

## Northernmost record of *Sardinella melanura* (Teleostei: Clupeiformes) from Ibaraki Prefecture, Japan

By

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**Abstract** A single specimen of Blacktip Sardinella, *Sardinella melanura* (Cuvier, 1829), collected from Kashima City, Ibaraki Prefecture, Japan is described in detail. Because the species has previously been recorded only south of Wakayama Prefecture, the present specimen represents the northernmost record of the species.

Key words: fish fauna, distribution, Actinopterygii, Clupeidae, Dorosomatidae

### Introduction

The sardine *Sardinella melanura* (Cuvier, 1829), a clupeiform fish characterized by distinct black spots on the posterior tips of both caudal fin lobes, is widely distributed in the Indo-Pacific, from the eastern coast of Africa to southern Japan, including the northern tip of Australia and French Polynesia. Records of the species in Japanese waters have been limited to prefectures south of and including Wakayama Prefecture, and the Ryukyu Archipelago and Ogasawara Islands (Whitehead 1985; Munroe et al. 1999; Motomura et al. 2001; Aonuma and Yagishita 2013). A single specimen of *S. melanura*, recently collected from the Kashima-nada Sea, Ibaraki Prefecture, by the second author, therefore represents the northernmost record of the species, and is herein described in detail.

### Material and methods

Counts and proportional measurements, expressed as percentages of standard length (SL), followed Stern et al. (2016), and are shown in Tables 1 and 2. All measurements were made with

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digital calipers to the nearest 0.01 mm. Institutional codes follow Sabaj (2020). The synonymy of *Sardinella melanura* (given below) includes only Japanese records of the species.

## Results

### *Sardinella melanura* (Cuvier, 1829)

(Standard Japanese name: Oguro-iwashi)

(Fig. 1)

(This synonym list only treats Japanese records of the species)

*Clupea oguro* Kishinouye, 1911: 384, fig. 2 on pl. XXX (type locality: Futami Harbour, Chichi-jima Island, Ogasawara Islands).

*Sardinella melanura*: Matsubara 1955: 191 (Chichi-jima Island, Ogasawara Islands); Kurata et al. 1971: 20 (Ogasawara Islands); Zama and Fujita 1977: 94 (Ogasawara Islands); Kanno et al. 1980: 123 (Ogasawara Islands); Hayashi et al. 1991: 95, fig. 1 [Haha-jima Island (Oki-ko Port) and Chichi-jima Island (Miyano-hama Beach), Ogasawara Islands]; Aonuma 1993: 205, unnumbered fig. (Chichi-jima Island, Ogasawara Islands); Sato 1997: 92, unnumbered fig. (Iriomote-jima Island, Yaeyama Islands, Ryukyu Archipelago); Aonuma 2000: 245, unnumbered fig. (Chichi-jima Island, Ogasawara Islands); Endo 2001: 150, unnumbered fig. (Iburi, Tosashimizu City, Kochi Prefecture); Motomura et al. 2001: 83, fig. 1 (Meitsu, Nango Town, Miyazaki Prefecture; estuary of Akirikami-gawa River, Tokuno-shima Island, Amami Islands, Ryukyu Archipelago); Sakai et al. 2001: 86 (Ishigaki-jima Island, Yaeyama Islands, Ryukyu Archipelago); Tachihara et al. 2001: 52, table 3-1 [Okinawa-jima Island (estuary of Gesashi-gawa River), Okinawa Islands, and Miyako-jima Island (estuary of Shimajiri-gawa River), Miyako Islands, Ryukyu Archipelago]; Aonuma 2002: 245, unnumbered fig. (Chichi-jima Island, Ogasawara Islands); Yoshigou and Nakamura 2002: 88 (Chichi-jima, Ogasawara Islands and Iriomote-jima Island, Yaeyama Islands, Ryukyu Archipelago); Tachihara et al. 2003: 485, table 1 [Miyako-jima Island (estuary of Shimajiri-gawa River), Miyako Islands and Ishigaki-jima Island (estuary of Urauchi-gawa River), Yaeyama Islands, Ryukyu Archipelago]; Nakane et al. 2005: 61, table 2 (Fukiage-hama Beach, Kagoshima Prefecture); Ogihara 2007: 9, fig. 21 (Uchinoura Bay, Kimotsuki Town, Kagoshima Prefecture); Motomura and Sakurai 2008: 33, fig. 29 (Uchinoura Bay, Kimotsuki Town, Kagoshima Prefecture); Kagoshima City Aquarium Foundation 2008: 51, unnumbered fig. [Minamisatsuma (Akime), Ibusuki (off Kaimon, “Kaiei” Area), and Uchinoura



Figure 1. Specimen of *Sardinella melanura*, NSMT-P 145795, 66.0 mm standard length, Kashima City, Ibaraki Pref., Japan [(A) lateral view of fresh specimen; (B) lateral, (C) dorsal, and (D) ventral views of preserved specimen).

Bay, Kagoshima Prefecture]; Hirata et al. 2010: 21 (Murote, Ainan Town, Ehime Prefecture); Hata and Motomura 2011: 57, fig. 8 (Uchinoura Bay, Kimotsuki Town, Kagoshima Prefecture); Torii et al. 2011: 123, table 3 (estuaries of Bumi-gawa and Oku-gawa rivers, Okinawa-jima Island, Okinawa Islands); Aonuma and Yagishita 2013: 299, unnumbered fig. [Ogasawara Islands, Wakayama Prefecture (Kushimoto Town), Miyazaki Prefecture, Kagoshima Prefecture (Akime, Ibusuki, and Uchinoura Bay), and Ryukyu Archipelago (Tokuno-shima and Iriomote-jima islands)]; Suda et al. 2014: 5 (Fukiage-hama Beach, Kagoshima Prefecture); Sasaki et al. 2014: 16, table 1 (Miyano-hama Beach, Chichi-jima Island, Ogasawara Islands); Yoshigou 2014: 48 [Tokuno-shima Island (Amami Islands), Okinawa-jima Island (Okinawa Islands), Miyako-jima Island (Miyako Islands), Ishigaki-jima and Iriomote-jima islands (Yaeyama Islands), Ryukyu Archipelago]; Ikeda and Nakabo 2015: 300, figs. 1–3 in pl. 43 [Minabe Town (Iwashiro) and

Table 1. Meristics of *Sardinella melanura* from Ibaraki Prefecture, Japan.

	Ibaraki Prefecture, Japan
	NSMT-P 145795
Standard length (mm)	66.0
Dorsal-fin rays (unbranched)	4
Dorsal-fin rays (branched)	13
Dorsal-fin rays (total)	17
Anal-fin rays (unbranched)	3
Anal-fin rays (branched)	17
Anal-fin rays (total)	20
Pectoral-fin rays (unbranched)	1
Pectoral-fin rays (branched)	14
Pectoral-fin rays (total)	15
Pelvic-fin rays (unbranched)	1
Pelvic-fin rays (branched)	7
Gill rakers on 1st gill arch (upper)	20
Gill rakers on 1st gill arch (lower)	36
Gill rakers on 1st gill arch (total)	56
Gill rakers on 2nd gill arch (upper)	19
Gill rakers on 2nd gill arch (lower)	37
Gill rakers on 2nd gill arch (total)	56
Gill rakers on 3rd gill arch (upper)	17
Gill rakers on 3rd gill arch (lower)	27
Gill rakers on 3rd gill arch (total)	44
Gill rakers on 4th gill arch (upper)	11
Gill rakers on 4th gill arch (lower)	18
Gill rakers on 4th gill arch (total)	29
Gill rakers on posterior face of 3rd gill arch	10
Prepelvic scutes	18
Postpelvic scutes	11
Total scutes	29
Scale rows in longitudinal series	38
Pseudobranchial filaments	15
Abdominal vertebrae	24
Caudal vertebrae	18
Total vertebrae	42

Table 2. Morphometrics of *Sardinella melanura* from Ibaraki Prefecture, Japan

	Ibaraki Prefecture, Japan
	NSMT-P 145795
Standard length (mm; SL)	66.0
As % SL	
Head length	26.0
Body depth	27.6
Pre-dorsal-fin length	45.9
Snout tip to pectoral-fin insertion	28.1
Snout tip to pelvic-fin insertion	52.8
Snout tip to anal-fin origin	77.6
Dorsal-fin base length	14.5
Anal-fin base length	16.9
Caudal-peduncle length	8.7
Caudal-peduncle depth	11.3
D–P1	32.3
D–P2	27.3
D–A	38.8
P1–P2	27.0
P2–A	26.4
Pectoral-fin length	18.6
Pelvic-fin length	12.4
Postorbital length	11.5
Maxilla length	10.8
Lower-jaw length	13.1

Abbreviations: D–P1 (distance from dorsal-fin origin to pectoral-fin insertion); D–P2 (distance from dorsal-fin origin to pelvic-fin insertion); D–A (distance between origins of dorsal and anal fins); P1–P2 (distance between insertions of pectoral and pelvic fins); P2–A (distance from pelvic-fin insertion to anal-fin origin).

Tanabe Bay, Wakayama Prefecture]; Hata et al. 2016: 27, fig. 1 (Tanega-shima Island, Osumi Islands, Ryukyu Archipelago); Iwatsuki et al. 2017: 30, table 1 (Hyuga-nada Sea, eastern coast of Kyushu); Hata 2017: 39, unnumbered fig. (Kagoshima Bay, Kagoshima Prefecture); Nakae et al. 2018: 215 (Uchiumi Bay, Amami-oshima Island, Amami Islands, Ryukyu Archipelago); Hata 2018: 76, unnumbered figs. (Uchinoura Bay, Kimotsuki Town, Kagoshima Prefecture); Kobayashi 2019: 66, unnumbered fig. (Kadogawa Bay, Nobeoka City, Miyazaki Prefecture);

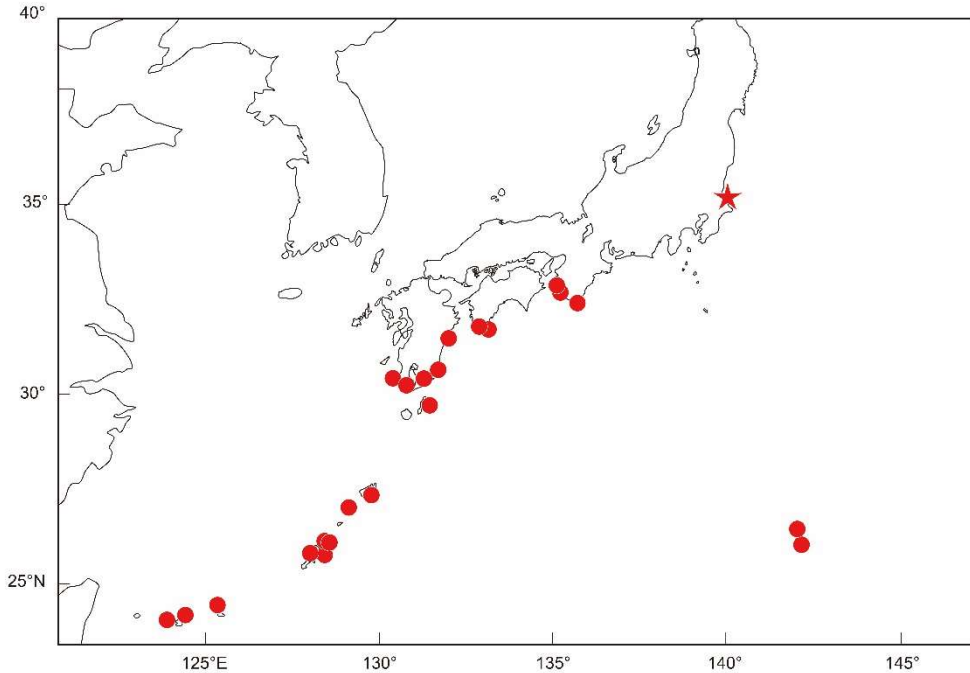


Figure 2. Distributional records of *Sardinella melanura* in Japanese waters. Star and circles represent localities of the specimen examined in this study, and previously published records, respectively.

Mitsui et al. 2020: 509, fig. 2i (otolith morphology; Kadogawa Bay, Nobeoka City, Miyazaki Prefecture); Hata 2020: 86, unnumbered figs. (Uchinoura Bay, Kimotsuki Town, Kagoshima Prefecture); Hata and Motomura 2021a: 395, fig. 4 (Tudumari-hama Beach, Iriomote-jima Island, Yaeyama Islands, Ryukyu Archipelago); Kobayashi 2021: 84, unnumbered fig. (Kadogawa Bay, Nobeoka City, Miyazaki Prefecture); Hata and Koeda 2022: 41, fig. 3C (estuary of Yofuke-gawa River, Okinawa-jima Island, Okinawa Islands, Ryukyu Archipelago).

**Material examined** NSMT-P 145795, 66.0 mm SL, sandy beach next to Kashima Fishing Port, Kashima City, Ibaraki Pref., Japan (sandy bottom), approx. 1m depth, 25 Oct. 2020, casting net, coll. K. Kanou.

**Description** Counts and measurements, expressed as percentages of SL, are given in Table 1. Body oblong, strongly compressed, deepest at dorsal-fin origin. Dorsal contour gradually rising from snout tip to dorsal-fin origin, subsequently lowering to upper margin of caudal-fin base. Ventral margin from lower-jaw tip to lower margin of caudal-fin base a broad convex parabolic curve with pelvic-fin insertion at midpoint. Abdomen covered with 29 prominently keeled scutes

from isthmus to anus. Pectoral-fin insertion anterior to posterior margin of opercle, below level of eye lower margin. Upper, lower, and posterior margins of pectoral fin nearly straight. Posterior tip of pectoral fin pointed, not reaching pelvic-fin insertion. Dorsalmost ray of pectoral fin unbranched, all other rays branched. Dorsal-fin origin slightly forward of body mid-point. Dorsal fin triangular, its contour rising from fin origin to fourth fin-ray tip, thereafter lowering to last-fin ray tip. Dorsal-fin first ray minute, located closely to second ray; anterior four rays unbranched, remainder branched; posteriormost ray not filamentous. Pelvic-fin insertion just below origin of seventh dorsal-fin ray. Pelvic fin triangular, its outer margin lowering from fin insertion to second fin-ray tip, subsequently rising to last fin-ray tip. Anterior and posterior margins of pelvic fin nearly straight. Posterior tip of depressed pelvic fin pointed, not reaching anus. Anteriormost ray of pelvic fin unbranched, other rays branched. Anal fin originating just behind anus. Anterior and posterior margins of anal fin nearly straight, ventral margin slightly concave. Anterior three rays of anal fin unbranched, other rays branched; last two rays slightly enlarged. Caudal fin forked, upper and lower margins straight. Posterior tips of both lobes of caudal fin rounded. Anus oval, horizontal axis longest. Mouth terminal, small, posterior tip of maxilla extending slightly beyond anterior margin of pupil, but not to anterior margin of iris. Tips of both jaws pointed, lower-jaw tip projecting slightly beyond snout tip. Teeth absent on jaws, palatal region, and tongue. Two supramaxillae, first elongated longitudinally; second paddle-shaped, anteriorly elongated longitudinally, posteriorly compressed laterally, deep and vertically symmetrical. Hypo-maxilla absent. Posterior ramus of lower jaw elevated. Orbit elliptical, horizontal axis longest. Eye positioned laterally on head, visible in dorsal view. Dorsal margin of eye above horizontal level of snout tip. Eye round, posterior part covered with adipose eyelid. Pupil round. Interorbital space flat. Nostrils close to each other, anterior to orbit, vertically elongate. Numerous bony striae on parietal region. Opercle smooth, without bony striae. Posterior margins of preopercle, subopercle and opercle convex, rounded, without serrations. Pseudobranchial filaments present on inner surface of opercle, exposed. Two fleshy outgrowths on posterior margin of gill opening; a single large papilla on ventral margin. Gill rakers long, slender, with numerous asperities on anterior and posterior faces. Gill filaments longer than corresponding gill rakers. Scales cycloid, thin, deciduous, those on lateral body surface with several centrally discontinuous vertical striae. No pores or longitudinal striae on scales. Longitudinally elongated sheath-like scales on bases of dorsal and anal fins. Predorsal scales paired. No elongate wing-like scales present beneath normal paired scales. Scales absent on head and fins, except a broad triangular sheath of scales on caudal fin.

Coloration of fresh specimen—Body uniformly silver, upper part electric green. Dorsum light brown. Two indistinct longitudinal dark lines on mid lateral surface of body. Lateral surface of head uniformly silver. Dorsum anterior to eye semi-translucent. Fin rays and fin membrane of pectoral, pelvic, dorsal, and anal fins white and translucent, respectively. Melanophores scattered along dorsal-fin rays. No spot on dorsal-fin origin. Posterior tips of both lobes of caudal fin jet black, immediately preceding areas white. Melanophores scattered along caudal fin rays. Pupil black, iris silver.

Coloration of preserved specimen—Body uniformly pale, light ivory. Dorsum dark. Melanophores densely scattered on upper lateral surface of body above a single longitudinal row of tiny black spots on mid lateral surface. Melanophores absent on pectoral, pelvic, and anal fins, but scattered along all fin rays of dorsal and caudal fins. Posterior tips of both caudal fin lobes brown, preceding areas faded, indistinct. Melanophores scattered on maxilla, around eye, preopercle, and dorsal surface of lower jaw tip. Dorsal surface of tongue and entire ventral surface of lower jaw dark. Melanophores absent on mouth roof, but several dark spots around palatines. Melanophores scattered on each of first to fourth gill arches, but not on gill rakers or gill filaments. Melanophores densely scattered on inner surface of opercle, absent on pseudobranchial filaments.

**Distribution** *Sardinella melanura* is widely distributed in the Indo-Pacific region from the eastern coast of Africa to Japan, including the northern coast of Australia and Tahiti, but has not been recorded from the Red Sea, Persian Gulf, or Bay of Bengal (Whitehead 1985; Munroe et al. 1999; Motomura et al. 2001; Randall 2005; Aonuma and Yagishita 2013; Hata et al. 2022; Anderson 2022). In Japanese waters, the species has been reported from the Ogasawara Islands, Wakayama, Ehime, Kochi, Miyazaki and Kagoshima prefectures, and the entire Ryukyu Archipelago (from Osumi Islands to Yaeyama Islands). It is here newly recorded from Ibaraki Prefecture (see synonym list; Fig. 2).

**Identification** The specimen collected from Ibaraki Prefecture was assignable to the genus *Sardinella*, as defined by Whitehead (1985) and Munroe et al. (1999), having prominently keeled scutes on the abdomen, paired predorsal scales, a symmetrical second supramaxilla, the anal fin with two posteriormost fin rays enlarged, gill opening with two fleshy outgrowths on the posterior margin, and absence of a hypo-maxilla. Furthermore, it conformed to *S. melanura*, having the following combination of characters that closely matched the diagnostic features given by Whitehead (1985), Munroe et al. (1999), Hata and Motomura (2021a), and Hata and Koeda



(2022): jet black blotches on posterior tips of both caudal fin lobes; no black spots on dorsal-fin origin; striae on lateral body scales interrupted centrally; no pores or longitudinal striae posteriorly on body scales; pelvic fin with eight rays. Within the genus *Sardinella*, four species, *Sardinella atricauda* (Günther, 1868), *Sardinella electra* Hata & Motomura, 2019, *Sardinella hualiensis* (Chu & Tsai, 1958), and *S. melanura*, are known to have black spots on the posterior tips of the caudal fin (Whitehead 1985; Munroe et al. 1999; Stern et al. 2016, 2017; Hata and Motomura 2019a–d, 2021a, b). However, *S. melanura* can be easily distinguished from *S. electra* and *S. hualiensis* by lacking a black spot on the dorsal-fin origin (vs. a distinct black spot present in both of the latter). The former differs from *S. atricauda* in having the body scales lacking pores and longitudinal striae (vs. numerous small pores and longitudinal striae posteriorly on the scales in the latter) (Whitehead 1985; Munroe et al. 1999; Hata and Motomura 2019a). Lower gill rakers on the first gill arch of the present specimen numbered 36, slightly lower than given for *S. melanura* by Whitehead (1985) and Munroe et al. (1999) (38–74), and Hata et al. (2016) (41–43). However, the present specimen (66.0 mm SL) was smaller than specimens reported by Hata et al. (2016) (81.1–112.7 mm), and because gill raker numbers in clupeiform fishes tend to increase with growth (Kinoshita 1977; Uotani 1984; Whitehead 1985; Whitehead et al. 1988; Munroe et al. 1999; Ishimori et al. 2013), the minor difference is regarded as intraspecific variation due to ontogenetic change.

**Remarks** As detailed by Hata et al. (2016) and summarized in Fig. 2 and the Japanese synonymy list, *S. melanura* has been recorded from the Pacific coast from Wakayama Prefecture to southern Kyushu, and the Ryukyu Archipelago and Ogasawara Islands. An additional Japanese record (not in the aforementioned list) was reported by Kaburagi (2016), who provided a photograph of *S. melanura* from Tanega-shima Island, captioned as “Oguro-iwashi” (standard Japanese name for *S. melanura*). Although Shimose (2021) referred to a photograph of a fish caught off the Yaeyama Islands as *S. melanura*, the photographed individual was identified here as *S. electra*, characterized by a black spot on the dorsal-fin origin (spot on dorsal-fin origin absent in *S. melanura*; Hata and Motomura 2019a). Incidentally, specimens collected from Ambon, Molucca Islands, Indonesia (MUFS 13619–13628, URM-P 34919–34920, 34922), reported as *S. melanura* by Motomura et al. (2001), were re-identified here as *S. atricauda*. Because the previous northernmost limit of the species’ distributional range was believed to be Minabe Town, Wakayama Prefecture (Ikeda and Nakabo 2015), the present specimen, the first record of *S. melanura* from Ibaraki Prefecture, has extended the northern limit by about two

degrees of latitude. Because *S. melanura* has at no time been recorded in ichthyofaunal studies of Ibaraki Prefecture (e.g., Asano et al. 1955; Asano 1956; Funabashi 1998; IMARS 2001, 2004, 2007), the occurrence of the species is thought to be extremely rare. Additionally, although *S. melanura* is known to school in coastal waters (Whitehead 1985; Munroe et al. 1999; Aonuma and Yagishita 2013), the present specimen was a solitary individual, indicating that reproduction of the species in Ibaraki Prefecture or neighboring waters is unlikely. As pointed out by previous studies, a warm water mass or warm water tongue originating from the Kuroshio Current sometimes extends into coastal waters off Ibaraki Prefecture (Kubo 1982, 1988; Kubo and Tomosada 1982; Kubo and Shimizu 1990). Because *S. melanura* is abundant off southern Kyushu (Iwatsuki et al. 2017; Kobayashi 2019, 2021), the occurrence of the species off Ibaraki Prefecture was likely a result of transportation from southern Japan by the Kuroshio Current. Previous Japanese distributional records of *S. melanura* indicated that the species occurs along the course of the Kuroshio Current in Japan (Fig. 2), and the likelihood that the species will be found in other areas located along the current path, such as Sagami Bay and Shizuoka Prefecture, is thought to be high. In recent years, many tropical fish species have been collected and/or reported from Ibaraki Prefecture. [e.g., *Moolgarda engeli* (Bleeker, 1858), *Decapterus macarellus* (Cuvier, 1833), *Chaetodon ephippium* Cuvier, 1831, *Eleotris fusca* (Bloch and Schneider, 1801), *Redigobius bikolanus* (Herre, 1927), and *Arothron mappa* (Lesson, 1831); Ibaraki Shimbun (2013); Oomori and Toyama (2020); Toyama et al. (2021a, b); Kobayashi et al. (2022); Munakata et al. (2022)]. Because Asano (1955) reported specimens of *Elops hawaiiensis* Regan, 1909 [collected from Kitaura Lake (southern Ibaraki Pref.) in 1943], *Megalops cyprinoides* (Broussonet, 1782) [from Nakaminato City (central Ibaraki Pref.) in 1950], and *Balistoides conspicillum* (Bloch & Schneider 1801) [from Oarai Beach (central Ibaraki Pref.) in 1947], and Koeda (2022) reported a specimen of *Chaetodon lineolatus* Cuvier, 1831 collected from southern Fukushima Prefecture (adjoining northern Ibaraki Pref.) in 1932, numerous tropical fish species have clearly occurred in waters off Ibaraki Prefecture and adjacent areas following transportation by the Kuroshio Current. In fact, in waters off eastern Kanto (including coastal waters off Ibaraki Pref.), seawater temperatures have risen by approx. 0.91°C during the period from 1906 to 2021 (Japan Meteorological Agency 2022). Therefore, it is likely that the survivability of tropical fishes in the aforementioned coastal waters has increased over the years, with future reports of tropical fishes in these waters likely to increase.

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