Conservation Ecology of Elasmobranchs

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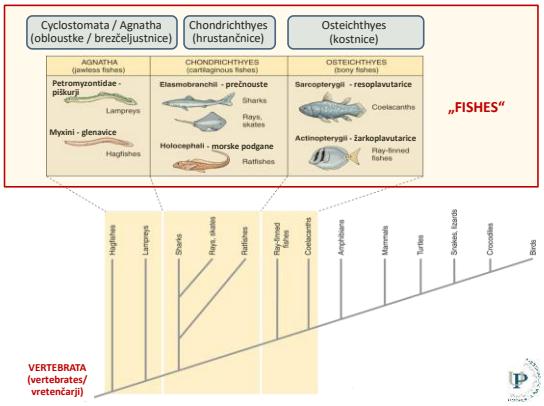


Chondrichthyes
Systematics

- Chondrichthyes – cartilaginous fishes (gr. *hondros* = cartilage + *ichthyos* = fish)
- ≈ 1050 living species

Chondrichthyes
Cartilaginous fishes

Elasmobranchii
Elasmobranchs

Gills on thin plates from connective tissue (*elasmos* = thin plate + *branchia* = gill)

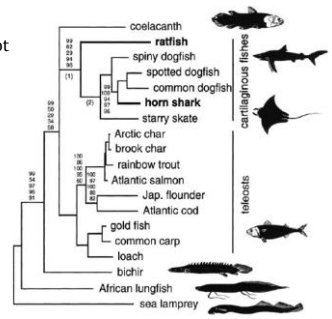
Selachii
sharks

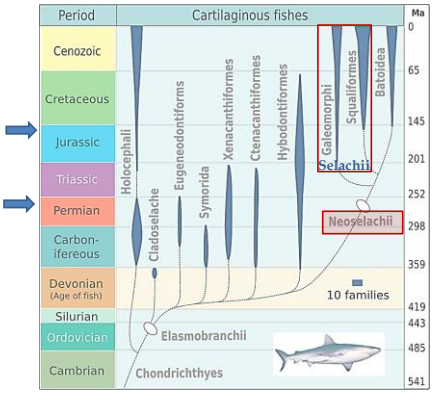
Batoidea
rays

Holocephali
Ratfishes

Gills covered by leathery operculum, „whole head"

- Chondrichthyes are not ancestral to bony fishes
- Terminal position in the piscine tree
- Derived monophyletic group





Holocephali
Ratfishes

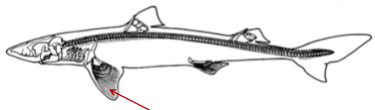
Order Chimaeriformes ≈ 35 species

- single gill opening covered by flap of connective tissue (operculum)
- no spiracle, no scales
- upper jaw firmly fused to the braincase
- similar to extinct spiny sharks
- first dorsal fin has venomous spine
- live in deep water
- small and rare
- one species in the Adriatic

Chimaera monstrosa

Elasmobranchii
Charachteristics

- Cartilaginous endoskelton
- Calcified vertebral column
- Placoid scales

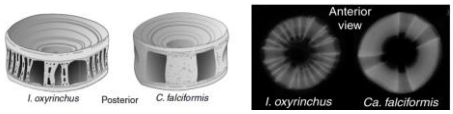


Ceratotrichia
- large colagen fibers
- reinforced with calcium salts
- fin support

- ventral mouth
- protrusible upper jaw
- tooth replacement system

Characteristics of Elasmobranchs:
1. Cartilaginous skeleton

- cartilage - substantial mineral fraction (39-55%)
- mineralized with crystals of calcium phosphate
- mineralization varies between species

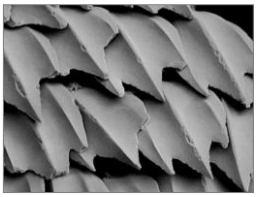


Mako shark (Isurus oxyrinchus) and silky shark (Carcharinus falciformis) vertebral centra

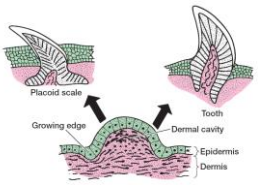
Characteristics of Elasmobranchs:
2. Placoid scales

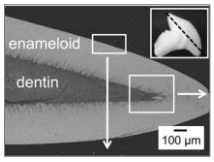
- dermal denticles (dermal teeth)
- made of dentine and enamel
- improved hydrodynamics
- placoid scales do not get larger as the animal grows - they grow more scales
- arranged in a regular pattern in sharks and an irregular pattern in batoids
- the shape is specific to individual species

Dogfish Shark skin section, HE X30

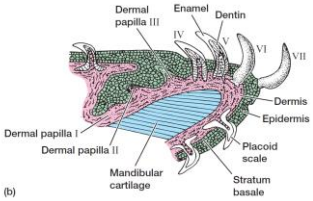


Scanning electron micrograph of the scales; White Shark





- produced by odontoblasts



Characteristics of Elasmobranchs:

3. Tooth replacement

- same structure as placoid scales
- 5-15 rows of teeth in jaw
- probably originated from scales around mouth
- identification:
  - shape of a teeth
  - number of teeth(dental formula)

Isurus oxyrinchus

Galeocerdo cuvier

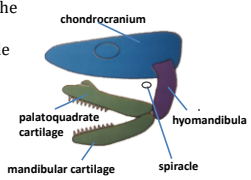
Carcharias taurus

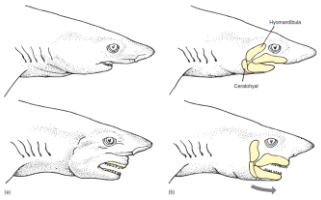
Characteristics of Elasmobranchs:

4. Jaws

- **hyostylic, protrusible jaws**
- modern elasmobranchs and most bony fishes
- upper jaw losed direct connection with the chondrocranium
- upper and lower jaws are supported solely by the hyomandibula

- hyostilic jaws attached flexibly to the chondrocranium (skull)
- elastic ligaments enable protrusible jaws
- allows consumption of large prey

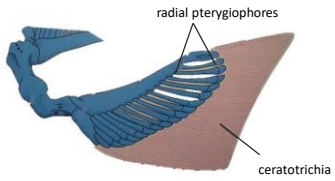




Cranial kinesis - movement of parts of a head skeleton

Characteristics of Elasmobranchs:
5. Ceratotrichia

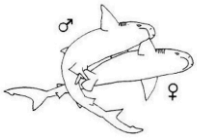
- Large elastic and colagen fibers which support the fin



Pelvic fin of *Squalus* sp.

Characteristics of Elasmobranchs:
6. Claspers

- pterigopod
- copulatory organs for internal fertilization
- modified inner edges of the pelvic fin

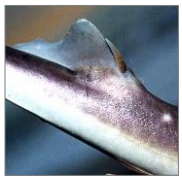


Characteristics of Elasmobranchs:

Spines

- spines are an adaptation for defending the animal against predators and are not used aggressively
- spiny dogfish (*Squalus acanthias*) has dorsal spines equipped with an irritating toxin
- skates (family Rajidae) may have rows of shortspines on the back
- stingrays - tail spines: modified placoid scales
  - often replace spines

Tail spine: middle and tip

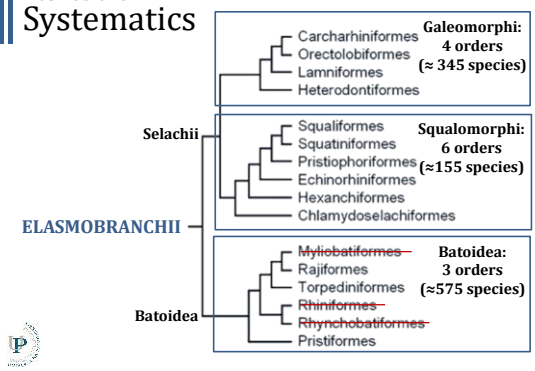


Taxonomy

Kingdom:	Animalia/Metazoa
Superphylum:	Chordata
Phylum:	Vertebrata
Superclass:	Gnathostomata
Class:	**Elasmobranchii**
Subclass:	Neoselachii
Infraclass:	Selachii
Superorder:	**1. Galeomorphi**
Superorder:	**2. Squalomorphi**
Superorder:	**3. Batoidea**

Elasmobranchii

Systematics



Selachii
Sharks

Galeomorphi
fusiform bodies, mainly top predators
("shark form")

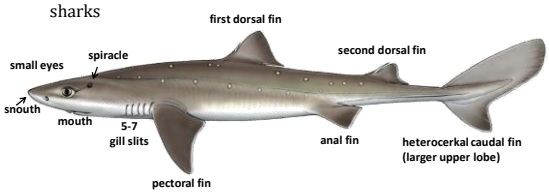
Carcharodon carcharias

Squalomorphi
smaller sharks, body rounded, mesopredators
("dogfish form")

Squalus acanthias

Selachii
External morphology

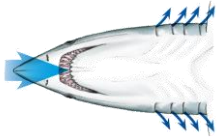
- fusiform body, 5-7 lateral gill slits
- countershaded coloration: dorsal side is darker than the ventral side (camouflage)
- *spiracle* – small opening behind the eye, brings oxygen-carrying water into the gill chamber; absent in fast-swimming sharks

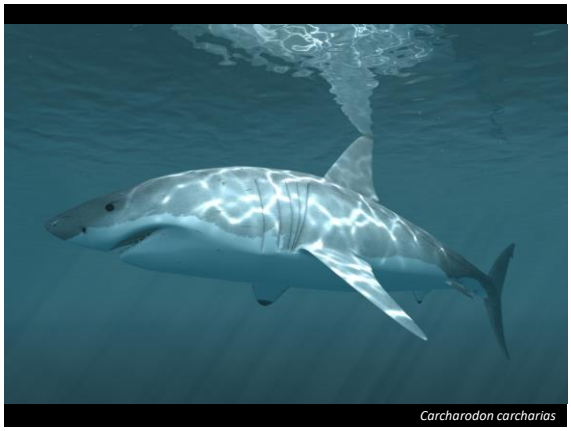


Respiration

- water enters the gill chambers through the mouth or spiracles and exits through the gill slits
  1) **buccal pumping** - buccal (cheek) muscles pull the water over the gills (nurse sharks, angel sharks and carpet sharks; skates and rays)
  2) **ram ventilation** - water flows into the mouth and flows out through the gills slits while swimming (active pelagic sharks)

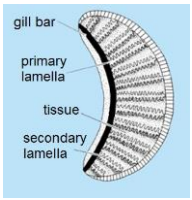
     obligate ram ventilation - great white shark (*Carcharodon carcharias*) and the shortfin mako (*Isurus oxyrinchus*)

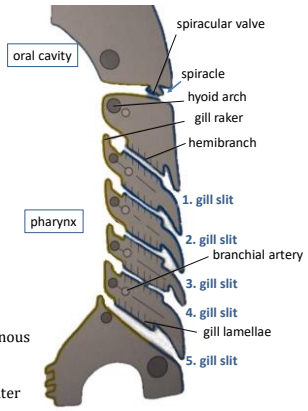




Carcharodon carcharias

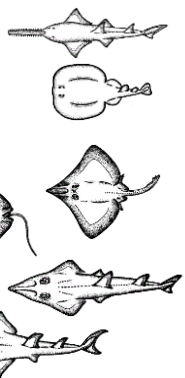
Gills





Gill raker (škržni luk)- cartilaginous projections on the gill support structure, protect the delicate gill filaments from particles in the water

Batoidea



≈ 573 species

1) Pristiformes (sawfish, 6 species)
2) Torpediniformes (electric rays, 69 sp.)
3) Rajiformes (skates and rays)

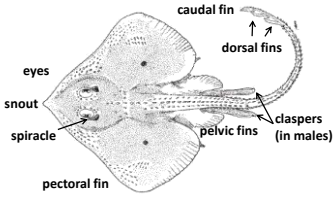
Myliobatidae, Rhinobatidae, Rajidae, Dasyatidae, Gymnuridae, Arhynchobatidae

Total: 489 species

External morphology

Skates and rays

- dorsoventrally-flattened body, expanded pectoral fins form a disc
- tail is long, dorsal fins small or absent, caudal fin reduced
- the spiracle is much larger and more developed

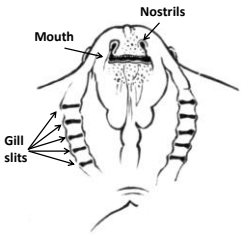



Raja montagui

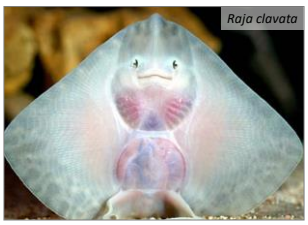
External morphology

Skates and rays

- external gill openings (5-6) – gill slits on the ventral side of the body



Ventral side


Raja clavata

Rays

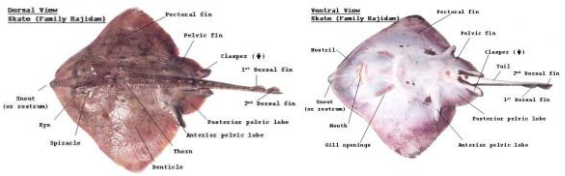
Pristiformes, Torpediniformes, Myliobatidae, Dasyatidae

- No thorns along middline of the back
- Each pelvic fin has one lobe
- Slender, whipe-like tail with one or two spines, usually without a dorsal fin
- Caudal fin: reduced or absent
- In general, larger than skates
- viviparous

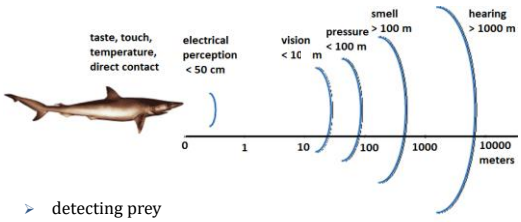

Myliobatis aquila - common eagle ray

Skates
fam. Rajidae

- Not a taxonomic group (morphological group)
- Most have elongated thorns along the midline of the back
- Prominent rostrum
- Pelvic fin: two lobes
- Tail relatively stocky, without a spine, usually with two small dorsal fins near its tip, and small caudal fin
- Oviparous



Sensory organs



- detecting prey
- detecting partners for mating
- avoiding predators
- orienting in the sea

Reproductive traits

- Very low fertility rate
  - from 1 (*Manta birostris*) to 300 pups (*Rhincodon typus*)
- Long gestation period
  - from 3 months for *Dasyatis* sp. to 24 months for *Squalus acanthias*

Reproductive cycles:

1) Continuous: species reproduce throughout the year (*S. acanthias*)
2) Seasonal: species are reproductively active for only a part of the year (*Sphyrna tiburo*)
3) Punctuated: species are pregnant for about a year and the next pregnancy is at least a year later (*Torpedo marmorata*)

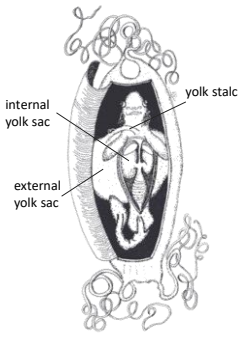
Reproductive strategies

- Internal fertilization
  - improves likelihood and efficiency of fertilization
  - ensures that energy is not wasted

1) **Oviparous** (egg-laying)
2) **Viviparous** (live-bearing)
   - Long gestation period
   - Reduced number of offspring
   - Increased degree of maternal protection during development of the embryos
   - Increased chance of survival of the offspring due to their large size at birth

Oviparity

- oviductal gland produces egg cases
- lay egg cases on the substrate or attach to bottom structures
- egg cases are first soft and pale; then they harden and darken in a few hours – prevent predation
- from two months to over one year - nourished by yolk sac
- mainly bottom dwellers, shallow water and small species
- e.g. Scyliorhinidae, Rajidae



Yolk is transferred from external yolk sac to internal yolk sac

Viviparity

- retaining embryos in the uterus during entire development
- embryos are born fully developed
- definitive maternal-fetal vascular connection is lacking

1) **Aplacental viviparity**
   - Yolk dependency
   - Oophagy and Embryophagy
   - Placental analogues
2) **Placental viviparity**

≈70% of all sharks are viviparous

Aplacental Viviparity
Yolk dependency

- the egg shell is often just a thin membrane
- more than one egg encapsulated in the membrane –a candle
- mother retains the egg, embryo sheds the membrane and develops in the mother's uterus
- embryos are small at birth due to the finite amount of nutrients available in the yolk sac
- **lecithotrophy** - no supplemental nourishment from the mother
- most common reproductive strategy
- Squaliformes, Hexaniformes, Squatiniformes, Rhinobatiformes, Pristiformes, Torpediniformes, some Carcharhiniformes

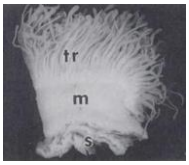
Squalus acanthias

Aplacental Viviparity
Oophagy and Embryophagy

- **Oophagy** - "egg eating„
- **Embryophagy**- intrauterine cannibalism
- embryos depend on yolk for a short period, and subsist by eating eggs or smaller embryos
- usually only one embryo survives in each uterus (there are two uteri)
- **Matrotrophy** - embryo is supplemented with adittional nutrition from the mother (ovulated eggs)
- facilitates the development of large embryos and prepares the embryo for a predatory life style
- mackerel sharks (order Lamniformes)

Aplacental Viviparity

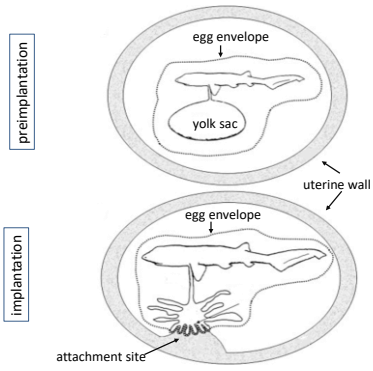
Placental analogues



- embryo receives nutrition from its mother in the form of uterine secretions
- trophonemata - long villous extensions of the uterine epithelium that secrete "uterine milk"
- uterine milk is ingested or absorbed by the embryo
- transfer of nutrients is much more efficient than through the yolk sac

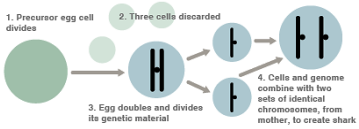
Placental Viviparity

- initial development is yolk
- yolk stalk (connects the embryo to the yolk): grows in the uterus and forms a **yolk sac placenta**
  - vascular organ composed of both maternal and fetal tissue
  - mediates exchange of nutrients, gases and waste products
- egg envelope: thin, flexible egg covering which encloses each fetus and fetal portion of the placenta
  - all metabolic exchange between mother and fetus is effected through the intervening egg covering
- some Carcharhiniformes (Lemon shark, Blue shark, Mako, Porbeagle, Salmon shark, Silvertip shark, Hammerheads)



Parthenogenesis

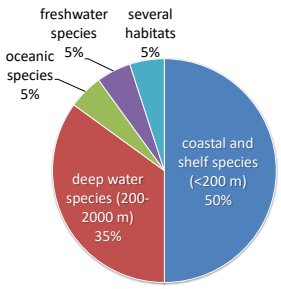
- "virgin birth"
- female sharks produce living offspring in captivity, in isolation from males - multiple viable offsprings
- fusion of post-meiotic products to generate a new embryo with the proper number of chromosomes - automictic parthenogenetic pathway
- confirmed only for Carcharhiniformes (placental viviparity)
  - hammerhead shark (*Sphyrna tiburo*), blacktip shark (*Carcharhinus limbatus*), white-spotted bamboo shark (*Chiloscyllium plagiosum*)



Ecology, beahviour and habitat use

Habitat selection

- physical parameters:
  - temperature, salinity, depth, sediment chracteristics, tydal flow
- biological parameters:
  - benthic vegetation, prey distribution, reproductive activity

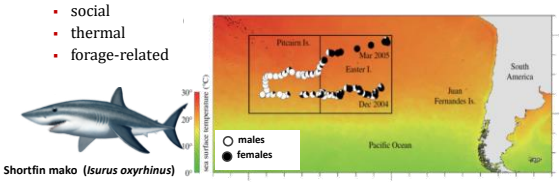


Behaviour ecology
Aggregations

1) movements & reproduction
2) greater protection from predators
3) locating and and capturing prey more efficiently - feeding sites
   - Giant manta rays (*Manta birostris):* 'cyclone feeding'
4) cleaning stations - fish (remoras): clean gills, mouth and skin - remove parasites, dead skin, clear wounds

Behaviour ecology
Segregations

- segregation by size and sex: blue sharks, hammerheads, spiny dogfish, whale sharks…
- habitat segregation by sex appears common among sharks
- adult males and females use different habitats either within the same or different areas
- reasons are most likely:
  - social
  - thermal
  - forage-related



Shortfin mako (*Isurus oxyrhinus*)

Diet

Four main diet types:

1) fish
2) mammals
3) crustaceans - bottom dwelling species
4) plankton

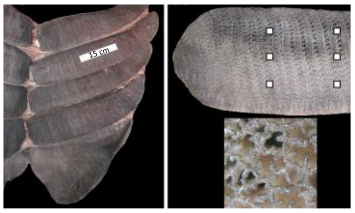



Filter-feeding elasmobranchs

- special gill mechanisms
- broad heads, terminal position of mouth
- reduced teeth
  - the Basking Shark (*Cetorhinus maximus*)
  - Megamouth Shark (*Megachasma pelagios*)
  - Whale Shark (*Rhincodon typus*)
  - Manta Ray (*Manta birostris*)
  - genus Mobula


Filter-feeding elasmobranchs

- **filtering pads** on each side of the pharynx
  - modified gill rakers
  - surface is composed of modified dermal denticles which form a mesh sieve with irregularly shaped holes
  - retain all organisms above 2 mm in size



Trophic position

- upper trophic levels – predators and mesopredators
- sharks as a group are predominantly tertiary consumers (TL>4)

Taxa	Number of estimated species	Mean TL	Minimum	Maximum
Sharks	149	4.0	3.1	4.7
Marine mammals	97	4.0	3.2	2.5
Seabirds	28	3.9	3.1	4.8

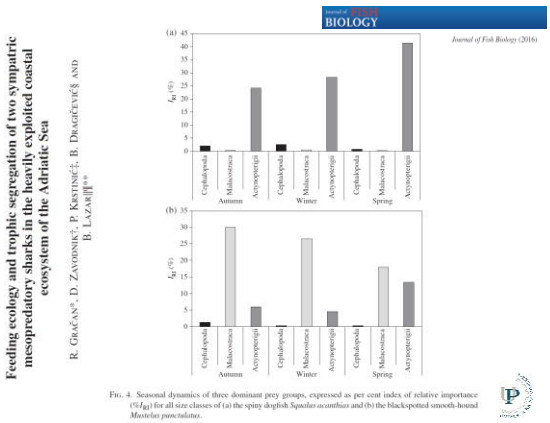
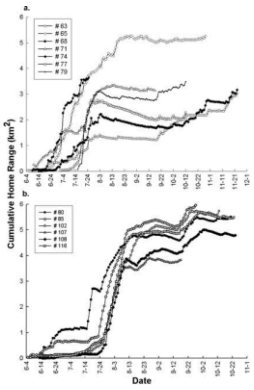


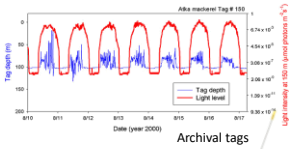
Fig. 4. Seasonal dynamics of three dominant prey groups, expressed as per cent index of relative importance (%I_{RI}) for all size classes of (a) the spiny dogfish *Squalus acanthias* and (b) the blackspotted smooth-hound *Mustelus punctulatus*.

Ontogenetic habitat shifts

- change in habitat with age / growth
- home ranges: increase with age/growth
  - sharks move from small nursery areas into areas not previously utilized
- synchronous population-level change in habitat use
  - shift from low to high trophic level prey
  - trophical niche shift



Behaviour ecology
Habitat use

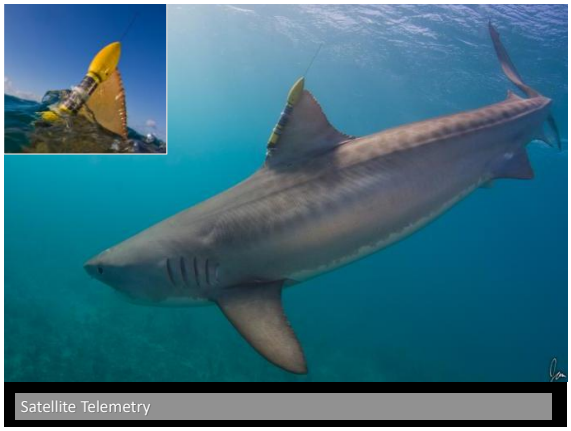


Archival tags

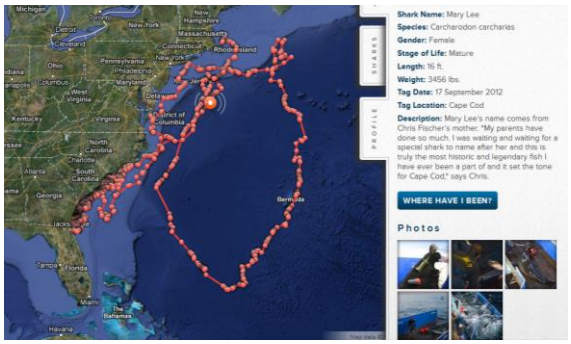
- migratory routes and residency patterns
- identify "hot spots", critical for mating, giving birth and feeding
- identify locations where sharks are influenced by fishery activities

✓ Provide info for implementation effective management strategies

'Spaghetti' tag

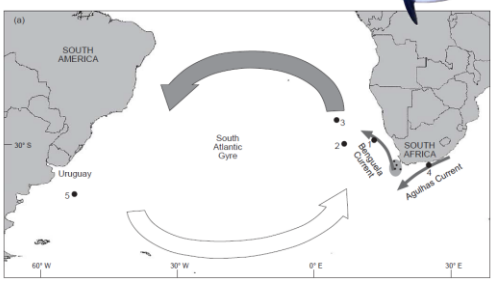


Global Shark Tracker



http://sharks-ocearch.verite.com/

Long-distance migrations
Trans-Atlantic migrations



Prionace glauca: clockwise circular migration associated with oceanic gyres

Behaviour ecology

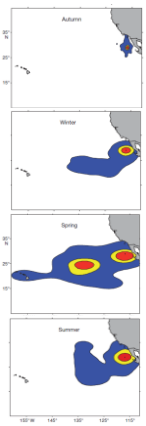
Seasonal movements

Reasons:

- Prey distribution
- Temperature regime
- Reproductive cycle

Carcharodon carcharias, Guadalupe Island, Mexico:

- Autumn: neritic habitat
- Winter: offshore pelagic phase
- Spring: pelagic phase, occupy large area
- Summer: similar to winter habitats
  - prey is the most probable motivating factor for migrations

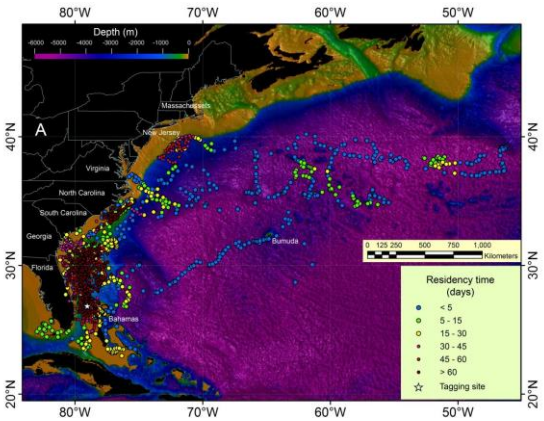


Behaviour ecology

Daily movements

- during the day the sharks are very passive
- active during the night - frequent trips to the open sea
- three principal types of movement:

1) **Resting** - navigating at low velocity in areas close to the island
   - resting occurred primarily during the day
   - sharks stayed close to the rocky areas and coral reefs
2) **Directional** - when sharks head toward open water or return to the island
3) **Non-directional / Erratic** - primarily in zones away from the shore
   - occur during the night
   - shark accelerate rapidly for a short time and then move slowly
   - assumed that these movements are a result of feeding habits



Site fidelity

Natal homing – animal migrates back to its specific birthplace, usually to reproduce

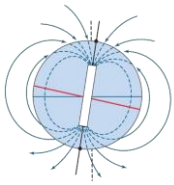
- Tagging data
- Genetic analysis

Orientation

1) **'Middle' distance orientation** – searching for food and returning within an animal's foraging range
   Mechanosensory and electrosensory systems
   - vertical migration – driven by light intensity
   - daily pattern of movement – navigation cue is the Sun
   - daily pattern of movement – water currents and tidal movements

2) **'Long' distance orientation**
   Olfaction, hearing and vision
   Oceanographic conditions (e.g. temperature)

   Directional movement in open oceans:
   - keeping track of left and right turns
   - underwater sound which travel long distances
   - geomagnetic cues



Life history

- slow growing
- late sexual mature
- low fecundity
- long gestation periods

↓

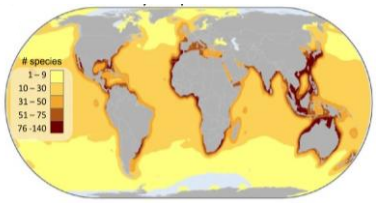
- low reproductive potential
- low intrinsic growth rates (*r*)

↓

- limited capacity to recover from declines

Extinction risk and conservation of the world's sharks and rays

Nicholas K Dulvy[1,2*], Sarah L Fowler[3], John A Musick[4], Rachel D Cavanagh[5], Peter M Kyne[6], Lucy R Harrison[1,2], John K Carlson[7], Lindsay NK Davidson[1,2], Sonja V Fordham[8], Malcolm P Francis[9], Caroline M Pollock[10], Colin A Simpfendorfer[11,12], George H Burgess[13], Kent E Carpenter[14,15], Leonard JV Compagno[16], David A Ebert[17], Claudine Gibson[3], Michelle R Heupel[18], Suzanne R Livingstone[19], Jonnell C Sanciangco[14,15], John D Stevens[20], Sarah Valenti[3], William T White[21]



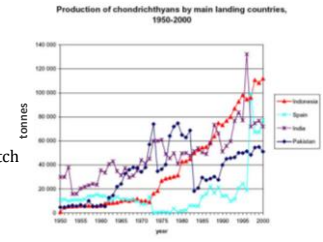
- Mediterranean : 49 shark species, 34 batoids, 1 chimaera
- Adriatic: 54-55 species of Elasmobranchs
  - 29 sharks, 24 batoids, 1 chimaera

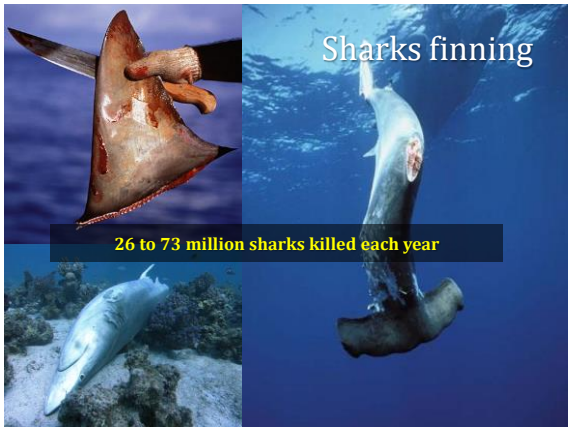
Human impact on sharks

- Fishery
- Habitat loss and degradation
- Global warming
- Pollution
  - Chemical pollution
  - Thermal pollution
  - Marine debris

Fishing

- Targeted catch (direct exploitation)
  - Commercial fisheries
  - Recreational fisheries
- Bycatch (indirect exploitation): accidental catch
  - Commercial fisheries
  - Recreational fisheries



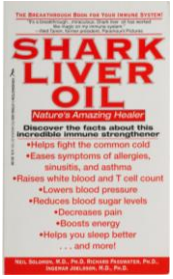


Products

- meat, fins, skin, cartilage and liver
- meat - salted, dried, smoked or processed into surimi
- fins - the most valuable product
  - traditional shark fin soup
  - first dorsal, pectorals and lower lobe of the caudal are the largest and most valuable fins
  - only the ceratotrichia from the upper part of the fin

Products

- shark cartilage - pharmaceutical industry
  - pills and capsules – cure for cancer?
- liver extracts - pharmaceutical products
  - squalene - used in lubricants and skin creams



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ECOLOGY LETTERS

Ecology Letters, (2010) 13: 1055–1071

REVIEW AND SYNTHESIS

Patterns and ecosystem consequences of shark declines in the ocean

Francesco Ferretti,[1]* Boris Worm,[1] Gregory L. Britten,[1] Michael R. Heithaus[2] and Heike K. Lotze[1]

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[2]Department of Biological Sciences, Florida International University, 3000 NE 151st, North Miami, FL 33181, USA

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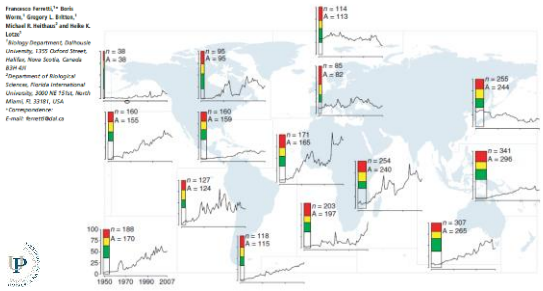
E-mail: ferretti@dal.ca

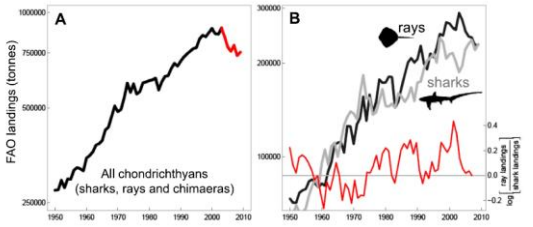


Extinction risk and conservation of the world's sharks and rays

eLIFE

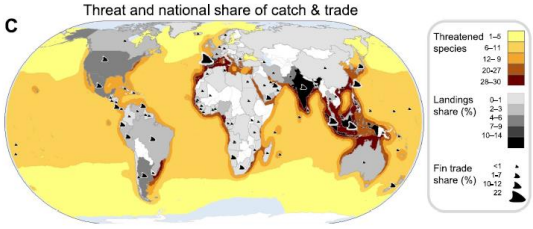
2014

Nicholas K Dulvy[1,2]*, Sarah L Fowler[3], John A Musick[4], Rachel D Cavanagh[5], Peter M Kyne[6], Lucy R Harrison[1,2], John K Carlson[7], Lindsay NK Davidson[1,2], Sonja V Fordham[8], Malcolm P Francis[9], Caroline M Pollock[10], Colin A Simpfendorfer[11,12], George H Burgess[13], Kent E Carpenter[14,15], Leonard JV Compagno[16], David A Ebert[17], Claudine Gibson[3], Michelle R Heupel[18], Suzanne R Livingstone[19], Jonnell C Sanciangco[14,15], John D Stevens[20], Sarah Valenti[5], William T White[20]



Extinction risk and conservation of the world's sharks and rays

eLIFE

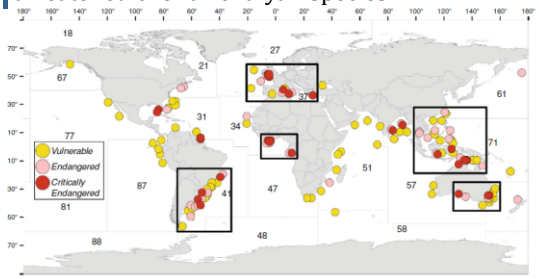


Extinction risk and conservation of the world's sharks and rays

Out of 1,041 globally distributed chondrichthyans:

- ¼ are threatened according to IUCN Red List
- Large-bodied, shallow-water species are at greatest risk
- five out of the seven most threatened families are rays
- chondrichthyan extinction risk is substantially higher than for most other vertebrates
- only 1/3 of species are considered "safe"

Global distribution of IUCN Red Listed threatened chondrichthyan species



Clusters of threatened species were found in 5 regions: (1) south-eastern South America; (2) *western Europe and the Mediterranean*; (3) western Africa; (4) South China Sea and Southeast Asia and (5) south-eastern Australia

Loss of Large Predatory Sharks from the Mediterranean Sea

Conservation Biology, Volume 22, No. 4, 952–964
©2008 Society for Conservation Biology
DOI: 10.1111/j.1525-1739.2008.00938.x

FRANCESCO FERRETTI,*† RANSOM A. MYERS,*‡ FABRIZIO SERENA,† AND HEIKE K. LOTZE*
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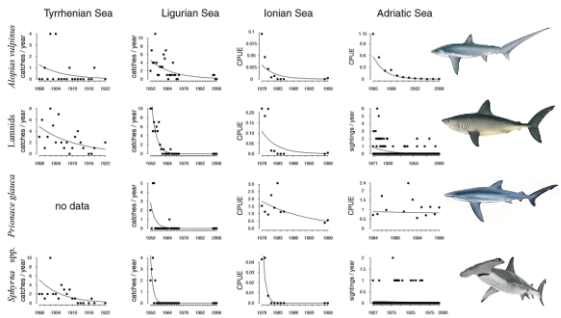
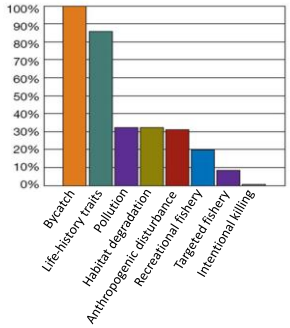
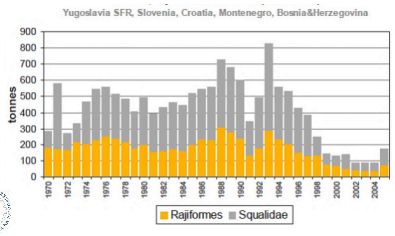


Summary of threats to chondrichthyan fishes in the Mediterranean Sea (IUCN)



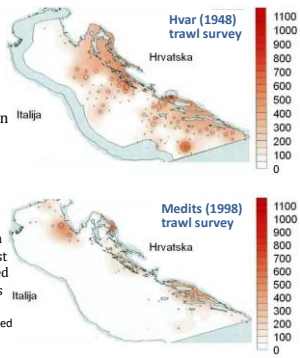
Capture of cartilaginous fishes

- cartilaginous species mostly aggregate in Squalidae and Rajformes
- difficult to identify catch trends for individual species



Elasmobranch communities in Adriatic

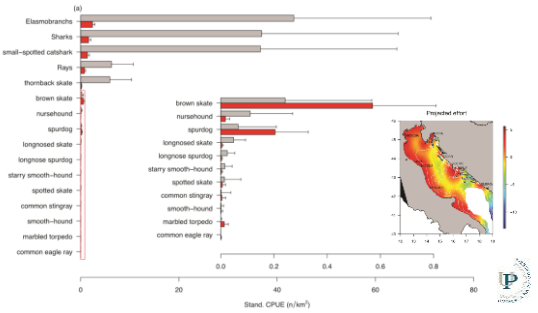
- decrease of elasmobranch abundance **by 61%**
- bigger sharks and rays species disappeared or were rarely found in the Medits 1998
- reduction of long lived and slowly growing species
- species composition changed
  - sharks showed declines
  - rays shifted in species composition
  - thornback skate *Raja clavata* - most abundant ray in the 1940s: declined
  - meso-pelagic rays and small skates increased:
    - brown skates *Raja miraletus* increased abundance



Long-term change in a meso-predator community in response to prolonged and heterogeneous human impact

SCIENTIFIC REPORTS | 3 : 1057 | DOI: 10.1038/srep01057

Francesco Ferretti[1,2], Giacomo C. Osio[3,4], Chris J. Jenkins[3], Andrew A. Rosenberg[2] & Heike K. Lotze[1]



NAT. CROAT. | VOL. 26 | No 2 | 313-320 | ZAGREB | DECEMBER 31, 2017

NEW DATA ON THE OCCURRENCE OF THE CRITICALLY ENDANGERED COMMON ANGELSHARK, *SQUATINA SQUATINA*, IN THE CROATIAN ADRIATIC SEA

Draško Holcer[1,2] & Bojan Lazar[3,4]

Journal of Applied Ichthyology

Rare or just unknown? The occurrence of the giant devil ray (*Mobula mobular*) in the Adriatic Sea

By D. Holcer[1,2], B. Lazar[2,3,4,5], P. Mackelworth[2] and C. M. Fortuna[6,2]

- Rare visitor in the Adriatic?
- Not even considered as part of Adriatic fauna!
- Long living, slow growing, late maturation, low fecundity – Endangered!

Abundance

- Sightings: 34 (2010) and 101 (2013)
- Estimated abundance 3.661 (CV=51%) (dive time corrected)
- Low densities in the entire Mediterranean

ECOLOGY LETTERS
REVIEW AND SYNTHESIS
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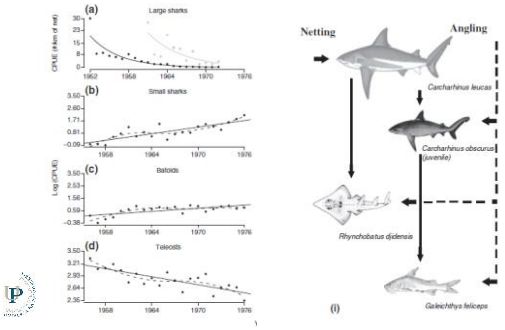
Patterns and ecosystem consequences of shark declines in the ocean



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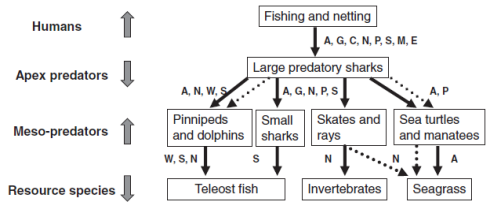


Figure 7 Documented ecosystem effects of fishing large sharks. Depicted are trophic (solid arrows) and behavioural (dotted arrows) interactions between humans, large and mesopredator elasmobranchs and their prey species. Block arrows represent overall population trends of the various functional groups. Regions in which particular interactions have been documented (see text) are indicated by letters (A, Australia; C, Caribbean; E, Europe; G, Gulf of Mexico; M, Mediterranean Sea; N, North American East Coast; P, Central Pacific; S, South Africa; W, North American West Coast). Note that few studies have documented effects on teleost and cephalopod prey.

Marine ecotourism

- swimming, viewing, touching, filming – disturbance
- disrupt the sharks' natural behaviour





Systematics

Squalomorphi:
- Squaliformes
- Squatiniformes
- Pristiophoriformes
- Echinorhiniformes
- Hexanchiformes
- Chlamydoselachiformes

Galeomorphi:
- Carchariniformes
- Orectolobiformes
- Lamniformes
- Heterodontiformes

Batoidea:
- Rajiformes
- Torpediniformes
- Pristiformes

Order
Hexanchiformes

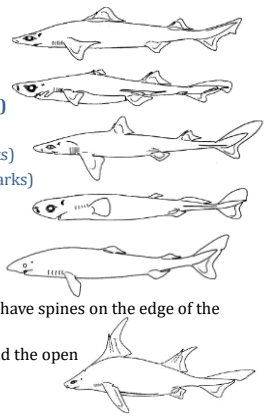
Family Hexanchidae

- closely resembles fossil forms: rounded snout, six long gill slits, single small dorsal fin, wide and rounded mouth
- found worldwide from tropical seas to northern temperate seas
- deep-benthic, littoral and semipelagic shark
- body size ranges from 1.5 to 5 m
- Red List assessment: Near Threatened

Glavonja šesteroškrgaš

Hexanchus griseus

Order
Squaliformes



Family Oxynotidae (rough sharks)
Family Squalidae (dogfishes)
Family Etmopteridae (lantern sharks)
Family Echinorhinidae (bramble sharks)
Family Centrophoridae
Family Dalatiidae
Family Somniosidae

- highly diverse group
- have a large spiracle, and mostly have spines on the edge of the dorsal fins
- found primarily in deep water and the open

Angular rough shark
Oxynotus centrina

- deepwater (up to 600m)
- bottom dwelling shark
- body size mostly <100 cm
- rare in Mediterranean
- Red List assessment: Vulnerable

Morsko prase

Spiny dogfish
Squalus acanthias

- small demersal shark
- of temperate continental shelf
- worlwide distribution
- naturally abundant – populations in decline
- Red list assessment: Near Threatened
  - in Mediterranean: Vulnerable

kostelj

Order
Squatiniformes

Family Squatinidae (angelsharks)

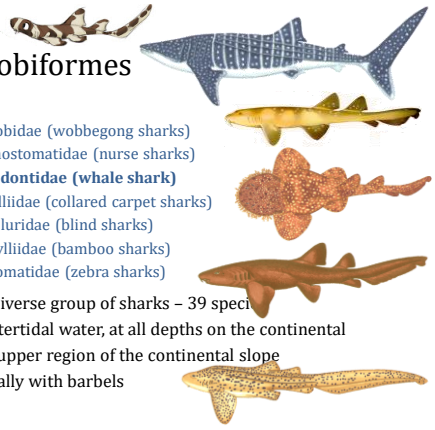
Squatina squatina

- common demersal predator
- coastal and outer continental shelfs in the Northeast Atlantic, Mediterranean and Black Seas
- often found buried in mud waiting to ambush small fish
- Red List assessment: Critically Endangered

Squatina squatina

Sklat sivac

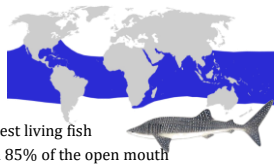
Order Orectolobiformes



Family Orectolobidae (wobbegong sharks)
Family Ginglymostomatidae (nurse sharks)
Family Rhincodontidae (whale shark)
Family Parascylliidae (collared carpet sharks)
Family Brachaeluridae (blind sharks)
Family Hemiscylliidae (bamboo sharks)
Family Stegostomatidae (zebra sharks)

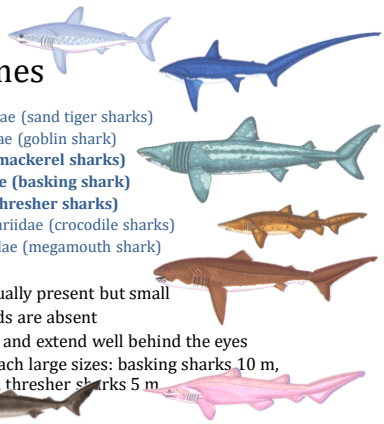
- large and diverse group of sharks – 39 speci
- found in intertidal water, at all depths on the continental shelf and the upper region of the continental slope
- mouth usually with barbels

Whale shark *Rhincodon typus*



- 20m long, weight 41 tons - the largest living fish
- swimms at velocity of 1.1m/s, with 85% of the open mouth
- on average, spents approximately 7.5h/day feeding
- approximate estimate of biomass consumption: 2.2kg/h
- oceanic species, inhabits warm waters
- Red List assessment: Vulnerable

Order Lamniformes



Family Odontaspididae (sand tiger sharks)
Family Mitsukurinidae (goblin shark)
Family Lamnidae (mackerel sharks)
Family Cetorhinidae (basking shark)
Family Alopiidae (thresher sharks)
Family Pseudocarchariidae (crocodile sharks)
Family Megachasmidae (megamouth shark)

- spiracles are usually present but small
- nictitating eyelids are absent
- mouth are large and extend well behind the eyes
- some species reach large sizes: basking sharks 10 m, megamouth and thresher sharks 5 m

Sea fox
Alopias vulpinus

- from 1.6 to 6 m body length
- up to 50 % of a body's length is the characteristic enlarged upper lobe of the caudal fin
- feed mainly on small fish that travel in schools and use enlarged caudal fin to tightly pack schools of fish to maximize strike success
- Red List assessment: Vulnerable

morska lisica

Basking shark
Cetorhinus maximus

- extended gill slits
- filter-feeder, pelagic species, cold-waters
- Red List assessment: Vulnerable

Golema psina

Shortfin mako
Isurus oxyrinchus

- extremely hydrodynamic body
- large black eyes
- true pelagic species with a primarily anti-tropical distribution
- the fastest shark, capable of attaining speeds of up to 32 km/h
- Red list assessment: Vulnerable
  - in Mediterranean: Critically Endangered

Kučak,mako

Order Carcharhiniformes







Family Scyliorhinidae (catsharks)
Family Proscylliidae (ribbontail catsharks)
Family Pseudotriakidae (false catsharks)
Family Leptocharildae (barbeled houndsharks)
Family Triakidae (smoothhound sharks)
Family Hemigaleidae (weasel sharks)
Family Carcharhinidae (requiem sharks)
Family Sphyrnidae (hammerhead sharks)

- eyes are lateral to dorsolateral with nictitating eyelids
- mouth are moderately large
- dominant in tropics
- pelagic and coastal species

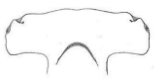
Great White Shark *Carcharodon carcharias*

- frequent in epipelagic nearshore waters
- mostly in temperate seas
- targeted for sportfishing income, commercial trophy hunting or human consumption
- Red List assessment: Vulnerable
  - in Mediterranean: Endangered

Veliki bijeli morski pas

Hammerhead shark *Sphyrna mokarran*

- active predators - favourite prey are stingrays
- large hammer-shaped head – cephalophoil head
- eyes located on the outer edges of the cephalophoil
- nostrils spread far apart
  - sensory advantages
- provide additional lift and maneuverability
- Red List assessment: Endangered



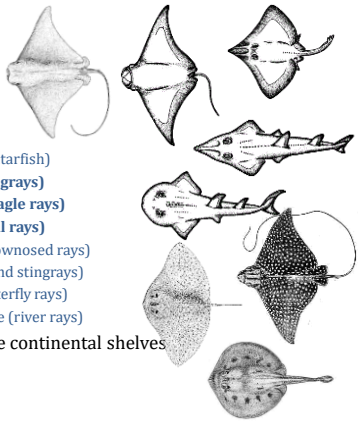
head morphology – ventral view

Small-spotted catshark
Scyliorhinus canicula

- commonly observed at depths to 100 m
- nocturnal species
- one of the most abundant elasmobranchs in the northeast Atlantic and Mediterranean
- Red List assessment: Least Concern

morska mačka

Order Rajiformes



Family Rajidae (skates)
Family Rhinobatidae (guitarfish)
Family Dasyatidae (stingrays)
Family Myliobatidae (eagle rays)
Family Mobulidae (devil rays)
Family Rhinopteridae (cownosed rays)
Family Urolophidae (round stingrays)
Family Gymnuridae (butterfly rays)
Family Potamotrygonidae (river rays)

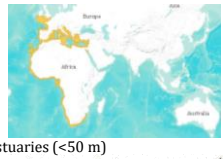
- widespread on the continental shelves

Common skate
Dipturus batis

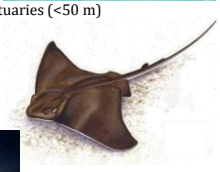
- was abundant on continental shelf of north-western Europe and Mediterranean
- largest skate in the world, reaching up to 250 cm in length
- a life span of approximately 50 years
- captured as part of the bycatch of multispecies trawl fisheries
- Red List assessment: Critically Endangered
  - in Mediterranean:
    Locally Extinct

kljunata raža

Common eagle rays
Myliobatis aquila



- temperate, tropical, and subtropical waters
- along coastlines in shallow lagoons, bays and estuaries (<50 m)
- often swims in groups close to the bottom
- minor commercial importance
- Red List assessment: Data Deficient
  - in Mediterranean: Near Threatened

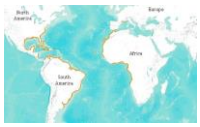


morski golub

Giant devilray
Mobula mobular

- plankton-feeding ray
- occurs in offshore deep waters, occasionally in shallow waters
- easily taken as by-catch on longlines, in swordfish pelagic driftnets, purse seines, trawls and fixed tuna traps
- Red List assessment: Endangered

Order
Pristiformes



Family Pristidae (sawfish)

- bladelike snout (rostrum) with lateral rostral teeth
- similar with sawsharks, but lack the barbels
- occur throughout the tropics and are rarely in temperate waters
- Red List assessment: Critically Endangered

Pristis pectinata

Order
Torpediniformes

Family Torpedinidae (electric rays)

- branchial muscles converted into electric organs
- worldwide in tropical to temperate seas, benthic usually in shallow water
- Red List assessment: Data Deficient

Torpedo marmorata

mramorna drhtulja

Contributed Paper

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Loss of Large Predatory Sharks from the Mediterranean Sea

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REVIEW AND SYNTHESIS

Patterns and ecosystem consequences of shark declines in the ocean

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Francesco Ferretti[1,2], Giacomo C. Osio[3,4], Chris J. Jenkins[5], Andrew A. Rosenberg[6] & Heike K. Lotze[1]