DISTRIBUTION OF LARVAL TUNAS IN MARQUESAN WATERS

By Eugene L. Nakamura and Walter M. Matsumoto, *Fishery Biologists (Research)*
Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii 96812

ABSTRACT

Spawning of tunas near the Marquesas Islands was investigated by studying the distribution of larval tunas collected in 1957 and 1958. Of the six species of larval tunas identified, larval skipjack (*Katsuwonus pelamis*) occurred most frequently. Prominent diel variation with greater catches at night was observed at a station occupied for 24 hours in December 1957 and March 1958 for larval skipjack and in January 1958 for larval yellowfin (*Thunnus albacares*). Both the incidence of the capture of larval tunas and their abundance were greater during the southern summer and fall (January to April) than in the other months of the year. There was no difference in abundance of larval tunas with respect to distance from shore, nor were there any differences in abundance among the four transects (north, east, south, and west of the islands) along which sampling was conducted. No significant correlation was found between abundance of invertebrate plankton and larval tunas nor between schools of adult tunas sighted and abundance of larval tunas. Temporal distribution of larvae indicated some spawning by skipjack throughout the year.

Oceanographic and fishing surveys in the Pacific near the Marquesas Islands (fig. 1) during 1957–58 were part of a program undertaken by the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii, to investigate the tuna resources in this area. Pertinent to this investigation was a study of the time and location of the spawning of tunas.

Methods of determining spawning activities of tunas involve inferences from studies of their ovaries and the distribution of their larvae. The latter method has been made possible by the identification (tentative for some species) and detailed descriptions of the larvae of skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), bigeye (*Thunnus obesus*), albacore (*Thunnus alalunga*), bluefin (*Thunnus thynnus orientalis*), longfin (*Thunnus tonggol*), three species of *Euthynnus*, and *Auxis* sp. (Matsumoto, 1958, 1959, 1962; Mead, 1951; Wade, 1951). Attempts to identify specifically eggs of these tunas have been unsuccessful because of their similarity

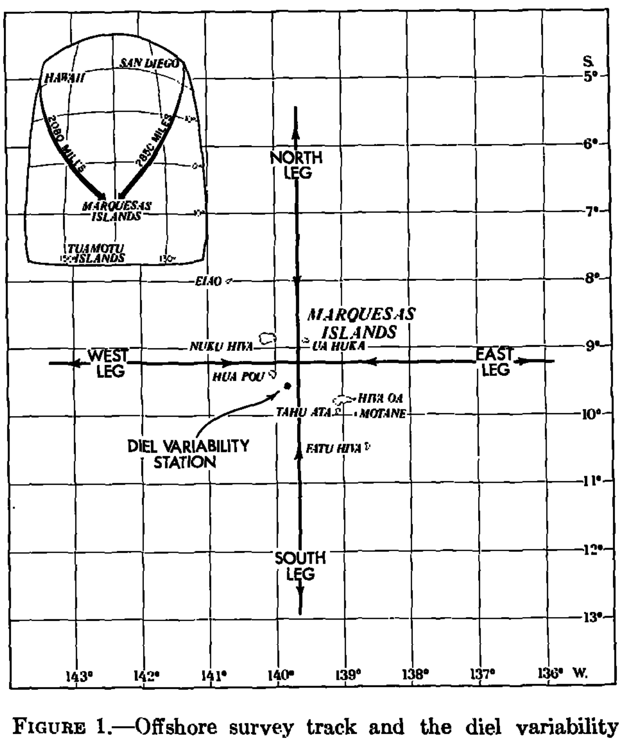

FIGURE 1.—Offshore survey track and the diel variability station in the Marquesas, 1957–58.

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in appearance and the overlapping ranges of their diameters (Matsumoto, 1958).

This report presents information on the abundance and distribution of larval tunas in the region of the Marquesas Islands. Six species of larval tunas were identified, but emphasis is on skipjack, as it occurred more often than the others. Inferences concerning skipjack spawning are compared with those derived from ovarian studies of this species from the same area (Yoshida, 1965).

COLLECTION OF SAMPLES

Plankton samples from which the larval tunas were sorted and counted were collected from research vessels of the Bureau of Commercial Fisheries in 1957 and 1958 on a standardized offshore survey pattern and at a diel variability station (fig. 1). The latter was situated at lat. 9°34′ S. and long. 139°50′ W. (about 15 miles southeast of the island of Hua Pou) and was occupied for 24-hour periods on six occasions. Cruises, dates, and numbers of samples obtained on the offshore surveys and at the diel variability station are summarized in tables 1 and 2 respectively. Fishery and environmental data collected on these cruises have been published by Wilson, Nakamura, and Yoshida (1958).

Plankton hauls were made with a net having a mouth diameter of 1 m. The net was constructed of nylon netting with mesh apertures of 0.66 mm. in the body and 0.31 mm. in the rear and cod end (for details of construction and dimensions, see King and Demond, 1953). A flowmeter mounted in the center of the mouth provided estimates of the amount of water strained.

TABLE 1.—*Cruises, dates, and numbers of zooplankton samples obtained on offshore surveys* [*CHG* = Charles H. Gilbert, *HMS* = Hugh M. Smith]

Cruise	Dates	Number of samples
CHG-35	Oct. 24–Nov. 7, 1957	46
HMS-43	Jan. 27–Feb. 12, 1958	22
CHG-38	Mar. 26–Apr. 9, 1958	24
HMS-45	May 15–May 30, 1958	21

TABLE 2.—*Cruises, dates, and numbers of zooplankton samples obtained at the diel variability station* [*CHG* = Charles H. Gilbert, *HMS* = Hugh M. Smith]

Cruise	Dates	Number of samples
CHG-35	Oct. 21–22, 1957	16
CHG-35	Dec. 1–2, 1957	16
HMS-43	Jan. 23–24, 1958	12
CHG-38	Mar. 6–7, 1958	12
CHG-38	Apr. 17–18, 1958	12
HMS-45	June 8–9, 1958	24

Oblique, open-net, ½-hour plankton hauls from the surface down to 140 m. and back to the surface were taken during the offshore surveys and at the diel variability station on all cruises. A second net was attached to the towing cable to permit sampling between 140 and 280 m. at the diel variability station on *Hugh M. Smith* cruise 45 (HMS-45). This latter net was similar to the open one but was modified to permit attachment of opening and closing devices (King, Austin, and Doty, 1957).

Two consecutive ½-hour tows were made during *Charles H. Gilbert* cruise 35 (CHG-35) to obtain data for testing the duplicability of the catches.

On the offshore surveys, plankton hauls were made twice each night, once before midnight (between 2000 and 0000 hours) and once after midnight (between 0200 and 0400 hours). At the diel variability station, duplicate hauls were made every 3 hours on CHG-35, while single hauls were taken at 2-hour intervals on the other cruises.

Plankton samples were preserved in 10 percent Formalin.[1]

In the laboratory all fish and fish eggs were sorted from plankton samples with the aid of binocular dissecting microscopes. From these collections of fish and eggs, larval tunas were separated and identified. Most of the larvae were less than 5 mm. in total length. Specimens greater than 10 mm. comprised a very small percentage of the total number.

TREATMENT OF DATA

Larval abundance is expressed as the number of larvae in a column of water 10 m. square and 140 m. deep. This value was obtained by multiplying the number of larvae per cubic meter of water strained by the volume of the column of water.

Nonparametric statistics (Siegel, 1956) were used in our analyses to avoid assumptions of normal distributions.

Data on plankton hauls and numbers of larval tunas collected at the diel variability station and on the offshore surveys are presented in appendix tables A-1 through A-8.

DUPLICABILITY OF CATCHES

Catches of larval tunas by successive tows were compared by Strasburg (1960). He found no sig-

[1] Trade names referred to in this publication do not imply endorsement of commercial products.

nificant difference and concluded that plankton nets were reliable tools for sampling larval tunas within the limitations of the method. All of his tows were taken at the surface and at night.

To determine if catches could be duplicated during other hours and with oblique tows, the data from the 39 pairs of plankton tows taken during CHG–35 were examined. The abundance of larval tunas calculated from catches of the first tow did not differ significantly (Wilcoxon matched-pairs signed-ranks test) from that of the second. We thus concluded that catches by oblique tows taken during day or night were duplicative.

SPECIES COMPOSITION

Larvae of the following species of tunas were identified in the Marquesan samples: skipjack, yellowfin, bigeye, albacore, little tunny (*Euthynnus affinis*), and frigate mackerel (*Auxis* sp.)[2]. Adults of all except *Auxis* have been caught either by longline, trolling, or pole-and-line fishing in the Marquesas (King et al., 1957; Austin, 1957; Wilson and Rinkel, 1957; Wilson et al., 1958; Yoshida, 1960). Another species, the dogtooth tuna (*Gymnosarda nuda*), also has been caught in the Marquesas by trolling near the islands, but its larva has not been identified.

The species composition of the larval tunas is shown in table 3. Skipjack was the dominant species throughout the offshore surveys and at all but one of the diel variability stations. At the diel variability station occupied during HMS–43, yellowfin was dominant (appendix table A–2). Other species were found in sporadic abundance, e.g., *Auxis* at the second diel variability station of CHG–35 (appendix table A–1), bigeye at the diel variability station of HMS–43 (appendix table A–2) and on the offshore surveys of CHG–38 (appendix table A–7) and HMS–45 (appendix table A–8).

TABLE 3.—*Species composition of larval tunas collected in Marquesan waters, 1957–58*

Species	Diel variability station		Offshore surveys	
	Number collected	Percent of total catch	Number collected	Percent of total catch
K. pelamis	351	63.8	472	83.0
T. albacares	63	11.5	19	3.3
T. obesus	30	5.5	41	7.2
T. alalunga	3	0.5	8	1.4
E. affinis	2	0.4	0	0
Auxis sp.	80	14.5	10	1.8
Unidentified tuna	21	3.8	19	3.3
Total	550		569	

[2] May include both *A. thazard* and *A. rochei* (=*A. thynnoides*); see Matsumoto (1959).

DIEL AND SEASONAL DISTRIBUTION

Diel variation in catches of larval tunas has been discussed by Wade (1951), Matsumoto (1958), and Strasburg (1960). All reported greater catches at night. The latter two authors attributed this primarily to vertical migration by the larvae into the upper surface layers of the ocean at night, although they did not rule out the possibility of net dodging during daylight.

Since Strasburg (1960) found practically no larval tunas below 140 m., our sampling did not extend below this depth (except at the diel variability station on HMS–45). By sampling the 0- to 140-m. depth range, we hoped that variations due to diel vertical migration would be kept to a minimum or even possibly eliminated.

Catches at the diel variability station during CHG–35, HMS–43, and CHG–38 provided evidence that this variation was not eliminated. Prominent diel variations occurred in December and March for skipjack and in January for yellowfin (fig. 2). Either the larvae did occur below 140 m., or they were more successful in escaping the net during the day in these instances. The problem of diel variation was complicated further by the inconsistency of the catches during the other months. For example, the highest catches of larval skipjack were obtained during or near twilight in April and June, while during October and January day catches were as good as night catches.

Average larval abundance during the offshore surveys of each cruise was compared with those of the other cruises for seasonal variation (fig. 3). The abundance during HMS–43 (January to February) and during CHG–38 (March to April) was significantly greater (Mann–Whitney U test, $p<0.05$) on both occasions than for either HMS–45 (May) or CHG–35 (October to November). No significant differences were found in other comparisons of offshore averages.

Averages for the diel variability station, computed from results of tows taken between 2000 and 0400 hours, the same hours during which tows were taken on the offshore surveys, also are shown in figure 3. The magnitudes and variations of these averages differ considerably from those of the offshore surveys.

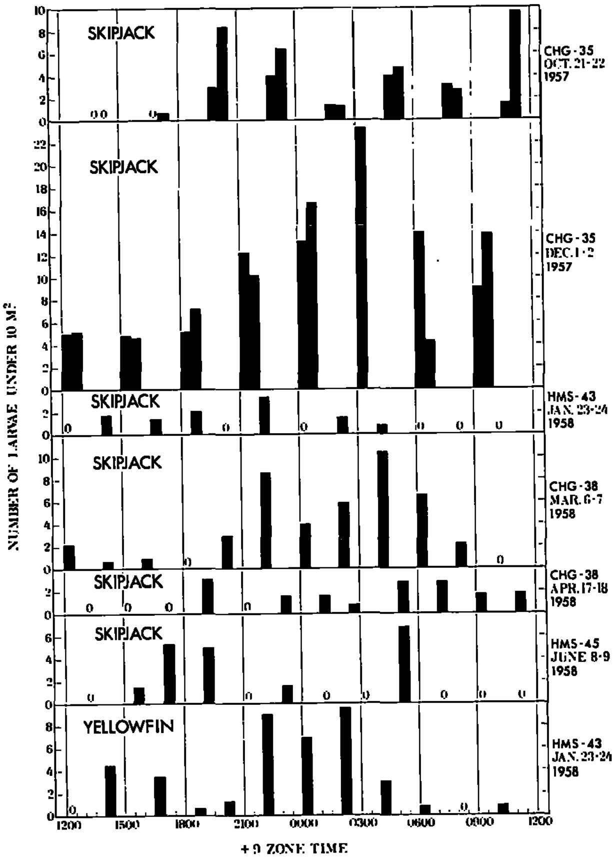

FIGURE 2.—Diel variation in abundance of larval skipjack and larval yellowfin.

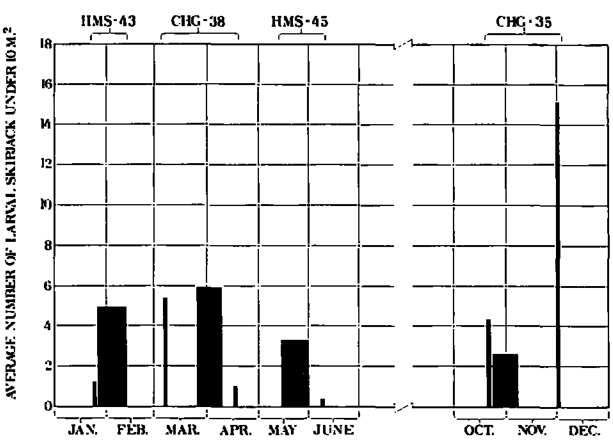

FIGURE 3.—Seasonal variation in the abundance of larval skipjack. The slender bars represent averages for the diel variability station, the thick bars averages for the offshore surveys.

The averages for the offshore surveys represent more samples and a greater areal and temporal coverage than those for the diel variability station. Based on the offshore data, skipjack spawning appears to be greater during the southern summer (January to February) and early fall (March to April), but paucity of data during the southern winter and spring (June to October) makes this conclusion tenuous.

VERTICAL AND HORIZONTAL DISTRIBUTION

Strasburg (1960) observed that most larval tunas were captured within the upper 60 m. of water, with 20 to 25 percent of the catch within the 70- to 130-m. depth, and practically none below 140 m. Since the possibility of larval tunas in waters below 140 m. had been indicated in the earlier cruises (fig. 2), special plankton hauls were planned for the diel variability station during HMS–45. A closing net of dimensions similar to those of the open net was added to the towing cable to permit sampling at depths between 140 and 280 m. Although simultaneous sampling was planned for depth ranges of 0 to 140 and 140 to 280 m., the actual maximum depth sampled by the upper net ranged between 121 and 150 m., while the depths sampled by the lower net ranged between 70 and 262 m. (appendix table A–4).

No larval tunas were caught by the lower net. Larvae were caught only in 6 of the 12 hauls by the upper net. Although the results did not conflict with those of Strasburg, the meager catches and the departures from the planned sampling depths caused the results to be inconclusive.

A relation between larval skipjack distribution and area was not evident. No significant areal association (Kendall coefficient of concordance) was found in the average abundance of larvae for the several legs of the offshore survey track, nor was a relation between larval distribution and proximity to land found in a comparison (Kendall coefficient of concordance) of the average abundance by inner, middle, and outer 75-mile sections of the offshore survey legs (tables 4 and 5).

TABLE 4.—*Average number of larval skipjack under 10 m.² of ocean surface for the north, south, east, and west legs of the offshore surveys (fig. 1).*

[Numbers of samples on which the averages are based are in parentheses]

Cruise	North leg	South leg	East leg	West leg
CHG-35...	2.5 (12)	3.3 (10)	0.9 (12)	3.9 (12)
HMS-43...	5.9 (6)	5.6 (6)	4.4 (4)	3.6 (6)
CHG-38...	11.4 (6)	4.2 (6)	4.0 (6)	3.9 (6)
HMS-45...	1.2 (5)	2.5 (6)	8.8 (5)	0.9 (5)

TABLE 5.—*Average number of larval skipjack under 10 m.² of ocean surface for the inner, middle, and outer 75-mile sections of the offshore surveys.*

[Numbers of samples on which the averages are based are in parentheses]

Cruise	Inner 75 miles		Middle 75 miles		Outer 75 miles	
CHG-35	2.3	(14)	2.7	(16)	2.9	(16)
HMS-43	1.9	(8)	6.1	(6)	7.1	(8)
CHG-38	6.2	(8)	5.7	(8)	5.7	(8)
HMS-45	3.2	(5)	4.8	(8)	1.9	(8)

Larval skipjack had been found to be widely distributed in the northeastern part of French Oceania previous to the series of cruises in this report. Figure 4 illustrates the locations around the Marquesas

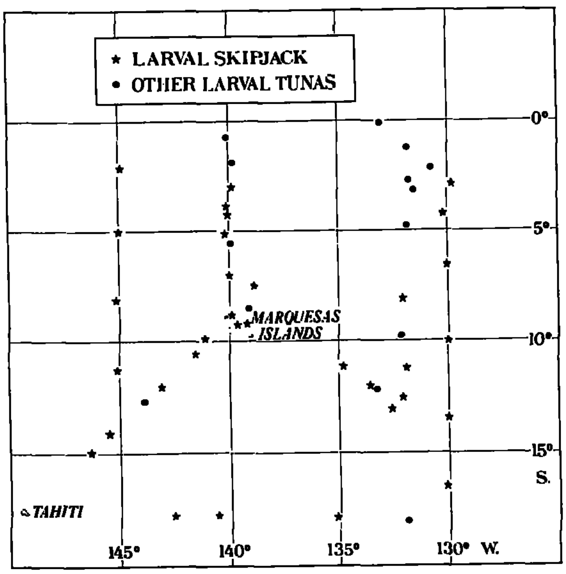

FIGURE 4.—Stations in northeastern French Oceania where larval tunas were collected on cruises earlier (1952–57) than those covered by this study. (Data from Matsumoto, 1958, and Strasburg, 1960.)

Islands where larval tunas were collected during cruises of vessels of the Bureau of Commercial Fisheries prior to those listed in table 1.

ABUNDANCE OF LARVAL TUNAS AND INVERTEBRATE PLANKTON

Relations between the abundance and distribution of invertebrate plankton and of larval tunas, if any exist, are obscure. If the plankton volumes and abundance of larval tunas are averaged for each of the offshore surveys, an obvious positive correlation

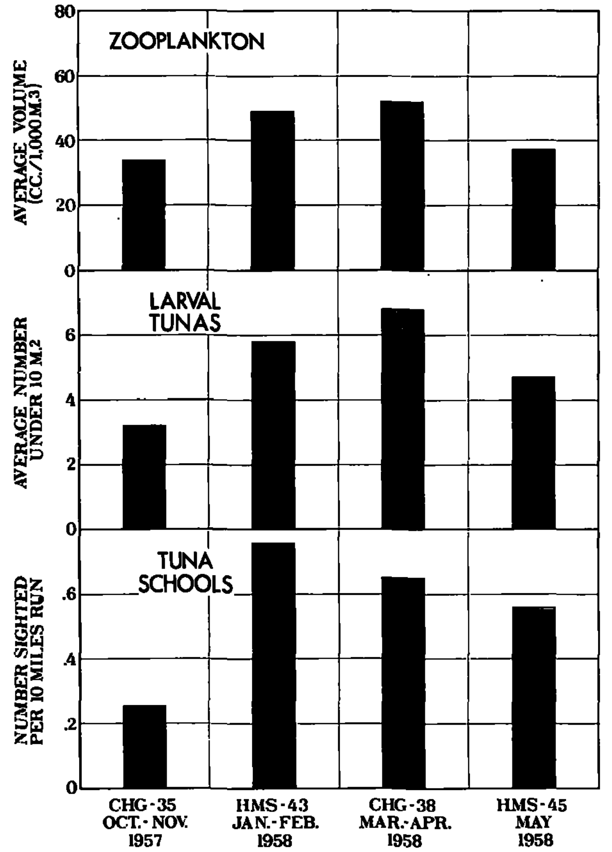

FIGURE 5.—Average abundance of zooplankton, larval tunas, and tuna schools for the offshore surveys.

can be seen (fig. 5), but in individual samples no significant correlations (Spearman rank correlation) were found. High and low measures of abundance of larval tunas were found in high as well as in low volumes of plankton. Strasburg (1960) reported that high catches of larval tunas came from samples of low and moderate volumes of plankton, while the samples with lowest and highest plankton volumes contained smaller numbers of larval tunas.

ABUNDANCE OF LARVAL AND ADULT TUNAS

Strasburg (1960) found a tendency for larval tunas to occur in larger abundance where there were more adults of the same species although the correlation was statistically nonsignificant. Similar comparisons by species were not possible with our data. Schools of adult tunas were located by sighting the associated bird flocks. Because of the necessity of covering a certain distance of the offshore surveys

TABLE 6.—*Average number of larval tunas under 10 m.² of ocean surface and number of schools sighted per 10-mile run for the legs of the offshore surveys*

Cruise	North leg		East leg		South leg		West leg		Entire survey	
	Schools	Larvae	Schools	Larvae	Schools	Larvae	Schools	Larvae	Schools	Larvae
CHG-35	0.405	3.2	0.183	1.8	0.207	3.4	0.226	4.3	0.256	3.2
HMS-43	1.020	7.2	.884	5.4	.569	6.8	.560	3.6	.758	5.8
CHG-38	.909	14.6	.390	4.4	.591	4.3	.708	3.9	.649	6.8
HMS-45	.591	3.9	.275	9.4	1.013	2.9	.380	2.9	.559	4.7

within an allotted time, investigation of schools was discontinued if the response to chumming was unfavorable. Consequently, the specific identity of many of the schools was not determined, and our examination of the relation between larval and adult abundance was in terms of the aggregate of all tuna species.

In comparing the number of schools sighted per 10-mile run and the average number of larval tunas under 10 m.² of ocean surface for the legs of the offshore surveys and for the inner, middle, and outer 75-mile sections of these legs, no significant correlations (Spearman rank correlation) were found (tables 6 and 7). For the entire offshore survey area, the averages for both adult tuna schools and larval tunas were highest during either HMS-43 or CHG-38, slightly lower during HMS-45, and lowest during CHG-35. A similar pattern was found in the average of zooplankton volumes. The variations of all three averages are illustrated in figure 5.

TABLE 7.—*Average number of larval tunas under 10 m.² of ocean surface and number of schools sighted per 10-mile run for 75-mile sections of the legs of the offshore surveys*

Cruise	Inner 75 miles		Middle 75 miles		Outer 75 miles	
	Schools	Larvae	Schools	Larvae	Schools	Larvae
CHG-35	0.452	2.8	0.305	3.0	0.030	3.7
HMS-43	.867	3.0	.554	7.4	.833	7.3
CHG-38	1.145	6.8	.460	7.1	.393	6.5
HMS-45	.412	3.8	.586	6.0	.695	3.9

INFERENCES CONCERNING SKIPJACK SPAWNING

Inferences about spawning based on the size of the larva upon hatching have been discussed by Matsumoto (1958). He hypothesized that skipjack are 2.5 mm. or less at hatching, that the eggs and larvae are planktonic and therefore subject to dispersion by currents, but that their displacement from the spawning site would be relatively insignificant unless the currents were exceptionally strong. Larval skipjack have been taken throughout the area around the Marquesas Islands (fig. 4). Most of the catch consisted of larvae between 3 and 4.5 mm. long, so we may assume that they had hatched recently. Since the currents around the Marquesas Islands are suspected to be weak (Sverdrup, Johnson, and Fleming, 1942: p. 702), these larvae could not have drifted very far from the spawning sites. Thus, skipjack spawning appears to occur throughout the sampled area.

Matsumoto (1958) has reported larval skipjack catches from long. 180° to 120° W., and on the basis of records of larvae and juveniles taken in the Philippine Islands (Wade, 1951) and off the coast of Central America (Schaefer and Marr, 1948; Mead, 1951) and of juveniles caught in the Marshall Islands (Marr, 1948), he has indicated the possibility that skipjack spawn throughout the equatorial waters of the Pacific. Subsequently, Klawe (1963) noted the occurrence of larval skipjack in the eastern tropical Pacific. Matsumoto (unpublished) recently obtained larval skipjack from areas west of 180°, particularly around the Marshall Islands and the eastern part of the Caroline Islands. Capture of larval skipjack in localities still farther west in the Marianas and Palau Islands was reported by Yabe, Yabuta, and Ueyanagi (1963). These records confirm Matsumoto's hypothesis of the transoceanic distribution of larval skipjack in the Pacific.

Matsumoto (1958) also has reported the north-south distribution of larval skipjack as extending from lat. 25° N., to 14½° S. in the central Pacific. The southern limit now may be extended to at least lat. 18° S.

Table 8 shows the months during which larval skipjack have been taken in northeastern French Oceania on various cruises by vessels of the Bureau of Commercial Fisheries. They were captured in all months except July, in which no sampling was done. Thus, skipjack spawning can be inferred to occur throughout the year in these waters. Yoshida (1965) likewise concluded from a study of skipjack ovaries that skipjack spawn year-round in the Marquesas.

Yoshida also concluded that spawning is greatest from November through April. Although the seasonal distribution of larval skipjack (fig. 3) is consistent with Yoshida's results, the data do not permit a comparison for all seasons.

TABLE 8.—*Months, years, and cruises during which larval skipjack have been captured in northeastern French Oceania. Italicized cruises sampled the Marquesan offshore survey area.*

[Data prior to October 1957 from Matsumoto (1958) and Strasburg (1960)]

Month	Year			
	1952	1956	1957	1958
January	-	-	-	*HMS-43*
February	-	-	HMS-38 *CHG-32*	*HMS-43*
March	-	HMS-33	HMS-38 *CHG-32*	*CHG-38*
April	-	-	-	*CHG-38*
May	-	-	-	*HMS-45*
June	*HMS-15*	-	-	*HMS-45*
July				
August	-	CHG-30	-	-
September	-	*CHG-30*	-	-
October	-	-	*CHG-35*	-
November	HMS-18	-	*CHG-35*	-
December	-	-	*CHG-35*	-

SUMMARY

1. The results of a study of the distribution of larval tunas in Marquesan waters are presented. Data were collected in 1957 and 1958 on repeated transits of a standardized offshore survey pattern and on repeated visits to a single station where diel variability of larval abundance was studied.

2. Larval tunas were sorted and counted from 113 plankton samples from the offshore surveys and 92 from the diel variability station. Larval abundance is expressed as the number of larvae under 10 m.^{2} of ocean surface down to a depth of 140 m.

3. Duplicability of larval catches by oblique tows taken at night or day was demonstrated.

4. Greater abundance of larval skipjack during darkness was evident at the diel variability station in December 1957 and March 1958 and of larval yellowfin in January 1958. Greater abundance of larval skipjack at twilight was found in April and June of 1958. Results of attempts to determine whether larvae were below 140 m. were inconclusive.

5. Data from the offshore surveys indicate greater abundance of larval tunas during the Marquesan summer and fall (January to April) than during other months.

6. Larval skipjack have been collected throughout the area of northeastern French Oceania bounded by long. 130° W. and 147° W. from the Equator to lat. 18° S.

7. High and low catches of larvae occurred in samples of high as well as of low plankton volume.

8. Average abundances of zooplankton, larval tunas, and tuna schools for the offshore surveys were lowest during CHG–35 (Oct.–Nov. 1957), highest during either HMS–43 (Jan.–Feb. 1958) or CHG–38 (Mar.–Apr. 1958), and intermediate during HMS–45 (May 1958).

9. According to records of the localities of the capture of larvae and juveniles, skipjack spawn throughout the tropical and subtropical zones of the Pacific Ocean. In northeastern French Oceania, skipjack appear to spawn throughout the year. The data are consistent with the conclusion reached from a study of skipjack ovaries that the spawning of skipjack in northeastern French Oceania is most active from November through April.

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APPENDIX

Table A-1.—*Data on plankton hauls and numbers of larval tunas collected at the diel variability station (9°34′ S., 139°50′W.) on* Charles H. Gilbert *cruise 35*

Station	Date (1957)	Collection time (+9ZT)	Depth of tow	Water strained	Larvae in sample[1]							
					SJ	YF	BE	AL	EU	AU	UN	Total
			M.	$M.^3$	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
18	Oct. 21	0739–0811	0–140	2185. 1	5							5
19	do	0814–0845	0–140	2112. 5	4						1	5
20	do	1035–1105	0–140	1927. 0	2			1(?)			3	6
21	do	1108–1137	0–140	1895. 9	13		4(?)					17
22	do	1335–1405	0–140	1789. 0								0
23	do	1406–1434	0–140	1860. 8								0
24	do	1632–1703	0–140	2082. 5								0
25	do	1706–1737	0–140	2068. 2	1							1
26	do	1933–2005	0–140	2331. 2	5	1					4	10
27	do	2007–2037	0–140	1842. 2	11							11
28	do	2235–2305	0–140	1735. 6	5							5
29	do	2306–2338	0–143	1979. 1	9		1					10
30	Oct. 22	0143–0213	0–140	2039. 6	2						1	3
31	do	0214–0244	0–140	2078. 5	2	1						3
32	do	0431–0459	0–140	1733. 9	5	1						6
33	do	0501–0532	0–140	2073. 1	7							7
119	Dec. 1	0608–0638	0–140	1705. 9	17							17
120	do	0639–0711	0–143	1936. 4	6							6
121	do	0905–0936	0–140	1709. 6	11						1	12
122	do	0939–1008	0–140	1917. 3	19					1		20
123	do	1205–1237	0–140	1681. 6	6							6
124	do	1239–1310	0–140	1599. 5	6					2	2	10
125	do	1506–1537	0–142	1765. 8	6		1					7
126	do	1539–1610	0–142	1809. 0	6				1		2	9
127	do	1805–1835	0–140	1361. 9	5							5
128	do	1836–1907	0–140	1352. 2	7							7
129	do	2103–2133	0–140	1375. 9	12					1	1	14
130	do	2134–2006	0–140	1503. 4	11		1			5		17
131	Dec. 2	0005–0035	0–140	1481. 8	14		2	1(?)		13		30
132	do	0037–0106	0–140	1516. 9	18		2(?)	1(?)	1	23	4	49
133	do	0304–0334	0–140	1564. 6	26					30		56
134[2]	do	0336–0405	0–140	1649. 7	8							8

[1] SJ = *Katsuwonus pelamis;* YF = *Thunnus albacares;* BE = *Thunnus obesus;* AL = *Thunnus alalunga;* EU = *Euthynnus affinis;* AU = *Auxis* sp.; UN = unidentified tuna.

[2] Sample considered atypical because salps comprised 95 percent (estimated) of the volume and 71 percent (estimated) of the organisms.

Table A-2.—*Data on plankton hauls and numbers of larval tunas collected at the diel variability station (9°34′ S., 139°50′ W.) on* Hugh M. Smith *cruise 43*

Station	Date (1958)	Collection time (+9ZT)	Depth of tow	Water strained	Larvae in sample[1]							
					SJ	YF	BE	AL	EU	AU	UN	Total
			M.	$M.^3$	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
22–1	Jan. 23	1622–1655	0–145	1991. 9	2	5						7
22–2	do	1825–1855	0–145	2023. 7	3	1						4
22–3	do	2005–2040	0–158	2104. 9		2	2					4
22–4	do	2207–2238	0–140	1711. 4	4	11	5					20
22–5	Jan. 24	0013–0048	0–140	2223. 4		11	4			1		16
22–6	do	0210–0241	0–141	1887. 6	2	13	4				1	20
22–7	do	0408–0438	0–148	1787. 0	1	4	2					7
22–8	do	0615–0649	0–158	1716. 8		1						1
22–9	do	0803–0832	0–140	1528. 0								0
22–10	do	1012–1042	0–149	1568. 6		1	1					2
22–11	do	1208–1245	0–158	1986. 8								0
22–12	do	1401–1431	0–140	1559. 6	2	5					1	8

[1] SJ = *Katsuwonus pelamis;* YF = *Thunnus albacares;* BE = *Thunnus obesus;* AL = *Thunnus alalunga;* EU = *Euthynnus affinis;* AU = *Auxis* sp.; UN = unidentified tuna.

Table A-3.—*Data on plankton hauls and numbers of larval tunas collected at the diel variability station (9°34′ S., 139°50′ W.) on* Charles H. Gilbert *cruise 38*

Station	Date (1958)	Collection time (+9ZT)	Depth of tow	Water strained	Larvae in sample[1]							
					SJ	YF	BE	AL	EU	AU	UN	Total
			M.	*M.*[3]	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
34-A	Mar. 6	0806–0836	0–140	1885.5	3							3
34-B	...do	1003–1033	0–141	1476.7						1		1
34-C	...do	1205–1237	0–140	1896.6	3							3
34-D	...do	1408–1438	0–140	1938.8	1							1
34-E	...do	1608–1636	0–140	1486.8	1							1
34-F	...do	1807–1837	0–142	1949.7		1						1
34-G	...do	2006–2036	0–142	1902.2	4					1		5
34-H	...do	2210–2240	0–140	1624.9	10	1						11
34-I	Mar. 7	0006–0037	0–142	1737.6	5					1		6
34-J	...do	0205–0235	0–140	1907.0	8					1		9
34-K	...do	0403–0434	0–142	1884.9	14							14
34-L	...do	0604–0634	0–140	1703.9	8	3						11
93-A	Apr. 17	1311–1341	0–140	1608.2								0
93-B	...do	1503–1533	0–140	1629.9								0
93-C	...do	1702–1732	0–140	1512.7								0
93-D	...do	1903–1933	0–142	1847.0	4							4
93-E	...do	2102–2132	0–140	1630.8								0
93-F	...do	2306–2336	0–140	1719.8	2							2
93-G	Apr. 18	0102–0133	0–142	1697.4	2							2
93-H	...do	0302–0332	0–142	1668.4	1		1					2
93-I	...do	0503–0533	[2]?	1478.7	3							3
93-J	...do	0702–0732	0–140	1478.4	3							3
93-K	...do	0903–0934	0–142	1696.3	2							2
93-L	...do	1102–1132	0–140	1573.3	2							2

[1] SJ—*Katsuwonus pelamis;* YF=*Thunnus albacares;* BE=*Thunnus obesus;* AL=*Thunnus alalunga;* EU=*Euthynnus affinis;* AU=*Auxis* sp.; UN=unidentified tuna.
[2] Cable meter failed.

Table A-4.—*Data on plankton hauls and numbers of larval tunas collected at the diel variability station (9°34′ S., 139°50′ W.) on* Hugh M. Smith *cruise 45*

Station	Date (1958)	Collection time (+9ZT)	Depth of tow	Water strained	Larvae in sample[1]							
					SJ	YF	BE	AL	EU	AU	UN	Total
			M.	*M.*[3]	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
120-1	June 8	1522–1552	0–122	937.5	1							1
120-2	...do	1522–1552	112–230	606.7								0
121-1	...do	1710–1739	0–125	797.5	3							3
121-2	...do	1710–1739	96–239	445.0								0
122-1	...do	1914–1941	0–126	845.2	3							3
122-2	...do	1914–1941	112–238	1041.1								0
123-1	...do	2105–2133	0–126	941.4								0
123-2	...do	2105–2133	71–238	1003.0								0
124-1	...do	2313–2347	0–137	865.6	[2]1							1
124-2	...do	2313–2347	103–240	394.6								0
125-1	June 9	0110–0144	0–137	852.6		1						1
125-2	...do	0110–[3]?	70–240	1482.7								0
126-1	...do	0308–0335	0–121	794.0								0
126-2	...do	0308–0335	107–229	598.8								0
127-1	...do	0510–0539	0–126	817.8	4							4
127-2	...do	0510–0539	103–238	681.1								0
128-1	...do	0711–0737	0–125	794.3								0
128-2	...do	0711–0737	94–245	447.1								0
129-1	...do	0910–0937	0–126	718.5								0
129-2	...do	0910–0937	76–238	939.8								0
130-1	...do	1108–1149	0–150	855.4								0
130-2	...do	1108–1149	71–262	[4]71.3								0
131-1	...do	1306–1333	0–123	702.0								0
131-2	...do	1306–1333	116–239	920.6								0

[1] SJ=*Katsuwonus pelamis;* YF=*Thunnus albacares;* BE=*Thunnus obesus;* AL=*Thunnus alalunga;* EU=*Euthynnus affinis;* AU=*Auxis* sp.; UN=unidentified tuna.
[2] A 27-mm. juvenile.
[3] Messenger time was not recorded.
[4] Flowmeter recording was extremely low.

TABLE A-5.—*Data on larval tunas collected during the offshore survey on* Charles H. Gilbert *cruise 35*

Station	Position		Date (1957)	Collection time (+9ZT)	Depth of tow	Water strained	Larvae in sample[1]							
	Lat. S.	Long. W.					SJ	YF	BE	AL	EU	AU	UN	Total
					M.	*M.*³	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
35	9°16′	137°52′	Oct. 24	2301-2329	0-182	1681.0								0
36	9°16′	137°52′	do	2333-0001	0-140	1546.8								0
38	9°22′	137°30′	Oct. 25	0259-0330	0-140	1316.0								0
38A	9°22′	137°30′	do	0332-0401	0-140	1487.2								0
38B	9°14′	136°20′	do	2256-2327	0-140	1760.4	2	1						3
39	9°14′	136°20′	do	2329-0001	0-140	1797.9	4	1	3					8
41	9°14′	136°34′	Oct. 26	0258-0329	0-173	1750.1	5						3	8
42	9°14′	136°34′	do	0330-0401	0-140	1694.2	2						5	7
44	9°17′	139°02′	do	2259-2329	0-140	1486.1								0
45	9°17′	139°02′	do	2331-0003	0-140	1582.7	1[2]							1
47	9°17′	139°16′	Oct. 27	0254-0324	0-140	1558.2								0
48	9°17′	139°16′	do	0326-0357	0-140	1463.9								0
50	11°03′	139°33′	do	2300-2330	0-140	1530.1	4						1	5
51	11°03′	139°33′	do	2332-0000	0-140	1354.9	2							2
53	11°22′	139°27′	Oct. 28	0258-0328	0-140	1533.9	5							5
54	11°22′	139°27′	do	0330-0401	0-140	1655.9	7						1	8
55	12°23′	139°36′	do	2300-2331	0-140	2011.0								0
56	12°23′	139°36′	do	2332-0000	0-140	1722.6	6							6
58	12°09′	139°30′	Oct. 29	0258-0327	0-140	1527.4	5							5
59	12°09′	139°30′	do	0329-0358	0-140	1453.1	6							6
60	9°36′	139°44′	Oct. 30	0300-0328	0-140	1134.0								0
61	9°36′	139°44′	do	0329-0400	0-140	1336.5	1							1
62A	7°20′	139°32′	Nov. 1	2258-2329	0-140	1663.2	6							6
63	7°20′	139°32′	do	2331-2359	0-140	1414.5	2							2
65	7°06′	139°30′	Nov. 2	0257-0327	0-140	3365.6								0
66	7°06′	139°30′	do	0332-0400	0-140	1633.8								0
67	6°04′	139°50′	do	2257-2327	0-140	1788.8								0
68	6°04′	139°50′	do	2329-0000	0-140	1915.1	2	1					1	4
70	6°26′	139°52′	Nov. 3	0302-0333	0-140	1807.4								0
71	6°26′	139°52′	do	0349-0419	0-140	1755.8	6							6
73	8°36′	139°31′	do	2305-2334	0-140	1390.0	8							8
74	8°36′	139°31′	do	2335-0005	0-140	1408.0	5					2		7
76	8°54′	139°38′	Nov. 4	0300-0330	0-140	854.4	2					3		5
77	8°54′	139°38′	do	0334-0404	0-140	715.8								0
79	9°13′	141°35′	do	2258-2328	0-140	2218.6	14			1			2	17
80	9°13′	141°35′	do	2331-0002	0-140	2168.1	14	1						15
82	9°12′	142°00′	Nov. 5	0256-0326	0-140	1813.9	1							1
83	9°12′	142°00′	do	0328-0356	0-140	1786.6	1							1
84	9°15′	142°46′	do	2259-2329	0-140	1490.9								0
85	9°17′	142°46′	do	2332-0004	0-140	1580.6								0
87	9°18′	142°23′	Nov. 6	0258-0329	0-140	1496.6	3						1	4
88	9°18′	142°23′	do	0334-0403	0-140	1449.6	12							12
90	9°15′	140°33′	do	2256-2326	0-140	1267.4	1							1
91	9°15′	140°33′	do	2328-2358	0-140	1192.9								0
93	9°13′	140°10′	Nov. 7	0258-0328	0-140	1264.4	4						1	5
94	9°13′	140°10′	do	0332-0402	0-140	1074.6	6							6

[1] SJ—*Katsuwonus pelamis;* YF = *Thunnus albacares;* BE = *Thunnus obesus;* AL = *Thunnus alalunga;* EU = *Euthynnus affinis;* AU = *Auxis* sp.; UN = unidentified tuna.
[2] A juvenile about 25 mm. long.

TABLE A-6.—*Data on larval tunas collected during the offshore survey on* Hugh M. Smith *cruise 43*

Station	Position		Date (1958)	Collection time (+9ZT)	Depth of tow	Water strained	Larvae in sample[1]							
	Lat. S.	Long. W.					SJ	YF	BE	AL	EU	AU	UN	Total
					M.	*M.*³	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
30	9°12′	139°17′	Jan. 27	2116-2151	0-141	1755.7								0
32	9°12′	138°48′	Jan. 28	0313-0342	0-160	1300.0	2		2				1	5
34	9°10′	136°50′	do	2110-2140	0-147	1750.6	13	1						14
36	9°10′	136°18′	Jan. 29	0313-0343	0-145	1617.9	6							6
39	9°37′	139°40′	Jan. 30	2109-2139	0-148	1688.4								0
41	10°14′	139°38′	Jan. 31	0312-0342	0-148	1516.8	3							3
42	12°02′	139°36′	do	2112-2142	0-154	1466.3	10							10
44	12°31′	139°34′	Feb. 1	0313-0343	0-185	1158.6	3							3
47	11°16′	139°42′	do	2110-2141	0-141	1551.1	12	3					2	17
49	10°43′	139°39′	Feb. 2	0313-0343	0-141	582.7	3		1					4
57	9°07′	141°05′	Feb. 5	2118-2145	0-141	1264.6								0
59	9°08′	141°32′	Feb. 6	0319-0344	0-142	1384.6								0
60	9°13′	143°02′	do	2113-2143	0-140	1403.1	13							13
62	9°15′	142°26′	Feb. 7	0315-1337	0-145	1468.9	6							6
64	9°13′	140°41′	do	2109-2133	0-167	1039.8	2							2
66	9°16′	140°06′	Feb. 8	0318-0348	0-140	1511.9								0
70	7°35′	139°40′	Feb. 9	2110-2137	0-140	1164.9	13	1						14
71	6°52′	139°40′	Feb. 10	0330-0359	0-141	1386.1	3							3
73	5°37′	139°50′	do	2113-2142	0-140	1363.7	8	1						9
75	6°21′	139°38′	Feb. 11	0319-0347	0-141	1279.6	1							1
76	8°30′	139°40′	do	2120-2146	0-140	957.7	1							1
78	9°03′	139°45′	Feb. 12	0312-0341	0-140	1199.9	5	1				4		10

[1] SJ = *Katsuwonus pelamis;* YF = *Thunnus albacares;* BE = *Thunnus obesus;* AL = *Thunnus alalunga;* EU = *Euthynnus affinis;* AU = *Auxis* sp.; UN = unidentified tuna.

TABLE A-7.—*Data on larval tunas collected during the offshore survey on* Charles H. Gilbert *cruise 38*

Station	Position		Date (1958)	Collection time (+9ZT)	Depth of tow	Water strained	Larvae in sample[1]							
	Lat. S.	Long. W.					SJ	YF	BE	AL	EU	AU	UN	Total
					M.	*M.*³	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
46	9°11′	138°06′	Mar. 26	2204–2234	0–140	1416.2								0
48	9°09′	137°34′	Mar. 27	0405–0435	0–142	1647.2	1							1
49	9°11′	136°15′	do	2104–2135	0–142	1703.6	5							5
51	9°07′	136°56′	Mar. 28	0304–0334	0–140	1776.7	6							6
53	9°09′	138°53′	do	2122–2151	0–140	1394.2								0
55	9°08′	139°27′	Mar. 29	0303–0332	0–140	1338.6	14	2						16
57	7°32′	139°46′	do	2104–2134	0–142	1275.6	29		10					39
59	6°57′	139°44′	Mar. 30	0305–0336	0–142	1363.8	2							2
60	5°44′	139°40′	do	2102–2132	0–140	1644.4	4							4
62	6°20′	139°39′	Mar. 31	0307–0337	0–140	1505.8	12		5	1				18
64	8°10′	139°44′	do	2103–2133	0–142	1475.9	13	2	1					16
66	8°38′	139°57′	Apr. 1	0306–0336	0–142	1456.4	8							8
69	9°08′	141°14′	Apr. 3	2104–2134	0–140	1543.7	1							1
71	9°07′	141°52′	Apr. 4	0309–0339	0–140	1751.3	6							6
72	9°05′	142°58′	do	2102–2133	0–142	1885.5	9							9
74	9°04′	142°28′	Apr. 5	0304–0334	0–142	1657.8	3							3
75	9°09′	140°28′	do	2103–2132	0–140	1212.8								0
77	9°12′	139°57′	Apr. 6	0309–0339	0–140	1333.3	8							8
78	10°52′	139°45′	do	2107–2137	0–142	1407.8								0
80	11°28′	139°48′	Apr. 7	0304–0335	0–140	1627.7	6							6
81	12°32′	139°43′	do	2103–2133	0–140	1546.5	5	1						6
83	12°00′	139°41′	Apr. 8	0305–0335	0–140	1921.8	12							12
84	10°02′	139°44′	do	2100–2130	0–142	1406.7	1							1
86	9°24′	139°51′	Apr. 9	0302–0332	0–142	1536.7	6							6

[1] SJ = *Katsuwonus pelamis;* YF = *Thunnus albacares;* BE = *Thunnus obesus;* AL = *Thunnus alalunga;* EU = *Euthynnus affinis;* AU = *Auxis* sp.; UN = unidentified tuna.

TABLE A-8.—*Data on larval tunas collected during the offshore survey on* Hugh M. Smith *cruise 45*

Station	Position		Date (1958)	Collection time (+9ZT)	Depth of tow	Water strained	Larvae in sample[1]							
	Lat. S.	Long. W.					SJ	YF	BE	AL	EU	AU	UN	Total
					M.	*M.*³	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
78	9°08′	138°10′	May 15	2004–2030	0–140	1392.8	4							4
79	9°12′	137°22′	May 16	0317–0346	0–161	1611.1	34							34
82	9°10′	136°10′	do	2000–2028	0–140	1432.8	6	2						8
83	9°13′	137°02′	May 17	0320–0347	0–139	1321.9	2							2
84	9°12′	139°07′	do	1959–2029	0–125	1601.3	3		1					4
87	9°12′	141°22′	May 19	2000–2029	0–140	1578.1								0
88	9°12′	142°02′	May 20	0313–0343	0–137	1357.3								0
90	9°12′	143°08′	do	1955–2026	0–140	1536.0			2	1				3
91	9°14′	142°20′	May 21	0309–0338	0–140	1592.1	4		3	5				12
94	9°12′	140°36′	do	2002–2031	0–137	1359.1	1							1
97	7°39′	139°45′	May 23	2001–2030	0–140	1421.6	1		9					10
98	6°54′	139°41′	May 24	0314–0343	0–140	1426.5								0
101	5°38′	139°40′	do	1958–2028	0–138	1491.0	2		3				1	6
102	6°24′	139°38′	May 25	0310–0344	0–140	1759.2	2	1						3
105	8°25′	139°42′	do	1959–2034	0–137	1926.3	2							2
107	10°55′	139°40′	May 27	2000–2028	0–139	1301.2	4							4
108	11°30′	139°39′	May 28	0312–0339	0–144	2165.0								0
110	12°41′	139°39′	do	2001–2040	0–133	2347.5								0
111	11°58′	139°40′	May 29	0306–0336	0–124	1459.1								0
113	10°11′	139°34′	do	1953–2025	0–140	1928.4	15		1					16
114	9°25′	139°34′	May 30	0315–0351	0–146	944.9						1		1

[1] SJ—*Katsuwonus pelamis;* YF = *Thunnus albacares;* BE = *Thunnus obesus;* AL = *Thunnus alalunga;* EU = *Euthynnus affinis;* AU = *Auxis* sp.; UN = unidentified tuna.