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By

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ABSTRACT

Ovaries were examined from 537 fish collected in the eastern tropical Atlantic, western tropical Atlantic, and off New York. The reported incidence of larval and juvenile K. pelamis was also reviewed. The minimum fork length of skipjack tuna at maturity was 435 mm. in the eastern tropical Atlantic, and 410 mm. in the western tropical Atlantic. All ovaries collected off New York were in an early stage of development. The percentage of skipjack tuna near spawning or recently spawned was greater in the western tropical Atlantic than in the eastern tropical Atlantic. Skipjack tuna spawn throughout the year in the areas studied in the tropical Atlantic. The number of eggs per spawning for fish 465 mm. to 809 mm. long was 262,000 to 1,331,000.

Nematodes identified as Philometra sp. and Spiruroidea infested the ovaries of about 90 percent of the mature skipjack tuna. Both taxa were found in the ovaries of tuna collected in all three areas.

INTRODUCTION

Until recently skipjack tuna (Katsuwonus pelamis) have not been of great importance to the Atlantic tuna fishery. Although the northwest Atlantic purse-seine fishery increased its catch of skipjack tuna from 12 percent of the total in 1962 (Wilson, 1965) to 55 percent in 1964 (Shomura, 1966), the fishery has not contributed much to the total Atlantic catch. Most of the catch is taken by longline, a type of fishing that is selective against smaller scombroids such as skipjack tuna, which made up less than 2 percent of the total Atlantic tuna catch in 1964. The surface fishery in the eastern Atlantic is concentrated on yellowfin tuna, but skipjack tuna are becoming more important. In 1967, skipjack tuna formed 12 percent of the total catch of 21 live-bait boats and 18 purse-seiners that fished along the West African coast in and south of the Gulf of Guinea (LeGuen, Poinsard, and Gayde, 1968). About 40 percent of the tuna caught in the same general area by American purse-seiners in 1967 were skipjack.

Gonad development and the distribution of identifiable larvae and juveniles have been used as evidence for spawning of skipjack tuna (Rothschild, 1965). Klawe (1963) said: "Knowledge of spawning habits is useful in the elucidation of the life history, ecology, and population structure of tropical tunas and is essential to the sound management of these resources."

I report here the results of examination of ovaries from 537 skipjack tuna, present determinations of fecundity, and review the occurrences of larvae and juveniles. Nematode infestation of the ovaries is also discussed.

Previous work on the biology of skipjack tuna in the Atlantic Ocean is limited. Howell-Rivero and Juarez F. (1954), Postel (1955), Frade and Postel (1955), and Gorbunova and Salabarria (1967) examined gonads of skipjack tuna; Klawe and Shimada (1959), Klawe (1960; 1961), Marchal (1963), Gorbunova and Salabarrai (1967), and Richards (in press) reported on the occurrences of larvae and juveniles.

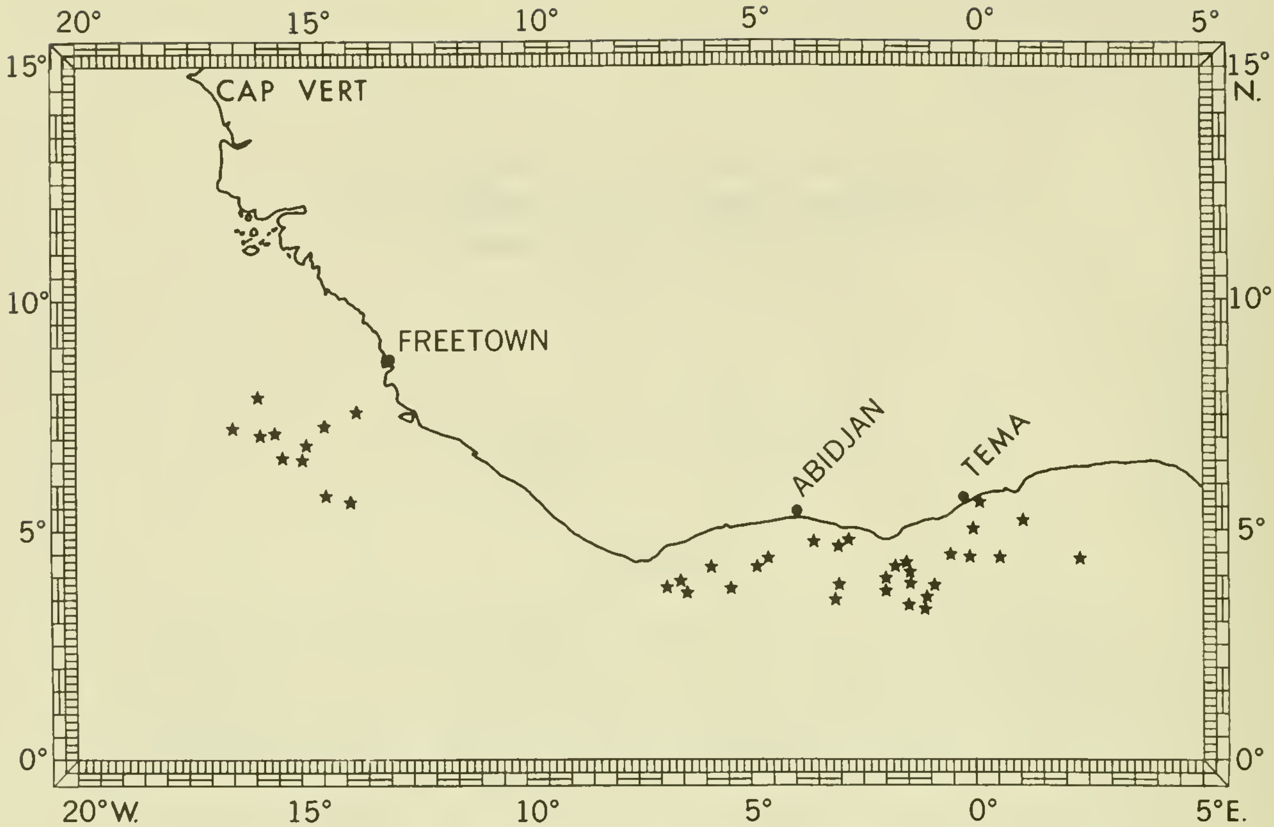

Figure 1.--Localities of collection of skipjack tuna ovaries in the eastern tropical Atlantic.

COLLECTION AND CLASSIFICATION OF SKIPJACK TUNA OVARIES

Skipjack tuna ovaries were collected from the eastern tropical Atlantic (fig. 1), western tropical Atlantic (fig. 2), and near 40°00' N., 72°00' W. (about 100 km. off New York). The tuna were captured on 9 cruises of three research vessels, and 12 cruises of nine commercial fishing vessels, from February 1964 through June 1967.

In the eastern tropical Atlantic, ovaries were collected from skipjack tuna from 47 fishing sites. The tuna were collected on three cruises of the BCF (Bureau of Commercial Fisheries) research vessel Geronimo--February to April and August to October 1964, and February to March 1965. The procedure was to catch 25 tunas from each school encountered, then record the fork length, weight, and sex of each fish. Stomachs and ovaries were removed and frozen (Sund and Richards, 1967). Skipjack tuna were also captured by the commercial fishing vessels Kuroshio Maru 71, 72, 73, 75, and 76 from September 1965 to January 1966. These fish were sampled in Tema, Ghana; the lengths were recorded, and the stomachs and gonads were removed, preserved in Formalin,[1] and shipped to the BCF Tropical Atlantic Biological Laboratory, Miami, Fla.

In the western tropical Atlantic, ovaries from 170 tunas at 30 fishing sites were collected in 1965-67 on two cruises of the Geronimo, three cruises of the Undaunted, and one cruise of the Oregon. Fishing locations of the Oregon are not shown in figure 2 because exact catch positions were not available; they are combined as one fishing site that extends along the island banks from the U.S. Virgin Islands to the northern banks of Montserrat, British West Indies. Periods during which ovaries were collected by the different vessels were: Geronimo--August to October 1965 and February to April 1966; Undaunted--February to April 1966, November 1966, and February to March 1967; and Oregon--June 1967. Sampling procedures aboard the Geronimo and Undaunted were the same as those used during the Geronimo cruises in the eastern tropical Atlantic. The Oregon's procedures differed--skipjack tunas collected were frozen and shipped intact to

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

Figure 2.--Localities of collection of skipjack tuna ovaries in the western tropical Atlantic.

the BCF Tropical Atlantic Biological Laboratory, where the fork length and weight of each fish were recorded, and stomachs and gonads were preserved in Formalin.

Off New York, specimens were collected in August 1965 and 1966 by the commercial fishing vessels Puritan, Lexington, City of Tacoma, and Chicken of the Sea; they were landed (and sampled) in Puerto Rico. After the lengths of these fish were recorded, the stomachs and gonads were removed, preserved in Formalin, and shipped to me. Ovaries from 90 fish were obtained from these ships (table 1).

The ovaries were divided into the five developmental stages shown below. Stages 1 to 3 were modified from Yoshida (1965) and stages 4 and 5 were modified from Schaefer and Orange (1956).

1. Early developing stage--Ova appear in all ovaries as simple transparent cells; the large ova contain a relatively large nucleus.
2. Developing stage--Ova are completely opaque because of the deposition of yolk granules.
3. Advanced stage--Ovaries range in development from those with ova still relatively opaque, containing a cluster of small oil droplets, to those with semitransparent ova containing a well-developed, bright yellow oil globule.
4. Ripe stage--Ova are translucent and loose in the lumen of the ovary; they may be extruded from the fish by external pressure on the abdomen. (No ripe specimens were found in the present study.)
5. Spawned stage--Remnants of ripe ova remain in the lumen or among the folds of the ovary, and are discovered only through microscopic examination. Ovaries in this stage are frequently enlarged, hollow, and flaccid. Except for the remnants of mature ova, the ovaries may be identical with those in stages 1, 2, or 3.

I assumed that skipjack tuna in the developing stage were nearing spawning condition and

Table 1.--Collection data on skipjack tuna ovaries collected in the tropical Atlantic Ocean, 1964-67

Ship	Cruise	Station	Position Lat. N.	Position Long.	Date	Fork length range	Fish in each developmental stage 1	2	3	5	Total fish
						Mm.	No.	No.	No.	No.	No.
Geronimo	3	36	03°53'	06°36' W.	2/11/64	535	--	--	1	--	1
Do	3	84	04°24'	00°32' E.	2/18/64	550-600	--	4	5	3	12
Do	3	241	03°40'	05°30' W.	4/15/64	444-652	--	2	5	--	7
Do	3	243	03°44'	05°27' W.	4/15/64	584	--	--	--	1	1
Do	4	82	04°13'	01°30' W.	8/17/64	535	--	1	--	--	1
Do	4	159	03°41'	06°55' W.	9/27/64	610	--	--	1	--	1
Do	4	160	03°42'	06°50' W.	9/27/64	600	--	--	1	--	1
Do	4	165	03°34'	06°26' W.	9/28/64	510-580	2	1	--	--	3
Do	4	173	04°11'	05°54' W.	9/29/64	545	--	1	--	--	1
Do	4	182	04°08'	04°53' W.	10/1/64	505	1	--	--	--	1
Do	4	190	04°28'	04°35' W.	10/2/64	520	1	--	--	--	1
Do	4	191	04°19'	04°36' W.	10/2/64	535	1	--	--	--	1
Do	4	234	03°48'	00°58' W.	10/10/64	440	1	--	--	--	1
Do	5	50	07°14'	16°33' W.	2/15/65	510-561	5	--	--	--	5
Do	5	63	07°02'	15°56' W.	2/16/65	471-559	2	--	--	--	2
Do	5	77	07°53'	16°00' W.	2/18/65	556	1	--	--	--	1
Do	5	83	07°03'	15°38' W.	2/19/65	531-598	4	--	--	1	5
Do	5	85	06°37'	15°28' W.	2/19/65	503-548	4	--	1	1	6
Do	5	91	06°30'	15°00' W.	2/20/65	491-527	--	--	2	1	3
Do	5	93	06°49'	14°57' W.	2/20/65	453	1	--	--	--	1
Do	5	124	05°44'	14°28' W.	2/23/65	450-537	1	--	5	--	6
Do	5	129	05°37'	13°54' W.	2/24/65	457-492	1	--	1	--	2
Do	5	135	07°15'	14°29' W.	2/25/65	553-587	4	--	--	--	4
Do	5	192	03°39'	02°00' W.	3/15/65	447-477	9	--	1	--	10
Do	5	193	03°52'	01°59' W.	3/15/65	454-499	10	--	--	--	10
Do	5	198	04°02'	01°28' W.	3/16/65	576-582	--	--	2	--	2
Do	5	199	03°53'	01°30' W.	3/16/65	478-510	3	--	--	--	3
Do	5	202	03°20'	01°29' W.	3/16/65	623	1	--	--	--	1
Do	5	207	03°15	01°07' W.	3/17/65	458-528	2	--	1	--	3
Do	5	209	03°29'	01°05' W.	3/17/65	446-471	10	--	--	--	10
Do	5	217	04°28'	00°33' W.	3/18/65	442-543	6	--	--	--	6
Do	5	227	04°26'	00°07' W.	3/19/65	434-474	7	--	--	--	7
Do	5	230	05°00'	00°01' W.	3/19/65	462-503	7	--	--	--	7
Do	5	245	05°13'	01°03' E.	3/21/65	448-472	3	--	--	--	3
Do	5	269	04°10'	01°45' W.	3/26/65	447-486	11	--	--	--	11
Do	5	275	03°50'	01°22' W.	3/27/65	576-639	10	--	--	--	10
Do	5	276	03°49'	01°25' W.	3/27/65	550-611	14	--	1	--	15
Do	5	298	03°24'	03°07' W.	3/30/65	453-504	8	--	3	--	11
Do	5	301	03°46'	03°00' W.	3/30/65	491-569	11	3	1	1	16
Kuroshio Maru 76	1	--	04°15'	01°42' W.	9/25/65	475-600	11	--	--	--	11
K. Maru 72	1	--	04°14'	01°33' W.	9/28/65	420-490	13	1	--	--	14
K. Maru 75	1	--	04°37'	03°02' W.	10/1/65	415-517	6	--	--	--	6
K. Maru 71	1	--	04°46'	02°50' W.	10/3/65	500-613	9	1	--	--	10
K. Maru 76	2	--	07°31'	13°48' W.	11/8/65	487-565	11	--	--	--	11
K. Maru 72	2	--	04°22'	02°19' E.	12/7/65	475-524	3	6	--	1	10
K. Maru 73	1	--	05°37'	00°04' E.	12/29/65	400-480	5	6	1	--	12
K. Maru 75	2	--	04°43'	03°34' W.	1/10/66	500-552	4	4	2	1	11
Geronimo	6	32	16°15'	63°08' W.	8/11/65	480-491	--	--	2	1	3
Do	6	53	13°33'	60°13' W.	8/21/65	527	--	--	1	--	1
Do	6	60	13°33'	62°13' W.	8/22/65	495	--	--	2	--	2

Table 1.--Collection data on skipjack tuna ovaries collected in the tropical Atlantic Ocean, 1964-67--Continued.

Ship	Cruise	Station	Position Lat. N.	Position Long.	Date	Fork length range	Fish in each developmental stage 1	2	3	5	Total fish
						Mm.	No.	No.	No.	No.	No.
Do	6	142	12°18'	69°31' W.	9/23/65	590	1	--	--	--	1
Do	6	197	15°29'	80°00' W.	10/12/65	530-600	--	--	2	--	2
Do	7	17	18°29'	62°51' W.	2/4/66	467	--	--	1	--	1
Do	7	22	13°44'	60°12' W.	2/6/66	520	--	--	1	--	1
Do	7	26	11°51'	60°34' W.	2/7/66	512	--	--	1	--	1
Do	7	43	05°45'	51°16' W.	2/21/66	530-590	--	--	2	--	2
Do	7	98	14°32'	64°30' W.	3/18/66	525	--	--	1	--	1
Do	7	108	12°30'	67°18' W.	3/21/66	540	--	--	1	--	1
Do	7	130	12°45'	62°10' W.	4/6/66	490-565	--	--	34	--	34
Do	7	131	13°17'	62°08' W.	4/6/66	470-525	--	--	7	--	7
Do	7	132	12°49'	62°09' W.	4/7/66	530	--	--	1	--	1
Do	7	133	12°47'	62°06' W.	4/7/66	480-565	--	--	22	--	22
Undaunted	2	21	16°36'	67°27' W.	2/21/66	528	--	--	1	--	1
Do	2	96	11°55'	60°27' W.	3/17/66	565	--	--	1	--	1
Do	2	103	12°01'	62°32' W.	3/26/66	566-659	--	--	9	--	9
Do	2	109	13°04'	62°02' W.	3/27/66	516-577	--	--	4	--	4
Do	2	113	13°20'	62°24' W.	3/27/66	499-587	--	--	5	--	5
Do	2	118	13°24'	61°44' W.	3/28/66	500-533	--	--	3	--	3
Do	2	121	13°16'	61°30' W.	3/28/66	531-565	--	--	4	--	4
Do	2	129	13°30'	61°49' W.	3/31/66	536-580	--	--	4	--	4
Do	2	133	12°56'	62°04' W.	4/1/66	774-809	--	--	2	--	2
Do	2	142	13°25'	62°49' W.	4/2/66	--	--	--	2	--	2
Do	5	379	13°21'	61°44' W.	11/9/66	517-590	1	--	1	--	2
Do	5	391	12°32'	61°35' W.	11/10/66	487-693	1	--	14	--	15
Do	6701	50	12°53'	62°25' W.	2/25/67	255-400	9	--	--	--	9
Do	6701	62	18°57'	68°07' W.	3/2/67	525-615	--	--	15	4	19
Oregon	118	--	see footnote [1]		June 67	410-560	--	--	4	6	10
Puritan	--	--	39°25'	72°64' W.	8/4-7/65	474-564	11	--	--	--	11
Lexington	--	--	40°05'	73°39' W.	8/4, 13-15/65	448-604	31	--	--	--	31
City of Tacoma	--	--	39°47'	72°24' W.	8/14/65	498-597	27	--	--	--	27
Chicken of the Sea	--	--	40°20'	72°30' W.	8/18-19/66	458-613	21	--	--	--	21

[1] Island banks from U.S. Virgin Islands to the northern banks of Montserrat, British West Indies.

that advanced and spawned stages indicated that spawning was imminent or recent.

CONDITION OF OVARIES AND DISTRIBUTION OF LARVAL AND JUVENILE SKIPJACK TUNA

The length at maturity for skipjack tuna near Cap Vert (eastern tropical Atlantic) is about 450 mm., according to Postel (1955). In the present study, the minimum size at maturity was considered to be the length of the smallest fish in developing, advanced, or spawned stages. The minimum size at maturity for skipjack tuna in the eastern tropical Atlantic was 435 mm. fork length, determined from a fish in the developing stage; the minimum size at maturity in the western tropical Atlantic was 410 mm. fork length, determined from a fish in the spawned stage. Seven fish smaller than 435 mm. from the eastern tropical Atlantic, and nine fish smaller than 410 mm. from the western tropical Atlantic were in the early developing stage and were considered immature.

The percentage of skipjack tuna near spawning or recently spawned was greater in the western tropical Atlantic than in the eastern tropical Atlantic. Among ovaries of eastern tropical Atlantic specimens, 73 percent were in the early developing stage and 27 percent were in the developing, advanced, and spawned stages. In the western tropical Atlantic, 7 percent of the ovaries were in the early developing stage, and 93 percent were in the advanced and spawned stages. All ovaries collected in the New York area were in the early developing stage.

Spawning seasons of skipjack tuna have been reported as June to September for males and July to October for females, near Cap Vert (Postel, 1955); from May to September near Dakar (Frade and Postel, 1955); all year, with a peak from April to July, near Cuba (Howell-Rivero and Juarez F., 1954); at a peak May through July in Cuban waters (Gorbunova and Salabarria, 1967).

Tuna ovaries in advanced and spawned stages were collected in the eastern tropical Atlantic in January through April, September, and December (fig. 3). Marchal (1963) found 95 juvenile skipjack tuna in the same area during February, March, and May. Richards (in press) found 427 larvae throughout the tropical Atlantic from February through April, and August through October, but the sizes of the larvae he examined differed widely between individual stations, and no size pattern emerged that could be related to growth.

Tuna ovaries in advanced and spawned stages were collected in the western tropical Atlantic

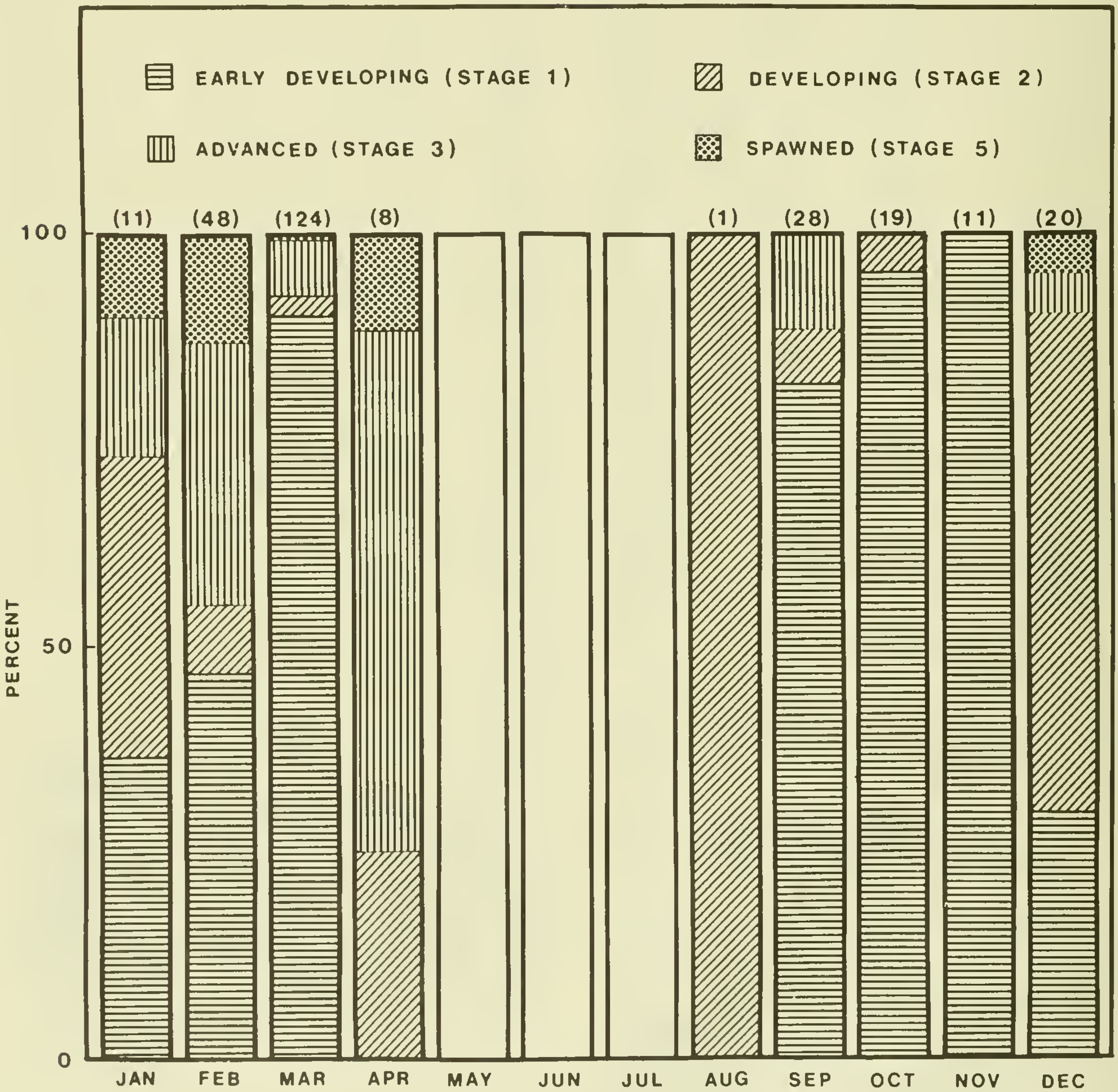

Figure 3.--Monthly percentage distribution of developmental stages of the ovaries of mature skipjack tuna from the eastern tropical Atlantic. No ovaries were collected in May through July.

in February through April, June, August, October, and November (fig. 4).

Collections of larval and juvenile skipjack tuna in the western tropical Atlantic have included: 6 juveniles in the Gulf of Mexico in August (Klawe and Shimada, 1959); 11 larvae in the Florida Current--4 in April, 1 in May, 3 in July, 2 in August, and 1 in October (Klawe, 1960); 20 juveniles between Cape Hatteras and the Bahama Islands in December (Klawe, 1961); 16 larvae in Cuban waters in May, August, and September (Gorbunova and Salabarria, 1967); 26 larvae off Bimini, the Bahamas, in June (William J. Richards, personal communication); and 18 juveniles from the stomachs of tunas captured off St. Vincent Island, British West Indies, in April, 1 juvenile off Cape Hatteras, N.C., in April, and 22 juveniles regurgitated by (chiefly) sooty terns (Sterna fuscata) on Bush Key, Dry Tortugas, Fla., in May through July (Thomas C. Potthoff, personal communication). A summary of the larval and juvenile collection data is shown in table 2.

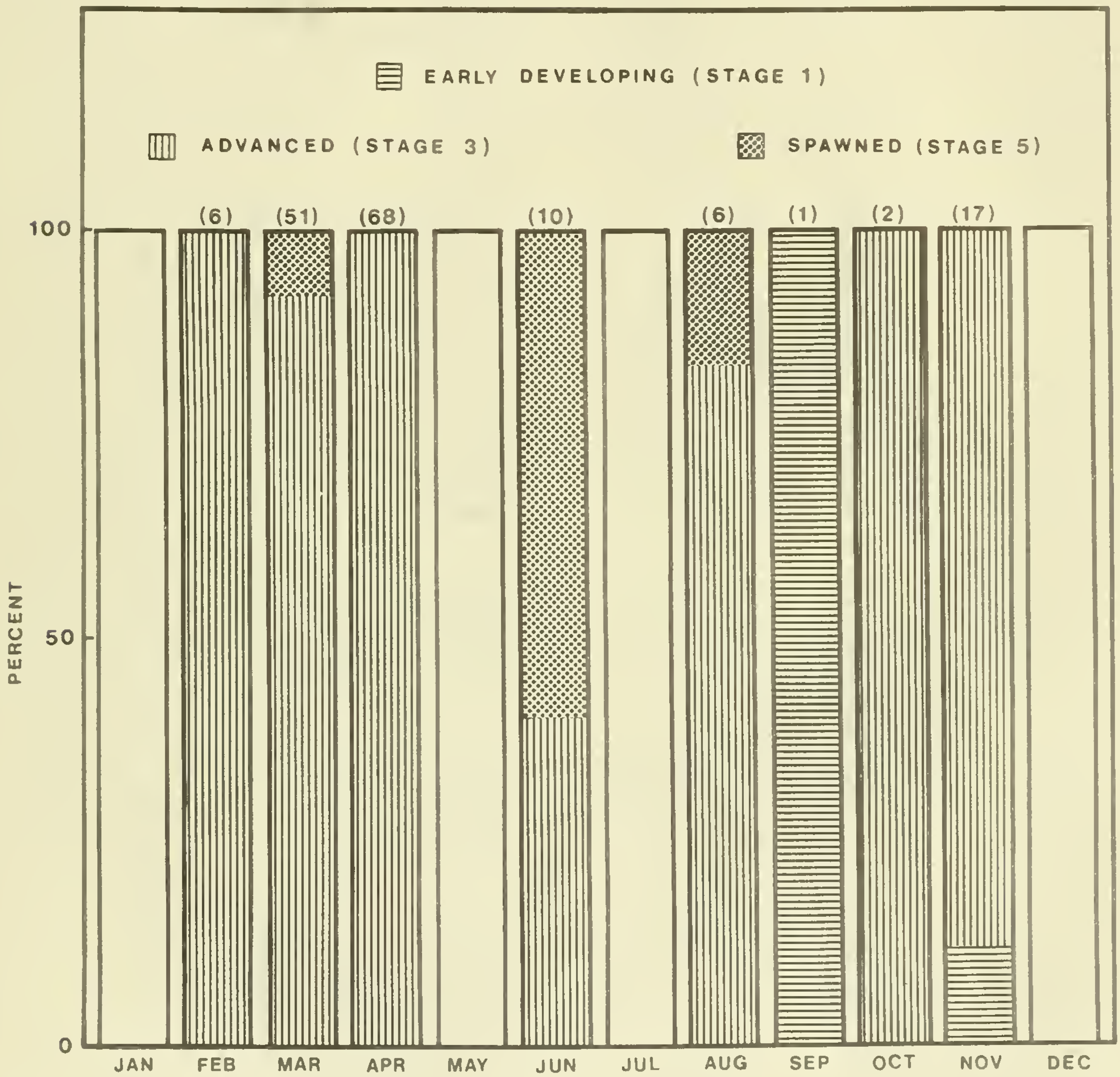

Figure 4.--Monthly percentage distribution of developmental stages of the ovaries of mature skipjack tuna from the western tropical Atlantic. No ovaries were collected in January, May, July, and December.

Table 2.--Distribution of larval and juvenile skipjack in the Atlantic Ocean as reported by various observers, 1959-67

Observer	Position Lat.	Position Long.	Date	Size range	Total fish
				Mm.	No.
Marchal (1963)	02°45' N.	04°00' W.	2/03/60	52.7-72.6	4
Do	04°00' N.	10°49' W.	3/20/60	20.0	1
Do	03°30' N.	03°00' W.	3/29/60	14.2-16	4
Do	03°59' N.	00°00' W.	5/18/60	30.8-41	2
Do	04°30' N.	01°24' W.	5/19/60	13.7-24	82
Do	04°01' S.	12°18' W.	3/05/62	55	2
Richards (in press)	00°15' S.	43°42' W.	2/17/63	6.2-8.2	2
Do	01°42' N.	42°57' W.	2/17/63	4.2-5.2	7
Do	02°35' S.	05°09' E.	2/17/63	2.7-3.7	6
Do	03°50' N.	42°08' W.	2/19/63	3.7-7.2	6
Do	06°28' S.	03°00' E.	2/19/63	5.2-7.2	4
Do	08°25' S.	02°18' E.	2/20/63	5.2	1
Do	02°12' N.	45°44' W.	2/21/63	--	2
Do	06°01' N.	03°24' E.	2/21/63	5.2	1
Do	04°51' N.	44°22' W.	2/22/63	--	2
Do	05°01' N.	03°22' E.	2/22/63	2.7-4.2	10
Do	06°47' S.	07°11' E.	2/23/63	5.2	1
Do	07°30' N.	50°30' W.	2/25/63	4.2	1
Do	00°01' N.	14°59' W.	2/26/63	8.2	1
Do	00°28' S.	14°56' W.	2/27/63	2.7-4.7	12
Do	07°00' S.	33°30' W.	3/02/63	4.7-5.7	4
Do	02°30' S.	15°00' W.	3/03/63	3.2	4
Do	00°22' N.	03°24' E.	3/03/63	3.2-5.2	14
Do	11°15' S.	15°01' W.	3/06/63	2.2-7.2	2
Do	03°07' S.	34°17' W.	3/07/63	3.7-5.7	2
Do	01°00' S.	35°00' W.	3/10/63	3.7	1
Do	00°30' N.	34°40' W.	3/11/63	4.2-6.2	5
Do	01°30' N.	35°00' W.	3/12/63	3.7-4.7	2
Do	02°30' N.	35°00' W.	3/13/63	5.2	2
Do	04°30' N.	35°03' W.	3/14/63	4.2-5.2	3
Do	06°44' N.	35°00' W.	3/15/63	4.2	1
Do	04°05' N.	37°10' W.	3/17/63	5.7-8.2	5
Do	03°00' N.	37°50' W.	3/18/63	7.2	1
Do	01°04' N.	43°04' W.	3/18/63	3.7-5.2	4
Do	01°41' N.	46°55' W.	3/18/63	6.2	1

Table 2.--Distribution of larval and juvenile skipjack in the Atlantic Ocean as reported by various observers, 1959-67--Continued

Observer	Position Lat.	Position Long.	Date	Size range	Total fish
				Mm.	No.
Do	02°24' N.	48°11' W.	3/19/63	6.2	1
Do	03°10' N.	42°08' W.	3/19/63	4.7	2
Do	01°30' N.	38°59' W.	3/19/63	4.2-7.7	3
Do	06°01' N.	03°24' E.	3/19/63	7.7	1
Do	07°31' N.	50°13' W.	3/21/63	4.2	1
Do	11°15' S.	15°30' W.	3/21/63	4.7	1
Do	08°11' S.	04°28' E.	3/21/63	5.2-7.2	2
Do	05°05' N.	03°24' E.	3/21/63	2.7-6.2	28
Do	07°56' S.	15°27' W.	3/22/63	2.2-4.2	9
Do	04°01' N.	03°24' E.	3/22/63	3.2-5.2	8
Do	01°30' S.	41°08' W.	3/22/63	3.2-5.7	6
Do	04°51' N.	04°02' W.	3/22/63	4.2	2
Do	04°10' N.	04°07' W.	3/23/63	4.2	1
Do	02°31' S.	15°33' W.	3/23/63	3.2	1
Do	09°15' S.	01°35' E.	3/23/63	4.2-7.2	3
Do	07°25' S.	02°35' E.	3/23/63	4.7-5.7	2
Do	03°00' N.	04°02' W.	3/24/63	3.2	7
Do	02°00' N.	04°06' W.	3/24/63	3.2	1
Do	01°03' N.	04°09' W.	3/24/63	4.2	3
Do	01°00' N.	04°12' W.	3/25/63	3.2-5.2	6
Do	00°30' N.	04°14' W.	3/25/63	3.2	1
Do	00°00'	04°02' W.	3/25/63	3.7	1
Do	05°05' S.	03°55' E.	3/25/63	5.2	1
Do	03°45' S.	04°43' E.	3/25/63	4.2	2
Do	02°00' S.	04°02' W.	3/26/63	2.7-3.7	3
Do	02°33' S.	04°02' W.	3/27/63	3.2	1
Do	00°22' S.	06°52' E.	3/27/63	6.2	1
Do	06°11' N.	13°26' W.	3/29/63	6.2	1
Do	03°00' S.	37°25' W.	4/04/63	5.2-5.7	2
Do	01°30' N.	37°24' W.	4/06/63	4.2-5.2	7
Do	03°23' N.	37°28' W.	4/07/63	5.2-6.2	2
Do	07°10' N.	37°24' W.	4/09/63	3.7-7.2	12
Do	19°58' N.	30°02' W.	8/01/63	2.7-4.7	6
Do	15°54' N.	27°52' W.	8/02/63	2.7	1
Do	03°00' N.	00°00'	8/02/63	4.7	2
Do	03°57' N.	03°55' W.	8/02/63	3.2-3.7	3
Do	03°28' N.	03°57' W.	8/02/63	5.2	3
Do	13°22' N.	26°25' W.	8/03/63	4.7	1
Do	00°30' N.	00°00'	8/03/63	4.7	1
Do	02°56' N.	03°58' W.	8/03/63	3.2-4.7	9

Table 2.--Distribution of larval and juvenile skipjack in the Atlantic Ocean as reported by various observers, 1959-67--Continued

Observer	Position Lat.	Position Long.	Date	Size range	Total fish
				Mm.	No.
Do	02°00' N.	04°01' W.	8/03/63	9.2	1
Do	01°30' N.	04°30' W.	8/04/63	5.2	1
Do	00°58' N.	04°04' W.	8/04/63	5.2-6.2	3
Do	00°30' N.	04°07' W.	8/04/63	4.2-7.2	10
Do	00°01' S.	04°09' W.	8/05/63	3.2-7.2	58
Do	00°29' N.	41°10' W.	8/06/63	4.7	1
Do	03°59' N.	24°56' W.	8/07/63	4.2-8.2	4
Do	00°05' S.	25°07' W.	8/09/63	4.2	1
Do	02°03' S.	25°07' W.	8/10/63	4.2	1
Do	07°22' N.	36°40' W.	8/10/63	6.2-7.7	2
Do	09°15' S.	01°40' E.	8/11/63	3.7	1
Do	08°08' N.	34°07' W.	8/13/63	9.7	1
Do	05°10' S.	03°36' E.	8/14/63	5.2	1
Do	13°17' N.	18°46' W.	8/30/63	5.2-6.2	9
Do	06°31' N.	44°14' W.	8/31/63	4.2-8.7	19
Do	02°43' N.	36°19' W.	8/31/63	5.7	1
Do	07°00' N.	20°04' W.	9/02/63	5.2	1
Do	12°38' N.	46°45' W.	9/04/63	4.2	1
Do	10°54' N.	46°18' W.	9/04/63	3.7-7.7	5
Do	07°39' N.	48°13' W.	9/05/63	3.2-6.2	4
Do	02°40' N.	20°00' W.	9/05/63	4.7	1
Do	01°30' N.	19°54' W.	9/06/63	8.2	1
Do	05°38' N.	49°03' W.	9/06/63	3.7-5.2	5
Do	04°03' S.	19°58' W.	9/09/63	5.7-6.2	3
Do	06°03' S.	20°17' W.	9/10/63	4.7-5.2	2
Do	03°48' N.	10°55' W.	9/12/63	3.7-6.2	6
Do	02°07' N.	11°00' W.	9/13/63	3.7-5.7	3
Do	05°22' S.	11°00' W.	9/18/63	3.7	1
Do	09°46' S.	11°39' W.	9/20/63	4.7-9.7	4
Do	12°20' N.	46°39' W.	9/22/63	8.2	1
Do	09°20' N.	49°42' W.	9/23/63	3.7-5.7	3
Do	06°40' N.	48°23' W.	9/24/63	7.2	1
Do	02°58' S.	07°30' W.	10/3/63	3.2-5.2	9
Do	00°03' N.	07°33' W.	10/5/63	3.7	1
Do	01°31' N.	07°26' W.	10/6/63	4.2-6.2	5

Table 2.--Distribution of larval and juvenile skipjack in the Atlantic Ocean as reported by various observers, 1959-67--Continued

Observer	Position Lat.	Position Long.	Date	Size range	Total fish
				Mm.	No.
Do	03°04' N.	07°17' W.	10/7/63	4.2	1
Klawe and Shimada (1959)	28°50' N.	87°48' W.	8/13/55	56	1
Do	28°47' N.	87°57' W.	8/15/55	47-50	2
Do	28°55' N.	88°00' W.	8/20/55	29-45	2
Do	28°12' N.	88°43' W.	8/24/55	49	1
Klawe (1960)	25°35' N.	79°56' W.	7/03/51	5.4-13.0	3
Do	25°34.5' N.	79°55' W.	8/13/51	3.9	1
Do	25°35' N.	79°25' W.	4/23/53	5.7	1
Do	25°35' N.	79°25' W.	4/23/53	6.9	1
Do	25°35' N.	79°25' W.	4/24/53	6.4	1
Do	25°35' N.	79°25' W.	5/21/53	4.5	1
Do	25°35' N.	79°25' W.	8/14/53	7.0	1
Do	25°35' N.	79°25' W.	10/4/55	7.4	1
Do	25°34.5' N.	79°19.7 W.	4/05/56	7.4	1
Klawe (1961)	32°59' N.	76°40' W.	12/5/54	49	1
Do	32°50' N.	76°44' W.	12/5/54	50	3
Do	32°50' N.	76°44' W.	12/5/54	29-54	7
Do	32°59' N.	76°40' W.	12/5/54	25-69	9
William J. Richards (personal communication)	25°43' N.	79°20' W.	6/02/66	4.2	1
Do	25°43' N.	79°21' W.	6/02/66	2.2-4.2	3
Do	25°43' N.	79°23' W.	6/03/66	5.2	1
Do	25°43' N.	79°22' W.	6/04/66	4.2	1
Do	25°43' N.	79°23' W.	6/04/66	4.2	2
Do	25°43' N.	79°24' W.	6/04/66	4.7	1
Do	25°43' N.	79°21' W.	6/05/66	4.2	1
Do	25°43' N.	79°22' W.	6/05/66	4.2	2
Do	25°43' N.	79°24' W.	6/05/66	4.2	1
Do	25°43' N.	79°20' W.	6/05/66	3.2	1
Do	25°43' N.	79°21' W.	6/05/66	3.2-6.2	2
Do	25°43' N.	79°24' W.	6/05/66	3.7-5.7	2

Table 2.--Distribution of larval and juvenile skipjack in the Atlantic Ocean as reported by various observers, 1959-67--Continued

Observer	Position Lat.	Position Long.	Date	Size range	Total fish
				Mm.	No.
Do	25°43' N.	79°21' W.	6/06/66	2.7-3.7	2
Do	25°43' N.	79°22' W.	6/06/66	3.2	1
Do	25°43' N.	79°23' W.	6/06/66	3.7-6.2	2
Do	25°43' N.	79°24' W.	6/06/66	3.2-4.2	3
Thomas C. Potthoff (personal communication)	12°45' N.	62°10' W.	4/06/66	46-108	18
Do	35°56' N.	72°32' W.	4/08/65	109	1
Do	Footnote[1]		May 61	38.2-59.5	2
Do	do		July 61	56.4-146.3	9
Do	do		7/09/62	100.6-118.0	2
Do	do		5/11-15/64	30.0	1
Do	do		6/22-30/64	50.0-64.5	2
Do	do		6/11/66	65.7	1
Do	do		6/13/66	109.7-125.3	2
Do	do		6/9/67	44.6-58.3	3
Gorbunova and Salabarria (1967)	Footnote[2]		May, Aug., Sept.	2.6-6.9	16

[1]Bush Key, Dry Tortugas, Fla.

[2]Cuban waters

I conclude, from the condition of the ovaries and the occurrences of larvae and juveniles, that skipjack tuna spawn throughout the year in the areas of study in the tropical Atlantic Ocean.

FECUNDITY

Fecundity of skipjack tuna has not been reported previously for fish from the Atlantic Ocean, but has been determined for fish from the Pacific Ocean (Yabe 1954, Joseph 1963, and Yoshida 1966) and the Indian Ocean (Raju 1964). I determined the fecundities of 13 skipjack tuna, 465 to 809 mm. fork length, collected within 13 days (March 26 - April 7, 1966) near St. Vincent Island in the Caribbean (table 1), on *Geronimo* cruise 7 (station 133) and *Undaunted* cruise 2 (stations 103, 109, and 113).

A sample of eggs of yellowfin tuna (*Thunnus albacares*) taken anywhere along the length of a single ovary or from either member of a pair is representative of eggs throughout the ovary, according to June (1953). Yuen (1955) confirmed this finding for bigeye tuna (*Thunnus obesus*), Otsu and Uchida (1959) for albacore (*Thunnus alalunga*), and Raju (1964) for skipjack tuna. I therefore used the following sampling procedure in estimating the number of eggs in seven ovaries that had been frozen and six that had been preserved in Formalin.

After excess tissue and moisture had been removed from the thawed or preserved ovaries, they were weighed to the nearest 0.1 g. A pie-shaped sample of about 0.5 g. was taken from the center of either the right or left ovary of each fish and weighed to the nearest 0.01 g. The samples from frozen ovaries were put in modified Gilson's fluid (Simpson, 1951), and then placed on a shaker table (continuously agitating) to increase the rate of breakdown of the connective tissue and free the individual eggs. The process took about 2 weeks. The eggs in samples from preserved ovaries were freed from the connective tissue with dissecting needles.

Egg diameters were ascertained by using an eye-piece micrometer to measure the axis of the egg as it lay parallel to the micrometer (Clark, 1925). Diameter frequencies were taken for each sample until the lower limit of the most advanced mode was defined. The total number of eggs in this mode was then counted. Fecundity was determined by multiplying the number of eggs in the most advanced mode of the sample by the weight of the two ovaries, and dividing the product by the weight of the sample. I assumed that the number of eggs maturing for the next spawning (fecundity) would be the same as the number of eggs in the most advanced modal group. Frequency distribution of egg diameters, as used for determining the most advanced mode for the first fish in table 3, is shown in figure 5. For this fish, only eggs larger than 0.4 mm. in diameter were counted.

Table 3.--Estimated number of eggs in the largest modal group in ovaries of 13 skipjack tuna collected in the western tropical Atlantic, March 26 to April 7, 1966

Ship, cruise, station	Date	Fork length	Eggs in the largest modal group
		Mm.	No.
Geronimo Cruise 7			
133	4/7/66	465	275,000
Do	do	540	472,000
Do	do	540	587,000
Undaunted Cruise 2			
129	3/31/66	580	482,000
103	3/26/66	587	465,000
Do	do	594	262,000
Do	do	604	877,000
Do	do	612	389,000
Do	do	616	689,000
Do	do	631	653,000
Do	do	659	857,000
133	4/1/66	774	1,331,000
Do	do	809	1,264,000

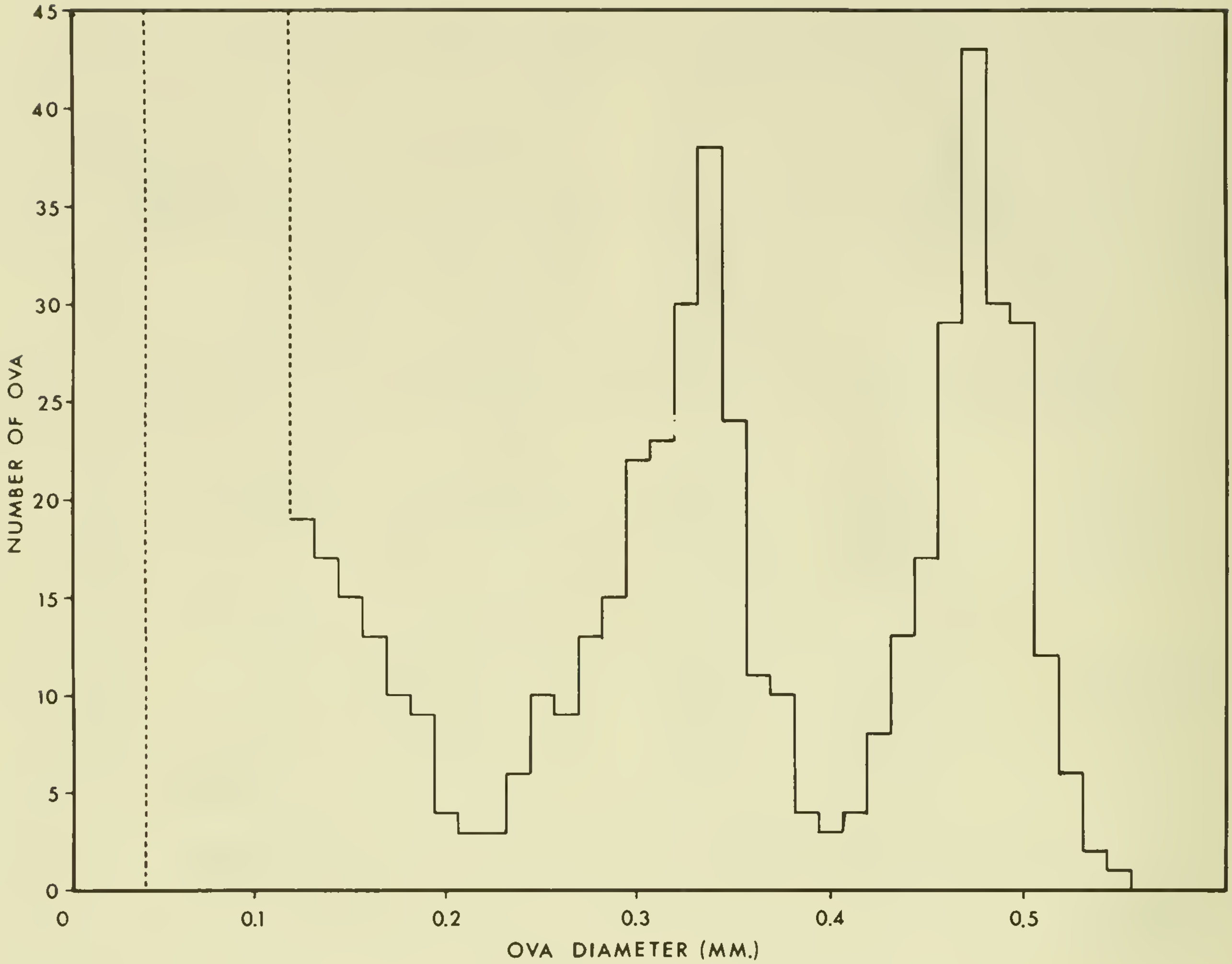

Figure 5.--Frequency distribution of egg diameters, used for defining the most advanced mode in the ovaries of a 540-mm. skipjack tuna.

Fork lengths and fecundities of 13 skipjack tunas are shown in table 3. A straight line was fitted to fork length versus fecundity by the method of least squares. The equation describing the regression line is $Y = -1333.541 + 3.238\ X$, where Y is the number of ova in the most advanced mode in thousands and X is the fork length of the fish in mm. The coefficient of correlation is 0.873 ($P \leq 0.01$, 11 d.f.). The line and scatter diagram are shown in figure 6, together with the data of Yabe (1954) and Yoshida (1966), and the regression lines of Raju (1964) and Joseph (1963). All data approximate my regression line except those of Joseph, probably because of the small size range of fish used in his determination. Although I used a straight line in the figure to facilitate comparison of my data with those of the other workers, I obtained a slightly better fit by using cube of the length versus fecundity (coefficient of correlation is 0.886, 11 d.f.)--as should be expected according to MacGregor (1957). The few data do not warrant reporting a detailed analysis.

NEMATODE INFESTATION OF THE OVARIES

The ovaries of about 90 percent of the mature skipjack tuna examined in the present investigation were infested with nematodes, but none were found in immature fish. The lumina of a pair of ovaries had contained up to about 75 nematodes, but they did not cause noticeable damage to the eggs.

Yuen and June (1957) found nematodes in the ovaries of yellowfin tuna from the Pacific, but the parasites were too poorly preserved to identify.

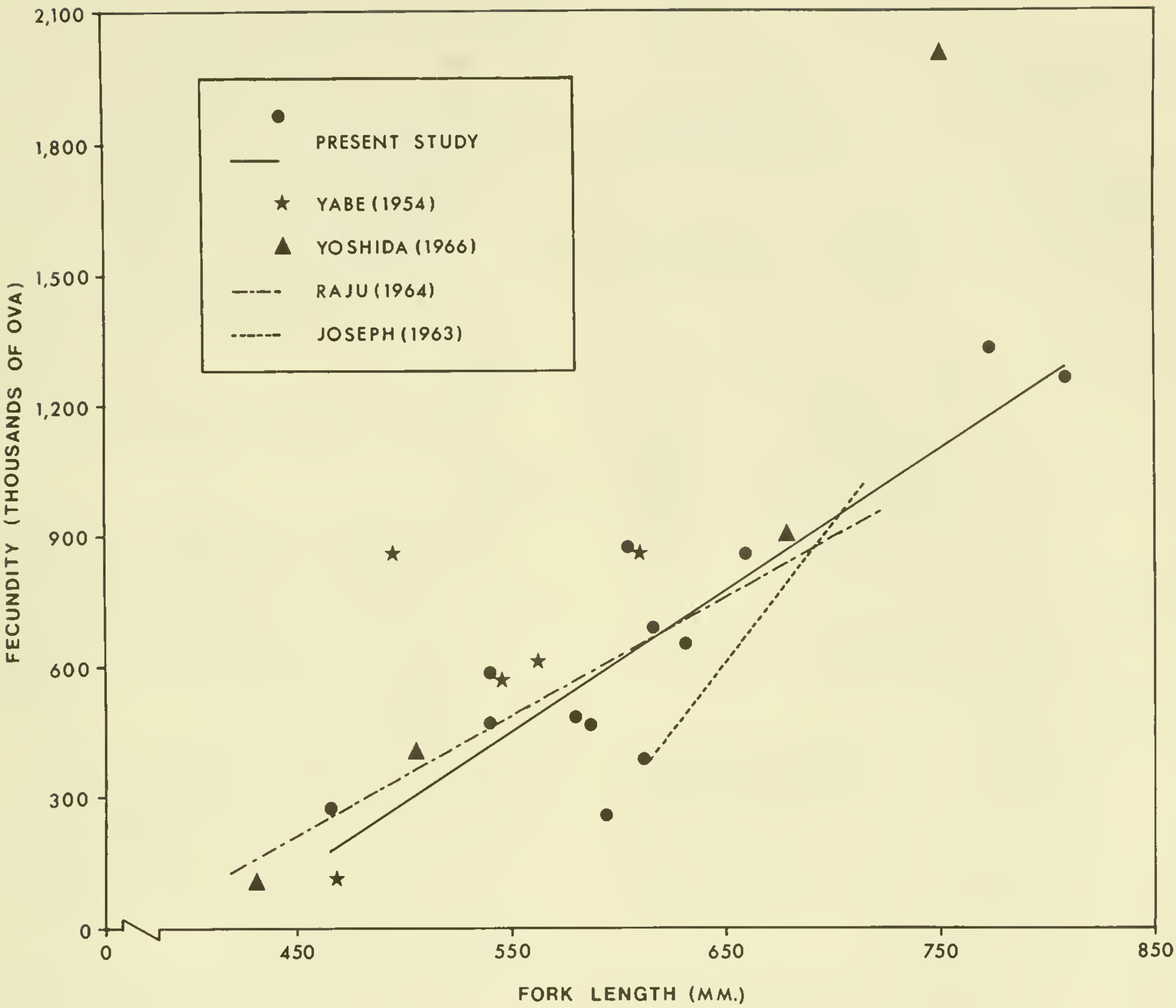

Figure 6.--Fork length-fecundity relation for skipjack tuna. Present data and regression line are shown, together with the data of Yabe (1954) and Yoshida (1966) and the regression lines of Raju (1964) and Joseph (1963).

Raju (1960) described an ovary of a skipjack tuna (collected in the Indian Ocean) that was infested with 68,200 larval nematodes; all the ova in the left ovary had been destroyed except the small transparent ones along the periphery.

Maybelle Chitwood (personnal communication) identified two taxa of nematodes from the ovaries of skipjack tuna caught in the eastern tropical Atlantic, western tropical Atlantic, and off New York. One was Philometra sp. (suborder Camallanata), and the other was a species of the superfamily Spiruroidea (suborder Spirurata). She reported that members of the Camallanata use a copepod or other marine invertebrate as an intermediate host; it is possible that marine spirurids use the same intermediate host as Philometra. Chitwood also stated that mature fertilized female nematodes are probably present in the ovaries. The embryos presumably are released when the fish spawns.

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