diversity

MDPI

Article

The Fishery Biology of Two Deep-Water Skates, *Bathyraja schroederi* and *Amblyraja frerichsi* (Rajiformes: Rajidae), from the Southeast Pacific Ocean

Carolina Vargas-Caro [1,2], María J. Indurain [1,2] and Carlos Bustamante [1,2,*]

[1] CHALLWA, Laboratorio de Biología Pesquera, Instituto de Ciencias Naturales Alexander von Humboldt, Facultad de Ciencias del Mar y de Recursos Biológicos, Universidad de Antofagasta, Antofagasta 1271155, Chile; c.vargascaro@challwa.org (C.V.-C.); maria.torres.indurain@ua.cl (M.J.I.)

[2] Programa de Conservación de Tiburones, Facultad de Ciencias del Mar y de Recursos Biológicos, Universidad de Antofagasta, Antofagasta 1240000, Chile

* Correspondence: carlos.bustamante@uantof.cl; Tel.: +56-55-2637610

Abstract: Chile is a biodiverse region for deep-water skates (Rajiformes), with 36 species documented in national waters, of which 73% correspond to deep-water species. Among them, the Thickbody skate (*Amblyraja frerichsi*) and Whitemouth skate (*Bathyraja schroederi*) are two poorly documented species with relatively high abundances. However, the current information is limited to a few specimens reported over the last 50 years between southern Brazil (SW Atlantic) and central Chile (SE Pacific). In the Southeast Pacific, both species are bycatch in the Patagonian toothfish (*Dissostichus eleginoides*) fishery, which operates along the Chilean coast between 800 and 1600 m of depth. This study examined aspects of demography and reproductive biology based on data from 190 specimens (125 *A. frerichsi* and 65 *B. schroederi*) obtained from the fishery in northern Chile. The new data contribute to enhancing our understanding of deep-water skate communities and highlight the vulnerability and fishing pressure experienced across their geographic distribution.

Keywords: elasmobranch biodiversity; skate; Patagonian toothfish

Citation: Vargas-Caro, C.; Indurain, M.J.; Bustamante, C. The Fishery Biology of Two Deep-Water Skates, *Bathyraja schroederi* and *Amblyraja frerichsi* (Rajiformes: Rajidae), from the Southeast Pacific Ocean. *Diversity* **2024**, *16*, 709. https://doi.org/10.3390/d16120709

Academic Editors: Simon Blanchet and Simon Weigmann

Received: 30 August 2024
Revised: 14 November 2024
Accepted: 18 November 2024
Published: 21 November 2024

1. Introduction

Skates (Chondrichthyes: Rajiformes) are considered the largest groups of elasmobranch fishes, with over 600 species worldwide [1], with Arhynchobatidae (Fowler, 1934) and Rajidae (Bonaparte, 1831) having the greatest number of species [2,3]. Skates inhabit most marine environments, from the sublittoral zone to deep waters [2,4]; however, their large body size and life history traits, such as slow growth, late sexual maturity, and low fecundity, make them highly vulnerable to overexploitation [5,6].

Overfishing is a major cause of the population decline and collapse of skate stocks worldwide [7]. The vulnerability to collapse due to the direct and indirect effects of fishing has been well documented for several species, including deep-sea rajids [8]. Although the catch may be incidental, demersal skates are usually retained for trade and human consumption, and may even become unofficial target species in many fisheries [9].

Chile is characterized by a great diversity of fishery resources with high commercial demand worldwide [9]. In this context, the Patagonian toothfish fishery (*Dissostichus eleginoides* Smitt, 1898) is one of the most representative, profitable, and productive fisheries in terms of export volume [10]. This fishery operates along the entire Chilean coast through artisanal (between 19.1° S and 47° S) and industrial fleets (south of 47° S) [11]. A strong interaction between this fishery and cartilaginous fishes has been reported in central–southern Chile, where sharks, skates, and chimeras are discarded dead without use or commercialisation [12]. According to Reyes et al. [13], two of the most common species in the bycatch of *D. eleginoides* in southern Chile are the Thickbody skate *Amblyraja frerichsi*

(Krefft, 1968) and, in lesser abundance, the Whitemouth skate *Bathyraja schroederi* (Krefft, 1968). However, both species have been inadequately documented in Chilean waters because of the low level of reporting catches at the species level by observers or fishers [14]. Interestingly, both species, *A. frerichsi* and *B. schroederi*, were described in the same year from juvenile specimens caught off the Rio de La Plata (Argentina and Uruguay Common Fishing Zone) between 800 and 1000 m depth during a research cruise [15]. Since then, only a handful of additional records of mostly immature individuals of these rare deep-water skates have been reported in the Southwest Atlantic Ocean [16,17]; until Stehmann and Pompert [18] described a mature male of *B. schroederi* for the first time in 2014.

In the Southeast Pacific, both skates have been reported in Chile almost 30 years after their original description from single specimens: *B. schroederi* off Talcahuano (36.5° S) and *A. frerichsi* off southern Chile (~42° S). However, reference specimens are mentioned as "material whose study is in progress" [19], and of which nothing has been published to date. Thus, there were no further details or preserved specimens to confirm this addition to Chilean biodiversity until Reyes et al. [13], who reported high bycatch rates of *A. frerichsi* in the Patagonian toothfish fishery off the Magellan Strait in 2006. Later, Bustamante et al. [20] reported mature *A. frerichsi* males and females in southern Chile. These authors also contributed to supplementing the anatomy and morphology of the species and extended the distribution range to 36° S in the Southeast Pacific. However, unverified records of single specimens have been reported from Coquimbo (30° S) [21], and the Tarapacá region (23° S) [22] may indicate a more extensive northern range than currently accepted. Indeed, Ñacari et al. [23] included specimens of *A. frerichsi* off Tocopilla, (22° S), and recently, Zavalaga et al. [24] reported a single specimen off Ilo, Peru (17° S). In contrast, the available data on *B. schroederi* are much more restricted, being limited to a few specimens caught off the coast of Valdivia [25].

Considering the scarcity of documented records on these two skates and the uncertainty regarding their geographic distribution, this study aimed to provide additional data on *B. schroederi* and *A. frerichsi*, with an emphasis on demographic information from specimens caught in northern Chile.

2. Materials and Methods

Between August and December 2021, 190 specimens (125 *A. frerichsi* and 65 *B. schroederi*) were obtained as bycatch from the Patagonian toothfish (*D. eleginoides*) artisanal fishery operating in northern Chile at depths ranging between 800 and 1000 m. The skates were caught between Iquique (21° S) and Antofagasta (24° S) and landed at the Antofagasta fishing terminal (Figure 1).

During sampling, the total length (L_T) of each specimen was measured following a standardised methodology [26], where the distance between the snout tip and the posterior apex of the caudal fin was measured. In addition, the sex of each specimen was determined by the presence of claspers in males and the postcloacal length of the left clasper (L_C) was measured in males. All measurements were made to the nearest centimetre (cm) and are presented as the mean ± SD. An $\chi 2$ goodness-of-fit test [27] was used to assess whether the male-to-female ratio significantly varied from 1:1. Additionally, the size frequency was determined individually by sex and potential deviations from normality were evaluated using the Kolmogórov–Smirnov (W) test.

For both male and female skates, sexual maturity stages were defined according to a modified scale [28,29], which allowed for the identification of immaturity (stages 1 and 2) and maturity (stages 3 and 4). The reproductive organs were examined and categorised according to changes in the ovaries, nidamental gland, and uterus of females and the testes and clasper glands in males. Additionally, binominal maturity data were determined by sex at 5 cm intervals (immature 0, mature 1). The median size at maturity in both sexes was calculated by fitting the following logistic curve (by minimisation of least squares) to the relationship between the fraction of mature individuals as a function of L_T:

$$Y = [1 + e^{-(a+bX)}] - 1, \tag{1}$$

where Y is the fraction of mature individuals in L_T X and a and b are model coefficients. The a:b ratio represents the size at which 50% of individuals are mature [27]. All statistical analyses were performed using the open-source R language, with the significance set at $p < 0.05$.

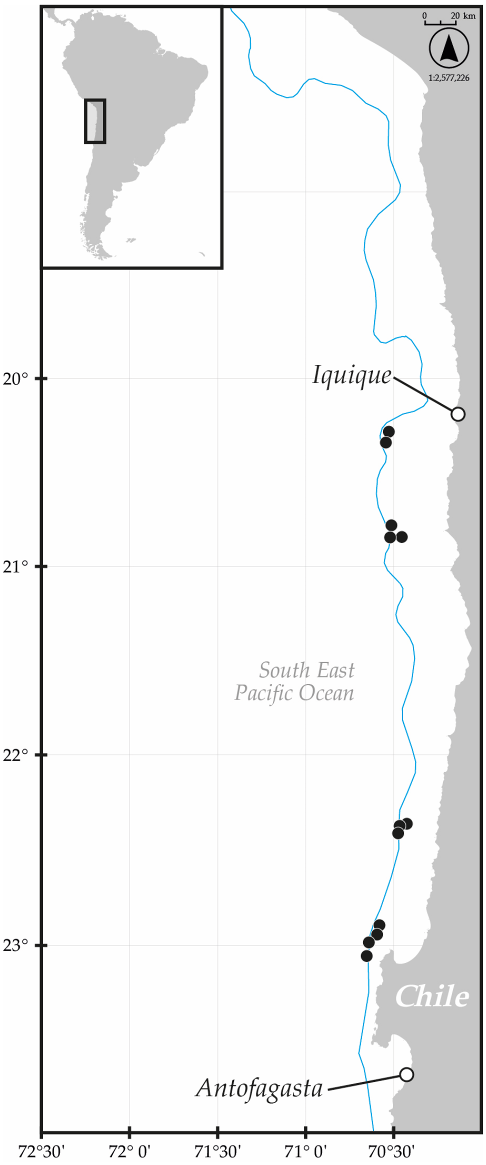

Figure 1. The geographical locations of commercial fishing operations targeting the Patagonian toothfish (*D. eleginoides*) surveyed in the present study in 2021. The circles represent longline sets where specimens of *B. schroederi* and/or *A. frerichsi* were collected. The solid blue line corresponds to the 1000 m isobath.

3. Results

3.1. Whitemouth Skate (Figure 2)

A total of 65 specimens were examined (25 males and 40 females). The catch composition sex ratio of 1:1.6 showed no significant differences between male and female proportions in landings ($\chi 2 = 3.465$, d.f. = 1, $p = 0.06$). The body size of the caught females ranged from 54.5 and 124 cm L_T (94.2 ± 18.3 cm), and males ranged from 49.5 and 103 cm L_T (83.4 ± 16.7 cm). The catch size distribution for males ($W = 0.8524$, $p < 0.05$) and females

($W = 0.9231$, $p < 0.05$) did not fit a normal distribution, with two peaks observed at small (50–60 cm L_T) and medium (90–100 cm L_T) sizes for both sexes (Figure 3a).

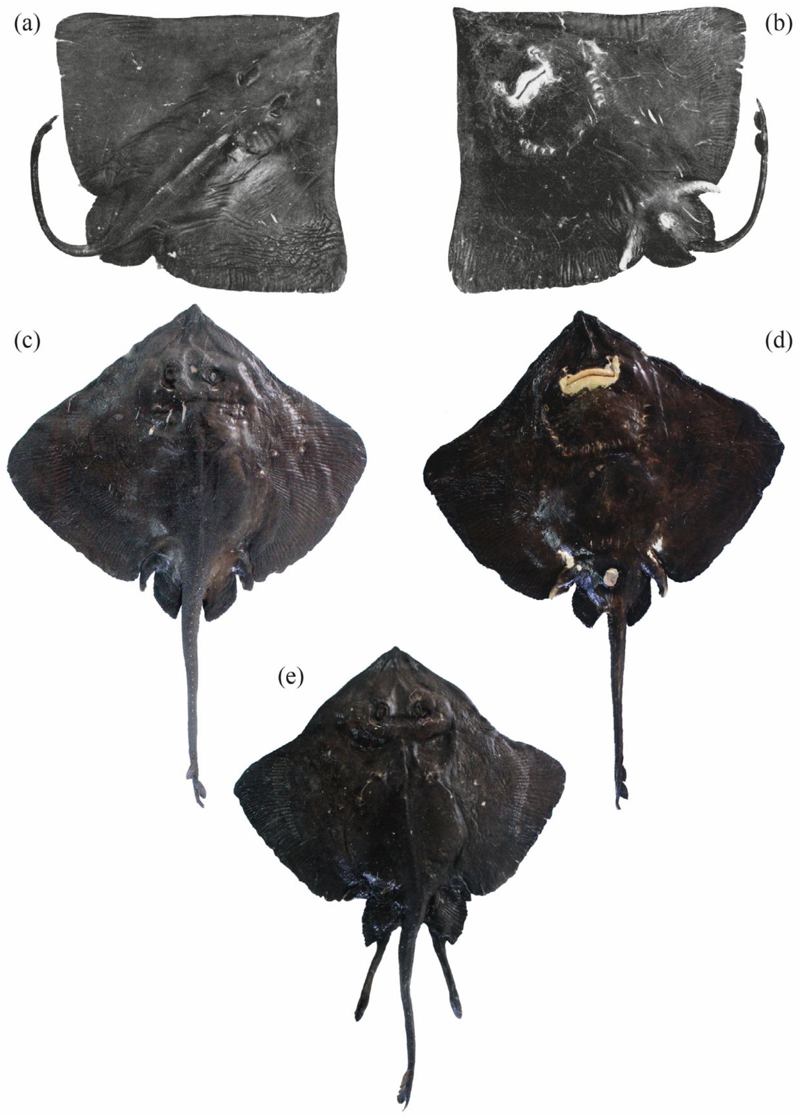

Figure 2. A Whitemouth skate (*Bathyraja schroederi*). Dorsal and ventral views of specimens from Argentina ((**a**,**b**), female 128 cm L_T) and Chile ((**c**,**d**), female 117 cm L_T; (**e**), male 122 cm L_T). The Argentinean specimen corresponded to the holotype (ISH-1531/66) described by Krefft [15], and the Chilean specimens were obtained in the present study. The image of the holotype is black and white.

Four stages of sexual maturity were identified in the sample by examining the internal reproductive organs: immature (Stage 1), juvenile (Stage 2), mature (Stage 3), and active (Stage 4). Stages 1 and 2 represented the immature fraction of the population, and stages 3 and 4 represented the reproductive adult fraction. According to an internal organ examination, 36% ($n = 9$) of the males and 32.5% ($n = 13$) of the females were immature. In addition, three males and four females were observed in stage 4, representing 12% and 10%, respectively (10.7% of the total population). Only one female was gravid, with one egg capsule per uterus. The clasper size (L_C) was recorded for only seven individuals, of which only one was active (stage 4). The maximum recorded clasper size for this mature male was 25 cm (Figure 3b). The size at which 50% of the males were mature (L_{50}) was 82.9 cm L_T (Figure 3c). However, the reproductive information for males should be used with caution and may not be representative of the population, considering the small sample size. In the case of females, 67.5% of the specimens in the catch were mature, with the largest immature individual measuring 107.3 cm L_T, and the smallest mature individual measuring 73.4 cm L_T. This is based on an estimated mean size at maturity of 92.5 cm L_{50} for females (Figure 3d).

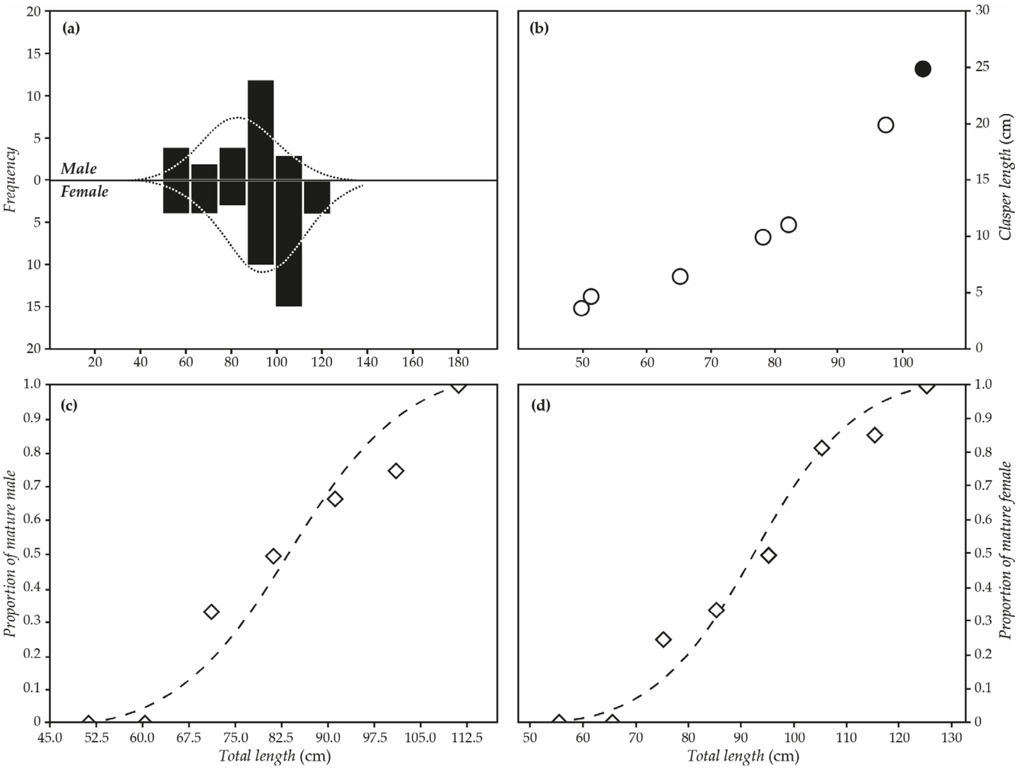

Figure 3. The size structure and reproductive biology of *B. schroederi* off northern Chilean waters: (**a**) the total length (L_T) the absolute frequency distribution of males and females; (**b**) the relationship between clasper length (L_C) and the total length and fitted logistic model for the proportion of mature males (**c**) and females (**d**) in the population. The dotted line in (**a**) represents the fit to the normal distribution. The white and black circles in (**b**) represent immature (stages 1 and 2) and mature specimens (stages 3 and 4).

Taxonomic Remarks

In 2022, Ebert et al. [30] described a new *Bathyraja* species based on two specimens (male and female) from Peruvian waters. However, under comparative examination, these specimens may correspond to adults of *B. schroederi.* The diagnostic features of *Bathyraja chapmani* from Ebert, Alfaro-Shigueto, Velez-Zuazo, Pajuelo and Mangel 2022 [30] overlap with those reported for *B. schroederi* [16–18] and reflect a morphological similarity that raises doubts about the validity of the new species. However, upon close examination, the external morphology of *B. chapmani* was within the range of the specimens reviewed in this study, and the diagnosis of both species was superimposed on the following features: "Broad rhombic disc, wider than long (1.25–1.3 times length). Anterior margin nearly straight; apices broadly rounded. Snout is moderately short, blunt at the tip, soft, and flexible vertically due to the very delicate rostral cartilage. Orbits small, slightly elevated above the head, interorbital space concave. Spiracle suboval, opening oblique, anterior margin opening extending forward, nearly to posterior margin of eye. Number of tooth rows in the maxilla 21–32. Tail moderately long and slender, length approximately equal to disc length. The upper disc is rather smooth and extensive in juveniles but limited to the anterior margin of the disc in adults. Upper disc without thorns, except for malar thorns in adult male. Dorsal surface of tail with single, median, continuous row of 19–30 posteriorly angled thorns. The ventral surface is completely smooth. Pelvic fins deeply notched between anterior and posterior lobes. Two small dorsal fins near the end of the tail, slightly separated without spines in interdorsal space. Epichordal caudal-fin lobe developed, length short and height low, separated by narrow interspace from second dorsal fin; hypochordal caudal lobe minute, length less than first-dorsal-fin height. Lateral folds extending almost the entire tail length. Abdominal vertebrae 28–42; predorsal tail vertebrae 75–87. Colour dark-plum-brown to greyish brown on dorsal and ventral surfaces, and lighter around mouth, gill slits, cloaca, and tip of anterior pelvic lobes".

The irregular spotted pattern on both the dorsal and ventral surfaces, described as a diagnostic feature of *B. chapmani* (Figure 4), may correspond to scars and bite marks made by marine leeches (Hirudinea: *Ceratobdella* Utevsky and Gordeev, 2015; Figure 4a) which regularly parasitise *B. schroederi* (Figure 4b). Although these "spots" may be associated with or reflect patterns in skin, they cannot be considered as natural markings (despite being of "natural" origin) within the phylogeny of *Bathyraja* species and do not support a comparative argument for the diagnosis of skates. Skin discolouration is not unusual on deep-water skates [31–33], and this may be the result of healed wounds and scars that may resemble small "spots" or "spotted patterns". Therefore, the presence of scars and bite marks from parasites may lead to misidentification, if mistaken for natural markings.

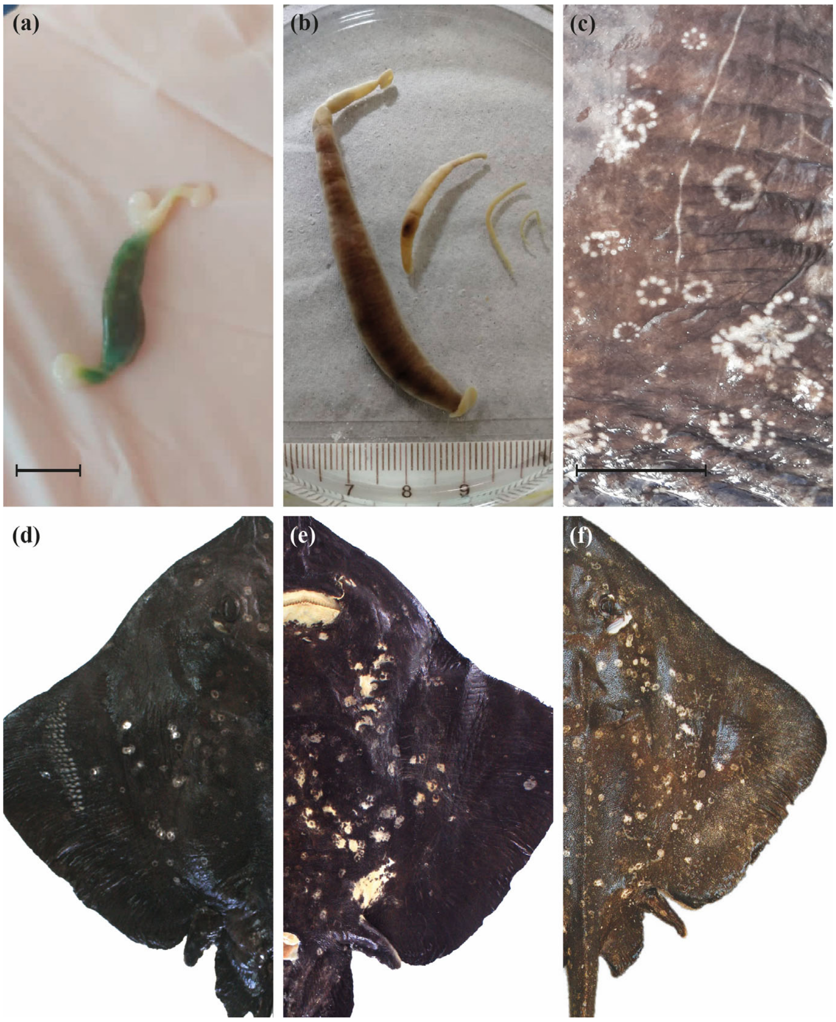

Figure 4. Photographs of fresh (**a**) and preserved (**b**) specimens of *Ceratobdella* sp., removed from the skin of *B. schroederi* from Chilean waters, with (**c**) close-up details of healed bite marks that resemble "spotted" or discoloured markings reported by Ebert et al. [30] to discriminate *Bathyraja* species in the SE Pacific. Dorsal (**d**) and ventral (**e**) views of the disc of *B. schroederi* from Chilean specimens compared (**f**) with those found in *B. chapmani* from Ebert et al. [30]. The scale bars in (**a**,**c**) represent 1 cm.

Further molecular taxonomy may help clarify the taxonomic status among *Bathyraja* species in the South Pacific basin. However, *B. chapmani* is likely invalid and should be considered a junior synonym for *B. schroederi*.

3.2. Thickbody Skate (Figure 5)

A total of 125 specimens were examined (62 male and 63 female). The catch composition sex ratio of 1:1.02 shows no significant differences between male and female proportions in landings ($\chi 2 = 0.008$, d.f. = 1, $p = 0.928$). The body size of females caught ranged between 44 and 176 cm L_T (85.4 ± 29.1 cm), and males ranged between 40 and 116.4 cm L_T (82.8 ± 18.6 cm) (Figure 3b). The catch size distribution for males could be fitted to a normal distribution ($W = 0.9676$, $p = 0.100$), but not for females ($W = 0.9345$, $p < 0.05$), where two peaks occurred at sizes close to 60 cm and 100 cm L_T (Figure 6a).

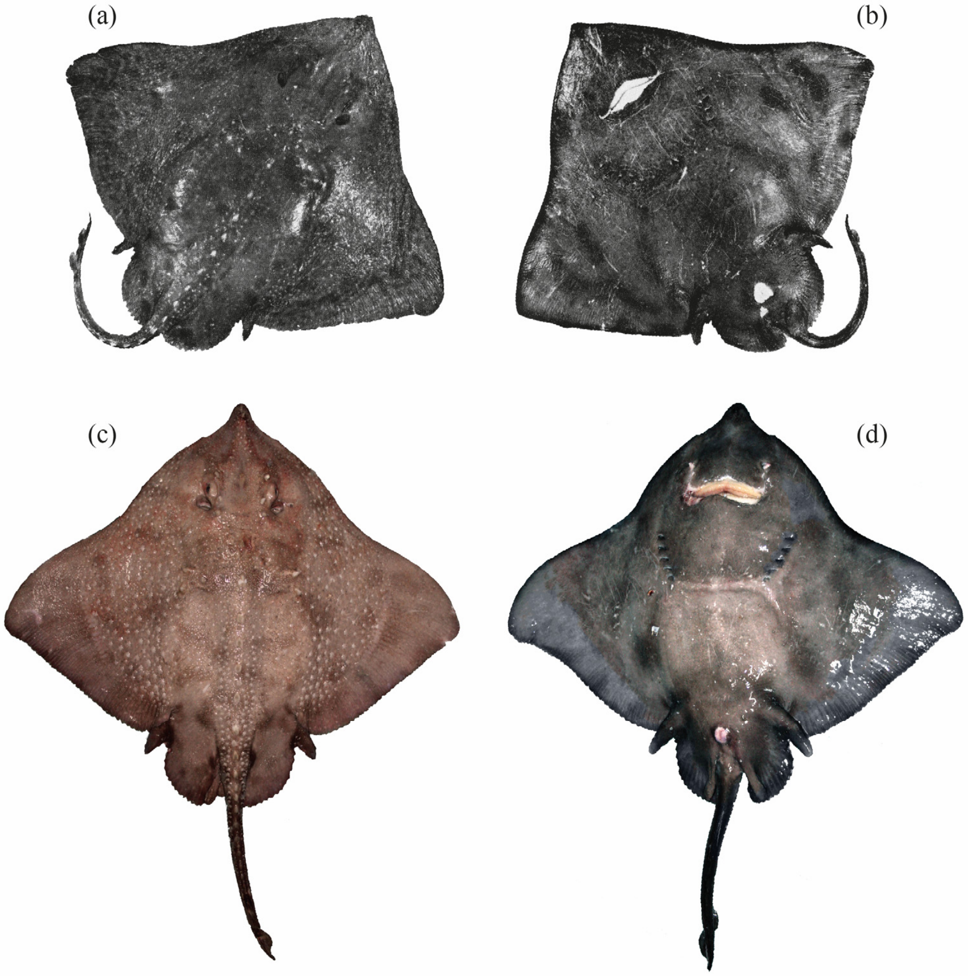

Figure 5. A Thickbody skate *Amblyraja frerichsi*. Dorsal and ventral views of specimens from Argentina ((**a**,**b**), female 81.7 cm L_T) and Chile ((**c**,**d**), female 88 cm L_T). The Argentinean specimen corresponded to the holotype (ISH-1532/66) described by Krefft [15], and the Chilean specimen was obtained in the present study. The image of the holotype is black and white.

Within the observed population, four stages of sexual maturity were identified by examining the internal reproductive organs. Accordingly, 66.1% ($n = 41$) of the males and 68.3% ($n = 43$) of the females were immature (stages 1 and 2). A small percentage of both sexes were reproductively active, representing 6.5% ($n = 4$) and 6.3% ($n = 4$) of males and females, respectively. Egg capsules were not observed in any of the examined females. The clasper size (L_C) of 33 individuals was recorded at four stages of sexual maturity, with a maximum observed size of 29 cm L_C (Figure 6b). The size at which 50% of the males were mature (L_{50}) was 98.4 cm L_T (Figure 6c), representing 24% of the analysed population. In the case of females, 20.6% of the specimens in the catch were mature with the largest immature individual being 107.8 cm $L_{T,}$ and the smallest mature individual being 96 cm L_T. This is based on an estimated mean size at maturity of 105.3 cm L_{50} for females (Figure 6d).

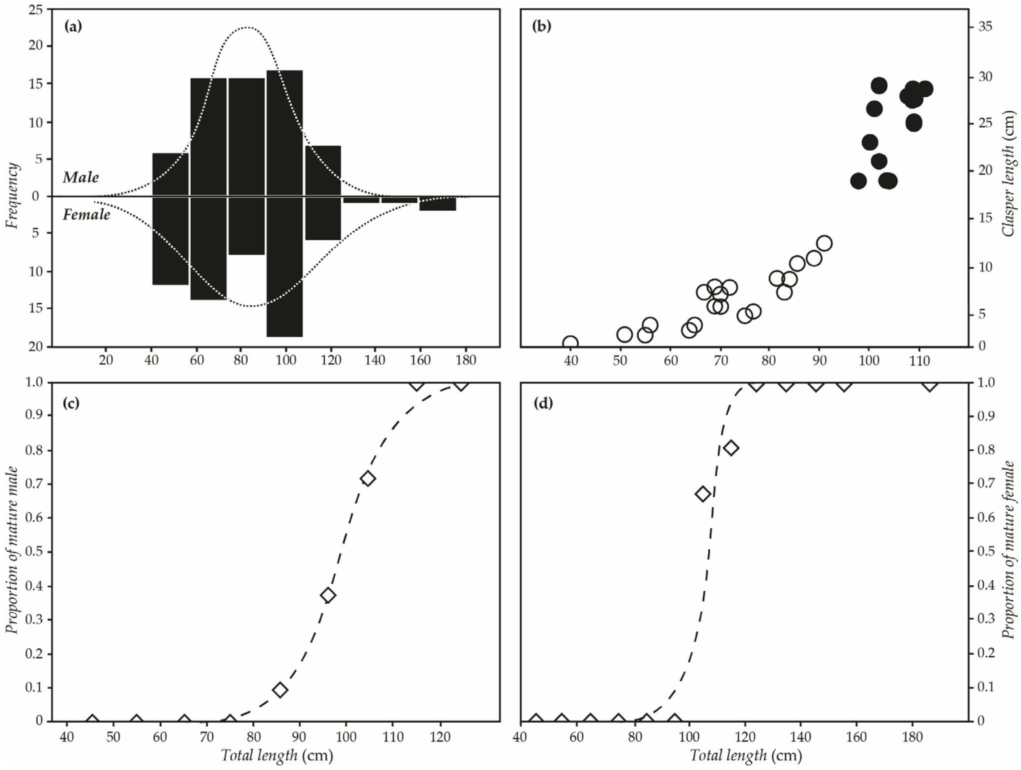

Figure 6. The size structure and reproductive biology of *A. frerichsi* off northern Chilean waters: (**a**) the total length (L_T) the absolute frequency distribution of males and females; (**b**) the relationship between clasper length (L_C) and the total length and fitted logistic model for the proportion of mature males (**c**) and females (**d**) in the population. The dotted line in (**a**) represents the fit to the normal distribution. The white and black circles in (**b**) represent immature (stages 1 and 2) and mature specimens (stages 3 and 4).

4. Discussion

From the new material obtained from northern Chile, it was possible to supplement the biological and ecological information related to the population structure and sexual maturity of the two deep-sea skates. Despite being described in the Southwest Atlantic almost 50 years ago, there are only anecdotal records of *A. frerichsi* and *B. schroederi*, especially because of the limited availability of incidentally caught specimens in fisheries operating around Patagonian and Circum Antarctic waters [13,34]. Sérét and Andreata [35] and recently, Stehmann and Pompert [18], confirmed the presence of *B. schroederi* in the Southwest Atlantic based on juvenile females and adult males from southern Brazil and the Falkland/Malvinas Islands, respectively. If the specimen from Talcahuano, Chile [19] is considered, the number of specimens available in the scientific literature is five. Fortunately, the material available for *A. frerichsi* was comparatively more abundant. Krefft [15] included observations of 35 specimens from the Southwest Atlantic. However, no additional information has been obtained from this ocean to date. In the Southeast Pacific, Reyes et al. [13] reported 155 specimens between 52° S and 57° S, and Bustamante et al. [20] examined 65 specimens from central and southern Chilean waters (37° S–49° S). Except for the parasitological study of Ñacari et al. [23], there is no information that accounts for the life history of *A. frerichsi* or *B. schroederi* northward of 37° S in the Southeast Pacific.

The information analysed here from specimens obtained in northern Chile represents an advance in the knowledge of *B. schroederi* and *A. frerichsi.*

The scarcity of comparative material from the region may also result in confusion when reporting on deep-water elasmobranchs. Despite the challenges associated with limited sample availability and observational capabilities in the deep ocean, it is crucial to maintain rigorous taxonomic practices when describing new species. Although the novelty of deep-water samples may raise our expectations, there is an intrinsic responsibility for taxonomic routines learned over the last century [2] that includes phenotypical adaptations and ontogenetic variations. The limited information available on *B. schroederi* plays a major role in the possible misidentification of the species, as could have been the case in Ebert et al. [30]. The overall comparison of *B. chapmani* with *B. schroederi* has been neglected despite being documented in the region. The interpretation of skin discolouration on the dorsal and ventral discs as natural markings may be flawed, as such markings may result from parasites and, therefore, should not be used to support the identification of new species. Expanding geographic and depth ranges across biogeographical regions in the Southeast Pacific would provide an accurate species distribution that aids in identifying potential endemism or range extensions. Future directions for the description of new species need to rely on integrative taxonomy to generate comprehensive revisions including morphological and molecular data.

An important aspect of the skates studied is the expansion of their latitudinal and bathymetric ranges in the Southeast Pacific. The depth range of *A. frerichsi* in Chilean waters is reported to be between 1037 m and 2250 m and between 37° S and 57° S [20]; however, there is no comparative information for *B. schroederi* in this same area. Based on observations of four individuals in the Southwest Atlantic, the depth range inhabited by *B. schroederi* may be between 800 m and 2380 m [34]. For the Southeast Pacific, the latitudinal and bathymetric distribution ranges are updated, and the presence of both species extends between 21°20′ S and 57° S, and between 800 m and 2250 m deep. Neither of the two species under study can be considered endemic to Patagonian waters because they are found in at least three different biogeographical regions: Patagonian waters, the transitional zone of central Chile, and Peruvian waters [36].

The current geographic distribution of *B. schroederi* includes Patagonian waters from southern Chile to southern Brazil, including the Falkland Islands [2]. Based on the specimens documented here, the distribution range may extend northward to the locality Caleta Chipana (21°20′ S), extending its distribution range in the Southeast Pacific approximately 2000 km north of the last record. This species is demersal on continental and insular slopes and in the abyssal plain at depths of 800–2380 m [2]; however, in the Southeast Pacific, it is found between 800 and 1500 m off Chile and 800 and 2380 m off Uruguay and Brazil in the Southwest Atlantic [15,17,34]. The species is vulnerable to fishing and is discarded dead by *D. eleginoides* longline fisheries (artisanal and industrial), which operate between 800 and 1600 m depth along their entire distribution area [14]. The relatively low contribution of mature females suggests that the species may have refugia in depth. However, it is not possible to quantify the impact of bycatch, and the volume of extraction/bycatch requires close monitoring to assess potential threats at the population level.

Recently, *A. frerichsi*, was assessed as “Vulnerable” by the IUCN Red List of Threatened Species [8] due to the levels of bycatch to which it is exposed in its area of distribution and inferred population reduction from catch records in the Southwest Atlantic. However, the potential and actual threats to *B. schroederi* were previously undocumented, and considering the information analysed here, an update of the conservation assessment is required to address their vulnerability to the fishery [34]. The fishing mortality of both skates and their relatively high abundance in the bycatch of the *D. eleginoides* fishery are factors that were not available at the time of the assessment of their conservation status.

The structuring forces of marine biogeographic zones tend to have less impact at depth [37], which generates potential stability in the deep-water ecosystem in front of the Southeast Pacific region. This situation has been evidenced in other cartilaginous fishes, where their presence has been documented in a wide latitudinal range (e.g., 30° N to 40° S for *Hydrolagus melanophasma*), but in a narrow depth band associated with the oceanic trenches of Mesoamerica and the Atacama in the Central and Southeast Pacific [38]. The size and sexual maturity structure of the analysed population suggest that *A. frerichsi* and *B. schroederi* may be sympatric in at least one section of their latitudinal distribution range. However, the adult fractions of both species would not occupy the same habitat on the bathymetric gradient. At depths between 800 and 1000 m, 70% of the males and 66% of the females of *A. frerichsi* were immature. However, in this same range, 60% of the *B. schroederi* individuals were mature specimens. This apparent lack of spatial overlap of the reproductively mature fractions of both species could be related to a differentiated trophic strategy, which allows latitudinal sympatry of congeneric species in different bathymetric ranges [39]. This phenomenon has not been documented in deep-water skates; however, it has been reported in skates from shallow waters between 10 m and 40 m deep [40,41] and inhabiting the continental shelf between 30 m and 366 m deep [42].

The increased demand for fish protein may lead to fishing efforts expanding towards new latitudes and depths [43]. This is evidenced by the exploration of new fishing grounds for *D. eleginoides* in the Southeast Pacific, which has extended into northern Peru and southern Ecuador over the last two decades [44]. In this "exploratory" fishery, the presence of elasmobranchs as bycatch has been poorly documented, yet deep-water skates and chimaeras are found to be a major component of the deep-water ecosystem in the Southeast Pacific [24,44]. For example, Zambrano et al. [45] reported over 6000 specimens of *H. melanophasma* from Ecuadorian waters at depths of 1600–1800 m between 2017 and 2021.

The primary focus of batoid research in Chilean waters has been to delineate the distribution patterns and feeding habits of species inhabiting the continental shelf [14]. Unfortunately, this has resulted in the overlooking of nearly 70% of the species inhabiting national waters [14], owing to the absence of scientific observations in deeper waters, rendering them obscure. The data analysed here represent the first step, significantly overdue, in contributing scientific information to the knowledge of the deep-sea ecosystem associated with the Humboldt Current System. In addition, the importance of the continuous monitoring of the bycatch of deep-water fisheries is highlighted, as it may become a source of important data for many poorly documented species and may aid in assessing the ecosystem impact of fisheries [46,47]. Documenting the total catch, including bycatch species, is a current challenge for the effective management of the *D. eleginoides* fishery in Chile, as the species is an international commodity subject of trade regulations that require mandatory reporting (and minimising) of the overall ecosystem impacts on non-target species [48,49].

Author Contributions: Conceptualisation, C.B. and C.V.-C.; methodology, M.J.I. and C.V.-C.; formal analysis, M.J.I. and C.B.; writing—original draft preparation, C.V.-C.; writing —review and editing, C.B.; funding acquisition, C.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Agencia Nacional de Investigación y Desarrollo de Chile (ANID FONDECYT Iniciación), grant number 11220358.

Institutional Review Board Statement: This study did not involve animal experimentation or harm. Specimens were obtained as bycatch from vessels that target *D. eleginoides* for trade according to the Chilean Law. All work was carried out with special fishing permits granted by the Fisheries Undersecretariat (E-PINV-2021-598).

Data Availability Statement: The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

Acknowledgments: The authors would like to acknowledge E. Adones, who contributed to the initial stage of this project and L. Ñacari, who aided with leech identification. The authors extend special thanks to D. Manzo and the fishing crew of L/P "HUAYCA", and to the staff of "Programa de Conservación de Tiburones", who aided in specimen sorting and sampling.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Weigmann, S. Annotated checklist of the living sharks, batoids, and chimaeras (Chondrichthyes) of the world, with a focus on biogeographical diversity. *J. Fish Biol.* **2016**, *88*, 837–1037. [CrossRef] [PubMed]
2. Last, P.R.; White, W.T.; De Carvalho, M.R.; Séret, B.; Stehmann, M.F.W.; Naylor, G.J.P. *Rays of the World*; CSIRO Publishing: Clayton South, Australia, 2016.
3. Fricke, R.; Eschmeyer, W.N.; Van der Laan, R. Eschmeyer's Catalog of Fishes: Genera, Species, References. Available online: http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp (accessed on 25 March 2024).
4. Ebert, D.; Compagno, L. Biodiversity and systematics of skates (Chondrichthyes: Rajiformes: Rajoidei). *Environ. Biol. Fishes* **2007**, *80*, 111–124. [CrossRef]
5. Dulvy, N.K.; Reynolds, J.D. Predicting Extinction Vulnerability in Skates. *Conserv. Biol.* **2002**, *16*, 440–450. [CrossRef]
6. Dulvy, N.K.; Fowler, S.L.; Musick, J.A.; Cavanagh, R.D.; Kyne, P.M.; Harrison, L.R.; Carlson, J.K.; Davidson, L.N.K.; Fordham, S.V.; Francis, M.P.; et al. Extinction risk and conservation of the world's sharks and rays. *eLife* **2014**, *3*, e00590. [CrossRef]
7. Dulvy, N.K.; Pacoureau, N.; Rigby, C.L.; Pollom, R.A.; Jabado, R.W.; Ebert, D.A.; Finucci, B.; Pollock, C.M.; Cheok, J.; Derrick, D.H.; et al. Overfishing drives over one-third of all sharks and rays toward a global extinction crisis. *Curr. Biol.* **2021**, *31*, 4773–4787. [CrossRef]
8. Pollom, R.; Dulvy, N.K.; Acuña, E.; Bustamante, C.; Chiaramonte, G.E.; Cuevas, J.M.; Herman, K.; Paesch, L.; Pompert, J.; Velez-Zuazo, X. *Amblyraja frerichsi: The IUCN Red List of Threatened Species*; IUCN SSC Shark Specialist Group: Dubai, United Arab Emirates, 2021; p. e.T44652A124437250. [CrossRef]
9. FAO. *The State of World Fisheries and Aquaculture 2020: Sustainability in Action*; The Food and Agriculture Organization (FAO): Rome, Italy, 2020.
10. Céspedes, R.; Vargas, C.; Adasme, L. Monitoreo de la pesquería del bacalao de profundidad (*Dissostichus eleginoides*): Observadores científicos y sus desafíos. *An. Inst. Patagon.* **2016**, *44*, 39–48. [CrossRef]
11. SUBPESCA. *Estado de Situación de las Principales Pesquerías Chilenas, Año 2023*; Subsecretaría de Pesca y Acuicultura: Valparaíso, Chile, 2023.
12. Lamilla, J.; Bustamante, C.; Roa, R.; Acuña, E.; Concha, F.; Meléndez, R.; López, S.; Aedo, G.; Flores, H.; Vargas-Caro, C. *Estimación del Descarte de Condrictios en Pesquerías Artesanales*; Fondo de Investigación Pesquera y de Acuicultura (FIPA N°208-60), Universidad Austral de Chile: Valdivia, Chile, 2010.
13. Reyes, P.R.; Torres, J.P.; Reyes, E.M. Peces abisales del extremo austral de América del sur (52° S–57° S), componentes de la fauna acompañante de la pesquería de palangre del bacalao de profundidad (*Dissostichus eleginoides* Smitt, 1898). *Rev. Biol. Mar. Oceanogr.* **2009**, *44*, 59–65. [CrossRef]
14. Bustamante, C.; Acuña, E.; Tapia-Jopia, C.; Vargas-Caro, C. *Actualización del Plan de Acción Nacional para la Conservación y Manejo de Tiburones de Chile*; Fondo de Investigación Pesquera y de Acuicultura (FIPA N°2021-24), Universidad de Antofagasta: Antofagasta, Chile, 2023.
15. Krefft, G. Neue und erstmaling nachgewiesene Knorpelfische aus dem Archibenthal des Südwestantlantiks, einschlieszlich einer Diskussion einiger *Etmopterus*—Arten südlicher Meere. *Archiv Fisch.* **1968**, *19*, 1–42.
16. Bizikov, V.; Arkhipkin, A.I.; Laptikhovsky, V.V.; Pompert, J.H.W. *Identification Guide and Biology of the Falkland Skates*; Fisheries Department, Falkland Island Government: Stanley, Falkland Islands, 2004.
17. Gomes, U.L.; Santos, H.R.S.; Gadig, O.B.F.; Signori, C.N.; Vicente, M.M. Guia para identificação dos tubarões, raias e quimeras do Rio de Janeiro (Chondrichthyes: Elasmobranchii e Holocephali). *Rev. Nord. Biol. Paraiba* **2019**, *27*, 171–368.
18. Stehmann, M.F.W.; Pompert, J.H.W. First mature male record of *Bathyraja schroederi* (Elasmobranchii, Arhynchobatidae) from the South Atlantic, with descriptions of its clasper and skeletal characters. *Zootaxa* **2014**, *3838*, 401–422. [CrossRef]
19. Pequeño, G. Peces de Chile. Lista sistemática revisada y comentada: Addendum. *Rev. Biol. Mar. Oceanogr.* **1997**, *32*, 77–94.
20. Bustamante, C.; Lamilla, J.; Concha, F.; Ebert, D.A.; Bennett, M.B. Morphological characters of the thickbody skate *Amblyraja frerichsi* (Krefft 1968) (Rajiformes: Rajidae), with notes on its biology. *PLoS ONE* **2012**, *7*, e39963. [CrossRef]
21. Acuña, E.; Rodríguez, M. Contribución al estudio de las rayas de profundidad (Familia Rajidae) del Norte de Chile. In *VII Jornadas de Ciencias del Mar*; Anon, Ed.; Sociedad Chilena de Ciencias del Mar: Concepción, Chile, 1987.
22. Vargas, M.; Sielfeld, W. Nuevos antecedentes sobre Rajiformes presentes en la costa norte de Chile (Primera Región: Tarapacá). In *IX Jornadas de Ciencias del Mar*; Anon, Ed.; Sociedad Chilena de Ciencias del Mar: Antofagasta, Chile, 1989.
23. Ñacari, L.A.; Sepúlveda, F.A.; Escribano, R.; Oliva, M.E. Two new species of *Acanthocotyle* Monticelli, 1888 (Monogenea: Acanthocotylidae), parasites of two deep-sea skates (Elasmobranchii: Rajiformes) in the South-East Pacific. *Parasit Vectors* **2019**, *12*, 512. [CrossRef]
24. Zavalaga, F.; Contreras, I.; Campos-León, S.; Moreno-Méndez, A.; Saldarriaga, M. New records and range extension of two deep-sea skate genera, *Amblyraja* and *Notoraja* (Elasmobranchii: Rajiformes), in the southeastern Pacific Ocean. *J. Mar. Biol. Assoc. United Kingd.* **2024**, *104*, e25. [CrossRef]
25. Bustamante, C.; Vargas-Caro, C.; Bennett, M.B. Not all fish are equal: Functional biodiversity of cartilaginous fishes (Elasmobranchii and Holocephali) in Chile. *J. Fish Biol.* **2014**, *85*, 1617–1633. [CrossRef]

26. Last, P.R.; White, W.T.; Pogonoski, J.J.; Gledhill, D.C. New Australian skates (Batoidea: Rajoidei)—Background and methodology. In *Descriptions of new Australian Skates (Batoidea: Rajoidei)*; Last, P.R., White, W.T., Pogonoski, J.J., Gledhill, D.C., Eds.; CSIRO Marine and Atmospheric Research: Hobart, Australia, 2008; pp. 1–8.
27. Sokal, R.R.; Rohlf, F.J. *Introduction to Biostatistics*, 2nd ed.; W.H. Freeman Press: New York, NY, USA, 1987.
28. Oddone, M.C.; Amorim, A.F.; Mancini, P.L.; Norbis, W.; Velasco, G. The reproductive biology and cycle of *Rioraja agassizi* (Müller and Henle, 1841) (Chondrichthyes: Rajidae) in southeastern Brazil, SW Atlantic Ocean. *Sci. Mar.* **2007**, *71*, 593–604. [CrossRef]
29. Bustamante, C.; Vargas-Caro, C.; Oddone, M.C.; Concha, F.; Flores, H.; Lamilla, J.; Bennett, M.B. Reproductive biology of *Zearaja chilensis* (Chondrichthyes: Rajidae) in the south-east Pacific Ocean. *J. Fish Biol.* **2012**, *80*, 1213–1226. [CrossRef]
30. Ebert, D.A.; Alfaro-Shigueto, J.; Velez-Zuazo, X.; Pajuelo, M.; Mangel, J.C. Bathyraja chapmani n. sp., a new deep-sea skate (Rajiformes: Arhynchobatidae) from the Southeast Pacific Ocean. *J. Ocean Sci. Found.* **2022**, *39*, 23–35. [CrossRef]
31. Tanzola, R.D.; Botté, S.E. Presencia de *Branchellion parkeri* Richardson, 1949 (Hirudinea: Piscicolidae) sobre *Sympterygia bonapartei* Muller & Henle, 1841 (Pisces: Rajidae) en el Atlántico Sur. *Nat. Neotrop.* **1998**, *29*, 65–68.
32. Utevsky, A.; Gordeev, I. New tentacled leech *Ceratobdella quadricornuta* n. g., n. sp. (Hirudinida: Piscicolidae) parasitic on the starry skate *Raja georgiana* Norman from the Scotia Sea, Antarctica. *Syst. Parasitol.* **2015**, *91*, 203–210. [CrossRef]
33. Benjamins, S.; Dodd, J.; Thorburn, J.; Milway, V.A.; Campbell, R.; Bailey, D.M. Evaluating the potential of photo-identification as a monitoring tool for flapper skate (*Dipturus intermedius*). *Aquat Conserv. Mar. Freshw. Ecosyst.* **2018**, *28*, 1360–1373. [CrossRef]
34. Dulvy, N.K.; Acuña, E.; Bustamante, C.; Herman, K.; Pompert, J.; Velez-Zuazo, X. *Bathyraja schroederi: The IUCN Red List of Threatened Species*; IUCN SSC Shark Specialist Group: Dubai, United Arab Emirates, 2020; p. e.T63137A3121362. [CrossRef]
35. Séret, B.; Andreata, J.V. Deep-sea fishes collected during cruise MD 55 off Brazil. *Cybium* **1992**, *16*, 81–100. [CrossRef]
36. Ojeda, F.P.; Labra, F.A.; Muñoz, A.A. Biogeographic patterns of Chilean littoral fishes. *Rev. Chil. Hist. Nat.* **2000**, *73*, 625–641. [CrossRef]
37. Toonen, R.J.; Bowen, B.W.; Iacchei, M.; Briggs, J.C. Marine Biogeography. In *Encyclopedia of Evolutionary Biology*; Kliman, R.M., Ed.; Academic Press: Oxford, UK, 2016; pp. 166–178.
38. Bustamante, C.; Flores, H.; Concha-Pérez, Y.; Vargas-Caro, C.; Lamilla, J.; Bennett, M.B. First record of *Hydrolagus melanophasma* James, Ebert, Long & Didier, 2009 (Chondrichthyes, Chimaeriformes, Holocephali) from the southeastern Pacific Ocean. *Lat. Am. J. Aquat. Res.* **2012**, *40*, 236–242.
39. Simpson, S.J.; Sims, D.W.; Trueman, C.N. Ontogenetic trends in resource partitioning and trophic geography of sympatric skates (Rajidae) inferred from stable isotope composition across eye lenses. *Mar. Ecol. Prog. Ser.* **2019**, *624*, 103–116. [CrossRef]
40. Mabragaña, E.; Giberto, D.A. Feeding ecology and abundance of two sympatric skates, the shortfin sand skate *Psammobatis normani* McEachran, and the smallthorn sand skate *P. rudis* Günther (Chondrichthyes, Rajidae), in the southwest Atlantic. *ICES J. Mar. Sci.* **2007**, *64*, 1017–1027. [CrossRef]
41. Humphries, N.E.; Simpson, S.J.; Wearmouth, V.J.; Sims, D.W. Two's company, three's a crowd: Fine-scale habitat partitioning by depth among sympatric species of marine mesopredator. *Mar. Ecol. Prog. Ser.* **2016**, *561*, 173–187. [CrossRef]
42. McEachran, J.D.; Boesch, D.F.; Musick, J.A. Food division within two sympatric species-pairs of skates (Pisces: Rajidae). *Mar. Biol.* **1976**, *35*, 301–317. [CrossRef]
43. Dulvy, N.K.; Forrest, R.E. Life histories, population dynamics, and extinction risks in Chondrichthyans. In *Sharks and Their Relatives II: Biodiversity, Adaptive Physiology and Conservation*; Carrier, J.C., Musick, J.A., Heithaus, M.R., Eds.; CRC Press: Boca Raton, FL, USA, 2010; pp. 639–680.
44. Alfaro-Shigueto, J.; Ebert, D.A.; Guidino, C.; Velez-Zuazo, X.; Romero, J.; Mangel, J.C. Deep-sea Chondrichthyans associated with the Patagonian toothfish *Dissostichus eleginoides* fishery off the coast of Peru. *Rev. Biol. Mar. Oceanogr.* **2022**, *57*, 249–254. [CrossRef]
45. Zambrano, R.; Coello, D.; Herrera, M. Modal and empirical lengths at sexual maturity for six deep-sea species in Ecuadorian oceanic waters. *Mar. Fish. Sci.* **2023**, *37*, 353–358. [CrossRef]
46. Simpfendorfer, C.A.; Kyne, P.M. Limited potential to recover from overfishing raises concerns for deep-sea sharks, rays, and chimaeras. *Environ. Conserv.* **2009**, *36*, 97–103. [CrossRef]
47. Navia, A.F.; Cortés, E.; Jordán, F.; Cruz-Escalona, V.H.; Mejía-Falla, P.A. Changes to Marine Trophic Networks Caused by Fishing. In *Diversity of Ecosystems*; Mahamane, A., Ed.; InTech Press: Rijeka, Croatia, 2011; pp. 418–452.
48. ISOFISH. *The Chilean Fishing Industry: Its Involvement in and Connections to the Illegal, Unreported and Unregulated Exploitation of Patagonian Toothfish in the Southern Ocean*; International Southern Oceans Longline Fisheries Information Clearing House (ISOFISH): Hobart, Australia, 1999.
49. Agnew, D. The illegal and unregulated fishery for toothfish in the Southern Ocean, and the CCAMLR catch documentation scheme. *Mar. Pol.* **2000**, *24*, 361–374. [CrossRef]