FishMed-PhD

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

CNR
IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

Mitigation measures for Endangered, Threatened and Protected species

Alessandro Lucchetti

LOWERING FISHING INTERACTIONS
life DELFI

Life

NATURA 2000

Goals of the lesson

- What is bycatch
- How to assess bycatch
- Bycatch by groups of species and gears
- Bycatch estimates
- How to mitigate bycatch

Vulnerable species

A taxon is considered vulnerable when facing a high risk of extinction in the wild in the medium-term future, unless the circumstances that are threatening its survival and reproduction improve (IUCN, 2017).

Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (1995): Appendix II (endangered or threatened species) and Appendix III (species whose exploitation is regulated) of the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean

The most widely accepted classification for the conservation of species is the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN).

Definitions

IUCN Red List of Threatened Species : it is a comprehensive inventory of the global conservation status of biological species. It uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies

Several categories: 'near threatened', 'vulnerable', 'endangered' or 'critically endangered'. Acronim: endangered, threatened and protected (ETP)

A species is categorized as 'vulnerable' according to such as reduction in population size, reduction in geographic range, or probability of extinction in the wild (IUCN, 2017). Thus vulnerability can be caused by habitat loss or direct mortality as a result of human activities

Definitions

But what's a protected species?

Species of particular scientific, ecological, cultural, or economic value, often rare or threatened.

It can be an organism (animal or plant, for example **Posidonia**) that lives in the sea and benefits from special legal protections to prevent its extinction or depletion—that is, its reduction.

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Why to protect?

Biological vulnerability (K-strategists)

Many marine mammals, turtles, elasmobranchs, and several seabirds have: slow growth, late maturity, few offspring/eggs, and long lifespans. Therefore, they recover slowly even after moderate population declines.

Loggerhead sea turtle (Caretta caretta)

- About 100 eggs per nest, but only ~1–2 out of 1,000 hatchlings reach maturity (≈0.1–0.2%).
- About 16–28 years to reach “adult” sizes associated with maturity: roughly ~80 cm carapace length and 50–70 kg.

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Great white shark (Carcharodon carcharias)

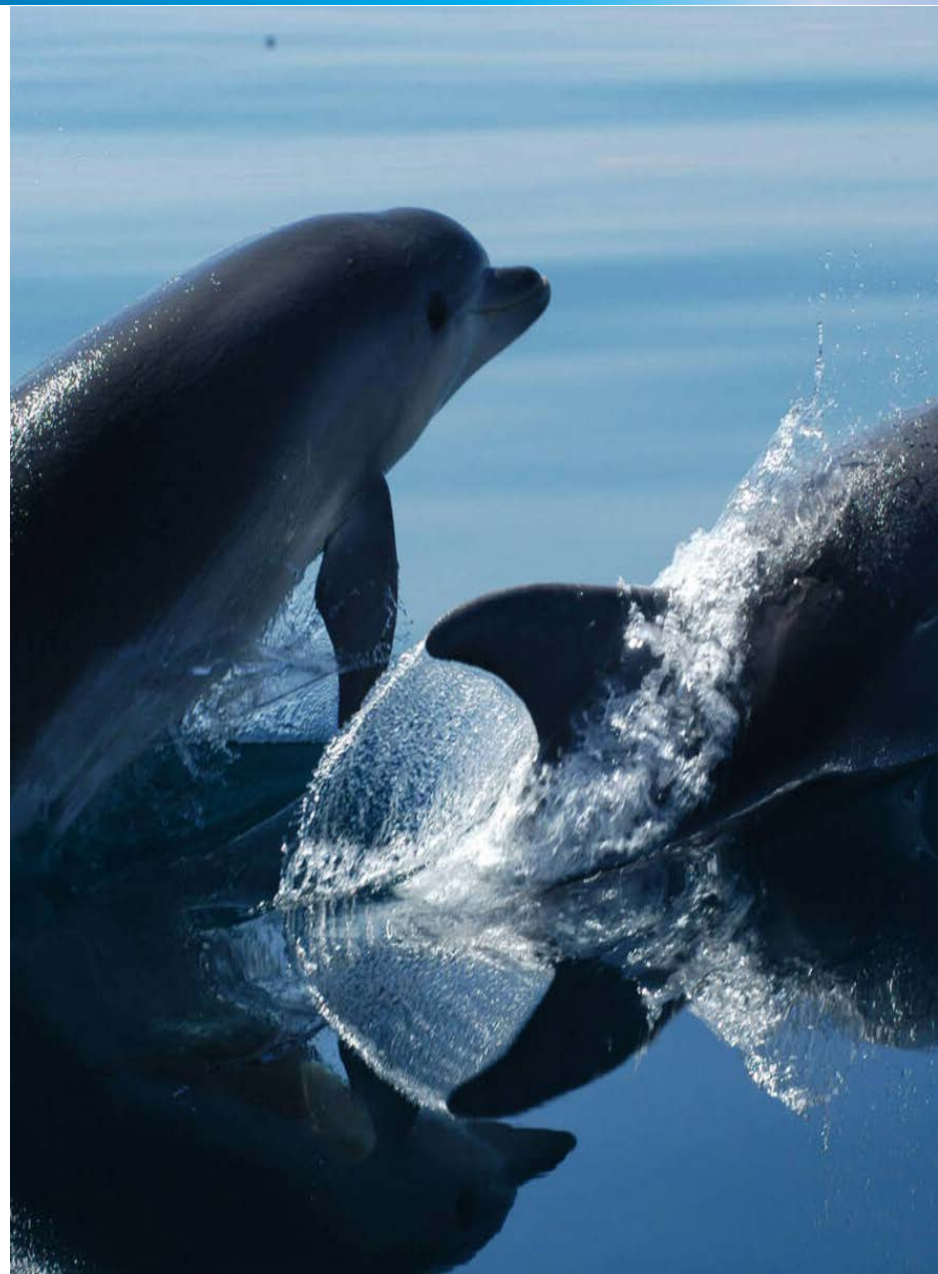
- Typically 2–10 pups.
- Maturity at around ~26 years in males and ~33 years in females.
- Males: mature at about 3.5–4.1 m total length (TL);
- females: mature at about 4.2–5.2 m TL.
- Newborns are large: ~109–165 cm TL and about ~20–30 kg.
- In the Mediterranean, there are likely fewer than 250 mature individuals remaining.

Why to protect?

Biological vulnerability (K-strategists)
Many marine mammals, turtles, elasmobranchs, and several seabirds have: slow growth, late maturity, few offspring/eggs, and long lifespans. Therefore, they recover slowly even after moderate population declines.

Bottlenose dolphin (*Tursiops truncatus*)

- Up to 11 births per female;
- average interval between pregnancies of 3–4 years.
- Females: sexual maturity is often reported between 7 and 12 years.
- Gestation: ~12 months.
- Newborn: birth length about 0.84–1.4 m; typical weight ~20 kg.



Why to protect?

Role in the ecosystems

Protecting marine species is essential because they

- sustain ecosystem equilibrium by regulating food webs through predation
- Food-web regulation (predation, grazing, scavenging that stabilizes trophic cascades)
- Connectivity between habitats (migrations and movements linking coastal–offshore systems; seed/larval dispersal) acting as ecological connectors that link habitats and maintain the flow of energy and biomass across seascapes
- by recycling nutrients
- To-down control of food webs
- Disease and pest control (removing weak/sick prey; controlling outbreak-prone species)

Why to protect?

Ecosystem services

- Water quality support (filtration by bivalves, sediment trapping by seagrass, reduced turbidity)
- Sediment stabilization & coastal protection (attenuating waves, reducing erosion, shoreline buffering)
- Nursery and shelter provision (creating refuges and recruitment habitat for fish and invertebrates)
- Support to fisheries productivity (spillover, maintaining key functional groups, healthier stocks over time)
- Cultural ecosystem services (recreation, ecotourism, education, heritage and identity values)
- Scientific and educational value (indicator species, sentinels of change, research opportunities)

Why to protect?

High and cumulative human pressures
They are affected by multiple factors at the same time: bycatch, depredation and conflicts with fisheries, habitat loss/degradation, pollutants (chemical and plastic), underwater noise, vessel traffic, climate change, and alien/invasive species. These impacts add up and can amplify each other.

Risk of extinction and irreversibility
When populations fall below critical thresholds (loss of genetic diversity), recovery can become unlikely or impossible within management-relevant timescales.

Indicator of environmental status
Many of these species are sentinels: they accumulate contaminants and are influenced by prey availability and habitat quality. Their condition reflects the ecosystem's "good status" (also useful for MSFD/GES).

Why to protect?

Socio-economic and cultural value
They support nature-based tourism and local identity; their presence increases the perceived value of coastal areas. Their loss can harm local economies and the environmental reputation of a territory.

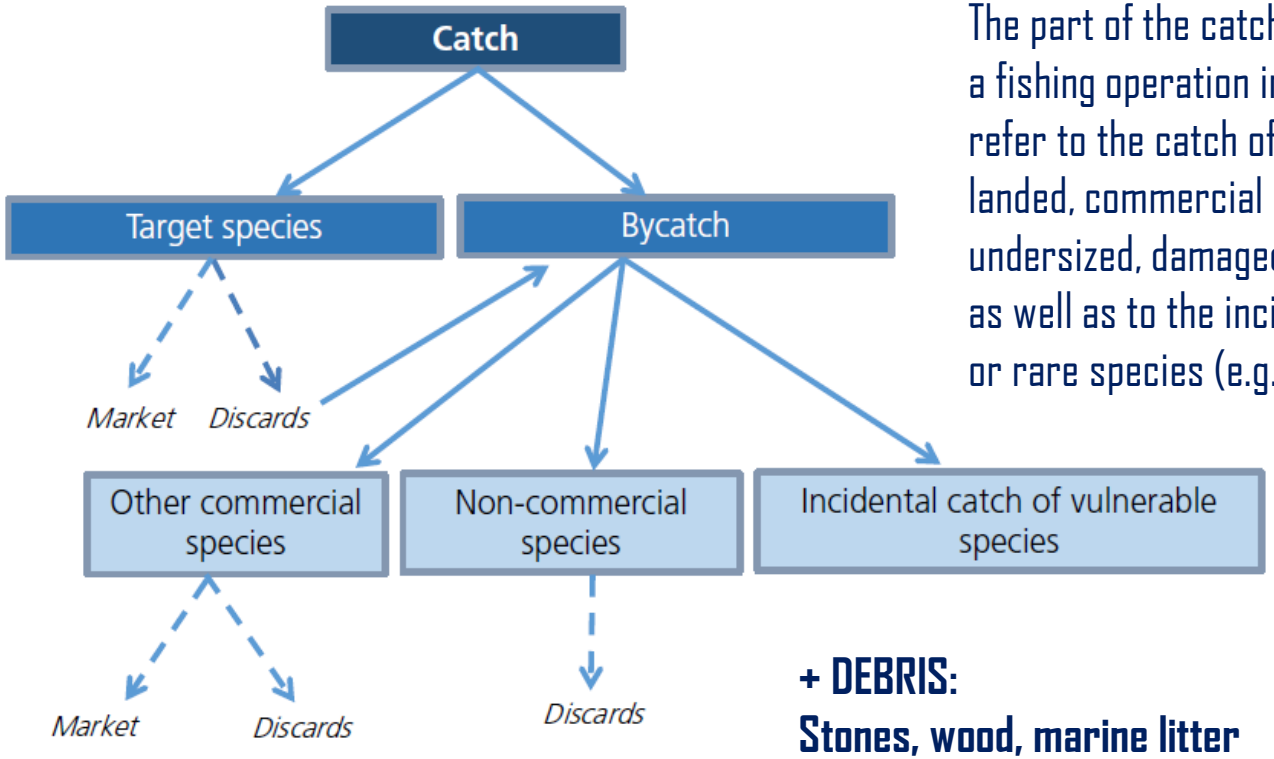
Regulatory obligations and international responsibility
They are often covered by listings and conventions (e.g., IUCN, CITES, CMS, regional agreements) and by EU/national obligations (e.g., Habitats/Birds Directives, MSFD). Protecting them reduces legal risks and can facilitate access to funding and management tools.

Why to protect?

Ethics and animal welfare (especially for vertebrates)

There is an ethical motivation to reduce suffering and avoidable mortality (bycatch, gear-related injuries, collisions, plastic ingestion), alongside growing public awareness and concern.

Definitions



Source GFCM, 2018

BYCATCH:

The part of the catch that is unintentionally captured during a fishing operation in addition to the target species. It may refer to the catch of other commercial species that are landed, commercial species that cannot be landed (e.g. undersized, damaged individuals), non-commercial species as well as to the incidental catch of endangered, vulnerable or rare species (e.g. sea turtles, sharks, marine mammals).

+ DEBRIS:

Stones, wood, marine litter

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Definitions

Bottom trawl

Bycatch, discard

Bycatch, commercial: *Umbrina cirrhosa*

Bycatch, vulnerable: *Caretta caretta*

Target species: *Squilla mantis*

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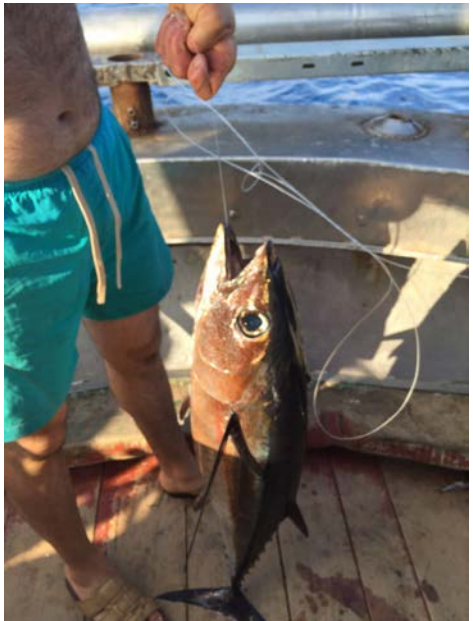
Definitions

Longline

Target species: *Xiphias gladius*

Bycatch, vulnerable



Bycatch, commercial:
Thunnus alalunga

Coryphaena hippurus

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Problem

Commercial fishing operations are one of the main causes of human-related injury and mortality for vulnerable species

Different fishing gears (trawls, passive nets, longlines etc.) can affect different species and different life stages

- Area
- Depth
- Gear properties (mesh size, net height, hook size and shape etc.)
- Towing speed
- Season

Fisheries can also impact marine animals unintentionally or indirectly by reducing their critical habitat and the availability of their pr

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Problem

Bycatch of vulnerable species is a growing concern for

- Conservation organizations
- Scientists
- Fishing industries
- Resource managers

- Large size of first maturity;
- high age of first maturity;
- Low growth rate;
- Long lived;
- Low reproduction output

} "*k strategy*"

Vulnerable species: low reproductive rates, low growth rate, elevated parental care (mammals), and low rates of natural mortality, "k" strategist species, may suffer greater impacts than "r" strategist species

Problem

- DIRECT MORTALITY

Direct mortality occurs when the animal is found dead inside the fishing gear due to drowning, injuries due to entanglement or due to impacts with the fishing gear components

- DELAYED MORTALITY

Delayed mortality occurs when the animal is released in apparently good condition, but dies after hours or days from damage caused by being underwater (anoxia, gas embolism, wounds etc.)

Gaps in knowledge

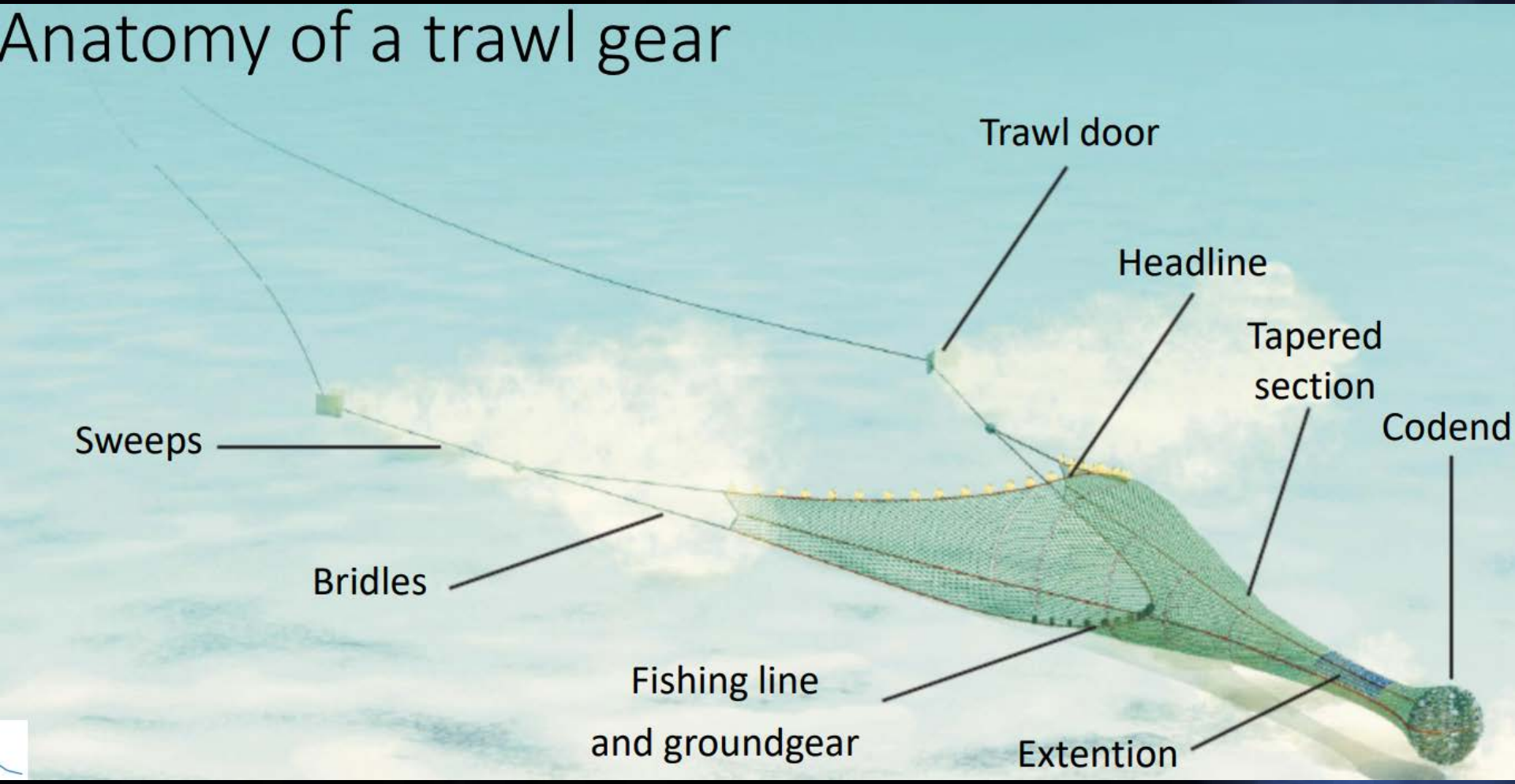
- Absence of both quantitative and qualitative data: studies on incidental catch of vulnerable species are absent for many fishing gear and countries of the Mediterranean and the Black Sea.

- There is not a standard for monitoring and data collection

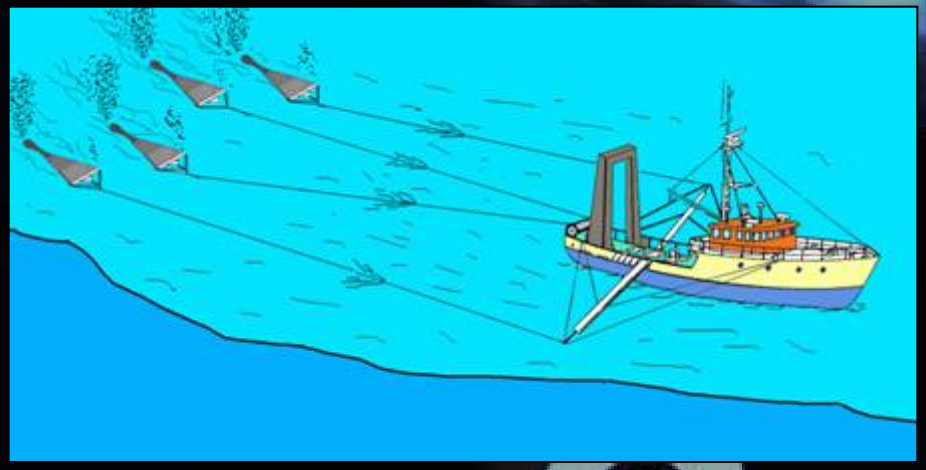
- Several databases (local), data gap and consistency

- This means that defining clear management targets for most fisheries is problematic.

BOTTOM TRAWL

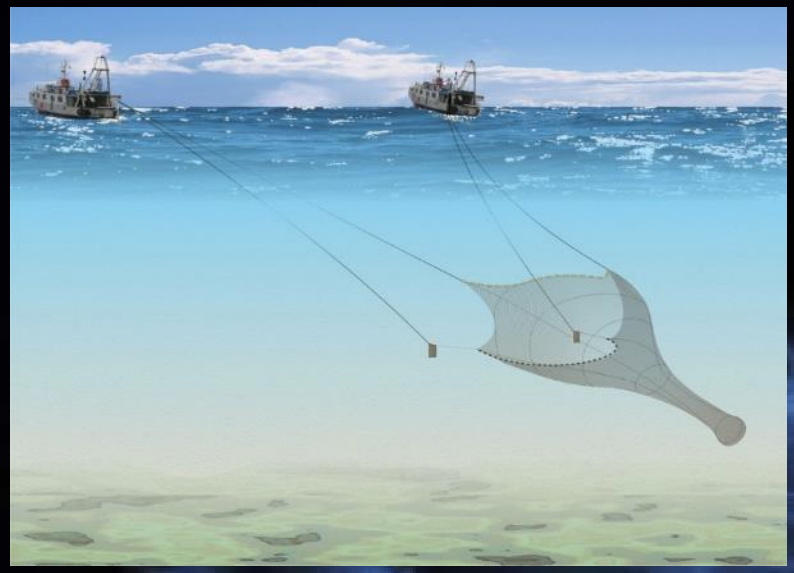


RAPIDO TRAWL

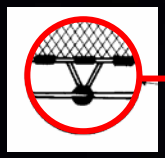


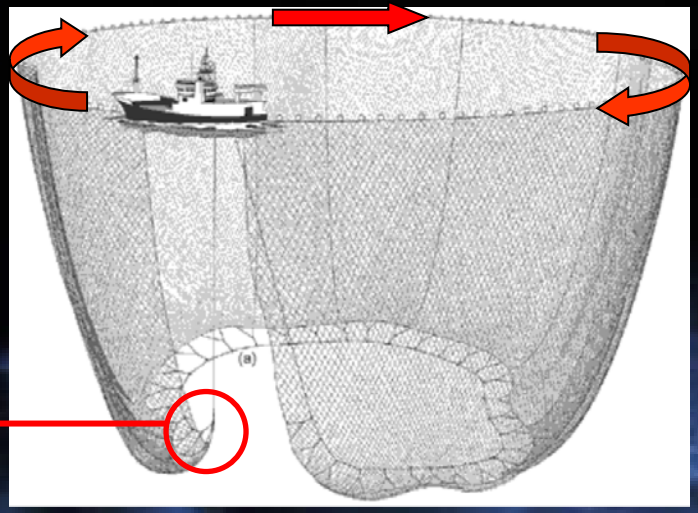
Lucchetti and Sala, 2010 (CJFAS)

Pelagic pair traw (PTM)

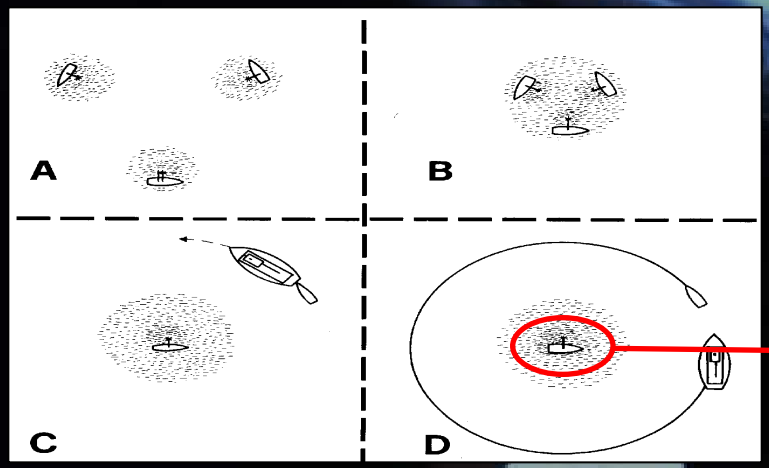


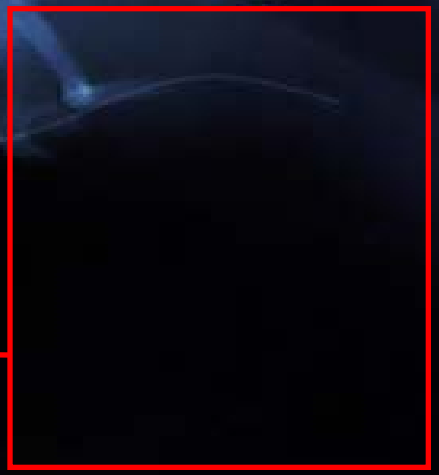
PURSE SEINE (PS)





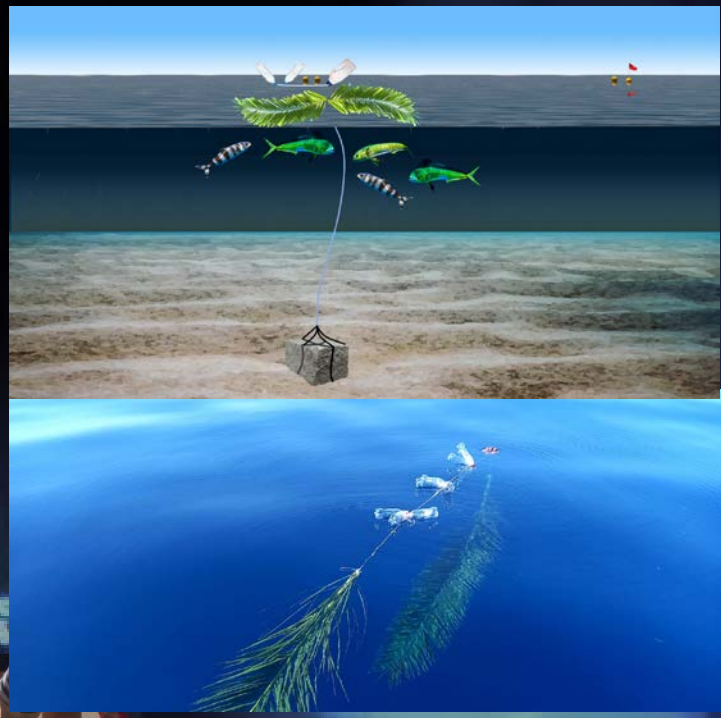
PURSE SEINE WITH LAMPS (PS)





FISH AGGREGATING DEVICES (FADs)

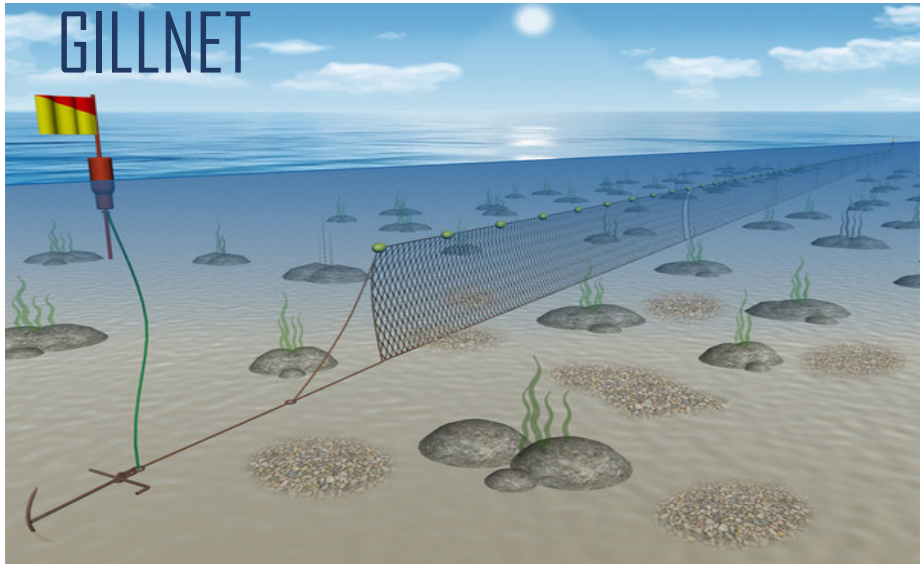
Fishing with 'cannizzati' or 'cannizzi' (especially in Sicily and Calabria), also known as 'shadow' fishing, is based on the attraction exerted on various pelagic species, which, once gathered together, are generally caught with surrounding nets. The cannizzi are usually made of palm branches tied together and held on the surface by improvised floats (empty plastic bottles and cans or polystyrene sheets). The cannizzi are connected on the bottom by a line (made of nylon or recycled material) to a weight of 8-10 kg (usually a stone or concrete artefact), Setting depths vary from 100 to 1,500 metres. At certain times of the year, many species such as amberjacks (Seriola dumerili), dolphinfish (Coryphaena hippurus), pilot fish (Naucrates ductor) and bonito (Sarda sarda) find refuge under the cannizzi, making them extremely vulnerable to fishing, especially with small surrounding nets.



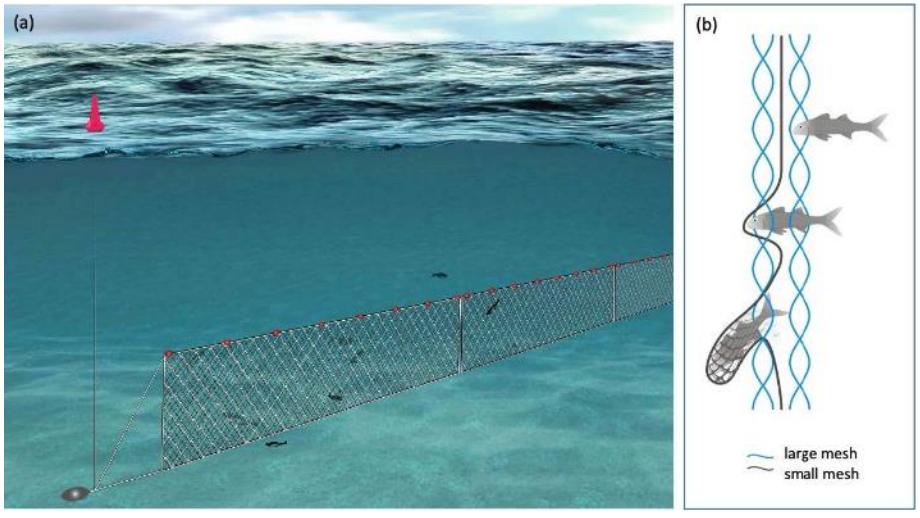
Each vessel sets from 20 to 100 FADs

Around 700 vessels in the MED

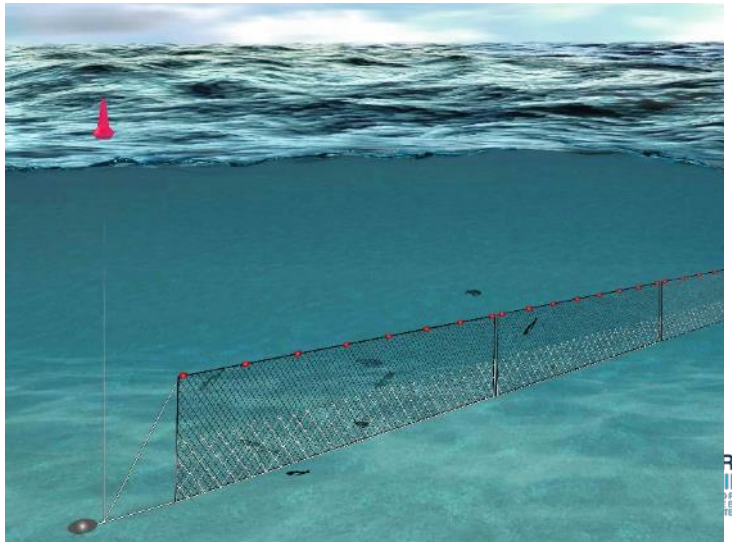
SET NETS



TRAMMEL NET



COMBINED NET



SMALL DRIFTING NETS (LEGAL)

The ferrettare are the only drift nets allowed in Italy. They are gillnets (a single piece of net), generally made of polyamide twine with a knot; they are not anchored to the bottom and can be dropped in midwater or with a headrope on the surface.
They are mainly used in Sicily, Calabria, Campania, Lazio and Liguria. They are banned in Sardinia. When fishing, they can "drift" even over a mile.

Foto Carbonara

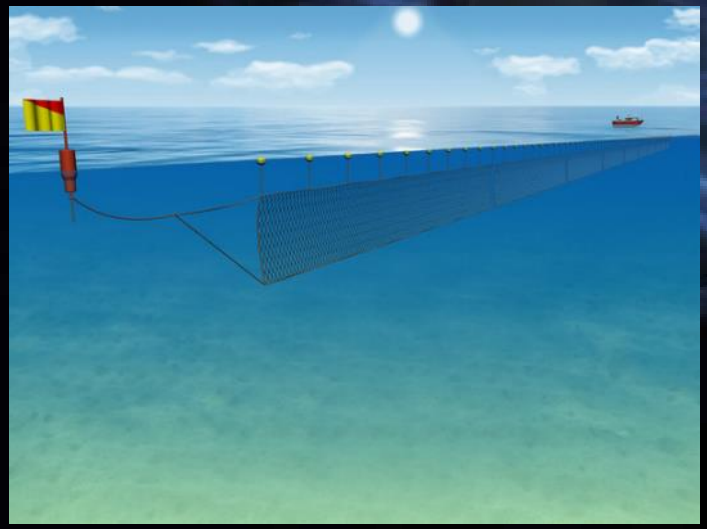


Foto Carbonara

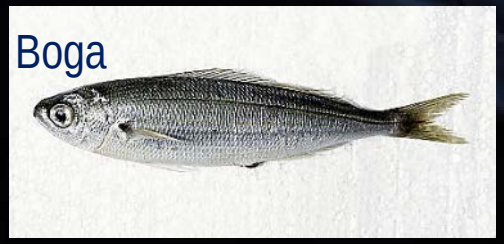
SMALL DRIFTING NETS (LEGAL)

TARGET SPECIES

Acciuga

Sardina

Boga



Alaccia

Suro - Sugarello

Pesce serra

Lanzardo

Sgombro

Specie target che destano preoccupazione per la dimensione delle maglie utilizzate (vicino a 100 mm)

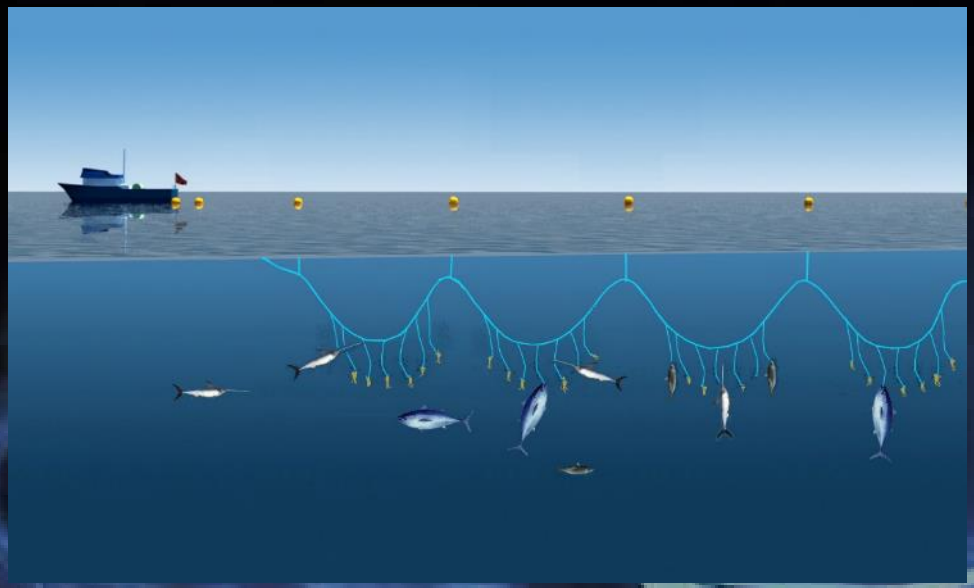
Biso - tombarello

Palamita

Alletterato

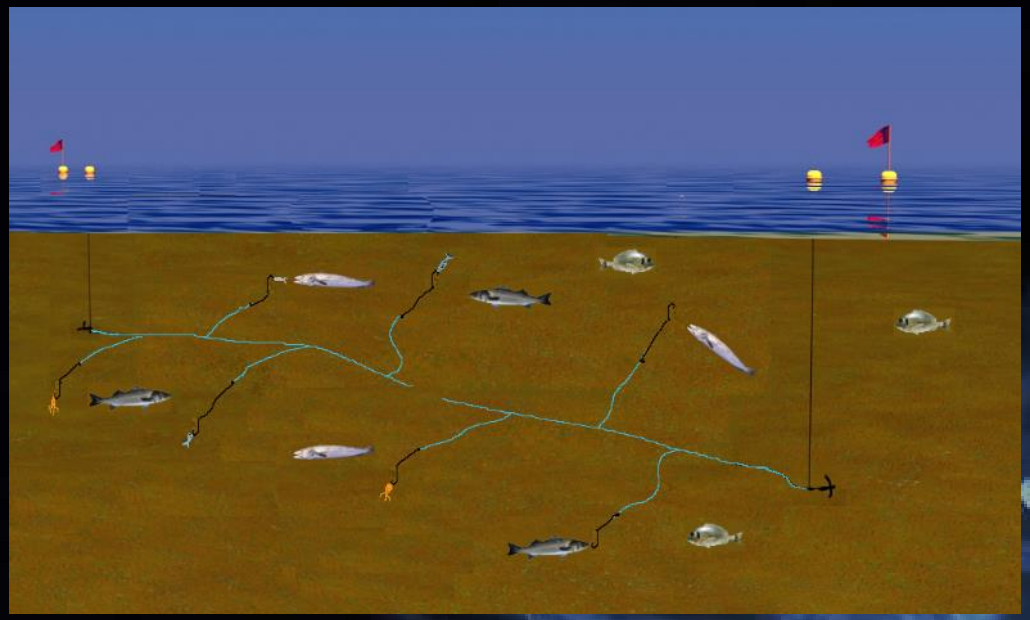
Ricciola

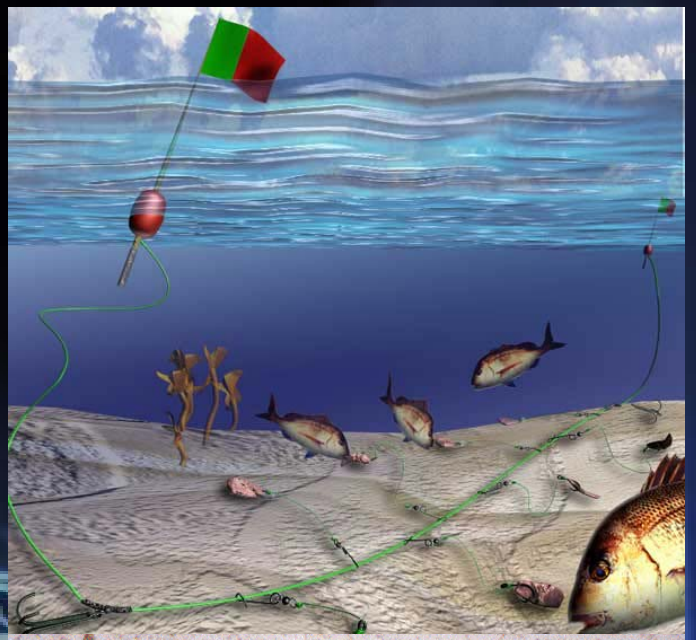
DRIFTING LONGLINE



Video: A. Petetta

BOTTOM LONGLINE





Closed areas-seasons?

Data collection

Collection of data on the incidental catch of vulnerable species (e.g. quantities, sizes, locations, fishing gear and timing of such bycatch)

- is key in understanding the nature and extent of this problem
- Identify hot-spots areas and periods (geographical or seasonal trend)
- which fishing gear are most damaging for a given species
- Which technical features of a gear can be modified or which BRD can be used
- improve knowledge on biology and ecology of these species

Adopt management measures for reducing interaction

Closed areas-seasons?

Data collection

SOURCE OF DATA

Fishery-dependent data: data are obtained from commercial fisheries.

Fishery-independent data: data are obtained from scientific surveys and ad hoc monitoring programmes

PSA – Risk assessment

BYCATCH RISK INDICATOR

Around 200 Species (from ICES and GFCM lists)

PRODUCTIVITY

Elasmobranchs
Marine mammals
Seabirds
Sea turtles

SUSCEPTIBILITY

- Areal overlap
- Vertical overlap

- Selectivity
- Post-capture mortality

- Bycatch
- IUCN

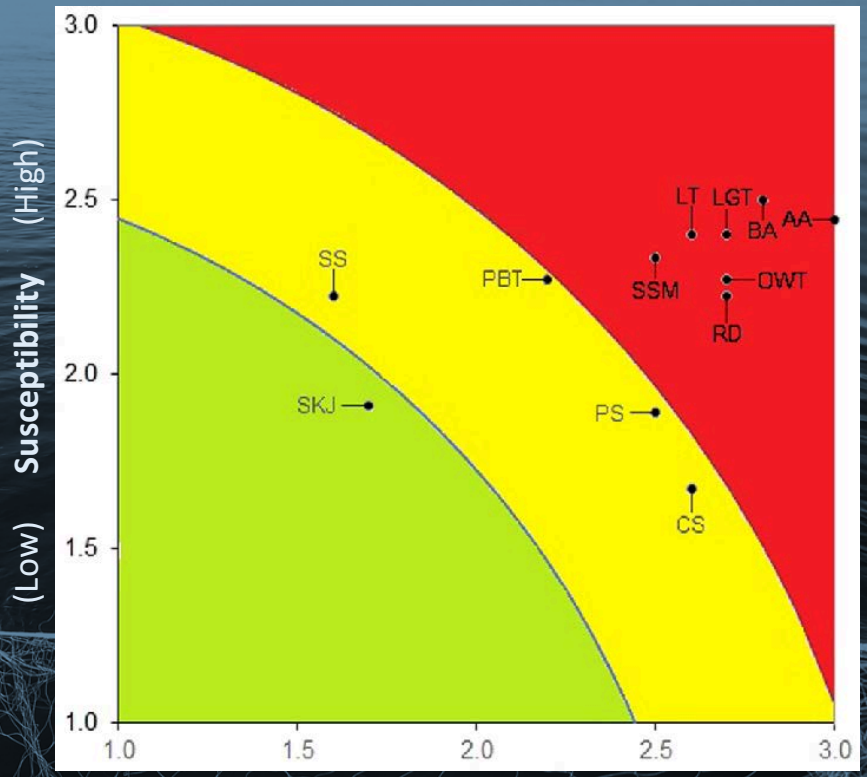
VULNERABILITY

PSA – Risk assessment

Productivity and Susceptibility Analysis (PSA)

- A semi-quantitative method used within the framework of Ecological Risk Assessment (ERA) to evaluate the relative vulnerability of marine species to fishing activities.

- To estimate the potential **vulnerability** of a species, it integrates species-specific attributes of biological **productivity** (e.g., growth rate, fecundity, lifespan) with **susceptibility** indicators (e.g., likelihood of capture, post-capture mortality, spatial overlap with fisheries)



$$\text{Vulnerability } (V) = \sqrt[2]{{P_T}^2 + {S_T}^2}$$

low risk (1, V< 2.64)
moderate risk (2.64 < V < 3.18)
high risk (V > 3.18)

PSA – Risk assessment

Vulnerable species

Group of vulnerable species	Family	Species	Common name
Cetaceans	Balaenopteridae	*Balaenoptera acutorostrata*	Common minke whale
		Balaenoptera borealis	Sei whale
		Balaenoptera physalus	Fin whale
		Megaptera novaeangliae	Humpback whale
	Balaenidae	*Eubalaena glacialis*	North Atlantic right whale
	Physeteridae	*Physeter macrocephalus*	Sperm whale
		Kogia sima	Dwarf sperm whale
	Phocoenidae	*Phocoena phocoena*	Harbour porpoise
	Delphinidae	*Steno bredanensis*	Rough-toothed dolphin
		Grampus griseus	Risso's dolphin
		Tursiops truncatus	Common bottlenose dolphin
		Stenella coeruleoalba	Striped dolphin
		Delphinus delphis	Common dolphin
		Pseudorca crassidens	False killer whale
		Globicephala melas	Long-finned pilot whale
		Orcinus orca	Killer whale
	Ziphiidae	*Ziphius cavirostris*	Cuvier's beaked whale
		Mesoplodon densirostris	Blainville's beaked whale
Seals	Phocidae	*Monachus monachus*	Mediterranean monk seal

Sharks, Rays, Chimaeras			
	Alopiidae	*Alopias vulpinus*	Common thresher
	Carcharhinidae	*Carcharhinus plumbeus*	Sandbar shark
		Carcharodon carcharias	Great white shark
		Prionace glauca	Blue shark
	Centrophoridae	*Centrophorus granulosus*	Gulper shark
	Cetorhinidae	*Cetorhinus maximus*	Basking shark
	Gymnuridae	*Gymnura altavela*	Spiny butterfly ray
	Hexanchidae	*Heptranchias perlo*	Sharpnose sevengill shark
	Lamnidae	*Isurus oxyrinchus*	Shortfin mako
		Lamna nasus	Porbeagle
	Myliobatidae	*Mobula mobular*	Devil fish
	Odontaspididae	*Carcharias taurus*	Sand tiger
		Odontaspis ferox	Small-tooth sand tiger shark
	Oxynotidae	*Oxynotus centrina*	Angular rough shark
	Pristidae	*Pristis pectinata*	Smalltooth sawfish
		Pristis pristis	Common sawfish
	Rajidae	*Dipturus batis*	Blue skate
		Leucoraja circularis	Sandy ray
		Leucoraja melitensis	Maltese skate
		Rostroraja alba	White skate
	Rhinobatidae	*Rhinobatos cemiculus*	Blackchin guitarfish
		Rhinobatos rhinobatos	Common guitarfish
	Sphyrnidae	*Sphyrna lewini*	Scalloped hammerhead
		Sphyrna mokarran	Great hammerhead
		Sphyrna zygaena	Smooth hammerhead
	Squatinidae	*Squatina aculeata*	Sawback angelshark
		Squatina oculata	Smoothback angelshark
		Squatina squatina	Angelshark
	Triakidae	*Galeorhinus galeus*	School/Tope shark

Group of vulnerable species	Family	Species	Common name
Sharks, Rays, Chimaeras	Alopiidae	*Alopias superciliosus*	Bigeye thresher
	Hexanchidae	*Hexanchus nakamurai*	Bigeyed sixgill shark
	Echinorhinidae	*Echinorhinus brucus*	Bramble shark
	Squalidae	*Squalus megalops*	Shortnose spurdog
	Centrophoridae	*Centrophorus uyato*	Little gulper shark
	Somniosidae	*Centroscymnus coelolepis*	Portugese dogfish
		Somniosus rostratus	Little sleeper shark
	Lamnidae	*Isurus paucus*	Longfin mako
	Scyliorhinidae	*Galeus atlanticus*	Atlantic sawtail catshark
	Carcharhinidae	*Carcharhinus altimus*	Bignose shark
		Carcharhinus brachyurus	Bronze whaler shark
		Carcharhinus brevipinna	Spinner shark
		Carcharhinus falciformis	Silky shark
		Carcharhinus limbatus	Blacktip shark
		Carcharhinus melanopterus	Blacktip reef shark
		Carcharhinus obscurus	Dusky shark
		Galeocerdo cuvier	Tiger shark
		Rhizoprionodon acutus	Milk shark
	Torpedinidae	*Tetronarce nobiliana*	Great torpedo ray
		Torpedo sinuspersici	Variable torpedo ray
	Rajidae	*Dipturus nidarosiensis*	Norwegian skate
		Leucoraja fullonica	Shagreen skate
		Leucoraja naevus	Cuckoo skate
		Raja brachyura	Blonde skate
		Raja montagui	Spotted skate
		Raja polystigma	Speckled skate
		Raja radula	Rough skate
		Raja undulata	Undulate skate
	Dasyatidae	*Bathyoshia centroura*	Roughtail stingray
		Dasyatis marmorata	Marbled stingray
		Dasyatis pastinaca	Common stingray
		Dasyatis tortonesei	Tortonese's stingray
		Himantura uarnak	Honeycomb whipray
		Taeniurops grabata	Round stingray
	Myliobatidae	*Aetomylaeus bovinus*	Bullray
	Rhinopteridae	*Rhinoptera marginata*	Lusitanian cownose ray
	Sphyrnidae	*Sphyrna tudes*	Smalleye hammerhead

Group of vulnerable species	Family	Species	Common name
Sea turtles	Cheloniidae	*Caretta caretta*	Loggerhead turtle
		Chelonia mydas	Green turtle
		Eretmochelys imbricata	Hawksbill Turtle
		Lepidochelys kempii	Kemp's ridley sea turtle
		Lepidochelys olivacea	Olive ridley sea turtle
	Dermochelyidae	*Dermochelys coriacea*	Leatherback sea turtle
	Trionychidae	*Trionyx triunguis*	African softshell turtle

Seabirds			
	Falconidae	*Falco eleonorae*	Eleonora's falcon
	Alcedinidae	*Ceryle rudis*	Pied kingfisher
		Halcyon smyrnensis	White-throated kingfisher
	Charadriidae	*Charadrius alexandrinus*	Kentish plover
		Charadrius leschenaultii columbinus	Greater sand plover
	Hydrobatidae	*Hydrobates pelagicus melitensis**	European storm-petrel (Mediterranean)
		*Hydrobates pelagicus**	European storm-petrel
	Laridae	*Larus audouinii**	Audouin's gull
		*Larus armenicus**	Armenian gull
		*Larus genei**	Slender-billed gull
		*Larus melanocephalus**	Mediterranean gull
		*Sternula albifrons**	Little tern
		*Thalasseus bengalensis**	Lesser crested tern
		*Thalasseus sandvicensis**	Sandwich tern
		*Hydroprogne caspia**	Caspian tern
		*Gelochelidon nilotica**	Common Gull-billed tern
	Pandionidae	*Pandion haliaetus*	Osprey
	Pelecanidae	*Pelecanus crispus*	Dalmatian pelican
		Pelecanus onocrotalus	Great white pelican
	Phalacrocoracidae	*Gulosus aristotelis desmarestii*	European shag (Mediterranean)
		Microcarbo pygmaeus	Pygmy cormorant
	Phoenicopteridae	*Phoenicopterus roseus*	Greater flamingo
	Procellariidae	*Calonectris diomedea**	Scopoli's shearwater
		*Calonectris borealis**	Cory's shearwater
		*Puffinus yelkouan**	Yelkouan shearwater
		*Puffinus mauretanicus**	Balearic shearwater
	Scolopacidae	*Numenius tenuirostris*	Slender-billed curlew

PSA – Risk assessment

Productivity

Productivity attributes to assess for each functional group according to MSC Fisheries Standard Toolbox (2023)

		Scores		
Species group	**Productivity attribute**	**High (1)**	**Moderate (2)**	**Low (3)**
Elasmobranchs (Both pelagic and demersal)	Average age at maturity	<5 years	5-15 years	>15 years
	Average maximum age	<10 years	10-25 years	>25 years
	Fecundity	>20000 eggs per year	100-20000 eggs per year	<100 eggs per year
	Average maximum size	<100 cm	100-300 cm	>300 cm
	Average size at maturity	<40 cm	40-200 cm	>200 cm
	Reproductive strategy	Broadcast spawner	Demersal egg layer	Viviparous/Ovoviviparous

PSA – Risk assessment

Productivity

Species group	Productivity attribute	Scores		
		High (1)	Moderate (2)	Low (3)
Cetaceans	Average age at maturity (Mysticetes)	<6 years	6-8 years	>8 years
	Average age at maturity (Odontocetes)	<6	6-11	>12
	Fecundity (Mysticetes)	>0.40	0.30-0.40	<0.30
	Fecundity (Odontocetes)	>0.58	0.23-0.58	<0.23
Pinnipeds	Average age at maturity	<5	5-7	>7
	Fecundity	>0.87	0.58-0.87	<0.58
	Average 'optimal' adult survival probability	<0.84	0.84-0.4	>0.94

PSA – Risk assessment

Productivity

Species group	Productivity attribute	Scores		
		High (1)	Moderate (2)	Low (3)
Sea Birds	Average 'optimal' adult survival probability	<0.81	0.81-0.94	>0.94
	Fecundity	>1 chick/year	1 chick/year	<1 chick/year
	Average age at first breeding	<3 years	3-7 years	>7 years
Sea turtles	Average age at maturity:	<15 years	15-25 years	>25 years
	Fecundity	>150	100-150	<100

PSA – Risk assessment

Susceptibility

Susceptibility attribute	Scores		
	Low (1)	**Moderate (2)**	**High (3)**
Areal overlap (Availability)	<10% overlap	10-30% overlap	>30% overlap
Encounterability	Low overlap with fishing gear (low encounter rate)	Medium overlap with fishing gear	High overlap with fishing gear (high encounter rate)
Selectivity of gear type:	If encountered, individuals are rarely (i.e., in less than 5% of deployments) caught / impacted.	If encountered, individuals are regularly (i.e., in 5–50% of deployments) caught / impacted.	If encountered, individuals are regularly (i.e., in 5–50% of deployments) caught / impacted.
Post-capture mortality (PCM)	Evidence of majority released alive post capture and survival. >66% of animals are returned alive and survive the encounter. If observers can verify that 66% are released alive in combination with a high risk score for selectivity, the team may reduce the PCM score to a low risk score (1).	Evidence of some released alive post capture and survival. 33–66% of animals are returned alive and survive the encounter. If observers can verify that 33–66% are released alive in combination with a high risk score for selectivity, the team may reduce the PCM score to a medium risk score (2).	Retained species or majority dead or low probability of survival when released.

PSA – Risk assessment

SUSCEPTIBILITY

- Areal overlap
- Vertical overlap

Calculated by combining FDI data with spatial (from AquaMaps) or vertical distribution information at species level

- Selectivity
- Post-capture mortality

Expert judgment at species level (unchanged across years and area)

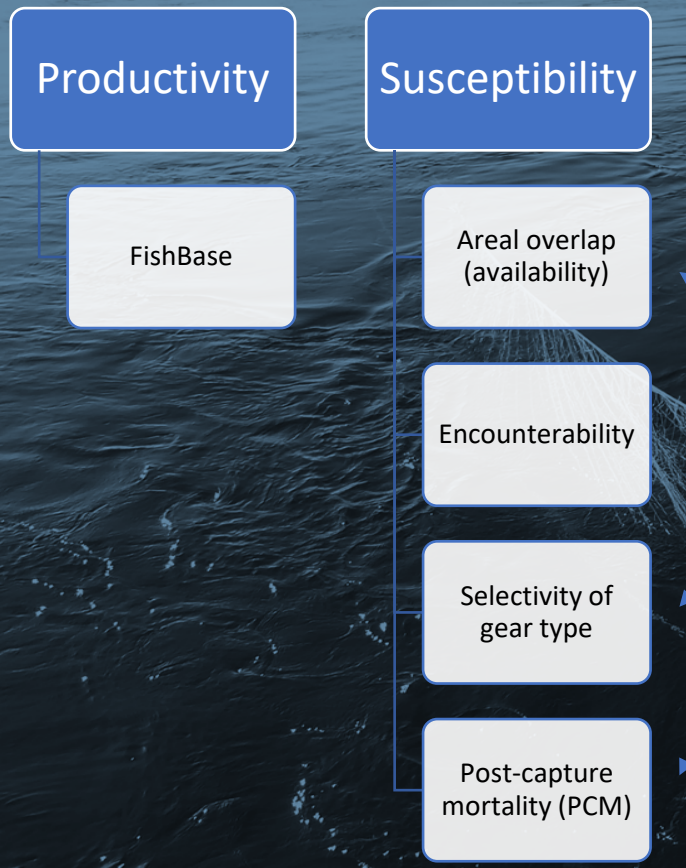
- Bycatch
- IUCN

Attributes developed ad hoc for the present study

- IUCN: assessment considered at the species level across the entire study period.
- Bycatch: based on species-specific bycatch rates reported in ICES WGBYC reports for the period 2018–2023.

PSA – Risk assessment

Data sources - PSA «classic»



The scoring of susceptibility attributes in the MSC PSA is primarily based on expert judgment, rather than direct quantitative data

PSA – Risk assessment

Data sources - «adapted» PSA

- Productivity
  - FishBase
- Susceptibility
  - Areal overlap (availability)
  - Encounterability
  - Selectivity of gear type
  - Post-capture mortality (PCM)
  - Bycatch Rate

quantitatively estimate the areal overlap by combining **effort** data with **presence** data

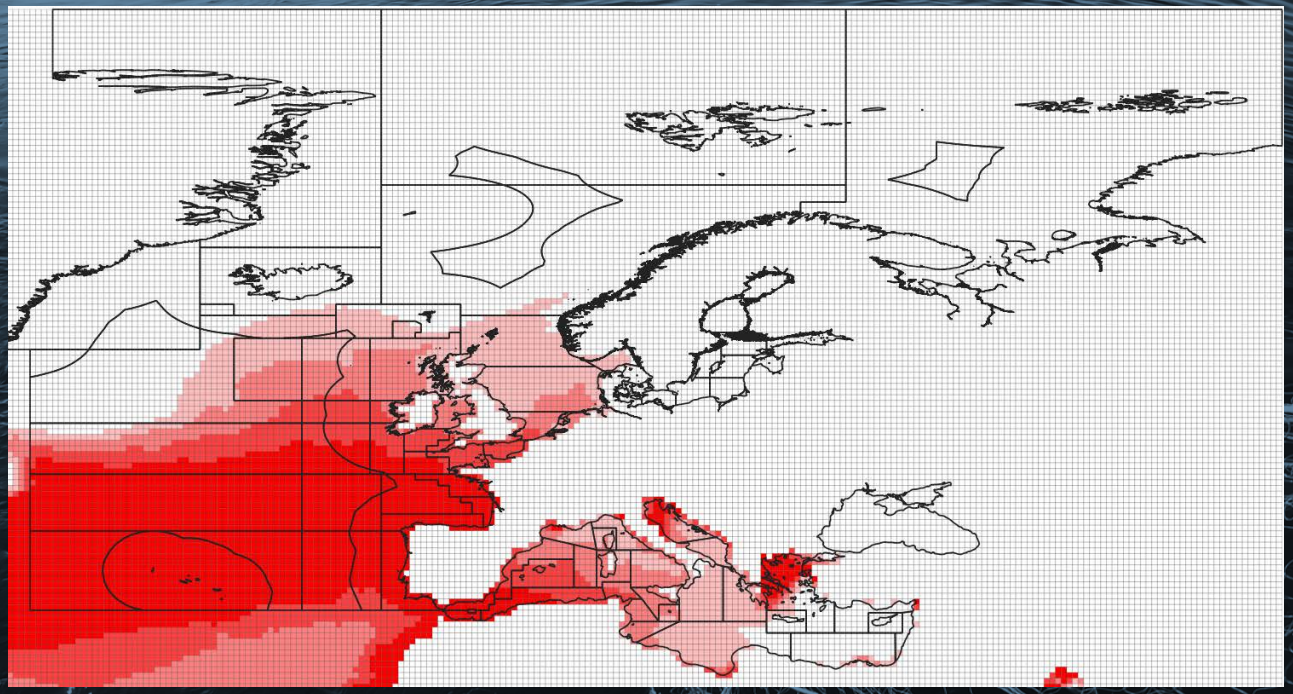
Global Fishing Watch

GFCM DCRF
DATA COLLECTION REFERENCE FRAMEWORK

PSA – Risk assessment

Habitat suitability - tot 177 species - % occ. (0-1)

Areal overlap



P. glauca

Susceptibility attribute	Scores		
	Low (1)	Moderate (2)	High (3)
Areal overlap (Availability)[1] Overlap of the fishing effort and the species group distribution	<10% overlap	10-30% overlap	>30% overlap

PSA – Risk assessment

Vertical overlap

- Species depth ranges were compiled through a dedicated literature review.
- For each spatial cell, bathymetric information (mean depth and variability) was derived from GEBCO data.
- The depth distribution within each cell was approximated to represent vertical heterogeneity.

For each species and fishing gear, vertical overlap was estimated as the probability that:

- the species occurs within the cell's depth range, and
- the gear operates within the same depth range.
- Bottom-contact gears were modeled as interacting with species close to the seabed (up to 800 m depth).

Continuous overlap values (0–1) were converted into ordinal susceptibility ranks (0–3).

Cells with no overlap (rank 0) were excluded from vulnerability calculations.

Susceptibility attribute	Scores		
	Low (1)	Moderate (2)	High (3)
Vertical overlap (Encounterability)[2] The position of the species group within the water column relative to the fishing gear	Low vertical overlap with fishing gear (<25% of species depth range)	Moderate vertical overlap with fishing gear (25–50% of species depth range)	High vertical overlap with fishing gear (>50% of species depth range)

PSA – Risk assessment

BYCATCH - 93 species

- Bycatch rate defined as the number of individuals incidentally caught per unit of monitored fishing effort (Days at Sea, DAS).
- Data derived from ICES WGBYC reports (2018–2023).
  - **2017 assumed equal to 2018**
  - **2024 assumed equal to 2023**
- Longlines treated separately as:
  - Pelagic (drifting)
  - Demersal (bottom-set)

- Data cleaning:
  - Removal of missing or non-plausible values
  - Exclusion of extreme values (>95th percentile)
  - Same trimming applied to derived total bycatch estimates

- Cleaned bycatch rates were classified into three species-specific classes (tertiles):
  - 1 = Low
  - 2 = Medium
  - 3 = High

Susceptibility attribute	Scores		
	Low (1)	Moderate (2)	High (3)
Bycatch rate Individuals accidentally caught per days at sea	By-catch rate ≤ first tertile (33rd percentile) of the species-specific distribution across the study area.	By-catch rate > first tertile and ≤ second tertile (66th percentile) of the species-specific distribution across the study area	By-catch rate > second tertile (66th percentile) of the species-specific distribution across the study area.

PSA – Risk assessment

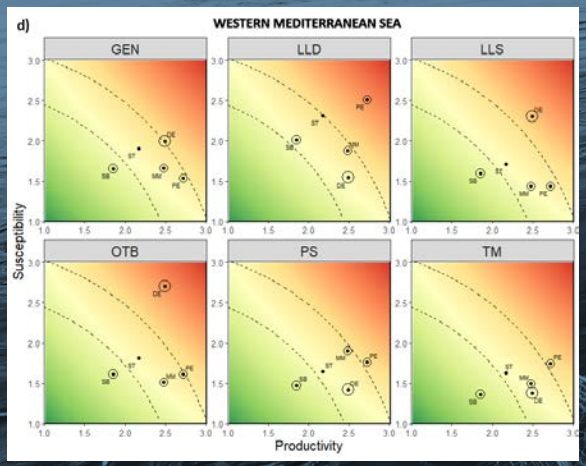
IUCN

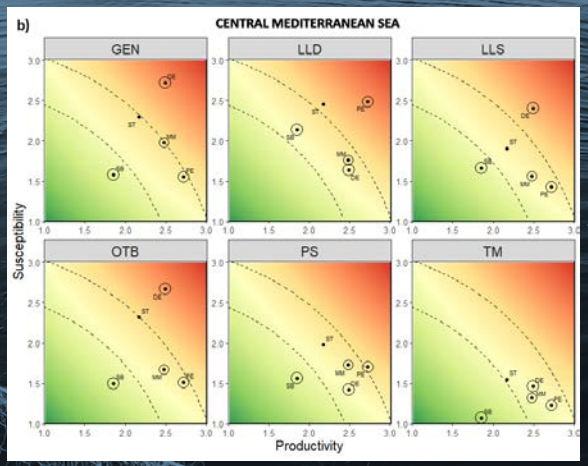
	IUCN historical categorization							
Species	2017	2018	2019	2020	2021	2022	2023	2024
Alca torda	NT	NT	NT	NT	LC	LC	LC	LC
Alle alle	LC	LC	LC	LC	LC	LC	LC	LC
Alopias vulpinus	EN	EN	VU	VU	VU	VU	VU	VU
Amblyraja hyperborea	LC	LC	LC	LC	LC	LC	LC	LC
Amblyraja radiata	LC	LC	LC	VU	VU	VU	VU	VU
Apristurus laurussonii	LC	LC	LC	LC	LC	LC	LC	LC
Ardenna gravis	LC	LC	LC	LC	LC	LC	LC	LC
Ardenna grisea	NT	NT	NT	NT	NT	NT	NT	NT
Aythya ferina	VU	VU	VU	VU	VU	VU	VU	VU
Aythya fuligula	LC	LC	LC	LC	NT	NT	NT	NT
Aythya marila	LC	LC	LC	LC	LC	LC	LC	LC
Balaena mysticetus	LC	LC	LC	LC	LC	LC	VU	VU
Balaenoptera acutorostrata	LC	LC	LC	LC	LC	LC	LC	LC
Balaenoptera borealis	EN	EN	EN	EN	EN	EN	LC	LC
Balaenoptera edeni	LC	LC	LC	LC	LC	LC	VU	VU
Balaenoptera musculus	EN	EN	EN	EN	EN	EN	NT	NT
Balaenoptera physalus	EN	VU	VU	VU	VU	VU	LC	LC

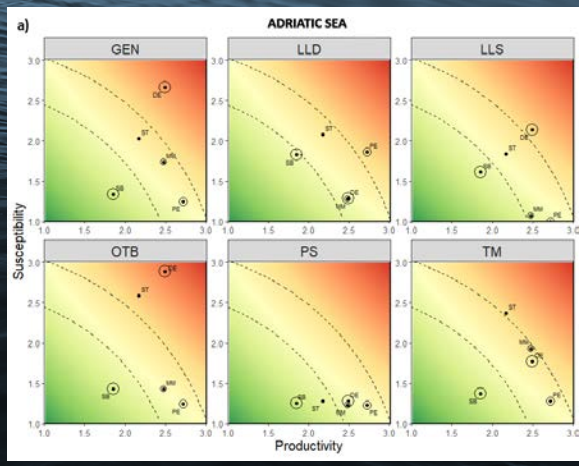
Susceptibility attribute	Scores		
	Low (1)	Moderate (2)	High (3)
IUCN status category	Least Concern (LC) or Near treatened (NT)	Vulnerable (VU)	Endangered (EN) or Critically endangered (CR)

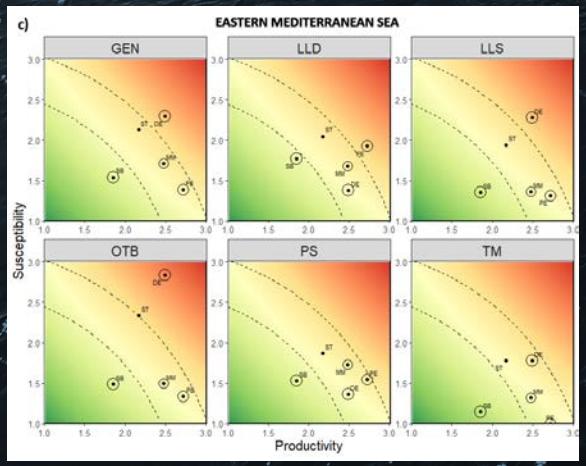
PSA – Risk assessment

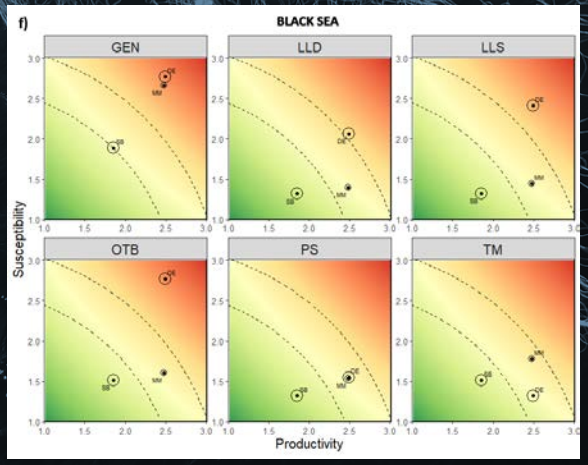
Risk assessment: PSA: Productivity and Susceptibility Analysis





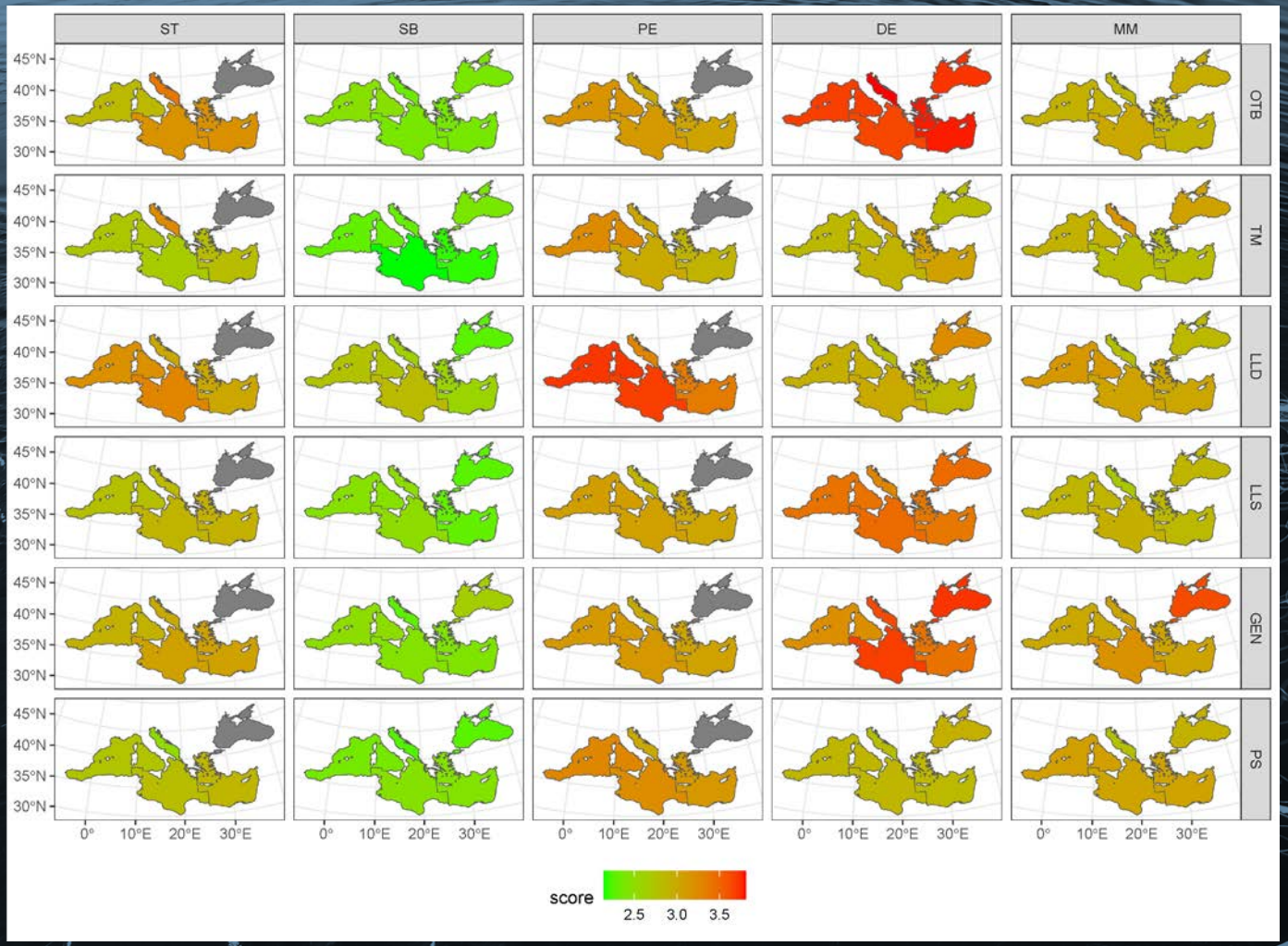




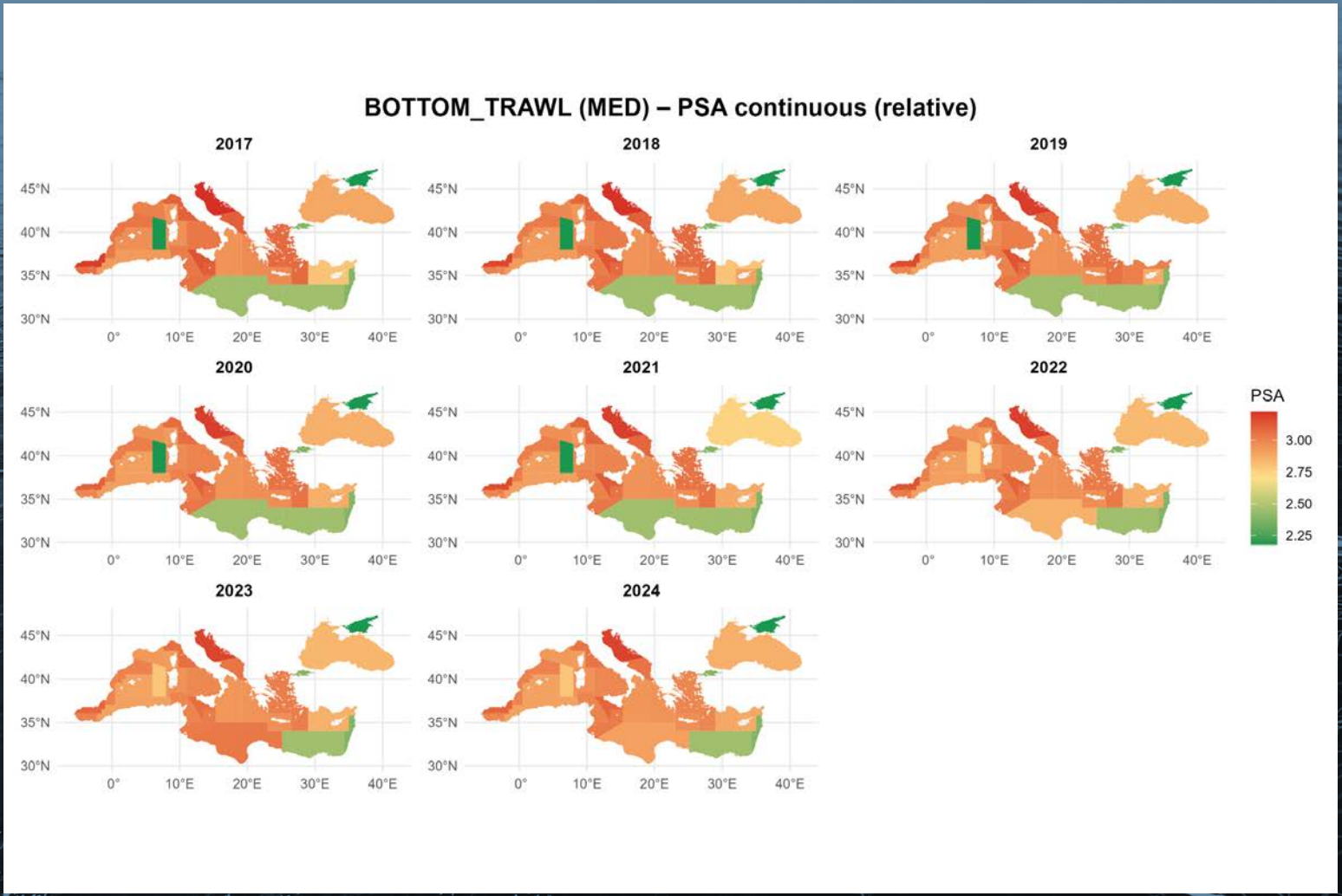


PSA – Risk assessment

Risk assessment: PSA: Productivity and Susceptibility Analysis



PSA – Risk assessment

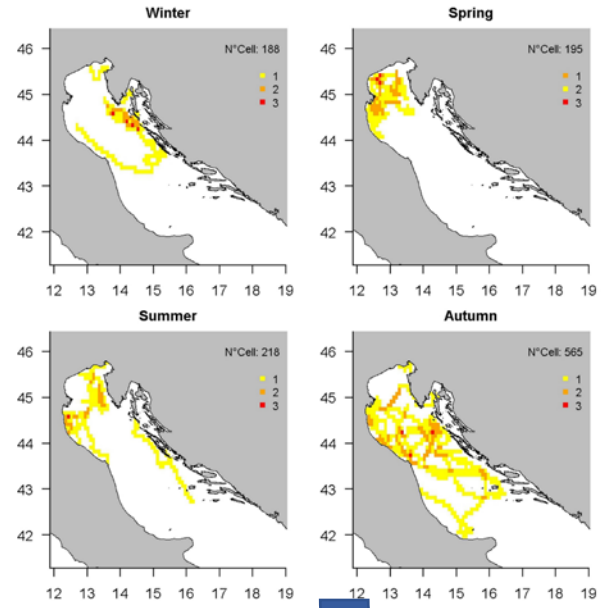


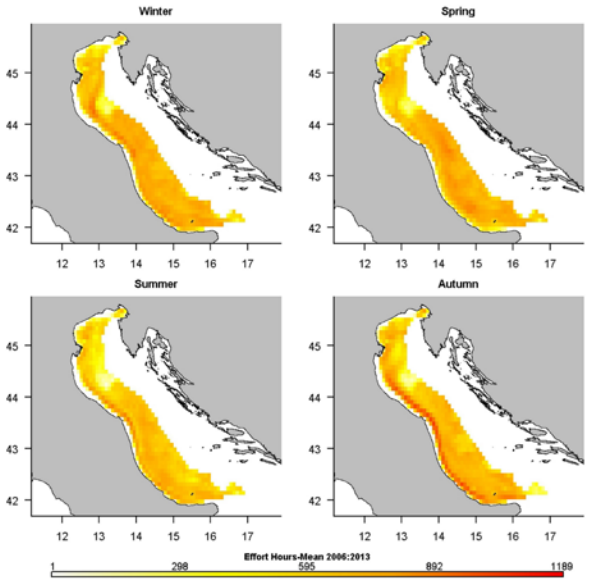
Closed areas-seasons?

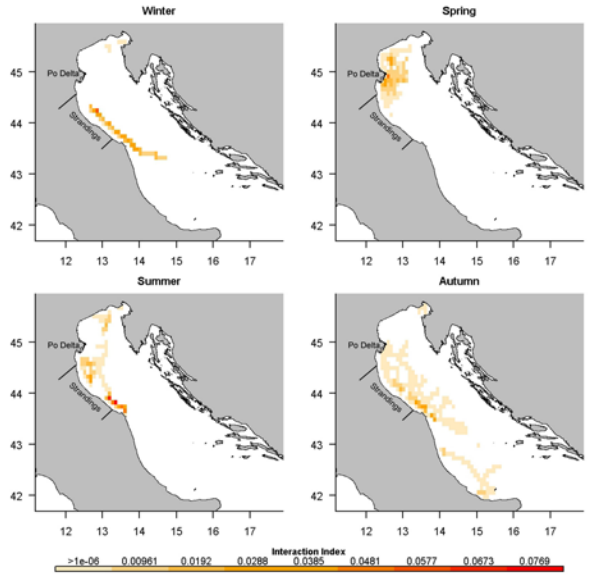
Risk assessment

Combining data from surveys (or tracking) with data on fishing effort

Track data (or sightings)	Effort (AIS)	Hot-spot bycatch







Lucchetti et al., 2016
(Ecol. Indicators)

CNR IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

Closed areas-seasons?

Risk assessment: PSA: Productivity and Susceptibility Analysis

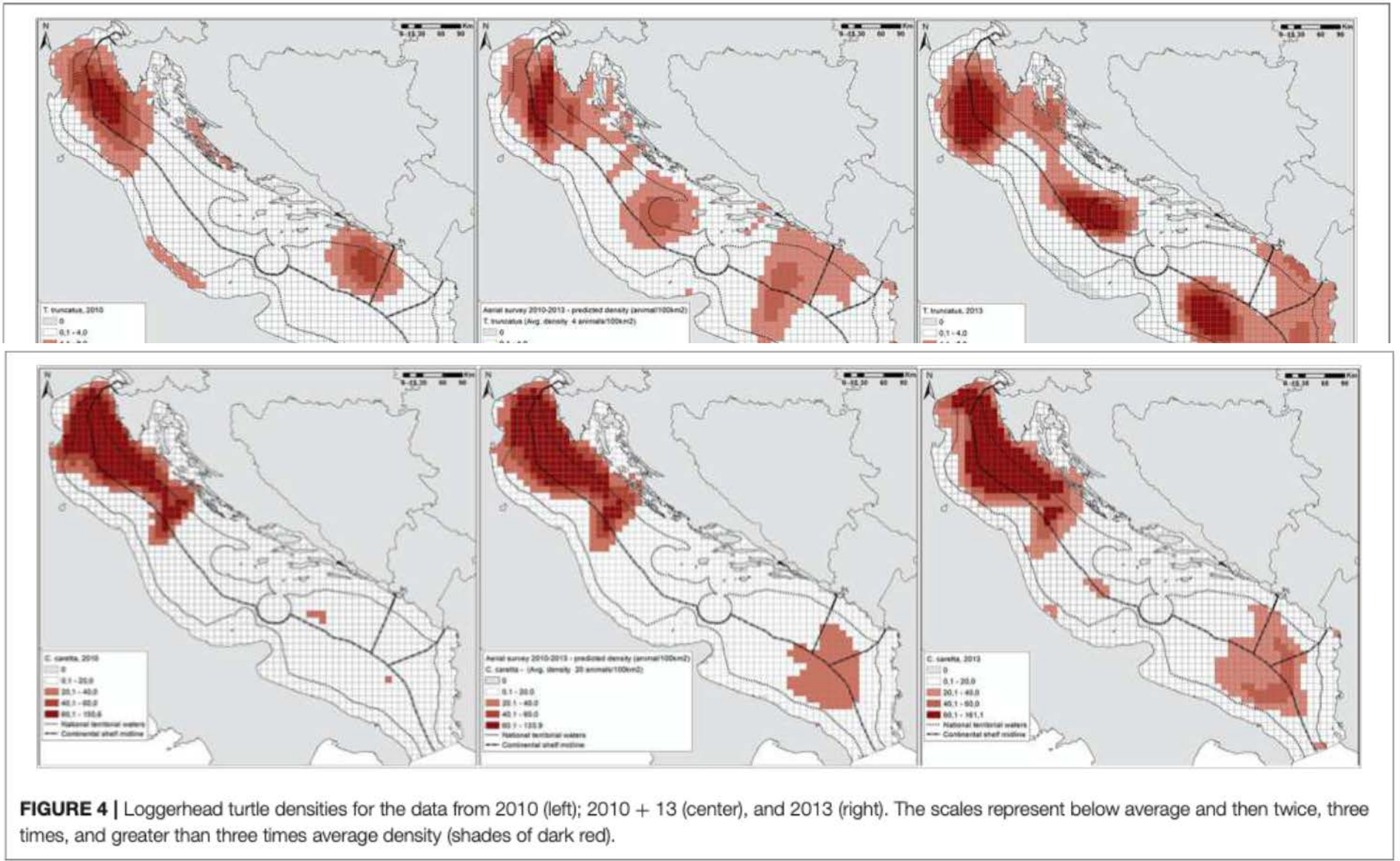


FIGURE 4 | Loggerhead turtle densities for the data from 2010 (left); 2010 + 13 (center), and 2013 (right). The scales represent below average and then twice, three times, and greater than three times average density (shades of dark red).

Closed areas-seasons?

Risk assessment: PSA: Productivity and Susceptibility Analysis

REPUBBLICA ITALIANA

BOLLETTINO UFFICIALE
REGIONE DEL VENETO

Venezia, martedì 25 agosto 2020 — Anno LI - N. 131

DELIBERAZIONE DELLA GIUNTA REGIONALE n. 1135 del 28 luglio 2020

Individuazione di nuovo Sito di Importanza Comunitaria denominato S.I.C. IT3270025 "Adriatico Settentrionale Veneto - Delta del Po". Rete ecologica europea Natura 2000. Direttive 92/43/CEE e 2009/147/CE. 283

[Sanità e igiene pubblica]

A seguito delle risultanze emerse nel corso del Seminario Biogeografico Marino con la Commissione Europea (Malta, 27-29 settembre 2016), sulla base del documento scientifico redatto da ISPRA, che individua l'Alto Adriatico come area critica per le specie tursiope (*Tursiops truncatus*) e tartaruga marina (*Caretta caretta*), trasmesso alle Regioni interessate con nota n. 20402 del 25/09/2017, e a fronte delle risultanze del Convegno sulle misure di gestione della pesca nei siti Natura 2000 (Zara, 6-12 ottobre 2017), il MATTM ha sollecitato le Regioni a designare i necessari SIC marini, a tutela delle due specie, entro le 12 mn italiane.

Codice	Tipologia (SIC, ZPS)	Nome	Provincia	Superficie (Ha)
IT4060018	SIC	Adriatico settentrionale - Emilia-Romagna	FE	31.160

Closed areas-seasons?

Risk assessment: PSA: Productivity and Susceptibility Analysis

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PBR: Potential Biological Removal

- An upper limit to the level of mortality that would allow a stock to achieve abundance ≥ the Maximum Net Productivity Level (MNPL)
- A stock whose abundance is at or above MNPL is referred to as being at "Optimum Sustainable Population" (OSP).
  - A goal of the Management of protected species
  - Assessing stock status relative to OSP is challenging because that determination rests on the ability to estimate abundance relative to K.
- Estimating bycatch and keeping it below PBR is analytically more feasible, more precise, and a more direct way of managing marine mammal stocks and ensuring that they reach/are maintained at OSP.

PBR: Potential Biological Removal

$$PBR = N_{min} \cdot 1/2\, R_{max} \cdot F_R$$ Marine mammals

Year	N_{best}	$CV(N_{best})$	N_{min}	R_{max}	F_r	PBR	ZMRG
1991	37,500	0.29	--	--		--	
1992	67,500	0.23	40,297*	0.040	0.5	403	40
1995	74,000	0.20	48,289**	0.040	0.5	483	48
1999	89,739	0.22	74,695	0.040	0.5	747	75
2006	89,054	0.47	60,970	0.040	0.5	610	61
2011	79,883	0.32	61,415	0.046[2]	0.5	706	71
2016[1]	95,543[3]	0.31	74,034	0.046[2]	0.5	844	84
2021 DRAFT	85,765	0.53	56,420	0.046[2]	0.5	649	65

N_{min} = Minimum population size

R_{max} = Maximum net productivity rate
- Default = 0.04 = Minimum population size

F_r = Recovery factor
- Default = 0.5 for depleted and threatened stocks and stocks of unknown status
- Default = 0.1 for endangered stocks

ZMRG = Zero Mortality Rate Goal • 10% of PBR

0.5

- Assumes that marine mammal population growth follows a logistic model: MNPL occurs at 0.5 K
- MNPL for marine mammals likely 0.6K - 0.8K (0.5 is precautionary)

PBR: Potential Biological Removal

$$PBR = N_{min} \bullet 1/2\, R_{max} \bullet F_R$$ Marine mammals

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ZMRG = Zero Mortality Rate Goal • 10% of PBR

R_{max}: Maximum potential population growth rate

- • May be estimated for individual stocks
- • Default = 0.04 for cetaceans, 0.12 for pinnipeds

PBR: Potential Biological Removal

$$PBR = N_{min} \cdot 1/2\, R_{max} \cdot F_R$$ Marine mammals

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- Default = 0.1 for endangered stocks

ZMRG = Zero Mortality Rate Goal • 10% of PBR

N_{min}: Minimum estimate of abundance

- Defined as the value at the 20th percentile of the distribution of estimated abundance
- Shown through simulations to provide a high level of confidence that management objectives can be achieved in spite of uncertainty in parameters used to estimate abundance

PBR: Potential Biological Removal

$$PBR = N_{min} \bullet 1/2\, R_{max} \bullet F_R$$ Marine mammals

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F_R = Recovery factor
- Default = 0.5 for depleted and threatened stocks and stocks of unknown status
- Default = 0.1 for endangered stocks

ZMRG = Zero Mortality Rate Goal • 10% of PBR

F_R: Recovery Factor

- Used as a conservative buffer against various plausible biases or assumption violations
- • Range: 0.1 – 1.0
  - o Default = 0.5
  - o = 0.1 – 0.3 for Endangered Species (depending on estimated abundance)

PBR: Potential Biological Removal

How is abundance (N_{min}) estimated?

- Aerial surveys and distance sampling methods (harbor porpoises) or pup counts (pinnipeds)
- Small-boat surveys and markrecapture methods (coastal bottlenose Dolphins, blue whales)
- Shore-based surveys (gray whales)

PBR: Potential Biological Removal

Sperm whale

$$PBR = 0.5\ R_{max}\ N_{min}\ F_R$$

$$PBR = 0.5\ (0.04)\ N_{min}\ (0.1)$$

Conventional approach: N_{min} based on average estimate of abundance from two most recent surveys

Year	N	N_{min}
2005	3140 (CV = 0.4)	
2008	300 (CV = 0.51)	
Average	971 (CV = 0.31)	751

Based on NOAA

PBR: Potential Biological Removal

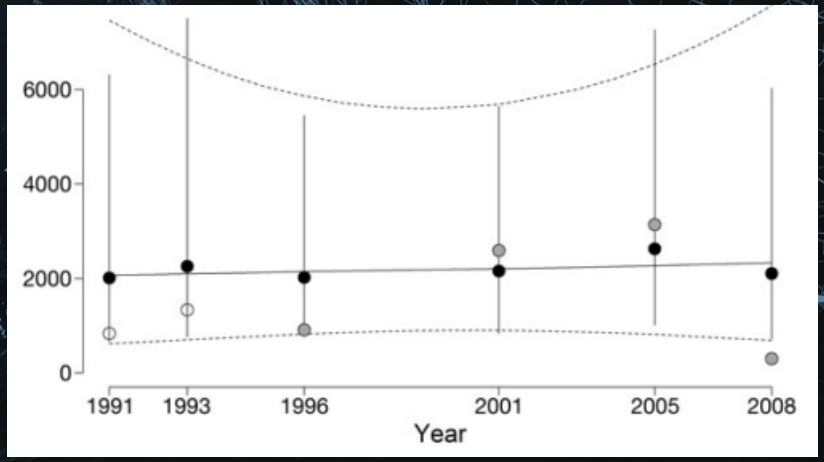
Sperm whale

$$PBR = 0.5\ R_{max}\ N_{min}\ F_R$$

$$PBR = 0.5\ (0.04)\ N_{min}\ (0.1)$$

Model-based approach: Nmin based on estimates of abundance from all previous surveys and Bayesian methods

$N_{min}(2008) = 1332$



Based on NOAA

PBR: Potential Biological Removal

Sperm whale

$$PBR = 0.5\ R_{max}\ N_{min}\ F_R$$

$$PBR = 0.5\ (0.04)\ N_{min}\ (0.1)$$

Model-based approach: N_{min} based on estimates of abundance from all previous surveys and Bayesian methods

Conventional Approach	PBR = 0.5 (0.04) (751) (0.1) = 1.5
Model-based Approach	PBR = 0.5 (0.04) (1332) (0.1) = 2.7

Based on NOAA

PBR: Potential Biological Removal

Sperm whale

Estimating bycatch and comparing to PBR

- Annual bycatch estimates are variable
- Pooling bycatch estimates across multiple years provides a more precise measure (especially for species caught infrequently).

Estimated bycatch for the drift gillnet fishery

Year	Observer coverage %	Observed M&SI	Estimated M&SI
2006	19%	0	0
2007	16%	0	0
2008	14%	0	0
2009	13%	0	0
2010	12%	2	16
Average			3.8

$$PBR = 0.5\ R_{max}\ N_{min}\ F_R$$

= 2.7 (model-based approach)

Based on NOAA

PBR: Potential Biological Removal

Sperm whale

Estimating bycatch and comparing to PBR

- Annual bycatch estimates are variable
- Pooling bycatch estimates across multiple years provides a more precise measure (especially for species caught infrequently).

Unsustainable: When annual human-caused mortality/serious injuries exceed the PBR

Bycatch/PBR>1

Although the "formal" threshold is PBR = 1, the aim is often to stay well below it (uncertainty buffer). In the US MMPA context, the long-term goal is often to reduce it to "insignificant" levels (approximately ~10% of the PBR).

Based on NOAA

Prohibited gear?

Illegal driftnets targeting swordfish (spadara nets) are still a matter of concern

Illegal since 1998: Council Regulation (EC) No 894/97 of April 29th 1997, amended by Council Reg. no. 1239/98 e Council Reg. no. 809/2007

Marine mammals

Fisheries → Mammals	Mammals → Fisheries
Entanglement	**Steal fish** from the nets, sometimes in a highly selective manner, directly causing commercial losses
Injuries to mammals due to impacts with fishing gears	**Damage and spoil fish** already caught in the nets which, being mutilated, is often no longer tradable
Reduce their critical habitat	**Damage the nets**, that need to be repaired or ne ones to be purchased
Reduce availability of their prey	As indirect economic loss, scare the schools of fish, **reducing the catch rates**; the time spent by fishermen to manage the interactions with dolphins causes a reduction in time spent on fishing activities
Ingestion of nets with letal consequences	**Remove baits** from hooks of longlines
Voluntary injuries	

Interactions dolphins-fishing activity is an environmental, economic and social concern!

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ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

Marine mammals

Interactions between marine mammals and fisheries in the Mediterranean and the Black Sea involve the following species:

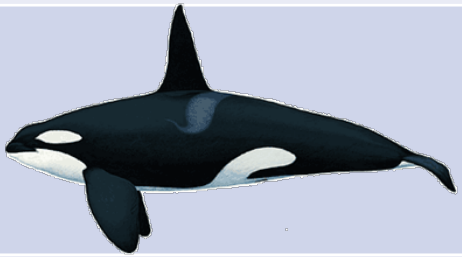
common bottlenose dolphins (*Tursiops truncatus*)

striped dolphin (*Stenella coeruleoalba*)

common dolphins (*Delphinus delphis*)

monk seals (*Monachus monachus*)

killer whales (*Orcinus orca*)
Morocco

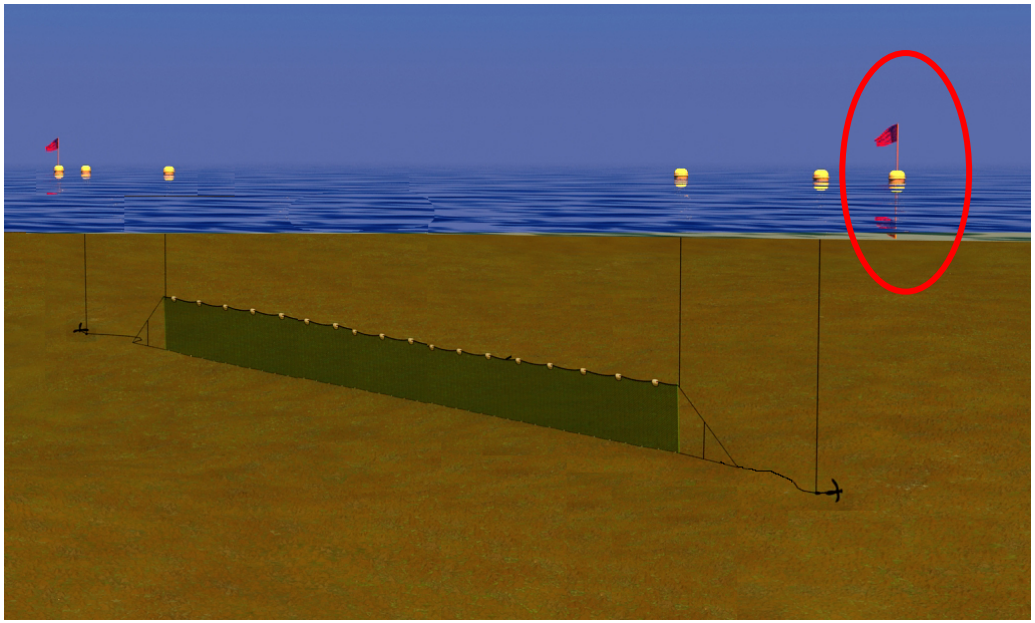


harbour porpoise (*Phocoena phocoena relicta*)
Black Sea

Marine mammals

Interactions between marine mammals and fisheries in the Mediterranean and the Black Sea involve mainly coastal fisheries

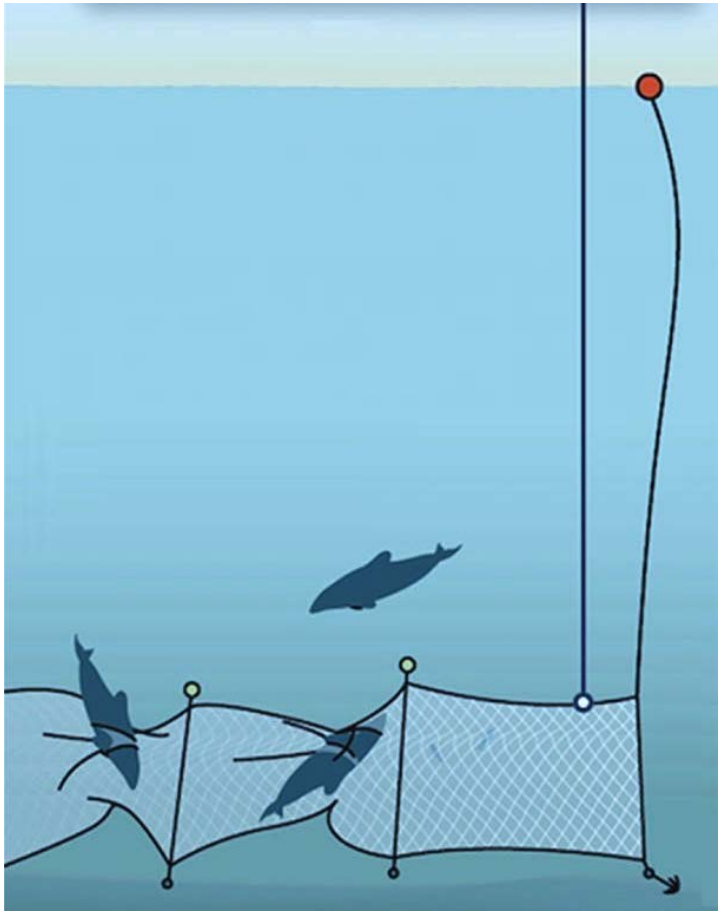
Passive nets (gillnets and trammel nest) are the main threat



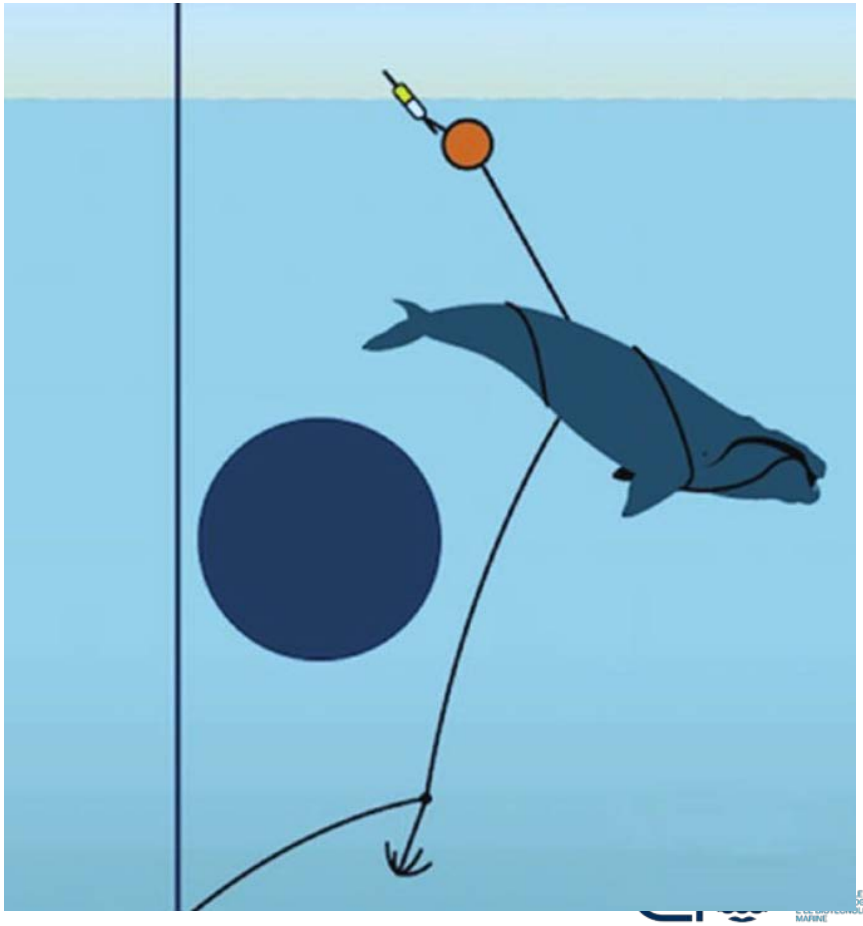
Marine mammals

Passive nets (gillnets and trammel nest)

Entanglement with meshes



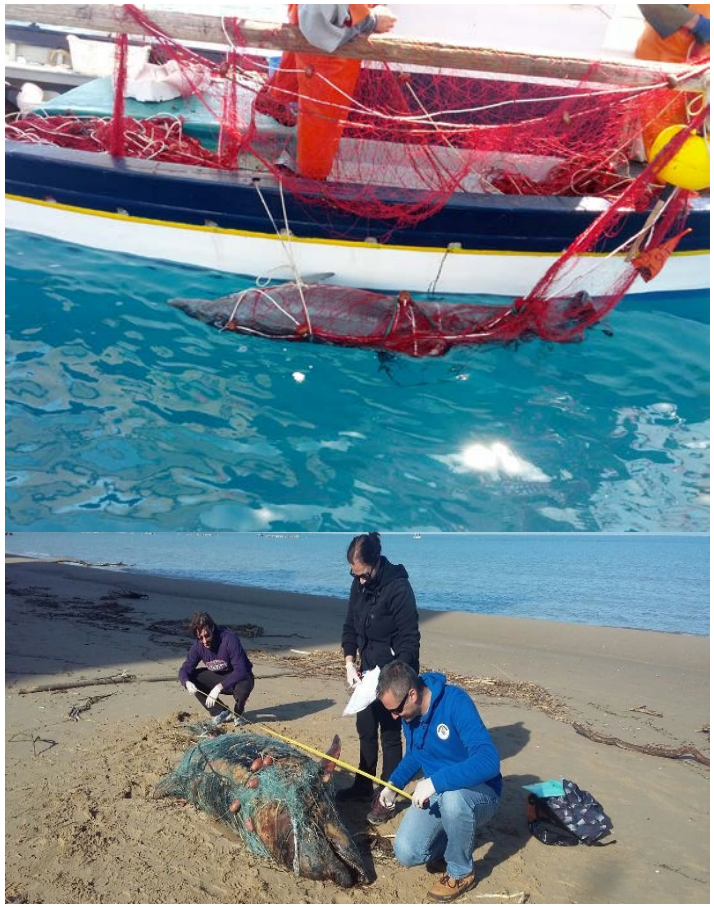
Entanglement with ropes, buoys



Marine mammals

Passive nets (gillnets and trammel nest)

Interaction with passive nets or part of them (floats)

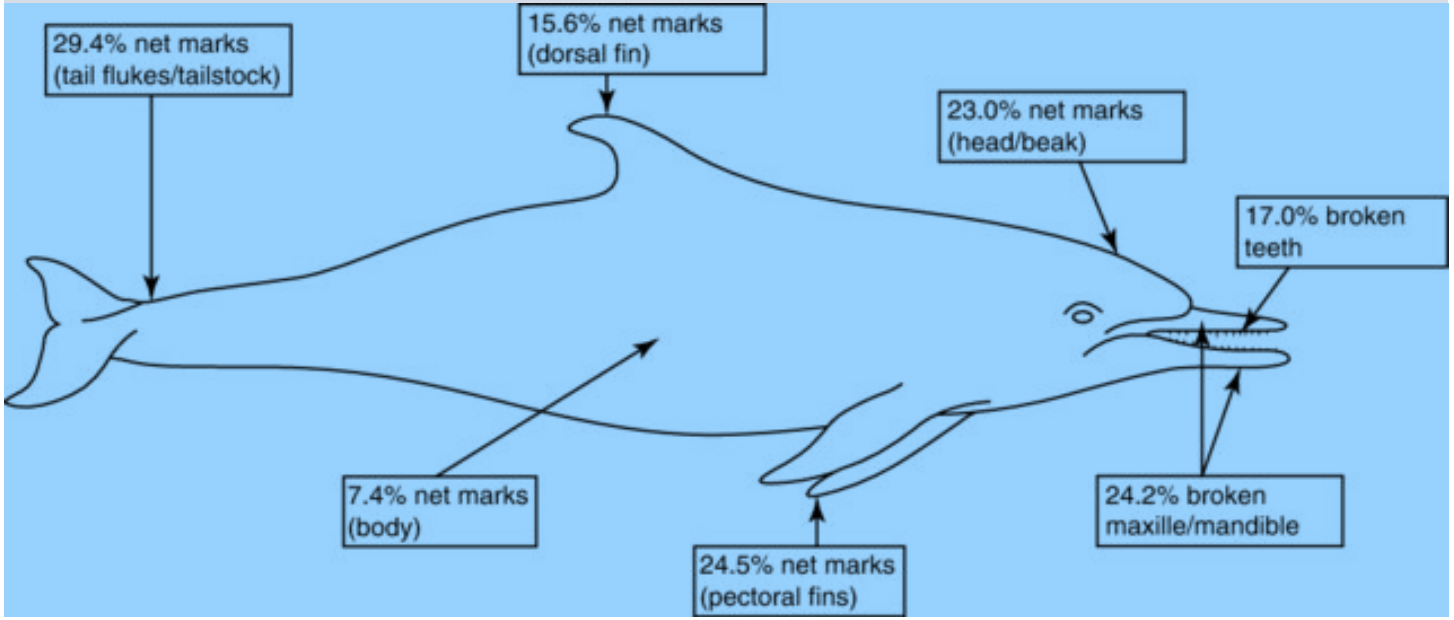


Ingestion of fishing nets

Marine mammals

Passive nets (gillnets and trammel nest)

Types of injury

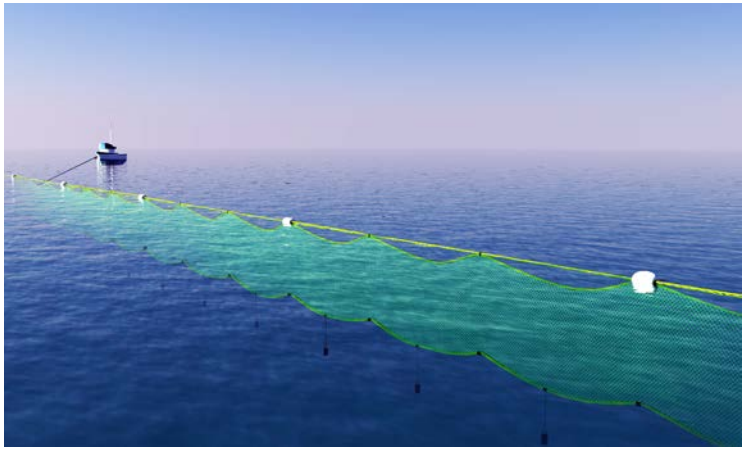


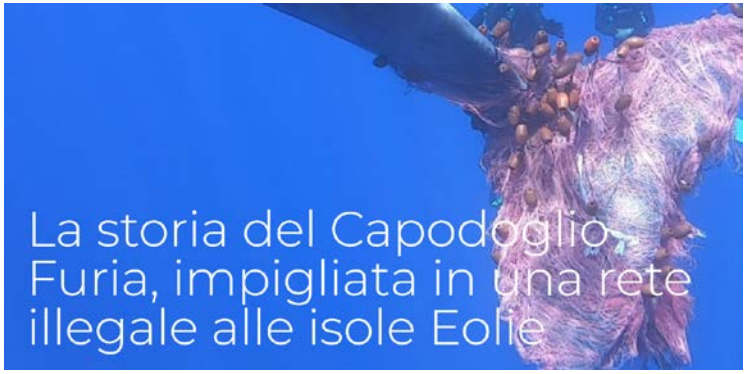
Source: Dolman and Moore, 2017

Marine mammals

Illegal driftnets targeting swordfish (spadara nets) are still a matter of concern

Illegal since 1998: Council Regulation (EC) No 894/97 of April 29th 1997, amended by Council Reg. no. 1239/98 e Council Reg. no. 809/2007





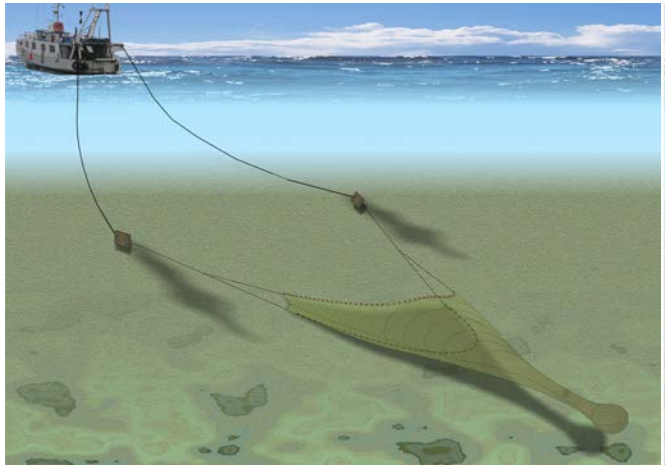
Marine mammals

Illegal driftnets targeting swordfish (spadara nets) are still a matter of concern

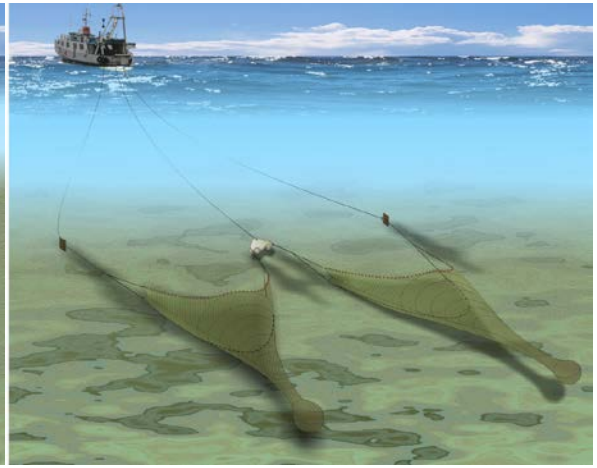
Marine mammals

Trawling (bottom and pelagic trawling)

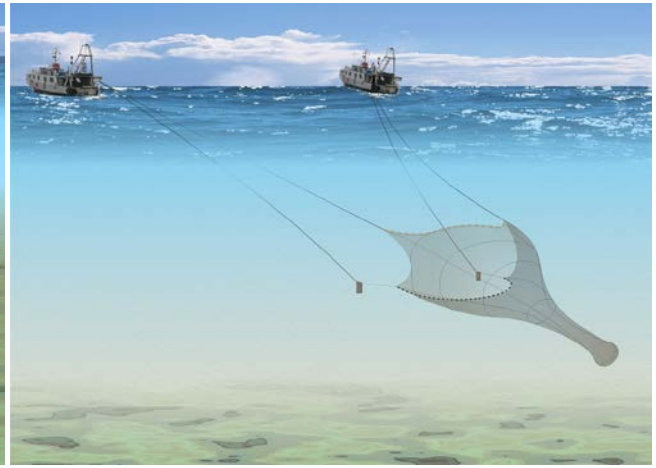
Bottom trawl



Twin trawl



Mid-water trawl

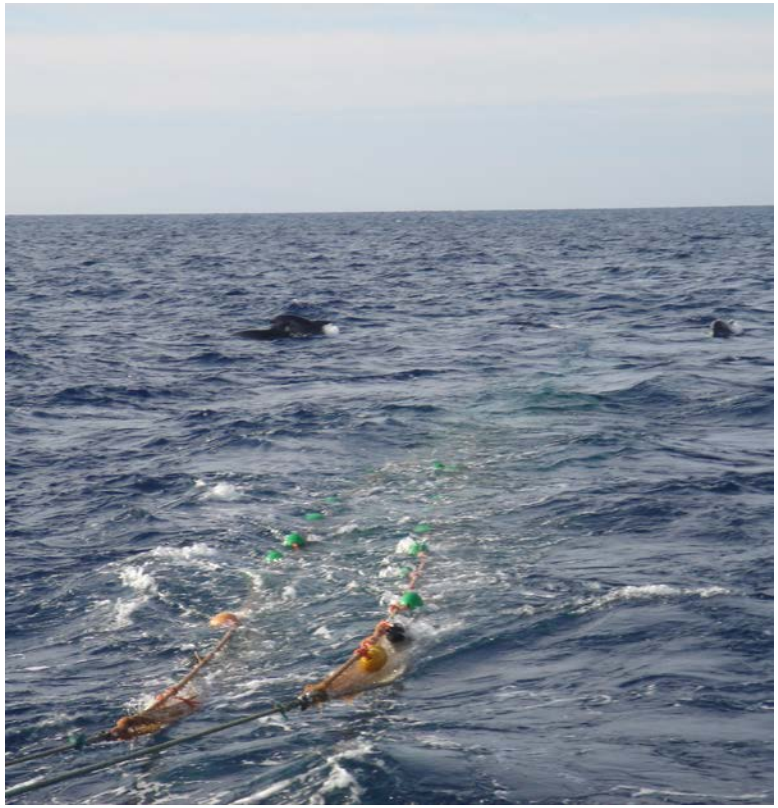


Marine mammals

Trawling (bottom and pelagic trawling)

Depredation

Dolphins have been reported to follow trawlers to take advantage of discarded fish or to seize fish from the net



Marine mammals

Trawling (bottom and pelagic trawling)

Bycatch

Marine mammals

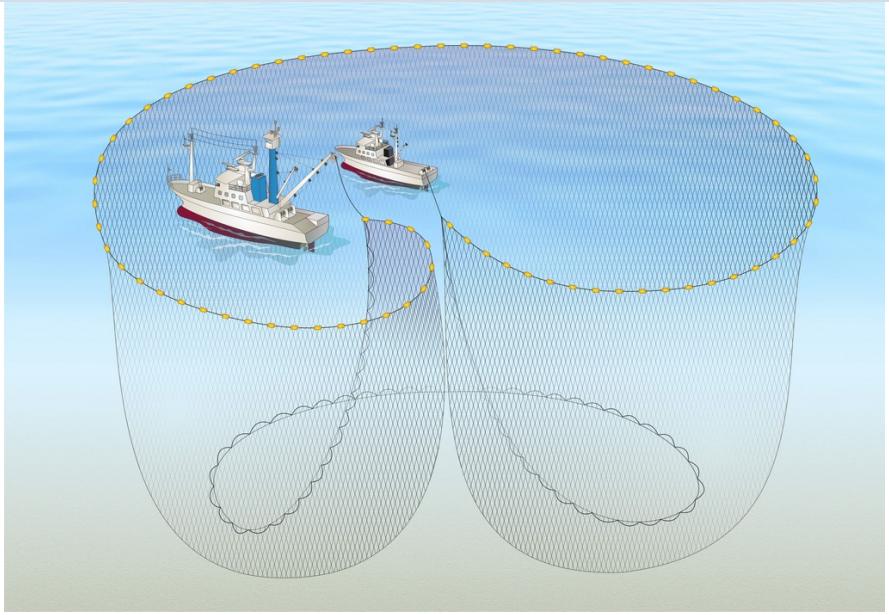
Trawling (bottom and pelagic trawling)

Playful behaviour

Depredation

Marine mammals

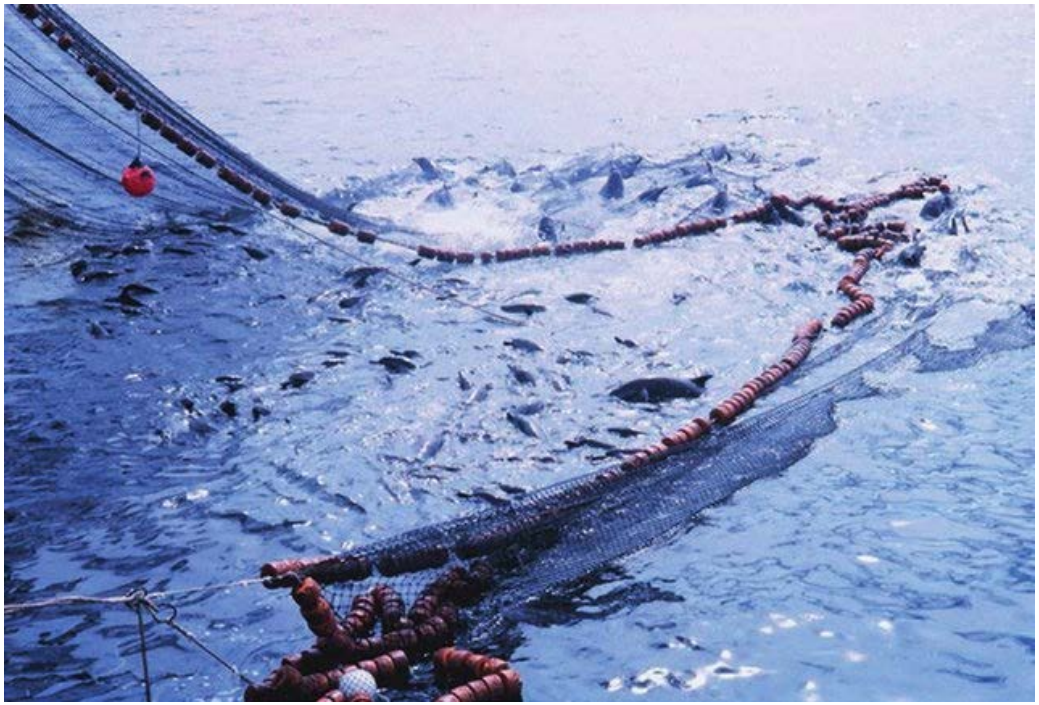
Purse seine



Marine mammals

Purse seine

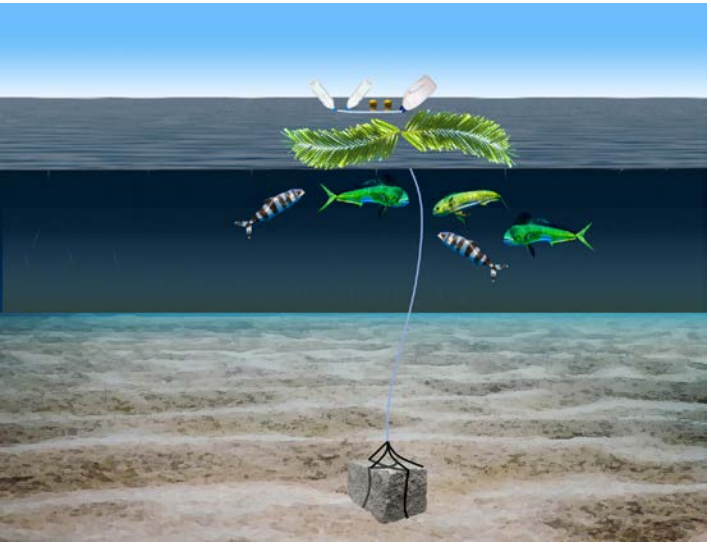
Fish Aggregating Device



Marine mammals

Purse seine

Fish Aggregating Device, in Italy: Cannizzi



Each vessel sets from
20 to 100 FADs

Around 700 vessels
in the MED

Sea turtles

Sea turtles can be affected at all life stages by anthropogenic factors: from eggs (destruction-modification of the nesting beaches) to young and adults (including fishing operations). As a result, all sea turtle species are subjects of conservation concern

Most of fishing gears involved

Fisheries → Turtles	Mammals → Fisheries
Entanglement	**Steal fish** from baited hooks reducing catch efficiency
Injuries to turtles due to impacts with fishing gears especially trawling	**Loss of time to disentangle**
Ingestion of hooks with letal consequences	Damage to fishing nets
Voluntary injuries	

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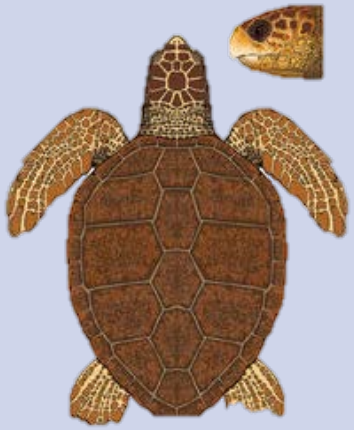
Sea turtles

Interactions between turtles and fisheries in the Mediterranean and the Black Sea involve the following species:

Loggerhead turtle (*Caretta caretta*)



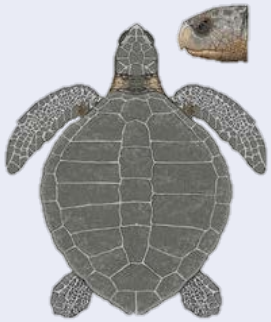
Green sea turtle (*Chelonia mydas*)

Sea turtles

Interactions between turtles and fisheries in the Mediterranean and the Black Sea RARELY involve the following species:

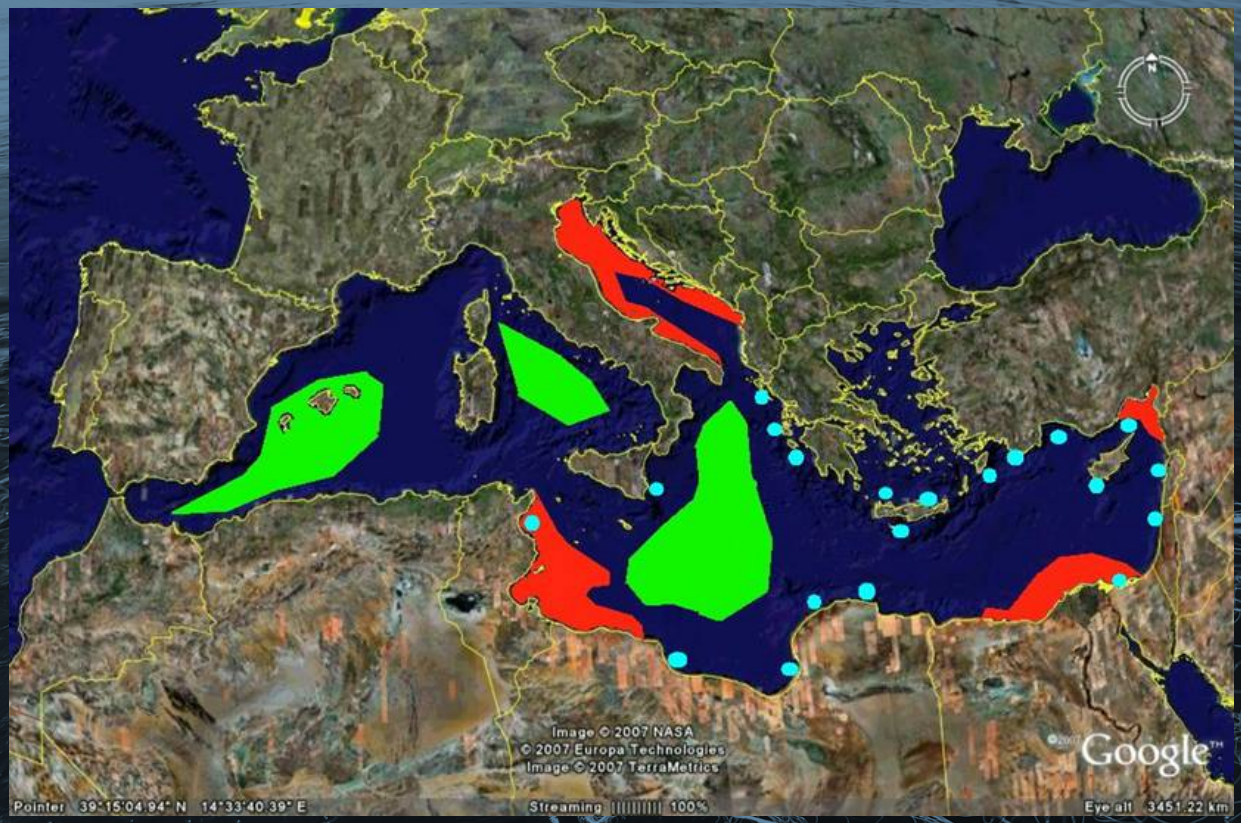
Leatherback turtle (Dermochelys coriacea)

Olive ridley turtle (*Lepidochelys olivacea*)



Sea turtles

Fisheries affect different ecological phases of sea turtles



Caretta caretta

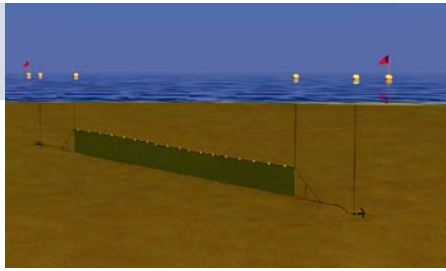
PELAGIC HABITATS (PELAGIC PHASE)

BOTTOM HABITATS (DEMERSAL PHASE)

MAIN SPAWINING AREAS

Sea turtles

Passive nets (gillnets and trammel nest)



- Interactions between sea turtles and passive nets is a matter of concern because of high direct mortality due to drowning

- Most of interactions occur when turtles try to feed on preys already caught by nets (depredation)

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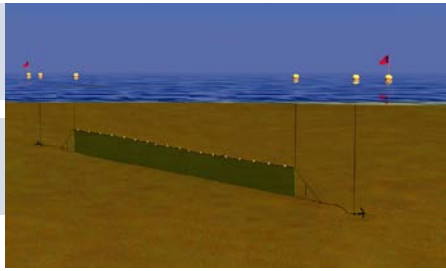
Sea turtles

Passive nets (gillnets and trammel nest)



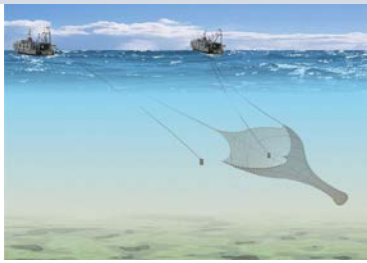
Parameters affecting sea turtle bycatch

- Mesh size: the larger mesh size the higher is the probability of bycatch
- Trammel net more dangerous than gillnet
- Hanging ratio: nets with a high slack
- Net height
- Soak time
- Bottom depth
- Habitat: e.g. south river Po, north Adriatic
- Buoys

Sea turtles

Trawling (bottom and pelagic trawling

Interactions between sea turtles and bottom trawling occur especially in neritic habitats (shallow waters) when turtles feed on prey on the bottom

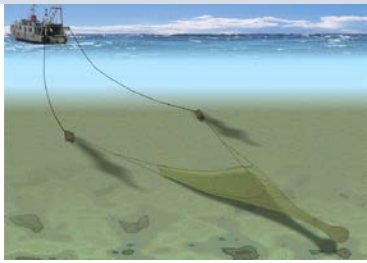


Pelagic trawling

Sea turtles

Bottom trawling

Interactions between sea turtles and bottom trawling occur especially in neritic habitats (shallow waters) when turtles feed on prey on the bottom



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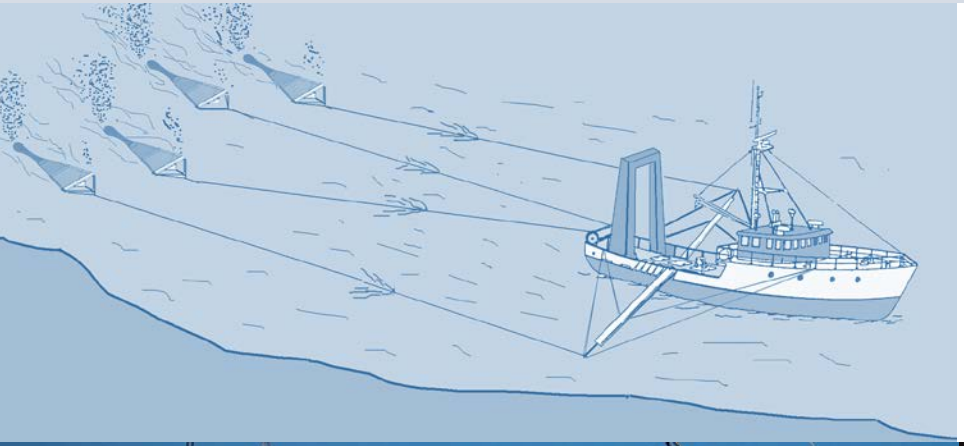
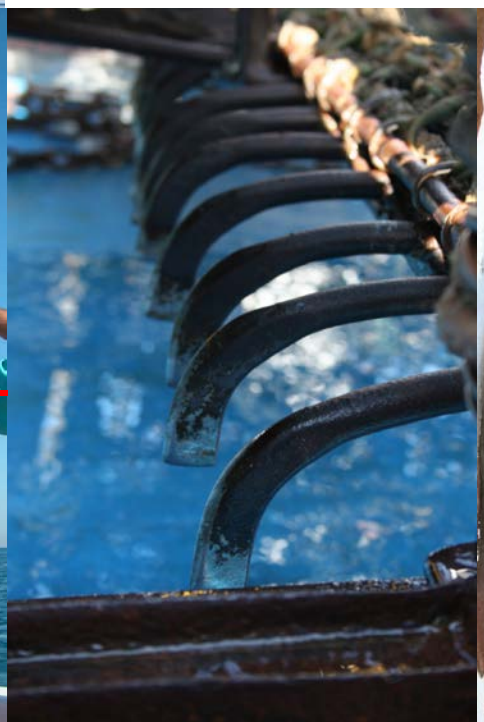
Sea turtles

Rapido trawling



It's a kind of beam trawl targeting common sole



Sea turtles

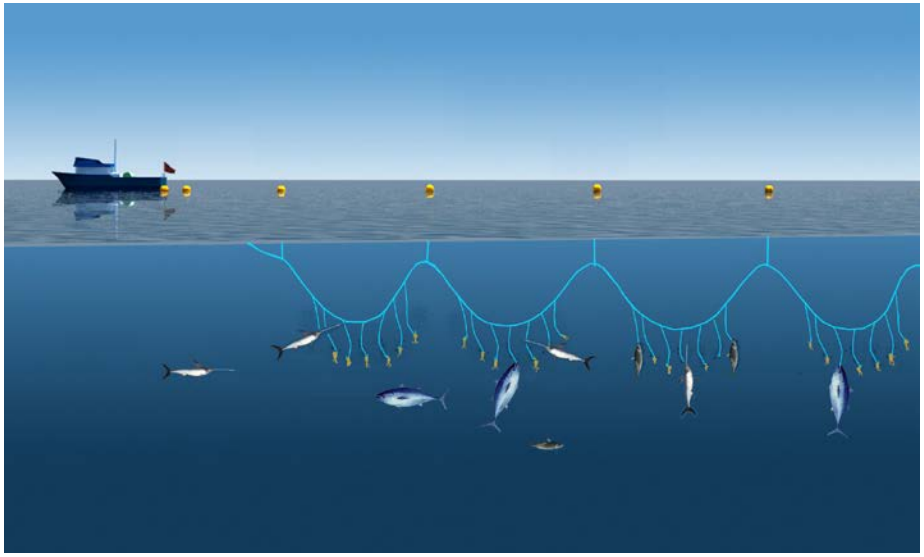
Rapido trawling

Sea turtles

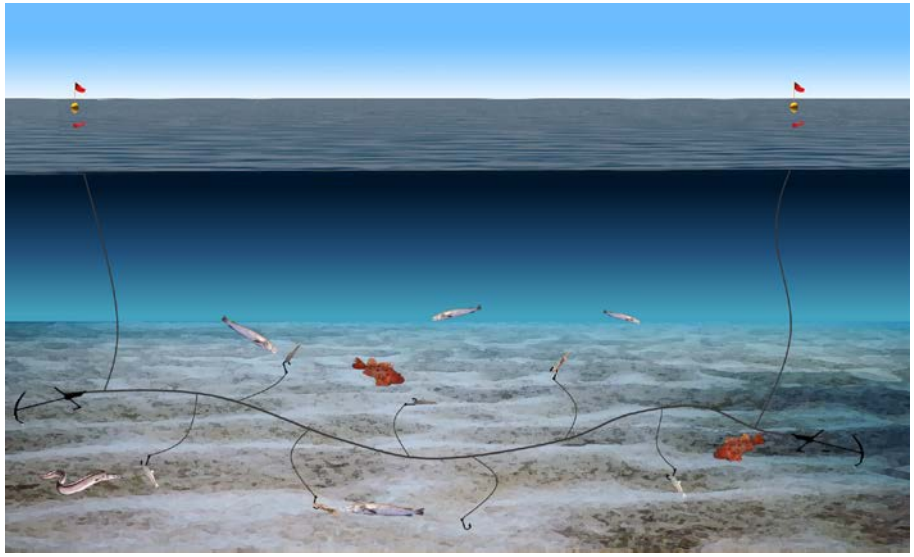
Longlines

- Interactions between sea turtles and longlines mainly occur when turtles try to feed on the bait on hooks
- Turtles can also get tangled on the main line or in the branchlines
- Thousand of hooks up to 60 km in length

Surface or drifting longline



Bottom longline



Sea turtles

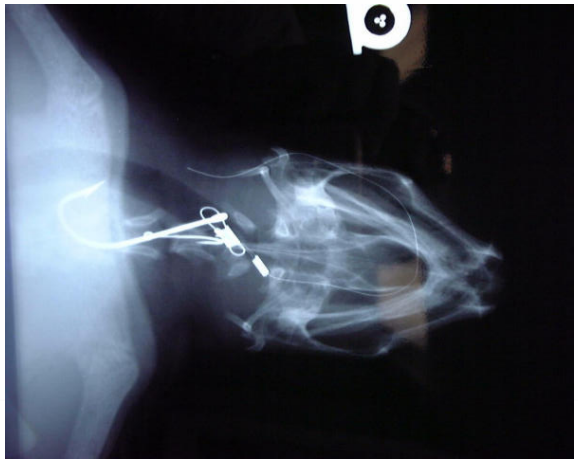
Drifting Longlines

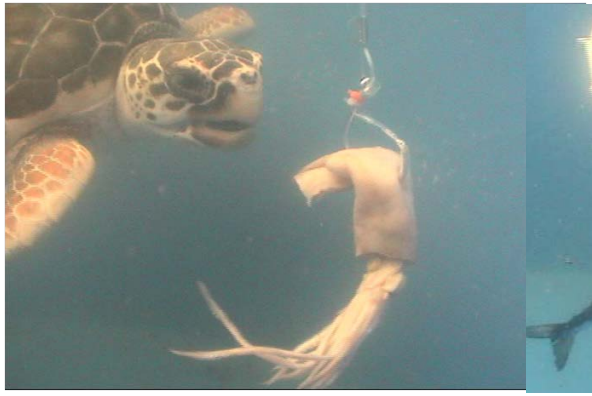
Sea turtles

Longlines

Parameters affecting sea turtle bycatch

- Hook size (length, gap etc.)
- Hook shape
- Type of bait (mackerel, squid, artificial bait)
- Depth setting
- Soak time
- Branchline length





Sharks and rays (SARs)

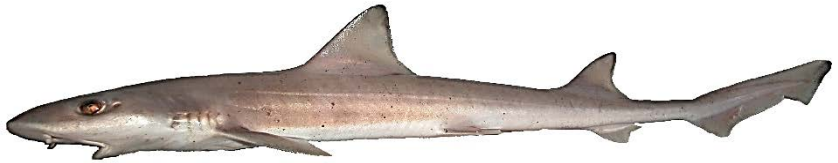
Main threats

- Sharks and rays are exploited by several fishing gears (passive nets, trawling, longlines, mostly).
- Only a few species are "formally protected"
- Several species have a commercial value, some of them are a target

Sharks and rays (SARs)

Common species of sharks in fishing activities

Spiny dogfish (*Squalus acanthias*)



Common smooth-hound (*Mustelus mustelus*)

Small-spotted catshark (*Scyliorhinus canicula)*

Blue shark (*Prionace glauca*)

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Sharks and rays (SARs)

Common species of rays in fishing activities

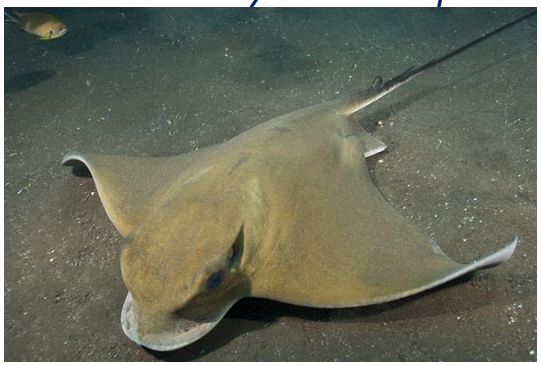
Raja clavata

Raja miraletus

Torpedo marmorata

Raja asterias

Myliobatis aquila



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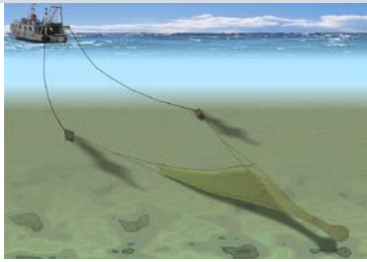
Sharks and rays (SARs)

Bottom trawling



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Sharks and rays (SARs)

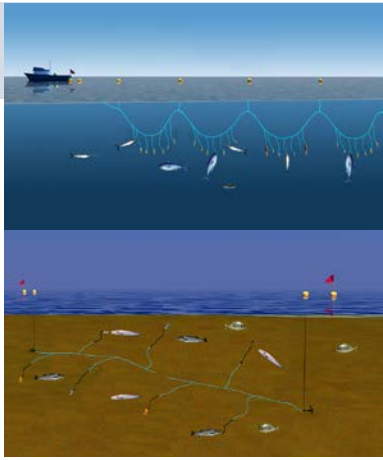
Rapido trawling

CNR IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

Sharks and rays (SARs)

Longlines

- Interactions between sharks and rays and longlines mainly occur when SARs try to feed on the bait on hooks



Target species: swordfish

Bycatch species: swordfish

Sharks and rays (SARs)

Bottom longline

Target species: Sparids, hake, Serranids etc.

Bycatch species: demersal sharks

Hexanchus griseus

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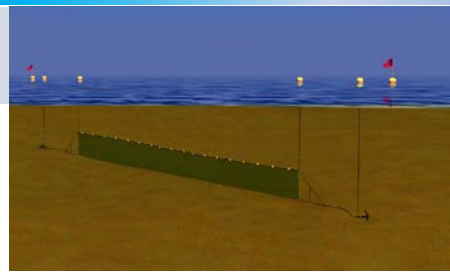
Sharks and rays (SARs)

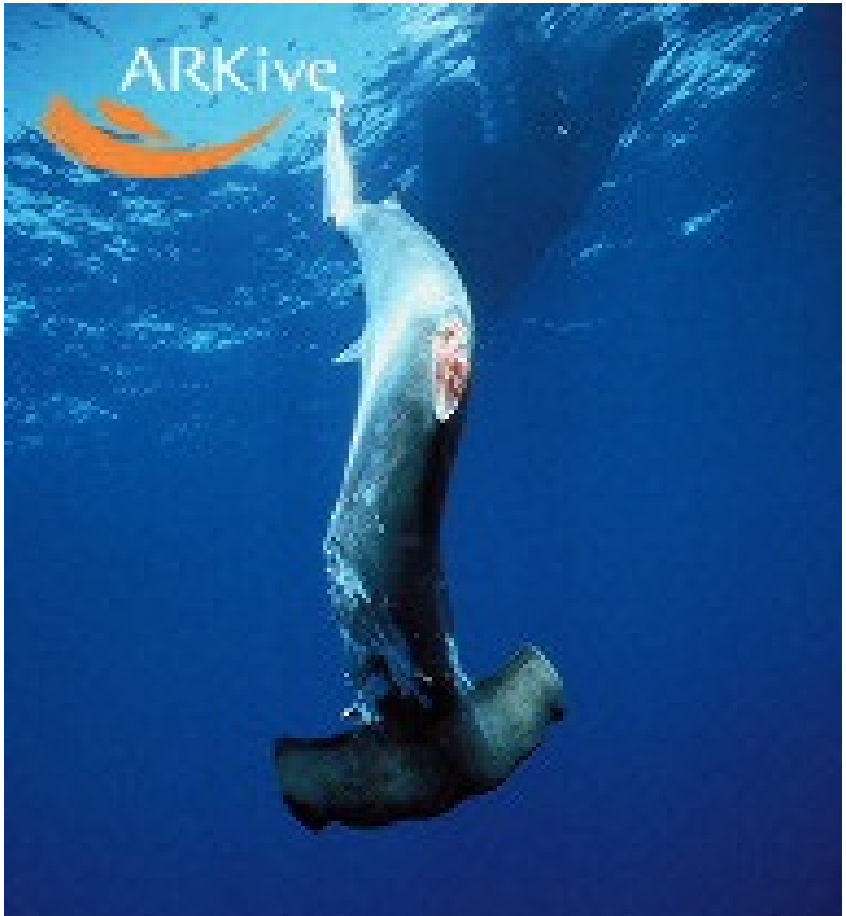
Passive nets (gillnets and trammel nets)



Interactions between sharks and rays and passive nets targeting turbot (*Scophthalmus maximus*) and rays

Sharks and rays

Longlines



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Bycatch Reducing Devices (BRDs)

Bycatch Reducer Devices – BRDs: device that aims at reducing the catch of incidental catch of unwanted species

Two types of advanced technology can be introduced in a fisheries:

- some technology can be adopted by fishermen voluntarily – e.g. to help catch more fish – a clear short-term benefits not obvious.
- Some technologies can be introduced as management measure to ensure a fishery is sustainable (BRD). In this case fishermen may need persuasion – e.g. more selective fishing gears to reduce discards – a longer-term benefit which is not obvious.

The first may need to be controlled or at least monitored (to avoid overexploitation)

The second may need to be initiated by management

Bycatch Reducing Devices (BRDs)

Before introducing a new technology it should take into account

- What are the problems to be solved and what are the targets (high discards of young fish (which species?, high discards of non-target species)
- Which of the possible solutions is best: a need to extend fishing to new areas, uneconomic fishing operations, new gears, modified gears etc

Experimental trials are essential in order to find out the right setup and to reduce the short term economic loss

Bycatch Reducing Devices (BRDs)

Before introducing a new technology it should take into account: What are likely the consequences

- Environmental impact (physical impact, type of bottom impacted)
- Selectivity (juveniles conservation, fishing mortality etc.). What are consequences for each fish stock affected
- What are the consequences for the total effort applied
- Economic benefit (working time, fish quality etc.)
- Social consequences (eg number of fishermen employed)
- Time scale
- How to evaluate the results

Bycatch Reducing Devices (BRDs)

Before introducing a new technology it should take into account: main issues

There are usually 3 issues

- the practical problem of introducing a new gear
- the immediate short-term effect on the economics of fishing (often a loss)
- and the longer term effect of a change when the stock has responded (should be a benefit of course!)

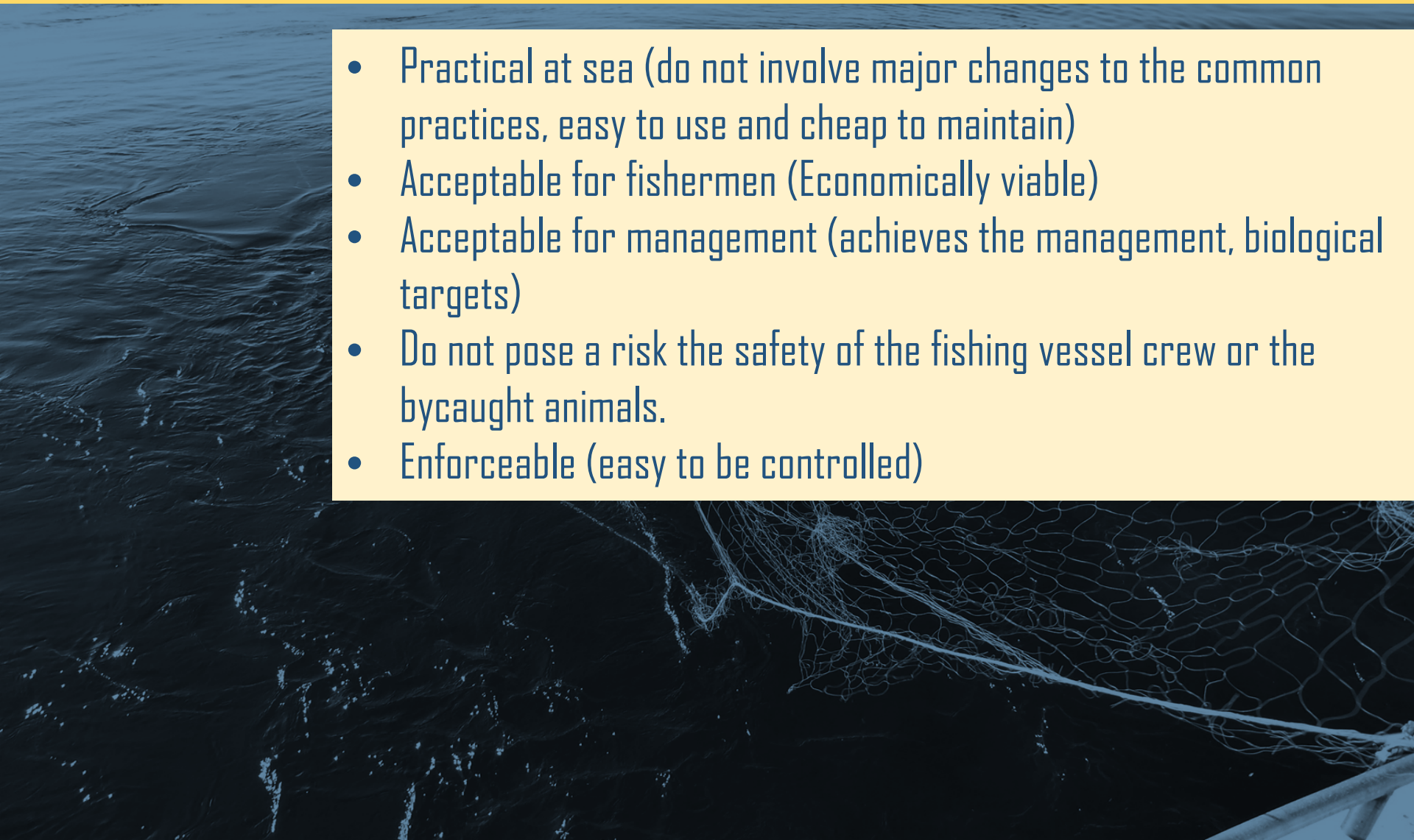
But fishermen usually do not like the long terms!!!

Stakeholders involvement: fishermen, netmakers, suppliers, scientists, enforcement officers as well as managers and the environmental bodies)

Bycatch Reducing Devices (BRDs)

Before introducing a new technology it should take into account: new technology should be

- Practical at sea (do not involve major changes to the common practices, easy to use and cheap to maintain)
- Acceptable for fishermen (Economically viable)
- Acceptable for management (achieves the management, biological targets)
- Do not pose a risk the safety of the fishing vessel crew or the bycaught animals.
- Enforceable (easy to be controlled)

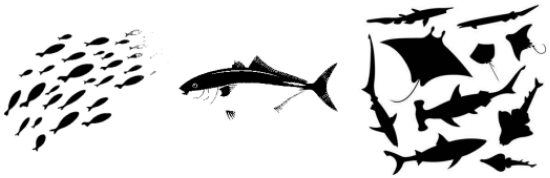


Bycatch Reducing Devices (BRDs)

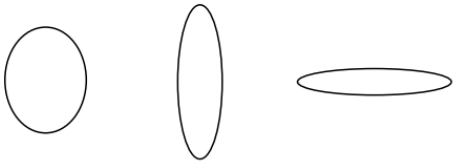
Planning mitigation measures

Morphological

Small fish *Large fish* *Large animals*

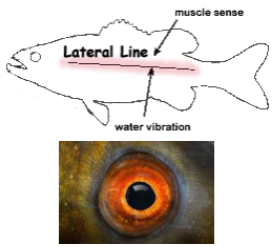


Round *Compressed* *Flat*



Physiological and Behavioural

Sense *Locomotion & Avoidance*



Behaviour

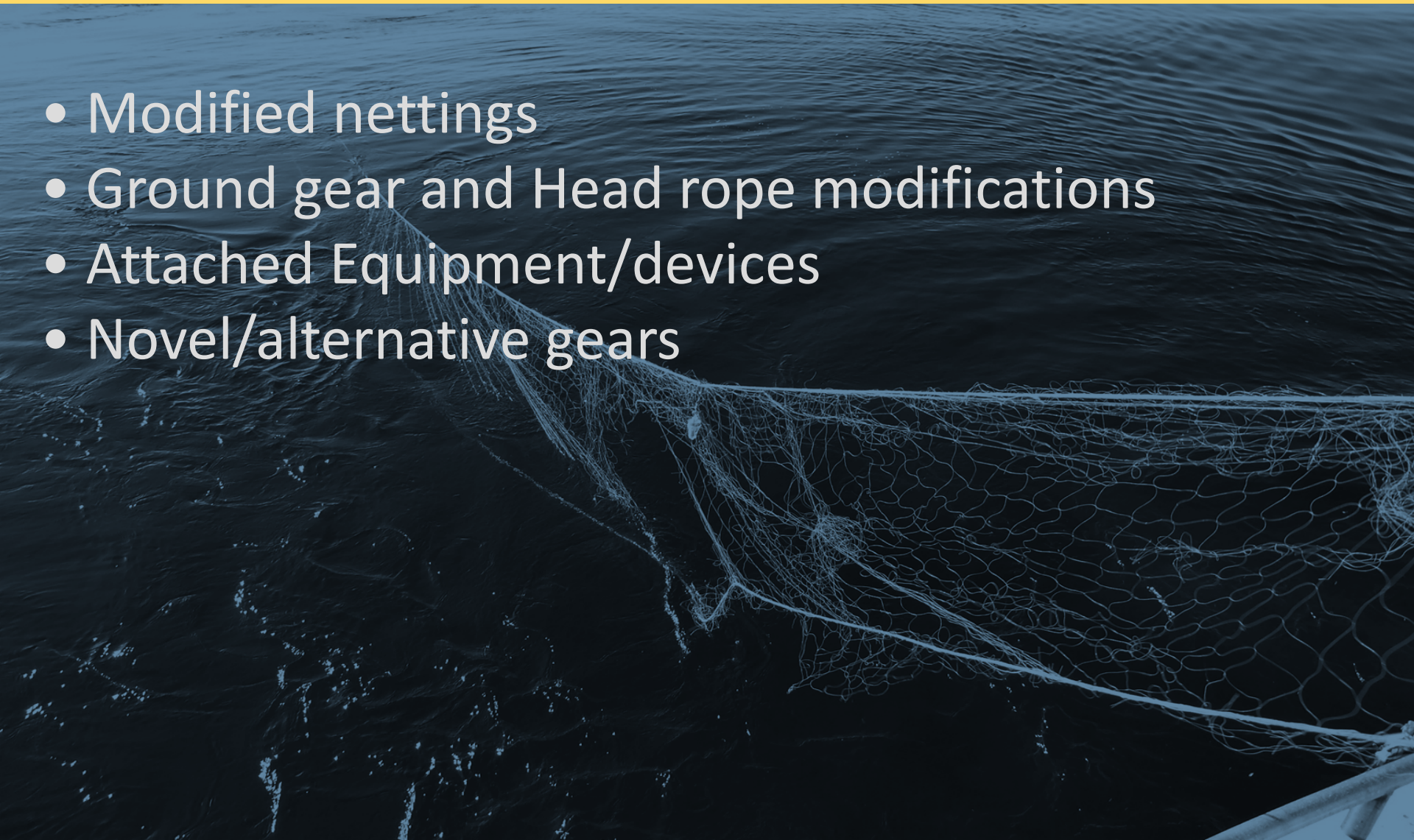
Locomotion *Avoidance*

seafish.org

wikimedia.org/wiki/File:Candle.jpg

Bycatch Reducing Devices (BRDs)

Classification of the BRDs

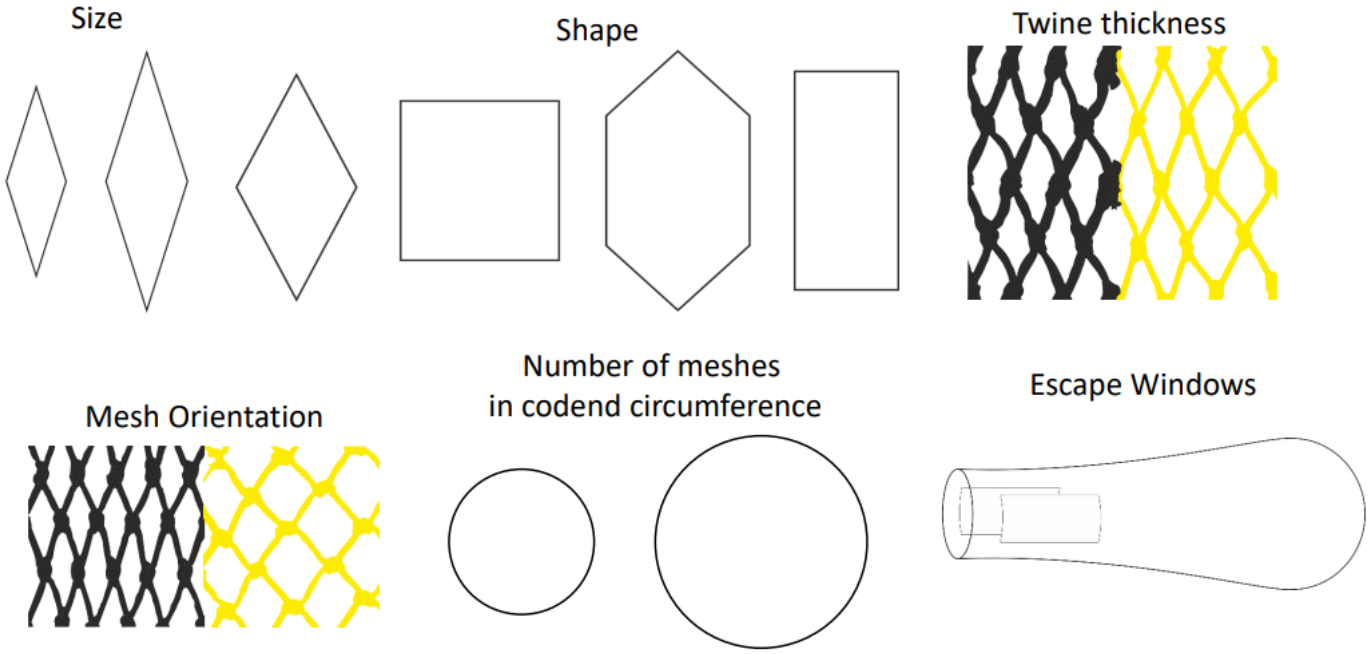


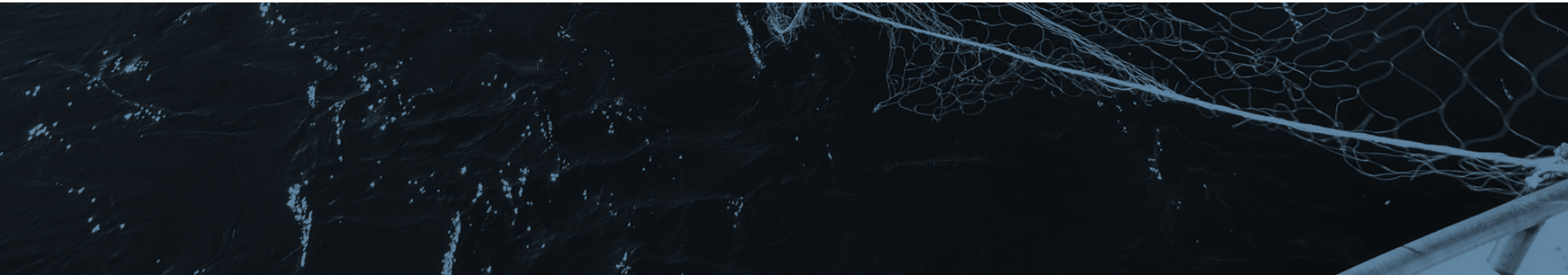
- Modified nettings
- Ground gear and Head rope modifications
- Attached Equipment/devices
- Novel/alternative gears

Bycatch Reducing Devices (BRDs)

Classification of the BRDs

- Modified nettings
  - Size
  - Shape
  - Diameter
  - Orientation
  - Number
  - Opening



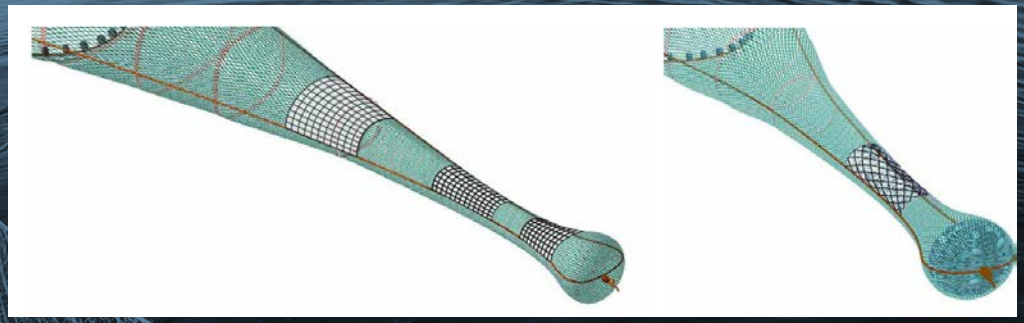


Bycatch Reducing Devices (BRDs)

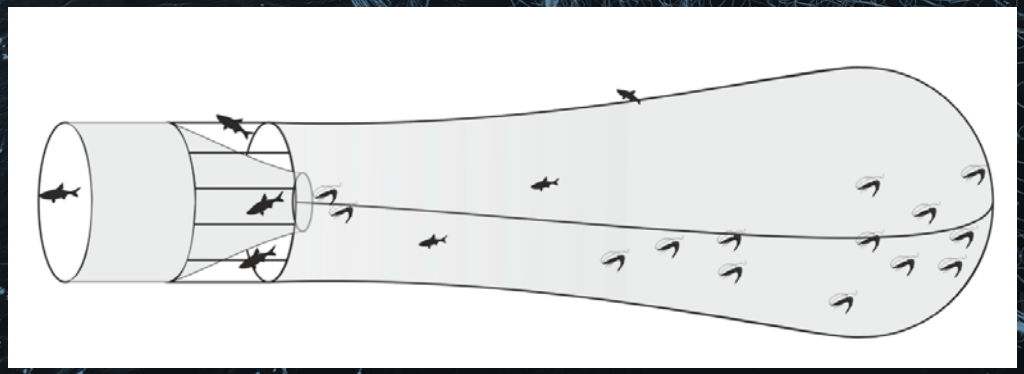
Classification of the BRDs: Modified netting

Square meshes

Escape windows



Escape gap

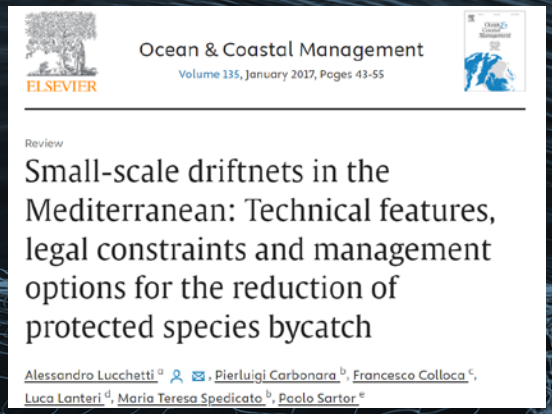


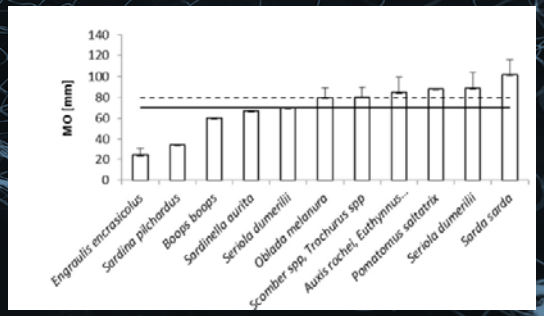
Bycatch Reducing Devices (BRDs)

Classification of the BRDs: Modified netting

Passive nets: The use of large meshes and net slakness, strongly increase the risk of megafauna entanglement

- 100 vessels are involved in the small scale driftnet fisheries in EU Mediterranean.
- The study confirm the full environmental sustainability of the small scale driftnets.
- Small meshes (70 mm) will save traditional mètiers and sensitive species.
- Using twines in small driftnets makes rather unlikely the catch of marine mammals.
- Within 3 miles from the coast driftnet-sensitive species interactions reduce.





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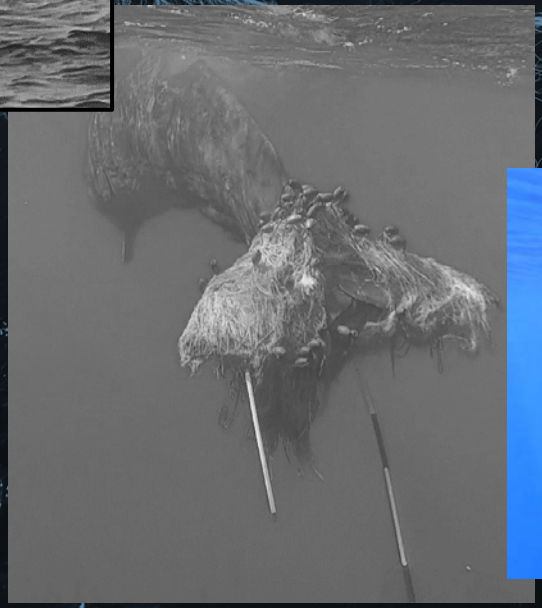
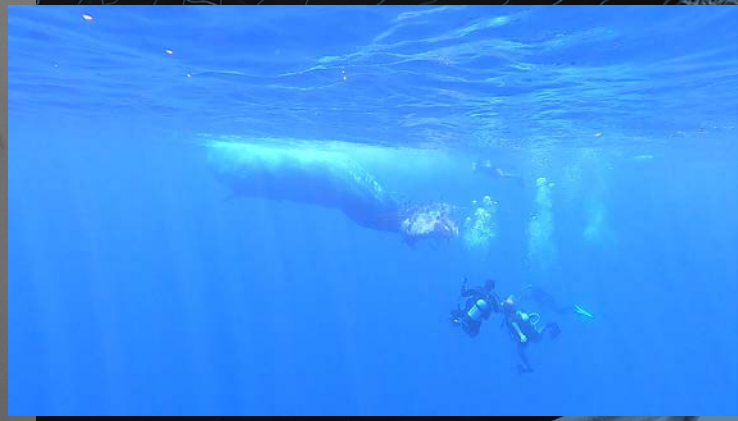




PLOS ONE

RESEARCH ARTICLE

Behaviour and vocalizations of two sperm whales (*Physeter macrocephalus*) entangled in illegal driftnets in the Mediterranean Sea

Monica Francesca Blasi[1©*], Valentina Caserta[1©], Chiara Bruno[1©], Perla Salzeri[1©], Agata Irene Di Paola[1©], Alessandro Lucchetti[2]

1 Filicudi WildLife Conservation, Località Stimpagnato, Filicudi, Lipari (ME), Italy, 2 Centro Nazionale Ricerca - Istituto per le Risorse Biologiche e le Biotecnologie Marine (CNR-IRBBM), Ancona, Italy

© These authors contributed equally to this work.
* blasimf@yahoo.com

Check for updates

Bycatch Reducing Devices (BRDs)

Classification of the BRDs: Modified netting

Passive nets: The use of large meshes and net slakness, strongly increase the risk of megafauna entanglement

In the case of fixed gillnets, the low hanging ratio increases the slack of netting panels, enabling gillnets to catch marine organisms also by entangling them, which does not happen frequently with driftnets.

Possible management strategies to reduce bycatch include technical modification to gear setting (such as reducing netting slack and using small meshes), bycatch reducer devices (such as LED UV), and area and seasonal gear restrictions to small-scale fisheries in areas of greatest concern in the northern Adriatic Sea

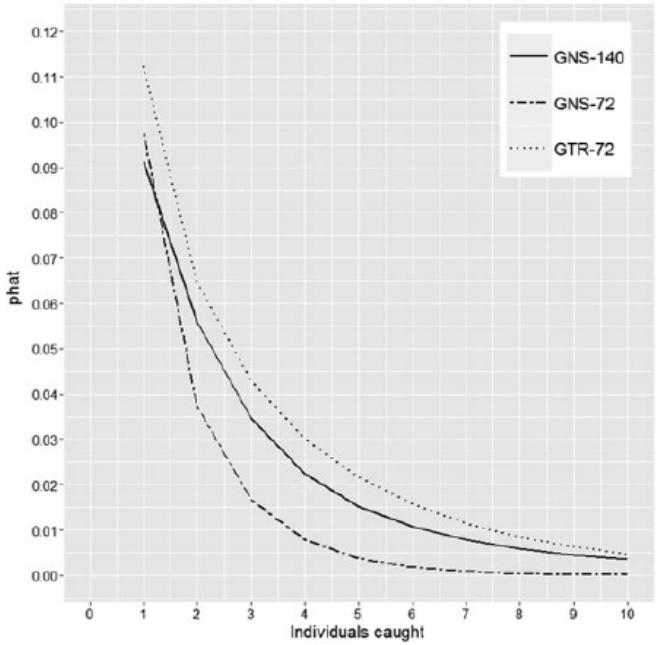
Received: 20 December 2016 | Revised: 22 March 2017 | Accepted: 12 April 2017
DOI: 10.1002/aqc.2787

WILEY

RESEARCH ARTICLE

Sea turtles bycatch in the Adriatic Sea set net fisheries and possible hot-spot identification

Alessandro Lucchetti | Claudio Vasapollo | Massimo Virgili



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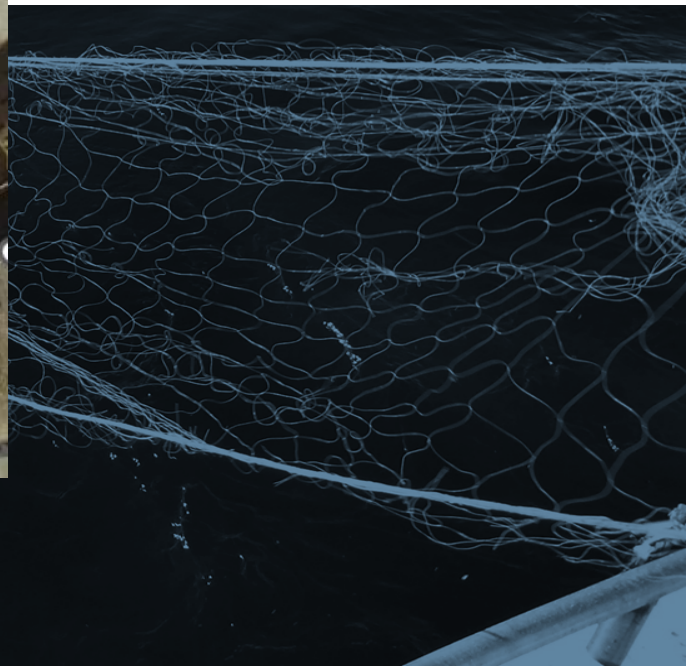


Bycatch Reducing Devices (BRDs)

Classification of the BRDs: Modified netting

Passive nets: The use of large meshes and net slakness, strongly increase the risk of megafauna entanglement

Obviously this strongly depends on life cycle....

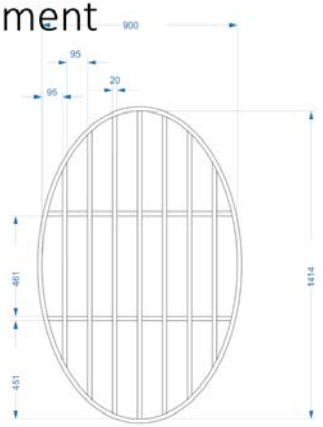
Bycatch Reducing Devices (BRDs)

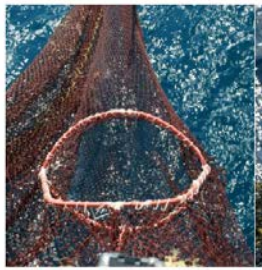
Classification of the BRDs: Attached equipment

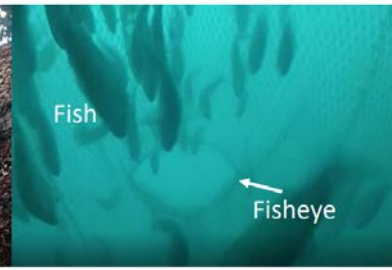
Attached Equipment

Soft
Net
Rope

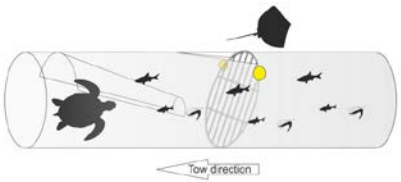
Hard
Rigid
Flexible



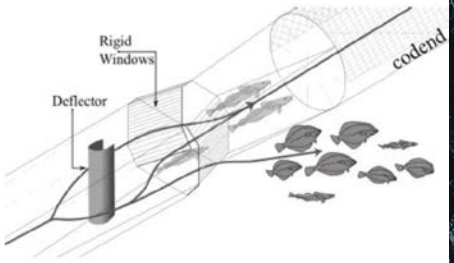




Perpendicular



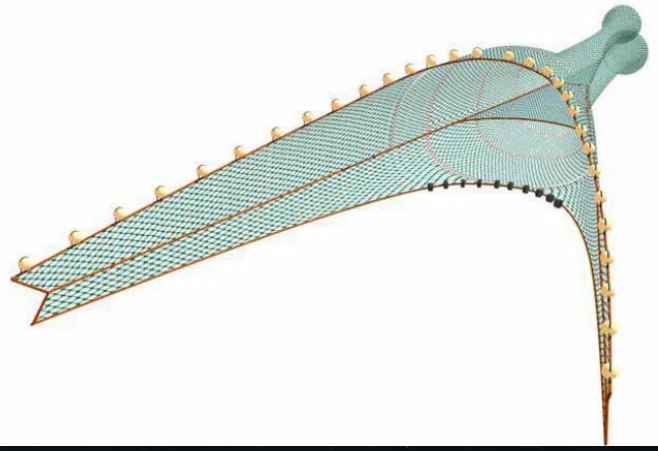
Parallel



Santos et al., 2015

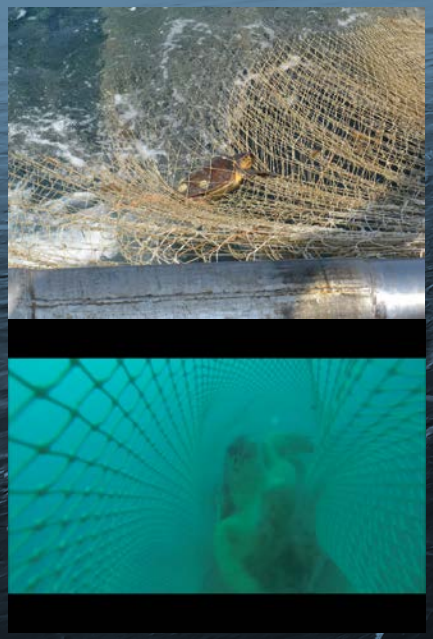
Santos, J., Herrmann, B., Mieske, B., Stepputtis D., Krumme, U., Nilson, H. 2015. Reducing flathfish bycatch in roundfish fisheries. Fis. Res. 174:64-73

Horizontal separator panel

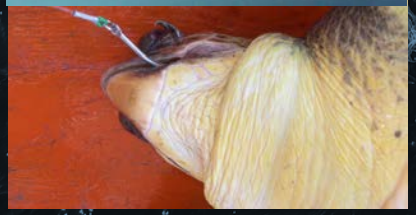


Reducing turtle bycatch

Main issues



Bycatch



Direct and Delayed Mortality

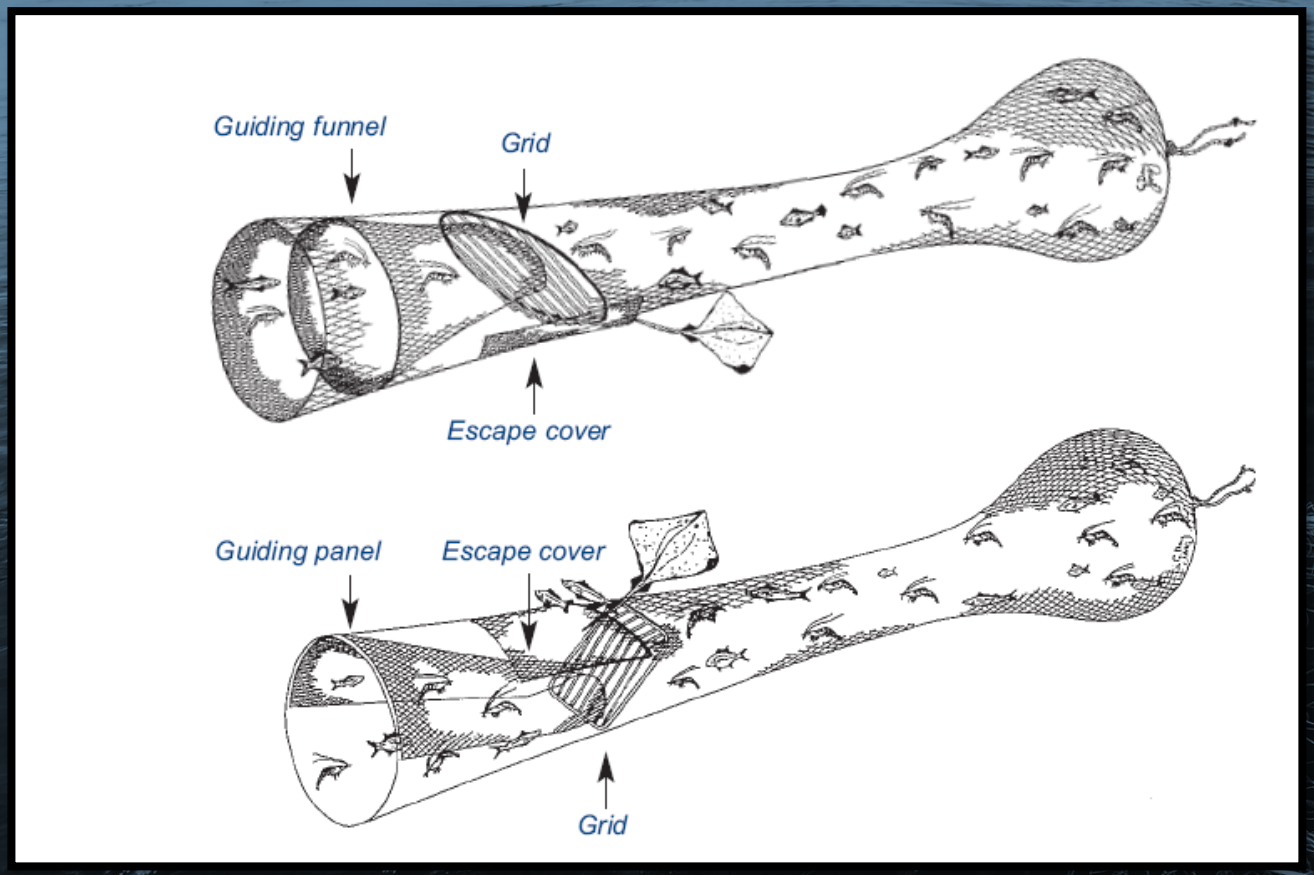
TartaLife

Life

NATURA 2000

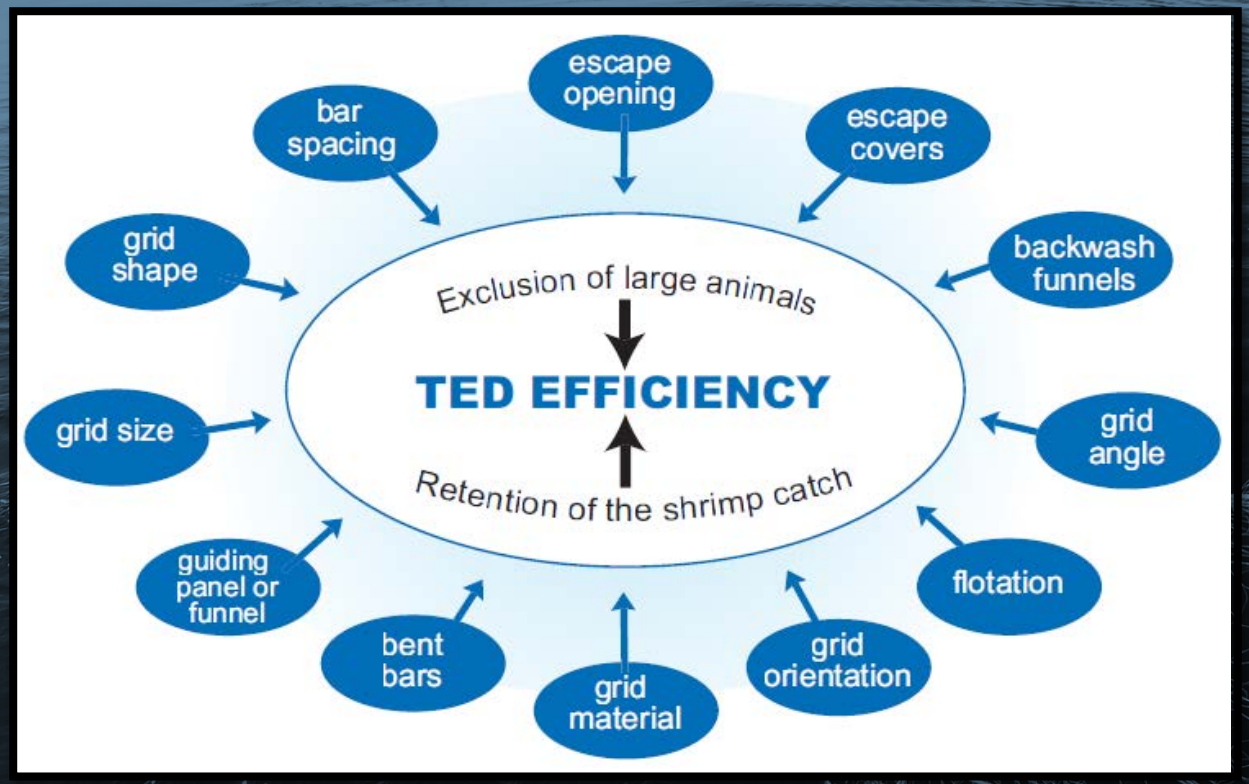
Reducing turtle bycatch

Turtle Excluder Devices (TEDs)



Reducing turtle bycatch

Turtle Excluder Devices (TEDs)



Reducing turtle bycatch

Turtle Excluder Devices (TEDs)

Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED

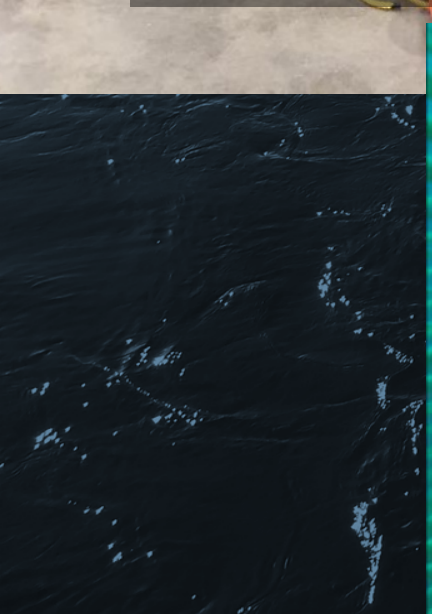
4 modelli di TED:
Classico a 7 barre verticali
Classico di grandi dimensioni
A barre strette
Con due fori laterali

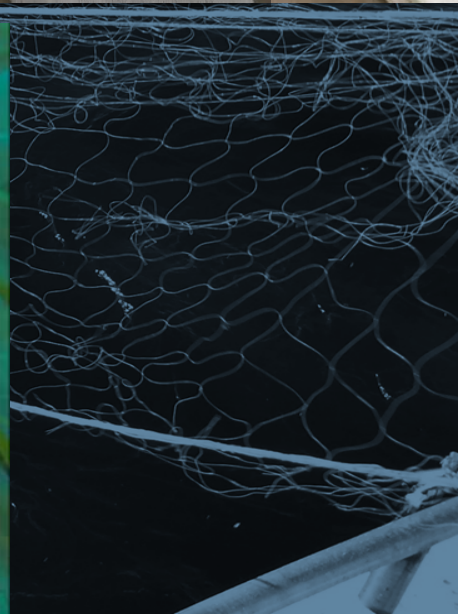
Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED

SUPERSHOOTER

FLEXGRID



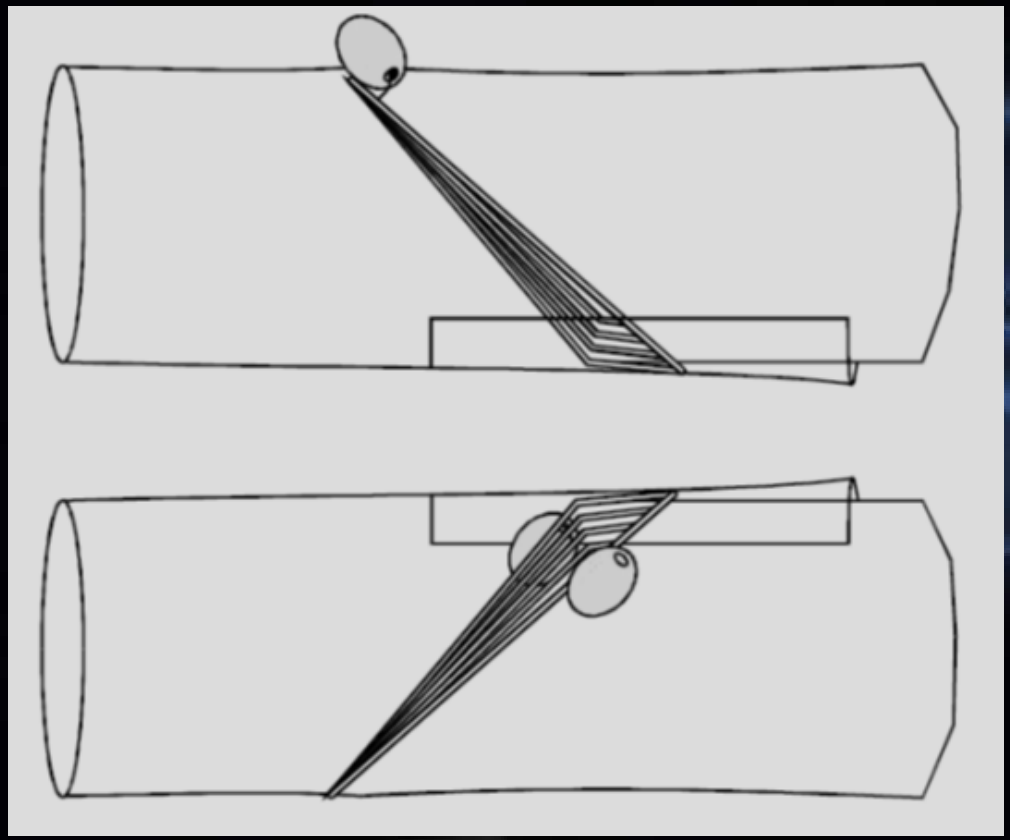


Reducing turtle bycatch

Turtle Excluder Devices (TEDs)

TartaLife
PESCA TARTAFREE
WWW.TARTALIFE.EU

EXIT HOLE POSITION



Adv.: discard reduction

(fishermen approval)

Adv.: easier turtle escape

Reducing turtle bycatch

Turtle Excluder Devices (TEDs)

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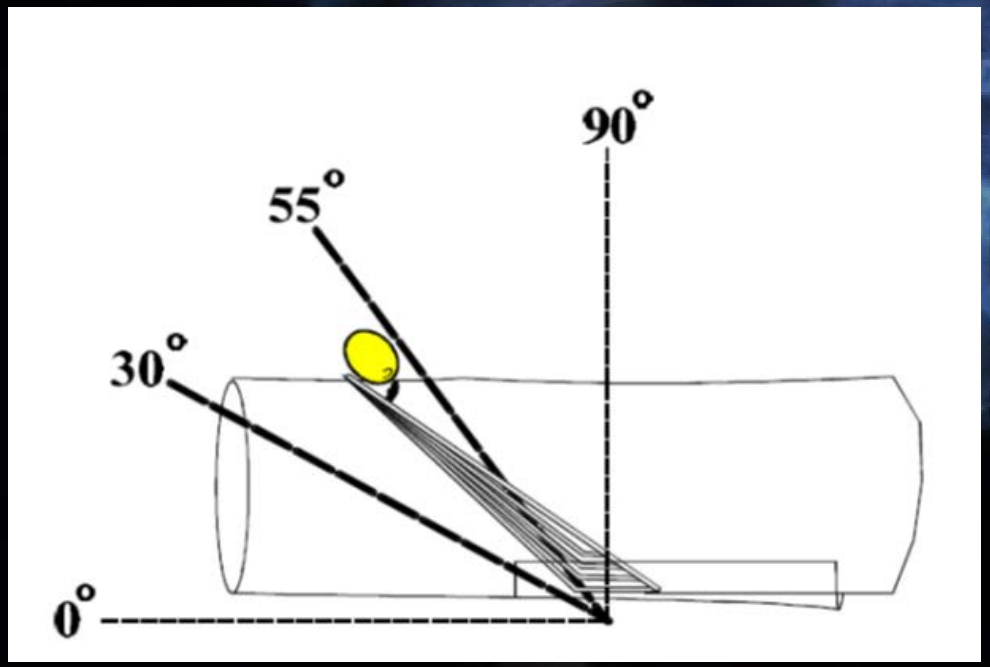
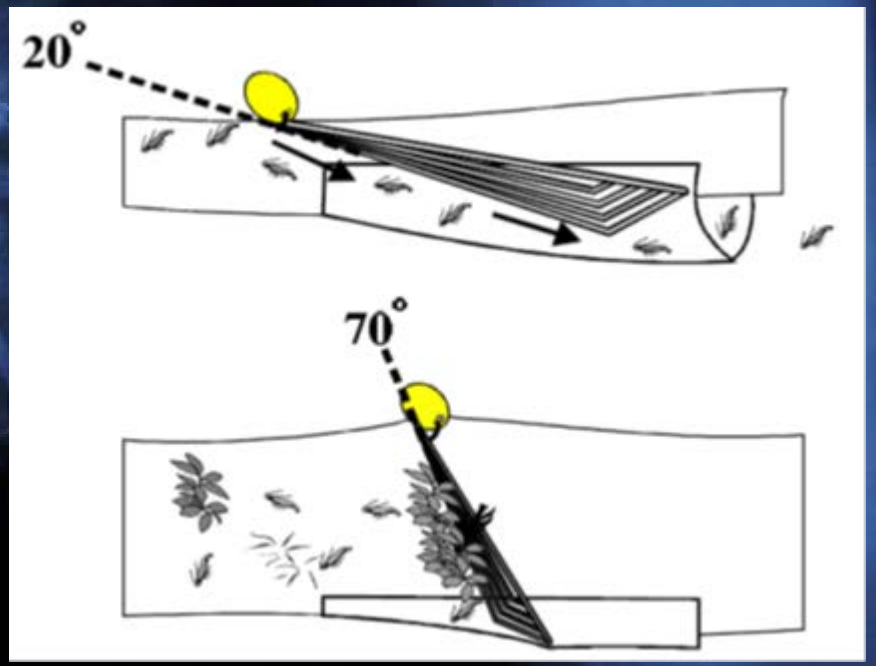
TED ANGLE

All hard TEDs must be installed at angles between 30° to 55° from the horizontal





Reducing turtle bycatch

Turtle Excluder Devices (TEDs)

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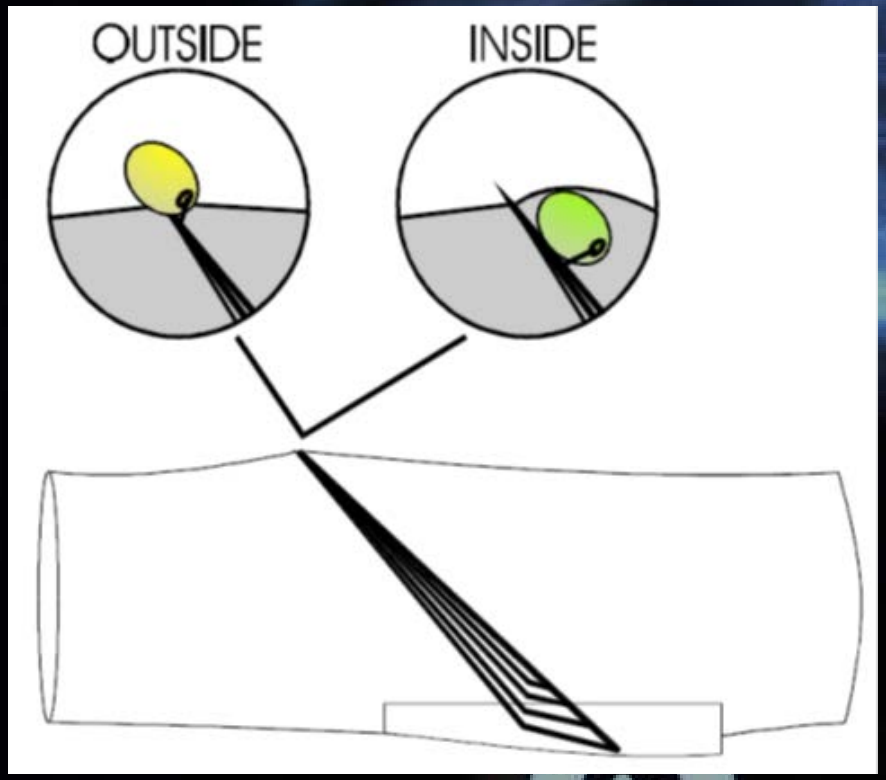
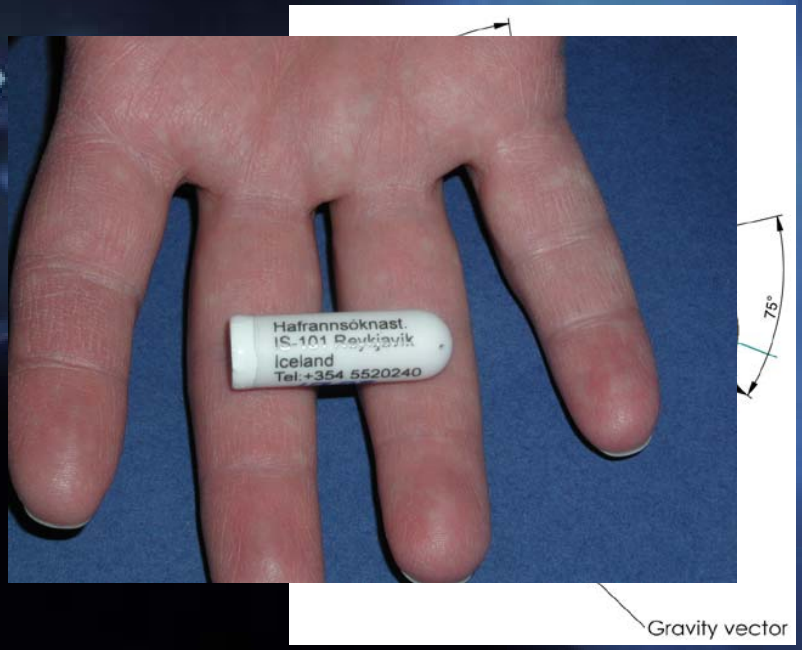
FLOATING

Floats help stabilize the TED in the water and prevent it from rolling over during deployment or retrieval





Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED

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DOI: 10.1051/alr/2016016
www.alr-journal.org

Aquatic Living Resources

Flexible Turtle Excluder Device (TED): an effective tool for Mediterranean coastal multispecies bottom trawl fisheries

Alessandro LUCCHETTI[a], Elisa PUNZO and Massimo VIRGILI

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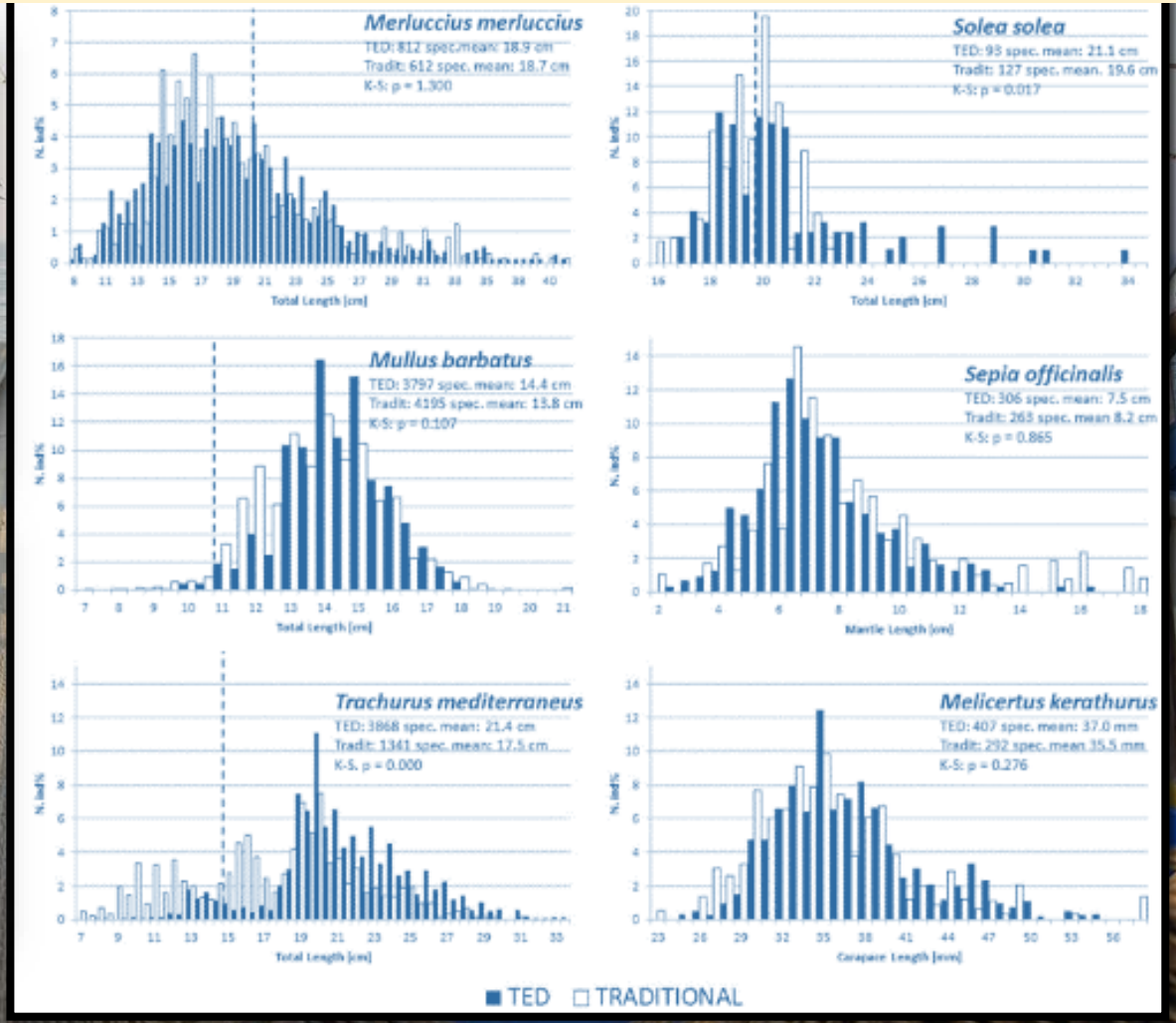
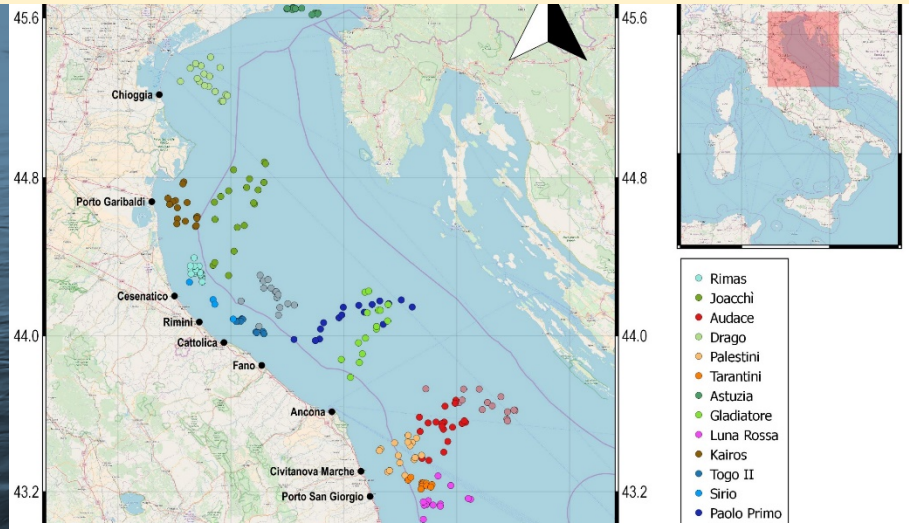
Received 15 January 2016; Accepted 18 April 2016

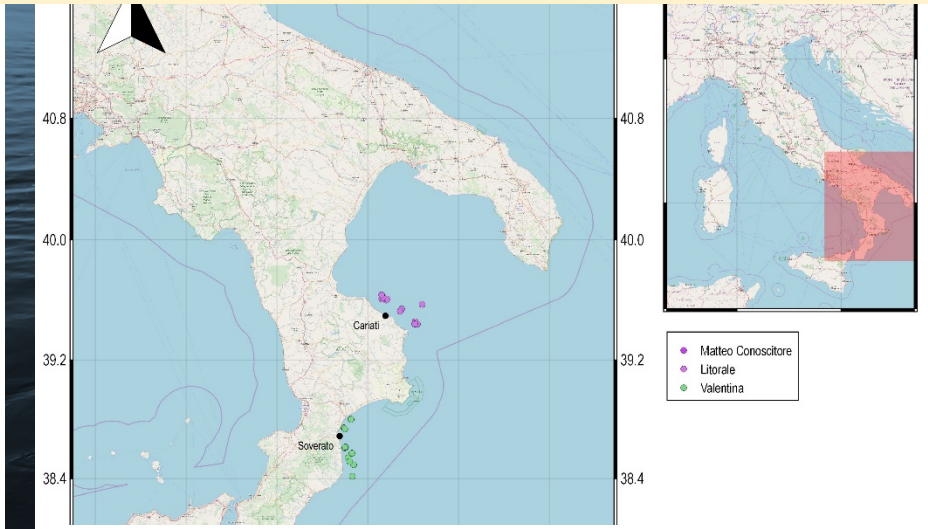
Abstract – The effect of a flexible Turtle Excluder Device (TED) on the catching efficiency and performance of a commercial bottom trawl was tested in a gear comparison study for a Mediterranean coastal multispecies bottom trawl fishery. The device affected neither bottom trawl technical performances (horizontal and vertical net opening and door spread) nor did it increase the required towing force, hence fuel consumption remained constant. Comparison of commercial catches for the major species demonstrated that using the TED did not affect catching efficiency, while it reduced the amount of debris. The device did not influence the size of commercial species, leaving the selective performance of the trawl unmodified. Underwater video camera recordings documented that fish caught in the net swam through the grid and easily reached the cod-end, missing the TED escape opening. Easy storage and improved catch retention compared with previous devices tested in this area make the present flexible TED a practical and valuable solution to reduce turtle bycatch in coastal Mediterranean demersal multispecies fisheries.

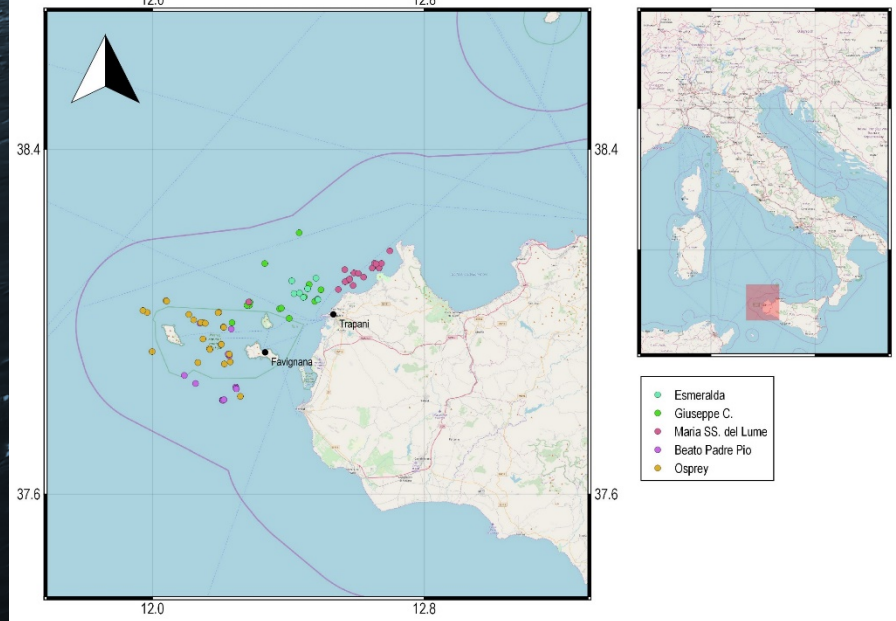


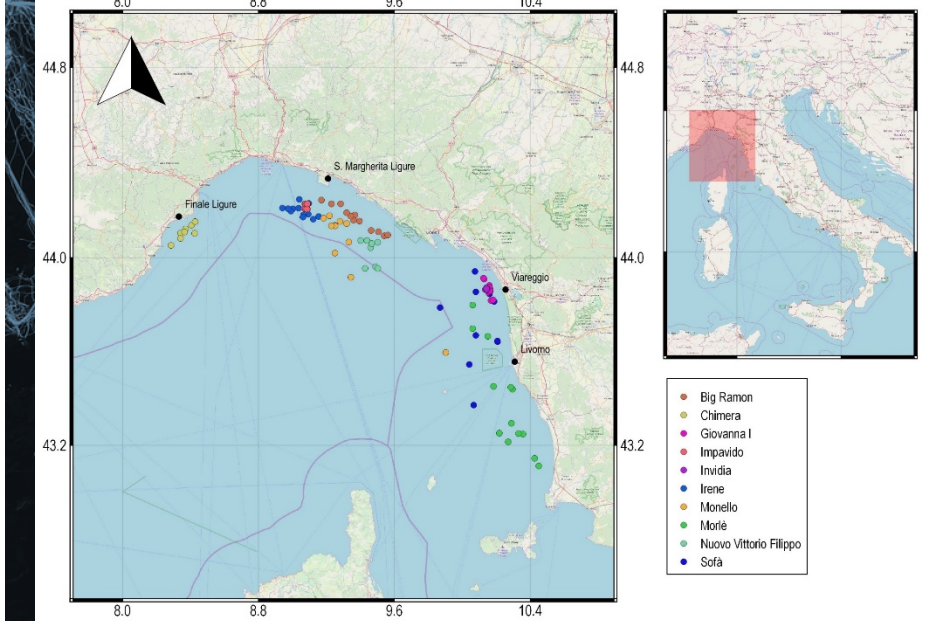
Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED



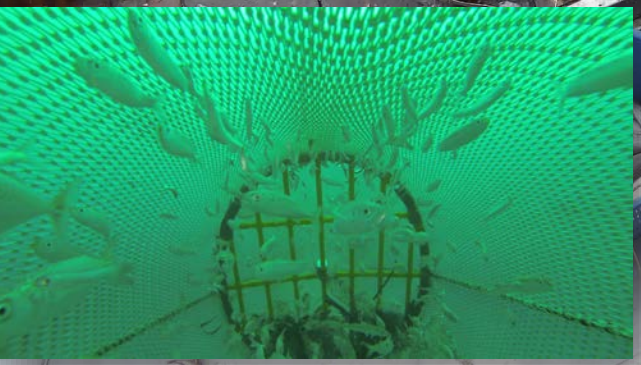


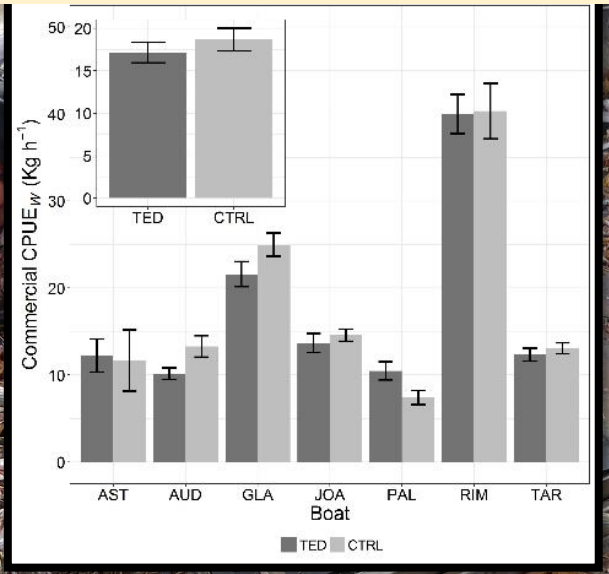


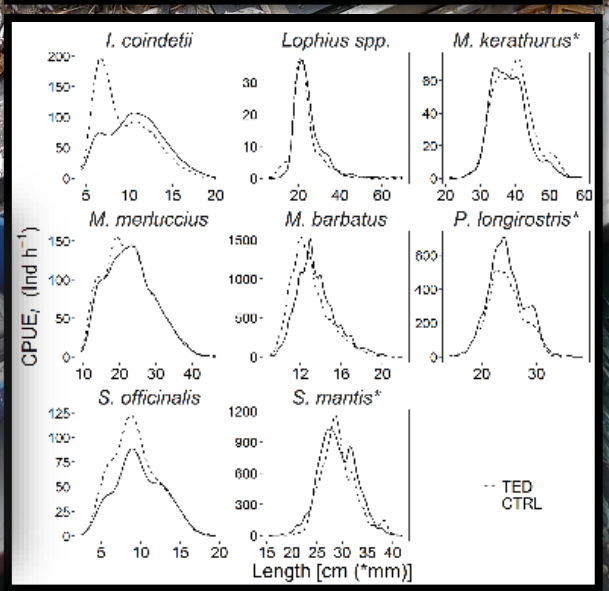


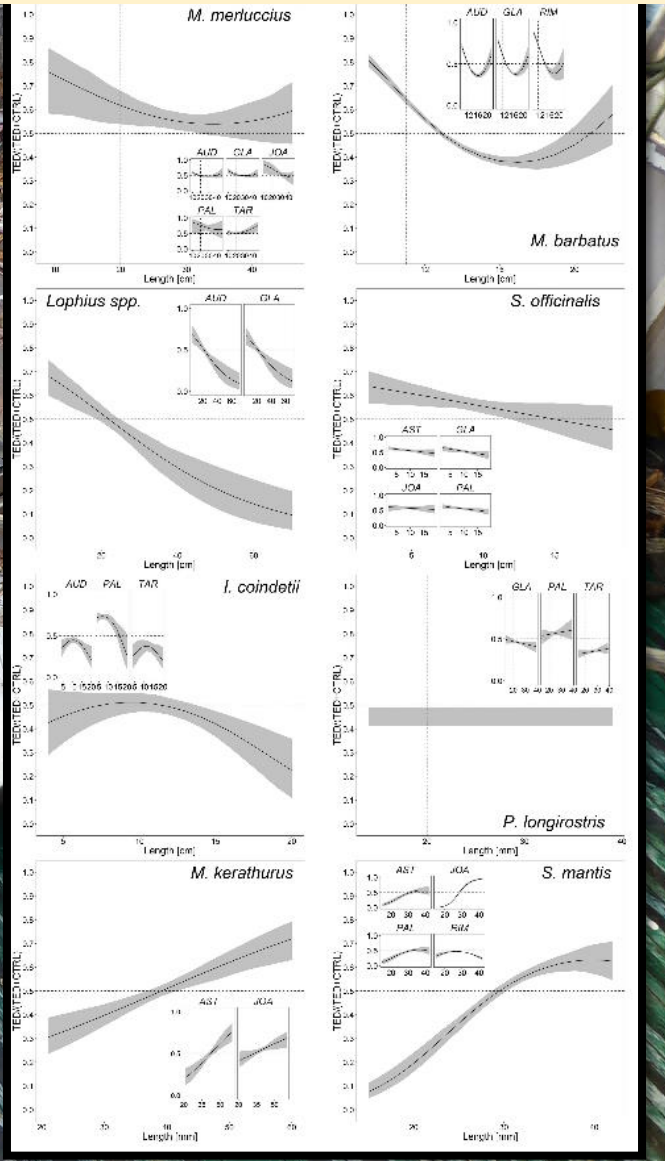
Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED



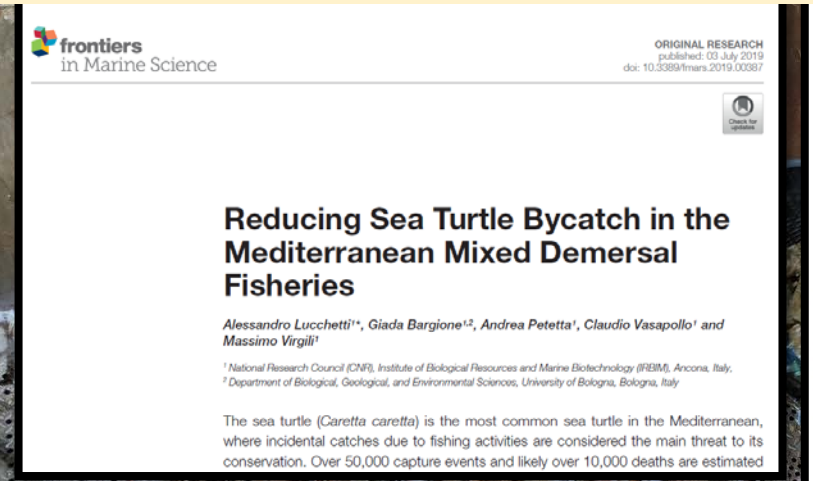






Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED



frontiers in Marine Science

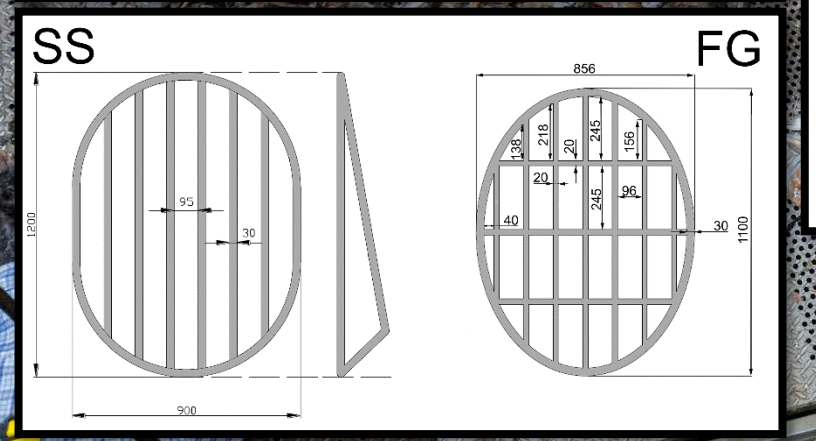
ORIGINAL RESEARCH
published: 03 July 2019
doi: 10.3389/fmars.2019.00387

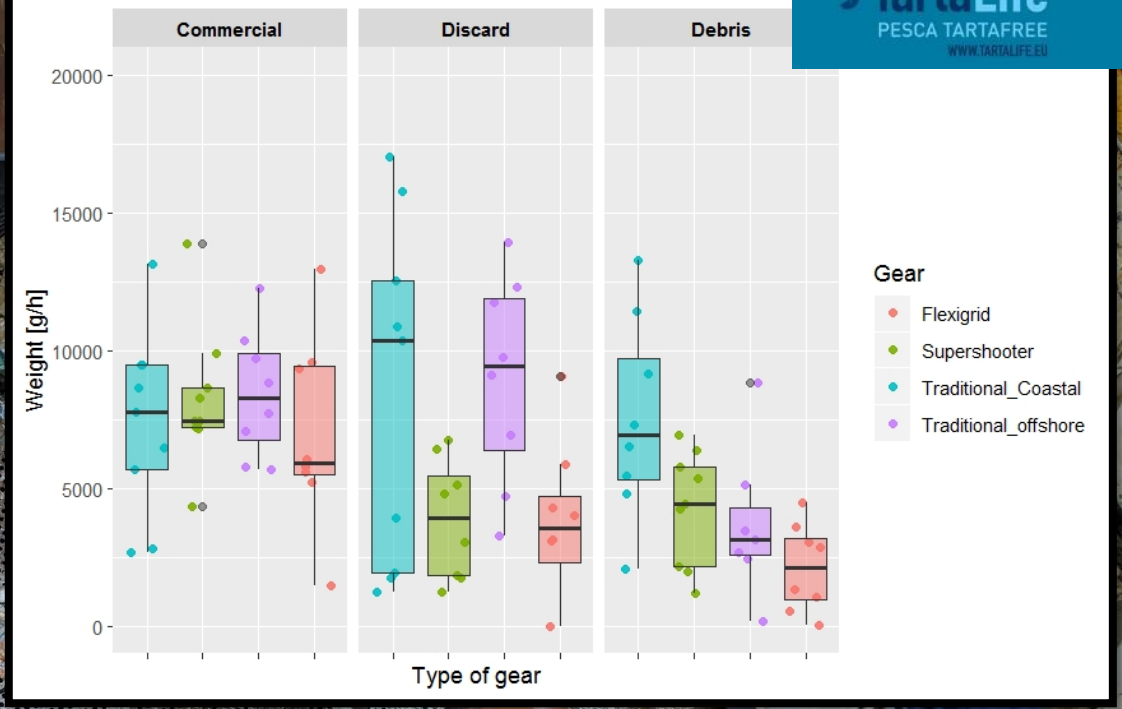
Reducing Sea Turtle Bycatch in the Mediterranean Mixed Demersal Fisheries

Alessandro Lucchetti[1], Giada Bargione[1,2], Andrea Petetta[1], Claudio Vasapollo[1] and Massimo Virgili[1]*

[1] National Research Council (CNR), Institute of Biological Resources and Marine Biotechnology (IRBIM), Ancona, Italy,
[2] Department of Biological, Geological, and Environmental Sciences, University of Bologna, Bologna, Italy

The sea turtle (*Caretta caretta*) is the most common sea turtle in the Mediterranean, where incidental catches due to fishing activities are considered the main threat to its conservation. Over 50,000 capture events and likely over 10,000 deaths are estimated



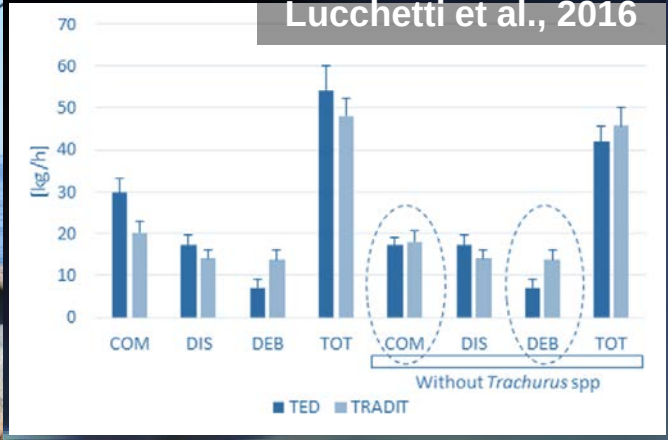


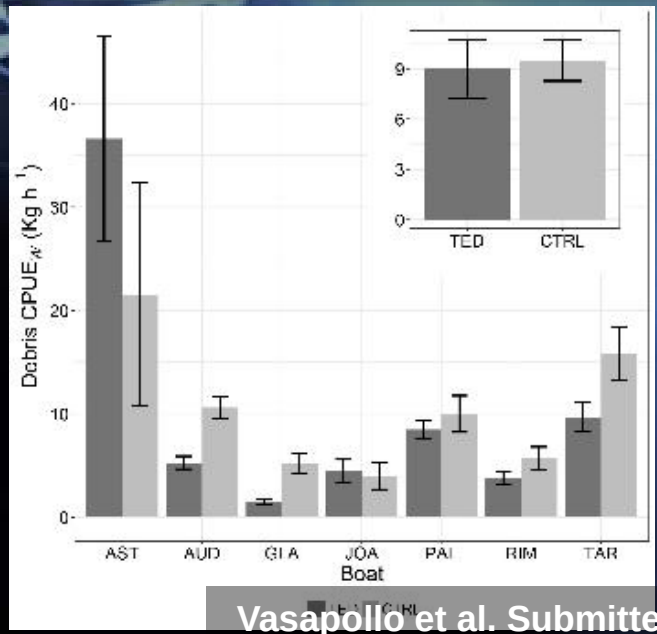
TartaLife
PESCA TARTAFREE
WWW.TARTALIFE.EU

Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED

Lucchetti et al., 2016





Vasapollo et al. Submitted

Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED

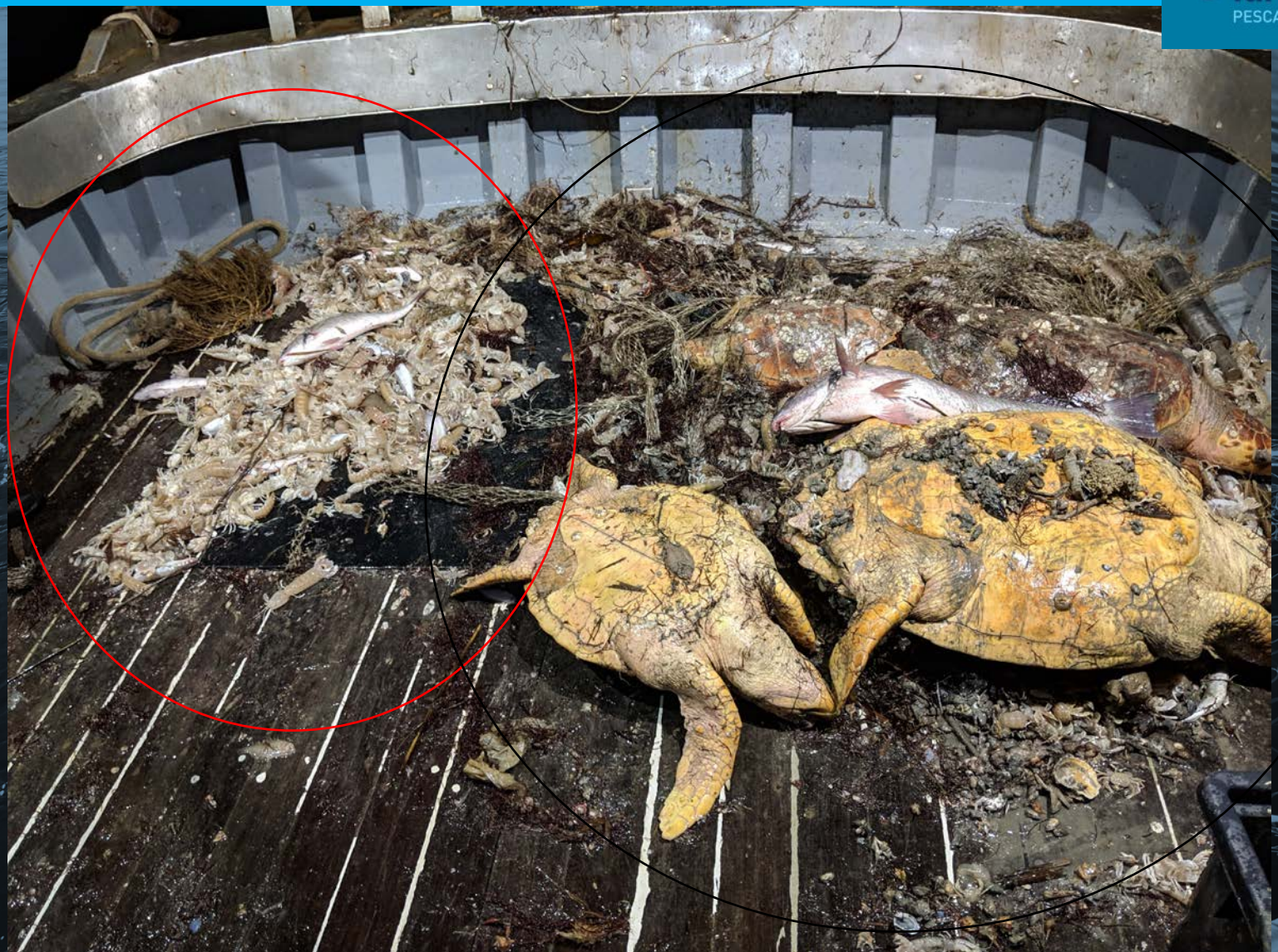
Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED

13 turtles caught without TED

Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED



Reducing turtle bycatch

Turtle Excluder Devices (TEDs): Flexible TED

CNR IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

NATIONAL BIODIVERSITY FUTURE CENTER

Manuale operativo per l'armamento e l'utilizzo di una *FLEXGRID* regolamentare per il Mediterraneo

NOAA

NOAA FISHERIES

NATURA 2000

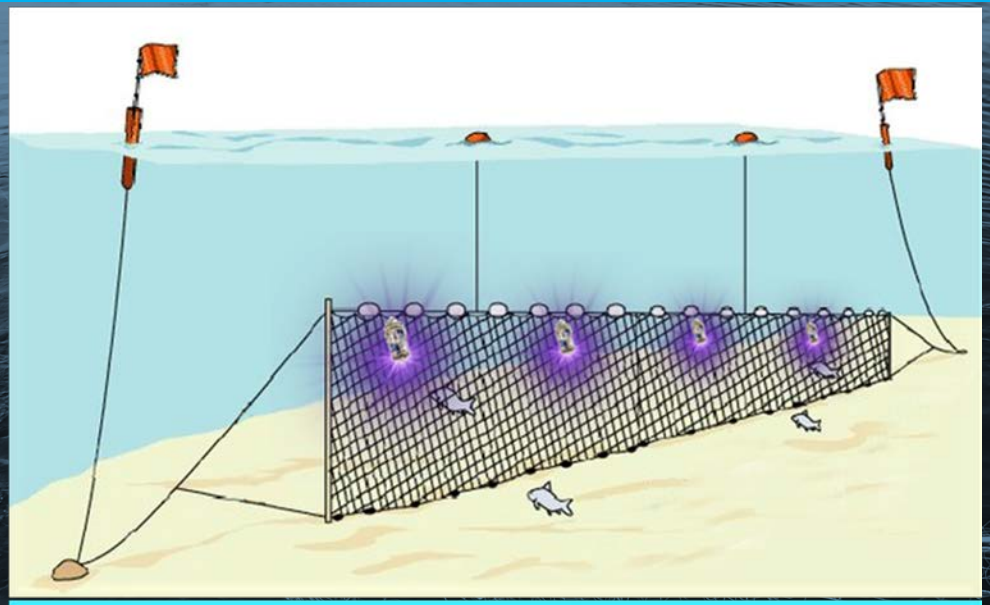
Life

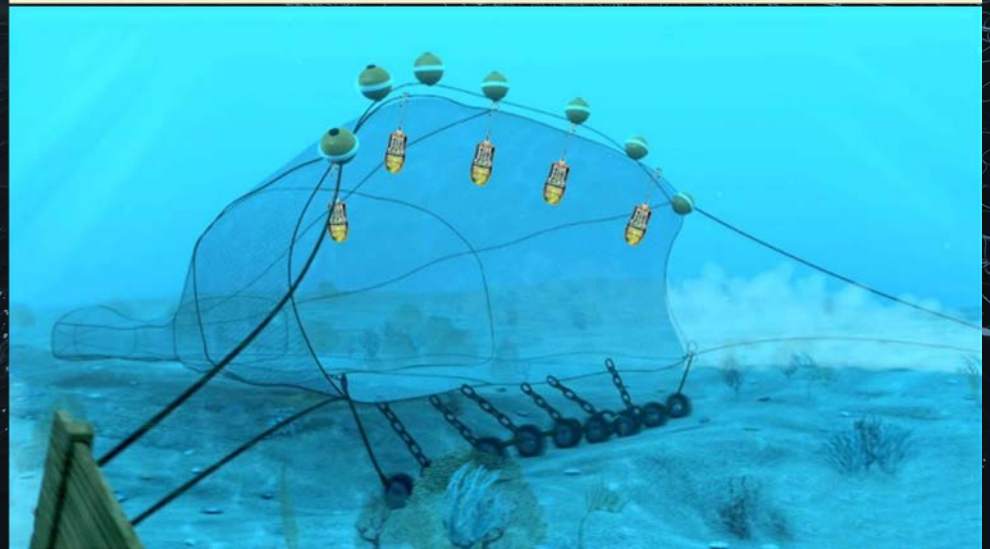
TartaLife

Reducing turtle bycatch

Visual deterrents

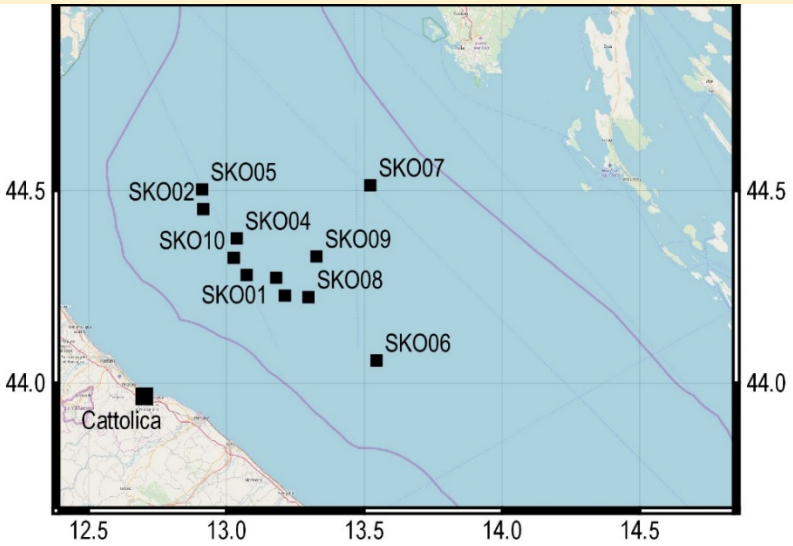
TartaLife
PESCA TARTAFREE
WWW.TARTALIFE.EU

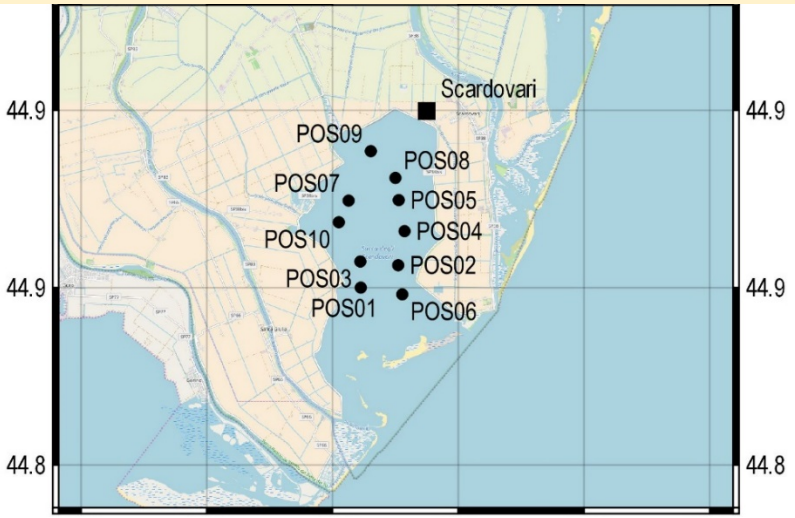


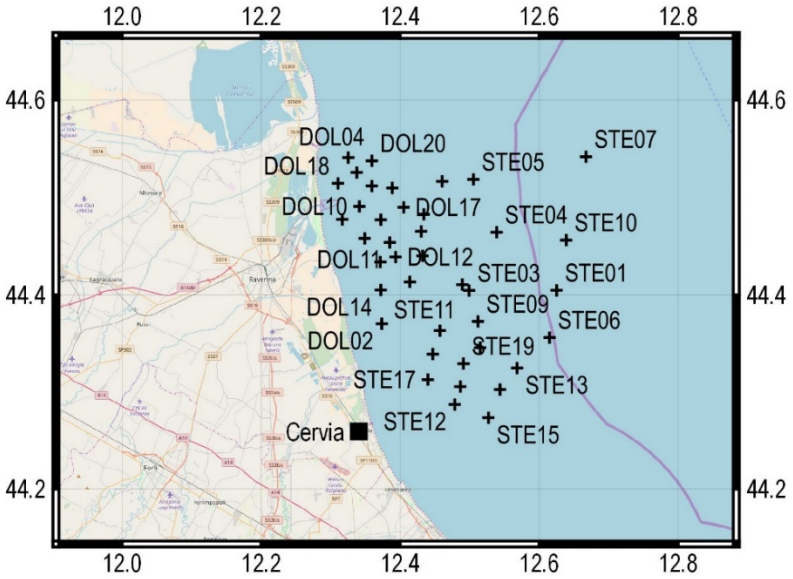


Reducing turtle bycatch

Visual deterrents



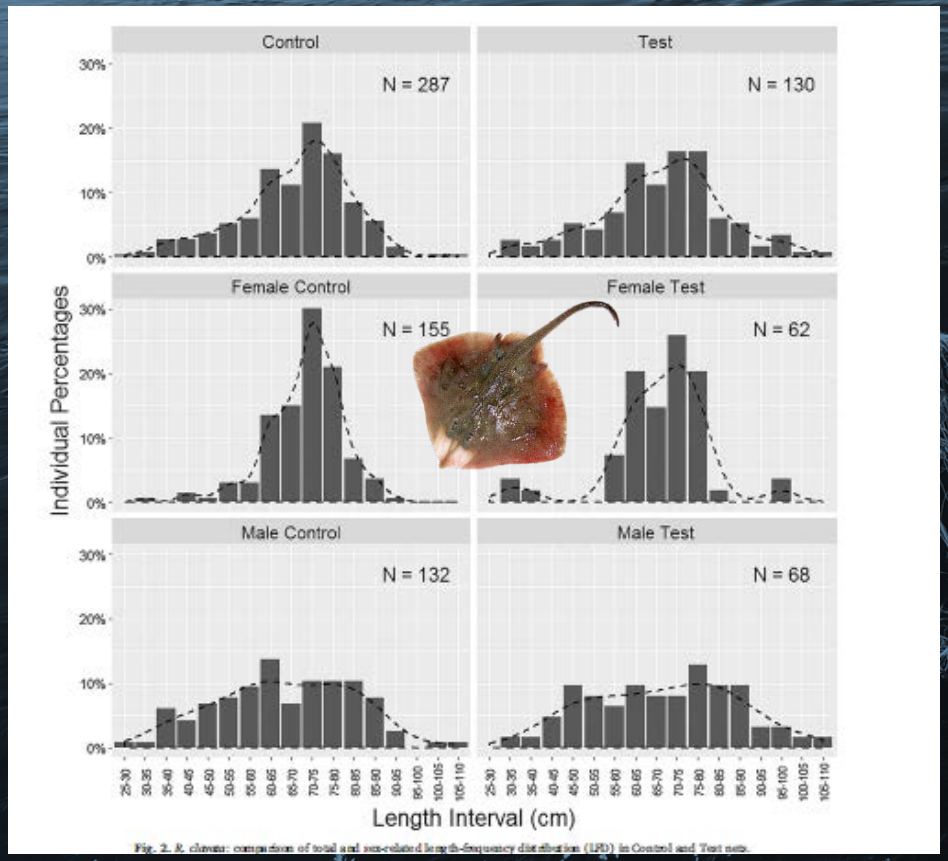




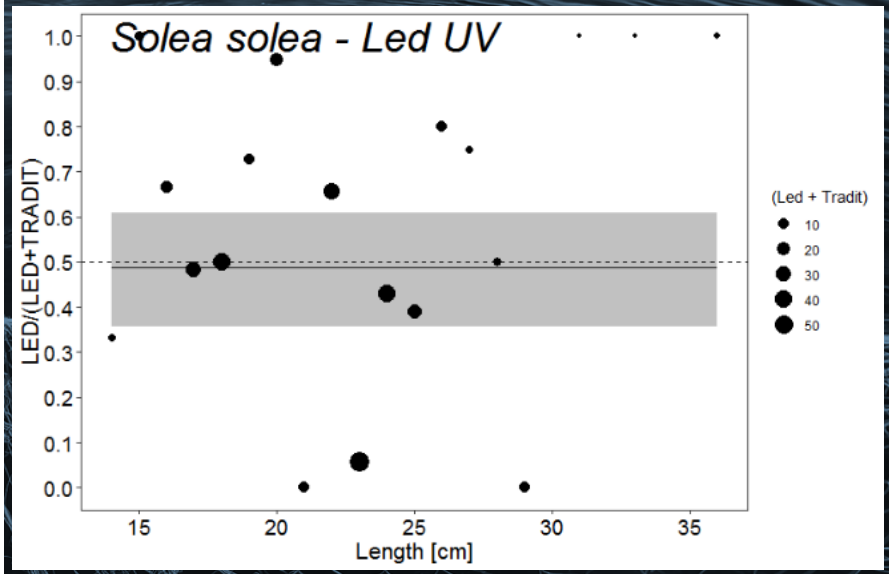
Reducing turtle bycatch

Visual deterrents

The results show that there is no significant difference between the catch performance of the gear in the presence or absence of LED-UV, with average catch amounts per haul for the cmmercial fraction being completely comparable.



Virgili et al. 2018



Lucchetti et al. 2019

Reducing turtle bycatch

Visual deterrents

All 11 turtles caught were caught in the absence of the light with a mortality rate of 30%.

Reducing bycatch

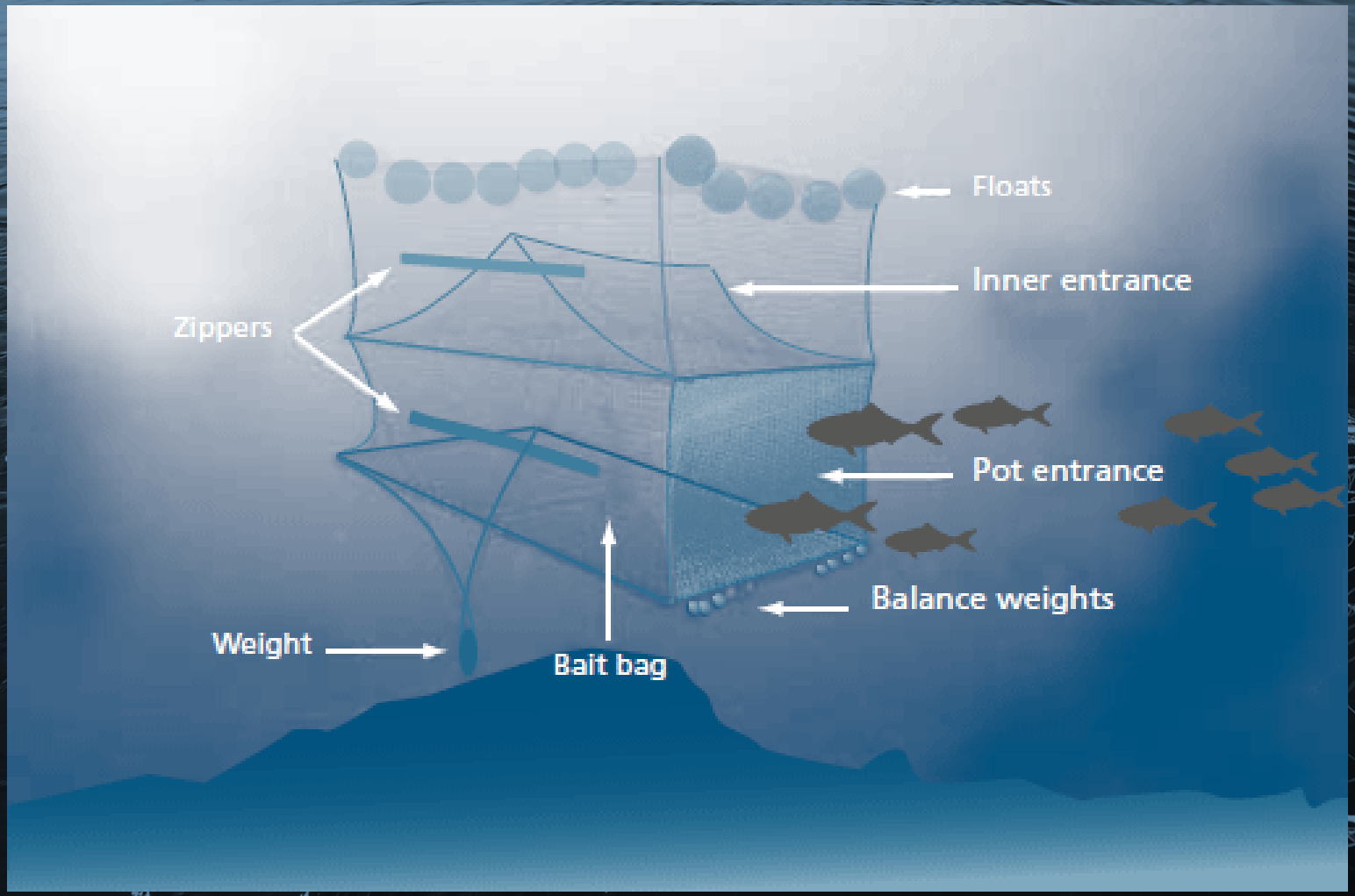
Alternative gears

More selective: pots

The main problem with the use of pot is the storage onboard and catch efficiency

Reducing bycatch

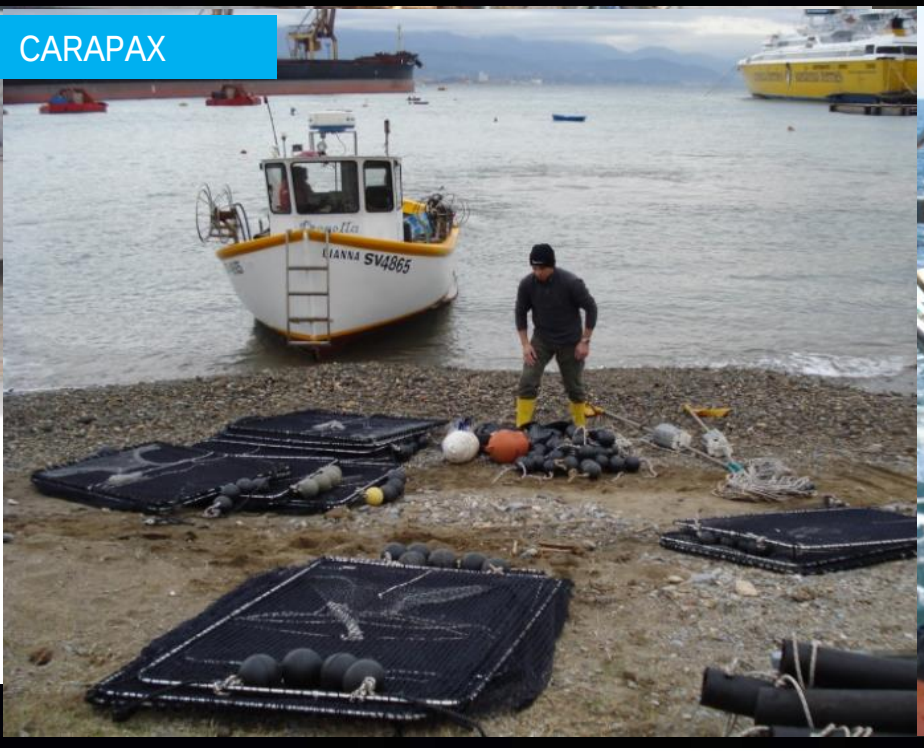
Foldable pots



Reducing turtle bycatch

Alternative gears

CARAPAX



TRAPULA

Reducing turtle bycatch

Alternative gears

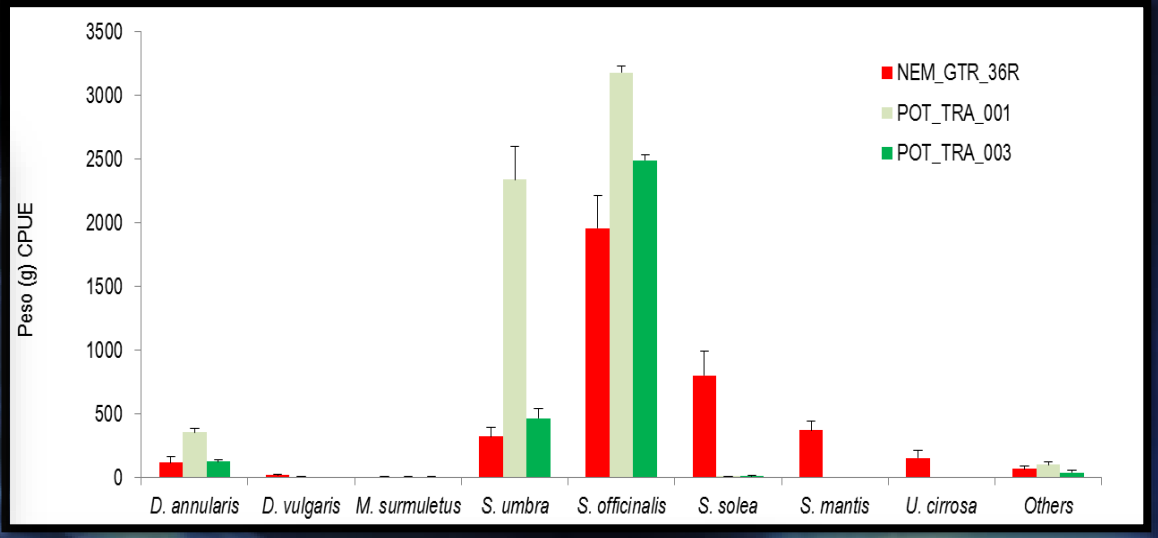
Small-single chamber

Big-single chamber

Big-triple chamber

Reducing turtle bycatch

Alternative gears

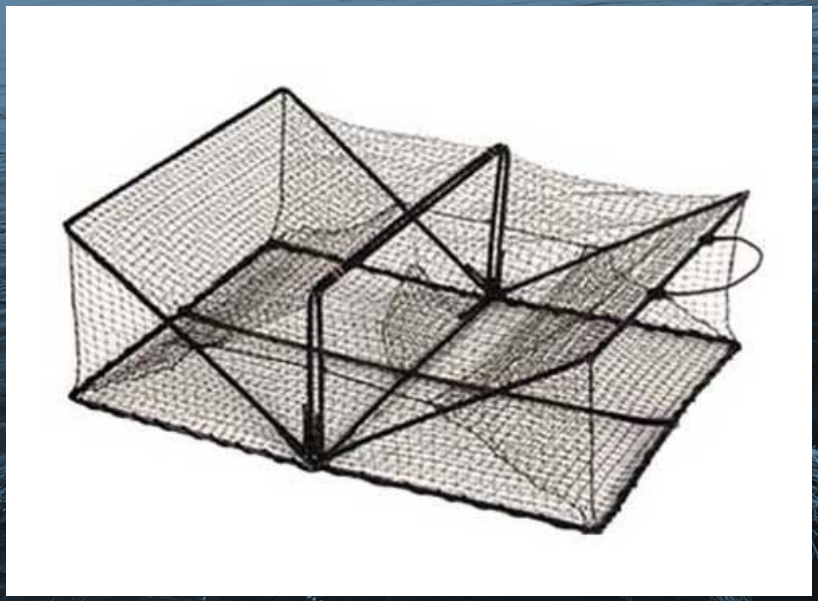


Reducing turtle bycatch

Alternative gears

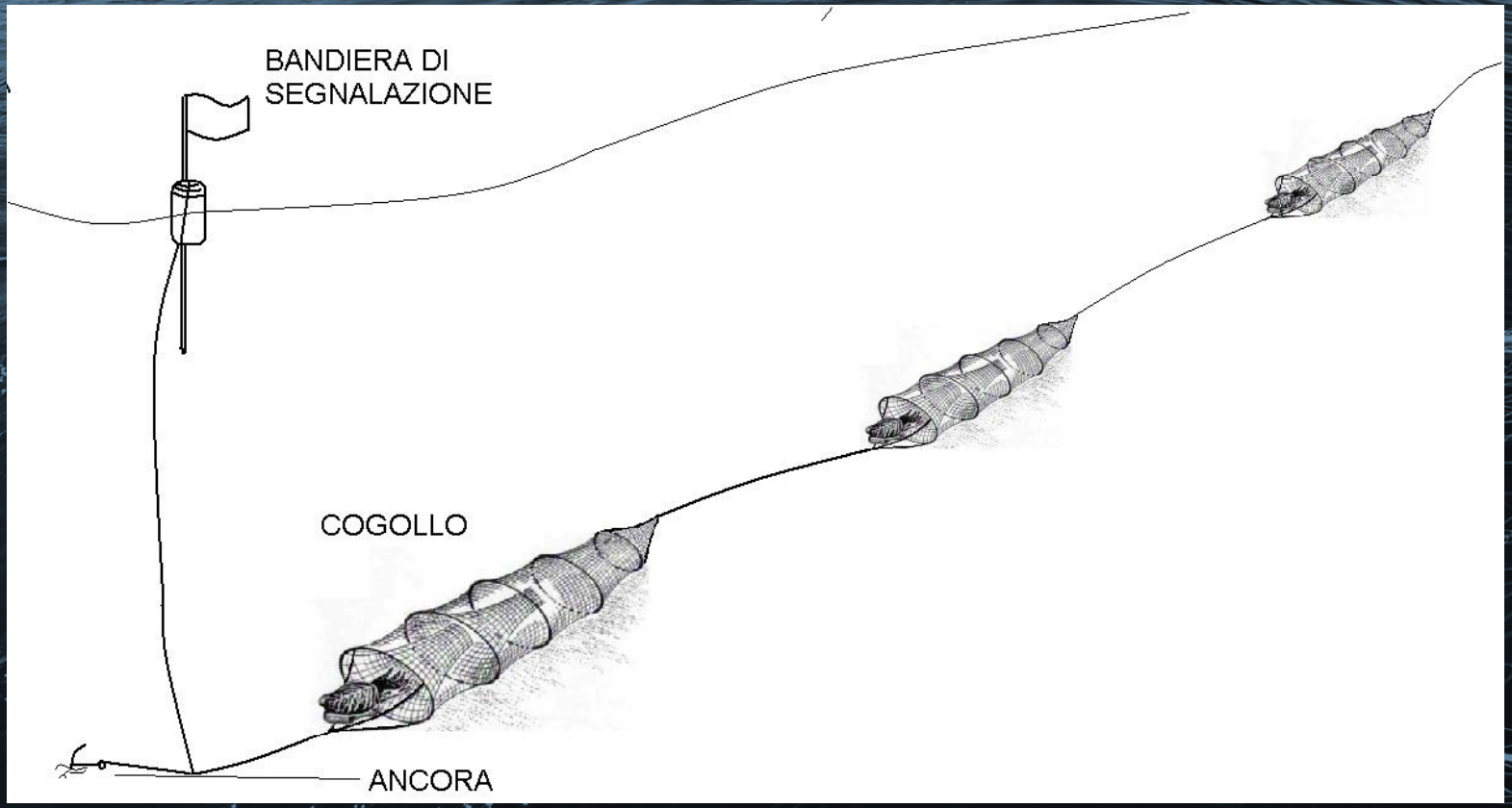
Reducing bycatch

Foldable pots



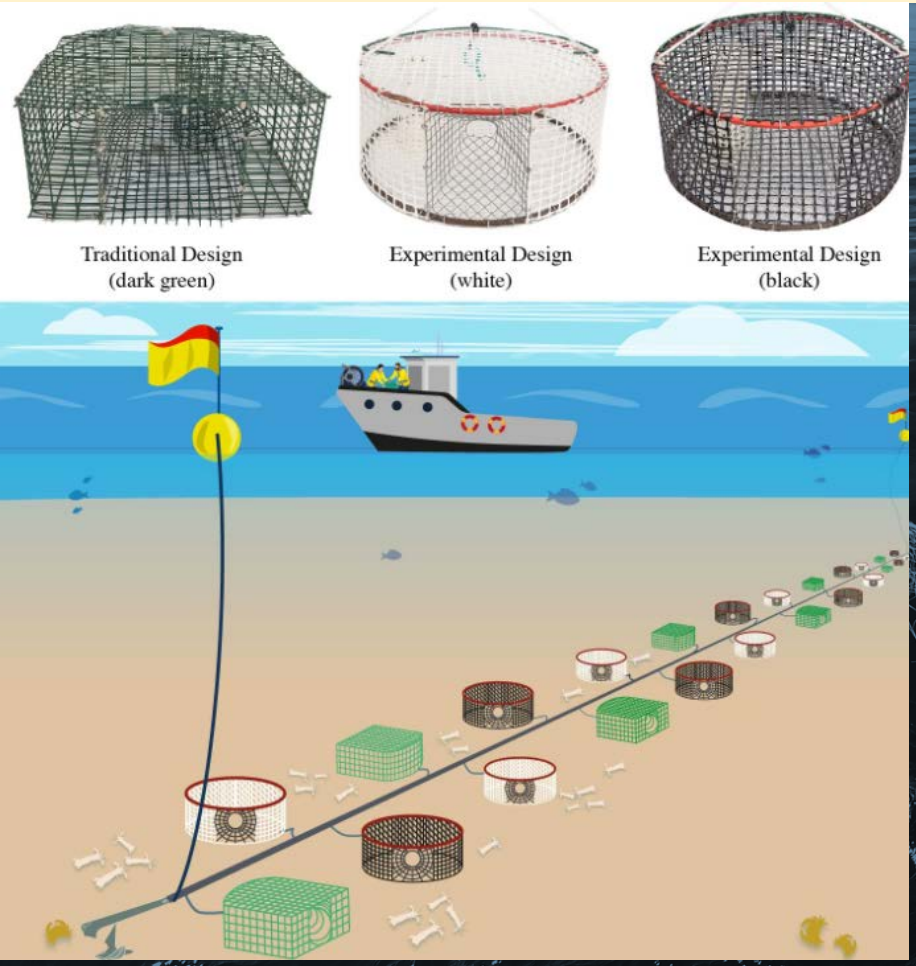
Reducing bycatch

Foldable pots



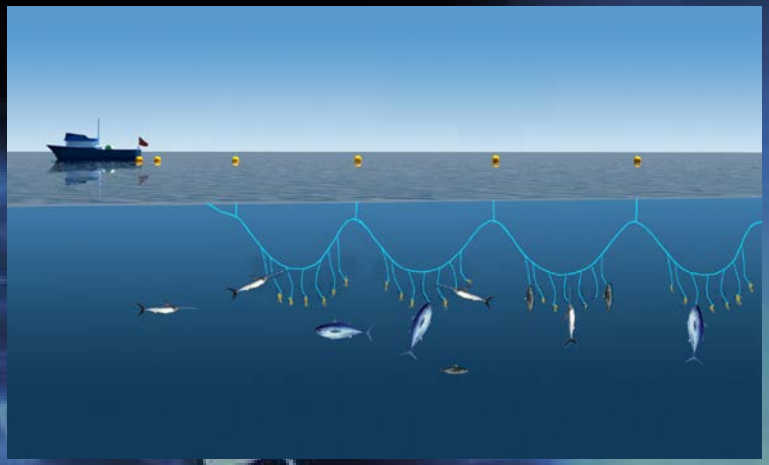
Reducing bycatch

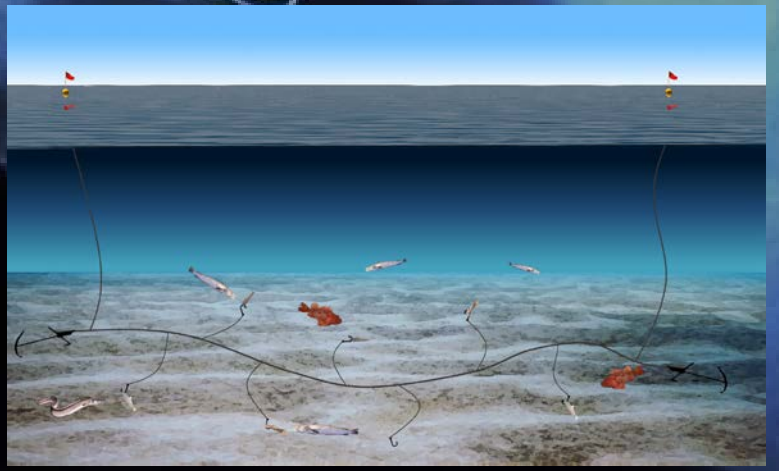
Alternative fishing gear



Reducing turtle bycatch

Longline

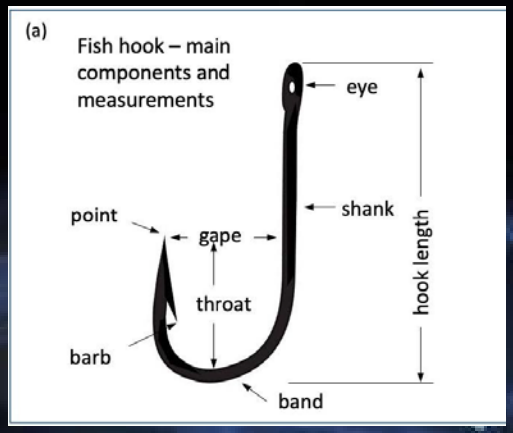




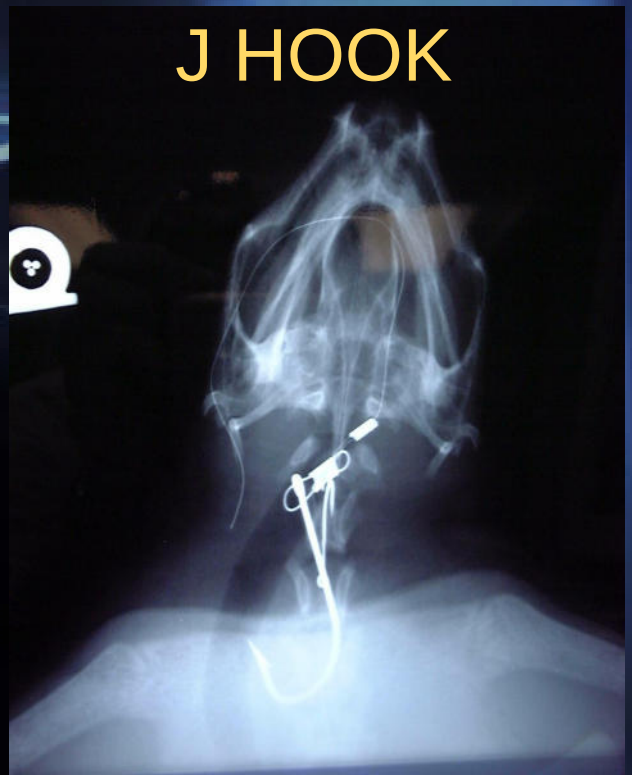
Reducing turtle bycatch

Hook shape: J hook vs CIRCLE hook

CIRCLE HOOK



J HOOK



Reducing turtle bycatch

Hook shape: J hook vs CIRCLE hook

Vol. 43: 517–542, 2020
https://doi.org/10.3354/esr01069
ENDANGERED SPECIES RESEARCH
Endang Species Res
Published December 17

REVIEW

Bycatch mitigation of protected and threatened species in tuna purse seine and longline fisheries

Yonat Swimmer[1,*], Erika A. Zollett[2], Alexis Gutierrez[3]

[1]NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, Hawaii 96818, USA
[2]Environmental Leadership Incubator, University of California, Santa Barbara, California 93106, USA
[3]NOAA Fisheries, Office of Protected Resources, Silver Spring, Maryland 20910, USA

- Variable depending on hook size and species
- Large circle hooks (16/0 or greater) and whole finfish bait reduced sea turtle bycatch and the deep ingestion in the gut of hooks when compared to J and tuna hooks with squid bait

Reducing turtle bycatch

Hook size: selectivity

11-03 **SWO**

RECOMMENDATION FOR MANAGEMENT MEASURES FOR MEDITERRANEAN SWORDFISH IN THE FRAMEWORK OF ICCAT

Technical characteristics of the fishing gear

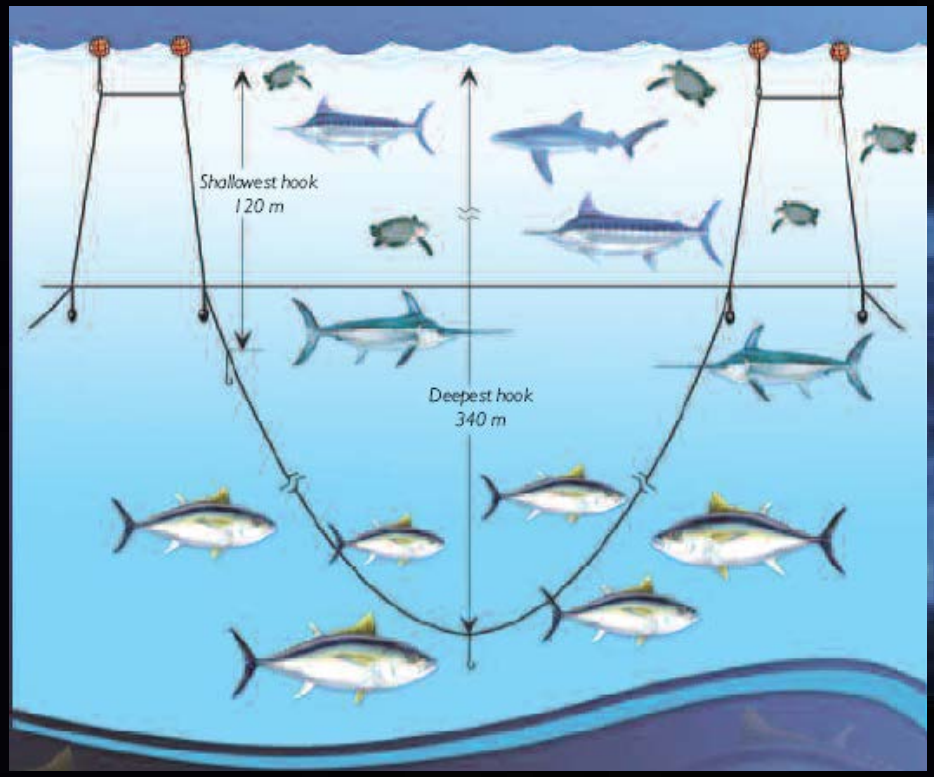
9. The maximum number of hooks that can be set or taken on board of vessels targeting swordfish should be fixed at 2800 hooks for swordfish fishery. A second set of rigged hooks may be allowed on board for trips longer than 2 days provided that are duly lashed and stowed in lower decks so that it may not readily be used.

10. Hook size should never be smaller than 7 cm of height for fishing targeting swordfish.

11. The length of the pelagic longlines will be of maximum 30 NM (55 km).

Reducing turtle bycatch

Depth setting



- Sea turtles spend the majority of their time in the upper column (<~40 m) which explains why rates of interactions in shallow-set longline fisheries are an order of magnitude higher than on deep-set gear (Gilman et al.2006)

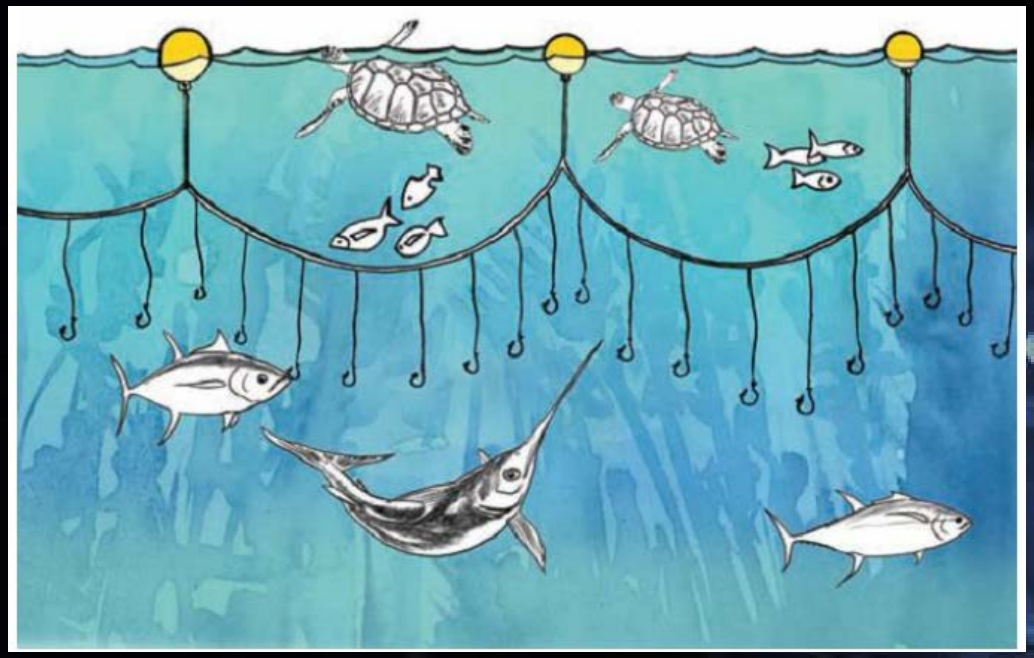
SCRS/2014/100 Collect. Vol. Sci. Pap. ICCAT, 71(5): 2006-2014 (2015)

EFFECTS OF THE INTRODUCTION OF THE MESOPELAGIC LONGLINE ON CATCHES AND SIZE STRUCTURE OF SWORDFISH IN THE LIGURIAN SEA (WESTERN MEDITERRANEAN)

Fulvio Garibaldi[1]

Reducing turtle bycatch

Shallow waters: Reducing tyme setting, daytime setting



- Reducing soak duration
- Limiting retrieval during daylight
- Night setting (also effective wit seabirds)

Vol. 43: 517–542, 2020
https://doi.org/10.3354/esr01069

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Bycatch mitigation of protected and threatened species in tuna purse seine and longline fisheries

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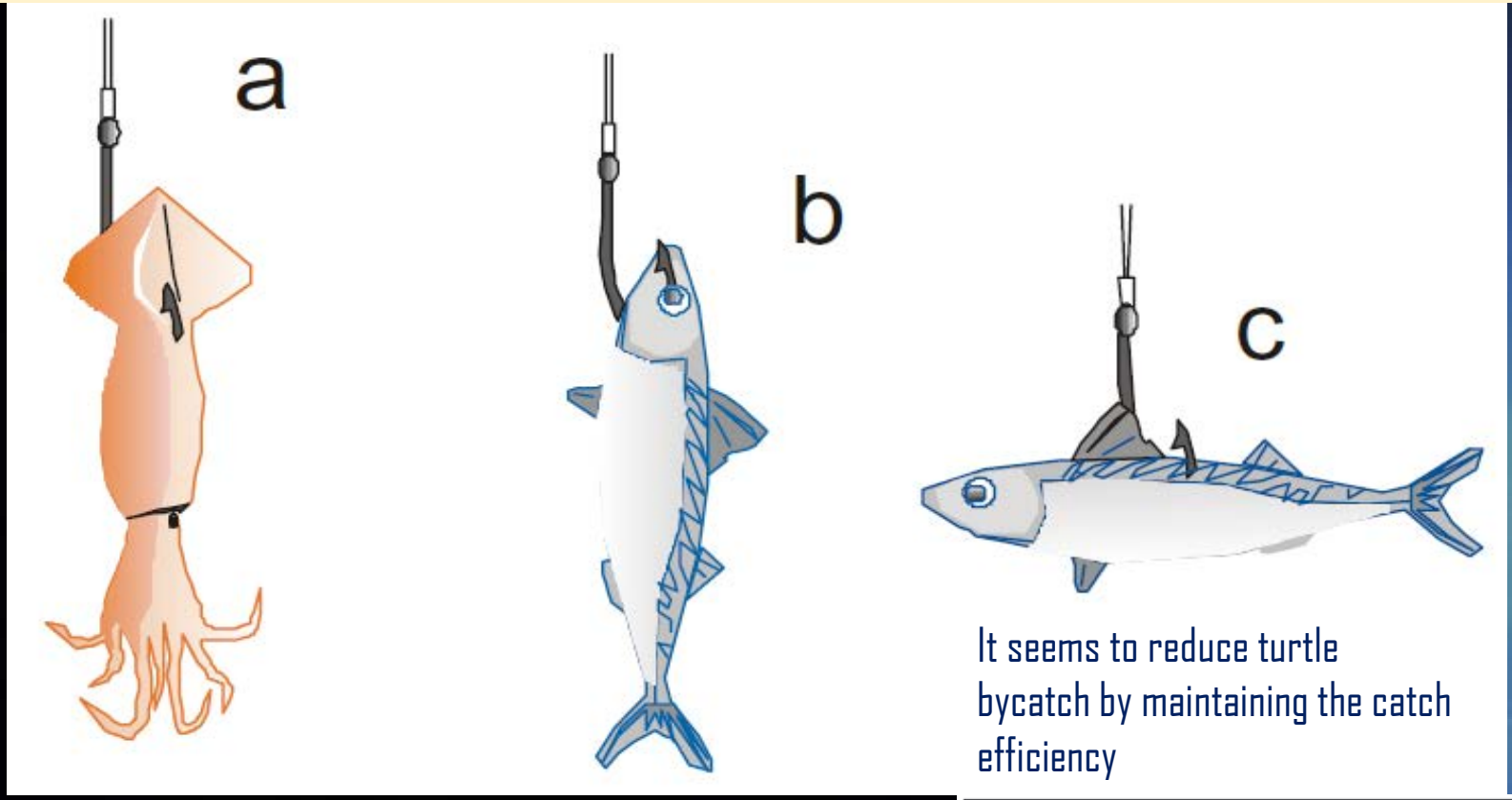
Reducing turtle bycatch

Bait type



It seems to reduce turtle bycatch by maintaining the catch efficiency

Different types of bait:
a) Squid; b) mackerel (vertical set); c) mackerel (horizontal set)

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Reducing elasmobranch bycatch

Shark Excluder Devices (SEDs)

Reducing elasmobranch bycatch

Shark Excluder Devices (SEDs)

Estuarine, Coastal and Shelf Science 296 (2024) 108594

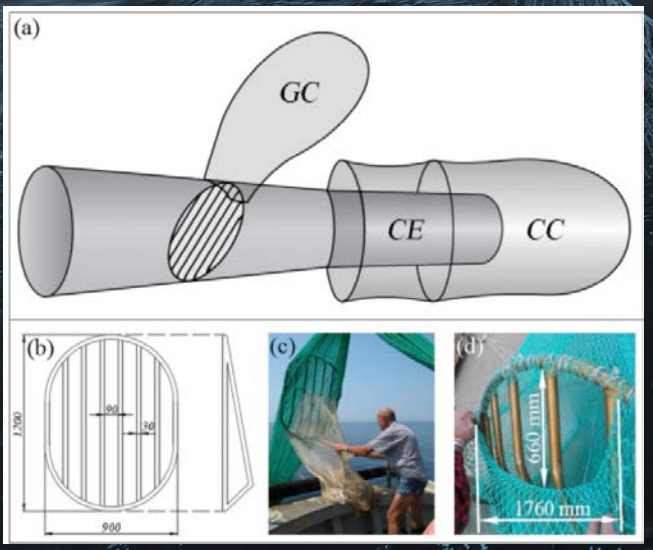
Contents lists available at ScienceDirect

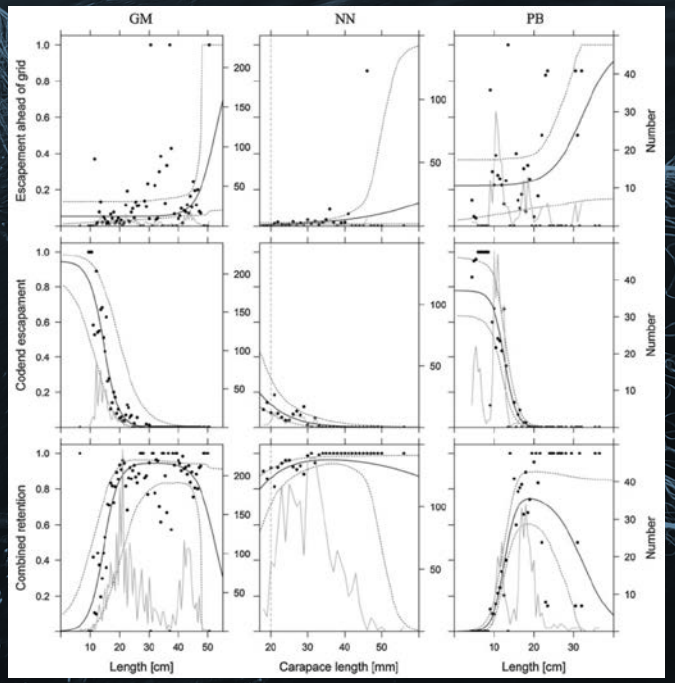
Estuarine, Coastal and Shelf Science

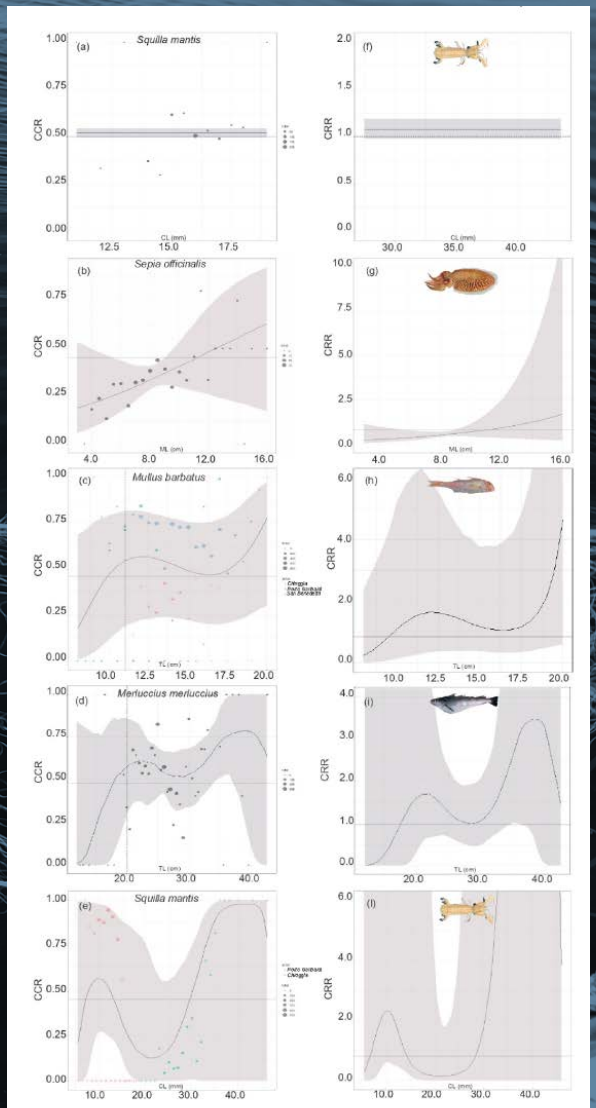
journal homepage: www.elsevier.com/locate/ecss

Performance of sorting grids on catching elasmobranchs in a multispecies Mediterranean bottom trawl fishery

Lorenzo Jacopo De Santis [a,1], Sara Bonanomi [a,*,1], Elia Bueloni [b], Andrea Petetta [a], Olga Annibale [c], Licia Finotto [d], Claudio Vasapollo [a], Carlotta Mazzoldi [d], Alessandro Lucchetti [a], Massimiliano Bottaro [e]

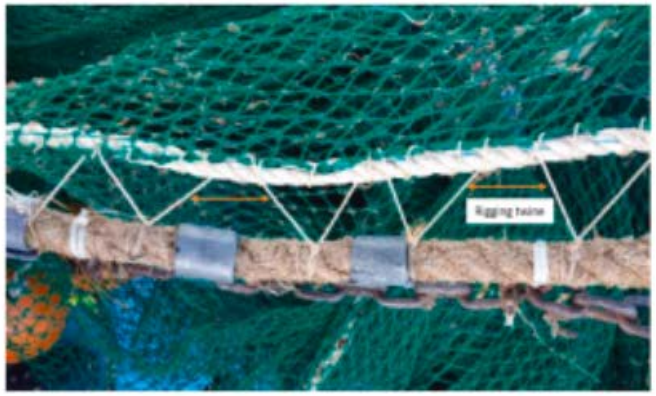


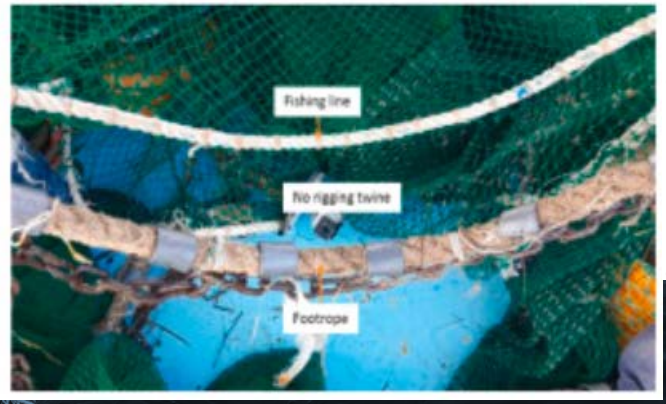




Reducing elasmobranch bycatch

Raised footrope



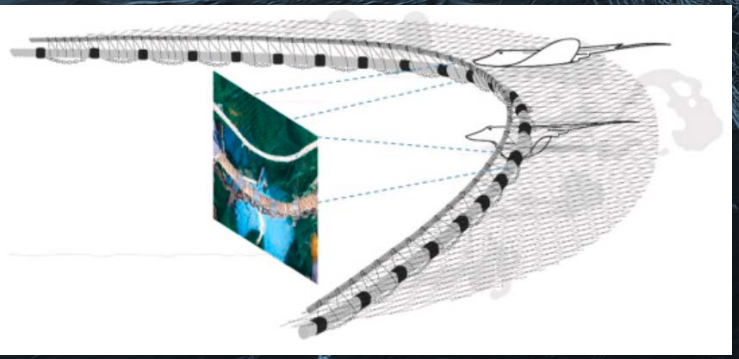


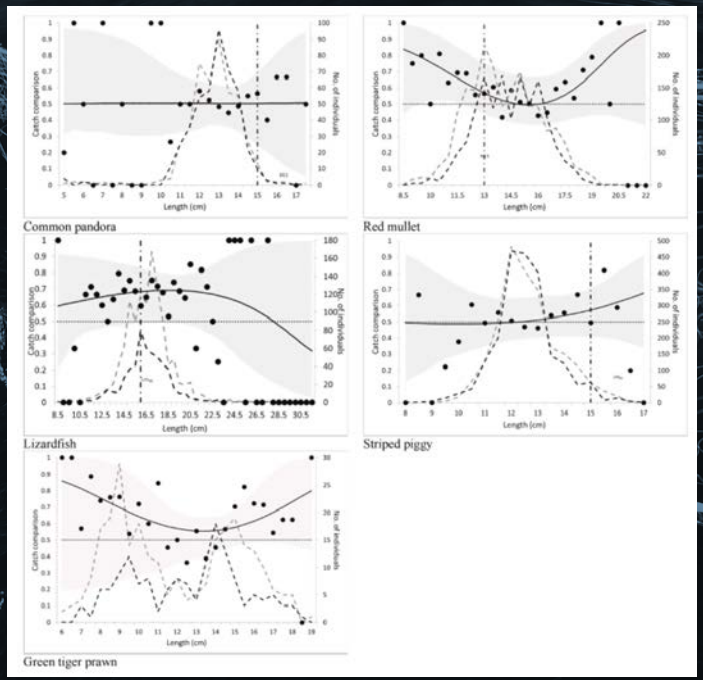
ELSEVIER

Ocean & Coastal Management
Volume 223, 15 May 2022, 106134

Effect of ground gear modification on bycatch of rays in mediterranean bottom trawl fishery

Y.E. Fakıoğlu [a], H. Özbilgin [b c], G. Gökçe [d], B. Herrmann [e f g]





Reducing elasmobranch bycatch

Longlines: Repelling shark magnet

(*from Sacchi*)

ELSEVIER

Fisheries Research

Volume 172, December 2015, Pages 345-351

Hooks equipped with magnets can increase catches of blue shark (*Prionace glauca*) by longline fishery

Sebastián Biton Porsmoguer [a], Daniela Bănaru [a], Charles F. Boudouresque [a], Ivan Dekeyser [a], Christophe Almarcha [b]

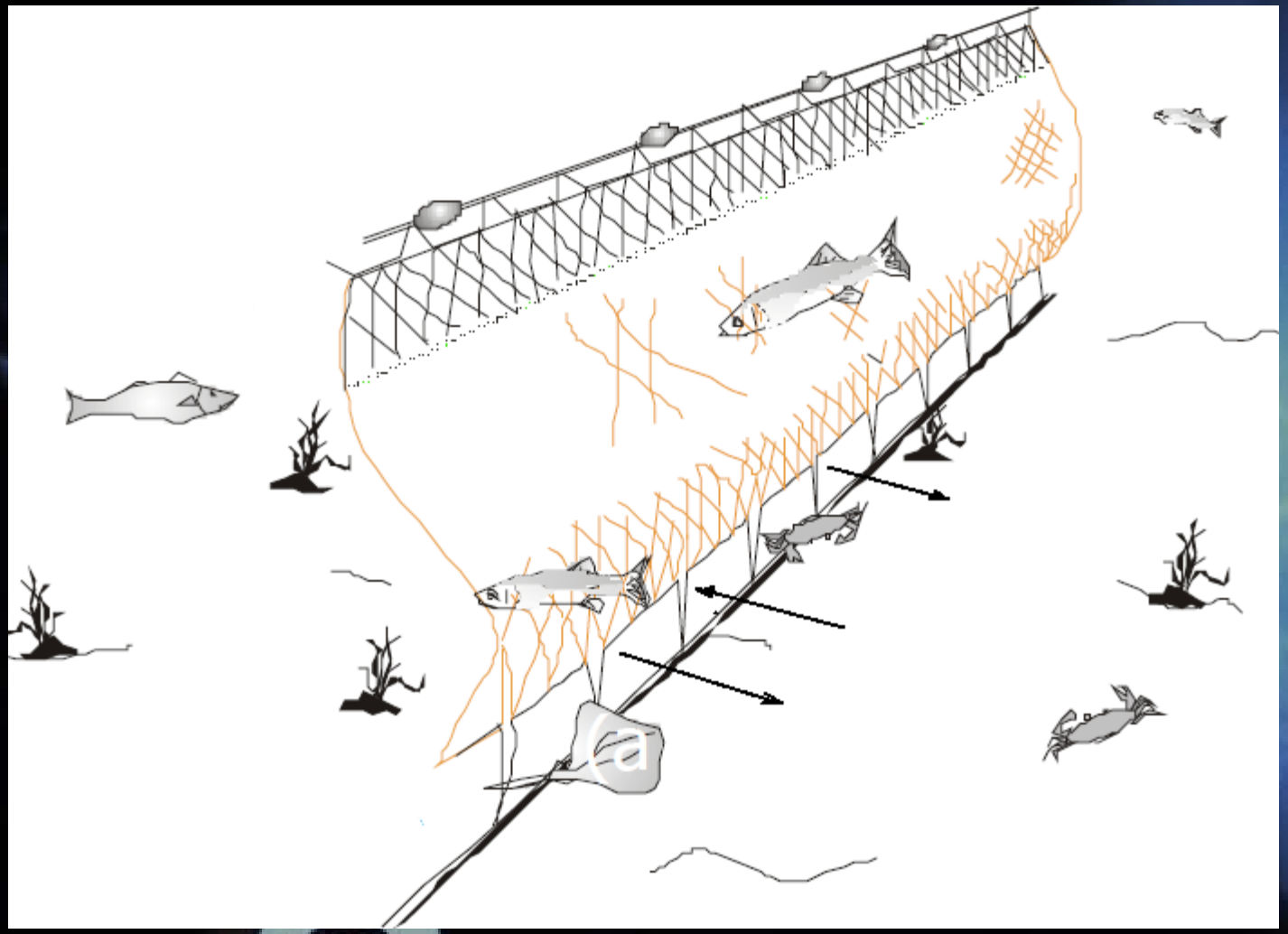
Reducing elasmobranch bycatch

Longlines

- Monofilament instead of wire leaders: potentially effective
- Circle hook: efficacy depends on species and area
- Reducing soak duration

Reducing elasmobranch bycatch

Passive nets: raised footrope

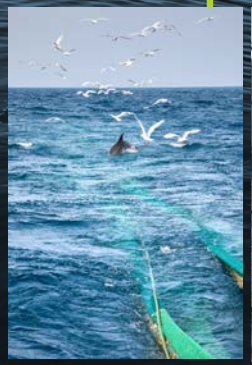


Marine mammals

Main issues

Bycatch

Depredation



Marine mammals

Main issues

Bycatch

Ingestion of net: Delayed mortality

Depredation

Catch damage

Marine mammals

Main issues

Economic loss up to 10K €

diversity
MDPI
Article

Fishers' Perception on the Interaction between Dolphins and Fishing Activities in Italian and Croatian Waters

Daniel Li Veli [1,*], Andrea Petetta [1], Giulio Barone [1], Ilaria Ceciarini [2], Enrica Franchi [3], Letizia Marsili [2,3], Guido Pietroluongo [4], Carlotta Mazzoldi [5], Draško Holcer [6,7], Stanislao D'Argenio [8], Sergio Guccione [9], Rosa Linda Testa [10], Monica Francesca Blasi [11], Maria Francesca Cinti [12], Salvatore Livreri Console [13], Ilaria Rinaudo [13] and Alessandro Lucchetti [1]

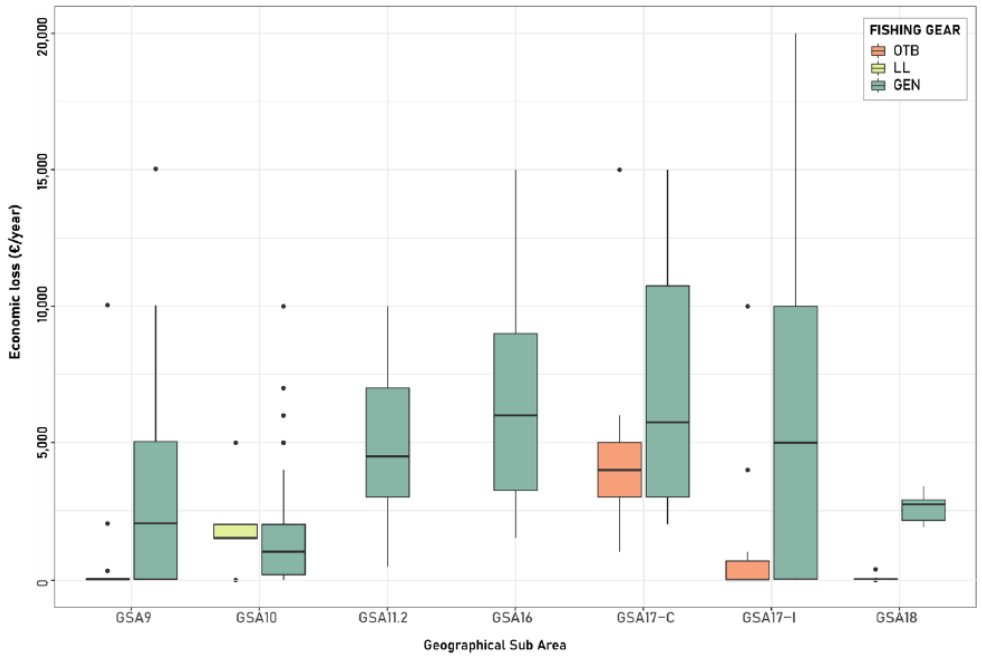


Figure 4. Estimated annual cost of damages caused by dolphins organized by area and type of fishing gear (set nets: GEN, bottom trawl: OTB, longlines: LL).

Marine mammals

Main issues

Interaction probability

diversity
MDPI
Article

Fishers' Perception on the Interaction between Dolphins and Fishing Activities in Italian and Croatian Waters

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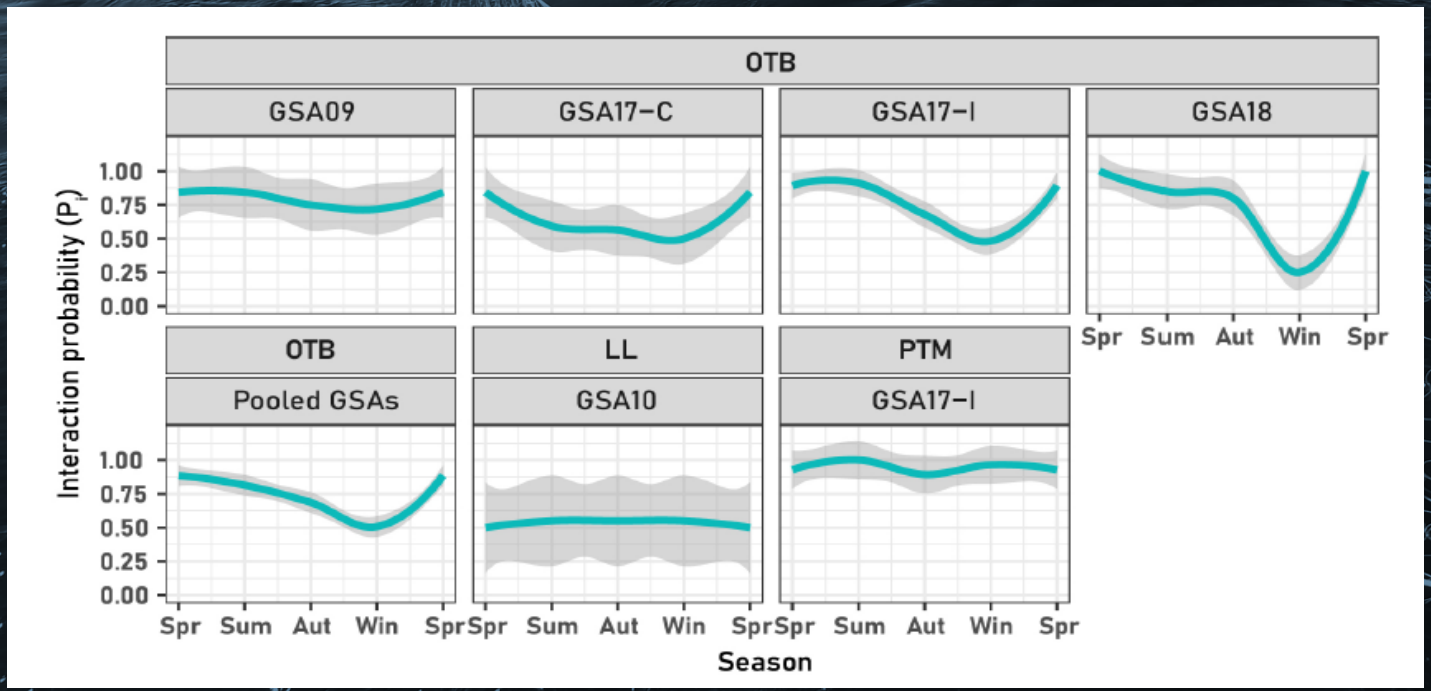
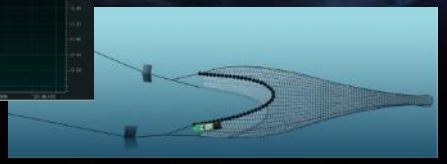


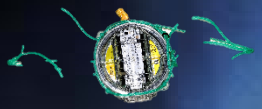
Marine mammals

Impatti specie vulnerabili: delfini

Dissuasori acustici



Dissuasori luminosi

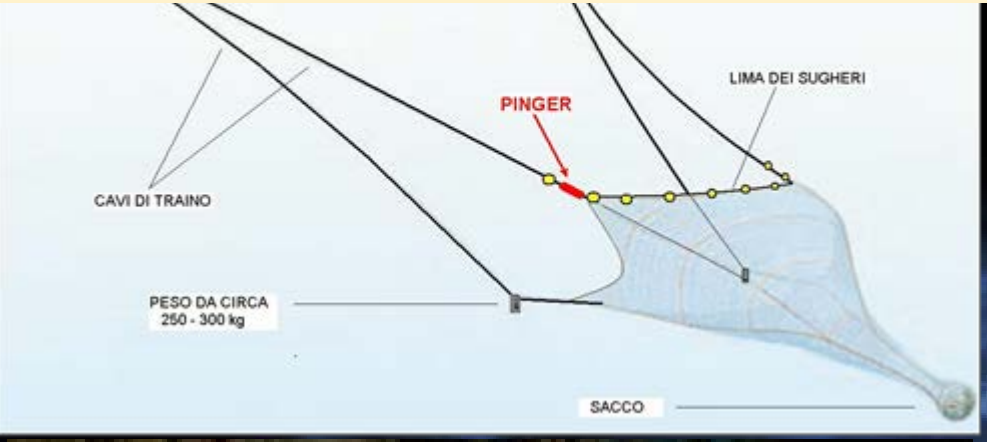


Reducing marine mammals bycatch

Acoustic deterrents

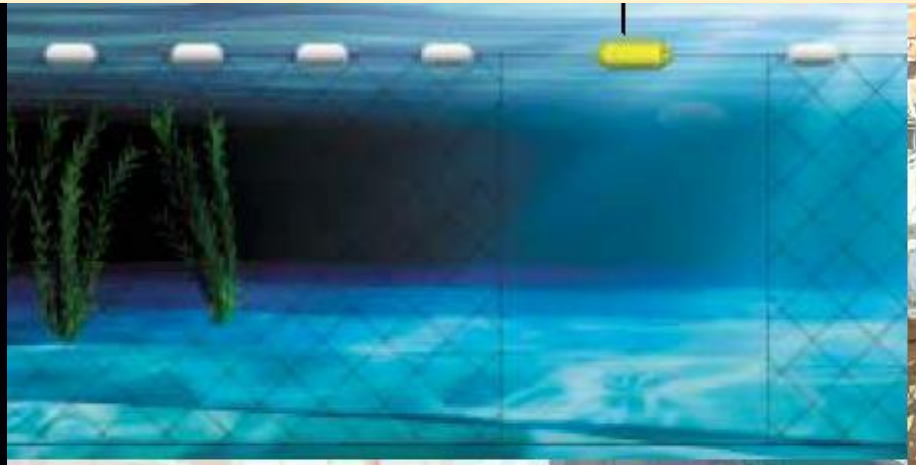
Reducing marine mammals bycatch

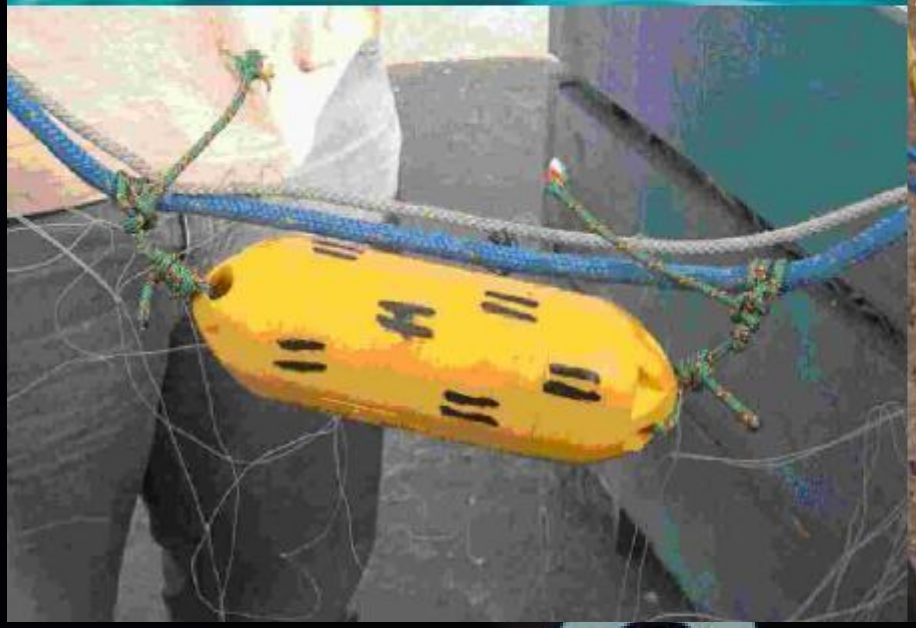
Acoustic deterrents



Reducing marine mammals bycatch

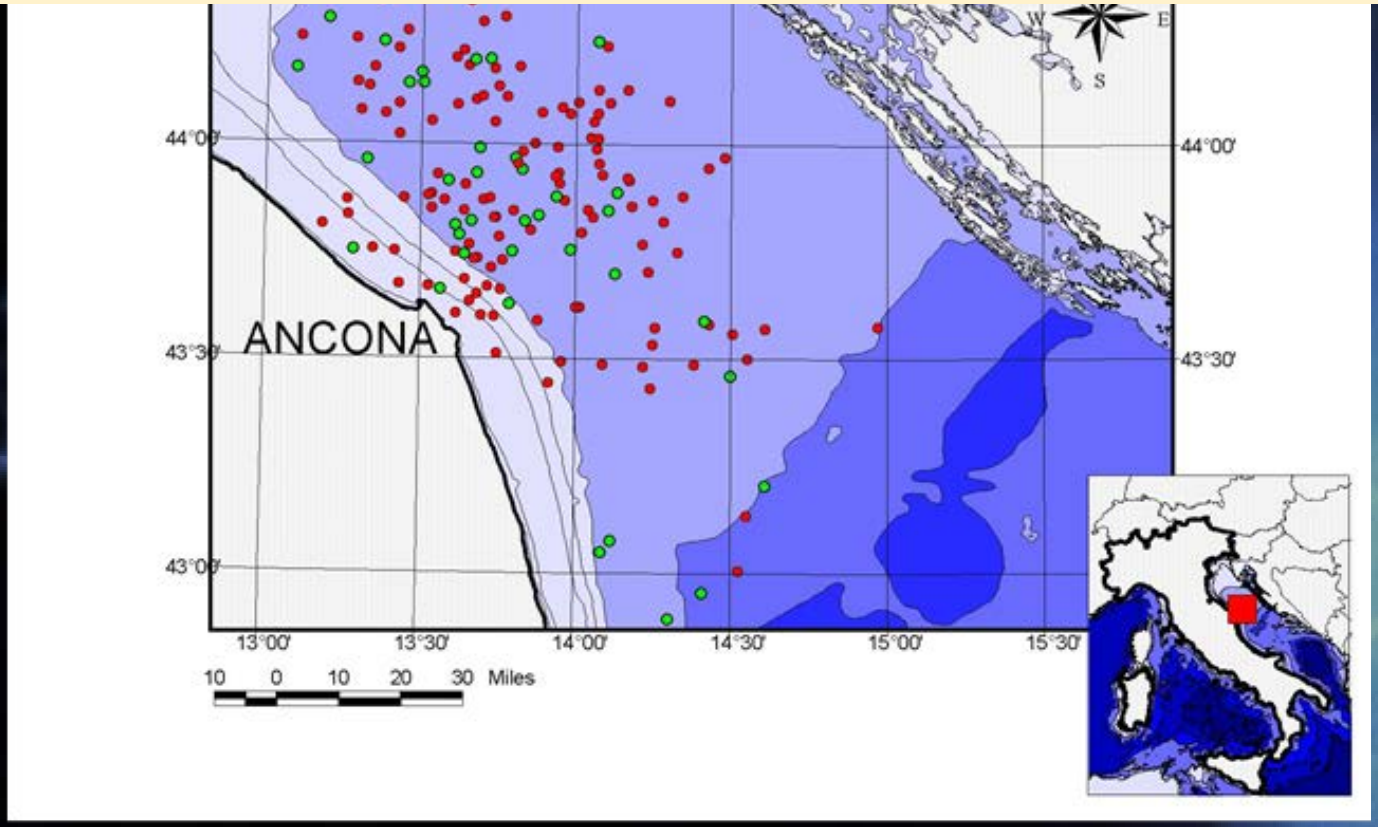
Acoustic deterrents





Reducing marine mammals bycatch

Acoustic deterrents



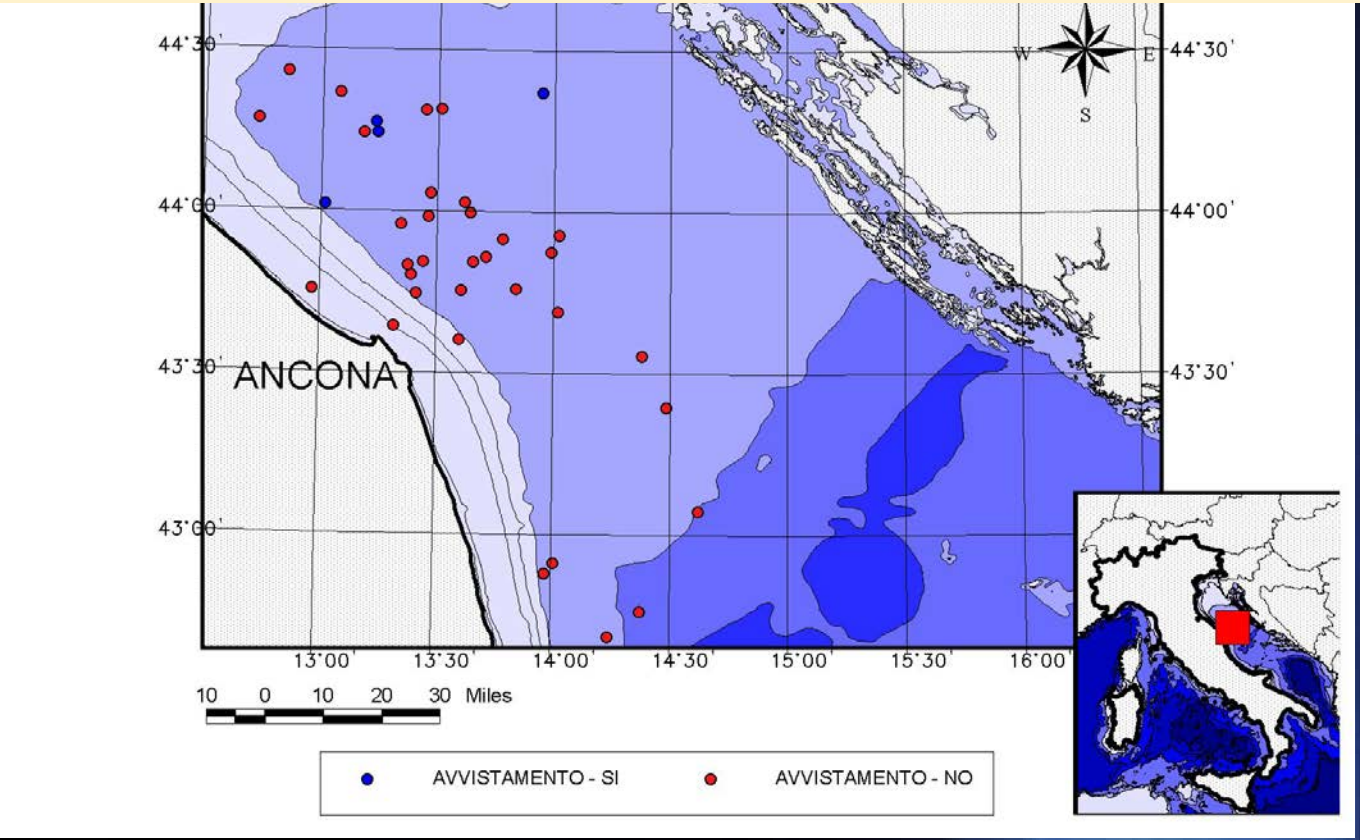
Green: hauls with pingers

Red: Hauls without pingers

Reducing marine mammals bycatch

Acoustic deterrents

pingers



Blue: sightings

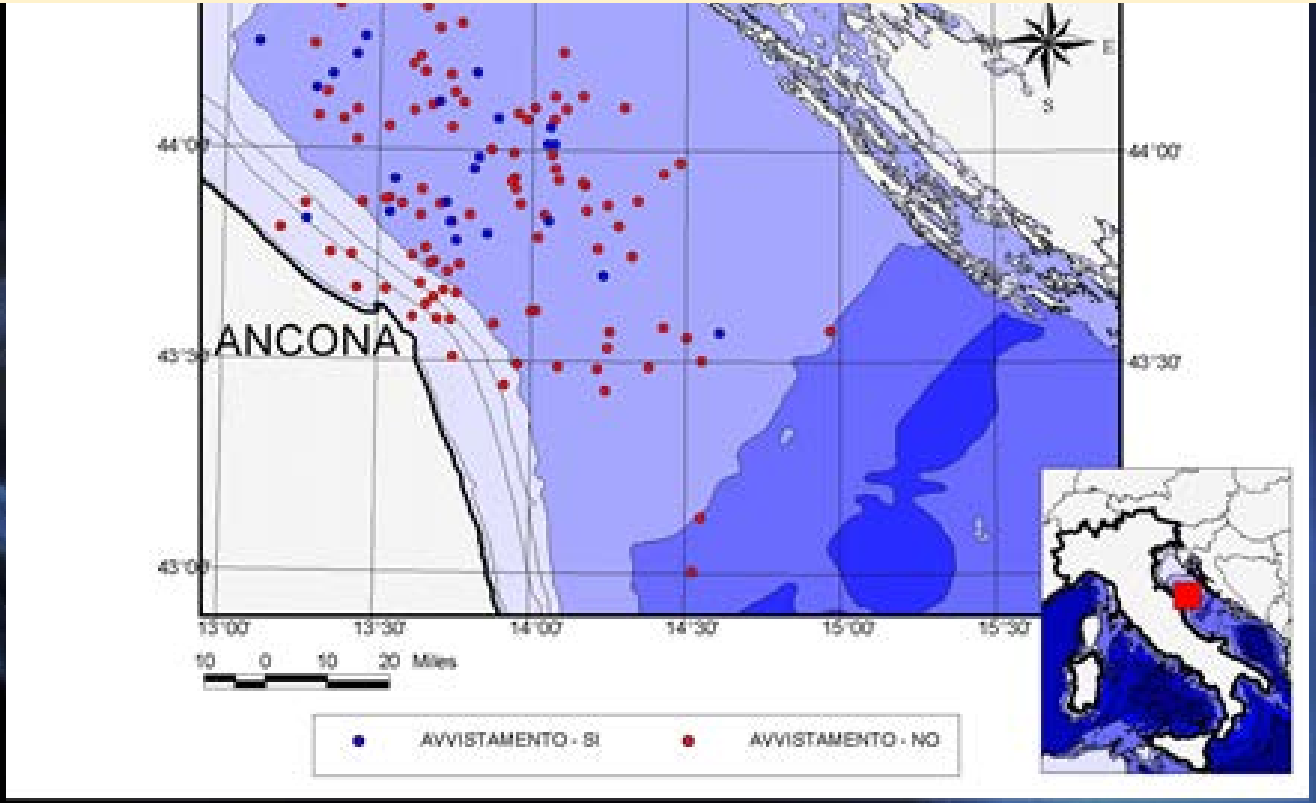
Red: no sightings

11%

Reducing marine mammals bycatch

Acoustic deterrents

pingers



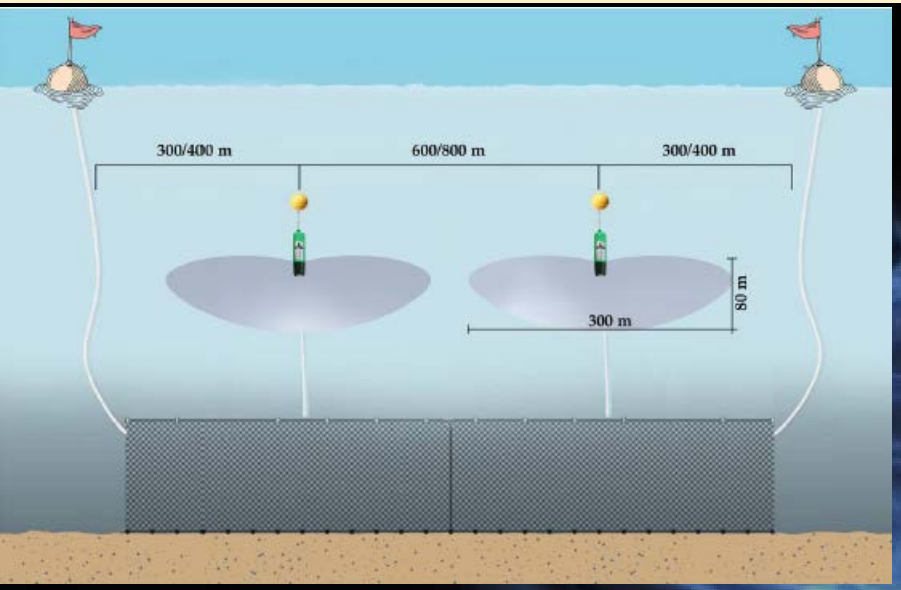
Blue: sightings

Red: no sightings

20%

Reducing marine mammals bycatch

Acoustic deterrents



LOWERING FISHING INTERACTIONS
life DELFI

The absence of dolphin in the neighbourhood of fishing areas thanks to the use of pingers increases the diversity of target species.

Catch damages caused by dolphins were statistically higher in nets without pinger than in nets with pinger ($p < 0.05$).

- Dolphin conservation faces numerous challenges, from habitat degradation to human activities impacting marine ecosystems, firstly fishing.
- Advancements in digital technologies offer promising solutions to address these challenges.

1. Artificial intelligence for dolphin detection
2. Photo identification platforms
3. Mobile applications (APP) to report dolphin sightings

New pinger

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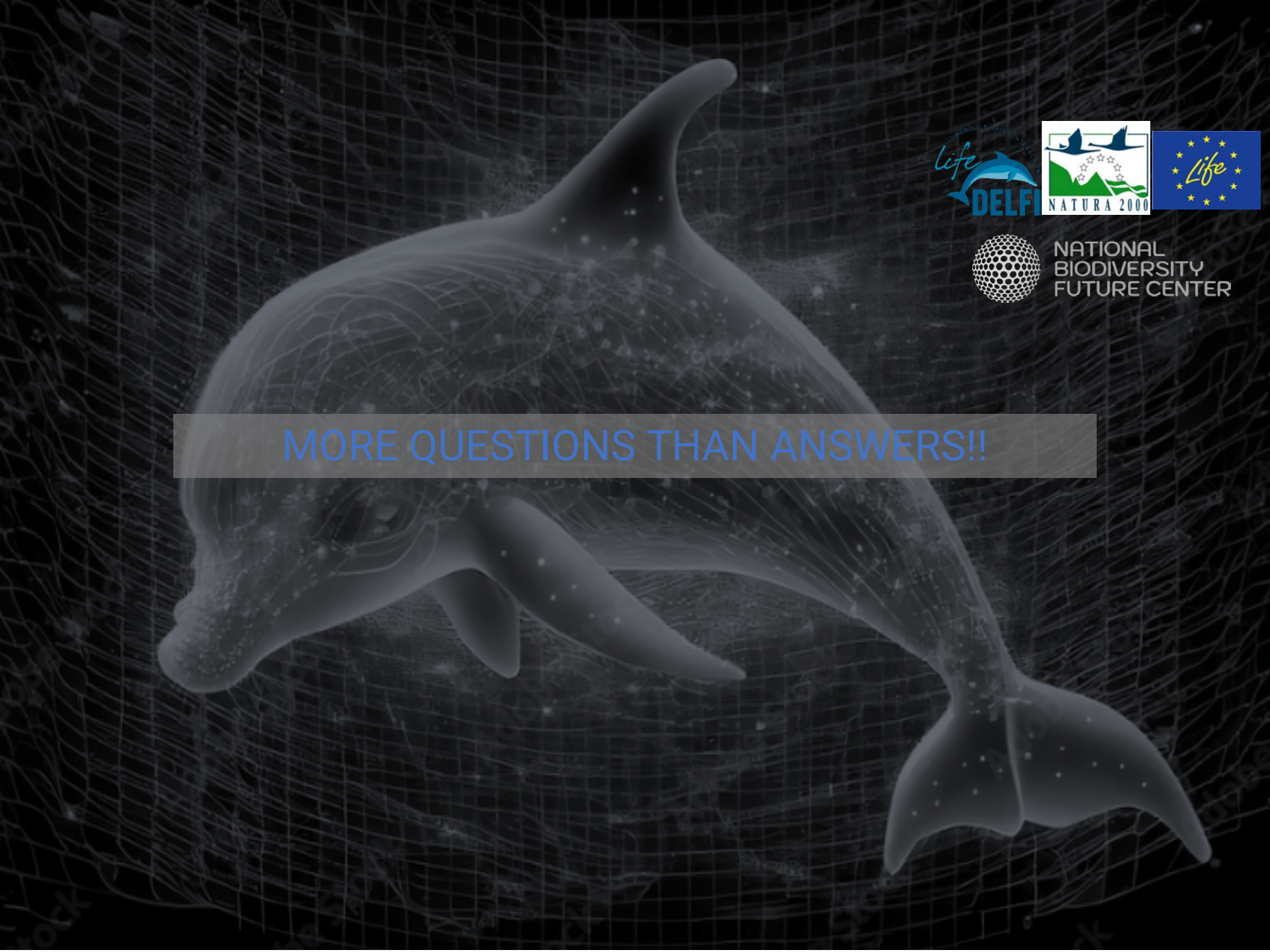
MORE QUESTIONS THAN ANSWERS!!

1. Innovative approach to limit the interaction between dolphins and fishing activities

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Main issue: are the available pingers really interactive?

- **employing a more accurate acoustic dolphin presence detection**
- **use an adaptative emission as deterrent**
- **require widely available hardware keeping low production costs**

- **Low cost (<300 €)**
- **Modular**
- **Easily replicable**
- **Customizable**

1. Innovative approach to limit the interaction between dolphins and fishing activities

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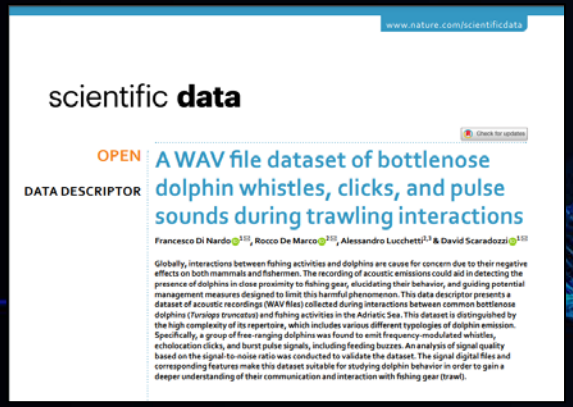
PILOT ACTION: PASSIVE ACOUSTIC MONITORING



www.nature.com/scientificdata

scientific data

OPEN

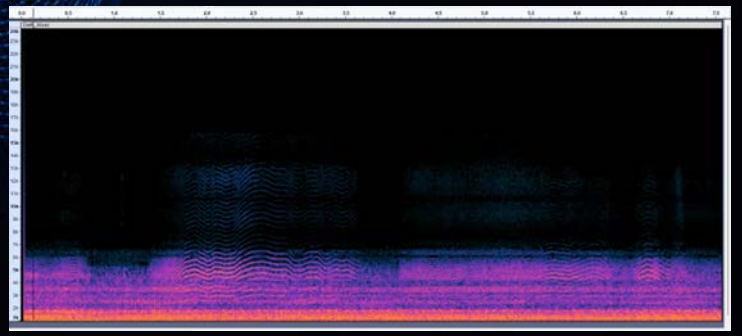
DATA DESCRIPTOR

A WAV file dataset of bottlenose dolphin whistles, clicks, and pulse sounds during trawling interactions

Francesco Di Nardo, Rocco De Marco, Alessandro Lucchetti & David Scaradozzi

Globally, interactions between fishing activities and dolphins are cause for concern due to their negative effects on both mammals and fishermen. The recording of acoustic emissions could aid in detecting the presence of dolphins in close proximity to fishing gear, elucidating their behavior, and guiding potential management measures designed to limit this harmful phenomenon. This data descriptor presents a dataset of acoustic recordings (WAV files) collected during interactions between common bottlenose dolphins (*Tursiops truncatus*) and fishing activities in the Adriatic Sea. This dataset is distinguished by the high complexity of its repertoire, which includes various different typologies of dolphin emission. Specifically, a group of free-ranging dolphins was found to emit frequency-modulated whistles, echolocation clicks, and burst pulse signals, including feeding buzzes. An analysis of signal quality based on the signal-to-noise ratio was conducted to validate the dataset. The signal digital files and corresponding features make this dataset suitable for studying dolphin behavior in order to gain a deeper understanding of their communication and interaction with fishing gear (trawl).

A dataset of acoustic recordings (WAV files) collected during interactions between common bottlenose dolphins (*Tursiops truncatus*) and fishing activities in the Adriatic Sea.



Need for OPEN DATA on acoustic records for different species

1. Innovative approach to limit the interaction between dolphins and fishing activities

NATIONAL BIODIVERSITY FUTURE CENTER

LOW COST RECORDING UNIT

PSU

COMPUTING UNIT

PREAMPLIFIER

HYDROPHON TRANSDUCER

remote sensing

MDPI

Article

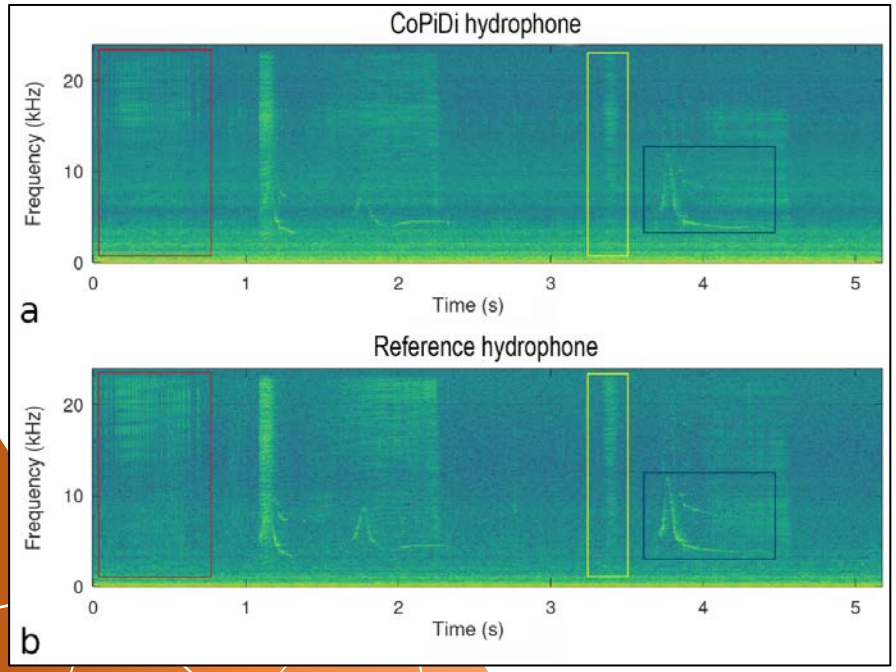
The Development of a Low-Cost Hydrophone for Passive Acoustic Monitoring of Dolphin's Vocalizations

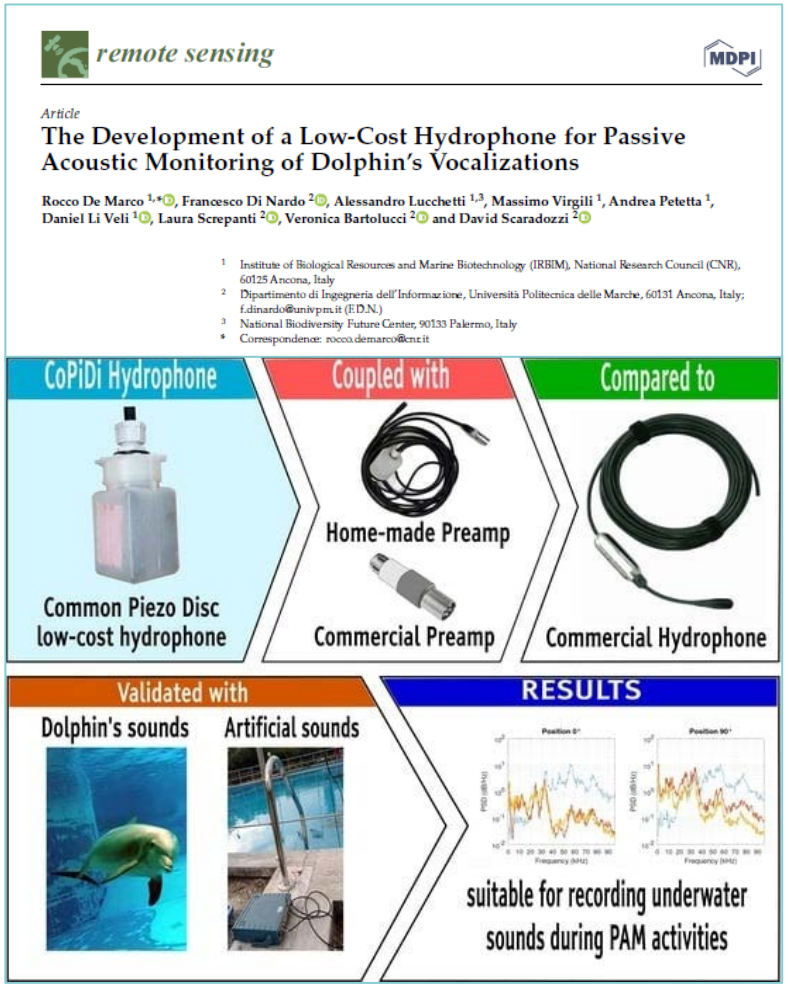
Rocco De Marco [1,*], Francesco Di Nardo [2], Alessandro Lucchetti [1,3], Massimo Virgili [1], Andrea Petetta [1], Daniel Li Veli [1], Laura Screpanti [2], Veronica Bartolucci [2] and David Scaradozzi [2]

[1] Institute of Biological Resources and Marine Biotechnology (IRBIM), National Research Council (CNR), 60125 Ancona, Italy
[2] Dipartimento di Ingegneria dell'Informazione, Università Politecnica delle Marche, 60131 Ancona, Italy; f.dinardo@univpm.it (F.D.N.)
[3] National Biodiversity Future Center, 90133 Palermo, Italy
* Correspondence: rocco.demarco@cnr.it

Validation of the low-cost hydrophone

The validation revealed that the significant cost savings associated with cheap technology (€10.00) minimally affected the recording device's performance in the frequency range of 0–35 kHz.

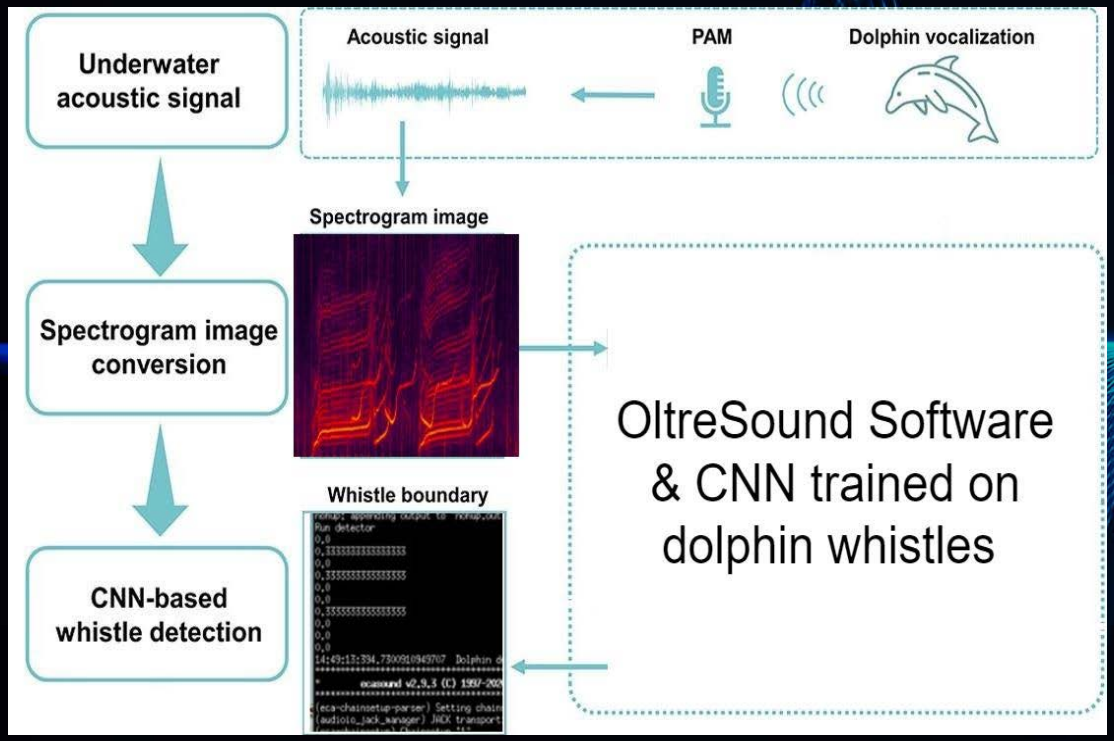




CNR IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

1. Innovative approach to limit the interaction between dolphins and fishing activities

NATIONAL BIODIVERSITY FUTURE CENTER

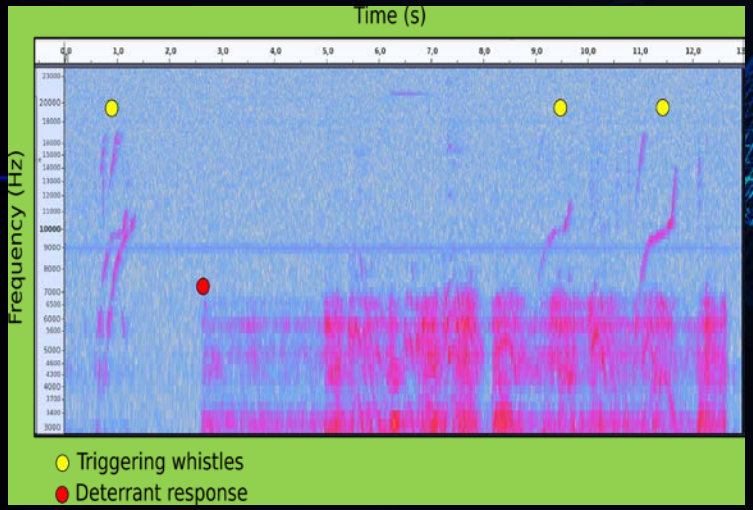


Acquired signals are filtered, preprocessed, and passed to a trained CNN to receive a binary response (Dolphin Yes/No)

1. Innovative approach to limit the interaction between dolphins and fishing activities

NATIONAL BIODIVERSITY FUTURE CENTER

VALIDATION TEST: RESULTS



Control hydrophone (AS/1) recording: just after a dolphin whistle has been recognized, a deterrent sound (in this case a low-frequency killer whale vocalization) is emitted by the AI pinger. Emission sound can vary (up to 96kHz frequency)

(A) place of the signal source reproducing bottlenose dolphin whistles

(B) IA pinger

(C) control hydrophone (AS/1) location

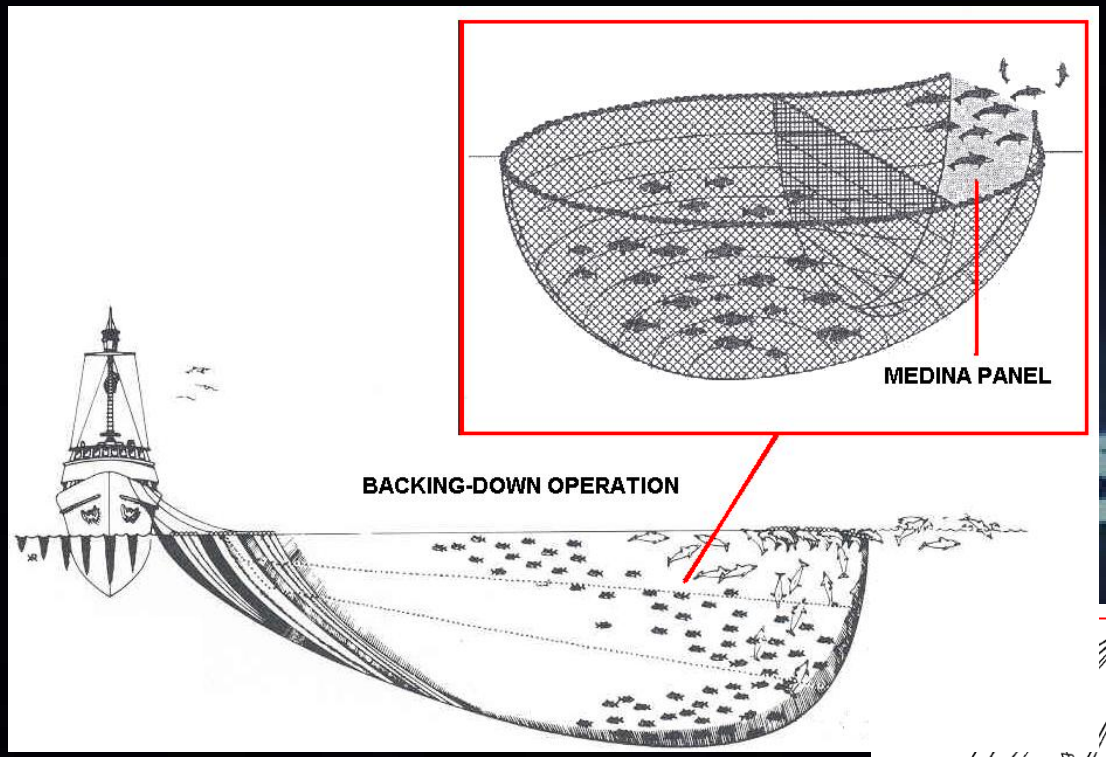
Reducing marine mammals bycatch

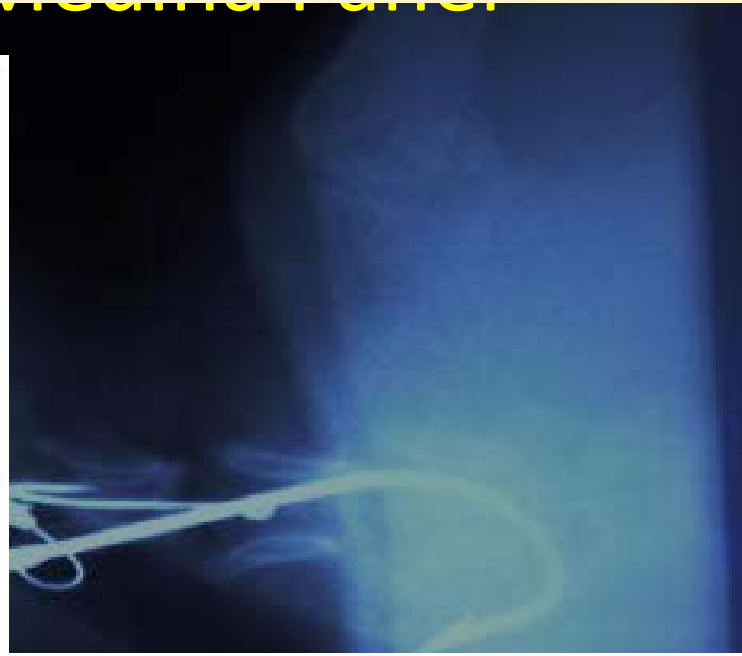
Acoustic Passive Reflectors

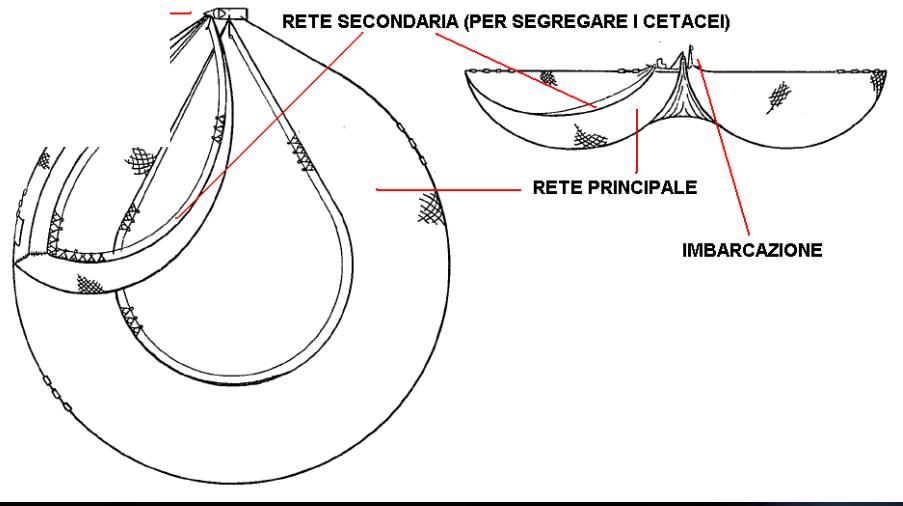
- To minimize bycatch of toothed whales (odontocetes) in gillnets
- increasing gillnet detectability for echolocating animals by making the nets more recognizable
- small, passive reflective objects (acrylic glass spheres) that can improve the visibility of gillnets at a broad range of frequencies
- Modifications of the netting material itself

Reducing marine mammals bycatch

Backing-down operation and Medina panel

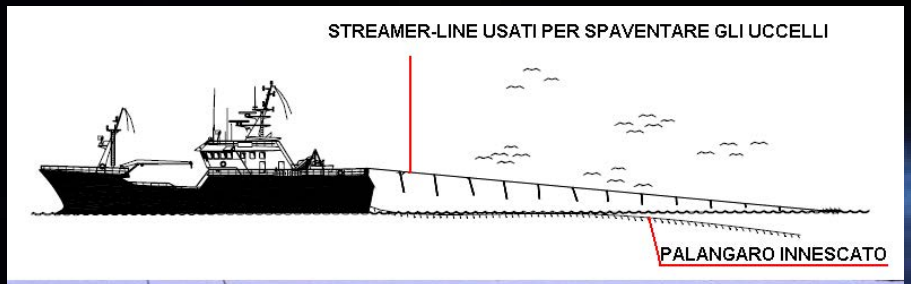






Reducing seabird bycatch

Streamer-line



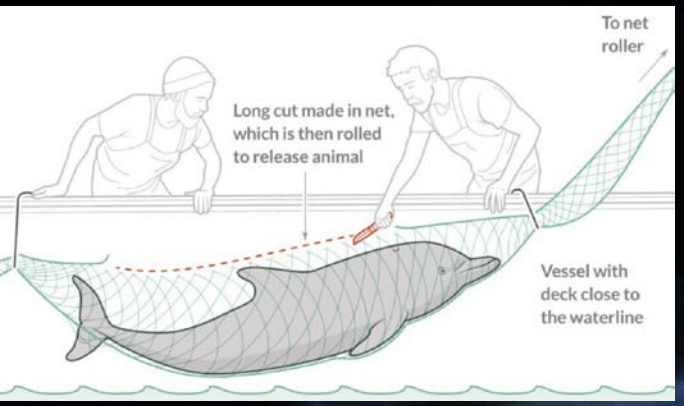
Reducing seabird bycatch

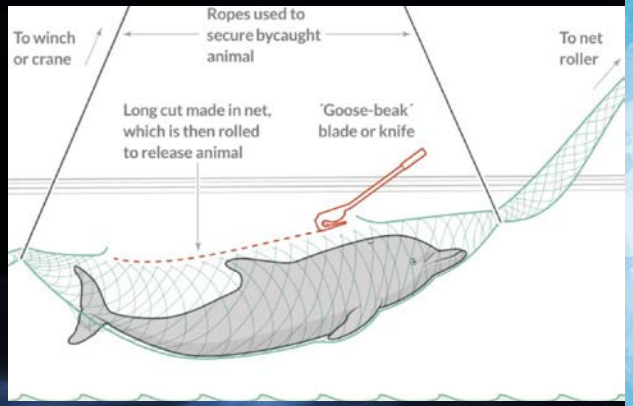
Night setting

Side sets

Underwater shooting

Handling practices





LOWERING FISHING INTERACTIONS
life DELFI
With the contribution of the EU Life Programme

Handling and release of cetacean bycatch

Animals that have been accidentally captured undergo heavy stress, the cause of which is often difficult to immediately identify.

This can lead to unpredictable reactions on the part of the animal, so it is important to learn how to handle the animals as gently as possible while maintaining an otherwise quiet and peaceful environment to avoid adding further stresses to the situation.

In fact, these small considerations increase the likelihood of cetacean survival.

If there is any doubt as to whether an animal is already dead or simply unresponsive, it is always better to act as though the animal were still alive, taking the same care and precautions used when managing an animal to return it to the water as soon as possible.

REMEMBER TO NOTIFY THE COAST GUARD AT THE TOLL FREE NUMBER 1530 TO RECORD THE DETAILS OF THE CATCH INCLUDING:

- Date
- GPS position (coordinates)
- Fisherman's contact information
- Boat name
- UE number
- Type/purpose of trip
- Fishing gear involved (e.g., net length, number of fishing lines, the duration of the trip, etc.)

IT IS IMPORTANT TO INCLUDE

- The name of the species captured
- The number of individuals
- Any additional notes (e.g., condition, any injuries/ wounds, particular details, etc.)

IF POSSIBLE, TAKE A PICTURE OF THE ANIMAL

credit: MPA Ilovaisa Punta Cadò Covella

- When lifting the animal on board, be sure to **avoid any rotation in the fins or tail while handling the net**. If this is not possible, return the entangled animal to the water and allow it to readjust to a better position before lifting again to avoid causing injury during the recovery process
- Ensure that the animal **is not in a position to hit any external objects**. It is advisable to attach an additional rope to the net as close to the animal as possible to have better control over its movements
- Position the animal **in the shade**, in a peaceful and secure location and away from any engine exhaust coming from the fishing vessel

marine
Become a RANGER!
Download the app on your Android or iOS devices to report dolphin sightings in real time

Handling practices

TartaLife
PESCA TARTAFREE

COME SALVARE UNA TARTARUGA MARINA

RIDUZIONE DELLA MORTALITÀ DELLA TARTARUGA MARINA NELLE ATTIVITÀ DI PESCA PROFESSIONALE

1 RECUPERO

- ☑ Liberala da reti e lenze con cura, facendo attenzione alla bocca e alle unghie.
- ☑ **Afferrala solo dalle estremità del carapace, non dalle pinne.**
- ☑ **Se ha abboccato all'amo issala a bordo utilizzando un retino.**
- ☒ **Mai lasciarla capovolta sul carapace.**

2 VALUTAZIONE STATO DI SALUTE

È in buone condizioni

- Se sollevandola muove le pinne ed è molto attiva.
- Se stimolata con le dita negli occhi reagisce chiudendo le palpebre.
- Se pinzando la zona vicino all'ano con le dita la tartaruga reagisce.
- **Falla riposare per un paio d'ore poi liberala.**
- **Se non si è sicuri delle condizioni, allertare la Capitaneria o il Centro di Recupero più vicino.**

Non è in buone condizioni

- Se sollevandola è poco reattiva e non muove le pinne.
- Se stimolata con le dita negli occhi non reagisce chiudendo le palpebre.
- Se pinzando la zona vicino all'ano con le dita la tartaruga non reagisce.
- **Allerta la Capitaneria e il Centro di Recupero più vicino.**

3 PRIMO SOCCORSO

- ☑ Se è stata catturata nelle reti stendila a pancia in giù in un luogo tranquillo su una superficie morbida, **sollevando il posteriore di 20-30 cm** per far defluire dai polmoni eventuale acqua ingerita.
- ☑ Se ha abboccato all'amo di un palangaro taglia la lenza il più vicino possibile alla bocca (Regolamento (UE) 2017/2107) e legala ad un pezzo di legno o plastica in modo che non la ingoi. Non tentare di aprire la bocca con strumenti vari né di tirare la lenza cercando di estrarre l'amo dalla bocca.
  In estate tienila all'ombra e coprila con un asciugamano bagnato sul carapace.

- ☒ Non tenerla immersa in acqua.
  In inverno tienila in un luogo caldo e asciutto e coprila con una coperta.
  Copri la testa e gli occhi, ma mai le narici.

4 RILEVAMENTO DATI

- ☑ Osserva se sono presenti targhette (in genere) sulle pinne.
  Prendi nota dell'ora e posizione di cattura.
  Misura le dimensioni del carapace.
- ☑ Consegnala al personale della Capitaneria di Porto o del Centro di Recupero, se in cattive condizioni oppure se ferita o se ha ingerito un amo.

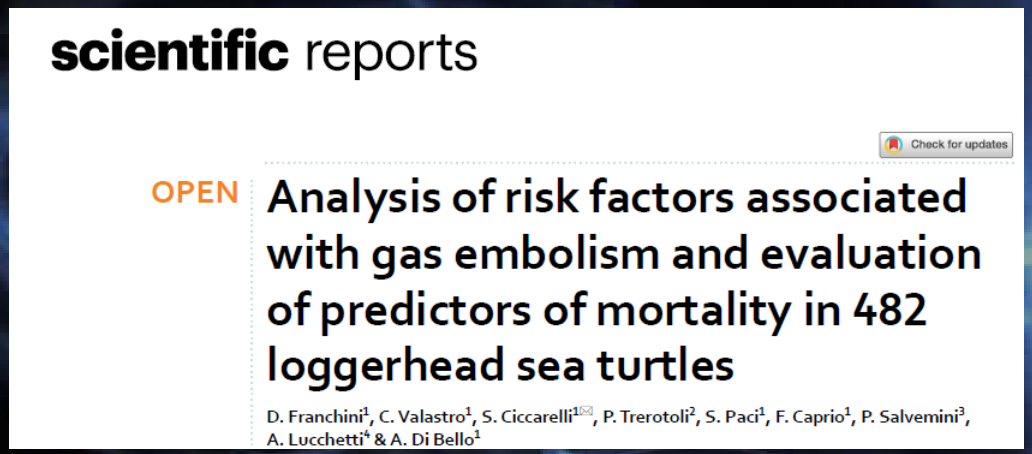
5 LIBERAZIONE

- ☑ Se è in buone condizioni liberala delicatamente, **cercando di lasciarla solo quando è vicina alla superficie dell'acqua, a motore in posizione neutra, senza le reti in acqua.**

Contatti

Progetto di · Con il contributo di · Coinvolgimento · Partner

Handling practices



scientific reports

Check for updates

OPEN

Analysis of risk factors associated with gas embolism and evaluation of predictors of mortality in 482 loggerhead sea turtles

D. Franchini[1], C. Valastro[1], S. Ciccarelli[1]✉, P. Trerotoli[2], S. Paci[1], F. Caprio[1], P. Salvemini[3], A. Lucchetti[4] & A. Di Bello[1]

How to involve fishers

Communication:
Change public perception

How to involve fishers

Engagement and responsibility

- Bottom-up approach: **involving fishers from the early stages**, seeking to develop technical solutions together (as well as any management measures)

- Consult with fishing communities early on to **gather their input, address their concerns, and incorporate their knowledge** on fishing gears (and into the design and management of MPAs).

- Involve fishers as participants and **active actors in the conservation process** (as stewards of the marine environment). This will enhance compliance and enforcement strategies (even in AMPs)

How to involve fishers

Trust of fishers

- Inclusive approach that **recognizes their expertise, concerns, and needs**.
- **Demonstrate competence** (including technical competence) on issues that concern them
- To **demonstrate empathy for their issues** beyond those strictly related to the project
- **Embarking** with them helps a lot in getting closer to them, because it creates an atmosphere of complicity, as they know that we understand their problems and their hardships.

How to involve fishers

Education, Outreach and capacity building

- Provide fishers with **clear and accessible information** about the purpose and benefits of the new gears/devices/measures (and MPAs).

- **Offer educational workshops**, presentations, and m… marine conservation objectives and the role of new… sensitive species, fish stocks and habitats.

- Provide **training, technical assistance** (and eventua… engage in monitoring of sensitive species (and co-r…

How to involve fishers

Business (avoiding commercial loss)

- **Recognize the economic** concerns of fishermen who may be impacted by new devices (and MPA regulations).

- **Alternative Livelihoods**: explore opportunities for alternative activities and gears, such as eco-tourism, sustaina nomic losses and provide alternative sources of

- **Recognize and ince** blish reward programs, certification schemes onstrate to contribute to conservation goals (fishing products through labelling).

Compensation?

How to involve fishers

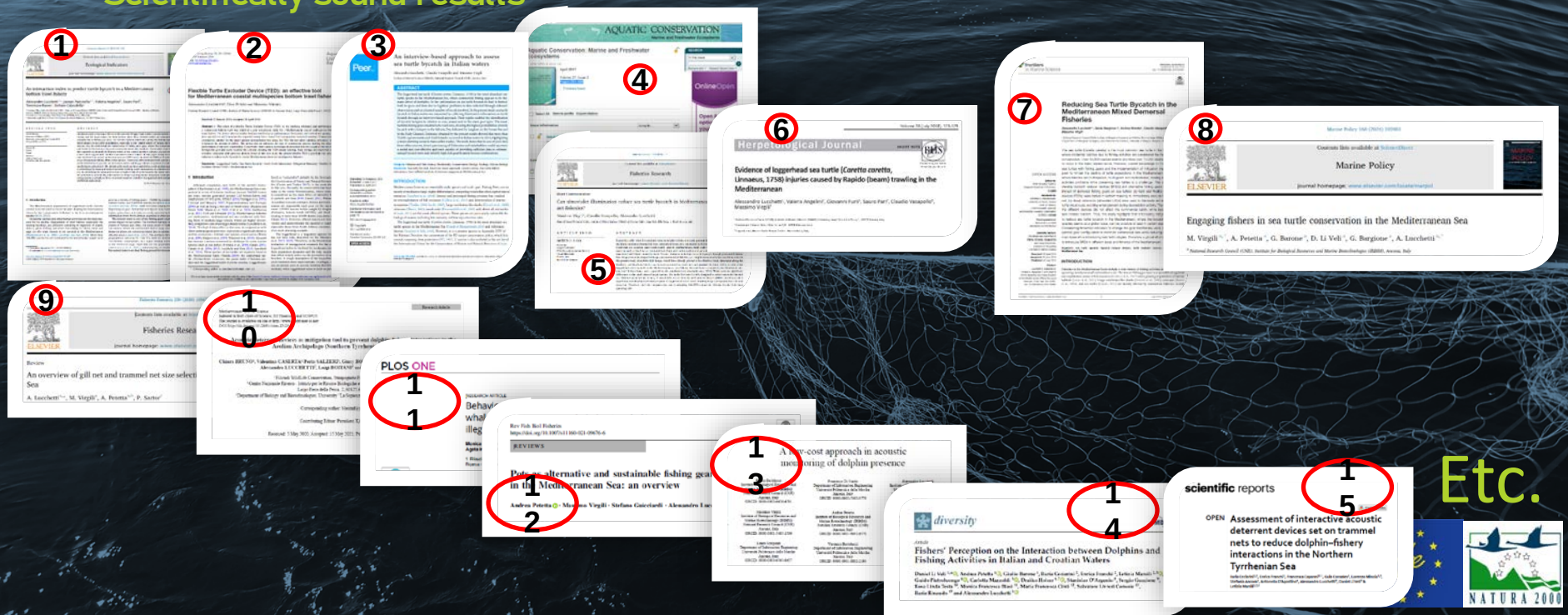
Presence

- Fishers must 'feel' the **constant presence** of the researchers (or MPA representatives).
- Too often, activities only go on as long as there is a project that guarantees a certain relationship.
- Then **when the project is over**, the presence disappears and the fishermen gradually lose interest in conservation and abandon the good practices undertaken

How to involve fishers

Scientific Credibility

- Scientifically sound results



Etc.

NATURA 2000

How to involve fishers

Fisher's collaboration

How to involve fishers

Next steps

Commitment of Members States!!

- New technical and management measures
- Funding opportunities
- Monitoring
- Eco-labelling or similar

Life

NATURA 2000

Now when the dolphin is caught and perceives itself to be trapped in the net, it bides its time, not at all disturbed but well pleased, for it feasts without stint on the fish that have been gathered with no trouble to itself. But as soon as it comes near the shore, it bites its way through the net and makes its escape. Yet if it should not get away in time, on the first occasion it suffers no harm: the fishermen merely sew rushes to its crest and let it go. But if it is taken a second time, they recognize it from the seam and punish it with a beating. This, however, rarely occurs: most dolphins are grateful for their pardon in the first instance and take care to do no harm in the future.

Plutarch (46-120 A.D)- De sollertia animalium (On the Intelligence of Animals)- chap. 26

Thank you

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