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MARINE & FRESHWATER RESEARCH

Corrigendum to: Search for the vulnerable giants: the presence of giant guitarfish and wedgefish in the Karimunjawa National Park and adjacent waters

Faqih Akbar Alghozali, Muhammad Wiralaga Dwi Gustianto, Ashma Hanifah, Maula Nadia, Widyastuti, Nauvan Prabhu, Lufni Fauzil Adhim, Khansa Alifa Nurhaliza, Hollie Booth, Muhammad Ichsan, Andhika Prasetyo and Nesha Ichida

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The authors of the above-mentioned paper regret to inform readers that, in the Online Early version of their paper, the last author was missing from the author list. The author list (including affiliations) should be as below (correction in bold):

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Mahardika Rizqi Himawan declares that they have no conflicts of interest for this paper nor do they have any relevant funding to declare.

We apologise for the error and any confusion this may have caused.

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Search for the vulnerable giants: the presence of giant guitarfish and wedgefish in the Karimunjawa National Park and adjacent waters

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ABSTRACT

Context. Giant guitarfish (Family: Glaucostegidae) and wedgefish (Family: Rhinidae) (Critically Endangered, IUCN Red List and CITES Appendix II) are highly exploited throughout their distribution because of their highly valued fins in the international market. Both are commonly caught as bycatch or secondary valuable catch in the Java Sea, including in Karimunjawa National Park, Central Java, Indonesia. **Aims.** Assess the presence and relative abundance of giant guitarfish and wedgefish species in Karimunjawa National Park and adjacent waters. **Methods.** Data were collected using baited remote underwater video (BRUV) surveys across 40 sites, covering multiple zonation areas and depth ranges. All species were identified to the species level and their relative abundance was tested with one-way PERMANOVA based on sites, zonation areas and depths. **Key results.** Two target species, *Glaucostegus typus* and *Rhynchobatus australiae*, were present in the study area with a maximum number of 3 and 6 and relative abundance of 0.0048 and 0.0096 respectively, over 477 BRUVs and 623.9 h of videos. Their presence during the study was not affected by sites, zonations or depth. **Implications.** The presence and relative abundance of both *G. typus* and *R. australiae* were low, which may be a result of decades of overfishing, and have provided the first information to the urgency of managing the species in the areas.

Keywords: BRUV, elasmobranch, giant guitarfish, Indonesia, Karimunjawa, presence, relative abundance, wedgefish.

Introduction

The cartilaginous fishes (Class Chondricthyes) is an ancient and diverse group of species, including sharks, rays, skates and chimera (Ebert *et al.* 2021), which is now one of the world's most threatened taxonomic groups (Dulvy *et al.* 2021). Of this group, giant guitarfish (Family: Glaucostegidae) and wedgefish (Family: Rhinidae) are among the most threatened, with the majority of species having recently been assessed as Critically Endangered by the IUCN Red List in 2018, because of extensive exploitation as target and valuable secondary catch (Kyne *et al.* 2019*a*, 2019*b*). These taxa are highly exploited throughout their distribution and have some of the highest-valued fins in the international market (Suzuki 2002; Dent and Clarke 2015; Moore 2017; Jabado 2018; Kyne *et al.* 2020; Haque *et al.* 2021). In 2019, both taxa were listed on the Convention on International Trade of Endangered Species (CITES) Appendix II at the CITES Conference of the Parties 18, which stipulates that any international trade in these taxa should be compatible with their survival in the wild (i.e. sustainable).

Indonesia is a global priority for conservation of giant guitarfish and wedgefish, because it is a hotspot of species diversity and also the world's largest shark and ray fishing nation (Dent and Clarke 2015). Giant guitarfish and wedgefish are extensively caught and utilised in many regions, including Aceh, West Kalimantan, East Lombok and the northern coast of

Java (Faizah and Chodrijah 2020; Simeon *et al*. 2020; Yuwandana *et al*. 2020; Booth *et al*. 2023*a*; Hermansyah *et al*. 2022). This creates a challenge for successful implementation of CITES, which was ratified by the Government of Indonesia in 2022 under the Minitrial Decree of the Ministry of Maritime Affairs and Fisheries Number 12 Year 2022 (recommends the catch quota and minimum catch size of 180 cm for giant guitarfish, *Glaucostegus* spp., and 170 cm for wedgefish, *Rhynchobatus* spp.) and Number 61 Year 2018 (concerning utilisation of protected or CITES listed fish species).

The Java Sea in northern Java is a priority location for giant guitarfish and wedgefish management in Indonesia, as it experiences intense fishing pressure, which creates a threat to these taxa; yet, it is also home to an important marine protected area (MPA), Karimunjawa National Park (KJNP), which offers a potential opportunity for improved fisheries management and conservation. Northern Java commercial fisheries frequently capture large giant guitarfish and wedgefish, particularly in vessels that use bottom longlines, gill-nets and trawls (Ministry of Maritime Affairs and Fisheries 2019; Yuwandana *et al*. 2020). The most commonly caught species are the giant guitarfish (*Glaucostegus typus*) and the bottlenose wedgefish (*Rhynchobatus australiae*) (Yuwandana *et al*. 2020). Both species have conservative life-history strategies, being slow-growing and long-lived (White 2007; Last and Stevens 2009; White *et al*. 2014*a*; Last *et al*. 2016). KJNP is located near the main fishing grounds of northern Java's fishing fleets and may serve as an important mating and nursery ground for giant guitarfish and wedgefish, on the basis of their ecology and breeding behaviour (Kyne *et al*. 2019*a*, 2019*b*). KJNP is a multi-use MPA, which is still home to four traditional fishing villages that are permitted to conduct small-scale fishing activities within the traditional fishing zones of KJNP, whereas commercial fishing is restricted. Local fishing within KJNP comprises small-scale fisheries (SSFs) that utilise handlines, gill-nets, fish traps and spearguns (Elasmobranch Project Indonesia, EPI, unpubl. data), and giant guitarfish are ocassionally caught (Elasmobranch Project Indonesia 2019). A whole giant guitarfish and wedgefish (locally known as '*kekeh*' and '*junjunan*' respectively) can fetch up to IDR15 000 and R50 000 kg^{-1} respectively for a large individual (~100 kg), or the equivalent of ~US$100 and ~$320 fish^{-1} at the time of writing (2022) if sold in KJNP (EPI, unpubl. data).

Despite the need and opportunity for giant guitarfish and wedgefish conservation and fisheries management in the Java Sea and KJNP, there is a lack of data describing the presence, distribution, status and local uses of these taxa, which hinders species-specific management and implementation of CITES. This study aims to fill this gap by providing baseline information on giant guitarfish–wedgefish and other elasmobranch species presence, distribution, and relative abundance in KJNP and adjacent waters, by using baited remote underwater videos (BRUVs). This is the first study of its kind in the Java Sea, and offers potential recommendations for area-based and fisheries management in and around KJNP.

Materials and methods

Study site

The study was conducted in the waters of KJNP (5°48′58.45″S, 110°28′07.04″E) in central Java Province, Indonesia (Fig. 1),

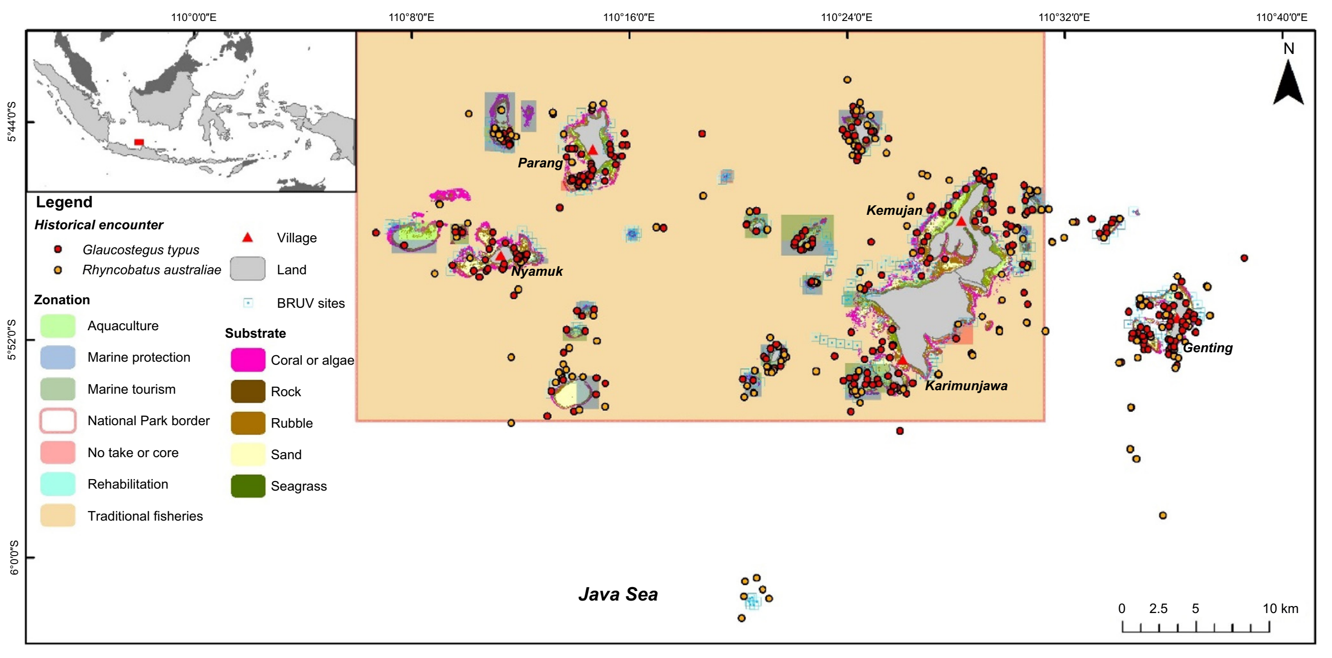

Fig. 1. Map of fishers' historical encounters with *G. typus* and *R. australiae* and BRUV survey sites in KJNP and adjacent waters.

which was declared as a Marine Protection Area (MPA) in 2001 (Direktorat Jenderal Perlindungan Hutan dan Konservasi Alam 2012), as well as the five islands east of the park (Cendikian, Gundul, Sambangan, Seruni and Genting). KJNP is a multi-use MPA, and since 2009, nine zones have been established, including the core (no-take), marine protection (no-take), marine utilisation, marine culture, traditional fisheries, forest, land utilisation, rehabilitation, and religion, culture and history zones. The core and traditional fisheries zone cover an area of 4446.29 and 1 028 992.49 km^2 respectively (see Balai Taman Nasional Karimunjawa (BTNKJ), Profil Kawasan Taman Nasional Karimunjawa at https://tnkarimunjawa.id/profil/index).

Baited remote underwater video

Baited remote underwater video surveys were conducted between August and October 2022 in 40 sites, which were selected on the basis of fishers' historical encounters with giant guitarfish and wedgefish in the national park (Corbett 2009) that were collected by the EPI team between April and June 2022 (EPI, unpubl. data) (Fig. 1). The survey period was chosen because it has the calmest and best weather conditions between the East and West Monsoon seasons. Depending on the region, both monsoon seasons have rough weather, including unusually strong wind and waves. During West Monsoon season, especially in KJNP, most fishers will not go fishing unless weather is good. The BRUV units were distributed in the following four park zones: marine tourism, marine protection, traditional fisheries and core zones. Six BRUV units were used with a modified structure following the design used by Phenix et al. (2019), namely, a pyramid steel frame with dimensions of 50 × 50 cm (base) × 25 × 25 cm (top) × 60 cm (slant height) and 30 × 30 cm plus shaped camera platform in the middle of the frame (Fig. 2). Each BRUV unit was equipped with a 100 cm long, 1″ (~2.5 cm) diameter PVC bait pole and a 30 cm long, 3″ (~7.6 cm) diameter PVC bait canister attached at the end.

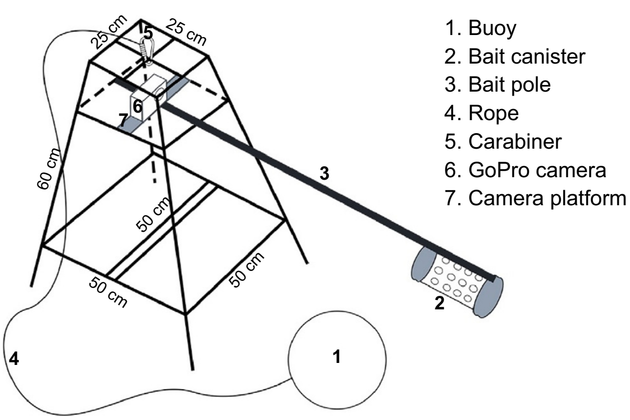

Fig. 2. BRUV structure design used in the study (modified from Phenix et al. 2019).

The bait used was 1 kg of tuna-like species of *Auxis thazard*, *Euthynnus affinis* or *Thunnus tonggol* (Harvey et al. 2007) for each deployment. These species are oilier than are reef fishes, crustaceans and squids, which is perfect for elasmobranch species, and will last longer during soaking. This helped prevent bias because the BRUV recording went closer to the 1–1.5-h mark (standard duration for elasmobranch study with BRUVs). GoPro (Hero Black 7 and 8) cameras with underwater housing and a setting of 1080p, 60 frames s^{-1} and a linear view were used and attached to the camera platform facing the bait canister. A buoy fixed to a rope was attached to the frame to mark the BRUV unit post-deployment. The technical details of the BRUV survey followed a modified design by Beer (2015), Bond et al. (2012) and Rizzari et al. (2014).

In total, 489 BRUV units were deployed across all 27 islands and 8 reef flats or sandbars within and adjacent to KJNP. Most of the deployments were at a depth of 20–30 m (40.7%) and the most common substrate where BRUV units were deployed was plain sand (68.8%) (Table 1). In terms of zones, BRUV units were mainly deployed in traditional fisheries (39.2%), marine tourism (20.3%) and marine protection (16.8%) zones, and 15.3% were deployed outside of the national park area. Surveys were conducted between 08:00 and 16:00 hours and ~12 BRUV units were deployed per day with a soak time of 70–80 min each. The depth range was within 1–40 m, with each deployment distancing between 300 and 1000 m to avoid sighting replication and overlapping bait plumes. Each BRUV unit was deployed carefully from a boat to the seafloor with the coordinates and depth was taken using a GPS and depth sounder.

Video review

All BRUV recordings were reviewed and analysed in real time using available media players (e.g. MPC-HC, VLC, Windows Media Player). The analysis of each video duration started once the BRUV unit fully settled on the seafloor (mark zero) and went on until the BRUV unit was pulled up or the battery has died. We recorded the duration length and substrate recorded during each BRUV drop. We excluded videos from BRUV units that fell with the camera facing the surface.

All giant guitarfish, wedgefish and all other elasmobranch were identified and recorded. Giant guitarfish is easily identified by its morphological differences, such as the snout, head shape and number of large thorns on the ventral side, whereas wedgefish is more difficult to distinguish owing to its similar white spot patterns within its species complex (Jabado 2019). We also recorded encounters of all other shark and ray species recorded by the BRUV units. This is because fisher encounters suggest that giant guitarfish and wedgefish are likely to be low in abundance in KJNP, and additional data on other shark and ray taxa allowed us to contextualise abundance of giant guitarfish and wedgefish relative to other species, and explore any patterns in spatial co-occurrence. The maximum number (n_{max}) of individuals

Table 1. Composition of depth, substrate and zonation of BRUV unit deployments in this study where *n* is the number of deployed BRUV units.

Depth range (m)	*n*	%*n*	Substrate	*n*	%*n*	Zonation	*n*	%*n*
0–10	33	6.9	Sand	328	68.8	Aquaculture	11	2.3
10.1–20	132	27.7	Sand, coral	29	6.1	Traditional fisheries	187	39.2
20.1–30	194	40.7	Sand, rubble	84	17.6	Marine protection	80	16.8
30.1–40	118	24.7	Sand, rubble, coral	17	3.6	Marine tourism	97	20.3
			Other	18	3.8	No-take or core	29	6.1
						Outside National Park	73	15.3

of each species in each video was then recorded. The relative abundance of each species was then calculated for their n_{max} per survey hour. Information on depth, substrate and deployment time were assigned against the species composition (Willis *et al.* 2000; Cappo *et al.* 2007*a*, 2007*b*; Harvey *et al.* 2007).

Data analysis

To understand any significant differences in distribution of giant guitarfish and wedgefish throughout the surveyed sites, one-way permutational ANOVA (PERMANOVA) with 9999 permutations and Euclidean similarity index were used to test differences in n_{max}, comparing west, east and outside of national park; in zonation, comparing no-take (core and marine protection), open access (rest) zone and outside of national park; and in depth, comparing 0–10, 10.1–20, 20.1–30 and 30.1–40 m (Beer 2015).

Ethical statement

The study was conducted under the research permit from BTNKJ (permit numbers 1567/T.34/TU/SIMAKSI/05/2022 and 1596/T.34/TU/SIMAKSI/08/2022) and Badan Riset dan Sumberdaya Manusia Kelautan dan Perikanan (BRSDMKP) (permit number 223/BRSDM/III/2022). No research ethic was legally required in 2021 for conducting research that involves human or wildlife and the permits issued by BTNKJ and BRSDMKP were sufficient to deem that the proposed research method and design were accepted by both authorities. The research did not perform any invasive activity to any wildlife in its process because of the research design of passive data collection and sandbed area as the targeted substrate.

Results

Of the 489 BRUV units that were deployed, 12 videos were excluded from the analysis because of falling backwards from strong currents, leaving a total of 477 videos (of 623.9 h) for inclusion in the study.

Species encountered and their relative abundance

In total, three encounters and three n_{max} were recorded for *G. typus* (Family: Glaucostegidae), whereas three encounters and six n_{max} were recorded for *R. australiae* (Family: Rhinidae). The remaining n_{max} recorded for target species are three for sharks and nine for rays (Fig. 3). The *G. typus* and *R. australiae* both exhibited a relative abundance of 0.0048 and 0.0096 n_{max} h^{-1} respectively (Fig. 3). These values are moderate relative to other species recorded during the study (Fig. 3). Species with the lowest relative abundance were the sicklefin weasel shark (*Hemigaleus microstoma*), leopard whipray (*Himantura undulata*), pink whipray (*Pateobatis fai*) and mangrove whipray (*Urogymnus granulatus*), whereas the highest was the oriental bluespotted maskray (*Neotrygon orientale*) (Fig. 3).

Spatial and depth distribution

All sharks and rays, including *G. typus* and *R. australiae*, were recorded at depths below 10 m (Table 2). Most shark and ray species were recorded at depths of 20.1–30 m, with a maximum depth of 35.5 m for blacktip reef shark (*Carcharhinus melanopterus*), 37.2 m for snaggletooth shark (*Hemipristis elongata*) and 22.8 m for the only encountered *H. microstoma*. All species were mostly encountered within the traditional fisheries, marine protection, marine tourism zones and outside of the national park area. Although some shark and ray species encountered were reef species, they were present in the observed substrate of pure sandbed and sandbed mixed with corals or rubbles. We did not find statistically significant differences in the n_{max} of *G. typus*, *R. australiae* and all shark and ray species combined across site, national park zonation and depth ($P > 0.05$) on the basis of the one-way PERMANOVA test (Table S1 of the Supplementary material).

Both *G. typus* and *R. australiae* encounters happened in the pure sandbed area, with one encounter of the *G. typus* having a mixture of sand and rubbles (Table 3, Fig. 4). The encounters were recorded at a depth of 15.6–35.6 m for *G. typus* and 22.2–35.6 m for *R. australiae*. The encounters showed that live sharksucker (*Echneis naucrates*) is a symbiont for both species. However, *R. australiae* was recorded to also have the common remora (*Remora remora*) and cobia (*Rachycentron*

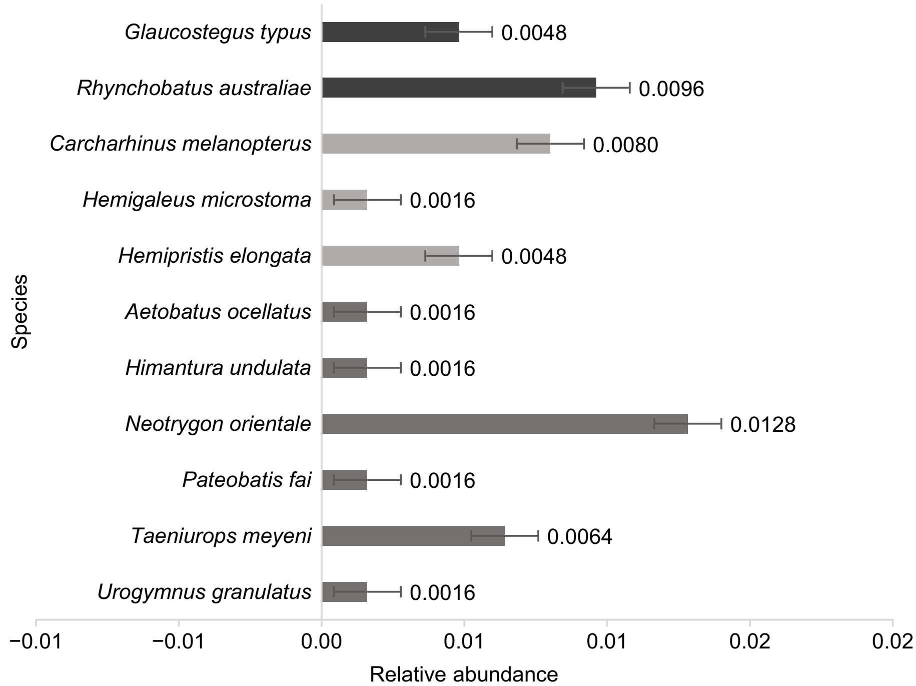

Fig. 3. Composition and relative abundance (n_{max} h^{-1}) of target species, including Glaucostegidae, Rhinidae and other elasmobranch species, across all BRUV recordings.

Table 2. Target species group distribution across depth, substrate and zonation of BRUV unit deployments.

Item	n_{max}			
	G. typus	*R. australiae*	Sharks	Rays
Depth range (m)				
0–10	–	–	–	–
10.1–20	1	–	–	5
20.1–30	2	4	7	12
30.1–40	–	2	2	2
Substrate				
Sand	2	6	6	10
Sand, coral	–	–	1	–
Sand, rubble	1	–	1	4
Sand, rubble, coral	–	–	–	2
Other	–	–	–	3
Zonation				
Aquaculture	–	–	–	–
Traditional fisheries	1	4	2	7
Marine protection	–	1	2	4
Marine tourism	–	1	–	6
No-take or core	1	–	–	–
Outside National Park	1	–	5	2

canadum) as its symbiont, although *R. canadum* appeared in massive numbers (12 and 24 individuals) in two *R. australiae* (both had only 1 n_{max}) encounters. The *R. australiae* individuals were all attracted to the baits on the BRUV units, compared with the *G. typus*, with only one encounter showing attraction of the species to the bait.

Discussion

This study deployed BRUV units in areas where fishers had historical encounters with *G. typus* and *R. australiae* in KJNP and its adjacent waters, to gather data on their contemporary presence and distribution. Our data have provided up-to-date information on the presence, status and ecology of guitarfish, wedgefish and other elasmobranchs in and around KJNP, which can be used to inform management.

On the basis of the IUCN Red List and government fisheries data, populations of wedgefish and giant guitarfish are declining globally and in Indonesia (Directorate General of Capture Fisheries 2015, 2017; Kyne *et al.* 2019*a*, 2019*b*). This is supported by the low value of relative abundance for both *G. typus* (n_{max} = 3; relative abundance = 0.0048) and *R. australiae* (n_{max} = 6; relative abundance = 0.0096) in KJNP and nearby waters, compared with other studies that recorded similar or higher value with lower sampling efforts (<100 deployments) such as in the Arabian Gulf (Jabado *et al.* 2021), Mozambique (O'Connor and Cullain 2021) and Western Australia (Schramm *et al.* 2020). Although there is no comparable BRUV data from a previous period, historic

Table 3. *G. typus* and *R. australiae* encounter description, including depth, substrate of encounter, symbiont, behaviour and BRUV unit deployment time.

Species	n_{max}	Location	Depth (m)	Substrate	Behaviour	Symbiont	n_{max}	BRUV unit drop time
G. typus	1	Malang Reef	15.6	Sand	Passing	*Echneis naucrates*	3	8:34:00 hours
	1	East Genting	26.8	Sand	Passing	*Echneis naucrates*	1	9:03:00 hours
	1	East Nyamuk	35.6	Sand, rubble	Attracted	–	–	9:30:00 hours
R. australiae	1	Tengah Island	22.2	Sand	Attracted	*Rachycentron canadum*	12	10:12:00 hours
						Echneis naucrates	2	
	1	Waka Reef	34.2	Sand	Attracted	*Rachycentron canadum*	1	10:37:00 hours
						Echneis naucrates	4	
	1	Cemara Sandbar	35.6	Sand	Attracted	*Rachycentron canadum*	24	1:15:00 hours
						Echneis naucrates	2	
						Remora remora	1	
	3	Alang-Alang	27.6	Sand	Attracted	*Rachycentron canadum*	2	1:51:00 hours
						Echneis naucrates	1	
						Remora remora	1	

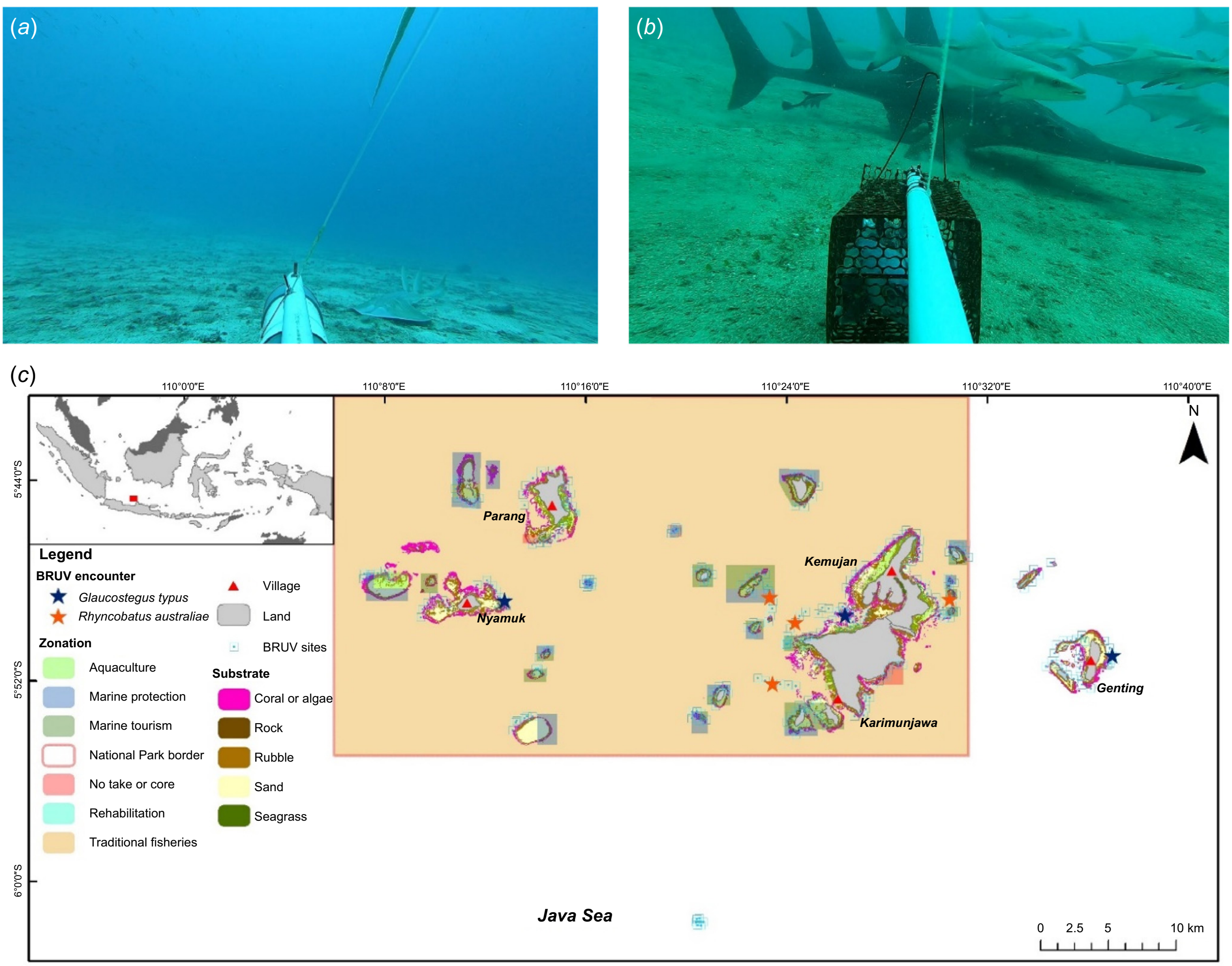

Fig. 4. Distribution of *G. typus* and *R. australiae* encounters. (*a*) Recording of *G. typus*, (*b*) recording of *R. australiae*, (*c*) map of BRUV unit deployment sites and *G. typus* and *R. australiae* encounter location in KJNP and nearby waters.

fisher encounters in comparison with this low relative abundance suggest their population may be declining as well.

Threats such as bycatch or valuable secondary catch from local artisanal fishers with gill-nets, handlines and spearfishing with compressor diving (EPI, unpubl. data, 2022), and commercial fishers from northern Java region who are known to fish within and nearby the national park waters (Yuwandana *et al.* 2020), may worsen both species population in either KJNP or Java Sea. However, further research is needed to confirm the more accurate trends in the population in KJNP.

Despite statistical analysis showing that the presence of *G. typus* and *R. australiae* were not affected by sites, national park zonations and depths, the low relative abundance value exhibited by *G. typus* and *R. australiae* in this study may reflect the true condition in the location where they were encountered, considering their possible low mobility shown in some studies of their sister species. A number of studies on a wedgefish species movement in Madagascar, Tanzania, Mozambique, and South Africa stated that the species showed residency to an area they inhabit, although some did large-scale coastal movements between South Aftrica and Mozambique (Bennett *et al.* 2021; Jordaan *et al.* 2021). Furthermore, another study in South Africa showed that most R. australiae individuals (stated as *R. djiddensis*) stayed within 5-km radius in a catch–recapture study (Jordaan *et al.* 2021). Additionally, a study on *G. typus* in Australia showed that the species moved only between 1 and 3 km in the span of 5 days (Crook 2020). These studies may also indicate that the low relative abundance of both species in this study may mean that both species are residents (do not travel far) of where they were found because both species are assumed to have a lower mobility than that of highly mobile shark species (e.g. *Carcharhinus amboinensis* and *C. sorrah*; Knip *et al.* 2011, 2012), and a higher mobility than that of disc-shaped rays (e.g. *Dasyatis lata* and *Urobatis helleri*; Vaudo and Lowe 2006; Cartamil *et al.* 2010; White *et al.* 2014*b*). However, further research with different approaches is needed to confirm this in KJNP because species may not have been encountered because of the limited BRUV unit deployment duration.

The presence of other elasmobranch species with a similar or higher trophic level (TL) (R. Froese and D. Pauly, FishBase, see www.fishbase.org) in the same habitat, including the *C. melanopterus* (TL 3.9), *H. elongata* (TL 4.3), *H. microstoma* (TL 4.2), *P. fai* (TL 3.7), blotched fantail ray (*Taeniurops meyeni*) (TL 4.2) and *U. granulatus* (TL 4.1), indicates other meso- or top-predators occurring in the same sandbed habitat as *G. typus* (TL 3.6) and *R. australiae* (TL 3.5). Additionally, the presence of other predators, such as *G. javanicus* (TL 3.9), other piscivorous (fish eater) and durophagous (crustacean or hard-shelled invertebrate eater) moray eel species (Table S2 of the Supplementary material; Mehta 2009) and *S. barracuda* (TL 4.5), was also recorded at a high number (Table S2) during this study, suggesting the possibility of predatory competition with *G. typus* and *R. australiae* for similar prey items (Vaudo and Heithaus 2011; Purushottama *et al.* 2020, 2022; Sreekanth *et al.* 2022), such as crustaceans and small fishes (Hiatt and Strasburg 1960; Hansen 2015). Predatory competition may worsen a species population assumed to be depleting (Hollowell 2013), especially for *G. typus* and *R. australiae*, considering that both are Critically Endangered (IUCN Red List). Further research with various approaches, including BRUV survey using baits of giant guitarfish and wedgefish preferred prey, deployment in night-time and at deeper depth of >40 m is needed to ascertain this assumption further. The present result described species encounters only in each national park zonation and further research will be needed to analyse the correlation or implication of the current zonation area with giant guitarfish and wedgefish presence, especially in areas with high human activity.

The single individuals recorded in each encounter of *G. typus* and *R. australiae* in this study, with the exception of one encounter with three individuals of *R. australiae* (as stated by local fishers that sometimes the species was found in a fever of 2–3), differs with the aggregation characteristic of some sister species (~50 individuals of *Pseudobatis horkelii*; Anderson *et al.* 2021; ~6 of *Glaucostegus cemiculus*; Chaikin *et al.* 2020; ~3 of *Glaucostegus halavi*; Michael 1993). However, there may be differences between examples used as a comparison with *G. typus* and *R. australiae* in terms of aggregation that may not be recorded during the study period.

All encounters with *G. typus* and *R. australiae* showed that at least the species was accompanied by at least a symbiont, commonly known as hitchhiker species, because they performed commensalism symbiosis with their host, including the *E. naucrates*, *R. remora* and *R. canadum*. Both *E. naucrates* and *R. remora* are common hitchhikers for large marine animals, including shark and ray (Curtis *et al.* 2015). An exception for *E. naucrates* is that it can often be found with no host animal in shallow inshore waters and near coral reefs (Collette *et al.* 2015*a*); hence, its n_{max} was not recorded outside of their presence with both *G. typus* and *R. australiae*. As for *R. canadum*, it is also a common hitchhiker on some sharks and rays (Michael 1993), although notably seen with reef manta rays (*Mobula alfredi*), oceanic manta rays (*Mobula birostris*) (Nicholson-Jack *et al.* 2021) and whale sharks (*Rhincodon typus*) (Dove and Pierce 2022). In this study, *R. canadum* was sighted as symbiont only for *R. australiae*, with one encounter of one individual accompanied by 24 of *R. canadum*. The presence of these symbionts with *G. typus* and *R. australiae* is the same as with any other host marine species because they benefit from eating the host's parasites as well as food scraps off the host (Curtis *et al.* 2015; Collette *et al.* 2015*a*, 2015*b*).

Limitations of the study

The limitation of the GoPro cameras as the main recording tools used in the BRUV structure may or may not have influenced the low encounter number of giant guitarfish and wedgefish. The limitation of GoPro usage in dark surroundings limits the quality of pictures or videos taken; hence, the study was performed during the day and may have created a bias, in that the species may have exhibited a higher relative abundance value if the study were performed during the night. The limited survey temporal period (August–October 2022) may also have affected the relative abundance value, because the presence of giant guitarfish and wedgefish may differ seasonally. However, high trophic consumers (>3) such as the giant guitarfish and wedgefish are assumed to be active during both the day and night opportunistically (Du Preez *et al.* 1988; Hammerschlag *et al.* 2017; Sreekanth *et al.* 2022). Therefore, the low relative abundance exhibited may strengthen the assumption that it reflects the true condition of both species at where they were encountered. Nonetheless, longer duration surveys and comparison studies conducted during the night are still needed to confirm this argument as well as to look at differences spatiotemporally.

Management implications

Given the extensive exploitation of giant guitarfish (Family: Glaucostegidae) and wedgefish (Family: Rhinidae) in both the Java Sea (Yuwandana *et al.* 2020) and Indonesia in general (Kyne *et al.* 2019*a*, 2019*b*), effective management will be needed to prevent local population decline or extinction (Dulvy *et al.* 2017). On the basis of the results and available knowledge, authors consider KJNP (see BTNKJ, Profil Kawasan Taman Nasional Karimunjawa at https://tnkarimunjawa.id/profil/index) as one of the last strongholds (White *et al.* 2017; MacKeracher *et al.* 2019) for both groups of species in Java Sea.

To maximise the effectiveness of giant guitarfish and wedgefish management in KJNP, we have several recommendations, including the following: strengthen research and monitoring, encourage management inclusivity and develop a scheme for fishers to minimise species mortality. These fisheries management actions are necessary for both small-scale fishers operating within traditional use zones of KJNP and commercial vessels from northern Java. This could be supported with species-specific data collection for both taxa, to fully understand ecology, exploitation levels and trade. This could include fisheries-dependent research such as catch-landing records in relation to fishing efforts (Yulianto *et al.* 2018), including understanding fishing efforts of fishers from Jepara region who have been said to fish for giant guitarfish and wedgefish in KJNP waters (Marganita *et al.* 2021). Moreover, fisheries-independent research (such as identification of critical habitat through live-specimen research) will be crucial to better understand the spatial and temporal movement of these species (Speed *et al.* 2010; Williamson *et al.* 2019). The combination of these types of research, and by additionally understanding the perspective of fishers in both species as a commodity, will provide robust evidence that can help inform an effective species management planning process alongside local fishers.

Second, it is important to acknowledge that ecological research alone will not reduce threats to sharks and rays in KJNP, because this will ultimately require a change in fisher behaviour (Booth *et al.* 2019). As such, this study could be complimented with socio-economic research to understand the underlying drivers and socio-economic importance of shark and ray fishing within KJNP and adjacent waters. This research could then help inform locally appropriate campaigns and interventions. Crucially, management planning where all actors, especially fishers, are represented in the decision-making process must be encouraged to improve inclusivity, transparency and minimise future conflicts in marine resource use (Gupta *et al.* 2020, Giareta *et al.* 2021; Booth *et al.* 2023*b*). In the long run, involving local fishers and communities will help KJNP Agency as the local authority to manage the species efficiently.

Last, we recommend that managers and other stakeholders develop a management scheme with the main objective of minimising giant guitarfish and wedgefish mortality in KJNP, while also considering local fishers' economy, as the target conservation species that have high economic value. This will be crucial for the scheme to be implemented sustainably and supported by local fishers. Some examples include the use of incentive schemes (e.g. using positive incentives where fishers are rewarded for not catching or releasing the species) or exploring alternative fisheries. Such schemes need careful planning, such that they align with locally accepted norms, fisheries characteristics, species survivability and financing sources (Gupta *et al.* 2020; Booth *et al.* 2023*b*), and we encourage more interdisciplinary research as a key next step for securing KJNP as a potential sanctuary for giant guitarfish and wedgefish in Indonesia.

Conclusions

This study provides the first baseline information on giant guitarfish and wedgefish presence and their ecological characteristics in KJNP and nearby waters by using a fisheries-independent method. Although future studies are needed to show a trend, the low n_{max} and relative abundance recorded in the study may be a reflection of the declining population in the Java Sea and Indonesia, as assessed for both species' declining populations nationally and globally (Kyne *et al.* 2019*a*, 2019*b*). However, further fisheries-dependent and non-dependent research is needed to better understand their population in KJNP and nearby waters, including fisheries threats from the nearby northern Java coastal area. Although both species are listed as critically endangered on the IUCN Red List, the information provided by this study urges stakeholders in KJNP and nearby waters to prioritise giant guitarfish and wedgefish conservation and management.

In future, good stakeholder engagement and participatory planning will be essential to co-design solutions for reducing mortality while maintaining the important role of fisheries in the North Java Sea.

Supplementary material

Supplementary material is available online.

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Data availability. The data that support this study will be shared upon reasonable request to and approval from the corresponding author.

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