. Résultats des essais effectués par Pacific Tuna Development Foundation. Extrait de "la Pêche maritime" d'octobre 1979.

MARCILLE, J., A. ASINE, L. MAREC and P. MARITERANGI (1979). La pêche bonitière à Tahiti. Office de la recherche scientifique et technique outre-mer, Centre ORSTOM de Papeete.

MARCILLE, J. and W. BOUR (1981). La pêche des thons dans l'océan Pacifique tropical. *Travaux et documents de l'ORSTOM* No.134. Office de la recherche scientifique et technique outre-mer, Paris.

MATSUMOTO, W.M. (1958). Description and distribution of larvae of four species of tuna in central Pacific waters. United States Fish and Wildlife Service Fisheries Bulletin 58:31-72.

MATSUMOTO, W.M. (1966). Distribution and abundance of tuna larvae in the Pacific Ocean. In Manar, T.A. (ed.). Proceedings of Governor's Conference, Central Pacific Fisheries Resources. pp 221-230.

MURPHY, G.I. (1963). Introduction of the Marquesan sardine, *Harengula vittata* (Cuvier and Valenciennes), to Hawaiian waters. Pacific Science 14(2):185-187.

MURPHY, G.I. (1977). Clupeoids. In Gulland, J.A. (ed.). Fish population dynamics. John Wiley and Sons, Chichester.

NAKAMURA, E.L. and W.M. MATSUMOTO (1965). Distribution of larval tunas in Marquesan waters. United States Bureau of Commercial Fisheries, Fisheries Bulletin 66(1):1-12.

NAKAMURA, E.L. and R.C. WILSON (1970). The biology of the Marquesan sardine, *Sardinella marquesensis*. Pacific Science 24(3):359-376.

NORDHOFF, C. (1930). Notes on the off-shore fishing of the Society Islands. Journal of the Polynesian Society Volume 39, Nos. 2 and 3.

ORANGE, C.J. (1961). Spawning of yellowfin tuna and skipjack in the eastern tropical Pacific as inferred from studies of gonad development. Inter-American Tropical Tuna Commission Bulletin 5:457-526, Inter-American Tropical Tuna Commission, La Jolla, California.

OTTINO, P. (1965). La pêche au grand filet ('upe'a rahi) à Tahiti. Office de la recherche scientifique et technique outre-mer, Paris.

PETIT, M. and F. GOHIN (1981). Prospection thonière par observations et radiométrie aériennes - territoire de Polynésie française. Rapport préliminaire No.4. Office de la recherche scientifique et technique outre-mer, Centre ORSTOM de Nouméa.

PETIT, M. et M. KULBICKI (1982). Radiométrie aérienne et prospection thonière - Polynésie française, rapport final. Notes et documents d'océanographie No.17. Office de la recherche scientifique et technique outre-mer, Centre ORSTOM de Tahiti.

POWELL, R. (1963). Pêche à la ligne verticale et pêche à la bonite. Tahiti, juin-juillet 1963. Rapport à la Commission du Pacifique Sud.

RANDALL, J.E. and R.K. KANAYAMA (1972). Hawaiian fish immigrants. In Sea Frontiers, Volume 18, No.3.

REREAO, R. and C. BESSINETON (1974). Rapport de mission à bord du Sea Treasure, senneur americain, du 29 octobre au 23 novembre 1974. Service territorial de la pêche et Centre océanographique du Pacifique.

RICHARDSON, B.J. (1983). Distribution of protein variation in skipjack tuna (*Katsuwonus pelamis*) from the central and south-western Pacific. Australian Journal of Marine and Freshwater Research 34:231-251.

ROTHSCHILD, B.J. (1965). Hypotheses on the origin of exploited skipjack tuna (*Katsuwonus pelamis*) in the eastern and central Pacific Ocean. *United States Fish and Wildlife Service Special Scientific Report - Fisheries* No.512.

ROYCE, W.F. (1954). Tuna bait survey. *Pan American Fisherman* 9(1): 10-11,24.

SCHAEFER, M., B. MILNER and G. BROADHEAD (1961). Tagging and recovery of tropical tunas 1955-1959. *Inter-American Tropical Tuna Commission Bulletin* No.5(5), Inter-American Tropical Tuna Commission, La Jolla, California.

SHARP, G.D. (1969). Electrophoretic study of tuna hemoglobins. *Comparative Biochemistry and Physiology* 31:249.

SKIPJACK PROGRAMME (1980a). Skipjack fishing effort and catch, 1972-78, by the Japanese pole-and-line fleet within 200 miles of the countries in the area of the South Pacific Commission. *Skipjack Survey and Assessment Programme Technical Report* No.2, South Pacific Commission, Noumea, New Caledonia.

SKIPJACK PROGRAMME (1980b). A preliminary comparison of fishing effectiveness between cultured and natural baitfish species used by tuna pole-and-line fishing gear. *Regional Technical Meeting on Fisheries 1980*, 12 : Working Paper No.17, South Pacific Commission, Noumea, New Caledonia.

SKIPJACK PROGRAMME (1980c). Summary of Skipjack Survey and Assessment Programme preliminary growth data. *Regional Technical Meeting on Fisheries 1980*, 12 : Working Paper No.19, South Pacific Commission, Noumea, New Caledonia.

SKIPJACK PROGRAMME (1981a). Further observations on fishing performance of baitfish species in the South Pacific Commission area. *Regional Technical Meeting on Fisheries 1981*, 13 : Working Paper No.13, South Pacific Commission, Noumea, New Caledonia.

SKIPJACK PROGRAMME (1981b). Effects of skipjack tagging procedures on subsequent tag recoveries. *Regional Technical Meeting on Fisheries 1981*, 13 : Working Paper No.8, South Pacific Commission, Noumea, New Caledonia.

SKIPJACK PROGRAMME (1981c). Skipjack migration, mortality, and fishery interactions. *Regional Technical Meeting on Fisheries 1981*, 13 : Working Paper No.9, South Pacific Commission, Noumea, New Caledonia.

SKIPJACK PROGRAMME (1981d). An assessment of baitfish resources in the South Pacific Commission area. *Regional Technical Meeting on Fisheries 1981*, 13 : Working Paper No.12, South Pacific Commission, Noumea, New Caledonia.

SKIPJACK PROGRAMME (1981e). An overview of results from analyses of data on growth of skipjack. *Regional Technical Meeting on Fisheries 1981*, 13 : Working Paper No.11, South Pacific Commission, Noumea, New Caledonia.

SPRAGUE, L.M. (1961). Narrative report Charles H. Gilbert cruise 50. United States Bureau of Commercial Fisheries Biological Laboratory, Honolulu. (Unpublished).

TANAKA, T. (1975). Atlas of skipjack fishing grounds in southern waters - 1974 fishing season (July 1974-May 1975). Tohoku Regional Fisheries Laboratory. Translation by T. Otsu, National Marine Fisheries Service, Honolulu Laboratory (April 1976).

TANAKA, T. (1980). Atlas of skipjack fishing grounds in southern waters - 1979 fishing season (May 1979-April 1980). Tohoku Regional Fisheries Laboratory. Translation by T. Otsu, National Marine Fisheries Service, Honolulu Laboratory.

UCHIYAMA, J.H. and P. STRUHSAKER (1981). Age and growth of skipjack tuna, Katsuwonus pelamis, and yellowfin tuna, Thunnus albacares, as indicated by daily growth increments of Sagittae. Fishery Bulletin, Volume 79, No.1.

UGOLINI, B. (1982). Développement de la pêche - rapport annuel 1981. Service de la pêche, French Polynesia.

UGOLINI, B., R. ROBERT and S. GRAND (1982). La pêche en Polynésie française. Office de la recherche et d'exploitation des ressources océaniques, Document No.2, French Polynesia.

VAN CAMPEN, W.G. (1953). Tuna fishing at Tahiti. Commercial Fisheries Review 15(10):1-4.

VAN PEL, H. and L.C. DEVAMBEZ (1957). The fisheries industry of French Polynesia. South Pacific Commission, Noumea, New Caledonia.

WALDRON, K.D. (1964). Fish schools and bird flocks in the central Pacific Ocean, 1950-1961. United States Fish and Wildlife Service, Special Scientific Report - Fisheries No.464.

WANKOWSKI, J.W.J. et P.J. DALZELL (undated). A study of a multispecies fishery for pelagic clupeoids in Papua New Guinea. Kanudi Fisheries Laboratory - Department of Primary Industry, Konedobu, Papua New Guinea.

WILLIAMS, F. (1972). Consideration of three proposed models of the migration of young skipjack tuna (Katsuwonus pelamis) into the eastern Pacific Ocean. Fishery Bulletin Volume 70(1).

WILSON, R.C. and T.S. AUSTIN (1957). Task force in the Marquesas. United States Fish and Wildlife Service, Pan American Fisherman 11(12):6-7, 14.

WILSON, R.C. and T.S. AUSTIN (1959). Tuna season in the Marquesas. Pacific Fisherman 57(1):29,31.

WILSON, R.C., E.L. NAKAMURA and H.O. YOSHIDA (1958). Marquesas area fishery and environmental data, October 1957-June 1958. United States Fish and Wildlife Service Special Scientific Report - Fisheries No.283.

WILSON, R.C. and M.O. RINKEL (1957). Marquesas area oceanographic and fishery data, January-March 1957. United States Fish and Wildlife Service Special Scientific Report - Fisheries No.238.

YOSHIDA, H.O. (1960). Marquesas area fishery and environmental data, January-March 1959. United States Fish and Wildlife Service Special Scientific Report - Fisheries No.348.

YOSHIDA, H.O. (1966). Skipjack tuna spawning in the Marquesas Islands and Tuamotu Archipelago. United States Fish and Wildlife Service Fisheries Bulletin 65(2):479-488.

YOSHIDA, H.O (1967). Longline fishing for deep-swimming tunas in the Marquesas Islands and adjacent areas. United States Fish and Wildlife Service Special Scientific Report - Fisheries No.546.

APPENDIX A. TUNA SURVEYS AND EXPLORATORY FISHING IN FRENCH POLYNESIA

Date	Craft	Gear	Areas	Comment	Source
Late 1940s	Calsea	Baitboat	Marquesas	Exploratory fishing en route to Philippines.	Felando, personal communication
March, July 1949	Hawaiian Tuna	Baitboat	Marquesas	Inadequate supply of bait. Small catches. Report of 34 kg SJ caught.	Royce 1954, Austin 1962 Van Campen 1965
March 1953	Challenger	Baitboat	Marquesas	Caught 33 tons YF.	Austin 1962, Royce 1954
Feb.- April 1954	Charles H. Gilbert Cruise No.15	Baitboat/Research	Marquesas Tuamotu	Bait very plentiful in Marquesas. Bait scarce in Tuamotu. Tuna abundant in Marquesas. Did not fish for tuna.	Royce 1954, Anon 1954
Jan. 1955	Paramount	Baitboat	Marquesas	Caught 50 tons, mostly YF.	Austin 1962 Wilson & Austin 1957
Late 1955	Hugh M. Smith Cruise No.31	Trolling/Research	Marquesas Line Is.	Transported 20 bkts MS to Hawaii. Surface tuna trolling in Marquesas.	Murphy 1963 Randall & Kanayama 1972 Anon 1956
Aug.- Sept. 1956	Charles H. Gilbert Cruise No.30	Baitboat/Research	Marquesas	345 tuna caught. Fished two schools. Transported 7,000 MS to Hawaii, 7 baiting stations, 239 bkts (Hawaiian) caught.	Austin 1957, Murphy 1963 Wilson & Austin 1957 Yoshida 1967
Aug.- Oct. 1956	Hugh H. Smith Cruise No.35	Trolling/Research	Marquesas Tuamotu Society Is. Cook Is. Line Is.	One SJ caught. Transported snappers and groupers to Hawaii from Society Is.	Austin 1957 Randall & Kanayama 1972 Wilson & Austin 1957
Jan.- March 1957	John R. Manning Cruise No.34	Trolling/Research	Marquesas Tuamotu Society Is. Line Is.	7 SJ and 1 YF trolled.	Wilson & Rinkel 1957 Wilson & Austin 1957 Yoshida 1967
Jan.- March 1957	Charles H. Gilbert Cruise No.32	Baitboat/Research	Marquesas Tuamotu Society Is.	1,778 bkts (Hawaiian) MS caught. 4,838 SJ and 52 YF caught by bait in 103 schools. 797 SJ and 10 YF tagged. Transported MS to Hawaii.	Wilson & Rinkel 1957 Murphy 1963 Anon 1957 Wilson & Austin 1957
Jan.- March 1957	Hugh H. Smith Cruise No.38	Trolling/Research	Marquesas Tuamotu Society Is.	2 SJ and 1 YF trolled.	Wilson & Rinkel 1957 Wilson & Austin 1957 Yoshida 1967
Oct.- Nov. 1957	Charles H. Gilbert Cruise No.35	Baitboat/Research	Marquesas Tuamotu Society Is.	2,104 SJ, 193 YF caught and 556 bkts (Hawaiian) MS caught. Tuna tagging attempted. Transported MS to Hawaii.	Wilson, Nakamura & Yoshida 1958 Murphy 1963
Jan.- Feb. 1958	Hugh H. Smith Cruise No.43	Baitboat/Research	Marquesas	1,160 SJ, 0 YF, and 722 bkts (Hawaiian) MS caught. Over 300 SJ tagged. Transported MS to Hawaii.	Wilson, Nakamura & Yoshida 1958 Anon 1958 Murphy 1963
Feb.- April 1958	Charles H. Gilbert Cruise No.38	Baitboat/Research	Marquesas Tuamotu Society Is.	1,771 SJ+YF and 450 bkts (Hawaiian) MS caught. Tuna tagging attempted. Transported 10,500 MS to Hawaii.	Wilson, Nakamura & Yoshida 1958 Murphy 1963
May- June 1958	Hugh H. Smith Cruise No.45	Baitboat/Research	Marquesas Tuamotu Society Is.	788 SJ, 0 YF and 301 bkts (Hawaiian) MS caught. Tuna tagging attempted. Transported MS to Hawaii.	Wilson, Nakamura & Yoshida 1958 Murphy 1963
Jan.- March 1959	Charles H. Gilbert Cruise No.43	Baitboat/Research	Marquesas Tuamotu Society Is.	1,430 SJ, 8 YF, 2 BE and 349 bkts (Hawaiian) MS caught. Transported MS to Hawaii.	Yoshida 1960 Murphy 1963 Hida & Morris 1963
Feb.- March 1959	Cape Falcon	Baitboat	Marquesas Tuamotu Society Is.	Imported bait from Mexico - Anchoveta (3,001 scoops). 81 SJ, 1,077 YF and 50 scoops MS caught.	Yoshida 1960
Nov. 1960	Charles H. Gilbert Cruise No.50	Baitboat/Research	Marquesas Tuamotu Society Is.	1,818 kg MS caught. Transported groupers and snappers from Moorea to Hawaii.	Sprague 1961 Randall & Kanayama 1972
1964- 1972	4 United States vessels	Purse-seiner	Marquesas Tuamotu Society Is.	2 trips in 1964, 1 trip in 1971, 1 trip in 1972.	No published reports Bayliff, personal communication
Oct.- Nov. 1971	Kerri M	Purse-seiner	Marquesas	160 tons SJ and 51 tons YF in 22 days, and 32 sets - 9 successful.	Marcille 1979 Anon (undated a) Marcille & Bour 1981
Feb.- June 1972	Moetu II	Baitboat	Society Is. Tuamotu	840 bkts bait. 29 tonnes tuna. 0.216 tonnes/day at sea.	Doumenge 1973 Anon 1974 Anon 1978a

Oct.- Nov. 1972	Kerri M	Purse-seiner	Marquesas	85 tons SJ and 2 tons YF in 21 days, and 37 sets - 7 successful.	Anon (undated a) Marcille & Bour 1981
Dec.- April 1972-73	Anela	Baitboat	Society Is. Tuamotu Marquesas	149 tons tuna. 1.192 tons/day at sea.	Doumenge 1973 Bard 1974, Anon 1974 Anon 1978a
March- April 1973	Redonda	Baitboat	Marquesas Society Is. Austral	Transported bait from American west coast. 274 bkts (Hawaiian) MS. 582 bkts in Society Is. 5 tons tuna, 0.168 tons/day at sea. Poor fishing in Austral Is.	Anon 1974 Doumenge 1973 Anon 1978a James 1982
Oct.- Nov. 1974	Sea Treasure	Purse-seiner	Marquesas Society Is. Tuamotu Line Is.	PTDF Charter. 5 sets - 3 successful - in 20 days. 17.5 tons, mostly SJ caught.	Anon (undated b) Rereao & Bessineton 1974 Marcille & Bour 1981
Feb. 1975	Japanese long-range vessel (name unknown)	Baitboat	Society Is.	Imported Japanese bait. 8 fishing days. 10.75 tons/day. 67 tons SJ and 19 tons BE.	Tanaka 1975 Skipjack Programme 1980a
March 1976-1981	Tainui	Baitboat/Research	Society Is. (incl. Scilly) Tuamotu Marquesas	ORSTOM/CNEXO tuna and baitfish research project in 1977, in co-operation with IATTC. 360 SJ, 47 YF tagged.	Anon 1978a-g Anon 1980b Bayliff & Hunt 1981 James 1982 Hallier 1980
March- May 1976	Sasayama Maru No.1	Baitboat	Society Is. Tuamotu Marquesas	88 bkts in Society Is. and 18 bkts in Tuamotu. 46 tons tuna, 0.852 tons/day at sea.	Anon 1976 Anon 1978a
Dec. 1976	Voyager	Purse-seiner	Marquesas	4 days. Only small jumper schools seen. No sets.	F. Gargas Jr., personal communication
May 1977	Kerri M	Purse-seiner	Marquesas	36 tons tuna in 3 days.	Marcille & Bour 1981
May 1977	Zapata Discoverer	Purse-seiner	Marquesas	45 tons in 3 days. Used helicopter.	Marcille 1979
July 1977- May(?) 1979	Moetu IV	Baitboat	Society Is. Tuamotu	Sponsored by SCEP. In April 1979 caught 6.5 tonnes SJ with 61 bkts milkfish in Tuamotu.	Anon 1978a Anon 1979a
Feb.- March 1978	Coriolis	Plankton collection gear	Society Is. Austral Is. Gambier Tuamotu	Collection of tuna juveniles, observation of surface schools of tuna and hydrology.	Henin *et al*. 1980
Feb.- April 1978	Mary K	Baitboat/Research	Marquesas Tuamotu Society Is.	Imported northern anchovies from Mexico. IATTC research project. Tagged 1,608 tuna. Used some milkfish.	Anon 1978h-j Bayliff & Hunt 1981
Sept. 1978- Feb. 1979	Tahitian bonitier (name unknown)	Pearl-shell trolling	Tuamotu	Sponsored by SCEP based at Apataki. 0.282 tons SJ+YF per day. 4 times average catch of Papeete-based boats.	Chabanne & Marcille 1980
Dec. 1978- May 1979	Cornucopia	Baitboat/Research	Marquesas	IATTC research project. Tagged 1,874 SJ and 72 YF. Caught 643 bkts (Hawaiian) MS. Used some milkfish.	Anon 1979b Bayliff & Hunt 1981
Dec. 1978- Feb. 1979	Hatsutori Maru No.1	Baitboat/Research	Tuamotu Society Is. Marquesas	SPC research project. Tagged 8,126 and 98 YF. Caught 1,457 bkts bait. Also used mollies and milkfish.	Kearney, Hallier & Gillett 1979 Anon 1980a
Jan.- April 1979	Aircraft	Radiometry Aerial spotting	Marquesas Tuamotu	CNEXO research project.	Marcille, personal communication
1979 (month unknown)	Name unknown	Purse-seiner	Marquesas	Seiner from eastern Pacific fishery. Effort recorded in Marquesas area but no catch made.	Anon 1980d
Dec. 1979- Feb. 1980	Hatsutori Maru No.5	Baitboat/Research	Marquesas Tuamotu Gambier Society Is.	SPC research project. Tagged 19,583 SJ, 1,171 YF, 35 BE and 1 FT. Caught 3,696 bkts bait. Also used milkfish.	Gillett & Kearney 1980 Anon 1980c

Feb.- Dec. 1981	Aircraft	Radiometry Aerial spotting	Society Is. Tuamotu Marquesas Austral Is. Gambier	ORSTOM research project. Visual spotting and radiometry using aero-commander aircraft. Two 100-tonne schools seen in Marquesas in June. Visible tuna population size estimated for Society, Marquesas and Tuamotu Islands.	Marcille, personal communication Bell, personal communication. Petit & Gohin 1981 Marcille & Bour 1981 Petit & Kulbicki 1982
Aug. 1981 to present	Rava'ai Nui	Baitboat Trolling Pearl-shell	Society Is. Tuamotu	"Super bonitier", 16.2m in length, with bait well capacity of 2 cubic metres. Operates by pearl-shell, trolling or live-bait technique. In 1981 caught 18 tonnes of fish (mostly tuna) in 76 days at sea.	Ugolini 1982 Ugolini, Robert & Grand 1982
Dec. 1981- Jan. 1982	Aquaholics IV	Night-time deep lining	Society Is.	Ikashibi fishing (mainly for YF) in the leeward Society Is. Hawaiian master fisherman and official of SPPF instructing local fishermen. Catches of between 30 and 210 kg per night.	Ugolini 1982 Franck 1982
Feb.- March 1982	Coriolis	Trolling/ Research	Austral Is. and S.E. of Austral Is. en route to New Zealand	Exploratory fishing for surface albacore. ORSTOM research project. Proper water temperature (16°-19°C) not encountered until well south of Austral Is. Total of 40 AL trolled.	Hallier, ORSTOM personal communication
March 1982	Taisei Maru No.24	Baitboat	Tuamotu	World's largest pole-and-line vessel (approx. 1200GT) imported bait from Japan in refrigerated wells. Caught 16.3 tonnes tuna in 3 fishing days.	Robert, SPPF, personal communication
Sept. 1982	Kaio Maru No.52	Baitboat	Society Is. and ?	443GT vessel chartered by JAMARC. Transported 3.5 tonnes of sardines from Japan in refrigerated wells. 3 weeks of survey planned.	Anon 1982a

Notes:
SPC - South Pacific Commission
ORSTOM - Office de la recherche scientifique et technique outre-mer
IATTC - Inter-American Tropical Tuna Commission
SCEP - Societe de commercialisation et d'exploitation du poisson
PTDF - Pacific Tuna Development Foundation
CNEXO - Centre national pour l'exploitation des oceans
JAMARC - Japan Marine Fishery Resource Centre.

Hawaiian bait bucket = approx. 3.5 kg
West coast scoop = " "
Bucket (unspecified) = " 1.5 kg

YF=yellowfin, SJ=skipjack, BE=bigeye, FT=frigate tuna, AL=albacore, MS=Marquesan sardine
Ton=short ton, Tonne=metric tonne.

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

South Pacific Commission Scientists

Robert Gillett	6-8 December 1978 2 January-3 February 1979 14 December 1979-15 February 1980
Jean-Pierre Hallier	6-31 December 1978 13-14 December 1979 15-17 February 1980
Christopher Thomas	6-31 December 1978
Charles Ellway	8 December 1978-26 January 1979 13-14 December 1979
Desmond Whyman	2 January-3 February 1979
James Ianelli	13 December 1979-15 February 1980
Pierre Kleiber	15 December 1979-24 January 1980
A.W. Argue	28 January-17 February 1980
Robert Kearney	18-24 January 1980

Inter-American Tropical Tuna Commission Scientists

William Bayliff	17 January-1 February 1979 19 December 1979-15 February 1980
Terry Foreman	19 December 1979-15 February 1980
James Joseph	18-24 January 1980

Observers

Benedito Tikomainiusiladi Ministry of Agriculture, Fisheries and Forests Fiji	17 January 1978-3 February 1979
Michel Lafitte, CNEXO	8 December 1978-15 January 1979
Ioane Futavae Tahitian Fisherman	2 January-1 February 1979
Daniel Davies R/V *Cornucopia*	2-6 January 1979
Gerald Parker Tahitian Fisherman	17 January-1 February 1979
Jacques Moriceau, CNEXO	18 January-1 February 1979
Gilles Omitai Service de la pêche Rangiroa	20 January 1980
Anthony Teanini Mayor of Fakarava Island	24 January 1979
Joseph Tokoragi Resident of Fakarava Island	24 January 1979
Allen Flohr Huahine Fisherman	29 January 1979

Robert Teheura Tahitian Fisherman	29 January 1979
Bruno Ugolini Service de la pêche	28 January-15 February 1980
Pierre Buttin Service de l'economie rurale	28 January-15 February 1980
Serge Brault Captain of *Tainui*	15-16 February 1980
Garth Harraway Commissioner of Pitcairn Island	4-15 February 1980

Marquesan and Tuamotu Fishermen

Robert Gendron	26 December 1979, 15 January 1980
Louis Gendron	26 December 1979
Raymond Gendron	26 December 1979
Samuel Bonno	26 December 1979
Laurent Falchetto	26 December 1979
Julian Tamarii	31 December 1979
Napoleon Tamarii	31 December 1979
Theodore Tamarii	31 December 1979
Jean-Michel Tamaree	31 December 1979
Topoea Ahecha	5 January 1980
Rene Hotoeua	5 January 1980
Desire Teikimoetoua	5 January 1980
Rene Ahwon	20 January 1980
Jean-Pierre Rochette	29 January 1980
Gustave Sanford	29 January 1980

Japanese Crew - Cruise One

Masahiro Matsumoto, Captain
Tsunetaka Ono
Yoshikatsu Oikawa
Yoshio Kadohno
Sakae Hyuga
Mikio Yamashita
Yoshihiro Kondoh
Nosomu Origuchi
Kohji Wakasaki

Japanese Crew - Cruise Two

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

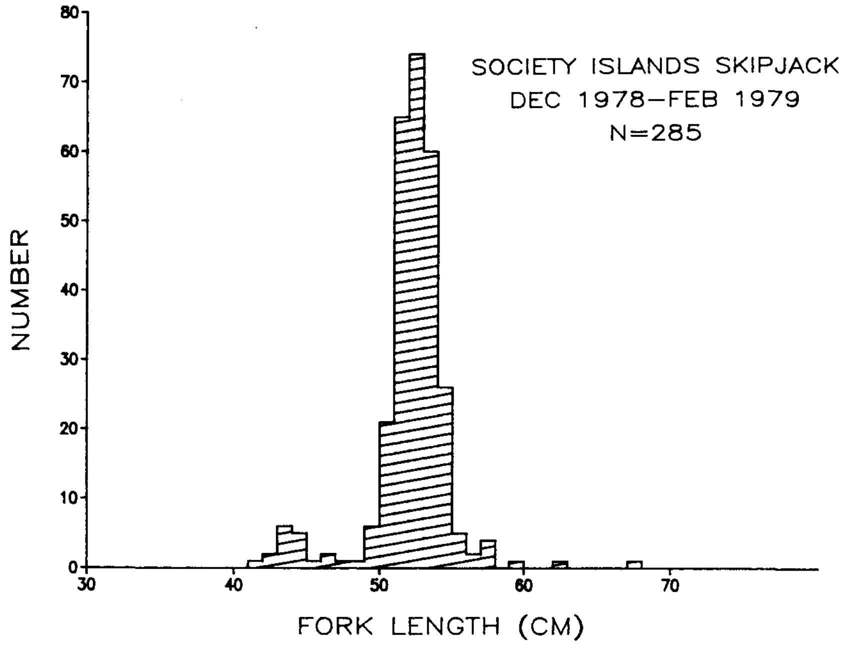
Fijian Crew - Cruise One

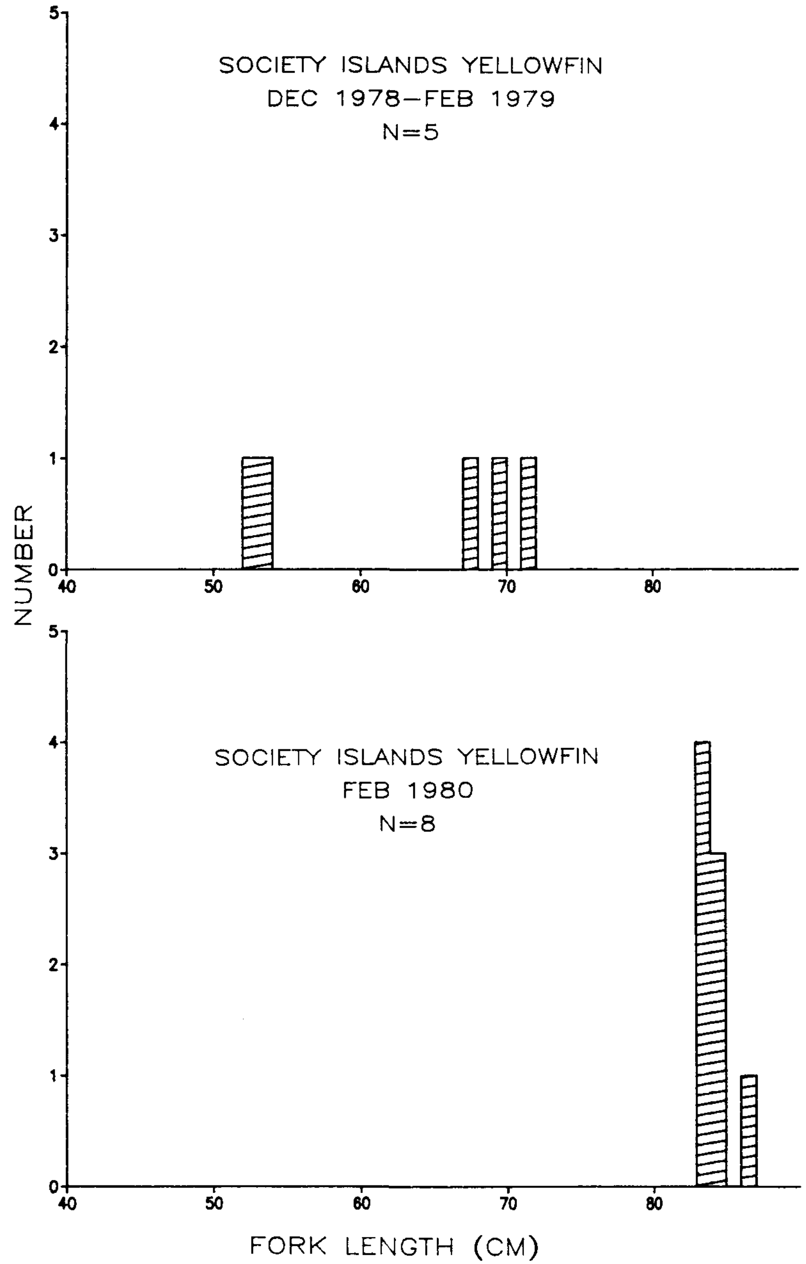
Eroni Marawa
Samuela Ue
Lui Andrews
Ravaele Tikovakaca
Samuela Delana
Jona Ravasakula
Vonitiese Bainimoli
Eroni Dolodai
Kitione Koroi
Josua Raquru
Veremalua Kaliseiwaqa
Mosese Cakau

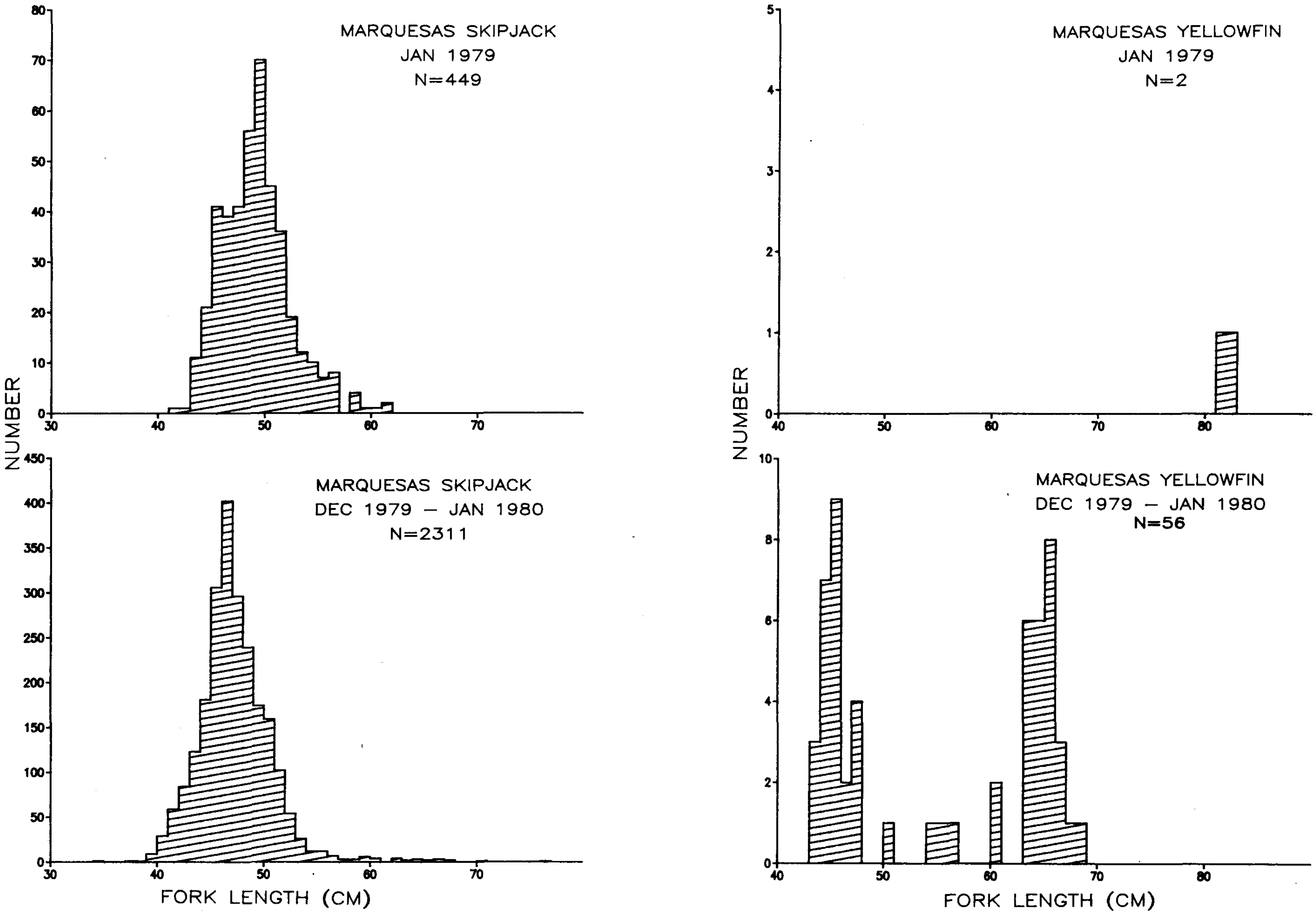
Fijian Crew - Cruise Two

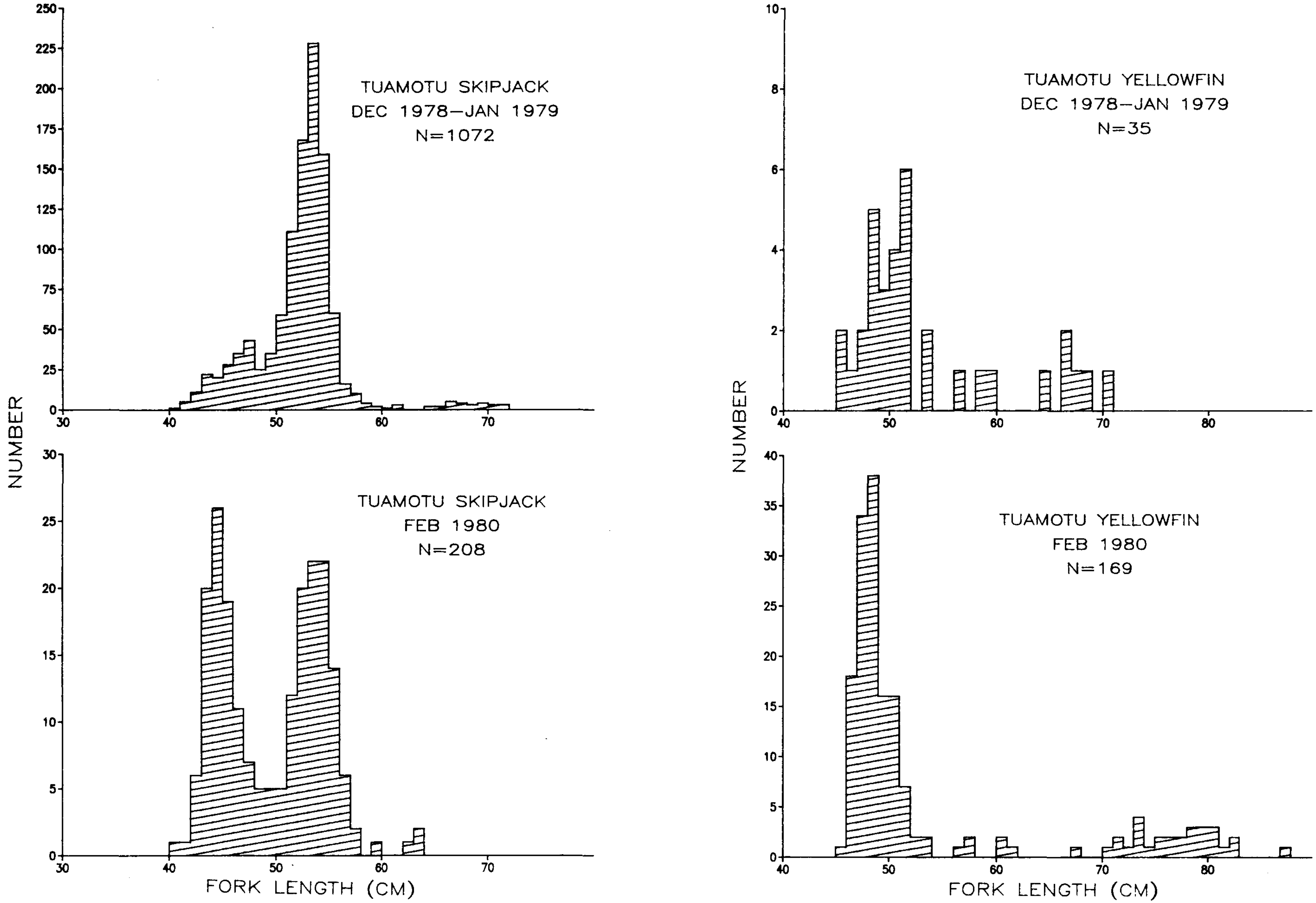
Ravaele Tikovakaca
Samuela Ue
Lui Andrews
Kitione Naivaurerega
Samuela Delana
Jona Ravasakula
Josua Raguru
Veremalua Kaliseiwaga
Eroni Dolodai
Metuisela Koroi
Luke Kaidrokai
Aminiasi Kuruyawa
Napolioni Ravitu

APPENDIX C. LENGTH FREQUENCIES OF SKIPJACK AND YELLOWFIN IN FRENCH POLYNESIA SAMPLED BY THE SKIPJACK PROGRAMME

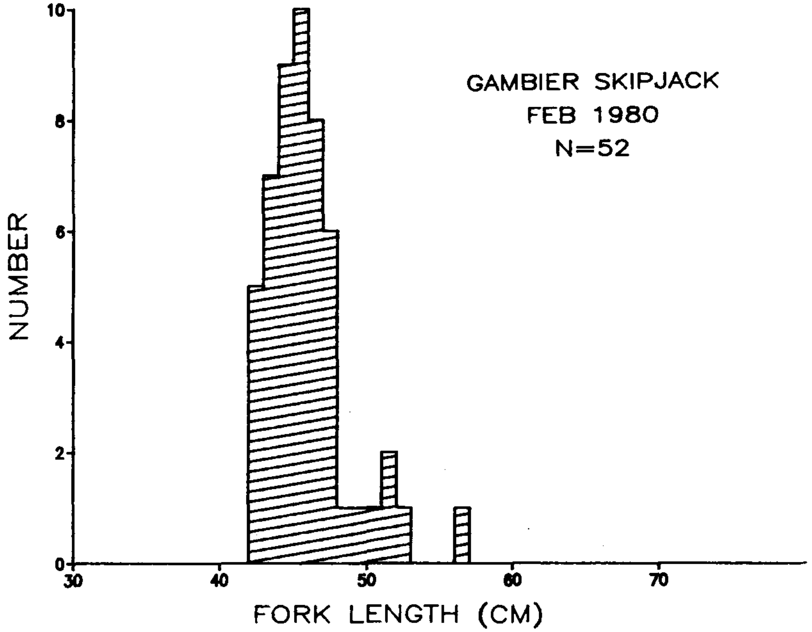


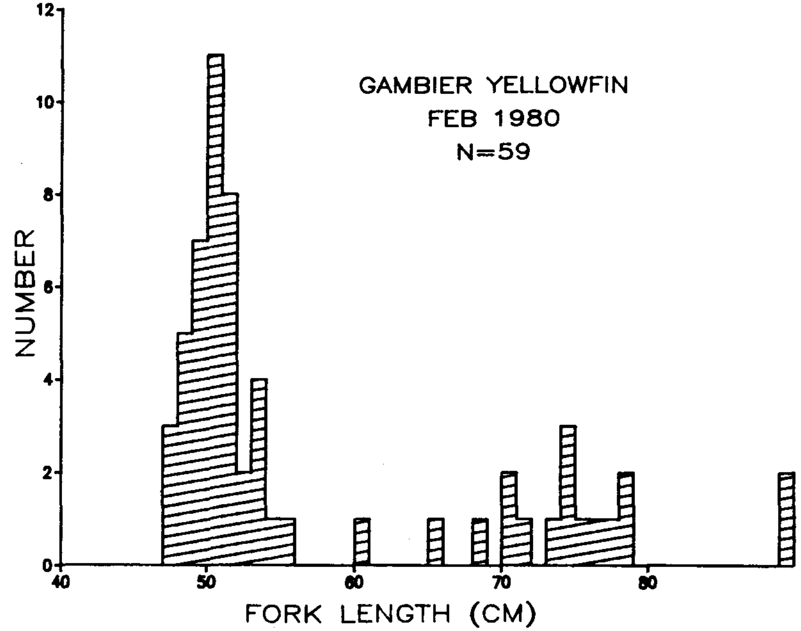



MARQUESAS SKIPJACK
JAN 1979
N=449
MARQUESAS YELLOWFIN
JAN 1979
N=2
MARQUESAS SKIPJACK
DEC 1979 – JAN 1980
N=2311
MARQUESAS YELLOWFIN
DEC 1979 – JAN 1980
N=56
NUMBER
NUMBER
FORK LENGTH (CM)
FORK LENGTH (CM)



TUAMOTU SKIPJACK
DEC 1978–JAN 1979
N=1072
TUAMOTU SKIPJACK
FEB 1980
N=208
TUAMOTU YELLOWFIN
DEC 1978–JAN 1979
N=35
TUAMOTU YELLOWFIN
FEB 1980
N=169
NUMBER
FORK LENGTH (CM)


GAMBIER SKIPJACK
FEB 1980
N=52
NUMBER
FORK LENGTH (CM)
0
2
4
6
8
10
30
40
50
60
70


GAMBIER YELLOWFIN
FEB 1980
N=59
NUMBER
FORK LENGTH (CM)
0
2
4
6
8
10
12
40
50
60
70
80

APPENDIX D. FRENCH POLYNESIA SKIPJACK AND YELLOWFIN RELEASE AND RECAPTURE INFORMATION (AS OF MAY 1982). For explanation of country abbreviations see Appendix F.

Skipjack

Release Area	Month/ Year	No. Released	Recapture Area	Month/ Year	No. Recaptured
MAQ	01/79	1,689	MAQ	02/79	1
MAQ	12/79	8,137	INT	09/80	2
			INT	02/81	2
			KIR	10/80	1
			MAQ	12/79	1
			MAQ	01/80	21
MAQ	01/80	10,456	HOW	03/81	1
			INT	03/81	1
			MAQ	01/80	14
			MAQ	02/80	3
			MAQ	05/80	1
			MAQ	09/80	1
			PHO	09/80	1
			SOC	12/80	1
TUA	12/78	2,304	SOC	02/79	1
			SOC	06/79	1
			SOC	07/79	1
			TUA	12/78	9
			TUA	01/79	2
			TUA	04/79	2
TUA	01/79	2,409	TUA	01/79	1
			TUA	04/79	10
			TUA	03/80	1
TUA	02/80	815	SOC	09/80	1
			SOC	11/80	1
SOC	12/78	828	SOC	12/78	5
			SOC	01/79	4
			SOC	02/79	4
			SOC	03/79	4
			SOC	04/79	1
			SOC	05/79	3
			SOC	06/79	2
SOC	01/79	896	SOC	01/79	8
			SOC	02/79	2
			SOC	03/79	1
			SOC	12/79	1
			SOC	07/80	1
SOC	02/80	1			0
GAM	02/80	174			0
TOTAL		27,709			116

Yellowfin

Release Area	Month/ Year	No. Released	Recapture Area	Month/ Year	No. Recaptured
MAQ	12/79	163			0
MAQ	01/80	25			0
TUA	12/78	62	SOC	03/79	1
TUA	01/79	32			
TUA	02/80	648	SOC	10/80	1
			SOC	12/80	1
			SOC	03/81	1
SOC	02/80	33	SOC	03/80	1
			SOC	08/80	1
GAM	02/80	302			0
TOTAL		1,265			6

APPENDIX E. FRENCH POLYNESIA INTERNATIONAL MIGRATION DATA

SKIPJACK

Release Date	Release Position	Release Size (cm)	Recapture Date	Recapture Position	Recapture Size (cm)
06/04/78	16°56'S 179°24'W	57.0	05/01/79	17°34'S 149°55'W	65.0
17/04/78	18°39'S 174°12'W	54.0	17/04/79	17°47'S 148°36'W	65.0
16/05/78	13°30'S 176°05'W	51.0	23/07/79	17°00'S 149°30'W	58.0
20/05/78	13°17'S 176°23'W	51.0	01/02/79	17°00'S 149°40'W	56.0
20/5/78	13°17'S 176°23'W	53.0	01/08/79	17°05'S 149°30'W	60.0
02/03/79	35°26'S 174°53'E	46.0	14/05/80	17°20'S 149°40'W	57.0
03/03/79	35°31'S 174°50'E	47.0	13/10/80	16°55'S 149°55'W	65.0
06/03/79	35°51'S 175°30'E	45.0	02/02/80	18°10'S 149°50'W	49.6
06/03/79	35°51'S 175°30'E	46.0	28/01/80	17°35'S 149°10'W	unknown
08/04/79	35°04'S 151°05'E	47.6	23/01/80	17°18'S 151°55'W	51.0
26/02/80	14°06'S 171°24'W	46.0	19/12/80	17°30'S 150°10'W	59.0
23/03/80	35°31'S 174°50'E	62.0	10/02/81	17°00'S 149°33'W	65.0
22/12/79	10°29'S 141°11'W	49.0	28/02/81	02°37'N 171°52'W	64.5
25/12/79	09°10'S 140°04'W	47.0	19/10/80	01°56'N 174°18'E	59.0
25/12/79	09°13'S 140°01'W	46.0	21/09/80	06°40'N 171°23'W	52.4
28/12/79	08°53'S 140°21'W	46.0	21/09/80	06°40'N 171°23'W	61.0
06/01/80	08°53'S 140°19'W	51.0	16/09/80	05°29'S 173°34'W	60.0
11/01/80	08°56'S	50.0	01/01/81 to 31/05/81	00°22'N 175°28'W	unknown
14/01/80	09°01'S 140°06'W	50.0	02/03/81	02°06'N 168°59'W	unknown

YELLOWFIN

Release Date	Release Position	Release Size (cm)	Recapture Date	Recapture Position	Recapture Size (cm)
12/02/80	16°21'S 146°57'W	66.7	13/07/81	08°14'N 139°25'W	104.0
IATTC Yellowfin Release					
01/03/78	07°58'S 139°58'W	52.0	12/07/79	11°47'N 130°25'W	unknown

APPENDIX F. 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)
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