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Article

Deep-Sea Fish Fauna on the Seamounts of Southern Japan with Taxonomic Notes on the Observed Species

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Abstract: Several volcanic islands and submarine volcanoes exist in the sea connecting the Izu-Bonin Islands with the Mariana Islands, with trenches and islands formed by the submergence of the Pacific Plate under the Philippine Sea Plate. Although designated as a Marine Protected Area (MPA) in December 2020, the seamounts' biodiversity has not been sufficiently researched. Therefore, direct observations and specimen sampling were conducted on four seamounts in this area using a remotely operated vehicle (ROV), autonomous underwater vehicle (AUV), and baited cameras (BCs). The ROV survey was conducted for 2–4 days on each seamount and divided into shallow and deep areas. During the expedition, 20 orders and 51 families of 81 deep-sea fish species were observed, including several potentially undescribed species, new genus or species records from Japanese waters, new depth records, new ecological information, and several rare fishes. The fish fauna and biodiversity abundance clearly differed among the seamounts; the seamount with a hydrothermal vent had the lowest diversity among the four seamounts. In shallow water, 23, 7, and 12 species were recorded only by ROV, AUV, and BC, respectively, indicating that combining these methods is beneficial for understanding the fish fauna of seamounts.

Keywords: remotely operated vehicle; autonomous underwater vehicle; baited camera; marine protected area; biodiversity; elasmobranch; benthos; habitat

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1. Introduction

The total area of territorial waters and the exclusive economic zone (EEZ) of Japan is approximately 12 times larger than its national land area. Although several research expeditions have targeted the trenches around Japan [1–3], only a few studies have focused on the fishes on Japanese seamounts. Okamura et al. [4] conducted one of the largest expeditions targeted at the seamounts in Japan and reported on the fish fauna of the Kyushu-Palau Ridge, which is located south of the Hyuga Sea, from southeastern Kyushu to Palau. They recorded 239 fish species from 92 families collected using a bottom trawl net and included midwater and pelagic fishes. However, exhaustive fish faunal research has not been conducted since then.

The sea expanse connecting the Izu-Bonin Islands to the Mariana Islands contains several volcanic islands, submarine volcanoes, and seamounts collectively called the Izu-Bonin-Mariana (IBM) arc system. The IBM arc system extends over 2800 km south from Tokyo, Japan, to beyond Guam and was formed by the subduction of the Pacific Plate beneath the Philippine Sea Plate. Although few expeditions have focused on the biodiversity of these seamounts, most of them were conducted on seamounts with hydrothermal vents [5]. Despite the lack of detailed information on their biodiversity, especially on fish fauna, the Nishi-Shichito Ridge and Central and Western Mariana ridges in the area were designated as a marine protected area (MPA), and were cataloged as Offshore Seabed Nature Conservation Areas under a newly enacted law in December 2020 [6,7] (Figure 1), owing to their specific environmental and geographical conditions. MPAs to conserve offshore areas were designated by considering ecosystem approaches, such as securing appropriate spatial coverage, appropriate balance between protection and use/exploitation, and included all types of ecosystems in either of the protected areas, which target seamounts, hydrothermal vents, submarine trenches, etc., based on Japanese Ecologically or Biologically Significant Marine Areas. The MPA of the Nishi-Shichito Ridge, 60 km in width, extends from the Izu Peninsula (33°00′ N) to ca. 170 km south (27°00′ N), covering an area of 36,576 km^2 [6]. The MPA of the central and western Mariana ridges extends from off Minami Iwo Jima Island (24°09′ N) to ca. 280 km southeast (22°30′) and ca. 380 km south (21°01′ N), respectively, covering a total area of 63,281 km^2 [7].

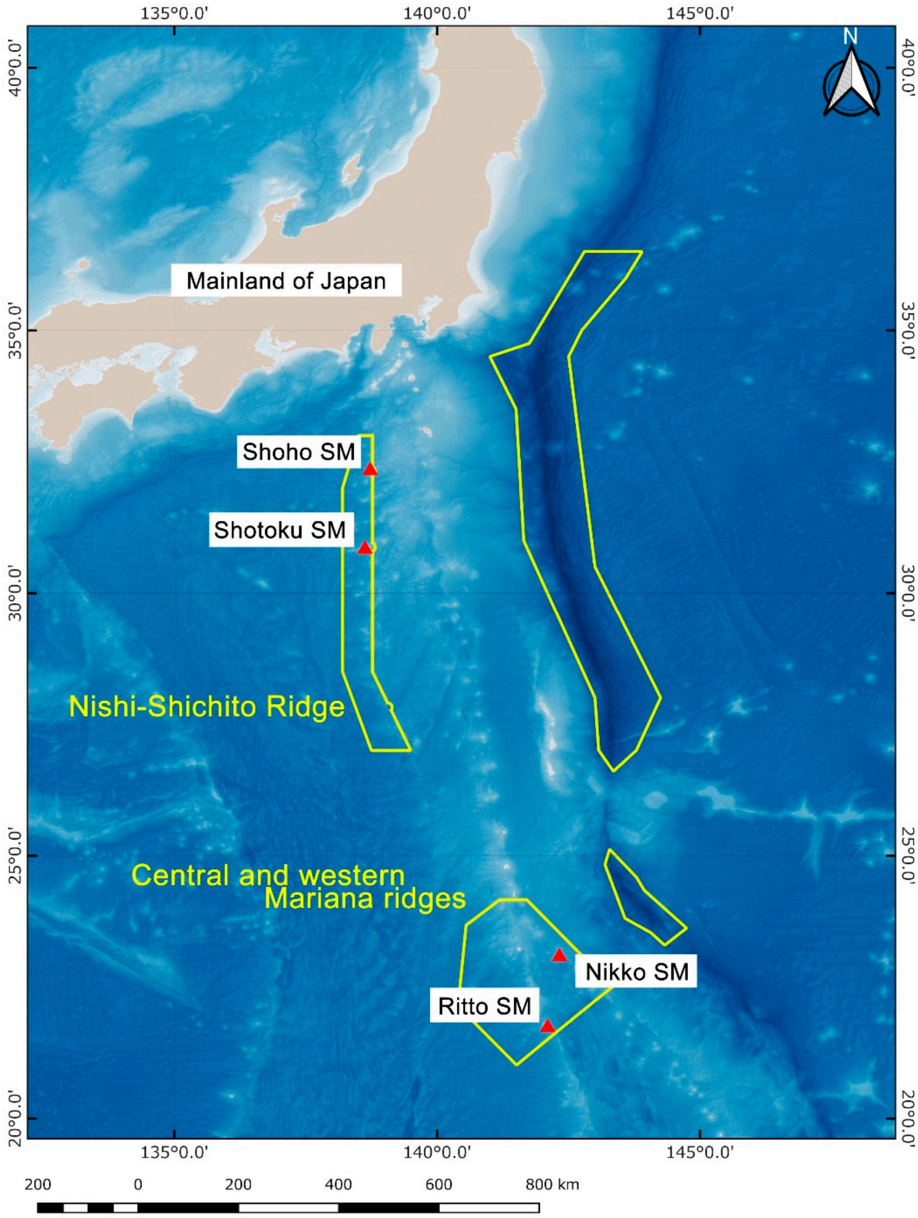

Figure 1. Map of the four seamounts (SM) researched in the present study. Yellow areas indicate marine protected areas.

Although the MPAs were designated to protect the biodiversity of these areas, baseline scientific information on the biodiversity of deep-sea offshore area ecosystems, especially on seamounts in the IBM arc system, is still insufficient for appropriate management. Therefore, in this study, direct observations and specimen sampling expeditions were performed at four seamounts in the area using a remotely operated vehicle (ROV), autonomous underwater vehicle (AUV), and baited camera (BCs) operated from aboard the Research Vessel (R/V) *Kaimei*.

2. Materials and Methods

2.1. Study Area

The expeditions were conducted on four seamounts located in the MPAs of the IBM arc system. Among the four seamounts, Shoho and Shotoku are located on the Nishi-Shichito Ridge, Ritto on the western Mariana Ridge, and Nikko on the central Mariana Ridge (Figure 1). The location and physical environment of each seamount are shown in Table 1. The target depth zone was separated into shallow (around 300–700 m, depending on the top of the seamount) and deep (around 2000 m) zones.

Table 1. Information of the seamounts, research periods, and numbers and total hours of ROV operation.

Name of Seamounts	Latitude	Longitude	Depth Range (m)	Hydrothermal Vent	Research Period	ROV Operation (h)	
						Shallow	Deep
Shoho	32°09′ N–32°29′ N	138°34′ E–138°54′ E	375–3300	Absent	27–30 Nov. 2020	3 (11.6)	1 (5.3)
Shotoku	30°37′ N–30°57′ N	138°23′ E–138°43′ E	270–3750	Absent	1–2 Dec. 2020	3 (7.7)	0 (0)
Ritto	21°37′ N–21°57′ N	141°53′ E–142°13′ E	504–3300	Absent	5–8 Dec. 2020	3 (11.8)	1 (4.8)
Nikko	22°53′ N–23°13′ N	142°10′ E–142°30′ E	392–3300	Present	9–11 Dec. 2020	2 (7.8)	1 (3.3)

2.2. Observation and Collection Methods

The cruise to study the four seamounts was undertaken at the end of 2020 (November 25 to December 12) using *R/V Kaimei*, a research vessel belonging to the Japan Agency for Marine-Earth Science and Technology (JAMSTEC, Kanagawa, Japan). A remotely operated vehicle (ROV: *KM-ROV*, length 3.6 m; width 3.2 m; height 2.3 m), operated by JAMSTEC, was employed to strategically sample key megabenthos at seven dive sites (comprising 14 dives of total 52.2 h; Table 1) and record video imagery during each dive. Continuous video footage was captured automatically throughout each dive, and additional still photographs were shot manually, as required. However, a deep zone survey could not be conducted on the Shotoku Seamount. Specimens were collected using a slurp-gun with a suction opening on the left manipulator and stored in a canister during the dives. Tissue samples were collected immediately and preserved in 99% ethanol. The fins of the fish specimens were extended, and fresh color photographs were shot in seawater. Specimens were preserved in 10% formalin, which was later replaced with 70% ethanol. Specimens collected during the cruise were deposited at JAMSTEC.

The autonomous underwater vehicle (AUV) *Youzan* was operated by IDEA Consultants, Inc. (Tokyo, Japan). Continuous video footage and still photographs were captured automatically at four-sec intervals throughout each dive. The AUV survey could not be conducted on the Shoho Seamount.

The two baited cameras (BCs) belonging to JAMSTEC were allowed to free fall from *R/V Kaimei* to a depth of around 300–700 m during the nighttime and were recovered by the *KM-ROV*. One kilogram of mackerel was placed in the bait cage, fixed in front of the camera, and continuous video footage was captured for 11 h. Only one BC was placed on the Nikko Seamount.

2.3. Species List

Scientific names and taxonomical attributions generally followed Nakabo [8], with a few modifications according to recent published or unpublished taxonomic studies. Authorship and published year followed the Eschmeyer's Catalog of Fishes [9]. Species in the same families were arranged alphabetically by species name. Standard Japanese names generally followed Motomura [10] and were arranged in Japanese "katakana".

Taxonomic notes on the remarkable species observed in the expedition are listed in taxonomic order. The distribution information of the species in the taxonomic notes generally followed Nakabo [8] and Motomura [9], with recently published taxonomic studies mentioned in the notes.

3. Results and Discussions

The species list of observed and collected fishes is shown in Table 2. The captured or photographed specimens for each species, except for a few with unclear photos, are shown in Figures 2–9. The presence of a total of 82 fish species belonging to 51 families in 20 orders was confirmed around the four seamounts based on observations for a combined time of 138.4 h (ROV 52.2 h; AUV 9.2 h; BC 77 h) during the expedition. Among the total species observed, 71 species from 45 families were recorded in the shallow zone, which displayed a higher diversity than the deep zone and revealed 11 species from nine families. Comparison among the seamounts indicated that the Ritto Seamount had the highest species diversity, with 35 species from 28 families; the Shotoku Seamount followed closely with 30 species from 22 families in the shallow zone. The species diversity was lower at the Shoho and Nikko Seamounts (13 species from 12 families and 14 species from 12 families, respectively) than at the other two seamounts. Because of the very few fish faunal studies on each seamount to date, all the observed species in each area in this expedition, except for *Symphurus thermophilus* (Cynoglossidae; Figure 8J), which is known as a species of hydrothermal vent ecology [11], were identified for the first time.

Although Scorpaenidae was the most speciose family in the expedition (six species), its members did not appear to be abundant on any seamount except *Idiastion pacificum* Ishida and Amaoka 1992 (Figure 6B), which was commonly observed on the Ritto Seamount. Serranidae was the second most speciose family (five species); however, it was only recorded on the Shotoku Seamount, except for an unidentified species (*Plectranthias* sp.; Figure 7A) observed on the Shoho Seamount. Moridae, with four species, was the third most speciose family. From this family, *Physiculus japonicus* Hilgendorf 1879 (Figure 4H) was commonly observed on the Shoho and Shotoku Seamounts but not recorded on the other two seamounts. On the other hand, *Laemonema robustum* Johnson 1862 (Figure 4G), *Physiculus rhodopinnis* Okamura 1982 (Figure 4I), and *Physiculus yoshidae* Okamura 1982 (Figure 4J) were recorded (the former two were abundant) on the Ritto and Nikko Seamounts, but not on the other two seamounts.

Species composition on the four seamounts was distinct between the Nishi-Shichito and Mariana Ridges (Table 3). Of the total fish species recorded on the Shoho Seamount, 46.2% overlapped with those on the Shotoku Seamount, but only 30.8% and 15.4% with those on the Ritto and Nikko Seamounts, respectively. Similarly, 78.6% of the fish species recorded on the Nikko Seamount overlapped with those on the Ritto Seamount, but 14.3% with those on the other two seamounts.

Table 2. Checklist of deep-sea fishes observed or collected from shallow zone (S) or deep zone (D) of four seamounts (SM) in IBM arc system. Observed method: R, ROV; A, AUV; B, BC. Asterisk (*), specimen(s) collected.

Taxon	Standard Japanese Name	Figure	Nishi-Shichito Ridge				Central and Western Mariana Ridges			
			Shoho SM		Shotoku SM		Ritto SM		Nikko SM	
			S	D	S	D	S	D	S	D
Carcharhiniformes										
Pseudotriakidae										
Pseudotriakis microdon de Brito Capello 1868	Chihirozame	Figure 2A					B			
Lamniformes										
Pentanchidae										
Galeus sauteri (Jordan & Richardson 1909)	Taiwan-yamorizame	Figure 2B					R/A/B			
Hexanchiformes										
Hexanchidae										
Hexanchus griseus (Bonnaterre 1788)	Kagurazame	Figure 2C			B		B			
Squaliformes										
Squalidae										
Squalus mitsukurii Jordan & Snyder 1903	Futo-tsunozame	Figure 2D	R/B		R/B		R/B			
Squalus sp.		Figure 2E					B			
Etmopteridae										
Etmopterus lucifer Jordan & Snyder 1902	Fujikujira	Figure 2F					B			

Table 2. *Cont.*

Taxon	Standard Japanese Name	Figure	Nishi-Shichito Ridge				Central and Western Mariana Ridges			
			Shoho SM		Shotoku SM		Ritto SM		Nikko SM	
			S	D	S	D	S	D	S	D
Myliobatiformes										
Plesiobatidae										
Plesiobatis daviesi (Wallace 1967)	Usuei	Figure 2G					R/A/B			
Albuliformes										
Halosauridae										
Halosauropsis macrochir (Günther 1878)	Kurobi-tokagegisu	Figure 2H								R
Anguilliformes										
Muraenidae										
Gymnothorax intesi (Fourmanoir & Rivaton 1979)	Minamimizore-utsubo	Figure 2I			R/B					
Gymnothorax ypsilon Hatooka & Randall 1992	Okinoshima-utsubo	Figure 2J			R					
Synaphobranchidae										
Histiobranchus bathybius (Günther 1877)	Soko-anago	Figure 2K		R						
Meadia abyssalis (Kamohara 1938)	Hirejiro-anago	Figure 2L	B		B		R			
Synaphobranchus kaupii Johnson 1862	Irako-anago	Figure 3A					R/B			
Synaphobranchus sp.		Figure 3B						R		
Congridae										
Conger erebennus (Jordan & Snyder 1901)	Dainan-anago	Figure 3C			B				R	
Nettastomatidae										
Nettastoma sp.		Figure 3D					R			
Stomiiformes										
Melanostomiidae										
Melanostomias sp.		Figure 3E			B					
Stomiiformes sp.										R
Aulopiformes										
Ipnopidae										
Bathypterois grallator (Goode & Bean 1886)	Oitohikiiwashi	Figure 3F								R
Chlorophthalmidae										
Chlorophthalmus albatrossis Jordan & Starks 1904	Aomeeso	Figure 3G	R *							
Chlorophthalmus sp.	Bake-aomeeso	Figure 3H					R/A		R/A	
Myctophiformes										
Neoscopelidae										
Neoscopelus microchir Matsubara 1943	Sango-iwashi	Figure 3I					R/A			
Myctophidae										
Myctophidae gen. sp.			R		R/B		R		R/B	
Polymixiiformes										
Polymixiidae										
Polymixia berndti Gilbert 1905	Arame-gimme	Figure 4A					B			
Polymixia japonica Günther 1877	Gimmedai	Figure 4B					R/A/B			
Polymixia sazanovi Kotlyar 1992	Okamura-gimme	Figure 4C					B			
Gadiformes										
Macrouridae										
Coelorinchus hubbsi Matsubara 1936	Moyouhige	Figure 4D	R *							
Ventrifossa sp.		Figure 4E					R/A/B		R/A	
Macrouroididae										
Squalogadus modificatus Gilbert & Hubbs 1916	Bakedara	Figure 4F		R						R
Moridae										
Laemonema robustum Johnson 1862	Kurodara	Figure 4G					R/A/B		R/A	
Physiculus japonicus Hilgendorf 1879	Chigodara	Figure 4H	R/B		R					
Physiculus rhodopinnis Okamura 1982	Aka-chigodara	Figure 4I					R *		R	
Physiculus yoshidae Okamura 1982	Oshare-chigodara	Figure 4J					R/A		R/A	
Ophidiiformes										
Ophidiidae										
Acanthonus armatus Günther 1878	Hanatoge-ashiro	Figure 5A		R						
Bassogigas gilli Goode & Bean 1896	Oitachiuo	Figure 5B						R		
Ophidiidae gen sp.		Figure 5C						R		
Lophiiformes										
Lophiidae										
Lophiodes sp.		Figure 5D					A		R/A	
Chaunacidae										
Chaunax penicillatus McCulloch 1915	Hanaguro-fusaanko	Figure 5E					R			
Chaunacops sp.		Figure 5F						R		
Beryciformes										
Trachichthyidae										
Gephyroberyx darwinii (Johnson 1866)	Hashikinme	Figure 5G			R					
Hoplostethus sp.		Figure 5H					R			
Berycidae										
Beryx splendens Lowe 1834	Kimmedai	Figure 5I					R/A/B			
Zeiformes										
Parazenidae										
Stethopristes sp.		Figure 6A					R*			
Perciformes										
Scorpaenidae										
Idiastion pacificum Ishida & Amaoka 1992	Kakure-kasago	Figure 6B					R */A			
Helicolenus hilgendorfii (Döderlein 1884)	Yume-kasago	Figure 6C	B							
Pontinus macrocephalus (Sauvage 1882)	Hiodoshi	Figure 6D			B					

Table 2. *Cont.*

Taxon	Standard Japanese Name	Figure	Nishi-Shichito Ridge: Shoho SM S	Nishi-Shichito Ridge: Shoho SM D	Nishi-Shichito Ridge: Shotoku SM S	Nishi-Shichito Ridge: Shotoku SM D	Central and Western Mariana Ridges: Ritto SM S	Central and Western Mariana Ridges: Ritto SM D	Central and Western Mariana Ridges: Nikko SM S	Central and Western Mariana Ridges: Nikko SM D
Scorpaenidae gen sp. 1					R					
Scorpaenidae gen sp. 2		Figure 6E			R/A					
Scorpaenidae gen sp. 3		Figure 6F							R	
Setarchidae										
Setarches guentheri Johnson 1862	Shiro-kasago	Figure 6G	R				R		R	
Triglidae										
Lepidotrigla sp.		Figure 6H					A			
Serranidae										
Caprodon schlegelii (Günther 1859)	Akaisaki	Figure 6I			R					
Hyporthodus octofasciatus (Griffin 1926)	Mahatamodoki				R					
Odontanthias sp.		Figure 6J			R					
Plectranthias kelloggi azumanus (Jordan & Richardson 1910)	Azuma-hanadai				R					
Plectranthias sp.		Figure 7A	R *							
Callanthiidae										
Grammatonotus sp.		Figure 7B			R					
Priacanthidae										
Cookeolus japonicus (Cuvier 1829)	Chikame-kintoki	Figure 7C			R/A					
Epigonidae										
Epigonus sp.		Figure 7D					R/A		R	
Scombropidae										
Scombrops boops (Houttuyn 1782)	Mutsu	Figure 7E			B					
Bramidae										
Eumegistus illustris Jordan & Jordan 1922	Chikame-echiopia	Figure 7F					R			
Emmelichthyidae										
Emmelichthyidae gen sp.			R							
Lutjanidae										
Etelis carbunculus Cuvier 1828	Hachijo-akamutsu				A					
Pristipomoides argyrogrammicus (Valenciennes 1832)**	Hanafuedai				A					
Chaetodontidae										
Prognathodes guyotensis (Yamamoto & Tameka 1982)	Urashima-chochouo	Figure 7G			R					
Pentacerotidae										
Pentaceros japonicus Steindachner 1883	Tsubodai	Figure 7H	R/B		R/B					
Pentaceros wheeleri (Hardy 1983)	Kusakari-tsubodai	Figure 7I	B							
Labridae										
Bodianus tanyokidus Gomon & Madden 1981	Zunaga-akabo	Figure 8A			A					
Labridae gen sp.		Figure 8B			A					
Centrolophidae										
Hyperoglyphe japonica (Döderlein 1884)	Medai	Figure 8C	R/B		R/B					
Psychrolutidae										
Psychrolutes sp.		Figure 8D						R		
Psychrolutidae gen sp.		Figure 8E								
Zoarcidae										
Zoarcidae gen sp.		Figure 8F					R			
Pinguipedidae										
Parapercis macrophthalma (Pietschmann 1911)	Shizukutoragisu	Figure 8G			A					
Gempylidae										
Ruvettus pretiosus Cocco 1833	Baramutsu	Figure 8H					A/B		A	
Caproidae										
Antigonia capros Lowe 1843	Hishidai	Figure 8I			R/B					
Pleuronectiformes										
Cynoglossidae										
Symphurus thermophilus Munroe & Hashimoto 2008	Ideyu-ushinoshita	Figure 8J							R */A	
Tetraodontiformes										
Triacanthodidae										
Macrorhamphosodes uradoi (Kamohara 1933)	Fuekawamuki	Figure 9A					R/A/B			
Triacanthodes anomalus (Temminck & Schlegel 1850)	Benikawamuki	Figure 9B					R/A/B		R/A/B	
Aracanidae										
Kentrocapros flavofasciatus (Kamohara 1938)	Kisuji-itomakifugu	Figure 9C			A *					
Order unknown										
Unidentified species 1		Figure 9D		R						
Unidentified species 2		Figure 9E			B					

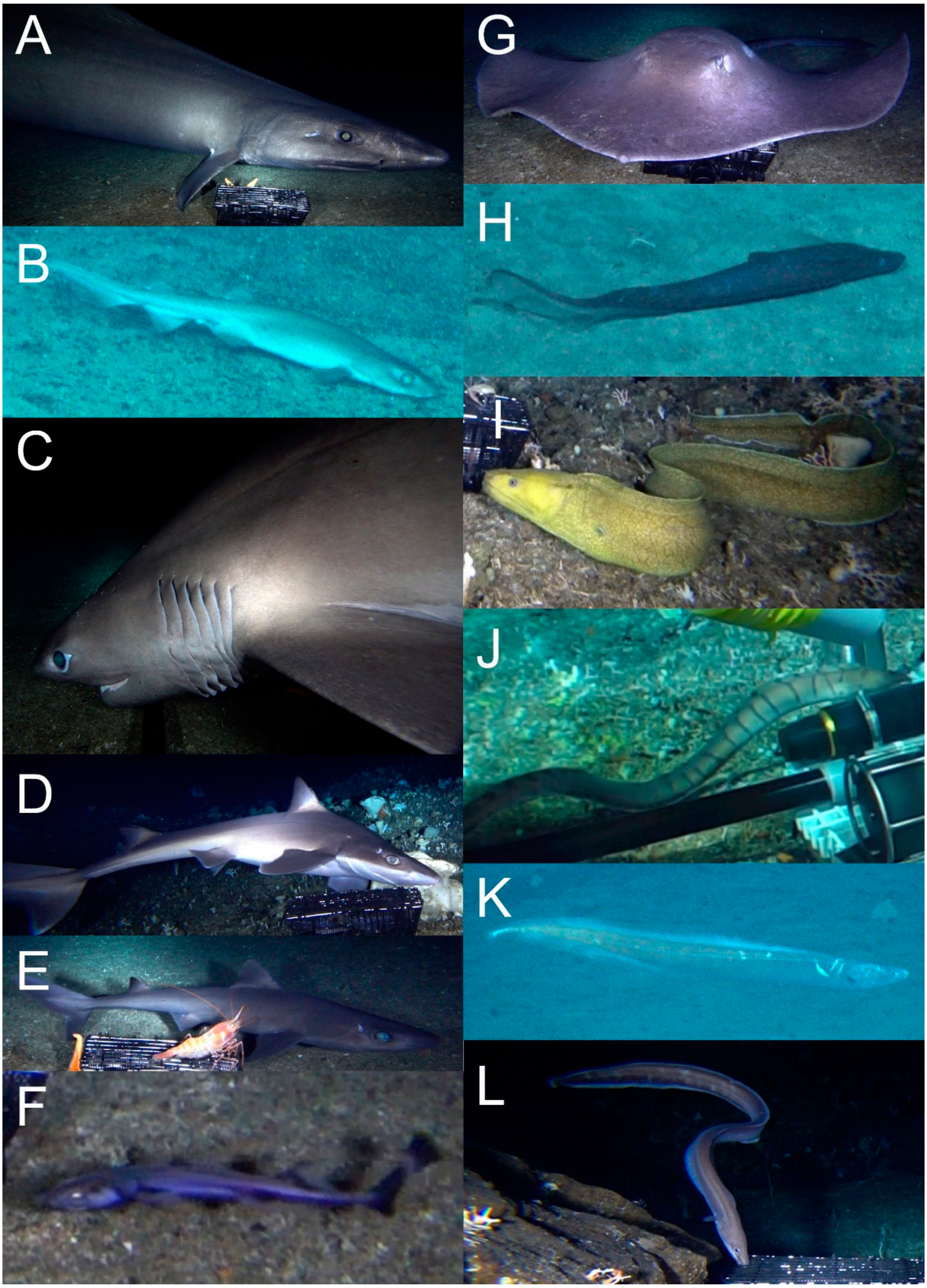

Figure 2. Underwater photographs of deep-sea fishes of seamounts (SM): (**A**) *Pseudotriakis microdon*, Ritto SM, 603 m depth; (**B**) *Galeus sauteri*, Ritto SM, 699 m depth; (**C**) *Hexanchus griseus*, Ritto SM, 603 m depth; (**D**) *Squalus mitsukurii*, Shotoku SM, 330 m depth; (**E**) *Squalus* sp., Ritto SM, 603 m depth; (**F**) *Etmopterus lucifer*, Ritto SM, 603 m depth; (**G**) *Plesiobatis daviesi*, Ritto SM, 603 m depth; (**H**) *Halosauropsis macrochir*, Nikko SM, 2006 m depth; (**I**) *Gymnothorax intesi*, Shotoku SM, 330 m depth; (**J**) *G. ypsilon*, Shotoku SM, 330 m depth; (**K**) *Histiobranchus bathybius*, Shoho SM, 2012 m depth; (**L**) *Meadia abyssalis*, Shoho SM, 406 m depth.

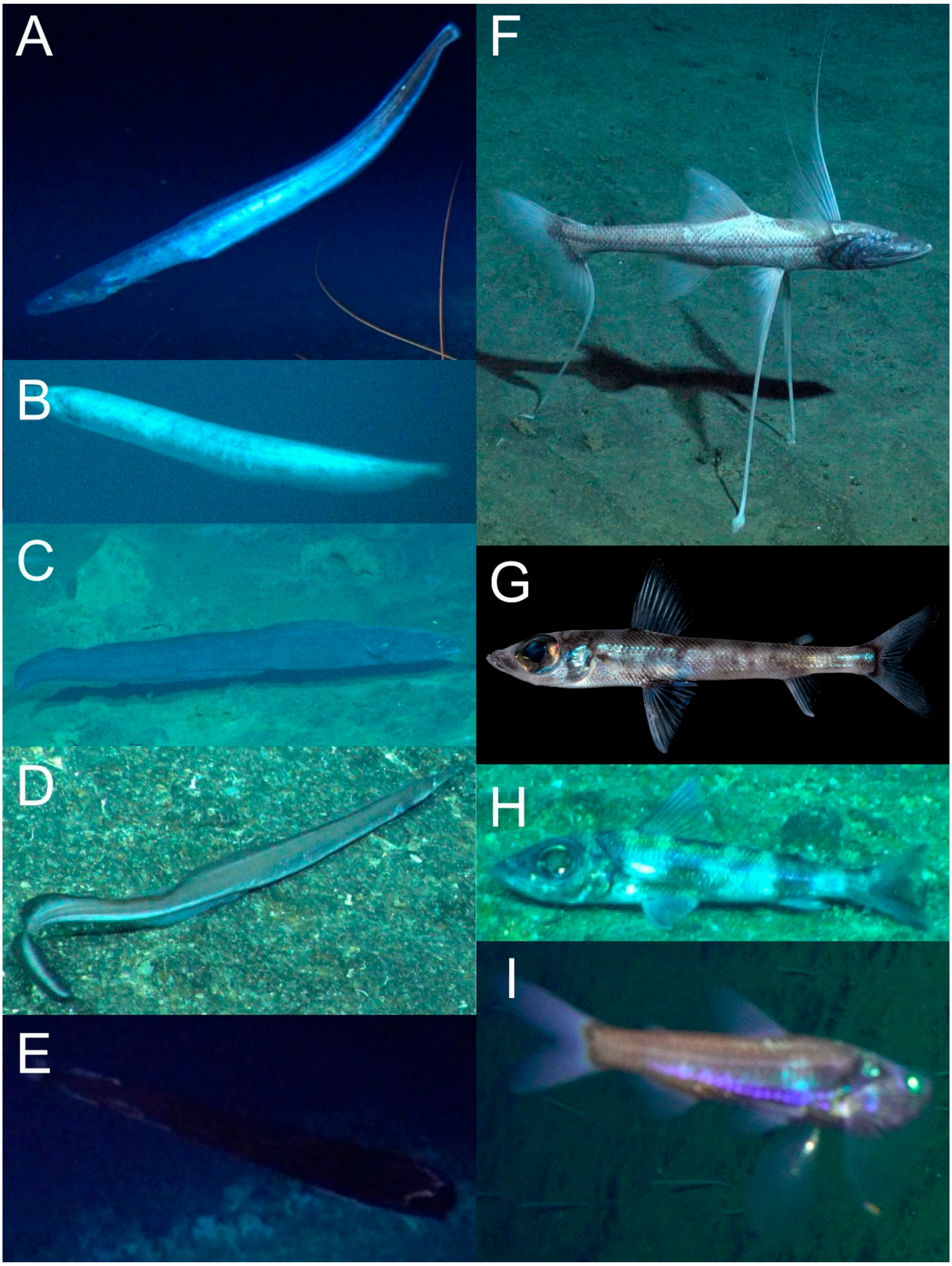

Figure 3. Underwater and specimen photographs of deep-sea fishes of seamounts (SM): (**A**) *Synaphobranchus kaupii*, Ritto SM, 696 m depth; (**B**) *Synaphobranchus* sp., Ritto SM, 2060 m depth; (**C**) *Conger erebennus*, Nikko SM, 500 m depth; (**D**) *Nettastoma* sp., Ritto SM, 665 m depth; (**E**) *Melanostomias* sp., Shotoku SM, 330 m depth; (**F**) *Bathypterois grallator*, Nikko SM, 2002 m depth; (**G**) *Chlorophthalmus albatrossis*, Shoho SM, 430 depth, KM#123-PI 01; (**H**) *Chlorophthalmus* sp., Ritto SM, 599 m depth; (**I**) *Neoscopelus microchir*, Ritto SM, 711 m depth.

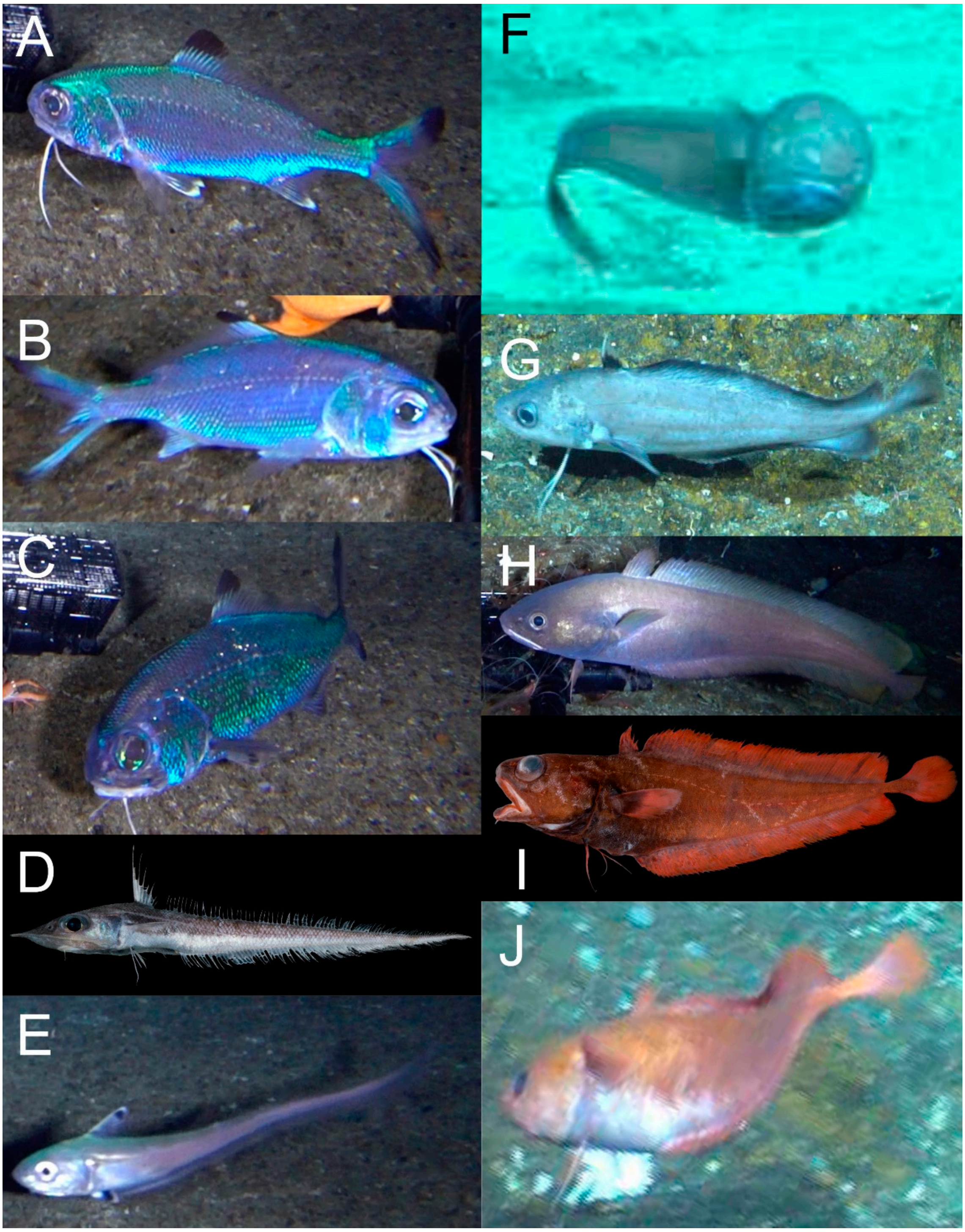

Figure 4. Underwater and specimen photographs of deep-sea fishes of seamounts (SM): (**A**) *Polymixia berndti*, Ritto SM, 603 m depth; (**B**) *Po. japonica*, Ritto SM, 603 m depth; (**C**) *Po. sazanovi*, Ritto SM, 603 m depth; (**D**) *Coelorinchus hubbsi*, Shoho SM, 431 m depth, KM#125-PI 01; (**E**) *Ventrifossa* sp., Ritto SM, 603 m depth; (**F**) *Squalogadus modificatus*, Shoho SM, 2039 m depth; (**G**) *Laemonema robustum*, Ritto SM, 617 m depth; (**H**) *Physiculus japonicus*, Ritto SM, 360 m depth; (**I**) *Ph. rhodopinnis*, Ritto SM, 617 m depth, KM#132-PI 03; (**J**) *Ph. yoshidae*, Ritto SM, 590 m depth.

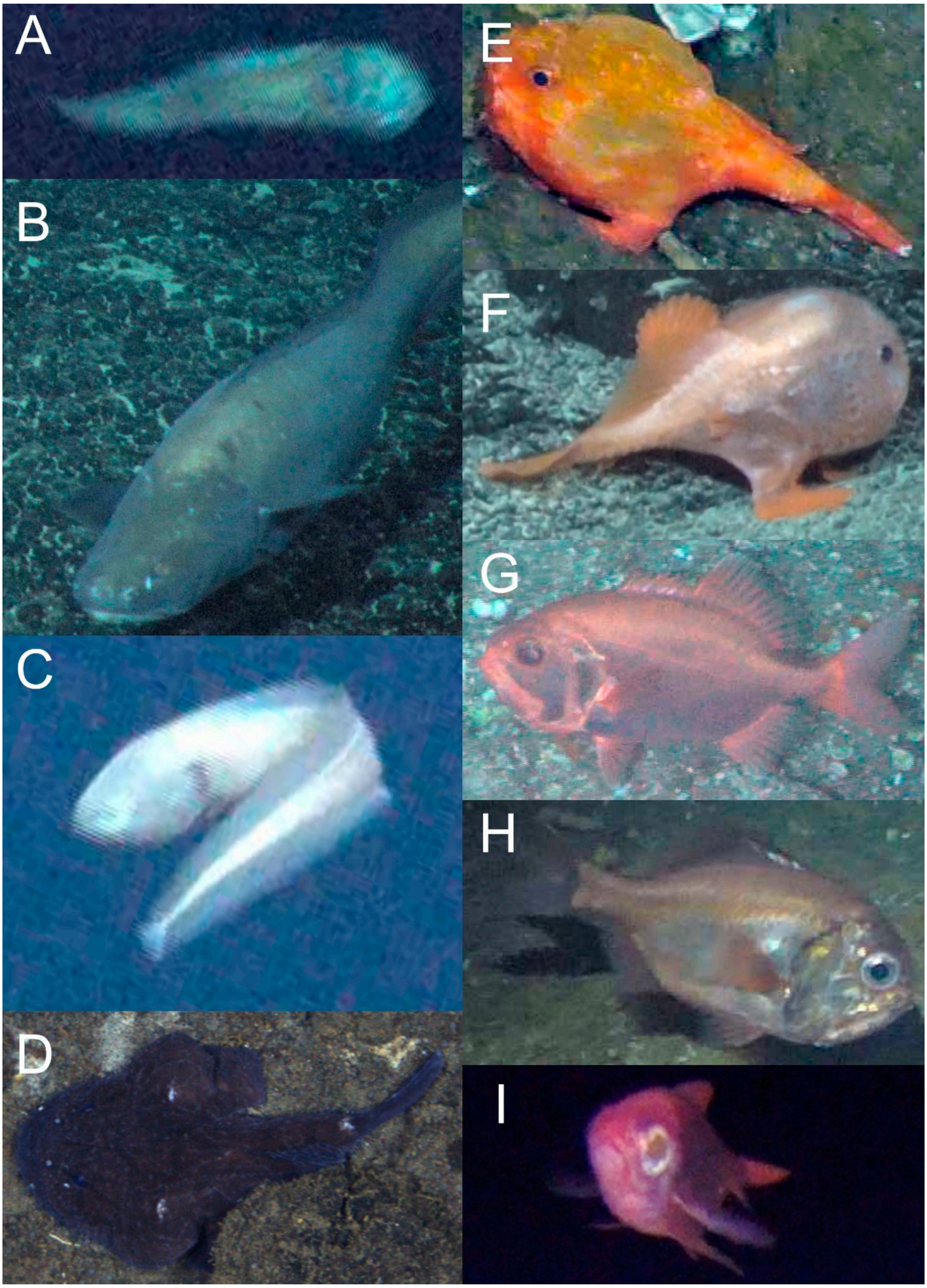

Figure 5. Underwater photographs of deep-sea fishes of seamounts (SM): (**A**) *Acanthonus armatus*, Shoho SM, 2016 m depth; (**B**) *Bassogigas gilli*, Ritto SM, 2052 m depth; (**C**) Ophidiidae gen sp., Ritto SM, 2053 m depth; (**D**) *Lophiodes* sp., Nikko SM, 553 m depth; (**E**) *Chaunax penicillatus*, Ritto SM, 508 m depth; (**F**) *Chaunacops* sp., Ritto SM, 1884 m depth; (**G**) *Gephyroberyx darwinii*, Shotoku SM, 314 m depth; (**H**) *Hoplostethus* sp., Ritto SM, 538 m depth; (**I**) *Beryx splendens*, Ritto SM, 603 m depth.

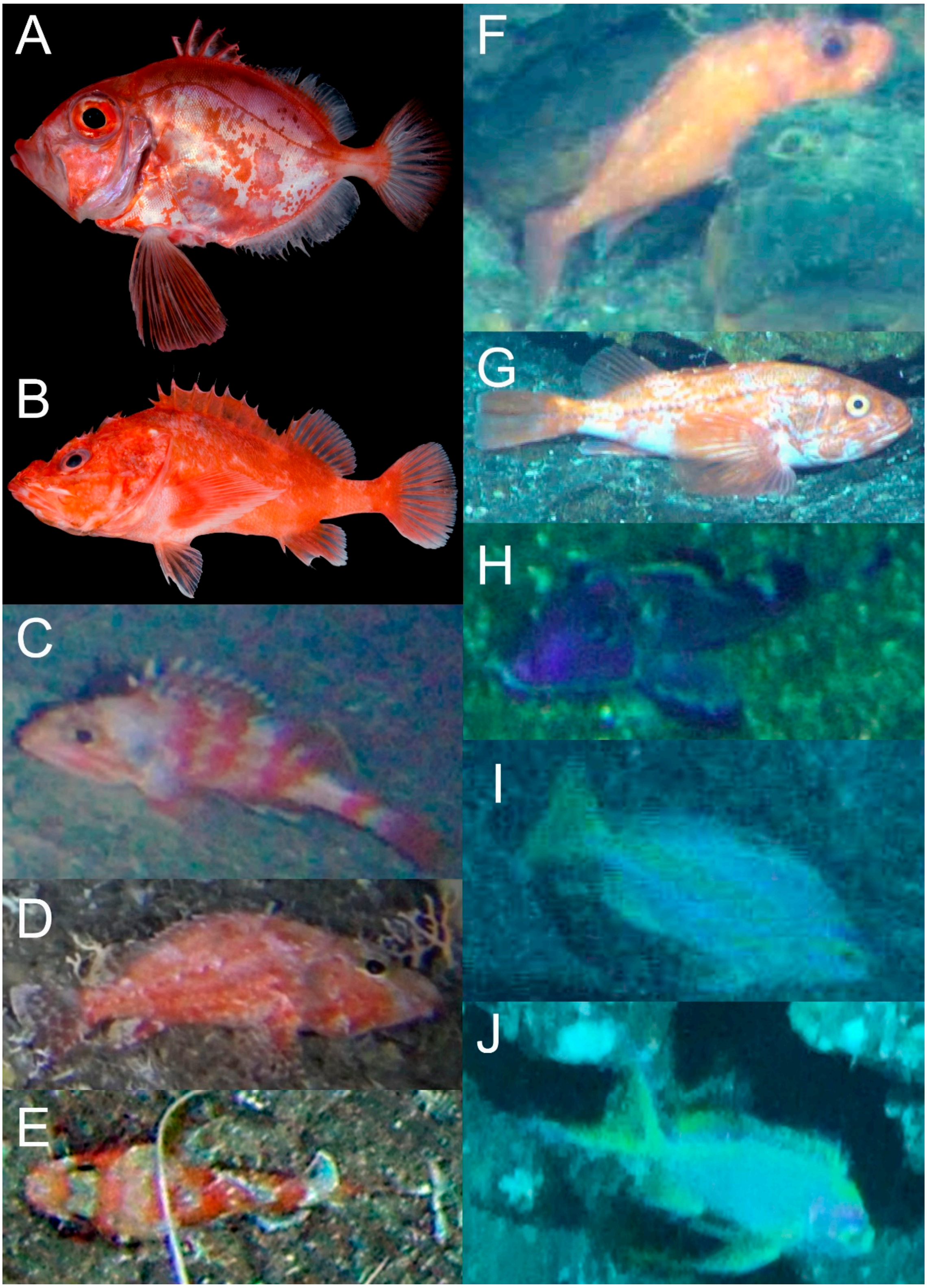

Figure 6. Underwater and specimen photographs of deep-sea fishes of seamounts (SM): (**A**) *Stethopristes* sp., Ritto SM, 519 m depth, KM#132-PI 01; (**B**) *Idiastion pacificum*, Ritto SM, 552 m depth, KM#132-PI 02; (**C**) *Helicolenus hilgendorfii*, Shoho SM, 356 m depth; (**D**) *Pontinus macrocephalus*, Shotoku SM, 330 m depth; (**E**) Scorpaenidae gen sp. 2, Shotoku SM, 269 m depth; (**F**) Scorpaenidae gen sp. 3, Nikko SM, 473 m depth; (**G**) *Setarches guentheri*, Ritto SM, 589 m depth; (**H**) *Lepidotrigla* sp., Ritto SM, 617 depth; (**I**) *Caprodon schlegelii*, Shotoku SM, 312 m depth; (**J**) *Odontanthias* sp., Shotoku SM, 328 m depth.

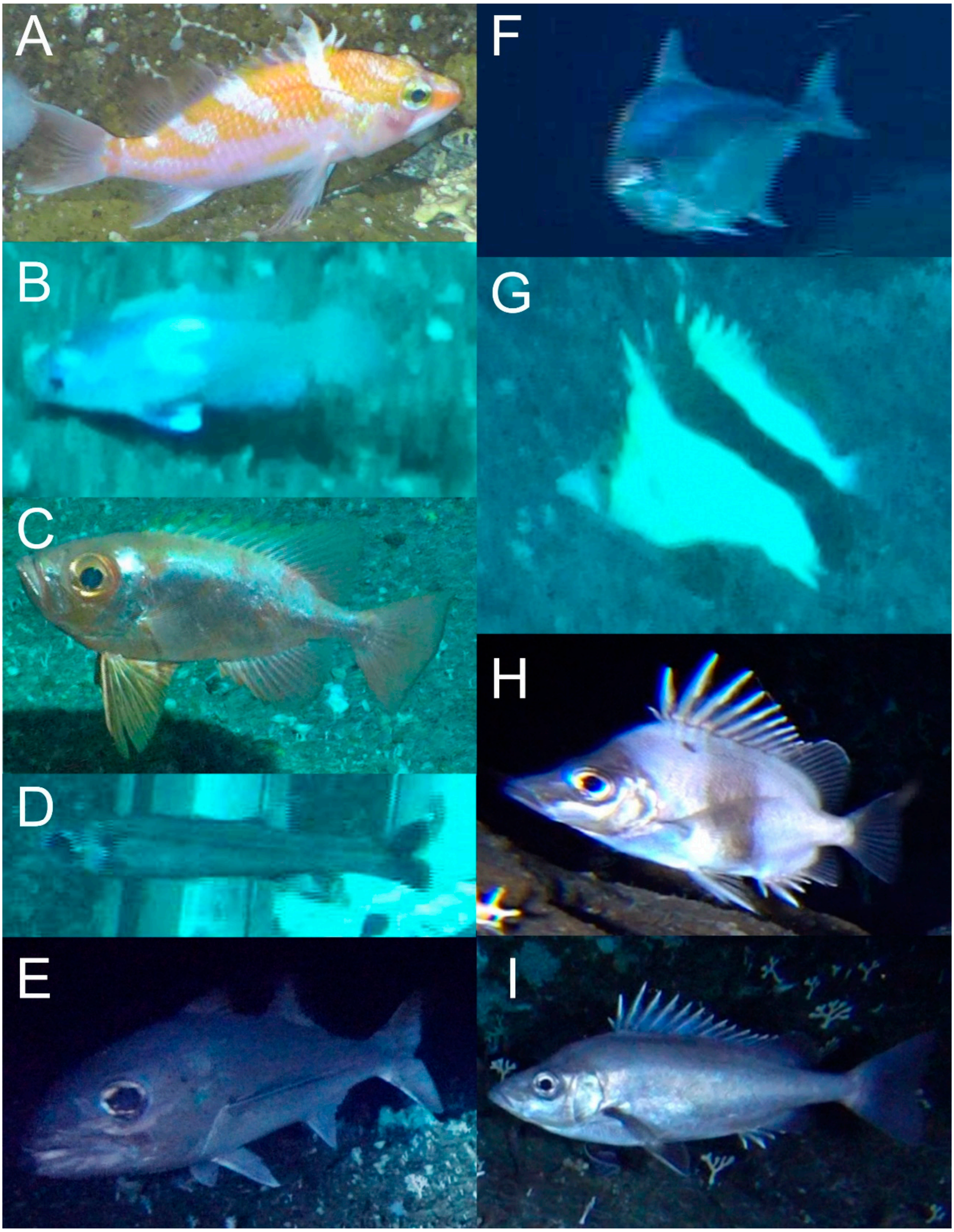

Figure 7. Underwater photographs of deep-sea fishes of seamounts (SM): (**A**) *Plectranthias* sp., Shoho SM, 406 m depth; (**B**) *Grammatonotus* sp., Shotoku SM, 328 m depth; (**C**) *Cookeolus japonicus*, SM, 312 m depth; (**D**) *Epigonus* sp., Ritto SM, 696 m depth; (**E**) *Scombrops boops*, Shotoku SM, 472 m depth; (**F**) *Eumegistus illustris*, Ritto SM, 585 m depth; (**G**) *Prognathodes guyotensis*, Shotoku SM, 321 m depth; (**H**) *Pentaceros japonicus*, Shoho SM, 356 m depth; (**I**) *Pentaceros wheeleri*, Shoho SM, 406 m depth.

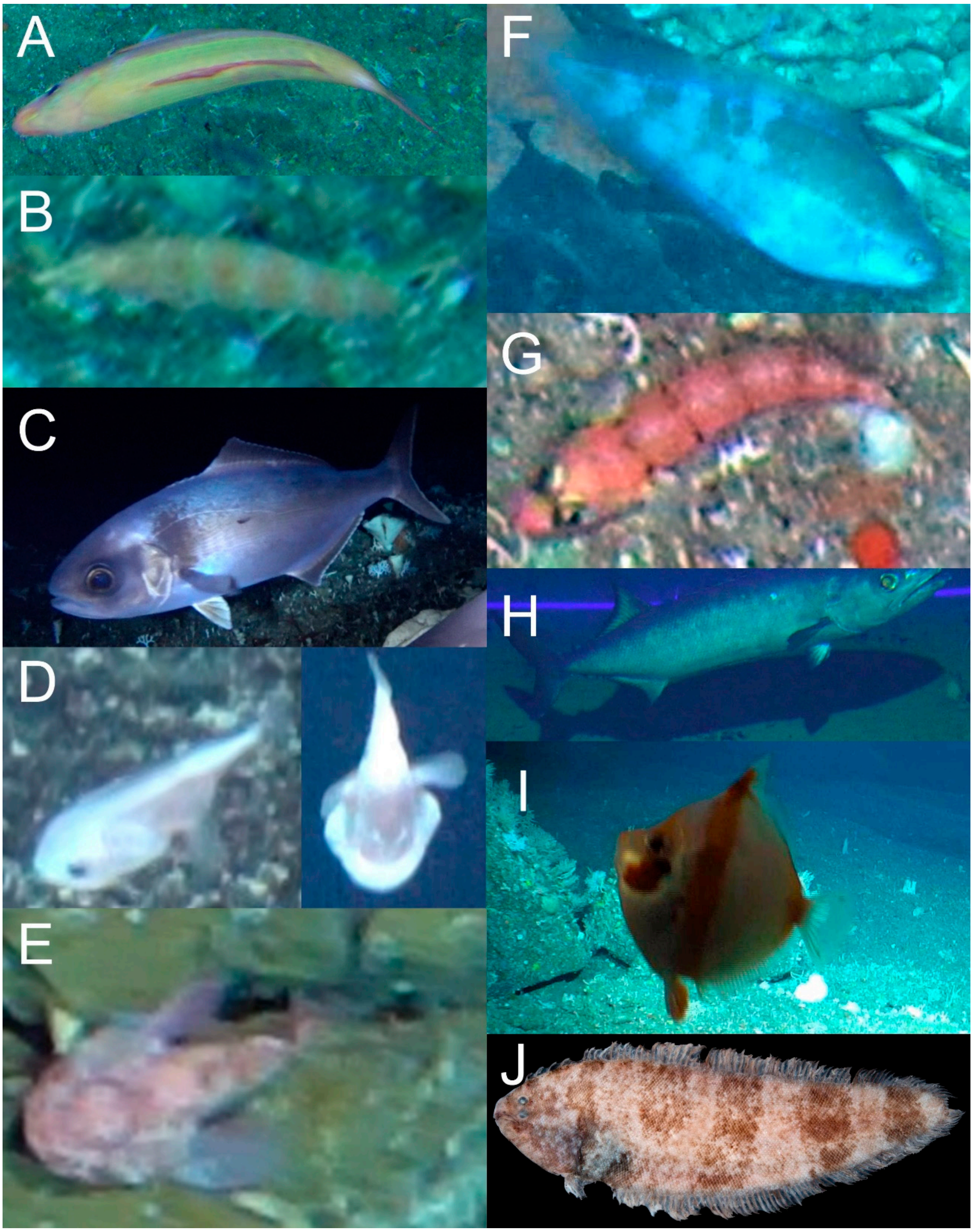

Figure 8. Underwater and specimen photographs of deep-sea fishes of seamounts (SM): (**A**) *Bodianus tanyokidus*, Shotoku SM, 271 m depth; (**B**) Labridae gen sp., Shotoku SM, 273 m depth; (**C**) *Hyperoglyphe japonica*, Shotoku SM, 472 m depth; (**D**) *Psychrolutes* sp., Ritto SM, 2053 m depth; (**E**) Psychrolutidae gen sp., Ritto 0SM, 539 m depth; (**F**) Zoarcidae gen sp., Ritto SM, 508 m depth; (**G**) *Parapercis macrophthalma*, Shotoku SM, 20 m depth; (**H**) *Ruvettus pretiosus*, Nikko SM, 764 m depth; (**I**) *Antigonia capros*, Shotoku SM, 319 m depth; (**J**) *Symphurus thermophilus*, Nikko SM, 467 m depth, KM133-PI 01.

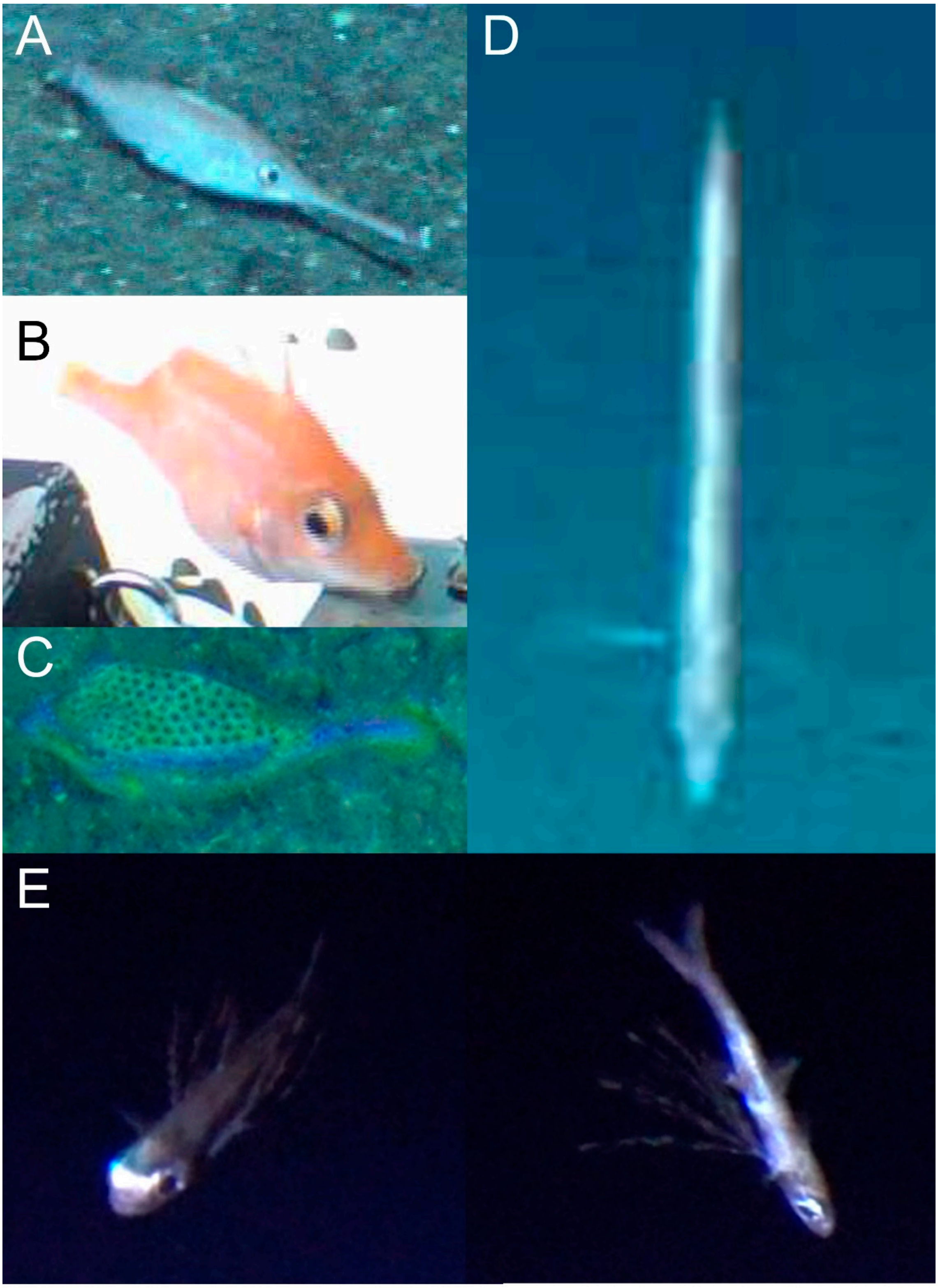

Figure 9. Underwater photographs of deep-sea fishes of seamounts (SM): (**A**) *Macrorhamphosodes uradoi*, Ritto SM, 696 m depth; (**B**) *Triacanthodes anomalus*, Ritto SM, 530 m depth; (**C**) *Kentrocapros flavofasciatus*, Shotoku SM, 270 m depth; (**D**) unidentified family 1, Shoho SM, 2026 m depth; (**E**) unidentified family 2, Shotoku SM, 330 m depth.

Table 3. Number of species shared between four seamounts (SM). Percentage in parentheses.

Name of SM	Number of Species	Overlapped with			
		Shoho	**Shotoku**	**Ritto**	**Nikko**
Shoho	13	-	6 (46.2)	4 (30.8)	2 (15.4)
Shotoku	30	6 (20.0)	-	4 (13.3)	2 (6.7)
Ritto	35	4 (11.4)	4 (11.4)	-	11 (31.4)
Nikko	14	2 (14.3)	2 (14.3)	11 (78.6)	-

During the expedition, large numbers of species remained unidentified, which was not attributable to the quality of the video or lack of specimens. There are potentially new species; however, specimen-based considerations were necessary to clarify their detailed taxonomy. In addition, new genera or species records in Japanese waters, new depth records, new ecological information, and several rare fishes were also recorded. The taxonomic notes on the recorded species are presented below.

Taxonomic Notes

1. *Pseudotriakis microdon* de Brito Capello 1868 (Pseudotriakidae; Figure 2A): Two large females and males of this species were observed using BC in a patchy sandy bottom in a rocky area at 603 m and 696 m depths of the Ritto Seamount, respectively. This species has previously been reported to be distributed on the continental shelf in Japanese waters; however, it was recorded for the first time on a seamount far separated from the shelf.
2. *Hexanchus griseus* (Bonnaterre 1788) (Hexanchidae; Figure 2B): Two large individuals of this species were observed through BC in a rocky area at 471 m depth of the Shotoku Seamount and 603 m on the Ritto Seamount. This species has previously been reported to be distributed on the continental shelf; however, it was recorded for the first time on a seamount far separated from the shelf.
3. Unidentified species, *Squalus* sp. (Squalidae; Figure 2E): A single individual of this species was captured by BC in a patchy sandy bottom on a rocky area at 603 m depth on the Ritto Seamount. This species belongs to the family Squalidae because it lacks a concave caudal-fin outer margin. However, this species is unique in having a dark body (no white ventral), dusky dorsal fins, blunt snout, and a lack of white margin on the caudal fin.
4. *Gymnothorax intesi* (Fourmanoir and Rivaton 1979) (Muraenidae; Figure 2I): Several individuals of this species were recorded by ROV and BC in a rocky area at 330 m depth on the Shotoku Seamount. This species was previously reported only in the Ryukyu Archipelago and Kagoshima in Japanese waters, and the distribution depth range was shallower than 200 m. The present observations represent a new distributional record for the deepest sighting of the species.
5. *Gymnothorax ypsilon* Hatooka and Randall 1992 (Muraenidae; Figure 2J): A single individual of this species was observed using the ROV in a rocky area at 330 m depth on the Shotoku Seamount. The distribution depth range of the species was earlier reported to be shallower than 200 m.
6. *Histiobranchus bathybius* (Günther 1877) (Synaphobranchidae; Figure 2K): A single individual of this species was observed by the ROV in a sandy area at 2012 m depth on the Shoho Seamount. This species has previously been recorded south of Tosa Bay and is known as a cold-water species that is mainly distributed in the northern Pacific. The present observations represent the southernmost distribution of this species.
7. *Bathypterois grallator* (Goode and Bean 1886) (Ipnopidae; Figure 3F): A single individual of this species was observed using the ROV in a sandy area at 2002 m depth on the Nikko Seamount. This species was previously reported to inhabit only the south of Tosa Bay and the Ryukyu Archipelago in Japanese waters. The present observations represent a new distributional record for this species.

8. *Chlorophthalmus* sp. (Chlorophthalmidae; Figure 3H): Several individuals of this species were recorded by ROV and AUV in sandy areas or patchy sand bottoms of rocky areas at a depth of around 460 m on the Ritto and Nikko Seamounts. This species matches well with *Chlorophthalmus* sp. 2 sensu Nakabo and Kai [12] as both have large and thick bodies, large eyes, and curved pelvic fin tips. This species was previously reported only to be present in the Kyushu-Palau Ridge, Tosa Bay, Kumanonada Sea, and Amami-Oshima Islands [13]. Thus, the present observations represent a new distributional record of this species.
9. *Polymixia sazanovi* Kotlyar 1992 (Polymixiidae; Figure 4C): Several individuals of this species were observed using BC in sandy bottoms of rocky areas at 603 m depth on the Ritto Seamount. This species was previously reported to exist only on the Kyushu-Palau Ridge, Atsumi Peninsula, Yoron-jima Island in the Amami Islands, Ishigaki-jima Island in the Yaeyama Islands, and in southern Taiwan [14,15]. The present observations represent a new distributional record of this species. *Polymixia japonica* Günther 1877 and *Polymixia berndti* Gilbert 1905 were observed in the same area in the present study, indicating that these similar congeners can share their habitat.
10. *Coelorinchus hubbsi* Matsubara 1936 (Macrouridae; Figure 4D), specimen No. KM#125-PI 01, 246.7 mm TL: A single specimen was collected by the ROV in patchy sand bottoms of rocky areas at 431 m depth on the Shoho Seamount. This species has previously been reported to be distributed on the continental shelf; however, it was recorded for the first time from a seamount far separated from the shelf.
11. *Laemonema robustum* Johnson 1862 (Moridae; Figure 4G): Several individuals of this species were recorded by ROV and AUV in rocky areas ranging from 380 to 500 m depths on the Ritto and Nikko Seamounts. This species was previously reported only on the Kyushu-Palau Ridge, Yokohama in the Kanagawa Prefecture, and Amami-oshima Islands in Japanese waters. The present observations represent a new distributional record of this species.
12. *Physiculus rhodopinnis* Okamura 1982 (Moridae; Figure 4I), specimen No. KM#132-PI 03, 156.4 mm SL: This was one of the most abundant species recorded by ROV and AUV in rocky areas ranging from 380 to 500 m depths on the Ritto and Nikko Seamounts. This species was previously reported only on the Kyushu-Palau Ridge in Japanese waters. The present observations represent a new distributional record of this species.
13. *Physiculus yoshidae* Okamura 1982 (Moridae; Figure 4J): Several individuals of this species were observed in rocky areas at a depth of 310–500 m on the Ritto and Nikko Seamounts, but with comparatively lower abundance than that of *P. rhodopinnis*. This species was previously reported only on the Kyushu-Palau Ridge, in the East China Sea, and southern Vietnam. The present observations represent a new distributional record of this species.
14. *Acanthonus armatus* Günther 1878 (Ophidiidae; Figure 5A): A single individual of this species was recorded by the ROV in a sandy area at 2016 m depth on the Shoho Seamount. This species was previously recorded only in Suruga Bay in Japanese waters. The present observation represents its second locality record in Japan.
15. *Bassogigas gilli* Goode and Bean 1896 (Ophidiidae; Figure 5B): Two individuals of this species were recorded by the ROV in a sandy area at depths of 1917 m and 1919 m of the Ritto Seamount. This species was previously reported only in the Okinawa Trough in Japanese waters. The present observations represent a new distributional record of this species.
16. Unidentified species, *Chaunacops* sp. (Chaunacidae; Figure 5F): A single individual of this species was observed by the ROV in a rocky area at 1884 m depth of the Ritto Seamount. This species seems to be similar to *Chaunacops coloratus* (Garman, 1899), which is mainly found in the eastern Pacific Ocean [16,17]. Although specimens need to be identified at the species level, fishes of this genus have never been recorded in

Japanese waters. Therefore, the present observation represents the first record of this genus from Japan.

17. Unidentified species, *Hoplostethus* sp. (Trachichthyidae; Figure 5H): Two individuals of this species were recorded by the ROV in a rocky area at 530 m and 580 m depths on the Ritto Seamount. This species has a significantly larger body (estimated to be 20–30 cm standard length) than the known Japanese species.
18. *Stethopristes* sp. (Parazenidae; Figure 6A), specimen No. KM#132-PI 01, @@ mm SL: Two individuals of this species were observed by ROV in the rocky area at 380 m and 390 m depths on the Ritto Seamount. The genus contains only a single species *Stethopristes eos* Gilbert 1905 which known from Hawaiian Islands and off Chile, and have never been recorded in Japanese waters [18]. The taxonomy of this specimen is currently under study by the first author.
19. *Idiastion pacificum* Ishida and Amaoka 1992 (Scorpaenidae; Figure 6B), specimen No. KM#132-PI 02, 95.7 mm SL: Several individuals of this species were recorded by ROV and AUV at the rocky area that ranges from 380 to 500 m depth on the Ritto Seamount, and a single specimen was collected at 410 m depth. This species was previously reported only on the Kyushu-Palau Ridge and Emperor Seamount Chain. The present observations and the specimen represent a new distributional record of the species.
20. Unidentified species, *Odontanthias* sp. (Serranidae; Figure 6J): Several individuals of this species were observed by the ROV in a rocky area at a depth of approximately 328 m on the Shotoku Seamount. This species belongs to *Odontanthias* based on its body and fin shape; however, its unique coloration and well-elongated anteriormost pelvic-fin ray, and upper and lowermost caudal-fin rays do not match with any known species from this genus.
21. Unidentified species, *Plectranthias* sp. (Serranidae; Figure 7A): A single individual of this species was observed through the ROV in a rocky area at 360 m depth on the Shoho Seamount. Although this species is similar to *Plectranthias purpuralepis* Tang, Lai, and Ho 2020, which was recently described at 200 m depth in northern Taiwan, it differs in its coloration and a few other characteristics. This species is going to be described as a new species by Wada and Senou [19].
22. Unidentified species, *Grammatonotus* sp. (Callanthiidae; Figure 7B): Several individuals of this species were recorded by the ROV in a rocky area at around 328 m depth on the Shotoku Seamount (sympatric with *Odontanthias* sp.). This species is similar to *Grammatonotus surugaensis* Katayama, Yamakawa, and Suzuki 1980 as it shares the elongated caudal-fin rays; however, the unidentified species has a shallower body depth than that of *G. surugaensis*. In addition, the distinct light-colored blotch observed on *Grammatonotus* sp. is unique and has not been found in any other known species of the genus.
23. Unidentified species, *Psychrolutes* sp. (Psychrolutidae; Figure 8D): A single individual of this species was observed using the ROV in a rocky area at 2053 m depth on the Ritto Seamount. Although specimens need to be identified at the species level, the species of this genus are known as cold-water deep-sea fishes.
24. Unidentified species, Zoarcidae gen sp. (Zoarcidae; Figure 8F): Several individuals of this species were observed by the ROV in a rocky area at 508 m depth on the Ritto Seamount. This species probably belongs to Ophidiidae with similar connected dorsal, caudal, and anal fins, simple pectoral fins (not as Liparidae), lacking or with very short pelvic fins (not as Ophidiidae), and blunt snout. Although most of the genera of Zoarcidae have an elongated body, *Bothrocarina* has a comparatively deeper body than the present unidentified species.
25. *Parapercis macrophthalma* (Pietschmann 1911) (Pinguipedidae; Figure 8G): A single individual of this species was observed using AUV in a rocky area at 270 m depth of Shotoku Seamount. This species was previously reported only on Susami in Wakayama Prefecture, Yamaguchi Prefecture, Tosa Bay, Kagoshima Bay, and Taiwan.

The present observations and the specimen represent a new distributional record of the species.

26. *Symphurus thermophilus* Munroe and Hashimoto 2008 (Cynoglossidae; Figure 8J), specimen No. KM#133-PI 01–04, 74.0–95.7 mm SL (four specimens): A large number of individuals were recorded by the ROV in the sandy bottom at the caldera of the Nikko Seamount and a few of them were collected. Some individuals were also observed by the AUV in a patchy sandy bottom at a rocky area at the outer slope of the seamount. Although this species was rarely observed outside the caldera, several individuals were recorded by the AUV on the sandy bottom in the rocky area.
27. *Kentrocapros flavofasciatus* (Kamohara 1938) (Aracanidae; Figure 9C), male: A single individual of this species was recorded by the AUV in a rocky area at 270 m on the Shotoku Seamount. This was the first recording of this species, previously reported as being distributed on the continental shelf, on a seamount far separated from the shelf.
28. Unidentified family (Figure 9D): A single individual of this species was captured by the ROV in a sandy area at 2015 m depth on the Shoho Seamount. This individual displayed a unique habit of adopting a head-down tail-up position and hovering almost 2 m from the sea bottom. Although at least two dorsal fins, a long body with low body depth throughout, pointed snout, and a forked caudal fin were confirmed, it was difficult to identify the specimen down to the family level.
29. Unidentified family (Figure 9E): A single individual of this species was observed in a rocky area at 330 m depth of the Shoho Seamount using the BC. This individual is unique, with long pelvic fin rays (estimated to be more than 50% of its body length), which have never been reported in any other family, including in larval stages. Two dorsal fins, forked caudal fin, short pectoral fin, and rounded snout, similar to Epigonidae, were confirmed but could not be identified to the family level.

In the shallow zone, 70 species were observed during the present expedition. In total, the ROV observed 50 species in a total operation time of 38.8 h in the shallow zone; this method captured the maximum number of species during the expedition, with 23 species observed only with this method. Although the total operation time of the AUV was less than that of the other two methods, it captured 25 species in 9.2 h, with seven of them observed only using this method. In total, 31 species were recorded by the BC after 77 h of operation. This method recorded high-resolution videos of the fishes in close proximity and contributed to accurate identification. For example, three species of *Polymixia* observed on the Ritto Seamount have very similar morphology and are difficult to identify at the species level with an ROV or AUV; however, we identified them based on the coloration of fins and counting scales using BC. In addition, the BC was useful for observing large-sized elasmobranch fishes, such as *Pseudotriakis microdon* (Pseudotriakidae) and *Hexanchus griseus* (Hexanchidae), which can escape from the sounds, lights, and/or vibrations of ROVs and AUVs. Our results indicate the efficiency of combining the three methods for faunal surveys of seamount fishes. Although a large number of interesting fish species were observed during the expedition, we could collect specimens of only six species, and several species were only identified at the family or genus level. To solve this problem, the innovation or creation of additional methods that focus on collecting specimens in deep-sea environments are strongly required to identify fishes at the species level and to achieve a better understanding of the biodiversity of deep-sea fish communities on seamounts.

Finally, the distribution of several unique and/or rare fishes, including that of several potentially undescribed species, were observed from the seamounts in the MPAs of the IBM arc system, and the species compositions were well-differentiated between the seamounts (especially ridges) and depths. These results confirm the unique, important, and rich biodiversity of the seamounts in Japanese MPAs. Nevertheless, continuous biodiversity surveys are required to verify the outcomes of the efforts to save these MPAs.

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References

1. Machida, Y. A new deep-sea ophidiid Fish, Bassozetus levistomatus, from the Izu-Bonin Trench, Japan. *Jpn. J. Ichthyol.* **1989**, *36*, 187–189. [CrossRef]
2. Fujii, T.; Jamieson, A.J.; Solan, M.; Bagley, P.M.; Priede, I.G. A large aggregation of Liparids at 7703 meter and a reappraisal of abundance and diversity of hadal fish. *BioSience* **2010**, *60*, 506–515. [CrossRef]
3. Ohashi, S.; Shinohara, G. An Additional Record of Bassozetus levistomatus Machida, 1989 from the Western North Pacific (Teleostei, Ophidiiformes, Ophidiidae). *Bull. Natl. Mus. Nat. Sci. Ser. A* **2015**, *41*, 69–75.
4. Okamura, O.; Amaoka, K.; Mitani, F. *Fishes of the Kyushu-Palau Ridge and Tosa Bay*; Japan Fisheries Resource Conservation Association: Tokyo, Japan, 1982; 435p, (In Japanese and English).
5. Fujikura, K.; Okutani, T.; Maruyama, T. *Deep-Sea Life-Biological Observations Using Research Submersibles*; Tokai University Press: Hadano, Japan, 2012; 487p. (In Japanese)
6. Ministry of the Environment. *Mid-Ocean Ridge/West Mariana Ridge Northern Offshore Seafloor Natural Environment Conservation Area Designation and Conservation Plan*; Ministry of the Environment: Tokyo, Japan, 2020; 8p. (In Japanese)
7. Ministry of the Environment. *West Seven Island Ridge Offshore Submarine Natural Environment Conservation Area Designation and Conservation Plan*; Ministry of the Environment: Tokyo, Japan, 2020; 8p. (In Japanese)
8. Nakabo, T. *Fishes of Japan with Pictorial Keys to the Species*, 3rd ed.; Tokai University Press: Hadano, Japan, 2013; 2428p. (In Japanese)
9. Eschmeyer's Catalog of Fishes. Available online: https://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp (accessed on 4 October 2021).
10. Motomura, H. *List of Japan's All Fish Species*; The Kagoshima University Museum: Kagoshima, Japan, 2020; 558p, (In Japanese and English).
11. Munroe, T.A.; Hashimoto, J. A new western Pacific Tonguefish (Pleuronectiformes: Cynoglossidae): The first Pleuronectiform discovered at active hydrothermal vents. *Zootaxa* **2008**, *1839*, 43–59. [CrossRef]
12. Nakabo, T.; Kai, Y. Chlorophthalmidae. In *Fishes of Japan with Pictorial Keys to the Species*, 3rd ed.; Nakabo, T., Ed.; Tokai University Press: Hadano, Japan, 2013; pp. 429–430, 1853–1854. (In Japanese)
13. Hata, H.; Yamaguchi, M.; Iwatsubo, H.; Motomura, H. First records of a species of *Chlorophthalmus* (Chlorophthalmidae) from the Ryukyu Islands, Japan. *Nat. Kagoshima* **2016**, *42*, 33–37. (In Japanese)
14. Koeda, K.; Hirasaka, H. Records of two deep-sea fishes, *Beryx splendens* (Beryciformes; Berycidae) and *Polymixia sazonovi* (Polymixiiformes; Polymixiidae), collected from off Ishigaki-jima Island. *Kuroshio Biosph.* **2021**, *18*, 29–37, (In Japanese with English abstract).

15. Koeda, K. Polymixiidae. In *Fishes of Southern Taiwan*; Koeda, K., Ho, H.-C., Eds.; National Museum of Marine Biology & Aquarium: Pingtung, Taiwan, 2019; pp. 342–345, (In English and Chinese).
16. Lundsten, L.; Johnson, S.B.; Cailliet, M.G.; Developer, A.P.; Clague, D.A. Morphological, molecular, and in situ behavioral observations of the rare deep-sea anglerfish *Chaunacop scoloratus* (Garman, 1899), order Lophiiformes, in the eastern North Pacific. *Deep Sea Res. I* **2012**, *68*, 46–53. [CrossRef]
17. Ho, C.-H.; McGrouther, M. A new anglerfish from eastern Australia and New Caledonia (Lophiiformes: Chaunacidae: Chaunacops), with new data and submersible observation of *Chaunacops melanostomus*. *J. Fish Biol.* **2015**, *86*, 940–951. [CrossRef] [PubMed]
18. Tyler, J.C.; O'Toole, B.; Winterbottom, R. Phylogeny of the genera and families of Zeiform fishes, with comments on their relationships with Tetraodontiforms and Caproids. *Smithsonian Contri. Zool.* **2003**, *618*, 1–110. [CrossRef]
19. Wada, H.; (Kanagawa Prefectural Museum, Odawara, Japan); Senou, H.; (Kanagawa Prefectural Museum, Odawara, Japan). Personal communication, 2021.