OBSERVATIONS ON JUVENILE OCEANIC SKIPJACK (*KATSUWONUS PELAMIS*) FROM HAWAIIAN WATERS AND SIERRA MACKEREL (*SCOMBEROMORUS SIERRA*) FROM THE EASTERN PACIFIC

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OBSERVATIONS ON JUVENILE OCEANIC SKIPJACK (*KATSUWONUS PELAMIS*) FROM HAWAIIAN WATERS AND SIERRA MACKEREL (*SCOMBEROMORUS SIERRA*) FROM THE EASTERN PACIFIC

From January to October 1948, the Pacific Exploration Co. operated the motor vessels, *Alaska* and *Oregon*, in exploratory tuna fishing in the waters around and southwest of the Hawaiian Islands. Scientists from the United States Fish and Wildlife Service were aboard these vessels to observe fishing activities and to collect biological and oceanographical data. I was aboard the *Oregon* from July through September 1948.

While operating in Hawaiian waters, seven juvenile *Katsuwonus pelamis* (Linnaeus) 1758 were collected. Six specimens, 113 to 118 mm. in total length,[1] were taken on July 13, from southwest of Oahu near 20°30′ N. latitude, 158°45′ W. longitude, and one specimen, approximately 183 mm. total length, was taken on September 3 off the Kona coast at 19°33′ N., 156°00′ W. The six small specimens were regurgitated by adult *K. pelamis*. The large specimen was removed from the stomach of an adult *K. pelamis*. These were preserved in formaldehyde and later transferred to a 70-percent alcohol solution. All specimens are somewhat damaged by digestion; however, they are easily recognized as scombroids by the body contours and the shape of the head. One specimen, 113 mm. in length, is in better condition than the remaining ones and is depicted in figure 1. The left side is undamaged except for a small area just ventral to the first dorsal fin. The following description is based mainly upon this fish.

Katsuwonus pelamis (Linnaeus) 1758

The belly is unpigmented except for a faint yellowish streak just posterior to the base of the ventral fins. There are no indications of lateral stripes. Pigmentation is concentrated at the level of the pectoral fin, and the whole dorsal surface above the level of the pectoral fin is darkly pigmented. Pigmentation extends beyond and below the caudal peduncle to the base of the caudal rays. The snout, upper and lower jaws, and the head anterior of the nape, are darkly pigmented subcutaneously. The upper posterior portion of the operculum is lightly pigmented. The most anterior dorsal spine is pigmented except at the distal end. There is a row of black spots along the posterior edge of this spine. Pigment is concentrated in the lower two-thirds of the second and third spines and at the base in the fourth and fifth spines. Coloration is lacking in the remainder of the visible spines. The first six rays of the second dorsal bear pigment spots extending about two-thirds of their length. Pigmentation of the dorsal fins differs from the 21-and 44-mm. specimens of *K. pelamis* from Central America, described by Schaefer and Marr (1948), in that in their specimens pigmentation is present in the distal half of the first dorsal and absent in the second dorsal.

A remnant of the corselet is present; presumably, the remainder was disgested. The anterior part of the lateral line is present and curves slightly upward over the pectoral. On the left side, the caudal peduncle has a lateral keel and a small dorsal and ventral keel at the base of the caudal. The right side is digested. The first dorsal has 14 visible spines with the second spine the longest. Space is present for two or three additional spines. Figure 1 is drawn with the two posterior spines reconstructed. Eight dorsal and seven anal finlets are present.

The intestine is straight except for one fold anterior to its origin. This fold is closely applied to the caecal mass. The caecal mass is large and extends the length of the body cavity. The liver is typical of the Katsuwonidae in that its right lobe is slender (Kishinouye 1923). This refers to the lobe on the specimen's right when the observer is looking at the dorsal surface and toward the fish's head. This lobe would be on the left when viewed ventrally, as reported by Schaefer and Marr (op. cit: 194).

The gill arches of this specimen show adult

[1] All lengths in this paper are the distance from the tip of the snout to the tip of the shortest median caudal ray.

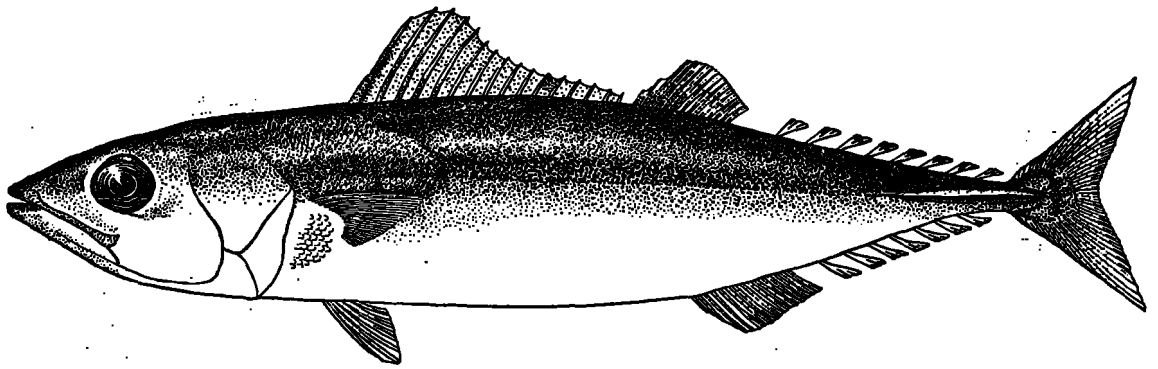

FIGURE 1.—*Katsuwonus pelamis*, 113 mm. long.

characteristics in the shape of the arch and fineness of the gill rakers. There are 16 gill rakers on the upper limb and 40 on the lower.

Four specimens were X-rayed for vertebral counts.[2] In addition, one specimen, approximately 116 mm. in length, was cleared and stained with alizarin dye after the method described by Hollister (1934). The vertebrae in the four X-rayed specimens each total 41 including the urostyle. It was not possible to determine the number of caudal and precaudal vertebrae from the X-ray plates. In the cleared and stained specimen there are 20 precaudal vertebrae. The tail region of this specimen is partially missing so it is not possible to make a total vertebral count. The structure of the vertebral column resembles the description given by Schaefer and Marr (op. cit: 194) of a *K. pelamis* 44 mm. in length, in that the "inferior foramina are large and well developed in precaudal vertebrae 14–20, as well as on the anterior caudal vertebrae." The "complex basket work," mentioned by Godsil and Byers (1944: 42), which is formed from the inferior foramina and haemal arches, is evident.

The characteristics of the vertebral column are sufficient to place these specimens in the Katsuwonidae of Kishinouye. Of the Katsuwonidae, the only species having a total of 41 vertebrae is *K. pelamis*. In addition, these specimens may be further separated from *Euthynnus* by the high gill-raker count. Therefore, classification as *K. pelamis* may be considered definite.

The discovery of these juvenile specimens indicates that *K. pelamis* spawns in the Hawaiian area. Although no juveniles have been previously reported from this area, Hawaiian commercial fishermen state that they have taken oceanic skipjack approximately 300 mm. in length. The discovery of juveniles and observations on maturity of adults has established a spawning area of oceanic skipjack off Central America (Schaefer and Marr 1948). Similar observations and collection of juveniles have established a spawning area in the Marshall Islands (Marr 1948). A paper by Kishinouye (1927) contains a description of a young oceanic skipjack 26 mm. in total length, taken from the stomach of an adult oceanic skipjack on April 14, 1924 near Suwase Jima (28°20′ N., 129° E.). Young fish, 3 to 6 mm. in total length, supposedly skipjack, are also noted. As this paper is not generally available, a translation is included here.[3]

Skipjack (Katsuwonidae): Larvae thought to be those of skipjack, two measuring approximately three millimeters in length, three of approximately four millimeters, and one specimen measuring almost six millimeters without the caudal fin, were recovered from plankton collections made by the Shoyo Maru off Shichito from late May to early June 1924. On the basis of comparisons with juveniles positively known to be skipjack, it is not thought unreasonable to conclude that these specimens are larval skipjack.

Larvae measuring approximately 3 millimeters in length were found among plankton collected southeast of Akuishijima on June 12, 1924. Having hatched only recently, they had just completed absorption of the yolk sac. Numerous melanophores are present about the brain, opercle, and body walls. The anterior body cavity narrows behind the head. The anus opens anterior of the tip of the pectoral fin. Teeth and opercular spines are not yet developed.

The larvae of approximately 4 millimeters in length were captured off Shichito during the summer of 1924. The head is well-developed; large sharp teeth, ten on both right and left sides, are present on the lower and upper jaws. Palatine teeth are absent as yet. Although myotomes are not well-formed posteriorly and their number difficult to determine, it appears as though 41 myotomes are present.

The head of the specimen which measures almost 6 millimeters

[2] These specimens and the *Scomberomorus maculatus* mentioned later were X-rayed through the courtesy of Dr. Dorothy J. Starks of Palo Alto, Calif.

[3] The reference to this paper was provided by Dr. Sidney Shapiro, and the translation was furnished through the courtesy of Bell Shimada, fishery research biologists, Pacific Oceanic Fishery Investigations, U. S. Fish and Wildlife Service.

without the caudal fin is large, and is nearly one-half of the body length. Both, eyes and mouth, are large, the tip of the snout is pointed and the upper jaw protrudes slightly beyond the lower jaw as in the specimens previously described.

Among my research material, the smallest specimen which can be clearly identified as a skipjack measures 26 millimeters in total length and was recovered by Mr. Umemoto on April 14, 1924 from the stomach of a skipjack taken at Gonsone. With the increase in width of the trunk so that it nearly equals the width of the head, the length has also increased; the anus has retreated posteriorly and opens immediately anterior to the anal fin. The fin (TN: no mention of any particular fin) is in line with the central axis of the body and the unpaired fins have also undergone specialization and resemble in form, those of the adults. The opercular spines have degenerated and are no longer conspicuous. The stomach is pointed and having become an elongated sac, occupies nearly the whole length of the body cavity. Pyloric caecae have developed on both anterior and posterior sides of the duodenum. Furthermore, by the presence of a pore in the urohyal there is no doubt that the specimen is the post-larva of a skipjack.

I have been unable to find any other reference to the presence of a pore in the urohyal of the Katsuwonidae. Examination of the urohyal in the specimens at hand revealed this bone to be very thin with a thick ridge at its ventral margin. It is translucent just above the ventral margin. Godsil and Byers (1944:45) noted this same characteristic. As Kishinouye's specimen was in a post-larval stage it is not unlikely that the urohyal was incompletely formed or that the area just above the ventral margin was transparent, thus giving the appearance of a pore.

Scomberomorus sierra (Jordan and Starks) 1895

The sierra mackerel is an excellent food fish found on the Pacific coast of Mexico and Central America. It is taken frequently by sportsmen and is probably abundant enough to support a sizable commercial fishery. However, this species has not been exploited to any degree. According to the California Division of Fish and Game (1935–47) the yearly deliveries to southern California from 1930–47 averaged slightly more than 13,500 pounds. The Atlantic cognate species (*Scomberomorus maculatus*) (Mitchill) 1815, is more extensively exploited. Landings along the South Atlantic States and Gulf States totaled 6,443,200 pounds in 1940 (Anderson and Power 1943). With the present world shortage of animal proteins, it is likely that a more important sierra-mackerel fishery will develop.

Little is known about the biology of the sierra mackerel. It is known to occur from Santa Monica south to the Galapagos Islands and Peru. Walford (1937:25) stated that fish taken in Mexico at the end of March had ripening ovaries and surmised that the spawning season was probably in late spring or summer. The capture of juveniles, which are probably *S. sierra*, tends to confirm this period and also indicates that spawning may take place earlier, perhaps during January or February in more southern waters. Limited spawning of *S. maculatus* has been reported off North Carolina from the latter part of June to nearly the end of August. (Hildebrand and Cable 1938:510). Earll (1882:404) had earlier reported that *S. maculatus* spawned in the Carolinas in April, in Chesapeake Bay in June, and in the vicinity of Long Island during late August to the middle of September.

The sierra mackerel is closely related to the Atlantic spanish mackerel (*S. maculatus*), if not identical with it. (Meek and Hildebrand 1923:325; Walford, 1937:24). The present description is intended to aid in correctly identifying these species when a more complete series of specimens is available.[4]

The following description is based on 12 juveniles ranging from 21 to 71 mm. in length. Eight specimens, 26.5 to 71 mm., were collected on March 24, 1939, from Potrero Grande Bay, Costa Rica, at 10°50′45″ N., 85°48′45″ W.[5] One specimen, 50.5 mm., was collected off Costa Rica (probably in the Gulf of Nicoya) in February 1947.[6] One specimen, 21.5 mm., was collected on September 24, 1948,and two specimens, 21 and 23.25 mm., were collected on September 25 from Ballenas Bay, Baja, Calif., at 26°43′ N., 113°30′ W.[7] All specimens were caught with dip nets at night, under flood lights and were preserved in formaldehyde. They were later transferred to alcohol. Two specimens, 43 and 61 mm., were cleared and stained for a study of skeletal structures. Representative specimens, 21 and 71 mm. total length, are depicted in figures 2 and 3.

As illustrated in figure 2, pigmentation in the smaller specimens is concentrated along the midline, along the bases of the dorsal and anal fins and finlets, on the nape, on the tip of the snout, and on the lower jaw. The brain covering is pigmented subcutaneously. The lateral peritoneum contains conspicuous melanophores. The posterior portion of the opercle contains melanophores, but is not so

[4] The name *Scomberomorus* (Lacépède) 1802, as opposed to *Cybium* (Cuvier) 1829, is used here following the discussion presented by Munro (1943: p. 66).

[5] Furnished through the courtesy of Dr. Rolf L. Bolin, Hopkins Marine Station, Stanford University.

[6] Furnished through the courtesy of M. B. Schaefer, Pacific Oceanic Fishery Investigations, U. S. Fish and Wildlife Service.

[7] Furnished through the courtesy of J. L. McHugh, Scripps Institution of Oceanography.

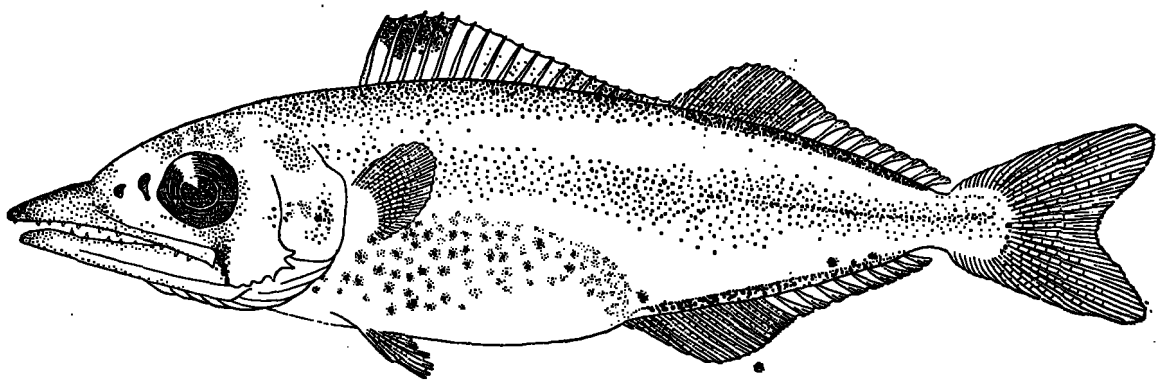

FIGURE 2.—*Scomberomorus sierra*, 21 mm. long.

darkly colored as the peritoneum. The distal half of the first dorsal is pigmented between the first and fifth spines and scattered spots are present along the length of the fin. The 21-mm. fish illustrated in figure 2 has a row of spots slightly above the base of the second dorsal fin. A similar, but lighter colored, row of spots is present just beneath the base of the anal fin. This coloration is not present in my other specimens although the base of the second dorsal is pigmented in fish larger than 39 mm. in total length. The remaining fins are colorless. At a total length of 26.5 mm. the snout and lower jaw are darker. The concentrated areas of pigment along the midline and the bases of the dorsals are spread laterally. The trunk, posterior opercle, and the midline back to the posterior end of the anal are silver. The larger fish, as shown in figure 3, have the snout well-pigmented. The entire dorsal area above the level of the eye is uniformly dark brown. The top of the head is unpigmented except between the orbits. The dark pigmentation extends around the base of the caudal rays. The operculum and the lateral and ventral surfaces are silver. The anterior portion of the first dorsal (third to fifth spines) is black to the base. Spots have increased along the length of the fin so that the distal part to the last five spines is nearly black, but not so dark as the anterior part. The pigmentation extends nearly to the base at the posterior end of the fin. The second dorsal is pigmented from the base to about one-third of its height. The remaining fins are colorless. Except for lateral spots and bars this condition is similar to that found in the adult fish.

The lateral line is first seen in fish of 47 mm. total length. It is clearly visible only from its origin above the pectoral insertion to the region of the seventh dorsal spine. There is a slight upward curve over the pectoral. In a specimen 55 mm. long the lateral line is visible over its entire length. It curves obliquely under the soft dorsal and undulates just below the midline to the caudal peduncle.

In all specimens the body is laterally compressed and the head is prominent. The maxillary extends just posterior to the vertical bisector of the eye. The snout is long and pointed. In smaller fish the upper jaw is hooked and there is a distinct groove at the articulation of the premaxillary. The lower jaw is slightly shorter than the upper in fish up to 47 mm. in total length. The jaws are equal in fish of 55 mm. total length.

The preopercle has six spines in all but the largest specimen. These spines are prominent in specimens of 39 mm. total length. By the time the fish is 55 mm. long the spines are beginning to be overgrown, and at 71 mm. only three blunt spines remain. Hildebrand and Cable (1938:516) reported eight preopercular spines on *S. maculatus* 14 mm. long. These had become overgrown at 22 to 25 mm., so that only two preopercular spines remained and all spines were nearly overgrown at 35 to 40 mm. Ehrenbaum (1924) figured and described an undetermined species of *Scomberomorus* 73 mm. long from the Togo Coast, West Africa. This specimen had five blunt spines remaining on the preopercular margin. Munro (1943) figured two *Scomberomorus* (*Indocybium*) *semifasciatus*, 45 and 58 mm. total length, from Townsville, North Queensland, Australia. Preopercular spines were not indicated on these specimens.

My smallest specimen (21 mm.) has a fin-ray count comparable to that found in the adult. The first dorsal has 19 spines, the second dorsal has 2 spines

plus 13 rays followed by 9 dorsal finlets. The counts for the second dorsal rays and dorsal finlets may be one in error due to difficulty in determining which is the last ray and which is the first finlet. The anal has 2 spines plus 15 rays followed by 9 finlets. These numbers may also be one in error as in the second dorsal and dorsal finlet counts. In this 21-mm. specimen the finlets are joined to one another and to the fin by a membrane which reaches nearly to their distal ends. With increase in size the distal extent of the membrane becomes relatively less, so that at 71 mm. the distal half of the finlets is free. In the 61-mm. stained specimen the fin rays number as follows: First dorsal, 18 spines; second dorsal, 2 spines plus 16 rays and 9 finlets; anal, 2 spines plus 18 rays and 8 finlets; pectoral, 19 rays; ventral, 1 spine plus 6 rays. There is no indication of a lateral keel on fish up to 71 mm. in total length.

Teeth are prominent in all specimens, but relatively more so in the smaller ones. These have about 16 triangular, laterally-compressed teeth on each side of the upper jaw and about 9 on each side of the lower jaw. The 61-mm. specimen which was cleared and stained has 12 prominent teeth on each side of the upper jaw and 10 prominent teeth on each side of the lower jaw. Rudimentary teeth are visible in the dentary and premaxillary. A total of 46 teeth are present in the upper jaw and 31 in the lower jaw. No teeth can be detected on the vomer or palatines, although adults are known to have viliform teeth on both the vomer and palatines. (Jordan and Evermann 1896: 873; Meek and Hildebrand 1923: 321.)

Gill rakers are small and are merely bumps along the arch. Their number is difficult to determine in the small fish. Gill raker counts in the larger specimens are as follows:

Total length in millimeters	*Lower limb*	*Upper limb*
71	7	4
55	8	4
47	8	3
39	8	3
35. 5	5	2

The liver is divided into three lobes. The right lobe is the longest and reaches one-half the length of the abdominal cavity. It is slightly attenuated at its posterior end. The other two lobes are comparatively short and thick. The stomach is large and reaches nearly the full length of the abdominal cavity. It lies above the remaining viscera. The caecal mass extends about one-third the length of the stomach. The right side is slightly extended. The intestine is straight except for one loop just posterior to its origin on the ventral surface of the stomach. Melanophores are present in the peritoneum.

In the 43-mm. fish which was cleared and stained, there are 20+28=48 vertebrae including the urostyle. In the 61-mm. specimen there are 19+28=47 vertebrae including the urostyle. This agrees rather closely with Starks (1910), who reported the vertebral count of a 24-in. *S. sierra* from Mazatlan, Mexico, as 19+29=48, excluding the hypural. Hildebrand and Cable (1938) reported vertebral counts for one specimen of *S. maculatus*, between 60 and 70 mm. long, as 23+30=53, and for another, 35 to 40 mm. as 22+31=53. A *Scomberomorus maculatus*, 167 mm. long, from Santos, Brazil, was X-rayed for a vertebral count [8] which was found to be 19+28=47. The structure of the vertebral column agrees generally with the description given by Starks for *S. sierra*. The first closed haemal arch is on the eleventh abdominal vertebra. Parapophyses

[8] This specimen was examined through the courtesy of Margaret H. Storey Natural History Museum, Stanford University.

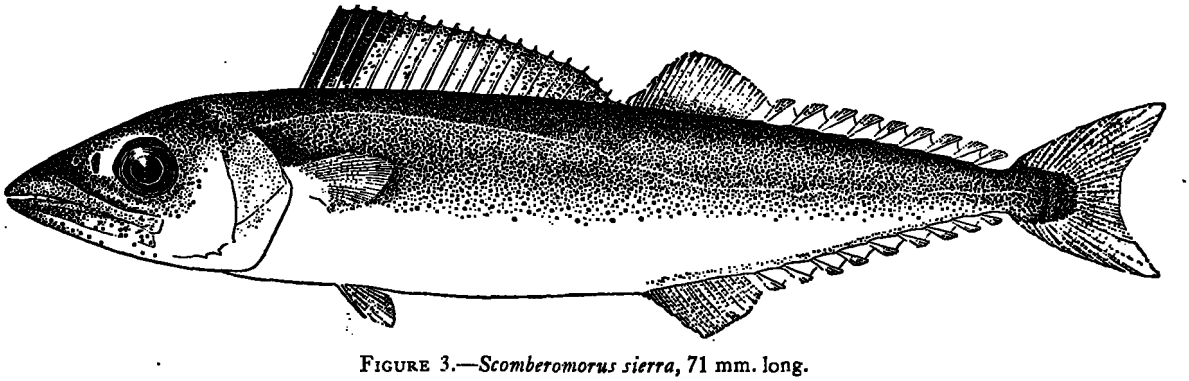

FIGURE 3.—*Scomberomorus sierra*, 71 mm. long.

are first developed on abdominal vertebrae 9 and 10. The haemal arches increase in length from the eleventh to the nineteenth vertebrae, where the first haemal spine appears. The first interhaemal is enlarged at the base and lengthened so that it extends to the base of the first haemal spine. Inferior foramina are developed on the bases of caudal vertebrae 12 to 26. These are small and are barely distinguishable on the more posterior vertebrae.

The specimens described herein may not all be *S. sierra*, as the various species of *Scomberomorus* are closely related and the young may not be separable at early stages. However, due to the rare occurrence of *S. concolor*, the only other species of *Scomberomorus* reported from the Pacific coast of North America, and the number of gill rakers in my larger specimens, it is probable that these specimens are *S. sierra*. A rather complete series of *S. maculatus* from the Atlantic coast of North America was described by Hildebrand and Cable (1938). The above specimens agree rather closely with the descriptions of Hildebrand and Cable for comparable sizes, except in the numbers of vertebrae and preopercular spines.

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