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Bycatch in an experimental fishery for Patagonian toothfish (*Dissostichus eleginoides*, Nototheniidae) in Ecuadorian oceanic waters

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Research Article

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Abstract

The objective of this paper was to characterize bycatch in an experimental fishery for Patagonian toothfish in Ecuador during 2017–2021. Diversity was analysed using Shannon, Margalef, Simpson, and Dominance indices. Bycatch representativity was calculated as the difference percentage between the target catch and non-target, in weight. The bycatch comprised 51 taxa and was composed primarily of fish. In addition, 12 species of pelagic habits (i.e. fishes and sharks) were also captured during the deployment/retrieval of fishing gear. The most frequent species (by number of individuals) were chimaeras (*Hydrolagus melanophasma*), grenadiers (*Antimora rostrata*, *Coryphaenoides delsolari*, and *Coryphaenoides armatus*), and sharks (*Etmopterus granulosus* and *Centroscymnus owstonii*). The diversity was medium low, according to the Shannon indices (0.5–1.8), with a negative trend for dominance and a positive trend for equitability.

Introduction

Patagonian toothfish (*Dissostichus eleginoides* Smith, 1898) is endemic to the Southern Hemisphere. It has a circumpolar distribution and is found around sub-Antarctic islands and seamounts. In the Atlantic Ocean, it extends north onto the Patagonian shelf and Uruguay, while in the Pacific Ocean, it occurs off Chile and Peru (Møller *et al.*, 2003; Collins *et al.*, 2007; Taki *et al.*, 2011; Aramayo, 2016). In Ecuador, Patagonian toothfish was recorded in research campaigns during 2008, occurring between 1200 and 1400 m depth, corresponding to the extreme northern area of its distribution (de González *et al.*, 2008).

Patagonian toothfish is a commercial species in the Tropical Pacific Ocean (TPO) region of South America and fished by bottom longline. Patagonian toothfish has been fished since 1980 off Chile, and since 1999 off Peru (Sancho-Andrade *et al.*, 2002; Collins *et al.*, 2010). An experimental fishery was developed in Ecuador between 2017 and 2022 for the assessment of the opening of commercial exploitation of Patagonian toothfish.

All the countries have reported bycatch in the Patagonian toothfish fishery. Bycatch includes non-target species that are landed and sold, species that are retained for consumption onboard, as well as those non-target species that are discarded. Discards are the portion of the catch returned to the sea (Alverson *et al.*, 1994). Common species reported as bycatch in longline fisheries for Patagonian toothfish fishery include grenadiers (Macrouridae), morid cods (Moridae), and skates (Rajiformes) (Collins *et al.*, 2010).

In Peruvian waters, reported bycatch has included chimaera (*Hydrolagus* sp.), sharks (*Somniosus* sp.), skates (*Bathyraja* sp.), teleosts (*Nezumia* sp. and *Trachyrincus helolepsis*), octopus (*Benthoctopus* sp.), and king crabs (*Lithodes* sp. and *Paralomis longipes*) (Aramayo, 2016). Bycatch is also a risk for the conservation of protected, threatened, and endangered species. Sharks and rays are highly vulnerable species in surface and bottom longline fisheries (Chaves, 2021), including in Ecuadorian waters (Sepa *et al.*, 2021). In Chile, an interaction of the Patagonian toothfish fishery with marine mammals (e.g. killer whales and sperm whales) and seabirds (e.g. *Diomedea* spp. and *Macronectes giganteus*) has also been reported (Guerrero and Arana, 2009; Céspedes *et al.*, 2016).

Ecuador has been a cooperating party in The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) since 2018 but became a member in 2022 (meetings: CCAMLR-XXXVII/14 and CCAMLR-41). Parties to CCAMLR must demonstrate responsibilities in the use and collection of data related to marine Antarctic resources. Therefore, the objective of this study was to provide initial data on the species and size composition, and species diversity, of the bycatch observed over the period 2017–2021. This study could be considered a baseline for determining the effect of Patagonian toothfish fishery on demersal species and benthic.

Materials and methods

We considered bycatch as non-target species landed and sold as well as those discarded. Bycatch data from an experimental fishery of Patagonian toothfish (June 2017–July 2021)

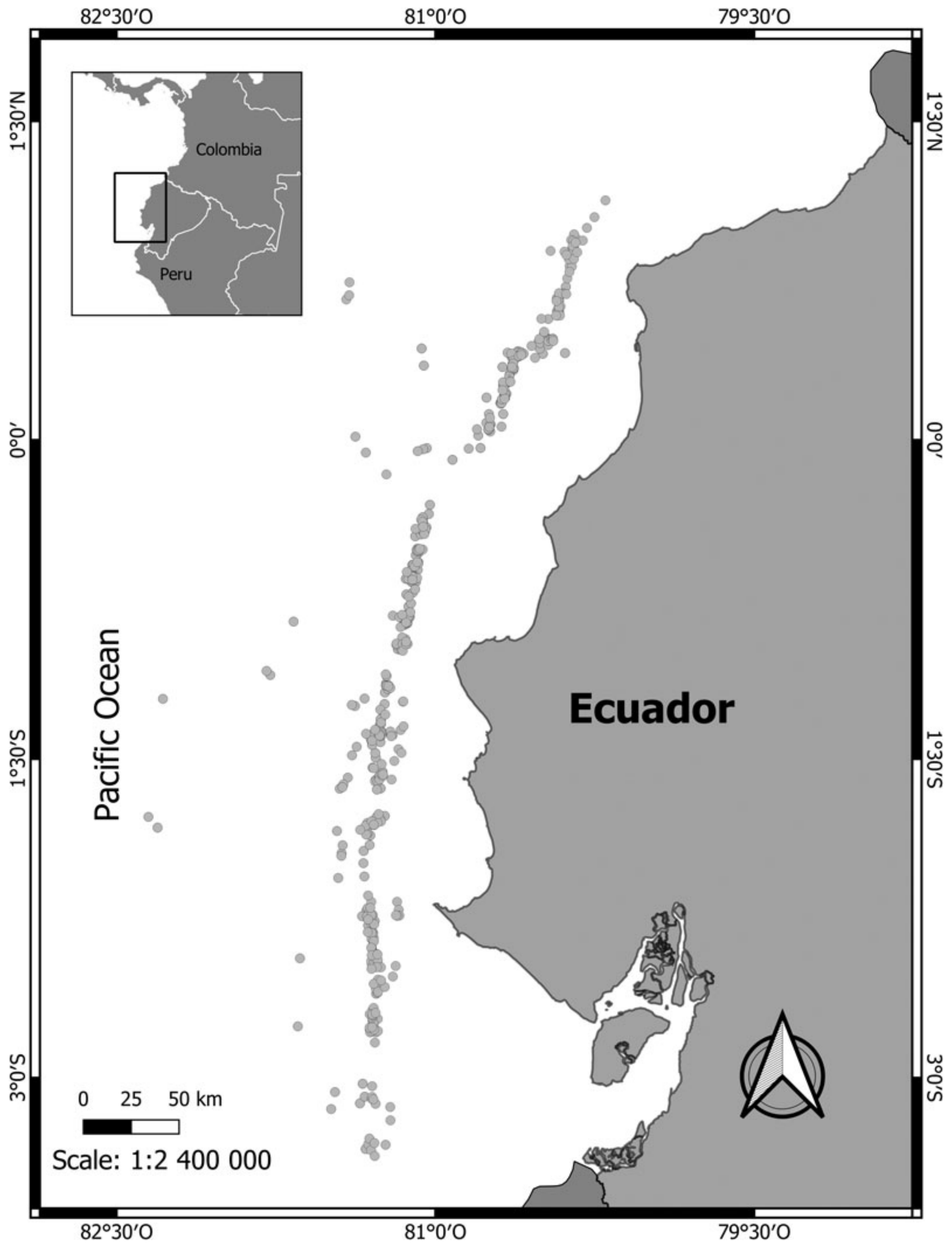

Figure 1. Study area and locations of observed hauls of the experimental fishery of Patagonian toothfish (*D. eleginoides*) in Ecuadorian oceanic waters, between June 2017 and July 2021.

were analysed. The data correspond to fishing trips undertaken by the same fishing vessel (only one vessel had a fishing permission), recorded by observers onboard. Fishing deployments (sets) were conducted at depths of 1000–2700 m (Figure 1).

Fishing gear was a horizontal bottom longline with a principal line and vertical drop lines rigged every 10 m. The hooks were circular with a crooked tip, size 14/0 (Sepa *et al*., 2021).

A total of 1500 or 2000 hooks were used per set, which were baited with the fish *Auxis thazard*. All the bycatch species were identified by two observers onboard using identification guides for the region (Fischer *et al*., 1995*a*, 1995*b*; Robertson and Allen, 2015; Ebert and Mostarda, 2016; Froese and Pauly, 2021). Scientific names were validated according to Eschmeyer's Catalog of Fishes (Fricke *et al*., 2022).

Each bycatch taxon was reported as the total number of individuals per species. The taxa captured during deployment/retrieval of the fishing gear were also reported as the number of individuals. Bycatch representativity was calculated as the difference percentage between the target catch and non-target, in weight. The diversity of bycatch was determined by Shannon (entropy), equitability (Pielou *J*), and dominance (1-Simpson) indices. The analysis was carried out using software Past ver. 4.10 (Hammer, 2022).

Results

A total of 60 fishing trips were analysed, comprising 100–330 sets per year. The catch of Patagonian toothfish has decreased since 2019 while the bycatch ratio has increased (Table 1). Bycatch was composed of 51 taxa, comprising fish (52%), skates and rays (23%), sharks (15%), crustaceans (6%), and cephalopods (4%). Macrouridae, Arhynchobatidae, and Somniosidae were the families with the most of bycatch species.

Table 1. Number (*n*) of trips and sets, fishing depth, Patagonian toothfish landed, bycatch representativity, and number of individuals in each bycatch taxa in an experimental fishery for Patagonian toothfish (*D. eleginoides*) in Ecuadorian oceanic waters

Details	2017	2018	2019	2020	2021
Trips (*n*)	9	10	14	17	10
Sets (*n*)	107	134	225	326	173
Fishing depth (m)	1237–2200	1239–2400	1219–2500	1136–2600	1090–2700
Patagonian toothfish (kg)	34,419	32,284	24,171	29,549	17,339
Bycatch ratio (%)	27	32	47	46	53
Bycatch taxa	2017 (*n*)	2018 (*n*)	2019 (*n*)	2020 (*n*)	2021 (*n*)
Alepocephalidae					
Alepocephalus rostratus		2			
Arhynchobatidae					
Notoraja martinezi		1			
Bathyraja brachyurops			7		
Bathyraja cousseauae			3		
Bathyraja griseocauda					2
Bathyraja macloviana			7		
Bathyraja schroederi			4	7	14
Bathyraja sp.		3	8	1	
Bathyraja spinosissima			3	13	13
Bythitidae					
Bythitidae spp.				6	1
Centrophoridae					
Centrophorus squamosus		12	51	96	102
Cephalopoda					
Octopoda (octopus)			2		
Oegopsida (squid)			1		
Chimaeridae					
H. melanophasma	1448	1735	2534	2750	1756
Congridae					
Conger sp.			1		2
Elopidae					
Elops affinis				8	5
Etmopteridae					
E. granulosus		40	193	480	312
Kyphosidae					
Girella sp.		1			
Liparidae					
Careproctus sp.			1		
Lithodidae					
Lithodes sp.	5	3	4	1	2
Paralomis sp.	3	5	1	2	4
Macrouridae					
C. anguliceps		1	1		
Coryphaenoides ariommus		12	1		
C. armatus		1	159	276	675
Coryphaenoides bucephalus	2			2	
Coryphaenoides bulbiceps				3	

(*Continued*)

Table 1. (*Continued.*)

Details	2017	2018	2019	2020	2021
Coryphaenoides capito		1		1	
C. delsolari	71	58	203	135	454
Coryphaenoides mexicanus				25	
Macrouridae (indet.)			1		
Nezumia sp.			2	23	230
Merlucciidae					
Merluccius gayi				1	
Moridae					
Antimora microlepis			2	17	127
A. rostrata	196	80	187	267	577
Physiculus sp.			18		
Myxinidae					
Myxini				2	1
Oneirodidae					
Oneirodes luetkeni			1		
Ophidiidae					
Ophidiidae (indet.)					2
Pandalidae					
Heterocarpus hostilis	1	2	2	1	1
Pentanchidae					
Apristurus sp.	1	1	1	1	1
Phycidae					
Urophycis sp.			1		
Rajidae					
Amblyraja doellojuradoi			15	42	43
Amblyraja frerichsi				1	
Amblyraja sp.		9	7		
Somniosidae					
C. owstonii		98	237	144	281
Scymnodalatias oligodon			1	2	
Somniosus antarcticus		2			
Somniosus pacificus			1	6	6
Stomiidae					
Chauliodus sp.			1		
Tetraodontidae					
Lagocephalus lagocephalus			4	4	1
Trichiuridae					
Trichiurus lepturus				1	

The years 2017 and 2018 presented the fewest number of taxa records. The most frequent bycatch species (by number of individuals) were *Hydrolagus melanophasma*, followed by *Antimora rostrata*, *Coryphaenoides delsolari*, *Coryphaenoides armatus*, *Etmopterus granulosus*, and *Centroscymnus owstonii*. Other taxa presented a record sporadic (Table 1).

A total of 12 pelagic taxa were captured during the deployment/retrieval of the fishing gear. *Coryphaena hippurus* presented the highest interannual presence, followed by *Pteroplatytrygon violacea*, which was the only myliobatiform ray recorded. The other species were caught sporadically (Table 2).

Dominance index showed a decrease towards 2021. Equitability and Shannon indices presented a positive trend. The diversity was between medium and low (0.5–1.8), according to the Shannon index (Figure 2).

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Table 2. Number of individuals fished during the deployment/retrieval of the fishing gear, by species, in an experimental fishery for Patagonian toothfish (*D. eleginoides*) in Ecuadorian oceanic waters

Groups	Taxa	2017	2018	2019	2020	2021
Ray						
	P. violacea			2	9	3
Fishes						
	C. hippurus		1	4	11	4
	R. pretiosus					2
	T. albacares		1			
	X. gladius				1	
Sharks						
	A. pelagicus			1		
	A. superciliosus	1				
	I. oxyrinchus			1		
	P. glauca					1
	P. kamoharai	2			9	
	S. lewini				1	
	S. zygaena				4	

Discussion

Bycatch in the Patagonian toothfish fishery in Ecuadorian oceanic waters included teleost, rays, sharks, crustaceans, and cephalopods. While those are characteristic species groups in deep longline fishing in the southern region of the TPO, the proportion in landings may vary by region, depth, and fishing gear (Collins *et al.*, 2010; Sellanes *et al.*, 2012).

In Ecuador, bycatch had more species than the reports from Chile (between 18 and 25 species) and Peru (11 species) (Lamilla *et al.*, 2010; Sellanes *et al.*, 2012; Aramayo, 2016). The most representative species were chimaeras (*H. melanophasma*), grenadiers (*A. rostrata*, *C. delsolari*, and *C. armatus*), and sharks (*E. granulosus*, and *C. owstonii*). *H. melanophasma* is a species associated with the Patagonian toothfish local fishery in Chile and Peru (Aramayo, 2016; Ñacari *et al.*, 2020). Grenadiers are common species in the Patagonian toothfish fishery globally, and *A. rostrata* is quite common in the southern TPO (Reyes *et al.*, 2009; Collins *et al.*, 2010).

Bait has the function of attracting target fishes, but it can also be consumed by non-target species (Emiati *et al.*, 2022). In Ecuador, the bait was the fish *A. thazard*, which is one of the food items of large pelagic fishes, including sharks (Aguilar-Palomino *et al.*, 1998; Estupiñán-Montaño *et al.*, 2009, 2019; Trujillo-Olvera *et al.*, 2018; Calle-Morán *et al.*, 2022).

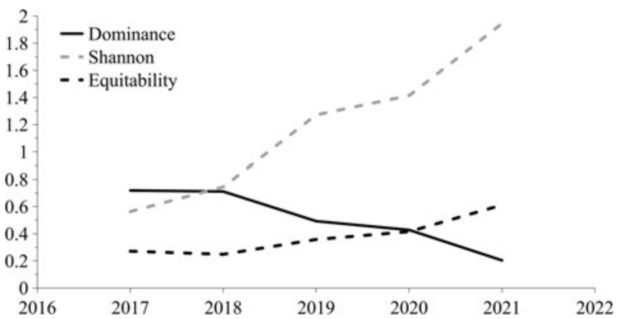

Figure 2. Trends in the diversity indices related to the bycatch of the experimental fishery of Patagonian toothfish (*D. eleginoides*) in Ecuadorian oceanic waters.

Large pelagic fish were also caught by the gear, presumably during the deployment/retrieval of the fishing gear. These included seven species of shark (*Pseudocarcharias kamoharai*, *Prionace glauca*, *Sphyrna lewini*, *Sphyrna zygaena*, *Alopias pelagicus*, *Alopias superciliosus*, and *Isurus oxyrinchus*), *P. violacea*, and four species of teleost (*C. hippurus*, *Xiphias gladius*, *Ruvettus pretiosus*, and *Thunnus albacares*). Sharks have commercial importance in Ecuador but are largely taken as incidental species (Martínez-Ortiz *et al.*, 2015; Coello and Herrera, 2018), while the teleosts observed are all targeted by local artisanal fisheries.

The observed diversity was medium to low, with a negative trend for dominance and a positive for evenness. The results are consistent with the relatively low diversity of the deep seabed, compared to the shallow water, but also noting that these were based on longline-caught fish and so will not be representative for the whole deep-sea fish assemblage in the area. There was a decrease in the diversity of species on the seabed as depth increased, which is reflected in the bycatch of the Patagonian toothfish fishery (Grassle, 1989; Costello and Chaudhary, 2017; Myers *et al.*, 2021).

In the period 2008–2010, research fishing was carried out in deep waters off the mainland coast of Ecuador (de González *et al.*, 2008; González-Troncoso, 2009, 2010). In 2008, the trawls were carried out between 500 and 1500 m, and in the same year, the Patagonian toothfish was recorded, between 1200 and 1400 m. The most representative species, according to the weight, were reported to be *Merluccius gayi*, *Rouleina attrita*, *C. delsolari*, *Dicrolene filamentosa*, *Haliporoides diomedeae*, *Dicrolene nigra*, *Alepocephalus* spp., *Nematocarcinus agassizii*, *Coryphaenoides carminifer*, *Nezumia* spp., *Etmopterus* spp., *Centroscyllium nigrum*, *Hydrolagus* spp., *Coryphaenoides anguliceps*, and *Benthoecetes tanneri* (de González *et al.*, 2008).

The mean diversity reported by de González *et al.* (2008) was 2.58 (SD ± 0.58), which is higher than our results. This is because trawling provides a view of the wider assemblage structure, while the longline refers to the proportion of the assemblage that is susceptible to being captured by the fishing gear.

Fish, sharks, rays, and other taxa (e.g. sea turtles) could be part of the bycatch in the Patagonian toothfish fishery. However, the low and sporadic presence of those taxa is because bottom longlines have a low impact on non-target species, contrary to surface longlines; despite this, they could affect certain benthic species and change the community structure in the long term (Pham *et al.*, 2014; Oliver *et al.*, 2015). The removal of vulnerable organisms could decrease their population, leaving it to the most resilient species, inclusively promoting an increase of opportunistic fauna in the ecosystem. In this sense, it is necessary to monitor, assess, and take decisions for improving fishing practices (e.g. fishing gear) and reducing bycatch (Pham *et al.*, 2014; Gilman *et al.*, 2022).

The diversity results in 2017 should be considered as minimum estimates, because the identification of species by fishing observers has improved since 2018. That occurred due to the complexity of the identification of deep-sea species present in Ecuadorian seas. However, the possible bias did not affect the trend in diversity indices. Patagonian toothfish fishery presented a decline in the catch trend and an increase in the bycatch for the period 2017–2021. It could show a negative effect on the target species population as well as on the bycatch species.

Data. The data that support the findings of this study are available from the Public Institute of Aquaculture Research and Fishery. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from M. Herrera with the permission of the Public Institute of Aquaculture Research and Fishery.

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Author's contribution. René Zambrano: definition, conceptualization, methodology, formal analysis, writing – original draft, writing – review and editing, and visualization. Dialhy Coello: definition, conceptualization, methodology, and writing – original draft. Marco Herrera: definition, conceptualization, project administration, and funding acquisition.

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Competing interest. None.

References

Aguilar-Palomino B, Galván-Magaña F, Abitia-Cárdenas LA, Muhlia-Melo A and Rodríguez-Romero J (1998) Aspectos alimentarios del dorado *Coryphaena hippurus* Linnaeus, 1758 en Cabo San Lucas California Sur, México. *Ciencias Marinas* **24**, 253–265.

Alverson DL, Freeberg MH, Murawski SA and Pope JG (1994) *A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper. No. 339*. Rome: FAO.

Aramayo V (2016) A brief synthesis on the marine resource Patagonian toothfish *Dissostichus eleginoides* in Peru. *Revista de Biologia Marina y Oceanografia* **51**, 229–239.

Calle-Morán MD, Hernández-Téllez AR, Tibán-Vivar ER, Intriago-Vera YE, del Valle-Coello IG, Loor-Jama BC and Ganchozo-López ÁR (2022) Diet composition and feeding habits of the crocodile shark, *Pseudocarcharias kamoharai*. *Environmental Biology of Fishes* **105**, 685–697.

Céspedes R, Vargas C and Adasme L (2016) Monitoreo de la pesquería del bacalao de profundidad (*Dissostichus eleginoides*): observadores científicos y sus desafíos. *Anales Instituto Patagonia (Chile)* **44**, 39–48.

Chaves PT (2021) Bycatch: causes, impacts, and reduction of incidental captures. In Leal-Filho W, Azul AM, Brandli L, Lange-Salvia A and Wall T (eds) *Life below Water. Encyclopedia of the UN Sustainable Development Goals*, pp. 1–11. Switzerland: Springer.

Coello D and Herrera M (2018) Desembarque de tiburones en las pesquerías artesanales del Ecuador durante el 2012. *Revista Científica de Ciencias Naturales y Ambientales* **12**, 1–8.

Collins MA, Brickle P, Brown J and Belchier M (2010) The Patagonian toothfish. Biology, ecology and fishery. In Michael Lesser (eds), *Advances in Marine Biology*, Vol. **58**. London: Academic Press.

Collins MA, Ross KA, Belchier M and Reid K (2007) Distribution and diet of juvenile Patagonian toothfish on the South Georgia and Shag Rocks shelves (Southern Ocean). *Marine Biology* **152**, 135–147.

Costello MJ and Chaudhary C (2017) Marine biodiversity, biogeography, deep-sea gradients, and conservation. *Current Biology* **27**, R511–R527.

de González EC, Maroto-Castaño MP and Muñoz-Recio A (2008) Informe de investigación pesquera, Campaña Ecuador 08. B/O Miguel Oliver 1–65.

Ebert DA and Mostarda E (2016) *Guía para la identificación de peces cartilaginosas de aguas profundas del Océano Pacífico Sudoriental. Programa FishFinder*. Roma: FAO.

Emiati E., Nasution P and Brown A (2022) The effect of bait types on the catch of bottom longline in Bantan Sari Village Bantan district Bengkalis regency. *Journal of Coastal and Ocean Sciences* **3**, 171–175.

Estupiñán-Montaño C, Cedeño-Figueroa L, Estupiñán-Ortiz JF, Galván-Magaña F, Sandoval-Londoño A, Castañeda-Suarez D and Polo-Silva CJ (2019) Feeding habits and trophic level of the smooth hammerhead shark, *Sphyrna zygaena* (Carcharhiniformes: Sphyrnidae), off Ecuador. *Journal of the Marine Biological Association of the United Kingdom* **99**, 673–680.

Estupiñán-Montaño C, Cedeño-Figueroa LG and Galván-Magaña F (2009) Hábitos alimentarios del tiburón martillo *Sphyrna lewini* (Griffith & Smith, 1834) (Chondrichthyes) en el Pacífico ecuatoriano. *Revista de Biología Marina y Oceanografía* **44**, 379–386.

Fischer W, Krupp F, Schneider W, Sommer C, Carpenter KE and Niem VH (1995*a*) *Guía FAO para la identificación de especies para los fines de la pesca. Pacifico centro-oriental. Volumen II. Vertebrados-Parte 1*. Roma: FAO.

Fischer W, Krupp F, Schneider W, Sommer C, Carpenter KE and Niem VH (1995*b*) *Guía FAO para la identificación de especies para los fines de la pesca. Pacifico centro-oriental. Volumen III. Vertebrados-Parte 2*. Roma: FAO.

Fricke R, Eschmeyer WN and Van der Laan R (2022) Eschmeyer's catalog of fishes: Genera, species, references. Available at http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp (accessed 15 April 2022).

Froese R and Pauly D (2021) FishBase. World Wide Web electronic publication. Available at www.fishbase.org (accessed 12 October 2021).

Gilman E, Hall M, Booth H, Gupta T, Chaloupka M, Fennell H, Kaiser MJ, Karnad D and Milner-Gulland EJ (2022) A decision support tool for integrated fisheries bycatch management. *Reviews in Fish Biology and Fisheries* **32**, 441–472.

González-Troncoso DM (2009) *Informe de la Campaña de investigación pesquera, Ecuador 2009. B/O Miguel Oliver*. Guayaquil.

González-Troncoso DM (2010) *Informe de la Campaña de investigación Oceanográfico-Pesquera, Ecuador 2010. B/O Miguel Oliver* 1–14.

Grassle JF (1989) Species diversity in communities deep-sea. *Trends in Ecology & Evolution* **4**, 12–15.

Guerrero A and Arana P (2009) Fishing yields and size structures of Patagonian toothfish (*Dissostichus eleginoides*) caught with pots and longlines off far southern Chile. *Latin American Journal of Aquatic Research* **37**, 361–370.

Hammer Ø (2022) Paleontological statistics. Natural History Museum, University of Oslo.

Lamilla J, Bustamante C, Roa R, Acuña E, Concha F, Melendez R, López S, Aedo G, Flores H and Vargas C (2010) Estimación del descarte de condrictios en pesquerías artesanales. Informe Final Proyecto del Fondo de Investigación Pesquera (F.I.P.) No. 2008-60. 1–259.

Martínez-Ortiz J, Aires-Da-Silva AM, Lennert-Cody CE and Maunder MN (2015) The ecuadorian artisanal fishery for large pelagics: Species composition and spatio-temporal dynamics. *PLoS ONE* **10**, e0135136.

Møller PR, Nielsen JG and Fossen I (2003) Patagonian toothfish found off Greenland. *Nature* **421**, 599–599.

Myers EMV, Anderson MJ, Liggins L, Harvey ES, Roberts CD and Eme D (2021) High functional diversity in deep-sea fish communities and increasing intraspecific trait variation with increasing latitude. *Ecology and Evolution* **11**, 10600–10612.

Ñacari LA, Sepulveda FA, Droguet F, Escribano R and Oliva ME (2020) *Calicotyle hydrolagi* n. sp. (Monogenea: Monocotylidae) infecting the deep-sea Eastern Pacific black ghost shark *Hydrolagus melanophasma* from the Atacama Trench, with comments on host specificity of *Calicotyle* spp. *Parasitology International* **75**, 102025.

Oliver S, Braccini M, Newman SJ and Harvey ES (2015) Global patterns in the bycatch of sharks and rays. *Marine Policy* **54**, 86–97.

Pham CK, Diogo H, Menezes G, Porteiro F, Braga-Henriques A, Vandeperre F and Morato T (2014) Deep-water longline fishing has reduced impact on vulnerable marine ecosystems. *Scientific Reports* **4**, 4837.

Reyes PR, Torres JP and Reyes EM (2009) 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). *Revista de Biologia y Oceanografia* **44**, 59–65.

Robertson DR and Allen GR (2015) Peces Costeros del Pacífico Oriental Tropical: sistema de Información en línea. Available at https://biogeodb.stri.si.edu/sftep/es/pages (accessed 14 April 2022).

Sancho-Andrade A, Ortiz -Von Halle B and Naranjo-Cuvi N (2002) *La pesca y el comercio de bacalao de profundidad Dissostichus eleginoides en América del Sur: Una perspectiva regional.* Quito: Traffic América del Sur.

Sellanes J, Pedraza MJ and Zapata Hernandez G (2012) Las areas de filtracion de metano constituyen zonas de agregación del bacalao de profundidad (*Dissostichus eleginoides*) frente a Chile central. *Latin American Journal of Aquatic Research* **40**, 980–991.

Sepa P, Coello D, Herrera M and Zambrano R (2021) Length-weight relationship of four deep-sea chondrichthyans (Elasmobranchii & Holocephali) in Ecuadorian oceanic waters. *Egyptian Journal of Aquatic Research* **48**, 397–399.

Taki K, Kiyota M, Ichii T and Iwami T (2011) Distribution and population structure of *Dissostichus eleginoides* and *D. mawsoni* on Banzare Bank (CCAMLR Division 58.4.3b), Indian Ocean. *CCAMLR Science* **18**, 145–153.

Trujillo-Olvera A, Ortega-García S, Tripp-Valdez A, Escobar-Sánchez O and Acosta-Pachón TA (2018) Feeding habits of the swordfish (*Xiphias gladius* Linnaeus, 1758) in the subtropical northeast Pacific. *Hydrobiologia* **822**, 173–188.