

A Note on the Occurrence of the Gold Spot Herring, *Herklotsichthys quadrimaculatus* (Rüppell) in Hawaii¹

WAYNE J. BALDWIN²

ABSTRACT: The occurrence of the gold spot herring, *Herklotsichthys quadrimaculatus*, is reported for Hawaii from the islands of Oahu, Molokai, and Lanai. This species was first collected in Kaneohe Bay, Oahu, in 1975, and appears to have largely replaced the Marquesan sardine, *Sardinella marquesensis*, introduced to Hawaii in the 1950s. Notes on the separation of the gold spot herring from other Hawaiian clupeids are provided in addition to a comparison of the Hawaiian specimens with specimens of gold spot herring from Red Sea and tropical Pacific localities.

THE IMPORTANCE OF LIVE baitfishes to the Hawaiian skipjack tuna pole-and-line fishery has been well documented (Brock and Takata 1955, Uchida and Sumida 1971, Hester 1974). The primary bait species utilized by this fishery is the *nehu*, *Stolephorus purpureus* Fowler, and Kaneohe Bay, Oahu, is one of the principal capture areas. Since 1975 increasing numbers of small clupeids (family Clupeidae) have been included in the bait catches and subsequently have been used as live bait.

Studies of collections of "sardines" captured in Kaneohe Bay and elsewhere in Hawaii since 1975 indicate that breeding populations of gold spot herring, *Herklotsichthys quadrimaculatus* (Rüppell), are present. The recorded range of this species is from East Africa to Japan and throughout the western Indo-Pacific, but there are no records of it occurring in Hawaii (Wongratana 1980). In the tropical Pacific Ocean the easternmost record south of the equator is Western Samoa and Majuro, Marshall Islands, north of the equator.

Three clupeids occur in Hawaii in addition to the gold spot herring (Gosline and Brock 1960, Murphy 1960): the round herring (*makiawa*), *Etrumeus teres* (DeKay); the sprat

(*piha*), *Spratelloides delicatulus* (Bennett); and the Marquesan sardine, *Sardinella marquesensis* Berry and Whitehead. All are silvery, schooling fishes, less than 25 cm in total length, and with the exception of the gold spot herring all lack distinctive markings. The gold spot herring differs from the other three species by the following combination of characters: fresh specimens with two golden-yellow spots, one above the other on the shoulder immediately posterior to the upper opercular margin; narrow wing-shaped scales present beneath the normal overlapping scales on the back between the head and the dorsal fin; supramaxillary not paddle-shaped but with the ventral margin of the expanded portion notably longer than the dorsal margin; a row of ventral scutes forming a saw-edged midventral ridge between the operculum and the anal fin; anterior transverse grooves of the mid-lateral scales continuous, not interrupted, and with the posterior margin of the scale toothed; number of gill rakers on the lower limb of the first gill arch 26–37; number of dorsal fin rays 17–19.

Prior to the discovery of the gold spot herring it was assumed that all "sardines" in Hawaii were Marquesan sardines introduced to Hawaii from the Marquesas Islands, French Polynesia, between 1955 and 1959, to supplement the limited resources of *nehu* (Murphy 1960, Brock 1960; Randall and Kanayama 1972). The original introductions were made around the island of Oahu; how-

¹ Contribution No. 680, Hawaii Institute of Marine Biology, P.O. Box 1346, Kaneohe, Hawaii 96744. Manuscript accepted 20 December 1983.

² University of Hawaii, Hawaii Institute of Marine Biology, P.O. Box 1346, Kaneohe, Hawaii 96744.

TABLE 1
 COUNTS MADE OF *Herklotsichthys quadrimaculatus*, RED SEA AND PACIFIC OCEAN LOCALITIES

LOCALITY	NO	SL (mm)	DORSAL	ANAL	PECTORAL	GILL RAKERS*	VENTRAL SCUTES†
Oahu							
Kaneohe	20	27-64	19-21	16-19	14-16	10-15 + 26-37	17-18 + 11-13
Kaneohe	8	88-98	18-19	16-18	15-16	13-16 + 33-36	18 + 12-13
Kaaawa	7	81-100	18-21	17-19	15-16	13-17 + 33-37	17-18 + 12-13
Molokai							
Kawela	13	59-86	18-20	17-19	15-16	12-15 + 32-36	16-19 + 10-13
Kaunakakai	9	105-113	18-20	16-19	14-16	14-16 + 34-36	17-18 + 12-13
Lanai							
Manele	2	104-124	18-19	17-19	16	15-17 + 34-36	18 + 11-12
Fiji	10	63-103	17-19	16-20	15-16	14-16 + 32-34	18-19 + 12-13
Palau	6	86-92	18-19	17-19	15-16	14-16 + 31-35	16-18 + 12-14
Palau	4	46-54	18-19	17-20	15-16	12-14 + 30-33	17-18 + 10-13
Palau	8	62-94	18-19	17-18	15-16	13-16 + 31-33	17-18 + 12-13
Palau	1	51	20	17	16	15 + 31	18 + 13
Marshall Is.							
Kwajalein	1	59	19	17	16	16 + 34	18 + 12
Wotje	9	92-111	18-19	17-18	15-16	14-16 + 34-36	17-18 + 12-13
Majuro	3	92-100	18-20	18-20	15-16	16-18 + 35-36	18 + 12-13
Majuro	10	82-110	18-20	17-19	15-16	14-17 + 33-36	17-18 + 12-13
Truk	1	86	19	18	15	16 + 32	17 + 13
Red Sea	10	67-92	17-19	16-19	15-16	14-18 + 34-37	17-19 + 12-14

* Upper gill raker count + lower gill raker count.

† Scutes anterior to origin of pelvic fins + scutes posterior to origin of pelvic fins.

ever, Hida and Morris (1963) noted that the Marquesan sardine eventually spread to most of the major Hawaiian islands. Unfortunately, this species made no significant contribution to the bait catch and seems to have vanished from most parts of Hawaii. The only recent collection of Marquesan sardines available for study consisted of seven adult specimens, 117-132 mm standard length (SL), taken on the island of Kauai (exact locality unknown), 17 April 1982. The most recent known specimens of Marquesan sardines taken from Oahu were collected by seine from the southeast sector of Kaneohe Bay on 27 June 1968.

Thousands of gold spot herring have been captured by Hawaii Institute of Marine Biology (HIMB) personnel around Oahu since 1975, mainly from Kaneohe Bay. Also, specimens were examined that were taken from Kawela and Kaunakakai Harbors, Molokai, 26 April and 7 July 1982, respectively, and from Manele, Lanai, 1 August 1982.

In addition to the Hawaiian specimens of gold spot herring, approximately 600 speci-

mens, 25-121 mm SL, were examined from Red Sea and tropical Pacific localities (Fiji, Solomon Islands, Pohnape, Kosrae, Marshall Islands, Western Samoa). Meristics taken from 122 specimens (Table 1) remain quite constant throughout its range in individuals of a comparable size, but some ontogenetic variation is apparent in the number of gill rakers of specimens < 80 mm SL. The total number of gill rakers on the first gill arch increased from 36 to 50 as size increased from 27 to 73 mm SL. The number of gill rakers showed little change in fish > 80 mm SL and remained constant between 46 and 53.

The biology of the gold spot herring was recently investigated by Williams and Clarke (1983) from study specimens collected by night purse seine in Kaneohe Bay. Additional specimens were obtained from other localities around Oahu by spear, hook and line, beach seine, cast net, and from commercial pole-and-line fishermen. At this time it appears that the Marquesan sardine no longer occurs, at least in sizable numbers, around Oahu and that it has been replaced by

the gold spot herring. In fact, the two species do not appear to coexist anywhere within the tropical Pacific Ocean. As noted by Williams and Clarke, a morphological or ecological difference may exist between the Marquesan sardine and the gold spot herring that gives the latter some advantage over the other in Hawaii.

How and when the gold spot herring first arrived in Hawaiian waters is largely a matter of speculation. It seems unlikely that this species was included in the introductions of Marquesan sardines since there are no records of it occurring in French Polynesia (Randall 1973, Wongratana 1980). Also, no specimens of gold spot herring were identified in the extensive collections of sardines made in the Marquesas Islands between 1954 and 1960 (Nakamura and Wilson 1970). Included in these collections were samples taken of Marquesan sardines when they were introduced into Hawaiian waters. The most likely route for the introduction of the gold spot herring into Hawaiian waters may have been in the live wells of a vessel returning to Hawaii from the Marshall Islands, the nearest area to Hawaii where large populations occur (Hida and Uchiyama 1977).

The similarity in general appearance of the gold spot herring to the Marquesan sardine makes it conceivable that the former species may have gone undetected in areas other than Kaneohe Bay before 1975. It's almost certain the gold spot herring was not in the bay before 1975 because none were taken in the seine collections made throughout the bay between Kualoa Point and Kokokahi during baitfish investigations that began in 1967 (Struhsaker, Baldwin, and Murphy 1975).

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