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

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 km² [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 km² [7].

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.

<table>
<thead>
<tr>
<th>Name of Seamounts</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Depth Range (m)</th>
<th>Hydrothermal Vent</th>
<th>Research Period</th>
<th>ROV Operation (h)</th>
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</thead>
<tbody>
<tr>
<td>Shoho</td>
<td>32°09’ N–32°29’ N</td>
<td>138°34’ E–138°54’ E</td>
<td>375–3300</td>
<td>Absent</td>
<td>27–30 Nov. 2020</td>
<td>3 (11.6) 1 (5.3)</td>
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<tr>
<td>Shotoku</td>
<td>30°37’ N–30°57’ N</td>
<td>138°23’ E–138°43’ E</td>
<td>270–3750</td>
<td>Absent</td>
<td>1–2 Dec. 2020</td>
<td>3 (7.7) 0 (0)</td>
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<tr>
<td>Ritto</td>
<td>21°37’ N–21°57’ N</td>
<td>141°53’ E–142°13’ E</td>
<td>504–3300</td>
<td>Absent</td>
<td>5–8 Dec. 2020</td>
<td>3 (11.8) 1 (4.8)</td>
</tr>
</tbody>
</table>

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 taxonomic 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, 136 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 139 recorded on the Nikko Seamount overlapped with those on the Ritto Seamount, but 14.3% 140 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.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Standard Japanese Name</th>
<th>Figure</th>
<th>Nishi-Shichito Ridge</th>
<th>Central and Western Mariana Ridges</th>
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<td>Shoho SM</td>
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<td>de Brito Capello 1868</td>
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<td>Galeus santieri (Jordan &amp; Richardson 1909)</td>
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<td>Squidus mitsukurii</td>
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<tr>
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<td>Futo-tsunozame</td>
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<td>Jordan &amp; Snyder 1902</td>
<td>Fujikujira</td>
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<td>Taxon</td>
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<td><em>Haloaurapis macrochir</em>   (Günther 1878)</td>
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<td>Unidentified species 2</td>
<td>Figure 9E</td>
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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 m depth; (I) Caprodon schlegeli, 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 macrophthalmus*, 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.
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

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**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.

<table>
<thead>
<tr>
<th>Name of SM</th>
<th>Number of Species</th>
<th>Overlapped with</th>
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<tr>
<td></td>
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<td>Shoho</td>
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<td>Shoho</td>
<td>13</td>
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<tr>
<td>Shotoku</td>
<td>30</td>
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<tr>
<td>Ritto</td>
<td>35</td>
<td>4 (11.4)</td>
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<tr>
<td>Nikko</td>
<td>14</td>
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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, Kumano-nada 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 (Morididae; 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 (Morididae; 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 macrophthalmalma* (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. *Kentrocapsrus 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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