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A Review of the Status of Sharks, Rays and Chimaeras of Panama to Guide Research and Conservation

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ABSTRACT

Chondrichthyan fishes (sharks, rays and chimaeras) are a group of high conservation concern globally. Species are impacted by varying threats, although fishing pressure is the primary stressor causing population declines. Panama comprises both Pacific and Caribbean coastlines with a diversity of estuarine and marine habitats supporting small to large-scale fisheries. Understanding the status of chondrichthyans within this Central America seascape can help inform and drive conservation and research. This paper represents the first comprehensive review of the chondrichthyans of Panama and presents a summary of (1) species diversity and distribution; (2) habitat; (3) extinction risk; (4) drivers of extinction risk; and (5) policy tools. The study also discusses current research and critical knowledge gaps and outlines recommendations for research, education and management. Panama supports 112 species of chondrichthyan, the majority of which are associated with coastal and shelf environments. Almost half (47.3%) are at risk of extinction globally, according to the IUCN Red List of Threatened Species. Many of the most frequently encountered species in fisheries are globally threatened, such as scalloped hammerhead *Sphyrna lewini* and silky shark *Carcharhinus falciformis*. This review found a general lack of species-specific fisheries data, limiting the assessment of local population trends. Further, although national, regional and international policy tools are in place, deficiencies in monitoring, enforcement and compliance are limiting their effectiveness. Policies should aim to improve data collection and compliance with current management tools while supporting research into life-history, critical habitats and the socioeconomic values of chondrichthyans. Addressing the research, education and management recommendations within this paper would improve the status of Panama's chondrichthyans and assist the country in meeting the 2030 Sustainable Development Goals (SDG), including SDG 14, which calls to 'conserve and sustainably use the oceans, seas, and marine resources for sustainable development'.

1 | Introduction

The world is currently facing a biodiversity loss and extinction crisis as human pressures on the natural environment continue to mount (O'Hara et al. 2021). One vertebrate group heavily impacted by human activities is the chondrichthyan fishes (sharks, rays and chimaeras). This diverse group, with over 1260 species (Weigmann et al. 2024), is distributed primarily in marine waters and is characterized by its inherent low biological productivity (Musick 1999). Exploitation and overfishing are driven by increasing demand for their products such as fins, livers, gill rakers and meat (Dulvy et al. 2017) and are frequently executed under poor fishery management arrangements (Davidson et al. 2015; Worm et al. 2024). It has been estimated that overfishing (primarily) and other human-induced stressors, such as habitat degradation, have caused an estimated one third (37%) of chondrichthyans to be threatened with extinction globally (Dulvy et al. 2021). This places chondrichthyans among the highest taxonomic groups in terms of extinction risk (IUCN 2024), underlining the urgent need to implement efficient fishery management and conservation practices to prevent extinctions and permit population recovery (Dulvy et al. 2021; Worm et al. 2024).

Chondrichthyans are a component of catches in Panama's fisheries, both on the Caribbean and Pacific coasts. Sharks and rays are exploited by a variety of small and large-scale fisheries (e.g., Harper et al. 2014; Robles et al. 2015; Rodríguez-Arriatti 2011), which exert a considerable level of pressure on their populations. A time series of landing data for industrial fisheries showed that between 1999 and 2013, shark production in Panama averaged 3514 t per year, with a peak in 2001 of 7509 t per year (Guzman et al. 2020). This represents approximately 2% of the total fishing production in the country (Guzman et al. 2020). There are several documented examples of local population depletion, for example, the largetooth sawfish *Pristis pristis* (López-Angarita et al. 2021) and bull shark *Carcharhinus leucas* (Rodríguez-Arriatti 2011), highlighting the effects that high fishing pressure can have on chondrichthyan species in Panama.

Panama has in place various fishery management policies, including those particularly relevant to sharks. A national law (Law No. 9 of March 2006) prohibits shark finning, and Panama is a party to several regional and international agreements, including Specially Protected Areas and Wildlife of the Caribbean (SPAW) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS) (summarized in Talwar et al. 2022). Additionally, certain regulations exist within protected areas, such as the ban on shark and ray fishing in Coiba National Park (Maté et al. 2015). Beyond current policy, there is a need to develop new robust instruments and management mechanisms that promote sustainable use of the resource while permitting the recovery of threatened species (e.g., Guzman et al. 2020; Arriatti et al. 2021; Bustamante 2023). There is also a need to develop and support research and outreach programmes to strengthen the scientific basis for management and to provide education on the status of chondrichthyans and their conservation.

This study represents the first comprehensive review of the chondrichthyan species of Panama. This work summarizes (1) species diversity and distribution; (2) habitat; (3) extinction risk; (4) drivers of extinction risk; and (5) policy tools. The study also provides a series of research, education and management recommendations. Together, these can guide strategies to better conserve chondrichthyan populations at local, national and regional scales.

2 | Methods

2.1 | Study Area

Panama is the southernmost Central American country and has both Pacific Ocean and Caribbean Sea (Atlantic Ocean) coasts. Its territory spans ~75,400 km^2 of land, with a coastline that spans ~3000 km. This coastline features a variety of habitats, including mangroves, seagrass beds, rocky and sandy shores, and coral reefs (Maté 2003).

Pacific Panama belongs to the Tropical Eastern Pacific biogeographic region (Robertson and Cramer 2009) with a coastline of 1697 km. The sea surface temperature ranges from 18°C to 28°C (Glynn and Maté 1997), with colder waters occurring during upwelling events in the Gulf of Panama (D'Croz and O'Dea 2007). Two large gulfs, the Gulf of Chiriquí in the west and the Gulf of Panama in the east, dominate Pacific Panama. Notable are coastal islands such as Coiba Island in the Gulf of Chiriquí, part of the Tropical Eastern Pacific Marine Corridor, a network of marine protected areas that also includes Cocos (Costa Rica), Malpelo and Gorgona (Colombia) and the Galápagos (Ecuador).

Caribbean Panama comprises 1295 km of coastline, with a continental shelf that ranges from 5.5 to 39 km wide (IGNTG 1988). Caribbean Panama lacks the seasonal upwelling seen in Pacific Panama. The sea surface temperature generally remains stable during most of the year at 29 ± 3°C. Variables such as nutrient input, turbidity and plankton are at lower levels than Pacific Panama, making the Caribbean typically oligotrophic. Two main archipelagos occur off the Caribbean coast of the country: Bocas del Toro in the west and Guna Yala in the east.

2.2 | Species Diversity and Distribution

Because there is no comprehensive checklist of chondrichthyans in Panama, species records were systematically reviewed by examining occurrence data and available literature. The following online resources were reviewed: Froese and Pauly (2022), Integrated Digitalized Biocollections (iDigBio 2018), Robertson and Allen (2015) and Robertson and van Tassell (2019). Additionally, we consulted Sea Around Us catch data (Pauly and Zeller 2015) for chondrichthyan species fished specifically in Pacific and Caribbean Panama.

We also performed a comprehensive literature review on chondrichthyans in Panamanian waters by utilizing Google Scholar and Web of Science with search terms relevant to chondrichthyans and Panama ('Chondrichthyes AND Panama', 'elasmobranch AND Panama', 'shark AND Panama', 'ray AND Panama', 'stingray AND Panama' and 'chimaera AND Panama'). We also consulted technical reports from local conservation agencies, such as the Aquatic Resource Authority of Panama (ARAP) and the Ministry of Environment, and theses from local universities (e.g., the University of Panama; International Maritime University of Panama), as well as theses from local universities, up to October 2022. Current taxonomy and nomenclature follow Fricke et al. (2022).

Geographic range information was obtained from the resources listed above and global field guides and reviews (Last et al. 2016; Weigmann 2016; Ebert et al. 2021). The geographic range of chondrichthyans was classified as (1) both Pacific and Caribbean; (2) Pacific only; or (3) Caribbean only, and we determined species diversity for each of these.

2.3 | Habitat

We grouped species into five basic habitat categories, similar to those used by Dulvy et al. (2021) and Grant et al. (2019), to better understand major habitat preferences: (1) coastal and continental shelf; (2) pelagic; (3) deepwater; (4) estuarine generalist; and (5) euryhaline generalist. Coastal and continental shelf species are those found in seas < 200 m deep on continental and insular shelves. Pelagic species are those found in open waters of the ocean, including the epipelagic (to 200 m), mesopelagic (200–1000 m) and bathypelagic (1000–4000 m) zones. Deepwater species are those found at depths > 200 m on the continental or insular slopes and abyssal plains. Estuarine generalists are species found in estuarine to marine habitats and are physiologically capable of penetrating lower salinity estuarine waters for long periods, yet they cannot tolerate prolonged freshwater exposure (Grant et al. 2019). Euryhaline generalists are those species found in a wide range of salinities, from freshwater to saltwater, and are physiologically capable of tolerating long-term exposure and often live in freshwater and/or estuarine conditions (Grant et al. 2019). There are no obligate freshwater (Grant et al. 2019) chondrichthyans in Panama, and this category was not further considered. We assigned each species to a habitat category based on the available ecological and biological information presented in the resources listed above.

2.4 | Extinction Risk

Extinction risk of each species was sourced from the IUCN Red List of Threatened Species (hereafter 'IUCN Red List'; IUCN 2024). The IUCN Red List Categories and Criteria have been applied to all chondrichthyans globally (IUCN 2024). The Red List categories given here are for assessments undertaken at the global level (i.e., across the entire world population of the species).

Species are categorized into one of the following categories: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC) or Data Deficient (DD) (IUCN 2012). Threatened species are any occurring in the categories CR, EN and VU. These species are considered to be facing an 'extremely high' (CR), 'very high' (EN) or 'high' (VU) risk of extinction in the wild. NT species 'do not qualify for CR, EN, or VU now, but are close to qualifying for or are likely to qualify for a threatened category in the near future'. LC species do not qualify for any of the previously mentioned categories. Finally, DD species have 'inadequate information to make a direct, or indirect, assessment of its risk of extinction' (IUCN 2012).

2.5 | Drivers of Extinction Risk

The literature on threats to chondrichthyans in Panama was reviewed to understand the pressures facing their populations. Threats were divided into fisheries, habitat modification, climate change and pollution.

2.6 | Policy Tools

The study also conducted a review of the national, regional and international policies relevant to chondrichthyan conservation and management in Panama. This was achieved through an examination of peer-reviewed literature and bibliographies of legal documents (regulations, laws and policies) that are associated with chondrichthyan conservation policies in the country.

3 | Results and Discussion

3.1 | Species Diversity and Distribution

To date, 112 chondrichthyan species from 36 families and 55 genera have been recorded in Panama (Table S1). This represents 8.85% of the total number of species reported worldwide (1266 species; Weigmann et al. 2024). Sharks are the most diverse group, with 56 species from 26 genera and 16 families, followed by rays with 50 species from 26 genera and 17 families and chimaeras with six species from three genera and two families. The number of shark species reported for Panama represents 10.26% of the species reported globally (56 of 546 species), whereas the number of rays represents 7.50% (50 of 667 species) and chimaeras 11.32% (6 of 53 species) (*sensu* Weigmann et al. 2024).

Pacific Panama has a higher diversity of chondrichthyans (65 species) than Caribbean Panama (60 species) (Figure 1). Sharks were slightly more diverse in Caribbean Panama (37 species) than Pacific Panama (32 species), rays less diverse in Caribbean Panama (19 species) than Pacific Panama (31 species) and chimaeras more diverse in Caribbean Panama (4 species) than Pacific Panama (2 species) (Figure 1). Thirteen species (all sharks) are shared between both sides of the country.

The most diverse shark families are requiem sharks (Carcharhinidae; 17 species), hammerhead sharks (Sphyrnidae; 6 species), deepwater catsharks (Pentanchidae; 6 species) and lanternsharks (Etmopteridae; 4 species), and the least diverse are dogfishes (Squalidae), bramble sharks (Echinorhinidae), horn sharks (Heterodontidae), whale sharks (Rhincodontidae) and mackerel sharks (Lamnidae), each represented by a single species. The most diverse ray families are hardnose skates (Rajidae; 9 species), round rays (Urotrygonidae; 9 species), guitarfishes (Rhinobatidae; 5 species) and stingrays (Dasyatidae; 4 species), and the least diverse are torpedo rays (Torpedinidae), banjo rays (Trygonorrhinidae), butterfly rays (Gymnuridae), eagle rays (Myliobatidae), cownose rays (Rhinopteridae) and softnose skates (Arhynchobatidae), each represented by a single species. Chimaeras are represented by two families: short-nosed chimaeras (Chimaeridae; 4 species) and long-nosed chimaeras (Rhinochimaeridae; 2 species).

Three chondrichthyans are endemic to Panama: The Panama ghost catshark (*Apristurus stenseni*) and reticulate round ray (*Urotrygon reticulata*) to Pacific Panama and the recently described angel shark *Squatina mapana* (Long et al. 2021) to Caribbean Panama. The status of these is poorly known, as they have not been subject to scientific studies beyond their taxonomic description.

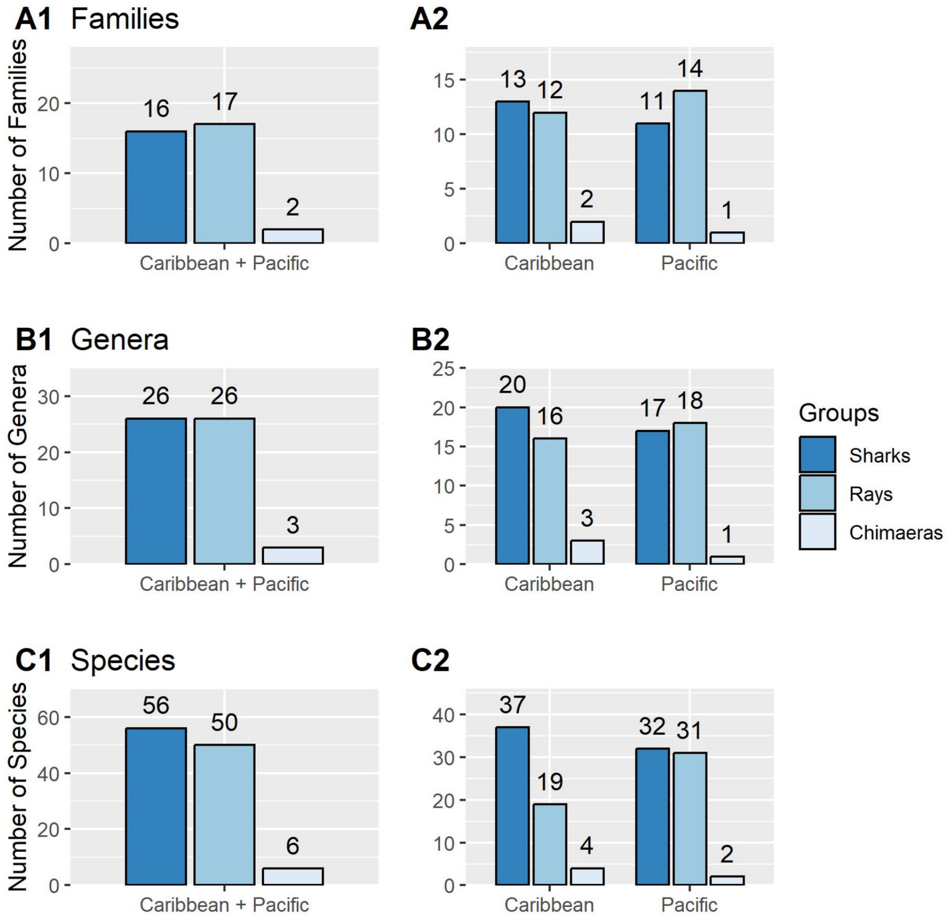

FIGURE 1 | Number of families, genera and species of chondrichthyans reported for Panama. (A1) Number of chondrichthyan families reported in Panama (Caribbean and Pacific combined); (A2) number of families reported from Caribbean or Pacific Panama; (B1) number of chondrichthyan genera reported in Panama (Caribbean and Pacific combined); (B2) number of genera reported from Caribbean or Pacific Panama; (C1) number of chondrichthyan species reported in Panama (Caribbean and Pacific combined); and (C2) number of species reported from Caribbean or Pacific Panama.

3.2 | Habitat

Most species (51.78%; 27 sharks and 31 rays) are associated with coastal and shelf environments. This is consistent with the habitat patterns of chondrichthyans worldwide (Dulvy et al. 2021). Coastal and shelf species are more diverse in Pacific Panama (19 sharks and 24 rays) than Caribbean Panama (16 sharks and 7 rays) (Figure 2). Deepwater environments represented the second highest diversity of species (34.82%; 21 sharks, 12 rays and 6 chimaeras) (Figure 2). Deepwater species are more diverse in Caribbean Panama (16 sharks, 9 rays and 4 chimaeras) than Pacific Panama (5 sharks, 3 rays and 2 chimaeras). Pelagic environments included 11 species (9.82%; 7 sharks and 4 rays). Pelagic species are more diverse in Pacific Panama (7 sharks and 3 rays) than Caribbean Panama (4 sharks and 1 ray) (Figure 2). Following the classification of elasmobranchs that occur in nonmarine environments by Grant et al. (2019), only four chondrichthyans reported in Panama have some occurrence in nonmarine environments (including freshwater). Among them, three are euryhaline generalist species, largetooth sawfish (*P. pristis*), bull shark (*C. leucas*) and longnose stingray (*Hypanus guttatus*), and one is an estuarine generalist species, smalltooth sawfish (*P. pectinata*) (Figure 2).

3.3 | Extinction Risk

Extinction risk is high among Panama chondrichthyans, with 53 species (47.3%) threatened with extinction, comprising 10 CR species (8.9%), 17 EN species (15.2%) and 26 VU species (23.2%) (Figure 3; Table S2). This is higher than the global extinction risk level of 32.0% threatened species (7.4% CR, 10.3% EN and 14.3% VU) (IUCN 2024). Least Concern species represent a high proportion (41 species; 36.6%), NT a moderate proportion (16 species; 14.3%) and DD a very low proportion (2 species; 1.8%) (Figure 3; Table S2). This follows a similar pattern in comparison to the global status of chondrichthyans (10.4% NT, 43.6% LC and 14.0% DD; IUCN 2024).

The number of threatened chondrichthyans is higher for Pacific Panama (39 species) than in Caribbean Panama (24 species) (Table S2). In general, sharks are the group most threatened (30 of 56 species; 53.6%), with 21 species in Pacific Panama compared to 19 threatened species reported for Caribbean Panama (Table S2). Of the 50 ray species, 23 (46.0%) are considered threatened, with 18 species at risk in Pacific Panama, compared to just 5 species in the Caribbean (Table S2). No chimaera species are threatened. There are the same number of

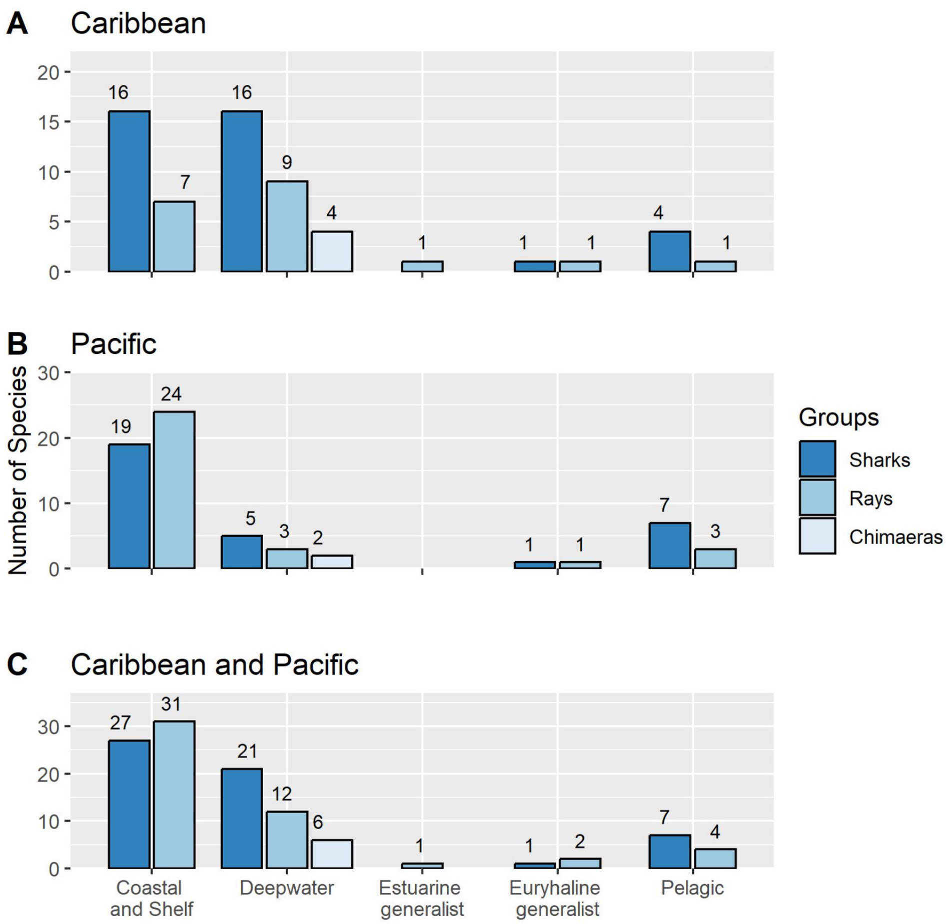

FIGURE 2 | Number of chondrichthyan species reported for Panama by habitat type. Number of species reported for (A) Caribbean; (B) Pacific; and (C) Caribbean and Pacific combined by habitat type. Five types of habitats are reported: coastal and shelf, deepwater, estuarine generalist, euryhaline generalist and pelagic (see text for definitions).

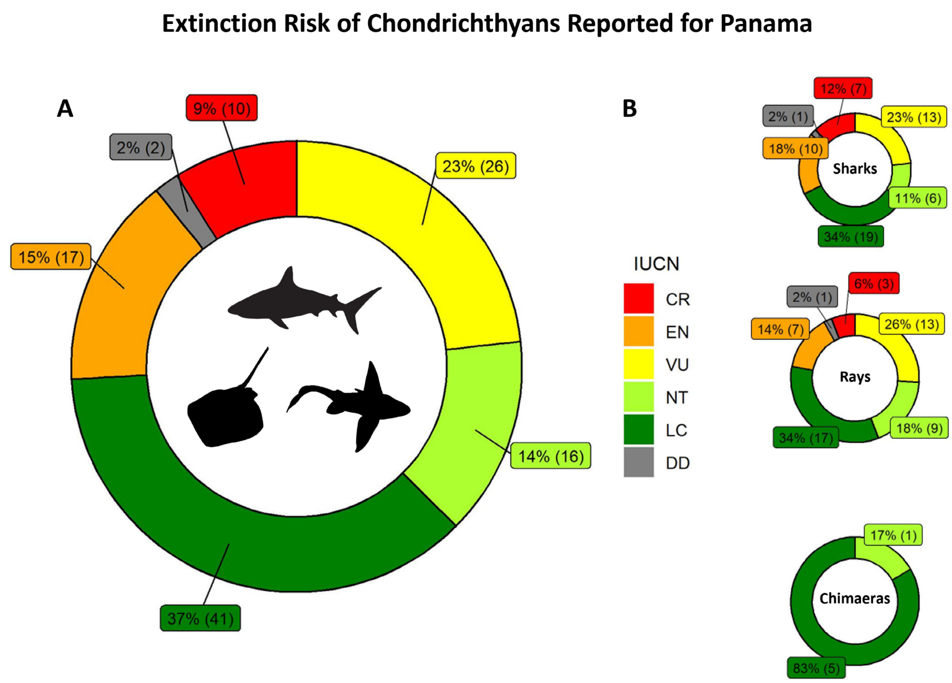

FIGURE 3 | IUCN Red List of Threatened Species status of chondrichthyan species reported for Panama. (A) status for all chondrichthyan species and (B) status by group (sharks, rays and chimaeras). The percentage of species in each category is provided with the number of species given in parentheses. IUCN Red List Categories: CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient. *Source*: IUCN (2024).

NT species in each of Pacific and Caribbean Panama (9 species each), whereas there are more LC species (27) in Caribbean Panama than Pacific Panama (15 species) (Table S2).

3.4 | Drivers of Extinction Risk

3.4.1 | Fisheries

Fishing pressure represents the most significant driver of risk for shark and ray populations in Panama. Because chimaeras are not targeted in fisheries and constitute minimal bycatch, this section will focus on sharks and rays. According to national statistics, from 1991 to 2020, shark and ray production represented an average of ~6400 t annually, or 0.95% per year of the total marine fisheries production of the country (Figure 4; Figure S1) (FAO 2020). The data showed two contrasting periods of catch: (1) 2000–2009, with an average of 5152 t/year and a peak in 2009 at 7033 t (~2.9% of the total national marine fisheries production), and (2) 2010–2020, with an average of 677 t/year and a peak in 2013 at 2127 t. The lowest reported catch fell outside these periods at 85 t in 1995 (0.04% of national production) (Figures 4 and S1). The reasons for variability in annual catches are unclear but may relate to changes in fisheries monitoring and data collection or changes in regulations, for example, since 2010, authorities banned longline vessels over six tons from operating in Panamanian waters (Guzman et al. 2020). Regardless, official shark catch records in Panama appear to be severely underestimated. Reconstruction of marine fisheries catches in Panama from 1950–2010 (Harper et al. 2014) and from 2011–2018 (Brown and Derrick 2020) estimated that ~75% of shark catches are missing from official statistics.

Limited data collection restricts an accurate assessment of catches (Guzman et al. 2020; Návalo et al. 2021). Species-specific catch data are available for only a few species reported in industrial and semi-industrial fisheries, although the time period of data availability is variable, and contemporary data are generally lacking. For shortfin mako (*Isurus oxyrinchus*), the average reported catch during 1999–2014 was 11.43 t/year with a peak of 49 t in 2007; for blacktip shark (*Carcharhinus limbatus*), the average reported catch during 2006–2014 was 8.44 t/year with a peak of 21 t in 2007; and for blue shark (*Prionace glauca*), the average reported catch during 1999–2019 was 258.9 t/year with peaks of 1134 t in 2008 and 1574 t in 2009 (FAO 2020). During the period 2006–2009, fishing statistics from a seafood processing company found that an average of 193 ± 31.2 t/year of sharks was caught in the Gulf of Panama and Gulf of Chiriquí (Guzman et al. 2020). Species and genera-specific data over this period are available for Pacific nurse shark (*Ginglymostoma unami*) (9.58 ± 4.1 tyear), pelagic thresher (*Alopias pelagicus*) (30.85 ± 11.9 t/year), tiger shark (*Galeocerdo cuvier*) (0.36 ± 0.3 t/year), requiem sharks (*Carcharhinus* spp.) (118.05 ± 20.6 t/year) and hammerheads (*Sphyrna* spp.) (35.67 ± 17.1 t/year) (Guzman et al. 2020).

In official landing data, sharks are commonly registered as 'Tiburón' or 'Cazón', and rays as 'Raya' or 'Mantarraya', which precludes species-level analyses of catch and trends. Monitoring surveys do, however, provide information on species that interact with major fishery types (Table 1). Four shark families, requiem (Carcharhinidae), thresher (Alopiidae), hammerhead (Sphyrnidae) and hound (Triakidae) sharks, and four ray families, stingrays (Dasyatidae), round rays (Urotrygonidae), pelagic eagle rays (Aetobatidae) and guitarfishes (Rhinobatidae), are the most exploited on both coasts of Panama (Table 1). This is consistent with global exploitation, where these families often dominate catches (Dulvy et al. 2021). At the species level, 40 chondrichthyan species (28 sharks; 12 rays) have been documented as being exploited by fisheries (Table 1), although the number of species interacting with fisheries is certainly higher

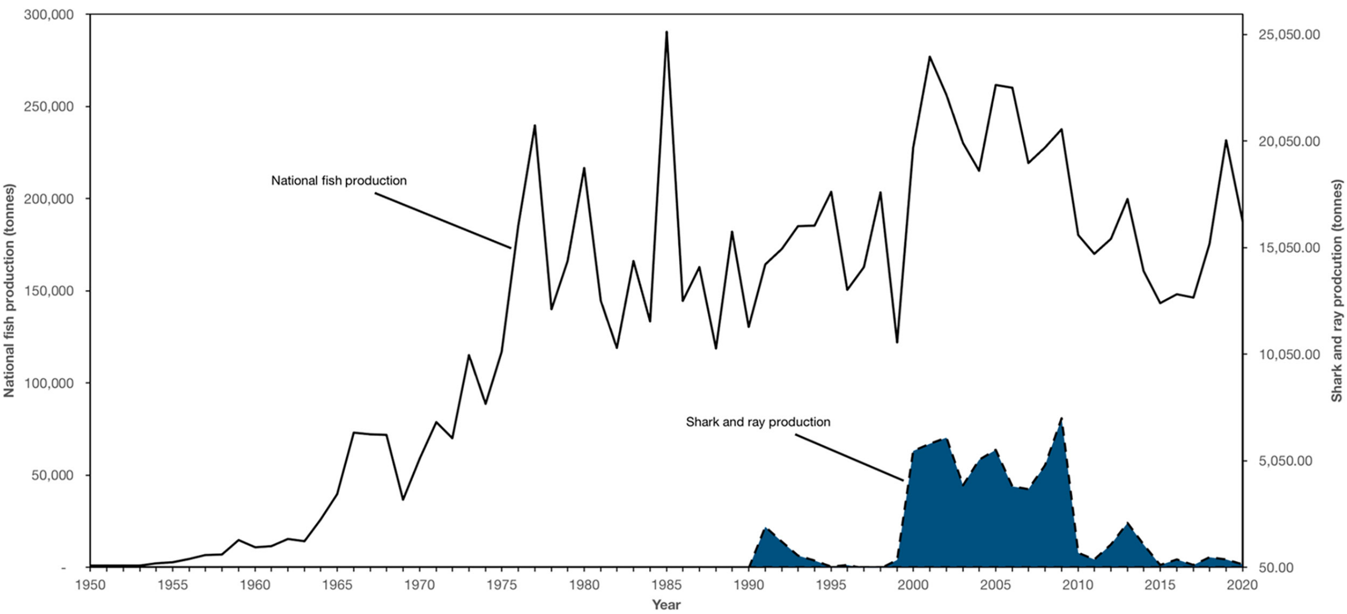

FIGURE 4 | National shark and ray production in Panama relative to national fish production. National fish production data cover the period 1950–2020, and national shark and ray production covers the period 1991–2020. *Source*: FAO (2020). Note the different scales on the axes where these are 1 order of magnitude apart.

TABLE 1 | Sharks and rays caught by fishery type in Panama. We calculated the percentage contributions of species for each fishery type by summing the number of individuals or volume captured and registered by each type of fishery in the following literature: Rodríguez-Arriatti (2014), Robles et al. (2015), CeDePesca (2016), Franco and Sánchez (2016), Guzman et al. (2020), FAO (2020), Arriatti et al. (2021), Návalo et al. (2021) and Vega et al. (2023). These references encompass the majority of Panama's fisheries and the shark and ray species that they interact with. IUCN Red List Categories: CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient(IUCN 2024). CITES, Convention on International Trade in Endangered Species of Wild Fauna and Flora: Appendix I, international trade prohibited (none of the species below are listed under this appendix); Appendix II, international trade regulated.

	Pacific				Caribbean
Species (IUCN Red List Category; CITES Appendix)	**Small-scale fisheries**	**Semi-industrial fisheries**	**Industrial pelagic fisheries[a]**	**Small pelagic fisheries**	**Small-scale fisheries**
Sharks					
Alopias pelagicus (EN; II)	0.15	12.15			
Alopias superciliosus (VU; II)	0.01				
Carcharhinus acronotus (EN; II)					1.65
Carcharhinus cerdale (CR; II)	7.9	1.92		0.77	
Carcharhinus falciformis (VU; II)	0.09	50.51			
Carcharhinus galapagensis (LC; II)	0.08			0.39	
Carcharhinus leucas (VU; II)	0.68				
Carcharhinus limbatus (VU; II)	2.55	1.14	1.33		0.99
Carcharhinus obscurus (EN; II)	0.1				
Galeocerdo cuvier (NT)	0.12	1.62			
Ginglymostoma cirratum (VU)					0.33
Ginglymostoma unami (EN)	0.24	1.97			
Heterodontus mexicanus (LC)		0.72			
Isurus oxyrinchus (EN; II)			3.21		
Mustelus dorsalis (VU)	0.04				
Mustelus henlei (LC)	0.86				
Mustelus lunulatus (LC)	2.16	9.28			
Nasolamia velox (EN; II)	1.75	1.56			
Prionace glauca (NT; II)	0.09	0.24	95.45		
Rhizoprionodon longurio (VU; II)	8.21	6.04			
Rhizoprionodon porosus (VU; II)					46.86
Sphyrna corona (VU; II)	2.6			2.7	

(Continues)

Species (IUCN Red List Category; CITES Appendix)	Pacific				Caribbean
	Small-scale fisheries	Semi-industrial fisheries	Industrial pelagic fisheries[a]	Small pelagic fisheries	Small-scale fisheries
Sphyrna lewini (CR; II)	69.47	12.81		96.14	34.32
Sphyrna media (CR; II)	0.73	0.06			
Sphyrna mokarran (CR; II)	0.02				0.66
Sphyrna tiburo (EN; II)	2.02				15.18
Sphyrna zygaena (VU; II)	0.02				
Triaenodon obesus (VU; II)	0.04				
Rays					
Aetobatus laticeps (VU)	0.98			28.89	
Hypanus dipterurus (VU)				6.67	
Hypanus longus (VU)	83.33			28.89	
Mobula munkiana (VU; II)	0.98				
Pseudobatos glaucostigmus (VU; II)	1.96				
Pseudobatos leucorhynchus (VU; II)	5.88				
Rostroraja velezi (VU)	0.98				
Styracura pacifica (VU)				4.44	
Urotrygon chilensis (NT)	1.96				
Urotrygon rogersi (NT)				31.11	
Zapteryx xyster (VU)	3.92				

[a]Refers to the percentage of the volume captured (in tonnes) from 1990 to 2020 (FAO 2020). The maximum number of individuals reported, as mentioned in the literature and by fisheries, is as follows: small-scale fisheries (sharks: 9951; rays: 102), Semi-industrial fisheries (sharks: 1671), small pelagic fisheries (sharks: 259; rays: 45) and small-scale fisheries in the Caribbean (sharks: 303).

when accounting for undocumented bycatch and discards. The most landed species includes many threatened species (IUCN 2024; Table 1), for example, *A. pelagicus* (EN), *S. lewini* (CR) and *C. falciformis* (VU), which are also migratory species that have undergone considerable global population decline (Pacoureau et al. 2021).

Small- and large-scale fisheries display differences in species catch composition, generally reflecting the habitat and spatial extent of fishing grounds. Small-scale fisheries (mainly gillnet and longline) interact more commonly with small to medium-sized inshore, coastal and estuarine species such as *S. lewini*, *R. longurio*, *C. limbatus*, Pacific smalltail shark *C. cerdale* and *Mustelus* spp. (e.g., Robles et al. 2015; Guzman et al. 2020; Arriatti et al. 2021); the nearshore industrialized purse seine fishery for small pelagic fishes in the Gulf of Panama (CeDePesca 2016) interacts with species such as *S. lewini* and scalloped bonnethead *S. corona*; and industrial longline fisheries operating on pelagic fishing grounds in the Gulf of Panama and Gulf of Chiriquí interact with larger-sized oceanic species such as *Alopias* spp., *C. falciformis*, *S. lewini* and *P. glauca* (Table 1). For species with complex life-histories encompassing inshore and offshore habitats, for example, *S. lewini*, fishing pressure may be exerted across the entire seascape and across life stages (Chávez et al. 2023). This species is the most exploited chondrichthyan in Panama and is globally Critically Endangered (IUCN 2024), occupying nearshore estuarine and mangrove habitats as neonates and early juvenile life stages, and pelagic habitats as larger juveniles and adults (Klimley and Nelson 1984; Duncan and Holland 2006). This species is subject to exploitation across its range of habitats in Panama.

3.4.2 | Habitat Modification

Habitat modification represents another critical threat to chondrichthyans. Habitat loss and degradation have impacted ~31% of threatened chondrichthyans globally (Dulvy et al. 2021). Coastal development in Panama has intensified in recent decades due to increases in population density, urbanization and tourism and industrial development (including ports). Such coastal changes may disrupt critical functions provided by coastal and estuarine environments, such as feeding and nursery grounds for shark and ray populations. For example, 11 potential shark nursery areas have been identified in Pacific Panama (Guzman et al. 2020) and at least two in Caribbean Panama (Návalo et al. 2021; Chevis and Graham 2022). The majority of these are inside or near mangrove-estuarine habitats. This habitat is under severe pressure, with 64% of the total mangrove cover in Panama lost in recent decades (López-Angarita et al. 2018). Notably, this habitat loss has impacted mangroves in protected areas such as Panama Bay (Castellanos-Galindo et al. 2017), a Wetland of International Importance (Ramsar Site). Thus, although protected areas are critical for the conservation of chondrichthyan populations, the enforcement of regulations is crucial for effective management of coastal marine habitats in Panama.

3.4.3 | Climate Change

The consequences of a changing climate on chondrichthyans in Panama remain unclear. Potential changes associated with climate change, such as ocean acidification, decreased oxygen levels, changed freshwater input and extreme thermal events, may be more pronounced on coral reefs than other habitats, which may make reef-associated species more susceptible to change (Chin et al. 2010). It is anticipated that climate change could potentially impact species distribution, behaviour and the availability of food resources, as well as alter life-history traits like growth rates and reproduction (Heupel et al. 2019). A deeper understanding of the potential impacts of climate change on chondrichthyans in Panama is urgently needed.

3.4.4 | Pollution

Marine pollution represents one of the most critical and increasing threats in the Anthropocene (Willis et al. 2022). Chondrichthyans can be exposed to pollution (e.g., metal, plastic, chemical and pharmaceutical pollution), which may pose health risks to the species themselves as well as human populations through consumption (Lipej et al. 2022; Tiktak et al. 2020). How pollutants impact chondrichthyans has not been evaluated in Panama. Notably though, various pollutants associated with urban wastewater discharge and industrial and agricultural practices, such as pharmaceutical components, metals, pesticides and plastics, have been detected in rivers, which discharge into the coastal marine environment of Panama (Wilkinson et al. 2022; Wilson et al. 2021). It remains unclear whether certain pollutants may become detrimental for specific populations in the future. This underscores the need for research to better understand the actual risks that pollutants pose to chondrichthyans.

3.4.5 | Policy Tools

National, regional and international policy tools relevant to chondrichthyans are in place in Panama. This includes five domestic policy tools, eight regional tools and three international tools (Table S3). The primary domestic legal tool for shark conservation is Law No. 9 of March 2006, which prohibits 'finning' or the practice of removing the fins of sharks and discarding the carcasses at sea. This regulation allows the landing of fins only if the total fin weight represents < 5% of the total shark carcass weight landed by vessel and by trip. Such fin-to-carcass ratios have some drawbacks, notably (1) restricting reliable identification of morphologically similar species in catch monitoring and (2) allowing potential up-valuing of catch where lower value fins are discarded for more valuable product because fins do not have to match carcasses (Shiffman and Hammerschlag 2016). Requiring sharks be landed with fins naturally attached circumvents these issues and allows accurate identification of landings. There is a new proposed law to change existing Law 9 to increase the conservation of sharks in Panama, which includes the requirement to land sharks with fins naturally attached (Vasquez 2023). However, the Panamanian government has not yet approved the proposal.

Panama is a signatory of several international treaties, such as the Convention on Migratory Species (CMS) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Table S3). CMS aims to provide a framework for the coordination of measures to improve the conservation of listed species, whereas CITES aims to regulate international trade. CITES Appendix II controls international trade through export permits where 'the specimen was legally obtained and if the export will not be detrimental to the survival of the species' (CITES 2024). This appendix includes many of the commonly exploited sharks of Panama, such as requiem sharks and hammerheads (Table 1). Under an Appendix II listing, export permits are issued by the CITES authority of the exporting country (i.e., Panama). A search of the online CITES database (https://trade.cites.org/en/cites_trade/) containing all CITES permits issued by Panama from 1975 to 2023 found only a single record of a species exported for commercial purposes (23 t of *I. oxyrhynchus* in 2020). However, the CITES database does not clearly state the origin of this record. Thus, this could be from Panama or another country or territory. Additional export permits were issued for scientific samples only (e.g., *S. lewini* and sawfishes, *Pristis* spp.). Considering the frequency at which CITES-listed species are landed in Panama (Table 1), the lack of CITES permit records indicates that species are either traded and consumed domestically only or exported without the necessary export permits. This suggests the need to reinforce the management and controls for the international trade of threatened species in the country, as has been suggested in previous reports (Ross et al. 2019).

Area-based management, including Marine Protected Areas (MPAs), is an important tool for chondrichthyan conservation (Chin et al. 2023; Davidson and Dulvy 2017). These areas act to preserve the abundance and diversity of marine organisms by reducing human activities and maintaining and recovering fishery productivity (Grorud-Colvert et al. 2021; Lynham and Villaseñor-Derbez 2024). In Panama, there are 29 MPAs with delimited polygons (www.protectedplanet.net). These protected areas cover ~54% (117,574.29 km^2 of 331,318 km^2 total marine and coastal area) of Panama, including the Cordillera de Coiba seamounts, which is critically important for the protection of deep-sea shark species (Guzmán et al. 2024). Panama's MPA network was implemented broadly for marine management purposes, not necessarily factoring in chondrichthyans, their critical habitats and their life-history. Important Shark and Ray Areas (ISRAs) are a new spatial planning approach aiming to highlight 'discrete, three-dimensional portions of habitat important for one or more shark, ray, or chimaera species' (Hyde et al. 2022). Six ISRAs were recently delineated in Pacific Panama, covering areas of importance for threatened species, range-restricted species, reproductive areas, feeding areas, resting areas, areas important for movement and areas of high diversity (Table 2; https://sharkrayareas.org/e-atlas/). Because these six ISRAs represent critical areas for shark and ray populations in Panama, they could be useful for designing or strengthening area-based management measures (e.g., MPAs) that strengthen conservation measures and sustainable fisheries. ISRA delineation is yet to occur in Caribbean Panama.

3.5 | Recommendations to Address Knowledge Gaps and Improve Management

3.5.1 | Research and Education

Although chondrichthyan research and public awareness in Panama have increased in recent years, there are considerable knowledge gaps that need to be addressed to meet management needs. These gaps exist across both Pacific and Caribbean Panama, although it is worth noting that very little research has historically been conducted in Caribbean Panama, where the largest marine protected area of the country, Banco Volcan, was established in 2023. Research and education recommendations are hereby presented (Table 3) focusing on (1) biology, distribution, habitat and status and (2) socioeconomic values and livelihoods. Engagement and partnership building are further cross-disciplinary elements required to meet research and education needs. For example, establishing agreements and partnerships between universities, non-governmental organizations and local authorities will assist in implementing these recommendations.

Understanding the basic biology, distribution and habitat of species is essential to ensure a strong foundation for implementing management (Jorgensen et al. 2021). Life-history parameters such as reproductive biology, age and growth, and natural mortality have been little studied in Panama (e.g., Guzman et al. 2020). There is a clear need to support basic biological and ecological research, including for exploited species where biological parameters can be applied to stock assessments and demographic analyses. Such analyses can provide understanding of species productivity and resilience, which, together with fishery-independent surveys to monitor catch and abundance (Rago 2005), can inform population status assessments (with priorities including exploited and threatened species).

Species-specific habitat use and movement patterns have also been little studied in Panama and have thus far focused on the whale shark *Rhincodon typus* (Guzman et al. 2018; Guzmán et al. 2022). Telemetry can provide insights into habitat occupancy, migration pathways, overlap with fishing grounds and movement between jurisdictions where transboundary management measures may need to be considered (Klimley et al. 2022; Lea et al. 2016; Queiroz et al. 2019). Mapping critical habitats can help understand areas of importance and guide spatial management (Hyde et al. 2022). One such example of critical habitat is reproductive areas (e.g., nursery areas), which have been identified for several species in Pacific Panama (e.g., *S. lewini*, bonnethead shark *S. tiburo*, *C. cerdale*; Guzman et al. 2020; Rodríguez-Arriatti 2014; Vega et al. 2023) and Caribbean Panama (e.g., *C. limbatus*, *S. lewini*; Chevis and Graham 2022; Návalo et al. 2021). Some reproductive areas, for example, the Tuira River and tributaries in Darién Province of Pacific Panama, a remanent nursery area for *P. pristis*, have been delineated as Important Shark and Ray Areas (https://sharkrayareas.org/e-atlas/), although further research is required to identify and map reproductive areas for poorly known species such as round rays (Morales-Saldaña et al. 2022). Given the severity of mangrove loss in Panama and Central America more broadly (López-Angarita et al. 2018), developing restoration plans with shark life-history in mind may facilitate enhanced conservation outcomes, particularly given that all species listed above for which reproductive areas have been identified are globally threatened species (IUCN 2024).

An understanding of perceptions of sharks among the general community and socioeconomic values, including through use and livelihoods, can complement biological knowledge and improve the effectiveness of management uptake (Booth et al. 2019). Such assessments have yet to be undertaken in Panama but could consist of three linked components: (1) assessing public knowledge and attitudes towards chondrichthyans, their uses and values and their conservation; (2) surveying the socioeconomic value of domestic fisheries production, trade and consumption; and (3) evaluating sustainable livelihood alternatives for local communities (e.g., shark tourism). The primary chondrichthyan product consumed domestically is shark meat (Teplitzky 2005), whereas there appears to be little consumption of rays, and shark fin is generally exported to the Asian and Canadian markets (Teplitzky 2005; Ross et al. 2019) or sold to local Asian restaurants (Návalo et al. 2021). How these products contribute to economic, food and nutrition security in Panama is an area requiring investigation. Once societal and economic values are better understood, developing public awareness and media campaigns on the values and importance of sharks may aid their conservation.

The implementation of management measures that have the potential to reduce access to a natural resource can come with adverse economic effects, and thus, nonextractive activities such as shark dive tourism may offer alternative values and livelihoods (Gallagher and Hammerschlag 2011; Cisneros-Montemayor et al. 2013). Seasonal *R. typus* aggregation sites at Coiba Island in the Gulf of Chiriquí and Archipelago las Perlas in the Gulf of Panama (Guzmán et al. 2022) may present opportunities for further development of shark tourism. To mitigate any negative consequences of such activities (e.g., habitat degradation, stress and alteration of shark behaviour; Montero-Quintana et al. 2020; Wong et al. 2019), guidelines for appropriate development for tourism activities associated with sharks and rays have been developed in Panama (Posada and Haubold 2017). However, it would also be beneficial to assess the effectiveness of these guidelines in mitigating these negative impacts. Understanding how well these guidelines reduce disturbances to shark and ray populations is crucial for ensuring sustainable ecotourism practices. Future research should evaluate compliance with these guidelines, their enforcement mechanisms and their long-term ecological and socioeconomic outcomes.

TABLE 2 | Description of the six Important Shark and Ray Areas (ISRA) of Pacific Panama (ISRA have not yet been delineated for Caribbean Panama).

ISRA details	Source
Gulf of San Miguel and Tuira River Depth range: 0–30 m; Size: 2623 km^2	https://sharkrayareas.org/portfolio-item/gulf-san-miguel-tuira-river-isra/
Description: This ISRA is located in Panama's far east, bordering Colombia. The area includes Punta Patiño, an internationally significant wetland (Ramsar Site). It is made up of a complicated network of rivers, deltas, mudflats and mangrove forest and includes Panama's largest watershed, the San Miguel. The Tuira River, Panama's biggest river and many tributaries, including the Tuquesa River, a tributary of the Chucunaque River, are also included.	
ISRA Criteria: Gulf of San Miguel and Tuira River is a crucial area for Largetooth Sawfish (*Pristis pristis*) reproduction and has been highlighted as a bright spot in the Eastern Pacific for this severely threatened species. This is owing to multiple recent reports in the area including neonates indicating the persistence of a breeding population.	
Northern Gulf of Panamá Depth range: 0–125 m; Size: 12,721 km^2	https://sharkrayareas.org/portfolio-item/northern-gulf-of-panama-isra/
Description: This ISRA encompasses a diverse range of coastal, shelf and insular habitats, including coral reefs, muddy substrates, rocky shorelines, rivers and mangrove ecosystems. Oceanographic characteristics promote high levels of primary productivity, including seasonal upwellings. The area encompasses significant biological reserves, including Wetlands of International Importance, a national mangrove-estuaries protected area and Las Perlas Archipelago, a cluster of 255 islands, which is regarded as the second-largest archipelago in the Eastern Tropical Pacific.	
ISRA Criteria: Northern Gulf of Panama is a reproductive area for Scalloped Hammerhead (*Sphyrna lewini*) and a feeding area for Whale Shark (*Rhincodon typus*). The area is home to several threatened species, such as Whitesnout Guitarfish (*Pseudobatos leucorhynchus*) and species with a restricted range, such as Southern Banded Guitarfish (*Zapteryx xyster*). Lastly, the area sustains a high diversity of sharks (21 species).	
Punta Chame and Panama Bay Depth range: 0–30 m; Size: 2623 km^2	https://sharkrayareas.org/portfolio-item/punta-chame-panama-bay-isra/
Description: This ISRA is divided into two distinct sections in the northern Gulf of Panama, which are separated by Panama City and the Panama Canal. The area includes the Panama Bay Wetland of International Importance (Ramsar Site) and habitats such as coastal mangroves and large mudflats with a high fish diversity. Oceanographic characteristics include periods of coastal upwelling, which result in seasonal fluctuations in marine productivity.	
ISRA Criteria: Punta Chame and Panama Bay is characterized by the presence of reproductive areas for the Critically Endangered Scalloped Hammerhead. The area also supports the threatened and range restricted Southern Banded Guitarfish.	
Gulf of Montijo Depth range: 0–50 m; Size: 868 km^2	https://sharkrayareas.org/portfolio-item/gulf-of-montijo-isra/
Description: This ISRA is located in central Pacific Panama. The Gulf of Montijo is designated as a Wetland of International Importance (Ramsar Site) and is incorporated into Panama's protected areas system as the Golfo de Montijo area de Recursos Manejados (Area of Managed Resources). It consists of a complex of coastal wetlands with deltas, rocky shores, mudflats, several species of mangroves and around 45 rivers and over 1000 streams. The area contains a cover of 190 km^2 of mangrove forest, which is considered one of the most important in Panama for its size and productivity. The area includes notable large islands, such as Isla Leones and Isla Cébaco, which are located in the middle and the entrance to the gulf, respectively.	
ISRA Criteria: Gulf of Montijo is a reproductive area for Scalloped Hammerhead and Scalloped Bonnethead (*Sphyrna corona*). The area is also a bright spot for Largetooth Sawfish, one of the most threatened chondrichthyan species, with multiple contemporary records.	

(Continues)

TABLE 2 | (Continued)

ISRA details	Source
Gulf of Chiriquí Depth range: 0–1000 m; Size: 7494 km^2	https://sharkrayareas.org/portfolio-item/gulf-of-chiriqui-isra/
Description: This ISRA covers a relatively large area of continental shelf in western Pacific Panama. It includes the Coiba National Park and its special zone of marine protection, which has been identified by UNESCO as a World Heritage Site. The area is located in the Corredor Marino del Pacific Oriental Tropical Ecologically or Biologically Significant Marine Area. The Gulf of Chiriquí contains 38 islands, including Coiba Island, which is the largest island in Pacific Central America. The area includes various habitats such as mangroves, seagrasses, coral reefs and sandy substrates.	
ISRA Criteria: The area is important for reproduction of Scalloped Hammerheads and Pacific Smalltail Shark (*Carcharhinus cerdale*). The area is an important foraging ground and movement area for Whale Sharks and an important resting area for Whitetip Reef Sharks (*Triaenodon obesus*), which are often seen resting in the rocky shorelines and coral reef zones of Coiba National Park. Lastly, Gulf of Chiriquí sustains a high diversity of threatened sharks (22 species).	
Panama Muertos Bay Depth range: 0–33 m; Size: 304 km^2	https://sharkrayareas.org/portfolio-item/panama-muertos-bay-isra/
Description: This ISRA covers a significant estuarine and riverine area in the western portion of the Gulf of Chiriquí. The area has a variety of marine, estuarine, and freshwater ecosystems, such as sandy beaches, mudflats, islands, rivers and, importantly, large mangrove forests in good biological condition. It overlaps with the Eastern Tropical Pacific Marine Corridor Ecologically or Biologically Significant Marine Area (EBSA).	
ISRA Criteria: Panama Muertos Bay is an important reproductive area for at least four different species of sharks: Scalloped Hammerhead, Blacktip Shark (*Carcharhinus limbatus*), Bonnethead Shark and Pacific Smalltail Shark.	

3.5.2 | Management

Relevant policy tools for the management and conservation of chondrichthyans in Panama have been outlined above. Additional management recommendations along with avenues to strengthen existing measures are hereby presented (Table 3). To better facilitate the development, implementation and enforcement of management measures, there is a need to strengthen human resource and institutional capacity for fishery monitoring, compliance and surveillance in Panama. Existing (e.g., current finning regulations) and newly implemented measures (e.g., our recommendation that sharks are required to be landed with fins naturally attached) require enforcement to be effective. This can only be achieved by strengthening resourcing, capacity and training, some of which will need to be developed at the regional level to promote the conservation and sustainable fishing and trade of migratory and transboundary species (Becerril-García et al. 2022).

As noted in this review, official shark and ray catch records in Panama appear to be significantly underestimated, with species-specific catch and trade data generally lacking. Improving fishery data collection to the species-specific level is needed for target and bycatch species, with priorities being heavily exploited threatened species. Expanding monitoring programmes to encompass all fisheries, including industrial shrimp trawl and semi-industrial longline fisheries, through the implementation of human observer programmes or electronic monitoring systems, would significantly improve species-specific data collection and catch monitoring (Gilman et al. 2019). This includes for rays, for which there has been little monitoring of catches in Panama, despite threatened species such as whitesnout guitarfish *Pseudobatos leucorhynchus* and longtail stingray *Hypanus longus* (both VU; IUCN 2024) being among the most frequent species of rays caught in Pacific Panama (Table 1). Further, *H. longus* is subject to targeted fishing by benthic longlines in the Gulf of Panama (Rodríguez-Arriatti 2011), yet monitoring is not in place. Therefore, exploited threatened species (CR, EN and VU) will need science-based catch restrictions, monitoring and data collection to ensure sustainability. For severely depleted species such as sawfishes (CR; IUCN 2024), complete protection is needed to permit the recovery of their populations.

Panama is a signatory to a variety of regional and international agreements aimed at resource sustainability, improved environmental outcomes and limiting negative impacts on at-risk species. A review of these instruments and their effectiveness and enforcement in Panama is recommended to identify opportunities for improvement. Effective compliance and enforcement with CITES, for example, would likely provide strong conservation outcomes for chondrichthyans listed on this agreement. Although Panama is a signatory to CMS, it has not signed the CMS Sharks MoU (Memorandum of Understanding on the Conservation of Migratory Sharks). By becoming a signatory to the Sharks MoU, Panama could not only enhance its international visibility in the field of shark conservation through cooperating with global shark conservation efforts but could also develop partnerships with other signatories that would benefit migratory sharks in the region.

The existing marine protected area network in Panama consists of 29 designated areas, whereas the ISRA process has highlighted

TABLE 3 | Recommended actions to improve the conservation and management of chondrichthyans in Panama. Recommendations are categorized into short-term actions (those that can be achieved in the immediate future), medium-term actions (those that will take a few years to achieve) and long-term actions (broader goals that may take many years to achieve).

Research and education	Timescale
Increase basic biological and ecological research, particularly for exploited species (see Table 1)	Medium
Conduct regular fishery-independent surveys to assess population status of exploited, bycatch and threatened species	Long
Assess the implementation of gear technology for bycatch reduction and mitigation (e.g., electrical deterrents and LED lights)	Long
Assess the trauma and injuries caused by fishing gear, along with the postcapture survival of bycatch	Medium
Map critical areas for sharks and rays to inform spatial management	Medium
Develop and implement restoration plans for critical habitats for chondrichthyans (e.g., mangroves and coral reefs)	Long
Undertake a survey of public knowledge and attitude towards chondrichthyans, their uses and values, and their conservation	Short
Undertake a socioeconomic survey of domestic values, trade and consumption of sharks and rays	Short
Evaluate sustainable livelihood alternatives for local communities (e.g., shark tourism)	Medium
Develop a strategic public awareness and media campaign on the values and importance of sharks and their conservation	Short
Establish agreements between universities and local authorities to conduct biological and ecological research, conservation planning and livelihoods research	Medium
Management	**Timescale**
Strengthen human resource and institutional capacity for fishery monitoring, compliance and surveillance	Long
Improve current general fishery data collection to the species-specific level (catch composition, catch-per-unit-effort and landings)	Medium
Improve fishery data collection to species-specific level for bycatch and discards	Medium
Extend observer programmes (either human observers or electronic monitoring systems) to all fisheries (e.g., industrial shrimp trawl fisheries and semi-industrial longliners)	Medium

(Continues)

TABLE 3 | (Continued)

Management	Timescale
Enforce current fishery regulations (e.g., finning bans)	Long
Implement new finning strategies, particularly requiring sharks be landed with fins naturally attached	Short
Establish maximum fishing limits for each targeted species based on scientific recommendations	Long
Develop and apply regulations that ensure the complete protection of all Critically Endangered species (e.g., a law that bans the fishing and commercialization of sawfishes, *Pristis* spp.)	Short
Review the effectiveness and enforcement of regional and international agreements in Panama to identify opportunities for improvement	Short
Ensure compliance and enforcement of international agreements (e.g., CITES and CMS) to regulate the international trade of threatened species and improve conservation of listed species	Long
Sign the CMS Sharks MoU (Memorandum of Understanding on the Conservation of Migratory Sharks)	Short
Strengthen marine protected area (MPA) enforcement	Long
Establish MPA no-take zones to restrict shark and ray fisheries and protect critical habitats for migratory and threatened populations	Long
Develop and implement regional collaborations that promote the conservation and sustainable fishing and trade of migratory sharks	Long
Develop effective MPA management and species conservation plans	Medium
Update the National Plan of Action for the Conservation and Management of Sharks (NPOA-Sharks)	Short

regions of particular significance for chondrichthyans in the Pacific waters of the country (Table 2) (this process will later be expanded to include the Caribbean region). Strengthening the enforcement of existing MPAs and establishing additional areas, which may include no-take zones to restrict fisheries and protect critical habitats for migratory and threatened populations, would assist in permitting species recovery. Developing effective MPA management plans will help implement and guide the management of reserves. Such management plans can be complementary to individual or multi-species conservation plans, which aim to ensure resource sustainability and species recovery. Finally, Panama's National Plan of Action for the Conservation and Management of Sharks (NPOA-Sharks) requires an update because it was published in 2017 (Posada et al. 2017).

4 | Conclusion

Despite the small size of the country, Panama supports a diversity of chondrichthyans (112 species comprising 56 sharks, 50 rays and 6 chimaeras), occupying habitats from rivers and estuaries to the deepsea and pelagic zones. A high proportion of these (47.3%) are globally threatened with extinction. Fishing activities from both small- and large-scale fisheries are the major stressors acting on populations, although the degree of habitat modification (particularly mangrove loss) is another significant threat. Although a number of policy tools are in place, deficiencies in monitoring, enforcement and compliance are limiting their effectiveness. We make a series of recommendations (Table 3) based on the status of chondrichthyans revealed through our review that would improve the conservation and management of Panama's sharks, rays and chimaeras. If effectively implemented, these would furthermore assist Panama in meeting the 2030 Sustainable Development Goals (SDG), including SDG 14, which calls to 'conserve and sustainably use the oceans, seas, and marine resources for sustainable development' (https://www.globalgoals.org/goals/14-life-below-water/).

Ethics Statement

No ethical and permit approvals were required for this work.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data are available in the Supporting Information.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.