

Notes on Larvae, Juveniles, and Spawning of Bonito (*Sarda*) from the Eastern Pacific Ocean

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TWO SPECIES OF BONITO occur along the Pacific coast of the Americas (Hildebrand, 1946).² *Sarda chiliensis* ranges from southern British Columbia to northern Chile; the other species, *S. orientalis*, is found from Baja California to the Galapagos Islands and northern Peru. These species are of considerable importance to both commercial and sport fisheries of certain countries (Walford, 1937; Berdegúe, 1956). The bonito fishery in Peru, especially for *S. chiliensis*, is particularly important. It contributes significantly to the economy, being valuable to the domestic market as well as for export. The following table gives the commercial catches of bonito, expressed in thousands of metric tons, during the past few years:

	OFF PERU	OFF CALIF.	WORLD TOTAL
1950	31.8	0.3	61.6
1951	51.2	0.4	76.9
1952	50.3	1.0	76.1
1953	44.4	1.4	83.8
1954	52.8	1.1	114.4
1955	71.8	0.1	173.1
1956	83.4	0.1	189.9
1957	58.6	0.1	145.5
1958	66.2	2.4	163.5

Despite the commercial importance of bonitos, knowledge of their biology is relatively meager. Little is known of the early life history and spawning, and descriptions of the eggs, larvae, and juveniles of *Sarda* are limited to a few reports. The only descriptions of young

bonitos from the eastern Pacific Ocean are those of *S. chiliensis* by Barnhart (1927) and Orton (1953a, 1953b). Descriptions of eggs and young from other parts of the world seas are limited to the reports listed in Table 1.

The information on spawning of bonito is scant. According to Vildoso (1955), *S. chiliensis* reproduces in Peruvian coastal waters from October to March with the peak of spawning occurring from December to February. From Barnhart's work (1927) it is evident that off La Jolla, California, *S. chiliensis* spawns in June. Walford (1937) stated that in the northern latitudes this species spawns during the late spring and summer close to shore to as far out as 80 mi. Observations on spawning bonito in other parts of the world are limited to the reports on *S. sarda* tabulated below:

AREA	SPAWNING TIME	REFERENCE
Mediterranean..	May-Jun.	Sanzo, 1932
Black Sea.....	Apr.-Aug.	Borcea, 1939, 1933 Vodyanitsky, 1936 Malyatsky, 1940 Numan, 1955
Atlantic, off Morocco..	Jun.-Jul.	Furnestini <i>et al.</i> , 1958
off Dakar.....	Feb.-Mar.	Frade and Postel, 1955
U.S. coast.....	Jul.	Sette, 1943
	Jun.	Bigelow and Schroeder, 1953

During the course of collecting biological material and other scientific data from commercial fishing vessels and research ships operating in waters of the eastern Pacific Ocean, staff members of the South Pacific Fishery Investigations of the U. S. Bureau of Commercial Fisheries, Scripps Institution of Oceanography, and the Inter-American Tropical Tuna Commission have captured a variety of larval and juvenile fish, including young of *Sarda*. The data on the collections of young bonito made by these organizations with some other records, kindly put

¹ Inter-American Tropical Tuna Commission, La Jolla, California. Manuscript received September 26, 1960.

² It is assumed that *S. lineolata* (Girard) = *S. chiliensis* (Cuvier and Valenciennes) and that *S. velox* Meek and Hildebrand = *S. orientalis* (Temminck and Schlegel). *S. chiliensis* and *S. sarda* from the Atlantic Ocean and adjacent seas may be synonymous. A detailed discussion on the relationship of the species of the genus *Sarda* is provided by Godsil (1955).

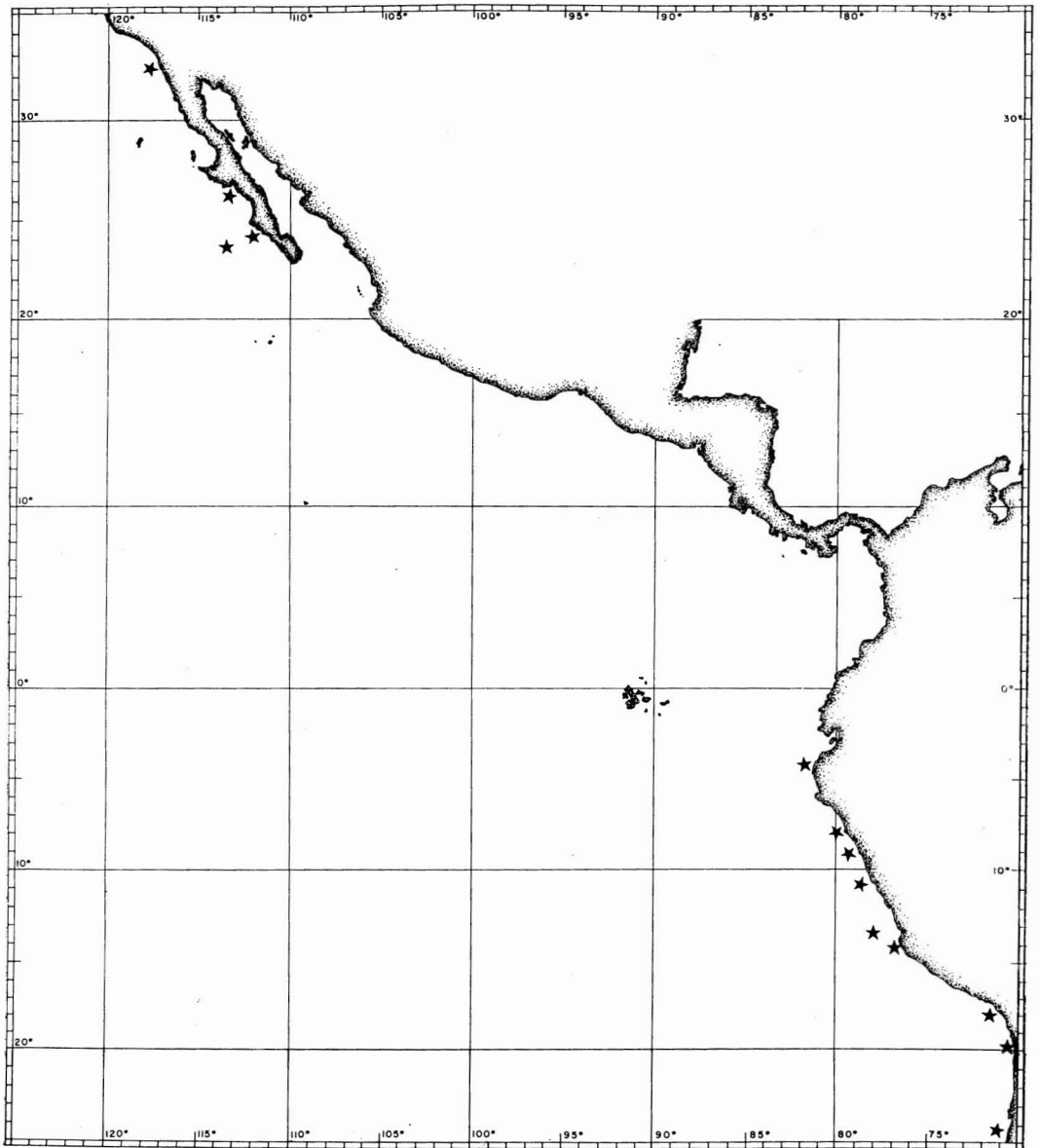


FIG. 1. Localities of capture of young *Sarda* in eastern Pacific Ocean.

at the Commission's disposal, are given in Table 2. The geographical distribution of these catches is shown in Figure 1.

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TABLE 1

SPECIES	MONTH COLLECTED	PLACE	SIZE OR STAGE	REFERENCE
<i>S. sarda</i>	Jun.	Mediterranean	7.2 mm.	Ehrenbaum, 1924
<i>S. sarda</i>	Jul.	Mediterranean	26.5, 32 mm.*	de Buen, 1930
<i>S. sarda</i>	Jun.	Mediterranean	eggs and early larvae	Sanzo, 1932
<i>S. sarda</i>	Jun.	Black Sea	eggs and early larvae	Vodyanitsky, 1936
<i>S. sarda</i>	Mar.	Gulf of Mexico	64, 67 mm.	Klawe and Shimada, 1959
<i>S. sarda</i>	Feb.	Western Atlantic	34 mm.	Klawe, in press
<i>S. orientalis</i>	Apr.	Japan	170 mm.	Kishinouye, 1923
<i>S. orientalis</i>	Sep.	Japan	230 mm.	Kishinouye, 1923

* The 17.5 mm. individual represented by de Buen (1930) in figure 1 and originally identified by him as *Sarda sarda* has 39 vertebrae and was reidentified by him as *Auxis thazard* (de Buen, 1932).

DESCRIPTION AND IDENTIFICATION OF LARVAE AND JUVENILES

Two larvae of total lengths 2.9 and 3.5 mm. captured in a plankton tow off Baja California (Table 2) have been previously identified as those of *Sarda* by Alhstrom. An illustration of the larger specimen is given in Figure 2. These larvae have the usual characteristics of larval scombroid fishes. When the material was compared with Sanzo's (1932) and Vodyanitsky's (1936) descriptions and illustrations of larvae of *S. sarda* hatched in the laboratory, the similarity was obvious, although their specimens were less advanced in development. Sanzo and Vodyanitsky report that their larvae measured about 4.3 mm. However, Sanzo and Vodyanitsky were working with fresh material, while the planktonic larvae caught off Baja California had been preserved in formalin.

Barnhart's (1927) observations concerning larval bonito are based on material hatched in the laboratory from eggs collected in a plankton net off La Jolla, California. One of the striking differences between his description and that of *S. sarda* by Sanzo and Vodyanitsky and that of *S. chiliensis* by Orton (1953a, 1953b) is the absence of melanophores in Barnhart's material. Barnhart credits the newly hatched bonito with a few yellow chromatophores; on the other hand, Sanzo and Vodyanitsky show that in addition to the yellow pigment there are melanophores on the eggs just prior to hatching and the larvae are also provided with numerous melanophores. Barnhart based his description upon material which probably had been preserved in Bouin's solution, which has the property of fading melanine according to Orton (1955).

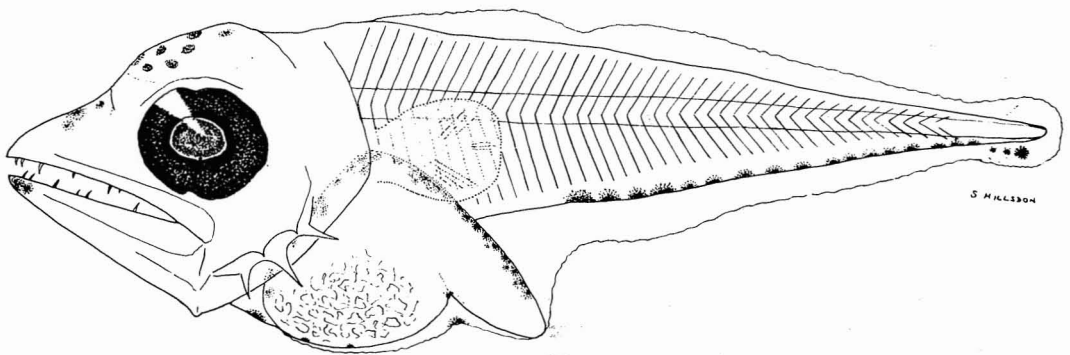


FIG. 2. A 3.5 mm. *Sarda* sp. caught on August 12, 1951, off Baja California.

TABLE 2
RECORDS OF CAPTURE OF DEVELOPING EGGS AND YOUNG *Sarda* FROM THE EASTERN PACIFIC OCEAN

DATE	GENERAL LOCALITY	LATI- TUDE	LONGI- TUDE	HOW CAPTURED	SIZE, ¹ mm.	NO.	SPECIES	REFERENCE OR COLLECTOR
Jun. 30, 1927	off La Jolla, Calif.			plankton net	eggs	?	<i>chiliensis</i>	Barnhart, 1927
May 17-18, 1947	off La Jolla, Calif.			night light, dip net	post-larva	1	<i>chiliensis</i>	Hubbs ²
Feb. 20, 1951	off Pt. Lobos, Peru			?	125-130	3	<i>chiliensis</i>	Vildoso, 1955
Aug. 5, 1951	off Baja Calif., Mexico	25° 35' N.	113° 56' W.	night light, dip net	42	1	<i>chiliensis</i>	Fish & Wildlife Service ³
Aug. 12, 1951	off Ballenas Bay, Baja Calif., Mexico	26° 29.5' N.	113° 29.2' W.	plankton net	2.9, 3.5	2	?	Fish & Wildlife Service ³
Jan. 3, 1956	off Pt. Negra, Peru			bait net	143-164	3	<i>chiliensis</i>	M.V. "Corsair" ⁴
Dec. 10, 1957	Independencia Bay, Peru	14° 14' S.	76° 12' W.	bait net	128	1	<i>chiliensis</i>	B.M. Chatwin & P. Boylan ⁴
Dec. 18, 1957	off Ilo, Peru			bait net	70-135	3	<i>chiliensis</i>	Arnold Neves ⁴
Dec. 31, 1957	off Pt. Pichalo, Chile	19° 35' S.	70° 16' W.	night light, dip net	37	1	<i>chiliensis</i>	B.M. Chatwin & P. Boylan ⁴
Jan. 3, 1958	off Pt. Dos Reyes, Chile	24° 30' S.	70° 49' W.	night light, dip net	39	1	<i>chiliensis</i>	E. Brinton ⁵
Jan. 3, 1958	off Pt. Dos Reyes, Chile	24° 36' S.	71° 01' W.	night light, dip net	36-44	3	<i>chiliensis</i>	E. Brinton ⁵
Jan. 14, 1958	SW off Fraile Pt., Peru	13° 14.8' S.	77° 55.5' W.	night light, dip net	34	1	<i>chiliensis</i>	E. Brinton ⁵
Feb. 1958	off Chimbote, Peru			bait net	89-129	3	<i>chiliensis</i>	Arnold Neves ⁴
May 6, 1958	Almejas Bay, Baja Calif., Mexico			bait net	103	1	<i>chiliensis</i>	M.V. "Lou Jean" ⁴
Feb. 1, 1959	Sama Cove, Peru			bait net	111	1	<i>chiliensis</i>	M.V. "Normandie" ⁴
Mar. 15, 1959	off Ilo, Peru			?	135-160	3	<i>chiliensis</i>	P. Talledo ⁶
Mar. 16, 1959	off Barranca, Peru			?	173, 199	2	<i>chiliensis</i>	Vildoso ⁶

¹ Direct distance from tip of snout to tip of shortest median caudal ray.

² Field-book data of C. L. Hubbs, Scripps Institution of Oceanography, La Jolla, Calif.

³ In the collection of the South Pacific Fishery Investigations of the U.S. Fish and Wildlife Service, La Jolla, Calif.

⁴ In the collection of the Inter-American Tropical Tuna Commission, La Jolla, Calif.

⁵ In the collection of the Scripps Institution of Oceanography, La Jolla, Calif.

⁶ In the collection of the laboratory of Pesca y Caza, Lima, Peru.

The planktonic specimens caught off Baja California have between 43 and 45 myomeres, the actual number being difficult to establish. The mouth is large and contains a set of large teeth. There are three spines along the posterior edge of the preoperculum. The unpaired fins show little development and are still represented

by the median fin fold. The embryonic pectorals can be distinguished but there is no indication of the pelvics. The pigmentation of the head consists of distinct chromatophores over the area of the brain and an aggregation of what appears to be a group of chromatophores at the symphysis of the pectoral girdle. There

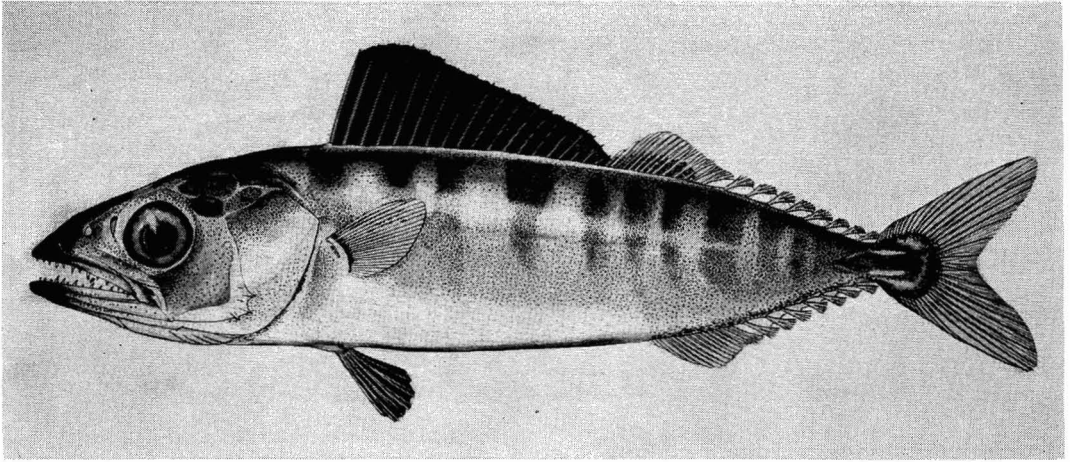


FIG. 3. A 42 mm. *Sarda chiliensis* caught on August 5, 1951, off Baja, California. Drawing by George Mattson of the U. S. Bureau of Commercial Fisheries.

are concentrations of chromatophores in various parts of the peritoneum but especially along its dorsal portion. A series of chromatophores can also be seen along the mid-ventral line extending almost to the tip of the urostyle.

Identification of the two specimens, as to which of the two species they represent (*S. chiliensis* or *S. orientalis*), is impossible without a complete developmental series.

Other specimens of *Sarda* available from the eastern Pacific Ocean are several individuals over 30 mm. in length caught off Chile and Peru and two individuals caught off Baja California. On the basis of gill raker counts (see

next paragraph), all individuals have been identified as *S. chiliensis*. A 43 mm. individual caught off Baja California is illustrated in Figure 3. The general appearance of these juveniles resembles that of *Euthynnus* sp. However, separation between these fishes is possible, as the outline of the first dorsal fin is concave in *Euthynnus* and convex in *Sarda* when the spines are erect. Upon closer examination the two genera can be separated easily, as the meristic counts differ considerably. The densely pigmented pelvic fins shown in Figure 3 are characteristic of small *Sarda*. It is worthwhile to mention that the first dorsal fin in small *S.*

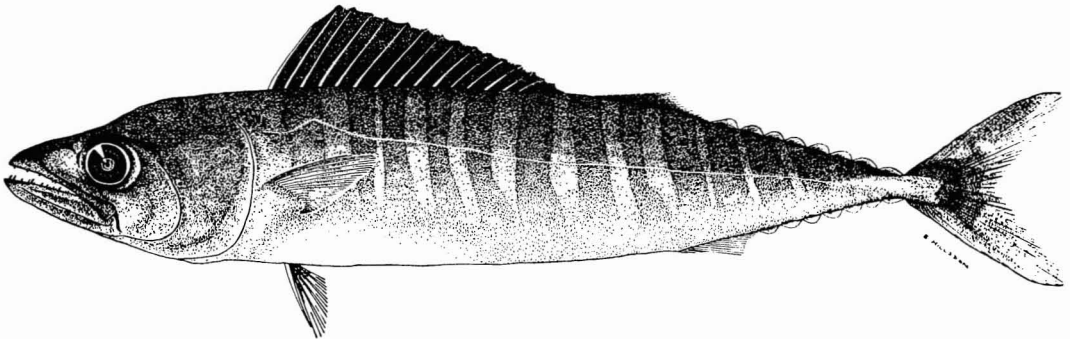


FIG. 4. A 160 mm. *Sarda chiliensis* caught on January 3, 1956, off northern Peru.

chiliensis is either dark with a lighter area in the posterior region of that fin or is uniformly dark. The bodies of all juvenile *S. chiliensis* examined are striped vertically. This also applies to other species of *Sarda* (Kishinouye, 1923; de Buen, 1930; Furnestin *et al.*, 1958; Klawe and Shimada, 1959). A 160 mm. individual of *S. chiliensis* is illustrated in Figure 4. The vertical striations still persist. According to Vildoso (1955), these vertical bars are replaced by oblique markings characteristic of *S. chiliensis* at an approximate length of 320 mm. It should be mentioned that adult *Sarda chiliensis*, when captured, briefly exhibit dusky vertical bands quite like those on preserved juveniles, although not as intense. The body shape of the specimen illustrated in Figure 4 is like that of an adult. The pigmentation of the pelvic fins at this size is confined only to the more basal portion.

As the gill rakers are one of the characteristics used for separating adults of *S. chiliensis* from *S. orientalis*, it is important to establish at what length they develop and at what length the final complement is attained. The gill raker counts for adult fish are 7 to 10 + 12 to 19 for *S. chiliensis*³ and 2 to 3 + 6 to 10 for *S. orientalis*. Some idea can be obtained from the following counts made on several smaller *S. chiliensis* caught off Peru and Chile.

SIZE, mm.	NO. OF GILL RAKERS	SIZE, mm.	NO. OF GILL RAKERS
34	7+1+15	89	7+1+17
36	7+1+15	94	9+1+16
37	4+1+16	106	7+1+15
39	5+1+14	111	8+1+17
41	7+1+15	128	9+1+17
44	7+1+16	129	7+1+15
70	7+1+18	135	7+1+15

CONCLUSIONS

All evidence indicates that spawning of *S. chiliensis* takes place in the warmer season off California, Baja California, Peru, and northern

³ Author examined 25 specimens of *S. chiliensis* caught off San Diego, California, on September 22, 1959, ranging in length from 330 mm. to 380 mm. The gill raker counts for this group of fish were 7 to 9+1+15 to 18.

Chile. It appears that it should be possible to distinguish between juveniles of *S. chiliensis* and *S. orientalis* by means of gill raker counts even at a relatively small size.

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