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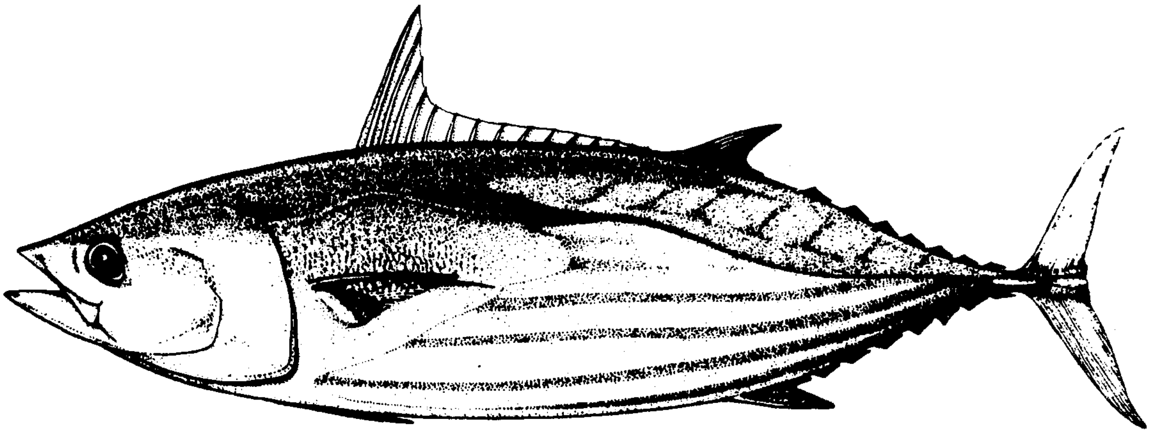
AN ASSESSMENT OF THE SKIPJACK AND BAITFISH RESOURCES OF NORTHERN MARIANA ISLANDS, GUAM, PALAU, FEDERATED STATES OF MICRONESIA, AND MARSHALL ISLANDS



Skipjack Survey and Assessment Programme
Final Country Report No. 18

South Pacific Commission
Noumea, New Caledonia
September 1984

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PREFACE

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

The Skipjack Programme has been succeeded by the Tuna and Billfish Programme which is receiving funding from Australia, France, New Zealand and the United States of America. The Tuna Programme is designed to improve understanding of the status of the stocks of commercially important tuna and billfish species in the region. Publication of final results from the Skipjack Programme, including results from the Programme's investigation of yellowfin tuna resources of the region, is continuing under the Tuna Programme.

Reports for each of the countries and territories for which the South Pacific Commission works have been prepared in a final country report series. This final country report includes results for Guam and the districts that comprised the United Nations Trust Territory of the Pacific Islands, since this was the administrative grouping of states in existence at the time the Skipjack Programme undertook its fieldwork, and accordingly results were combined for these states in the Programme's preliminary country report series. The name Trust Territory and Guam is used throughout this report when referring to collective results.

Most final country reports have been co-operative efforts involving all members of the Tuna Programme staff in some way. The staff of the Tuna Programme at the time of preparation of this report comprised the Programme Co-ordinator, R.E. Kearney; Research Scientists, A.W. Argue, C.P. Ellway, R.S. Farman, R.D. Gillett, L.S. Hammond, P. Kleiber, W.W. Parks, J.R. Sibert, W.A. Smith and M.J. Williams; Research Assistants, Susan Van Lopik and Veronica van Kouwen; and Programme Secretary, Carol Moulin.

The Skipjack Programme received valuable assistance from fisheries specialists and other officials in each of the states that were surveyed; to all these people we are indeed most grateful.

Tuna Programme
South Pacific Commission

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1.0 INTRODUCTION

Skipjack (*Katsuwonus pelamis*) have dominated commercial fisheries in the waters of Northern Mariana Islands, Guam, Palau, Federated States of Micronesia, and Marshall Islands for the last 50 years. In the 1930s, Japanese pole-and-line vessels based in this region used locally caught live bait to harvest between 1,300 (1930) and 33,000 (1937) tonnes of skipjack each year (Rothschild & Uchida 1968). This fishery declined during World War II, and later resumed on a small scale with distant-water pole-and-line vessels that were based in Japan and used live bait from Japan. The distant-water fishery gradually expanded further into the waters of this area and annual skipjack catches rose from a few thousand tonnes during the mid-1960s to over 90,000 tonnes in the 1970s (Skipjack Programme 1980). During 1960-70, Japanese companies commenced sizable joint-venture, pole-and-line fisheries in Palau, Papua New Guinea, Solomon Islands and Fiji (Kearney 1982a), and beginning in the 1970s, Japan and the United States intensified exploratory purse-seining in tropical waters north of the Equator.

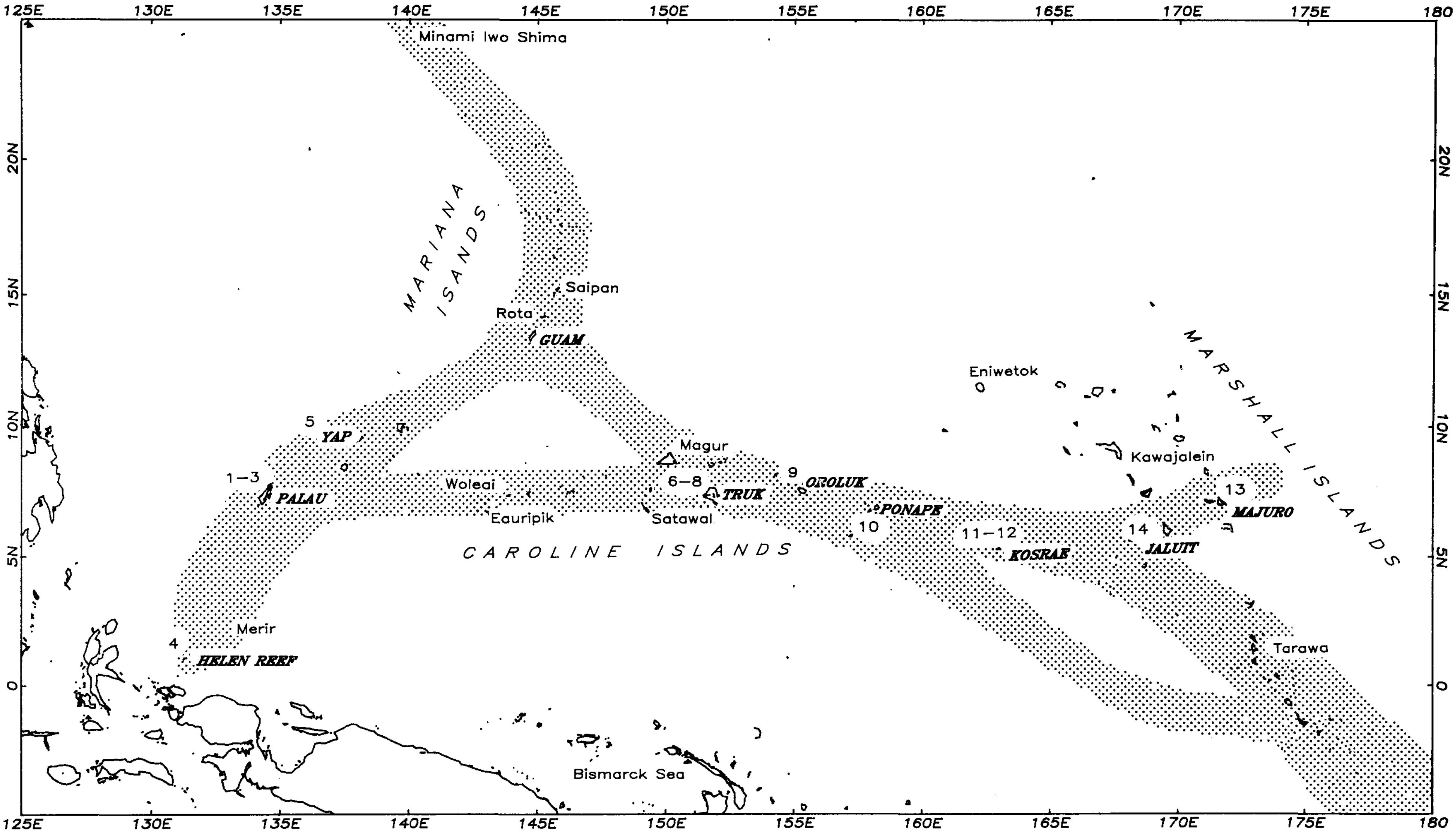
Since skipjack fisheries offered significant potential for economic development within the region of the South Pacific Commission, and their expansion was anticipated, there was need for improved scientific knowledge of skipjack and baitfish resources to ensure that catches could be sustained. Countries in the Commission region with locally based fisheries were particularly concerned about interactions between their skipjack fisheries and the large distant-water fishery by Japan. The Commission's Skipjack Survey and Assessment Programme was designed to provide new information on the status of skipjack and baitfish resources throughout the region, and on interactions amongst regional fisheries.

At the time of the Skipjack Programme, Northern Mariana Islands, Palau, Yap, Truk, Ponape, Kosrae, and Marshall Islands constituted the Trust Territory of the Pacific Islands, which, together with Guam, were administered by the United States. The 200-mile zones of these states encompass a sea area of some 6.6 million square kilometres, approximately 20 per cent of the sea area within the boundaries of the Commission (Figure A, inside front cover). Because of the enormous sea area of the Trust Territory and Guam, the Skipjack Programme conducted three surveys in it (Figure 1) totalling 115 days. The first survey was divided into two periods, July-August and October-November 1978, the second survey took place during November 1979, and the third survey during July-August 1980. Preliminary results from the first and second surveys have been reported by Kearney, Gillett & Whyman (1979) and Kearney & Hallier (1980). This report presents final results from all three surveys, compares these results to those from surveys by other institutions and by the Programme in other countries, and discusses the management implications of the findings.

1.1 Fishery Development

Subsistence fishermen in Micronesia used canoes, fishing lines and shell lures to catch skipjack for centuries before European contact (Anell 1955). In the nineteenth and early twentieth century, Spain and Germany had control over the Mariana, Caroline and Marshall Islands (Carter 1981); however, commercial fishing for skipjack did not develop until Japan gained

FIGURE 1. SURVEY AREA AND BAITFISHING LOCALITIES (numbers) FOR THE SKIPJACK PROGRAMME SURVEY IN THE WATERS OF THE TRUST TERRITORY OF THE PACIFIC ISLANDS AND GUAM



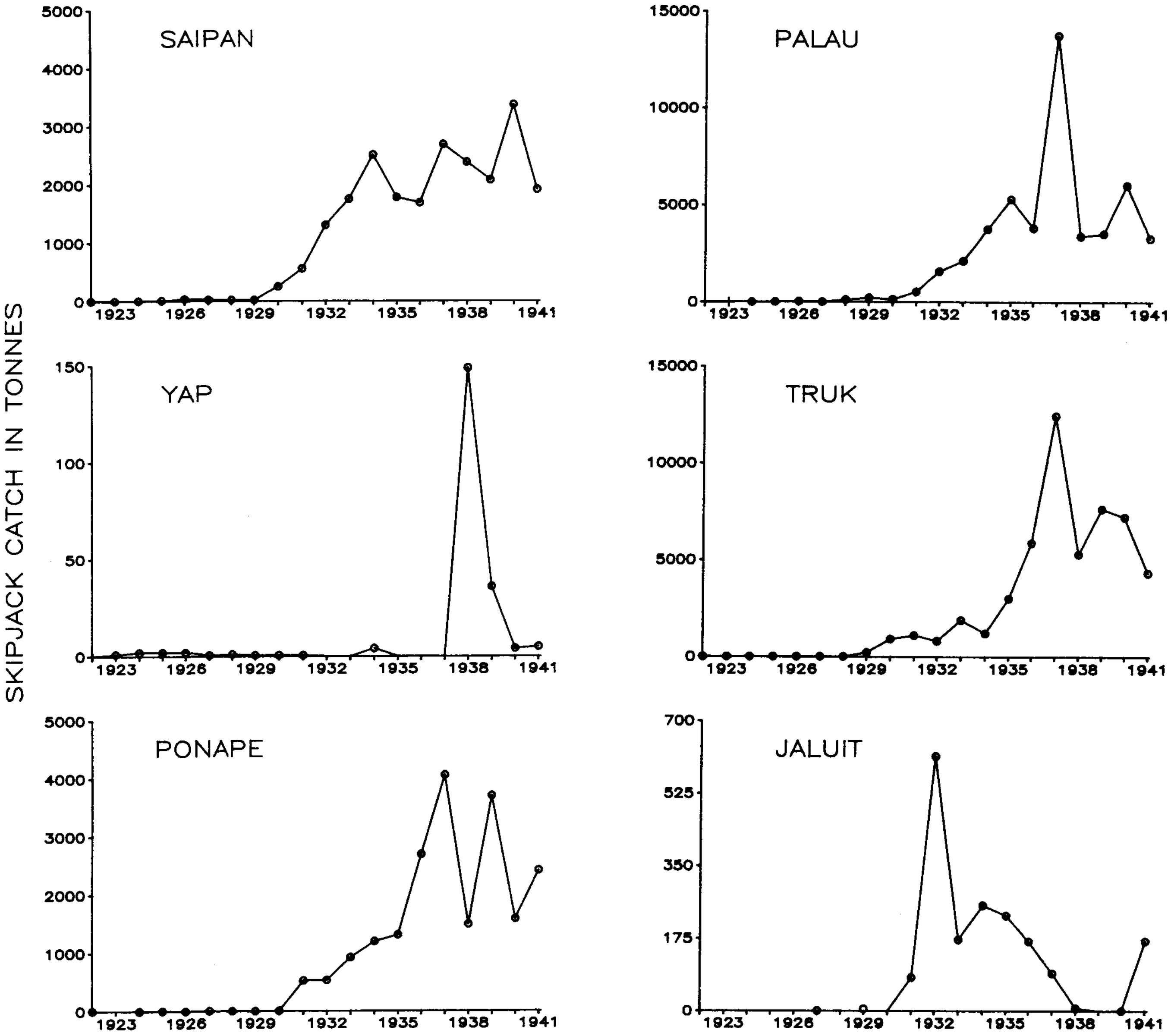
control of these islands at the beginning of World War I (Smith 1947). The Japanese initiated fisheries for live bait and skipjack first in Saipan in the Mariana Islands, then in Palau, and in the late 1920s in Truk in the Caroline Islands. By the mid-1930s live-bait and skipjack fishing grounds also included Rota and Tinian islands in the Mariana Islands, Yap, Ponape and Kosrae islands in the Caroline Islands, and Ailinglapalap and Jaluit atolls in the Marshall Islands (Anon. 1943; Smith 1947; Gawel 1982). Commercial catches of skipjack in the Mariana, Caroline and Marshall Islands increased rapidly in the 1930s (Figure 2) and reached a maximum of 33,000 tonnes in 1937, over 75 per cent of which came from Palau and Truk (Rothschild & Uchida 1968). At the height of the fishery there were about 45 skipjack pole-and-line vessels based in Palau (Smith 1947), 40 in Truk (Wilson 1971), 19 in Saipan (Ikebe & Matsumoto 1938), and 12 in Ponape (Wilson 1977a). Most of the catch was processed locally and exported to Japan in the form of "katsuobushi"; however, small canneries operated in Palau (Smith 1947) and Jaluit (Anon. 1943). During the pre-war period there was very little participation by Micronesians in the fishery; Okinawan fishermen manned the fishing vessels and Japanese operated the processing facilities on shore (Smith 1947). Commercial fishing activity in the area ceased during World War II.

Live-bait fishing for skipjack resumed on a small scale in the late 1940s in the Mariana Islands (Smith 1947), and was reported in the mid-1950s in Guam (van Pel 1955). Harvesting of skipjack on a large scale did not resume until the early 1960s when the Japanese distant-water pole-and-line fleet began fishing in the Mariana and northwest Caroline Islands (Rothschild & Uchida 1968). These vessels transported live bait (principally _Engraulis japonicus_ and _Sardinella melanosticta_) from Japan to the fishing grounds. Their reported skipjack catch between 1972 and 1978 in the Trust Territory and Guam reached a maximum of 96,000 tonnes in 1973 (Figure 3), and averaged 64,000 tonnes in this period (Skipjack Programme 1980). The average annual catch of other tuna species by the pole-and-line fleet was 1,300 tonnes. Annual skipjack catches by the Japanese fleet in many of these areas showed the same trends during this period (Figure 4). Monthly fishing effort also exhibited consistent patterns (Figure 5). Effort by the Japanese fleet was highest between February and April, and lowest between May and July. The lull during the boreal spring and summer coincided with movement of many of these vessels to subtropical waters north of the Trust Territory and Guam, and to the Japanese home-water fishery where catches peak during spring-summer months (Kearney 1979). The fishery in Northern Mariana Islands, being further north than those in the other states, had a spring-summer peak in pole-and-line effort similar to that of the Japanese home-water fishery.

From 1964 the Van Camp Seafood Company of the United States operated a live bait fishery for surface tunas in Palau. This fishery took an average of 6,600 tonnes of skipjack annually between 1978 and 1981 (Tuna Programme unpublished data) with 8 to 15 locally based pole-and-line vessels manned mainly by foreign crews. It ceased in 1982 as a result of a general weakness in markets for tuna, increases in fuel costs and growth of purse-seine fishery.

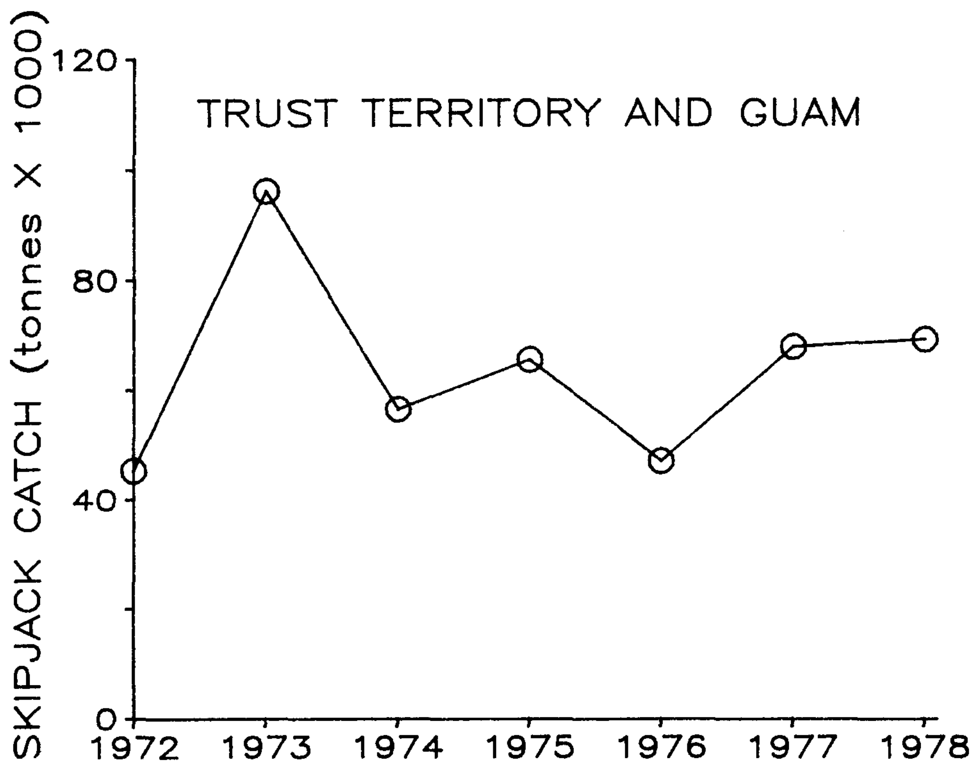
Japan-based longliners have fished in the waters of the Trust Territory and Guam since the early 1950s. Taiwanese longliners also fished in most of this area from 1967 to 1977, but at much lower effort levels than the Japanese fleet (Skipjack Programme 1981a). Klawe (1978) presents the most recent, published estimates of catch in tonnes by Japanese, Taiwanese and Korean longline fleets operating in the Trust Territory and Guam. For 1975 and 1976, the total longline catch averaged 20,400 tonnes, 94 per cent by Japan and 3 per cent each by Taiwan and Korea. Over 50 per

FIGURE 2. HISTORICAL SKIPJACK CATCH BY JAPANESE POLE-AND-LINE VESSELS BASED AT VARIOUS LOCATIONS IN THE MARIANA, CAROLINE AND MARSHALL ISLANDS. Catches from Rothschild & Uchida (1968).



cent of this average catch was yellowfin (*Thunnus albacares*), 35 per cent bigeye (*T. obesus*), 4 per cent albacore (*T. alalunga*) and 8 per cent billfish species. Skipjack comprised less than 0.5 per cent of the longline catch.

FIGURE 3. ANNUAL CATCH OF SKIPJACK BY JAPANESE DISTANT-WATER POLE-AND-LINE VESSELS IN THE WATERS OF THE TRUST TERRITORY AND GUAM, 1972 TO 1978. Catches from Skipjack Programme (1980).



There is a large fleet of foreign vessels currently fishing in the waters of the Trust Territory and Guam. In the first part of 1983, the Federated States of Micronesia had licensing agreements with Japan, the United States, Korea and Taiwan covering a total of 608 tuna fishing vessels (M. McCoy, Micronesian Maritime Authority, personal communication). For the Marshall Islands, there were 436 applications for fishing privileges from Japanese longline and pole-and-line vessels in 1982 (S. Muller, Ministry of Foreign Affairs, Marshall Islands, personal communication), and many of these vessels were undoubtedly licensed to fish in other areas of the Trust Territory and Guam as well. The Programme does not have information on the numbers of foreign vessels fishing in the waters of Northern Mariana Islands, Guam and Palau, but an estimate of in excess of 1,000 longline, pole-and-line and purse-seine vessels for the total Trust Territory and Guam does not seem unreasonable.

There has been very rapid development of the purse-seine component of the fishery over the last three years as knowledge of fishing grounds increased and improvements were made to fishing gear and techniques (Iizuka & Watanabe 1983; Kearney 1983a; Wilson 1983). In late 1983 there were over 100 purse-seiners from the United States, Japan and Korea (Tuna Programme unpublished data) operating in the tropical western Pacific, primarily in northern waters of Papua New Guinea, southern waters of the Federated States of Micronesia, western waters of Kiribati and in international waters between these countries. It is estimated that the harvest of skipjack by this fleet may approach 300,000 tonnes in 1983.

FIGURE 4. ANNUAL CATCH (1972 TO 1978) OF SKIPJACK BY JAPANESE DISTANT-WATER POLE-AND-LINE VESSELS IN THE WATERS OF YAP, TRUK, PONAPE, AND KOSRAE IN FEDERATED STATES OF MICRONESIA, AND IN NORTHERN MARIANA ISLANDS, GUAM, PALAU AND MARSHALL ISLANDS

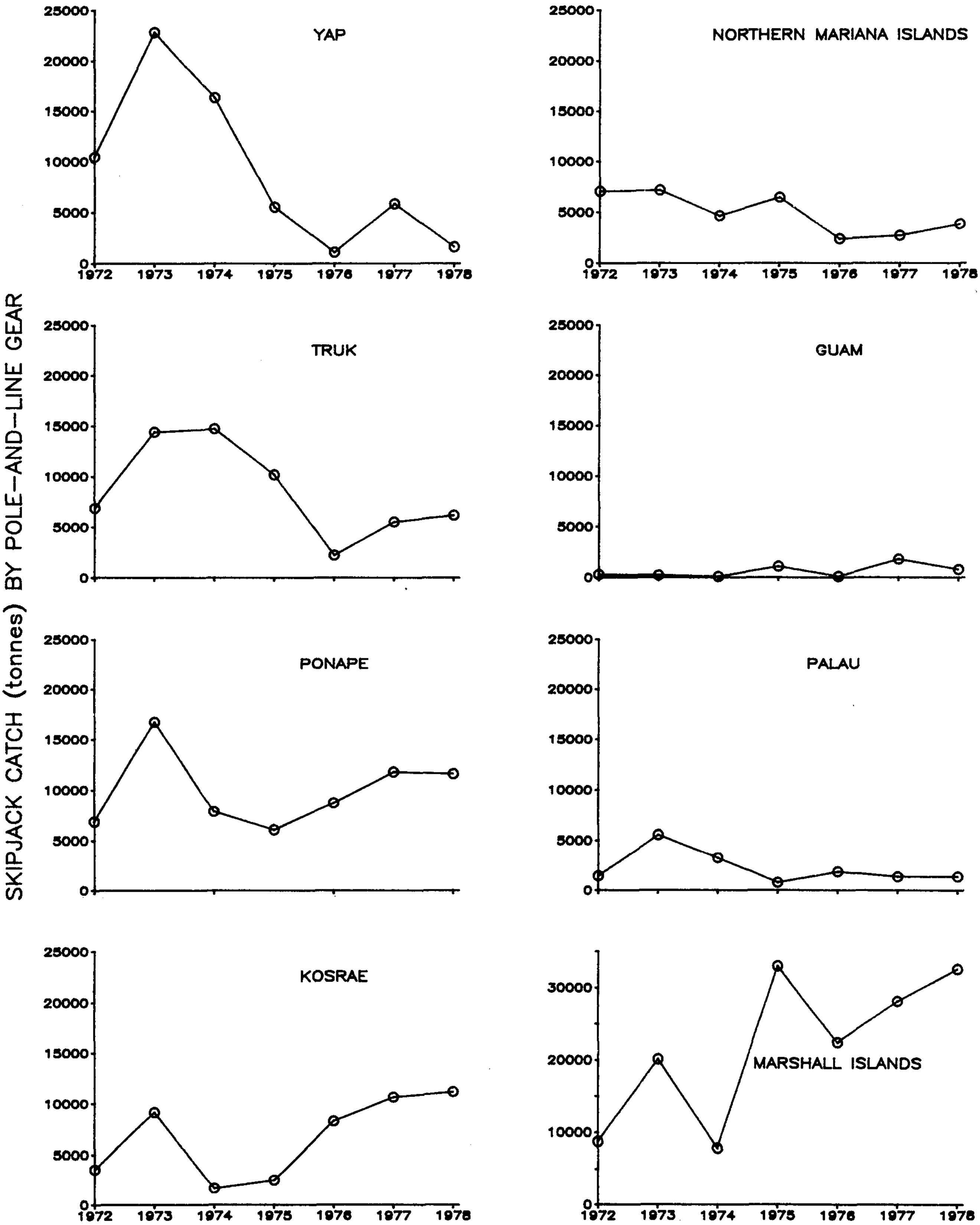
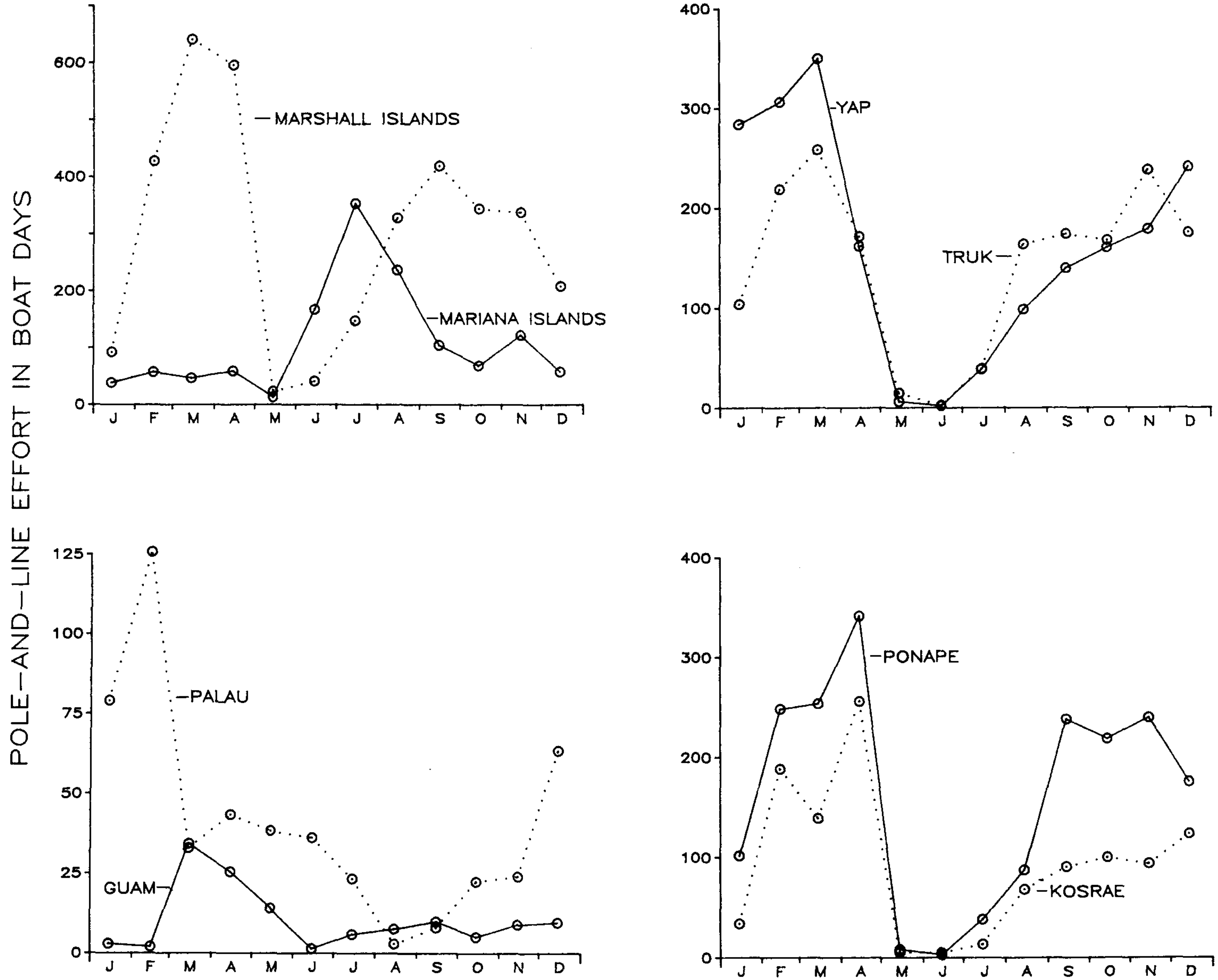


FIGURE 5. AVERAGE MONTHLY EFFORT (BOAT DAYS) FROM 1972 TO 1978 FOR MARSHALL ISLANDS, NORTHERN MARIANA ISLANDS, PALAU, GUAM AND STATES IN FEDERATED STATES OF MICRONESIA. Fishing effort from Skipjack Programme (1980).



1.2 Previous Tuna and Baitfish Surveys

Japan undertook investigations into the marine resource potential of Micronesia in the 1920s (Smith 1947). A fisheries experimental station was established in Palau (Nishi 1968) and from this station Japan carried out surveys on tuna in areas as far away as the Marshall Islands.

Several research surveys were sponsored by the United States Government in the decade following World War II. In the late 1960s and early 1970s, there were both Japanese- and United States-sponsored surveys aimed at evaluating the skipjack and baitfish resources of Micronesia. On many of the Japanese surveys there were releases of tagged skipjack and yellowfin. By 1971, several Japanese firms were actively pursuing the establishment of joint-venture skipjack fisheries in Truk and Ponape. Under the United States/Japan War Claims Agreement, Japan gave seven 26-gross tonne skipjack, pole-and-line vessels to the Trust Territory Government in 1976 (Rechebei 1976). Some of these vessels were subsequently used for live-bait fishing in Palau, Truk and Ponape. In 1978, maritime authorities were established in Palau, Federated States of Micronesia, and Marshall Islands with responsibility for managing the exploitation of fisheries resources in the 200-mile extended fishery zones of these states (Anon. 1979).

Purse-seining for skipjack was first attempted in Micronesia in 1948 by a United States-financed survey using the vessel Alaska from the eastern Pacific tuna fishery. The survey was considered unsuccessful and further purse-seining trials were not attempted until 1960 when the Japanese purse-seiner Kenyo Maru operated in the Equatorial Pacific during the off-season (winter months) in Japan. In the late 1960s and early 1970s, several more Japanese seiners fished in tropical waters during the Japanese off-season, and seven United States, industry-sponsored purse-seiners made an exploratory cruise in 1970 to the western Pacific. These were followed by exploratory fishing sponsored by the Japan Marine Fishery Resource Research Center (JAMARC) between 1974 and 1976, which demonstrated that a year-round purse-seine fishery was possible in the Caroline Islands. Between 1976 and 1982, ten United States purse-seiners were sponsored by the Pacific Tuna Development Foundation to fish for varying periods in the western Pacific.

Baitfish surveys date back to the 1920s when Japanese companies first showed interest in commercial pole-and-line fishing in the Caroline and Mariana Islands. After World War II the United States conducted surveys of baitfish resources and subsistence fisheries in the Mariana, Caroline and Marshall Islands. Since that time many United States and Japanese surveys have assessed various aspects of baitfish resources throughout the Trust Territory and Guam.

Appendix A lists and comments on exploratory tuna fishing, fisheries development, and fisheries research surveys in the Mariana, Caroline and Marshall Islands. As more surveys have taken place in this area than in any other part of the region served by the South Pacific Commission, the list may well be incomplete, but should be a base for future investigators to build from.

2.0 METHODS

2.1 Vessels and Crew

Two Japanese commercial fishing vessels, the Hatsutori Maru No.1 and the Hatsutori Maru No.5, were chartered at different times by the Skipjack Programme from Hokoku Marine Products Company Limited, Tokyo, Japan. Details of both vessels are given in Kearney (1982a). The 192-tonne Hatsutori Maru No.1 was used between October 1977 and July 1979 and the 254-tonne Hatsutori Maru No.5 was used between November 1979 and August 1980.

The Hatsutori Maru No.1 was operated with at least three Skipjack Programme scientists, nine Japanese officers and twelve Fijian crew. For the Hatsutori Maru No.5, an additional three Fijian crew were employed. Appendix B lists scientists, observers and crew who were on board during surveys in the waters of Northern Mariana Islands, Guam, Palau, Federated States of Micronesia and Marshall Islands.

2.2 Fishing and Tagging

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

The number of crew on the vessels Hatsutori Maru No.1 and No.5 was fewer than either of these carry when fishing commercially. The effective number of fishermen was further reduced because at least one crew member was required to assist each scientist in the tagging procedures. Moreover, the need to pole tuna accurately into the tagging cradles reduced the speed of individual fishermen. Clearly, these factors decreased the fishing power of the vessels under research conditions. During the first survey in the waters of Fiji (26 January-18 February, 28 March-10 April 1978), the Hatsutori Maru No.1 fished commercially for approximately one month, as part of the charter agreement between the Programme and the vessel's owner. From comparison of commercial and survey catches at this time, it was estimated that the fishing power of the Hatsutori Maru No.1 during commercial fishing was 3.47 times its fishing power during survey fishing (Kearney 1978a). It was assumed that the same conversion factor applied to the Hatsutori Maru No.5.

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

2.3 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, weight, sex, gonad weight, stage of sexual maturity, and records of stomach contents. In addition, a log was maintained of all fish schools sighted throughout the Programme. Where possible the species composition of each school was determined. Records were kept of the chumming response and catch by species from each school. Argue (1982) describes methods used for the collection of these data.

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

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

2.4 Baitfishing

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

2.5 Data Compilation and Analysis

Five separate logbooks (Kearney 1982c) formed the basis for compiling data accumulated during the fieldwork outlined in Sections 2.2 to 2.4. The techniques used to enter data from these logs into computer files and to process data are discussed in Kleiber & Maynard (1982). Electrophoretic data from blood samples and parasite identifications from skipjack viscera were also coded and entered into computer files. Data processing was carried out on the Programme's Hewlett Packard 1000 computer in Noumea.

Assessment of the skipjack resource and possible interactions among skipjack fisheries was approached from several viewpoints. Data from skipjack tag releases and recoveries have formed the basis of investigation of movement patterns, fishery interactions and population dynamics, using analytic techniques described in Skipjack Programme (1981b) and Kleiber, Argue & Kearney (1983a). Methods employed in biological studies of growth are described in Lawson, Kearney & Sibert (1984) and Sibert, Kearney & Lawson (1983), and of tuna juvenile abundance, in Argue, Conand & Whyman (1983). Procedures used to compare fishing effectiveness of different baitfish families are described in Skipjack Programme (1981c) and Argue, Williams & Hallier (ms.). Evaluation of population structuring across the whole of the western and central Pacific has centred on a comparison of the tagging results with results from blood genetics analyses (Anon. 1980, 1981; Skipjack Programme 1981d). Occurrence and distribution of skipjack parasites have also been evaluated (Lester 1981; Lester, Barnes & Habib ms.).

3.0 SUMMARY OF FIELD ACTIVITIES

In the waters of the Trust Territory and Guam the research vessels spent 78 days fishing, 7 days baiting, 13 days in port and 17 days steaming (Table 1, Figure 1). Survey days and time spent searching and fishing were distributed amongst the states of this region in rough proportion to their sea areas (Table 2). Survey catches were not so distributed (Table 1). The Programme made good catches in Palau and Federated States of Micronesia, poor catches in Northern Mariana Islands and Marshall Islands, and no catch in Guam. The total catch by live-bait, pole-and-line fishing in the Trust Territory and Guam was 54.2 tonnes, of which 90 per cent was skipjack, 8 per cent was yellowfin, and 3 per cent was other species. (See Section 4.2 for further comments on fishing results.)

TABLE 1. SUMMARY OF DAILY FIELD ACTIVITIES IN THE WATERS OF NORTHERN MARIANA ISLANDS (MAR), GUAM (GUM), PALAU (PAL), FEDERATED STATES OF MICRONESIA (KOS, PON, YAP, TRK), AND MARSHALL ISLANDS (MAS). Schools sighted are given by species: SJ = skipjack or skipjack with other species except yellowfin, YF = yellowfin or yellowfin with other species except skipjack, S+Y = skipjack with yellowfin or skipjack with yellowfin and other species, OT = other species without skipjack or yellowfin, UN = unidentified, but most likely schools with tuna. Survey number (1,2,3) appears after each abbreviation.

Date	General Area		Principal Activity	Bait Carried (kg)	Hours Fishing and Sighting	Schools Sighted (numbers)					Fish Tagged (numbers)			Fish Caught (kg)		Total Catch (kg)
						SJ	YF	S+Y	OT	UN	SJ	YF	OT	SJ	YF	
26/07/78	Majuro	MAS1	Fishing	140	12	1	1	2	0	2	122	6	0	366	48	415
27/07/78	Majuro	MAS1	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
28/07/78	Majuro-Jaluit	MAS1	Fishing	38	1	0	1	0	0	0	0	0	0	0	0	0
29/07/78	Jaluit	MAS1	Baiting	0	0	-	-	-	-	-	-	-	-	-	-	-
30/07/78	Jaluit	MAS1	Fishing	140	11	0	0	0	0	3	0	0	0	0	0	0
31/07/78	Jaluit-Kosrae	MAS1	Fishing	92	10	0	0	0	0	0	0	0	0	0	0	0
31/07/78	Jaluit-Kosrae	KOS1	Fishing	92	2	0	0	0	0	1	0	0	0	0	0	0
01/08/78	Kosrae	KOS1	Fishing	80	8	0	0	0	0	5	0	0	0	0	0	0
02/08/78	Kosrae-Ponape	KOS1	Fishing	162	6	0	0	0	0	2	0	0	0	0	0	0
02/08/78	Kosrae-Ponape	PON1	Fishing	162	5	0	0	0	0	0	0	0	0	0	0	0
03/08/78	SE Ponape	PON1	Fishing	126	12	0	0	0	0	10	0	0	0	0	0	0
04/08/78	N Ponape	PON1	Fishing	260	8	1	0	0	0	4	18	0	0	72	0	72
05/08/78	Ponape	PON1	Fishing	165	11	0	0	0	3	3	0	0	0	0	0	8
06/08/78	NW Ponape	PON1	Fishing	216	10	3	1	1	0	4	294	0	0	1045	0	1049
07/08/78	Oroluk	PON1	Baiting	0	5	0	0	0	0	1	-	-	-	-	-	-
08/08/78	Oroluk	PON1	Fishing	20	12	1	0	0	0	3	116	0	0	519	0	519
09/08/78	Truk	TRK1	Baiting	0	0	-	-	-	-	-	-	-	-	-	-	-
10/08/78	Truk	TRK1	Fishing	168	8	1	0	0	0	5	720	0	0	2208	0	2208
11/08/78	Truk	TRK1	Fishing	170	8	0	0	1	0	3	0	0	0	0	0	0
12/08/78	Truk-Guam	TRK1	Fishing	111	11	0	0	0	0	0	0	0	0	0	0	0
13/08/78	Guam-Saipan	GUM1	Fishing	114	8	0	0	0	0	0	0	0	0	0	0	0
13/08/78	Guam-Saipan	MAR1	Fishing	114	3	0	0	0	0	0	0	0	0	0	0	0
14/08/78	Saipan	MAR1	Fishing	108	6	1	0	0	0	2	0	0	0	0	0	0
06/10/78	S Bonin Is	MAR1	Steaming	287	5	0	0	0	0	1	0	0	0	0	0	0
07/10/78	Mariana Is	MAR1	Fishing	254	8	1	0	0	0	1	8	0	0	80	0	80
08/10/78	Saipan-Rota Is	MAR1	Fishing	212	7	0	0	0	0	2	0	0	0	0	0	0
09/10/78	Rota Is-Guam	MAR1	Fishing	158	5	0	1	0	0	0	0	0	0	0	0	0
09/10/78	Rota Is-Guam	GUM1	Fishing	158	4	0	0	0	0	0	0	0	0	0	0	0
10/10/78	Guam	GUM1	In Port	111	0	-	-	-	-	-	-	-	-	-	-	-
11/10/78	SW Guam	GUM1	Fishing	90	6	0	0	0	0	0	0	0	0	0	0	0
12/10/78	Guam-Yap	YAP1	Fishing	81	12	0	0	0	0	0	0	0	0	0	0	0
13/10/78	Yap-Palau	YAP1	Fishing	74	12	2	0	0	0	0	52	0	0	278	0	278
14/10/78	Palau	PAL1	In Port	33	0	-	-	-	-	-	-	-	-	-	-	-
15/10/78	Palau	PAL1	In Port	18	0	-	-	-	-	-	-	-	-	-	-	-
16/10/78	Palau	PAL1	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
17/10/78	Palau	PAL1	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
18/10/78	E Palau	PAL1	Fishing	201	10	0	0	0	0	6	0	0	0	0	0	0
19/10/78	E Palau	PAL1	Fishing	273	10	1	0	0	2	1	278	0	0	1853	0	1861
20/10/78	E Palau	PAL1	Fishing	309	14	1	0	0	0	1	440	0	0	2577	0	2577
21/10/78	E Palau	PAL1	Fishing	347	10	0	0	0	0	0	0	0	0	0	0	0
22/10/78	Palau-Yap	YAP1	Fishing	315	11	0	1	1	0	1	726	2	0	3079	5	3098
23/10/78	Yap	YAP1	Fishing	53	12	0	0	1	0	2	0	8	0	10	8	17
24/10/78	Yap-Truk	YAP1	Fishing	30	10	0	0	0	1	3	0	0	0	0	0	4
25/10/78	W Truk	TRK1	Baiting	0	10	0	0	0	0	8	-	-	-	-	-	-
26/10/78	Truk	TRK1	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
27/10/78	Truk	TRK1	Fishing	77	8	0	0	0	0	3	0	0	0	0	0	0
28/10/78	Truk	TRK1	Fishing	359	11	0	0	0	2	7	0	0	0	0	0	4
29/10/78	Truk-Ponape	TRK1	Fishing	231	1	0	0	0	0	0	0	0	0	0	0	0
29/10/78	Truk-Ponape	PON1	Fishing	231	10	1	3	3	0	1	82	29	0	495	526	1021
30/10/78	W Ponape	PON1	Fishing	36	4	0	0	3	0	0	0	0	0	5	0	5
31/10/78	Ponape-Pakin	PON1	Fishing	371	6	2	0	0	1	3	235	0	0	914	0	914
01/11/78	Ponape	PON1	Fishing	210	10	0	0	0	3	5	0	0	0	0	0	0
02/11/78	Ponape	PON1	Fishing	252	10	0	0	0	1	5	0	0	0	0	0	0
03/11/78	E Ponape	PON1	Fishing	113	11	1	0	1	0	4	187	57	0	591	76	674
04/11/78	Ponape-Kosrae	KOS1	Steaming	0	12	0	0	0	0	1	-	-	-	-	-	-
05/11/78	Ponape-Kosrae	KOS1	Fishing	164	10	1	3	1	0	5	135	1	0	151	9	164
06/11/78	Kosrae-Majuro	MAS1	Steaming	0	9	0	0	0	0	4	-	-	-	-	-	-
07/11/78	SW Majuro	MAS1	Steaming	0	12	0	0	0	0	5	-	-	-	-	-	-
08/11/78	Majuro	MAS1	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
09/11/78	Majuro	MAS1	Fishing	365	9	1	1	0	1	3	0	2	0	1	44	46
10/11/78	Majuro	MAS1	Fishing	68	10	1	0	0	0	2	164	0	0	572	0	572
11/11/78	Majuro	MAS1	Fishing	57	7	0	0	0	0	2	0	0	0	0	0	0
12/11/78	Majuro	MAS1	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
13/11/78	Majuro	MAS1	Baiting	0	0	-	-	-	-	-	-	-	-	-	-	-
14/11/78	Majuro	MAS1	Baiting	21	0	-	-	-	-	-	-	-	-	-	-	-
06/11/79	N Mariana Is	MAR2	Fishing	615	11	0	0	0	2	3	0	0	0	0	0	2
07/11/79	Almagan Is	MAR2	Fishing	576	7	1	0	1	1	2	187	0	0	579	0	579
08/11/79	E Mariana Is	MAR2	Fishing	500	9	0	0	0	0	0	0	0	0	0	0	0
09/11/79	N Truk	TRK2	Fishing	497	11	1	0	0	0	0	0	0	0	6	0	6
10/11/79	Hall Is	TRK2	Fishing	476	11	1	0	0	1	4	334	0	0	1227	0	1227
11/11/79	Oroluk	PON2	Fishing	393	11	3	2	1	1	5	376	5	0	655	208	863
12/11/79	Ponape	PON2	Fishing	201	6	3	0	0	0	1	95	0	0	65	0	65
13/11/79	Ponape	PON2	In Port	654	0	-	-	-	-	-	-	-	-	-	-	-
14/11/79	Ponape	PON2	Fishing	393	11	4	0	0	3	9	0	0	0	0	0	2
15/11/79	Ponape-Pakin	PON2	Fishing	411	12	2	2	0	1	3	68	4	0	56	3	189

TABLE 1. (cont.)

Date	General Area		Principal Activity	Bait Carried (kg)	Hours Fishing and Sighting	Schools Sighted (numbers) SJ	YF	S+Y	OT	UN	Fish Tagged (numbers) SJ	YF	OT	Fish Caught (kg) SJ	YF	Total Catch (kg)
16/11/79	E Ponape	PON2	Fishing	512	10	0	0	1	0	1	397	138	0	345	117	536
17/11/79	W Kosrae	KOS2	Fishing	420	10	1	0	1	0	1	47	547	1	35	417	517
18/11/79	Kosrae	KOS2	Fishing	345	11	0	1	1	1	8	82	12	0	388	15	439
19/11/79	Kosrae	KOS2	Fishing	134	11	0	1	0	1	7	0	0	0	0	0	6
20/11/79	E Kosrae	KOS2	Fishing	152	11	0	0	1	0	0	33	38	0	22	29	52
21/11/79	Ebon	MAS2	Fishing	84	10	0	3	1	0	10	41	86	6	97	413	522
16/07/80	NW Kosrae	KOS3	Steaming	0	9	0	0	0	0	10	-	-	-	-	-	-
17/07/80	Ponape	PON3	Steaming	0	7	1	0	0	0	10	-	-	-	-	-	-
18/07/80	Ponape	PON3	Fishing	231	3	1	0	0	0	0	959	0	0	5997	0	5997
19/07/80	Ponape	PON3	Fishing	866	7	2	0	2	0	1	904	6	0	3803	27	3830
20/07/80	Ponape	PON3	Fishing	188	7	2	0	2	0	0	607	38	0	2621	169	2790
21/07/80	Ponape	PON3	Fishing	242	5	3	0	0	0	1	511	0	0	3320	0	3412
22/07/80	Ponape	PON3	Fishing	51	5	1	0	1	1	1	8	3	0	20	12	32
23/07/80	Ponape	PON3	Fishing	44	2	1	0	0	0	0	204	0	0	1390	0	1390
24/07/80	Ponape	PON3	Fishing	272	8	2	0	1	2	3	125	6	0	966	55	1057
25/07/80	Ponape	PON3	Fishing	144	5	1	0	0	3	0	332	0	0	2094	0	2152
26/07/80	Ponape	PON3	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
27/07/80	Ponape	PON3	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
28/07/80	W Ponape	PON3	Steaming	0	0	-	-	-	-	-	-	-	-	-	-	-
29/07/80	E Truk	PON3	Steaming	0	10	0	0	0	0	8	-	-	-	-	-	-
29/07/80	W Ponape	TRK3	Steaming	0	1	0	0	0	0	0	-	-	-	-	-	-
30/07/80	E Truk	TRK3	Steaming	0	11	0	0	0	0	16	-	-	-	-	-	-
31/07/80	W Satawal	YAP3	Steaming	0	6	0	0	0	0	9	-	-	-	-	-	-
01/08/80	W Woleai	YAP3	Steaming	0	10	0	0	0	0	3	-	-	-	-	-	-
02/08/80	W Yap	YAP3	Steaming	0	4	0	0	0	0	2	-	-	-	-	-	-
03/08/80	Palau	PAL3	Steaming	0	5	0	0	0	0	5	-	-	-	-	-	-
04/08/80	Palau	PAL3	In Port	0	0	-	-	-	-	-	-	-	-	-	-	-
05/08/80	W Palau	PAL3	Fishing	180	9	4	1	1	1	1	8	3	0	21	5	138
06/08/80	S Palau	PAL3	Steaming	185	10	0	0	0	0	7	0	0	0	0	0	0
07/08/80	N Helen Reef	PAL3	Fishing	110	2	0	0	3	0	0	28	146	0	68	625	718
08/08/80	Helen Reef	PAL3	Fishing	180	9	0	10	0	1	1	0	0	0	0	0	12
09/08/80	Helen Reef-Tobi	PAL3	Fishing	68	11	1	2	2	0	1	367	23	0	403	31	520
10/08/80	Helen Reef	PAL3	Baiting	12	0	-	-	-	-	-	-	-	-	-	-	-
11/08/80	Helen Reef	PAL3	Fishing	156	2	0	0	1	0	0	151	123	0	305	167	516
12/08/80	Helen Reef	PAL3	Fishing	140	2	0	0	2	0	0	543	114	0	765	139	921
13/08/80	Helen Reef	PAL3	Fishing	207	4	0	0	3	0	0	696	168	9	1274	325	1665
14/08/80	Helen Reef	PAL3	Fishing	57	2	0	0	2	0	0	637	10	0	1026	22	1058
15/08/80	Helen Reef-Merir	PAL3	Fishing	23	12	2	0	0	0	21	13	0	0	36	0	36
16/08/80	S Palau	PAL3	Steaming	0	5	0	0	0	0	8	-	-	-	-	-	-
17/08/80	E Palau	PAL3	Fishing	47	8	0	0	0	0	5	0	0	0	0	0	0
18/08/80	W Palau	PAL3	Fishing	413	8	0	0	3	0	2	2501	517	9	3314	636	4094
19/08/80	W Palau	PAL3	Fishing	239	5	0	0	1	0	1	1363	184	0	1786	320	2224
20/08/80	E Palau	PAL3	Fishing	179	6	1	0	0	0	3	208	0	0	1064	0	1064
21/08/80	Yap	YAP3	Steaming	0	2	0	0	0	0	4	-	-	-	-	-	-
22/08/80	Yap	YAP3	Fishing	255	5	1	0	0	0	2	0	0	0	0	0	0
23/08/80	Yap-Guam	YAP3	Steaming	0	0	-	-	-	-	-	-	-	-	-	-	-
GRAND TOTAL			Days*	115	802	59	34	45	33	303	15402	2276	25	48564	4451	54217
NORTHERN MARIANA ISLANDS			Days	8	61	3	1	1	3	11	195	0	0	659	0	661
GUAM			Days	3	18	0	0	0	0	0	0	0	0	0	0	0
PALAU			Days	26	144	10	13	18	4	63	7233	1288	18	14492	2270	17404
FEDERATED STATES OF MICRONESIA			Days	62	488	43	14	23	25	198	7647	894	1	32377	1676	34597
MARSHALL ISLANDS			Days	16	91	3	6	3	1	31	327	94	6	1036	505	1555

* Survey days in two different areas were assigned to the area which had the greatest number of hours spent searching and fishing.

TABLE 2. NUMBER OF SURVEY DAYS AND HOURS SPENT SEARCHING AND FISHING (in brackets) IN THE WATERS OF NORTHERN MARIANA ISLANDS, GUAM, PALAU, FEDERATED STATES OF MICRONESIA, AND MARSHALL ISLANDS*

Month/Year (Survey Number)	Northern Mariana Islands	Guam	Palau	Federated States of Micronesia: Yap	Truk	Ponape	Kosrae	Total	Marshall Islands	Grand Total
July 1978 (1)	-	-	-	-	-	-	(2)	(2)	6(34)	6(34)
August 1978 (1)	1(9)	1(8)	-	-	4(27)	6(63)	2(14)	12(104)	-	14(121)
October 1978 (1)	4(25)	2(10)	8(44)	5(57)	4(30)	3(20)	-	12(107)	-	26(186)
November 1978 (1)	-	-	-	-	-	3(31)	2(22)	5(53)	9(47)	14(100)
November 1979 (2)	3(27)	-	-	-	2(22)	6(60)	4(43)	12(115)	1(10)	16(152)
July 1980 (3)	-	-	-	1(6)	1(12)	13(59)	1(9)	16(86)	-	16(86)
August 1980 (3)	-	-	18(100)	5(21)	-	-	-	5(21)	-	23(121)
TOTALS	8(61)	3(18)	26(144)	11(84)	11(91)	31(32)	9(90)	62(488)	16(91)	115(802)
Approximate Sea Area (km^2)**	771,000	213,000	622,000					2,989,000	2,025,000	6,620,000

* Survey days in two different areas were assigned to the area which had the greatest number of hours spent searching and fishing.

** These areas are based on boundaries prepared by Skipjack Programme staff for the purpose of scientific analysis of the Programme's data, thus they should not be taken as an authority on the extent of the areas of jurisdiction of each state.

The Programme made a total of 98 bouki-ami and 5 beach seine hauls at 14 localities in Palau, Federated States of Micronesia and Marshall Islands (Table 3). Ten bait species accounted for 91 per cent of 10,728 kg of bait caught by bouki-ami gear (Table 4), and 3 bait species accounted for 98 per cent of 139 kg of bait caught by beach seine gear. In addition, 1,386 kg of bait was purchased before the vessel left Japan in October 1978 (750 kg of Sardinops melanosticta) and again in November 1979 (636 kg of Engraulis japonicus) for use en route to and within the Trust Territory and Guam.

A total of 15,402 skipjack, 2,276 yellowfin and 25 other tunas were tagged and released. As of 10 October 1983, there have been recoveries of 792 skipjack, 71 yellowfin and none of the other species.

The size frequency distribution for tagged skipjack released during surveys in the Trust Territory and Guam in July-August (Figure 6, upper graph) has distinct modes at 37 cm, 50 cm and 64 cm; the size frequency distribution for skipjack tag releases during surveys in October-November has modes at 30 cm and 54 cm (Figure 6, middle graph). The size frequency distribution for all Programme releases of tagged skipjack (Figure 6, lower graph) has a broad peak extending approximately 3 cm on either side of the modal length of 51 cm.

Eleven skipjack blood samples each of approximately 100 specimens were collected from individual schools in Palau and Federated States of Micronesia.

4.0 RESULTS AND DISCUSSION

4.1 Baitfishing

4.1.1 General observations

Results from the Programme's baiting at 14 localities in the Trust Territory and Guam (four in Palau, eight in Federated States of Micronesia, two in Marshall Islands) are detailed in Table 3. For larger localities, such as Helen Reef in Palau and Ponape Harbour in the Federated States of Micronesia, results are shown separately for all anchorages that were further than one nautical mile apart. Table 5 presents a summary of catch data for the 10 most common species caught by bouki-ami gear in Palau, Federated States of Micronesia and Marshall Islands. There were more than 10 species identified from bouki-ami hauls in these states (Appendix C); however, the 10 species listed accounted for over 90 per cent of the catch by weight. In this and subsequent baitfish tables the total catch includes a small percentage of bait (<10%) that was discarded while loading the bait on board the research vessel (e.g. dead bait, bait in excess of baitwell holding capacity, undesirable species). For some presentations of baitfish data, catches were averaged over anchorages within localities (or areas), in order to give equal weight to each anchorage regardless of the number of hauls per anchorage.

The average catch per bouki-ami haul in the Trust Territory and Guam, 110 kg, was comparable with the Programme's overall average of 121 kg per bouki-ami haul, whereas the average catch per beach seine haul, 28 kg, was considerably below the overall average of 45 kg per beach seine haul (Kearney 1983b).

Bait purchased in 1978 in Japan suffered abnormally high mortality due to poor water flow from a build-up of debris in the pump lines after painting of the baitwells (Kearney et al. 1979). In 1979, bait from Japan

TABLE 3. SUMMARY OF BAITFISHING EFFORT AND CATCH BY THE SKIPJACK PROGRAMME IN THE WATERS OF PALAU, FEDERATED STATES OF MICRONESIA, AND MARSHALL ISLANDS. Baitfishing was not attempted in Northern Mariana Islands and Guam.

Locality Number	Anchorage	Time of Hauls	Number of Hauls	Dominant Species	Est. Av. Catch per Haul (kg)	Mean Length (mm)	Other Common Species
				Palau			
1	Rock Islands 07°17′N 134°25′E	Night	10	Stolephorus heterolobus Archamia lineolata Spratelloides delicatulus	116	51	Selar crumenophthalmus Rastrelliger brachysoma Herklotsichthys quadrimaculatus
2	Urukthapel Hbr 07°17′N 134°27′E	Night	2	Stolephorus heterolobus Sardinella clupeoides Hypoatherina temmincki	87	64	Spratelloides delicatulus Leiognathus bindus Rastrelliger kanagurta
	Urukthapel Hbr 07°17′N 134°26′E	Night	2	Stolephorus heterolobus Herklotsichthys quadrimaculatus Sp. of Mullidae	23	52	Selar crumenophthalmus Hypoatherina temmincki Spratelloides delicatulus
3	Malakal Hbr 07°20′N 134°26′E	Night	4	Stolephorus heterolobus Spratelloides delicatulus Hypoatherina temmincki	81 37 18	74 49 49	Leiognathus bindus Herklotsichthys quadrimaculatus Apogon(Rhabdamia) cypselurus
	Malakal Hbr 07°20′N 134°27′E	Night	2	Stolephorus heterolobus Hypoatherina temmincki Spratelloides delicatulus	51 28 10	73 47 49	Herklotsichthys quadrimaculatus Atherinomorus lacunosa Leiognathus bindus
4	Helen Reef 02°52′N 131°46′E	Night	2	Dussumieria sp. Spratelloides delicatulus Apogon(Rhabdamia) cypselurus	71 12 10	157 43	Spratelloides gracilis Hypoatherina temmincki Archamia lineolata
	Helen Reef 02°57′N 131°49′E	Night	3	Spratelloides delicatulus Hypoatherina temmincki Spratelloides gracilis	17 9 1	44 58 52	Archamia zosterophora Sp. of Apogonidae Sp. of Synodontidae
	Helen Reef 02°55′N 131°46′E	Night	4	Spratelloides delicatulus Dussumieria sp. Hypoatherina temmincki	26 25 13	42 152 50	Spratelloides gracilis Apogon(Rhabdamia) cypselurus Spratelloides sp.
	Helen Reef 02°51′N 131°44′E	Night	5	Spratelloides delicatulus Hypoatherina temmincki Spratelloides sp.	67 8 6	45 53 50	Apogon(Rhabdamia) cypselurus Spratelloides gracilis Sp. of Crustacea
				Federated States of Micronesia			
5	Tomil Hbr (Yap) 09°30′N 138°08′E	Night	2	Stolephorus heterolobus Leiognathus bindus Archamia lineolata	100 14 8	60	Stolephorus indicus Hypoatherina temmincki Atherinomorus lacunosa
6	Tol Island (Truk) 07°22′N 151°38′E	Day	1	Spratelloides delicatulus Sp. of Labridae	49		
	Tol Island (Truk) 07°22′N 151°38′E	Night	2	Hypoatherina ovalaua Spratelloides delicatulus Sardinella sirm	32 30	49 30	Apogon(Rhabdamia) cypselurus Stolephorus heterolobus Stolephorus devisi
	Tol Island (Truk) 07°22′N 151°39′E	Night	2	Spratelloides delicatulus Hypoatherina ovalaua Sardinella sirm	71 15	36 46	Herklotsichthys quadrimaculatus Sp. of Carangidae Bregmaceros sp.
7	Tarik Island (Truk) 07°20′N 151°46′E	Night	2	Atherinomorus lacunosa Hypoatherina ovalaua Herklotsichthys quadrimaculatus	19 19		Spratelloides delicatulus
8	Fefan Island (Truk) 07°23′N 151°48′E	Night	2	Sardinella sirm Hypoatherina ovalaua Atherinomorus lacunosa	105 22 22	165 54 54	Spratelloides delicatulus Selar crumenophthalmus Herklotsichthys quadrimaculatus
9	Oroluk Lagoon (Ponape) 07°37′N 155°22′E	Night	1	Spratelloides delicatulus Hypoatherina ovalaua Atherinomorus lacunosa	16 1 1		Archamia lineolata Sp. of Holocentridae Sp. of Squid
10	Ponape Hbr (Ponape) 06°59′N 158°12′E	Night	25	Stolephorus heterolobus Stolephorus devisi Hypoatherina ovalaua	54 31 28	49 53	Herklotsichthys quadrimaculatus Spratelloides delicatulus Hypoatherina temmincki
	Ponape Hbr (Ponape) 07°00′N 158°12′E	Night	10	Stolephorus heterolobus Stolephorus devisi Herklotsichthys quadrimaculatus	74 54 12	60 55 66	Hypoatherina temmincki Spratelloides delicatulus Stolephorus indicus

TABLE 3. (cont.)

Locality Number	Anchorage	Time of Hauls	Number of Hauls	Dominant Species	Est. Av. Catch per Haul (kg)	Mean Length (mm)	Other Common Species
11	Lele Hbr (Kosrae)			Stolephorus devisi	25	53	Stolephorus indicus
	05°19'N	Night	8	Stolephorus heterolobus	24		Stolephorus bataviensis
	163°01'E			Herklotsichthys quadrimaculatus	21	99	Archamia lineolata
12	Coquille Hbr (Kosrae)			Selar crumenophthalmus	19	213	Kyphosus cinerascens
	05°21'N	Night	2	Scomberoides sp.			Monodactylus argenteus
	162°57'E			Caranx sp.			Caranx sexfasciatus
				Marshall Islands			
13	Majuro Lagoon			Spratelloides delicatulus	13	41	Sp. of Lethrinidae
	07°08'N	Day	3	Atherinomorus lacunosa	3	50	Sp. of Pomacentridae
	171°16'E			Sp. of Hemirhamphidae			Herklotsichthys quadrimaculatus
	Majuro Lagoon			Sardinella sirm	200	165	Spratelloides delicatulus
	07°05'N	Night	2	Selar crumenophthalmus			Hypoatherina ovalaua
	171°12'E			Rastrelliger kanagurta			Sp. of Carangidae
	Majuro Lagoon			Hypoatherina ovalaua	23	57	Sp. of Holocentrida
	07°05'N	Night	1	Spratelloides delicatulus	10	38	Rastrelliger kanagurta
	171°10'E			Herklotsichthys quadrimaculatus			
	Majuro Lagoon			Hypoatherina ovalaua	13	46	Sp. of Holocentridae
	07°07'N	Night	2	Spratelloides delicatulus	12	39	Apogon(Rhabdamia) cypselurus
	171°20'E			Atherinomorus lacunosa	2	64	Sp. of Mullidae
	Majuro Lagoon			Spratelloides delicatulus	10	4	
	07°08'N	Night	1	Hypoatherina ovalaua			
	171°16'E						
14	Jaluit Lagoon			Spratelloides delicatulus	37		
	05°59'N	Day	1	Hypoatherina ovalaua	1		
	169°43'E						
	Jaluit Lagoon			Hypoatherina ovalaua	48	60	Bregmaceros sp.
	05°59'N	Night	2	Spratelloides delicatulus			Grammatorcynus bicarinatus
	169°43'E			Herklotsichthys quadrimaculatus			Atherinomorus lacunosa

* Several recent revisions of scientific names are used in this report. The most notable changes in nomenclature are :

Herklotsichthys punctatus to Herklotsichthys quadrimaculatus
Pranesus pinguis to Atherinomorus lacunosa

Explanatory Notes

Anchorage : Recorded positions are truncated to the nearest minute. For large bays there may be more than one position tabulated.

Number of Hauls : Number of hauls at the anchorage position. A haul is defined as any time the net was placed in the water.

Dominant Species : Those species (maximum of three) that made up at least one per cent of the numbers caught from one or more bait hauls at a particular location, ranked on their weighted proportion of the catch.

Average Catch (species) : The average catch in kilograms per haul is given for dominant species for each anchorage and gear type. This average catch is the product of the total catch in kilograms for the particular anchorage and gear type and the weighted proportion of the particular species in this catch. The weighted proportion of each species was determined from the numerical proportion in the catch multiplied by the cube of the mean standard length for that species, anchorage and gear type, and by a scaling factor. The scaling factor was chosen so that the sum of weighted proportions would equal the sum of numerical proportions. If the mean standard length was unknown, the numerical proportion was used. Since the average catch per haul is given for only the dominant three species, the total of these is generally less than the total catch for the anchorage and gear type.

Mean Length : Weighted by numerical abundance when there were multiple hauls at the same location.

TABLE 4. THE TEN MOST COMMON SPECIES OF BAITFISH CAUGHT BY THE SKIPJACK PROGRAMME WITH BOUKI-AMI GEAR AND BEACH SEINE GEAR IN THE TRUST TERRITORY AND GUAM

	BOUKI-AMI				BEACH SEINE			
	Bait Species	Total kg	Kg per Haul	Per cent per Haul	Bait Species	Total kg	Kg per Haul	Per cent per Haul
1	Stolephorus heterolobus	4,279	44	40	Spratelloides delicatulus	125	25	89
2	Stolephorus devisi	1,510	15	14	Atherinomorus lacunosa	9	2	7
3	Spratelloides delicatulus	1,080	11	10	Hypoatherina ovalaua	1	<1	2
4	Hypoatherina ovalaua	1,013	10	9	Sp. of Letherinidae	-	-	-
5	Herklotsichthys quadrimaculatus	646	7	6	Sp. of Pomacentridae	-	-	-
6	Sardinella sirm	615	6	5	Sp. of Hemirhamphidae	-	-	-
7	Hypoatherina temmincki	333	3	3	Sp. of Bothidae	-	-	-
8	Dussumieria sp.	241	2	2	Sp. of Mullidae	-	-	-
9	Stolephorus indicus	95	1	1	Herklotsichthys quadrimaculatus	-	-	-
10	Atherinomorus lacunosa	87	1	1	Sp. of Labridae	-	-	-
Total Caught		10,728	110	91*	Total Caught	139	28	98
Total Loaded Alive		9,620	98		Total Loaded Alive	137	27	
Hauls		98			Hauls	5		
Nights		52			Days	4		
Total Catch per Night		206			Total Catch per Day	35		

* The 10 species accounted for 91 per cent of the grand total caught.

FIGURE 6. LENGTH FREQUENCY DISTRIBUTIONS FOR SKIPJACK TAGGED DURING JULY-AUGUST AND OCTOBER-NOVEMBER IN THE TRUST TERRITORY AND GUAM, AND FOR THE TOTAL SKIPJACK PROGRAMME STUDY AREA. N is the sample size.

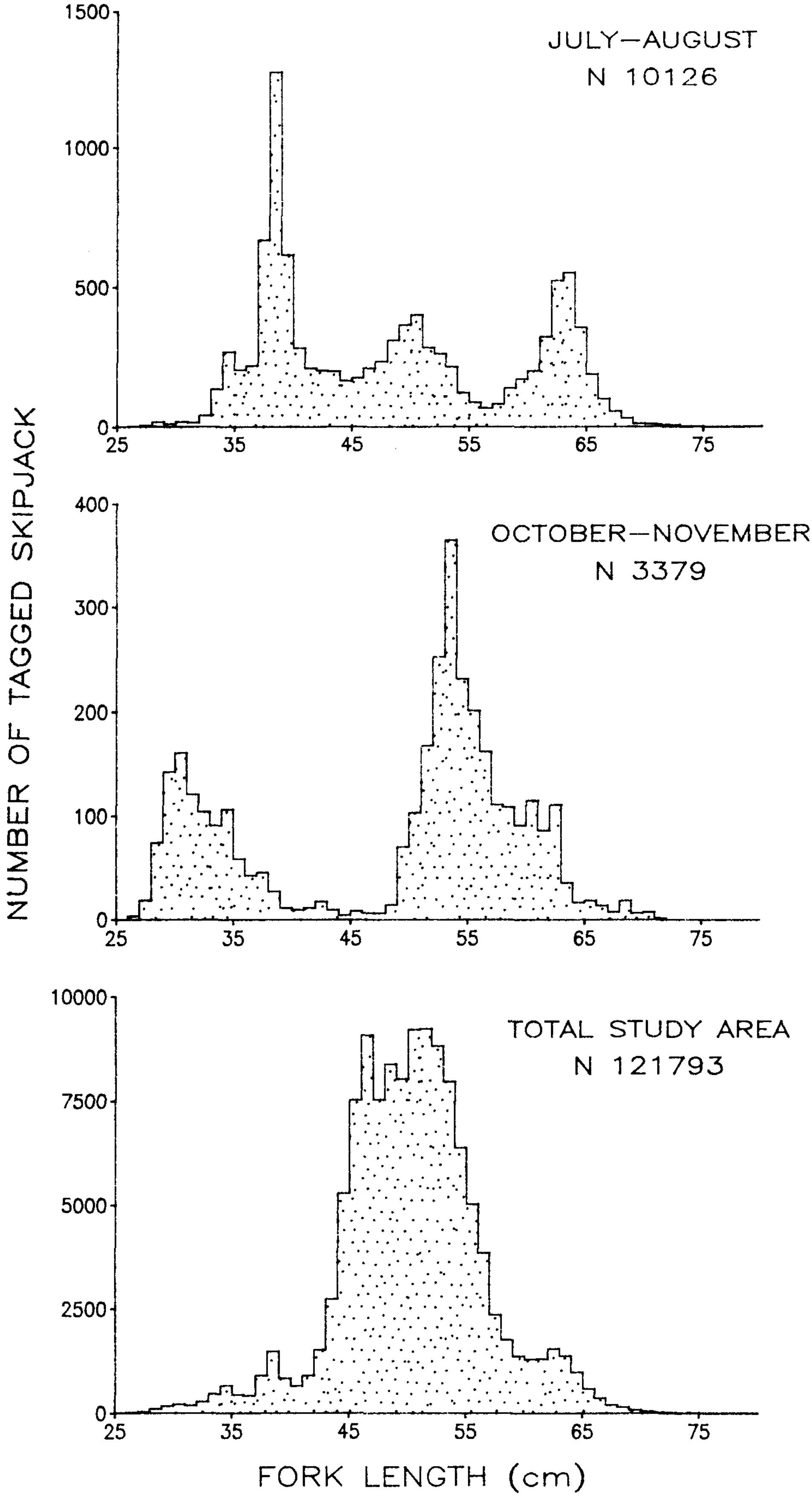


TABLE 5. THE TEN MOST COMMON SPECIES OF BAITFISH CAUGHT BY THE SKIPJACK PROGRAMME WITH BOUKI-AMI GEAR IN PALAU, FEDERATED STATES OF MICRONESIA, AND MARSHALL ISLANDS

	PALAU				FEDERATED STATES OF MICRONESIA			
	Bait Species	Total kg	Kg per Haul	Per cent per Haul	Bait Species	Total kg	Kg per Haul	Per cent per Haul
1	<u>Stolephorus heterolobus</u>	1,807	53	55	<u>Stolephorus heterolobus</u>	2,472	44	36
2	<u>Spratelloides delicatulus</u>	682	20	21	<u>Stolephorus devisi</u>	1,510	27	22
3	<u>Hypoatherina temmincki</u>	244	7	7	<u>Hypoatherina ovalaua</u>	867	16	13
4	<u>Dussumieria</u> sp.	241	7	7	<u>Herklotsichthys quadrimaculatus</u>	610	11	9
5	<u>Apogon cypselurus</u>	68	2	2	<u>Spratelloides delicatulus</u>	354	6	5
6	<u>Spratelloides gracilis</u>	55	2	2	<u>Sardinella sirm</u>	209	4	3
7	<u>Leiognathus bindus</u>	48	1	1	<u>Stolephorus indicus</u>	95	2	2
8	<u>Herklotsichthys quadrimaculatus</u>	36	1	1	<u>Hypoatherina temmincki</u>	89	1	1
9	<u>Spratelloides</u> sp.	32	1	1	<u>Atherinomorus lacunosa</u>	83	1	1
10	<u>Sardinella clupeoides</u>	4	<1	<1	<u>Archamia lineolata</u>	64	1	1
	Total Caught	3,310	97	97	Total Caught	6,811	122	93
	Total Loaded Alive	2,996	88		Total Loaded Alive	6,059	108	
	Hauls	34			Hauls	56		
	Nights	18			Nights	29		
	Total Catch per Night	184			Total Catch per Night	235		

MARSHALL ISLANDS

	Bait Species	Total kg	Kg per Haul	Per cent per Haul
1	<u>Sardinella sirm</u>	402	50	66
2	<u>Hypoatherina ovalaua</u>	146	18	24
3	<u>Spratelloides delicatulus</u>	44	6	8
4	<u>Atherinomorus lacunosa</u>	4	1	1
5	<u>Apogon cypselurus</u>	-	-	-
6	<u>Herklotsichthys quadrimaculatus</u>	-	-	-
7	<u>Bregmaceros</u> sp.	-	-	-
8	<u>Atherinomorus lacunosa</u>	-	-	-
9	Sp. of Holocentridae	-	-	-
10	<u>Grammatorcynus bicarinatus</u>	-	-	-
	Total Caught	609	76	99
	Total Loaded Alive	567	71	
	Hauls	8		
	Nights	5		
	Total Catch per Night	122		

suffered little mortality (<20%) over a 10-day period and was used to fish schools successfully in the waters of Northern Mariana Islands and the Federated States of Micronesia (Kearney & Hallier 1980).

4.1.2 Palau

The Palau Islands have supported a large commercial baitfishery since the 1930s and between 1964 and 1972 the Palau fleet of approximately 12 pole-and-line vessels caught an average of 94 kg of bait per vessel per night (Muller 1977). This fishery was dominated by the anchovy Stolephorus heterolobus, which Muller (1977) estimated could sustain an annual harvest of approximately 160 tonnes. On occasion, the annual bait catch exceeded 200 tonnes. The Palau baitfishery recently (1982) ceased operation, although this was not due to a lack of bait.

The Programme baited at four localities in Palau, three in the Palau Islands (Rock Islands, Urukthapel Harbour and Malakal Harbour) and the fourth at Helen Reef, just to the north of Indonesia. Over half of the Programme's catch in Palau was Stolephorus heterolobus (Table 5), which is considered to be one of the most effective tropical bait species for skipjack pole-and-line fishing (Skipjack Programme 1981c; Argue et al. ms.). The Programme's average catch per haul from the four localities was 97 kg, and catch per night was 184 kg (Table 5).

The largest islands in Palau where baitfishing occurs are just over 60 metres high, few exceed 800 ha, and they are all circled by a 113 km coral reef (Wilson 1977b). The three baiting localities used by the Programme in this area were fished at the same time by some of the relatively small (<80 tonnes) pole-and-line vessels based in Palau. The Programme's average catch from a total of 20 hauls in this area was 98 kg, three quarters of which was Stolephorus heterolobus (Table 6). At Helen Reef the Programme caught an average of 76 kg per haul, mostly of sprats (Table 6). Table 7 presents average baitfish catches for repeat visits to the same baiting locality. Catches during the first visit to Palau in October 1978 averaged 131 kg per haul, and averaged 87 kg per haul during the second visit in August 1980. In the experience of the Programme, the size of the Palau Islands lagoon, the availability of good baitfish habitat, and the presence of stolephorid anchovies confirm that Palau Islands have a substantial baitfish resource.

4.1.3 Federated States of Micronesia

The Programme baited at eight localities in Ponape, Kosrae, Truk and Yap. These areas have all been surveyed previously for bait (Appendix A), and prior to World War II they supported commercial bait fisheries by locally based pole-and-line vessels.

The Programme made 56 bouki-ami hauls in the Federated States of Micronesia (Table 5), 57 per cent of the total hauls for the Trust Territory and Guam, and caught 6,811 kg of bait, of which 60 per cent were stolephorid anchovies. Other common species were the hardyhead (Hypoatherina ovalaua, 13% by weight) and the gold spot herring (Herklotsichthys quadrimaculatus, 9% by weight). For the combined catch from the Federated States of Micronesia, the Programme's catch per haul was 122 kg, and per night, 235 kg; both values were higher than values for Palau and Marshall Islands.

Previous surveys have successfully caught bait at night at many sites around Ponape Island, and Japanese live-bait, pole-and-line vessels based in Ponape prior to World War II used drive-in nets and nets set over coral

TABLE 6. AVERAGE BAIT CATCH AND SPECIES COMPOSITION FOR ATOLL AND HIGH ISLAND BAITING AREAS FISHED BY THE SKIPJACK PROGRAMME IN THE WATERS OF PALAU, FEDERATED STATES OF MICRONESIA, AND MARSHALL ISLANDS

ATOLLS			HIGH ISLANDS		
Bait Species, Baiting Areas (number of hauls/anchorages)	Average Kg Caught per haul	(% Total)	Bait Species, Baiting Areas (number of hauls/anchorages)	Average Kg Caught per Haul	(% Total)
HELEN REEF (PALAU)			PALAU ISLANDS (PALAU)		
Spratelloides delicatulus	31	(41)	Stolephorus heterolobus	72	(74)
Dussumieria sp.	24	(32)	Spratelloides delicatulus	9	(9)
Hypoatherina temmincki	8	(10)	Hypoatherina temmincki	9	(9)
Apogon cypselurus	3	(4)			
Spratelloides sp.	2	(3)			
Spratelloides gracilis	<1	(<1)			
Total	76	(90)	Total	98	(98)
Helen Reef (14/4)			Rock Island (10/1) Urukthapel Harbour (4/2) Malakal Harbour (6/2)		
OROLUK LAGOON (FEDERATED STATES OF MICRONESIA)			PONAPE ISLAND (FEDERATED STATES OF MICRONESIA)		
Spratelloides delicatulus	16	(80)	Stolephorus heterolobus	64	(44)
Hypoatherina ovalaua	1	(5)	Stolephorus devisi	42	(29)
Atherinomorus lacunosa	1	(5)	Hypoatherina ovalaua	14	(9)
			Herklotsichthys quadrimaculatus	6	(4)
Total	20	(90)	Total	146	(86)
Oroluk Lagoon (1/1)			Ponape Harbour (35/2)		
MAJURO LAGOON (MARSHALL ISLANDS)			KOSRAE ISLAND (FEDERATED STATES OF MICRONESIA)		
Sardinella sirm	50*	(73)	Stolephorus devisi	13	(22)
Hypoatherina ovalaua	9	(13)	Stolephorus heterolobus	12	(20)
Spratelloides delicatulus	8	(12)	Herklotsichthys quadrimaculatus	10	(17)
Atherinomorus lacunosa	1	(1)	Selar crumenophthalmus	10	(17)
			Stolephorus indicus	5	(9)
Total	69	(99)	Total	59	(75)
Majuro Lagoon (6/4)			Lele Harbour (8/1) Coquille Harbour (2/1)		
JALUIT LAGOON (MARSHALL ISLANDS)			TRUK ISLANDS (FEDERATED STATES OF MICRONESIA)		
Hypoatherina ovalaua	48	(96)	Sardinella sirm	26	(30)
			Spratelloides delicatulus	25	(29)
			Hypoatherina ovalaua	22	(26)
			Atherinomorus lacunosa	5	(6)
Total	50	(96)	Total	86	(91)
Jaluit Lagoon (2/1)			Tol Island (14/1) Tarik Island (2/1) Fefan Island (2/1)		
			YAP ISLAND (FEDERATED STATES OF MICRONESIA)		
			Stolephorus heterolobus	100	(78)
			Leiognathus bindus	14	(11)
			Archamia lineolata	8	(6)
			Total	129	(95)
			Tomil Harbour (2/1)		

* All Sardinella sirm were caught in one large haul (402 kg, 99% S. sirm) on 9 November 1978.

TABLE 7. A COMPARISON OF SKIPJACK PROGRAMME BAITFISH CATCHES WITH BOUKI-AMI GEAR FOR REPEAT VISITS TO THE SAME BAITING AREAS IN PALAU AND FEDERATED STATES OF MICRONESIA

PONAPE ISLAND

Year/ Month	Bait Species		Average Kg Caught per haul	(% Total)
78/08	Stolephorus devisi		68	(87)
	Stolephorus heterolobus		5	(7)
	Hypoatherina ovalaua		1	(1)
	6 hauls	Total	78	(94)
78/10	Stolephorus heterolobus		178	(87)
	Hypoatherina ovalaua		19	(9)
	2 hauls	Total	204	(96)
78/11	Stolephorus heterolobus		84	(74)
	Hypoatherina ovalaua		1	(1)
	6 hauls	Total	113	(75)*
79/11	Hypoatherina ovalaua		105	(45)
	Stolephorus heterolobus		61	(26)
	Herklotsichthys quadrimaculatus		46	(20)
	6 hauls	Total	234	(91)
80/07	Stolephorus devisi		63	(48)
	Stolephorus heterolobus		46	(35)
	Herklotsichthys quadrimaculatus		12	(9)
	15 hauls, 2 anchorages	Total	132	(92)

KOSRAE ISLAND

Year/ Month	Bait Species		Average Kg Caught per Haul	(% Total)
78/08	Stolephorus devisi		30	(61)
	Archamia lineolata		12	(25)
	Herklotsichthys quadrimaculatus		3	(6)
	Stolephorus indicus		3	(5)
	2 hauls	Total	49	(97)
78/11	Stolephorus devisi		68	(70)
	Archamia lineolata		11	(11)
	Stolephorus indicus		6	(6)
	2 hauls	Total	97	(87)
79/11	Stolephorus heterolobus		24	(34)
	Herklotsichthys quadrimaculatus		19	(27)
	Selar crumenopthalmus		9	(13)
	Stolephorus indicus		9	(13)
	6 hauls, 2 anchorages	Total	70	(87)

TRUK ISLANDS

Year/ Month	Bait Species		Average Kg Caught per haul	(% Total)
78/08	Spratelloides delicatulus		51	(69)
	Hypoatherina ovalaua		23	(31)
	4 hauls, 2 anchorages	Total	74	(100)
78/10	Sardinella sirm		52	(53)
	Hypoatherina ovalaua		21	(21)
	Atherinomorus lacunosa		20	(20)
	4 hauls, 2 anchorages	Total	99	(94)

PALAU ISLANDS

Year/ Month	Bait Species		Average Kg Caught per Haul	(% Total)
78/10	Stolephorus heterolobus		129	(98)
	8 hauls	Total	131	(98)
80/07	Stolephorus heterolobus		61	(70)
	Spratelloides delicatulus		9	(10)
	Hypoatherina temmincki		6	(7)
	12 hauls, 5 anchorages	Total	87	(87)

* One 125 kg haul of a large predator (Selar boops) was released and is not included here.

heads to make sufficient catches of sprats (Dussumieriidae), cardinalfish (Apogonidae) and fusiliers (Caesiodidae) to support a modest fishery (Anon. 1937a; Wilson 1977a). The Programme made 35 hauls in Ponape Harbour at two anchorages for an average catch per haul of 146 kg (Table 6); Stolephorus heterolobus and S. devisi accounted for 73 per cent of this average catch. Baitfishing took place in four months (July, August, October, November) in the period August 1978 to July 1980 (Table 7). Catches of anchovy (Stolephorus spp.) varied two-fold between August 1978 and October 1978, but this variation was much less than that exhibited by hardyheads and gold spot herring. Good catches of anchovies by the Programme and by other relatively recent surveys (Appendix A) suggest that the total baitfish resource may previously have been underestimated.

Compared with Ponape Island, Kosrae Island has few baiting localities, other than Okat and Lelu Harbours, that are suitable for use of bouki-ami gear by vessels of the size of the Hatsutori Maru No.1 and No.5. The Programme baited at Kosrae on three occasions (August 1978, November 1978, November 1979) for a total of 10 bouki-ami hauls at these two localities. An average catch per haul of 59 kg (Table 6) resulted. Stolephorid anchovies contributed between 47 per cent (November 1979) and 76 per cent (November 1978) of the catch (Table 7), but were represented in the catch only at Lelu Harbour (Table 3). Based on the echo sounder trace, anchovies were thought to be present at Okat Harbour. They probably did not respond to dimming of the bait lights due to the presence of many large predators (Selar crumenopthalmus). The average catch per haul at Lelu Harbour was 95 kg, of which 52 per cent were anchovies. Stolephorus indicus, a species that suffers high mortality from the effects of capture and handling, accounted for approximately 10 per cent of the anchovy catch. Beach seining had been used prior to World War II to obtain bait for pole-and-line fishing at Kosrae (Gawel 1982), and this could be a means of supplementing night catches so long as the concerns of inshore fishermen are accommodated. Overall, the baitfish resource at Kosrae is limited compared with that of Ponape and Truk.

Baitfish from Truk supplied a large locally based Japanese pole-and-line fishery before World War II (Smith 1947). Fishermen used specially designed nets (Wilson 1971) to fish concentrations of fusiliers (Caesiodidae) and cardinalfish (Apogonidae) around coral heads, and also to fish sprats (Dussumieriidae) in obstruction-free waters. They also used beach seines for hardyheads and gold spot herring in shallow water near beaches and mangroves (Wilson 1971). The annual bait catch must have been substantial, at times greater than 150 tonnes, to support tuna catches that exceeded 5,000 tonnes (Figure 2) in several years between 1936 and 1941.

At Truk, the Programme made eight bouki-ami hauls at three localities (Tol Island, Tarik Island and Fefan Island), for an average catch per haul of 86 kg (Table 6); and made one beach seine haul at Tol Island (Table 3) yielding 49 kg of sprats (Spratelloides delicatulus). The bouki-ami catch in Truk, averaged over anchorages at the three localities, consisted of approximately equal amounts of sardines (Sardinella sirm), sprats (Spratelloides delicatulus) and hardyheads (Hypoatherina ovalaua and Atherinomorus lacunosa) (Table 6). Anchovies were present in low numbers in two of four hauls at Tol Island in August 1978. The Programme has found that skipjack and other surface tunas respond well to sprats and sardines (Argue et al. ms.), but these species are not popular in Truk because local fishermen have found them to be subject to high mortality. The Programme used handling techniques that minimised mortality for delicate species (Hallier et al. 1982), and as a result the Hatsutori Maru No.1 was able to transport 110 kg of sprats from Truk to Saipan with less than 25 per cent mortality over a four-day period. This, coupled with previous success of the commercial fishery and the moderate bouki-ami catch of sardines, sprats and hardyheads demonstrated by the Programme, would appear to compensate for low abundance of anchovies in these waters, and confirms that baitfish are abundant at Truk.

Prior to World War II, Japanese fishing and survey operations at Yap Island reported an abundant supply of bait, mainly Stolephorus heterolobus (Ikebe & Matsumoto 1937). The Programme made two bouki-ami hauls in Tomil Harbour on 21 August 1980. The average catch was 129 kg, of which 78 per cent was Stolephorus heterolobus (Table 6). The success of the pre-war Japanese surveys and the brief Hatsutori Maru No.5 survey, coupled with the likelihood that some of the many beaches in Tomil Harbour and elsewhere around Yap Island are suitable for beach seining, confirm a moderate baitfish resource at Yap.

Oroluk Island, between Truk and Ponape, is one of about 10 atolls in the Federated States of Micronesia which have adequate passes and depths for bouki-ami fishing by vessels of the type used by the Programme. Oroluk Island was fished by the Programme on 7 August 1978. Baitfish were absent around the lights at midnight when the first haul was normally made, but were sufficient prior to dawn for a haul; however, it yielded only 20 kg of mostly sprats (Table 6). In 1980, similar results were obtained by a Pacific Tuna Development Foundation vessel which used a lift net to capture 19 kg of bait in two hauls (PTDF 1980b). The Programme's catch at atolls and high islands are contrasted in Section 4.1.5.

4.1.4 Marshall Islands

Previous surveys in Marshall Islands encountered highly variable baitfish abundance. Hida & Uchiyama (1977) found that herring (Herklotsichthys quadrimaculatus) and hardyheads (Atherinomorus lacunosa) at Majuro fluctuated widely in abundance between May 1972 and April 1973. JAMARC pole-and-line vessels, similar to the Programme's, surveyed seven atolls for bait in October-November 1977 (JAMARC 1978) and eleven atolls between August and November 1978 (Iwasa & Mizuno 1979). At Majuro, their catches averaged approximately 90 kg per haul in 1977, and 194 kg per haul in 1978. Similar variability occurred between visits to Jaluit (30 kg per haul in 1977 versus 124 kg per haul in 1978). Species of sprats, hardyheads and sardines were included in Japanese catches at both atolls. A more recent Japanese survey in 1982 at Majuro (Anon. 1983b) encountered poor weather and low baitfish catches.

The Programme baited at Majuro (nine bouki-ami hauls, three beach seine hauls) and at Jaluit (two bouki-ami hauls, one beach seine haul), two of 33 atolls (Douglas 1969) in Marshall Islands. The catch from both atolls averaged 76 kg per bouki-ami haul (122 kg per night) (Table 5) and 22 kg per beach seine haul. Hardyheads (Hypoatherina ovalaua) were among the most common species at both Majuro and Jaluit lagoons (Table 6) and average catches per haul of hardyheads were, respectively, 9 kg and 48 kg. In contrast, beach seine catches at both lagoons (Table 3) were dominated by sprats (Spratelloides delicatulus) (88%). Hardyheads are not particularly effective for tuna, but sprats are considered to be nearly as effective as stolephorid anchovies (Skipjack Programme 1981c; Argue et al. ms.).

Bouki-ami fishing was attempted at Majuro on the night of 27 July 1978. The first haul was not completed because there was a lack of bait, and there was no pre-dawn haul due to strong winds. During November 1978 the bouki-ami catch at Majuro, averaged over anchorages, was 69 kg (Table 6); however, there was one large haul of 402 kg of sardines

(Sardinella sirm) which dominated the catch (73% by weight). Excluding this haul reduced the average catch in November to 29 kg per haul, of which 71 per cent were hardyheads and 21 per cent were sprats.

Results from past surveys and those of the Programme suggest a highly variable bait resource for pole-and-line fishing in Marshall Islands.

4.1.5 Comparison of baitfish catch between atolls and high islands

The Skipjack Programme surveyed the baitfish resources of atolls and high islands with fringing reefs over much of the central and western tropical Pacific using standard sampling and fishing procedures. In Palau, Federated States of Micronesia, and Marshall Islands surveys were conducted at four atolls (Helen Reef, Oroluk, Majuro, Jaluit) and five high islands (Palau Islands, Ponape Island, Kosrae Island, Truk Islands, Yap Islands). Table 6 presents catch rates for each area separately. Table 8 presents catch rates, by family and species of baitfish, averaged over these atolls and high islands.

Baitfish in seven families accounted for 90 per cent of the average catch of 104 kg per haul from high islands, whereas baitfish in four families accounted for 96 per cent of the average catch of 54 kg per haul from atolls. Species of stolephorid anchovies, which are amongst the most effective for tuna live-bait fishing, dominated (59%) the catch from high islands, but were absent from atoll catches. Other effective species at high islands were from the families Dussumieriidae, Clupeidae and Apogonidae. Together, species in these four families constituted 76 per cent of the catch from high islands, but only 65 per cent of the catch from atolls, thus increasing the discrepancy between atolls and high islands in terms of the effectiveness as bait of the catch.

The degree of variability in baitfish abundance is an important factor to consider when evaluating the commercial potential of baitfish resources. Table 9 presents average baitfish catches for repeat visits by the Programme to baiting localities at three atolls (Butaritari in Kiribati, Penrhyn in Cook Islands, Funafuti in Tuvalu) and four high islands (Thousand Ships Bay in Solomon Islands, Ponape harbour, Palau harbour, Seeadler harbour in Papua New Guinea). A two-way analysis of variance, taking into account unequal replication of hauls, was used to test whether variance in catch per haul was higher, between surveys, for atolls or for high islands. The variance between survey periods for atoll sites was significantly higher ($p<0.01$) than the variance between survey periods for high island sites. These results support the contention (Shomura 1977) that atolls are less reliable sources of bait for pole-and-line fishing than high islands. Since atolls also produce lower average catches of less effective species, it is clear that atolls in general offer much less potential for commercial baitfish operations than high islands.

4.2 Tuna Fishing Success

The first survey by the Programme of the Trust Territory and Guam began in July 1978 in Marshall Islands under poor weather conditions. Coupled with poor weather was a lack of schools, as evidenced by the low sighting rates of between 0.33 and 0.56 schools per hour at this time (Table 10). Furthermore, less than 25 per cent of the schools responded positively to chum, in spite of the fact that most of the baitfish used as chum were stolephorid anchovies. This was well below the Programme's overall chumming response rate of 47 per cent. The survey catch for July and August 1978, raised by the factor 3.47 (Kearney 1978a) to estimate

TABLE 8. A COMPARISON BETWEEN ATOLLS AND HIGH ISLANDS IN THE TRUST TERRITORY AND GUAM OF THE AVERAGE BOUKI-AMI CATCH PER HAUL FOR BAITFISH SPECIES IN EIGHT FAMILIES. Catches in this table are averages of the values in Table 6 for four atolls and five high islands.

Family Number	Baitfish	Atolls: Kg per Haul	Atolls: Per cent	High Islands: Kg per Haul	High Islands: Per cent
	BAITFISH FAMILIES				
1	Engraulidae (Anchovies)	-	-	61	59
2	Dussumieriidae (Sprats)	21	39	7	7
3	Atherinidae (Hardyheads)	17	31	10	9
4	Clupeidae (Herring)	13	24	8	8
5	Apogonidae (Cardinalfish)	1	2	2	2
6	Leiognathidae (Ponyfish)	-	-	3	3
7	Carangidae (Scad)	-	-	2	2
8	Miscellaneous	2	4	11	10
	Total	54	100	104	100

BAITFISH SPECIES

Atolls	Kg per Haul	Per cent	High Islands	Kg per Haul	Per cent
Spratelloides delicatulus (2)*	14	(26)	*Stolephorus heterolobus* (1)	50	(48)
Hypoatherina ovalaua (3)	14	(26)	*Stolephorus devisi* (1)	11	(10)
Sardinella sirm (4)	13	(24)	*Hypoatherina ovalaua* (3)	7	(7)
Dussumieria sp. (2)	6	(11)	*Spratelloides delicatulus* (2)	7	(7)
Hypoatherina temmincki (3)	2	(4)	*Sardinella sirm* (4)	5	(5)
Apogon cypselurus (5)	1	(2)	*Herklotsichthys quadrimaculatus* (4)	3	(3)
Spratelloides sp. (2)	<1	(1)	*Leiognatus bindus* (6)	3	(3)
Atherinomorus lacunosa (3)	<1	(1)	*Selar crumenopthalmus* (7)	2	(2)
Spratelloides gracilis (2)	<1	(1)	*Hypoatherina temmincki* (3)	2	(2)
			Archamia lineolata (5)	2	(2)
			Atherinomorus lacunosa (3)	1	(1)
Total	54	(96)	Total	104	(90)
Hauls/anchorages (23/10)			Hauls/anchorages (75/14)		

* Number in brackets denotes baitfish family, see left column.

TABLE 9. BAITFISH CATCHES IN THREE ATOLL AREAS AND FOUR HIGH ISLAND AREAS SURVEYED ON TWO OCCASIONS BY THE SKIPJACK PROGRAMME. Data for Kiribati, Cook Islands, Tuvalu, Solomon Islands and Papua New Guinea from, respectively, Kleiber & Kearney (1983), Lawson & Kearney (1982), Ellway et al. (1983), Argue & Kearney (1982) and Tuna Programme (1984).

	SURVEY PERIOD ONE			SURVEY PERIOD TWO		
	No. of Hauls (month)	Dominant Species	Average Catch per Haul	No. of Hauls (month)	Dominant Species	Average Catch per Haul
		ATOLLS				
Butaritari (Kiribati)	13 (July 1978)	Apogon cypselurus	25	4 (Nov. 1979)	Spratelloides delicatulus	9
		Hypoatherina ovalaua	19		Hypoatherina ovalaua	8
		Dussumieria sp.	18		Apogon cypselurus	4
		Total	81		Total	22
Penrhyn (Cook Islands)	10 (Dec. 1978)	Spratelloides delicatulus	46	3 (Dec. 1979)	Spratelloides delicatulus	1
		Sp. of Atherinidae	2			
		Total	57		Total	1
Funafuti (Tuvalu)	4 (June/July 1978)	Spratelloides delicatulus	250	11 (July 1980)	Spratelloides delicatulus	32
		Archamia lineolata	12		Atherinomorus lacunosa	7
		Bregmaceros sp.	2		Archamia lineolata	2
		Total	265		Total	41
		HIGH ISLANDS				
Thousand Ships Bay (Solomon Islands)	1 (Oct. 1977)	Stolephorus devisi	105	14 (June 1980)	Stolephorus devisi	54
		Stolephorus heterolobus	81		Stolephorus heterolobus	46
					Stolephorus buccaneeri	36
		Total	219		Total	155
Ponape Harbour (Federated States of Micronesia)	21 (July/August)	Stolephorus devisi	64	14 (Oct./Nov.)	Stolephorus heterolobus	88
		Stolephorus heterolobus	34		Hypoatherina ovalaua	56
		Herklotsichthys quadrimaculatus	9		Herklotsichthys quadrimaculatus	28
		Total	117		Total	178
Palau Harbour (Palau)	8 (Oct. 1978)	Stolephorus heterolobus	129	12 (Aug. 1980)	Stolephorus heterolobus	61
					Spratelloides delicatulus	9
					Hypoatherina temmincki	6
		Total	131		Total	87
Seeadler Harbour (Papua New Guinea)	2 (Oct. 1977)	Stolephorus devisi	46	6 (June 1979)	Stolephorus devisi	44
		Stolephorus bataviensis	3		Stolephorus heterolobus	8
		Stolephorus heterolobus	3		Stolephorus sp. (juveniles)	5
		Total	77		Total	65

TABLE 10. TOTAL SCHOOLS SIGHTED PER HOUR SPENT SEARCHING AND FISHING, PERCENTAGE OF SCHOOLS WITH DIFFERENT TUNA SPECIES, AND TOTAL SCHOOLS SIGHTED FOR NORTHERN MARIANA ISLANDS, GUAM, PALAU, FEDERATED STATES OF MICRONESIA, AND MARSHALL ISLANDS

Month/Year (Survey Number)	Northern Mariana Islands	Guam	Palau	Federated States of Micronesia					Marshall Islands	Total
				Yap	Truk	Ponape	Kosrae	Total		
July 1978 (1)	-	-	-	-	-	-	0.50	0.50	0.29	0.31
August 1978 (1)	0.33	0	-	-	0.37	0.56	0.50	0.50	-	0.45
October 1978 (1)	0.24	0	0.25	0.21	0.67	0.85	-	0.46	-	0.36
November 1978 (1)	-	-	-	-	-	0.65	0.50	0.58	0.47	0.51
November 1979 (2)	0.37	-	-	-	0.32	0.84	0.56	0.63	1.40	0.64
July 1980 (3)	-	-	-	1.50	1.33	0.85	1.11	0.99	-	0.99
August 1980 (3)	-	-	0.96	0.57	-	-	-	0.57	-	0.89
TOTAL	0.31	0	0.75	0.39	0.58	0.74	0.59	0.62	0.48	0.59
	Percentage Species Composition for Schools with Known Species									
Skipjack	50%	-	62%	71%	57%	65%	46%	63%	46%	61%
Yellowfin	25%	-	69%	43%	14%	31%	69%	35%	69%	46%
Other tuna	38%	-	9%	14%	43%	24%	15%	24%	8%	19%
	Percentage of Schools with Unknown Species									
	58%	-	58%	79%	87%	52%	75%	65%	70%	64%
Total schools	19	-	108	33	53	164	53	303	44	474

commercial catch, averaged only 0.78 tonnes per day. Continuation of the first survey in October 1978 in Northern Mariana Islands met with the same weather conditions. School sighting rates were again poor (Table 10). Many schools were observed to be feeding intensely on the pelagic anchovy, Stolephorus buccaneeri (Section 4.3.3). These schools did not respond well to bait thrown from the Hatsutori Maru No.1 as evidenced by the poor chumming rate (<25%) and low commercial catch rate (1.45 tonnes per fishing day). Argue & Kearney (1982) suggested that the presence of Stolephorus buccaneeri in Solomon Islands during November 1977 was at least partially responsible for poor catches there at that time, and this situation may also have prevailed in the Trust Territory and Guam.

The second cruise commenced on 2 November 1979 from Japan with the research vessel carrying a full load of bait (Sardinella melanosticta) purchased in Japan. Again, poor weather hampered the start of the survey. The first skipjack were tagged in the eastern waters of Northern Mariana Islands where the vessel had moved to avoid a typhoon. Relatively poor fishing conditions continued through to Truk (Table 10). Calmer weather was encountered in mid-November around Ponape and fishing improved, although many of the skipjack and yellowfin caught here were very small (<35 cm). Between Ponape and Majuro skipjack schools did not respond well to the bait. Overall, chumming success for this survey was only 30 per cent and Stolephorus buccaneeri were again found in many skipjack stomachs. The estimated commercial catch was only 1.16 tonnes per day.

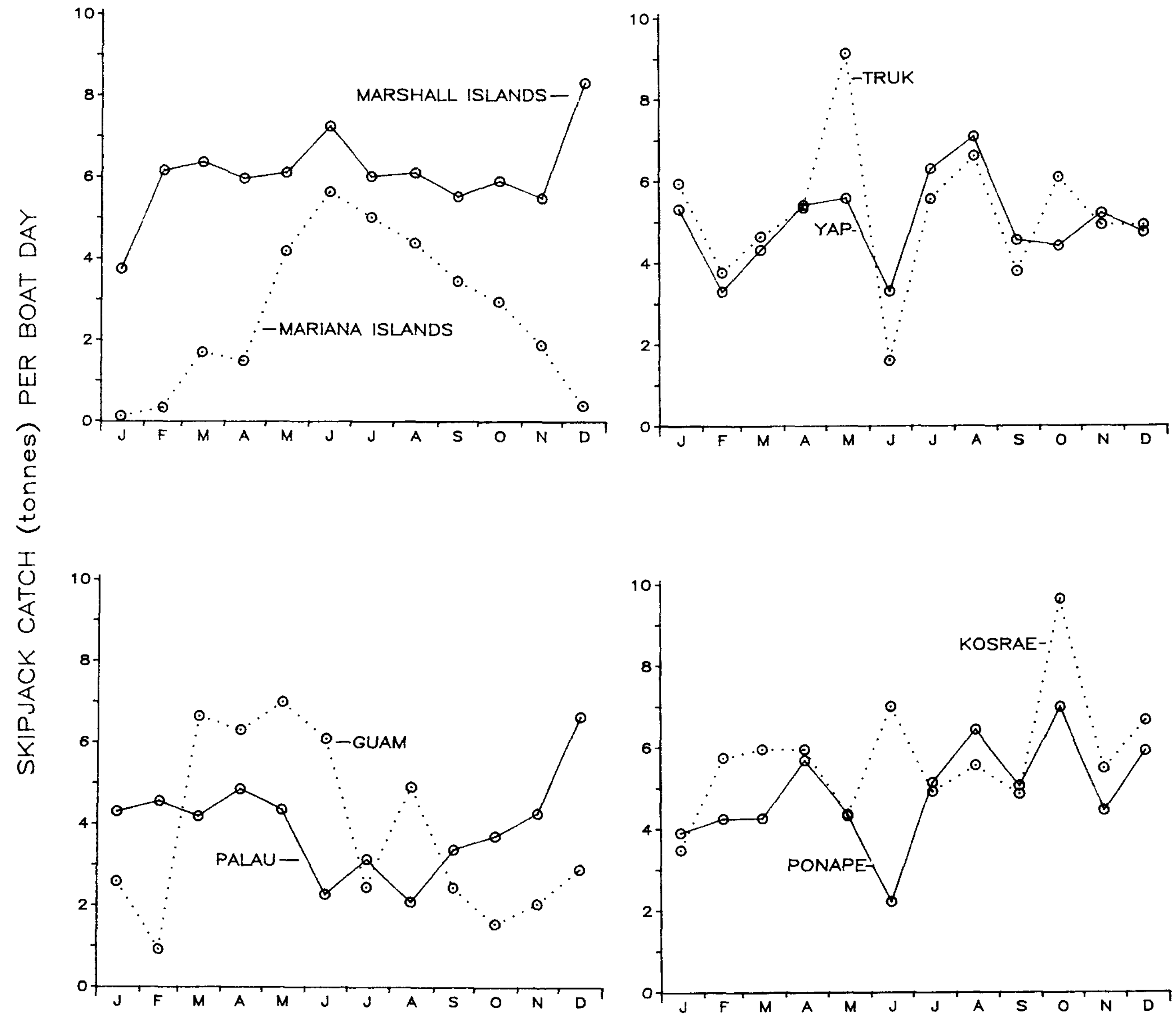
The third survey in the Trust Territory and Guam took place during July and August 1980. The weather was fine, bait catches were good and school sighting rates were high (Table 10). The estimated commercial catch around Ponape was 8.96 tonnes per day. The Programme also had successful baiting and skipjack fishing at Palau Islands and Helen Reef in Palau. The estimated commercial catch in Palau was 3.46 tonnes per day overall, and 2.36 tonnes per day at Helen Reef.

While in the Trust Territory and Guam the Programme sighted a total of 474 schools. Species composition could be identified for only 36 per cent of schools. Of these, 61 per cent contained skipjack and 46 per cent contained yellowfin (Table 10). For the whole study area, species composition could be identified for 49 per cent of the schools; 79 per cent of these contained skipjack and 31 per cent contained yellowfin (Kearney 1983b).

The overall estimate of commercial catch rate by the Programme's survey vessels in the Trust Territory and Guam was 2.41 tonnes of skipjack, yellowfin and other tunas per fishing day, 28 per cent less than the Programme's average of 3.35 tonnes for the whole study area (Kearney 1983b). Poor weather, limited bait supplies, poor response by tuna to the bait and lack of time in the most productive portions of this large area contributed to the Programme's low catch rate.

The amount of information on tuna abundance gained from the Programme's 78 fishing days in an area as large as the Trust Territory and Guam is limited. Catch data from more than 50,000 fishing days in this area between 1972 and 1978 by the Japanese pole-and-line fleet are more informative. Figure 7 presents Japanese catch of skipjack per fishing day, averaged over months from 1972 to 1978, for individual states of the Trust Territory and Guam. Average daily catch per month was variable but quite high in all states (most between 2.0 and 8.0 tonnes per day) during this period, and is without any obvious seasonality within all states except Northern Mariana Islands. Clearly, this vast area contains large quantities of skipjack.

FIGURE 7. AVERAGE MONTHLY CATCH PER FISHING DAY (1972 TO 1978) BY JAPANESE DISTANT-WATER POLE-AND-LINE VESSELS FISHING IN STATES OF FEDERATED STATES OF MICRONESIA, NORTHERN MARIANA ISLANDS, GUAM, PALAU AND MARSHALL ISLANDS. Data from Skipjack Programme (1980).



4.3 Skipjack Population Biology

A summary of the biological data collected in the Trust Territory and Guam appears in Table 11. These data cover July-August (1978 and 1980) and October-November (1978 and 1979) sampling periods, and results of analyses of skipjack sexual maturity, juvenile recruitment and diet are presented separately for these periods. Tagging, blood and parasite sampling data were combined for these periods to analyse skipjack population structure, as were tagging data to analyse skipjack growth.

4.3.1 Sexual maturity

Female skipjack gonads were classified into seven maturity stages ranging from immature (stage 1) through maturing (stages 2 and 3), mature (stage 4), ripe (stage 5), spent (stage 6) and recovering (stage 7). In some parts of the study area gonads from small skipjack could not be sexed (these gonads generally weighed less than 1 gm). Half of these skipjack have been assumed to be females and have been assigned maturity stage one. Figure 8 presents female skipjack maturity data for July-August and October-November periods in the Trust Territory and Guam. The upper graphs show the size (fork length) frequency distributions of late maturing and more advanced female skipjack (stage 3 and higher), and immature-early maturing female skipjack (stages 1 and 2). It is clear for both periods that 45 cm is a separation point between female skipjack with immature-early maturing gonads and female skipjack with gonads at later maturity stages. In the lower graphs it can be seen that late maturing skipjack (stage 3) dominate, as they did in most samples of the Programme's catches in the tropical Pacific. The presence of females with mature gonads (stage 4) and spent/recovering gonads (stages 6 and 7) in the samples implies that at least some skipjack spawning took place during both periods. The higher incidence of stage one gonads in October-November coincided with relatively large catches of small (<35 cm) skipjack at this time.

Seasonal change in female gonad index[1] for all Skipjack Programme samples from tropical waters show that skipjack spawning is most frequent south of the Equator during spring-summer months (October to March) (Figure 9). The few data from north of the Equator in Figure 9 suggest that skipjack spawning is most intense there in summer months (July-August). These trends are comparable to those presented by Naganuma (1979) for samples collected from a wide area of the tropical Pacific, and to that presented by Lewis (1981) for samples from the Papua New Guinea fishery.

4.3.2 Juvenile recruitment

Another index of spawning activity is the incidence of skipjack juveniles observed in the stomachs of predators. Argue et al. (1983) present detailed analyses of the tuna juvenile data, taking into account size-selective predation by adults, and time of day, distance from land and season in which adults were sampled. Skipjack juveniles occurred most frequently in the stomachs of skipjack between October and March in the

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

TABLE 11. SUMMARY OF NUMBERS OF FISH SAMPLED FOR BIOLOGICAL DATA BY THE SKIPJACK PROGRAMME FROM THE WATERS OF THE TRUST TERRITORY AND GUAM DURING JULY-AUGUST AND OCTOBER-NOVEMBER SAMPLING PERIODS, 1978 TO 1980

Species	Number Measured		Number Weighed		Number Examined for Sex		Number Examined for Stomach Content		Number Examined for Tuna Juveniles	
	July Aug.	Oct. Nov.	July Aug.	Oct. Nov.	July Aug.	Oct. Nov.	July Aug.	Oct. Nov.	July Aug.	Oct. Nov.
Skipjack *Katsuwonus pelamis*	1,385	987	503	411	510	441	161	153	458	444
Yellowfin *Thunnus albacares*	332	279	225	159	184	154	88	68	204	159
Mackerel Tuna *Euthynnus affinis*	191	34	10	34	7	32	5	19	10	30
Frigate Tuna *Auxis thazard*	12	1	3	0	3	0	3	0	3	0
Rainbow Runner *Elagatis bipinnulatus*	106	139	7	87	4	5	4	3	7	3
Dolphinfish *Corphaena hippurus*	36	1	25	1	0	1	3	1	3	1
Wahoo *Acanthocybium solandri*	0	1	0	1	0	1	0	1	0	1
Little Dolphinfish *Corphaena equisetis*	0	1	0	1	0	0	0	0	0	0
White-spotted Triggerfish *Canthidermis rotundatus*	4	1	0	1	0	0	0	0	0	0
Layang Scad *Decapterus macrosoma*	2	0	2	0	2	0	2	0	2	0
TOTALS	2,068	1,444	775	695	710	634	266	245	687	638

FIGURE 8. LENGTH FREQUENCY DISTRIBUTIONS (upper graphs) OF IMMATURE-EARLY MATURING (clear) AND MATURING (stippled) FEMALE SKIPJACK, AND FREQUENCY DISTRIBUTIONS OF FEMALE SKIPJACK MATURITY STAGES (lower graphs), FOR SKIPJACK SAMPLED DURING JULY-AUGUST AND OCTOBER-NOVEMBER TIME PERIODS IN THE TRUST TERRITORY AND GUAM. N is the sample size.

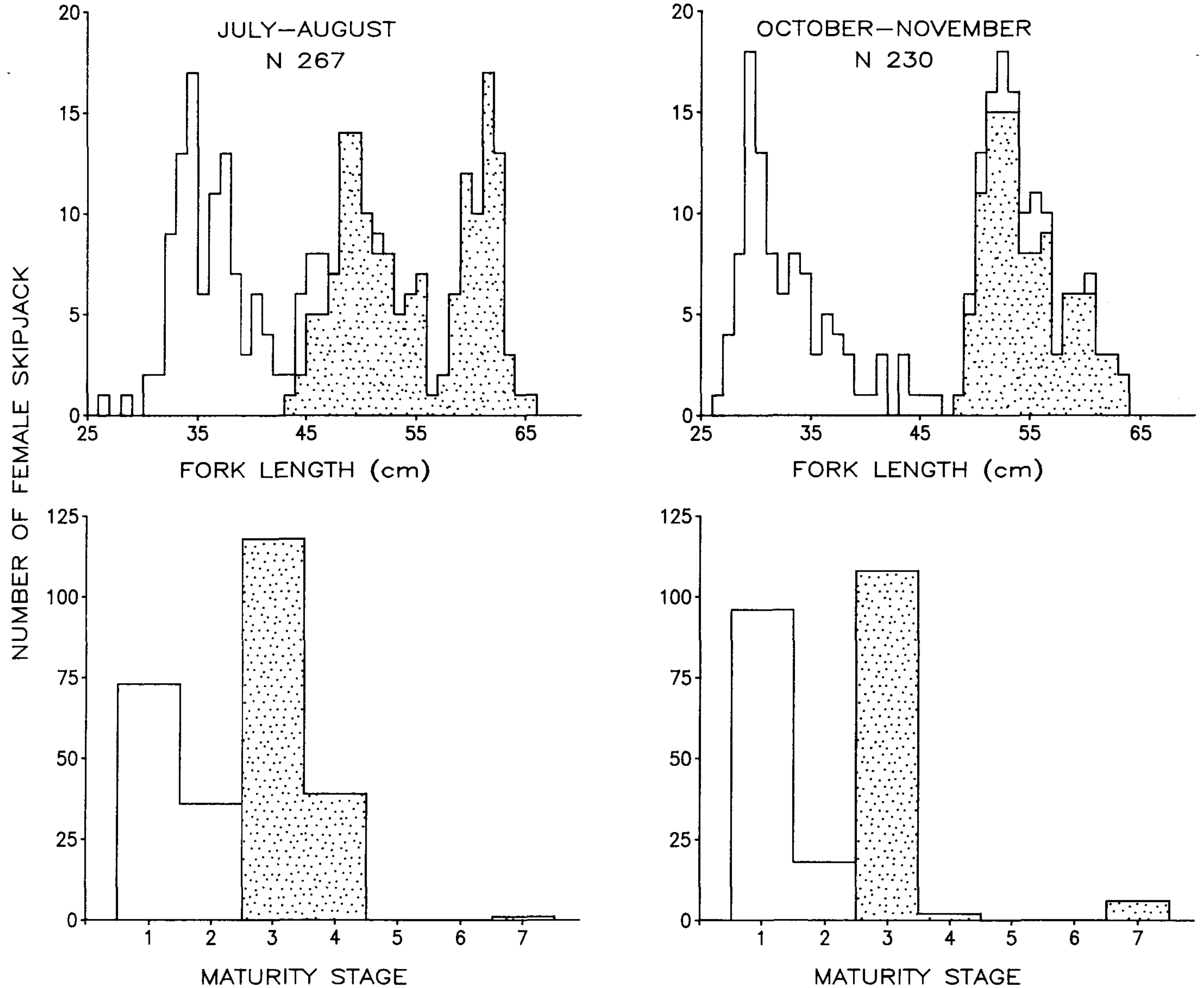
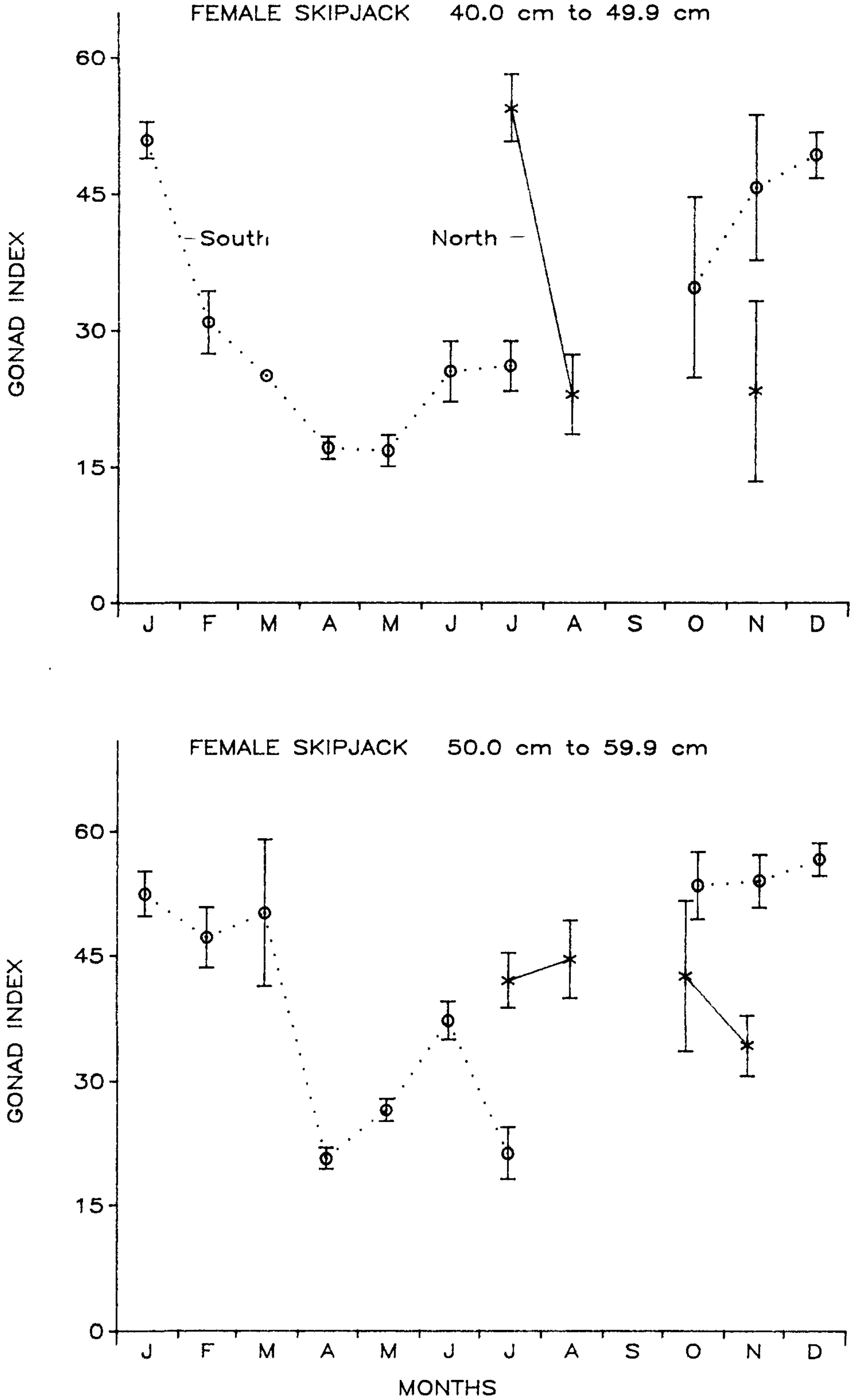


FIGURE 9. AVERAGE FEMALE SKIPJACK GONAD INDICES AND TWO STANDARD ERRORS ON EITHER SIDE OF THE AVERAGES, BY MONTH, FOR SKIPJACK SAMPLED FROM TROPICAL WATERS NORTH AND SOUTH OF THE EQUATOR. Sample sizes generally exceeded 75 for each month and female skipjack size class.



Programme's samples from tropical waters south of the Equator, which is roughly the period of maximum skipjack gonad development in these waters. Argue et al. also show that during the 1977 to 1980 survey period, relative abundance of juvenile skipjack within the study area was highest in two areas, one roughly bounded by Solomon Islands, Papua New Guinea and Vanuatu, and the other including the Marquesas and Tuamotu Islands.

Less than three skipjack juveniles per 100 skipjack predator stomachs were observed in the Trust Territory and Guam during the July-August and October-November surveys (Table 12). These were among the lowest levels observed in the Programme study area. Although some skipjack spawning undoubtedly takes place in these waters, the data on juveniles suggest that this was not a major spawning area around the time of the surveys. The majority of recruits are postulated to come from other areas, although the available data are too few to identify these areas.

4.3.3 Diet

Twenty-nine diet items were recorded from 161 skipjack sampled during July-August, and 41 diet items were recorded from 153 skipjack sampled during October-November (Table 13). The wide variety of diet items observed in these skipjack, as well as in skipjack from other tropical waters, indicates that skipjack are opportunistic feeders.

Common diet items of skipjack sampled from the Trust Territory and Guam in July-August, other than chum, were fish remains, surgeonfish (Acanthuridae), squid (Cephalopoda), triggerfish (Balistidae) and squirrelfish (Holocentridae). During October-November the only major change was the occurrence of anchovies (*Stolephorus buccaneeri*) in third place behind fish remains. This pelagic species was commonly found in stomachs of skipjack sampled by the Programme from tropical waters of the western Pacific.

4.3.4 Growth

Of the 792 recoveries of skipjack tagged in the Trust Territory and Guam, 287 were included in analyses of growth (Table 14). The remainder failed to meet criteria for reliability of recovery date or measurement records (see Sibert et al. 1983). Half of the recoveries (144) were from within the combined 200-mile zone of the Trust Territory and Guam, where they were at liberty for an average of 143 days. These fish were in the mid-range of both size-at-release and time-at-liberty in comparison to other countries, but have some of the highest size increments. The remainder (143) were recovered outside the combined 200-mile zone and were at liberty for an average of 179 days. These fish were in the low-range of size-at-release, in the mid-range of days-at-liberty, and have moderate size increments.

The merits of skipjack growth determinations based on tag recapture studies, relative to those based on other methods, have been discussed by Josse et al. (1979). Analytical techniques for estimating growth of skipjack from the Programme's tag recapture data are presented in Sibert et al. (1983) and Lawson et al. (1984). The application of these data to growth studies is complicated by the deterministic growth of skipjack (Joseph & Calkins 1969), in which growth rate, measured by the rate of increase in length, declines as fish become larger. Thus, observed length increments of skipjack may be expected to differ according to both the size of the fish when tagged and the duration of their period at liberty until recapture. The effects of both factors are evident in the summary of length increments for fish in two size classes, 30-49 cm and 50-70 cm, at

TABLE 12. INCIDENCE OF TUNA JUVENILES IN THE STOMACHS OF SKIPJACK AND OTHER SPECIES SAMPLED FROM THE WATERS OF THE TRUST TERRITORY AND GUAM IN JULY-AUGUST AND OCTOBER-NOVEMBER (in brackets)

Predator	Predators Examined	Prey Species (tuna juveniles)	No. of Prey	Predators with Prey	Prey per 100 Predators	Percentage of Predators with Prey
Skipjack	458 (444)	Skipjack	5 (13)	3 (9)	1.09 (2.93)	0.66 (2.03)
		Yellowfin	- (1)	- (1)	- (0.23)	- (0.23)
		Dogtooth Tuna	- (1)	- (1)	- (0.23)	- (0.23)
Yellowfin	204 (159)	Skipjack	1 (1)	1 (1)	0.49 (0.63)	0.49 (0.63)
Wahoo	- (1)	Skipjack	- (2)	- (1)	- (200.0)	- (100.00)
		Albacore	- (1)	- (1)	- (100.00	- (100.00)
Mackerel Tuna	10 (30)					
Rainbow Runner	7 (3)					
Dolphinfish	3 (1)					
Frigate Tuna	3 -					
Layang Scad	2 -					
TOTALS	687 (638)		6 (19)			

TABLE 13. DIET ITEMS FOUND IN STOMACHS OF SKIPJACK SAMPLED BY THE SKIPJACK PROGRAMME FROM THE WATERS OF THE TRUST TERRITORY AND GUAM IN JULY-AUGUST AND OCTOBER-NOVEMBER

July-August

Item No.	Diet Item (Fish and Invertebrates)	Number of Stomachs	Percentage Occurrence
1	Chum from *Hatsutori Maru*	131	81.37
2	Fish remains (not chum)	65	40.37
3	Acanthuridae	28	17.39
4	Squid (Cephalopoda)	28	17.39
5	Balistidae	18	11.18
6	Holocentridae	16	9.94
7	Shrimp (Decapoda)	15	9.32
8	Alima stage (Stomatopoda)	13	8.07
9	Stomatopoda	10	6.21
10	Megalopa stage (Decapoda)	7	4.35
11	Chaetodontidae	5	3.11
12	Phyllosoma stage (Decapoda)	5	3.11
13	*Stolephorus buccaneeri* (Engraulidae)	5	3.11
14	Blue goatfish (Mullidae)	4	2.48
15	Carangidae	3	1.86
16	Gempylidae	3	1.86
17	Exocoetidae	3	1.86
18	Tetrodontidae	3	1.86
19	Aluteridae	3	1.86
20	Pteropoda (Gasteropoda)	2	1.24
21	Tuna juvenile (Scombridae)	2	1.24
22	Synodontidae	2	1.24
23	Amphipoda	1	0.62
24	*Stolephorus indicus* (Engraulidae)	1	0.62
25	Juvenile fish	1	0.62
26	Syngnathidae	1	0.62
27	Tunicate (Urochordata)	1	0.62
28	Crustacean remains	1	0.62
29	Siganidae	1	0.62
	Total Stomachs Examined	161	
	Percentage Empty Stomachs	6.21	

October-November

Item No.	Diet Item (Fish and Invertebrates)	Number of Stomachs	Percentage Occurrence
1	Chum from *Hatsutori Maru*	82	53.59
2	Fish remains (not chum)	48	31.37
3	*Stolephorus buccaneeri* (Engraulidae)	34	22.22
4	Acanthuridae	29	18.95
5	Holocentridae	28	18.30
6	Squid (Cephalopoda)	24	15.69
7	Alima stage (Stomatopoda)	20	13.07
8	Stomatopoda	20	13.07
9	Balistidae	13	8.50
10	Shrimp (Decapoda)	12	7.84
11	Chaetodontidae	11	7.19
12	Juvenile fish	10	6.54
13	Megalopa stage (Decapoda)	9	5.88
14	Gempylidae	5	3.27
15	Myctophidae	5	3.27
16	Tuna juvenile (Scombridae)	4	2.61
17	Amphipoda	4	2.61
18	Phyllosoma stage (Decapoda)	4	2.61
19	Serranidae	4	2.61
20	Aluteridae	3	1.96
21	Gastropoda	3	1.96
22	Exocoetidae	3	1.96
23	*Decapterus* sp. (Carangidae)	3	1.96
24	Oxystoma crab larva (Decapoda)	2	1.31
25	Ostraciidae	2	1.31
26	Synodontidae	2	1.31
27	Bramidae	2	1.31
28	Crustacea	2	1.31
29	Unidentified fish	2	1.31
30	Argonauta (Cephalopoda)	2	1.31
31	Fistulariidae	1	0.65
32	*Gastrophysus* sp. (Lagocephalidae)	1	0.65
33	Scaridae	1	0.65
34	Tunicate (Urochordata)	1	0.65
35	Plastic material	1	0.65
36	Octopus (Cephalopoda)	1	0.65
37	Anchovy juvenile (Engraulidae)	1	0.65
38	Syngnathidae	1	0.65
39	Carangidae	1	0.65
40	Priacanthidae	1	0.65
41	Diodontidae	1	0.65
	Total Stomachs Examined	153	
	Percentage Empty Stomachs	7.84	

TABLE 14. SUMMARY OF SKIPJACK PROGRAMME GROWTH INCREMENT DATA FOR SKIPJACK AT LIBERTY FROM 10 TO 365 DAYS. Country abbreviations are explained in Appendix E.

	RECAPTURES WITHIN COUNTRY OF RELEASE						RECAPTURES OUTSIDE COUNTRY OF RELEASE					
Country and Visit	Sample Size	Mean Size at Release	Mean Size at Recapture	Mean Days at Liberty	Increment Mean	Increment Standard Deviation	Sample Size	Mean Size at Release	Mean Size at Recapture	Mean Days at Liberty	Increment Mean	Increment Standard Deviation
Visits to Trust Territory and Guam												
KOS2	0						2	54.5	58.0	80.0	3.50	2.12
MAR2	1	49.0	58.0	245.0	9.00	-	5	49.0	53.6	192.6	4.60	7.73
MAS1	1	52.0	53.0	26.0	1.00	-	0					
PAL1	0						14	59.0	63.1	113.6	4.14	4.59
PAL3	14	40.8	47.8	85.3	7.00	5.55	143	40.6	49.3	171.0	8.71	6.49
PON1	7	53.9	57.7	84.7	3.86	2.67	12	53.9	57.6	152.4	3.67	3.37
PON2	0						1	32.0	52.0	325.0	20.00	-
PON3	13	51.4	57.2	168.0	5.77	2.31	43	55.4	59.9	186.0	4.47	4.30
TRK1	1	50.0	56.0	121.0	6.00	-	10	49.7	56.7	152.6	7.00	2.79
TRK2	1	53.0	54.0	21.0	1.00	-	6	53.5	60.0	186.2	6.50	4.04
YAP1	2	52.5	61.5	137.0	9.00	2.83	11	52.8	56.9	143.4	4.09	2.12
TTPI *	144	49.7	55.7	143.1	5.99	4.98	143	43.4	51.3	179.0	7.81	6.37
Visits to Other SPC Regions												
FIJ1	431	48.0	48.6	23.9	0.65	2.29	3	51.3	55.3	68.7	4.00	2.65
FIJ2	208	51.2	55.3	108.7	4.09	5.34	9	51.7	61.3	237.8	9.67	11.86
KIR1	279	48.4	49.8	56.0	1.43	2.18	15	51.0	55.2	137.3	4.20	3.43
MAQ2	26	48.3	48.0	18.9	-0.27	1.31	3	48.0	60.0	273.7	12.00	3.00
PNG2	609	54.6	55.2	51.5	0.63	3.17	37	51.5	56.8	197.8	5.32	4.58
SOL1	38	51.8	54.3	192.5	2.45	4.28	2	52.5	57.5	199.0	5.00	0.00
ZEA1	213	45.8	46.4	37.9	0.64	2.30	11	47.5	54.2	305.7	6.64	3.41

* Results for visits KOS2, MAR2, MAS1, PAL1, PAL3, PON1, PON2, PON3, TRK1, and YAP1 combined.

TABLE 15. SUMMARY OF LENGTH-AT-RELEASE, LENGTH-AT-RECAPTURE, TIME-AT-LIBERTY, AND GROWTH INCREMENTS FOR SKIPJACK TAGGED DURING ALL VISITS TO THE TRUST TERRITORY AND GUAM. Country abbreviations are explained in Appendix E.

Recapture Country	Release Length Range	Days at Liberty Range	Sample Size	Release Length (cm) Mean	Release Length (cm) SD	Recapture Length (cm) Mean	Recapture Length (cm) SD	Days at Liberty Mean	Days at Liberty SD	Growth (cm) Mean	Growth (cm) SD	Percent Non-Growers
TTPI Releases Recaptured within TTPI 200-Mile Zone												
TTPI	30.0 - 49.0	0 - 9	2	44.5	6.4	39.0	0.0	0.0	0.0	-5.50	6.36	100.0
TTPI	30.0 - 49.0	10 - 29	3	40.3	3.5	45.7	4.0	25.7	2.1	5.33	5.13	0.0
TTPI	30.0 - 49.0	30 - 89	13	38.9	2.5	44.5	3.5	53.0	11.4	5.54	3.64	7.7
TTPI	30.0 - 49.0	90 - 179	20	43.4	5.3	51.6	4.1	128.6	31.8	8.15	3.95	10.0
TTPI	30.0 - 49.0	180 - 365	25	43.1	5.1	55.2	4.9	241.6	39.8	12.12	5.23	0.0
TTPI	30.0 - 49.0	366 - 730	10	43.2	4.3	57.1	6.7	512.3	114.6	13.90	6.79	0.0
TTPI	30.0 - 49.0	10 - 365	61	42.2	4.9	51.3	6.0	153.8	86.2	9.08	5.19	4.9
TTPI	50.0 - 70.0	0 - 9	71	61.3	3.5	60.9	3.6	3.6	2.8	-0.37	1.96	88.7
TTPI	50.0 - 70.0	10 - 29	3	55.0	4.4	55.7	3.8	25.3	4.0	0.67	0.58	33.3
TTPI	50.0 - 70.0	30 - 89	13	54.8	3.8	57.6	4.0	61.4	22.1	2.77	2.55	15.4
TTPI	50.0 - 70.0	90 - 179	48	55.1	4.6	58.3	4.0	121.6	20.5	3.15	3.03	12.5
TTPI	50.0 - 70.0	180 - 365	19	55.6	5.9	61.8	5.1	237.6	52.4	6.26	3.48	5.3
TTPI	50.0 - 70.0	366 - 730	5	51.0	1.7	63.4	2.2	530.8	54.7	12.40	2.97	0.0
TTPI	50.0 - 70.0	10 - 365	83	55.2	4.7	58.9	4.5	135.3	69.0	3.71	3.33	12.0
TTPI	30.0 - 70.0	0 - 9	73	60.8	4.5	60.3	5.0	3.5	2.8	-0.51	2.24	89.0
TTPI	30.0 - 70.0	10 - 29	6	47.7	8.8	50.7	6.5	25.5	2.9	3.00	4.15	16.7
TTPI	30.0 - 70.0	30 - 89	26	46.9	8.7	51.0	7.6	57.2	17.8	4.15	3.39	11.5
TTPI	30.0 - 70.0	90 - 179	68	51.7	7.2	56.3	5.1	123.7	24.3	4.62	4.02	11.8
TTPI	30.0 - 70.0	180 - 365	44	48.5	8.3	58.1	5.9	239.9	45.2	9.59	5.38	2.3
TTPI	30.0 - 70.0	366 - 730	15	45.8	5.2	59.2	6.3	518.5	96.9	13.40	5.72	0.0
TTPI	30.0 - 70.0	10 - 365	144	49.7	8.0	55.7	6.4	143.1	77.0	5.99	4.98	9.0
Recaptures by State												
MAR	30.0 - 70.0	10 - 365	4	56.0	6.2	63.3	6.7	192.5	50.8	7.25	2.75	0.0
MAS	30.0 - 70.0	10 - 365	21	52.8	5.7	56.8	5.5	156.4	94.1	4.05	3.57	14.3
PAL	30.0 - 70.0	10 - 365	15	41.7	7.9	48.5	7.7	88.1	88.9	6.80	5.39	6.7
FSM	30.0 - 70.0	10 - 365	104	50.0	7.8	56.2	5.6	146.4	69.1	6.21	5.17	8.7
Total	30.0 - 70.0	10 - 365	144	49.7	8.0	55.7	6.4	143.1	77.0	5.99	4.98	9.0
Recaptures Outside of TTPI 200-Mile Zone												
INT	30.0 - 70.0	10 - 365	57	46.8	8.6	55.0	8.6	195.2	84.2	8.18	6.36	7.0
PNG	30.0 - 70.0	10 - 365	56	40.7	5.1	49.6	3.6	181.3	96.8	8.82	5.56	7.1
IND	30.0 - 70.0	10 - 365	19	40.9	5.6	43.8	5.2	94.1	24.2	2.89	6.47	21.1
KIR	30.0 - 70.0	10 - 365	3	46.7	6.8	55.0	4.0	200.7	101.4	8.33	7.09	0.0
SOL	30.0 - 70.0	10 - 365	2	33.0	1.4	53.0	1.4	308.5	23.3	20.00	0.00	0.0
HOW	30.0 - 70.0	10 - 365	2	50.5	3.5	59.0	0.0	350.5	13.4	8.50	3.54	0.0
Unknown	30.0 - 70.0	10 - 365	2	37.5	2.1	41.0	9.9	84.0	29.7	3.50	7.78	50.0
JAP	30.0 - 70.0	10 - 365	1	53.0	0.0	60.0	0.0	205.0	0.0	7.00	0.00	0.0
MTS	30.0 - 70.0	10 - 365	1	49.0	0.0	55.0	0.0	235.0	0.0	6.00	0.00	0.0
Total	30.0 - 70.0	10 - 365	143	43.4	7.5	51.3	7.5	179.0	92.4	7.81	6.37	9.1
Total Recaptures of TTPI Releases												
All	30.0 - 70.0	10 - 365	287	46.6	8.4	53.5	7.3	161.0	86.8	6.90	5.77	9.1

large for various time periods (Table 15). The average increments of fish in the former group were about two to three times those of fish in the latter group. However, differences in growth rate became much less marked in fish recaptured after longer periods (e.g. 366-730 days), probably because individuals tagged in the smaller size class grew into the larger size class within a year, experiencing progressively less growth.

4.3.4.1 Standardised growth increments

Exact comparisons of the length increment data in Table 15 with results from other studies cannot be made since the continuously changing growth rate during the life of a skipjack dictates that valid comparisons exist only between data sets comprising fish tagged when at the same size, and recaptured after the same period at liberty. To facilitate comparisons between data sets, such as those from different countries or from different release times in the same country, Sibert et al. (1983) derived a "standardised increment" of growth. They employed a linear approximation of the von Bertalanffy growth model in an analysis of covariance, to determine the growth increment for a "standard" fish measuring 50 cm when released, and at large for 90 days before recapture within a country's 200-mile zone. Only fish at large for periods between 10 and 365 days were used in this analysis.

The standardised increments are listed in Table 16 for fish tagged on Skipjack Programme visits from which tag recoveries were sufficient for analysis. Growth varied within the South Pacific Commission region, with the Ponape increments in the middle of the range and Palau increments at the top of the range shown in Table 16. The confidence intervals for these increments are wide, reflecting the variable nature of skipjack growth and the occurence of large numbers of fish which did not increase in length. In spite of the apparent overlap, the analysis of covariance by Sibert et al. (1983) revealed that significant differences in growth existed between country data sets, between data sets from different visits to a country, and between data sets for "migrant" and "resident" fish. Thus, while significant geographical differences in fish growth can be identified, they cannot be regarded as stable, because equally significant differences can occur between different data sets from within the same country.

TABLE 16. STANDARDISED INCREMENTS (cm) FOR SKIPJACK THAT WERE 50 CM FORK LENGTH AT RELEASE, WERE AT LARGE FOR 90 DAYS, AND WERE RECAPTURED WITHIN COUNTRY OF RELEASE, FOR VARIOUS SPC COUNTRIES. The 95 per cent confidence interval of each increment is given in parentheses. Country abbreviations are explained in Appendix E.

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

4.3.5 Population structure

4.3.5.1 Tagging and blood genetics

There was movement of some tagged skipjack over much of the western and central Pacific (Figure B, inside back cover), suggesting that genetic exchange is possible among all countries within the Programme's study area. On the other hand, fishery interaction analyses completed to date suggest that the actual level of exchange, for skipjack of the size caught by pole-and-line gear, is low among at least the locally based skipjack fisheries in the study area (Kearney 1982b; Argue & Kearney 1982, 1983; Kleiber & Kearney 1983).

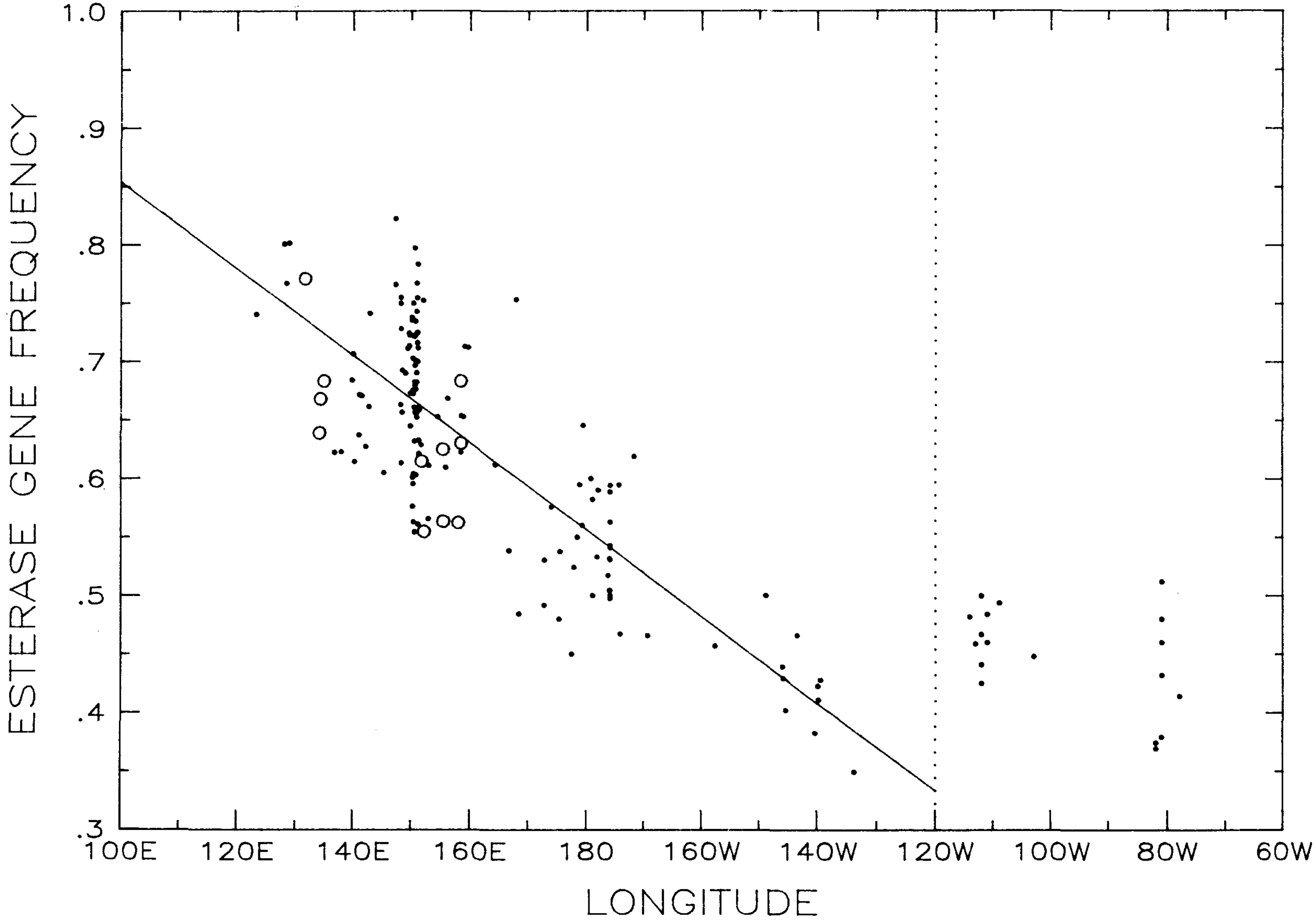
Results from electrophoretic analysis of skipjack blood samples show a decline in esterase gene frequency, a genetic marker used to infer population structure, from west to east across the Pacific between approximately 120°E and 120°W (Figure 10). The esterase gene frequencies for samples taken in the waters of Palau and Federated States of Micronesia were all within the 95 per cent prediction limits for the regression of esterase gene frequency on longitude. There was considerable variation in individual esterase gene frequency values along this average line, although the cause of this variability was unclear (Anon. 1981).

Several models of skipjack population structure in the Pacific Ocean have been proposed (Fujino 1972, 1976; Sharp 1978; Anon. 1981). One of these models, suggested by the Programme's tagging and blood genetics data, is called the clinal population structure model (Anon. 1981). It has a basic premise that the probability of breeding between skipjack is inversely proportional to the distance between them. Acceptance of this model implies that there are no genetically isolated skipjack subpopulations in the study area, which is contrary to hypotheses advanced by Fujino (1972, 1976) and Sharp (1978). Previously, Fujino's hypothesis of two isolated subpopulations, one in the central and eastern Pacific and the other in the western Pacific, had been used to support grouping of certain western Pacific countries for management purposes (Kearney, personal communication).

The gradient in esterase gene frequency is consistent with several possible distributions of skipjack spawning, one being a relatively even distribution of spawning in tropical waters across the study area. Alternatively, one could view the gradient as the result of "overlap" of skipjack from two or more centres of higher spawner density at the approximate extremes of the study area or beyond. Occurrence of skipjack juveniles also appeared highest at the longitudinal extremes of the Programme study area (Argue et al. 1983), thus lending support to the latter view of the distribution of skipjack spawning. The similarity between eastern Pacific esterase gene frequencies (to the right of the dotted line in Figure 10) and those from French Polynesia suggests that eastern Pacific skipjack have the same genetic origin as skipjack in French Polynesia and thus could collectively represent the group at one extreme.

After two workshops hosted by the South Pacific Commission to examine the question of skipjack population structure, it was concluded (Anon. 1981; Skipjack Programme 1981d; Argue, Kleiber, Kearney & Sibert ms.) that there was no evidence of barriers to the interaction of fisheries between neighbouring regions as previous researchers (Fujino 1972, 1976; Sharp 1978), using different sets of blood genetics data, had suggested. Furthermore, the blood genetics data supported the conclusion that interaction between fisheries at the longitudinal extremes of the study area is minimal, and that the degree of interaction should increase as the distance between fisheries decreases.

FIGURE 10. SKIPJACK SERUM ESTERASE GENE FREQUENCY VERSUS LONGITUDE OF THE SAMPLE LOCATION. Open circles denote samples taken in the waters of Palau (4) and Federated States of Micronesia (7). The regression line was fitted to data for 145 samples to the left of the dotted line; the correlation coefficient was -0.81. Esterase gene frequencies for 18 eastern Pacific samples are shown to the right of the dotted line.



4.3.5.2 The occurrence of parasites

Parasite samples were taken over a wide range of tropical waters, including those of Palau and Federated States of Micronesia during the third visit, and including subtropical waters of New Zealand and Norfolk Island. Results from a multivariate analysis presented by Lester (1981) show that the parasites of tropical samples from widely separated areas are quite similar. Skipjack caught in New Zealand carried many tropical as well as subtropical parasites, which suggested that skipjack in New Zealand were recent arrivals from tropical waters (Lester et al. ms.). Analyses of parasite data did not suggest a way of clarifying fishery interactions in tropical waters using parasite fauna, nor was definition of skipjack population structure greatly improved by analysis of these data.

4.4 Skipjack Tagging Analyses

The cut-off date for tag recoveries presented in this report was 10 October 1983. The Programme received a total of 6,235 recoveries from 140,463 skipjack releases between October 1977 and August 1980 in the total study area, only two of these since August 1983. Few tag recoveries are expected in the future; consequently this report includes virtually all tag recoveries that will result from releases by the Programme.

4.4.1 General results

Skipjack were tagged in the Trust Territory and Guam at the beginning (October-November) and end (July-August) of cruises by Skipjack Programme research vessels (Table 17). From a total of 15,402 releases, 792 (5.1%) were returned. Most releases were during July-August (11,435), and by area, most releases were in the waters of Palau (7,233) and Federated States of Micronesia (7,647). Table 17 shows that tag return rates for visits to each state were less than 8 per cent; most were between 3 and 7 per cent.

Tag releases during July-August resulted in a 5.7 per cent return rate, significantly higher ($p<0.01$) than the 3.7 per cent return rate for October-November releases of smaller fish (Figure 6). Skipjack of 45 cm and larger had nearly identical return rates for the two time periods (5.4% and 5.2%), which implies that larger skipjack released during both time periods were exposed to similar levels of tag recovery effort. Almost half of the October-November releases were in November 1979 when very small skipjack (<35cm) were common throughout the area surveyed and constituted just under half of the Programme's catch at this time in the Trust Territory and Guam (Kearney & Hallier 1980). These very small skipjack experienced a longer period of natural mortality than larger fish, since at time of tagging they were not fully recruited to surface fishing gears; as well, they may have been exposed to higher rates of tag shedding and mortality due to tagging, immediately after release, than larger skipjack (Skipjack Programme 1981e; Kleiber et al. 1983a).

Total tag returns for each state (Table 17) have been divided into local returns, returns from states other than the state where tags were released (international returns), and returns for which there was insufficient information to assign a country of recovery. Overall, approximately equal numbers of tags were recovered locally and internationally. Fifteen per cent (116) of all returns were in the unknown location category. Within this category there were 57 from transhipped fish handled at processing plants in Japan, United States, Canada, American Samoa and Puerto Rico for which not even recapture method could be

TABLE 17. NUMBER OF RELEASES, RECAPTURES, AND PERCENTAGE OF TAGS RECAPTURED, BY VISIT, FOR TAGGED SKIPJACK RELEASED IN NORTHERN MARIANA ISLANDS, PALAU, FEDERATED STATES OF MICRONESIA, AND MARSHALL ISLANDS

Tagging Period	Northern Mariana Islands	Palau	Federated States of Micronesia	Marshall Islands	Total
July 1978	-	-	-	122/0/0%	122/ 0/0%
August 1978	-	-	1148/ 64/5.6%	-	1148/ 64/5.6%
October 1978	8/0/0%*	718/ 54/7.5%	1095/ 48/4.4%	-	1821/102/5.6%
November 1978	-	-	322/ 11/3.4%	164/5/3.1%	486/ 16/3.3%
November 1979	187/9/4.8%	-	1432/ 19/1.3%	41/0/0%	1660/ 28/1.7%
July 1980	-	-	3650/165/4.5%	-	3650/165/4.5%
August 1980	-	6515/417/6.4%	-	-	6515/417/6.4%
Total Releases (% released July-August)	195(0%)	7233(90.1%)	7647(62.7%)	327(37.3%)	15402(74.2%)
Local Returns	2(1.0%)	108(1.5%)	210(2.8%)	-	320(2.1%)
International Returns	7(3.6%)	258(3.6%)	87(1.1%)	4(1.2%)	356(2.3%)
Unknown Location	-	105(1.5%)	10(0.1%)	1(0.3)	116(0.8)
Total Returns	9(4.6%)	471(6.5%)	307(4.0%)	5(1.5%)	792(5.1%)

* Tag releases/tag returns/percentage of tags returned.

determined. Of the remaining 59, 43 were recaptured by purse-seine gear, 13 by pole-and-line gear and 3 by unknown gear. Considerable time was spent checking bills-of-lading and other transhipment and company records to determine more accurate recapture information for these tags, but this provided little extra information.

Most (92%) of the tag returns could be attributed to a particular fishing gear (Table 18). Pole-and-line and seine gear accounted for over half and close to one-third of all returns respectively. Over 90 per cent of the 227 purse-seine returns were from the last release of tags by the Programme in Palau. The timing of recoveries from these releases in August 1980 coincided with a period of rapid expansion by distant-water purse-seine fleets in waters to the east of Palau (Section 1.1). Further results and discussion of the late releases in Palau are in Section 4.4.4.4.

TABLE 18. NUMBER AND PERCENTAGE OF SKIPJACK TAG RECOVERIES BY GEAR TYPE, FOR RELEASES OF TAGGED SKIPJACK IN THE TRUST TERRITORY AND GUAM

Recovery Gear	Number of Recoveries	Percentage
Pole-and-line	423	53.4
Purse-seine	227	28.7
Artisanal/Subsistence*	27	3.4
Unknown	3	0.4
Shore Facilities	57	7.2
Research Vessels	55	6.9
Total	792	100.0

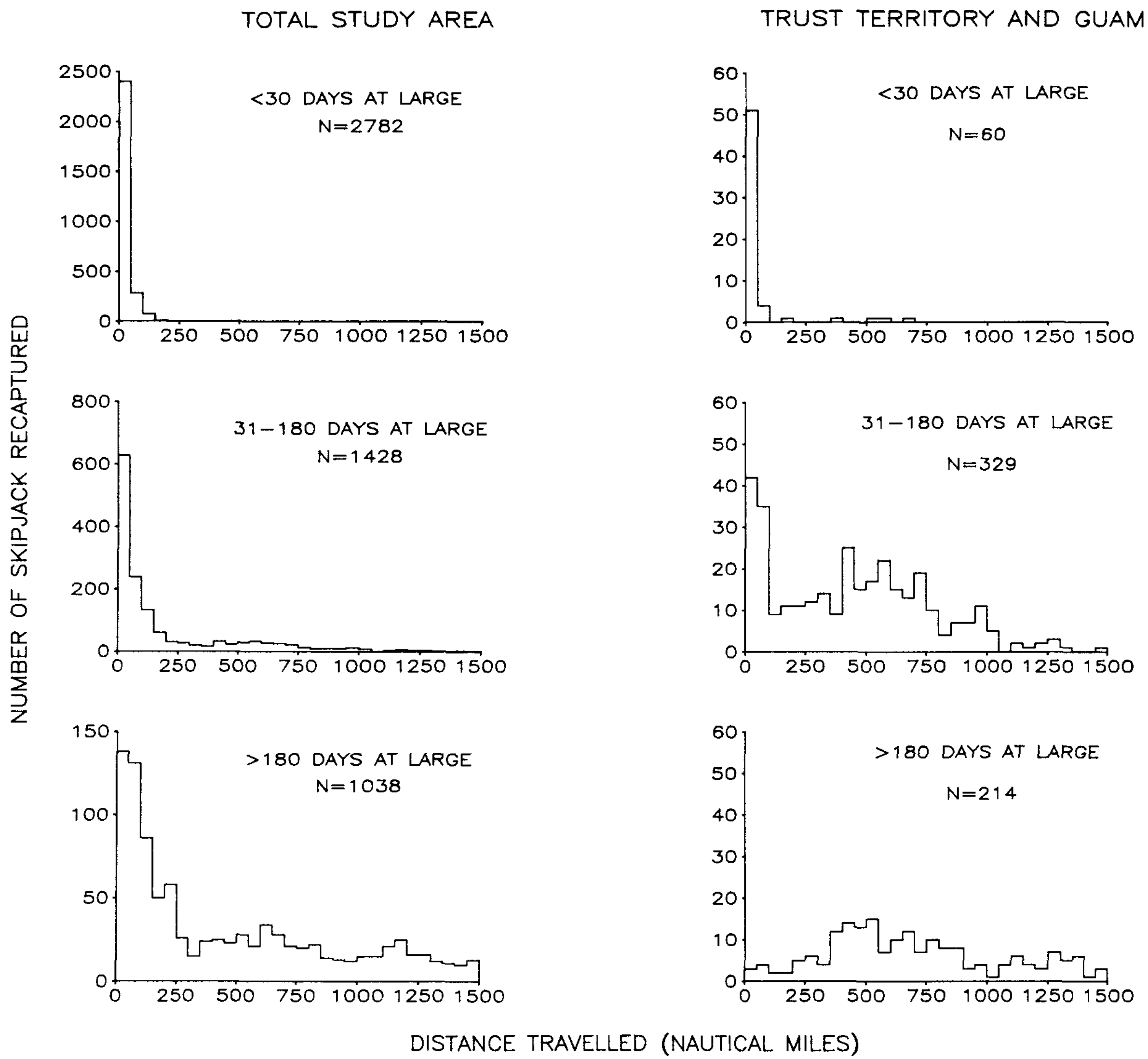
* Includes single recoveries by longline and recreational gear.

4.4.2 International migrations

Figure B presents a selection of all Skipjack Programme tag returns plotted as arrows between tagging and recovery location. Returns were selected by plotting no more than one example of a migration in each direction between any pair of ten degree squares and no more than two examples of a migration wholly within any ten degree square. The impression from this figure is one of considerable mixing of skipjack, with little evidence of oceanographic barriers to movement of skipjack within the study area. The apparent lack of movement north or south of the area surveyed reflects poor chances for recovery as a result of low fishing effort and environmental barriers to migration at the latitudinal extremes (skipjack are seldom encountered polewards of 40 degrees latitude or in waters colder than 16°C).

The overall impression of many wide-ranging international migrations depicted by Figure B does not accurately reflect the average case for all tag recoveries. This figure overemphasises the less numerous long-distance migrations, due to the procedure used to select returns for the figure. In fact, the majority (84%) of the Programme's tag returns from all releases were made less than 250 nautical miles from their release site and within 180 days of tagging (Figure 11, left side). Long-distance migrations were prevalent only within the group of skipjack that were at large for more

FIGURE 11. **NUMBERS OF SKIPJACK TAG RECOVERIES BY DISTANCE TRAVELLED AND TIME-AT-LARGE FOR THE TOTAL SKIPJACK PROGRAMME DATA SET (graphs on left side) AND FOR RELEASES OF TAGGED SKIPJACK IN THE TRUST TERRITORY AND GUAM (graphs on right side). Data are for tag returns received by 10 October 1983. Recaptures for 103 fish, which travelled more than 1,500 nautical miles, are included in the sample sizes, but are not shown in the graphs.**



than 180 days (lower left graph, Figure 11). On the right side of Figure 11 are graphs for returns from skipjack tag releases in the Trust Territory and Guam. A similar pattern to that for the total data set is evident, although a lower proportion (33%) of Trust Territory and Guam recoveries occurred within 180 days and 250 miles of their release. The total data set includes releases of 47,599 skipjack within locally based fisheries in Papua New Guinea, Solomon Islands, Fiji and New Zealand where there was opportunity for large numbers of early recoveries. In contrast, Trust Territory and Guam releases of tagged skipjack occurred over a wide area and seldom in the vicinity of active fisheries. Furthermore, fisheries in this area, particularly pole-and-line fisheries, were distributed over a much broader area (Section 4.4.4.3) than locally based fisheries elsewhere; hence there was more area into which tagged skipjack could migrate and have a reasonable probability of recapture.

Tag recovery data for the Trust Territory and Guam (Figure 12 and Table 19) contain much information on skipjack movement. However, to quantify movement patterns it is necessary to have complete catch statistics for the major fisheries that recovered tags, during the period that tags were at large (1977-1982). These were predominantly the Japanese distant-water pole-and-line fishery and the Japanese and United States distant-water purse-seine fisheries. Unfortunately, at the time of writing, the Programme has officially received complete data for only Japanese pole-and-line catches from 1972 to 1978. The lack of complete statistics for other years and for the purse-seine fishery has been a serious impediment to Programme analyses of skipjack movement and population dynamics, particularly those pertaining to the Trust Territory and Guam where tag recoveries were predominantly from these fisheries.

4.4.2.1 Tag migrations from states of the Trust Territory and Guam

There were 346 tagged skipjack recovered outside the waters of states of the Trust Territory and Guam with recovery information that was sufficiently precise to allow their migrations to be plotted. These include skipjack that migrated between states in the Trust Territory and Guam, as well as skipjack that were recovered outside the Trust Territory and Guam. Figure 12 depicts straight line migration trajectories for 105 of these recoveries (see figure caption). Complete tagging and recovery information for all 346 skipjack are listed in Appendix D. Table 19 shows the monthly returns of these skipjack for each state in which they were recovered.

There were international recoveries of tagged skipjack released in each state of the Trust Territory and Guam, and as illustrated by Figure 12, these skipjack moved in all directions. One notable migration was by a skipjack tagged on 29 October 1978 in Ponape and recovered on 3 May 1979 off Japan, a distance of 1,791 nautical miles at an average migration rate of 9.6 nautical miles per day. The longest migration was by a tagged skipjack released on 13 August 1980 in Palau and recovered 2,743 nautical miles to the east in international waters between Marshall Islands and the Line Islands of Kiribati after 688 days at large (4.0 nautical miles per day).

Releases in Palau resulted in 77 tag returns from fisheries in Papua New Guinea, 69 tag returns from fisheries in Federated States of Micronesia, and lesser numbers of returns from the Philippines, Indonesia, Marshall Islands, Kiribati, Solomon Islands and Japan (Table 19). Releases in Federated States of Micronesia resulted in 37 tag returns from fisheries in Marshall Islands, and only 19 returns in total from the waters of

FIGURE 12. MIGRATION ARROWS FOR 105 OF 346 TAGGED SKIPJACK THAT MADE INTERNATIONAL MIGRATIONS FROM THE WATERS OF NORTHERN MARIANA ISLANDS, PALAU, FEDERATED STATES OF MICRONESIA, AND MARSHALL ISLANDS. Recoveries have been selected to show no more than one example of movement in each direction between any pair of five degree squares. Each tick mark on the arrows represents 30 days at large. The boundaries were prepared by the Skipjack Programme for scientific analyses and should not be taken as an authority on the extent of the areas of jurisdiction shown.

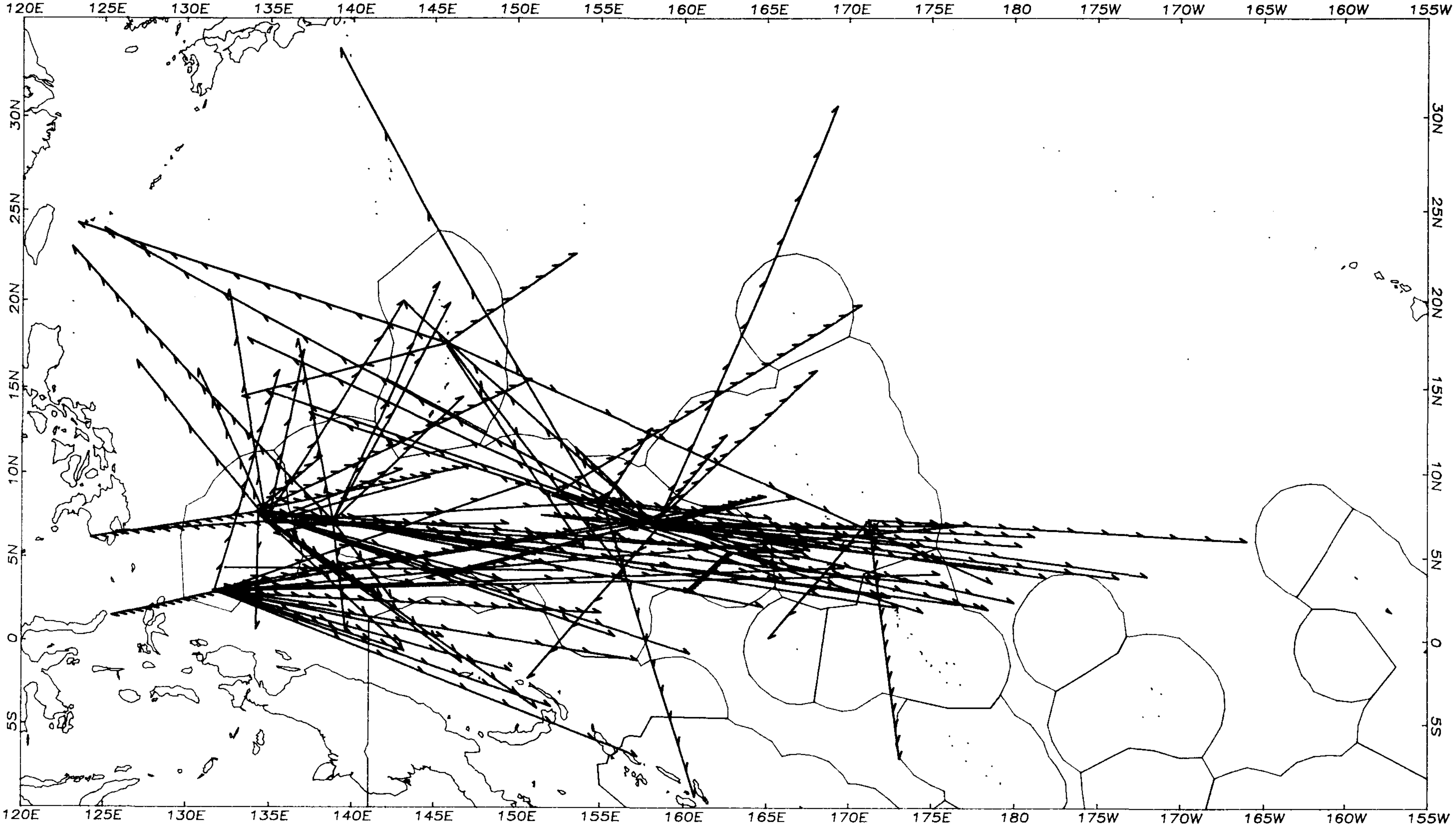


TABLE 19. RECOVERIES BY MONTH AND RECAPTURE AREA OF SKIPJACK TAGS RELEASED IN NORTHERN MARIANA ISLANDS, PALAU, FEDERATED STATES OF MICRONESIA AND MARSHALL ISLANDS. Country abbreviations are explained in Appendix E.

			RECAPTURE AREA														
Release Date	No. of Releases	Month of Recapture	JAP	MTS	MAR	PHL	IND	PAL	FSM	MAS	KIR	PNG	SOL	NAU	HOW	INT	Total
NORTHERN MARIANA ISLANDS																	
79/11	187	79/11															-
		79/12															-
		80/01															-
		80/02							1								1
		80/03							1								1
		80/04							1							1	2
		80/05															-
		80/06		1	1												2
		80/07			1												1
		80/08														1	1
		80/09															-
		80/10	1														1
		Total	1	1	2	-	-	-	3	-	-	-	-	-	-	2	9
PALAU																	
78/10	718	78/10						32									32
		78/11							2								2
		78/12														1	1
		79/01										1				1	2
		79/02							4								4
		79/03		2												4	6
		79/04														1	1
		79/05															-
		79/06															-
		79/07															-
		79/08				1											1
		79/09															-
		79/10															-
		79/11															-
		79/12															-
		80/01															-
		80/02								1							1
		Total	-	-	-	1	-	32	8	1	-	1	-	-	-	7	50
80/08	6,515	80/08						8									8
		80/09						7				4				1	12
		80/10					9	48	8							1	66
		80/11					11	7	11		2	7				8	46
		80/12					4			1		21				6	32
		81/01					3		4	1		4				2	14
		81/02			1			3	3			7				1	15
		81/03							5			4				6	15
		81/04						1	6		1	2				9	19
		81/05						2	2			3	1			8	16
		81/06							8				1			1	10
		81/07										15				8	23
		81/08										2				3	5
		81/09					1		3	1		1					6
		81/10										1				1	2
		81/11										1				1	2
		81/12				2			3								5
		82/01							1			1				1	3
		82/02				1				1							2
		82/03								1						3	4
		82/04							1							1	2
		82/05							2								2
		82/06															-
		82/07							1							1	2
		Unknown				2						3					5
		Total	-	-	1	5	28	76	58	5	3	76	2	-	-	62	316
FEDERATED STATES OF MICRONESIA																	
78/08	1,148	78/08							7								7
		78/09							1								1
		78/10							3								3
		78/11							2	1							3
		78/12							21								21
		79/01							4								4
		79/02							5							1	6
		79/03							3								3
		79/04								1							1
		79/05															-
		79/06														1	1
		79/07															-
		79/08															-
		79/09															-
		79/10														1	1
		79/11								1							1
		79/12														2	2
		Unknown							8								8
		Total	-	-	-	-	-	-	54	3	-	-	-	-	-	6	63
78/10	1,095	78/10															-
		78/11															-
		78/12							9								9
		79/01					2		3							2	7
		79/02			2		1	1	6								10
		79/03			1				6							2	9
		79/04							6							2	9

TABLE 19. (cont.)

Release Date	No. of Releases	Month of Recapture	JAP	MTS	MAR	PHL	IND	PAL	FSM	MAS	KIR	PNG	SOL	NAU	HOW	INT	Total
		79/05	2							1							3
		79/06															-
		79/07															-
		79/08									1					1	2
		79/09															-
		79/10													1		1
		79/11															-
		79/12															-
		80/01															-
		80/02															-
		80/03									1						1
		80/04														1	1
		Unknown								1							1
		Total	2	-	3	-	3	1	24	2	2	-	-	-	1	8	46
78/11	322	78/11								1							1
		78/12							3								3
		79/01							1								1
		79/02															-
		79/03															-
		79/04										1				1	2
		79/05															-
		79/06															-
		79/07															-
		79/08														1	1
		79/09															-
		79/10															-
		79/11															-
		79/12															-
		80/01															-
		80/02														1	1
		Unknown							1								1
		Total	-	-	-	-	-	-	5	1	-	1	-	-	-	3	10
79/11	1,432	79/11							1								1
		79/12							1								1
		80/01															-
		80/02							1		3						4
		80/03							4								4
		80/04							3								3
		80/05															-
		80/06															-
		80/07														1	1
		80/08															-
		80/09															-
		80/10								2			1				3
		80/11															-
		80/12															-
		81/06														1	1
		Total	-	-	-	-	-	-	10	5	-	-	1	-	-	2	18
80/07	3,650	80/07							56								56
		80/08							6								6
		80/09							6								6
		80/10							11	6	1						18
		80/11							11	5							16
		80/12								2						2	4
		81/01							6	2						1	9
		81/02			1				7	3							11
		81/03							6								6
		81/04							3							3	6
		81/05								1						3	4
		81/06								2						2	4
		81/07							1						1		2
		81/08															-
		81/09	1						2	1							4
		81/10							1								1
		81/11							1								1
		81/12															-
		82/01															-
		82/02								4						1	5
		Unknown				1											1
		Total	1	-	1	1	-	-	117	26	1	-	-	-	1	12	160
								MARSHALL ISLANDS									
78/11	164	78/11															-
		78/12								1							1
		79/01															-
		79/02															-
		79/03															-
		79/04												1			1
		79/05															-
		79/06															-
		79/07															-
		79/08															-
		79/09															-
		79/10														1	1
		79/11															-
		79/12															-
		80/01															-
		80/02														1	1
		Total	-	-	-	-	-	-	-	1	-	-	-	1	-	2	4

Northern Mariana Islands, the Philippines, Indonesia, Palau, Kiribati, Papua New Guinea, Nauru, and Howland Island. Thirty-one returns from fisheries in Indonesia and seven returns from fisheries in the Philippines were all from releases in Palau and Federated States of Micronesia. There were only 13 recoveries by large locally based pole-and-line fisheries in Papua New Guinea (12) and Solomon Islands (1), all from August 1980 releases in Palau.

International recoveries were 3.6 per cent of releases in Northern Mariana Islands, 3.6 per cent of releases in Palau, 1.1 per cent of releases in Federated States of Micronesia and 0.9 per cent of releases in Marshall Islands. These were above levels of one per cent and less for international recoveries from releases in Papua New Guinea, Solomon Islands and New Zealand (Tuna Programme 1984; Argue & Kearney 1982, 1983).

4.4.2.2 International migrations to states of the Trust Territory and Guam

Straight-line trajectories for 61 tagged skipjack that migrated to the waters of Guam and the states of the Trust Territory are shown in Figure 13. Tagging and recovery information for these fish is detailed in Appendix D. Table 20 presents tag returns from Northern Mariana Islands, Guam and Palau by country of tagging and month of recovery. Tables 21 and 22 present similar data for the Federated States of Micronesia and Marshall Islands respectively. These three tables also contain returns from releases in other states of the Trust Territory and Guam.

All but two of the 61 international "migrants" were released in waters to the south and southeast of the Trust Territory and Guam, which is hardly surprising considering that there were over 70,000 tag releases to the south and southeast compared to only 108 releases in waters to the north. By far the largest number of international migrants to the Trust Territory and Guam (28) arose from skipjack released in Papua New Guinea, most of which were released just to the north of the Bismarck Sea. These returns and 16 returns from 4,403 releases in Kiribati accounted for 72 per cent of the 61 international migrants to the Trust Territory and Guam. The longest migration was by a skipjack tagged on 22 December 1977 in New Caledonia that underwent a net movement of 2,405 nautical miles to Northern Mariana Islands in 438 days (5.5 nautical miles per day). Most international migrants were recovered in a narrow band between 3°N and 7°N latitude (Figure 13). This distribution of recoveries probably reflects the distribution of fishing at the time these tagged skipjack were at large, but this cannot be verified until complete catch statistics are available.

4.4.3 Mortality and production

The Programme has estimated population parameters for skipjack stocks exploited by locally based fisheries in Fiji (Kearney 1982b), Solomon Islands (Argue & Kearney 1982), Kiribati (Kleiber & Kearney 1983), French Polynesia (Gillett & Kearney 1983), Papua New Guinea (Tuna Programme 1984) and New Zealand (Argue & Kearney 1983). Kleiber et al. (1983a) discuss the principles of these analyses, as well as presenting estimates of skipjack population parameters for the study area. This report uses their analytical procedures to estimate population parameters for the Trust Territory and Guam. Parameter estimates could not be obtained for discrete national or state areas because in each case there were either insufficient tag returns or incomplete catch data. Therefore parameters were estimated for the total sea area of the Trust Territory and Guam, from an aggregate data set.

FIGURE 13. MIGRATION ARROWS FOR 61 TAGGED SKIPJACK THAT MADE INTERNATIONAL MIGRATIONS TO THE WATERS OF NORTHERN MARIANA ISLANDS, GUAM, PALAU, FEDERATED STATES OF MICRONESIA, AND MARSHALL ISLANDS. Each tick mark on the arrows represents 30 days at large. The boundaries were prepared by the Skipjack Programme for scientific analyses and should not be taken as an authority on the extent of the areas of jurisdiction shown.

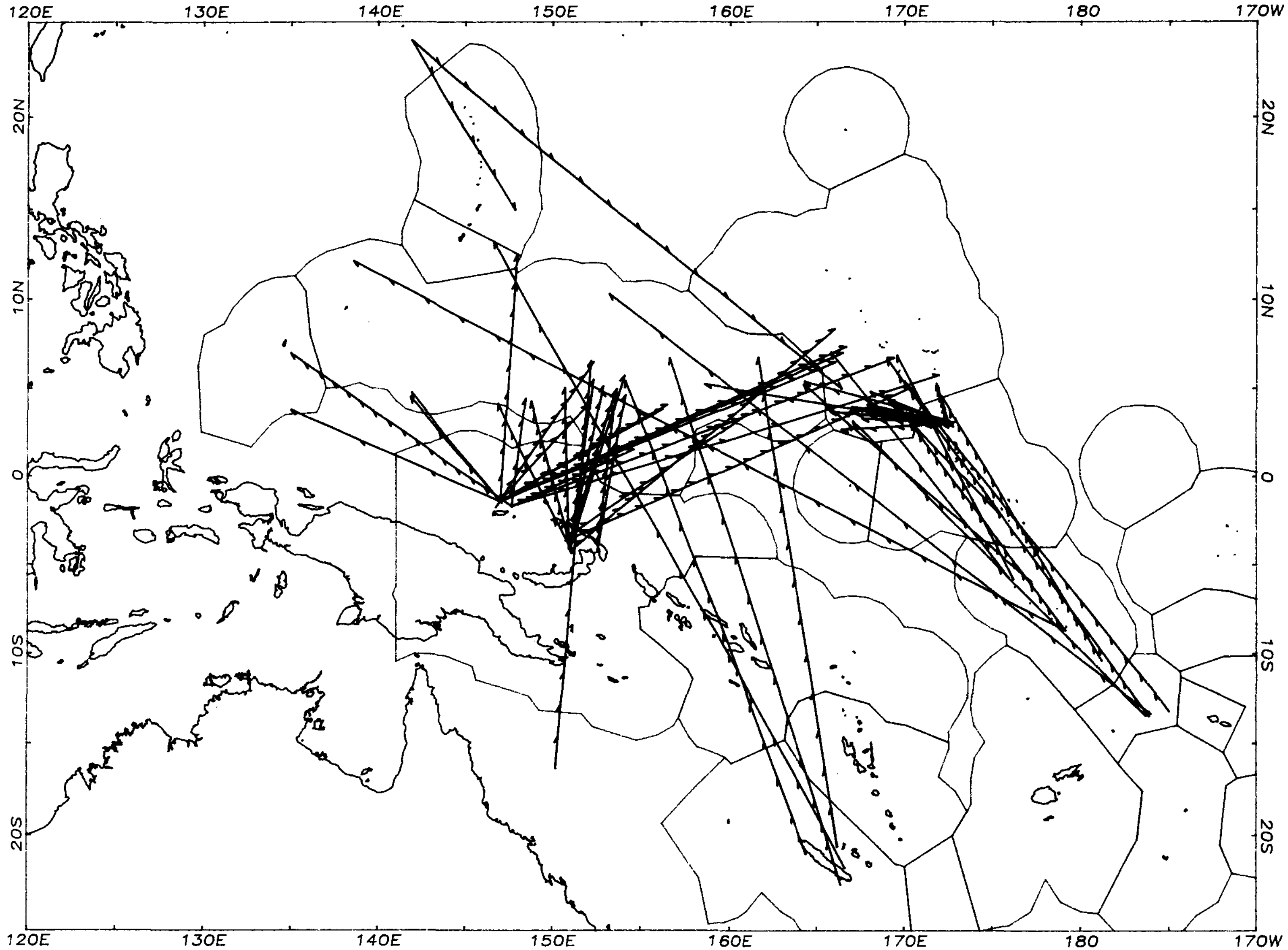


TABLE 20. MONTHLY SKIPJACK TAG RECOVERIES BY ALL FISHING GEARS IN THE WATERS OF NORTHERN MARIANA ISLANDS, PALAU AND GUAM OF TAGS RELEASED IN OTHER STATES. Year/month of tagging and number of tag releases are at the top of each column. Palau recoveries in brackets; Guam recoveries marked with an asterisk; X denotes month of tagging.

	Palau	Federated States of Micronesia		Japan	Papua New Guinea	New Caledonia	Total Tag Recoveries
	80/08	78/10	80/07	78/10	79/06	77/12	
	6,515	1,095	3,650	108	4,423	6,572	
78/10		X		X			-
78/11							-
78/12							-
79/01							-
79/02		2(1)		1			3(1)
79/03		1				1	2
79/04							-
79/05							-
79/06					X		-
79/07			X				-
79/08							-
79/09					(1)		(1)
79/10							-
79/11							-
79/12							-
80/01							-
80/02							-
80/03					1*		1*
80/04							-
80/05							-
80/06							-
80/07							-
80/08	X						-
80/09							-
80/10					(1)		(1)
80/11							-
80/12							-
81/01							-
81/02	1		1				2
81/03							-
81/04							-
81/05							-
TOTAL	1	3(1)	1	1	(2)1*	1	7(3)1*

TABLE 21. MONTHLY SKIPJACK TAG RECOVERIES BY ALL FISHING GEARS IN THE WATERS OF FEDERATED STATES OF MICRONESIA OF TAGS RELEASED IN OTHER STATES. Year/month of tagging and number of tag releases are at the top of each column; X denotes month of tagging.

Recovery Year/Month	Northern Mariana Islands 79/11 187	Palau 78/10 718	Palau 80/08 6,515	Papua New Guinea 79/05 3,227	Papua New Guinea 79/06 4,423	Tuvalu 78/07 820	Kiribati 78/07 4,403	Wallis and Futuna 78/05 13,513	New Caledonia 78/01 3,622	Queensland 79/05 2,651	Total Tag Recoveries
78/10		X					1				1
78/11		2									2
78/12						1	1				2
79/01									1		1
79/02		4							2		6
79/03		2						1			3
79/04											-
79/05				X						X	-
79/06					X						-
79/07											-
79/08											-
79/09					2						2
79/10					1						1
79/11	X				2						2
79/12											-
80/01											-
80/02	1			1	1						3
80/03	1			1	4	1					7
80/04	1			2	1						4
80/05					2					1	3
80/06					1						1
80/07											-
80/08			X								-
80/09											-
80/10			8								8
80/11			11								11
80/12											-
81/01			4								4
81/02			3								3
81/03			5								5
81/04			6								6
81/05			2								2
81/06			8								8
81/07											-
81/08											-
81/09			3								3
81/10											-
81/11											-
81/12			3								3
82/01			1								1
82/02											-
82/03											-
82/04			1								1
82/05			2								2
82/06											-
82/07			1								1
TOTAL	3	8	58	4	14	2	2	1	3	1	96

TABLE 22. MONTHLY SKIPJACK TAG RECOVERIES BY ALL FISHING GEARS IN THE WATERS OF MARSHALL ISLANDS OF TAGS RELEASED IN OTHER STATES. Year/month of tagging and number of tag releases are at the top of each column; X denotes month of tagging.

	Palau		Federated States of Micronesia					Japan	Papua New Guinea		Kiribati	Tuvalu			Wallis and Futuna	Total
Recovery	78/10	80/08	78/08	78/10	78/11	79/11	80/07	78/10	79/05	79/06	78/07	78/06	78/07	80/07	78/05	Tag
Year/Month	718	6,515	1,148	1,095	322	1,432	3,650	108	3,227	4,423	4,403	1,766	820	318	13,513	Recoveries
78/09															1	1
78/10	X			X				X								-
78/11			1		1						3					5
78/12								1			4					5
79/01											4					4
79/02																-
79/03																-
79/04			1								1					2
79/05				1					X							1
79/06										X						-
79/07																-
79/08																-
79/09																-
79/10																-
79/11			1			X									1	2
79/12																-
80/01												1				1
80/02	1					3				1	2		1		1	9
80/03																-
80/04																-
80/05																-
80/06																-
80/07							X							X		-
80/08		X												X		-
80/09																-
80/10						2	6			3						11
80/11							5							1		6
80/12		1					2		1							4
81/01		1					2									3
81/02							3			2				1		6
81/03																-
81/04																-
81/05							1									1
81/06							2									2
81/07																-
81/08																-
81/09		1					1									2
81/10																-
81/11																-
81/12																-
82/01																-
82/02		1					4									5
82/03		1														1
Unknown month				1												1
TOTAL	1	5	3	2	1	5	26	1	1	6	14	1	1	2	3	72

4.4.3.1 Analytical methods

A non-linear, least squares fitting technique (Conway, Glass & Wilcox 1970) was used to fit a tag attrition model (Kleiber et al. 1983a) to the tag release, tag recapture and catch data for the Trust Territory and Guam. This model predicts the number of tag returns per monthly time period, r_i, using the equation:

$$r_i = \frac{\alpha\beta N_o C_i}{P(Z_c+\psi)} e^{-i(Z_c+\psi)}\left(e^{Z_c+\psi}-1\right) \qquad (1)$$

where α = the proportion of tagged fish that survive and retain their tags after the trauma of tagging

β = the proportion of recaptured tags that are returned with usable recapture information

N_o = the number of tagged fish that were released

C_i = catch in tonnes per month

Z_c = average instantaneous attrition rate per month, based on catch and including fishing mortality, natural mortality, decreased vulnerability and emigration

ψ = average instantaneous, long-term loss of tags per month due to mortality and tag shedding

P = standing stock (tonnes) available to surface fishing gear

It is assumed that the standing stock (population) of skipjack is in a steady state. In other words, over the period of tag returns, recruits to the fishable stock through immigration and growth of small fish are assumed, on average, to have equalled losses from the fishable stock due to fishing, natural death, reduced vulnerability and emigration. Long-term tag shedding and long-term tag mortality, ψ, were estimated to be small, less than 0.01 (Skipjack Programme 1981e), and thus not an important component of total attrition. One could also view the attrition rate as the turnover rate, or the average fraction of the population that is renewed each month. It follows that the throughput, T, or biomass (tonnes) cycling through the population each month is

$$T = Z_c P \qquad (2)$$

The throughput is a rate against which catch, also a rate, can be compared. The appropriate measure is the harvest ratio, H_c, given by

$$H_c = \frac{F_c}{Z_c} = \frac{\overline{C}}{T} \qquad (3)$$

where F_c = is a catch-based estimate of instantaneous fishing mortality

$\overline{C}$ = average catch per month over the duration of the tagging experiment

The harvest ratio gives a relative measure of the effect of fishing. If fishing mortality is a small fraction of attrition, it is likely that fishing is not affecting the population, and total catch could be increased by increased fishing pressure (Kleiber et al. 1983a).

Using catches and tag returns in Table 23, the analytical procedure provided estimates and 95 per cent confidence intervals for average tag attrition per month, average throughput (tonnes) per month, population size (tonnes), and harvest ratio (unitless). A goodness of fit statistic measured the proportion of total variation explained by the model.

TABLE 23. TAG RETURNS AND CATCH USED TO ESTIMATE β AND POPULATION PARAMETERS FOR THE TRUST TERRITORY AND GUAM

	Tag Returns	
	Usable	Reject
Fishermen	190	9
Shore	26	6
Total	216	15

Monthly Period	Tag Returns	Average Catch (tonnes)
1	45	4900
2	14	4900
3	10	4900
4	43	4900
5	35	4900
6	16	4900
7	14	4900
8	16	4900
9	5	4900
10	2	4900
11	0	4900
12	4	4900
13	0	4900
14	0	4900
15	3	4900
16	3	4900
17	1	4900
18	1	4900
19	2	4900
20	2	4900
21	0	4900
22	0	4900
23	0	4900
24	0	4900

4.4.3.2 Tagging and catch data

Tags were released during July-August and October-November and these returns and releases could either be combined or kept separate in the analyses. Since there were no obvious differences in migration patterns between periods (Figure 14) and the individual states showed little incidence of seasonality in pole-and-line catch per unit effort (Figure 7), it was decided to combine data for the two periods.

The pattern of tag migrations within the Trust Territory and Guam, for the combined data set (Figure 15), shows that some tagged skipjack moved over most of this area. This suggests that with time there was mixing of tagged and untagged skipjack over much of the Trust Territory and Guam. However, the effective boundary of the stock of which **P** is a measure is not likely to be exactly the same as the combined 200-mile zone of states of the Trust Territory and Guam, since tagged skipjack migrated from this area, thus expanding the effective area of the tagging experiment. Kleiber et al. (1983a) discussed simulation results, which suggested that standing stock estimates for Papua New Guinea and Solomon Islands corresponded to populations in areas approximately 10 per cent larger than the fished areas of these countries. The applicability of these results to the Trust Territory and Guam is presently being examined.

All tag releases except those for the last survey in Palau (August 1980) were considered. The 1980 Palau releases were excluded because they were small fish (41 cm average fork length) and were recaptured through to July 1982 (Table 19), thus including a seven-month period when the seine fishery was increasing most rapidly and the Programme had incomplete estimates of catch statistics for pole-and-line and purse-seine gear. Figure 16 (upper graph) shows that the size frequency distribution of tagged skipjack, excluding the Palau 1980 releases, was similar to the size frequency distribution of skipjack sampled between 1978 and 1981 from the Japanese pole-and-line catch (Tuna Programme unpublished data).

The graph of tag return rate versus fish size for skipjack in two-centimetre intervals (Figure 16, lower graph), shows a pattern of recovery rates similar to that observed from many of the countries for which the Programme has data (e.g. Argue & Kearney 1982, 1983). Such patterns probably reflect systematic, size-related changes in mortality and other processes that determine the rate at which tags are recaptured.

The Programme had estimates of skipjack pole-and-line catch by Japanese distant-water pole-and-line vessels for the Trust Territory and Guam for 1972 to 1978 (Skipjack Programme 1980), total skipjack catch by the Japanese distant-water fleet for 1973 to 1981 (Iizuka & Watanabe 1983), 1979 Japanese pole-and-line catch by one degree square (Fisheries Agency of Japan 1982) raised by a factor 1.11 to account for missing data (Skipjack Programme 1980), and pole-and-line catch by locally based pole-and-line boats for 1978 to 1981 (Tuna Programme unpublished data). Since the Programme did not have estimates of purse-seine catch by Japan and the United States for the Trust Territory and Guam, it was decided to consider catch, and subsequent tag returns, only from Japanese and locally based pole-and-line vessels.

To apply the analytical model to an aggregate set of data, a constant monthly catch rate must be assumed for the period of the tagging experiment (Kleiber et al. 1983a). The period considered for tag releases and recoveries in the Trust Territory and Guam was 1978 to 1981 since this period included 99 per cent of the useable tag returns and preceded much of

FIGURE 14. MIGRATION ARROWS FOR 93 OF 502 SKIPJACK TAGGED IN THE WATERS OF THE TRUST TERRITORY AND GUAM DURING 1978 TO 1980 SKIPJACK PROGRAMME SURVEYS IN JULY AND AUGUST (page 58) AND SUBSEQUENTLY RECOVERED, AND MIGRATION ARROWS FOR 64 OF 135 SKIPJACK TAGGED IN THE WATERS OF THE TRUST TERRITORY AND GUAM DURING SURVEYS IN OCTOBER AND NOVEMBER (page 59) AND SUBSEQUENTLY RECOVERED. Recoveries have been selected to show no more than one example of movement in each direction between any pair of five degree squares. Each tick mark on the arrows represents 30 days at large. The boundaries were prepared by the Skipjack Programme for scientific analyses and should not be taken as an authority on the extent of the areas of jurisdiction shown.

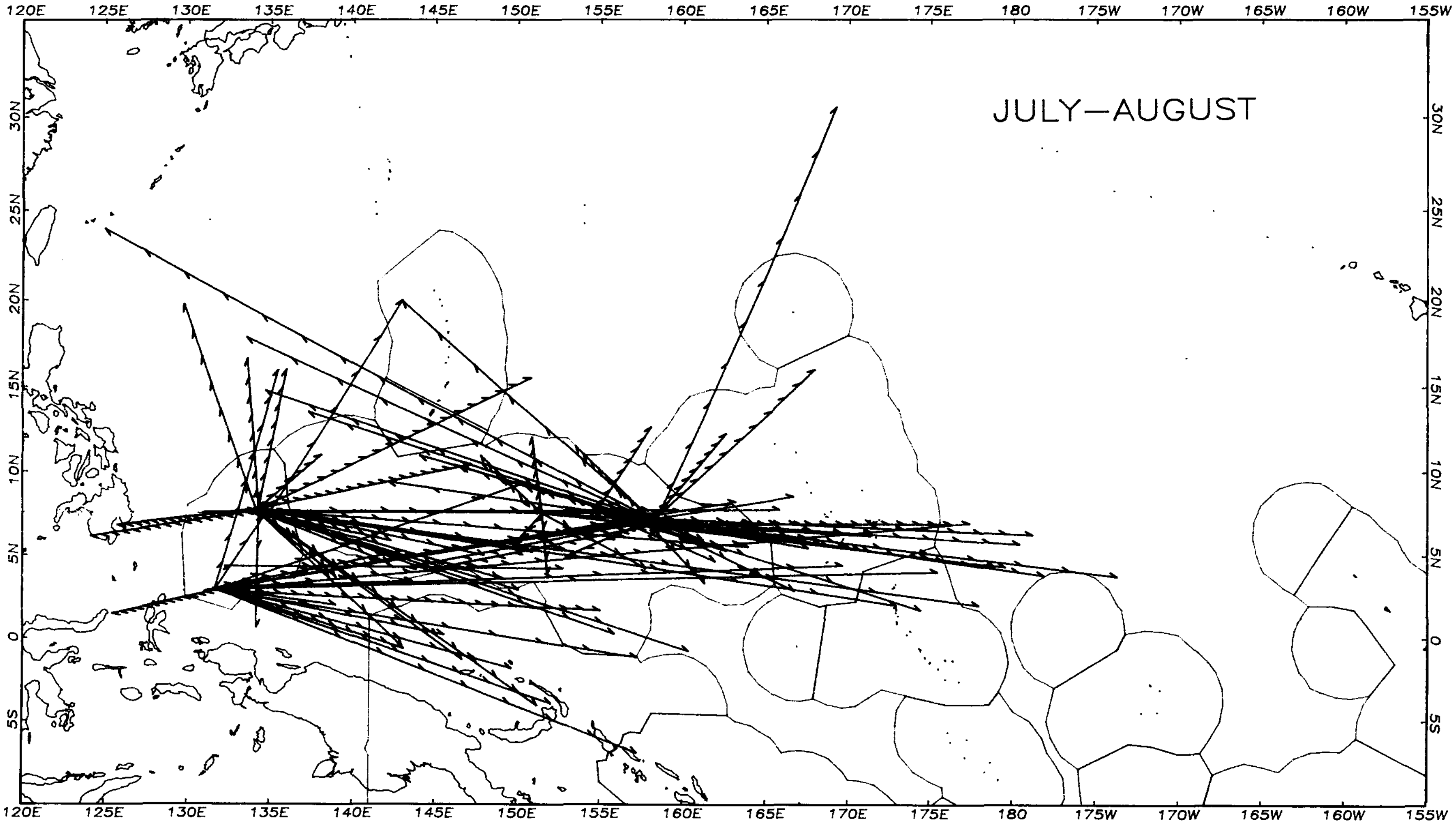


FIGURE 14. (cont.)

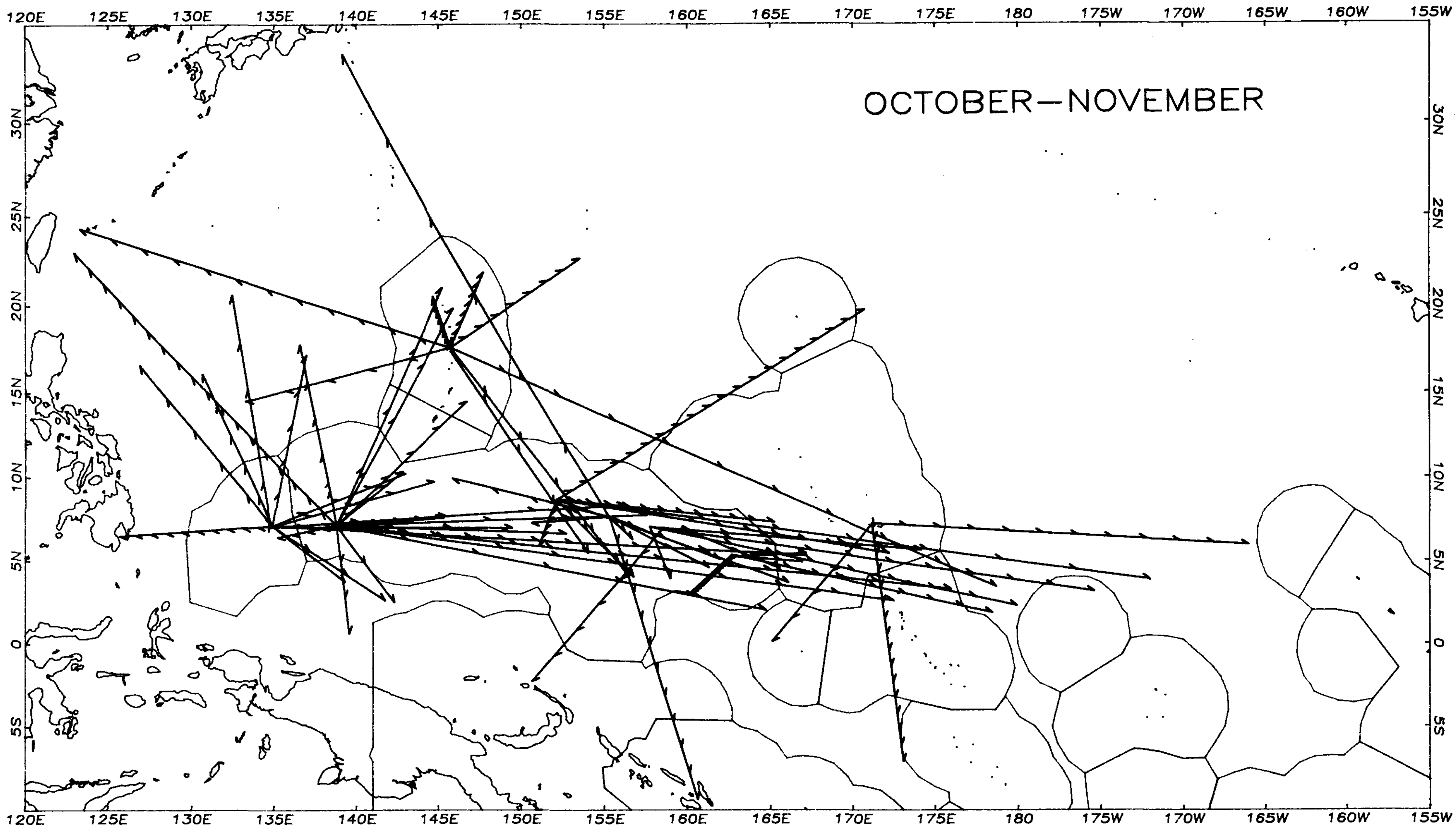


FIGURE 15. MIGRATION ARROWS FOR 75 OF 408 SKIPJACK TAGGED AND RECOVERED IN THE WATERS OF THE TRUST TERRITORY AND GUAM. Recoveries have been selected to show no more than one example of movement in each direction between any pair of five degree squares. Each tick mark on the arrows represents 30 days at large. The boundaries were prepared by the Skipjack Programme for scientific analyses and should not be taken as an authority on the extent of the areas of jurisdiction shown.

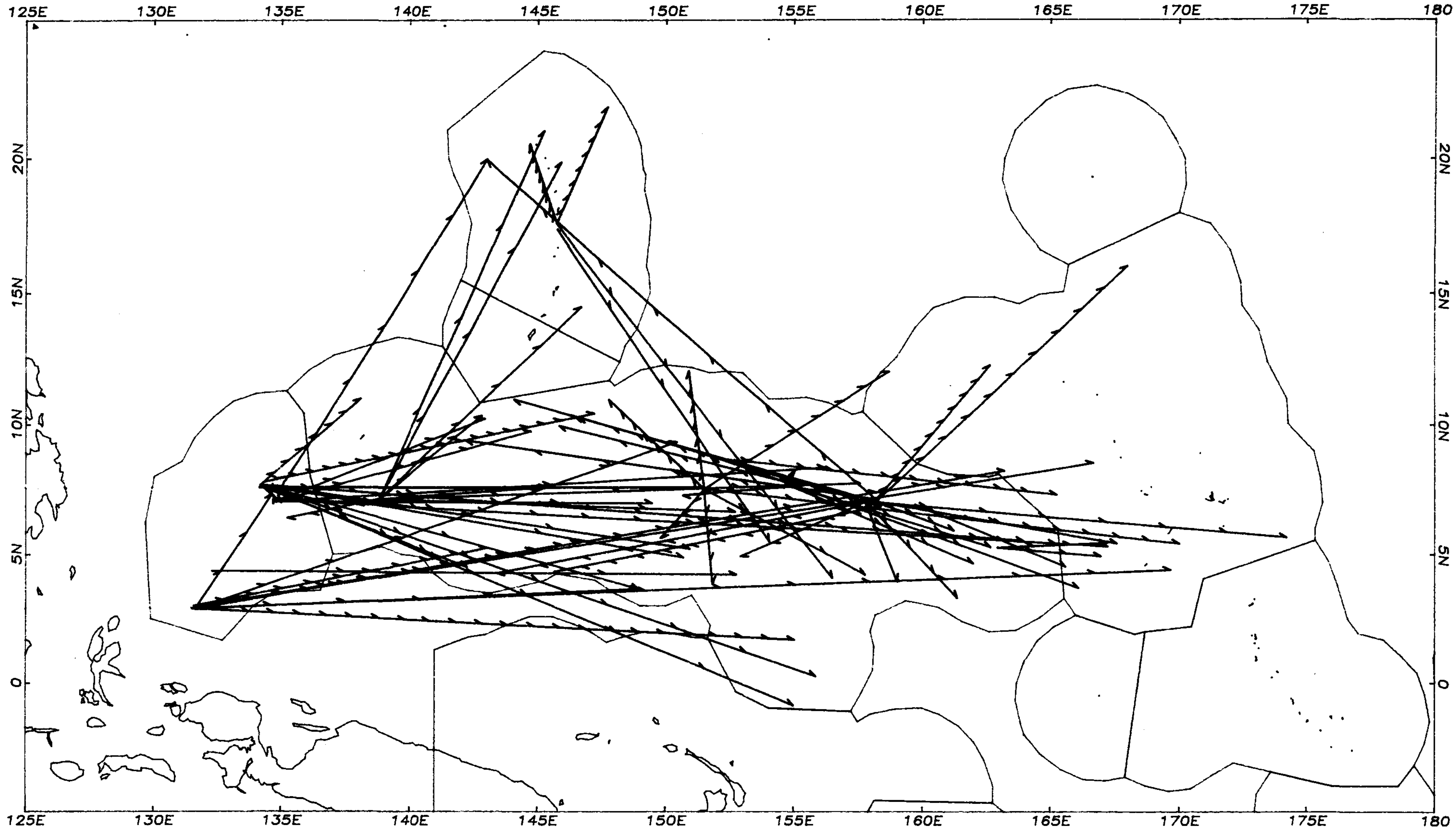
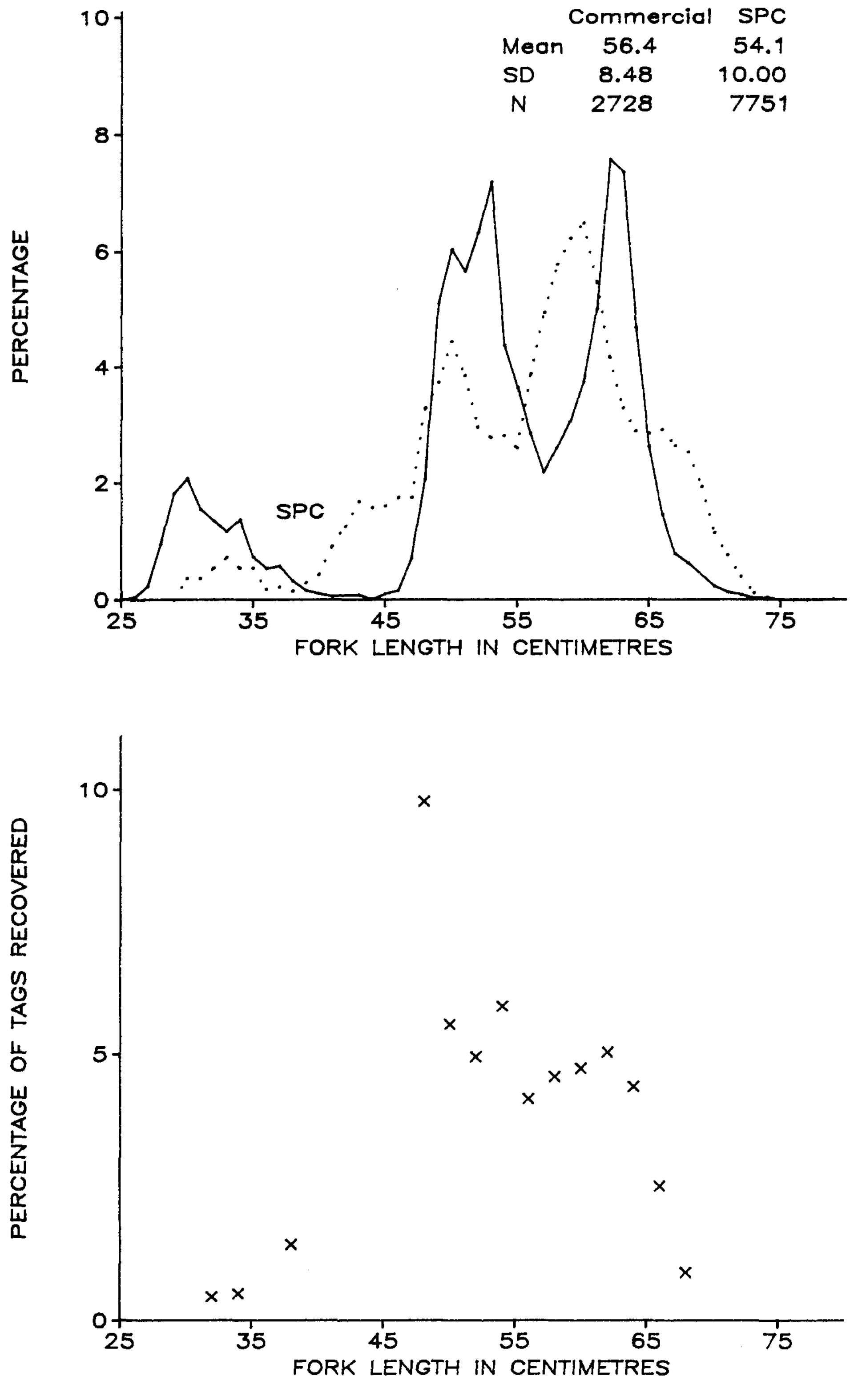


FIGURE 16. LENGTH FREQUENCY DISTRIBUTION FOR TAGGED SKIPJACK RELEASED DURING 1978 TO 1980 IN THE TRUST TERRITORY AND GUAM (EXCLUDING AUGUST 1980 RELEASES IN PALAU), CONTRASTED WITH THE LENGTH FREQUENCY DISTRIBUTION FOR SKIPJACK SAMPLED FROM 1978 TO 1981 FROM JAPANESE POLE-AND-LINE CATCHES IN APPROXIMATELY THE SAME AREA (upper graph). In the lower graph the Xs denote the tag recovery percentages for tagged skipjack within ten-centimetre length intervals. Mean fish lengths, standard deviations of the means (SD) and sample sizes (N) are indicated.



the increase in purse-seine fishing activity for which there are no catch and effort data. The average monthly pole-and-line catch for 1978 to 1981 was the sum of average monthly catch by locally based vessels in Palau (550 tonnes; Tuna Programme unpublished data), average monthly catch for other locally based pole-and-line gear (50 tonnes; M. McCoy, personal communication), and average monthly catch for Japanese distant-water pole-and-line gear (4,300 tonnes). The Japanese catch was estimated by calculating the average fraction that the Trust Territory and Guam catch was of the total distant-water skipjack catch by Japanese pole-and-line gear in 1978 and 1979, multiplying this fraction by the total distant-water pole-and-line catch by Japan in 1980 and 1981 to estimate pole-and-line catches in the Trust Territory and Guam for these years, averaging 1978 to 1981 Trust Territory and Guam catches, and then dividing by twelve. The resulting monthly average, rounded to 4,300 tonnes and added to catches by locally based vessels, gives the value of 4,900 tonnes per month used in Table 23.

Finally, the factor $\alpha\beta$ was estimated following the procedures in Kleiber et al. (1983a) and using the tag returns by fishermen and shore-workers at the top of Table 23. Best and worst values of β, calculated from these returns, were averaged to give a value of 0.76 for Trust Territory and Guam releases. The product of α, assumed to be 0.9 (Kleiber et al. 1983a), and β was 0.68.

4.4.3.3 Estimates of turnover, population size, throughput and harvest ratio

Figure 17 shows the numbers of tag returns versus the numbers of months these tags were at large after release for the total Skipjack Programme study area (upper graph), and for the Trust Territory and Guam (lower graph). These relationships are what would be expected if all tags were released simultaneously in the different areas. The straight lines in the graphs depict the average number of tag recoveries one would predict per month from fitting the mathematical model of Section 4.4.3.1 to the catches and resulting tag returns. Table 24 presents population parameter estimates and goodness of fit statistics for both data sets.

The data points in Figure 17 deviate little from the line predicting the average number of tag returns per month, although returns were somewhat more variable for the Trust Territory and Guam data set (compare goodness of fit statistics in Table 24). The attrition rate, estimated from the fitting procedure, was 0.17 per month for the total study area and 0.23 for the Trust Territory and Guam (Table 24). These estimates have overlapping confidence limits and they are not significantly different. At these rates, after six months at large approximately 70 per cent of the tag releases were unavailable for recapture, and after a year this had increased to approximately 90 per cent.

The population estimate for the Trust Territory and Guam, 658,000 tonnes (confidence range 373,000 to 1,305,000 tonnes), was 22 per cent of the population estimate of three million tonnes (2.5 million to 3.7 million tonnes) for the total study area. Average monthly catch for the Trust Territory and Guam, divided by population size, provided an estimate of average monthly fishing mortality of 0.007, which is a small proportion of the monthly attrition rate, and is very similar to the overall estimate of 0.006 for fishing mortality. Thus, losses through natural death, decreased vulnerability to fishing, and emigration must account for most tag attrition. It is difficult to partition these three loss factors, although considering the size of the areas, it is assumed that emigration is the smallest of the three.

FIGURE 17. NUMBERS OF SKIPJACK TAG RECOVERIES VERSUS MONTHS-AT-LARGE FOR THE TOTAL SKIPJACK PROGRAMME STUDY AREA (upper graph) AND FOR THE TRUST TERRITORY AND GUAM (lower graph). Data are for tag returns received by 10 October 1983. The Y-axis is in logarithmic scale.

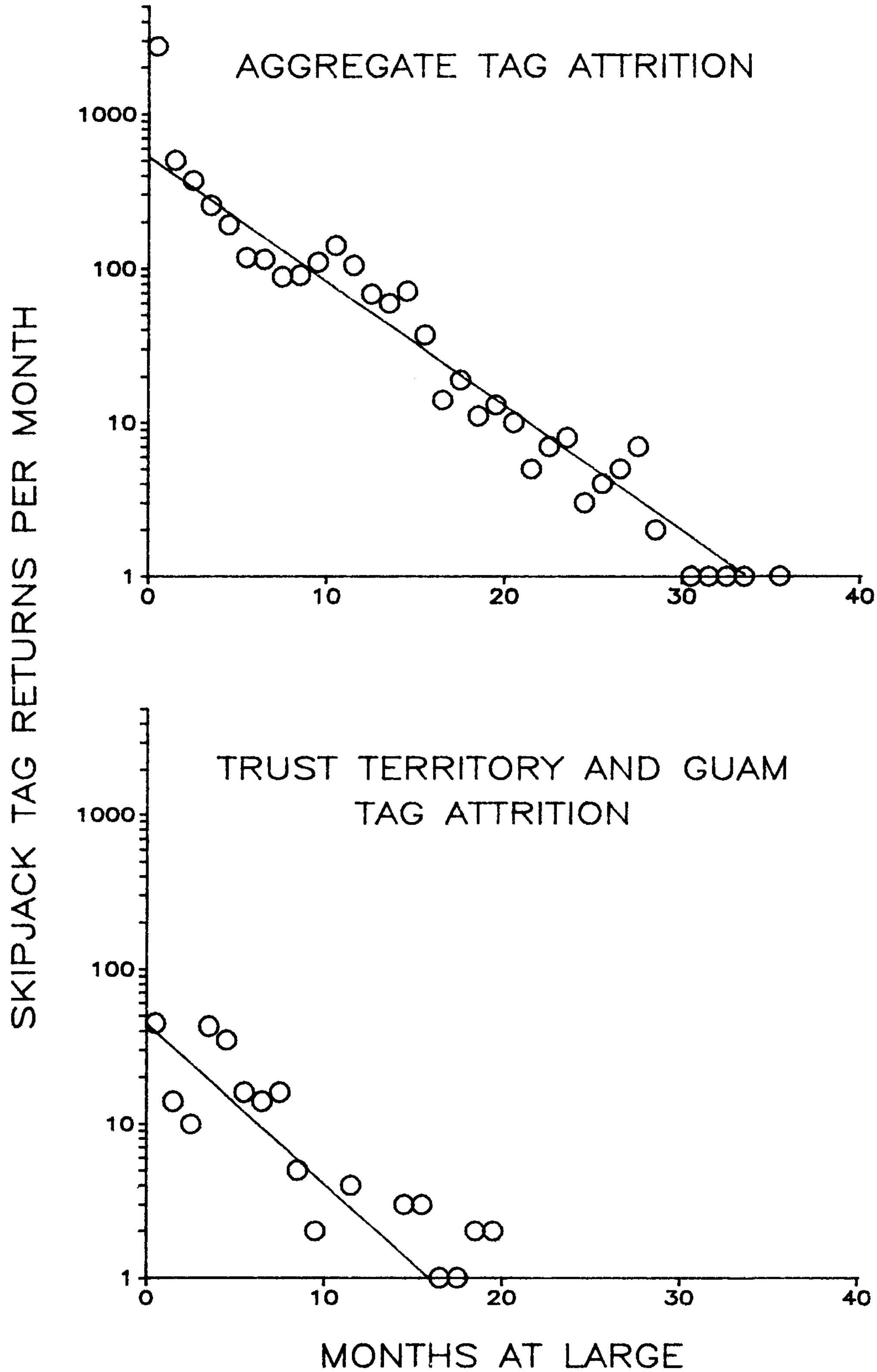


TABLE 24. SKIPJACK POPULATION PARAMETER ESTIMATES AND 95 PER CENT CONFIDENCE INTERVALS FOR THE TOTAL STUDY AREA, AND FOR THE TRUST TERRITORY AND GUAM. Results for total study area from Kleiber, Argue & Kearney (1983a).

	Total Study Area		Trust Territory and Guam	
	Estimate	Confidence Interval	Estimate	Confidence Interval
Attrition (turnover) per month	0.17	(0.15-0.20)	0.23	(0.14-0.36)
Population size (tonnes)	3,000,000	(2,500,000-3,700,000)	658,000	(373,000-1,305,000)
Average catch (tonnes per month)*	19,000	-	4,900	-
Throughput (tonnes per month)	520,000	(460,000-590,000)	153,000	(103,000-252,000)
Harvest ratio	0.037	(0.032-0.042)	0.032	(0.020-0.048)
Goodness of fit statistic	0.95		0.71	

* Catch for the total study area was estimated for all gear types combined; catch for Trust Territory and Guam was estimated for pole-and-line gear (Section 4.4.3.2).

Monthly throughput, the product of population size and monthly attrition, measures the tonnes of skipjack being recruited to the standing stock each month, which is assumed for the duration of the tagging experiment to be matched by an equal amount leaving each month. For the Trust Territory and Guam, recruitment was estimated to be 153,000 tonnes per month (103,000 to 252,000 tonnes).

The low harvest ratio of approximately three per cent for the Trust Territory and Guam suggests there is potential for greatly increased catches from this region before recruitment would be affected. Kleiber et al. (1983a) reached the same conclusion for the study area as a whole. The experience with much more mature skipjack fisheries off the coast of Japan and in the eastern Pacific, where there has been no relationship between catch per unit effort and effort over a period of 20 or more years (Joseph & Calkins 1969; Kearney 1979) also suggests that increased fishing effort in the Trust Territory and Guam is unlikely to result in an appreciable decline in catch per unit effort.

4.4.4 Fishery interactions

One of the principal objectives of the Skipjack Programme was to investigate the degree of interaction among skipjack fisheries throughout the western and central Pacific. Table 25 summarises the returns from tagged skipjack released throughout the total study area, by country/territory of release and recovery. This form of presentation takes no account of tag recovery effort, that is, the catch from which the tags were recovered, and therefore does not adequately quantify fishery interactions. Complete catch data were available to the Programme for locally based fisheries during the period tags were at large, but not for distant-water pole-and-line and purse-seine fisheries that operate in much of the central and western Pacific (Section 4.4.2). Over the period of the tagging experiment they accounted for a significant percentage (~20%) of Skipjack Programme tag returns.

4.4.4.1 Analytical methods and data

Using 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 stock/recruitment relationship for skipjack exploited by mature fisheries suggested that between-generation fishery interactions were negligible for skipjack fisheries in the western and central Pacific. Therefore, evaluation of interactions within one generation was considered more urgent.

The measure of interaction, $\mathbf{I}$, used here is the fraction of recruitment (throughput) to the stock vulnerable to the destination country's fishery that is due to immigration from the donor country (Kleiber, Argue & Kearney 1983b). Its mathematical formulation is:

$$I_{1\rightarrow 2} = \frac{\beta_1}{\beta_2}\left(\frac{T_1}{\alpha\beta_1}\right)\frac{R_{1\rightarrow 2}}{N_{o1}\bar{C}_2} \qquad (4)$$

where the subscripts refer to the donor (1) and destination (2) countries and where

TABLE 25. RELEASE AND RECAPTURE SUMMARY FOR TAGGED SKIPJACK RELEASED BY THE SKIPJACK PROGRAMME IN ALL COUNTRIES, TERRITORIES AND SUBDIVISIONS THEREOF AS OF 10 OCTOBER 1983. Releases and recoveries are arrayed by tagging or recovery location, usually a country or territory except in cases where smaller geographical divisions were more informative; abbreviations are explained in Appendix E. Not included in the table are returns for which the country or area was unknown.

COUNTRY OF RECAPTURE

NUMBER OF RELEASES BY COUNTRY

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

$R_{1\to 2}$ = the number of donor country tag releases recaptured by the destination country fishery

N_{o1} = the number of tag releases in the donor country

$\bar{C}_2$ = average catch in the destination country fishery over a 12-month period bracketing the period of tag returns, or averaged from one month before the first return to one month after the last return when tag returns spanned a period of more than one year.

If $\alpha\beta_1$ is unknown, the quantity $T_1/\alpha\beta_1$ can still be estimated from expression one in Section 4.4.3.1, and $I_{1\to 2}$ can in turn be estimated under the assumption that β_1 equals β_2. When α and β values are known, Equation (4) simplifies to

$$I_{1\to 2} = \frac{T_1 R_{1\to 2}}{\beta_2 \alpha N_{o1} \bar{C}_2} \qquad (5)$$

This was the equation used to estimate interaction in the following two sections.

Values for the parameters were obtained from several sources. First, values for T_1, N_{o1}, and β_2 for stocks of skipjack vulnerable to locally based pole-and-line fisheries in Papua New Guinea, Solomon Islands and Kiribati were taken from Tables 2 to 4 in Kleiber et al. (1983a). Average monthly catch, $\bar{C}_2$, for the Papua New Guinea pole-and-line fishery was from Tuna Programme (1984) and for the Solomon Islands pole-and-line fishery from Argue & Kearney (1982). Secondly, for states within the Trust Territory and Guam, the estimate of 153,000 tonnes for T in the whole area (Table 24) was prorated amongst states, on the basis of estimated sea area for each state, to estimate T_1 for each state (Table 2). The overall estimate of β (Section 4.4.3.2) was assumed to apply to each state. Values for N_{o1} were from Table 17, excluding the tag releases for Palau in August 1980. Most of these skipjack were less than 45 cm fork length at time of tagging and were subsequently recovered mainly by purse-seine gear rather than by pole-and-line gear. The analysis of interactions based on this release is treated separately in Section 4.4.4.4. The only fishery in the Trust Territory and Guam with usable catch data, other than the local Palau fishery, was the Japanese distant-water pole-and-line fishery. The average percentage in 1978 and 1979 that the Japanese pole-and-line catch in each state was of the total Japanese pole-and-line catch in all states, was multiplied by the estimate of 1978 to 1981 average monthly Japanese pole-and-line catch in all states in the Trust Territory and Guam (from Section 4.4.3.2) to estimate average monthly catch for each state. Finally, numbers of tagged skipjack that migrated between fisheries were obtained from Appendix D.

4.4.4.2 International fishery interactions

Previously, there were four pairs of countries and territories in the Skipjack Programme study area for which interactions had been quantified. These were Papua New Guinea - Solomon islands, New Zealand - Fiji, New Zealand - Society Islands, and New Zealand - Western Samoa (Argue & Kearney 1982, 1983). Skipjack emigrants from fished areas in these countries were estimated to contribute 1 to 14 per cent of throughput for the destination country's fished stock.

Table 26 presents estimates of interaction between skipjack stocks in the waters of states of the Trust Territory and Guam and nearby countries. All estimates were about one per cent or less. This result is not surprising for the estimates involving skipjack from Kiribati, since Kiribati throughput is low and represents a very small fished area around one atoll (Kleiber & Kearney 1983). It is surprising for Solomon Islands and Papua New Guinea since both have large fished areas with high throughputs. Migrants from these countries contributed little to throughput in states of the Trust Territory and Guam, even though these stocks are separated by a distance of less than 800 nautical miles. In comparison, stocks in Solomon Islands, Papua New Guinea, New Zealand, Fiji, Society Islands and Western Samoa are separated generally by much greater distances, yet migrants between these stocks comprised a larger proportion of the throughput of the respective destination countries. This result suggests that the degree of mixing across the Equator in the area of the Trust Territory and Guam is less than that between countries at higher latitudes south of the Equator.

It should be noted that these analyses apply only to skipjack of the size tagged by the Programme (most were between 40 and 60 cm). Skipjack smaller than this could very well move large distances and contribute significantly to interactions between stocks in the fished areas.

In general, fishery interactions can be expected to increase as the distance between fisheries decreases. If fisheries in neighbouring countries operate in waters adjacent to common borderlines, the degree of interaction would be expected to be higher. Furthermore, if different gear types operate in the same area, such as purse-seine and pole-and-line fleets operating on the same or nearby fishing grounds within a country, then the degree of interaction would be much higher than that illustrated above.

4.4.4.3 Fishery interactions within the Trust Territory and Guam

Table 27 presents estimates of interaction amongst stocks of skipjack fished by Japanese pole-and-line fisheries in Northern Mariana Islands, Palau, Federated States of Micronesia, and Marshall Islands. These estimates are quite high, ranging from two per cent between Palau and Marshall Islands to 37 per cent between Federated States of Micronesia and Marshall Islands. The Japanese pole-and-line catch was widely dispersed in this large area, as can be seen from the distribution by one degree square of average annual catch in 1977, 1978 and 1979 (Figure 18). Skipjack were caught in most one degree squares in the Trust Territory and Guam, and in 1978 high catches were made in the boundary area between Federated States of Micronesia and Marshall Islands. The proximity of the pole-and-line fleets that fish each states' zone was probably responsible for high levels of interaction illustrated in Table 27. Of course skipjack might also migrate more in this area, which includes the eastward-flowing north equatorial counter current and the westward-flowing north and south equatorial currents (Gorshkov 1976). It is noteworthy that interaction levels were highest for migrants moving from west to east, for example, between Palau and Federated States of Micronesia, and between Federated States of Micronesia and Marshall Islands. Reciprocal movement, although evidenced by a few returns of tagged skipjack (Figure 14), was not measured in the interaction analyses since these few recoveries were by fisheries other than the pole-and-line fishery, and there were insufficient catch data to complete interaction analyses.

TABLE 26. ESTIMATED PER CENT OF THROUGHPUT FROM MIGRANTS (INTERACTION) RESULTING FROM SKIPJACK MOVING BETWEEN PALAU, FEDERATED STATES OF MICRONESIA, MARSHALL ISLANDS, SOLOMON ISLANDS, PAPUA NEW GUINEA AND KIRIBATI. Capitalised headings in the body of the table denote the direction of skipjack movement.

Tagging Period (1)	No. of Tags Released (2)	Estimated Monthly Throughput in Tonnes (Donor Country) (3)	No. of Tags Recovered (4)	Average Monthly Destination Country Catch (tonnes) (5)	Destination Country β (6)	Interaction (%) (7)*
		FEDERATED STATES OF MICRONESIA TO SOLOMON ISLANDS				
78/07-80/07	7,647	69,000	1	1,760	0.72	0.8
		FEDERATED STATES OF MICRONESIA TO PAPUA NEW GUINEA				
78/07-80/07	7,647	69,000	1	1,800	0.76	0.7
		PAPUA NEW GUINEA TO PALAU				
79/05-79/06	6,009	13,000	1	380	0.76	0.8
		PAPUA NEW GUINEA TO FEDERATED STATES OF MICRONESIA				
79/05-79/06	6,009	13,000	10	2,330	0.76	1.4
		PAPUA NEW GUINEA TO MARSHALL ISLANDS				
79/05-79/06	6,009	13,000	2	1,320	0.76	0.5
		KIRIBATI TO FEDERATED STATES OF MICRONESIA				
78/07	4,403	400	2	2,330	0.76	<0.1
		KIRIBATI TO MARSHALL ISLANDS				
78/07	4,403	400	13	1,320	0.76	0.1

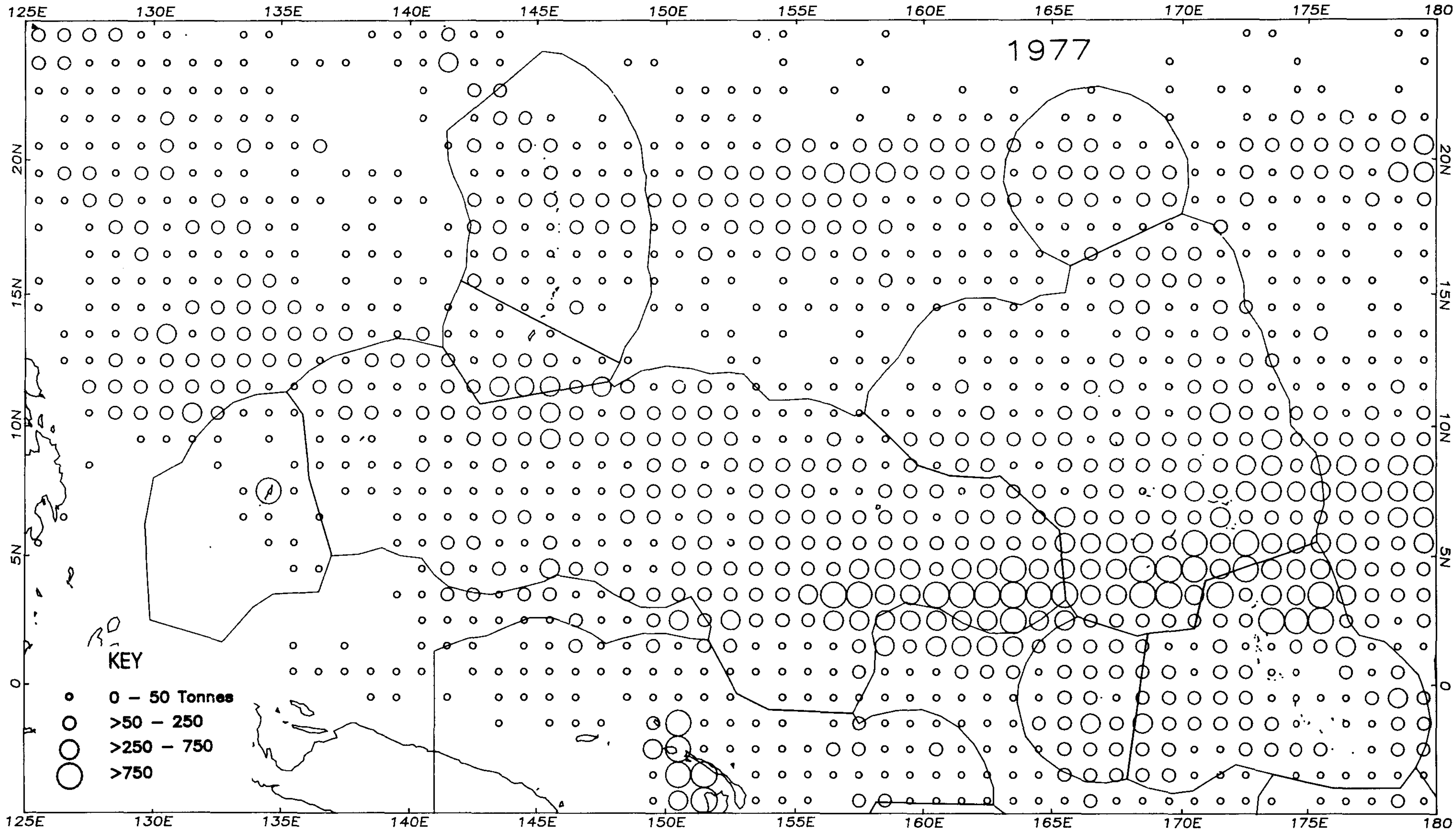
* Column(7) = (100 x Column(3) x Column(4)) / (Column(5) x Column(2) x Column(6) x 0.9)

TABLE 27. ESTIMATED PER CENT OF THROUGHPUT FROM MIGRANTS (INTERACTION) RESULTING FROM SKIPJACK MOVING BETWEEN STATES OF THE TRUST TERRITORY AND GUAM. Catch and tag returns by Japanese distant-water pole-and-line gear. Abbreviations are explained in Appendix E.

Donor Country	Tag Releases	Throughput (tonnes/month)	Destination Country Estimates of Interaction* (Number of tag recoveries)					
			MAR	PAL	FSM	MAS	GUM	Total
Northern Mariana Islands	195	18,000	(2)	-	17.4%(3)	-	-	(5)
Palau (October 1978)	718	14,000	-	(15)	8.6%(7)	2.2%(1)	-	(23)
Federated States of Micronesia	7,647	69,000	10.8%(4)	-	(117)	37.0%(37)	-	(158)
Marshall Islands	327	47,000	-	-	-	-	-	-
Guam	-	5,000	-	-	-	-	-	-
Total	8,887	153,000	(6)	(15)	(127)	(38)	-	(186)
Average Monthly Catch (tonnes)			490	70	2,330	1,320	90	4,300

* Interaction = (100 x Tag recoveries x Throughput) / (Destination country catch x Donor country releases x 0.77 x 0.9).

FIGURE 18. ANNUAL CATCHES IN 1977, 1978 AND 1979 BY JAPANESE DISTANT-WATER POLE-AND-LINE VESSELS IN THE WATERS OF AND SURROUNDING THE TRUST TERRITORY AND GUAM. Area of the circles is proportional to catch (see key). The boundaries were prepared by the Skipjack Programme for scientific analyses and should not be taken as an authority on the extent of the areas of jurisdiction shown.



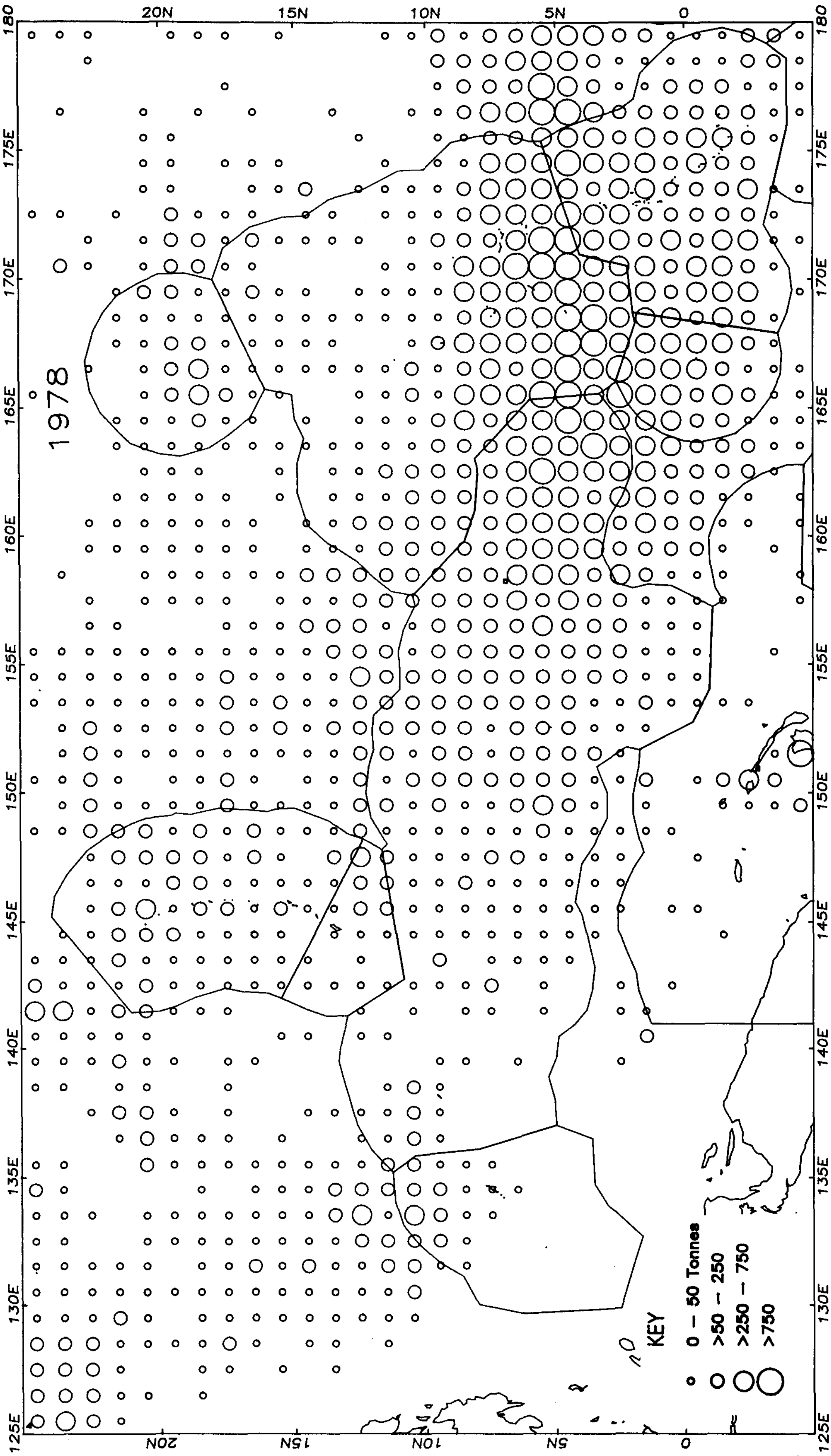
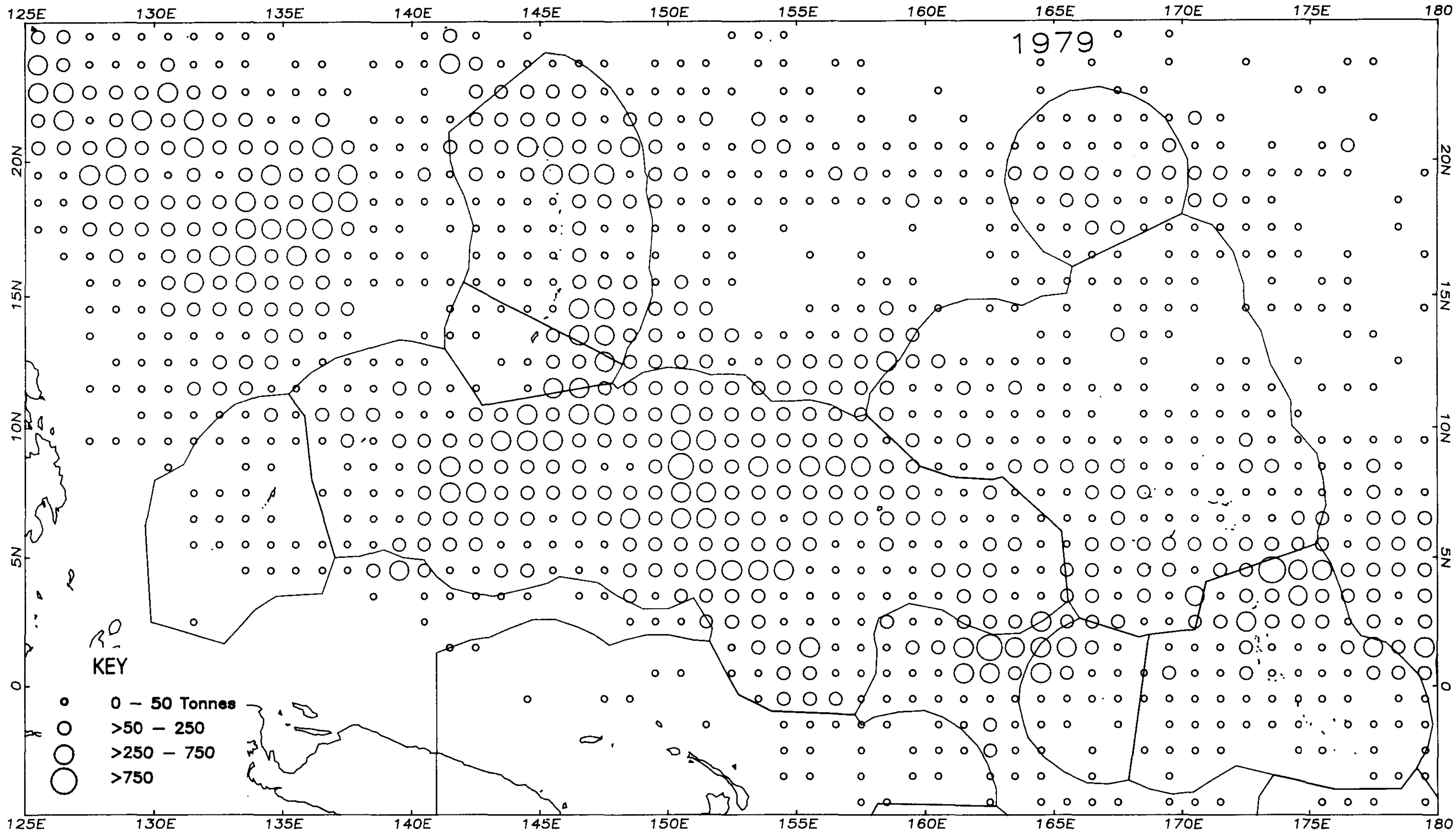


FIGURE 18. (cont.)

FIGURE 18. (cont.)



Interaction estimates for the Trust Territory and Guam may be biased because average throughput and catch levels had to be used. The distribution of catch by Japanese pole-and-line vessels might have been quite different in 1980 and 1981, when most tag recoveries occurred, from that 1978 and 1979. Since complete statistics were not available for the later years, estimates of interaction for the Trust Territory and Guam in Tables 26 and 27 should be considered preliminary. Nevertheless, the estimates in Table 27 are sufficiently high to suggest that interactions amongst fisheries in the states of the Trust Territory and Guam are greater than interactions amongst the locally based fisheries in the rest of the Programme's study area.

4.4.4.4 Palau interactions

Skipjack from Palau were estimated (Table 27) to have contributed approximately nine per cent to throughput in Federated States of Micronesia, and approximately two per cent to throughput in Marshall Islands, based on returns from October 1978 tag releases. None of the October tagged skipjack was returned from catches by large locally based pole-and-line fisheries in Papua New Guinea and Solomon Islands. Skipjack tagged in August 1980 in Palau were treated separately (Table 28). Estimates of contribution to recruitment to pole-and-line fisheries in Federated States of Micronesia (3.6%) and Marshall Islands (1.3%), were less than those based on October 1978 releases; however, migrants from August releases in Palau were estimated to contribute 1.7 per cent to recruitment in Papua New Guinea and 0.4 per cent to recruitment in Solomon Islands. Several factors may have contributed to different results for the two Palau releases. First, skipjack released in August 1980 were considerably smaller than skipjack released in October 1978. Small fish may experience higher mortality than larger fish, as discussed in Section 4.4.1. This would lower the estimates of interaction for small fish. Secondly, small fish may disperse further, as hypothesised by Kearney (1978b), hence contributing recruits to fisheries over a wider area.

Soon after the release of tagged skipjack in August 1980 in Palau, purse-seine catches by vessels from Japan, United States and other countries increased dramatically between latitudes 1°N and 5°N and longitudes 135°E and 152°E (Iizuka & Watanabe 1983). Over half of all tag returns from August 1980 releases were by purse-seine gear, and approximately one-quarter of these were returned from catches in international waters between Federated States of Micronesia and Papua New Guinea (Table 29), providing evidence of increased fishing pressure by purse-seiners in this area. If it is assumed that most returns from shore facilities in North America and United States territories were caught by purse-seine gear, then over 60 per cent of the 417 total returns could be attributed to purse-seiners. In contrast, less than five per cent of returns from earlier Trust Territory and Guam releases were from purse-seine catches.

It is unfortunate that complete catch statistics are not yet available for the purse-seine fleets. On the basis of tag returns, it would appear that purse-seiners catch considerably more skipjack migrants from Palau than do pole-and-line vessels. Since migrants between states in the Trust Territory and Guam appeared to contribute heavily to recruitment within states (Section 4.4.4.3), there would appear to be potential for substantial fishery interactions within this general area. Interactions between Trust Territory and Guam fisheries and the purse-seine fishery in the strip of international waters just to the south are also likely to be substantial.

TABLE 28. ESTIMATED PER CENT OF THROUGHPUT FROM MIGRANTS (INTERACTION) BASED ON RELEASES OF TAGGED SKIPJACK IN AUGUST 1980 IN PALAU. There were 6,515 tag releases in Palau and throughput was 14,000 tonnes per month.

Destination Country	Fishery	Average Monthly Catch (1)	β_2 (2)	Tag Recoveries (3)	Interaction Per cent (4)**
Northern Mariana Islands	Japanese pole-and-line	460*	0.76	1	0.7
Federated States of Micronesia	Japanese pole-and-line	2,200*	0.76	25	3.6
Marshall Islands	Japanese pole-and-line	1,230*	0.76	5	1.3
Papua New Guinea	Local pole-and-line	2,220	0.76	12	1.7
Solomon Islands	Local pole-and-line	1,830	0.72	2	0.4

* Calculated by prorating the total distant-water catch by Japanese pole-and-line vessels in 1980 and 1981 to these states using the average per cent their catch was of the total in 1978 and 1979.

** Column(4)=(100 x Column(3) x 14,000) / (Column(1) x 6515 x Column(2) x 0.9).

TABLE 29. RECOVERIES OF TAGGED SKIPJACK, BY TYPE OF GEAR, FROM TAG RELEASES IN PALAU IN AUGUST 1980

Recovery Location	Pole-and-line			Seine						Miscellaneous (including SPC and unknown gear)	Shore localities***	Grand Total
	Japan	Other	Total	Japan	United States	Philip-pines	Korea	Unknown	Total			
Palau	-	72	72	-	-	-	-	-	-	4	-	76
Other countries	35	20	55	117*	-	2	-	-	119	4	-	178
Interna-tional	8	5	13	48	1	-	-	-	49**	-	-	62
Unknown	4	5	9	4	25	1	2	9	41	1	50	101
Total	47	102	149	169	26	3	2	9	209	9	50	417

* These 117 returns were from Papua New Guinea (62), Federated States of Micronesia (32), Indonesia (22) and Kiribati (1).

** 47 of 49 returns were from international waters between Palau, Federated States of Micronesia, Indonesia and Papua New Guinea.

*** Recoveries from shore facilities in Canada (2), United States (35), American Samoa (5) and Puerto Rico (8).

5.0 SUMMARY AND CONCLUSIONS

5.1 Northern Mariana Islands

Before World War II there was a sizable pole-and-line fishery by Japanese vessels based in Saipan. Stolephorid anchovies dominated bait catches (Ikebe & Matsumoto 1938) and the bait resource was sufficient to support a skipjack catch of 2,000 to 4,000 tonnes by this fishery.

The Programme did not bait in Northern Mariana Islands and fishing for skipjack and other surface tunas took place under poor weather conditions. However, catches by the previous locally based fishery, and annual skipjack catches of 3,000 to 8,000 tonnes in Northern Mariana Islands by the Japanese distant-water pole-and-line fleet in recent years (1972-1978), suggest that skipjack are abundant. From 195 skipjack tag releases in Northern Mariana Islands, there were recoveries in the waters of Japan, Federated States of Micronesia, and international waters. The interaction analyses suggested that interchange of skipjack of the size fished by pole-and-line gear was relatively high between certain states of the Trust Territory and Guam. Estimates of the per cent of recruitment from migrants were 11 and 17 per cent for skipjack moving between Northern Mariana Islands and Federated States of Micronesia.

5.2 Guam

The Programme spent only 18 hours sighting and fishing in the waters of Guam during two surveys and saw no tuna schools, probably because sea conditions were quite rough at the time of these surveys. The Japanese distant-water fleet harvested in excess of 1,000 tonnes in Guam in 1975 and 1977, and between 1972 and 1978 obtained catch per unit of effort levels that were similar to those in nearby states. Thus there is no reason to believe that skipjack are any less abundant in Guam than they are in surrounding states.

5.3 Palau

The baitfish resources of Palau have supported a sizable locally based pole-and-line fishery at various times since the early 1930s. Annual skipjack catches by this fleet between 1978 and 1981 averaged 6,600 tonnes, and Japanese distant-water pole-and-line vessels using bait from Japan harvested an average (1972-1978) of 2,000 tonnes of skipjack from the waters of Palau. This, coupled with the Programme's favourable baiting and fishing results, confirms that both skipjack and baitfish are abundant in Palau.

The Programme released 7,233 tagged skipjack in Palau. Tag returns were received from fisheries in the Philippines, Indonesia, Papua New Guinea, Solomon Islands, Northern Mariana Islands, Federated States of Micronesia, Marshall Islands and Kiribati. The interaction analyses suggested that migrants from the Palau area contributed most recruits to fisheries in Federated States of Micronesia and Marshall Islands. Levels of interaction between skipjack stocks fished in Palau and stocks fished by locally based pole-and-line fisheries in Papua New Guinea and Solomon Islands were much lower. The analysis of returns from August 1980 tag releases in Palau suggested that purse-seiners operating in Papua New Guinea waters north of the Bismarck Sea, southern waters of Federated States of Micronesia, and in international waters between these countries could be harvesting a large fraction of the skipjack migrants from Palau.

Catch data were not available for the purse-seine fishery, so these interactions could not be quantified.

5.4 Federated States of Micronesia

Before World War II the baitfish resource at Ponape, Kosrae, Truk and Yap supported locally based pole-and-line fisheries that together harvested as much as 15,000 tonnes of skipjack annually. Previous baitfish surveys and results from Skipjack Programme surveys showed that stolephorid anchovies dominated bait catches at each of these high islands, except Truk. At Truk, anchovies were present, but not common in the Programme's catch. The combination of past performance of the locally based pole-and-line vessels and good bait catches by the Programme's research vessels confirms that bait resources are sufficient to support small-to-moderate bait fisheries again.

The fishery for skipjack in Federated States of Micronesia and adjoining countries and international waters has changed dramatically in the last ten years. Between 1972 and 1978 Japanese distant-water pole-and-line vessels caught an average of 34,000 tonnes of skipjack per year from Federated States of Micronesia, and catches by purse-seine vessels were negligible. Now (1983) the total skipjack catch from the waters of Federated States of Micronesia has at least doubled, and purse-seiners probably take over two-thirds of this catch.

Most Skipjack Programme tagging in Federated States of Micronesia took place before the shift to purse-seine fishing. From mortality and production analyses in Section 4.4.3.3 for the Trust Territory and Guam as a whole, it was concluded that skipjack catches could be substantially increased before subsequent recruitment would be likely to be impaired. These results were assumed to apply equally to each state in the Trust Territory and Guam; consequently there should be no concern that the recent increase in catch in Federated States of Micronesia, or elsewhere in the Trust Territory and Guam, is reducing recruitment between skipjack generations. On the other hand, within-generation effects, that is, interactions between fisheries operating on the same skipjack cohorts, are probably of considerable importance to Federated States of Micronesia. The analyses of interaction (Section 4.4.4.3), although preliminary because complete catch statistics were unavailable for all gears and countries, suggested that migrants from Federated States of Micronesia contributed 11 per cent to recruitment in Northern Mariana Islands and 37 per cent to recruitment in Marshall Islands. Migrants from Palau contributed an estimated 9 per cent to recruitment in Federated States of Micronesia, and migrants from Northern Mariana Islands contributed an estimated 17 per cent to recruitment in Federated States of Micronesia. In addition, the interaction analyses suggested that fisheries in Federated States of Micronesia may interact most with fisheries in countries to the west and east.

5.5 Marshall Islands

The bait resource in Marshall Islands is spread amongst many of the 33 atolls. At two of the largest atolls, Majuro and Jaluit, the Programme achieved modest catches, mostly of sprats and hardyheads. It was clear, however, from comparison of the bait catches at a number of atolls and high islands fished by the Programme, that catches per haul were much lower and more variable at atolls, and atoll catches included less effective species for pole-and-line fishing. These results confirmed those of previous surveys by Japanese and United States agencies. Thus, it is unlikely that extensive bait fisheries can be supported in Marshall Islands other than for a few vessels operating on a periodic basis.

During the 1970s, Japan harvested an average of 33,000 tonnes of skipjack from Marshall Islands by pole-and-line gear, an obvious indication of the size of the skipjack resource in these waters. Catch by this fishery appears to have fallen recently, and unlike many states in this area, Marshall Islands does not regularly permit purse-seining in its waters.

The Programme encountered poor fishing conditions in Marshall Islands and only 327 tags were released, resulting in four returns, one in the area of release, two from international waters to the southeast and east, and one from Nauru. There were 72 tag returns in Marshall Islands from releases in other countries. From the interaction analyses it was estimated that skipjack migrants from Federated States of Micronesia contributed 37 per cent of the recruits to the pole-and-line fishery in Marshall Islands. Migrants from Palau contributed an additional two per cent of the Marshall Island recruits, and there were small contributions of recruits from Papua New Guinea and Kiribati. These preliminary analyses suggested that Marshall Islands may be at the end of a gauntlet of fishing perhaps starting in Palau, or even as far west as the Philippines. Thus, the possibility that fisheries to the west may be reducing skipjack abundance in Marshall Islands should be considered.

5.6 General Conclusions

5.6.1 Baitfish assessment

The Skipjack Programme results concerning baitfish in the Trust Territory and Guam were limited to surveys in Palau, Federated States of Micronesia, and Marshall Islands. In the first two states, results confirmed those of previous surveys and those from locally based pole-and-line fisheries. Both states have sizable stocks of anchovies (*Stolephorus heterolobus* and *S. devisi*) and sufficient baiting localities amongst their high islands to support moderate bait fisheries. Marshall Islands, however, is composed of atolls, which are not suitable habitats for consistent production of bait, nor are they habitats for stolephorid anchovies, the most effective of the baitfishes for pole-and-line fishing. In summary, then, the bait resource in the Trust Territory and Guam is most certainly greatest in the states with high islands, and as in the past, the bait resource in these states should be able to sustain small to moderate locally based pole-and-line fisheries.

5.6.2 Skipjack assessment

There is no doubt that skipjack are abundant in the Trust Territory and Guam. On the basis of Skipjack Programme tagging data, the level of catch between 1978 and 1981 was only a small percentage of throughput (<4%), which implied a large potential for increased catches before recruitment might be reduced. Recent development of the purse-seine fishery has undoubtedly realised some of this potential, although it is unlikely that the total catch is much more than double that prior to 1981. Thus the present harvest ratio probably remains below 0.15, a level that Kleiber et al. (1983a) considered still to provide considerable potential for increased total catch.

Interaction amongst skipjack fisheries appears to be the major concern for the Trust Territory and Guam. Although the evidence from tagging and blood genetics analyses does not support the hypothesis that skipjack in the Trust Territory and Guam belong to any identifiable subpopulation that is isolated from the rest of the Pacific skipjack resource, there is reason to believe that there are different rates of exchange of skipjack amongst states of the Trust Territory and Guam and with surrounding countries. Unfortunately not all catch data were available for the distant-water fleets that operate in this general area, thus interaction analyses were incomplete. Furthermore, most tagging took place before development of the purse-seine fishery, and was to the north or south of the present purse-seine fishing grounds. So, even if complete statistics were available, the tagging data would not be adequate to allow full evaluation of the impact of the present purse-seine fishery.

Preliminary analyses suggest that levels of interaction amongst adjacent, and in places overlapping, fisheries in the states of the Trust Territory and Guam may be high, but the available catch and tagging data were insufficient to quantify all of these interactions. States of this region are developing management strategies that tie revenues from the catch by distant-water fishing nations to the catches these nations make in each country's zone (Forum Fisheries Agency unpublished reports), yet catch in one zone may greatly affect the catch taken in adjacent zones. Clearly more data are urgently required. These should include complete catch statistics and additional tagging designed to estimate particular fishery interactions. Such information will greatly assist the states of the Trust Territory and Guam to maximise economic benefits from the large skipjack resource.

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APPENDIX A. EXPLORATORY TUNA FISHING, FISHERIES DEVELOPMENT AND FISHERIES RESEARCH SURVEYS IN THE TRUST TERRITORY OF THE PACIFIC ISLANDS AND GUAM

DATE	VESSEL	COMMENT	SOURCE
Jan.-Feb. 1900	Albatross	Collection of fish specimens, description of traditional fishing practices, and fishing trials were carried out by the United States Commission of Fish and Fisheries in Marshall Islands, Kosrae Island, Ponape Island, Truk Islands, Guam and in six other Pacific Island groups.	Alexander 1902
1925-1926	Hakuo Maru	A baitfish and skipjack survey of Palau, prior to the commercial fishery. Three fishing companies began to operate in Palau as a result of this study.	Anon 1937a
1926-1927	Unyo Maru	Longline, trolling, bouki-ami, and beach seine surveys of the Marshall Islands were carried out by the fisheries school of the Japan Ministry of Agriculture and Forestry.	Anon undated
Late 1920s	Vessel(s) unknown	Baitfish were found at Truk after which the live-bait pole-and-line fishery began.	Smith 1947
1934	Various	Three commercial skipjack fishing enterprises set-up in Yap by Okinawans. Bait was plentiful but skipjack schools were scarce, consequently the operations were transferred to different islands.	Ikebe & Matsumoto 1937
1935	?	Bait survey of Saipan was made by Nanko Fishing Co., and concluded that no suitable bait was available from September to November.	Ban 1941
Mid-1930s	?	An investigation of baitfish, skipjack and yellowfin resources around Ponape by a Japanese fisheries research team. Bait captured was mainly fusiliers, *Decapterus* sp. and gold spot herring.	Anon 1937b
June-Aug. 1936	?	A preliminary study of the skipjack fishery at Yap by a Japanese fisheries research team showed that the area had value as a skipjack fishing ground.	Ikebe & Matsumoto 1937
June-July 1937	Zuiho Maru (SJ) Hakuo Maru (bait)	Survey of bait and skipjack resources at Woleai, Lamotrek and Puluwat. Eight divers found a fair amount of bait at Lamotrek, but no effort was made to capture it. They found no bait at Puluwat by diving or by using night lights. Bait was captured by "bouki-ami" in Woleai and 785 skipjack and 209 yellowfin were caught during 7 fishing days of pole-and-line fishing; 100 tuna were tagged and released.	Matsumoto 1937
Aug.-Sept. 1937	Zuiho Maru (SJ) Hakuo Maru (bait)	Continuation of the above study at Yap. Bait was abundant, mainly *Stolephorus* sp. and apogonids, which were stored in holding pens. Skipjack fishing took place on 10 days, 16 schools were sighted, 11 were fished and 1,000 skipjack and 151 yellowfin were caught. Authors concluded that skipjack grounds around Yap "have a certain value".	Ikebe & Matsumoto 1937
Oct.-Dec. 1937	Ebisu Maru Sakigake Maru	Japanese baitfish survey of Saipan to assess methods of bait capture during the off-season for skipjack. The authors suggested that sprats and carangids could be used as alternative baitfish to anchovies.	Ikebe & Matsumoto 1938
1939	-	Taxonomic work was done on the fishes of Palau, including those used as baitfish.	Aoyagi 1941
April-Oct. 1941	?	Longline surveys for tuna were made at 11 positions in waters 15 miles east of Palau.	Anon 1942
May 1941	Zuiho Maru	Investigations of tuna abundance were made around Helen Reef and Tobi and Halmahera Islands.	Ikebe 1941
Sept. 1941-Jan. 1942	-	A study of spawning of skipjack was made at the Palau Tropical Biological Station.	Matsui 1942
Feb.-Sept. 1946	USS Bowditch	"Operation Crossroads" was a United States-sponsored survey to describe the fish fauna in the Marshall Islands before the atom bomb tests.	Schultz 1953
May-Aug. 1946	LCI No.983 and Naval air transport service	Survey of subsistence and offshore fisheries of the former Japanese Mandated Islands by United States Fish and Wildlife Service. The islands visited were Eniwetok, Jaluit, Ailinglaplap, Kwajalein, Kapingamarangi, Nukuoro, Ponape, Kosrae, Majuro, Likiep, Guam, Saipan, Tinian, Rota, Palau and Kayangel. The report contains information on the state of the fisheries during the Japanese occupation and recommendations for future research.	Smith 1947

1946-1947	?	Field studies conducted to measure the relative abundance of reef, lagoon and pelagic fishes around Bikini Atoll. Tunas were caught by commercial fishermen using trolling techniques.	Schultz 1953
July-Sept. 1947	USS Chilton	United States Government sponored survey to describe the fish fauna in the Marshall Islands after the atom bomb test. Information from this survey and the 1946 "Operation Crossroads" survey was incorporated into "Fishes of the Marshall and Mariana Islands" (Schultz 1953), which has proven a useful reference for baitfish taxonomy of this area.	Schultz 1953
Jan.-April 1948	Alaska	A 100-ft purse-seiner owned by Pacific Exploration Company, operating under contract to Reconstruction Finance Corporation, surveyed Marshall and Eastern Caroline Islands for tuna and did some bait scouting. The vessel visited Milli, Kwajalein and Ebon in the Marshall Islands, several islands between Kosrae and Truk, and also Kuop, Nama, Losap and Kapingamarangi. Only four tuna schools were seen in Caroline Islands; no sets were made. Bait was not especially abundant. Local residents reported that in the pre-war fishery, Japanese had taken bait at Losap and Satawan. It was concluded that the cruise was made at the wrong time of the year.	Smith & Schaefer 1949
March-May 1948	Oregon	A 100-ft baitboat owned by Pacific Exploration Company, operating under contract to the Reconstruction Finance Corporation, surveyed several areas in the central and western Pacific for baitfish and tuna. Little bait was found at Tinian, Saipan, Alamagan, Pagan, Maug and Rota; some catches were made at Guam. The vessel visited Ulithi for one and a half days; little bait was found, but local residents said Japanese had taken bait there previously. A half day was spent at Yap, but no bait was found. Bait was abundant at Palau, but difficult to catch. The survey vessel scouted for tuna as far south as Helen Reef.	Smith & Schaefer 1949
1955	Name unknown	A 53-ft former Japanese fishing vessel was purchased in Saipan and fitted for live bait tuna fishing in Guam. Part of the crew were experienced tuna fishermen from Saipan. Anchovies were used as bait; maximum catch per day was less than one tonne.	van Pel 1955
Sept. 1955	Amphibious aircraft Various govt. vessels	A general survey of fisheries in the Caroline Islands by the SPC Fisheries Officer. The report contains recommendations for "developing fisheries for and by the local people" and comments on starting a tuna fishery. A similar survey and report was completed for Guam.	van Pel 1955, van Pel 1956
1963	Kenyo Maru	This purse-seine vessel, owned by Taiyo Fishing Company, was the first Japanese purse-seiner to fish in the western equatorial Pacific. Fishing was done in the off-season for the Japanese home water fishing grounds.	Honma & Suzuki 1978
1965-1966	Taikei Maru Nissho Maru	Two Japanese purse-seiners undertook trial fishing operations in the southwest Pacific; catches were limited.	Franklin 1982
1966-1967	Tokai Daigaku Maru	A research vessel operated by Tokai University Oceanographic Research Institute encountered good pole-and-line fishing in the Caroline Islands.	Anon. 1967
Jan. 1967-June 1969	Panglau Oro	An 11.3 metre Hawaiian sampan was used for an exploratory fishing survey of the inshore fisheries resources of Guam. Limited trolling for tuna suggested that this method was not economically feasible in Guam waters. Day and night baiting trials yielded very little bait.	Ikehara, Kami & Sakamoto 1970
June 1967-March 1969	Emeraech	A total of 265 skipjack were tagged by the United States Bureau of Commercial Fisheries in Palau. Two tagged fish were recovered locally and three were recovered by Japanese vessels in Yap state.	Otsu 1970
1968	?	A bait survey was conducted in Truk lagoon by a United States fishing company under an agreement with the Trust Territory Administration. Results showed that there were no commercial quantities of live bait species available during the survey period, and that Hawaiian and Palauan baitfishing methods were not appropriate for Truk.	Wilson 1971
Late 1960s-early 1970s	Vessel unknown	A cursory baitfish survey of Kapingamarangi Lagoon was conducted by a starfish control team. They did not find large concentrations of baitfish.	Wilson 1977a

1970	Conquest, Cabrillo, Polaris, Connie Jean, Mermaid, Pacific Queen, Kerri M	Seven United States purse-seiners made an exploratory fishing cruise to the western Pacific. All vessels except Conquest, Cabrillo and Polaris withdrew from the exploratory operation before reaching Palau.	A. Felando (pers.com.), Shohara 1970
June.-Aug. 1970	5.1-metre mokil-type boat	The Trust Territory Marine Resources Division carried out a diving survey of baitfish resources in Truk Lagoon using two Okinawan fishermen, assisted by six local divers They found reasonable abundance of six bait species, some of which live around coral heads and must be taken with a specially designed net.	Wilson 1971
Oct. 1970-March 1971	Names unknown (Two Japanese purse-seiners)	Two purse-seine vessels were chartered by the Japanese Government to fish between the Equator and 9°N. Catches reached 18 tonnes per set, but most were much smaller. It was concluded that skipjack can be seined in tropical waters under certain conditions.	Anon 1974
Nov. 1970-March 1971	Vessel unknown	41 yellowfin were tagged and released in the western Caroline Islands; no recapture information available.	IATTC unpublished data
1970/1971	Purse-seine vessel (name unknown)	233 skipjack were tagged and released by the Far Seas Fisheries Research Laboratory of Japan.	IATTC unpublished data
1970/1972	Taikei Maru No.23 Joban Maru No.58	Two Japanese purse-seiners were chartered by the Japan Fishery Agency for experimental seining in the Caroline Islands and Bismarck Sea. These surveys showed that improved fishing techniques, modified fishing gear and more information on the distribution of schools were necessary for successful seining.	Honma & Suzuki 1978
1971	?	A study by the Japanese Overseas Fishing Company to determine the feasibility of starting a pole-and-line skipjack fishery based in Ponape. No details available.	Anon 1971
April-July 1971	Townsend Cromwell (Cruise 53)	A United States NMFS survey to scout for concentrations of baitfish in the Mariana, Caroline and Marshall Islands. Observations were made by walking along beaches, skin-diving, scuba-diving and night lighting. The survey visited Ulithi, Yap, Elato, Lamotrek, Pulawat, Pulap, Ulul, Truk, Nama, Losap, Lukunor, Satawal, Nukuoro, Kapinga Marangi, Ponape, Kosrae, Namdrik, Jaluit and Majuro islands. Islands surveyed to the south and west of Truk had no substantial amounts of baitfish other than sprats. Anchovies were found in Ponape and Kosrae. Large concentrations of bait were seen in Jaluit.	Hida 1971, Gawel 1982, NMFS unpublished data
July-Oct. 1971	5.1 metre mokil-type boat	The Ponape Marine Resources Division used two Okinawan fishermen to carry out a bait survey at Ponape Island. Seven bait species were found to have potential as live bait for pole-and-line fishing. Stolephorid anchovies were observed, but not in commercial abundance.	Wilson 1977a
Oct.-Dec. 1971	Townsend Cromwell (Cruise 55)	A pelagic resources survey by NMFS in Mariana Islands, Ponape and Marshall Islands. Bait surveys were carried out at Ponape, Jaluit, Majuro, Maloclap, Wotje and Likiep; 60 hours were spent between Ponape and Jaluit tracking 2 skipjack carrying sonic tags.	Anon 1972a
Dec. 1971-July 1973	-	This project was funded by the Trust Territory Administration, the United States Sea Grant Program and Van Camp Seafood Company to study the population biology of the anchovy, *Stolephorus heterolobus*, in Palau. It was concluded that the baitfishery in Palau was operating near its optimal level.	Muller 1977
1972	?	A baitfish survey of Ponape by the trading firm Iida obtained favourable results.	Anon 1972c
Feb.-April 1972	Townsend Cromwell (Cruise 57)	The NMFS conducted a pelagic fish resource and baitfish survey in Palau, Helen Reef, Yap, Ponape and Marshall Islands.	Anon 1972b
Feb.-May 1972	Anela	An NMFS survey in Marshall Islands, American Samoa, Western Samoa and Fiji to determine availability and catchability of baitfish and tuna. In Marshall Islands, the pole-and-line vessel fished for tuna near Majuro, Arno, Jaluit, Kili Islands and averaged 3.5 tonnes of tuna per day in February, and 0.6 tonnes of tuna per day in April. Bait was abundant in Majuro in February but scarce in April. There were good concentrations of bait in Jaluit in April.	Uchida & Sumida 1973, Anon 1972d

May 1972	Name unknown	A Japanese live-bait and tuna fishing survey in the Marshall Islands reported having caught as much as 500 bkts of bait in a single set at an unknown location.	Hida & Uchiyama 1977
Jan. 1973	Yaizu	A Japanese survey tagged and released 722 skipjack; 6 were subsequently recovered in Kiribati, Papua New Guinea, Indonesia and Yap.	Anon undated
Feb. 1973	Miyazaki Maru	A Japanese survey tagged and released 1,958 skipjack north of Yap Island; 18 were subsequently recovered in an area bounded by Ponape, Indonesia and Taiwan.	Anon undated
July 1973, July 1974	Hanatoky	A 24.5-ft dory built by Ponape Community Action Agency was fitted with a baitwell for experimental live-bait tuna fishing. During five trips in 1973 it caught 1,360 lbs of tuna.	Perez & Sablan 1974
Jan.1974 to ?	Fuji Maru	A research vessel of the Shizuoka Prefectural Fisheries Station conducted research in Caroline Islands on the problem of mortality of baitfish when transported on long-range pole-and-line boats.	Anon 1975
July-Oct. 1974	Akitsu Maru No.20	A JAMARC-sponsored baitfish and skipjack fishing survey visited Mariana and Truk Islands; however, it concentrated mainly in the Ponape area where the average nightly bait catch was 70.5 kg, and the average daily pole-and-line catch of tuna was one tonne.	JAMARC 1975
Aug.-Nov. 1974	Fukuichi Maru	A Japanese survey tagged 30 skipjack in the area 1°-5°N,136°-148°E; none was recaptured.	Kasahara undated
1974-1976	Fukuichi Maru	The 499-tonne "American-style" Japanese purse-seiner was chartered by JAMARC to study the feasibility of year-round operations in the vicinity of the Caroline Islands. Results were: June to November 1974, 2 trips, 468 tonnes of tuna; 1975, 857 tonnes of tuna; and May to August 1976, 857 tonnes of tuna. This survey has been credited with opening up the southern water fishery for year-round operations by Japanese purse-seiners.	Anon 1976b
Jan. 1975	Yaizu	A Japanese survey tagged and released 324 skipjack in two days in the area 5° to 7°N, 144°E; three were subsequently recovered in international waters south of FSM.	Kasahara undated
May-Sept. 1975	Akitsu Maru No.20	JAMARC sponsored a survey of baitfish and pole-and-line fishing for skipjack in Bonin, Mariana, Ponape, Truk and Palau Islands. Baitfishing was not attempted in the Bonin and Mariana Islands, but 2,149 kg of tuna were caught with pole-and-line gear. In Ponape, they caught an average of 90 kg of bait per night for 24 nights and an average of 63 kg of tuna per day for 20 days fishing. In Truk they caught an average of 100 kg of bait per night for 24 nights and an average of 109 kg of tuna per day for 19 days. In Palau they caught an average of 163 kg of bait per night and an average of 876 kg of tuna per day over 7 fishing days.	JAMARC 1976
Jan. 1976	Miyazaki Maru	A Japanese survey tagged 138 skipjack north of Yap Island; none was reported recovered.	Anon undated
May-Oct. 1976	Hatsutori Maru No.3	A JAMARC-sponsored baitfish and pole-and-line fishing survey in Ponape, Truk and Palau. In Ponape they caught an average of 89 kg of bait per night for 10 nights, and an average of 3,437 kg of tuna per day for 5 days. In Truk they caught an average of 89 kg of bait per night for 10 nights and an average of 231 kg of tuna per day for 11 days. In Palau Island they caught an average of 159 kg of bait per night for 35 nights (426 kg per night for 3 nights at Helen Reef), and an average of 976 kg of tuna per day for 22 days.	JAMARC 1977
June-Sept. 1976	Townsend Cromwell (Cruise 76-05-72)	This was an expedition to scout for tuna schools and drift logs. In the Mariana Islands, 21 bird flocks were sighted in 10 days of scouting. In Palau, Yap, Truk, Ponape and Marshall Islands, 54 bird flocks were sighted in 22 days of searching; 13 large drift logs were seen south of Caroline Islands, but none was associated with tuna schools.	Anon 1976a
July-Oct. 1976	Mary Elizabeth	A 1,100-ton United States purse-seiner on a PTDF project made 27 sets, 18 of which were successful. The vessel caught 134 tons of skipjack and 77 tons of yellowfin and bigeye in 60 fishing days.	PTDF 1977b

July-Oct. 1976	Zapata Pathfinder	A 1,700-ton United States purse-seiner on a PTDF project made 26 sets, 11 of which were successful. The vessel caught 115 tons of skipjack and 68 tons of yellowfin and bigeye in 61 fishing days.	PTDF 1977b
Aug.-Oct. 1976	Apollo	A 2,000 ton United States purse-seiner on a PTDF project spotted 83 schools, made 29 sets, 13 of which were successful. The vessel caught 258 tons of skipjack and 67 tons of yellowfin and bigeye in 50 fishing days.	PTDF 1977b
July-Nov. 1977	Hatsutori Maru No.3	A JAMARC-sponsored baitfish and pole-and-line fishing survey in Palau and the Marshall Islands. At Palau Island they caught 130 kg of bait per night for 44 nights (average 94 kg for 9 nights at Helen Reef) and averaged 1,745 kg of tuna per day for 17 days. In the Marshall Islands they caught an average of 83 kg per night for 3 nights and averaged 966 kg of tuna per day for 17 days.	JAMARC 1978
July-Dec. 1977	32-ft fibreglass diesel boat (name unknown)	A PTDF trolling project in Truk made 36 fishing survey trips (85 days) in six months and caught 9.7 tonnes of fish, including 4.6 tonnes of skipjack, around Truk and Hall Islands, for an average of 11.5 kg of fish per hour.	PTDF 1977a, PTDF 1979d
Aug. 1977-April 1978	Jeanette C	A 950-ton United States purse-seiner on a PTDF project caught 1,800 tons of tuna (76% skipjack) in 114 sets during 164 fishing days.	Souter & Broadhead 1978
March, Oct.-Dec. 1978	Shirochitori	266 skipjack were tagged and released from a Japanese pole-and-line vessel in the central Caroline Islands.	Fishery Agency of Japan 1979
June/July 1978	Genpuku Maru No.82	A tagging project by the Far Seas Fisheries Research Laboratory of Japan using a 500-gross tonne Japanese purse-seiner, tagged and released 24 bigeye and 875 yellowfin in the western Caroline Islands.	Far Seas Fisheries Research Laboratory 1979
June-Sept. 1978	Tuku	A PTDF project to develop night tuna handlining in Truk caught 2,480 lbs of mostly yellowfin. July was the most productive month.	PTDF 1982
July-Aug. 1978, Oct.-Nov. 1978	Hatsutori Maru No.1	A 192-gross tonne Japanese bait boat was chartered by the SPC for tuna and baitfish assessment over a wide area of the central and western Pacific. 3,577 skipjack were tagged and released in Marshall Islands, FSM, Northern Mariana Islands and Palau, and 182 were later recaptured.	Kearney et al. 1979
July 1978, Feb. 1979	Bold Venture	The PTDF chartered a 950-ton United States purse-seiner (sister ship of Jeanette C) that made 56 sets, of which 31 were successful, for a catch of 315 tons of skipjack and 124 tons of yellowfin and bigeye during 95 fishing days.	PTDF 1979c, Souter & Salomons 1980
Aug.-Nov. 1978	Hatsutori Maru No.5	A JAMARC-sponsored baitfish and pole-and-line survey in the Marshall Islands bait-fished at 11 atolls for an average catch of 155 kg of bait per night, and caught an average of 876 kg of tuna per day over 33 fishing days.	Iwasa & Mizuno 1979
Sept. 1978-Mar. 1979	"B-2", 28-ft boat 16-ft boat, 23-ft boat, whale boat	The SPC Deep Sea Fisheries Development Project made 38 fishing trips, mainly for bottomfish, in the area of Yap, Hunter Bank, Ulithi and Ngulu. Trolling for pelagic species was carried out on most of these trips and 58 kg of skipjack and yellowfin were caught.	Mead & Crossland 1980
Oct.-Dec. 1978	Yaizu	110 skipjack were tagged and released from a Japanese pole-and-line vessel in the central and eastern Caroline Islands.	Fishery Agency of Japan 1979
Nov.-Dec. 1978	Fuji Maru	550 skipjack were tagged and released from a Japanese pole-and-line vessel in the central Caroline Islands.	Fishery Agency of Japan 1979
Nov. 1978-May 1979	IWA Pacific Nomad	A 55-ft west coast-type troller on a PTDF project fished in the area of Ponape, Truk, Guam and Northern Marianas. Baitfishing was attempted in Ponape, Nukuoro, Kapinga-marangi and Guam. The combined skipjack and yellowfin catch was 4.1 tons. The project demonstrated that west coast-style trolling techniques are not productive for tropical tuna in the western Pacific.	PTDF 1979b, Steward 1980, PTDF 1982

Dec. 1978	Sinmiyakojo Maru	80 skipjack were tagged and released from a Japanese pole-and-line vessel around Kosrae.	Fishery Agency of Japan 1979
Dec. 1978-April 1979	Lois Ann	A PTDF project to develop Ika-Shibi fishing in Guam made 39 night fishing trips with 46 trainees, but catch rates were low.	PTDF 1982
1978-1981	Angarap	A co-operative survey between the Government of Palau, Japan International Co-operation Agency, Tokai University and PTDF to study baitfish resources and bait "conditioning" in Palau.	PTDF 1982
1979	Jeannette C	This United States purse-seiner commenced commercial fishing in the western Pacific in 1979.	PTDF 1980c
April-May 1979	14-ft aluminium runabout	The SPC Deep Sea Fisheries Development Project fished in Kosrae, mainly for bottom-fish; during three trips devoted to trolling they caught 148 kg of tuna.	Mead & Crossland 1979
June-Oct. 1979	Island Princess	A 1,500-ton United States purse-seiner on a PTDF project caught 541 tons of tuna (82% skipjack, 18% yellowfin) in 13 successful sets out of a total of 43 sets during 110 days at sea (92% of tuna caught were school fish). The best fishing was north of Ulithi Island, although a wide area of the western Pacific was covered.	Souter & Salomons 1980
July 1979	Frontier	This United States purse-seiner commenced commercial fishing in the western Pacific in July 1979.	PTDF 1979a, PTDF 1980c
July-Aug. 1979	Jeanette C	A 950-ton United States purse-seiner on a PTDF project made 24 sets, of which 20 were successful for a catch of 205 tons of skipjack and 109 tons of yellowfin and bigeye during 35 fishing days.	PTDF 1979a
Aug. 1979	Voyager	This was the first United States purse-seiner to operate commercially in the western Pacific, fully independent of any charter or commercial sponsorship. It caught a full load of tuna (1,700 tons) in the western Pacific and departed for the American Samoa cannery in August 1979.	PTDF 1979a, PTDF 1980a, Felando (pers.com.)
Aug. 1979-Sept. 1980	Madonna	Live bait and tuna survey sponsored by PTDF in Truk, Ponape, Nukuoro and Oroluk using a United States bait boat. In Ponape, baiting was carried out on 71 nights and an average of 159 kg of bait was caught per night. In Truk, the major effort was on tuna fishing.	PTDF 1980c
Oct.-Dec. 1979	Kuroshiro Maru	Larval fish were collected by net from 15 stations north and south of Nukuuro, Ponape state.	IOC 1979
Nov. 1979, July-Aug. 1980	Hatsutori Maru No.5	A 254-gross tonne Japanese bait boat chartered by SPC for tuna and baitfish assessment over a wide area of the central and western Pacific. The survey visited Kosrae, Ponape Truk, Palau, Mariana and Yap Islands and tagged and released 11,825 skipjack in these areas, of which 610 were subsequently recovered.	Kearney & Hallier 1980
Dec. 1979-June 1980	Brenda	A PTDF trolling survey in the Marshall Islands using a local 30-ft diesel troller caught 9,298 lbs of mainly skipjack and yellowfin in 65 trips.	PTDF 1981, PTDF 1982
June-Aug. 1980	White Star	A 60-day PTDF charter of a World War II United States Navy craft converted into a purse-seiner. The vessel made 29 sets, of which 9 were successful for a catch of 293 tons of skipjack and 7 tons of yellowfin.	PTDF 1980b, PTDF 1982
June-Aug. 1980	Island Princess	During a 60-day PTDF charter, a 1,500-ton United States purse-seiner made 71 sets, of which 27 were successful for a catch of 588 tons of skipjack and 17 tons of yellowfin and bigeye. Most sets were on school fish.	PTDF 1980b
July 1980-June 1981	Mokorkor	A PTDF project using a local pole-and-line vessel to assess the potential for a year-round tuna fishery by Trukese fishermen. The vessel operated in Truk, Hall, Losap and Mortlock Islands for one year, and caught 102 tonnes of tuna.	PTDF 1980c

June-Aug. 1982	<u>Western Pacific</u>	A 1,150-ton United States purse-seiner on a PTDF project surveyed Mariana, Truk, Ponape, Kosrae and Marshall Islands. The vessel made 27 sets, of which 14 were successful for a catch of 249 tons of skipjack and 323 tons of yellowfin during 65 fishing days.	Bailey & Souter 1982
July-Aug. 1982	<u>Townsend Cromwell</u> (Cruise 82-04)	A survey of coastal, pelagic and demersal fish resources in the Mariana archipelago during which some night baitfishing was carried out at Saipan, Pagan and Maug. At the best location (Saipan), 26 kg of sprats were captured.	Anon 1982a
Aug.-Oct. 1982	Local vessels	A Japanese survey to study the feasibility of providing long-range pole-and-line vessels with bait from Marshall Islands. It was concluded that there was no immediate possibility of supplying commercial quantities of bait.	Anon 1982b, Anon 1983b
Feb. 1983	<u>Fuji Maru</u>	A tagging survey by Shizuoka Prefectural Fisheries Experiment Station tagged and released 250 skipjack from a pole-and-line vessel in the Caroline Islands.	Anon 1983a

FSM = Federated States of Micronesia
JAMARC = Japan Marine Fisheries Resource Research Center
NMFS = United States National Marine Fisheries Service
PTDF = Pacific Tuna Development Foundation
SPC = South Pacific Commission

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

South Pacific Commission Scientists

Robert Gillett	26 July - 14 August 1978 12 October - 14 November 1978 18 July - 26 August 1980
Jean-Pierre Hallier	6-10 October 1978 30 October - 14 November 1978 2-21 November 1979 16-20 July 1980
Charles Ellway	2-21 November 1979 16 July - 26 August 1980
James Ianelli	26 July - 30 August 1978 2-21 November 1979 16 July - 26 August 1980
Des Whyman	6 October - 12 November 1978
Pierre Kleiber	26 July - 14 August 1978
Christopher Thomas	26 July - 14 August 1978 12-14 November 1978

Observers

Bill Puleloa Division of Marine Resources, Majuro	27 July - 3 August 1978
Mike McCoy Division of Marine Resources, Ponape	6-9 August 1978
Benedict Hallens Division of Marine Resources, Ponape	6-9 August 1978 1-5 November 1978
Ioanis Pretrick Division of Marine Resources, Ponape	6-9 August 1978
Richard Howell Division of Marine Resources, Truk	9-10 August 1978 26-27 October 1978
Tame Aitaro Truk fisherman	9-10 August 1978
Rocky Taitos Truk fisherman	9-10 August 1978
Francois Conand Office de la recherche technique et scientifique outre-mer, Noumea	12-31 October 1978
Mike White Division of Marine Resources, Truk	27-31 October 1978
Ken McHugh Division of Marine Resources, Palau	17-20 October 1978
Peter Sitan Division of Marine Resources, Truk	26 October 1978
Angken Kudura Division of Marine Resources, Truk	26 October 1978
Kohachi Hayashi Tohoku Regional Fisheries Research Laboratory, Japan	9-20 November 1979
Toshitaka Suzuki Fishery Agency of Japan	9-20 November 1979
Thurston Siba Kosrae fisherman	17-18 November 1979
Justus Abraham Kosrae fisherman	17-18 November 1979
Saloman Bautista PTDF vessel crew	21 July 1980

Burne Hill Micronesian Maritime Authority	20, 22 July 1980
Mark Maxey Federated States of Micronesia Congress	22 July 1980
Richard Croft Division of Marine Resources, Ponape	24 July 1980
Julian Dashwood Cook Islands Department of Agriculture	8-14 November 1978
Semu Uili Tokelau Department of Agriculture and Fisheries	12-14 November 1978
George Clement New Zealand Ministry of Agriculture and Fisheries	8-14 November 1978

<u>Japanese Crew</u>
<u>Cruise One</u>

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

<u>Japanese Crew</u>
<u>Cruises Two and Three</u>

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

<u>Fijian Crew</u>
<u>Cruise One</u>

Eroni Marawa
Ravaele Tikovakaca
Samuela Ue
Lui Andrews
Vonitiese Cakau
Samuela Delana
Jona Ravasakula
Jone Manuku
Lui Diva
Kitione Koroi
Taniela Verekila

<u>Fijian Crew</u>
<u>Cruise Two</u>

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

<u>Fijian Crew</u>
<u>Cruise Three</u>

Eroni Marawa
Kitione Naivaurerega
Samuela Ue
Lui Andrews
Samuela Delana
Jona Ravasakula
Josua Raguru
Eroni Dolodai
Metuisela Koroi
Luke Kaidrukiya
Aminiasi Kuruyawa
Jovesa Buarua
Sovita Lequeta
Tuimasi Tuilekutu

APPENDIX C. BAIT SPECIES COMPOSITION, PERCENTAGE OF BOUKI-AMI HAULS CONTAINING A PARTICULAR SPECIES, AND ESTIMATED TOTAL CATCH (kg) BY SPECIES, FOR SKIPJACK PROGRAMME SURVEYS IN THE WATERS OF PALAU, FEDERATED STATES OF MICRONESIA, AND MARSHALL ISLANDS*

PALAU

Species	Percentage Occurrence	Estimated Catch (kg)
Stolephorus heterolobus	59	1807
Spratelloides delicatulus	94	682
Hypoatherina temmincki	74	244
Dussumieria sp.	35	241
Apogon(Rhabdamia) cypselurus	47	68
Spratelloides gracilis	35	55
Leiognathus bindus	47	48
Herklotsichthys quadrimaculatus	50	36
Spratelloides sp.	12	32
Sardinella clupeoides	9	4
Sardinella sirm	6	4
Parapriacanthus beryciformes	12	1
Archamia lineolata	38	1
Sp. of Platacidae	3	0
Sp. of Leiognathidae	3	0
Sp. of Squid	44	0
Sp. of Apogonidae	6	0
Rastrelliger kanagurta	24	0
Sp. of Crustacea	21	0
Sp. of Acanthuridae	12	0
Sphyraena sp.	6	0
Rastrelliger brachysoma	6	0
Selar crumenophthalmus	26	0
Hypoatherina ovalaua	18	0
Sp. of Echenidae	26	0
Sp. of Trichiuridae	3	0
Sp. of Carangidae	18	0
Sp. of Mullidae	18	0
Sp. of Sphyraenidae	26	0
Megalaspis cordyla	3	0
Sp. of Syngnathidae	3	0
Decapterus macrosoma	9	0
Sp. of Crustacea	3	0
Leiognathus elongatus	3	0
Caesio coerulaureus	3	0
Cheilodipterus macrodon	6	0
Caranx sp.	3	0
Atherinomorus lacunosa	3	0
Thrissina baelama	3	0
Scomberoides sp.	3	0
Gazza minuta	6	0
Pseudamia polystigma	3	0
Sp. of Blenniidae	3	0
Sp. of Synodontidae	21	0
Decapterus maruadsi	3	0
Pterocaesio pisang	6	0
Dipterygonotus leucogrammicus	3	0
Parapriacanthus sp.	3	0
Archamia zosterophora	12	0
Sp. of Balistidae	3	0
Fistularia sp.	6	0
Stomatopod larvae	3	0
Sp. of Lutjanidae	3	0
Sp. of Anguillidae (juvenile)	6	0
Sp. of Holocentridae	21	0
Total bouki-ami hauls	34	

FEDERATED STATES OF MICRONESIA

Species	Percentage Occurrence	Estimated Catch (kg)
Stolephorus heterolobus	64	2472
Stolephorus devisi	46	1510
Hypoatherina ovalaua	52	867
Herklotsichthys quadrimaculatus	88	610
Spratelloides delicatulus	52	354
Sardinella sirm	39	209
Stolephorus indicus	64	95
Hypoatherina temmincki	27	89
Atherinomorus lacunosa	34	83
Archamia lineolata	43	64
Stolephorus bataviensis	14	49
Selar crumenophthalmus	46	39
Leiognathus bindus	18	28
Apogon(Rhabdamia) cypselurus	61	5
Pranesus duodecimalis	7	4
Sp. of Holocentridae	54	1
Pterocaesio sp.	9	0
Sp. of Tetrodontidae	11	0
Sp. of Siganidae	23	0
Stomatopod larvae	5	0

Sp. of Synodontidae	11	0
Sp. of Myctophidae	5	0
Cheilodipterus macrodon	13	0
Scomberoides sp.	4	0
Sp. of Sphyraenidae	34	0
Sp. of Acanthuridae	41	0
Bregmaceros sp.	16	0
Sp. of Squid	13	0
Fistularia petimba	4	0
Sp. of Labridae	4	0
Kyphosus cinerascens	4	0
Leiognathus smithursti	5	0
Dussumieria sp.	48	0
Leiognathus equulus	2	0
Platax teira	2	0
Megalops cyprinoides	2	0
Pranesus endrachtensis	2	0
Sp. of Carangidae	25	0
Monodactylus argenteus	4	0
Sp. of Atherinidae	2	0
Hypoatherina cylindrica	2	0
Pseudamia polystigma	11	0
Archamia zosterophora	4	0
Caranx sexfasciatus	4	0
Dipterygonotus leucogrammicus	2	0
Sardinella sp.	2	0
Apogon fragilis	4	0
Leiognathus sp.	4	0
Decapterus macrosoma	5	0
Alectis ciliaris	4	0
Sp. of Mullidae	13	0
Sardinella clupeiodes	7	0
Zanclus canescens	2	0
Priacanthus sp.	7	0
Sp. of Anguillidae (j)	7	0
Caranx sp.	11	0
Siphamia tubulata	2	0
Sp. of Pomacentridae	2	0
Euthynnus affinis	2	0
Stolephorus sp.	4	0
Sp. of Priacanthidae	9	0
Sp. of Chaetodontidae	30	0
Pterocaesio diagramma	4	0
Pterocaesio pisang	9	0
Sp. of Balistidae	11	0
Mullodichthys samoensis	14	0
Mullodichthys sp.	5	0
Sp. of Apogonidae	5	0
Gazza minuta	20	0
Sp. of Lutjanidae	9	0
Selar boops	13	0
Sp. of Hemirhamphidae	2	0
Rastrelliger kanagurta	4	0
Scomberoides sp.	29	0
Fistularia sp.	5	0
Total bouki-ami hauls	56	

MARSHALL ISLANDS

Species	Percentage Occurrence	Estimated Catch (kg)
Sardinella sirm	13	402
Hypoatherina ovalaua	88	146
Spratelloides delicatulus	100	44
Atherinomorus lacunosa	38	4
Grammatorcynus bicarinatus	25	0
Apogon(Rhabdamia) cypselurus	50	0
Herklotsichthys quadrimaculatus	38	0
Bregmaceros sp.	38	0
Elagatis bipinnulatus	13	0
Sp. of Sphyraenidae	25	0
Sp. of Holocentridae	38	0
Sp. of Carangidae	25	0
Sp. of Mullidae	13	0
Selar crumenophthalmus	13	0
Rastrelliger kanagurta	25	0
Total bouki-ami hauls	8	

* Several recent revisions of scientific names are used in this report. The most notable changes in nomenclature are :

Herklotsichthys punctatus to Herklotsichthys quadrimaculatus
Pranesus pinguis to Atherinomorus lacunosa

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

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--MIGRANTS FROM STATES OF THE TRUST TERRITORY & GUAM TO OTHER STATES--

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S INT 800415 160 1430N 13315E 0743 500M 580W 1B11010 JAPPOL
S MTS 800629 235 2238N 15332E 0533 490M 553W 1B11211 JAPPOL
S INT 800822 289 0327N 17840E 2114 500M 410C 1B11427 JAPPOL
S JAP 801020 348 2420N 12320E 1316 490M 575J 1B11440 JAPPOL

        MAR 623 791107 1200 1722N 14546E   55    0    0
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S TRK 800428 173 0631N 15032E 0708 480M 568W 1B11461 JAPPOL YAI

        PAL 314 781019 1200 0702N 13448E  278    0    0
S TRK 790208 112 0658N 14929E 0874 630M 644W SF02322 JAPPOL YAI
S PON 790218 122 0820N 15612E 1275 627B 649W SK30920 JAPPOL YAI
S YAP 790226 130 0944N 14445E 0612 600M 640W SK30960 JAPPOL
S INT 790315 147 2036N 13227E 0825 610M 650J SF02332 JAPPOL
S YAP 790322 154 0754N 14558E 0666 620M 620W SF02351 JAPPOL

        PAL 315 781020 1300 0706N 13454E  440    0    0
S YAP 781118 029 0525N 14338E 0531 600M 600W SF02372 JAPSEN
S YAP 781124 035 0524N 14405E 0557 590M 645W SF02420 JAPPOL
S INT 781209 050 0345N 13918E 0331 600M 630C SF02500 JAPSEN
S INT 790106 078 0238N 14145E 0489 570M 597W SH00206 JAPSEN YAI
S PNG 790111 083 0054N 14123E 0537 580M 616W SK30301 JAPSEN YAI
S YAP 790225 128 1013N 14258E 0514 620M 660W SK29947 JAPPOL
S YAP 790319 150 0849N 14706E 0732 600M 655W SF02447 JAPPOL
S INT 790326 157 1635N 12657E 0736 565M 750C SK29964 JAPPOL
S INT 790328 159 1710N 13700E 0616 590M 589W SH00225 JAPPOL
S INT 790330 161 1605N 13040E 0594 530M 600W SF02434 JAPPOL
S INT 790403 165 1642N 13531E 0577 570M 630W SH00229 JAPPOL
S PHL 790827 311 0630N 12545E 0546 590M 633E SF02382 PHLART
S MAS 800209 477 0518N 16714E 1931 590M 645J SK30331 JAPPOL

        PAL 928 800807 0745 0421N 13218E    3   70    0
S TRK 801123 108 0412N 15246E 1225 580Q 606W 2E22145 JAPPOL

        PAL 929 800809 1600 0300N 13135E   85   16    0
S IND 801018 070 0200N 13900E 0449 350M 406C 1B13932 JAPSEN
S SOL 810528 292 0656S 15715E 1649 340M 540B 2E22153 SOLPOL
S YAP 810611 306 0514N 14302E 0698 340M 515W 2E22154 JAPSEN YAI
S PNG 810805 361                     360M 480C 1B14318 JAPSEN YAI

        PAL 930 800809 1615 0300N 13136E  282    7    0
S INT 801015 067 0326N 14341E 0724 340M 421J 2E22472 JAPSEN
S IND 810102 146 0300N 13600E 0264 340M 330E 2E22540 JAPSEN
S PNG 810103 147 0012N 14534E 0854 340M 471W 2E22479 JAPSEN YAI
S PNG 810411 245 0150S 14940E 1122 340M 550E 2E22523 PNGPOL
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        PAL 931 800811 0715 0257N 13140E  151  123    0
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S YAP 810322 223 0538N 14056E 0577 480M 517W 2E22354 JAPSEN YAI
S INT 810411 243 1600N 13530E 0815 422T 630W 2E22611 JAPPOL
S INT 810514 276 0420N 14017E 0523 470M 550W 2E22324 JAPSEN YAI
S SOL 810612 305 0730S 15900E 1752 422T 560W 2E22606 SOLPOL
S PNG 810704 327 0357S 15203E 1290 422T 510W 2E22544 PNGPOL
S INT 810831 385 0207N 14215E 0636 422T 521W 2E22563 JAPSEN YAI
S MAS 820308 574 0813N 16313E 1909 540M 633W 2E22595 JAPPOL

        PAL 932 800812 0710 0252N 13140E  241   77    0
S INT 800917 036 0246N 14243E 0662 350M 378W 1B14570 JAPSEN
S INT 801204 114 0200N 14100E 0562 334T 381E 1B14492 PALPOL
S PNG 810412 243 0355S 15131E 1258 360M 600W 1B14286 PNGPOL
S PNG 810701 323 0027S 14202E 0653 334T 510W 1B14497 JAPSEN YAI
S PNG 810711 333 0340S 15200E 1281 360M 520W 1B14245 PNGPOL
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        PAL 933 800812 0745 0253N 13140E  302   37    0
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S IND 801015 064 0243N 13702E 0322 440T 422W 2E23085 JAPSEN YAI
S TRK 801027 076 0339N 14856E 1035 440T 445W 2E23009 JAPSEN YAI
S PNG 801103 083 0011S 14114E 0603 480M 500W 1B14684 JAPSEN YAI
S PNG 801129 109 0047N 14250E 0681 440T 475W 2E23016 JAPSEN YAI
S PNG 801201 111 0250S 15010E 1161 440T 400B 2E22370 PNGPOL
S PNG 801221 131 0018S 14302E 0708 440T 494W 2E23092 JAPSEN
S PNG 801224 134 0021S 14352E 0757 440T 514W 2E22358 JAPSEN
S PNG 810225 197 0016N 14534E 0848 420M    U 2E22837 JAPSEN YAI
S TRK 810303 203 0919N 15025E 1183 440T 552W 2E22366 JAPPOL YAI
S PNG 810307 207 0029S 14319E 0727 440T 491W 2E22361 JAPSEN YAI
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S PON 810424 255 0138N 15406E 1347 500M 532J 2E22881 JAPPOL
S INT 810716 338 0239N 14000E 0500 470M 542W 2E22863 JAPSEN YAI
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S PON 820703 690 0140N 15502E 1403 470M 586W 2E22808 JAPSEN YAI

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S IND 801015 063 0200N 13900E 0443 480M 381C 2E22923 JAPSEN
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S IND 801018 066 0200N 13900E 0443 460M 510E 2E23376 JAPSEN
S TRK 801113 092 0417N 15400E 1340 480M 487W 2E22705 JAPPOL YAI
S INT 801120 099 0255N 15006E 1105 470M 435W 2E22744 JAPSEN
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S PNG 801222 131 0019S 14238E 0685 405M 486W 2E23209 JAPSEN
S PNG 801222 131 0019S 14238E 0685 440M 452W 1B14975 JAPSEN
S PNG 801230 139 0043S 14303E 0716 360M 448W 1B14864 JAPSEN
S PNG 810304 203 0059S 14406E 0781 440M 498W 1B14933 JAPSEN YAI
S PNG 810506 266 0111S 15715E 1554 415M 527W 1B14741 JAPSEN
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S PNG 810730 351 0021N 14213E 0651 460M 524W 1B14734 JAPSEN YAI
S MAS 810912 395 0423N 16941E 2278 460M 590W 2E23358 JAPPOL
S INT 820402 597 0241N 14157E 0616 430M 565W 2E22752 JAPSEN YAI
S INT 820702 688 0656N 17724E 2743 450M 685W 2E22728 JAPPOL YAI

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S PNG 810810 362 0033N 14345E 0742 470M 515W 2E23529 JAPSEN YAI

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S IND 801113 091 0017N 13636E 0336 420M 439W 2E23915 JAPSEN YAI
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S IND 801121 099 0035N 13950E 0511 440M 483E 2E23200 PALPOL
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S INT 801120 094 0255N 15006E 0987 380M 467W 2E24057 JAPSEN YAI
S MAS 801230 134 0744N 16551E 1878 390M 524W 2E24223 JAPPOL YAI
S PHL                                430M    U 2E24224 PHLSEN TEI
S YAP 810125 160 0430N 14215E 0511 420M 513W 2E23977 JAPSEN YAI
S PNG                                420M    U 2E23981 PNGPOL TEI
S PNG 810210 176 0022N 14145E 0623 395M 494W 2E23982 JAPSEN YAI
S YAP 810608 294 0551N 14222E 0494 420M 528W 2E23784 JAPSEN YAI
S PNG 810717 333 0057N 14320E 0673 400M 541J 2E24203 JAPSEN YAI

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S YAP 801016 059 0506N 14044E 0421 380M 442W 2E25052 JAPSEN YAI
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S HOW 791007 341 0310N 17522W 1619 530M 592W SK30657 JAPPOL YAI

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-----MIGRANTS TO STATES OF THE TRUST TERRITORY AND GUAM------

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CAL 110 780115 0840 2058S 16424E 842 0 0
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QLD 531 790503 1105 1622S 15012E 725 3 0
S TRK 800513 376 0633N 15211E 1380 480M 600W SK34612 JAPPOL

JAP 310 781005 1145 2403N 14152E 108 0 0
S MAS 791215 436 0458N 16626E 1823 438B 627W SF01969 JAPPOL

PNG 551 790527 1600 0330S 15105E 95 0 0
S MAS 801221 574 0502N 17022E 1264 560M 690C SK36773 JAPPOL

PNG 582 790607 1145 0415S 15100E 119 49 0
S MAS 810212 616 0821N 16603E 1176 510M 660W SK44156 JAPPOL

PNG 594 790615 1040 0125S 14700E 513 220 1
S MAS 801028 501 0628N 16604E 1236 520M 626J SK44471 JAPPOL
S MAS 801031 504 0721N 16642E 1291 500M 622W SK38154 JAPPOL YAI
S MAS 810205 602 700N 16630E 1272 515M 645W SK44919 JAPPOL YAI

PNG 597 790617 1030 0142S 14741E 184 0 0
S MAS 800210 238 0544N 17200E 1524 550M 630W SK38748 JAPPOL
S MAS 801025 496 0643N 16925E 1396 515M 645W SK38814 JAPPOL

KIR 273 780705 1745 0206S 17524E 194 0 0
S MAS 790126 205 0428N 16904E 0547 470M 530C SK23873 JAPPOL

KIR 276 780713 0930 0256N 17245E 83 0 0
S MAS 781208 148 0449N 16802E 0304 510M 523W SK24445 JAPPOL

KIR 277 780713 1200 0255N 17240E 303 0 0
S MAS 781130 140 0311N 17032E 0129 486B 550W SK24538 JAPPOL

KIR 281 780713 1713 0304N 17235E 205 0 0
S MAS 781228 168 0406N 16941E 0184 491B 535W SK24740 JAPPOL
S MAS 790131 202 0516N 17152E 0139 490M 610W SK24753 JAPPOL

KIR 283 780713 1825 0303N 17232E 135 7 0
S MAS 781125 135 0318N 16737E 0295 610M U SK25151 JAPPOL

KIR 285 780714 1230 0308N 17238E 229 0 0
S MAS 800206 572 0358N 16700E 0341 490M 600W SK25333 JAPPOL

KIR 287 780716 0803 0257N 17245E 573 0 0
S MAS 781228 165 0406N 16941E 0196 520M 541W SK25711 JAPPOL

KIR 288 780717 0729 0305N 17244E 251 0 0
S MAS 790127 194 0350N 16855E 0233 480M 560W SK26029 JAPPOL

KIR 291 780722 1150 0300N 17248E 842 0 0
S MAS 781201 132 0330N 17015E 0156 500M 520J SK26570 JAPPOL
S MAS 800207 565 0406N 16752E 0303 470M 600W SK26680 JAPPOL

KIR 294 780723 1135 0305N 17238E 103 0 0
S MAS 790109 170 0312N 17013E 0145 510M 570C SK27439 JAPPOL
S MAS 790411 262 0342N 16547E 0412 500M 550W SK27615 JAPPOL

KIR 298 780724 1215 0300N 17249E 107 0 0
S MAS 781127 126 0241N 16626E 0383 490M 533W SK27779 JAPPOL

TUV 247 780625 1220 1023S 17848W 486 16 0
S MAS 800125 579 0432N 17211E 1045 490M 616J SK21534 JAPPOL

TUV 266 780701 1710 0842S 17910E 470 0 0
S MAS 800208 587 0420N 16925E 0976 520M 450D SK22799 JAPPOL

TUV 908 800708 0815 0549S 17615E 71 0 0
S MAS 810208 215 0652N 16935E 0859 650M 691W 1E18112 JAPPOL

TUV 909 800708 1120 0543S 17558E 216 0 0
S MAS 801101 116 0703N 16549E 0978 630M 655W 1E14900 JAPPOL

WAL 201 780513 1450 1328S 17618W 300 0 0
S MAS 780909 119 0310N 16705E 1405 620M 620B SK12042 JAPPOL

WAL 214 780517 1150 1329S 17607W 1034 0 0
S MAS 800213 637 0641N 16900E 1500 520M 650W SK15081 JAPPOL

WAL 237 780531 1500 1313S 17458W 337 0 0
S MAS 791125 543 0524N 17001E 1431 515M 613W SK19955 JAPPOL

CODES FOR LENGTH MEASUREMENTS, RECAPTURE GEARS AND COUNTRY ABBREVIATIONS

Release Length Credibility

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

Recapture Length Credibility

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

Nationality of Recapture Vessel

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

Type of Recapture Vessel

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

Port Where Fish Were Unloaded If Found In Market, Cannery, etc.

END	Ensanada, Mexico
KOR	Koror, Palau
MAY	Mayaguez, Puerto Rico
MAZ	Mazatlan, Mexico
SAC	St. Andrews, New Brunswick, Canada
SHI	Shimizu, Japan
TGO	Tago, Japan
TEI	Terminal Island, San Diego, California
YAI	Yaizu, Japan
YAM	Yamakawa, Japan

APPENDIX E. ABBREVIATIONS FOR COUNTRIES, TERRITORIES AND SUBDIVISIONS THEREOF

AMS - American Samoa
CAL - New Caledonia
COK - Cook Islands
FIJ - Fiji
FSM - Federated States of Micronesia
GAM - Gambier Islands (French Polynesia)
GIL - Gilbert Islands (Kiribati)
GUM - Guam
HAW - Hawaii
HOW - Howland and Baker Islands (U.S. Possessions)
IND - Indonesia
INT - International waters
JAP - Japan
JAR - Jarvis (U.S. Territory)
KIR - Kiribati
KOS - Kosrae (Federated States of Micronesia)
LIN - Line Islands (Kiribati)
MAQ - Marquesas Islands (French Polynesia)
MAR - Northern Mariana Islands
MAS - Marshall Islands
MTS - Minami-tori shima (Japan)
NAU - Nauru
NCK - Northern Cook Islands
NIU - Niue
NOR - Norfolk Island
NSW - New South Wales (Australia)
PAL - Palau
PAM - Palmyra (U.S. Possession)
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)
TTPI - Trust Territory of the Pacific Islands
TUA - Tuamotu Islands (French Polynesia)
TUV - Tuvalu
VAN - Vanuatu
WAK - Wake Island (U.S. Possession)
WAL - Wallis and Futuna
WES - Western Samoa
YAP - Yap (Federated States of Micronesia)
ZEA - New Zealand