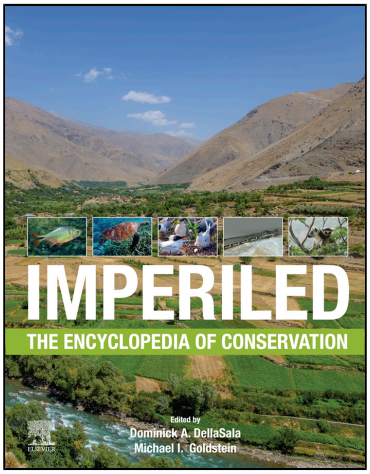

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Eastern Pacific Round Rays

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Glossary

Bycatch species Species taken incidentally during fishing operations targeting other species. Species caught as bycatch can be landed (generally termed byproduct) or released at sea alive (although may be injured) or dead.

Chondrichthyans The cartilaginous fishes; a diverse group of ~1250 fishes characterized by a skeleton mainly composed of cartilage. This group includes sharks, rays, and chimaeras (ghost sharks).

Eastern Pacific Ocean The Pacific Ocean region associated with the American continents; spanning from Alaska in North America to Chile in South America.

Elasmobranchs A sub-group of chondrichthyans (cartilaginous fishes) that comprise the sharks and rays; but not the chimaeras (ghost sharks).

Gillnets Fishing gear that consists of a mesh net made of nylon that is suspended vertically in the water column. Nets vary in length and mesh size and can be set on the bottom or in the water column.

Industrial fisheries Those fisheries where the total capital investment is relatively large (e.g., larger fishing vessels, longer range, sophisticated fishing equipment, long-term fish storage), and fishery products are for domestic or global markets.

Longlines A fishing gear that consists of a long monofilament mainline suspended horizontally in the water column or on the seabed with baited hooks (hundreds to thousands of hooks) attached separately along the mainline.

Small-scale fisheries In a broad sense, those fisheries where the total capital investment is relatively low (e.g., small fishing boats, restricted range, limited technology), which usually operate nearshore, and where the fishery products are for subsistence consumption or for local and domestic markets. Often referred to as artisanal or subsistence fisheries.

Target species Species that are intended to be caught by a particular fishery.

Trawls A fishing gear that is comprised of nets dragged on the seabed (benthic trawls) or in the water column (pelagic trawls). Trawls are largely non-selective fishing gear and, because of the direct physical damage to the seafloor, are considered one of the most destructive fishing methods.

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Abstract

Due to the ongoing and increasing demand for their products, chondrichthyan populations are often subject to intense exploitation by many small-scale and industrial fisheries worldwide. This situation generates an urgent need for conservation and management of many chondrichthyan species. This includes the Eastern Pacific round rays of the family Urotrygonidae, which are small, inconspicuous, and commonly overlooked throughout most of the range. The present article provides an overview of the endemic round rays of the Eastern Pacific (United States to Chile) and summarizes the existing information of several aspects of this group, including their diversity, geographic range and habitat, life history traits, main threats, and conservation status. Of 17 round ray species globally, 14 are found in the Eastern Pacific. Conservation concern has been raised for three threatened and six Near Threatened species. Round rays are commonly caught as bycatch, retained or discarded, by a diversity of both small-scale and industrial fisheries that operate throughout their range which either lack management or effective enforcement of regulations. This highlights the need to closely monitor the populations of these species and conduct research to develop conservation and management strategies. As with many other elasmobranchs, there is a significant lack of biological, ecological, and fishery-related data (e.g., landings, catch rates) for most round ray species. This situation hampers the development of conservation plans for the threatened species and underlines the need to create adequate fishery monitoring and management programs. The Critically Endangered reticulate round ray, a narrow range endemic of the Gulf of Panama, is an urgent priority for conservation planning with no reports of its persistence since 1990. Improving fishery management will be critical to prevent further decline and extinction of the Eastern Pacific round ray populations.

Introduction

Globally, sharks and their relatives face an elevated risk of extinction (IUCN, 2021). The impact of fisheries and other human-induced stressors such as habitat loss and degradation have caused 36% of chondrichthyan fishes assessed to be considered threatened with global extinction (IUCN, 2021). This places chondrichthyans among the highest extinction risk levels of assessed vertebrates and highlights the urgent need to implement effective fishery management and conservation planning that may prevent extinctions and ensure the survival of their populations. Critical information gaps regarding the status and impact of threats remain for many species. This lack of information is particularly evident for those species that are poorly known, non-charismatic, and that usually fetch a low market price or have no value for their products. These factors mean that such species are commonly overlooked by fisheries management.

One such group which have been traditionally disregarded are the round rays (family Urotrygonidae). Round rays are small stingrays (maximum size of <70 cm total length; TL) distributed exclusively in tropical and temperate coastal marine waters of North, Central, and South America. They are commonly found in nearshore environments and are mainly associated with soft-sediment seafloor habitats, where they are able to find their prey, usually crustaceans, mollusks, polychaetes, and bony fishes. As a result of their demersal habit (i.e., species associated with the seafloor) and low mobility, these species are commonly caught as bycatch in bottom trawl fisheries. Due to their small body size and low or no economic value, they are commonly discarded overboard, usually dead or seriously injured, but are also sometimes retained for the local market. Many of the fisheries which catch them lack effective management (e.g., low taxonomic resolution of catch data, limited monitoring, limited catch regulations, poor enforcement) which not only hinders their management and conservation but may also lead to unnoticed population depletions.

This article presents an overview of the current status of endemic round rays of the Eastern Pacific, which contains 14 of the 17 species belonging to this family. This article provides a summary of several important aspects of this group, including their diversity, geographic range and habitat, life history traits, main threats, and conservation status. It also highlights the current extinction risk of species in order to create awareness of the decline in some species and the importance of implementing management measures before their populations reach the point of no return.

Diversity

Worldwide there are 26 recognized families of rays (Last et al., 2016). The family Urotrygonidae, or round rays, are a family of stingrays comprising 17 species across two genera: *Urobatis* (6 species) and *Urotrygon* (11 species). For the most part, these species (14 species; 82%) are endemic to the Eastern Pacific Ocean (**Fig. 1** shows some examples of round rays). The remaining species, yellow round ray *Urobatis jamaicensis*, smalleye round ray *Urotrygon microphthalmum*, and Venezuelan round ray *Urotrygon venezuelae*, are distributed in the Western Atlantic (Last et al., 2016). Species within this family are characterized by their disc, or body, which is nearly round in shape, which gives the group their common name. However, the body of most species is wider than it is long, giving the appearance of an oval shape. The group also displays several other notable characteristics, such as the lack of dorsal or anal fins, a snout ranging from very pronounced to almost imperceptible, and a short tail, usually no longer than the body length, with a serrated stinging spine and a caudal fin (Last et al., 2016). Some species also exhibit small, bluntly tipped or pointed thorns on their dorsal surface. Dorsal coloration varies from dark brown with small and irregular brownish-black blotches, e.g., blotched round ray *Urotrygon chilensis*, to yellowish or whitish densely covered with fine brownish or orange reticulations, e.g., the leopard round ray *Urobatis pardalis*, from which the species derives its name.

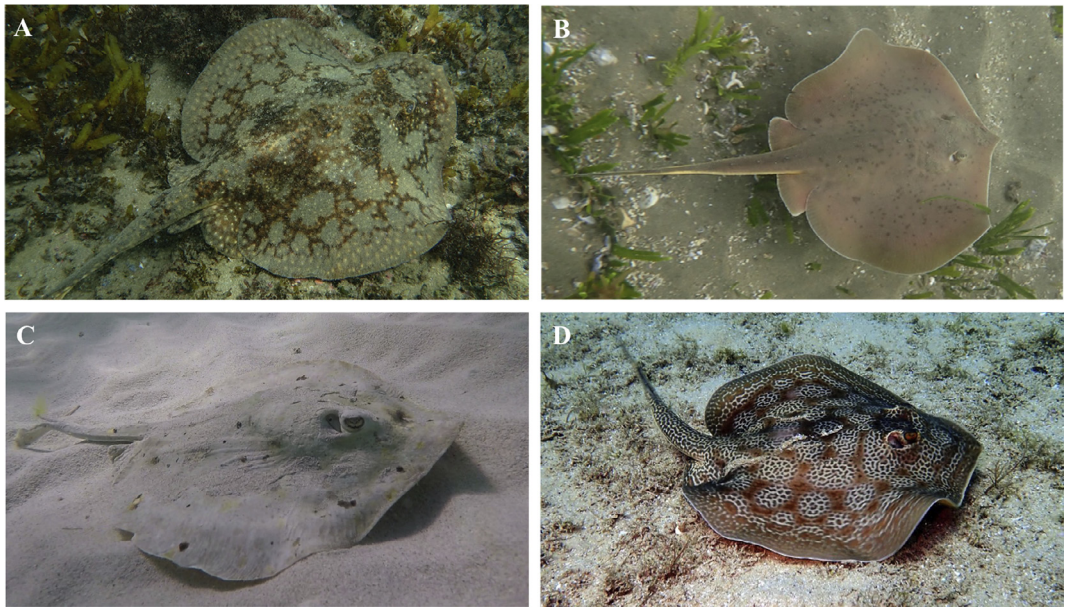

Fig. 1 Examples of the diversity of Eastern Pacific round rays. (A) Tumbes round ray *Urobatis tumbesensis*; (B) blotched round ray *Urotrygon chilensis*; (C) spotted round ray *Urobatis maculatus*; (D) Haller's round ray *Urobatis halleri*. Photo credits: Adriana González Pestana (Photo A and B), Sebastian Hernandez Muñoz (Photo C), Steven Lara (Photo D).

Geographic range and habitat

The distribution of round rays in the Eastern Pacific varies widely. The most broadly distributed species is Haller's round ray *Urobatis halleri*, ranging from northern California, United States to northern Peru. Other species are restricted to smaller areas: e.g., the dwarf round ray *Urotrygon nana* ranges from central Mexico to Panama; the Tumbes round ray *Urobatis tumbesensis* from Colombia to northern Peru, and the Cimar round ray *Urotrygon cimar* from central Mexico to Costa Rica. There are also some species endemic to specific countries. This is the case for the bullseye round ray *Urobatis concentricus* which is endemic to Mexico, the reticulate round ray *Urotrygon reticulata*, which is only found in the Gulf of Panama, and the leopard round ray, which is present only in Costa Rica. Although there have been reports of these last two species outside of their endemic range, they have not been confirmed yet and as such, these species are treated as endemic at the country level.

Round rays range across 11 Eastern Pacific countries, with varying levels of species richness. Mexico and Costa Rica have the greatest number of round rays, while species richness in the United States and Chile is relatively low (**Fig. 2**). Furthermore, there are some regions with high species richness, such as the Gulf of California (Mexico), coastal areas from the Gulf of Tehuantepec (Mexico) to the Gulf of Panama and from southern Colombia to Ecuador (**Fig. 3**).

Round rays are mostly found in tropical waters, with some species such as Haller's round ray ranging into temperate waters. They primarily inhabit coastal and continental shelf waters at depths <100 m. However, Roger's round ray *Urotrygon rogersi* was recently caught by bottom trawling in the Gulf of California at a depth of 235 m (Acevedo-Cervantes et al., 2017). This report not only represents the deepest record for this species, which usually inhabits between 2 and 30 m but is also the greatest depth reported for any round ray so far. Rounds rays are commonly associated with soft-bottom benthic habitats (e.g., mud and sand) and rubble substrates. Some species, such as Haller's round ray, can also be found near coral reef ecosystems; other species, including the dwarf round ray and Tumbes round ray, have also been reported in estuaries and mangrove environments, which demonstrates the diversity of coastal shallow water habitats exploited by this group of rays.

Life history traits

Information on life history traits (e.g., maximum size, growth rate, age, and size at maturity) for Eastern Pacific round rays has many data gaps (**Table 1**). There have been very few studies focusing on understanding the basic biology of these species. Round rays are among the smallest of the rays; in the Eastern Pacific they reach a maximum size of <60 cm TL, ranging from as small as 24 cm TL (reticulate round ray) to 58 cm TL (bullseye round ray).

Age and growth data on round rays are limited, but what has been documented so far indicates that their lifespan is relatively short. The oldest known maximum age is 14 years (females) and 12 years (males) in the blotched round ray (Guzmán-Castellanos, 2015). The spinytail round ray *Urotrygon aspidura* can reach a maximum age of 7.5 years for females and 5.5 years for males

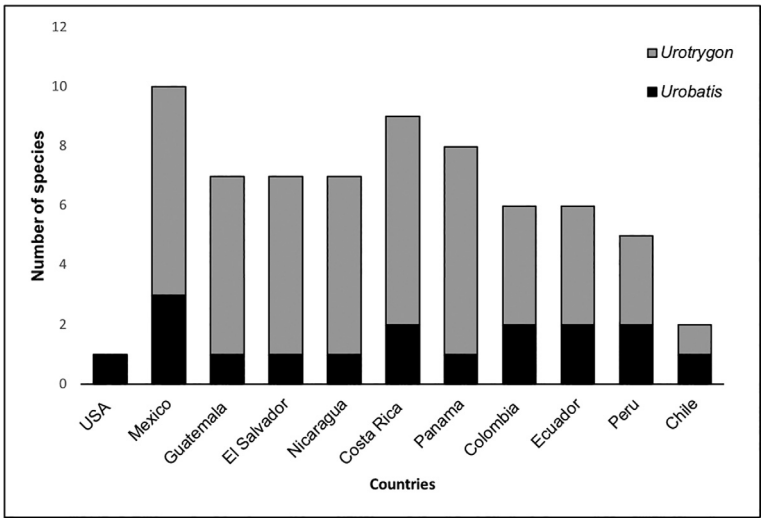

Fig. 2 Number of species of round rays in each Eastern Pacific country from north to south.

(Torres-Palacios et al., 2019), while Roger's round ray has a reported maximum age of ~8 years for females and ~6 years for males (Mejía-Falla et al., 2014).

According to the literature, most round rays reach sexual maturity over a narrow size range, between 20 and 30 cm TL, although smaller species such as the dwarf round ray reach sexual maturity at 12–17 cm TL. The reproductive strategy for this group is exclusively viviparous, which means they give live birth. The reproductive cycle varies between species. Thus, some species such as Roger's round ray have a triannual reproductive cycle or give birth three times a year (Mejía-Falla et al., 2012), while others have an annual reproductive cycle (e.g., Haller's round ray). Litter size is among the lowest reported for elasmobranchs, ranging from 1 to 4 pups (e.g., Roger's round ray) or 2 to 6 pups (e.g., Haller's round ray) (**Table 1**).

The round rays also include some of the earliest ages at sexual maturity of any elasmobranch, with a 1–4 year range. This is notable since elasmobranchs are generally renowned for their late ages at maturity, although this is a common characteristic of larger and longer-living species. In Haller's round ray, females and males mature at ~3.8 years (Hale and Lowe, 2008); in the spinytail round ray, females and males mature at 2.3 years (Torres-Palacios et al., 2019); and in Roger's round ray, maturity is reached earlier, at ~1 year (Mejía-Falla et al., 2014) (**Table 1**). For other parameters (e.g., growth rate, mortality rate), data are largely unknown limiting our understanding of the population dynamics of this group.

Major threats

As with many other elasmobranchs, the main driver of the decline in Eastern Pacific round ray populations are fisheries. As mentioned above, species of round rays are commonly found in shallow coastal and estuarine environments, where they often overlap spatially with numerous fisheries that operate across their shallow depth range and with little refuge (e.g., unfishable rocky habitats) from fishing activities. This makes round rays highly susceptible to capture in coastal fisheries and increases the probability of population declines, especially in the tropical Eastern Pacific region where range-restricted species (e.g., reticulate round ray) overlap with elevated fishing pressure throughout most of their distribution.

Round rays are not targeted commercially for any industrial or small-scale fisheries in the Eastern Pacific. This is due to their small body size and lack of marketable products making them of low commercial importance compared to moderate and large-sized elasmobranchs (e.g., requiem sharks, Carcharhinidae; hammerhead sharks, Sphyrnidae; stingrays, Dasyatidae). However, they are primarily captured as bycatch by bottom gillnetting and trawling (**Table 2**). Small-bodied rays like round rays are highly susceptible to capture by trawling due to the bottom-dwelling habits and limited mobility. The serrated stinging spine of stingrays (including round rays) can also cause entanglement in fishing nets. They are also reported less frequently in other fishing methods. For example, in coastal zones of Ecuador, the blotched round ray has been found in beach seine fisheries; in Mexico, the bullseye round ray has been reported caught by spearfishing, although this practice is rare; and in southern California, Haller's round ray is often reported as incidentally caught in recreational line fishing (**Table 2**).

Importantly, most fisheries that interact with round rays lack management or effective enforcement regulations. In some small-scale and commercial fisheries, practices such as severing the tail of round rays before being returned to the sea may reduce the survival probability of species. Therefore, implementing measures that promote better fishing practices, such as proper handling techniques of incidental catches, would contribute to maintaining the population levels of these species.

Although most species are usually discarded when caught, there is also some retention. Little is known about use and trade, but in both industrial and small-scale fisheries, round rays are used for bait, fish meal, local consumption (meat), or for sale in local

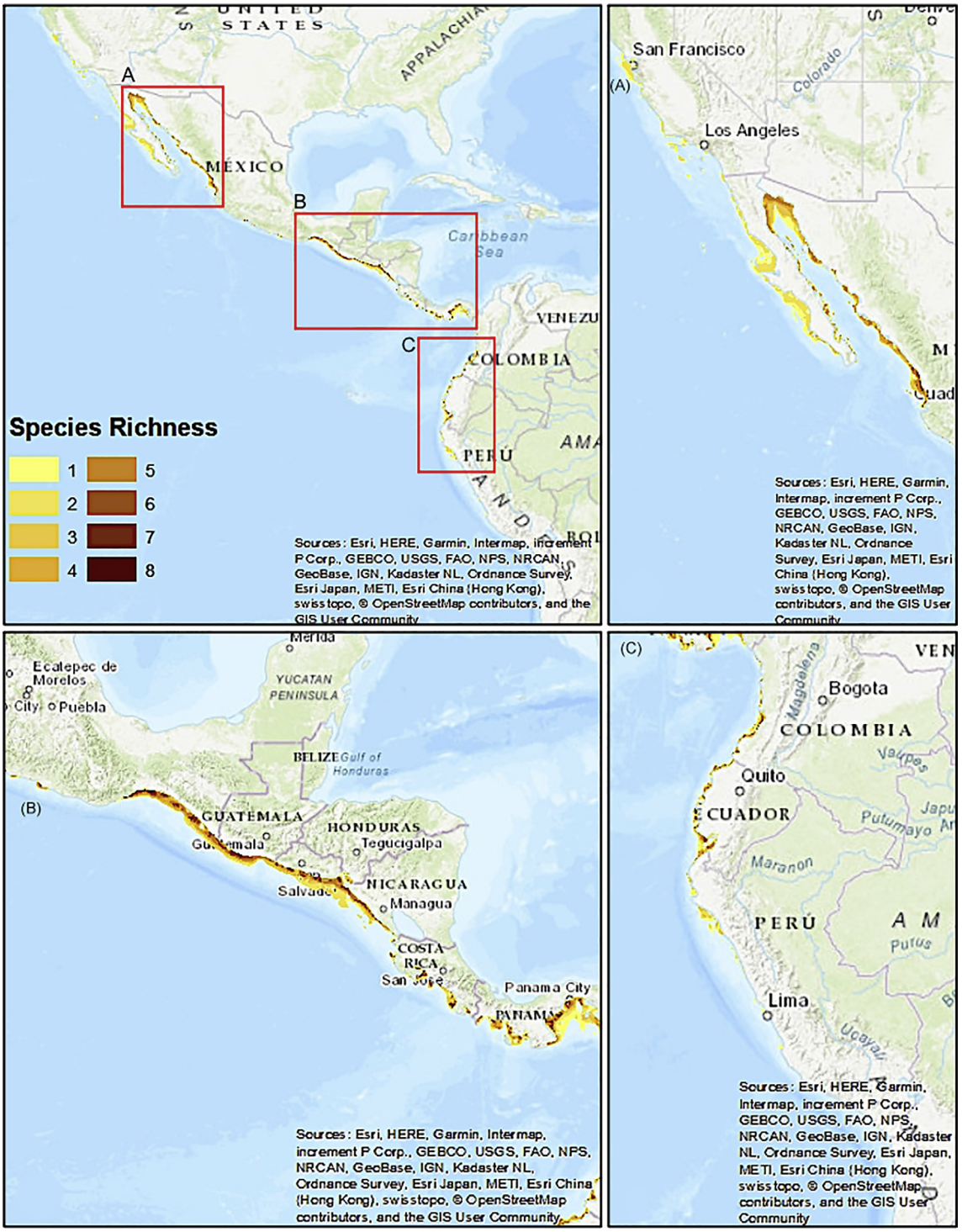

Fig. 3 Map of species richness of Eastern Pacific round rays. The map was compiled based on the current geographic ranges and maximum depths reported for each species (from IUCN, 2021). *Urobatis marmoratus* is not plotted on the map since the depth range for this species is unknown. ESRI (2019) ArcGIS desktop: Release 10.8. Redlands, CA: Environmental Systems Research Institute.

markets. For example, the Tumbes round ray is commercially important for local markets in Peru (Ramos, 2015). Furthermore, some species of round rays like Haller's round ray are collected for the aquarium trade, where they fetch around US$200 per individual, but there is little information about the volume of this, or other species, collected for this purpose.

Although small-scale and industrial fisheries represent the primary threat to round rays, a variety of other threats also act upon them. Coastal habitat degradation due to several anthropogenic activities such as dredging, sand mining, construction of ports and

Table 1 Distribution and life history traits of Eastern Pacific round rays.

Common and scientific name	*Distribution*	*Depth range (m)*	*Maximum size (cm TL)*	*Size at maturity (cm TL)*	*Size at birth (cm TL)*	*Litter size*	*Age at maturity (years)*
Bullseye round ray *Urobatis concentricus*	Eastern Central Pacific: Isla cedros, Baja California (including the Gulf of California) to Bahía Huatulco, Oaxaca, Mexico	0–109	58.4	♀ 41[a]	n/a	3	♀ 3[a]
Haller's round ray *Urobatis halleri*	Eastern Central and Southeast Pacific: Northern California (United States), including the Gulf of California, to northern Peru	0–91	~55	♂ ~24 ♀ ~24	6–8 (DW)	2–6	♀♂ 3.8 (Seal Beach, California, United States) ♀♂ 2.5 (Southern California, United States)
Spotted round ray *Urobatis maculatus*	Eastern Central Pacific: Bahia Sebastian, Baja California (including the Gulf of California), to Puerto Vallarta, Jalisco, Mexico	0–30	42	n/a	n/a	n/a	n/a
Leopard round ray *Urobatis pardalis*	Eastern Central Pacific: Costa Rica	1–53	46.2	n/a	n/a	n/a	n/a
Tumbes round ray *Urobatis tumbesensis*	Southeast Pacific: Colombia to Northern Peru	1–20	41	♂ 30	n/a	n/a	n/a
Chilean round ray *Urobatis marmoratus*	Southeast Pacific: Quintero, Chile	n/a	38.5	♂ 31	n/a	n/a	n/a
Spinytail round ray *Urotrygon aspidura*	Eastern Central and Southeast Pacific: Baja California and Central Mexico to northern Peru	5–100	42	♂ 23 ♀ 25	13?	1–4	♂ 2.2[b] ♀ 2.3[b]
Blotched round ray *Urotrygon chilensis*	Eastern Central and Southeast Pacific: Baja and Gulf of California, Mexico, to northern Chile	1–60	43	♂ 25.3 ♀ 26.2	14–16	1–5	♂ 2.0 ♀ 2.2 (Mexico)
Cimar round ray *Urotrygon cimar*	Eastern Central Pacific: Central Mexico to Costa Rica	1–85	38	♂ 22	n/a	n/a	n/a
Munda round ray *Urotrygon munda*	Eastern Central and Southeast Pacific: Central Mexico to Peru	5–50	25	♂ ~20	9	n/a	n/a
Dwarf round ray *Urotrygon nana*	Eastern Central Pacific: Central Mexico to Panama	2–15	26	♂ 13.4 ♀ 11.7–16.6	7.6–8.6	1–6	n/a
Reticulate round ray *Urotrygon reticulata*	Eastern Central Pacific: Gulf of Panama	1–15	24	n/a	n/a	n/a	n/a
Roger's round ray *Urotrygon rogersi*	Eastern Central and Southeast Pacific: Baja and Gulf of California, Mexico, to Ecuador	2–235 (primarily 2–30)	~46	♂ 26–28 ♀ 30–32	11.5–14.7	1–4	♀ 1.0 ♂ 1.0 (Colombia)
Fake round ray *Urotrygon simulatrix*	Eastern Central and Southeast Pacific: Mexico, Costa Rica, Panama, and possibly Colombia	2–18	27	n/a	n/a	n/a	n/a

See each species assessment from IUCN (2021) for data sources and more details. DW, disc width; TL, total length; n/a, not available.

[a]Suggested values.

[b]Suggested for Colombia.

Data sourced from IUCN (2021) The IUCN Red List of Threatened Species. Version 2021-1. Available at: www.iucnredlist.org. (Accessed 25 March 2021).

Table 2 The types of fisheries where round ray species have been reported (dark gray cells), are likely to be caught (light gray cells), or are not known/reported to be caught (white cells).

Species	*Type of fisheries*						
	Trawl	*Gillnet*	*Longline*	*Pelagic trawl*	*Recreational*	*Beach seine*	*Spearfishing*
Bullseye round ray *Urobatis concentricus*							
Haller's round ray *Urobatis halleri*							
Spotted round ray *Urobatis maculatus*							
Leopard round ray *Urobatis pardalis*							
Tumbes round ray *Urobatis tumbesensis*							
Chilean round ray *Urobatis marmoratus*							
Spinytail round ray *Urotrygon aspidura*							
Blotched round ray *Urotrygon chilensis*							
Cimar round ray *Urotrygon cimar*							
Munda round ray *Urotrygon munda*							
Dwarf round ray *Urotrygon nana*							
Reticulate round ray *Urotrygon reticulata*							
Roger's round ray *Urotrygon rogersi*							
Fake round ray *Urotrygon simulatrix*							

marinas, and increased runoff of pollutants and sediments, which are common threats along the tropical Eastern Pacific coast, could have a significant impact on the occurrence of certain species of round rays. This is particularly evident in those species that have been found in close association to coastal marine habitats severely impacted by coastal changes. For example, both the dwarf round ray and Tumbes round ray have been found in association with mangrove habitats. In the tropical Eastern Pacific, this habitat has been subject to high levels of clearing for coastal development and aquaculture with 39% loss of mangrove in Costa Rica, 68% in Panama, 57% in Colombia, and 62% in Ecuador (López-Angarita et al., 2016). This loss of habitat may have population-level effects on biodiversity that impact the dwarf round ray and Tumbes round ray. Furthermore, it is expected that the cumulative impacts of fisheries, habitat destruction, and other anthropogenic stressors will have negative consequences on round ray populations. It is unknown how a changing climate will affect the distributions and populations of round rays.

Conservation status

The International Union for Conservation of Nature (IUCN) Red List of Threatened Species provides the world's most comprehensive database of extinction risk. To evaluate extinction risk, a species is assessed against the IUCN Red List Categories and Criteria and can be assigned one of two extinction categories (Extinct, Extinct in the Wild), three threatened categories (Critically Endangered, Endangered, Vulnerable), Near Threatened, Least Concern, or Data Deficient. See IUCN (2012) for definitions and an overview of the assessment method. All Eastern Pacific rounds rays have been assessed on the IUCN Red List (IUCN, 2021) and a summary of their status is provided below (**Table 3**). No round rays have been assessed as Extinct or Extinct in the Wild, although there is a great concern for the status of the Critically Endangered species. Full assessments are publicly accessible on the IUCN Red List website (IUCN, 2021).

Critically Endangered species

The reticulate round ray is the only Critically Endangered round ray species. It is rare and is distributed exclusively in the Gulf of Panama. Its extent of occurrence has been estimated as 25,300 km^2. The distribution of this species overlaps with many intense and

Table 3 IUCN Red List category for each Eastern Pacific round ray species.

Common and scientific name	*Previous Red List Category (Year)*	*Current Red List Category (Year)*	*Population Trend*	*Rationale*
Bullseye round ray *Urobatis concentricus*	DD (2006)	LC (2020)	Stable	Captured in small-scale and industrial fisheries. Usually discarded, and before being discarded, the spine or the tail is cut off which may result in a high level of mortality. High biological productivity. It is common and there is no indication of considerable population reduction
Haller's round ray *Urobatis halleri*	LC (2006)	LC (2015)	Stable	Population stable or increasing in the northern part of its range. Unknown trend in rest of its distribution range. Exposed to significant levels of exploitation and unmanaged fishing pressure throughout areas of its range, with little refuge. High biological productivity. It is common and there is no indication of considerable population reduction
Spotted round ray *Urobatis maculatus*	DD (2006)	LC (2020)	Stable	Captured in small-scale and industrial fisheries. Usually discarded, and before being discarded, the spine or the tail is cut off which may result in a high level of mortality. High biological productivity. It is common and there is no indication of considerable population reduction
Leopard round ray *Urobatis pardalis*	NE	LC (2020)	Stable	Restricted range off Costa Rica. Abundant in visual and underwater video surveys. Some refuge from fishing and suspected low levels of mortality due to fishing
Tumbes round ray *Urobatis tumbesensis*	DD (2007)	VU (2020)	Decreasing	Exposed to significant levels of exploitation and unmanaged fishing pressure throughout most of its range, with little refuge. Habitat quality and area of occupancy declining due to mangrove loss. High biological productivity
Chilean round ray *Urobatis marmoratus*	DD (2004)	DD (2020)	Unknown	Endemic to Chile. Only a single record is known from 1892. The original description is limited, and the specimen is lost. No available information on habitat, depth range, or interactions with fisheries
Spinytail round ray *Urotrygon aspidura*	DD (2009)	NT (2020)	Decreasing	Exposed to significant levels of exploitation and unmanaged fishing pressure throughout most of its range, with little refuge. High biological productivity and stable trends in Colombia
Blotched round ray *Urotrygon chilensis*	DD (2004)	NT (2020)	Decreasing	Exposed to significant levels of exploitation and unmanaged fishing pressure throughout most of its range, with little refuge. High biological productivity
Cimar round ray *Urotrygon cimar*	NE	NT (2020)	Decreasing	A rare and poorly known species. Exposed to significant levels of exploitation and unmanaged fishing pressure throughout most of its range, with little refuge
Munda round ray *Urotrygon munda*	DD (2009)	NT (2020)	Decreasing	A rare and poorly known species. Exposed to significant levels of exploitation and unmanaged fishing pressure throughout most of its range, with little refuge
Dwarf round ray *Urotrygon nana*	DD (2009)	NT (2020)	Decreasing	Exposed to significant levels of exploitation and unmanaged fishing pressure throughout most of its range, with little refuge. Habitat quality and area of occupancy declining due to mangrove loss. High biological productivity
Reticulate round ray *Urotrygon reticulata*	VU (2009)	CR (2020)	Decreasing	Endemic to Panama. Restricted range, heavy and unmanaged fishing pressure across its entire known range. No refuge. Lack of contemporary records
Roger's round ray *Urotrygon rogersi*	DD (2009)	NT (2020)	Decreasing	Exposed to significant levels of exploitation and unmanaged fishing pressure throughout most of its range, with little refuge. High biological productivity and remains abundant in some areas
Fake round ray *Urotrygon simulatrix*	VU (2009)	VU (2020)	Decreasing	A rare and poorly known species. Its range is poorly defined. Exposed to significant levels of exploitation and unmanaged fishing pressure throughout most of its range, with little refuge. Lack of contemporary records in Panama

CR, Critically Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient; NE, Not Evaluated. See IUCN (2012) for explanation of categories.
Source: IUCN (2021) The IUCN Red List of Threatened Species. Version 2021-1. Available at: www.iucnredlist.org. (Accessed 25 March 2021).

unmanaged fisheries due to its narrow, shallow depth range (1–15 m) and its habitat preference (soft-bottom habitats), with little refuge from fishing activities. There are about 1500 registered small-scale vessels that operate along the coast of the Gulf of Panama. Most of them employ bottom gillnets and longlines, which commonly interact with round rays. This category of fishery is poorly documented in Panama, as the quality and amount of data for elasmobranch catches are limited, and most landing sites are rarely monitored. A similar situation occurs in industrial fisheries, such as shrimp trawling, that also operate in the Gulf of Panama. This fishery was initiated in 1950 with fewer than 10 small fishing boats but has grown, reaching almost 200 registered vessels in 2015.

Another type of fishery operating in Pacific Panama targets small pelagic fishes (anchovies, herrings) on soft-benthic nearshore habitats. This fishery operates exclusively on the coastal zone of the Gulf of Panama, and it is known that several species of elasmobranch are caught as bycatch, including Roger's round ray and the spinytail round ray. Reticulate round rays have not been reported in the scientific literature since 1988 for Panama, although there is a museum record from 1990. No recent records of the species have been found despite recent efforts to find it through local fishers, fisheries observers, and seafood markets in the Gulf of Panama. According to the most recent conservation assessment it is inferred that this species has undergone a population reduction of more than 80% over the last three generations (15 years). This inferred reduction and a lack of recent records raises serious concerns regarding its population status. Urgent research is required to understand its interaction with local fisheries along with the implementation of local fishing regulations that prohibit the retention, landing, and commercialization of this species to minimize further population decline.

Vulnerable species

Two species of round rays have been assessed as Vulnerable: the fake round ray *Urotrygon simulatrix* and the Tumbes round ray. It has been suggested that these species are as highly productive as other tropical round rays, which can help them withstand high levels of fishing pressure across their range. Despite this, it is suspected that both species have undergone a population reduction of 30–49% over the last three generations (15 years). The fake round ray is poorly known, and its distribution is not well defined. This species was originally described from specimens collected in Panama, and there are additional museum records from Mexico, Costa Rica, and Colombia, although this last record is probably a misidentification (Mejía-Falla and Navia, 2019). There is no information on catches or landings for this species. However, its geographic distribution and narrow depth range (2–18 m) overlap with large- and small-scale fisheries, with little refuge from fishing. Notably, there are no recent records of the fake round ray in Panama despite attempts to locate it. Further knowledge may show that this species meets a higher threatened category.

The Tumbes round ray is distributed in the Southeast Pacific, from Colombia to northern Peru. This species is caught as bycatch in trawl and small-scale fisheries, but catch rates are not homogenous through its range. While the Tumbes round ray is rare in Colombia, it is more commonly found in northern Peru, interacting with coastal small-scale fisheries, where it is commercially important for local markets (Ramos, 2015). The main area of its distribution is in Ecuador, where the species overlaps with intense fishing pressure and inadequately managed fisheries, which suggests a reduction of the population in this particular area. Given its association with mangroves and the rate of mangrove loss in the tropical Eastern Pacific (López-Angarita et al., 2016), a decline in abundance is expected. Thus, the combination of poorly managed fisheries across their range and habitat degradation are believed to have cumulatively led to a population reduction. Monitoring of the Tumbes round ray population is required to generate a baseline and establish conservation and management plans.

Near Threatened species

Round rays assessed as Near Threatened are among the most common rays caught in small-scale and industrial fisheries across their range. For example, the blotched round ray is one of the most abundant species caught as bycatch in some areas of Costa Rica and is commonly caught in commercial trawls in Guatemala and Mexico. Roger's round ray is a relatively frequent catch in industrial shrimp trawls in Costa Rica and it is the most common elasmobranch species caught in small-scale trawl fisheries in Colombia. Similarly, the spinytail round ray is also commonly caught by industrial shrimp trawl fisheries in Costa Rica, Colombia, and Ecuador. Some of these species have shown high biological productivity. For example, Roger's round ray reaches sexual maturity at very early ages ($\sim$1 year) with more than one reproductive cycle per year (triannual reproductive cycle), which provide some resilience to the current level of fishing effort. However, these species are subject of heavy and largely unmanaged fishing pressure across parts of their range and it is suspected that they have undergone a population reduction of 20–29% over the last three generations (15 years). Since this group is among the most frequently captured of the round rays in many fisheries, it is necessary to closely monitor these populations and reinforce fishery regulations to control the current level of exploitation to prevent further declines.

Least Concern species

Although some round ray species assessed as Least Concern are subject to bycatch in small-scale and industrial fisheries throughout most of their range, the populations of these species are considered stable. The bullseye round ray and spotted round ray *Urobatis maculatus*, which are endemic to Mexico (including the Gulf of California), are caught as bycatch in shrimp trawl fisheries and small-scale gillnets. They reach sexual maturity at an early age and their biological productivity is high enough to tolerate the current level of fishing pressure over the majority of their range. Similarly, populations of leopard round ray, only found in Costa Rica, overlap

with some nearshore fisheries. However, it is considered a species with a low level of mortality from fishing as it likely finds refuge from fishing in coral reefs and rocky habitats and has an inferred high biological productivity.

Haller's round ray has a broad range in the Eastern Pacific and is also considered a very productive species which infers a certain level of resilience to fisheries. This species is commonly caught by recreational fisheries in California and is a dominant shrimp trawl bycatch species along the coast of Baja California Sur and the Gulf of California in Mexico. Due to the high mortality and exploitation rates by industrial shrimp trawl fisheries in the Gulf of California, it has been suggested that this species is overexploited there (Morales-Azpeitia et al., 2013) although long-term data are lacking. Haller's round ray is abundant in southern California, and it has been suggested that the population is stable or increasing. However, in other places where this species ranges, such as Central and South America, there is no fishery information for this species. This warrants further research attention, but overall, the population is not considered to have undergone a reduction approaching the threatened category thresholds.

Data Deficient species

The only Data Deficient species is the Chilean round ray *Urobatis marmoratus*. This species was described in 1892 from a single specimen collected from Quinteros, Chile; since then, no other specimen has been reported in the literature. The description of this species is incomplete and there is no opportunity to re-describe the species, since the only known specimen is reported missing. This makes the taxonomic validity of this species uncertain. A significant amount of basic information for this species, such as habitat and depth range, was not defined in its original description making it difficult to infer the level of interaction with fisheries. Further information on this species is needed to help elucidate its taxonomy and understand potential threats and conservation status.

Conservation efforts

Fishery management measures and conservation actions are indispensable mechanisms for maintaining shark and ray populations and permitting their recovery where needed. So far, there are no specific conservation and management actions toward any Eastern Pacific round ray species. Nevertheless, there are some fishery management measures implemented by certain countries that can help to reduce the fisheries impacts on round ray populations and their habitats.

In Costa Rica and Ecuador, for example, shrimp trawl fisheries have been banned in their waters mainly due to the deleterious consequences on seabed habitat and its biodiversity. In Panama and Colombia, seasonal closures of the shrimp trawl fishery have been implemented to protect the reproductive period of several shrimp species. In Peru, trawling has been prohibited in the coastal zone (within five nautical miles from the coast) yet fishing still occurs illegally in northern Peru (SPDA, 2020). In addition, the implementation of some gear modifications in shrimp-trawl fisheries such as the use of turtle exclusion devices (TEDs), are also effective in reducing elasmobranch bycatch by excluding larger sharks and rays. However, they may not exclude small-size stingrays (e.g., round rays).

Fishing regulations have also been implemented in other types of fisheries that overlap with round rays, such as the industrial small-pelagic fisheries in Panama, which have established a closing fishing season to protect their target species (sardines and anchovies), the prohibition of mechanized and manual beach seines in nearshore areas of Peru, and a 3-month closure season for commercial fisheries in Mexico that target elasmobranchs.

Marine Protected Areas (MPAs) are another conservation tool that might benefit round ray populations. These delimited areas of the marine environment are very popular as effective spatial management methods and may help to preserve the abundance and diversity of several marine populations, including elasmobranchs, protect critical habitats such as foraging and nursery areas, and enhance the resilience of the ecosystems to anthropogenic stressors while at the same time aiding the increase and maintenance of fishery production. Although clear evidence of their benefit to round ray populations is lacking, it has been speculated that no-take MPAs or other management approaches that reduce bycatch and fisheries interaction with round ray populations may provide important conservation benefits (Lyons et al., 2015).

Fisheries management measures and MPAs should be seen as positive actions toward the conservation of Eastern Pacific round rays, either directly by controlling the actual and potential fishing pressure on their populations or indirectly by diminishing the fishing effects on their habitats. However, fishery surveillance and effective enforcement of fisheries regulations are still some of the major challenges facing fishery management in most parts of the Eastern Pacific region.

Conclusions

Chondrichthyan populations are declining mainly due to the ongoing and increasing demand of their products such as fins, livers, gill rakers, and meat, which makes them the subject of intense exploitation by many fisheries all over the world. This situation generates an urgent need for conservation and management of many species, including those small and less conspicuous elasmobranchs such as the Eastern Pacific round rays. These species are not targeted by any fisheries but are incidentally caught by poorly managed fisheries throughout most of their range. There is only limited fishery-related data (e.g., landings, catch rates) available for round

rays. This lack of data hampers the complete assessment of the health of their populations and underlines the need to create adequate fishery management programs.

There are many gaps in our understanding of the general biology, behavior, and ecology of round rays from the Eastern Pacific region. This may pose a considerable challenge for conservation of their populations, since this information is relevant to sustain adequate fishery management of elasmobranch populations. Studies on the life history characteristics of fish (e.g., age and size at maturity, number and size of offspring, growth patterns), for example, are crucial to determining the response of fish populations to the effects of fisheries, facilitating the assessment of the health of their populations, and are useful for making inferences and predictions about the future of their populations. Certainly, improving the monitoring, management, and enforcement of fisheries throughout the Eastern Pacific will be important to prevent further declines and extinctions of Eastern Pacific round ray populations.

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