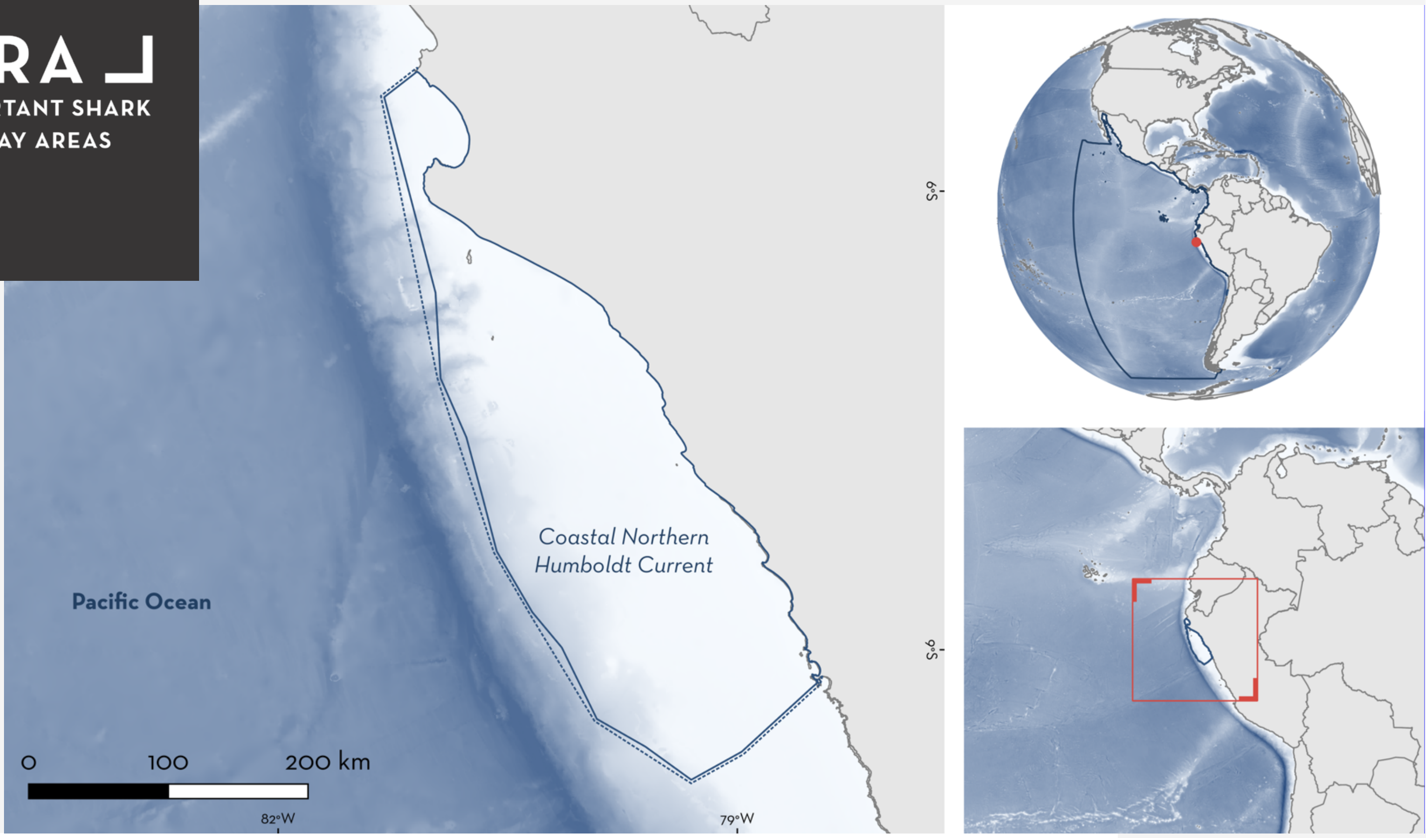
ISRA
IMPORTANT SHARK AND RAY AREAS



Blue lines indicate the area meeting the ISRA Criteria; dashed lines indicate the suggested buffer for use in the development of appropriate place-based conservation measures

COASTAL NORTHERN HUMBOLDT CURRENT ISRA

Central and South American Pacific Region

PERU

0–1,000 metres

63,598.5 km²

SUMMARY

Coastal Northern Humboldt Current extends from the southern Piura region to northern La Libertad region in Peru. It is located within the Northern Humboldt Current System, one of the most productive marine systems in the world and overlaps with major upwelling centres. The area overlaps with Lobos de Tierra and Lobos de Afuera islands, a marine protected area system which are both Key Biodiversity Areas. The area has exceptional marine productivity and a variety of habitats dominated by rocky shores and sandy substrates. Within this area there are: **threatened species** (e.g., Spotted Houndshark *Triakis maculata*); **range-restricted species** (e.g., Humpback Smoothhound *Mustelus whitneyi*); **reproductive areas** (e.g., Smooth Hammerhead *Sphyrna zygaena*); **feeding areas** (e.g., Chilean Eagle Ray *Myliobatis chilensis*); and the area sustains a **high diversity of sharks** (17 species).

CRITERIA

Criterion A – Vulnerability; Criterion B – Range Restricted;
Sub-criterion C1 – Reproductive Areas; Sub-criterion C2 – Feeding Areas
Sub-criterion D2 – Diversity

DESCRIPTION OF HABITAT

Coastal Northern Humboldt Current extends from the southern Piura region to northern La Libertad region in Peru. Situated within the Humboldt Current Large Marine Ecosystem (LME), the area overlaps with the Northern Humboldt Current System (NHCS), which is one of the most productive ocean ecosystems due to its coastal upwelling producing a high abundance of zooplankton that sustains the ecosystem (Pennington et al. 2006). Oceanographic features, associated with wind forcing, create strong upwelling and high levels of primary productivity in the offshore waters of northern Peru (Bakun & Weeks 2008; Montecino & Lange 2009). Warm subtropical waters move closer to the coast in the austral summer and autumn, and coastal upwelling disperses them in winter and spring (Bakun & Weeks 2008). This upwelling, and its associated productivity, allow the development of an exceptionally high biomass of ecologically important marine species such as Peruvian Anchoveta *Engraulis ringens* and Humboldt Squid *Dosidicus gigas* (Bakun & Weeks 2008; Gonzalez-Pestana et al. 2022).

Within the NHCS, six major upwelling centres have been identified which are characterised by a higher concentration of phytoplankton. These have been classified as Ecologically or Biologically Significant Marine Areas (EBSA), namely the Humboldt Current Upwelling System in Peru and the Permanent Upwelling Cores and Important Seabird Areas of the Humboldt Current in Peru (CBD 2020). These centres tend to be associated with prominent continental features such as peninsulas and semi-protected bays where nutrients are concentrated, producing 'upwelling shadows' (Graham et al. 1992).

This area overlaps with Punta Illescas which represents the northern most upwelling centre. Punta Illescas has unique coastal topography as the second westernmost point of the south-eastern Pacific shoreline and produces a strong upwelling (Chavez & Messie 2009). It is also at the narrowest part of the continental shelf along the Peruvian coast which enhances productivity (Jacox & Edwards 2011). The northern area is influenced by the Cromwell Current which is the main contributor to coastal upwelling in northern Peru (Zuta & Guillen 1970), allowing a rich demersal subsystem due to its high oxygen levels (Vargas & Mendo 2010), supporting the Peruvian Hake *Merluccius gayi peruanus* demersal fishery.

This area overlaps with Lobos de Tierra and Lobos de Afuera islands which are part of a marine protected area system and have been identified as Key Biodiversity Areas.

This Important Shark and Ray Area is delineated from surface waters (0 m) to 1,000 m based on the vertical distribution of Qualifying Species that is restricted by the depth contour of this area.

ISRA CRITERIA

CRITERION A – VULNERABILITY

Sixteen Qualifying Species considered threatened with extinction according to the IUCN Red List of Threatened Species™ regularly occur in the area. Threatened sharks comprise four Critically Endangered, two Endangered, and four Vulnerable species. Threatened rays comprise one Endangered, and five Vulnerable species (IUCN 2022).

CRITERION B – RANGE RESTRICTED

Coastal Northern Humboldt Current holds the regular presence of six resident range-restricted species: Chilean Angelshark, Humpback Smoothhound, Spotted Houndshark, Chilean Eagle Ray, Peruvian Eagle Ray, and Shorttail Fanskate. Chilean Angelshark, Spotted Houndshark, Chilean Eagle Ray, and Peruvian Eagle Ray are restricted to the Humboldt Current LME. Shorttail Fanskate occurs primarily in the Humboldt Current LME and only marginally into the Pacific Central-American Coastal LME. Humpback Smoothhound occurs in the Humboldt Current LME and the Pacific Central-American Coastal LME.

These species are regularly encountered and often targeted in small-scale fisheries (Alfaro-Shigueto et al. 2010; Céspedes 2014; Gonzalez-Pestana et al. 2016, in press; Córdova-Zavaleta 2022). Some of them represent the most landed sharks (Chilean Angelshark, Humpback Smoothhound) or rays (Chilean Eagle Ray, Peruvian Eagle Ray) in Peru and have their most important landing sites and fishery areas in this area (Gonzalez-Pestana et al. 2016, in press; IMARPE landings statistics between 2010–2020). Shorttail Fanskate is the most abundant (according to biomass) bycatch ray species in the Peruvian Hake industrial trawling fishery which operates within this area (Céspedes 2014).

SUB-CRITERION C1 – REPRODUCTIVE AREAS

Coastal Northern Humboldt Current is an important reproductive area for five sharks.

The Peruvian fishery for Smooth Hammerhead that operates in this area is composed of neonates, young-of-the-year, juveniles, and adult females (Castañeda 2001; Gonzalez-Pestana 2014, 2018; Torres 2018; Córdova-Zavaleta 2022). Studies with samples from ~12,000 individuals indicate that the smallest individuals measured 44 cm of total length (TL) while the size ranged between 70 to 115 cm TL. Size-at-birth for this species is reported at 49–63 cm TL (Rigby et al. 2019). During late austral spring and early summer (November to January) females in advanced pregnancy stages were captured as this life-stage is targeted (Castañeda 2001; Gonzalez-Pestana 2014, 2018). Sharks are born in late spring and early summer (with open umbilical scars recorded), and they stay in this area for their first year with some individuals staying up to two years (Gonzalez-Pestana 2014, 2018).

Tope Shark is caught by small-scale fisheries operating in this area. San Jose and Santa Rosa (Lambayeque region) are the most important landing sites for this species along the Peruvian coast, representing 78% of the total landings of the species in Peru (IMARPE national reports). Between 2015–2019, 382 individuals were sampled within this area. In San Jose (Lambayeque region), animals measured on average 112.5 ± 29 cm TL with a minimum size of 50 cm TL, and in Salaverry (La Libertad region) an average 132.1 ± 23.2 cm TL with a minimum size of 80 cm TL (Córdova-Zavaleta 2022). Most individuals were juveniles (size-at-maturity: 206–235 [males] and 227–244 [females] cm TL; Ebert et al. 2021), and some were young-of-the-year since size-at-birth is between 26–40 cm TL.

Between 2015–2019, 954 Copper Sharks were sampled measuring 105.6 ± 22.3 cm TL with a minimum size of 50 cm TL (Córdova-Zavaleta 2022). Most individuals were juveniles (size-at-maturity: 120–135 [males] and 134–140 [females] cm TL; Peres & Vooren 1991), and some were neonates and young-of-the-year since size-at-birth is between 59–70 cm TL (Ebert et al. 2021; Drew et al. 2017).

Pregnant females of Humpback Smoothhound have been observed in this area. Sampled individuals (n = 41) from March to July 2013, and May to September 2016, were pregnant females (average body size: 88.1 ± 17.8 cm TL) in varied stages of embryonic development. Neonates (n = 16) were also recorded (Gonzalez-Pestana et al. 2019). The largest embryo measured 23 cm TL and the smallest free-living neonate, with an open umbilical scar, measured 22.4 cm TL. Additionally, captures of gravid females have been observed during two fishery trips off northern Lambayeque coast and off Punta Illescas (Adriana Gonzalez-Pestana pers. obs. 2022).

Eighty to 85% of Chilean Eagle Ray landings within this area were composed of immature individuals, including neonates (with minimum body sizes of 30 cm disc width [DW]), with mature adult females (some pregnant with litter sizes of 2–4 pups commonly captured in the austral summer; Torres 1978; Castañeda 1994). Between 2015 and 2019, 4,577 individuals were sampled measuring on average 75.6 ± 28.7 cm DW with minimum sizes of 20 cm DW (Córdova-Zavaleta 2022). For this species, the size-at-maturity is 115 cm DW (Castañeda 1994). The size-at-birth is unknown; yet embryos with a body size of 29 cm DW have been reported in this area (Castañeda 1994). Thus, mostly juveniles, including neonates, are recorded in this area.

SUB-CRITERION C2 – FEEDING AREAS

Coastal Northern Humboldt Current is an important feeding area for eight sharks. The two most common prey species (Peruvian Anchoveta and Humboldt Squid) represent one of the most abundant marine resources worldwide as these are the most caught species (fish and invertebrate, respectively) (FAO 2022). Peru is responsible for the largest volumes captured for both species (FAO 2022). The Peruvian Anchoveta is one of the main reasons why the NHCS produces more fish per surface unit than any other marine ecosystem (Chavez et al. 2008). Within Peru, historically the largest fishery has been concentrated in northern Peru for Humboldt Squid (Csirke et al. 2018) and in northern-central Peru for Peruvian Anchoveta (Castillo et al. 2015), both located within this area. During warm periods (El Niño events or summers), these species aggregate in major upwelling centres associated with the NHCS EBSA (with traditional ecological evidence that Humboldt Squid aggregates in the central part of this area), as these centres serve as a refuge, given the persistence of upwelling in them (Bertrand et al. 2004, CBD 2017, Jian et al. 2020). Also, in the northern part of this area, one of the largest abundances of Peruvian Hake has been recorded as the fishery has developed into one of the main fisheries in Peru (Arellano & Swartzman 2010).

Results from a diet analysis of 485 Smooth Hammerheads (neonates, young-of-the-year, juveniles, and adult females) between 2013–2015, found that Humboldt Squid (27% Index of Relative Importance [IRI]) and Patagonian Squid *Doryteuthis gahi* (37% IRI) were the main prey (Gonzalez-Pestana et al. 2017). Smooth Hammerheads presented a narrow trophic niche (i.e., highly specialised predator) in this area. In this study, 78% of stomachs contained food items and in one adult (230 cm TL) stomach, 74 pairs of squid beaks were counted (the equivalent of 74 cephalopods) (Gonzalez-Pestana et al. 2017). Other diet studies of Smooth Hammerhead in the eastern Pacific Ocean (Ecuador and Baja California) indicate that this species feeds mainly on cephalopods (Bolaño 2009; Estupiñan-Montaño et al. 2009; Galvan-Magaña et al. 2013). Smooth Hammerhead has been the third most captured shark species by fisheries in Peru and the most frequently captured shark species off northern Peru between 1997–2021 (Gonzalez-Pestana et al. 2016; IMARPE landings statistics). Most of the landings and fishing areas are in Piura, Lambayeque, and La Libertad (within this area). One of the most important fishing areas in Peru are around the Lobos de Tierra and Lobos de Afuera Islands, offshore of Lambayeque (Carbajal et al. 2007; Llanos et al. 2009). Thus, this area represents an important feeding ground for this species along the Eastern Pacific.

Juvenile Chilean Eagle Ray prey on teleost fishes (Peruvian Hake and Peruvian Anchoveta), crustaceans (i.e., crabs and stomatopods), gastropod molluscs, and polychaetes (Torres 1978; Castañeda 1994; Segura-Cobeña 2017). Thus, this species feeds on both pelagic and demersal prey. The most recent study sampled 77 individuals in 2015 and found 93.5% of stomachs contained food items. Prey varied according to body size, seasonality, and ENSO conditions in which the Peruvian Anchoveta represented a more important prey during warmer conditions (Gonzalez-Pestana et al. 2021b).

An analysis of stomach contents from 74 Pacific Guitarfish (mostly adults) between January 2015 and August 2016, indicated that prey included coastal crustaceans (stomatopods and crabs) and teleosts (mainly Peruvian Anchoveta); diet varied according to ontogeny (Gonzalez-Pestana et al. 2021a, 2021b).

An analysis of stomach contents from 44 Tope Sharks (adults and juveniles) between January 2015 and August 2016, determined that it preys mostly on teleost fishes (Peruvian Hake and Peruvian Anchoveta) and secondarily on cephalopods (Gonzalez-Pestana et al. 2021a).

An analysis of stomach contents from 69 Copper Sharks (adults and juveniles) between January 2015 and August 2016, determined that it preys mostly on teleosts in which the Peruvian Anchoveta is the most important prey (43% Prey-specific Index of Relative Importance [PSIRI]). This species is considered a predator with a high degree of specialisation (Gonzalez-Pestana et al. 2021a). In other places where its diet has been studied (South Africa and Argentina), its diet is composed mainly of small pelagic schooling fishes (Cliff & Dudley 1992; Lucifora et al. 2009; Smale 1991).

An analysis of stomach contents from 76 Humpback Smoothhounds (mostly adults) between January 2015 and August 2016, determined that the species preys mainly on Peruvian Anchoveta (21% PSIRI), and secondarily on crustaceans (crabs and stomatopods) and molluscs (gastropods and cephalopods) (Samame et al. 1989; Gonzalez-Pestana et al. 2021a). Diet varies according to season (Samame et al. 1989).

An analysis of stomach contents from 43 Spotted Houndsharks between January 2015 and August 2016, determined that the species preys mostly on teleost fishes (e.g., Peruvian Anchoveta) and crustaceans (Gonzalez-Pestana et al. 2021a).

An analysis of stomach contents from 72 Broadnose Sevengill Sharks between 2015 and 2019, determined that the species preys mostly on teleost fishes and marine mammals (sea lions and small cetaceans). This diet varies according to ontogeny with larger individuals preying less on teleosts (20% IRI) and more on marine mammals (61% IRI) (Kohatsu 2020). In other places (California, USA; South Africa; Argentina; Tasmania, Australia) where Broadnose Sevengill Shark diet has been studied, adults prey mainly on marine mammals (Ebert 2002; Lucifora et al. 2005; Barnett et al 2010; Hammerschlag et al. 2019). This area overlaps with large rookeries of South American Sea Lion *Otaria flavescens* located in Lobos de Tierra and Lobos de Afuera Islands, representing the main colonies of pinnipeds in northern Peru (Majluf & Trillmich 1981). This area also overlaps with an Important Marine Mammal Area which represents an ideal habitat for several marine mammals, in particular small cetaceans (i.e., Burmeister's Porpoise *Phocoena spinipinnis* and Dusky Dolphin *Lagenorhynchus obscurus posidonia*) (IMMA 2022). Furthermore, the most important landing sites in Peru for Broadnose Sevengill Shark is adjacent to this area (i.e., Lambayeque region) (IMARPE landings statistics).

SUB-CRITERION D2 – DIVERSITY

Coastal Northern Humboldt Current sustains a high diversity of Qualifying Species (17 species). This equals the regional diversity threshold (17 species) for the Central and South Pacific American region.

Pelagic Thresher, Common Thresher, Diamond Stingray, and Spinetail Devil Ray are frequently captured by small-scale fisheries operating and landing in this area (Gonzalez-Pestana et al. 2016, in Press; Alfaro-Cordova et al. 2017; Torres 2017; Gonzalez-Pestana 2022). Other species such as the Rasptail Skate is the most abundant bycatch ray species (e.g., a total of 556 individuals captured between April and July of 2009) and represents the highest catch-per-unit-effort in the trawl fishery for Peruvian Hake that operates within this area (Céspedes 2014). Large female adults of Whale Sharks aggregate along the shelf break in this area from December through March (Hearn et al. 2016, 2017; Ryan et al. 2017).

Acknowledgments

Ximena Velez-Zuazo (Smithsonian Institute), Joanna Alfaro-Shigueto (ProDelphinus; Universidad Cientifica del Sur), Francisco Córdova-Zavaleta (Centro Interdisciplinario de Ciencias Marinas), and Adriana Gonzalez Pestana (IUCN SSC Shark Specialist Group - ISRA Project; Universidad Cientifica del Sur; ProDelphinus) contributed and consolidated information included in this factsheet. We thank the participants of the 2022 ISRA Region 12 – Central and South American Pacific workshop for their contributions to this process.

This factsheet has undergone review by the ISRA Independent Review Panel prior to its publication.

This project was funded by the Shark Conservation Fund, a philanthropic collaborative pooling expertise and resources to meet the threats facing the world's sharks and rays. The Shark Conservation Fund is a project of Rockefeller Philanthropy Advisors.

Suggested citation

IUCN SSC Shark Specialist Group. 2023. Coastal Northern Humboldt Current ISRA Factsheet. Dubai: IUCN SSC Shark Specialist Group.

QUALIFYING SPECIES

<table>
<tr><th rowspan="2">Scientific Name</th><th rowspan="2">Common Name</th><th rowspan="2">IUCN Red List Category</th><th rowspan="2">Global Depth Range (m)</th><th colspan="9">ISRA Criteria/Sub-criteria Met</th></tr>
<tr><th>A</th><th>B</th><th>C1</th><th>C2</th><th>C3</th><th>C4</th><th>C5</th><th>D1</th><th>D2</th></tr>
<tr><td colspan="13">SHARKS</td></tr>
<tr><td>Alopias pelagicus</td><td>Pelagic Thresher</td><td>EN</td><td>0–300</td><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="10">X</td></tr>
<tr><td>Alopias vulpinus</td><td>Common Thresher</td><td>VU</td><td>0–150</td><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Carcharhinus brachyurus</td><td>Copper Shark</td><td>VU</td><td>1–145</td><td>X</td><td></td><td>X</td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Galeorhinus galeus</td><td>Tope Shark</td><td>CR</td><td>0–826</td><td>X</td><td></td><td>X</td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mustelus whitneyi</td><td>Humpback Smoothhound</td><td>CR</td><td>16–211</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Notorynchus cepedianus</td><td>Broadnose Sevengill Shark</td><td>VU</td><td>0–570</td><td>X</td><td></td><td></td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rhincodon typus</td><td>Whale Shark</td><td>EN</td><td>0–1,928</td><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sphyrna zygaena</td><td>Smooth Hammerhead</td><td>VU</td><td>1–200</td><td>X</td><td></td><td>X</td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Squatina armata</td><td>Chilean Angelshark</td><td>CR</td><td>0–400</td><td>X</td><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Triakis maculata</td><td>Spotted Houndshark</td><td>CR</td><td>10–200</td><td>X</td><td>X</td><td></td><td>X</td><td></td><td></td><td></td><td></td></tr>
</table>

QUALIFYING SPECIES

Scientific Name	Common Name	IUCN Red List Category	Global Depth Range (m)	ISRA Criteria/Sub-criteria Met								
				A	B	C1	C2	C3	C4	C5	D1	D2
RAYS												
Hypanus dipterurus	Diamond Stingray	VU	0–150	X								
Mobula mobular	Spinetail Devil Ray	EN	0–1112	X								
Myliobatis chilensis	Chilean Eagle Ray	VU	0–100	X	X	X	X					
Myliobatis peruvianus	Peruvian Eagle Ray	VU	0–50	X	X							X
Pseudobatos planiceps	Pacific Guitarfish	VU	1–50	X			X					
Rostroraja velezi	Rasptail Skate	VU	30–300	X								
Sympterygia brevicaudata	Shorttail Fanskate	NT	8–100		X							

SUPPORTING SPECIES

Scientific Name	Common Name	IUCN Red List Category
SHARKS		
Echinorhinus cookei	Prickly Shark	DD
Heterodontus quoyi	Galápagos Bullhead Shark	LC
Megachasma pelagios	Megamouth Shark	LC
RAYS		
Gymnura crebripunctata	Mazatlán Butterfly Ray	NT
Pteroplatytrygon violacea	Pelagic Stingray	LC
Tetronarce tremens	Chilean Torpedo	LC
Urotrygon chilensis	Blotched Round Ray	NT

IUCN Red List categories: *CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient.*

REFERENCES

Alfaro-Shigueto J, Mangel JC, Pajuelo M, Dutton PH, Seminoff JA, Godley BJ. 2010. Where small can have a large impact: structure and characterization of small-scale fisheries in Peru. *Fisheries Research* 106: 8–17. https://doi.org/10.1016/j.fishres.2010.06.004

Alfaro-Cordova E, del Solar A, Alfaro-Shigueto J, Mangel JC, Diaz B, Carrillo O, Sarmiento D. 2017. Captures of manta and devil rays by small-scale gillnet fisheries in northern Peru. *Fisheries Research* 195: 28–36. https://doi.org/10.1016/j.fishres.2017.06.012

Arellano CE, Swartzman G. 2010. The Peruvian artisanal fishery: changes in patterns and distribution over time. *Fisheries Research* 101(3): 133–145.

Bakun A, Weeks SJ. 2008. The marine ecosystem off Peru: What are the secrets of its fishery productivity and what might its future hold? Progress in *Oceanography* 79: 290–299. https://doi.org/10.1016/j.pocean.2008.10.027

Barnett A, Abrantes K, Stevens JD, Yick JL, Frusher SD, Semmens JM. 2010. Predator–prey relationships and foraging ecology of a marine apex predator with a wide temperate distribution. *Marine Ecology Progress Series* 416: 189–200. https://doi.org/10.3354/meps08778

Bertrand A, Segura M, Gutiérrez M, Vasquez L. 2004. From small-scale habitat loopholes to decadal cycles: a habitat-based hypothesis explaining fluctuation in pelagic fish populations of Peru. *Fish and Fisheries* 5: 296–316.

Bolaño N. 2009. Ecología trófica del tiburon martillo *Sphyrna zygaena* (Linnaeus, 1758) en aguas Ecuatorianas. Unpublished Master's Thesis, Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas, La Paz.

Carbajal W, Castañeda J, Castro J, De la Cruz J, Galán J, Ramírez P, Bances S, Salcedo J, Rojas VM. 2007. Seguimiento e investigación de las pesquerías artesanales en Lambayeque. Informe Anual del Centro de Investigaciones Pesqueras de Santa Rosa del Instituto del Mar del Perú.

Castañeda J. 1994. La pesquería artesanal y biología pesquera de especies de importancia económica en la caleta San Jose desde Feb. 1991 a Set. 1992. Unpublished Bachelor's Thesis, Universidad Nacional Mayor de San Marcos, Lima.

Castillo PR, Madureira L, Marangoni J, Gerlotto F, Guevara-Carrasco R. 2015. Variability in distribution and aggregation behavior of the Peruvian anchovy (*Engraulis ringens*) analyzed using a fifteen year long series of acoustic surveys (2000–2014). In 2015 IEEE/OES Acoustics in Underwater Geosciences Symposium (RIO Acoustics) (pp. 1-9). IEEE.

Chavez FP, Bertrand A, Guevara-Carrasco R, Soler P, Csirke J. 2008. The Northern Humboldt Current System: brief history, present status and a view towards the future. *Progress in Oceanography* 79: 95–105.

Chavez FP, Messie M. 2009. A comparative analysis of eastern boundary upwelling ecosytems. *Progress in Oceanography* 83: 80–96. https://doi.org/10.1016/j.pocean.2009.07.032

Cliff G, Dudley SFJ. 1992. Sharks caught in the protective gill nets off Natal, South Africa. 6. The copper shark *Carcharhinus brachyurus* (Günther). *South African Journal of Marine Science* 12(1): 663–674.

Céspedes C. 2014. Captura incidental de fauna marina en la pesquería de *Merluccius gayi peruanus*: Análisis y recomendaciones para su mitigación. Unpublished Master's Thesis, Universidad Nacional Agraria la Molina, Lima.

Córdova–Zavaleta, FA. 2022. La pesquería artesanal de elasmobranquios en la zona norte–centro del Perú, redes de enmalle como caso de estudio. Unpublished Master's Thesis, Instituto Politecnico Nacional, La Paz.

Csirke J, Argüelles Torres J, Alegre Norza Sior ARP, Ayón Dejo P, Bouchon Corrales M, Castillo Mendoza G, Castillo R, Cisneros R, Guevara-Carrasco R, Lau L, et al. 2018. Biología, estructura poblacional y pesquería de pota o calamar gigante (*Dosidicus gigas*) en el Perú. *Boletin Instituto del Mar del Perú* 33(2): 302–364.

Secretariat of the Convention on Biological Diversity (CBD). 2020. Ecologically or Biologically Significant Marine Areas (EBSAs). Special places in the world's oceans. Volume 5: Eastern Tropical and

Temperate Pacific Ocean. Available at: https://www.cbd.int/marine/ebsa/booklet-05-ettp-en.pdf Accessed September 2022.

Drew M, Rogers P, Huveneers C. 2017. Slow life-history traits of a neritic predator, the bronze whaler (*Carcharhinus brachyurus*). *Marine and Freshwater Research* 68(3): 461–472. https://doi.org/10.1071/MF15399

Ebert DA. 2002. Ontogenetic changes in the diet of the sevengill shark (*Notorynchus cepedianus*). *Marine and Freshwater Research* 53(2): 517–523. https://doi.org/10.1071/MF01143

Ebert DA, Dando M, Fowler S. 2021. *Sharks of the World: A complete guide*. Plymouth: Wild Nature Press.

Estupiñan-Montaño C, Cedeño-Figueroa LG, 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(2): 379–386.

FAO. 2022. The state of world fisheries and aquaculture 2022. Towards blue transformation. Rome: FAO. Available at: https://doi.org/10.4060/cc0461en Accessed October 2022.

Galván-Magaña F, Polo-Silva C, Hernández-Aguilar SB, Sandoval-Londoño A, Ochoa-Díaz MR, Aguilar-Castro N., Castañeda-Suarez D, Cabrera A, Baigorri-Santacruz A, Torres-Rojas YE, Abitia-Cárdenas LA. 2013. Shark predation on cephalopods in the Mexican and Ecuadorian Pacific Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography* 95: 52–62.

Graham W, Field J, Potts D. 1992. Persistent 'upwelling shadows' and their influence on zooplankton distributions. *Marine Biology* 114: 561–570.

Gonzalez-Pestana A. 2014. Ecología trófica y áreas de crianza del tiburón martillo, *Sphyrna zygaena* (Linnaeus 1758), juvenil de la zona del norte del Perú. Unpublished Bachelor's Thesis, Universidad Cientifica del Sur, Lima.

Gonzalez-Pestana A, Kouri C, Velez-Zuazo X. 2016. Shark fisheries in the Southeast Pacific: A 61-year analysis from Peru. *F1000Research* 3. https://doi.org/10.12688/f1000research.4412.2

Gonzalez-Pestana A, Acuna-Perales N, Coasaca-Cespedes J, Cordova-Zavaleta F, Alfaro-Shigueto J, Mangel JC, Espinoza P. 2017. Trophic ecology of the smooth hammerhead shark (*Sphyrna zygaena*) off the coast of northern Peru. *Fishery Bulletin* 115(4): 451–459.

Gonzalez-Pestana A. 2018. Habitat suitability of juvenile smooth hammerhead shark (*Sphyrna zygaena*) off northern Peru. Unpublished Master's Thesis, James Cook University, Queensland.

Gonzalez-Pestana A, Alfaro-Shigueto, J, Mangel, J. 2019. Aspects of reproductive biology of the humpback smooth-hound shark (*Mustelus whitneyi*) off northern Peru. *Marine and Freshwater Research* 70(8): 1185–1188. https://doi.org/10.1071/MF18382

Gonzalez-Pestana A, Mangel JC, Alfaro-Córdova E, Acuña-Perales N, Córdova-Zavaleta F, Segura-Cobeña E, Benites D, Espinoza M, Coasaca-Céspedes J, Jiménez A, et al. 2021a. Diet, trophic interactions and possible ecological role of commercial sharks and batoids in northern Peruvian waters. *Journal of Fish Biology* 98(3): 768–783.

Gonzalez-Pestana A, Silva-Garay L, Quiñones J, Mayaute L, Manrique M, Segura-Cobeña E, Espinoza P, Moscoso V, Velez-Zuazo X, Alfaro-Shigueto J, Mangel JC. 2021b. Geographic and ontogenetic variation in the diet of two commonly exploited batoids (Chilean eagle ray and Pacific guitarfish) off Peru: evidence of trophic plasticity. *Environmental Biology of Fishes* 104(12): 1525–1540. https://doi.org/10.1007/s10641-021-01157-w

Gonzalez-Pestana A, Velez-Zuazo X, Alfaro-Shigueto J, Mangel JC. In Press. Batoid fishery in Peru (1950-2015): Magnitude, management and data needs. *Revista de Biología Marina y Oceanografía.*

Gonzalez-Pestana A. 2022. Catch composition of mobulid rays (*Mobula* spp.) in northern Peru reveals a potential nursery area for *M. mobular*. *Environmental Biology of Fishes* 105(7): 963–969. https://doi.org/10.1007/s10641-022-01301-0

Gonzalez-Pestana A, Alfaro-Shigueto J, Mangel JC. 2022. A review of high trophic predator-prey relationships in the pelagic Northern Humboldt system, with a focus on anchovetas. *Fisheries Research* 253: 106386. https://doi.org/10.1016/j.fishres.2022.106386

Hammerschlag N, Williams L, Fallows M, Fallows C. 2019. Disappearance of white sharks leads to the novel emergence of an allopatric apex predator, the sevengill shark. *Scientific Reports* 9(1): 1908. https://doi.org/10.1038/s41598-018-37576-6

Hearn A, J Green, MH Roman, D Acuña-Marrero, E Espinoza, Klimley AP. 2016. Adult female whale sharks make long distance movements past Darwin Island (Galapagos, Ecuador) in the Eastern Tropical Pacific. *Marine Biology* 163: 213–224. https://doi.org/10.1007/s00227-016-2991-y

Hearn A, Espinoza E, Ketchum J, Green J, Peñaherrera C, Arauz R, Fischer C, Steiner T, Shillinger G, Henderson S, Bessudo S, Soler G, Klimley AP. 2017. Una década de seguimiento de los movimientos de tiburones resalta la importancia ecológica de las islas del norte: Darwin y Wolf. Puerto Ayora: DPNG, CGREG, FCD y GC.

IUCN. 2022. The IUCN Red List of Threatened Species. Version 2022-1, Available at: https://www.iucnredlist.org/ Accessed November 2022.

Important Marine Mammals Areas (IMMA). 2022. Continental Shelf of the Northern Humboldt Current IMMA. Available at: https://www.marinemammalhabitat.org/portfolio-item/continental-shelf-of-the-northern-humboldt-current-imma/ Accessed December 2022.

Jacox MG, Edwards CA. 2011. Effects of stratification and shelf slope on nutrient supply in coastal upwelling regions. *Journal of Geophysical Research: Oceans* 116(C3): C03019. https://doi.org/10.1029/2010JC006547

Jian W, Jingwen G, Ting L, Songling Z, Yuanyuan T, Xinjun C, Wei Y. 2020. Spatio-temporal variations in the habitat of jumbo squid *Dosidicus gigas* in the Southeast Pacific Ocean off Peru under anomalous climate conditions. *Haiyang Xuebao* 42(10): 92–99.

Kohatsu SN. 2020. Ecología trófica del tiburón de siete agallas *Notorynchus cepedianus* en el norte del Perú. Unpublished Bachelor's Thesis, Universidad Cientifica del Sur, Lima.

Llanos J, Galán J, Castañeda J, Castro J, De la Cruz J, Ramírez P, Bances S, Torres D. 2009. Investigaciones de IMARPE Sede Lambayeque Durante 2009. Reporte de Investigación del Instituto del Mar del Perú (IMARPE).

Lucifora LO, Menni RC, Escalante AH. 2005. Reproduction, abundance and feeding habits of the broadnose sevengill shark *Notorynchus cepedianus* in north Patagonia, Argentina. *Marine Ecology Progress Series* 289: 237–244. https://doi.org/10.3354/meps289237

Lucifora LO, García VB, Menni RC, Escalante AH, Hozbor NM. 2009. Effects of body size, age and maturity stage on diet in a large shark: ecological and applied implications. *Ecological Research* 24(1): 109–118. https://doi.org/10.1007/s11284-008-0487-z

Majluf P, Trillmich F. 1981. Distribution and abundance of sea lions (*Otaria byronia*) and fur seal (*Arctocephalus australis*) in Peru. *Zeitschrift Fur Säugetierkunde* 46: 384–393.

Montecino V, Lange CB. 2009. The Humboldt Current System: Ecosystem components and processes, fisheries, and sediment studies. *Progress in Oceanography* 83(1–4): 65–79. https://doi.org/10.1016/j.pocean.2009.07.041

Pennington JT, Mahoney KL, Kuwahara VS, Kolber DD, Calienes R, Chavez FP. 2006. Primary production in the eastern tropical Pacific: a review. *Progress in Oceanography* 69: 285–317. https://doi.org/10.1016/j.pocean.2006.03.012

Peres MB, Vooren CM. 1991. Sexual development, reproductive cycle, and fecundity of the school shark *Galeorhinus galeus* off southern Brazil. *Fishery Bulletin* 89: 655–667.

Ryan JP, Green JR, Espinoza E, Hearn AP. 2017. Association of whale sharks (*Rhincodon typus*) with thermo-biological frontal systems of the eastern tropical Pacific. *PLoS One* 12(8): e0182599. https://doi.org/10.1371/journal.pone.0182599

Samame M, Castillo J, Espino M. 1989. El tollo un recurso demersal, algunos aspectos de la biología y pesquería de *Mustelus whitneyi*. *Revista del Pacifico Sur*. Special Volume 1989

Segura-Cobeña E. 2017. Composición de la dieta de la Raya Águila Chilena *Myliobatis chilensis* (Philippi, 1892) en la caleta de San José, Lambayeque. Unpublished Bachelor's Thesis, Universidad Científica del Sur, Lima.

Smale MJ. 1991. Occurrence and feeding of three shark species, *Carcharhinus brachyurus, C. obscurus* and *Sphyrna zygaena*, on the Eastern Cape coast of South Africa. *South African Journal of Marine Science* 11(1): 31–42.

Torres Carrasco AA. 2018. Variación espacio-temporal en las capturas provenientes de la pesquería artesanal de tiburón con red de enmalle de superficie, durante octubre 2016 a marzo 2018. Unpublished Bachelor's Thesis, Universidad Nacional de Piura, Piura.

Vargas N, Mendo J. 2010. Relación entre la distribución espacial de la merluza peruana (*Merluccius gayi peruanus* Ginsburg) y la extensión sur de la corriente de Cromwell. *Informe IMARPE* 37(3–4).

Zuta S, Guillen O. 1970. Oceanografia de las aguas costeras del Perú. *Boletin Instituto del Mar del Perú* 2(5): 157–324.