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ARTICLE

Batoid fishery in Peru (1950-2015): Magnitude, management and data needs

Pesquería de batoideos en Perú (1950-2015): Magnitud, manejo y necesidades de información

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Resumen.- Los desembarques históricos de la Organización de las Naciones Unidas para la Agricultura y la Alimentación (1950-2015) se utilizaron para estimar la contribución de la pesquería de batoideos peruana al Pacífico Este, y los desembarques específicos de especies del Instituto del Mar del Perú (1997-2015) se utilizaron para identificar las especies más desembarcadas, sus lugares de desembarque, variación mensual a lo largo del año y artes de pesca más utilizados. Además, se evaluaron las normativas e investigaciones para identificar potenciales vacíos que estarían obstaculizando el manejo y la conservación de batoideos en el Perú. Los resultados mostraron que en el Pacífico Este, Perú ocupó el segundo lugar, después de Chile, en desembarques de batoideos entre 1950 y 2015. De las 23 especies de batoideos marinos que interactúan con las pesquerías peruanas, los grupos taxonómicos más desembarcados, entre 1997 y 2015, fueron: *Myliobatis* spp. (*i.e., M. chilensis* y *M. peruvianus*; 45% de los desembarques de batoideos), *Mobula* spp. (principalmente *M. mobular*, y secundariamente *M. thurstoni, M. munkiana, M. tarapacana;* 28%), *Pseudobatos planiceps* (6%) e *Hypanus dipterurus* (6%). La mayoría de estas especies se desembarcan en el norte de Perú, siendo las redes de enmalle el arte de pesca más utilizado para capturarlas. Los desembarques de batoideos se produjeron durante todo el año; sin embargo, para *H. dipterurus* y *P. planiceps* los desembarques fueron mayores durante el verano austral. Solo existen tres medidas de manejo pesquero para los batoideos en Perú para tres especies (*i.e., Mobula birostris, Pristis pristis, Rhinoptera steindachneri*) y dos taxones (*i.e., Mobula* y *Myliobatis*), las cuales no se cumplen totalmente. La investigación sobre batoideos peruanos en el Perú es limitada ya que solo existen 25 estudios entre los años 1978 y 2022 para los cuales las especies más estudiadas son *M. birostris, M. chilensis y M. peruvianus*. Este estudio establece una línea base de información para los batoideos en Perú para orientar su manejo, investigación y conservación.

Palabras clave: Pesquerías artesanales, Pacífico sudeste, rayas guitarras, rayas mobulas, rayas águilas

Abstract.- Historical landings from the Food and Agriculture Organization (1950–2015) were used to estimate the contribution of the Peruvian batoid fishery to the eastern Pacific Ocean, and species-specific landings from Instituto del Mar del Peru (1997-2015) were used to identify the most-landed species, their landings sites and monthly variation throughout the year, and fishing gear types most used. The regulatory and research landscape were evaluated toward identifying potential gaps that may be hindering conservation and management of batoids in Peru. Results showed that in the eastern Pacific, Peru ranked second, after Chile, for batoid landings from 1950 to 2015. Of the twenty-three species of marine batoids that interact with Peruvian fisheries, the most landed taxonomic groups, from 1997 to 2015, were: *Myliobatis* spp. (*i.e., M. chilensis* and *M. peruvianus*; 45% of batoids landings), *Mobula* spp. (primarily *M. mobular*, and secondarily *M. thurstoni, M. munkiana, M. tarapacana;* 28%), *Pseudobatos planiceps* (6%), and *Hypanus dipterurus* (6%). Most of these species are landed in northern Peru, where gillnets are the most-used fishing gear to capture them. Batoid landings occurred year-round; yet, for *H. dipterurus* and *P. planiceps* landings were highest during the austral summer. Only three management measures exist for batoids fisheries in Peru for three species (*i.e.*, *M. birostris, Pristis pristis, Rhinoptera steindachneri*) and two taxa (*i.e., Mobula* and *Myliobatis*) which are not fully enforced. Batoid research in Peru is limited, with only 25 publications from 1978 to 2022, in which the most studied species are *Mobula birostris, M. chilensis and M. peruvianus.* This study establishes an information baseline for batoids in Peru that can help guide their management, research, and conservation.

Key words: Small-scale fisheries, Southeast Pacific, guitarfishes, mobulid rays, eagle rays

Introduction

Eagle rays, mobulid rays, guitarfishes, sawfishes and their relatives (Batoidea, 633 spp., hereafter batoids; Last *et al.* 2016) constitute the most at-risk group of elasmobranchs due to overfishing (Dulvy *et al.* 2000, 2014). Sharks and batoids are phylogenetically sister clades, and thus, they share some biological characteristics such as low fecundity, few offspring, slow growth, and late maturation (Last *et al.* 2016). As with sharks, these characteristics limit the ability of batoids to recover from population declines (Walker & Hislop 1998, Bräutigam *et al.* 2015). Furthermore, information on their taxonomy, biology (*e.g.*, population structure), and fisheries (*e.g.*, catch and bycatch rates) is still limited (Dulvy *et al.* 2000, 2014), hampering their management and conservation.

Batoids are captured and retained in different fisheries worldwide as both target and bycatch species (Stevens *et al.* 2005). Historically, these fishes have been used for direct human consumption and as bait (Essumang 2010, Couturier *et al.* 2012). Mobulid rays are particularly prized; their gill rakers are valued in Asian dried seafood and traditional Chinese medicine markets (O'Malley *et al.* 2017). This combination of directed and incidental captures with limited fisheries management policies has caused population depletions for many batoid species (Brander 1981, Casey & Myers 1998, Walker & Hislop 1998). For example, in the northeast Atlantic, the blue skate *Dipturus batis* was historically one of the most abundant batoids; by the 1970s this skate was extirpated from the Irish sea (Brander 1981); the main reason for this was fisheries over-exploitation (Casey & Myers 1998, Dulvy *et al.* 2000). The collapse of batoid populations could affect human food security, and coastal livelihoods (Moore & Grubbs 2019).

In Peru, Cornejo *et al.* (2015) reported 43 batoid species; yet this group has been subject to taxonomic revisions (Last *et al.* 2015). As a result, this number has been reduced to 37 species in Peruvian waters. Many of these species are directly targeted, mostly by Peruvian small-scale fisheries; yet limited information exists about their fishery interactions (*e.g.*, Alfaro-Cordova *et al.* 2017). The goal of this study was to establish an information baseline for batoids in Peru and to provide a comparison with other batoid fisheries around the world, specifically with the Eastern Pacific. The objectives of this study were (1) to describe and analyse the trajectory of the Peruvian batoid fishery and assess its landings contribution from 1950 to 2015, (2) to identify the most landed species in the contemporary batoid fishery, their landing sites and monthly variation throughout the year, and the most used fishing gears from 1997 to 2015, and (3) to evaluate the regulatory and research landscape towards identifying potential gaps that may be hindering conservation and management.

Materials and methods

Two sets of data were used to analyse fishery landings. To describe and analyse the trajectory of the Peruvian batoid fishery and assess its landing contribution in the Pacific Ocean and also in the eastern Pacific, batoid landings (as a broad category) were used in Peru from 1950 to 2015 available at the Food and Agriculture Organization (FAO) under Global Capture Production obtained from the software FishStatJ (FAO 2022). To identify the most landed species in the contemporary batoid fishery, their landing sites and variation throughout the year, and the most-used fishing gears, landing reports at species-level were used from Instituto del Mar del Perú (IMARPE) from 1997 to 2015 (since 1997 IMARPE has recorded landings at the species-level). To prevent misidentification, they were grouped *M. chilensis* and *M. peruvianus* into *Myliobatis* spp., and *M. mobular*, *M. thurstoni*, *M. munkiana*, *M. tarapacana* and *M. birostris* into *Mobula* spp. These landing reports are from the Peruvian small-scale fishing fleet [*i.e.*, fishing vessels with a maximum of 32.6 m^3 of gross registered tonnage, up to 15 m length, and operating manually (DS N° 012-2001-PE)[1]].

To assess trends in landings over time, a generalized least square (GLS) model was used to fit a linear model, maximizing the restricted log-likelihood (REML), with unequal variances to account for measurement uncertainty. The nlme package (Pinheiro *et al.* 2014) in R v3.6.2 (R Core Team 2019) was used for this analysis. The confidence intervals (CI) of the GLS model parameters were estimated using nonparametric bootstrapping with replacement (R= 1,000) of the resulting coefficients with the R package boot (Davison & Hinkley 1997, Canty & Ripley 2013). To maximize recognition of any significant trends in landings, the 1950-2015 dataset from FAO was grouped into 10-year blocks, except for the last segment of 6 years (2010 to 2015). The 1997-2015 dataset from IMARPE was grouped into 10-year (1997 to 2006) and 9-year (2007 to 2015) blocks. The monthly landings by species from 1997 to 2015 was also analysed using boxplots which shows the spread and centre of a dataset. To determine if significant differences occurred among months, a one-way analysis of variance (ANOVA) with pairwise multiple comparisons by Tukey posthoc tests were used. Before any statistical analysis was performed the data were tested for homogeneity of variances with Levene's test (Levene 1960). Finally, landings by site and fishing gear by species from 1997 to 2015 were analyzed. Once the most-used fishing gear was determined, species (other than batoids) associated with these fishing gears were identified through a review of published peer-reviewed literature.

[1]DS N°. 012-2001-PE. Reglamento de la Ley General de Pesca. Decreto Supremo N. 012-2001-PE. Lima, 13 de marzo de 2001. <https://cdn.www.gob.pe/uploads/document/file/418473/Decreto_Supremo_N%C2%BA_012-2001-PE.pdf>

To evaluate the regulatory and information landscape for the conservation and management of batoids, first the current national laws regulating Peruvian batoid fisheries were identified and reviewed. Second, available scientific information on batoids was assessed based on peer reviewed publications from scientific journals and other electronic sources. To obtain data from electronic sources, a structured Boolean search was performed on search engines such as Google Scholar[2], and ScienceDirect™[3], with the following keywords: “batoids”, “elasmobranchii”, “Peru”. A keywords search including species inhabiting Peruvian waters using the species checklist of Cornejo *et al.* (2015) was conducted. As species and genus names are regularly modified with advances in taxonomy and some species are known in the literature by different names, the different Latin names known for each batoid species were used by considering the list of synonyms available at the California Academy of Sciences web site (California Academy of Sciences 2023)[4]. To extract data published in journals not accessible via internet (*e.g.*, theses or old articles), a manual search was performed. Collected data were arbitrarily grouped under the following categories: taxonomy, life history, spatial ecology, environmental effects, ecosystem role, fishery status, population status, and human dimensions. These corresponded to research needs for the development of effective conservation management of elasmobranchs as identified by Simpfendorfer *et al*. (2011). For articles that included more than one topic, all the topics were considered to avoid underestimating the total number of topics addressed. The total number of published studies for batoids, the species that have been studied, and the topics (*i.e.*, research needs) assessed were calculated. For theses that have been published in peer-reviewed journals, only the published version was considered.

Results

Batoid fisheries in Peru

In Peru 202,422 tonnes (t) of batoids were landed from 1950 to 2015, with an average of 3,067 ± 2,766 (mean ± SD) t per year (ranged from 300 in 1950 to 11,284 in 1988, Fig. 1). Landings increased at an average of 27.4% per year (slope= 0.282; 95% CI: 0.19, 0.389) from 1960 to 1969. An increase was also observed from 1980 to 1989 (9.4% per year, slope= 0.089; 95% CI: 0.034, 0.141). However, from 2000 to 2010, landings declined by an average of 11.6% per year (slope= -0.123; 95% CI: -0.229, -0.026, Table 1). From 2010 to 2015, no significant trend was observed.

Peruvian batoid fisheries from a worldwide and regional perspective

Peru ranked 19th in total landings among the 106 countries reporting batoid landings from 1950 to 2015. In the Pacific Ocean, Peru ranked 8th among 27 countries that reported batoid landings. The annual contribution of Peru to total batoid landings in the Pacific Ocean increased from 1.1% in 1950 to its highest level of 21.7% in 1967 when it ranked second, after Japan (33.8%, Fig. 1). In the Pacific Ocean, Peru’s contribution to total batoid landings has decreased since the year 2000 to an average annual contribution of 2.0 1.5%. In the eastern Pacific, Peru ranks second with 22% of total batoid landings, after Chile (36%) and followed by the United States (21%) and Mexico (15%).

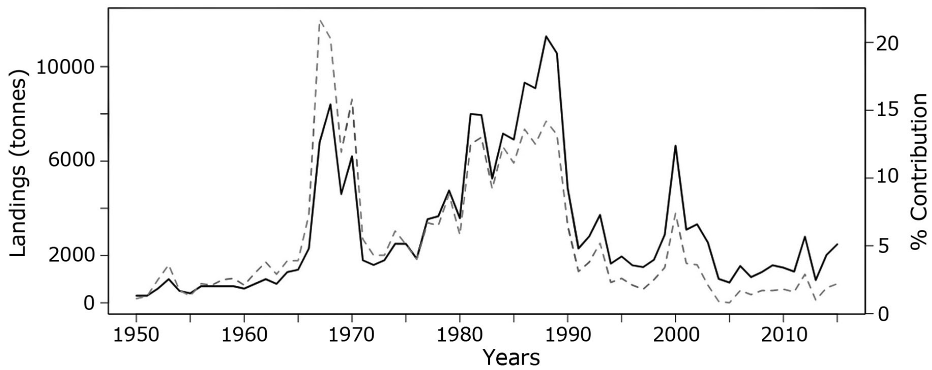

Figure 1. Sixty-six years (1950-2015) of marine batoid landings in Peru (solid line) and its percentage contribution to landings for the Pacific basin (dotted line) / Sesenta y seis años (1950-2015) de desembarques de batoideos marinos en el Perú (línea continua) y su contribución porcentual a los desembarques de la cuenca del Pacífico (línea de puntos)

[2]<https://scholar.google.com/>
[3]<https://www.sciencedirect.com/>
[4]<https://www.calacademy.org/>

Table 1. Trends and variations in Peruvian marine batoid landings / Tendencias y variaciones en los desembarques de batoideos marinos en el Perú

Species	Year	Year Predictor		t-ratio	*P*-value	RSE	95% CI of slope		Change in landings		
		Slope	SE				2.50%	97.50%	Mean	2.50%	97.50%
Batoids	1950-1959	0.083	0.037	2.264	n.s.	0.134	-0.018	0.125			
	1960-1969	0.282	0.0421	6.703	< 0.005	0.139	0.19	0.389	27.4	22.1	44
	1970-1979	0.045	0.051	0.875	n.s.	0.165	-0.137	0.143			
	1980-1989	0.089	0.025	3.519	< 0.05	0.077	0.034	0.141	9.4	4.1	15
	1990-1999	-0.070	0.038	-1.848	n.s.	0.123	-0.162	0.021			
	2000-2010	-0.123	0.045	-2.676	< 0.05	0.172	-0.229	-0.026	-11.6	-19.2	-3.2
	2010-2015	0.077	0.103	0.753	n.s.	0.157	0.046	0.214			
Myliobatis spp.	1997-2006	-0.036	0.029	-1.237	n.s.	0.110	-0.099	0.029			
	2007-2015	0.153	0.018	8.351	< 0.005	0.057	0.118	0.183	16.6	12.4	20.8
Mobula spp.	1997-2006	0.148	0.094	1.563	n.s.	0.380	-0.036	0.316			
	2007-2015	0.092	0.067	1.370	n.s.	0.219	0.057	0.233			
Pseudobatos planiceps	1997-2006	-0.127	0.024	-5.22	< 0.05	0.116	-0.18	-0.069	-11.9	-16.0	-7.7
	2007-2015	0.041	0.069	0.585	n.s.	0.264	-0.114	0.235			
Hypanus dipterurus	1997-2006	-0.123	0.029	-4.109	< 0.05	0.142	-0.213	-0.061	-11.5	-16.4	-6.4
	2007-2015	0.027	0.054	0.510	n.s.	0.222	-0.136	0.134			

SE: standard error; n.s.: not significant *P*-value (> 0.05)
RSE: model residual standard error; upper and lower limits of 95% confidence interval
Mean annual change in landings was calculated as = [(slope - 1) x 100]
The upper and lower limits of change in landings were calculated as = [(slope ± 1.96 SE -1) x 100]
CI= confidence interval
Overall batoid captures (1950-2015) are from FAO, and group-specific landings (1997-2015) are from IMARPE
Change in landings include 95%

Species-specific landing analysis

Twenty-three batoid species interact with Peruvian fisheries which represents 62% of the total species reported in Peru (Table 2). Four taxonomic groups represented 85.7% of total batoids landings from 1997 to 2015: *Myliobatis* spp. (45.4% of landings), *Mobula* spp. (28.0%), *Pseudobatos planiceps* (6.4%), and *Hypanus dipterurus* (5.9%). Less important species in landings were (in order of decreasing abundance): *Rhinoptera steindachneri*, *Urotrygon* spp., *Gymnura crebripunctata*, *Tetronarce tremens*, and *Sympterygia brevicaudata.*

Species-level landings from IMARPE from 1997 to 2015 indicate some species exhibited increases while other species declined (Table 1; Fig. 2). Landing of *Myliobatis* spp. exhibited a significant average increase of 16.6% per year (*P*-value < 0.005, slope= 0.153, 95% CI: 0.118, 0.183) from 2007 to 2015, reaching its peak in 2014. For *Mobula* spp., no significant trends in landings were observed between the two periods (1997-2006 and 2007-2015). Yet, *Mobula* spp. reached peak landings in 2015. For *P. planiceps* and *H. dipterurus*, landings from 1997 to 2006, exhibited a significant average decrease of 11.9% (*P*-value < 0.05, slope= -0.127, 95% CI: -0.18, 0.069) and 11.5% (*P*-value < 0.05, slope= -0.123, 95% CI: -0.213, -0.061) per year, respectively. For both species, from 2007 to 2015, no significant trends in landings were observed.

Table 2. Conservation status for the batoid species reported in Peruvian fisheries. Conservation status according to IUCN Red List (IUCN 2023) / Estado de conservación de las especies de batoideos reportadas en la pesca peruana. Estado de conservación de acuerdo con la Lista Roja de la UICN (IUCN 2023)

Scientific name	Common name		Conservation status
	English	Spanish	
Dasyatidae			
Hypanus dipterurus	Diamond Stingray	Batanas	VU
Urotrygonidae			
Urotrygon aspidura	Spiny-tail round ray	Raya con aguijón	NT
Urotrygon chilensis	Chilean round ray	Raya con espina	NT
Urotrygon munda	Munda round ray		NT
Urotrygon rogersi	Rogers round ray	Raya tapadera	NT
Mobulidae			
Mobula mobular	Spinetail mobula	Manta	EN
Mobula munkiana	Munk's devil ray	Manta	VU
Mobula tarapacana	Chilean devil ray	Manta	EN
Mobula thurstoni	Smoothtail mobula	Manta	EN
Mobula birostris	Giant evil ray	Manta	EN
Myliobatidae			
Aetobatus laticeps	Spotted eagle ray	Raya pico de pato	VU
Myliobatis longirostris	Snouted eagle ray	Raya águila hocicuda	VU
Myliobatis chilensis	Chilean Eagle Ray	Raya águila	VU
Myliobatis peruvianus	Peruvian eagle ray	Raya águila	VU
Torpedinidae			
Tetronarce tremens	Chilean torpedo	Tembladera	LC
Narcinidae			
Narcine entemedor	Giant electric ray	Raya eléctrica	VU
Rajidae			
Rostroraja velezi	Velez ray	Raya Bruja	VU
Rostroraja equatorialis	Ecuatorial ray	Raya Bruja	VU
Sympterygia brevicaudata	Shorttail fanskate	Pastelillo	NT
Rhinobatidae			
Pseudobatos planiceps	Pacific guitarfish	Guitarra común	VU
Zapteryx xyster	Banded guitarfish	Guitarra mariposa	VU
Rhinopterinae			
Rhinoptera steindachneri	Pacific cownose ray	Gavilán	NT
Gymnuridae			
Gymnura crebripunctata	Butterfly ray	Raya mariposa	NT

LC- Least Concern, NT-Near Threatened, VU-Vulnerable, EN-Endangered

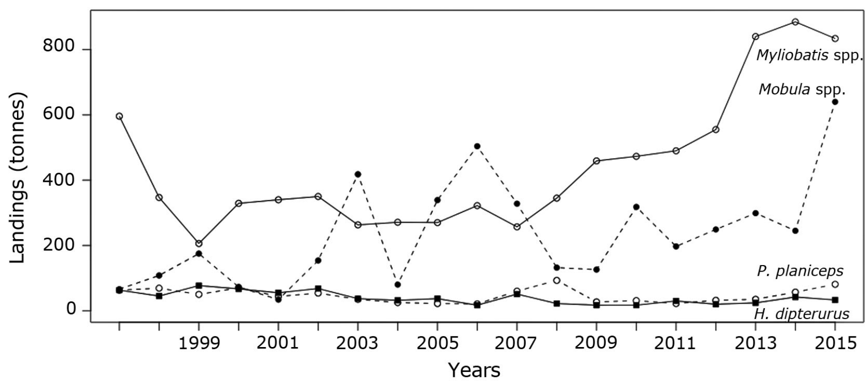

Figure 2. Landing of the four most commercial exploited marine batoid groups in Peru from 1997 to 2015: *Myliobatis* spp. (solid line-open circle), *Mobula* spp. (dashed line-close circle), *Pseudobatos planiceps* (dashed line-open circle) and *Hypanus dipterurus* (solid line-close square). *Myliobatis* spp. includes: *M. chilensis* and *M. peruvianus*; *Mobula* spp. includes: *M. mobular, M. thurstoni, M. munkiana, M. tarapacana* and *M. birostris* / Desembarques de los cuatro grupos de batoides marinos más explotados comercialmente en el Perú entre 1997 y 2015: *Myliobatis* spp. (círculo abierto de línea continua), *Mobula* spp. (círculo cerrado de línea discontinua), *Pseudobatos planiceps* (círculo abierto de línea discontinua) e *Hypanus dipterurus* (cuadrado cerrado de línea continua). *Myliobatis* spp. incluye: *M. chilensis* y *M. peruvianus*; *Mobula* spp. incluye: *M. mobular, M. thurstoni, M. munkiana, M. tarapacana* y *M. birostris*

Batoid landings occurred year-round (Fig. 3). Pairwise multiple comparisons showed that no significant differences in landings occurred between months for *Mobula* spp. and *Myliobatis* spp. Yet, for *H. dipterurus* and *P. planiceps* landings were highest during the austral summer (ANOVA, $P < 0.001$).

Batoid landings were not homogeneously distributed among the 115 official landing sites distributed along the Peruvian coast (INEI 2012)[5]. A tendency to land certain species at specific points, especially in northern Peru, was observed from 1997 to 2015 (Fig. 4). For *Myliobatis* spp., the most important landing points were in northern (64.6% landings; *i.e.*, San Jose and Chimbote) and central (16.7%; *i.e.*, Huacho and Pucusana). For *Mobula* spp., the landing points in northern Peru accounted for 78.8% of fishing landings (*i.e.*, Mancora, Zorritos, Cancas, La Cruz and Salaverry). For *P. planiceps*, 70.6% of total landings were similarly distributed in northern (33.9%; *i.e.*, Puerto Pizarro) and central (31.45%; *i.e.*, San Andres). For *H. dipterurus*, a single landing point on the central coast (*i.e.*, San Andres) accounted for 41.1% of landings (Fig. 4).

Batoids were most frequently captured by gillnets: *Myliobatis* spp. (85% of landings), *H. dipterurus* (68.3%), *P. planiceps* (51.7%), and *Mobula* spp. (50.2%), (Fig. 5). Purse seine vessels had the second-highest landings of *Mobula* spp. (47.8% of landings) and *H. dipterurus* (18.6%). Beach seines and trawling were important fishing gears to capture *P. planiceps* with 18.2% and 8.2% of landings, respectively. Since 2009 national reports from IMARPE stopped reporting trawl and beach seine landings. Depending on the gear used by small-scale fisheries, the species associated changes (Table 3).

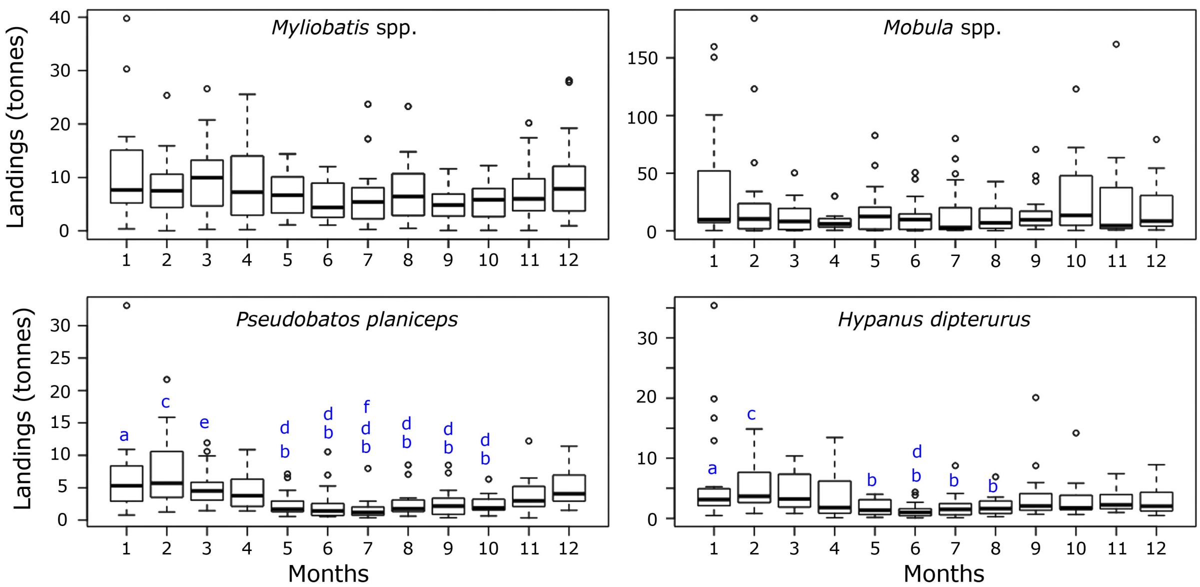

Figure 3. Monthly landings of the four most commercially exploited marine batoid groups in Peru from 1997 to 2015. *Myliobatis* spp. includes: *M. chilensis* and *M. peruvianus; Mobula* spp. includes: *M. mobular, M. thurstoni, M. munkiana, M. tarapacana* and *M. birostris*. Central lines represent median value, box limits represent upper and lower quartiles, whiskers are data points a half times the interquartile range above and below the upper and lower quartile, and dots represent outliers. Different letters represent significant differences between months ('a' significant different from 'b', 'c' from 'd', 'e' from 'f') / Desembarques mensuales de los cuatro grupos de batoides marinos más explotados comercialmente en Perú entre 1997 y 2015. *Myliobatis* spp. incluye: *M. chilensis* y *M. peruvianus*; *Mobula* spp. incluye: *M. mobular, M. thurstoni, M. munkiana, M. tarapacana* y *M. birostris*. Las líneas centrales representan el valor de la mediana, los límites de las cajas representan los cuartiles superior e inferior, los bigotes son puntos de datos de la mitad del rango intercuartílico por encima y por debajo del cuartil superior e inferior, y los puntos representan valores atípicos. Letras diferentes representan diferencias significativas entre meses ('a' significativamente diferente de 'b', 'c' de 'd', 'e' de 'f')

[5]INEI. 2012. I Censo Nacional de Pesca Artesanal. Ámbito Marítimo. 2012. Instituto Nacional de Estadística e Informática, Lima. <https://www2.congreso.gob.pe/sicr/cendocbib/con4_uibd.nsf/8AAFE566D4CB310205257B8100774CED/%24FILE/censo-pesquero-artesanal.pdf>

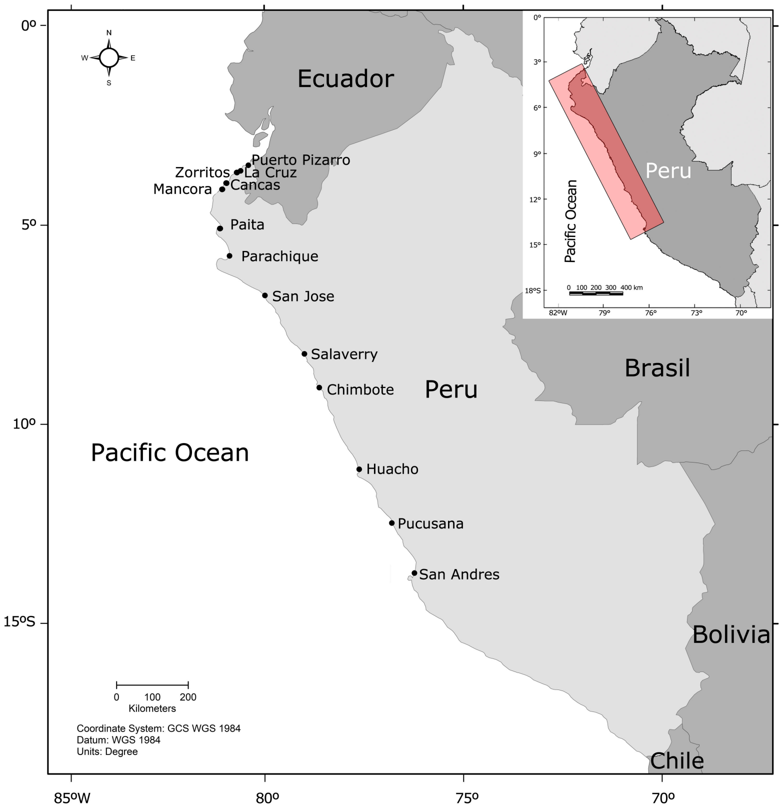

Figure 4. Highest reported Peruvian batoid landing points (black circles) from 1997 to 2015 / Los puntos de desembarques de batoideos peruanos más altos (círculos negros) reportados entre 1997 y 2015

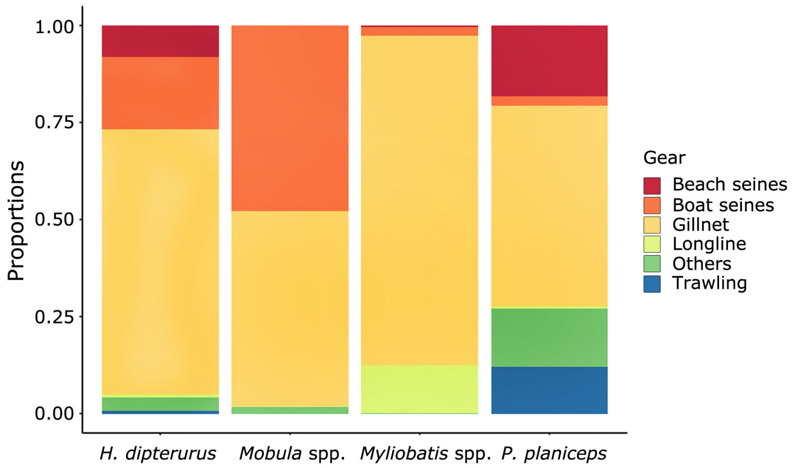

Figure 5. Proportions of landings by fishing gear of the most commercial batoid species from 1997 to 2015 in Peru. *Myliobatis* spp. includes: *M. chilensis, M. peruvianus*; *Mobula* spp. includes: *M. mobular, M. thurstoni, M. munkiana, M. tarapacana* and *M. birostris* / Proporciones de desembarques por artes de pesca de las especies de batoideos más comerciales entre 1997 y 2015 en Perú. *Myliobatis* spp. incluye: *M. chilensis*, *M. peruvianus*; *Mobula* spp. incluye: *M. mobular*, *M. thurstoni*, *M. munkiana*, M. tarapacana y *M. birostris*

Table 3. Species associated within batoid`s fisheries according to fishing gear used by small-scale fisheries / Especies asociadas a la pesca de batoideos según los artes de pesca utilizados por la pesca artesanal

Fishing gear type	Captured batoids	Target species	Reference(s)
Bottom gillnet	*Pseudobatos planiceps* and *Myliobatis* spp.	Flounder (*Paralichthys adspersus*), Peruvian banded croaker (*Paralonchurus peruanus*), lobster (*Panulirus gracilis*), smooth hounds (*Mustelus* spp., *Triakis* spp.)	Castañeda 1994, Alfaro-Shigueto *et al*. 2010, Salazar 2018
Driftnet	*Myliobatis* spp. and *Mobula* spp.	Hammerhead sharks (*Sphyrna zygaena*), thresher sharks (*Alopias* spp.), angel sharks (*Squatina californica*), smooth hounds, bonito (*Sarda chilensis*), dolphinfish (*Coryphaena hippurus*), billfishes (Istiophoridae and Xiphiidae), and yellowfin tuna (*Thunnus albacares*)	Castañeda 1994, Alfaro-Shigueto *et al.* 2010, Alfaro-Cordova *et al.* 2017, Salazar 2018
Purse seines	*Mobula* spp.	Pacific harvestfish (*Peprilus medius*) and Pacific thread herring (*Opisthonema libertate*)	Ganoza *et al.* 2007
Trawling	*Pseudobatos planiceps*	Shrimps (*Penaeus* spp.), sand perches (*Diplectrum* spp.), Peruvian hake (*Merluccius gayi*), lumptail searobin (*Prionotus stephanophrys*), banded croaker (*Paralonchurus* spp.), Peruvian weakfish (*Cynoscion analis*), and other 73 species	Salazar 2018
Beach seinses	*Pseudobatos planiceps*	Flathead grey mullet (*Mugil cephalus*), Peruvian weakfish (*Cynoscion analis*), corvina (*Cilus gilberti*), and other 17 species	Salazar 2018

National legislation for the conservation and management of batoids

Peru's NPOA-elasmobranchs (approved in 2014; El Peruano 2014[6]) is the most recent NPOA in the southeastern Pacific region and since approval, only two regulations have been implemented: the prohibition of the fishery, landing and commercialization of *Mobula birostris* (El Peruano 2015)[7] and largetooth sawfish (*Pristis pristis*) (El Peruano 2020)[8]. Before NPOA implementation, a fishery measure was in place to regulate the minimum gillnet mesh size (20-33 cm) for the capture of *Mobula* spp., *Myliobatis* spp. and *Rhinoptera steindachneri* (El Peruano 2001)[9].

In the last two decades, two fishing gear regulations may have restricted the fishery of batoids within 5 nm of the coast. In 2001, the government prohibited the use of bottom trawling in the coastal zone (within 5 nm from the coast), and mechanized beach seines (DS N° 012-2001-PE)[1] and manual beach seines, (El Peruano 2009)[10] both of which operate in the littoral zone.

Another measure that regulates the bycatch of batoids is the management plan of the Peruvian hake (*Merluccius gayi peruanus*) which identifies the most frequent bycatch species and establishes that these must be used only for direct human consumption (DS Nº 003-2019-PRODUCE 2003)[11]. In Peruvian waters, the Peruvian hake is caught mainly through bottom trawlers. The total incidental catches of species considered as accompanying fauna of the Peruvian hake should not exceed 10% of the catch – and this rule only applies for trawler vessels-factories. According to this management plan, two batoid taxa are included as bycatch (*i.e*., *Myliobatis* spp. and *Psammobatis* spp.).

[7]El Peruano. 2015. Prohiben extracción de la especie Mantarraya gigante con cualquier arte o aparejo de pesca y/o cualquier otro instrumento, en aguas marinas de la jurisdicción peruana. Resolución Ministerial Nº 441-2015-PRODUCE. Lima, 31 de diciembre de 2015. <https://faolex.fao.org/docs/pdf/per153305.pdf>

[8]El Peruano. 2020. Prohíben extracción de la especie pez sierra, en aguas marinas de la jurisdicción peruana, así como su desembarque, transporte, retención, transformación y comercialización. Resolución Ministerial N° 056-2020-PRODUCE. Lima, 5 de febrero de 2020. <https://www.gob.pe/institucion/produce/normas-legales/437206-056-2020-produce>

[9]El Peruano. 2001. Resolución Nº 209-2001-PE ─ Tallas mínimas de captura y tolerancia máxima de ejemplares juveniles de principales peces marinos e invertebrados. Lima, 26 de junio de 2001. <https://www.fao.org/faolex/results/details/es/c/LEX-FAOC031908/>

[10]El Peruano. 2009. Prohiben la utilizaci6n del arte de la pesca denominado chinchorro manual para realizar operaciones de pesca en todo el litoral peruano. Resolución Ministerial Nº 112-2009- PRODUCE. Lima, 13 de marzo de 2009. <https://www.fao.org/faolex/results/details/es/c/LEX-FAOC088349/>

[11]DS Nº 003-2019-PRODUCE. Decreto Supremo que modifica el Reglamento del Ordenamiento Pesquero del Recurso Merluza, aprobado por Decreto Supremo N° 016-2003-PRODUCE. Decreto Supemo N° 003-2019- PRODUCE. Lima, 6 de mayo de 2019. <https://www.fao.org/faolex/results/details/es/c/LEX-FAOC066045/>

Research situation of batoids in Peru

Twenty-five studies related to batoids in Peru have been published in peer-review scientific journals or defended in theses dissertations from 1978 to 2022 (Table 4). The most studied species were *Mobula birostris*, *M. chilensis* and *M. peruvianus* (four studies each). The most common topics were ecosystem role (n: 7 studies); followed by life history and fishery status (n: 4 studies); taxonomy, spatial ecology, and human dimensions (n: 3 studies each); and environmental effects (n: 2 studies each). Population status was the only research need that has not been addressed. Research have increased on the last 6 years (2017-2022) with 81% of studies published in these years.

Discussion

The Peruvian batoid fishery is an important fishery for the eastern Pacific contributing 22% of landings in the region. Therefore, batoids are an important marine resource in Peruvian waters. Two taxa (*i.e.*, *Myliobatis* spp. and *Mobula* spp.) and two species (*i.e.*, *Pseudobatos planiceps*, *Hypanus dipterurus*) were identified as the most landed batoids in Peruvian waters and these are classified as Threatened by the IUCN Red List of Threatened Species (IUCN 2023). Limited information (*i.e.*, biology, ecology and fishery interactions) is available for these species, and some of them (*i.e.*, *M. peruvianus* and *M. chilensis*) have restricted distributions in the Eastern Pacific. This circumstance of large quantities of landings combined with open data needs and management deficiencies likely jeopardizes population viabilities.

Why have Peruvian batoid landings decreased?

A general trend was observed for the 66 years of Peruvian batoid landings that were analyzed. During the first forty years, landings increased to a maximum of 11,284 t in 1988, and in the last fifteen years landings have decreased or remained stable, with a value of 2,478 t in 2015. These trends are similar to other batoid fisheries around the world. The most plausible reason for the decline in global elasmobranch landings is population declines resulting from increased fishing pressure, not recent improvements in international or national fisheries management (Davidson *et al.* 2016). Davidson *et al*. (2016) found that as elasmobranch landings increased, human coastal population size (as an indirect measure of fishing pressure) increased. Also, as the strength of a country's National Plan of Action for elasmobranchs (NPOA-elasmobranchs) (*i.e.*, fishery management performance) decreased, elasmobranch landing increased (Davidson *et al.* 2016). The authors also identified scientific capacity as a strong predictor since high scientific capacity is associated with desirable conservation status (*i.e.*, low number of Threatened species and high

Table 4. Available scientific information on batoids in Peru from 1978 to 2022 were grouped under research needs for the development of effective conservation management of elasmobranchs as identified by Simpfendorfer *et al.* (2011) / Información científica disponible sobre batoideos en Perú de 1978 a 2022 agrupados bajo las necesidades de investigación para el desarrollo de una gestión eficaz de la conservación de elasmobranquios identificadas por Simpfendorfer *et al.* (2011)

Research needs	Species	References
Taxonomy	*Pseudobatos planiceps, Rostroraja velezi, Sympterygia brevicaudata, Urotrygon chilensis, Hypanus dipterurus, Pteroplatytrygon violacea, Myliobatis peruvianus, Myliobatis chilensis*	Cornejo *et al.* 2015*, Sánchez-Rea 2020, Molina-Salgado *et al.* 2022
Life history	*Myliobatis chilensis, Myliobatis peruvianus, Mobula birostris, Mobula mobular*	Torres 1978, Cabanillas-Torpoco *et al.* 2019, Valderrama-Herrera 2019, Gonzalez-Pestana 2022
Spatial ecology	*Mobula birostris, Pristis pristis*	Mendoza *et al.* 2017, Cabanillas-Torpoco *et al.* 2020, Andrzejaczek *et al.* 2021
Ecosystem role	*Pseudobatos planiceps, Hypanus dipterurus, Rostroraja velezi, Myliobatis peruvianus, Myliobatis chilensis, Urotrygon chilensis, Mobula mobular*	Manrique & Mayaute 2017, Alfaro-Cordova *et al.* 2018, Coasaca-Céspedes *et al.* 2018, Silva-Garay *et al.* 2018, Gonzalez-Pestana *et al.* 2020, Molina-Salgado *et al.* 2022, García-Yarihuaman & Mantarí-Gavilano 2021
Fishery status	*Myliobatis chilensis, Myliobatis peruvianus, Mobula* spp.; *Pseudobatos* sp.	Torres 1978, Rojas 2016, Alfaro-Cordova *et al*. 2017, Urbina & Alvarado 2021
Human dimensions	*Mobula birostris, Myliobatidae*	Bradley 2012, Mauricio-Llonto 2015, Guirkinger *et al.* 2021
Environmental effects	*Mobula birostris, Mobula mobular*	Moreno & Gonzalez-Pestana 2017, Lezama-Ochoa *et al.* 2019

*Checklist of elasmobranchs in Peru

number of Least Concern species) (Lucifora *et al.* 2019). Therefore, human coastal population size, strength of NPOA-elasmobranchs and scientific capacity were identified as predictable variables for landings trajectories, and ultimately these variables have the potential to predict overfishing or population decline. MacNeil *et al.* 2020 have also found a strong correlation between large coastal populations and poor governance with coastal reef shark depletions in the world's tropical oceans.

In Peru, these same factors may have played significant roles in the landings decrease observed since 1988. The coastal population has greatly increased in Peru in the last half-century: from 28% in 1940 to 58% in 2017 (INEI 2017)[12] boosting a demand for seafood - 12,000 *cevicherías* (seafood restaurants) operate in Lima alone (Christensen *et al.* 2014). Peruvian small-scale fisheries have also grown, suggesting an increase in fishing effort. The number of vessels and fishers increased by 186% and 140%, respectively, from 1995-1996 to 2015 (Escudero 1997, Castillo *et al*. 2018) along with the average length of gillnets from 72-81 m to 800-3,300 m, from 1970 to 2005 (Castillo 1970, Alfaro-Shigueto *et al.* 2010). The Peruvian small-scale fishing effort, from 1950 to 2018, has strongly increased, particularly since 2006 where this fishery has become unsustainable and uneconomic (De la Puente *et al.* 2020). Furthermore, scientific capacity could be considered poor as the number of published studies in Peru are low (n: 25 studies) and most species that interact with fisheries are threatened (65.2%) (Table 2).

The findings of this present study support Davidson *et al*. (2016) by suggesting that the Peruvian batoid fishery landings have decreased or remained stable due to population declines in targeted species. This is the result of a combination of factors, including increased fishing pressure, insufficient scientific capacity, and limited fishery management performance. Contrary to Davidson *et al*. (2016) which states that recent improvement in international or national fisheries management was not yet strong enough to account for the recent decline in chondrichthyan landings, in Peru the situation is even worst as management has been limited with no improvement at least for the most landed batoid species. Thus, the effective implementation of management based on science is urgently needed to improve the conservation of this threatened group.

[12]INEI. 2017. Perú: Pefil Sociodemográfico. Cap. 1. Características de la población. Instituto Nacional de Estadísticas e Informática, Lima. <https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1539/cap01.pdf>

Management and conservation gaps

In total, three management and conservation regulations exist for batoids in Peru. These regulate fishery activities for three species (*i.e.*, *Mobula birostris*, *Pristis pristis*, *Rhinoptera steindachneri*) and two taxa (*i.e.*, *Mobula* and *Myliobatis*); these is a low number compared to the twenty-three species that interact with fisheries. For some species like sawfish, their regulation was decreed when they were almost extirpated from Peruvian waters (Mendoza *et al.* 2017). Other regulations like minimum gillnet mesh size are not fully enforced since evidence suggests that reported mesh sizes of gillnet ranged from 10.2 to 25.4 cm for the capture of *Myliobatis* spp. and *Mobula* spp. in at least eleven ports from 2000 to 2007 (Alfaro-Shigueto *et al.* 2010). Furthermore, the effectiveness of gillnet mesh size selectivity needs to be corroborated. Thus, further studies could evaluate this.

A clear gap in Peru's national legislation for batoids is the limited management measures for mobulid rays (*i.e.*, manta and devil rays). Only *M. birostris* is protected in Peru, yet its capture is rare (Alfaro-Cordova *et al.* 2017). From July 2012 to June 2013 -before its fishery ban was established- nine landing points in northern Peru were monitored and seven individuals of *M. birostris* were registered at three landing points (*i.e.*, Zorritos, La Cruz and Puerto Pizarro) (Avila *et al*. 2014). Acknowledging that both manta and devil rays have similarly low productivity (Pardo *et al*. 2016) and that devil rays are subject to higher levels of exploitation than oceanic manta rays (*i.e.*, *M. birostris*), it is recommended that devil rays receive a similar level of protection. This biased toward protecting elasmobranch species with lowest risks of extinction is because these are considered charismatic species which are well-known by the public and are often used either as flagships for environmental organizations or as eco-tourism attractions (Momigliano & Harcourt 2014).

According to the fisheries management plan of Peruvian hake, only two batoid taxa are caught as bycatch; yet, Céspedes (2013) and Zavalaga *et al.* (2018) have identified eight batoid species that are captured as bycatch in trawl fisheries directed to Peruvian hake in northern Peru *(Rostroraja velezi*, *Rostroraja equatorialis, Sympterygia brevicaudata, P. planiceps, Zapteryx xyster, Tetronarce tremens*, *Gymnura crebripunctata, Urotrygon chilensis*), with *R. velezi* and *S. brevicaudata* as the most frequently captured. Also, Céspedes (2013) observed that IMARPE inspectors showed little interest in batoid species that are caught, many of which are killed and discarded. The Peruvian hake fishery is one of the main industrial and artisanal fisheries at the national level in which bottom trawling is the most used fishing gear (Arellano & Swartzman 2010), so the impact on batoid populations could be great since trawling has the highest level of discards of all fisheries (Pérez-Roda *et al.* 2019). For example, the trawling fishery in Costa Rica captures twenty-five species of elasmobranchs representing more than 36% of species reported in this country (Bussing & López 2009).

Mobulid rays: important fishery in the Eastern Pacific, extinction risk and insufficient management measures

Mobula spp. are among the most caught batoid species in Peru, a country with the second-largest batoid fishery in the eastern Pacific and among the five countries with the highest catch of *Mobula* spp. (Heinrichs *et al.* 2011). Alfaro-Cordova *et al.* (2017) established that the catch rates (*i.e.*, CPUE) of mobulid rays in northern Peru was higher than the catches reported by other studies worldwide (Molony 2005, Hall & Roman 2013). Also, the coastal upwelling of northern Peru has been identified among the three most important habitat hotspots for *Mobula mobular* in the Eastern Pacific due to its high marine productivity (Lezama-Ochoa *et al.* 2019). Northern Peru has been identified as a nursery area for this species (Gonzalez-Pestana 2022). This suggests that Peru is an important habitat for mobulid rays in the Eastern Pacific.

A decline in the relative abundance and landings of *Mobula* spp. has been reported in many parts of the world (Ward-Paige *et al.* 2013, Lewis *et al.* 2015, White *et al.* 2015). A similar scenario could be unfolding in Peru. The majority of mobulid catch in northern Peru were juveniles (Avila *et al.* 2014[13], Rojas 2016; Alfaro-Cordova *et al.* 2017, Gonzalez-Pestana 2022). Furthermore, mobulid rays exhibit low biological productivity and have some of the lowest intrinsic rates of population increase of all elasmobranchs (Couturier *et al.* 2012, Pardo *et al.* 2016). These traits, coupled with the reported fishing pressure raises conservation concerns. Mobulid rays are unlikely to sustain high levels of fishing pressure before populations collapse and may require an extended period to recover (Hutchings & Reynolds 2004).

Considering the multi-species nature of small-scale fisheries, species-specific management (*i.e.*, target-based policies) would be hard to implement (Mejía-Falla *et al.* 2019). Yet, if a capture ban is implemented for mobulid rays, fishers might be more likely to release them alive and with potential for post-release survival. Eighty percent of mobulid rays captured by gillnet fisheries in northern Peru are recovered alive (Alfaro-Cordova *et al.* 2017), and an initial study have found that post-release survival rate of *M. mobular* is 50-60% from tuna purse seine fisheries (Francis & Jones 2016). Implementation of safe handling and release techniques could further promote increased survival (Poisson *et al.* 2014).

International treaties, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), to which Peru is a signatory, create mechanisms to protect threatened species at a global level. The inclusion of *Mobula* spp. in Appendix II of CITES[14], at the 17th Meeting of the Conference of the Parties (CoP17, Johannesburg)[15] in 2016, would not affect the national utilization of products from *Mobula* spp. caught within national waters - as is the case in Peru for which its products are used locally (Ayala & Romero 2016, Alfaro-Cordova *et al.* 2017). However, if the species is exported, CITES would require that the country implements conservation measures. Some evidence suggests that a cross-border market of mobulid meat occurs between Peru and Ecuador (Alfaro-Cordova *et al.* 2017). The Convention of the Conservation of Migratory Species (CMS)[16] is another international treaty that includes *Mobula* spp. in Appendices I and II. This inclusion in CMS Appendix I has management implications at a national level since Peru is obligated to protect them by prohibiting the capture of *Mobula* spp. within Peruvian waters.

Pacific guitarfish: important fishery in Peru and risk of extirpation

Peru has historically had the largest fishery of Pacific guitarfish. There are considerable conservation concerns related to this fishery since Pacific guitarfish is the third most landed batoid species in Peruvian fisheries, a country with the second-highest batoid landings in the Eastern Pacific, and no species-specific fishing regulations. Furthermore, the Eastern Pacific has been identified as a hotspot of Data Deficient guitarfish species worldwide (Moore 2017).

P. planiceps belongs to the order Rhinopristiformes; the most threatened order of marine fishes (Dulvy *et al.* 2016, Moore 2017, Kyne *et al.* 2019). Landings and catch rates for guitarfishes - including Rhinobatidae - have declined worldwide, up to 80% (Villwock-de Miranda & Vooren 2003, Moore *et al.* 2017, Jabado 2018, Kyne *et al.* 2019, D'Alberto *et al.* 2019a). The Brazilian guitarfish, *Pseudobatos horkelii*, with sizes similar to *P. planiceps*, is considered Critically Endangered by the IUCN Red List of Threatened Species and suffered severe declines in abundance due to intensive fisheries (Moore 2017). Smaller guitarfishes, such as *Pseudobatos productus* and *Zapteryx brevirostris* (170 and 66 cm TL, respectively, compared with 114 cm TL of *P.*

[13]Avila J, K Forsberg, W Purizaca, M Harding & J Stewart. 2014. Pesquería de *Mobula* spp. (Mobulidae) en la costa norte de Perú. IV Congreso de Ciencias del Mar del Perú, Lima.

[14]CITES. Which sharks and rays were listed at CoP17? <https://cites.org/eng/prog/shark/sharks.php#mobula>

[15]<https://cites.org/eng/cop17>

[16]CMS. *Mobula* Rays (genus *Mobula*) Appendices I and II. Convention on Migratory Species of Wild Animals, Bonn. <https://www.cms.int/en/document/mobula-rays-genus-mobula-appendices-i-and-ii-0>

planiceps), are less productive and have below-average rates of population increase compared to other chondrichthyans (D'Alberto *et al.* 2019b). The unregulated fishing pressure that most guitarfish species currently experience is thus likely unsustainable. Therefore, *P. planiceps* should be a high priority for conservation and management actions.

Beach seines and trawling reported high landings for *P. planiceps*, but in 2001, the Peru government prohibited their use since these fishing gears have been recognized as destructive for the marine ecosystem (Salazar 2018). These measures might have reduced the landings of this species. Since 2009 national reports from IMARPE stopped reporting trawl and beach seine landings. Yet, in northern Peru, illegal small-scale trawling within 5 nm from the coast is known to occur (Ganoza *et al.* 2021) and landings take place at clandestine locations and are not reported by IMARPE. Furthermore, Céspedes (2013) and Zavalaga *et al.* (2018) reported that the Peruvian hake trawl fishery continues to catch *P. planiceps* as bycatch, beyond 5 nm from the coast in which the industrial fishery operates.

Information gaps

There is a strong ongoing need for scientific research to help improve the conservation management of batoids. Simpfendorfer *et al.* (2011) prioritized eight research topics that are needed for the development of effective conservation management. In Peru, seven of these topics have been briefly considered for a few species with a total of 25 studies in 44 years. Momigliano & Harcourt (2014) reviewed the last 20 years of scientific studies of shark conservation and management; they determined that countries like Australia and USA had the highest scientific output (120-160 studies); while the lowest output was from 1 to 20 studies per country. Thus, Peru stands with a low performance, considering that the period assess in Momigliano & Harcourt (2014) is smaller. However, this limited knowledge is changing as in recent years the number of studies has increased.

Effective fishery management requires an understanding of biological, ecological and fisheries information. Landings statistics for Peruvian batoid currently report biomass, but information on number of individuals, gender and size composition, and fishing areas are limited. Of particular importance is the recording of information on fishing effort to help determine the impact that fishing activity has on batoid stocks. For *Myliobatis* spp., studies in northern Peru have established that 85% of landings were immature individuals and those pregnant females, with litters of 2 to 4 pups, are captured in the summer (Torres 1978, Castañeda 1994). As with most other batoids, these catch characteristics make these species vulnerable to population declines and reinforce the need for fisheries research and management measures.

An information gap was the landings analysis by species before 1997. According to the results obtained, *P. planiceps* and *H. dipterurus* exhibited significant decreases in landings between 1997 and 2006 and no significant trend thereafter. Declines before 1997 may have gone unnoticed. Importantly, the maximum landing for batoids overall was in 1988, almost 10 years before species-specific landings were registered. Therefore, when analysing fishing trends for the most landed batoid species, it must be recognized that the human impact on these species predates scientific observation (Pauly 1995).

The understanding of the current state of batoid populations in Peru could be enhanced in part through taxonomic research and better species identification. *Mobula* spp. could be misidentified to the species level. According to IMARPE landings statistics, from 1997 to 2010, *M. thurstoni* was the most landed mobulid ray, and from 2011 to 2015, IMARPE only reported at genus level (*Mobula* spp.). Other reports have identified *M. mobular* (formerly known as *M. japanica)* as the most landing mobulid rays species in Peru (Rojas 2016, Alfaro-Cordova *et al.* 2017, Gonzalez-Pestana 2022). This inconsistency could be the result of misidentification by official IMARPE reporters due to morphological similarities between mobulid rays (Couturier *et al.* 2012) and other identification difficulties as mobulids are landed slaughtered, with few animals characteristics diagnosis. Furthermore, Peruvian landing statistics report *Urotrygon* species as a genus and not at the species level.

Another important but under-studied research topic is human dimensions in the management and conservation of batoids (Simpfendorfer *et al.* 2011). In Peru only three studies have considered this topic. Guirkinger *et al.* (2021) explored the perspectives and attitudes of fishers towards compliance motivations for the fishery ban on *M. birostris*. Compliance was mostly hindered due to economic hardship, lack of legitimacy towards authorities driven by corruption, and low social influence to comply. This study highlights the importance of understanding fishermen's values and perceptions for the conservation of batoids. Another important research need is to understand the cultural value of batoids. In Peru, batoids have an ancient traditional and culinary importance that dates back to 4450-3800 B.C. (Bradley 2012, Mauricio-Llonto 2015). Therefore, the conservation of batoids also has cultural implications since the loss of one threatens the other (Millennium Ecosystem Assessment 2005). Therefore, further studies should assess the use of this cultural heritage as a tool to promote the conservation of batoids (Parsons *et al.* 2014).

Population status is another important research need that has not been addressed for batoids in Peru. The Peruvian Red List of Threatened Species – prepared by Minister of Agriculture – assesses the conservation status of wild species. This includes terrestrial species and only those marine species that reproduce on land (seabirds, sea turtles and pinnipeds) (SERFOR 2018). Therefore, batoids are not included in their analysis. This represents a drawback for its conservation. Batoids are considered hydrobiological resources by the Peruvian state in which four exploitation levels have been recognized (*i.e.*, unexploited, sub exploited, fully exploited and in recovery) (DS N° 012-2001-PE)[1]. Until recently, the Peruvian State did not recognize an over-exploited category. Yet, this exploitation level is in the process of being recognized. Furthermore, the level of exploitation of any batoid species has not been evaluated. This limits the ability to develop or implement informed sustainable fisheries management. IUCN Red List Categories align with fisheries reference points, so species that are classified as Critically Endangered (CR) or Endangered (EN) are likely to be subject unsustainable fishing, while those undergoing shallower declines (*e.g.*, Least Concern, Near Threatened) are more likely to be sustainably fished (Dulvy *et al.* 2017)

Recommendations and next steps

Going forward, fisheries research should first focus on the four most-landed batoid taxa at the ports with the highest landings. Fishing data collection should include body sizes, estimate catch rates (*i.e.*, CPUE) and locate fishing areas. Also, batoid species with high bycatch (*e.g.*, *R. velezi*, *S. brevicaudata*) should also have a high priority. Due to the multi-species nature of small-scale fisheries, limit-based management (*e.g.*, no-take reserves) might be more attainable than target-based management (Mejía-Falla *et al.* 2019). In places where people engage in coastal shark fishing no-take reserves have improved shark abundance; also, banning the use of gillnets in spatial management can greatly improve the elasmobranch conservation (MacNeil *et al.* 2020). Therefore, identification of a habitat hotspot for these highly commercial species would be necessary (*e.g.*, Elliott *et al.* 2020). Along the Peruvian coast, there are seven protected marine areas, which represent 8% of the Peruvian Exclusive Economic Zone; yet less than 1% is fully or highly protected from fishing. In most reserve areas, fisheries are permitted with a management plan; however, there is no specific management for batoids in these reserves, and none of them have been designed with elasmobranchs in mind. The IUCN Shark Specialist Group has launched a global project to identify Important Shark and Ray Areas (ISRAs) based on key life-history traits, and other criteria; this effort has the potential to focus conservation where it is most needed and is a useful spatial planning tool for decision-makers in Peru (Hyde *et al*. 2022). In Peruvian waters five ISRAs have been identified which include batoids; thus these should be prioritized for management (Jabado *et al*. 2023). Finally, regional collaborations are needed for the management of batoid because most of the species that interact with the fisheries are also distributed in the Eastern Central Pacific. The results presented here can provide guidance in the design of these actions for the management and conservation of batoids.

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