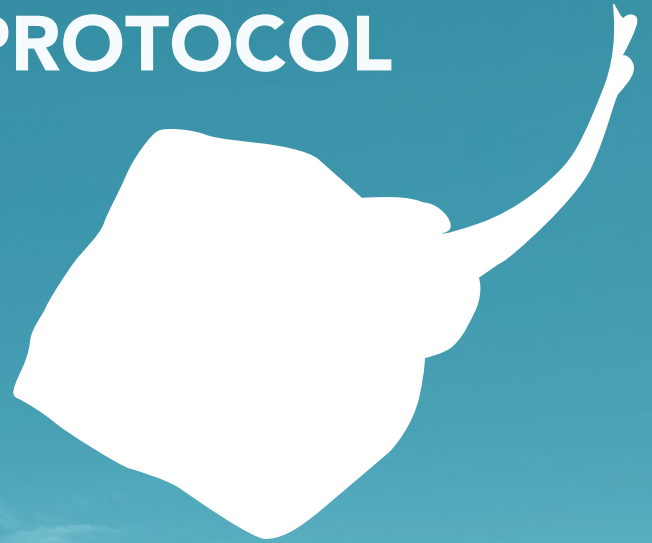


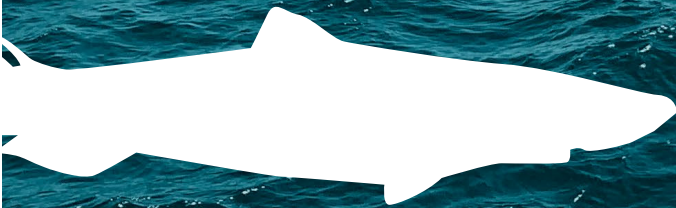
HANDLING PROTOCOL



# SHARKS AND SKATES

FOR BOTTOM TRAWL FISHING VESSELS

Case study on a crustacean trawler in southern  
Portugal within the scope of the Delasmop project  
"Deep-sea elasmobranchs of Portugal"



DELASMOP

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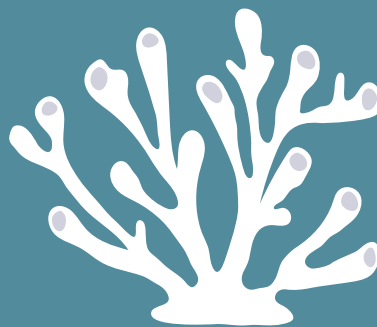


## Funding



# ACKNOWLEDGEMENTS

A special thanks to the vessel owner, the skipper, and the fishers who were directly involved in the project and made it possible for our team to join their daily activities and collect these important data. Without their collaboration, this work would not have been possible. To the various researchers, interns, volunteers, and students who assisted us in the field and laboratory activities within the scope of ECOREACH, a research group of CCMAR. To the Fisheries, Biodiversity and Conservation research group of CCMAR, for their partnership and access to the laboratory and van that was sometimes used to transport our team and materials to the field. We also thank the researchers from the University of Algarve, CIIMAR, BIOPOLIS/CIBIO-InBIO, and from the Faculty of Science from the University of Porto, and researchers from CESAM University of Aveiro who collaborated with us. We also acknowledge the Sustainable Horizons SHEs, a Horizon Europe project of the European Union (No. 101071300) for their support in research conditions and open science.



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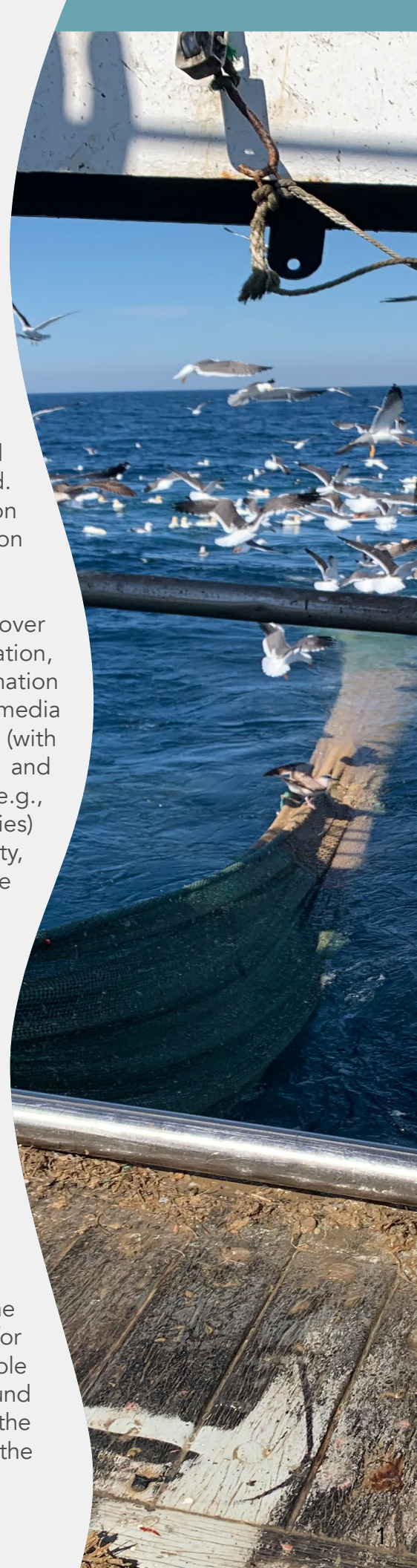
# SUMMARY

This handling guide was developed within the scope of the Delasmop project, an acronym for “Deep-sea elasmobranchs of Portugal,” which aims to provide information about the elasmobranchs (sharks and skates) that inhabit the deeper waters off the Portuguese coast. The project was carried out as part of a PhD thesis in Marine, Earth, and Environmental Sciences at the University of Algarve. It benefited from valuable partnerships with the Centre for Marine Sciences (CCMAR/CIMAR LA), the Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/CIMAR), the company OLSPS International Ltd. and OLSPS Marine, and was funded by the Save Our Seas Foundation (#SOSF501), the EEA Grants (#PT-INNOVATION-007), and the Foundation for Science and Technology (FCT).

Through scientific activities conducted aboard a commercial vessel over two years (2020 to 2022), information was collected on the conservation, ecology, and biology of deep-sea shark and skates species. This information was disseminated at scientific events, participatory meetings, in the media (e.g., the Biosfera program from RTP), on social media, in workshops (with children in science centers from the North to the South of Portugal), and through the production of educational and informational materials (e.g., [educational videos](#), infographics, reproductions of the studied species) aimed at various target audiences such as the scientific community, fisheries managers, associations, fishermen, ship owners, and the general public.

This ‘best practices’ guide is intended for crustacean trawling vessels that have significant interactions with these animals, but the techniques provided here may also be of benefit by other fisheries that also interact with these animals. In addition to recommending best practices for handling these animals on board, it addresses the main identification characteristics of deep-sea sharks and skates in Portugal. The drawings of these animals were all hand-drawn by the artist Luis Thiem and kindly offered to the Delasmop project. They are accurate illustrations; however, they are not scientific illustrations, so there may be some differences between the drawing and the real specimen.

This guide is structured as follows: an introduction to the theme and the problem of bycatch of sharks and skates; suggestions for best practices for handling sharks and skates on board trawlers (using as support the available literature and Delasmop project results); presentation of the species found in Portuguese waters; various appendices containing the main results of the Delasmop project; and a general discussion on strategies to mitigate the impacts of bottom trawling on elasmobranch mortality.

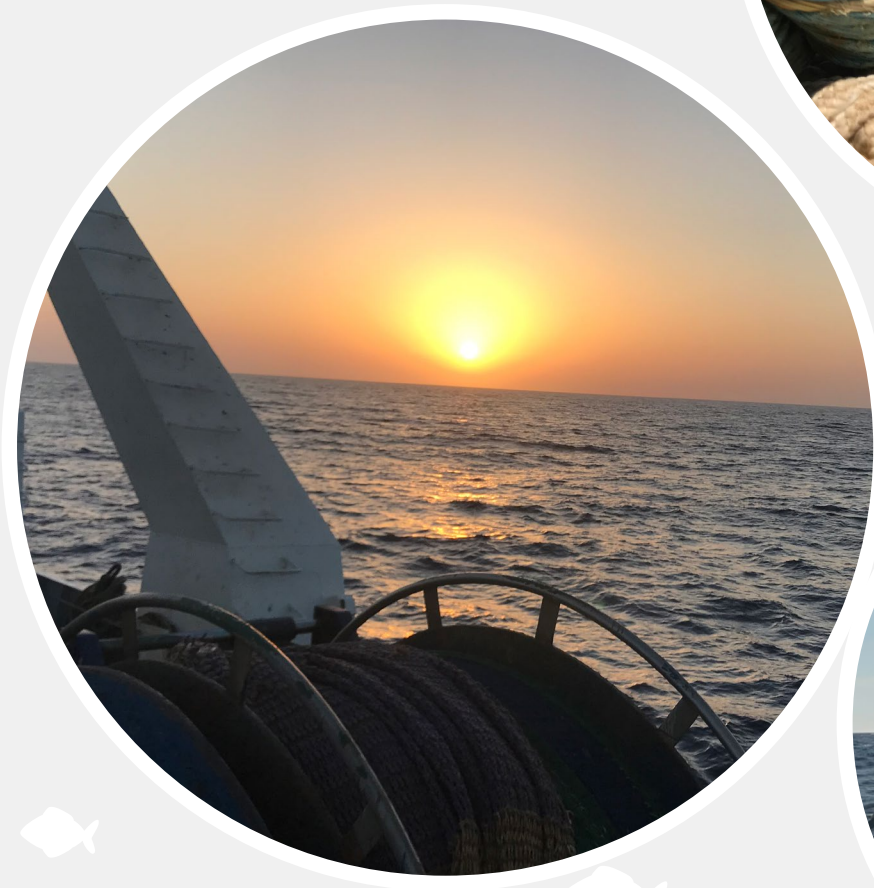
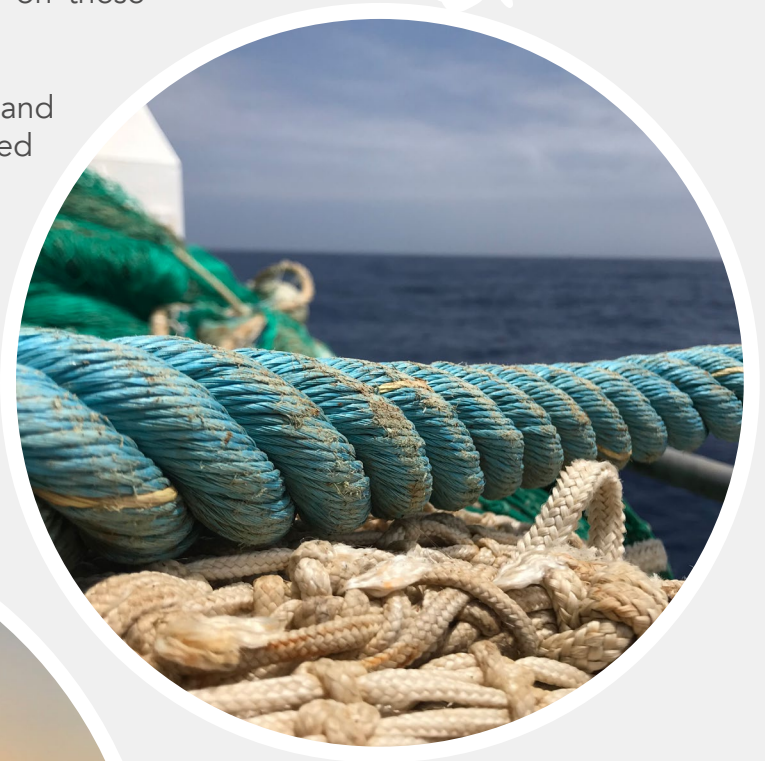


By summarizing the Delasmop project results and incorporating knowledge from specialized literature, the following pages of this protocol offer a comprehensive and practical approach to promote more conscious and effective handling of deep-sea elasmobranchs, aiming to mitigate the harmful impacts of bottom trawling on these vulnerable animals.

A booklet with information on handling sharks and skates on board trawlers was developed and printed for quick reference when at sea.

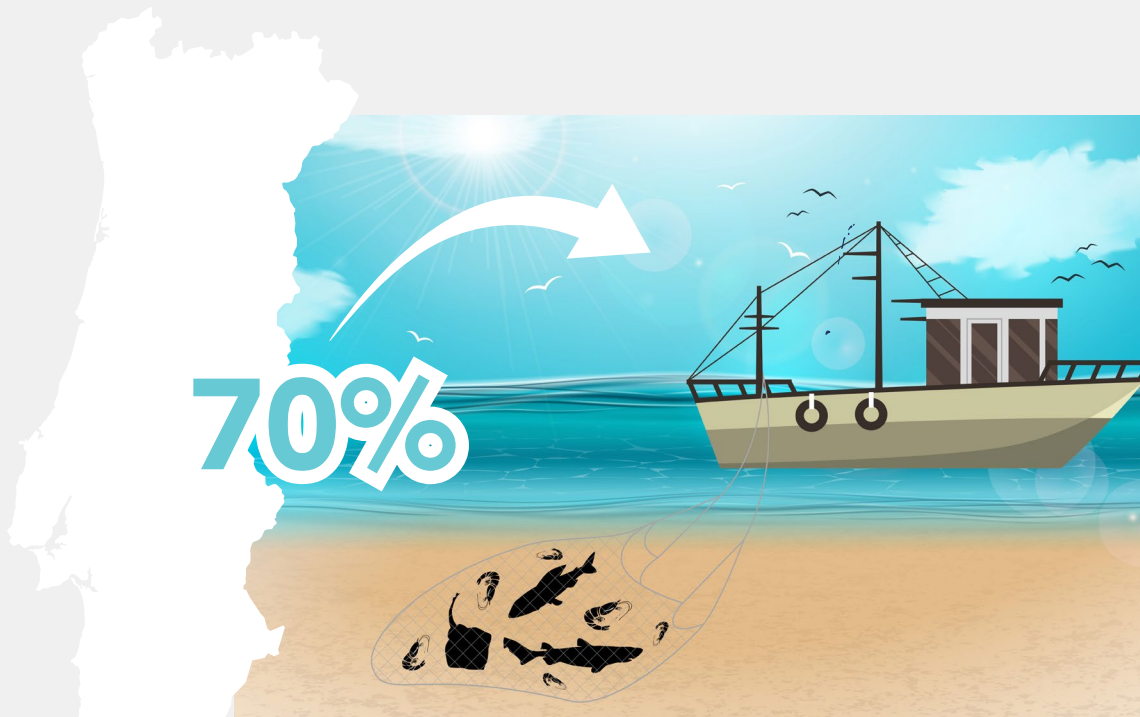
We hope this guide is useful to you. We are available for suggestions and to answer any questions.

Contact us through this [form](#).



# BACKGROUND

Crustacean bottom trawling is an ancient and traditional fishery with significant importance in the Portuguese economy. Although it targets species such as shrimp, prawns, and Norway lobster, the low selectivity of this method results in considerable amounts of bycatch, meaning all other organisms that are not the fishing target may be retained for sale or personal consumption, or discarded due to low economic interest or regulatory measures. On the Portuguese coast, specifically in the South and Southwest, crustacean trawling has on average, a 70%<sup>1</sup> discard rate, and a significant proportion (up to 58%) consists of deep-sea elasmobranchs<sup>1-4</sup> (sharks and skates) (Figure 1).



**Figure 1:** Discards in crustacean trawlers account for about 70% of the total catch in southern Portugal, with deep-sea elasmobranchs comprising a significant portion of these discards (up to 58%).

Deep-sea elasmobranchs are sharks and skates that mostly live beyond 400 meters of depth and have low resilience, as this group consists of species with long and slow reproductive cycles, long lifespans, and slow growth rate<sup>5</sup>. Moreover, despite being returned to the sea, most specimens are already dead or dying by the time they reach the vessel's deck<sup>6-9</sup>. This makes them highly susceptible to overexploitation, which can negatively impact their populations and consequently disrupt the fragile deep-sea ecosystem. Because they are often discarded, they remain largely unknown to science and the general public, unlike the more iconic great white shark, whale shark, and manta ray, for example.

To mitigate the impacts of crustacean trawling on deep-sea elasmobranchs, some strategies can be adopted, such as developing guides and protocols for best practices on board<sup>10-11</sup>, highlighting the importance and objective of this guide.

# ELASMOBRANCH'S HANDLING\*

## WHAT TO DO?

### SMALL SHARKS AND SKATES (<1 m)

Hold the animal preferably by the **snout** and **support the base** of the tail. For species with a slippery snout, you can **opt to hold by the spiracles**. Keep the animal as upright as possible to **avoid bending the tail** and compromising the vertebrae.



Hold at the **base of the tail** and **behind the pectoral fins** or hold by the **dorsal fin**, supporting the animal's body on your arm.

\* Images inspired by the "Shark's Trust Best Handling Guides" and Sandra Sharma "Shark and Ray Handling Practices" (AFMA)

## MEDIUM-SIZED SHARKS AND SKATES (1-2 m)



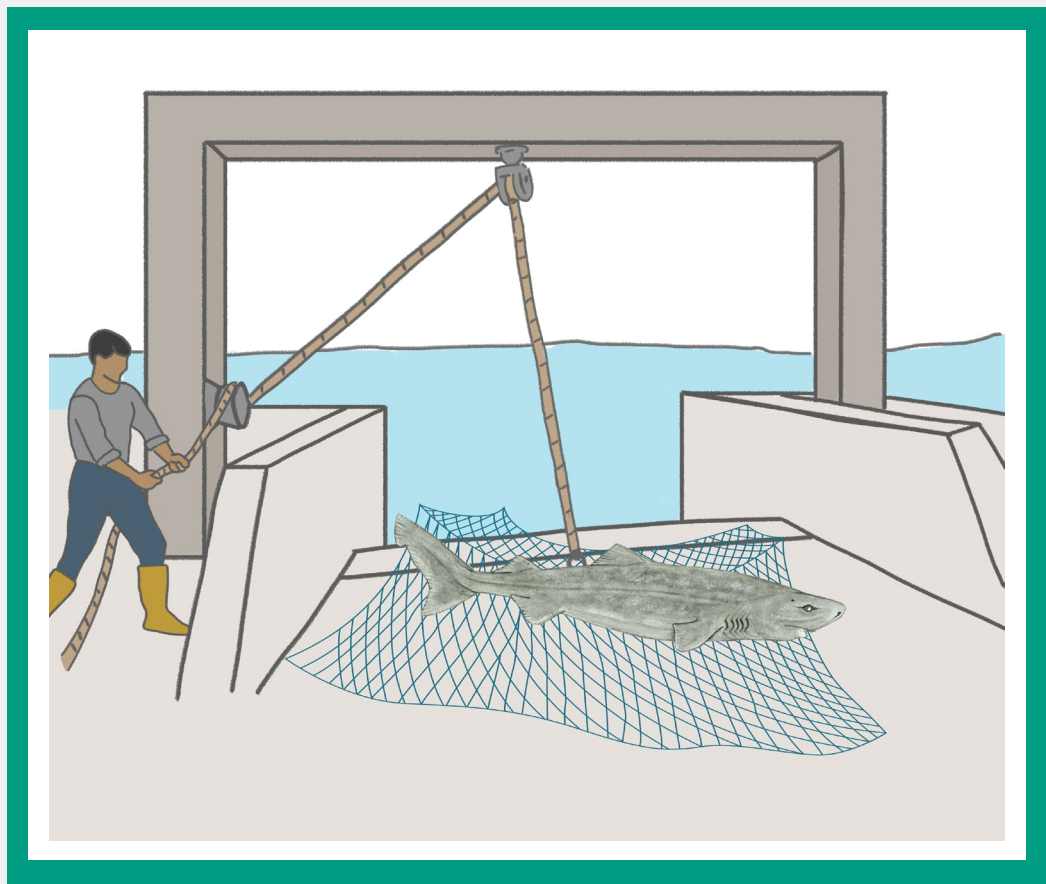
Two people hold the skate by its **wings**, supporting the **snout** and the **wings** with their hands as shown in the image.



For these animals, it is ideal for **two people** to handle them simultaneously: one person should **hold the tail**, while the other **holds the dorsal and pectoral fins** (at the level of the gill slits). It may be necessary to place a **fish in the mouth** to prevent bites.

Alternatively, you can **support the body from underneath** and **hold by the pectoral fin**, as shown in the image.

## VERY LARGE SHARKS (>2 m)



Before removing the animal from the fishing net, place a **piece of unused net** on the deck and **position the animal on top of it**. Stop the vessel and gently **pull the net back into the water** with the help of a crane.



# WHAT NOT TO DO?



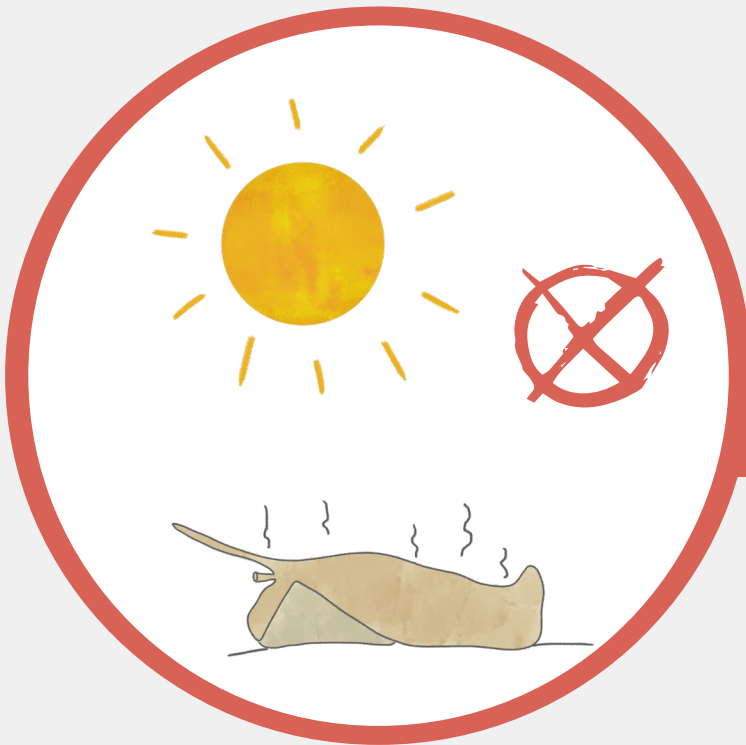
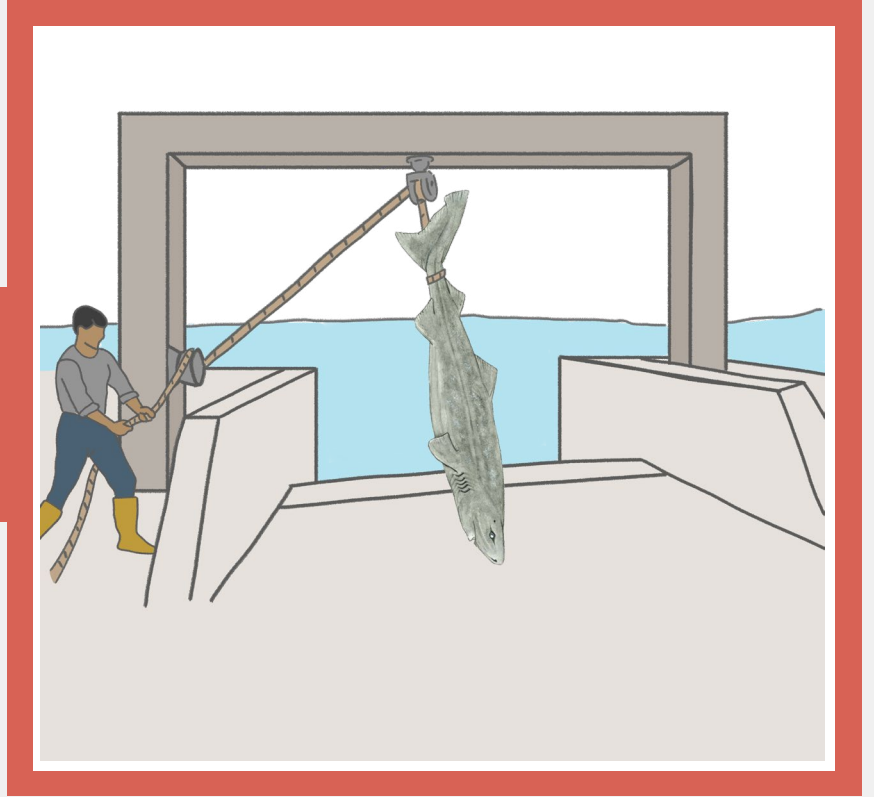
**Never** hold sharks or skates **by the tail** alone.



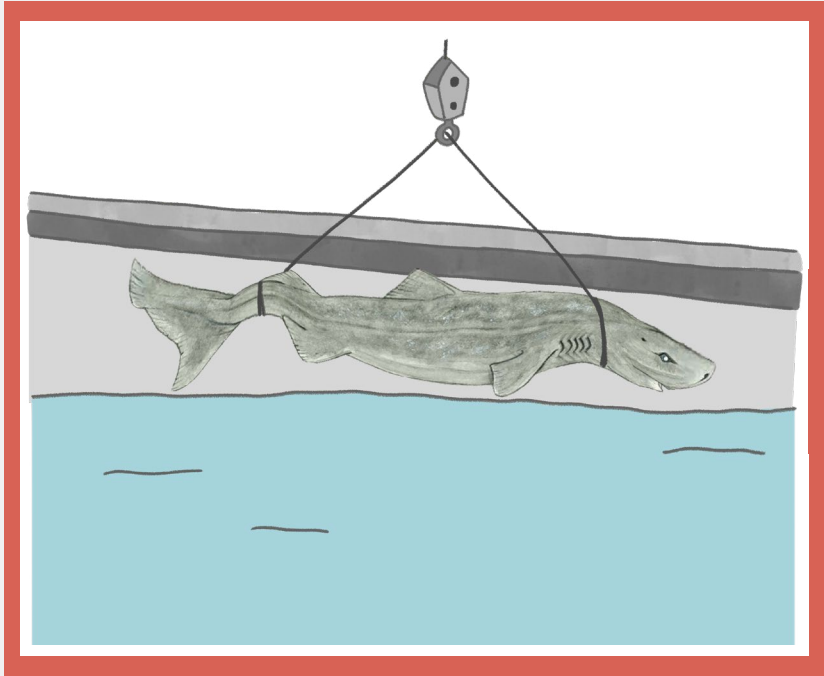
**Never** hold skates or sharks by the **gill slits**.



**Do not lift** very large sharks **by the tail** alone (or by tail and head together), as this can **cause damage to their vertebrae**.



**Never** leave the animals **exposed to the sun**.



Do not lift sharks with **cables tied** to their extremities, as this can cause **damage to their vertebrae**.



**Do not** move the animal **using gaffs** or other objects.

# DEEP-SEA SHARKS AND SKATES OF PORTUGAL

## Legends

Level of difficulty in identification



Easy



Intermediate



Hard

Conservation status according with IUCN Red List criteria in Europe (Nieto et al., 2015) \*



Critically endangered



Endangered



Vulnerable



Near Threatened



Least Concern



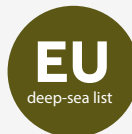
Data Deficient



Not Evaluated



Species has a Total Allowable Catch (TAC)  
[Regulation \(EU\) No. 2024/257](#)



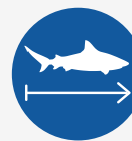
Species present on the deep-sea shark list  
[Regulation \(EU\) n° 2024/257](#)



Species appeared in the Delasmop project



Minimum and maximum depths recorded for the species



Maximum size of sharks

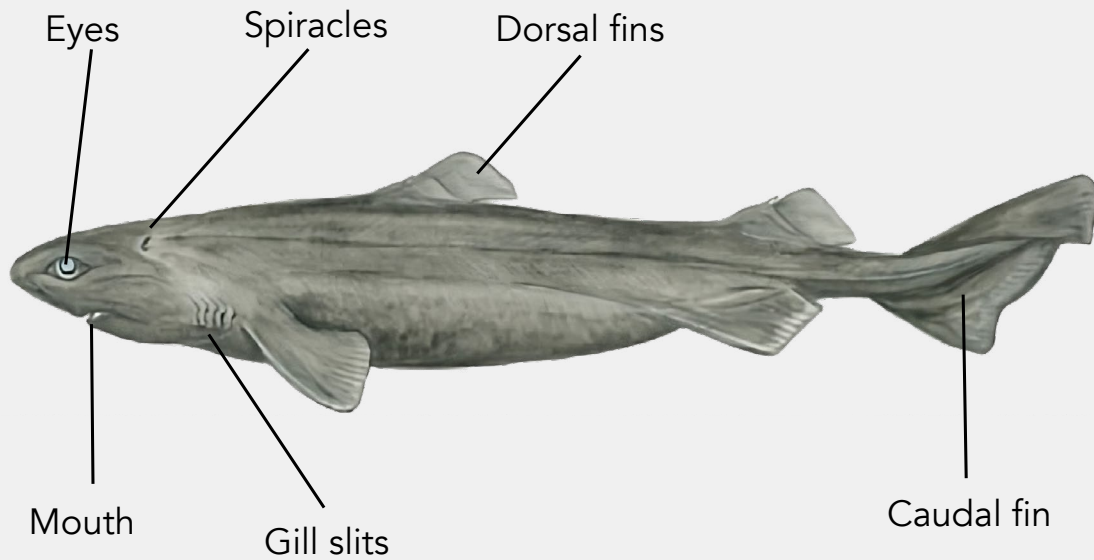


Maximum size of skates

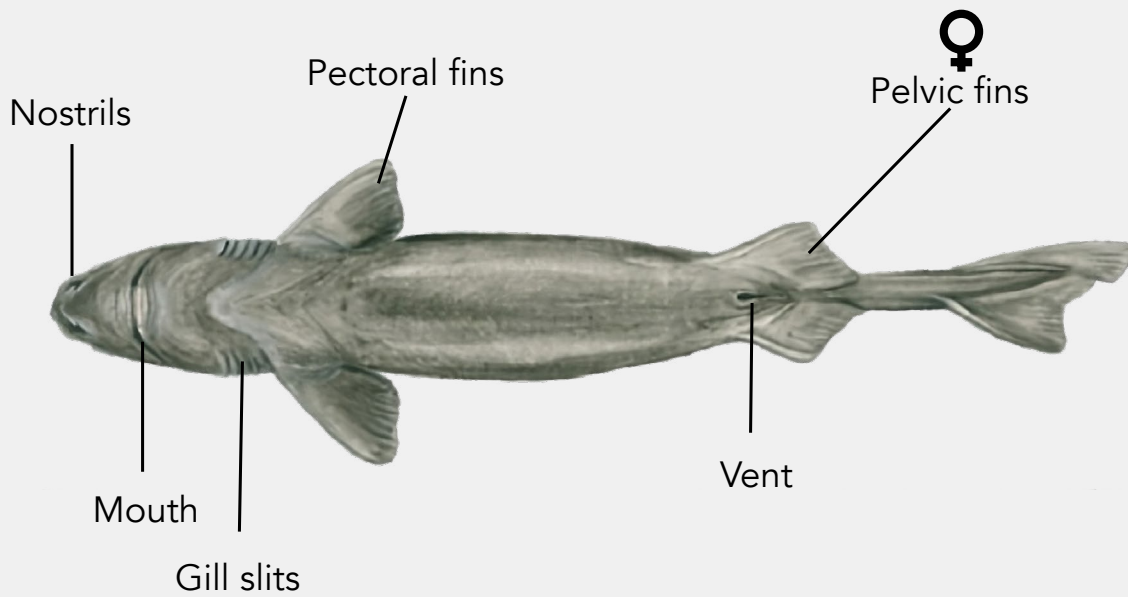
\*Nieto, A., Ralph, G. M., Comeros-raynal, M. T., Kemp, J., Criado, M. G., Allen, D. J., et al. (2015). European Red List of Marine Fishes.

# SHARKS

## Lateral view

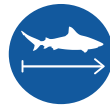


## Ventral view



# ORDER: CARCHARHINIFORMES | FAMILY PENTANCHIDAE

## *Galeus melastomus*<sup>a</sup> | SHO



90cm



55-2000m



BLACKMOUTH CATSHARK



labial furrows white or greyish

two to three blotches on lower caudal margin

## *Galeus atlanticus*<sup>b</sup> | GHA



46cm



220 - 790m



ATLANTIC SAWTAIL CATSHARK



labial furrows black

one or two black lines on lower caudal margin

<sup>\*a</sup> More abundant and frequently caught off the southern coast of Portugal within Delasmop project.

<sup>\*b</sup> Minimum registered depth reported by Delasmop project.

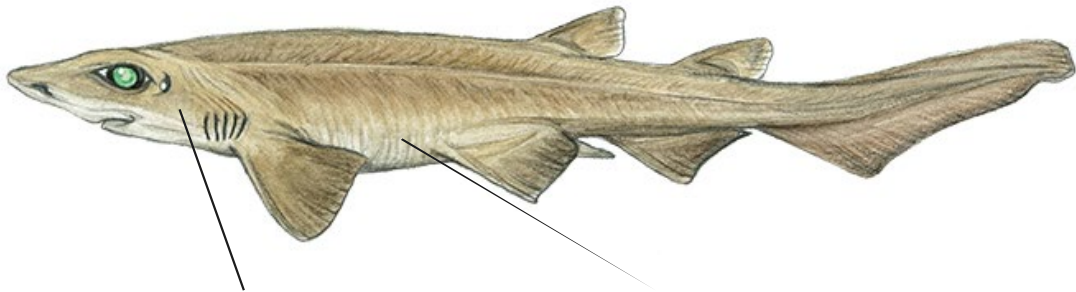
*Galeus murinus* | GAM



63cm



380-1300m

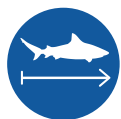


relatively large spiracles positioned right behind the eyes

Uniformly brown body

MOUSE CATSHARK

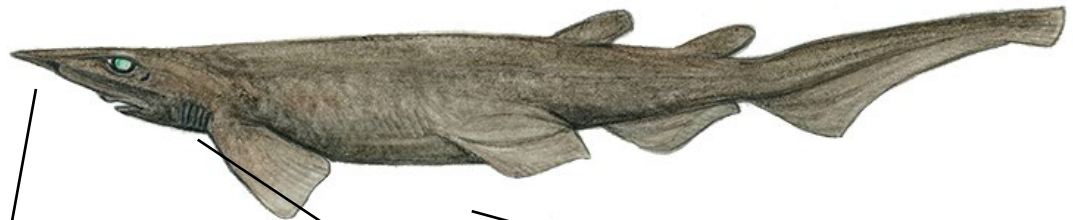
*Apristurus laurussonii* | APQ



72cm



560-2060m



Long and wide bell shaped snout

gill slits moderately small

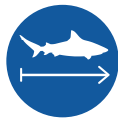
Pectoral fins relatively large and broad

MADEIRA CATSHARK

ORDER: CARCHARHINIFORMES | FAMILY: PSEUDOTRIAKIDAE

*Pseudotriakis microdon* | PTM

FALSE CATSHARK



296cm



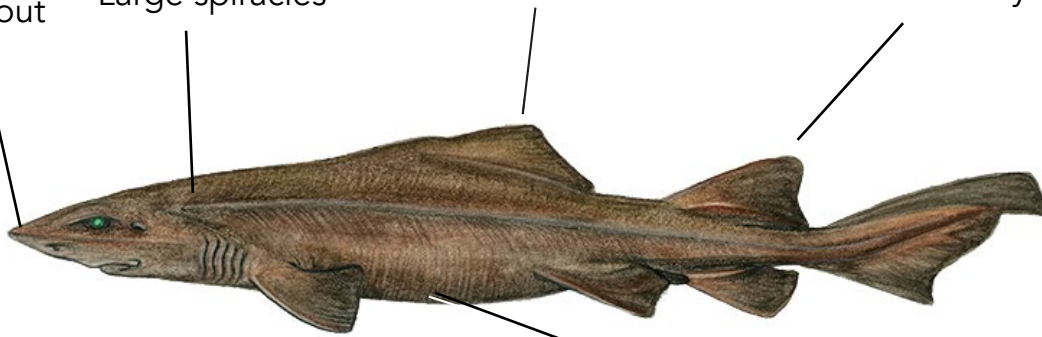
100-2430m

Long snout

Large spiracles

First dorsal fin very large and long

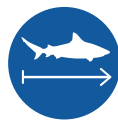
Fins are darker than the rest of the body



Body brown to black without markings

ORDER: SQUALIFORMES | FAMILY: ECHINORHINIDAE

*Echinorhinus brucus* | SHB

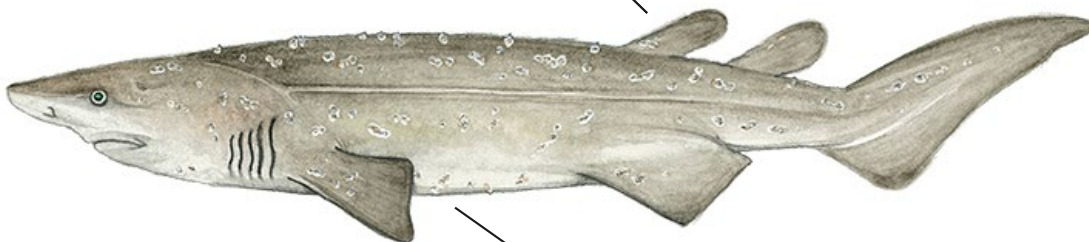


326cm



18-1214m

First dorsal fin originating behind pelvic fin origin

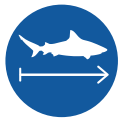


Covered with spiky denticles and enlarged thorns

BRAMBLE SHARK

ORDER: HEXANCHIFORMES | FAMILY: CHLAMYDOSELACHIDAE

*Chlamydoselachus anguineus* | HXC



195cm



20-1500m



Short snout with terminal mouth

Body elongated and eel-like



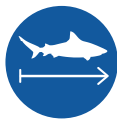
Six pairs of gill slits

Anal fin much larger than dorsal fin

FRILLED SHARK

ORDER: HEXANCHIFORMES | FAMILY: HEXANCHIDAE

*Hexanchus griseus* | SBL



550cm

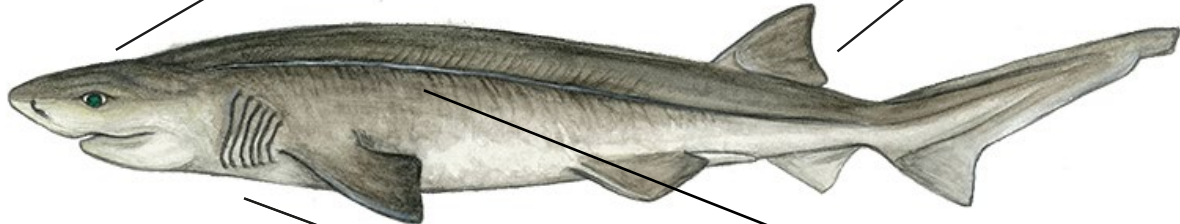


0-2500m



Blunt head

One dorsal fin



Six pairs of gill slits

Whitish lateral line

BLUNTNOSE SIXGILL SHARK

ORDER: HEXANCHIFORMES | FAMILY: HEXANCHIDAE

*Hexanchus vitulus* | HXN

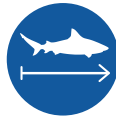
BIGEYE SIXGILL SHARK



Narrow head



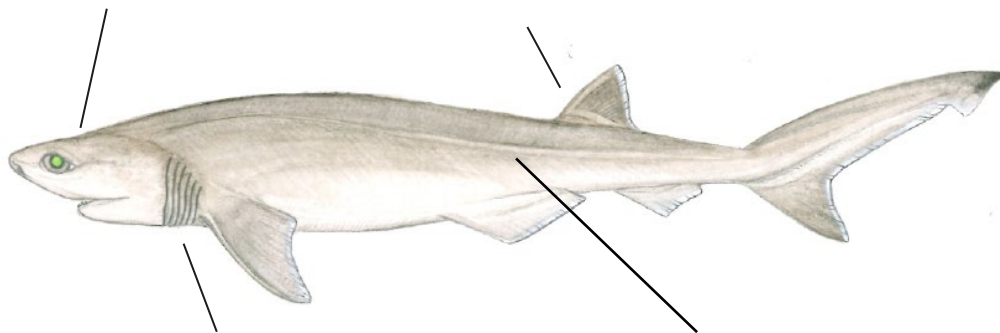
One dorsal fin



180cm



90-702m



Six pairs of gill slits

Lateral line without a clear pattern

*Heptanchias perlo* | HXT

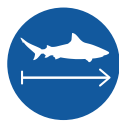
SHARPNOSE SEVENGILL SHARK



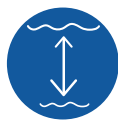
Narrow head



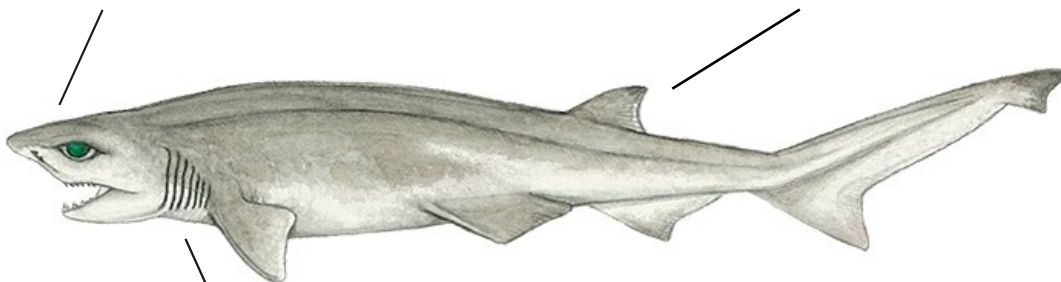
One dorsal fin



140cm



27-1000m



Seven pairs of gill slits

ORDER: LAMNIFORMES | FAMILY: MITSUKURINIDAE

*Mitsukurina owstoni* | LMO



620cm

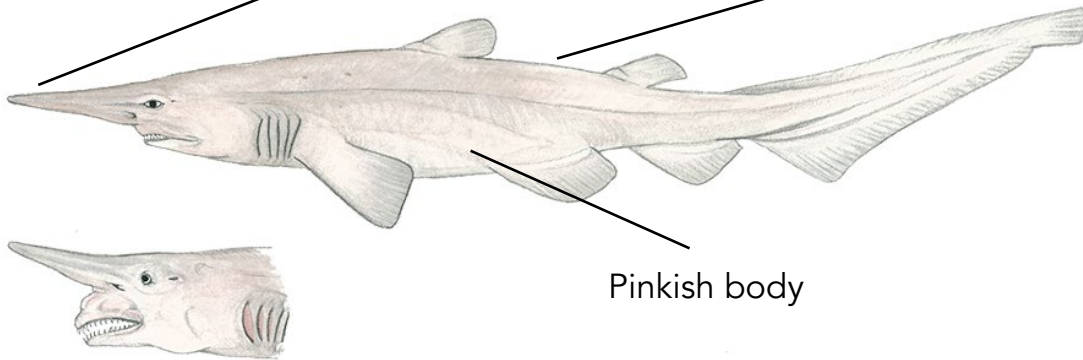


100-1300m



Snout extremely long,  
flat and blade-like

Smooth skin

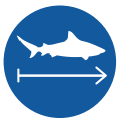


Pinkish body

GOBLIN SHARK

ORDER: SQUALIFORMES | FAMILY: CENTROPHORIDAE

*Centrophorus squamosus* | GUQ



164cm



230-2400m



Inner tips of pectoral  
fins without extensions

LEAFSCALE GULPER SHARK

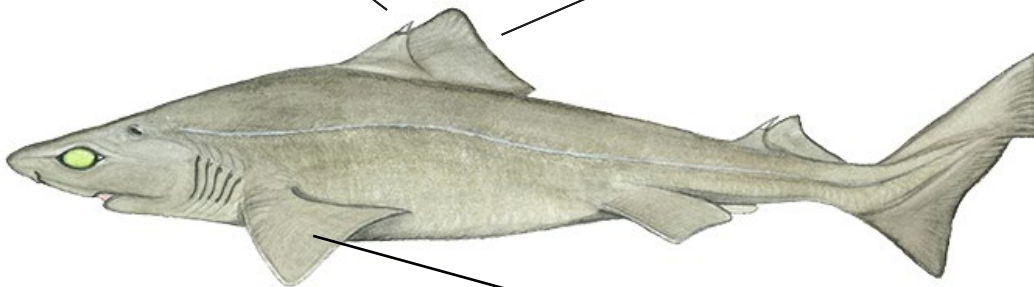
*Centrophorus granulosus* | GUP

GULPER SHARK



First dorsal fin low with long fin base

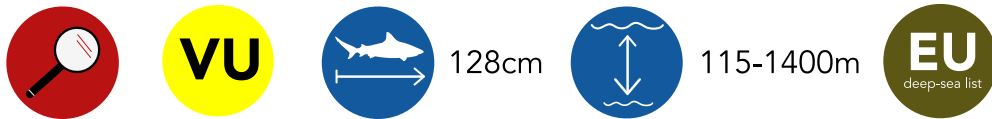
No obvious dark tip in first dorsal fin



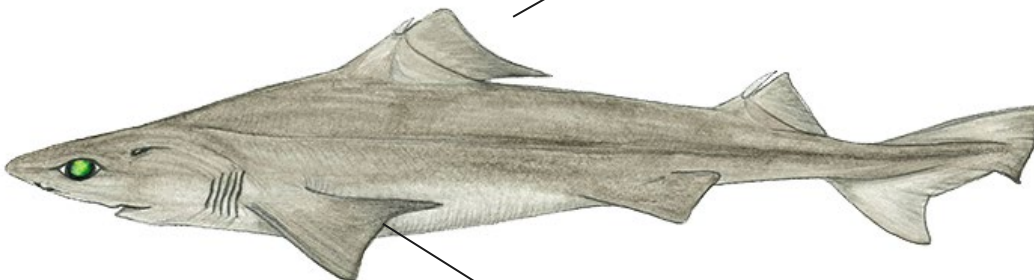
Inner tips of pectoral fins with extensions

*Centrophorus uyato* | CPU

LITTLE GULPER SHARK



Dark or black dorsal fin tips



Inner tips of elongated pectoral fins

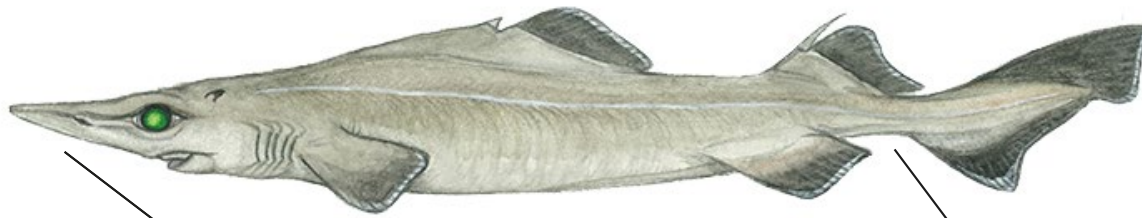
*Deania calceus*\* | DCA



122cm



60-1490m

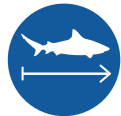


Long, flat snout

No subcaudal keel

BIRDBEAK DOGFISH

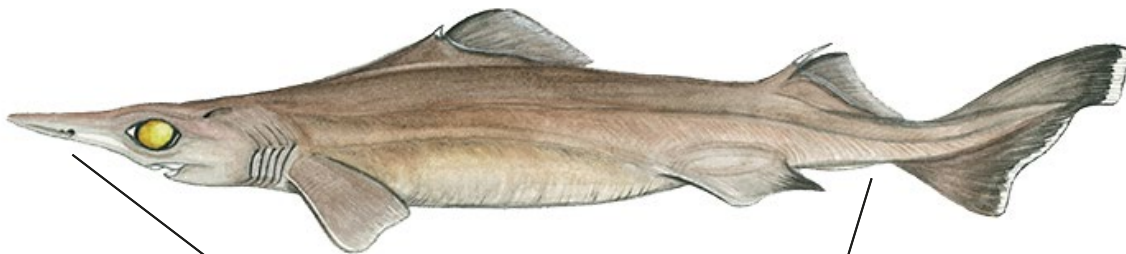
*Deania profundorum* | SDU



97cm



275-1785m



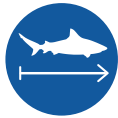
Long, flat snout

Subcaudal keel

LONGSNOUT DOGFISH

\* Shark species with the highest mortality rate among the species studied by Delasmop, with 100% at-vessel mortality.

*Centroscymnus owstonii* | CYW



120cm

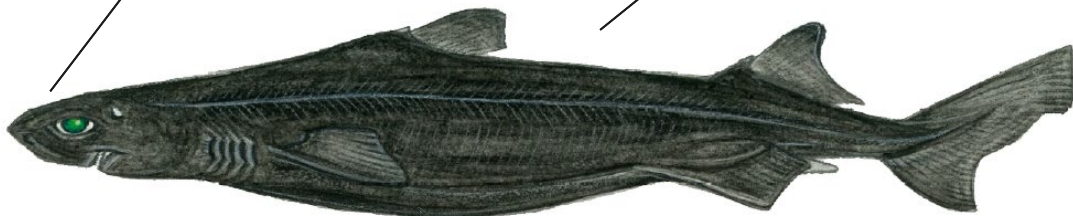


150-1500m



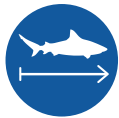
Snout moderately long

Dorsal fins spines present but very inconspicuous



Long lateral ridge along lower flank present

*Centroscymnus coelolepis*\* | CYO



122cm

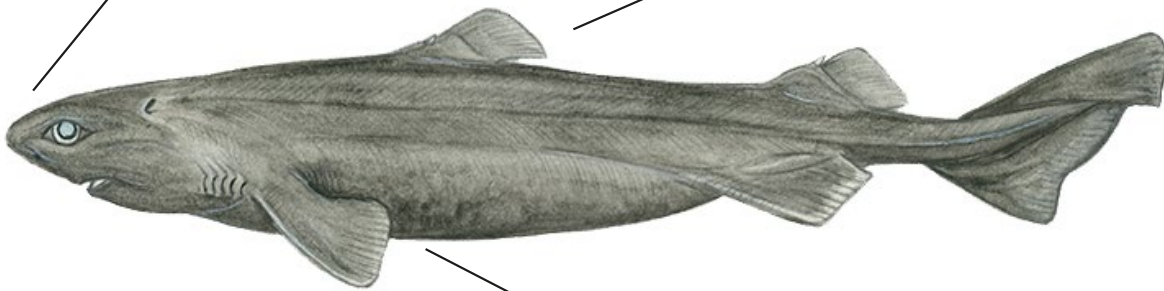


270-3675m



Extremely short snout

Dorsal fins spines present but very inconspicuous



No long lateral ridge along lower flank

\*It is the shark species that reaches the greatest depths.

*Scymnodon ringens*\* | SYR



110cm

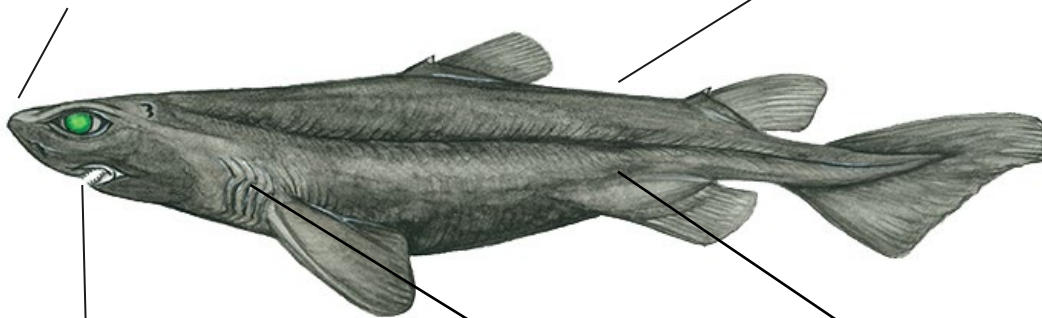


200-1600m



Short snout

Dorsal fins spines present but very inconspicuous



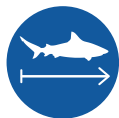
Mouth very large and broadly arched

Large gill slits

Sturdy body

KNIFETOOTH DOGFISH

*Zameus squamulosus* | SSQ

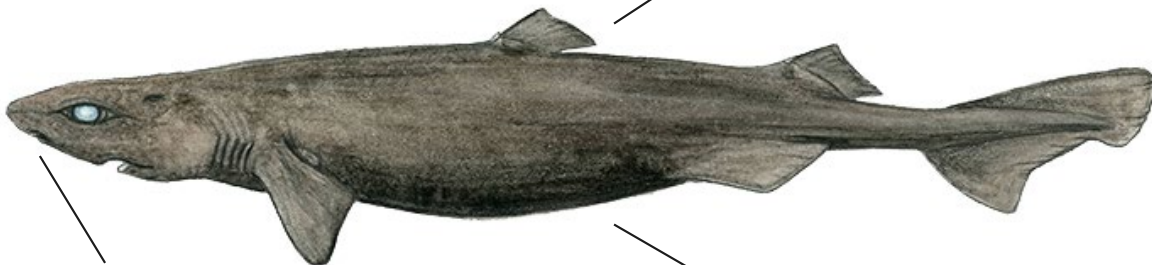


84cm



0-1450m

Small spines at the dorsal fins



Snout moderately long

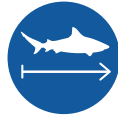
Slender body

SMALLMOUTH KNIFETOOTH DOGFISH

\*More abundant and frequently caught off the southwestern coast of Portugal within Delasmop project.

ORDER: SQUALIFORMES | FAMILY: SOMNIOSIDAE

*Scymnodalotias garricki* | QUX



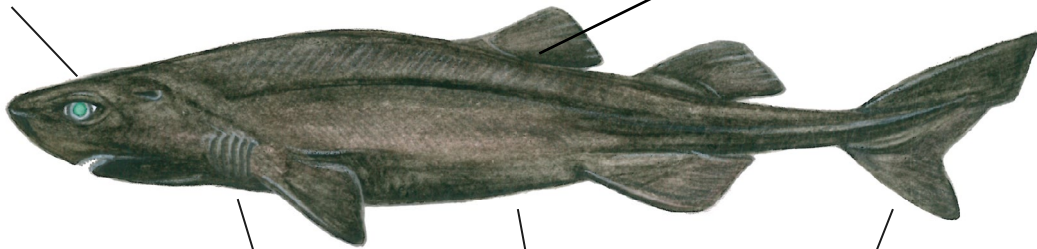
80cm



300 - > 2000m

Oval, large greenish eyes

Dorsal fins spines absent



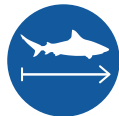
Large gill slits

Stocky body

Caudal fin asymmetrical with short lower lobe

AZORES DOGFISH

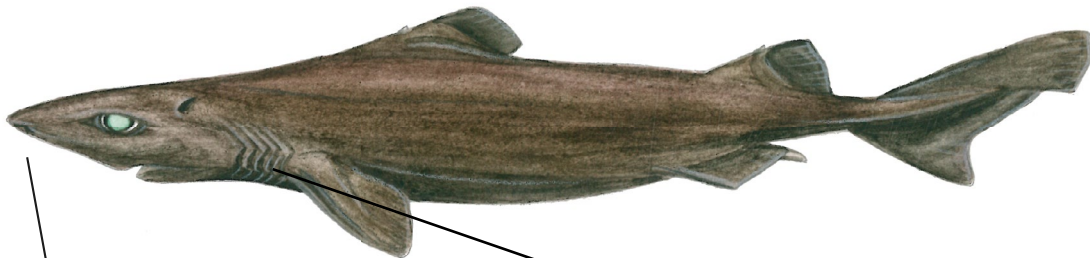
*Centroselachus crepidater* \* | CYP



105cm



200-1500m



Snout greatly elongated

Small gill slits

LONGNOSE VELVET DOGFISH

\*Found beyond 1000 m depth off the Portuguese coast.

*Somniosus microcephalus* | GSK



**NT**



756cm

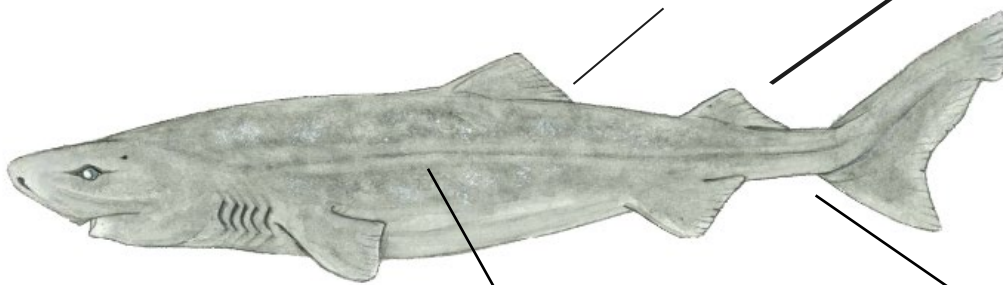


0-2647m



Dorsal fins spines absent

Second dorsal fin smaller than first



Medium gray or brown colour; occasionally with small dark and light spots

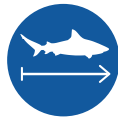
Presence of a low keel on the caudal peduncle

GREENLAND SHARK

*Somniosus rostratus* | SOR



**DD**



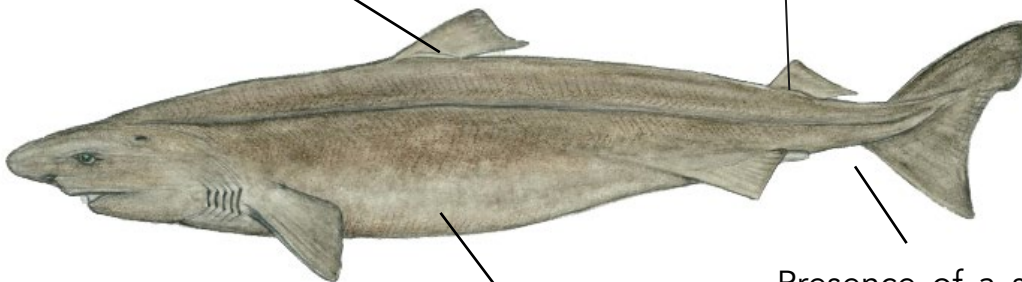
143cm



180-2200m

Dorsal fins with free tips

Dorsal fins spines absent



Uniform brownish colour without spots

Presence of a strong keel on the caudal peduncle

LITTLE SLEEPER SHARK

*Etmopterus pusillus* | ETP

SMOOTH LANTERNSHARK



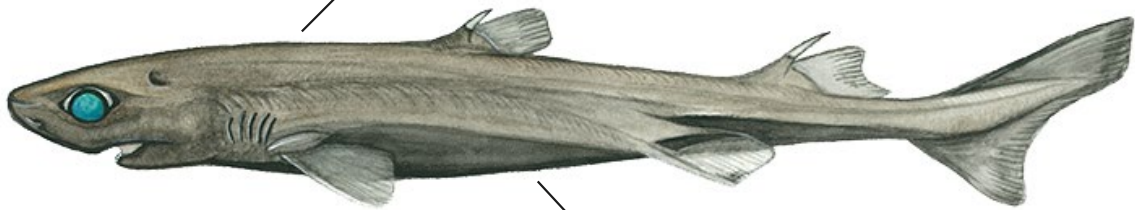
50cm



274-2000m



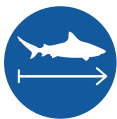
Smooth skin



Lateral body colour relatively uniform

*Etmopterus spinax* \* | ETX

VELVET BELLY



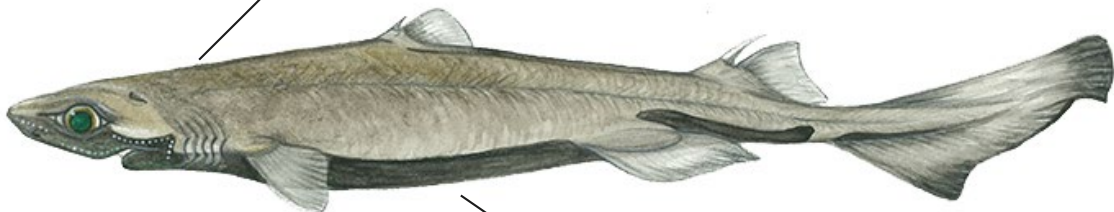
45cm



70-2000m



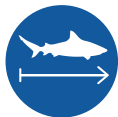
Rough skin



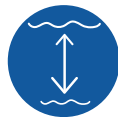
Body colour sharply demarcated

\*Small bioluminescent shark species and the second most abundant off the southern coast of Portugal by Delasmop project.

*Etmopterus princeps* | ETR



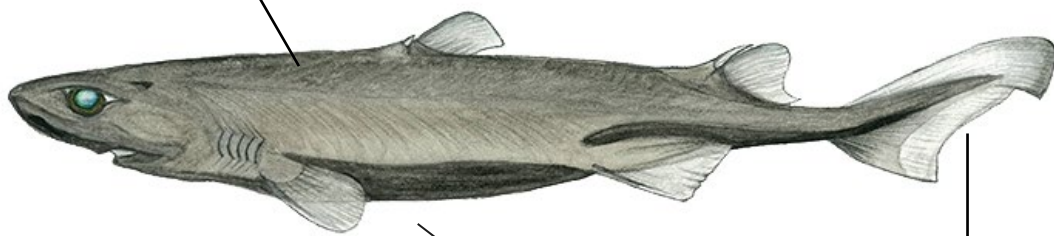
89 cm



350-2200m



Large body in comparison to other lanternsharks

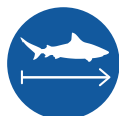


Body mostly uniformly coloured

No marks on the caudal fin

GREAT LANTERNSHARK

*Centroscyllium fabricii* | CFB



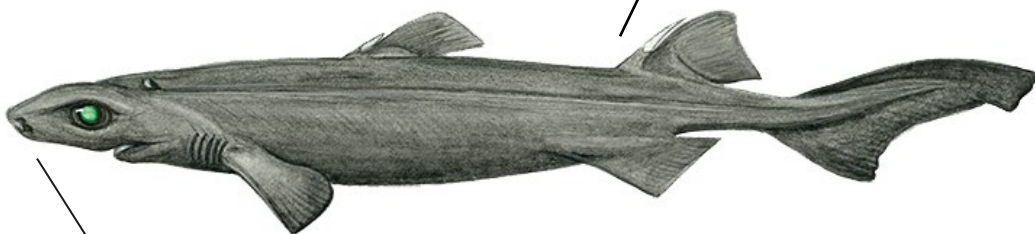
107cm



50-2250m



Second dorsal fin spine larger than the first spine



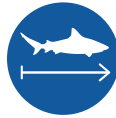
Large nostrils

BLACK DOGFISH

ORDER: SQUALIFORMES | FAMILY: DALATIIDAE

KITEFIN SHARK

*Dalatias licha*\* | SCK



182cm

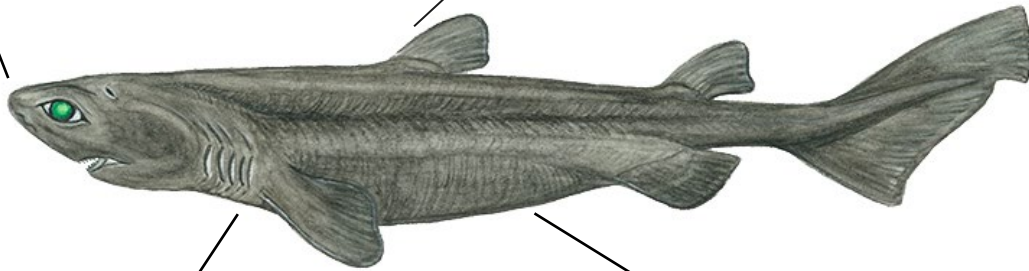


37-1800m



Short snout

Dorsal fins spines absent

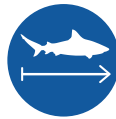


Relatively small gill slits

Body evenly dark

SPINED PYGMY SHARK

*Squaliolus laticaudus* | QUL

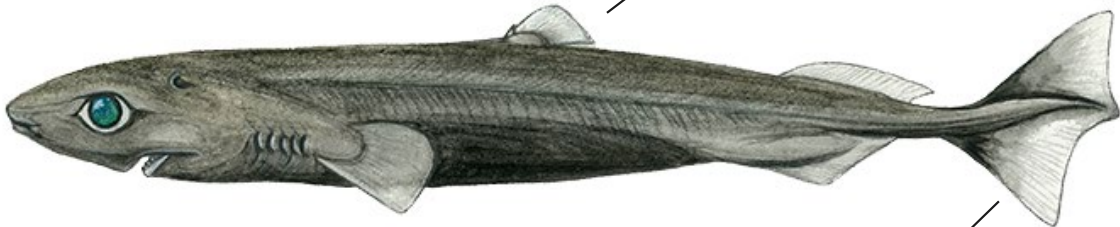


28cm



200-500m

First dorsal fin with a spine



Caudal fin paddle-shaped

\*Largest known bioluminescent vertebrate.

*Oxynotus paradoxus*\* | OXN



118cm

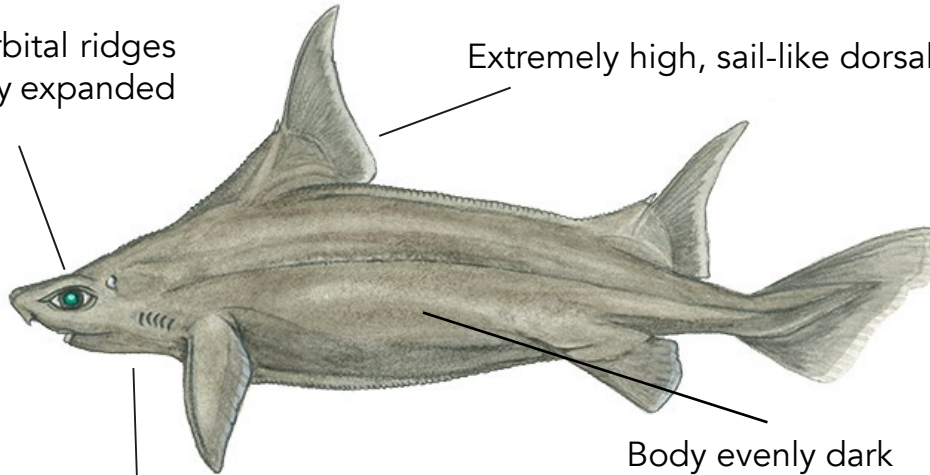


265-1238m



Supraorbital ridges not greatly expanded

Extremely high, sail-like dorsal fins

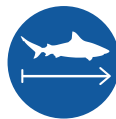


Spiracles relatively small and circular

Body evenly dark

SAILFIN ROUGHSHARK

*Oxynotus centrina* | OXY



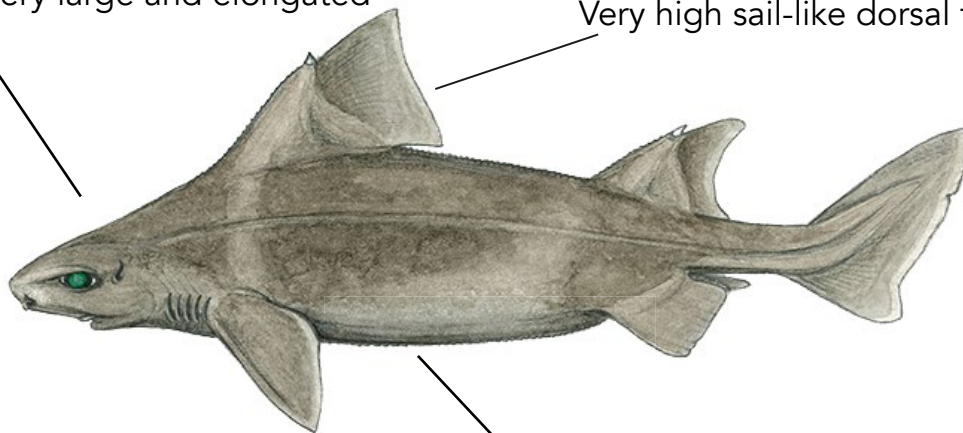
150cm



50-800m

Spiracles very large and elongated

Very high sail-like dorsal fins

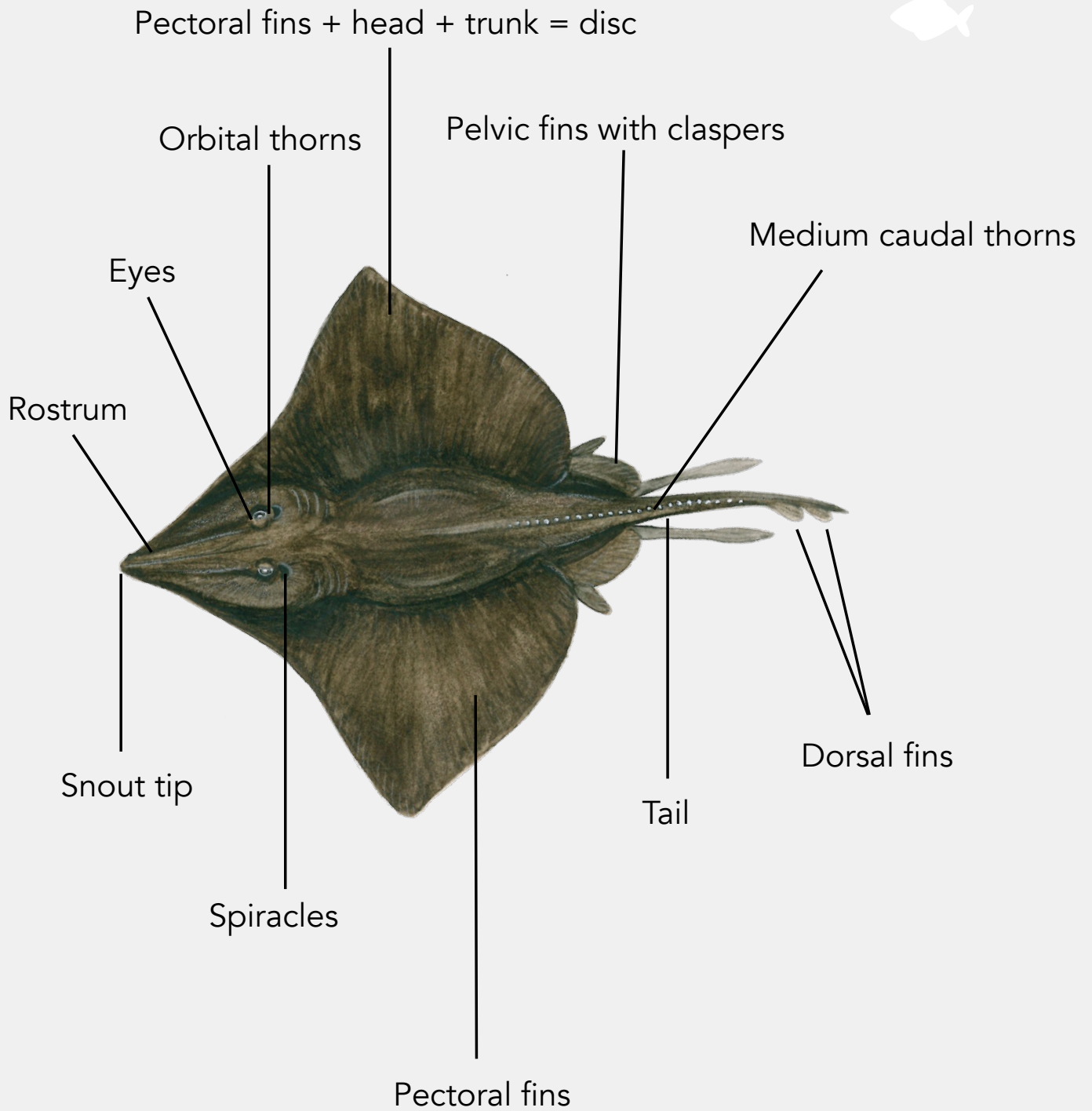


Gray to brownish gray in colour with darker spots on head and flank (stronger in adults)

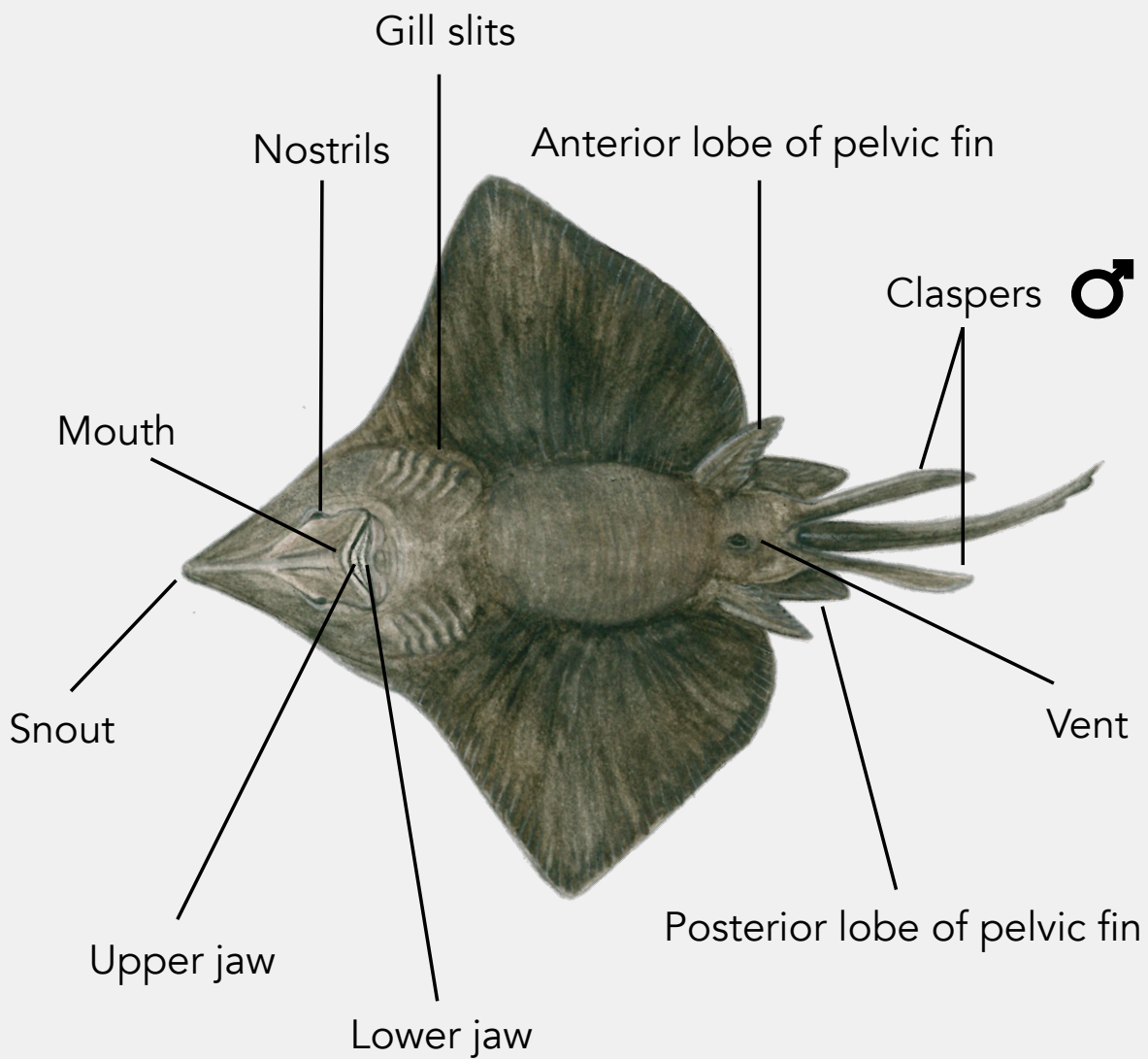
ANGULAR ROUGHSHARK

\*Greatest depths achieved for this species (Graça Aranha et al., 2024).

## Dorsal view



## Ventral view



*Dipturus batis*\* | RJB



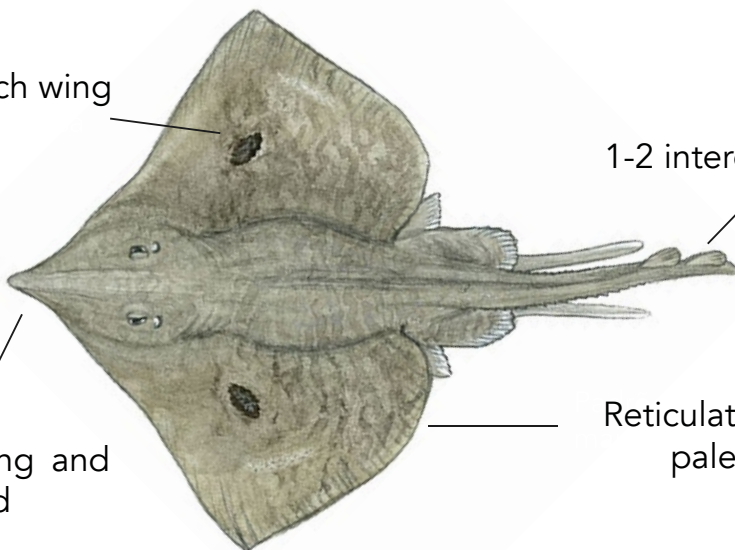
145cm



0-600m

Oval ocellus on each wing

Snout long and pointed



1-2 interdorsal thorns

Reticulated pattern of pale spots

BLUE SKATE

*Dipturus intermedius*\* | DRJ



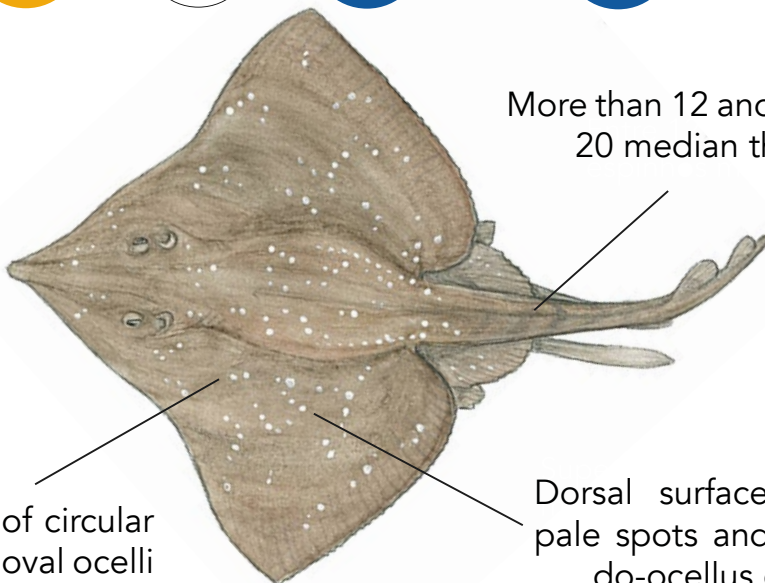
250cm



0-1500m

More than 12 and less than 20 median thorns

With pattern of circular pseudo-ocelli or oval ocelli



Dorsal surface with scattered pale spots and a circular pseudo-ocellus on each wing

FLAPPER SKATE

\*Global IUCN Red List status is 'critically endangered. Cannot be caught, retained, transhipped or landed (Regulation EU 2024/257).'

ORDER: RAJIFORMES | FAMILY: RAJIDAE

*Dipturus nidarosiensis* | JAD

NORWEGIAN SKATE



NT



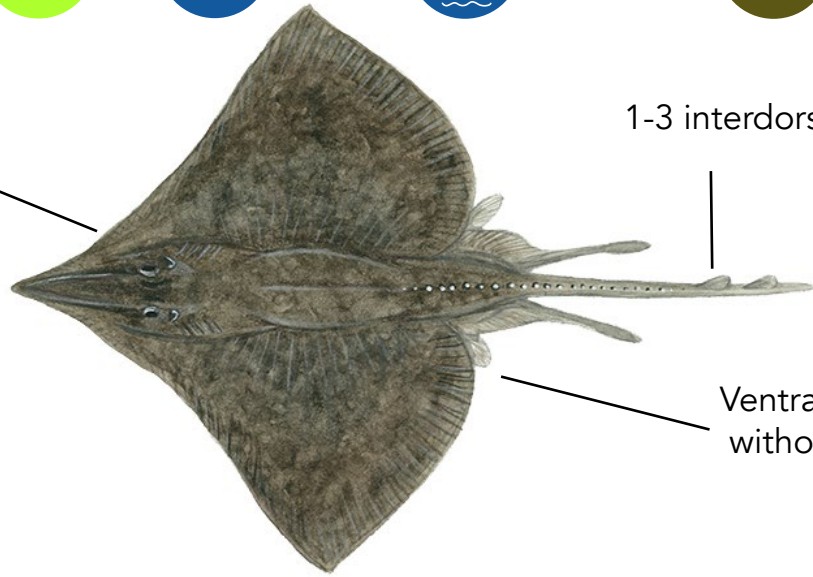
250 cm



125-1420m

TAC

dorso uniformly dark without spots



1-3 interdorsal thorns

Ventral surface without spots

*Dipturus oxyrinchus* | RJO

LONGNOSED SKATE



NT



150cm



70-1230m

TAC



Less than 12 median thorns

Dorsal surface with widely spaced light and dark spots, but without pattern of circular pseudo-ocelli or oval ocelli on each wing

*Neoraja iberica* | RAJ



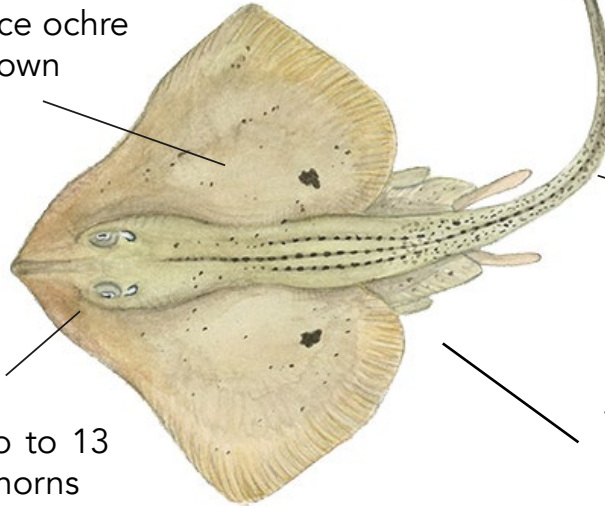
35 cm



270-785m



Dorsal surface ochre to grey-brown



Tail same colour as disc

Eyes with up to 13 small orbital thorns

Ventral surface without spots

IBERIAN PYGMY SKATE

*Rajella bigelowi* | JRW



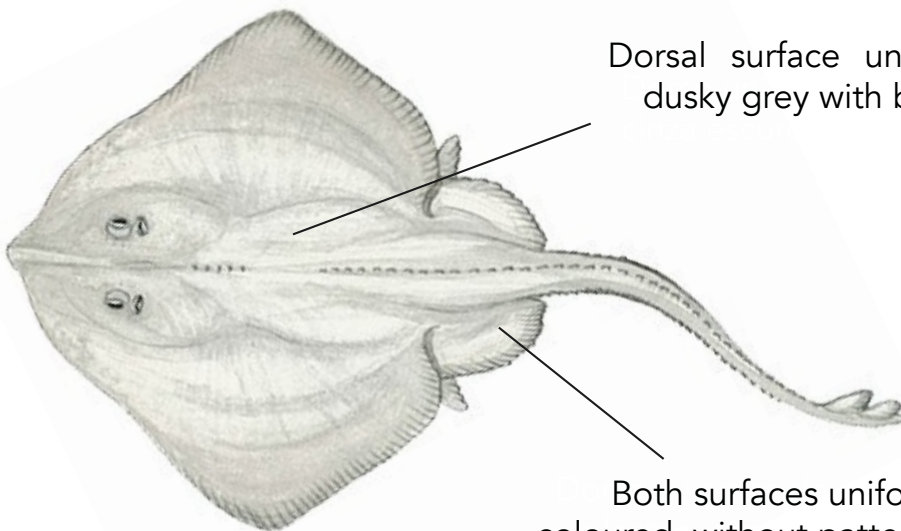
55cm



625-4156m



Dorsal surface uniformly dusky grey with black



Both surfaces uniformly coloured, without patternation

BIGELOW'S RAY

*Rajella kukujevi* | RJV

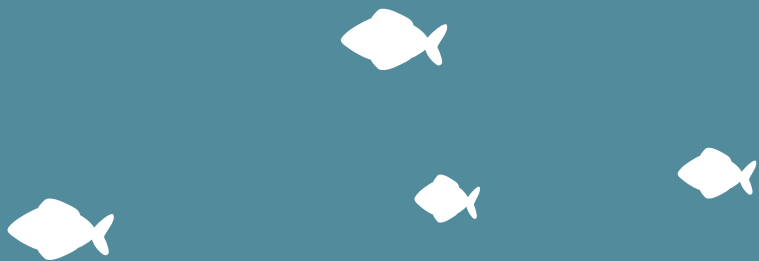
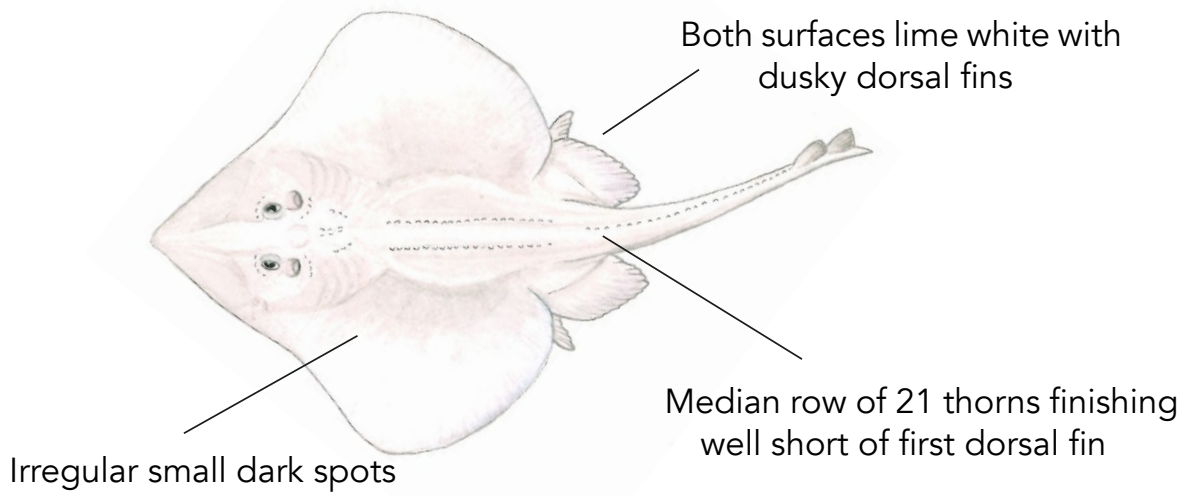
MID-ATLANTIC SKATE



84cm



750-2190m

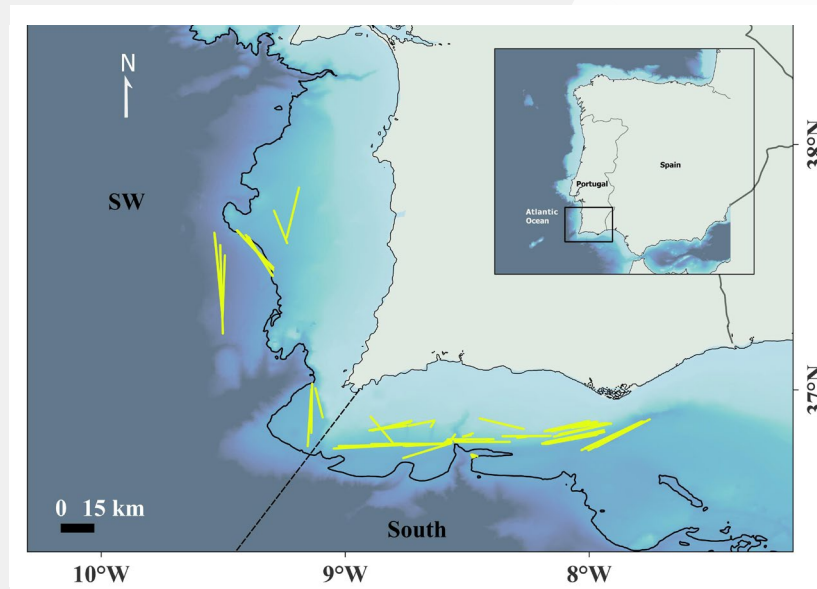


# ANNEX - DELASMOP PROJECT



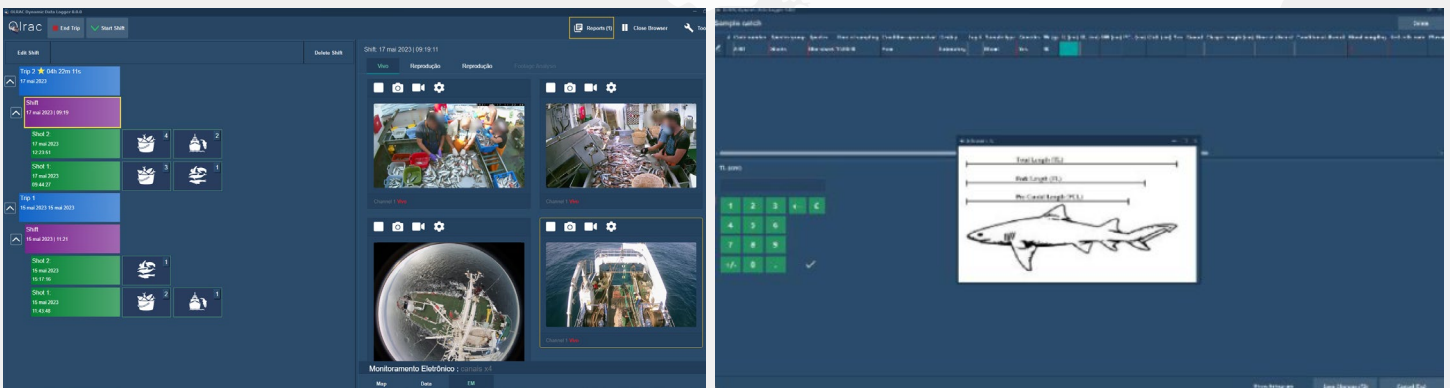
# FIELD

Over two years, from June 2020 to May 2022, ten trips were opportunistically conducted on a commercial crustacean bottom trawling vessel along the southern (coordinates  $\sim 37^{\circ}$ - $36^{\circ}$ N and  $9^{\circ}$ - $7.5^{\circ}$ W) and southwestern (coordinates  $\sim 39^{\circ}$ - $37^{\circ}$ N and  $9^{\circ}$ - $11^{\circ}$ W) coasts of Portugal (Figure 2).






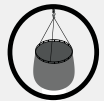






**Figure 2:** Map of the area sampled by a crustacean trawling vessel as part of the Delasmop project. Each yellow line corresponds to the start and end of a fishing haul.

During the trips, researchers from the Delasmop project collected several types of information about the fishing activity and the animals caught, which were recorded in the Olrac DDL® fishing logbook adapted for scientific purposes (Figures 3 and 4).



**Figures 3 and 4:** Olrac® DDL electronic monitoring software and fishing reports adapted for scientific use within the Delasmop project, for collecting information on sharks and skates in crustacean bottom trawl fishery.

# FISHING INFORMATION

-  Fishing effort (h; calculated from when the net touches the bottom until it starts to be hauled)
-  Fishing speed (nm/h ; automatically calculated by the Olrac DDL® software based on the start and end distance of the haul and the haul time)
-  Fishing haul coordinates (automatically entered into the Olrac DDL® software via GPS)
-  Net mesh size (55 or 70 mm)
-  Target species (information provided by the skipper at the start of each haul)
-  Net weight (kg; estimate made by the skipper)
-  Depth (m; obtained through the vessel's Scanmar® device or the Star Oddi® mini-CTD)
-  Bottom and surface temperature (°C; measured using the Star Oddi® mini-CTD)
-  Salinity (measured using the Star Oddi® mini-CTD)
-  Air exposure (minutes; measured from the moment the net is out of water until the sorting of the catch begins)

# ANIMAL INFORMATION

Identification of shark and skate species<sup>12-13</sup>



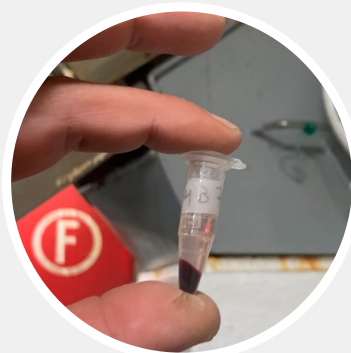
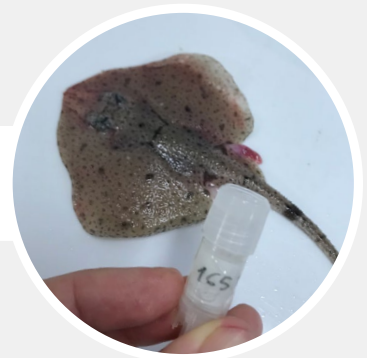
Sex (male: presence of claspers on the pelvic fins; female: absence of claspers)

Weight (kg; measured with an onboard scale or for animals > 1m, the weight was estimated using available literature)



Total length (cm; measured from the tip of the snout to the tip of the caudal fin)

Muscle sample (for isotopic and nucleic acid analyses)



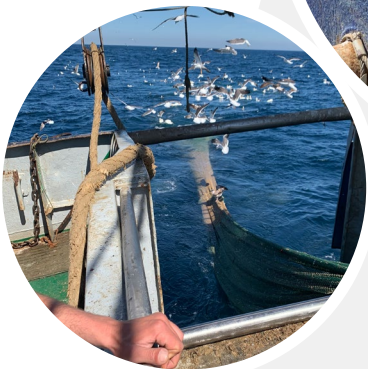
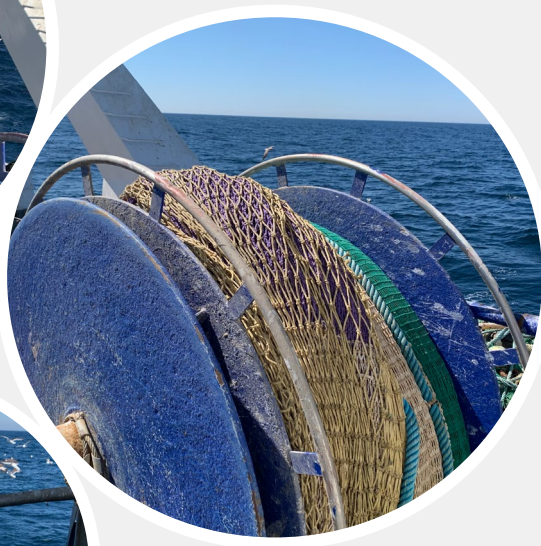
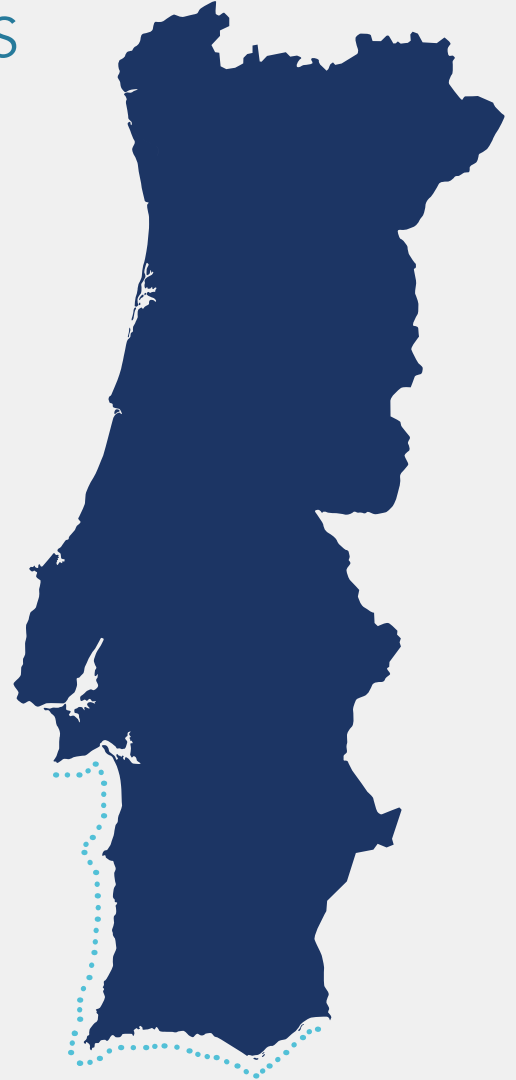
Blood with plasma separation on board (for stress analysis)

# CHARACTERIZATION OF FISHING AND BYCATCH OF ELASMOBRANCHS

## WHERE ARE CRUSTACEAN TRAWLERS OPERATING IN PORTUGAL?

Crustacean trawling activities are concentrated in the South of Portugal due to the extended continental shelf with more uniform depths, which provides access to deeper waters closer to the coast<sup>14</sup>. There is a higher fishing effort along the southern coast compared to the southwestern coast<sup>1, 15-18</sup>. This was also detected during our study, where the fishing effort in the South was three times greater than in the Southwest<sup>4</sup>. A total of 259 h, divided into 61 hauls (2-6 h each), were conducted in the South of Portugal at depths ranging from 96 to 810 m. In the Southwest, 92 h of fishing effort were conducted, divided into 16 hauls (3-9 h each), at depths between 403 and 1244 m.

Due to the different fishing depths in the southern and southwestern regions, the physicochemical characteristics of these regions are not comparable. Therefore, analyses were conducted separately for each coast.

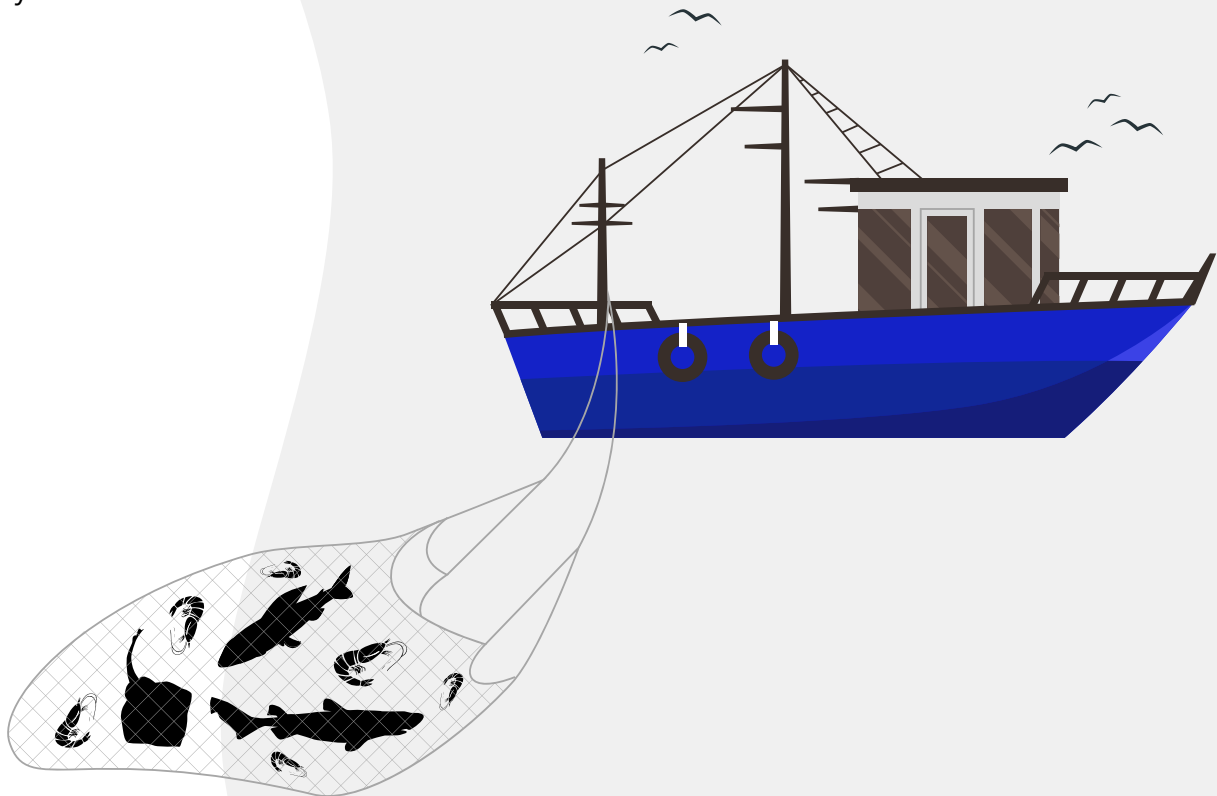


The southern coast is characterized by a typically narrow continental shelf and, as it is located at the northern edge of the Eastern North Atlantic Upwelling Region, it is significantly affected by seasonal coastal upwelling phenomena<sup>19</sup>. Cold, nutrient-rich waters are brought to the surface between June and October, while warmer waters from offshore regions reach the shelf between November and May. The steep slope of the continental shelf, between 800-1500 m, limits bottom trawling activities to depths of up to 800 m.

The southwestern coast is influenced by the mixing of Atlantic Intermediate Water and Mediterranean Water flowing through the Strait of Gibraltar, which provides relatively warm (~13°C) and salty (~36.3) water at intermediate depths (~900 m)<sup>20, 21</sup>. In this region, the continental shelf slope is moderate, allowing easier access to depths beyond 800 m.

## WHO ARE THE DEEP-SEA SHARKS AND SKATES OF PORTUGAL?

A total of 1559 specimens belonging to 18 species (15 sharks and 3 skates) were studied. In the South, out of the 14 identified species, the most frequently caught species was the blackmouth catshark. In the Southwest, out of the 16 captured species, the most frequent was the knifetooth dogfish shark. All hauls conducted in the Southwest contained deep-sea elasmobranchs, whereas in the south, only 71% of the hauls contained elasmobranchs.



Species	Common names	Number of specimens captured	
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## SHARKS

### Order

#### Carcharhiniformes

**Areas**  
South    Southwest

<i>Galeus atlanticus</i>	Atlantic sawtail catshark	47	17
<i>Galeus melastomus</i>	Blackmouth catshark	450	44

#### Hexanchiformes

<i>Chlamydoselachus anguineus*</i>	Frilled shark	3	
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#### Lamniformes

<i>Mitsukurina owstoni</i>	Goblin shark	1	
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#### Squaliformes

<i>Centrophorus granulosus*</i>	Gulper shark	10	
<i>Centrophorus squamosus*</i>	Leafscale gulper shark	3	2
<i>Centroscymnus coelolepis*</i>	Portuguese dogfish	1	3
<i>Centroselachus crepidater*</i>	Longnose velvet dogfish	17	
<i>Dalatias licha*</i>	Kitefin shark	9	4
<i>Deania calceus*</i>	Birdbeak dogfish	1	45
<i>Deania profundorum</i>	Longsnout dogfish	167	41
<i>Etmopterus pusillus</i>	Smooth lanternshark	115	16
<i>Etmopterus spinax*</i>	Velvet belly	264	39
<i>Oxynotus paradoxus *</i>	Sailfin roughshark	4	
<i>Scymnodon ringens *</i>	Knifetooth dogfish	101	97

## SKATES

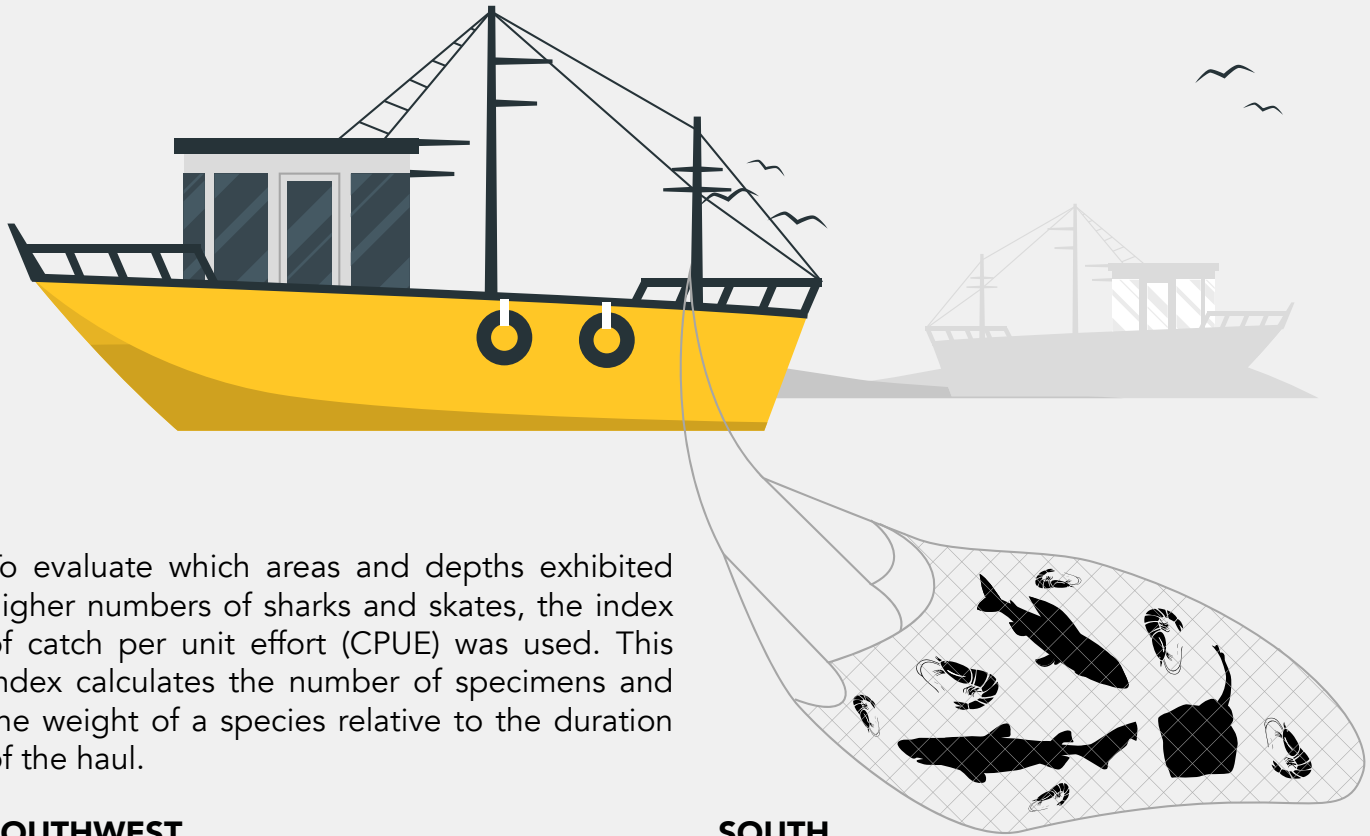
### Order

#### Rajiformes

<i>Dipturus nidarosiensis</i>	Norwegian skate	4	15
<i>Dipturus oxyrinchus</i>	Longnosed skate	30	7
<i>Neoraja iberica</i>	Iberian pygmy skate	2	

\* Deep-sea Sharks for which Retention is Prohibited for Vessels in the European Union (Regulation 2024/257)

# WHERE ARE THEY MORE CONCENTRATED?



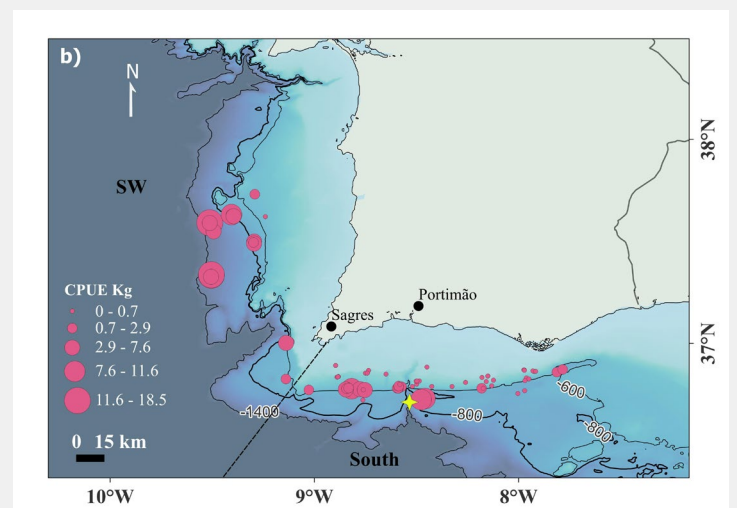
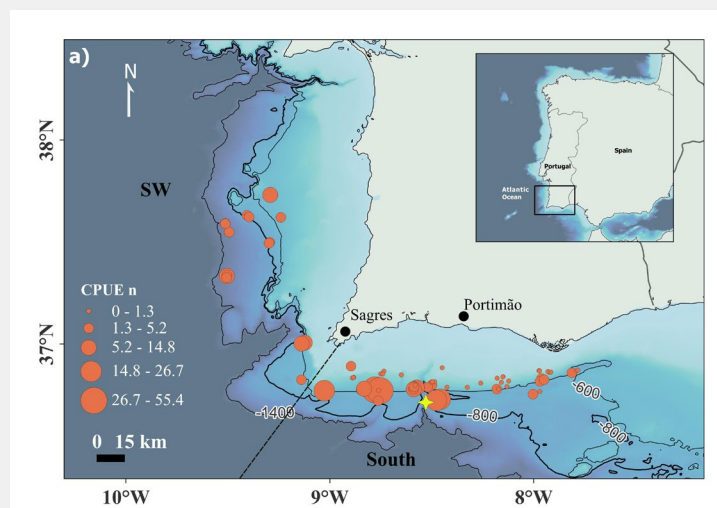
To evaluate which areas and depths exhibited higher numbers of sharks and skates, the index of catch per unit effort (CPUE) was used. This index calculates the number of specimens and the weight of a species relative to the duration of the haul.

## SOUTHWEST

Higher CPUE by number (CPUE n) was observed between 500-700 m. However, the highest values of CPUE by weight (CPUE kg) were observed beyond 1200 m, indicating the presence of larger animals at greater depths, as opposed to what was observed at shallower depths. Some species were exclusively found below 1200 m, such as the critically endangered birdbeak dogfish and Portuguese dogfish, and the rare goblin shark and frilled shark (Figures 5 and 6).

## SOUTH

A higher CPUE by number (CPUE n) and CPUE by weight (CPUE kg) of specimens was identified between 500-600 m depth between Portimão and Sagres. Some species, such as the knifetooth dogfish and longsnout dogfish, showed high CPUE n in the Portimão Canyon at around 800 m depth. In the Portimão Canyon, high CPUE kg was also identified for species threatened with extinction, such as the Portuguese dogfish and leafscale gulper shark, and the Norwegian skate, which is near-threatened (Figures 5 and 6).



**Figures 5 and 6:** Maps of the study area showing the catch per unit effort (CPUE) values for the number of specimens (left) and weight in kg (right) of deep-sea sharks and skates.

# OVERLAP WITH BOTTOM TRAWLING ACTIVITIES

To assess whether the feeding areas of deep-sea elasmobranchs overlap with bottom trawl fishing areas on the South coast of Portugal, the main prey were identified and evaluated to determine if they had been consumed in the days preceding the captures.

The diet determination was conducted through the analysis of stomach contents<sup>52</sup> from specimens of species that arrived dead on board (smooth lanternshark, blackmouth catshark, knifetooth dogfish, longnosed skate), and also through stable isotope analysis of nitrogen ( $\delta^{15}\text{N}$ :  $^{15}\text{N}/^{14}\text{N}$ ) and carbon ( $\delta^{13}\text{C}$ :  $^{13}\text{C}/^{12}\text{C}$ ) for frequently captured species (birdbeak dogfish, longsnout dogfish, velvet belly, blackmouth catshark, and knifetooth dogfish).

Nucleic acid ratios (RNA:DNA) were used to determine if the animals had been feeding in the days or weeks prior to capture, thus assessing their nutritional status and condition. Analysis of percentiles by species, given the lack of baseline values for such comparisons, indicated that the average values were closer to the 75<sup>th</sup> percentile. This was considered indicative of recent feeding and good condition, as opposed to the 10<sup>th</sup> percentile, where the condition would be imminently weaker.

Thus, it was concluded that the deep-sea elasmobranch species evaluated during the Delasmop project feed on crustaceans, including commercially important species to varying extents, along with other fish and cephalopod species<sup>22</sup>. Moreover, the majority of species showed average RNA:DNA values closer to the 75<sup>th</sup> percentile, suggesting that the animals were likely using the area or nearby zones for feeding, indicating an overlap of their feeding areas with crustacean trawl fishing on the South coast of Portugal.



Credits: Chimera Visuals



# IMPACT OF TRAWLING ON SHARKS AND SKATES

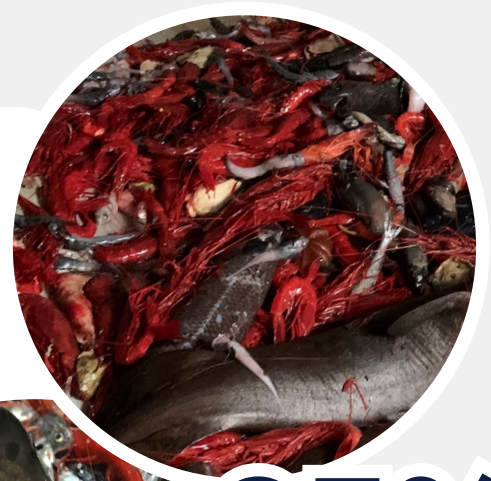
Deep-sea elasmobranchs are a frequent bycatch in crustacean trawling. The weight of elasmobranch bycatch on the South coast varied between 0 and 47% of the total net weight, while on the Southwest coast, the values varied between 1 and 58%.

## AT-VESSEL MORTALITY RATES

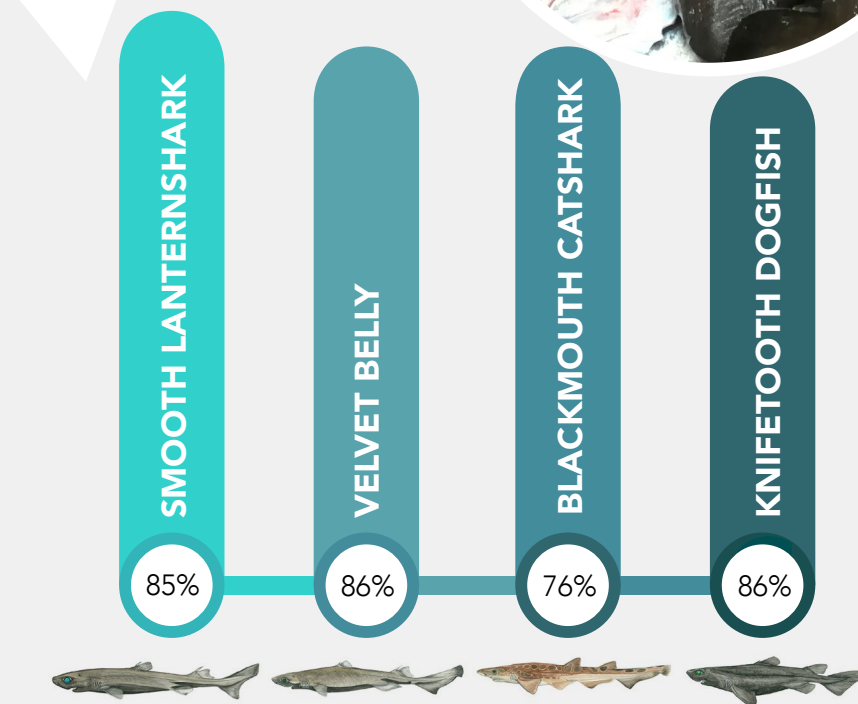
Onboard mortality rates were assessed for the most abundant shark species. Whenever a shark was spotted during the sorting process, it was immediately placed in a cooled (temperature 13°C) and oxygenated tank, where body and spiracle movements were assessed, as well as the presence or absence of lesions on the body. Animals that were dead or in poor condition showed no (or few) body and spiracle movements and could have wounds on the body. Animals in good and excellent condition showed strong and vigorous body and spiracle movements and also few or no lesions on the body.



The number of dead and poor-condition specimens (95%, i.e. 1073) was higher than the number of specimens in good and excellent condition (5%, i.e. 53). The blackmouth catshark had the lowest number of dead specimens compared to the other species (Figure 7).



**95%**  
mortality



**Figure 7:** Proportion of dead specimens of the sharks most frequently caught by a crustacean trawler in the South and Southwest coasts of Portugal.

To assess which parameters are responsible for higher shark mortality, logistic regression models were used. The models indicated that higher mortality rates were experienced by knifetooth dogfish specimens and also by smaller specimens in general, caught in trawls with greater temperature differences between the surface and the ocean floor. Hauls where the net had more fish (i.e. heavier net) catching prawns and shrimps (mesh size 55 mm), also presented higher mortality rates among specimens of the studied species.

# STRESS

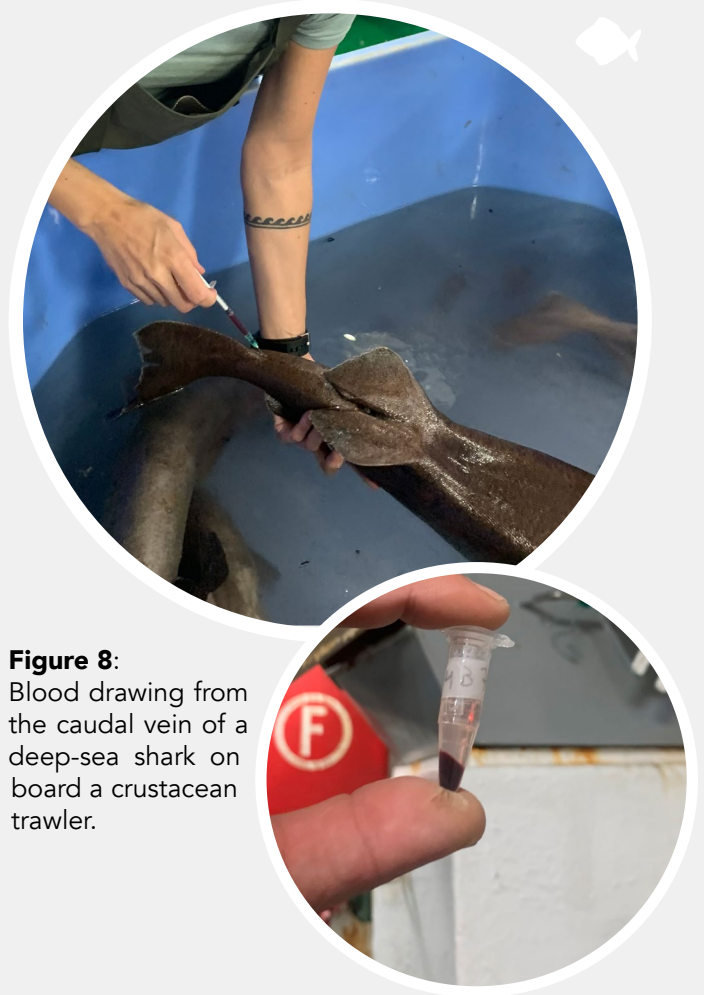
In order to assess the potential stress<sup>53</sup> to which deep-sea sharks are subjected during bottom trawling activities, some physiological parameters were measured in their blood plasma and related with fishing procedures and environmental factors. The target species for this analysis were the smooth lanternshark, velvet belly, blackmouth catshark, and the knifetooth shark.

On board, blood samples were collected from the caudal vein of sharks that presented excellent, good or poor conditions, using a 1 ml heparinized syringe (Figure 8); the plasma was separated by centrifugation and frozen until laboratory analysis. The sharks were released after the procedure.

In the laboratory, the concentrations (mmol/L) of metabolites (glucose, urea and lactate) and electrolytes (phosphorus, potassium, chloride, sodium, magnesium and calcium) in blood plasma were determined using commercial kits (Spinreact®) related to the physiological response to stress.

An increase in the concentration of some of these physiological indicators was observed due to greater fishing depths, greater temperature differences and also higher fishing speed.

As they live in an environment characterized by cold waters and higher pressures, an abrupt transition in temperature and rapid changes in pressure may result in higher stress and mortality rates. However, greater temperature differences are related to lower concentrations of glucose (for the velvet belly), potassium (for smooth lanternshark) and urea (blackmouth catshark), which may indicate that the physiological responses to the stress of capture had not yet been triggered or that they were already returning to baseline levels<sup>23-25</sup>.



**Figure 8:** Blood drawing from the caudal vein of a deep-sea shark on board a crustacean trawler.

The fishing effort showed, for the most part, a negative correlation with the plasma levels of glucose, chloride, magnesium, potassium and sodium, i.e., longer hauls are associated with lower concentrations of these indicators. This could indicate a stabilization of the response after long hauls, or perhaps the specimens studied entered the net just before the end of each haul and these responses had not yet been triggered, which could be the case for some specimens studied, but is unlikely to happen to the majority. Therefore, the first hypothesis is most likely, but further studies are needed to assess the onset and stabilization times of these indicators.

The maximum chloride and magnesium values for the velvet-belly (349.8 and 7.61 mmol/L respectively) and the smooth lanternshark (325.8 and 8.85 mmol/L respectively) were very high when compared with those found in 46 articles on stress indicators in elasmobranch plasma. In relation to three articles on deep-sea sharks <sup>23-25</sup>, the highest lactate levels were found for the blackmouth shark (33.11 mmol/L) and sodium for the velvet-belly (357.8 mmol/L) and smooth lanternshark (425.5 mmol/L).

The plasma lactate levels are related to an extreme physiological response, since this glucose metabolite is generated under greater energy demand due to anaerobic respiration caused by high stress or high physical activity. The lactate values, all above 5 mmol/L in the species analyzed in this study, indicate that the sharks may be under stress. The literature indicates that, for pelagic sharks, values above 16 mmol/L are correlated with higher mortality rates<sup>26</sup>, which may indicate that the blackmouth shark in this study may not survive the fishing procedures, even if they are in good or excellent physical condition.

Although there are numerous physiological indicators that identify whether a fish is under stress, our understanding of what the absolute levels of these indicators mean is rudimentary, especially in non-experimental contexts in wild sharks. As the baseline levels of these plasma indicators of stress for deep-sea sharks are not known, some caution is advised when interpreting the results obtained. High levels of an indicator may signal a fish under stress, but lower levels of an indicator do not necessarily mean the opposite.

More research is therefore needed to establish a more robust analysis of the relationship between physiological indicators of stress and fishing variables, which could provide the basis for establishing additional recommendations aimed at improving the welfare and effective management of discarded deep-sea sharks.



# CONVERSATIONS WITH THE SECTORS



Meetings and workshops were held to present the project and its main objectives to fisheries managers and fishers, and to hear questions and concerns about elasmobranch bycatch. In addition, fishers were trained in the use of an electronic monitoring tool under the [EMREP project](#).

92%

**Indicated incorrect handling techniques**

68%

**Believe that the majority of animals returned to the sea survive**

85%

**Are not aware of the regulations**

## WHAT ARE THE FISHERS PERCEPTIONS?

To find out how fishers perceive deep-sea elasmobranchs, surveys were conducted<sup>54</sup> in the main fishing ports in southern Portugal, where around nine crustacean trawling vessels were approached, totalling 34 fishermen aged between 25 and 76.

Several questions were raised, specifically about the frequency of fishing, identification, survival and handling of the species caught, as well as regulations involving these animals.

Among the main parameters that could affect the survival of elasmobranchs, fishers pointed out the weight of the net, the speed of the net ascent and the duration of the haul as the factors with the greatest impact.

In general, the vast majority of fishers demonstrated a limited understanding of the issues raised: 92% indicated incorrect handling techniques as the most frequently used, others were unable to identify (from the elasmobranchs' illustrations within this guide) the species with which they have the most contact and 68% reported believing that the majority of animals returned to the sea survive. Furthermore, more than 85% stated that they were not aware of the regulations regarding deep-sea elasmobranchs. These responses, among others provided by the surveys, indicate a limited understanding and therefore there is a need to promote to fishers more awareness-raising and clarification actions on the subject.

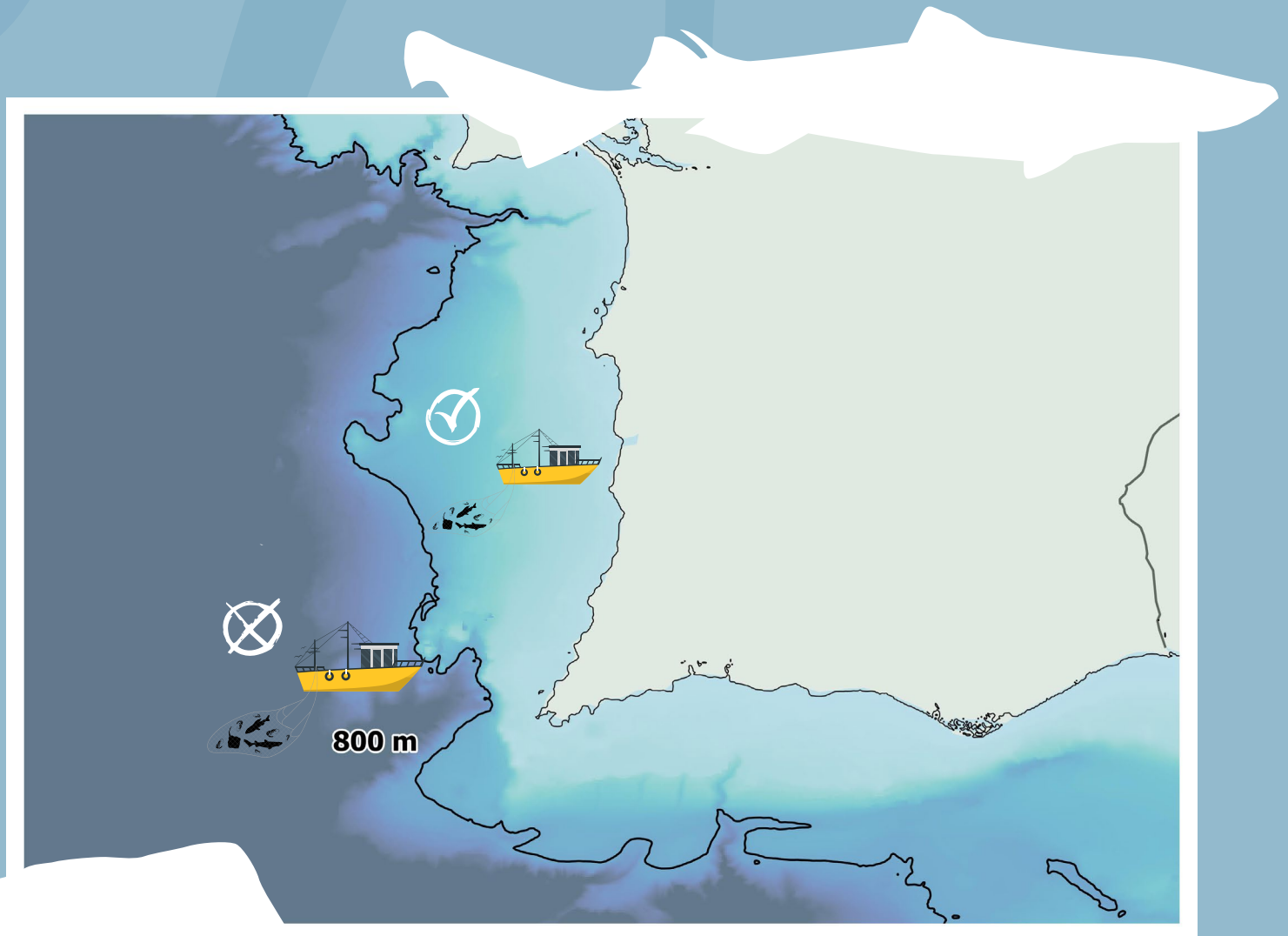
# GENERAL CONCLUSIONS

The Delasmop project identified a negative impact of bottom trawling on the survival of deep-sea elasmobranchs. The high mortality rates and low growth and reproduction rates of these animals, combined with the insufficient knowledge of fishers who deal with these species on a daily basis, highlights the urgent need for improved management strategies and the need for greater communication between researchers, managers and fishers. This is essential to gain greater understanding of the issues that permeate both parties and to discuss ways to mitigate the current impact of fishing on local populations of deep-sea elasmobranchs.



# STRATEGIES TO MITIGATE THE IMPACTS OF BOTTOM TRAWLING

## SHARKS AND SKATES



# REDUCING BYCATCH

## PREVENTION MEASURES

Reducing the bycatch of deep-sea elasmobranchs is one of the main strategies for mitigating the impact of bottom trawling on these animals. One way to reduce catches is to avoid spatial (horizontal and vertical) and temporal overlap between fishing operations and areas where there is a known concentration of deep-sea elasmobranchs. To achieve this, it will be necessary to gain greater knowledge of habitat use and the times of year when the animals are most susceptible to capture.

## RECOMMENDATIONS FOR PORTUGAL

According to the information collected by the Delasmop project (section **"Delasmop Project"**), in order to avoid bycatch of deep-sea elasmobranchs on the southern coast of Portugal, it is recommended to limit crustacean bottom trawling whenever possible to a depth of 500 m, especially in the areas between the cities of Portimão and Sagres and also in the Portimão canyon (close to 800 m). These were the areas and depths that presented the highest CPUE n and CPUE kg values. On the southwest coast, it is suggested to avoid crustacean bottom trawling activities beyond 800 m in accordance with the recommendations of [Regulation \(EU\) 2016/2336](#), especially in areas below 1200 m, which is where the highest CPUE kg values of rare and endangered species were obtained.

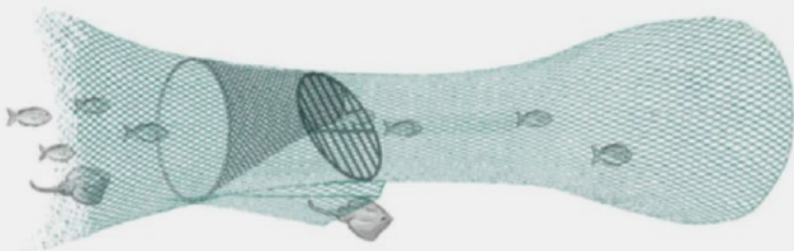
It is also recommended that further studies be carried out to identify other sensitive habitats, such as nursery areas, and a temporal analysis of the interaction between fishing and the occurrence of these species.



## BYCATCH REDUCTION MECHANISMS

The use of weights to stir the substrate at the mouth of the net to help increase the catch of target species may result in an increase in the bycatch of elasmobranchs, especially skates. Removing these weights has proven effective in reducing the catch of elasmobranchs. However, this removal may also result in a decrease in the catch of some target species<sup>27</sup>.

The use of devices in trawl nets also helps to reduce bycatch of elasmobranchs and other unwanted species and has shown positive results in some countries. They consist of modifications made to the nets, where a grid (firm or flexible) is placed in front of the entrance to the codend, which allows the target species to pass through, diverting elasmobranchs out of the net through a lower or upper opening. These devices depend on the type of species to be excluded, i.e. whether they have more demersal habits (lower opening, Figure 9) or more pelagic habits (upper opening). These devices have shown a significant reduction in elasmobranch catches in some trials carried out in several countries<sup>27-31</sup>. However, the effectiveness of such measures in reducing bycatch of deep-sea elasmobranchs, specifically in the European crustacean trawl fishery, requires further investigation.



**Figure 9:** Codend with a device to exclude bycatch of demersal fish, such as skates. Illustrations taken from Sacchi <sup>32</sup>.

## RECOMMENDATIONS FOR PORTUGAL

Given the proven effectiveness of the use of grids to exclude elasmobranchs in crustacean trawlers in other countries, and due to the lack of strategies to reduce elasmobranch bycatch in trawl fisheries in Portugal, it is suggested that trials be carried out to test the functionality of such mechanisms in reducing bycatch, as a way of mitigating the current impacts that crustacean trawling has on these animals.

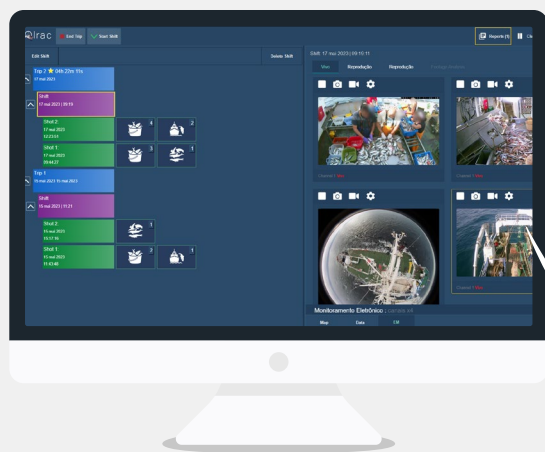
It is also recommended that further studies be carried out to identify other sensitive habitats, such as nursery areas, and a temporal analysis of the interaction between fishing and the occurrence of these species.



# IDENTIFICATION OF DISCARDS

Deep-sea elasmobranchs are discarded by crustacean bottom trawlers, either due to existing regulations or because they have low commercial value. This results in a low number of records of the occurrence of these species<sup>33-34</sup>, which makes it difficult to obtain information on the status of populations and distribution patterns. The landing obligation (Article 15 of [Regulation \(EU\) No. 1380/2013](#)) applies to species with a total allowable catch (TAC), such as skates and rays in the Northeast Atlantic Ocean. This means that specimens with a TAC must be landed, even if they are not marketed, so that their numbers are counted against quotas, unlike when they are discarded. However, since 2019, when its implementation was achieved by European Union countries and fisheries (with some exceptions), there has been little adherence from the fishing industry<sup>35-36</sup>. In this regard, efforts to identify what is discarded need to be made without fishers continuing to be

hampered with the obligation to report discarded species and the obligation to land species with a TAC. Therefore, it is essential to intensify and diversify monitoring measures, in order to obtain data on discards in a more autonomous way. Monitoring by onboard observers is the most common method for collecting data in commercial fisheries. However, in the case of deep-sea fisheries, such as crustacean trawling, only 20% of the commercial fleet should be monitored ([Regulation \(EU\) No. 2016/2336](#)). In this regard, electronic monitoring using on-board cameras would be an added value, as it could be applied to the entire fleet, maintaining a high level of identification remotely<sup>37</sup>.



## RECOMMENDATIONS FOR PORTUGAL

An electronic monitoring trial was carried out during the activities of the Delasmop project. Surveillance cameras on board a crustacean trawling vessel, integrated into an electronic fishing logbook, made it possible to identify sharks and skates down to the genus level and many specimens down to the species level<sup>37</sup>.

It is understood that the use of electronic monitoring could help in the identification not only of elasmobranchs, but also of other species subject to regulations and expanded to other fisheries. However, its functionality would need to be tested and in this regard, it is suggested that tests of this technology be carried out in different fisheries in order to identify discards of other species of conservation interest.

# REDUCING MORTALITY

Reducing mortality depends on greater control of factors and variables involved in fishing activities. During fishing, a series of factors such as duration of air exposure, fish handling, net configuration, fishing duration and vessel speed, along with environmental variables such as water temperature and pressure changes, can contribute to at-vessel mortality<sup>4,38-41</sup>. Deep-sea elasmobranchs often arrive on board in poor condition, with little or no body movement, which suggests that their survival after discards is unlikely.

After discards, mortality can be attributed to internal injuries caused by barotrauma or crushing within the fishing net, in addition to stress resulting from fishing activities and handling on board. This stress can lead to an increase in the

concentration of certain plasma markers, which could result in the death of the animals shortly after discards (see subsection "**Stress**").

## RECOMMENDATIONS FOR PORTUGAL

Depth is strongly linked to the distribution of deep-sea elasmobranchs, so that greater depths (> 400 m) in addition to presenting a higher probability of bycatch of deep-sea elasmobranchs<sup>4,42,43</sup> may be associated with higher mortality, since differences in pressure and temperatures (between the bottom and surface waters) can cause barotrauma and thermal shock, respectively.



# TO MITIGATE SUCH EFFECTS, IT IS SUGGESTED:



Reducing the fishing depth, maintaining < 800 m in accordance with the recommendations by law ([Regulation \(EU\) 2016/2336](#)), however, if possible, maintaining < 500 m. This will result in a decrease in the catch of deep-sea elasmobranchs, but also in a decrease in the probability of mortality due to barotrauma and thermal shock.



Restricting fishing to times of the year when surface water and air temperatures are lower or when there is little stratification in the different water layers is recommended, since rising temperatures have been associated with decreased condition in many taxa and decreased survival<sup>4,38-41</sup>.



Decreasing the hauling speed of the net, to allow a more gradual transition between zones with different pressures and temperatures.



If the animal arrives on board alive and has good physical condition, i.e. strong body and spiracles movements and does not present significant injuries, its return should be prioritized. To this end, better handling practices are essential to increase the chances of survival of these animals after their release<sup>44</sup> (see section **"Elasmobranch's handling"**).



To increase post-discard survival rates, the most effective measure would be to limit the air exposure time<sup>45-51</sup>, for which a reduction in sorting time is necessary.

Reducing haul duration would reduce the number of animals in the net per haul, as well as the weight of the net, reducing the possibility of death by crushing.



Keep the haul speed to the minimum possible, since greater speed was associated to increased stress levels in some shark species (see subsection **"Stress"**).

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