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ORIGINAL RESEARCH

Critical habitats for sharks and rays in Asia remain largely unprotected

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Abstract
The Asia region harbors exceptional chondrichthyan (shark, ray, and chimaera) diversity but faces intense fishing pressure. The Important Shark and Ray Area (ISRA) process provides a collaborative, evidence-based framework to identify critical habitats and inform spatial management. We assessed ISRAs across the Bay of Bengal, Southeast Asia, and the Northwest Pacific to characterize their extent, ecological significance, and conservation relevance. We delineated 122 ISRAs spanning ~ 1 million km^2 (~3% of the region) across 12 jurisdictions and international waters, encompassing habitats for 121 species (~ 30% of Asia's chondrichthyans), 76% of which are threatened. Depleted taxa (e.g., giant guitarfishes, Glaucostegidae) were represented, but charismatic megafauna (e.g., Whale Shark *Rhincodon typus*) were overrepresented. In contrast, deepwater and freshwater species were underrepresented. Reproductive Areas were the most common ISRA sub-criterion applied (52% of ISRAs), largely in nearshore zones, while areas for range-restricted species were less frequently (18%) identified. Twelve ISRAs overlapped with biodiversity hotspots, including seven in areas of high overall chondrichthyan species richness and five in areas of high range-restricted species richness. Citizen science was the predominant research method used to delineate ISRAs, while fisheries data were underused despite the region's major fisheries footprint. Geographic coverage was uneven: Indonesia held the most ISRAs (n = 40; 71.7% of ISRA coverage) while eight jurisdictions (e.g., Viet Nam, China, Republic of Korea) lacked ISRAs due to data gaps. Protection shortfalls are stark: MPAs cover < 5% of national waters in 16 jurisdictions (eight with < 1%); 5.4% of ISRA area lies within MPAs; and only 2.8% of ISRA spatial extent overlaps with no-take zones. These results provide a regional foundation to guide spatial planning, prioritize management, close data gaps, and support recovery of Asia's diverse and imperiled chondrichthyan assemblages.

Keywords Citizen science · Chondrichthyans · Conservation · Diversity hotspots · Marine protected areas · Spatial planning

Introduction

Marine biodiversity is declining at an unprecedented rate, threatening ecosystems and the vital services they provide (IPBES 2024). Among the main drivers of this decline are overexploitation (particularly from fisheries), habitat degradation, and climate change (e.g.O'Hara et al. 2021; Nikolaou & Katsanevakis 2023). To prevent species extinctions and safeguard ecosystems, urgent action is needed, particularly through the establishment of protected areas and sustainable management measures (Langhammer et al. 2024). Recent progress in marine conservation includes species recovery, habitat protection, and improved fisheries management (Knowlton 2021), although significant challenges remain due to growing demands on ocean resources, pollution, and climate change (Vargas-Fonseca et al. 2024). The Kunming-Montreal Global Biodiversity Framework (KMGBF), adopted under the Convention on Biological Diversity (CBD), commits governments to conserving 30% of Earth's land and seas by 2030 (Target 3; CBD 2022). For marine and coastal areas, this will be primarily achieved through the establishment and effective governance of Marine Protected Areas (MPAs) and Other Effective Area–based Conservation Measures (OECMs).

The Asia region is defined here as encompassing jurisdictions from the east coast of India to the Russian Federation and waters from the Bay of Bengal to the Sea of Okhotsk (hereafter referred to as 'Asia'). Most of this region stands as the global epicenter of marine biodiversity (Hoeksema 2007; Sanciangco et al. 2013) including the northwest Pacific as a major hotspot of chondrichthyan species richness (Lucifora et al. 2011; Stein et al. 2018; Dulvy et al. 2021). Asia also supports the highest global richness of chondrichthyans, with 399 species (~33% of all known sharks, rays, and chimaeras) (IUCN SSC SSG 2023a; Weigmann et al. 2024), including at least ten species occurring in freshwater habitats (Grant et al. 2019; Mather et al. 2023) and high levels of endemism in northeastern Asia (Stein et al. 2018). Yet this exceptional diversity is under acute pressure: 49% of Asia's chondrichthyans are threatened with extinction (sharks, 43%; rays, 59%) (IUCN SSC SSG 2023a), with ongoing population declines driven primarily by overexploitation (Clark-Shen et al. 2023). Alarmingly, the region has already recorded the first documented modern extinction of a marine fish species, the Java Stingaree (*Urolophus javanicus*), while the Lost Shark (*Carcharhinus obsoletus*) is considered Critically Endangered – Possibly Extinct (Dulvy et al. 2020; Constance et al. 2023). These stark realities, combined with dense human populations that rely heavily on aquatic resources for food, livelihoods, and trade (Pomeroy 2007; Brewer et al. 2013; Cinner et al. 2013; FAO and INFOFISH 2022; FAO 2024a, 2024b), highlight both the urgency and the opportunity to implement effective, regionally tailored conservation measures. To safeguard Asia's aquatic biodiversity, fisheries sustainability, and the well-being of coastal communities, as agreed under the KMGBF, immediate action is needed, making the identification of critical habitat a particularly high-impact opportunity in this region.

Four Asian nations, led by Indonesia, account for most of the global reported landings of chondrichthyans (Dent and Clarke 2015; Prasetyo et al. 2021; Worm et al. 2024) and dominate international trade in shark and ray products (Niedermüller et al. 2021; Clark-Shen et al. 2023; Palacios et al. 2024). Declines in reported catches and landings (Blaber et al. 2009; Arunrugstichai et al. 2018), together with shifting exploitation patterns (Bonfil 2002; Clark-Shen et al. 2025), suggest widespread stock depletion. Asia's exceptional chondrichthyan diversity, high endemism, and the contrasting ecological and threat profiles among species, such as differences in life history traits, habitat use, or exposure to fisheries, challenges conservation across this region (Salayo et al. 2008; Weigmann et al. 2024). A combination of spatial, temporal, behavioral, and species-specific measures – including protected areas, fisheries management (i.e., input and output controls), sustainable tourism, trade regulations, enforcement, and community engagement – are essential to stop ongoing population declines (Dulvy et al. 2017; Friedman et al. 2018; Albano et al. 2021; Booth et al. 2021).

Central to these efforts is the identification and protection of critical habitats that underpin chondrichthyan survival and recovery (Hyde et al. 2022). Such habitats support feeding, reproduction, resting, and movement, and are vital for the persistence of threatened species (Vance 2003; Taylor et al. 2005; Michael et al. 2006; Camaclang et al. 2015). Despite this importance, aquatic species remain underrepresented in spatial conservation efforts (Corrigan et al. 2014; Hyde et al. 2022), and data-driven designation processes may inadvertently reflect patterns of research effort and data availability rather than ecological priority, potentially resulting in spatial or taxonomic biases. To address these gaps, systematic identification of critical habitats for chondrichthyans is needed to strengthen representativeness in spatial conservation planning. As such, the IUCN Species Survival Commission (SSC) Shark Specialist Group (SSG) developed the Important Shark and Ray Areas (ISRA) approach (Hyde et al. 2022), which identifies 'discrete three-dimensional portions of habitat, important for one or more shark, ray, or chimaera species, that are delineated and have the potential to be managed for conservation' (Hyde et al. 2022).

Here, we assess critical habitats identified for chondrichthyans through the ISRA process in the Asia region, examining their characteristics, ecological significance, and conservation implications. Specifically, we aim to: (1) identify the species and ecological traits used for ISRA delineation, their extinction risk, and the ISRA Criteria applied; (2) examine overlap between ISRAs and partial or no-take MPAs to evaluate the current extent of protection of critical chondrichthyan habitats and how these relate to Target 3 of the KMGBF ('conserve 30% of land, waters and seas by 2030'); (3) evaluate the data types and methods used for ISRA delineation and their contributions across jurisdictions, species, and ISRA Criteria; (4) classify broad habitat types identified as critical under ISRA Criteria; and (5) assess spatial overlap between ISRAs and hotspots of species richness. This study provides the first comprehensive baseline for chondrichthyan habitat conservation in Asia, offering critical guidance for future research, management, and policy action in one of the world's most biodiverse yet heavily exploited regions.

Methods

Study area

For the purpose of the ISRA project, the 'Asia region' (thereafter referred to as 'Asia') was defined as encompassing the marine, coastal, and inland waters around the Bay of Bengal, Southeast Asia, and the Northwest Pacific Ocean, covering a total of 19 jurisdictions (countries and territories) and areas beyond national jurisdiction (Fig. 1; IUCN SSC SSG 2023b). Asia includes 13 Large Marine Ecosystems (LMEs), and several river basins where obligate freshwater and euryhaline generalist (hereafter 'freshwater species') chondrichthyan species are distributed (IUCN SSC SSG 2023b). This region covers the Food and Agriculture Organization of the United Nations (FAO) Major Fishing Areas 57, 61, and 71.

Identification of Important Shark and Ray Areas

We applied the ISRA Criteria (Hyde et al. 2022; IUCN SSC SSG 2024a) to identify and define areas based on the known regular and/or predictable presence and/or behaviour of chondrichthyans in Asia. Four criteria incorporating seven sub-criteria are included: *Vulnerability* (Criterion A; species listed as threatened [Critically Endangered, CR; Endangered, EN; or Vulnerable, VU] on the IUCN Red List of Threatened Species or a national assessment; IUCN 2025); *Range Restricted* (Criterion B; where a species' entire distribution is limited to one LME or two adjoining LMEs); *Life-History* (Criterion C; Reproductive Areas [C1], Feeding Areas [C2], Resting Areas [C3], Movement [C4], and Undefined Aggregations [C5]); and *Special Attributes* (Criterion D; Distinctiveness [D1; related to distinct biological, behavioral, or ecological characteristics] and Diversity [D2; species richness]). ISRA criteria or subcriteria are weighted equally, with only one criterion needed to qualify as an ISRA (except Criterion A that needs an additional criterion to be met). Species are referred to as 'Qualifying Species' when they occur regularly or predictably within an area

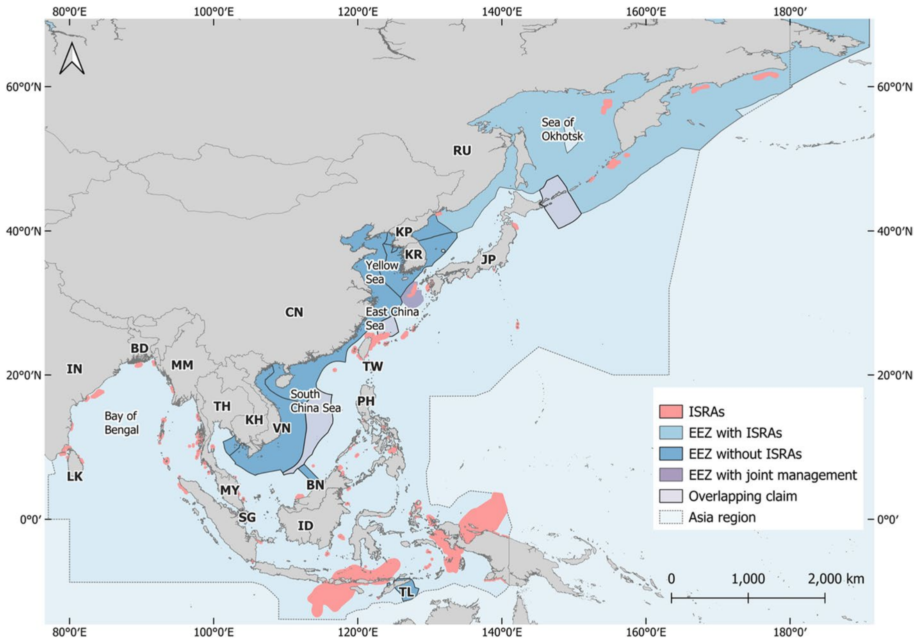

Fig. 1 Important Shark and Ray Areas (ISRAs) in the Asia region. EEZ: Exclusive Economic Zone. Jurisdictions are labelled using their standardized two-letter codes: BD, Bangladesh; BN, Brunei Darussalam; KH, Cambodia; CN, China; TW, Chinese Taipei; KP, Democratic People's Republic of Korea; IN, India; ID, Indonesia; JP, Japan; KR, Republic of Korea; LK, Sri Lanka; MM, Myanmar; MY, Malaysia; PH, The Philippines; RU, Russian Federation; SG, Singapore; TH, Thailand; TL, Timor-Leste; VN, Viet Nam

that meets the ISRA Criteria (IUCN SSC SSG 2024a). A regional expert workshop was held in Bali, Indonesia, in January 2024 to identify ISRAs in Asia. Alongside the ISRA project team, 208 contributors from 19 jurisdictions proposed areas perceived as important for chondrichthyan survival, drawing on both published (e.g., scientific papers, books) and unpublished (e.g., technical reports, unpublished theses and/or datasets, and citizen science) data sources (IUCN SSC SSG 2024b). Only ecologically relevant, contemporary data (defined as the last 15 years, i.e., from 2009–2024) were considered. This timeframe was used to ensure that ISRA delineation reflects current habitat use and ecological relevance, while accounting for ongoing population and environmental changes. Proposed areas were assessed during the workshop and reviewed by an independent panel to determine if the ISRA Criteria were met. Further details are available in Hyde et al. (2022) and the *ISRA Guidance on Criteria Application* document (IUCN SSC SSG 2024a).

Jurisdictions, Qualifying Species, extinction risk, and ISRA Criteria

Data on the ISRA Criteria met by Qualifying Species across Asia were examined through descriptive statistics. An ISRA may include numerous Qualifying Species, each of which may qualify for multiple ISRA Criteria. Second, total ISRA coverage was calculated by: (1) jurisdiction (based on Exclusive Economic Zones [EEZs] as defined by the United Nations Convention on the Law of the Sea [UNCLOS]); (2) Qualifying Species; and (3) ISRA Criteria. ISRA surface area by jurisdiction and Qualifying Species was reported with and without Sub-criterion C4 – Movement, which are areas typically much larger than other ISRAs. To avoid skewing results, six Movement areas covering 88% of total ISRA area were excluded from certain analyses (Table S1). Information was summarized separately for marine ISRAs and for inland ISRAs (i.e., freshwater habitats).

Spatial overlap between ISRAs and protected areas

Spatial layers of Protected Areas (PA) in Asia were retrieved from the World Database on Protected Areas (WDPA) (UNEP-WCMC and IUCN 2025) in March 2025. From this dataset, we excluded areas with the following attributes: (1) international designations, such as World Heritage Sites (UNEP-WCMC 2019; Grorud-Colvert et al. 2021); (2) areas without official designation or at an early-stage of establishment (i.e., proposed, inscribed), to only include those with a designated and established status (indicated by *Designated* and *Established* value in the *Status* field of the database); and/or (3) areas with non-defined boundaries (i.e., polygon was not available). This approach assumes that, in the early stages of PA establishment, regulatory changes may lag; thus, effective protection does not begin until implementation (Grorud-Colvert et al. 2021).

The IUCN categories for each PA were extracted from the WDPA (except for India; see below). These were then categorized into two groups to classify their level of protection: no-take PAs, where all extractive activities are prohibited (aligned with IUCN MPA management categories I, II, or III; as per Day et al. 2019), and partial PAs (also known as multiple-use PAs), where extractive activities (e.g., fisheries) are allowed to some extent (aligned with IUCN MPA management categories IV, V, VI, or other classification types). PAs that did not include an IUCN category were classified as partial PAs. For India, we used the IUCN categorizations assigned in Sivakumar et al. (2013) to determine if PAs were no-take or partial.

For MPAs, we only included *coastal: marine and terrestrial* protected areas (i.e., marine environment overlap ranges from 10–90% of their area; defined as coastal and indicated by the value 1 in the *Marine* field of the database) and *predominantly or entirely marine* protected areas (i.e., marine environment overlap is ≥ 90% of their area; defined as marine and indicated by a value of 2) (UNEP-WCMC 2019). All remaining areas were considered MPAs with numbers reported separately for coastal and marine. Terrestrial areas were excluded from the spatial analysis by using the coastline as the boundary. No-take and partial MPAs were dissolved separately to prevent double counting. In cases where there was an overlap between no-take and partial MPAs, that area was classified as a partial MPA. For inland PAs, we included areas that were *predominantly or entirely terrestrial* (indicated by a 0 value in the *Marine* field of the WDPA database), and *coastal: marine and terrestrial* (UNEP-WCMC 2019) for the jurisdictions where freshwater species occur (i.e., Bangladesh, Brunei Darussalam, Cambodia, India, Indonesia, Laos, Malaysia, Myanmar, Thailand, and Viet Nam) (IUCN 2025; Last et al. 2016).

Our analysis only included protected areas reported by governments to WDPA. Few jurisdictions in the region do not report MPA spatial data to the WDPA: China, India, and the Democratic People's Republic of Korea. We relied on Bohorquez et al. (2021) to obtain total MPA area extent for China, including both no-take and partial protection zones. These data were used to calculate the proportion of the EEZ under protection. Spatial data for India were sourced directly from contributors, and this information was cross-referenced with the list of MPAs included in the Ministry of Environment and Forests of the Indian government website (https://wiienvis.nic.in/database/mpa_8098.aspx).

To evaluate the coverage of MPAs by jurisdiction and determine the expansion needed to meet Target 3 of the KMGBF (CBD 2022), we analyzed the proportion of each jurisdiction's EEZ, covered by both no-take and partial MPAs. The EEZs of India and the Russian Federation both extend beyond the boundaries of the ISRA Asia region. For this analysis, we included all MPAs within the full EEZs of these two jurisdictions, as defined under UNCLOS, regardless of whether those areas fall within the Asia region. This allowed an assessment of national-level MPA coverage and progress towards global targets. Overlap results were interpreted relative to overall MPA coverage within each EEZ to account for differences in jurisdictional size and protection extent.

We measured the percentage area and number of ISRAs overlapping with PAs and MPAs at two designation levels (partial and no-take) by jurisdiction, calculated as the proportion of each ISRA under these categories. For this ISRA–MPA overlap analysis, results for Russia and India were based on the portions of their EEZs that overlap with the ISRA Asia region.

Spatial overlap was classified and reported into four categories: high (>75–100%), moderate (>25–75%), low (>0–25%), and none (0%). Spatial analyses were conducted using QGIS Geographic Information System software 3.22 version and ArcGIS Pro 3.3 version (ESRI Inc 2024) and area calculations were conducted using the World Cylindrical Equal Area projection.

Research methods and data types

To evaluate how ISRAs were identified, as well as potential biases and gaps, we examined the research methods used by contributors and the types of data collected for each. Research methods were classified into the following categories: aerial surveys, citizen science, harvest fisheries, electronic tracking, local ecological knowledge (LEK), mark-recapture, remote video, scientific fishing, and visual census (for definitions, see Table 1). The types of biological or ecological data derived from each were classified into the following categories: demographic, behavioural, trophic and spatial (Table 1). Descriptive statistics were used to investigate the importance of each research method and data types (determined by the frequency of inclusion in ISRA delineation) collected across: (1) ISRAs; (2) jurisdictions; (3) Qualifying Species; and (4) ISRA Criteria.

ISRA habitat classification

To provide a standardized format and common terminology for analysis, broad habitat types were classified according to the *Coastal and Marine Ecological Classification Standard* (CMECS) (NOAA 2012). Habitats for each ISRA were classified into the following aquatic systems: freshwater (inland waters, such as rivers and lakes), estuarine (transitional areas where freshwater mixes with seawater), and marine. The marine sub-system was further divided into nearshore, offshore, and oceanic zones (see Fig. S1 for an explanation of how these were defined). Each ISRA could be classified under several habitat types.

The minimum and maximum depths of each ISRA were used to characterize three vertical habitat attributes: (1) position relative to the surface (i.e., surface or subsurface); (2)

Table 1 Research methods and data types used to delineate Important Shark and Ray Areas (ISRA) in Asia based on Garcia-Rodriguez et al. (2025)

Research method	Definition
Aerial surveys	Surveys using aerial platforms, including unmanned aerial vehicles (UAVs or drones), helicopters, and microlights
Citizen science	Data collected from the wider public from formal projects or opportunistic observations. This usually consists of video or photographic records. Information sourced from social media is included in this category (Nascimiento et al. 2024). Details of social media posts (e.g., species, location) were verified with evidence (usually photos or videos) or confirmed using other research methods. These included diver, shore-based, boat-based, and recreational fisher observations
Harvest fishing	Fisheries-dependent data collection from the harvesting of fish and other aquatic species for consumption, and/or sale and profit, typically using vessels and various fishing gear. This encompasses small-scale (e.g., subsistence, artisanal) and large-scale (i.e., industrial) fisheries. Data on catches and landings may be collected across the seafood value chain, including from the aquatic environment, landing sites, and fish markets, as long as the fishing location can be identified. Includes data collection by observers on active fishing vessels. The fishing gear used included trawls, gillnets, longlines, hook-and-line, harpoons, seine nets, spears, and traps and pots
Electronic tracking	Movement data recorded using acoustic or satellite telemetry
Local ecological knowledge	Anecdotal or historical data collected from local community members (e.g., fishers, villagers). These need to be verified with evidence (usually photos or videos) or confirmed using other research methods. All information provided must also be supported by contemporary evidence (i.e., from the last 15 years)
Mark-recapture	Encounter records collected using simple numbered tags (conventional tagging) or photos (photo-identification) of an animal's natural markings to distinguish individuals
Remote video	Footage collection using camera traps or animal borne cameras which included Baited Remote Underwater Video Systems (BRUVS); Remote Underwater Video (RUVS); unbaited videos
Scientific fishing	Fisheries-independent catch records collected specifically for specimen sampling or to record catch-per-unit-effort. The fishery gear used included trawl, gillnet, seine, longline, and angling
Visual census	Visual census conducted as part of a structured survey and may be assisted with photography, videography (including Diver Operated Video Systems), or other data collection tools. This census could be collected from underwater, shore, or vessel
Data type	Definition
Demographic	(1) Counts: Number of individuals, sightings, or records. Primarily used to support the delineation of Range Restricted (B), Undefined Aggregations (C5), or Diversity (D2) (2) Resightings: Number of individuals resighted. Repeated observations or detections of the same individual over time, typically identified through physical tags (mark-recapture) or natural markings (photo-identification) (3) Life-stages—body size: total length or disc width recorded to identify early life-stages (e.g., neonates or young-of-the-year); (4) Life-stages—reproductive indicators: umbilical scars, egg cases, distended abdomens or visible embryos (suggestive of pregnancy); reproductive signs including mating scars, sperm in the cloaca, or an inflamed cloaca; examination of reproductive organs that provides information on maturity, fecundity, and breeding cycles (5) Life-stages—ageing: vertebral analysis that counts growth bands to estimate age, growth, and life-stage assessment Life-stage data types (3–5) are primarily used to support the delineation of Reproductive Areas (C1)
Behavioural	Number of observations of reproductive (i.e., courtship, mating), feeding, resting, and distinctive behaviours. Primarily used to support the delineation of Reproductive Areas (C1), Feeding Areas (C2), Resting Areas (C3), or Distinctiveness (D1)

Table 1 (continued)

Research method	Definition
Trophic	Number of individuals with stomach contents or isotopic signatures of local prey. Primarily used to support the delineation of Feeding Areas (C2)
Spatial	Number of individuals following similar spatial movement patterns. Primarily used to support the delineation of Movement (C4)

maximum depth (i.e., 0–200 m, 201–1000 m, > 1000 m), regardless of their minimum depth; and (3) habitat relative to the benthos (i.e., pelagic, benthic, or both). To further examine ISRA coverage in the deep sea, any ISRA that included one or more Qualifying Species 'whose distribution is predominantly at, are restricted to, or spend the majority of their life-cycle at depths below 200 m (Kyne and Simpfendorfer 2010), was classified as a 'deepwater ISRA' to examine the geographical coverage of deepwater species.

Chondrichthyan and range-restricted species richness

Species richness maps were created for (1) marine chondrichthyan species and (2) range-restricted species. This analysis was based on available IUCN Red List range maps for 367 chondrichthyan species, representing 92% of the known chondrichthyan diversity in the region (IUCN 2025). IUCN Red List range maps were not available for 19 species due to data deficiency on their distribution (Table S2). Species distribution maps were rasterized into 0.01° grid cells and subsequently merged to enable spatial analysis. Only the extant distribution of species was considered. All analyses were conducted using the Overlay toolset on ArcGIS Pro 3.3 (ESRI Inc 2024).

Species occurring in freshwater habitats in Asia (n = 10; Grant et al. 2019) were excluded from the chondrichthyan and range-restricted species richness analyses. IUCN Red List geographic range maps for obligate freshwater species in Asia are currently delineated using hydrobasin units, resulting in an overestimation of range extent as they include substantial terrestrial catchment areas. This lack of resolution precludes reliable fine-scale spatial analyses for these species. Moreover, for certain euryhaline generalist species (i.e., Ganges Shark [*Glyphis gangeticus*] and Largetooth Sawfish [*Pristis pristis*]), their contemporary freshwater distribution is uncertain due to localized extinctions and misidentification (Rigby et al. 2021; Yan et al. 2021).

ISRAs identified under Sub-criterion D2 – Diversity included those that meet a regional threshold for chondrichthyan species richness (IUCN SSC SSG 2024a). This threshold was based on a relative numerical assessment, considering the overall chondrichthyan diversity within each region. To determine this threshold, species richness maps were generated to identify the maximum number of species occurring in a single 0.01° grid cell. The final threshold was set at 30% of the maximum species count (103 species), resulting in a regional marine species threshold of 31 species (Table S3; IUCN SSC SSG 2024a). This threshold was used here to identify areas of *high chondrichthyan species richness*. To identify diversity hotspots of *exceptionally high chondrichthyan species richness*, a higher threshold was set at 80% of the maximum richness per cell, corresponding to 82 species (Table S3). The spatial overlap was then assessed between areas of *high* and *exceptionally high chondrichthyan species richness*, all delineated ISRAs, and the subset of ISRAs triggered under Sub-criterion D2 – Diversity. The overlap was quantified using percentage area. For freshwater species (n = 10), a 50% threshold was used to apply Sub-criterion D2 – Diversity (n = 5) to avoid the over-application of the sub-criterion given the low number of species (IUCN SSC SSG 2024b).

Following the methods described above, the threshold for range-restricted species richness was set at four species, corresponding to 30% of the maximum count (12 species) observed per 0.01° grid cell (Table S3). Areas with ≥ 4 range-restricted species were considered to have *high range-restricted species richness*. To identify areas of *exceptionally high range-restricted species richness*, a threshold corresponding to 80% of the maximum observed richness, was also calculated, resulting in a threshold of 10 species. The spatial overlap between areas of *high* and *exceptionally high range-restricted species richness*, all delineated ISRAs, and ISRAs identified under Criterion B – Range Restricted, was then assessed.

Additionally, percentile thresholds were derived from the raster richness maps in QGIS using the GRASS GIS *r.quantile* tool. In the empirical distribution of overall chondrichthyan species richness, values of 31 and 82 species, representing 30% and 80% of the regional maximum richness, corresponded to the 85th and 99th percentiles, respectively. For range-restricted species richness, the corresponding values were four and ten species, which represented 30% and 80% of the regional maximum richness and fell at the 85th and 99th percentiles, respectively (Table S3).

Data analysis

Analyses were descriptive and comparative. We used summary statistics (frequencies, proportions, and spatial extent) to evaluate patterns across jurisdictions, Qualifying Species, ISRA Criteria, habitat types, and data sources. Spatial overlap between ISRAs and protected areas was quantified as the proportion of ISRA area intersecting with no-take and partial MPAs, and categorized into four overlap classes (none, low, moderate, high).

Comparisons among jurisdictions and protection categories were interpreted in relation to the proportion of each EEZ covered by MPAs to account for differences in EEZ size and overall protection extent. No inferential statistical tests were applied, as the study aims to provide a baseline regional assessment and identify broad patterns, gaps, and priorities for conservation planning.

Results

Important Shark and RayAreas in the Asia region

A total of 122 ISRAs were delineated for 121 Qualifying Species covering an area of 1,079,537 km^2 (min = 0.14 km^2, average = 8,849 km^2, max = 420,817 km^2) in 12 jurisdictions (Fig. 1). The following sections present the results for marine ISRAs (n = 120), followed by those pertaining to inland ISRAs (n = 2).

Marine Important Shark and Ray Areas

Marine ISRAs accounted for 3% of the marine region and represented 99.9% of the total ISRA extent (Table S1). ISRAs mostly occupied national waters (99% of total ISRA extent) with two ISRAs overlapping partially with areas beyond national jurisdiction. In terms of total size, C4 – Movement areas covered the largest extent (87.9% of the total ISRA coverage).

The jurisdictions with the highest number of ISRAs and their corresponding EEZ coverage were: Indonesia (n = 40; 12.9% of EEZ), Japan (n = 14; 0.4% of EEZ), and India (n = 11; 1.5% of EEZ) (Fig. S2). The jurisdiction with the largest ISRA coverage was Indonesia, representing 71.7% of the total ISRA coverage in Asia (Fig. S3). When ISRAs delineated under C4 – Movement were excluded, the largest ISRA coverage remained in Indonesia (20.3% coverage), followed by the Russian Federation (16.2%) (Fig. S2). The number of Qualifying Species for each jurisdiction is displayed in Fig. S2. Eight jurisdictions lacked sufficient contemporary data to meet the ISRA Criteria: Brunei Darussalam, Cambodia, China (including Hong Kong and Macau Special Administrative Regions [SAR]), Democratic People’s Republic of Korea, Republic of Korea, Singapore, Timor-Leste, and Viet Nam. Therefore, no ISRAs were identified in these jurisdictions.

Qualifying Species, extinction risk, and ISRA Criteria

Marine ISRAs included 117 Qualifying Species (53 sharks; 63 rays; 1 chimaera) from 10 orders and 35 families. This accounts for 30% of the total known Asian chondrichthyan diversity (26% sharks; 37% rays; 9% chimaeras). Qualifying Species from nine families accounted for the majority of ISRAs delineated (83% of all ISRAs) including the widespread requiem sharks (Carcharhinidae) and whiptail stingrays (Dasyatidae) (Fig. S3). Four chondrichthyan orders were not included in ISRAs due to insufficient data available to apply the ISRA Criteria: Echinorhiniformes (n = 2 species in Asia), Heterodontiformes (n = 2), Hexanchiformes (n = 5), and Pristiophoriformes (n = 2).

Six species were associated with both the largest number and spatial extent of ISRAs (Fig. S4), all of which are threatened according to the IUCN Red List, with a total number of 91 ISRAs (76% of marine ISRAs) and a combined area of 1,003,503 km^2 (Fig. 2; Fig. S4). From this group, the Whale Shark (*R. typus*), Oceanic Manta Ray (*Mobula birostris*), and Reef Manta Ray (*M. alfredi*) were the only three species with areas for C4 – Movement delineated. When these areas were excluded from the analysis, their spatial extent ranked third, thirteenth, and twentieth, respectively.

Overall, 88 (75%) marine Qualifying Species in Asia are threatened with extinction (Fig. 3) and meet ISRA Criterion A – Vulnerability. The most frequently applied ISRA Criterion (excluding A – Vulnerability) was C1 – Reproductive Areas resulting in the delineation of 64 ISRAs for 61 Qualifying Species (Fig. S4). These were most frequently identified for Blacktip Reef Shark (n = 13 ISRAs), (*Carcharhinus melanopterus*) Scalloped Hammerhead (n = 9), (*Sphyrna lewini*) Reef Manta Ray (n = 7), (*Rhynchobatus australiae*) and Bottlenose Wedgefish (n = 6). For C5 – Undefined Aggregations, 42 ISRAs were delineated for 28 Qualifying Species, primarily for Reef Manta Ray (n = 10 ISRAs), Scalloped Hammerhead (n = 10), Oceanic Manta Ray (n = 7), and Whale Shark (n = 6) (Fig. S4). For C2 – Feeding Areas, 23 ISRAs were delineated for 15 Qualifying Species, primarily for

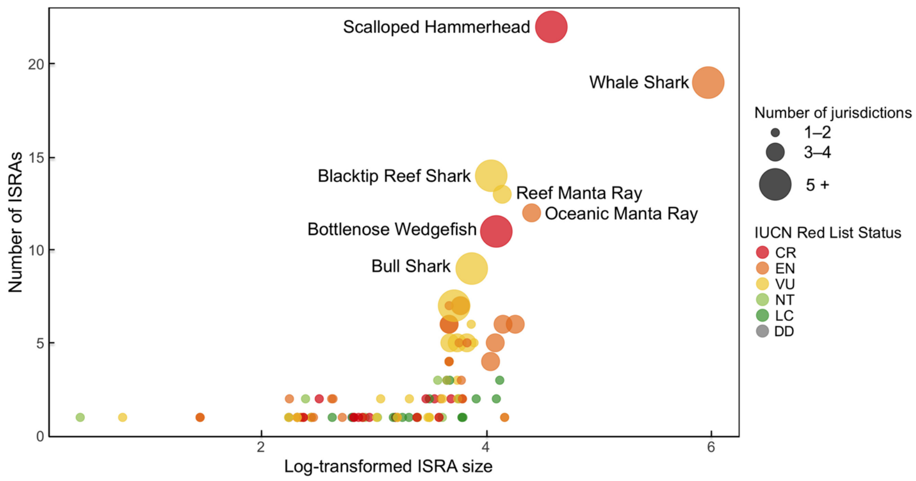

Fig. 2 Qualifying Species (QS) occurring in Important Shark and Ray Area (ISRAs) in Asia, showing number and size of ISRAs, number of jurisdictions, and the IUCN Red List of Threatened Species category for each QS. IUCN Red List categories: CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient. The names of the seven species for which the most ISRAs were delineated are shown. Bubbles below Bull Shark represent the other QSs (refer to Figure S2 for full species lists)

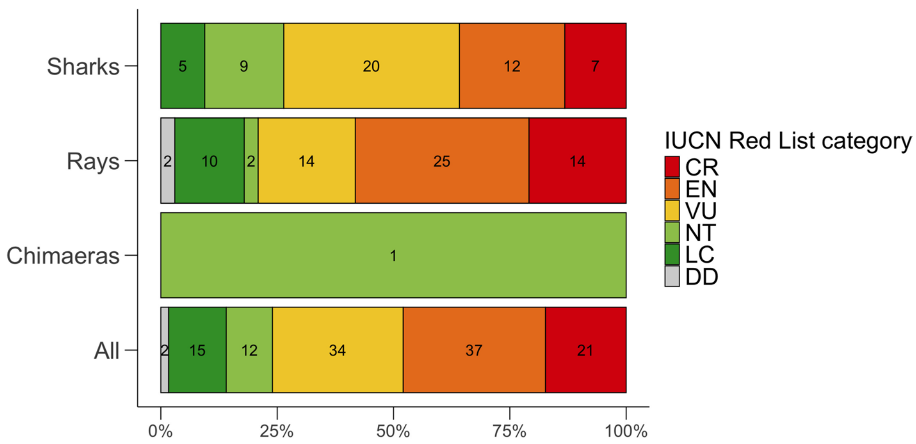

Fig. 3 IUCN Red List of Threatened Species extinction risk category for the 121 Qualifying Species occurring in Important Shark and Ray Areas (ISRAs) in Asia (IUCN 2025). IUCN Red List categories: CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient

Whale Shark (n=7), Reef Manta Ray (n=6), and Oceanic Manta Ray (n=4) (Fig. S4). For B – Range Restricted, 22 ISRAs were delineated for 25 Qualifying Species, with three ISRAs delineated for each of the following species: Spotted-belly Catshark (*Atelomycterus erdmanni*), Raja Ampat Epaulette Shark (*Hemiscyllium freycineti*), and Indonesian Wobbegong (*Orectolobus leptolineatus*) (Fig. S4). In the Asia region, 122 species are considered range-restricted, including 69 sharks, 61 rays, and two chimaeras; 20.5% of these species are represented within designated ISRAs.

Amongst the least applied ISRA Sub-Criteria, C3 – Resting Areas were represented in seven ISRAs for four Qualifying Species, while C4 – Movement was represented in six ISRAs for four Qualifying Species, with Whale Shark being the most frequent (n=3) (Fig. S4). Sub-Criterion D1 – Distinctiveness was represented in two ISRAs for one species. Sub-Criterion D2 – Diversity was represented in four ISRAs encompassing 48 Qualifying Species (12% of Asian chondrichthyans) in which the number of species ranged between 32–44 for each ISRA. Indonesia had the most ISRAs delineated for all criteria, except for C3 – Resting Areas (Fig. 4A). Sub-Criterion C4 – Movement was delineated only in Indonesia and Japan (Fig. 4B).

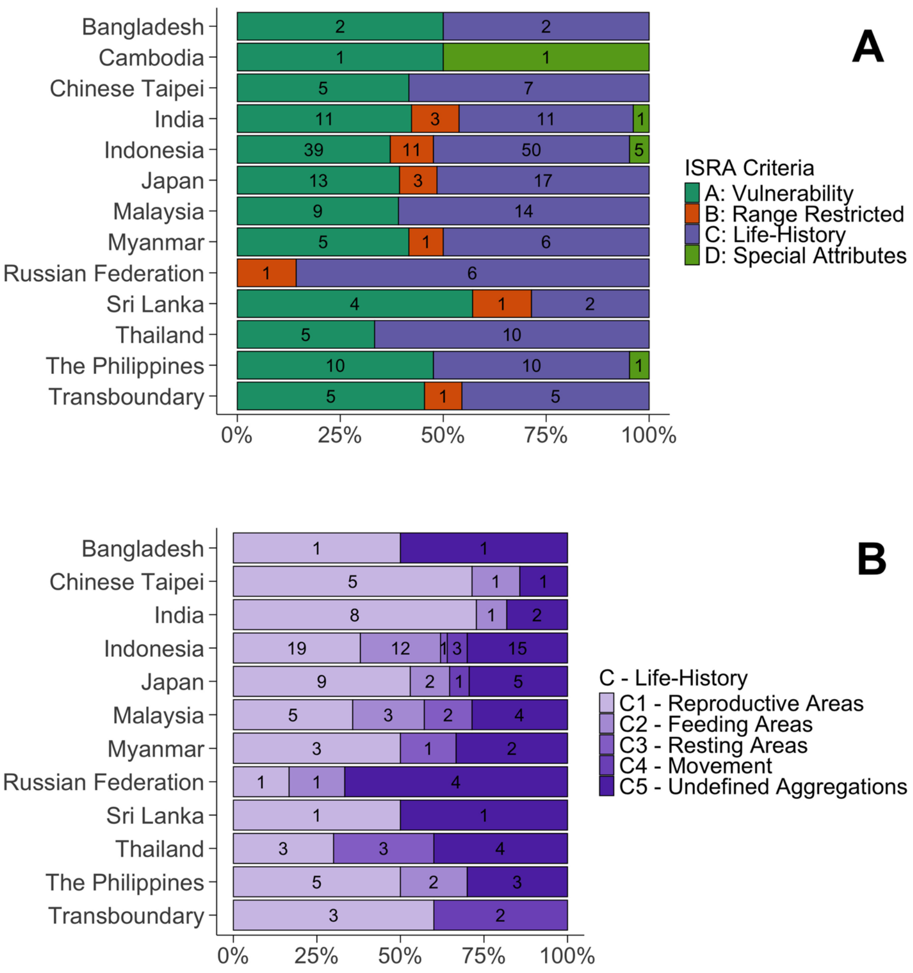

Fig. 4 Important Shark and Ray Areas (ISRA) Criteria applied by jurisdiction in Asia. A: Criteria A to D; B: Life-History Sub-criteria C1 to C5. The numbers in the bars represent the number of ISRAs for each ISRA criteria/sub-criteria. A transboundary ISRA is an area that spans the maritime jurisdiction of two or more jurisdictions or lies within international waters

Spatial overlap between ISRAs and marine protected areas

A total of 1,671 MPAs cover 885,005 km^2 (2.9% of Asia) (Fig. S5; TableS4). Bangladesh (7.3%) followed by Japan (7.2%) and Thailand (4.9%) were the jurisdictions with the highest proportion of their EEZ designated as MPAs (Fig. 5). Most jurisdictions protected less than 1% of their waters, including Chinese Taipei, Timor-Leste, Viet Nam, Myanmar, India, Sri Lanka, Brunei Darussalam, and Singapore. The vast majority of MPAs (n = 1,049; 83% of all MPAs, excluding China with 273 MPAs) are designated as partial MPAs, covering a total area of 354,790 km^2. In contrast, no-take MPAs represent only 17.2% of all MPAs (n = 218) despite accounting for 53% of the total MPA area (392,827 km^2). Notably, six large no-take MPAs, distributed across Japan and Indonesia comprise 70% of the total no-take MPA area in the region.

Half of the ISRAs identified in Asia (n = 62; 50.8%) overlapped fully or partially with MPAs (no-take and partial). Of these, 27 ISRAs overlapped with 30 no-take MPAs and 46 ISRAs overlapped with 79 partial MPAs. The degree of overlap varied. For no-take MPAs, only 15 ISRAs had high overlap (> 75–100%) and 7 moderate overlap (> 25–75%), while the vast majority (95 ISRAs) had no overlap (0%). Similarly, for partial MPAs, 16 ISRAs showed high overlap (> 75–100%) and 11 moderate overlap (> 25–75%), but 77 had no overlap (0%). A smaller number of ISRAs fell into the low overlap category (> 0–25%), with 5 ISRAs for no-take MPAs and 18 for partial MPAs. Therefore, only 5.4% of the ISRA coverage in the region overlapped with MPAs, covering a total of 57,819 km^2, and only 2.8% of ISRA coverage overlapped with no-take MPAs. Thailand (52.2%) accounted for the highest overlap between ISRAs and overall MPAs, followed by Bangladesh (36.1%) and Japan (24.3%) (Fig. 5).

The most frequently applied ISRA Criterion that overlapped with MPAs (excluding A – Vulnerability) was C1 – Reproductive Areas (no-take = 17; partial = 25), followed by C5

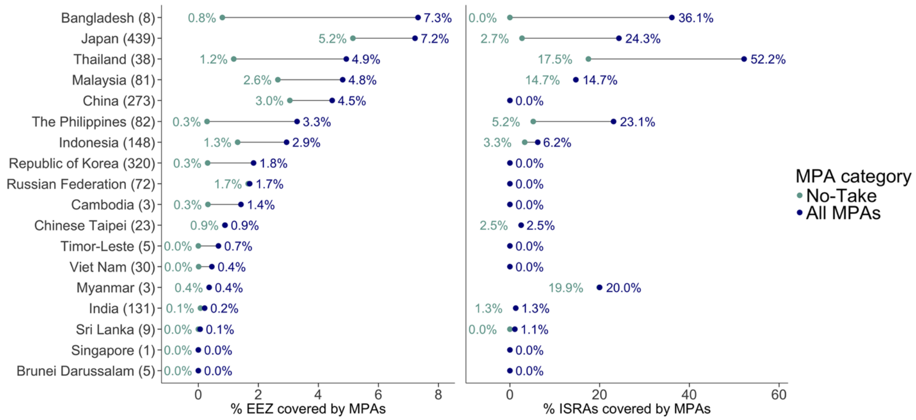

Fig. 5 Marine protected area (MPA) coverage in the Asia region for all jurisdictions excluding the Democratic People's Republic of Korea. (A) The percentage of the exclusive economic zone (EEZ) covered by MPAs for each jurisdiction in the Asia region. Numbers in parentheses indicate the number of MPAs. For India and the Russian Federation, all MPAs and its entire EEZ were included, including areas beyond the Asia region. (B) Percentage of Important Shark and Ray Areas (ISRAs) covered by MPAs for each jurisdiction in the Asia region. To classify their level of protection, MPAs are grouped into no-take PAs, where all extractive activities are prohibited, and partial MPAs where extractive activities are allowed to some extent. 'All MPAs' include no-take and partial MPAs

– Undefined Aggregations (no-take = 10; partial = 18) and C2 – Feeding Areas (no-take = 6; partial = 11). In terms of size, C4 – Movement was the ISRA Criterion with the highest area overlap with MPAs (no-take = 21,370 km^2; partial = 19,620 km^2), followed by C1 – Reproductive Areas (no-take = 4,043 km^2; partial = 8,096 km^2).

ISRAs for 80 species (66% of all Qualifying Species; 20% of all species in the region) overlapped with MPAs, and 75% of these species are classified as threatened (Fig S5). The extent of overlap varied considerably among ISRAs, with most intersecting only a small extent with MPAs. In contrast, ISRAs for a few species (e.g., Whale Shark and Reef Manta Ray) overlapped with more than six MPAs.

Research methods and data types

Nine research methods were used to collect the data used for ISRA delineations (Fig. 6, Fig. S7). At the ISRA level, 57 ISRAs (47.9%) were delineated using citizen science data (86% from diver observations); 22 fully and 35 partially based on citizen science. This was followed by 49 ISRAs informed by harvest fisheries data (partially = 20; fully = 29) (36% from gillnet and 33% from trawl fisheries), 29 ISRAs based on LEK (partially = 29), 22 ISRAs on

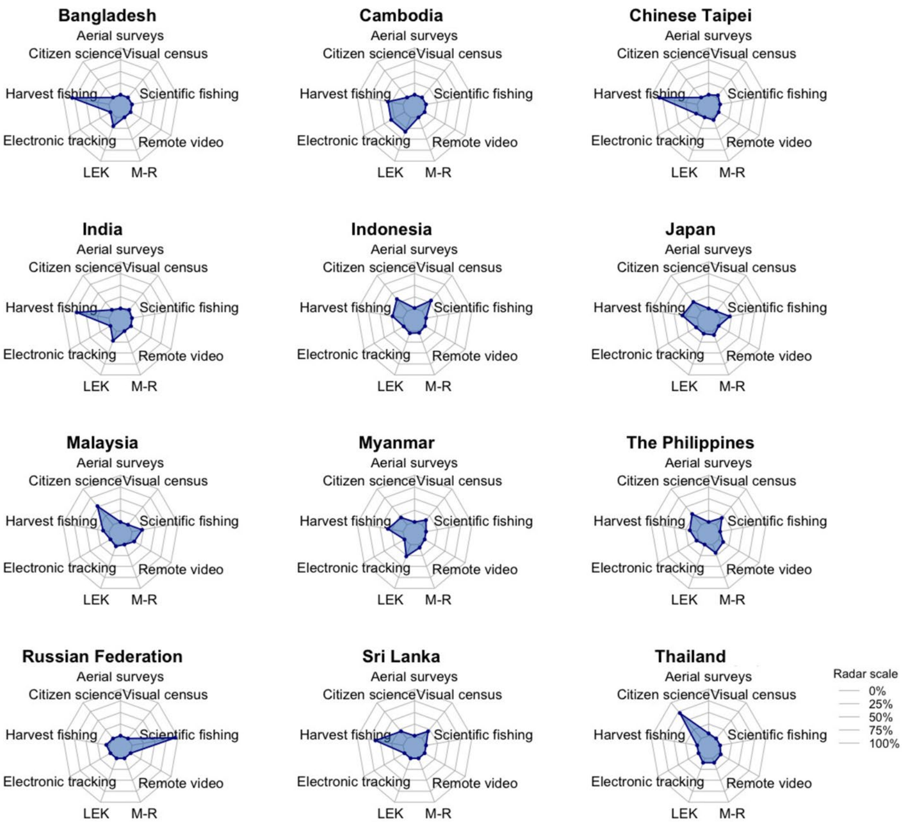

Fig. 6 Research methods used to collect data that supported the delineation of Important Shark and Ray Areas (ISRAs) by jurisdiction in Asia. LEK, Local Ecological Knowledge; M-R, Mark-Recapture. Refer to Table 1 for research method definitions

visual census (partially = 1; fully = 21), and 18 ISRAs partly supported by mark-recapture data. Citizen science and harvest fishing were the primary data sources for most Qualifying Species (Table 2) and across jurisdictions (Fig. 6).

For most ISRAs delineated for B – Range-Restricted, C1 – Reproductive Areas, C2 – Feeding Areas, C3 – Resting Areas, and C5 – Undefined Aggregations, the primary data sources used for delineation were harvest fishery data and citizen science, contributing between 17 and 38% depending on the criterion. Notably, C3 – Resting Areas relied exclusively on citizen science, while other criteria such as C4 – Movement were supported primarily by electronic tracking (67%) (Fig. S6, Fig. S7).

The most frequently included data types were counts combined with life-stage classifications (n = 101), including 78 reports of neonates, 64 reports young-of-the-year, and 50 reports of pregnant females. This was followed by counts alone (n = 74) and behavioural observations (n = 42) (Fig. S6, Fig. S7).

ISRA habitat classification

Four ISRAs occurred in the estuary sub-system, 108 in the marine sub-system, and eight across both estuary and marine sub-systems. The highest number of marine areas were delineated in the nearshore zone (n = 44; 36% of all ISRAs) (Fig. S1). Most ISRAs were found within the upper 200 m of the water column (n = 83; 68% of all ISRAs), and a large portion extended to the surface (0 m) as the upper depth limit (n = 106; 86%). Most ISRAs were both benthic and pelagic (n = 83; 68%). Eleven deepwater ISRAs were delineated for 14 deepwater Qualifying Species, six within waters of the Russian Federation and one each across Japan, Chinese Taipei, Sri Lanka, Indonesia, and India.

Chondrichthyan and range-restricted species richness

Marine ISRAs covered 2.0% of the total area with *high chondrichthyan species richness* (≥31 species). Most ISRAs (n = 93) overlapped with these areas although the degree of overlap varied (Table 3). For ISRAs identified for D2 – Diversity, the extent of overlap varied considerably, ranging between 27–85%. Notably, the majority of D2 – Diversity areas (62.5% of their total extent) located in West Papua, overlapped with *low species richness* areas. The three locations exhibiting *exceptionally high chondrichthyan species richness* (≥82 species; Taiwan Strait, Palk Strait [between India and Sri Lanka], and Sarawak

Table 2 Contribution of different research methods to the identification of Qualifying Species used in Important Shark and Ray Areas (ISRA) delineation in the Asia region (in descending order of the total number of Qualifying Species). See Table 1 for definitions of research methods

Research method	Total Species	Sharks	Rays	Chimaeras
Harvest fishing	94	38	55	1
Citizen science	53	24	29	0
Visual census	41	22	19	0
Local ecological knowledge	30	14	16	0
Scientific fishing	21	6	15	0
Electronic tracking	11	7	4	0
Remote video	7	4	3	0
Mark-recapture	5	3	2	0
Aerial surveys	2	1	1	0

Table 3 Number of Important Shark and Ray Areas (ISRAs) in the Asia region overlapping with areas of *high* and *exceptionally high species* richness: marine chondrichthyan (≥31 and 82 species per cell, respectively) and range-restricted (≥4 and 10 species per cell, respectively). Overlap is categorized as high (>75–100%), moderate (>25–75%), low (>0–25%), and none (0%)

	Number of ISRAs			
Species richness types	High overlap	Moderate overlap	Low overlap	No overlap
High chondrichthyan species richness	41	31	21	29
Exceptionally high chondrichthyan species richness	0	3	4	115
High range-restricted species richness	17	11	10	84
Exceptionally high range-restricted species richness	1	0	4	117
High chondrichthyan species richness and high range-restricted species richness	12	12	12	86

[Malaysian Borneo]) overlapped with ISRAs (n=5), but none of these ISRAs were identified under D2 – Diversity (Fig. 7A; Table 3).

Marine ISRAs covered 4.5% of the total area with *high range-restricted species richness* (≥4 species). Around one quarter of all ISRAs in the region (n=38) overlapped with areas of *high range-restricted species richness*, though the degree of overlap varied (Table 3). Eight ISRAs under B – Range Restricted overlapped with areas of *high range-restricted species richness*; however, the extent of this overlap varied between 37–100%. The three locations with *exceptionally high range-restricted species richness* (≥10 species; eastern side of Japan's main islands, Chinese Taipei, and Palk Strait) all contained ISRAs (n=7), two of which were identified under B – Range Restricted (Fig. 7B; Table 3).

Thirty-six ISRAs overlapped fully or partially with areas of both *high chondrichthyan species richness* and *high range-restricted species richness* across Bangladesh, Chinese Taipei, Japan, India, Sri Lanka, Indonesia, Malaysia, Myanmar, and the Philippines.

Inland ISRAs

Two ISRAs were identified in the freshwater sub-system. These areas were delineated in Indonesia and Cambodia and included three obligate freshwater species (*Fluvitrygon* spp. whiprays) and the euryhaline generalists, Giant Freshwater Whipray (*Urogymnus polylepis*) and Bull Shark (*Carcharhinus leucas*). All of the species are threatened. The delineation was based on three ISRA Criteria: A – Vulnerability, D1 – Distinctiveness, applied to the unique biological traits of the Giant Freshwater Whipray, and D2 – Diversity. In the case of Cambodia, this was the only ISRA designated in the jurisdiction.

Spatial overlap between ISRAs and protected areas

A total of 1,386 inland protected areas (no-take=739, partial=647) are established across ten Asian jurisdictions (Bangladesh, Brunei Darussalam, Cambodia, India, Indonesia, Laos, Malaysia, Myanmar, Thailand, and Viet Nam) where freshwater species occur (Fig. S8). Of the two ISRAs delineated for freshwater chondrichthyan species, only the Mekong Deep

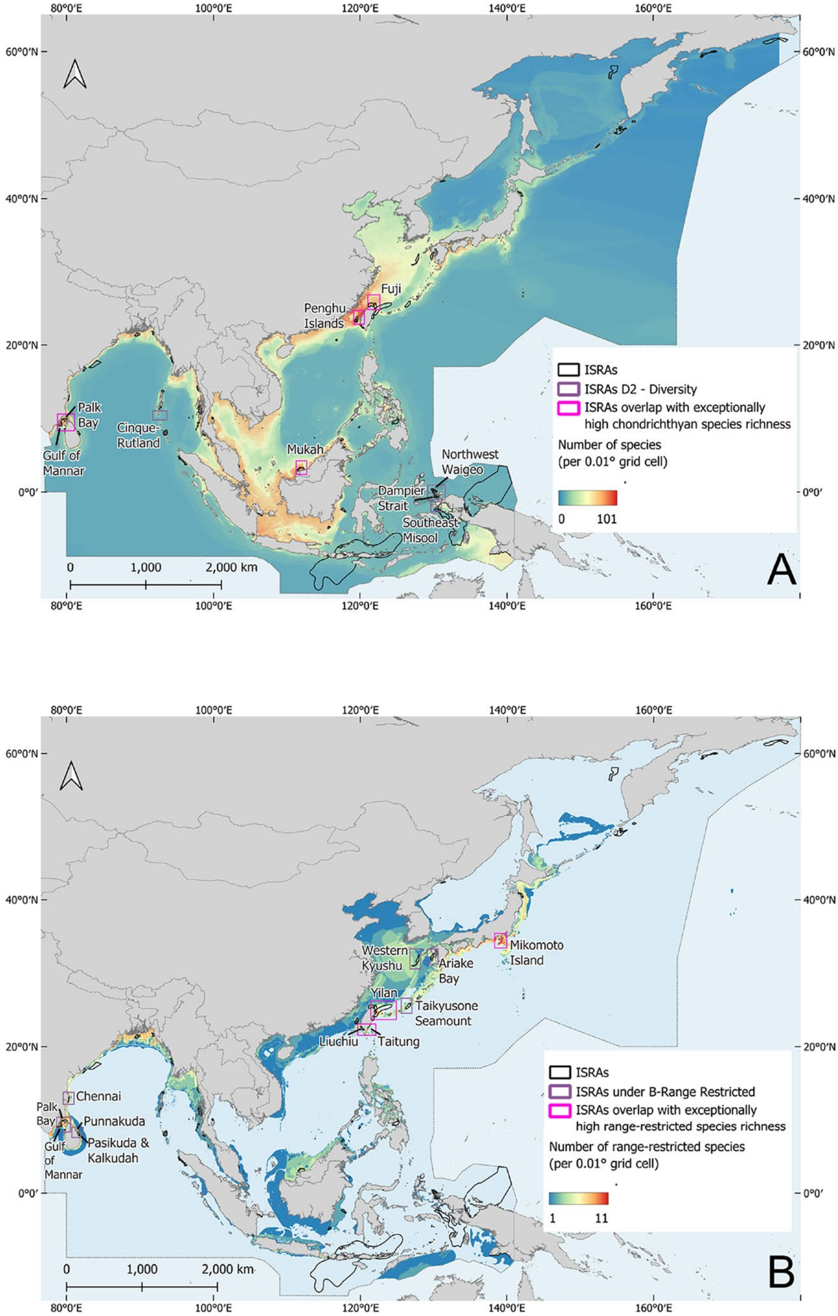

Fig. 7 Spatial overlap between Important Shark and Ray Areas (ISRAs) in the Asia region with areas of A: chondrichthyan species richness; B: chondrichthyan range-restricted species richness. ISRA Criterion D2—Diversity, are those areas with ≥ 31 Qualifying Species; *exceptionally high chondrichthyan species richness* is defined as those areas with ≥ 82 species; and *exceptionally high range-restricted species richness* is defined as those areas with ≥ 10 range-restricted species in 0.01° grid cells

Pools ISRA in Cambodia overlaps a partial inland protected area (60 km or 40.2% of ISRA area).

Discussion

This study provides the first in-depth regional assessment of critical habitats for chondrichthyans in Asia, establishing a baseline for a region of exceptional diversity that is also exposed to the world's highest fishing pressures (FAO 2024a, b). Here, we assess the role of ISRAs in guiding conservation actions across Asia building on our evaluation of species, ecological traits, and ISRA Criteria (Objective 1), and their overlap with MPAs in relation to Target 3 of the KMGBF (Objective 2). We highlight the shortfalls in MPA coverage and governance challenges, and the opportunities to strengthen protection by aligning MPAs with ISRA boundaries. We further examine the contribution of different data types and methods to ISRA delineation (Objective 3), and the range of critical habitats identified across the region (Objective 4), alongside spatial patterns of species richness (Objective 5) We also discuss the knowledge gaps for deepwater, range-restricted, and freshwater species. Finally, we outline key recommendations and future priorities to address research gaps and improve future ISRA delineation.

Shortfalls in MPA coverage and governance challenges

The coverage of MPAs in Asia remains limited. As of March 2025, no Asian jurisdiction had achieved Aichi Target 11 (conserving at least 10% of coastal and marine waters by 2020), with regional MPA coverage lagging behind global averages (<5% compared to 9% globally or 18% of the global EEZ area; Rechberger et al. 2025; Seguin et al. 2025). The Asia region has been identified as a priority region for MPA expansion (Rechberger et al. 2025). ISRAs provide actionable guidance for area-based management by informing MPA designation or expansion and guiding spatial fisheries management measures (Mouton et al. 2025; Rohner et al. 2025). They can also contribute directly to meeting international biodiversity targets such as Target 3 of the KMGBF (Hyde et al. 2022). Mainstreaming ISRAs into National Biodiversity Strategies and Action Plans (NBSAPs), Key Biodiversity Areas (KBA), and National Plans of Action for the Conservation and Management of Sharks (NPOAs) offers an evidence-based mechanism to accelerate conservation. Indeed, ISRAs have been recognized as a key tool to assist countries in meeting global biodiversity targets with Parties to the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and Signatories to its daughter agreement, the Sharks Memorandum of Understanding (Sharks MOU), adopting several decisions related to ISRAs (CMS 2023; Jabado et al. 2025). Parties and Signatories have been requested to take into account identified ISRAs for spatial planning and conservation action, specifically for the benefit of CMS-listed shark and ray species, while facilitating implementation of KMGBF targets. Similarly, an analysis of ISRAs and KBAs indicate that these are complementary approaches with one fifth of ISRAs being able to be recognized as KBAs covering three quarters of globally threatened and two thirds of non-threatened restricted-range sharks (Boyd et al. 2025).

Our findings also highlight how fisheries data have been used to delineate ISRAs inside existing MPAs, including three no-take and 10 partial MPAs. These cases illustrate how formal designation does not always safeguard susceptible species (Mangubhai et al. 2011; Seguin et al. 2025). In Japan, for example, shark culling occurs and is subsidized within some MPAs that overlap with ‘common fishery right areas’ managed by local cooperatives. While these systems support traditional community-based management, they rarely include protective measures for chondrichthyans. Japan is also among the jurisdictions with the highest industrial fishing detections inside MPAs (Seguin et al. 2025). To ensure that MPAs conserve chondrichthyans, management plans must explicitly include identified critical habitats (e.g., ISRAs), assess species’ vulnerability to extractive and non-extractive activities (e.g., tourism), and ensure compliance with MPA regulations (Chin et al. 2023; Mouton et al. 2025).

Mismatch between ISRAs and MPAs

A striking mismatch exists between ISRAs and MPAs with 94.6% of critical chondrichthyan habitat remaining outside MPAs. This gap is larger than in the Central and South American Pacific (84.4%; Mouton et al. 2025) and slightly higher than in the Western Indian Ocean (92.9%; Cochran et al. in 2026). Some jurisdictions (e.g., Thailand, Bangladesh, Japan, the Philippines, Myanmar, and Malaysia) show higher overlap (14.7–52.2%), though research efforts that supported ISRA delineation can be biased toward MPAs (e.g., in the Philippines). Strict protection remains scarce; no-take MPAs cover only ~ 1% of the Asia region and 2.8% of ISRA coverage. Despite these limitations, examples such as Tubbataha Reefs Natural Park (the Philippines) and Raja Ampat (Indonesia) demonstrate that well-managed no-take MPAs can support population recovery of reef sharks and manta rays (Jaiteh et al. Philippines2016; Murray et al. 2019; Setyawan et al. 2022a). Expanding and strengthening MPAs by incorporating ISRAs presents a critical opportunity for conservation, particularly in the 41 ISRAs already partially overlapping with MPAs.

Most ISRAs (79%) were delineated in coastal and nearshore areas where Qualifying Species use habitats throughout their life cycle or during specific stages. Eighty-six ISRAs support 71 coastal Qualifying Species, representing 12 of the 13 historically most depleted chondrichthyan families (Squatinidae are not represented) (Dulvy et al. 2021, 2024), including long overlooked taxa such as giant guitarfishes and wedgefishes (Kyne et al. 2024). Although many MPAs overlap with nearshore ISRAs, the level of protection remains insufficient. Coastal ecosystems are subject to intense fishing pressure, habitat degradation, and climate-driven impacts (Todd et al. 2010; Eddy et al. 2021; Sudo et al. 2021; Bhowmik et al. 2022). These ISRAs capture highly threatened species with severe depletion histories, yet management rarely meets their ecological needs. Aligning area-based management with species’ spatial and life-history requirements is essential to reverse declines (Hyde et al. 2022; Shidqi et al. 2024).

Many MPAs are poorly designed and managed, constraining their conservation outcomes (Mouillot et al. 2024; Rechberger et al. 2025). For instance, the Izu-Ogasawara Trench in Japan, one of Asia’s largest no-take MPAs, lacks a management plan and has unclear monitoring, compliance, and surveillance practices. Overall, weak enforcement and chronic underfunding compound shortcomings in the effectiveness of MPAs (Burke et al. 2002; Gill et al. 2017; Iacarella et al. 2021; Jompa et al. 2023). Rapid expansion of protected areas has also raised concerns about overlooking habitat quality and ecological representativeness (Watson et al. 2023; Rohner et al. 2025). Chondrichthyans are often overlooked and/

or excluded from MPA management objectives (Giménez et al. 2020; Faure-Beaulieu et al. 2023). In the Central and South American Pacific, only 11% of MPAs list them as a conservation value (Mouton et al. 2025). Further, nearly half of MPAs worldwide are ≤ 1 km^2 (Rechberger et al. 2025), providing limited benefit to highly mobile species (Goetze et al. 2024). ISRAs can help correct these shortcomings by ensuring that protected area networks include habitats critical for life-history processes (Rohner et al. 2025).

Inaccurate reporting of protection levels to the WDPA is a further concern. MPAs recorded as no-take are often multiple-use, leading to inflated estimates of strict protection. For example, Indonesia's two largest 'no-take' MPAs (ranked 4th and 5th largest in the Asia region), when assessed against their zoning, allow fishing in > 96% of their area (Balai Besar TNTC 2009; SIDAKO 2025). Verifying WDPA classifications through a review of management plans and adopting more nuanced frameworks (Horta e Costa et al. 2016; e.g., Marine Protection Atlas: Grorud-Colvert et al. 2021) would provide a clearer picture of true protection levels across the region and help prioritize conservation action.

Effective conservation also relies on strong local engagement with coastal communities, supported by awareness, socio-economic incentives, and alternative livelihoods (Muallil et al. 2019; Booth et al. 2021; Iacarella et al. 2021; Shidqi et al. 2025). Involving those most dependent on marine resources enhances legitimacy, fosters stewardship, and ultimately improves conservation outcomes (Mascia et al. 2010; Oldekop et al. 2016; Kamil et al. 2017). Other Effective Area-based Conservation Measures (OECMs) can deliver ecological benefits while being inclusive of community priorities (Gurney et al. 2021; Mouillot et al. 2024), although their often small size may limit benefits for wide-ranging species (Rocliffe et al. 2014). Few jurisdictions empower local governments to manage MPAs with the Philippines standing out as a notable exception. Its > 1,800 locally managed marine areas illustrate the benefits of municipal leadership (Rechberger et al. 2025). Well-managed MPAs can also provide direct economic incentives through tourism, often generating sufficient revenue to cover management costs and deliver profits for communities within a few years (Costello 2024; Rechberger et al. 2025). Recreational divers, who value the dive opportunities that MPAs provide (Morse et al. 2024), can contribute substantially to local economies (Costello et al. 2024) while also participating in citizen science to monitor chondrichthyan populations. The Misool Marine Reserve in Indonesia, financed exclusively through dive tourism, represents a particularly successful model (Rechberger et al. 2025).

Importance of citizen science and fisheries data

Asia holds a major share of global marine tourism, leads in shark-based tourism (Spalding et al. 2017; Schuhbauer et al. 2023), and supports the world's largest chondrichthyan fisheries (Worm et al. 2024). This is reflected in our results, where both citizen science and fisheries data emerged as the dominant sources underpinning ISRA delineation across jurisdictions and criteria. Citizen science emerged as a major contributor to ISRA delineation in Asia (e.g., Ward-Paige et al. 2018; Setyawan et al. 2020, 2025; Magson et al. 2022), particularly in dive tourism hotspots such as Indonesia (Spalding et al. 2017; Mustika et al. 2020). Charismatic species like Whale Sharks and manta rays attract strong public interest, driving data collection through wildlife tourism (Cisneros-Montemayor et al. 2013; Ducatez 2019). Consequently, ISRAs in tropical regions often overrepresent these species (Cochran et al. in 2026; García-Rodríguez et al. 2025). However, most tourism-based citizen science remains limited to nearshore, high-visibility areas during daytime (Thiel et al. 2014; Earp and Liconti 2019), leaving range-restricted, deepwater, and freshwater taxa underrepresented (Gupta et al. 2022; García-Rodríguez et al. 2025). Expanding citizen science to focus on these neglected groups offers a major opportunity (Araujo et al. 2020; Cochran et al. in 2026). With > 120 million recreational divers and fishers, Asia holds enormous untapped potential for scalable citizen science (Ward-Paige and Lotze 2011; Thiel et al. 2014; Raoult et al. 2016; De Brauwer et al. 2017; Ward-Paige et al. 2023). Structured programs, focusing on photo-identification databases and organized engagement of passive contributors (e.g., social media, incidental records; Nascimento et al. 2024), could generate robust datasets, strengthen long-term monitoring, and foster environmental stewardship (Cooper et al. 2007; Cerrano et al. 2017; McKinley et al. 2017; Chin and Pecl 2018). At the same time, the rapid growth of marine wildlife tourism in Asia poses risks from unsustainable practices (Wong et al. 2019; Penketh et al. 2021). ISRAs delineated through tourism-based citizen science can highlight priority areas where management is urgently needed to regulate tourism impacts, such as habitat damage, change in species behaviour, and vessel strikes.

Tourism based citizen science has contributed substantially to ISRA delineation, but fisheries, despite being the most widespread activity affecting sharks and rays in Asia, remain an underutilized and insufficiently integrated source of information. Asia hosts the world's largest chondrichthyan fishery and fleet (FAO 2024b; Worm et al. 2024). Yet, integration of fisheries information into ISRA delineation is limited. For example, in Indonesia, only 15 ISRAs were informed using fisheries data, despite the jurisdiction reporting the world's largest chondrichthyan catches (Worm et al. 2024). Across South and Southeast Asia, most chondrichthyan catches are incidental or opportunistic, often aggregated as 'shark' or 'ray' in catch data, thus obscuring species-specific data and trend patterns (White and Dharmadi 2007; Lam and Sadovy de Mitcheson 2011; Haque et al. 2021). Limited taxonomic resolution in catch data, driven by high species diversity, morphologically similar species, and limited taxonomic expertise, further constrains accurate monitoring (Dharmadi et al. 2015; Prasetyo et al. 2021). Barriers to use these data for ISRA delineation also include the limited life-stage-specific data and minimal spatial reporting on fishing grounds. As a result, 58% of the 112 most frequently caught species in the region (Jabado et al. 2024a) lack associated ISRAs delineation, despite many being threatened. Training in species identification, expanded monitoring infrastructure, digital reporting systems, and use of onboard electronic monitoring to capture catch composition and effort would improve data availability (Tyabji et al. 2020; Soares and Jabado 2024). The Scalloped Hammerhead illustrates this potential; as the second most caught species across eight Asian jurisdictions (Jabado et al. 2024a), it is represented in 22 ISRAs, with fisheries data supporting 38% of these. Similar targeted efforts could improve coverage for other commercially important species. Complementary non-invasive methods are also essential data collection tools. Remote underwater video (Oliver et al 2011; Leonetti et al. 2024), visual censuses (Murray et al. 2019), and aerial surveys (Butcher et al. 2021; Oleksyn et al. 2021; Setyawan et al. 2022b) can provide habitat-use data to support the application of the ISRA Criteria (García-Rodríguez et al. 2025; Cochran et al. in 2026). Electronic tracking, though underutilized in Asia due to cost and logistics, could substantially improve delineation of C4—Movement areas (Sequeira et al. 2025). Regional training and technology transfer are critical to overcome these barriers.

Knowledge gaps across regions and taxa

Several jurisdictions lack ISRAs altogether, despite extensive coastlines and high biodiversity. China, Viet Nam, and the Korean Peninsula collectively encompass ~2 million km^2 of EEZ including including coastal systems influenced by major river discharges (e.g., Mekong River, Red River, Yangtze River) and the Yellow Sea, which likely harbor critical habitats (e.g., Kim et al. 2019), yet no ISRAs have been delineated due to data deficiencies. Other underrepresented areas, include the Sulu Archipelago in the Philippines, an artisanal shark-fishing hotspot with cultural reliance on shark and ray products (Muallil and Hapid 2020; Bensual et al. in press). Contributing factors that prevent the delineation of areas primarily include limited baseline data and systematic research (Clark-Shen et al. 2023; Jabado et al. 2024a), a lack of species-specific data from fisheries catches (Ali and Isa 2003; Escobar Jr. 2003; Azri et al. 2020), and constrained institutional capacity and centralized decision-making (Clark-Shen et al. 2023). Further, marine tourism in most of these jurisdictions is underdeveloped, reducing opportunities for data availability through citizen science (O'Malley et al. 2013; Spalding et al. 2017). Addressing these challenges requires increased research effort and targeted capacity development, including baseline surveys and institutional support. Methods used elsewhere in the region can guide identification in data-limited areas and expanding ISRA delineation in these jurisdictions is essential for comprehensive representation of chondrichthyan habitats across Asia.

Of the four ISRAs identified under Sub-criterion D2 – Diversity, three lie within the Coral Triangle, a global epicenter of marine biodiversity in the Indo-Malayan region. Coastal species richness peaks here across multiple taxa (Roberts et al. 2002; Reaka et al. 2008; Polidoro et al. 2010; Tittensor et al. 2010; Bellwood et al. 2012; Goulding and Dayrat 2023), supporting their designation. However, our species richness results align with global analyses that identify Taiwan and Japan as major hotspots of species richness (Lucifora et al. 2011; Stein et al. 2018; Dulvy et al. 2021). This mismatch was reflected in our findings, with most of the D2 – Diversity ISRAs (62.5% of their total extent), in West Papua, overlapping with areas of relatively low chondrichthyan richness. This can partially be explained by underlying data sources used in the D2 analyses, where the full extent of some species' geographic range may not have been mapped or where new information used to delineate ISRAs includes range expansions. They also suggest that global richness patterns differ for coastal compared to deepsea species, with the latter peaking in the northwestern Pacific (Finucci et al. 2024). Improving distributional data will be essential for capturing and interpreting these diversity patterns.

Deepwater and range-restricted chondrichthyan species are also poorly represented, despite Asia being a global hotpot for these two groups (Stein et al. 2018; Dulvy et al. 2021). Only 12% of deepwater (Kyne and Simpfendorfer 2010) and 21% of range-restricted (IUCN SSC SSG 2023a) species occurring in the region are included in ISRAs. Shortfalls include: (1) only two deepwater ISRAs (Taikyusone Seamount in Japan, Turtle-Northern Islands in Taiwan) occur in the highest deepwater species richness zones (Dulvy et al. 2021); (2) only two ISRAs provide relatively limited spatial coverage of the highest range-restricted species richness zone (the Palk Strait in India/Sri Lanka); and (3) only one ISRA has been delineated for chimaeras, despite the East China Sea being a global hotspot for chimaera richness (Finucci et al. 2021). With 39% of range-restricted species threatened, improved representation will require cross-jurisdictional collaboration (e.g., in India–Sri

Lanka; Japan–China–Chinese Taipei; Brunei Darussalam–Malaysia). Further, with several deepwater species experiencing steep population declines (García et al. 2008; Finucci et al. 2024), precautionary fishing depth limits and restrictions on seabed mining could protect vulnerable habitats as fishing expands into deeper waters (Finucci et al. 2024).

Freshwater habitats were substantially underrepresented. Only two inland ISRAs were delineated, despite Asia hosting some of the world's largest river systems. Limited life-history data prevented the application of ISRA Criterion C for most freshwater species. Yet these species face severe threats from fisheries, pollution, damming, and land-use change, particularly linked to hydropower and palm oil expansion (Fitzherbert et al. 2008; Kyne and Lucifora 2022; Mather et al. 2023). In the Mekong River, where one freshwater ISRA was identified, hydropower expansion compounds pressures from the world's largest inland fishery (Baran and Myschowoda 2009; Winemiller et al. 2016; Lee et al. 2023). Given ~ 88% declines in large-bodied freshwater taxa since the 1970s (Dudgeon et al. 2006; He et al. 2019; Sayer et al. 2025), urgent data collection and targeted ISRA delineation in rivers are needed, especially considering the small area that overlaps with inland protected areas (60 km^2).

Recommendations and future priorities

ISRAs identified in Asia face a range of dynamic and cumulative pressures, including fishing, habitat degradation, and the accelerated impacts of climate change. Strengthening their conservation impact will require urgent, regionally coordinated action (Table 4). Mainstreaming ISRAs into national spatial planning, fisheries management, and MPA expansion strategies is essential to align with biodiversity targets such as KMGBF Target 3. Embedding ISRAs into NBSAPs, NPOAs, and other governance mechanisms would provide a consistent evidence base for accelerating conservation, while long-term monitoring, supported by citizen science and fisheries data, should enable regular reassessment and capture ecological change.

Research must also address significant data gaps. Priorities include expanding ISRA delineation into underrepresented jurisdictions (including the eight jurisdictions without any ISRAs), conducting systematic surveys at the 45 Areas of Interest identified across Asia (Jabado et al. 2024b), and improving coverage for range-restricted, freshwater, deepwater species, and chimaeras. While the recommendations outlined here would improve conservation and management outcomes, funding and governance constraints may impact their implementation. Future ISRA delineation should anticipate climate-driven range shifts and connectivity needs, ensuring networks remain adaptive and ecologically coherent. Inclusive and community-based approaches are central to long-term success. Local engagement, socio-economic incentives, and co-management are critical for fostering stewardship and securing legitimacy. Well-managed MPAs and OECMs show how conservation can deliver ecological and economic benefits (Rechberger et al. 2025), and integrating ISRAs within such frameworks will ensure protection is both scientifically robust and socially grounded. Together, these actions highlight the need to expand area-based conservation, close data gaps, and strengthen stewardship to safeguard the well-known and overlooked imperiled shark and ray assemblages in Asia.

Table 4 Recommendations to support future Important Shark and Ray Areas (ISRAs) delineation and improve the protection and management of existing ISRAs in Asia

Recommendations	Actions
Integrate ISRAs into policy, establish their legal protection, and prioritize diversity hotspots for management	Integrate ISRAs into national and regional marine spatial planning and biodiversity strategies
	Establish or expand MPAs and OECMs integrating ISRAs, focusing on no-take zones to meet global biodiversity targets
	Prioritize management efforts on chondrichthyan species richness hotspots, range-restricted species richness hotspots (see Fig. 8 for specific areas and ISRAs), and heavily depleted chondrichthyan families (Dulvy et al. 2021, 2024)
Improve fisheries management	Integrate ISRAs into fishery management plans
	Enforce existing regulations in fished ISRAs, including gear restrictions, catch prohibitions, incidental catch regulations, spatial restrictions, and seasonal closures
	Implement targeted incidental catch reduction and safe release measures within ISRAs
Build capacity, collaboration, and empower communities	Invest in training, baseline research, and institutional capacity for monitoring in underrepresented jurisdictions Coordinate regional management for transboundary ISRAs Engage local communities in ISRA conservation through co-management, education, and livelihood support
Strengthen research, data collection, and monitoring	Increase financial support for research on chondrichthyans in ISRAs Strengthen collaboration, networking, and knowledge and technology exchange among researchers Prioritize ISRA delineation in areas with the highest range-restricted species richness Broaden research in the 45 Areas of Interest identified in Asia, including the eight jurisdictions lacking ISRAs (Jabado et al. 2024b) Support research for underrepresented groups (range-restricted, deepwater, freshwater, and chimaera species)
	Improve species-specific fisheries data collection, especially in small-scale fisheries
	Conduct research on site-specific threats to chondrichthyans within ISRAs Establish long-term monitoring programs in ISRAs identified using standardized data types (see Figure S4) to support adaptive management
Enhance distribution maps for freshwater and euryhaline species	Improve the spatial resolution of distribution maps for freshwater and euryhaline species by delineating ranges at appropriate ecological scales, incorporating verified occurrence data, and accounting for local extinctions

MPAs, marine protected areas; OECMs, Other Effective Area-based Conservation Measures

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request. The complete information for species, habitats, and ISRA Criteria related to each one of the ISRAs can be found and downloaded from the ISRA website (https://sharkrayareas.org/). IUCN distribution maps are available on the IUCN Red List website [https://www.iucnredlist.org/].

Declarations

Competing interests The authors declare no competing interests.

Disclaimer The designation of geographical entities in this publication, and the presentation of the material, do not imply the expression of any opinion on the part of the IUCN Species Survival Commission Shark Specialist Group concerning the legal status of any country, territory or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

References

Albano PS, Fallows C, Fallows M, Schuitema O, Bernard AT, Sedgwick O, Hammerschlag N (2021) Successful parks for sharks: no-take marine reserve provides conservation benefits to endemic and threatened sharks off South Africa. Biol Conserv 261:109302. https://doi.org/10.1016/j.biocon.2021.109302

Ali A, Isa MM (2003) Review of shark fisheries in the ASEAN region. In: Proceedings of the ASEAN-SEAFDEC Regional Meeting on Fish Trade and Environment, Bangkok, pp 37–52

Araujo G, Legaspi C, Matthews K, Ponzo A, Chin A, Manjaji-Matsumoto BM (2020) Citizen science sheds light on the cryptic ornate eagle ray *Aetomylaeus vespertilio*. Aquat Conserv Mar Freshw Ecosyst 30:2012–2018. https://doi.org/10.1002/aqc.3457

Arunrugstichai S, True JD, White WT (2018) Catch composition and aspects of the biology of sharks caught by Thai commercial fisheries in the Andaman Sea. J Fish Biol 92:1487–1504. https://doi.org/10.1111/jfb.13605

Azri A, Taha H, Arai T (2020) Molecular and morphological evidence for the identity of the blackspot shark, *Carcharhinus sealei*, and the Indonesian whaler shark, *C. tjutjot*, with notes on their population structures. Environ Biol Fishes 103:1453–1461. https://doi.org/10.1007/s10641-020-01025-z

Balai Besar TNTC (2009) Buku zonasi Taman Nasional Teluk Cenderawasih, Kabupaten Nabire dan Teluk Wondama, Provinsi Papua dan Papua Barat. Balai Besar TNTC, Manokwari

Baran E, Myschowoda C (2009) Dams and fisheries in the Mekong Basin. Aquat Ecosyst Health Manag 12(3):227–234. https://doi.org/10.1080/14634980903149902

Bellwood DR, Renema W, Rosen BR (2012) Biodiversity hotspots, evolution and coral reef biogeography. In: Gower D, Johnson K, Richardson J, Rosen B, Rüber L, Williams S (eds) Biotic evolution and environmental change in Southeast Asia. Cambridge Univ Press, Cambridge, p 216

Bensual MS, Attip FJ, Jauhari RA, Sali MA, Rodriguez CIL, Yusop NA, Hamisain APD, Abduraup YT, Ammang MAT, Hapid MGN, Muallil RN (in press) Tiger sharks and whale carcasses: A conservation perspective on local shark fishing practices in Sibutu, Tawi-Tawi, Southern Philippines. J Threat Taxa

Bhowmik AK, Padmanaban R, Cabral P, Romeiras MM (2022) Global mangrove deforestation and its interacting social-ecological drivers: a systematic review and synthesis. Sustainability 14:4433. https://doi.org/10.3390/su14084433

Blaber SJM, Dichmont CM, White W, Buckworth R, Sadiyah L, Iskandar B, Nurhakim S, Pillans R, Andamari R, Dharmadi F (2009) Elasmobranchs in southern Indonesian fisheries: The fisheries, the status of the stocks and management options. Rev Fish Biol Fish 19:367–391. https://doi.org/10.1007/s11160-009-9110-9

Bohorquez JJ, Xue G, Frankstone T, Grima MM, Kleinhaus K, Zhao Y, Pikitch EK (2021) China's little-known efforts to protect its marine ecosystems safeguard some habitats but omit others. Sci Adv 7:eabj1569. https://doi.org/10.1126/sciadv.abj1569

Bonfil R (2002) Trends and patterns in world and Asian elasmobranch fisheries. Wildlife Conservation Society

Booth H, Mardhiah U, Siregar H, Hunter J, Giyanto PMIH, Marlow J, Cahyana A, Boysandi DAYL, Lewis S (2021) An integrated approach to tackling wildlife crime: Impact and lessons learned from the world's largest targeted manta ray fishery. Conserv Sci Pract 3:e314. https://doi.org/10.1111/csp2.314

Boyd C, Charles R, García-Rodríguez E, Gonzalez-Pestana A, Kyne PM, Rohner CA, Jabado RW (2025) Applying the Key Biodiversity Area Standard to important sites for sharks. Conserv Lett 18:e13117. https://doi.org/10.1111/conl.13117

Brewer TD, Cinner JE, Green A, Pressey RL (2013) Effects of human population density and proximity to markets on coral reef fishes vulnerable to extinction by fishing. Conserv Biol 27:443–452

Burke L, Selig E, Spalding M (2002) Reefs at risk in Southeast Asia. World Resources Institute, Washington, DC

Butcher PA, Colefax AP, Gorkin RA III, Kajiura SM, López NA, Mourier J, Raoult V (2021) The drone revolution of shark science: a review. Drones 5:8. https://doi.org/10.3390/drones5010008

Camaclang AE, Maron M, Martin TG, Possingham HP (2015) Current practices in the identification of critical habitat for threatened species. Conserv Biol 29:482–492. https://doi.org/10.1111/cobi.12428

Cerrano C, Milanese M, Ponti M (2017) Diving for science – science for diving: volunteer scuba divers support science and conservation in the Mediterranean Sea. Aquat Conserv 27:303–323. https://doi.org/10.1002/aqc.2663

Chin A, Pecl G (2018) Citizen science in shark and ray research and conservation: strengths, opportunities, considerations, and pitfalls. In: Carrier JC, Heithaus MR, Simpfendorfer CA (eds) Shark research: emerging technologies and applications for the field and laboratory. CRC Press, Boca Raton, pp 299–311

Chin A, Molloy FJ, Cameron D, Day JC, Cramp J, Gerhardt KL, Heupel MR, Read M, Simpfendorfer CA (2023) Conceptual frameworks and key questions for assessing the contribution of marine protected areas to shark and ray conservation. Conserv Biol 37:e13917. https://doi.org/10.1111/cobi.13917

Cinner JE, Graham NA, Huchery C, MacNeil MA (2013) Global effects of local human population density and distance to markets on the condition of coral reef fisheries. Conserv Biol 27:453–458

Cisneros-Montemayor AM, Barnes-Mauthe M, Al-Abdulrazzak D, Navarro-Holm E, Sumaila UR (2013) Global economic value of shark ecotourism: implications for conservation. Oryx 47:381–388. https://doi.org/10.1017/S0030605312001718

Clark-Shen N, Chin A, Arunrugstichai S, Labaja J, Mizrahi M, Simeon B, Hutchinson N (2023) Status of Southeast Asia's marine sharks and rays. Conserv Biol 37:e13962. https://doi.org/10.1111/cobi.13962

Clark-Shen N, Chin A, Gan C, Ting KXT, Terence C, Kai JNZ, Hutchinson N (2025) Overfished and under conserved: life-history, ecology and supply chain of the endangered whitespotted whipray (*Maculabatis gerrardi*) and sharpnose whipray (*Maculabatis macrura*) from South-East Asia. Pac Conserv Biol 31:139–152. https://doi.org/10.1071/PC24086

Cochran J, Charles R, Temple A, Kyne P, García-Rodríguez E, Gonzalez-Pestana A, Battle-Morera A, Mouton T, Armstrong A, Rohner C et al (2026) Only one percent of Important Shark and Ray Areas in the Western Indian Ocean are fully. Ecol Evol. https://doi.org/10.1002/ece3.72690

Constance J, Ebert DA, Fahmi, Finucci B, Simeon B, Kyne PM (2023) *Urolophus javanicus*. The IUCN Red List of Threatened Species 2023: e.T60095A229337053. https://doi.org/10.2305/IUCN.UK.2023-1.RLTS.T60095A229337053.en (Accessed 30 September 2024)

Convention on Biological Diversity (CBD) (2022) Kunming-Montreal Global Biodiversity Framework. Fifteenth Meeting, Montreal, Canada. https://www.cbd.int/gbf/

Convention on the Conservation of Migratory Species of Wild Animals (CMS) (2023) Sharks MOS4 - 4th Meeting of the Signatories to the Memorandum of Understanding on the Conservation of Migratory Sharks. Available at: https://sharks.cms.int/sites/default/files/document/cms_sharks-mos4_decisions_rev_1_e.pdf

Cooper CB, Dickinson J, Phillips T, Bonney R (2007) Citizen science as a tool for conservation in residential ecosystems. Ecol Soc 12:11. https://doi.org/10.5751/ES-02197-120211

Corrigan CM, Ardron JA, Comeros-Raynal MT, Hoyt E, Notarbartolo di Sciara G, Carpenter KE (2014) Developing Important Marine Mammal Area criteria: learning from ecologically or biologically significant areas and Key Biodiversity Areas. Aquat Conserv Mar Freshw Ecosyst 24:166–183. https://doi.org/10.1002/aqc.2513

Costello MJ (2024) Evidence of economic benefits from marine protected areas. Sci Mar 88:1. https://doi.org/10.3989/scimar.05240.01A

Day J, Dudley N, Hockings M, Holmes G, Laffoley D, Stolton S, Wells S, Wenzel L (2019) Guidelines for applying the IUCN protected area management categories to marine protected areas. IUCN, Gland, Switzerland

De Brauwer M, Harvey ES, McIlwain JL, Hobbs JPA, Jompa J, Burton M (2017) The economic contribution of the muck dive industry to tourism in Southeast Asia. Mar Policy 83:92–99. https://doi.org/10.1016/j.marpol.2017.05.033

Dent F, Clarke S (2015) State of the global market for shark products. FAO Fisheries and Aquaculture Technical Paper. Food and Agriculture Organization, Rome, Italy

Dharmadi F, Satria F (2015) Fisheries management and conservation of sharks in Indonesia. Afr J Mar Sci 37(2):249–258. https://doi.org/10.2989/1814232X.2015.1045431

Ducatez S (2019) Which sharks attract research? Analyses of the distribution of research effort in sharks reveal significant non-random knowledge biases. Rev Fish Biol Fish 29:355–367. https://doi.org/10.1007/s11160-019-09556-0

Dudgeon D, Arthington AH, Gessner MO et al (2006) Freshwater biodiversity: importance, threats, status and conservation challenges. Biol Rev 81:163–182. https://doi.org/10.1017/S1464793105006950

Dulvy NK, Simpfendorfer CA, Davidson LN, Fordham SV, Bräutigam A, Sant G, Welch DJ (2017) Challenges and priorities in shark and ray conservation. Curr Biol 27:R565–R572. https://doi.org/10.1016/j.cub.2017.04.038

Dulvy NK, Pacoureau N, Rigby CL, Pollom RA, Jabado RW, Ebert DA, Simpfendorfer CA (2021) Overfishing drives over one-third of all sharks and rays toward a global extinction crisis. Curr Biol 31:4773–4787. https://doi.org/10.1016/j.cub.2021.08.062

Dulvy NK, Pacoureau N, Matsushiba JH, Yan HF, VanderWright WJ, Rigby CL, Simpfendorfer CA (2024) Ecological erosion and expanding extinction risk of sharks and rays. Science 386:eadn1477. https://doi.org/10.1126/science.adn1477

Dulvy NK, Kyne PM, Finucci B, White WT (2020) 2020 *Carcharhinus obsoletus*. The IUCN Red List of Threatened Species pp.e.T115696622A115696628 https://doi.org/10.2305/IUCN.UK.2020-3.RLTS.T115696622A115696628.en (Accessed 6 August 2025)

Earp HS, Liconti A (2019) Science for the future: The use of citizen science in marine research and conservation. In: Jungblut S, Liebich V, Bode M (eds) YOUMARES 9 – The oceans: Our research, our future. Proceedings of the 2018 Conference for Young Marine Researchers, Oldenburg, Germany, pp 1–19. Cham: Springer International Publishing https://doi.org/10.1007/978-3-030-20389-4_1

Eddy TD, Lam VW, Reygondeau G, Cisneros-Montemayor AM, Greer K, Palomares MLD et al (2021) Global decline in capacity of coral reefs to provide ecosystem services. One Earth 4:1278–1285. https://doi.org/10.1016/j.oneear.2021.08.016

Escobar SL Jr (2003) Introduction of trade related issues on shark fisheries. In: Proceedings of the ASEAN-SEAFDEC Regional Meeting on Fish Trade and Environment, Bangkok, Thailand. Secretariat, Southeast Asian Fisheries Development Center, pp 37–52

ESRI Inc. ArcGIS Pro 3.3. ESRI Inc.; 2024

FAO, INFOFISH (2022) The small-scale fisheries and aquaculture sector in Asia – small in scale, big in value. FAO, Bangkok. https://doi.org/10.4060/cc0026en

FAO (2024b) The state of world fisheries and aquaculture 2024 – Blue transformation in action. FAO, Rome. https://doi.org/10.4060/cd0683en

FAO (2024a) FAO Regional Office for Asia and the Pacific. https://www.fao.org/asiapacific/news/news-detail/fao-report--global-fisheries-and-aquaculture-production-reaches-a-new-record-high/en#:~:text=Asia%20accounted%20for%20167.1%20million,97%20percent%20of%20global%20algae (Accessed 27 September 2025)

Faure-Beaulieu N, Lombard AT, Olbers J, Goodall V, da Silva C, Daly R, Harris J (2023) A systematic conservation plan identifying critical areas for improved chondrichthyan protection in South Africa. Biol Conserv 284:110163. https://doi.org/10.1016/j.biocon.2023.110163

Finucci B, Cheok J, Ebert DA, Herman K, Kyne PM, Dulvy NK (2021) Ghosts of the deep – biodiversity, fisheries, and extinction risk of ghost sharks. Fish Fish 22:391–412. https://doi.org/10.1111/faf.12526

Finucci B, Pacoureau N, Rigby CL, Matsushiba JH, Faure-Beaulieu N, Sherman CS, Dulvy NK (2024) Fishing for oil and meat drives irreversible defaunation of deepwater sharks and rays. Science 383:1135–1141. https://doi.org/10.1126/science.ade9121

Fitzherbert EB, Struebig MJ, Morel A, Danielsen F, Brühl CA, Donald PF, Phalan B (2008) How will oil palm expansion affect biodiversity? Trends Ecol Evol 23:538–545. https://doi.org/10.1016/j.tree.2008.06.012

Friedman K, Gabriel S, Abe O, Nuruddin AA, Ali A, Hassan RBR, Ye Y (2018) Examining the impact of CITES listing of sharks and rays in Southeast Asian fisheries. Fish Fish 19:662–676. https://doi.org/10.1111/faf.12281

García VB, Lucifora LO, Myers RA (2008) The importance of habitat and life history to extinction risk in sharks, skates, rays and chimaeras. Proc R Soc B Biol Sci 275:83–89. https://doi.org/10.1098/rspb.2007.1295

García-Rodríguez E, Gonzalez-Pestana A, Charles R, Palacios MD, Notarbartolo di Sciara G, Alfaro-Shigueto J, Jabado RW (2025) Mapping Important Shark and Ray Areas (ISRAs) in the Central and South American Pacific: existing knowledge and data needs. PLoS ONE 20:e0322445. https://doi.org/10.1371/journal.pone.0322445

Gill DA, Mascia MB, Ahmadia GN, Glew L, Lester SE, Barnes M et al (2017) Capacity shortfalls hinder the performance of marine protected areas globally. Nature 543:665–669. https://doi.org/10.1038/nature21708

Giménez J, Cardador L, Mazor T, Kark S, Bellido JM, Coll M, Navarro J (2020) Marine protected areas for demersal elasmobranchs in highly exploited Mediterranean ecosystems. Mar Environ Res 160:105033. https://doi.org/10.1016/j.marenvres.2020.105033

Goetze JS, Heithaus MR, MacNeil MA et al (2024) Directed conservation of the world's reef sharks and rays. Nat Ecol Evol 8:1118–1128. https://doi.org/10.1038/s41559-024-02386-9

Goulding TC, Dayrat B (2023) The Coral Triangle and Strait of Malacca are two distinct hotspots of mangrove biodiversity. Sci Rep 13:15793. https://doi.org/10.1038/s41598-023-42057-6

Grant MI, Kyne PM, Simpfendorfer CA, White WT, Chin A (2019) Categorising use patterns of non-marine environments by elasmobranchs and a review of their extinction risk. Rev Fish Biol Fish 29:689–710. https://doi.org/10.1007/s11160-019-09576-w

Grorud-Colvert K, Sullivan-Stack J, Roberts C, Constant V, Horta e Costa B, Pike EP, Lubchenco J (2021) The MPA guide: A framework to achieve global goals for the ocean. Science 373:eabf0861. https://doi.org/10.1126/science.abf0861

Gupta T, Karnad D, Kottillil S, Kottillil S, Gulland EM (2022) Shark and ray research in India has low relevance to their conservation. Ocean Coast Manag 217:106004. https://doi.org/10.1016/j.ocecoaman.2021.106004

Gurney GG, Darling ES, Ahmadia GN, Agostini VN, Ban NC, Blythe J, Jupiter SD (2021) Biodiversity needs every tool in the box: use OECMs. Nature 595:646–649. https://doi.org/10.1038/d41586-021-02041-4

Haque AB, Cavanagh RD, Seddon N (2021) Evaluating artisanal fishing of globally threatened sharks and rays in the Bay of Bengal, Bangladesh. PLoS ONE 16:e0256146. https://doi.org/10.1371/journal.pone.0256146

He F, Zarfl C, Bremerich V, David JNW, Hogan Z, Kalinkat G, Tockner K, Jähnig SC (2019) The global decline of freshwater megafauna. Glob Change Biol 25:3883–3892. https://doi.org/10.1111/gcb.14753

Hoeksema BW (2007) Delineation of the Indo-Malayan centre of maximum marine biodiversity: the Coral Triangle. In: Renema W (ed) Biogeography, time, and place: distributions, barriers, and islands. Springer, Dordrecht, pp 117–178

Horta e Costa BH, Claudet J, Franco G, Erzini K, Caro A, Gonçalves EJ (2016) A regulation-based classification system for marine protected areas (MPAs). Mar Policy 72:192–198. https://doi.org/10.1016/j.marpol.2016.06.021

Hyde CA, Notarbartolo di Sciara G, Sorrentino L, Boyd C, Finucci B, Fowler SL, Jabado RW (2022) Putting sharks on the map: a global standard for improving shark area-based conservation. Front Mar Sci 9:968853. https://doi.org/10.3389/fmars.2022.968853

Iacarella JC, Clyde G, Bergseth BJ, Ban NC (2021) A synthesis of the prevalence and drivers of non-compliance in marine protected areas. Biol Conserv 255:108992. https://doi.org/10.1016/j.biocon.2021.108992

IUCN SSC Shark Specialist Group (SSG) (2023a) Inventory of knowledge: geographic ranges of sharks, rays, and chimaeras in Asia, Important Shark and Ray Areas (ISRA) Region 9. September 2023. IUCN SSC Shark Specialist Group, Dubai

IUCN SSC Shark Specialist Group (SSG) (2023b) Inventory of knowledge: Summary of existing spatial data in the Asia Region, Important Shark and Ray Areas (ISRA) Region 09. August 2023. Dubai: IUCN SSC Shark Specialist Group

IUCN SSC Shark Specialist Group (SSG) (2024a) Important Shark and Ray Area (ISRA): Guidance on criteria application. Version 2, April 2024. Dubai: IUCN SSC Shark Specialist Group

IUCN SSC Shark Specialist Group (SSG) (2024b) Important Shark and Ray Areas regional expert workshop report: Asia. May 2024. Dubai: IUCN SSC Shark Specialist Group

IUCN (2025) The IUCN Red List of Threatened Species. Version 2025–1. https://www.iucnredlist.org (Accessed 27 September 2025)

Jabado RW, Morata AZA, Bennett RH, Finucci B, Ellis JR, Fowler S, Grant MI, Barbosa Martins AP, Sinclair SL (2024a) The global status of sharks, rays, and chimaeras. Gland, Switzerland: International Union for Conservation of Nature and Natural Resources. https://portals.iucn.org/library/node/52102

Jabado RW, García-Rodríguez E, Kyne PM, Charles R, Bettcher Brito V, Armstrong AO, Gonzalez-Pestana A, Batlle-Morera A, Palacios MD, Notarbartolo di Sciara G, Rohner CA. (2024b). Asia: A regional compendium of Important Shark and Ray Areas. Dubai: IUCN SSC Shark Specialist Group. https://doi.org/10.59216/ssg.isra.2024.r9

Jabado RW, Taylor C, García-Rodríguez E, Batlle-Morera A, Palacios MD, Charles R, Bettcher Brito V, Rohner CA, Armstrong AO, Gonzalez-Pestana A, Kyne PM (2025) Ocean Travellers: Safeguarding Critical Habitats for Migratory Sharks and Rays. Dubai: IUCN SSC Shark Specialist Group. https://doi.org/10.59216/ssg.1.polrep.2025

Jaiteh VF, Lindfield SJ, Mangubhai S, Warren C, Fitzpatrick B, Loneragan NR (2016) Higher abundance of marine predators and changes in fishers' behavior following spatial protection within the world's biggest shark fishery. Front Mar Sci 3:43. https://doi.org/10.3389/fmars.2016.00043

Jompa J, Putri AP, Moore AM, Tamti H, Haerani S (2023) The transference of marine protected area management authority in Indonesia: problems encountered, consequences and ways to move forward. Mar Policy 155:105756. https://doi.org/10.1016/j.marpol.2023.105756

Kamil KA, Hailu A, Rogers A, Pandit R (2017) An assessment of marine protected areas as a marine management strategy in Southeast Asia: a literature review. Ocean Coast Manag 145:72–81. https://doi.org/10.1016/j.ocecoaman.2017.05.008

Kim YS, Jang CJ, Noh JH, Kim KT, Kwon JI, Min Y, Jeong JY (2019) A Yellow Sea monitoring platform and its scientific applications. Front Mar Sci 6:601. https://doi.org/10.3389/fmars.2019.00601

Knowlton N (2021) Ocean optimism: moving beyond the obituaries in marine conservation. Annu Rev Mar Sci 13:479–499. https://doi.org/10.1146/annurev-marine-040220-101608

Kyne PM, Lucifora LO (2022) Freshwater and euryhaline elasmobranchs. In: Carrier JC, Musick JA, Heithaus MR, Yopak KE (eds) Biology of sharks and their relatives. CRC Press, Boca Raton, FL, pp 567–602

Kyne PM, Simpfendorfer CA (2010) Deepwater chondrichthyan. In: Carrier JC, Musick JA, Heithaus MR, Yopak KE (eds) Sharks and their relatives II. CRC Press, Boca Raton, FL, pp 37–65

Kyne PM, Carlson P, Aitchison RM, Al Hameli S, Alberto BM, Gonzalez-Pestana A, Ebert DA (2024) Global status and research priorities for rhino rays. Endang Species Res 55:129–140. https://doi.org/10.3354/esr01366

Lam VY, Sadovy de Mitcheson Y (2011) The sharks of South East Asia – unknown, unmonitored and unmanaged. Fish Fish 12:51–74

Langhammer PF, Bull JW, Bicknell JE, Oakley JL, Brown MH, Bruford MW, Butchart SHM, Carr JA, Church D, Cooney R, Cutajar S, Foden W, Foster MN, Gascon C, Geldmann J, Genovesi P, Hoffmann M, Howard-McCombe J, Lewis T, Macfarlane NBW, Melvin ZE, Merizalde RS, Morehouse MG, Pagad S, Polidoro B, Sechrest W, Segelbacher G, Smith KG, Steadman J, Strongin K, Williams J, Woodley S, Brooks TM (2024) The positive impact of conservation action. Science 384:453–458. https://doi.org/10.1126/science.adj6598
Last PR, White WT, de Carvalho MR, Séret B, Stehmann MFW, Naylor GJP (2016) Rays of the world. CSIRO Publishing, Clayton South
Lee D, Eschenroeder JC, Baumgartner LJ, Chan B, Chandra S, Chea S, Chhut C, Everest E, Hom R, Heng K et al (2023) World Heritage, hydropower, and Earth's largest freshwater fish. Water Basel 15:1936. https://doi.org/10.3390/w15101936
Leonetti FL, Bottaro M, Giglio G, Sperone E (2024) Studying chondrichthyans using baited remote underwater video systems: a review. Animals Basel 14:1875. https://doi.org/10.3390/ani14131875
Lucifora LO, García VB, Worm B (2011) Global diversity hotspots and conservation priorities for sharks. PLoS ONE 6(5):e19356. https://doi.org/10.1371/journal.pone.0019356
Magson K, Monacella E, Scott C, Buffat N, Arunrugstichai S, Chuangcharoendee M et al (2022) Citizen science reveals the population structure and seasonal presence of whale sharks in the Gulf of Thailand. J Fish Biol 101:540–549. https://doi.org/10.1111/jfb.15121
Mangubhai S, Saleh M, Muljadi A, Rhodes KL, Tjandra K (2011) Do not stop: the importance of seamless monitoring and enforcement in an Indonesian marine protected area. J Mar Biol 2011:501465. https://doi.org/10.1155/2011/501465
Mascia MB, Claus CA, Naidoo R (2010) Impacts of marine protected areas on fishing communities. Conserv Biol 24:1424–1429
Mather R, Chin A, Rigby C, Cooke SJ, Fahmi HAB, Grant MI (2023) Murky waters: Assessing the vulnerabilities of Indo-West Pacific non-marine elasmobranchs to inform future conservation planning priorities. Aquat Conserv Mar Freshw Ecosyst 34:e4039. https://doi.org/10.1002/aqc.4039
Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (2024) Summary for policymakers of the Thematic Assessment Report on the interlinkages among biodiversity, water, food and health of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. McElwee PD, Harrison PA, van Huysen TL, Alonso Roldán V, Barrios E, Dasgupta P, DeClerck F, Harmáčková ZV, Hayman DTS, Herrero M, Kumar R, Ley D, Mangalagiu D, McFarlane RA, Paukert C, Pengue WA, Prist PR, Ricketts TH, Rounsevell MDA, Saito O, Selomane O, Seppelt R, Singh PK, Sitas N, Smith P, Vause J, Molua EL, Zambrana-Torrelio C, Obura D (eds). Bonn, Germany: IPBES Secretariat. https://doi.org/10.5281/zenodo.13850289
McKinley DC, Miller-Rushing AJ, Ballard HL, Bonney R, Brown H, Cook-Patton SC et al (2017) Citizen science can improve conservation science, natural resource management, and environmental protection. Biol Conserv 208:15–28. https://doi.org/10.1016/j.biocon.2016.05.015
Michael L, Morrison ML, Marcot BG, Mannan RW (2006) Wildlife–habitat relationships: concepts and applications, 3rd ed. Island Press, Washington, DC
Morse M, McCauley D, Orofino S, Stears K, Mladjov S, Caselle J, Freedman R (2024) Preferential selection of marine protected areas by the recreational scuba diving industry. Mar Policy 159:105908. https://doi.org/10.1016/j.marpol.2023.105908
Mouillot D, Velez L, Albouy C, Casajus N, Claudet J, Delbar V, Thuiller W (2024) The socioeconomic and environmental niche of protected areas reveals global conservation gaps and opportunities. Nat Commun 15:9007. https://doi.org/10.1038/s41467-024-53241-1
Mouton TL, Gonzalez-Pestana A, Rohner CA, Charles R, García-Rodríguez E, Kyne PM, Jabado RW (2025) Shortfalls in the protection of Important Shark and Ray Areas undermine shark conservation efforts in the Central and South American Pacific. Mar Policy 171:106448. https://doi.org/10.1016/j.marpol.2024.106448
Muallil RN, Hapid MGN (2020) Preliminary report on an artisanal fishery for thresher sharks (*Alopias spp.*) in Tawi-Tawi, Southern Philippines. Mar Policy 117:103894. https://doi.org/10.1016/j.marpol.2020.103894
Muallil RN, Deocadez MR, Martinez RJS, Campos WL, Mamauag SS, Nañola CL Jr, Aliño PM (2019) Effectiveness of small locally-managed marine protected areas for coral reef fisheries management in the Philippines. Ocean Coast Manag 179:104831. https://doi.org/10.1016/j.ocecoaman.2019.104831
Murray R, Conales S Jr, Araujo G, Labaja J, Snow SJ, Pierce SJ, Songco A, Ponzo A (2019) Tubbataha Reefs Natural Park: the first comprehensive elasmobranch assessment reveals global hotspot for reef sharks. J Asia-Pac Biodivers 12:49–56. https://doi.org/10.1016/j.japb.2018.09.009
Mustika PLK, Ichsan M, Booth H (2020) The economic value of shark and ray tourism in Indonesia and its role in delivering conservation outcomes. Front Mar Sci 7:261. https://doi.org/10.3389/fmars.2020.00261

Nascimento LS, Júnior MN, Hara CS, Noernberg MA (2024) Passive citizen science: social media as a tool for marine wildlife observation. Mar Ecol Prog Ser 740:219–233. https://doi.org/10.3354/meps14629

National Oceanic and Atmospheric Administration (NOAA) (2012) Coastal and marine ecological classification standard. Marine and Coastal Spatial Data Subcommittee. https://iocm.noaa.gov/standards/cmecs-home.html (Accessed 27 September 2025)

Niedermüller S, Ainsworth G, de Juan S, Garcia R, Ospina-Alvarez A, Pita P, Villasante S (2021) The shark and ray meat network: A deep dive into a global affair. WWF Mediterranean Marine Initiative, Rome, Italy

Nikolaou A, Katsanevakis S (2023) Marine extinctions and their drivers. Reg Environ Change 23(3):88. https://doi.org/10.1007/s10113-023-02081-8

O'Hara CC, Frazier M, Halpern BS (2021) At-risk marine biodiversity faces extensive, expanding, and intensifying human impacts. Science 372:84–87. https://doi.org/10.1126/science.abe6731

O'Malley MP, Lee-Brooks K, Medd HB (2013) The global economic impact of manta ray watching tourism. PLoS ONE 8:e65051. https://doi.org/10.1371/journal.pone.0065051

Oldekop JA, Holmes G, Harris WE, Evans KL (2016) A global assessment of the social and conservation outcomes of protected areas. Conserv Biol 30:133–141. https://doi.org/10.1111/cobi.12568

Oleksyn S, Tosetto L, Raoult V, Joyce KE, Williamson JE (2021) Going batty: the challenges and opportunities of using drones to monitor the behaviour and habitat use of rays. Drones 5:12. https://doi.org/10.3390/drones5010012

Oliver SP, Hussey NE, Turner JR, Beckett AJ (2011) Oceanic sharks clean at coastal seamount. PLoS ONE 6:e14755. https://doi.org/10.1371/journal.pone.0014755

Palacios MD, Weiand L, Laglbauer BJ, Cronin MR, Fowler S, Jabado RW, Stevens GM (2024) Global assessment of manta and devil ray gill plate and meat trade: conservation implications and opportunities. Environ Biol Fishes 108:611–638. https://doi.org/10.1007/s10641-024-01636-w

Penketh L, Schleimer A, Labaja J, Snow S, Ponzo A, Araujo G (2021) Scarring patterns of whale sharks, *Rhincodon typus*, at a provisioning site in the Philippines. Aquat Conserv Mar Freshw Ecosyst 31:99–111. https://doi.org/10.1002/aqc.3437

Polidoro BA, Carpenter KE, Collins L, Duke NC, Ellison AM, Ellison JC et al (2010) The loss of species: mangrove extinction risk and geographic areas of global concern. PLoS ONE 5(4):e10095. https://doi.org/10.1371/journal.pone.0010095

Pomeroy R (2007) Fish wars: conflict and collaboration in fisheries management in Southeast Asia. Mar Policy 31:645–656. https://doi.org/10.1016/j.marpol.2007.03.012

Prasetyo AP, McDevitt AD, Murray JM, Barry J, Agung F, Muttaqin E, Mariani S (2021) Shark and ray trade in and out of Indonesia: addressing knowledge gaps on the path to sustainability. Mar Policy 133:104714. https://doi.org/10.1016/j.marpol.2021.104714

Raoult V, David PA, Dupont SF, Mathewson CP, O'Neill SJ, Powell NN, Williamson JE (2016) GoPros™ as an underwater photogrammetry tool for citizen science. PeerJ 4:e1960. https://doi.org/10.7717/peerj.1960

Reaka ML, Rodgers PJ, Kudla AU (2008) Patterns of biodiversity and endemism on Indo-West Pacific coral reefs. Proc Natl Acad Sci USA 105(Suppl 1):11474–11481. https://doi.org/10.1073/pnas.0802594105

Rechberger KD, Mayorga J, Booth M, Sala E (2025) A pathway to protect 30% of coastal waters by 2030. Mar Policy 180:106773. https://doi.org/10.1016/j.marpol.2025.106773

Rigby CL, Derrick D, Dulvy NK, Grant MI, Jabado RW (2021) *Glyphis gangeticus*. The IUCN Red List of Threatened Species 2021: e.T169473392A124398647. https://doi.org/10.2305/IUCN.UK.2021-2.RLTS.T169473392A124398647.en (Accessed 22 July 2025)

Roberts CM, McClean CJ, Veron JE, Hawkins JP, Allen GR, McAllister DE et al (2002) Marine biodiversity hotspots and conservation priorities for tropical reefs. Science 295(5558):1280–1284. https://doi.org/10.1126/science.1067728

Rocliffe S, Peabody S, Samoilys M, Hawkins JP (2014) Towards a network of locally managed marine areas (LMMAs) in the Western Indian Ocean. PLoS ONE 9:e103000. https://doi.org/10.1371/journal.pone.0103000

Rohner CA, Richardson AJ, García-Rodríguez E, Charles R, Batlle-Morera A, Bortoluzzi JR, Jabado RW (2025) Important shark and ray areas can inform conservation planning in the Mediterranean and Black Seas. iScience 26:113192. https://doi.org/10.1016/j.isci.2025.113192

Salayo N, Garces L, Pido M, Viswanathan K, Pomeroy R, Ahmed M, Siason I, Seng K, Masae A (2008) Managing excess capacity in small-scale fisheries: perspectives from stakeholders in three Southeast Asian countries. Mar Policy 32:692–700. https://doi.org/10.1016/j.marpol.2007.12.001

Sanciangco JC, Carpenter KE, Etnoyer PJ, Moretzsohn F (2013) Habitat availability and heterogeneity and the Indo-Pacific warm pool as predictors of marine species richness in the tropical Indo-Pacific. PLoS ONE 8:e56245. https://doi.org/10.1371/journal.pone.0056245

Sayer CA, Fernando E, Jimenez RR, Macfarlane NB, Rapacciuolo G, Böhm M, Darwall WR (2025) One-quarter of freshwater fauna threatened with extinction. Nature 638:138–145. https://doi.org/10.1038/s41586-024-08375-z

Schuhbauer A, Favoretto F, Wang T, Aburto-Oropeza O, Sala E, Millage K, Cisneros-Montemayor A (2023) Global economic impact of scuba dive tourism. Preprint. https://doi.org/10.21203/rs.3.rs-2609621/v1

Seguin R, Le Manach F, Devillers R, Velez L, Mouillot D (2025) Global patterns and drivers of untracked industrial fishing in coastal marine protected areas. Science 389:396–401. https://doi.org/10.1126/science.ado9468

Sequeira AM, Rodríguez JP, Marley SA, Calich HJ, van der Mheen M, VanCompernolle M et al (2025) Global tracking of marine megafauna space use reveals how to achieve conservation targets. Science 388:1086–1097. https://doi.org/10.1126/science.adl0239

Setyawan EDY, Erdmann MV, Lewis SA, Mambrasar R, Hasan AW, Templeton S, Pilkington-Vincett R (2020) Natural history of manta rays in the Bird's Head Seascape, Indonesia, with an analysis of the demography and spatial ecology of *Mobula alfredi* (Elasmobranchii: Mobulidae). J Ocean Sci Found 36:49–83. https://doi.org/10.5281/zenodo.4396260

Setyawan E, Stevenson BC, Erdmann MV, Hasan AW, Sianipar AB, Mofu I, Constantine R (2022a) Population estimates of photo-identified individuals using a modified POPAN model reveal that Raja Ampat's reef manta rays are thriving. Front Mar Sci 9:1014791. https://doi.org/10.3389/fmars.2022.1014791

Setyawan E, Stevenson BC, Izuan M, Constantine R, Erdmann MV (2022b) How big is that manta ray? A novel and non-invasive method for measuring reef manta rays using small drones. Drones 6:63. https://doi.org/10.3390/drones6030063

Setyawan E, Hasan AW, Malaiholo Y, Sianipar AB, Mambrasar R, Meekan M, Erdmann MV (2025) Insights into the population demographics and residency patterns of photo-identified whale sharks *Rhincodon typus* in the Bird's Head Seascape, Indonesia. Front Mar Sci 12:1607027. https://doi.org/10.3389/fmars.2025.1607027

Shidqi RA, Erdmann MV, Setyawan E, Lezama-Ochoa N, Sari DR, Sianipar AB, Croll DA (2024) Identifying spatial movements and residency of pelagic thresher sharks (*Alopias pelagicus*) using satellite and passive acoustic telemetry to inform local conservation in Central Indonesia. Frontiers in Fish Science 2:1391062. https://doi.org/10.3389/frish.2024.1391062

Shidqi RA, Sari DR, Alopen J, Bang YM, Arianto I, Kopong PN, Booth H (2025) Designing and evaluating alternative livelihoods for shark conservation: a case study on thresher sharks in Alor Island, Indonesia. Oryx 59:19–30. https://doi.org/10.1017/S0030605324001376

SIDAKO (2025) Sistem Database Konservasi Dit KKHL. https://sidako.kkp.go.id/sidako/map Accessed 26 July 2025

Sivakumar K, Mathur VB, Pande A (2013) Coastal and marine protected areas in India: Challenges and way forward. In: Sivakumar K (ed) Coastal and marine protected areas in India: Challenges and way forward. ENVIS Bulletin: Wildlife & Protected Areas 15. Wildlife Institute of India, Dehradun, pp 1–12

Soares ALF, Jabado RW (2024) Fisher perceptions of catch and trade of sharks and rays in Angolan small-scale fisheries. Aquat Conserv Mar Freshw Ecosyst 34:e4168. https://doi.org/10.1002/aqc.4168

Spalding M, Burke L, Wood SA, Ashpole J, Hutchison J, Zu Ermgassen P (2017) Mapping the global value and distribution of coral reef tourism. Mar Policy 82:104–113. https://doi.org/10.1016/j.marpol.2017.05.014

Stein RW, Mull CG, Kuhn TS, Aschliman NC, Davidson LN, Joy JB, Mooers AO (2018) Global priorities for conserving the evolutionary history of sharks, rays and chimaeras. Nat Ecol Evol 2:288–298. https://doi.org/10.1038/s41559-017-0448-4

Sudo K, Quiros TAL, Prathep A, Luong CV, Lin HJ, Bujang JS et al (2021) Distribution, temporal change, and conservation status of tropical seagrass beds in Southeast Asia: 2000–2020. Front Mar Sci 8:637722. https://doi.org/10.3389/fmars.2021.637722

Taylor MF, Suckling KF, Rachlinski JJ (2005) The effectiveness of the endangered species act: a quantitative analysis. Bioscience 55:360–367. https://doi.org/10.1641/0006-3568(2005)055[0360:TEOTES]2.0.CO;2

Thiel M, Penna-Díaz MA, Luna-Jorquera G, Salas S, Sellanes J, Stotz W (2014) Citizen scientists and marine research: volunteer participants, their contributions, and projection for the future. Oceanogr Mar Biol Annu Rev 52:257–314

Tittensor DP, Mora C, Jetz W, Lotze HK, Ricard D, Van Berghe E, Worm B (2010) Global patterns and predictors of marine biodiversity across taxa. Nature 466(7310):1098–1101. https://doi.org/10.1038/nature09329

Todd PA, Ong X, Chou LM (2010) Impacts of pollution on marine life in Southeast Asia. Biodivers Conserv 19:1063–1082. https://doi.org/10.1007/s10531-010-9778-0

Tyabji Z, Wagh T, Patankar V, Jabado RW, Sutaria D (2020) Catch composition and life history characteristics of sharks and rays (Elasmobranchii) landed in the Andaman and Nicobar Islands, India. PLoS ONE 15:e0231069. https://doi.org/10.1371/journal.pone.0231069

UNEP-WCMC (2019) User manual for the World Database on Protected Areas and World Database on Other Effective Area-Based Conservation Measures: 1.6. UNEP-WCMC, Cambridge, UK

UNEP-WCMC, IUCN (2025) Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-Based Conservation Measures (WD-OECM) [Online], February 2025. UNEP-WCMC and IUCN, Cambridge, UK. Available at: www.protectedplanet.net (Accessed 27 September 2025)

Vance M (2003) The biological foundation of critical habitat for species at risk: A literature review. Paper for the Critical Habitat Working Group

Vargas-Fonseca OA, Halpern BS, Blanchard JL, Bryndum-Buchholz A, Cheung WWL, Coll M, Du Pontavice H, Fulton EA, Jennings S, Lotze HK, Maury O, McDonald G, Mendenhall E, Payne MR, Rantanen E, Singh GG, Stock CA, Sumaila UR, Watson RA, McCauley DJ (2024) Knowns and unknowns in future human pressures on the ocean. Earths Future 12:e2024EF004559. https://doi.org/10.1029/2024EF004559

Ward-Paige CA, Lotze HK (2011) Assessing the value of recreational divers for censusing elasmobranchs. PLoS ONE 6:e25609. https://doi.org/10.1371/journal.pone.0025609

Ward-Paige CA, Westell A, Sing B (2018) Using eOceans diver data to describe contemporary patterns of marine animal populations: a case study of sharks in Thailand. Ocean Coast Manag 163:1–10. https://doi.org/10.1016/j.ocecoaman.2018.05.023

Ward-Paige CA, Sykes H, Osgood GJ, Brunnschweiler J (2023) Corrigendum to: community-driven shark monitoring for informed decision making: a case study from Fiji. Pac Conserv Biol 29:463. https://doi.org/10.1071/PC22009

Watson JE, Venegas-Li R, Grantham H, Dudley N, Stolton S, Rao M, Ward M (2023) Priorities for protected area expansion so nations can meet their Kunming-Montreal Global Biodiversity Framework commitments. Integr Conserv 2:140–155. https://doi.org/10.1002/inc3.24

Weigmann S, Didier D, Finucci B, Nakaya K, Naylor GJP, Séret B, Straube N, Vaz DFB (2024) Biodiversity, taxonomy, and systematics of extant chondrichthyan fishes. In: Sinclair SL (ed) The global status of sharks, rays, and chimaeras. IUCN, Gland, Switzerland. https://portals.iucn.org/library/node/52102

White WT, Dharmadi (2007) Species and size compositions and reproductive biology of rays (Chondrichthyes, Batoidea) caught in target and non-target fisheries in eastern Indonesia. J Fish Biol 70:1809–1837

Winemiller KO, McIntyre PB, Castello L, Fluet-Chouinard E, Giarrizzo T, Nam S et al (2016) Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. Science 351:128–129. https://doi.org/10.1126/science.aac7082

Wong CM, Conti-Jerpe I, Raymundo LJ, Dingle C, Araujo G, Ponzo A, Baker DM (2019) Whale shark tourism: impacts on coral reefs in the Philippines. Environ Manage 63:282–291. https://doi.org/10.1007/s00267-018-1120-y

Worm B, Orofino S, Burns ES, D'Costa NG, Feitosa LM, Palomares ML et al (2024) Global shark fishing mortality still rising despite widespread regulatory change. Science 383:225–230. https://doi.org/10.1126/science.adf8984

Yan HF, Kyne PM, Jabado RW, Leeney RH, Davidson LN, Derrick DH, Dulvy NK (2021) Overfishing and habitat loss drive range contraction of iconic marine fishes to near extinction. Sci Adv 7:eabb6026. https://doi.org/10.1126/sciadv.abb6026

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