New Report of *Zu cristatus* (Bonelli, 1819) in the Ionian Sea with an In-Depth Morphometrical Comparison with All Mediterranean Records

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Abstract: Monitoring the occurrence and distribution of rare fish species is essential, especially in a semi-closed basin such as the Mediterranean Sea. Biologically interesting species often represent fishing waste (being part of the by-catch) and therefore are not retained, leading to a huge gap in data collection. Here we report about the occurrence in the Ionian Sea of a *Zu cristatus* (Bonelli, 1819) specimen, a mesopelagic fish from the order Lampriformes considered rare in the whole Mediterranean basin. The sample was captured at a depth of 720 m off the coast of Noto (Sicily, Italy) by deep-sea longline fisheries. The biometrics and meristic data were compared with all the available data on specimens previously reported in the Mediterranean Sea. It is interesting to note that, among the few records in the literature, most reports mention a lower depth range for this species. In fact, it is quite known that juvenile specimens of *Z. cristatus* were frequently found in shallow waters, while information about the biology of the adult stage is scarce, indicating they would seem to prefer much deeper environments. Considering the difficulty to collect data on this rare fish, this contribution can help to improve the knowledge about its distribution.

Keywords: zoological records; teleost; deep-sea fishes; phylogeny; marine environment; ontogeny; by-catch; biodiversity; Lampridiformes; Acanthomorpha

1. Introduction

The deep oceans represent the largest habitat on the planet [1,2]. The shallower and more illuminated waters are those mainly inhabited by marine organisms. In contrast, a relatively smaller number of organisms are able, through morphological and functional evolutive adaptations, to live in the more inhospitable deep waters [3,4]. Indeed, deep seas are characterized by extremely harsh conditions, such as high hydrostatic pressure, darkness, low temperature, scarce food, and low oxygen availability [5,6]. Therefore, deep-sea organisms have developed specific morphologic and genetic adaptations to survive in these extreme habitats [7,8].

Fishes represent the main components of the deep-sea megafauna [9]. Evolutionary adaptations to deep-sea life appear to have occurred independently in at least 22 fish orders [10,11]. Several studies have investigated the genetic adaptations that allow vision in the dark of deep environments [12,13]. Others have focused on morphological and structural adaptation to high hydrostatic pressure [14,15]. However, the details of these processes are to be deepened and other adaptation strategies remain largely unknown. The gaps in existing knowledge are also due to the difficulties associated with sampling efforts,

finding specimens, and the consequent studies, as well as the probability of collecting not very abundant species [16–18].

Among the deep-sea fish species, it is sporadic to find specimens of the family Trachipteridae (Swainson, 1839) of the order Lampriformes [19,20]. Actually, beyond Trachipteridae, the other five families belong to this order: Lampridae, Veliferidae, Radiicephalidae, Lophotidae, and Regalecidae [21,22]. Although they are uncommon, are occurring in all oceans. They generally present a naked body with some cycloid or modified ctenoid scales along the lateral line, often spiny and deciduous. Only some species of the families Lampridae and Veliferidae show the body partially covered by thin scales [23,24]. An elongated and compressed ribbon-like body characterizes the entire family. Two characteristics shared by all the species belonging to the Trachipteridae family are the total absence of an anal fin and a long caudal fin, with the presence of the upper lobe only, oriented perpendicularly to the body [22,25]. Also, the dorsal fin is often very long, with its origin well behind the tip of the snout, showing the typical crimson red color of trachipterids fins. Due to their life in deep-sea environments, all these species present large eyes, which are more suitable for capturing the lowest light radiation [22]. Moreover, like all Lampriformes, these fish possess the capacity to protrude and expand significantly their buccal cavity during their feeding activities [26]. In this way, they can hunt pelagic organisms with fewer difficulties in the darkness.

Recently, due to their ecological importance, was observed an increased interest in mesopelagic and bathypelagic communities of the Mediterranean Sea [27–30]. Despite this, the information about Lampridiformes distribution is very scarce and fragmented [31]. Currently, the species reported in this basin, with the documented capture of very few specimens, are: *Lampris guttatus*, *Lophotus lacepede*, *Trachipterus arcticus*, *Trachipterus trachypterus*, *Regalecus glesne*, and *Zu cristatus* [21,25].

The species of the Trachipteridae family are circumglobally distributed, represented by about ten species belonging to three well-defined genera: *Zu* (Walters and Fitch, 1960), *Desmodema* (Walter and Fitch, 1960) and *Trachipterus* (Goüan, 1770); all these genera are present in all oceans [25,32]. The genus *Desmodema* (Walters & Fitch, 1960) consists of two species *Desmodema lorum* (Rosenblatt & Butler, 1977) and *Desmodema polystictum* (Ogilby, 1898); the genus *Zu* (Walters & Fitch, 1960) counts two species, *Z. cristatus* (Bonelli, 1819) and *Zu elongatus* (Heemstra & Kannemeyer, 1984); the large genus *Trachipterus* (Goüan, 1770) comprises six species: *Trachipterus altivelis* (Kner, 1859), *T. arcticus* (Brünnich, 1788), *Trachipterus fukuzakii* (Fitch, 1964), *Trachipterus ishikawae* (Jordan & Snyder, 1901), *Trachipterus jacksonensis* (Ramsay, 1881), *T. trachypterus* (Gmelin, 1789), with several species belonging to this family that have more synonyms (e.g., *Trachipterus misakiensis*, *Trachypterus altivelis*, *Trachypterus nigrifrons*). Studies on the taxonomy and biogeography of Trachipteridae were focused mainly on a regional scale (e.g., Southwest Pacific, [33]; New Zealand, [34]; the Mediterranean and Northeast Atlantic, [35]; Eastern Pacific, [36]; Tasmania, [37]; South African Waters, [20]; Japan, [38]; Korea, [39]; North Pacific, [32]) unfortunately often accompanied by limited and incomplete data. Indeed, the ecological characteristics of these species that make them rare, merged with their low commercial value and related scarce interest from fisheries [40], make these species very elusive for researchers.

Due to the scarcity of data, the evolutionary relationships within Trachipteridae are poorly known [25,41,42]. Moreover, a bit of confusion about the nomenclature and classification of trachipterids genera and species have been recorded over time [39]. Due to the known allometric growth that characterizes this family, drastic morphological changes occur during the ontogeny, with significant morphological and functional differences between juvenile and adult stages within the same species. This variability, combined with their rarity, has led to the description of different life stages as separate species rather than as part of the ontogenetic continuum of a single species, thus inflating the apparent diversity at the species level [42,43]. Over 30 nominal species have been assigned to the family Trachipteridae, even if the valid species probably do not exceed ten [41]. However,

an actual complete global overview of the family was missed due to the scarcity of data mentioned above.

The scalloped ribbonfish *Z. cristatus* (Bonelli, 1820) is a meso-bathypelagic and cosmopolitan species which inhabits the Mediterranean Sea, the Azores, and Madeira in the Atlantic, Pacific, and Indian Oceans [19]. Data on the biology and ecology of this species are limited. Literature sources report that this is the only species of the genus that inhabits the Mediterranean Sea [44]. It was reported in tropical and temperate waters of all the oceans [19,45–49]. In particular, in the Mediterranean basin, individuals of this family are often caught accidentally with professional fishing gear (mainly deep-sea longline and trawling nets), but rarely and in small numbers [19,40,49,50]. The scalloped ribbonfish presence has been reported at various depths, from shallow water in juvenile stages to deep-sea environments, until 2000 m, as recently reported by Tiralongo, highlighting its meso-bathypelagic nature strictly related to its ontogenetic development [49]. This species is known for its morphological features and particular head-up swimming [51]. The diet of adult scalloped ribbonfish is mainly constituted of small fish and cephalopods [52]. The few records of *Z. cristatus* in the Mediterranean basin show that this fish is present in the entire geographical area, with prevalence in the Central Mediterranean Sea [19,45,53]. From the scarce literature, the capture of scalloped ribbonfish seems to be related to the spawning season in which these fish are more mobile and defenseless [45,54]. In particular, the occurrence of *Z. cristatus* has been reported in the Adriatic Sea [45], Ionian Sea [49], Ligurian Sea [40,55,56], Tyrrhenian Sea [19,46,57], the western Mediterranean between the coasts of Spain and Algeria [58,59], Catalunya [60,61] and in the Gulf of Tunis (North of Tunisia) [47], the Eastern Mediterranean in Greece [62] and Turkey [63].

Given the ecological relevance of mesopelagic and bathypelagic organisms and the complexity of deep-sea environments, the phylogeny, genetic adaptations, and distribution triggers of rare mesopelagic species require broader and more complete knowledge.

The present manuscript describes a new record of *Z. cristatus* in the Ionian Sea, providing a comprehensive revision of all the Mediterranean Sea references and accurate comparison between present data and those from the literature.

2. Materials and Methods

2.1. Sample Collection

An adult specimen of Z. *cristatus* was occasionally captured at about 720 m of depth by longline swordfish fisheries off the coast of Noto, Siracuse, Italy (36°50′05″ N 15°16′49″ E) (Figure 1).

Figure 1. Capture site of *Z. cristatus* (36°50′05″ N 15°16′49″ E). Figure obtained with GIS software [64].

Historically, the fisheries of this area are focused on capturing commercially important species such as *Lepidopus caudatus*, (Euphrasen, 1788) and *Xiphias gladius*, (Linnaeus, 1758). Lapridiformes are considered by-catch species and are often discarded as fishing waste [40,65]. The analyzed specimen was retained as unknown fishing waste, collected at the landing for studying purposes, and stored at −20° for further analysis (Figure 2).

Figure 2. *Z. cristatus* specimen of this study just hoisted on board.

2.2. Morphological Identification of the Specimen and Data Collection

The specimen identification and necroscopy procedures were performed at the Department of Chemical, Biological, Pharmacological and Environmental Sciences of the University of Messina (Messina, Italy). The sample was transported frozen and immediately processed after it arrived at the laboratory. All the measurements for the species identification were taken following identification keys proposed by Olney in 1999 for the Trachipteridae family [26]. Biometric data were compared to the Standard Length (SL), Total Length (TL), and Head Length (HL), as a percentage. Epaxial musculature samples were taken for further analysis and stored at −80 °C. Length data were collected using a standard icthyometer of 100 cm length and precision of 1 mm, additionally, other precision measuring sticks (0.1 mm in accuracy) for the fins and detailed measures, while a precision scale was used for the total weight (UW8200S, Shimadzu Corporation, Kyoto, Japan).

3. Results

Species Identification

Morphological identification of the specimen revealed it as *Zu cristatus* [20,26]. The analysis of diagnostic characters shows features in line with those previously reported by other authors for the species, such as a naked body, apart from the lateral line scales, of which the last 47 were spiny and pointed in an alternate direction; two lobes formed the caudal fin, and spiny plates adorned the ventral portion of the tail. The caudal portion of the body was evidently scalloped (Figure 3a).

Tables 1 and 2 show all the biometric and meristic data obtained from the morphological examination of the specimen, also providing a comparison with literature data of other specimens previously reported in the Mediterranean area.

The specimen resulted in 1210 mm in total length (TL) and 4000 g in weight, and the SL resulted in 87.6% of the TL. It was a mature female with evidently developed gonads (Figure 4a). The elongated and compressed ribbon-like silver body was adorned by evident crimson reddish fins with some (apparently six) oblique dusky bars, more noticeable in the fresh specimen (Figure 2) but still present after death (Figures 3a and 4b). Particularly evident was the scalloped shape of the body proceeding towards the tail, resulting in higher pectoral fins insertion, and gradually decreasing moving to the caudal portion of the body.

The head appears round compared to the shape of the rest of the body and the absence of the anterior palatomaxillary ligament and the palatine prong, permitted the maxilla to extend freely with the premaxilla during jaw protrusion (Figure 3d).

Figure 3. Biometric and meristic data collection of the *Z. cristatus* specimen during the necroscopy. (**a**) entire specimen; (**b**) measurement check; (**c**) posterior view of gill rakes; (**d**) detail of the maxilla and the premaxilla extension during jaw protrusion.
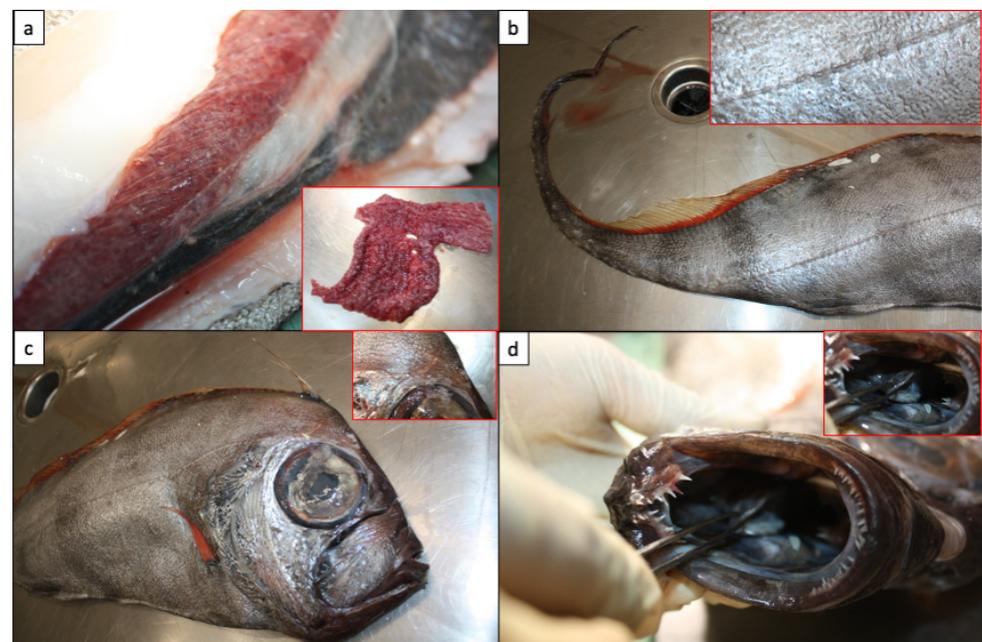
Figure 4. Details of the *Z. cristatus* specimen analysed in the present study. (**a**) mature female gonads, with details of eggs in the red box; (**b**) posterior part of the *Z. cristatus* with evident ventral and tail spines, and tubular lateral line scales in the red box; (**c**) anterior part of the specimens, with the large eye, oblique pectoral fin, and the first evidently elongated rays of the dorsal fin, insertion of the lateral line in the red box; (**d**) mouth cavity armed with upper and lower jaws teeth, and some palatine ones in the red box.

Table 1. Biometric data of the specimen of this study, compared with some *Z. cristatus* specimens reported with details in the Mediterranean area. [1] Falsone et al., 2017; [2] Psomadakis et al., 2007; [3] Tortonese, 1958; [4] Roig & Demestre, 1982; [5] Bianco et al., 2006; [6] Ibanez & Gallego, 1974; [7] Garcia-Barcelona et al., 2014. % SL was referred to as a percentage of the standard length; % TL was referred to as a percentage of the total length; % HL was referred to as a percentage of the head length. * Identify the studies with two described specimens. The first column numbers all referred to the specimen 1 reported in the study; the second column numbers all referred to specimen 2 reported in the study.

Biometric (mm)	Present Study (Ionian Sea)		[1] Southern Tyrrhenian Sea		[2] Ligurian Sea *		[3] Ligurian Sea		[4] Iberian Sea *		[5] Central Tyrrhenian Sea		[6] Iberian Sea		[7] Balearic Sea	
Total length	1210		876		1031–1219		1105		1115–700				875		878	
Fork length	1090															
		% TL		% TL		% TL		% TL		% TL		% TL		% TL		% TL
Standard length	1060	87.6	733	83.7	926–1105	89.8–90.6	980	88.7	1000	89.7	180		785	89.7	803	91.5
		% SL		% SL		% SL		% SL		% SL		% SL		% SL		% SL
Head length	181	17.1	128	17.5	153–191	16.5–17.3	160	16.3	165–85		38	21	175	22.3	165	20.5
Pre-orbital length	50	4.7	39.6	5.4		5.6		5.6	5–3				55	7		
Post-orbital length	58	5.5							5.5–2.7							
Eye diameter	62	5.8	47.8	6.5		6.2		5.8					66	8.4	54	6.7
Opeculum height	198	18.7	146.2	19.9												
Upper jaw length	75	7.1	53.7	7.3											68	8.5
Lower jaw length	107	10.1	75.3	10.3		9.2									93	11.6
Pre-pectoral length	161	15.2														
Pectoral fin length	74	7.0	47.7	6.5		6.1–6.5		6.6	7–3.5				65	8.3	61	7.6
Width of pectoral fin base	13	1.2	10	1.4												
Maximum height of dorsal fin	67	6.3	91.3	12.5		6.6		7.1								
Dorsal fin length	950	89.6													840	104.6
Caudal fin length	128	12.1	130.2	17.3		10.3		12.8	11.5–11				90	11.5	66	8.2
Lateral line length	1000	94.3														
Spiny lateral line length	520	49.1														
Maximum height of the body	230	21.7				19.7–21.3		21.4	20.5–11		41.4	22.8	195	24.8	125	15.6
		% HL		% HL		% HL		% HL		% HL		% HL		% HL		% HL
Pre-orbital length	50	27.6	39.6	30.9		29.4–32.5		34.4					55	31.4		
Post-orbital length	58	32.0	46.5	36.3												
Eye diameter	62	34.3	47.8	37.3		34.6–35.6		35.6			2.1	5.6	66	37.7	54	32.7
Opeculum height	198	109.4	146.2	114,2												
Upper jaw length	75	41.4	53.7	41.9											68	41.2
Lower jaw length	107	59.1	75.3	58.8											93	56.4
Total weight (g)	4000		1301		4400		2800		2160–500							

Table 2. Meristic data of the specimen of this study. compared with some *Z. cristatus* specimens reported with details in the Mediterranean area. [1] Falsone et al. 2017; [2] Psomadakis et al. 2007; [3] Tortonese. 1958; [4] Roig & Demestre. 1982; [5] Bianco et al. 2006; [6] Ibanez & Gallego. 1974; [7] Garcia-Barcelona et al. 2014. * Identify the studies with two described specimens. The first column numbers were all referred to the specimens 1 reported in the study; the second column numbers were all referred to specimens 2 reported in the study.

Meristic (Counts)	Present Study (Ionian Sea)	[1] Southern Tyrrhenian Sea	[2] Ligurian Sea *	[3] Ligurian Sea	[4] Iberian Sea *	[5] Central Tyrrhenian Sea	[6] Iberian Sea	[7] Balearic Sea
Lateral line scales	101		102–96			107		96
Last spine	47							38
Pectoral fin rays	10	11	10–11	10	11–11	12	11	11
Dorsal fin spines	6							
Dorsal fin rays	122	126	125–130	125	117 (6–111)–132 (6–126)	120	120	119
Caudal fin rays	9 + 3	9	9–9	9 + 1	9 + 4–9 + 4		9 + 3	
Caudal fin spines	9							
Upper jaw teeth	18	18	14–21				16	8
Lower jaw teeth	12	12	10–10				10	12
Palatine teeth	4	4	4–4				2	4
Vomerine teeth	4	3	3–4				2	3
Gill rakes total	11	11	10–11	11	10–10	11		11
Gill rakes epibranchial	3	3	3–3	2	2–2	3		3
Gill rakes ceratobranchial	8	8	7–8	9	8–8	8		8
Vertebrae	62	62						

The dorsal fin originated with six elongated rays above the orbit. It continued for the entire body length until the tail. The dorsal fin showed six evident spines. Among the two lobes which constituted the caudal fin, the upper was upturned and formed by nine elongated rays, while the lower was constituted by three rays fused in a single spiny nubbin. Moreover, the caudal fin showed nine evident spines. The anal and the pelvic fins were absent, with the pelvic one just sketched by some spiny nubbins. The pectoral fins were constituted by ten relatively short rays with the base originating in the ventral half of the body, with an oblique, almost vertical orientation.

4. Discussion

The knowledge of the distribution and diversity of aquatic organisms is essential to better evaluate their conservation status [1,29,66,67]. The current state of the art is affected by the limitation of professional fisheries focusing on a restricted number of commercially interesting species. These limitations led to a scarcity of data on many ecologically essential species with no commercial value [40,68,69]. Among these, Lampriformes species have a confirmed ecological role in the mesopelagic trophic webs. They arouse the scientific community's interest concerning their adaptations to life in deep-sea environments. Indeed, the process that led several Lampriformes species to pass from the shallow waters, in which they live in juvenile stages, to the high-depth oceans in adult life hides adaptive mechanisms still largely unknown [70,71].

The Trachipteridae family represents the most diffused in the Mediterranean Sea within the Lampriformes order, with the confirmed presence of at least three species, *T. arcticus*, *T. trachypterus*, and *Z. cristatus* [25]. Despite this, the knowledge base on these species is still scarce. For these reasons, each contribution related to their geographical and bathymetrical occurrence is essential, particularly those accompanied by good morphometric data, description of biological and reproductive features, and genetic achievements. These aspects are essential, especially for species such as *Z. cristatus* that during their life cycle carry out a metamorphosis in the passage from juvenile to the adult stage. Heemstra and Kannemeyer in 1984 related this passage to the size of about 600–800 mm, but Palmer in 1961 previously reported that the typical features of juvenile specimens could retain over this size range, relating it to a "definitive developmental stage" not strictly correlated with age or size [20,35]. Supporting this second theory, Ji et al. reported in 2009 the occurrence of a specimen of 528 mm in SL that showed almost all the typical features of the adult stage, well below the range indicated by Heemstra and Kannemeyer [39].

The specimen of *Z. cristatus* captured in the late spring of 2020 and described in this study, was an adult female with well-developed amber gonads extended for the entire abdominal cavity length, ready for egg emission [68,72] (Figure 4a). Some authors previously reported the late spring/early summer as the spawning season of this species in the Mediterranean Sea [19,48,54]. The eggs appeared reddish colored with a large diameter of over 2 mm, as reported by Walters and Fitch in 1960 [73]. This information is also consistent with the founding of some embryonated scalloped ribbonfish eggs by Dulčic et al. in September 1998 in the Adriatic Sea [45]. Our findings, according to these previous contributions, could suggest for the Ionian Sea the spawning season for this species between May and August. Considering that this is the first contribution of some reproductive features of *Z. cristatus* from the Ionian Sea, we can give no other interpretations of his early life stages in this geographical area.

Despite this species has been reported at various depths, from shallow water at juvenile stages to deep-sea environments, in the Ionian Sea, this is the second record, following the recent one documented by Tiralongo and colleagues for the same area [49]. It is interesting to note how both these two specimens are among the deepest overall (720 m and 2000 m, respectively), thus denoting, based on the few available data, a tendency of this species to live deeper than normal in this area of the Mediterranean Sea.

At the macroscopical examination, the dorsoventrally compressed body, with a pronounced scalloped shape after the anus, is typical of the species *Z. cristatus* in comparison

to *Z. elongatus* which usually shows a lighter decrease of body depth proceeding until the tail [43]. This peculiar body shape could be involved in the typical swimming style of the species, usually in a head-up position, with a major contribution of the fins compared to muscles. This is confirmed by the reduction in ventral scalloping observed in the adult specimens compared to the juvenile ones; indeed, during the adult stage, the contribution of muscles in swimming behavior increases, while in the juveniles the very reduced muscular posterior part of the body is functionally replaced by the fins [35]. The silvery color of the body, with six dark oblique bars, is characteristic of the genus, such as the reddish crimson fins. Despite some authors describing these bars as present only in the juvenile stage, our specimen showed rather evidently this feature, which probably depends on the conservation status of the samples [20]. Despite this, in accordance with Palmer, a reduction in the evidence of dark body bars was observed, proceedings from the head to the caudal region of the body, typical of the adult stage of the species [35]. Occasionally could be present some dark spots on the body or fins, especially in juvenile individuals [43]. Our adult specimen did not show these features.

The specimens analyzed in the current study had a TL of 1210 mm, resulting in the second-longest specimen caught among the reported Mediterranean ones, compared to the specimen with a TL of 1219 mm described by Psomadakis et al. in 2007 from the Ligurian Sea [48]. The SL was 1060 mm, resulting in 87.6% of the TL. This value results average compared to all other Mediterranean records, which start from 83.7% for a specimen from the Southern Tyrrhenian Sea [19], up to 91.5% for a specimen from the Balearic waters [59]. This percentage is almost identical in all the specimens with a TL comparable to this study, confirming the order of this relation between SL and TL on about 88–89% for the adult stage. Also, the head length shows a similar trend resulting in 17.1% of SL, a comparable value to the other similar specimens analyzed that reached the 16.5% to 17.5% range for this relation. In comparison, the smaller ones show values over 20%, highlighting that in juvenile stages the head length is greater proportionally to the TL [46].

The pre-orbital length, post-orbital length, and operculum height data did not show differences when compared with the SL among literature data on the studied species, in this case, between adult and juvenile stages. Remarkably, the relation between pre-orbital length and HL varies from 27.6% detected in this study, to 35.3% reported for a specimen from the Iberian Sea [60]; while the post-orbital length showed a less broad range (31.8–36.3%). The value of the relationship between the operculum height and the HL was over 100%, 109.4% for this study and 114.2% for the specimen from the Southern Tyrrhenian Sea [19] respectively, due to the particular shape of this species.

Regarding eye diameter, this species is known for its giant orbits. It is helpful to have a better view of the darkness of deep-sea environments, which usually moves during adult life. The specimen of this study showed an eye diameter length that resulted in 5.8% and 34.3%, respectively of SL and HL. These values are comparable with those of specimens of similar size (5.7–6.2% of SL, 34.3–35.8% of HL) [48,74] while resulting both lower when compared to smaller specimens (6.5–8.6% of SL, 32.7–37.3% of HL), which showed a more prominent eye size compared to the rest of the body [19,59,61]. It is interesting to note how the juvenile specimen reported by Bianco and colleagues [46] shows values of eye diameter length resulting in 5.6% of SL and 26.3% of HL. This shows how the development of the head structure in this species occurs first compared to the rest of the body. Indeed, in larval and juvenile stages, swimming is guaranteed by the movements of the long fins [25,75]; consequently, lateral musculature is less used and developed compared to adults.

The studied specimen's upper jaw and lower jaw lengths did not show values significantly different from the others used for different size comparisons with SL, resulting in a range of 7.1–8.5% and 9.2–11.6% for the upper jaw and the lower jaw, respectively. Similarly, the comparisons of these measures with the HL resulted in 41.2–41.9% and 53.4–59.1% in range for the upper and lower jaw, respectively. However, these represent high values compared to the average of the teleosts due to the importance of the buccal apparatus in

this species, which could be highly protruded during predation activity, and is essential in a dark environment such as the deep sea.

Regarding pre-pectoral length, lateral line length, and spiny lateral line length, resulted respectively in 15.2%, 94.3%, and 49.1% of SL; this document represents the first reporting these data for this species in the Mediterranean Sea, so no comparisons with literature data were possible. However, the pre-pectoral length value resulted similarly to the juvenile specimens reported by Angulo and Lopez-Sanchez in 2017, and originally caught in 1988 in the eastern Pacific Ocean (Gulf of Papagayo, Costa Rica), which showed a value of 14.2% of SL.

The pectoral fin length resulted in 7% of SL, which is considered normal as an upper limit, compared to the similar size specimens that reported the same value (6.1–7% of SL in range) [48,60,74], while the smaller specimens showed more variable values with a range of 5.9–8.3% of SL [19,59–61]. Considering some higher values from smaller-sized specimens, it is probable that this feature reduces its length compared to the SL passing from the juvenile to the adult stage. This transition is occurring because, during the juvenile phase, all the fins are mainly used for swimming [43]. At the same time, in the adult stage, the role of the pectoral fins becomes more stabilizing, with more power provided by the muscular structure. For the same reasons, a similar trend is shown by the caudal fin length resulting in 12.1% of SL at the upper limit of the range for same-size specimens (10.3–12.1% of SL) [48,60,74], while smaller-sized specimens show a more comprehensive range with higher values (8.2–18.6% of SL) [19,59–61]. It is interesting to note how these fins' measurements (and generally all the recorded features) from the specimen reported by Garcia-Barcelona and colleagues result in unusually low values compared to other specimens of similar size, altering ranges [59]. Considering that this latter is the unique record from the Balearic Sea, it would be exciting to have some new data from these waters to study more in-depth if there exists a relationship between this species' features and the source geographical area. The pectoral fin base width resulted in 1.2% of SL, a similar value to the one reported by Falsone and colleagues for their small-sized specimen (1.4% of SL), which is the only other value reported for this parameter from the Mediterranean Sea [19].

Regarding the dorsal fin length, our specimen data resulted in 89.6% of the SL, a relatively lower value compared to the only other available, the one reported by Garcia-Barcelona et al. in 2014 [59], which indeed resulted in 104.6% of the SL. However, it is conceivable that measurement error could have occurred during that study, as the authors may have wrongly considered part of the dorsal fin as caudal, which is too short compared with all the other studies. The measurements of the fins in these fishes are conditioned by the state of conservation of the specimens. Particularly delicate, the fins can be partially damaged during the capture and storage operations, altering the measurements in those cases. This affects especially the fish caught with trawling nets due to the destructive nature of this fishing method. We believe that in this case, our value is accurate because the specimen analyzed in the present paper was caught with longline fishing and was in good status. Considering some other related taxa references, other authors reported on extended dorsal fins in *Trachipterus* and *Desmodema* species but never exceeding the whole length of the back and in any case the SL [76–78].

Differently, some authors collected the dorsal fin's maximum height. From our specimen, we reported a value of 6.3% of the SL, comparable with those from the other two big-sized specimens, which resulted in 6.6% and 7.1% of SL, recorded by Psomadakis et al. in 2007, and Tortonese [48,74]. Psomadakis and colleagues also report another small-sized individual with the highest value of this parameter (16.4% of the SL), similarly to what was documented by Falsone et al. in 2017, which reported in another specimen of similar size a maximum height of the dorsal fin of 12.5% of SL [19], confirming that, also for the dorsal fin, the young specimens show fins more developed in length compared to body size.

Regarding the body height (or body depth), the comparison between the Mediterranean specimens reveals some interesting question marks. Indeed, this is one of the most important features considered decisive in the identification of the *Zu* genus specimens. In

detail, *Z. elongatus* should be characterized by a maximum body height of 12–16 of the SL, while the range of this parameter for identifying a specimen as *Z. cristatus* is 20–26% of the SL [20,26,41,75,79,80]. Our specimens reveal a maximum body height of 21.7% of the SL, a value within the species range and comparable to other reports by different authors for six of the evaluated specimens [46,48,60,61,74]. Differently, two smaller-sized specimens, reported respectively by Roig & Demestre in 1982 [60] and by Garcia-Barcelona et al. in 2014 [59], showed values of this parameter more in line with the range of *Z. elongatus*. Indeed, the body depth record for these two specimens was 11% and 15.6% of the SL. These values represent an interesting anomaly, although all other parameters measured confirmed the identification as *Z. cristatus*. Hence, it is probable that the validity of this parameter as an identifying character can in some way be put in question, especially among the juvenile specimens; greater deepening needs a wider basin of analyzed samples.

Regarding the total weight, the Mediterranean Sea literature provides data coming from only seven specimens. Hence, an evaluation approach to the length-weight relationship would not be significant. However, looking at the recorded data in relation to the SL, some interesting insights come out. Our specimen showed a total weight of 4000 g with an SL of 1060 mm, values comparable with just another specimen recorded by Psomadakis et al. in 2007 from the Ligurian Sea, with a total weight of 4400 g with an SL of 1105 mm [48]. Comparing the three small-sized specimens in a range of 926–1000 mm of SL between them, the total weight resulted comprised of 2160 g and 2800 g [48,60,74]. According to the literature, the two smallest recorded specimens showed a total weight of 500 g and 1301 g, respectively with 590 mm and 733 mm of SL [19,60]. From an evaluation of these data, it is evident, that the development of *Z. cristatus* favors the length in the juvenile phase, increasing in weight going towards the adult stage. Particularly interesting is to note how, comparing the big-sized specimens with the medium-sized ones, a difference of a few mm in SL could lead to the highest difference in total weight. This is due to the characteristic shape of the species that, during the adult phase of the life cycle, becomes more dorsoventrally compressed and consequently weighted. Moreover, as reported by Palmer in 1961, passing from juvenile to adult stage *Z. cristatus* become less laterally compressed, and thus massive [35]. These developmental features were confirmed by the relationship between the maximum height of the body and the SL of the specimens compared in this manuscript. Indeed, the abnormal low values recorded for the smaller size specimens, resembling *Z. elongatus* for body depth values, are revealed also in the lowest weight compared to the SL. Those apparently abnormal values probably reveal information on the development of the species, which appears like *Z. elongatus* in the juvenile stage, while taking on a certain shape and height of the body that characterizes the species becoming adult. More data on weight, in the various stages of growth, may lead in the future to establish a real length-weight relationship, which will certainly help to revise the identification keys in these regards.

Meristic count comparisons between the specimen herein reported and the literature shows some interesting points of discussion. Indeed, these features are historically involved in the process of morphological identification of the species, discriminating between the Lampriformes order members [20,26,41,75,79,80]. Vertebrae count is one of the main features to discriminate between *Z. cristatus* and *Z. elongatus*, with the last one usually revealing a higher number of elements (84–87). Our specimen reveals 62 elements, the same as the one reported by Falsone and colleagues [19], confirming the species identification and the validity of this discriminant character. Similarly, the lateral line scales are considered as a discriminant character between the two species of the genus *Zu*, with *Z. cristatus* that show a few total elements (between tubular and spiny scales) comprise in a range of 99–106, while *Z. elongatus* is identified by a higher number of total elements in a range of 126–130 [20,26,41,75]. Our specimen reveals 101 total lateral line elements, of which the last 47 were spiny. Comparing this data with the literature specimens, it is interesting to note just how a specimen reported by Psomadakis and colleagues [48] shows a similar number of 102. All the other references reported values out of the above-mentioned range

for species identification, between 96 (in two different cases) to 107 [46,48,59]. Even if these values do not deviate sufficiently to question the identification of the species, is evident how a revision of morphological identification keys should be carried out based on these data. The lateral line is also important in the discrimination among the genera of the Trachipteridae family [20,41]. Particularly, the last lateral line portion of species belonging to the genus *Zu* usually slides along the ventral side of the tail, showing several sharp spines pointing in an alternate direction, both in the juvenile and the adult stages [43]. Differently, the species of the genus *Trachipterus* are characterized by a posterior portion of the lateral line that proceeds well above the ventral edge of the tail, showing the lateral line spines that project laterally without pointing in alternate directions [26,80].

Pectoral fin rays were 10 in the analyzed specimen, and, comparing this count with those from the literature (from 10 to 12), it is in line with the expected value for this species [19,46,48,59–61,74]. The caudal fin of our sample consisted of two lobes, the upper of which was sharply upturned. This is an important feature within the Trachipteridae family, to distinguish the genera *Zu* and *Trachipterus*, from the genus *Desmodema* which does not show the evident upturned tail. Moreover, the ventral edge of the tails was provided by nine spiny plates, another feature that characterizes the members of the *Zu* and *Trachipterus* genera.

Regarding caudal-fin rays, our specimen has shown nine rays on the upper lobe and three on the lower one. These values are comparable with the others from the literature reporting uniformly nine rays on the upper lobe [19,48,60,61,74], while more variability was shown for the caudal lobe. Indeed, just Ibanez and Gallego described in 1974 a specimen with 3 rays on the lower caudal lobe, while Roig and Demestre documented in 1982 two specimens with 2 rays on the lower caudal lobe, and Tortonese in 1958 recorded a specimen with a lower caudal lobe constituted by just 1 single ray [60,61,74]. The rays' reduction in the lower caudal lobe characterizes this species during the shift to the adult stage, this can explain the observed data variability and probably led to this abnormal range of annotated data [35]. Moreover, despite some authors reporting the lower lobe of the caudal fin as constituted by one or two long filaments [20,73], their fragility makes them difficult to record, as very often they are lost during capture phases. Apart from rare cases, only on living recorded specimens through underwater filming, has been possible to observe these features [43].

The pelvic and anal fins were absent in our specimen. As confirmed by previous authors the anal fin is considered absent in this species, while the pelvic fins seem to be present only in the juvenile stage of the species, probably because in this phase all the fins are essential for swimming. Shifting to the adult stage, at an estimated size of 800 mm, these fins disappeared, and a small nubbin is usually found at pelvic fins insertion [20,81]. However, Palmer in 1961 untied this, like other characteristics of development, from just a concern of size, as influenced by the development of the single specimen [35]. Considering the size of our specimen, we confirm these previous descriptions about the absence of pelvic fins in the adult stage of *Z. cristatus*.

The dorsal fin is the most evident in *Z. cristatus*, due to its reddish crimson color and the first very elongated rays, for this reason, Walters and Fitch described it in 1960 as an evident pennant [73]. Palmer reported in 1961 that the first six elongated rays are interested during the development of the fish by a reduction in length, compared to the TL [35], so is conceivable that juvenile specimens show very elongated rays compared to the adults. Moreover, the number of dorsal fin rays is another important feature used for the discrimination between the genus *Desmodema*, which usually show a total number between 120 and 124, and the genera *Zu* and *Trachipterus*, which usually have more than 124 rays on their dorsal fin [20,26,79,80]. Even more specifically, the genus *Zu* usually has less than 150 elements, while the genus *Trachipterus* is the one with the more complex dorsal fin, showing usually more than 150 elements [20,26,79,80]. Our specimen showed a dorsal fin consisting of 122 rays with six evident spines in its posterior portion. This value is considered if it does not allow distinguishing between the genera *Zu* and *Desmodema*.

The other references from Mediterranean literature show a range for this data between 117 and 132 total dorsal-fin elements, with half references that report values common to the *Desmodema* genus, denoting a high variability of this parameter [19,46,48,59–61,74]. However, curiously the two data that delimit the range, are reported by the same author for the two different specimens annotated during the same study, recording six elongated dorsal fin rays for both specimens, followed by 111 and 126, respectively for the bigger and the smaller ones [60]. It is evident how, as already discussed, the fins cannot represent a fundamental character for the identification of Trachipteridae species, as they are often missed or damaged through the fishing methods and therefore lead, as in this case, too unreliable data because influenced by third factors. For example, Hayashi refers, in a general description of the species, to no separation between the first six elongated rays and the rest of the dorsal fin rays [38]; on the contrary, in our specimen, the first rays were lightly separated from the rest of the dorsal fin, as described by Martin in 2015 [43]. Our suggestion is to consider the counts and features of all the fin elements, and their length and height ratios with respect to the rest of the body (e.g., SL) of Trachipteridae species, as secondary factors alongside them by several other parameters during the morphological identification of the species.

Regarding the buccal apparatus, our specimen has shown 18 upper jaw teeth, 12 lower jaw teeth, four palatine teeth, and four vomerine teeth. The same numbers, apart from one less vomerine tooth, were reported by Falsone et al. 2017 for their specimen from the Southern Tyrrhenian Sea [19]. The other studied adult specimens showed a more variable number of teeth, particularly the upper jaw ones with a range from 8 to 21 [48,59,61]. It is interesting to note how the specimen reported by Ibanez and Gallego, in 1974 from the Iberian Sea, had a low number of all teeth (16 on the upper jaw, 10 on the lower jaw, 2 palatines, 2 vomerine) [61]. Equally attractive, are the just eight upper jaw teeth shown by the specimen reported from the Balearic Sea by Garcia-Barcelona et al. in 2014 [59]. It is highly probable that *Z. cristatus*, being an active predator of fishes, molluscs, and crustaceans, may encounter the accidental loss of some teeth during its feeding behavior. Moreover, the geographical area of these recorded specimens with a lower teeth number is similar and could be interesting in a different kind of scalloped ribbonfish' preys that led to a greater loss of teeth [82]. However, to support this hypothesis more information on the diet of these fishes would be required. Hence, another interesting piece of literature data is the occurrence of a specimen with 21 upper jaw teeth recorded by Psomadakis et al. in 2007 from the Ligurian Sea [48]; a strange value that could be explained by an abnormal regeneration after the loss of some teeth or genetical-based alterations [83,84].

About the gill rakes, all the literature data showed a total number of 10–11, of which 2 or 3 are epibranchial and 7 to 9 are ceratobranchial. Our specimen has shown 3 epibranchial and 8 ceratobranchial gill rakes, the most shared values across the literature specimens, and is considered as "normal" [19,46,48,59,60,74].

5. Conclusions

Our knowledge of the distribution of some marine teleost is affected by a scarcity of data, especially for those rare and difficult to sample. Moreover, the poor knowledge, combined with the low commercial value of these organisms, leads to a lack of interest in them. Therefore, more detailed information on these taxa is essential, and each new contribution can lead to interesting new insights. Our report represents the second occurrence of the scalloped ribbonfish in the Ionian Sea, but the first with collected in-depth data. Furthermore, this adult big-sized specimen represents one of the deepest occurrences overall for the species (720 m). From the comparison between our morphometric and meristic data with the few references with comparable data, much information resulted fragmented or, in several cases, missed. It is evident how in this species the data of the juvenile specimens appear different from those of the adults, resulting in them being partially incomparable.

Due to the scarcity of the adult stage data from the literature, most identification keys and diagnoses available for *Z. cristatus* were based on juvenile characters, increasing the

inaccuracy. New benchmarks should be established for the two main developmental stages separately, to correlate new data more appropriately. The increasing information about Lampriformes will certainly be useful in understanding their ecological roles and morphological adaptation to deep-sea life. Hence, our report, representing the most carefully recorded occurrence from the Mediterranean Sea, could be a new essential reference for future studies.

References

1.　Webb, T.J.; Berghe, E.V.; O'Dor, R. Biodiversity's big wet secret: The global distribution of marine biological records reveals chronic under-exploration of the deep pelagic ocean. *PLoS ONE* **2010**, *5*, e10223. [CrossRef]

2.　Levin, L.A.; Bett, B.J.; Gates, A.R.; Heimbach, P.; Howe, B.M.; Janssen, F.; McCurdy, A.; Ruhl, H.A.; Snelgrove, P.; Stocks, K.I.; et al. Global Observing Needs in the Deep Ocean. *Front. Mar. Sci.* **2019**, *6*, 241. [CrossRef]

3.　Yancey, P.H.; Speers-Roesch, B.; Atchinson, S.; Reist, J.D.; Majewski, A.R.; Treberg, J.R. Osmolyte adjustments as a pressure adaptation in deep-sea chondrichthyan fishes: An intraspecific test in arctic skates (*Amblyraja hyperborea*) along a depth gradient. *Physiol. Biochem. Zool.* **2018**, *91*, 788–796. [CrossRef] [PubMed]

4.　Priede, I.G. *Deep-Sea Fishes: Biology, Diversity, Ecology and Fisheries*; Cambridge University Press: Cambridge, UK, 2017.

5.　Lupše, N.; Cortesi, F.; Freese, M.; Marohn, L.; Pohlman, J.-D.; Wysujack, K.; Hanel, R.; Musilova, Z. Visual gene expression reveals a cone to rod developmental progression in deep-sea fishes. *Mol. Biol. Evol.* **2021**, *38*, 5664–5677. [CrossRef]

6.　Childress, J.J.; Seibel, B.A. Life at stable low oxygen levels: Adaptations of animals to oceanic oxygen minimum layers. *J. Exp. Biol.* **1998**, *201*, 1223–1232. [CrossRef]

7.　Brown, A.; Hauton, C.; Stratmann, T.; Sweetman, A.; van Oevelen, D.; Jones, D.O.B. Metabolic rates are significantly lower in abyssal Holothuroidea than in shallow-water Holothuroidea. *R. Soc. Open Sci.* **2018**, *5*, 172162. [CrossRef] [PubMed]

8.　Wang, K.; Shen, Y.; Yang, Y.; Gan, X.; Liu, G.; Hu, K.; Li, Y.; Gao, Z.; Zhu, L.; Yan, G.; et al. Morphology and genome of a snailfish from the Mariana Trench provide insights into deep-sea adaptation. *Nat. Ecol. Evol.* **2019**, *3*, 823–833. [CrossRef]

9.　Haedrich, R.L.; Rowe, G.T. Megafaunal biomass in the deep sea. *Nature* **1977**, *269*, 141–142. [CrossRef]

10.　Weber, A.A.T.; Hugall, A.F.; O'Hara, T.D. Convergent evolution and structural adaptation to the deep ocean in the protein-folding chaperonin CCTα. *Genome Biol. Evol.* **2020**, *12*, 1929–1942. [CrossRef]

11.　Lan, Y.; Sun, J.; Xu, T.; Chen, C.; Tian, R.; Qiu, J.W.; Qian, P.Y. De novo transcriptome assembly and positive selection analysis of an individual deep-sea fish. *BMC Genom.* **2018**, *19*, 394. [CrossRef]

12.　Davies, W.L.; Carvalho, L.S.; Tay, B.H.; Brenner, S.; Hunt, D.M.; Venkatesh, B. Into the blue: Gene duplication and loss underlie color vision adaptations in a deep-sea chimaera, the elephant shark *Callorhinchus milii*. *Genome Res.* **2009**, *19*, 415–426. [CrossRef] [PubMed]

13.　Valen, R.; Edvardsen, R.B.; Søviknes, A.M.; Drivenes, Ø.; Helvik, J.V. Molecular evidence that only two opsin subfamilies, the blue light- (SWS2) and green light-sensitive (RH2), drive color vision in Atlantic Cod (*Gadus morhua*). *PLoS ONE* **2014**, *9*, e115436. [CrossRef] [PubMed]

14.　Morita, T. Comparative sequence analysis of myosin heavy chain proteins from congeneric shallow- and deep-living rattail fish (genus *Coryphaenoides*). *J. Exp. Biol.* **2008**, *211*, 1362–1367. [CrossRef] [PubMed]

15.　Morita, T. Structure-based analysis of high pressure adaptation of α-actin. *J. Biol. Chem.* **2003**, *278*, 28060–28066. [CrossRef]

16.　Gage, J.D.; Bett, B.J. Deep-Sea Benthic Sampling. In *Methods for the Study of Marine Benthos*, 3rd ed.; Blackwell Science Ltd.: Oxford, UK, 2005; pp. 273–325. [CrossRef]

17. Consalvey, M.; Clark, M.R.; Rowden, A.A. The Future of Biological Sampling in the Deep Sea. *Biol. Sampl. Deep. Sea* **2016**, *19*, 431–436. [CrossRef]

18. Montagna, P.A.; Baguley, J.G.; Hsiang, C.Y.; Reuscher, M.G. Comparison of sampling methods for deep-sea infauna. *Limnol. Oceanogr. Methods* **2017**, *15*, 166–183. [CrossRef]

19. Falsone, F.; Geraci, M.L.; Scannella, D.; Okpala, C.O.R.; Giusto, G.B.; Bosch-Belmar, M.; Gancitano, S.; Bono, G. Occurrence of two rare species from order lampriformes: Crestfish *Lophotus lacepede* (Giorna, 1809) and scalloped ribbonfish *Zu cristatus* (Bonelli, 1819) in the northern coast of sicily, Italy. *Acta Adriat.* **2017**, *58*, 137–145. [CrossRef]

20. Heemstra, P.C.; Kannmeyer, S.X. The families Trachipertidae and Radiicephalidae (Pisces, Lampriformes) and a new species of *Zu* from South Africa. *Ann. South Afr. Mus.* **1984**, *94*, 13–39.

21. Quigley, D.T. *Sherkin Comment*; Sherkin Island Marine Station: Cork, Ireland, 2012; p. 12.

22. Nelson, J.S.; Grande, T.C.; Wilson, M.V.H. *Fish of the World*; Wiley: Hoboken, NJ, USA, 2016; pp. 1–752.

23. Underkoffler, K.E.; Luers, M.A.; Hyde, J.R.; Craig, M.T. A taxonomic review of *Lampris guttatus* (Brünnich 1788) (Lampridiformes; Lampridae) with descriptions of three new species. *Zootaxa* **2018**, *4413*, 551–565. [CrossRef]

24. Heemstra, P.C. Family No. 118: Veliferidae. In *Smith's Sea Fishes*; Smith, M.M., Heemstra, P.C., Eds.; Macmillan: Johannesburg, South Africa, 1986; pp. 398–399.

25. Martin, J.; Hilton, E.J. A taxonomic review of the family Trachipteridae (Lampridiformes), with an emphasis on taxa distributed in the Western Pacific Ocean. *Zootaxa* **2021**, *5039*, 301–351. [CrossRef]

26. Olney, J.E. Order Lampriformes. In *FAO Species Identification Guide for Fishery Purposes. The Living Marine Resources of the Western Central Pacific. Volume 3: Batoid Fishes, Chimaeras and Bony Fishes Part 1 (Elopidae to Linophrynidae)*; Carpenter, K.E., Niem, V.H., Eds.; FAO: Rome, Italy, 1999; pp. 952–959, ISBN 92-5-104302-7.

27. Martín-Cuadrado, A.B.; López-García, P.; Alba, J.C.; Moreira, D.; Monticelli, L.; Strittmatter, A.; Gottschalk, G.; Rodríguez-Valera, F. Metagenomics of the deep Mediterranean, a warm bathypelagic habitat. *PLoS ONE* **2007**, *2*, e914. [CrossRef] [PubMed]

28. D'iglio, C.; Albano, M.; Tiralongo, F.; Famulari, S.; Rinelli, P.; Savoca, S.; Spanò, N.; Capillo, G. Biological and ecological aspects of the blackmouth catshark (*Galeus melastomus*, Rafinesque, 1810) in the southern tyrrhenian sea. *J. Mar. Sci. Eng.* **2021**, *9*, 967. [CrossRef]

29. D'Iglio, C.; Albano, M.; Famulari, S.; Savoca, S.; Panarello, G.; Di Paola, D.; Perdichizzi, A.; Rinelli, P.; Lanteri, G.; Spanò, N.; et al. Intra- and interspecific variability among congeneric *Pagellus* otoliths. *Sci. Rep.* **2021**, *11*, 16315. [CrossRef]

30. Moullec, F.; Velez, L.; Verley, P.; Barrier, N.; Ulses, C.; Carbonara, P.; Esteban, A.; Follesa, C.; Gristina, M.; Jadaud, A.; et al. Capturing the big picture of Mediterranean marine biodiversity with an end-to-end model of climate and fishing impacts. *Prog. Oceanogr.* **2019**, *178*, 102179. [CrossRef]

31. Angulo, A.; Lopez-Sanchez, M.I. New records of lampriform fishes (Teleostei: Lampriformes) from the Pacific coast of lower Central America, with comments on the diversity, taxonomy and distribution of the Lampriformes in the eastern Pacific Ocean. *Zootaxa* **2017**, *4236*, 573–591. [CrossRef]

32. Savinykh, V.F.; Baitalyuk, A.A. Taxonomic status of ribbonfishes of the genus *Trachypterus* (Trachipteridae) from the northern part of the Pacific Ocean. *J. Ichthyol.* **2011**, *51*, 581–589. [CrossRef]

33. Augee, M.L. *Proceedings of the Linnean Society of New South Wales: Editorial*; Linnean Society of New South Wales: Sydney, Australia, 2003; Volume 124.

34. Hamilton, H. Notes on the occurrence of the genus *Trachipterus* in New Zealand. *Trans. Proc. Roy. Soc. N. Z.* **1915**, *48*, 370–382.

35. Palmer, G. The Dealfishes (Trachipteridae) of the Mediterranean and north east Atlantic. *Bull. Br. Mus. Nat. Hist. Zool.* **1961**, *7*, 335–351. [CrossRef]

36. Fitch, J.E. The unicornfish, *Eumecichthys fiski* (Gunther), in the eastern tropical Pacific. *Calif. Fish Game* **1966**, *52*, 208–210.

37. Scott, E.O.G. Observations on some Tasmanian fishes: Part XXIX. *Pap. Proc.-R. Soc. Tasman.* **1983**, *117*, 167–202. [CrossRef]

38. Hayashi, M. Trachipteridae. In *Fishes of Japan with Pictorial Keys to the Species*; Nakabo, T., Ed.; Tokai Univ. Press: Tokyo, Japan, 2002; pp. 404–406.

39. Ji, H.W.; Yoon, S.C.; Kim, J.K. Taxonomic review of the family Trachipteridae (Lampridiformes) from Korea. *Korean J. Ichthyol.* **2009**, *21*, 273–282.

40. Garibaldi, F. By-catch in the mesoplagic swordfish longline fishery in the ligurian sea (Western Mediterranean). *ICCAT* **2015**, *71*, 1495–1498.

41. Olney, J.E.; Johnson, G.D.; Baldwin, C.C. Phylogeny of lampridiform fishes. *Bull. Mar. Sci.* **1993**, *52*, 137–169.

42. Miya, M.; Takeshima, H.; Endo, H.; Ishiguro, N.B.; Inoue, J.G.; Mukai, T.; Satoh, T.P.; Yamaguchi, M.; Kawaguchi, A.; Mabuchi, K.; et al. Major patterns of higher teleostean phylogenies: A new perspective based on 100 complete mitochondrial DNA sequences. *Mol. Phylogenet. Evol.* **2003**, *26*, 121–138. [CrossRef]

43. Martin, J.M. Phylogeny, Ontogeny and Distribution of the Ribbonfishes (Lampridiformes: Trachipteridae). Master's Thesis, Virginia Institute of Marine Science, Gloucester Point, VA, USA, 2015; Paper 1539616922. [CrossRef]

44. Albano, M.; D'Iglio, C.; Spanò, N.; Fernandes, J.M.O.; Savoca, S.; Capillo, G. Distribution of the Order Lampriformes in the Mediterranean Sea with Notes on Their Biology, Morphology, and Taxonomy. *Biology* **2022**, *11*, 1534. [CrossRef]

45. Dulčić, J. First record of scalloped ribbon fish, *Zu cristatus* (Pisces: Trachipteridae), eggs in the Adriatic Sea. *J. Plankton Res.* **2002**, *24*, 1245–1246. [CrossRef]

46. Bianco, P.G.; Zupo, V.; Ketmaier, V. Occurrence of the scalloped ribbonfish *Zu cristatus* (Lampridiformes) in coastal waters of the central Tyrrhenian Sea, Italy. *J. Fish Biol.* **2006**, *68*, 150–155. [CrossRef]
47. Bradai, M.N.; El Ouaer, A. New record of the scalloped ribbon fish, *Zu cristatus* (Osteichthyes: Trachipteridae) in Tunisian waters (central Mediterranean). *ANZIAM J.* **2014**, *5*, e59. [CrossRef]
48. Psomadakis, P.N.; Bottaro, M.; Vacchi, M. *On Two Large Specimens of Zu Cristatus (Trachipteridae) from the Gulf of Genoa (NW Mediterranean)*; Cybium: Paris, France, 2007; Volume 31, pp. 480–482.
49. Tiralongo, F.; Lillo, A.O.; Tibullo, D.; Tondo, E.; Martire, C.L.; D'Agnese, R.; Macali, A.; Mancini, E.; Giovos, I.; Coco, S.; et al. Monitoring uncommon and non-indigenous fishes in Italian waters: One year of results for the AlienFish project. *Reg. Stud. Mar. Sci.* **2019**, *28*, 100606. [CrossRef]
50. Macali, A.; Semenov, A.; de Mendoza, F.P.; Dinoi, A.; Bergami, E.; Tiralongo, F. Relative influence of environmental factors on biodiversity and behavioural traits of a rare mesopelagic fish, *Trachipterus trachypterus* (gmelin, 1789), in a continental shelf front of the Mediterranean Sea. *J. Mar. Sci. Eng.* **2020**, *8*, 581. [CrossRef]
51. Bianchi, G.; Carpenter, K.E.; Roux, J.-P.; Molloy, F.J.; Boyer, D.; Boyer, H.J. Species identification guide for fishery purposes. In *Field Guide to the Living Marine Resources of Namibia*; FAO: Windhoek, Namibia, 1999; ISBN 9251043450.
52. Whitehead, P.J.P.; Bauchot, M.L.; Hureau, J.C.; Nielsen, J.; Tortonese, E. *Fishes of the North-Eastern Atlantic and the Mediterranean*; UNESCO Headquarters: Paris, France, 1984; Volume 1.
53. Kaminas, A.; Minasidis, V.; Doumpas, N.; Aga-Spyridopoulou, R.N. Occurrence of Trachipterus trachypterus and Zu cristatus in the Greek Seas: Contribution of citizen science projects in rare species monitoring. In *Proceedings of the HydroMedit 2021*; University of Thessaly: Wallos, Greece, 2021.
54. Sparta', A. *Trachipteridae. Fauna e flora del golfo di Napoli. Monografia della Stazione zoologica di Napoli*; Stazione Zoologica di Napoli: Napoli, Italy, 1956.
55. Fisher, W.; Bauchot, M.L.; Schneider, M. *Fiches FAO d'Identification des Especes Pour les Besoins de la Pêche. Méditerranée et Mer Noire (Zone de Pêche 37)*; FAO: Rome, Italy, 1987; Révision 1, Volume 2. Available online: http://www.fao.org/3/x0170f/x0170f00.htm (accessed on 6 March 2022).
56. Bottaro, M.; Ferrando, S.; Ferrando, T.; Psomadakis, P.N.; Vacchi, M. Melanism in the gastric mucosa of the scalloped ribbonfish from the Ligurian Sea. *J. Fish Biol.* **2005**, *66*, 1489–1492. [CrossRef]
57. Zenetos, A.; Akel, E.H.K.; Apostolidis, C.; Bilecenoglu, M.; Bitar, G.; Buchet, V.; Chalari, N.; Corsini-Foka, M.; Crocetta, F.; Dogrammatzi, A.; et al. New mediterranean biodiversity records (April 2015). *Mediterr. Mar. Sci.* **2015**, *16*, 266–284. [CrossRef]
58. Quignard, J.P.; Tomasini, J.A. Mediterranean fish biodiversity. *Biol. Mar. Mediterr.* **2000**, *7*, 1–66.
59. García-Barcelona, S.; García-Cancela, R.; Cayuela, M.J.; Fernández-Peralta, L.; de Carlos, A.; Bañón, R.; Macías, D.; Báez, J.C. Descripción de dos ejemplares de *Zu cristatus* (Bonelli, 1820) capturados accidentalmente con un palangre semipelágico en el Mediterráneo occidental. *Arx. Miscel·Lània Zoològica* **2014**, *14*, 91–98. [CrossRef]
60. Roig, A.; Demestre, M. Nota sobre la captura de dos *Zu cristatus* (Bonelli, 1820) en aguas del litoral catalán (Pisces, Trachipterigidae). *Misc. Zool.* **1982**, *6*, 152–154.
61. Ibáñez, M.; Gállego, L. A New Record of a *Zu Cristatus* (Trachipteridae Pisces) Off the Coast of Blanes (Spain). *Vie Milieu* **1974**, 523–526.
62. Papaconstantinou, C. Fauna Graeciae, IV Pisces. Check-list Mar. Fishes Greece. Available online: https://agris.fao.org/agris-search/search.do?recordID=XF2016062731 (accessed on 5 October 2022).
63. Golani, D.; Ozturk, B.; Basusta, N. Fishes of the Eastern Mediterranean. *Isr. J. Aquac.-Bamidgeh* **2007**, *59*, 260. [CrossRef]
64. Prakash Maurya, S.; Ohri, A.; Mishra, S. Open Source GIS: A Review. In Proceedings of the National Conference on Open Source GIS: Opportunities and Challenges Department of Civil Engineering, Varanasi, India, 9–10 October 2015; pp. 150–155.
65. Orsi Relini, L.; Palandri, G.; Garibaldi, F.; Cima, C. Longline sworfish fishery in the Ligurian Sea: Eight years of observations on target and by-catch species. *Collect. Vol. Sci. Pap. Comm. Conserv. Atl. TUNAS* **1998**, *49*, 146–150.
66. Sanfilippo, M.; Albano, M.; Manganaro, A.; Capillo, G.; Spanò, N.; Savoca, S. Spatiotemporal Organic Carbon Distribution in the Capo Peloro Lagoon (Sicily, Italy) in Relation to Environmentally Sustainable Approaches. *Water* **2022**, *14*, 108. [CrossRef]
67. D'Iglio, C.; Natale, S.; Albano, M.; Savoca, S.; Famulari, S.; Gervasi, C.; Lanteri, G.; Panarello, G.; Spanò, N.; Capillo, G. Otolith Analyses Highlight Morpho-Functional Differences of Three Species of Mullet (Mugilidae) from Transitional Water. *Sustainability* **2021**, *14*, 398. [CrossRef]
68. D'Iglio, C.; Albano, M.; Famulari, S.; Spanò, N.; Rinelli, P.; Savoca, S.; Capillo, G. Basic Intersexuality (Abnormal Hermaphroditism) in the Blackmouth Catshark, *Galeus melastomus*, (Rafinesque, 1810), from the Southern Tyrrhenian Sea (Central Mediterranean Sea). *Fishes* **2022**, *7*, 120. [CrossRef]
69. D'Iglio, C.; Famulari, S.; Albano, M.; Giordano, D.; Rinelli, P.; Capillo, G.; Spanò, N.; Savoca, S. Time-Scale Analysis of Prey Preferences and Ontogenetic Shift in the Diet of European Hake *Merluccius merluccius* (Linnaeus, 1758) in Southern and Central Tyrrhenian Sea. *Fishes* **2022**, *7*, 167. [CrossRef]
70. Dragicevic, B.; Pallaoro, A.; Grgicevic, R.; Lipej, L.; Dulcic, J. On the occurrence of early life stage of the king of herrings, *Regalecus glesne* (Actinopterygii: Lampriformes: Regalecidae), in the Adriatic Sea. *Acta Ichthyol. Piscat.* **2011**, *41*, 251. [CrossRef]
71. Francour, P.; Cottalorda, J.-M.; Aubert, M.; Bava, S.; Colombey, M.; Gilles, P.; Kara, H.; Lelong, P.; Mangialajo, L.; Miniconi, R. Recent occurrences of opah, *Lampris guttatus* (actinopterygii, lampriformes, lampridae), in the western mediterranean sea. *Acta Ichthyol. Piscat.* **2010**, *40*, 91–98. [CrossRef]

72. Sang, H.M.; Lam, H.S.; Hy, L.H.K.; Ky, P.X.; Minh-Thu, P. Changes in plasma and ovarian steroid hormone level in wild female blue tang fish *Paracanthurus hepatus* during a reproductive cycle. *Animals* **2019**, *9*, 889. [CrossRef] [PubMed]

73. Walters, V.; Fitch, J.E. The families and genera of the Lampridiform (Allotriognath) suborder Trachipteroidei. *Calif. Fish Game* **1960**, *46*, 441–451.

74. Tortonese, E. Cattura di Trachypterus cristatus Bon. e note sui Trachypteridae del Mar Ligure. *Doriana* **1958**, *2*, 1–5.

75. Olney, J.E. Lampridiformes: Development and relationships. *Ontog. Syst. Fishes* **1984**, 368–379.

76. Borme, D.; Voltolina, F. On the occurrence of ribbon fish *Trachipterus trachypterus* (Gmelin, 1789) in the Gulf of Trieste (Northern Adriatic Sea). *Ann. Ser. Hist. Nat.* **2006**, *16*, 181–188.

77. Moritz, T.; Stümer, D.; Jakobsen, K.; Jakobsen, J. Observations on two live specimens of *Trachipterus arcticus* (Lampriformes: Trachipteridae) from the Azores. *Cybium* **2015**, *39*, 78–80.

78. Rosenblatt, R.H.; Butler, J.L. The ribbonfish genus *Desmodema*, with the description of a new species (Pisces, Trachipteridae). *Fish. Bull.* **1977**, *75*, 843–855.

79. Charter, S.R. Lampridiformes, Lophotidae, Radiicephalidae, Trachipteridae. In *The Early Stages of Fishes in the California Current Region*; California Cooperative Oceanic Fisheries Investigations Atlas, Ed.; Allen Press, Inc.: Lawrence, KS, USA, 1996; pp. 659–677.

80. Robins, C.R.; Ray, G.C.; Douglass, J. *A Field Guide to Atlantic Coast Fishes of North America*; Houghton Mifflin Harcourt: Boston, MA, USA, 1986; ISBN 0395975158.

81. Bolin, R.L. New Fish Records from Southern California. *Copeia* **1933**, *1933*, 35. [CrossRef]

82. Tucker, A.S.; Fraser, G.J. Evolution and developmental diversity of tooth regeneration. In *Proceedings of the Seminars in Cell & Developmental Biology*; Elsevier: Amsterdam, The Netherlands, 2014; Volume 25, pp. 71–80.

83. Bei, M. Molecular genetics of tooth development. *Curr. Opin. Genet. Dev.* **2009**, *19*, 504–510. [CrossRef] [PubMed]

84. Wang, X.; Fan, J. Molecular genetics of supernumerary tooth formation. *Genesis* **2011**, *49*, 261–277. [CrossRef] [PubMed]