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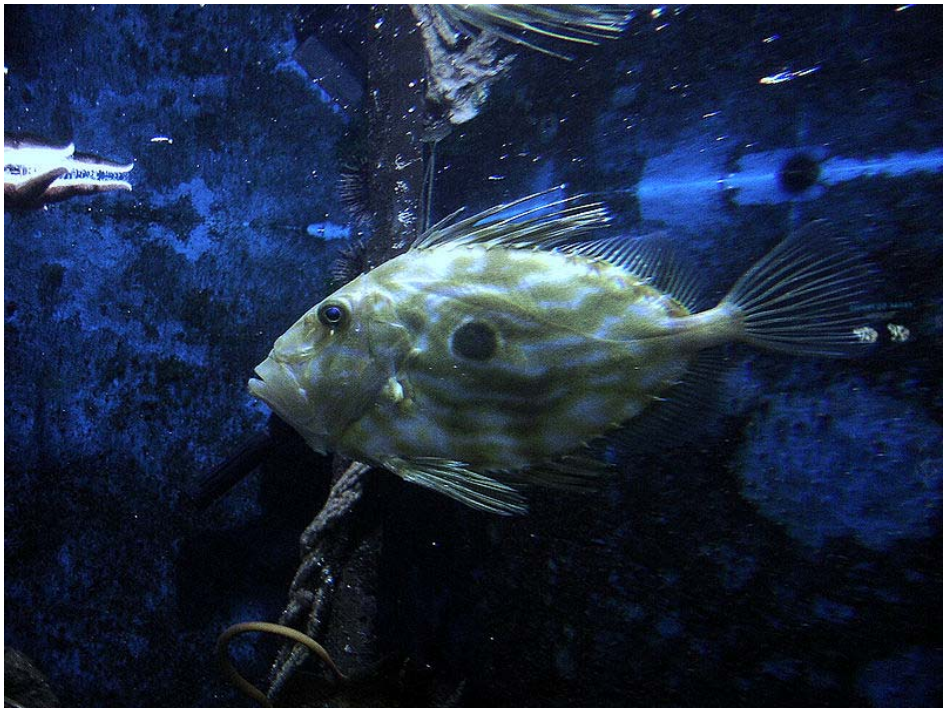
Rare and Endangered Fish Species in The Adriatic Sea and Proposal for Marine Flagship Species



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Rare and Endangered Fish Species in The Adriatic Sea and Proposal for Marine Flagship Species

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1. Introduction

Marine ecosystems are covering approximately 70% of Earth's surface and account for approximately 97% of all Earth's water. Fishes account for more than half of all living vertebrates on Earth and they are the most successful vertebrates in aquatic habitats worldwide. Their diversity is very high and extraordinary, in terms of habitats they inhabit, morphology and biology. They inhabit all aquatic habitats on Earth, starting from temperate lakes, rivers and oceans, to extreme condition habitats such as ocean depths, swamps, temporary pools and ponds, underground ponds, etc. Regardless their diversity, all fishes can be defined as an aquatic vertebrates with gills and with limbs in the shape of fins (Nelson, 1994).

Number of valid living species is almost 28,000, which are broken down in 515 families and 62 orders. Of these, 108 are jawless fish (70 hagfish and 38 lampreys); 970 are cartilaginous sharks (403), skates and rays (534), and chimaeras (33); and the remaining 26,000+ species are bony fishes. Considering their habitats, 41% of species live in fresh water, 58% in sea water, and 1% move between fresh water and the sea during their life cycles (Cohen 1970). Geographically, the highest diversities are found in the tropics. The Indo-West Pacific area that includes the western Pacific and Indian oceans and the Red Sea has the highest diversity for a marine area, while South America, Africa, and Southeast Asia, in that order, contain the most freshwater fish species (Berra 2001; Lévêque *et al*. 2008).

Considering European marine environment, it includes a vast expanse of the northeastern Atlantic Ocean, the brackish waters of the Baltic Sea, the warm salty waters of the Mediterranean Sea and the murky depths of the Black Sea. In the Mediterranean Sea, the deepest waters are found to the south of Greece, with sea bottom areas there reaching 5,200 metres of depth (Coll *et al*. 2012). In the

Black Sea, the bottom reaches 2,563 metres depth, some 30 nautical miles north off the Turkish coast, while the deepest point of Adriatic Sea is in its south part, 1,300 meters. High diversity of European marine habitats encompasses a great diversity of sub-tropical, temperate, and Arctic marine fishes. Total number of marine fishes worldwide is 17,700, and European marine area is inhabited with 1,256 species from 2018 families (Eschmeyer, 2015). Not all of 1,256 species are originally native to European waters. In the case of the Mediterranean Sea, the Suez Canal provides an ongoing route for migration of "Lessepsian migrants" from Indo-Pacific region (Golani and Appelbaum-Golani, 2010), and the Straits of Gibraltar of Atlantic species into the Mediterranean Sea (Golani *et al*. 2002). In the Northeast Atlantic, there is ongoing northward migration of sub-tropical species due to increasing sea surface temperatures (Simpson *et al.*, 2011).

According to the most recent census, there are 407 fish species and subspecies recorded in the Adriatic Sea (Jardas, 1996). That number has since grown to 449 species, which is about of 66% of the species and subspecies of the Mediterranean (Dulčić & Dragičević, 2011). In the Mediterranean there are 664 species of fish recorded (557 *Osteichthyes*, 86 *Chondrichtyes* and 3 species of *Agnatha*) which are sorted into 156 families (Quigrand & Tomasini, 2000; Bailly *et al*., 2001), but now it is considered that there are 716 species (Golani *et al,* 2002). However, some of the findings for some species (20 species, at least) are very old and unreliable. Every year, new species are recorded in the Adriatic, and the actual number of species that inhabit Adriatic or breed in it is still unknown.

The Adriatic is in the third place in the Mediterranean according to the number of species, but only in the fifth place according to the index of biodiversity. The number of species decreases going from South to North Adriatic, with 89% of all species found in the South

Adriatic, 78% in the Central Adriatic, and 65% in the North Adriatic Sea.

Current number of 449 fish species and subspecies observed in the Adriatic so far cannot be taken as definite for a number of reasons. Firstly, it is not possible to give a definite answer to the question of whether some fish species caught in the Adriatic in fact live there or occur occasionally. For example, some rare Adriatic fish were found only once or only a few times, or the observation was dubious for some reason. Such fish include the species: *Pristis pectinata, Rhinobatos rhinobatos, Regalecus glasne, Lophotus lacepedei, Ammodytes tobianus* and some others. Secondly, most of the south Adriatic basin has not been sufficiently explored in terms of its ichthyofauna, particularly not at depths of more than 500 m. It is therefore logical to expect future explorations of the region to increase the number of known meso- and bathypelagic, and bathybenthonic fish of the Adriatic. It is very likely that new species or subspecies will be found in the region of the continental shelf, in spite of the fact that the Adriatic shelf is one of the best explored as far as the ichthyofauna is concerned. Such a possibility is indicated by some recent discoveries of new species in the Adriatic as reported above (Dulčić *et al*., 1999). Lastly, the third reason for uncertainty about the exact number of fish species in the Adriatic relates to some unresolved systematic (taxonomic) and other status questions on some fish species (Pallaoro and Kovačić, 2000; Dulčić *et al*., 2003).

Considering endemic species, with all discussions about taxonomic status and geographic range, it is considered that 6 endemic specie lives in the Adriatic Sea: *Acipenser nacarii* (family Acipenseridae), 4 species of goby: *Knipowitchia panizzae*, *Pomatoschistus canestrinii*, *Speleogobius trigloides*, *Gobius kolombatovici* (family Gobiidae) and *Syngnathus taenionotus* (family Sygnathidae).

Fishes are among the most endangered marine species due to their high economic importance for humanity, they are subject of fishery, and in most cases under overfishing. At the moment, 123 fish species are listed as endangered (28% of known species in Adriatic Sea) in the Red Book of marine fishes of Croatia (Jardas *et al*., 2008). One Chondrichthyes species is already considered extinct and further 12 are endangered in the region, while 2 Osteichthyes species are considered extinct and 8 are endangered (Dulčić & Dragičević, 2011). There are different reasons for endangerment: fisheries, habitat degradation, marine pollution, alien species, climate changes, but usually the endangerment is brought through synergy of different factors.

1.1. Pressures and threats to fish species in the Adriatic Sea

Fish are the most threatened animals in the sea due to their high economic importance. **Fisheries** is the most direct and most negative pressure to fish species worldwide. Of more than 400 fish species in Adriatic, 120 species have high commercial and economic importance and are target species in fisheries. Beside these 120 species, there is high number of other species that are not directly targeted by fisherman but are accidentally caught as by-catch or discard. Fisheries is influencing and threatening fish species in two ways: directly through fishing mortality by reducing the number of fish in population, and indirectly by interrupting food chains in the sea and affecting larger number of species and populations. Depending on fishing tools used, those negative effects can have higher or lower impact. Some fishing tools have higher selectivity and target larger individuals, allowing young and juveniles to remain in the sea (longlines, gillnets), while others (pelagic and benthic trawls) catch all individuals in their way, resulting in high amounts of by-catch, discard and accidental catches. In addition to direct reduction of the number of individuals, some fishing tools also affect habitats and cause habitat degradation. Overfishing led to decreased

population of many species in the Adriatic Sea, like *Sardina pilchardus*, *Engraulis encrasicolus*, *Mullus barbatus*, etc, but the species under the most intense pressure by overfishing are the cartilaginous species due to their late maturation, small number of offspring, etc.

Habitat degradation rapidly increased during previous decades as a consequence of human activities in coastal region of the Adriatic Sea. As the result of tourist development, significant work in construction and structure building was made along the coastline: marinas, ports, beaches, etc., leading to habitat degradation and changes in ecological factors in the ecosystem. Important communities of seagrasses and photophilic algae inhabiting areas from 0.5 to 40 meters of depth are centres of biodiversity in the sea, representing spawning, nursery, feeding and hiding places for large number of fish and other marine organisms. Any change in communities of seagrasses and their degradation and defragmentation has negative influence not only on species that are directly connected to them, but also on other species by interrupting food chains.

Marine pollution is caused by numerous human activities on land and sea: wastewater from municipalities and industry, marine transportation, agriculture and aquaculture activities, etc. Marine pollution causes numerous environmental changes: decrease in water transparency, lower oxygen concentration, changes in phytoplankton composition and chlorophyll *a* concentration, resulting in water blooming, poisoning of animals.

Allochtonous and invasive species cause disturbance in the ecological balance in marine ecosystems, especially in benthic communities. Numerous warm-water species appeared in the Adriatic, like algae *Caulerpa racemosa* and *Caulerpa taxifolia*, which spread very rapidly and overgrew autochthonous communities, causing changes in biodiversity and influencing many

fish species and their early life forms, especially herbivorous species. More than 40 new fish species have been recorded in past decades in the Adriatic. These include lessepsian migrants coming from the Red Sea, or Atlantic species coming through the Gibraltar. New species compete with autochthonous species for food, free niches. Such uinvasive species are usually very adaptable.

Climate change is one more threat to fish species. In the Adriatic Sea, surface temperature increased by 0.3°C since 1990 (Dulčić *et al.*, 1999), and in some inner parts and bays it can reach almost 30°C during summer months. This can lead to the appearance of new thermophilic species, and overall changes in qualitative and quantitative composition of ichthyofauna.

2. List of rare and endangered fish species in the Adriatic Sea

In order to prepare the list of rare and endangered fish species in the Adriatic Sea, the following literature data was used: two legal documents governing protection status of fish in Montenegro, Law on Nature Protection (Official Gazette of Montenegro 18/16) and Law on Marine Fisheries and Mariculture (Official Gazette of Montenegro 56/09, 47/15), IUCN Red List of Threatened species for Mediterranean, European Red List of marine fishes (Nieto *et al.*, 2015) and Red Book of Marine Fishes of Croatia (Jardas *et al.*, 2008). All available lists of threatened and protected marine fish species were compared and cross referenced, amended with species protected by Montenegrin legislation and the final list of all Adriatic species that are threatened was prepared (Table 1).

Table 1. List of Adriatic fish species that are listed on IUCN Red list and protected by national legislation

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Aetomylaeus bovinus (Geoffroy Saint-Hilaire, 1817)	Bullray	CR						
Carcharias taurus (Rafinesque, 1810)	Sand Tiger Shark	CR						X
Carcharodon carcharias (Linnaeus, 1758)	Great White Shark	CR		Annex II	App I / App II	Annex II	X	X
Dipturus batis (Linnaeus, 1758)	Common Skate	CR						X
Isurus oxyrinchus (Rafinesque, 1810)	Shortfin Mako	CR		Annex III	App I I	Annex III		X
Lamna nasus (Bonnaterre, 1788)	Porbeagle	CR		Annex III	App I I	Annex III		X
Leucoraja circularis (Couch, 1838)	Sandy Skate	CR						X

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Odontaspis ferox (Risso, 1810)	Smalltooth Sand Tiger	CR						X
Prionace glauca (Linnaeus, 1758)	Blue Shark	CR		Annex III	App I I	Annex III		
Squatina oculata (Bonaparte, 1840)	Smoothback Angelshark	CR						X
Squatina squatina (Linnaeus, 1758)	Angelshark	CR		Annex III	App I / App II	Annex III		X
Lestidiops sphyrenoides (Risso, 1820)	Barracudina	CR						
Sphyraena viridensis (Cuvier, 1829)	Yellowmouth Barracuda	CR						
Acipenser naccarii (Bonaparte, 1836)	Adriatic Sturgeon	CR/ VU	x	Annex II	App I I	Annex II	X	X
Acipenser sturio (Linnaeus, 1758)	Atlantic Sturgeon	CR/RE	x	Annex II	App I / App II	Annex II	X	X
Mobula mobular (Bonnaterre, 1788)	Devil Ray	EN		Annex II	App I / App II	Annex II	X	X
Alopias vulpinus (Bonnaterre, 1788)	Common Thresher Shark	EN			App I I			
Alosa fallax (Lacepède, 1803)	Twaite Shad	EN	x	Annex III		Annex III		
Aphanius fasciatus(Valenciennes, 1821)	Mediterranean Killifish	EN	x	Annex II /Annex III		Annex II		
Carcharhinus plumbeus (Nardo, 1827)	Sandbar Shark	EN						
Cetorhinus maximus (Gunnerus, 1765)	Basking Shark	EN		Annex II	App I / App II	Annex II	X	X
Epinephelus marginatus (Lowe, 1834)	Dusky Grouper	EN		Annex III		Annex III		
Raja radula (Delaroche, 1809)	Rough Skate	EN						
Rostroraja alba (Lacepède, 1803)	White Skate	EN		Annex III		Annex III		X
Squalus acanthias (Linnaeus, 1758)	Spiny Dogfish	EN			App I I			

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Thunnus thynnus (Linnaeus, 1758)	Atlantic Bluefin Tuna	EN				Annex III		
Alectis alexandrina (Geoffroy Saint-Hilaire, 1817)	Alexandria Pompano	EN						
Echelus myrus (Linnaeus, 1758)	Painted Eel	EN						
Galeus melastomus (Rafinesque, 1810)	Blackmouth Catshark	EN						
Remora remora (Linnaeus, 1758)	Common remora	EN						
Bathytoshia centroura (Mitchill, 1815)	Roughtail Stingray	VU						
Dasyatis pastinaca (Linnaeus, 1758)	Common Stingray	VU						
Galeorhinus galeus (Linnaeus, 1758)	Liver-oil Shark	VU						X
Labrus viridis (Linnaeus, 1758)	Green Wrasse	VU						
Mustelus asterias (Cloquet, 1819)	Starry Smoothhound	VU						
Mustelus mustelus (Linnaeus, 1758)	Common Smoothhound	VU						
Mustelus punctulatus (Risso, 1827)	Blackspotted Smoothhound	VU						
Myliobatis aquila (Linnaeus, 1758)	Common Eagle Ray	VU						
Sciaena umbra (Linnaeus, 1758)	Brown Meagre	VU		Annex III		Annex III		
Umbrina cirrosa (Linnaeus, 1758)	Shi Drum	VU		Annex III		Annex III		
Dalophis imberbis (Delaroche, 1809)	Armless snake eel	VU						
Gymnammodytes cicerelus (Rafinesque, 1810)	Mediterranean Sand Eel	VU						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Merlangius merlangus (Linnaeus, 1758)	Whiting	VU						
Oxynotus centrina (Linnaeus, 1758)	Angular roughshark	VU						X
Pomatoschistus tortonesei (Miller, 1969)	Tortoneses goby						X	X
Gobius niger (Linnaeus, 1758)	Black goby	NT						
Hippocampus guttulatus (Cuvier, 1829)	Long-snouted Seahorse	NT					X	X
Hippocampus hippocampus (Linnaeus, 1758)	Short-snouted Seahorse	NT		Annex II		Annex II	X	X
Pleuronectes platessa (Linnaeus, 1758)	European Plaice	NT						
Raja clavata (Linnaeus, 1758)	Thornback Skate	NT						
Scyliorhinus stellaris (Linnaeus, 1758)	Nursehound	NT						
Xiphias gladius (Linnaeus, 1758)	Swordfish	NT				Annex III		
Chelon labrosus (Risso, 1827)	Thicklip Grey Mullet	NT						
Epigonus denticulatus (Dieuzeide, 1950)	Pencil Cardinal	NT						
Sarpa salpa (Linnaeus, 1758)	Goldline	NT						
Dipturus oxyrinchus (Linnaeus, 1758)	Longnosed Skate	NT/VU						
Squalus blainville (Risso, 1827)	Longnose Spurdog	DD/NT						
Bothus podas (Delaroche, 1809)	Wide-eyed Flounder	LC/ NT						
Diplodus puntazzo (Walbaum, 1792)	Sharpsnout Seabream	LC/NT						
Diplodus sargus (Linnaeus, 1758)	White Seabream	LC/NT						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Labrus mixtus (Linnaeus, 1758)	Cuckoo Wrasse	LC/NT						
Liza saliens (Risso, 1810)	Leaping Mullet	LC/NT						
Lophius piscatorius (Linnaeus, 1758)	Angler	LC/NT						
Muraena helena (Linnaeus, 1758)	Black Moray	LC/NT						
Pegusa lascaris (Risso, 1810)	Sand Sole	LC/NT						
Platichthys flesus (Linnaeus, 1758)	European flounder	LC/NT						
Psetta maxima (Linnaeus, 1758)	Turbot	LC/NT						
Raja asterias (Delaroche, 1809)	Starry Ray	LC/NT						
Raja polystigma (Regan, 1923)	Speckled Skate	LC/NT						
Scophthalmus rhombus (Linnaeus, 1758)	Brill	LC/NT						
Scorpaena scrofa (Linnaeus, 1758	Red Scorpionfish	LC/NT						
Spondyliosoma cantharus (Linnaeus, 1758)	Black Seabream	LC/NT						
Trachinus araneus (Cuvier, 1829)	Spotted Weever	LC/NT						
Zeus faber (Linnaeus, 1758)	Atlantic John Dory	LC/NT						
Chelon labrosus (Risso, 1827)	Thicklip Grey Mullet	LC/VU						
Hexanchus griseus (Bonnaterre, 1788)	Bluntnose Sixgill Shark	LC/VU						
Mugil cephalus (Linnaeus, 1758)	Flathead Mullet	LC/VU						
Pagrus pagrus (Linnaeus, 1758)	Red Porgy	LC/VU						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Argyrosomus regius (Asso, 1801)	Meagre	LC						
Aspitrigla cuculus (Linnaeus, 1758)	Red Gurnard	LC						
Atherina boyeri (Risso, 1810)	Big-scale Sand Smelt	LC						
Atherina hepsetus (Linnaeus, 1758)	Mediterranean Sand Smelt	LC						
Chelidonichthys lucerna (Linnaeus, 1758)	Tub Gurnard	LC						
Dentex dentex (Linnaeus 1758)	Common Dentex	LC						
Dentex gibbosus (Rafinesque, 1810)	Pink Dentex,	LC						
Dicentrarchus labrax (Linnaeus, 1758)	European Seabass	LC						
Dicentrarchus punctatus (Bloch, 1792)	Spotted Seabass	LC						
Diplodus vulgaris (Saint-Hilaire, 1817)	Common Two-banded Seabream	LC						
Echiichthys vipera (Cuvier, 1829)	Lesser Weever,	LC						
Eutrigla gurnardus (Linnaeus, 1758)	Grey gurnard	LC						
Gymnothorax unicolor (Delaroche, 1809)	Brown Moray	LC						
Labrus merula (Linnaeus, 1758)	Brown Wrasse	LC						
Lepidorhombus boscii (Risso, 1810)	Fourspotted Megrim	LC						
Lepidorhombus whiffiagonis (Walbaum, 1792)	Megrim	LC						
Lichia amia (Linnaeus, 1758)	Leerfish	LC						
Lithognathus mormyrus (Linnaeus, 1758)	Striped Seabream	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Liza aurata (Risso, 1810)	Golden Grey Mullet	LC						
Liza ramada (Risso, 1827)	Grey Mullet	LC						
Lophius budegassa (Spinola, 1807)	Black-bellied Angler	LC						
Microchirus ocellatus (Linnaeus, 1758)	Foureyed Sole	LC						
Mullus surmuletus (Linnaeus, 1758)	Striped Red Mullet	LC						
Nerophis ophidion (Linnaeus, 1758)	Straightnose Pipefish	LC						
Ophisurus serpens (Linnaeus, 1758)	Serpent Eel	LC						
Pagellus acarne (Risso, 1827)	Axillary Seabream,	LC						
Pagellus bogaraveo (Brünnich, 1768)	Blackspot Seabream	LC						
Pagellus erythrinus (Linnaeus, 1758)	Common Pandora	LC						
Petromyzon marinus (Linnaeus, 1758)	Sea Lamprey	LC	x			Annex III		
Phycis phycis (Linnaeus, 1766)	Forkbeard	LC						
Pteroplatytrygon violacea (Bonaparte, 1832)	Pelagic Stingray	LC						
Raja miraletus (Linnaeus, 1758)	Brown Skate	LC						
Raja montagui (Fowler, 1910)	Spotted Skate	LC						
Salmo trutta trutta (Linnaeus, 1758)	Brown Trout	LC						
Scyliorhinus canicula (Linnaeus, 1758)	Small Spotted Catshark	LC						
Seriola dumerili (Risso, 1810)	Greater Amberjack	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Solea solea (Linnaeus, 1758)	Dover Sole	LC						
Sparus aurata (Linnaeus, 1758)	Gilt-head Seabream	LC						
Symphodus doderleini (Jordan, 1890)	Long stripped wrasse	LC						
Symphodus tinca (Linnaeus, 1758)	East Atlantic Peacock Wrasse	LC						
Syngnathus abaster (Risso, 1827)	Black-striped Pipefish	LC		Annex III				
Syngnathus acus (Linnaeus, 1758)	Longsnout Pipefish	LC						
Syngnathus typhle (Linnaeus, 1758)	Broadnosed Pipefish	LC						
Tetronarce nobiliana (Bonaparte, 1835)	Great Torpedo Ray,	LC						
Torpedo marmorata (Risso, 1810)	Spotted Torpedo	LC						
Torpedo torpedo (Linnaeus, 1758)	Common Torpedo Ray	LC						
Trachinus radiatus (Cuvier, 1829)	Starry Weever	LC						
Trigla lyra (Linnaeus, 1758)	Piper	LC						
Zosterisessor ophiocephalus (Pallas, 1814)	Grass Goby	LC						
Acantholabrus palloni (Risso, 1810)	Scale-rayed Wrasse	LC						
Aidablennius sphynx (Valenciennes, 1836)	Sphinx blen ny	LC						
Alopias superciliosus (Lowe, 1841)	Bigeye thresher	LC			App I I			
Apletodon incognitus (Hofrichter & Patzner, 1997)		LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Apogon imberbis (Linnaeus, 1758)	Cardinal Fish	LC						
Apterichtus anguiformis (Peters, 1877)	Slender Finless Eel	LC						
Apterichtus caecus (Linnaeus, 1758)	European Finless Eel	LC						
Arctozenus risso (Bonaparte, 1840)	Spotted Barracudina	LC						
Argyropelecus hemigymnus (Cocco, 1829)	Half-naked Hatchetfish	LC						
Ariosoma balearicum (Delaroche, 1809)	Half-naked Hatchetfish	LC						
Arnoglossus imperialis (Rafinesque, 1810)	Imperial Scaldfish	LC						
Arnoglossus laterna (Walbaum, 1792)	Mediterranean Scaldfish	LC						
Arnoglossus thori (Kyle, 1913)	Thor's Scaldfish	LC						
Auxis rochei (Risso, 1810)	Bullet tuna	LC						
Bathophilus nigerrimus (Giglioli, 1882)	Scaleless Dragonfish	LC						
Bathypterois mediterraneus (Vaillant, 1888)	Spiderfish	LC						
Bellottia apoda (Giglioli, 1883)		LC						
Benthocometes robustus (Goode & Bean, 1886)	Robust Cusk-eel	LC						
Blennius ocellaris (Linnaeus, 1758)	Butterfly Blenny	LC						
Boops boops (Linnaeus, 1758)	Bogue	LC						
Buenia affinis (Iljin, 1930)	De Buen's Goby	LC						
Buglossidium luteum (Risso, 1810)	Solenette	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Callanthias ruber (Rafinesque, 1810)	Parrot Seaperch	LC						
Callionymus lyra (Linnaeus, 1758)	Common dragonet	LC						
Callionymus maculatus (Rafinesque, 1810)	Spotted dragon	LC						
Callionymus pusillus (Delaroche, 1809)	Sailfin Dragonet	LC						
Callionymus risso (Lesueur, 1814)	Risso's Dragonet	LC						
Capros aper (Linnaeus, 1758)	Boarfish	LC						
Carcharhinus brachyurus (Günther, 1870)	Copper Shark	LC						
Centracanthus cirrus (Rafinesque, 1810)	Curled Picarel	LC						
Centrolophus niger (Gmelin, 1789)	Rudderfish, Blackfish	LC						
Cheilopogon heterurus (Rafinesque, 1810)	Blotchwing Flyingfish	LC						
Chelidonichthys cuculus (Linnaeus, 1758)	Red Gurnard	LC						
Chelidonichthys lastoviza (Bonnaterre, 1788)	Streaked gurnard	LC						
Chelidonichthys obscurus (Walbaum, 1792)	Longfin gurnard	LC						
Chimaera monstrosa (Linnaeus, 1758)	Rabbitfish	LC						
Chlopsis bicolor (Rafinesque, 1810)	Bicoloured False Moray	LC						
Chlorophthalmus agassizi (Bonaparte, 1840)	Agassiz's Thread-sail Fish	LC		Annex II				
Chromis chromis (Linnaeus, 1758)	Damselfish	LC		Annex II				
Chromogobius zebratus (Kolombatovic, 1891)	Kolombatovic's Goby	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Citharus linguatula (Linnaeus, 1758)	Spotted Flounder,	LC						
Clinitrachus argentatus (Risso, 1810)	Cline	LC						
Coelorinchus caelorhincus (Risso, 1810)	Hollowsnout Grenadier,	LC						
Coelorinchus mediterraneus (Iwamoto & Ungaro, 2002)	IT: Pesce sorcio	LC						
Conger conger (Linnaeus, 1758)	Conger Eel	LC						
Corcyrogobius liechtensteinI (Kolombatovic, 1891)	Liechtenstein's Goby	LC						
Coris julis (Linnaeus, 1758)	Mediterranean Rainbow Wrasse	LC						
Coryphoblennius galerita (Linnaeus, 1758)	Montagu's Blenny	LC						
Crystallogobius linearis (Düben, 1845)	Crystal Goby	LC						
Cubiceps gracilis (Lowe, 1843)	Longfin Cigarfish	LC						
Cyclothone braueri (Jespersen & Tåning, 1926)	Bent-tooth Lightfish	LC						
Dactylopterus volitans (Linnaeus, 1758)	Flying Gurnard	LC						
Dasyatis pastinaca (Linnaeus, 1758)	Common Stingray	LC						
Dentex macrophthalmus (Bloch, 1791)	Large-eyed Dentex	LC						
Diaphus metopoclampusb (Cocco, 1829)	Spothead Lantern Fish	LC						
Diaphus rafinesquii (Cocco, 1838)	White-spotted Lantern Fish	LC						
Didogobius schlieweni (Miller, 1993)	Andromeda goby	LC						
Didogobius splechtnai (Ahnelt & Patzner, 1995)	Splechtna's Goby	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Diplecogaster bimaculata (Bonnaterre, 1788)	Two-spotted Clingfish	LC						
Diplodus annularis (Linnaeus, 1758)	Annular Seabream	LC						
Diplodus cervinus (Lowe, 1838)	Zebra Seabream	LC						
Echinorhinus brucus (Bonnaterre, 1788)	Bramble Shark	LC						
Echiodon dentatus (Cuvier, 1829)		LC						
Engraulis encrasicolus (Linnaeus, 1758)	European Anchovy	LC						
Epinephelus aeneus (Geoffroy Saint-Hilaire, 1817)	White Grouper	LC						
Euthynnus alletteratus (Rafinesque, 1810)	Little Tunny	LC						
Evermannella balbo (Risso, 1820)	Balbo Sabretooth	LC						
Gadella maraldi (Risso, 1810)	Gadella	LC						
Gadiculus argenteus (Guichenot, 1850)	Silvery Pout	LC						
Gaidropsarus vulgaris (Cloquet, 1824)	Three-bearded Rockling	LC						
Glaucostegus cemiculus (Geoffroy Saint-Hilaire, 1817)	Blackchin Guitarfish	LC	Possibly EXTINCT					X
Glossanodon leioglossus (Valenciennes, 1848)	Smalltoothed Argentine	LC						
Gnathophis mystax (Delaroche, 1809)	Thinlip Conger	LC						
Gobius ater (Bellotti, 1888)	Bellotti's Goby	LC						
Gobius auratus (Risso, 1810)	Golden goby	LC						
Gobius bucchichi (Steindachner, 1870)	Bucchich's Goby	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Gobius couchi (Miller & El-Tawil, 1974)	Couch's Goby	LC						
Gobius fallax (Sarato, 1889)	Sarato's Goby	LC						
Gobius geniporus (Valenciennes, 1837)	Slender Goby	LC						
Gobius kolombatovici (Kovačić & Miller, 2000)		LC						
Gobius roulei (Linnaeus, 1758)	Roule's Goby	LC						
Gobius vittatus (Linnaeus, 1758)	Striped Goby	LC						
Gonichthys coccoi (Cocco, 1829)	Cocco's lanternfish	LC						
Gonostoma denudatum (Rafinesque, 1810)	Bristlemouth	LC						
Gonostoma elongatum (Günther, 1878)	Elongated Bristlemouth Fish	LC						
Gouania willdenowi (Risso, 1810)	Blunt-snouted Clingfish	LC						
Grammonus ater (Risso, 1810)	Black brotula	LC						
Gymnura altavela (Linnaeus, 1758)	Spiny Butterfly Ray	LC						
Helicolenus dactylopterus (Delaroche, 1809)	Blackbelly Rosefis	LC						X
Hoplostethus mediterraneus (Cuvier, 1829)	Silver Roughy	LC						
Hygophum benoiti (Cocco, 1838)	Benoit's Lanternfish	LC						
Hygophum hygomii (Lütken, 1892)	Bermuda Lantern Fish	LC						
Ichthyococcus ovatus (Cocco, 1838)	Lightfish	LC						
Katsuwonus pelamis (Linnaeus, 1758)	Skipjack Tuna	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Lagocephalus lagocephalus (Linnaeus, 1758)	Oceanic Puffer	LC						
Lampanyctus crocodilus (Risso, 1810)	Jewel Lanternfish	LC						
Lebetus guilleti (Le Danois, 1913)	Guillet's Goby	LC						
Lepadogaster lepadogaster (Bonnaterre, 1788)	Shore Clingfish	LC						
Lepidion lepidion (Risso, 1810)	Mediterranean Codling	LC						
Lepidopus caudatus (Euphrasen, 1788)	Silver Scabbardfish	LC						
Leucoraja fullonica (Linnaeus, 1758)	Shagreen Skate	LC						
Lobianchia dofleini (Zugmayer, 1911)	Dofleini's Lantern Fish	LC						
Lophotus lacepede (Giorna, 1809)	Crested Oarfish	LC						
Macroramphosus scolopax (Linnaeus, 1758)	Longspine Snipefish	LC						
Merluccius merluccius (Linnaeus, 1758)	European Hake	LC						
Microlipophrys adriaticus (Steindachner & Kolombatovic, 1883)	Combtooth blenny	LC						
Microlipophrys canevae (Vinciguerra, 1880	Canevas blenny	LC						
Microlipophrys dalmatinus (Steindachner & Kolombatovic, 1883)	Dalmatian blenny	LC						
Microstoma microstoma (Risso, 1810)	Dusky Pencilsmelt	LC						
Monochirus hispidus (Rafinesque, 1814)	Whiskered Sole	LC						
Mullus barbatus (Linnaeus, 1758)	Red Mullet	LC						
Myctophum punctatum (Rafinesque, 1810)	Spotted Lanternfish	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Nettastoma melanurum (Rafinesque, 1810)	Blackfin Sorcerer	LC						
Notoscopelus elongatus (Costa, 1844)		LC						
Oblada melanura (Linnaeus, 1758)	Saddled Seabream	LC						
Odondebuenia balearica (Pellegrin & Fage, 1907)	Coralline Goby	LC						
Opeatogenys gracilis (Canestrini, 1864)		LC						
Parablennius gattorugine (Linnaeus, 1758)	Tompot blenny	LC						
Parablennius rouxi (Cocco, 1833)	Longstriped blenny	LC						
Parablennius tentacularis (Brünnich, 1768)	Tentacled blenny	LC						
Parophidion vassali (Risso, 1810)	Rosy snake blanny	LC						
Peristedion cataphractum (Linnaeus, 1758)	Armed gurnard	LC						
Plectorhinchus mediterraneus (Guichenot, 1850)	Rubberlip grunt	LC						
Pomatomus saltatrix (Linnaeus, 1766)	Bluefish	LC						
Pomatoschistus bathi (Miller, 1982)	Bath's goby	LC						
Pomatoschistus norvegicus (Collett, 1902)	Norway goby	LC						
Priacanthus arenatus (Cuvier, 1829)	Atlantic bigeye	LC						
Psenes pellucidus (Lütken, 1880)	Bluefin driftfish	LC						
Pseudaphya ferreri (Buen & Fage, 1908)	Ferrer's goby	LC						
Pteroplatytrygon violacea (Bonaparte, 1832)	Pelagic stingray	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Ranzania laevis (Pennant, 1776)	Slender sunfish	LC						
Rhinobatos rhinobatos (Linnaeus, 1758)	Common guitarfish	LC						
Salaria pavo (Risso, 1810)	Peacock blenny	LC			App I I			X
Sarda sarda (Bloch, 1793)	Atlantic bonito	LC						
Sardina pilchardus (Walbaum, 1792)	European pilchard	LC						
Sardinella aurita (Valenciennes, 1847)	Round sardinella	LC						
Scomber colias (Gmelin, 1789)	Atlantic chub mackerel	LC						
Scomber japonicus (Houttuyn, 1782)	Pacific chub mackerel	LC						
Scomber scombrus (Linnaeus, 1758)	Atlantic mackerel	LC						
Scorpaena elongata (Cadenat, 1943)	Slender rockfish	LC						
Scorpaena loppei (Cadenat, 1943)	Cadenat's rockfish	LC						
Scorpaena maderensis (Valenciennes, 1833)	Madeira rockfish	LC						
Scorpaena notata (Rafinesque, 1810)	Red scorpionfish	LC						
Scorpaena porcus (Linnaeus, 1758)	Black scorpionfish	LC						
Seriola fasciata (Bloch, 1793)	Lesser Amberjack	LC						
Serranus cabrilla (Linnaeus, 1758)	Comber	LC						
Serranus hepatus (Linnaeus, 1758)	Brown Comber	LC						
Serranus scriba (Linnaeus, 1758)	Painted Comber	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Solea aegyptiaca (Chabanaud, 1927)	Egyptian Sole	LC						
Sphoeroides pachygaster (Müller & Troschel, 1848	Blunthead Puffer	LC						
Sphyraena sphyraena (Linnaeus, 1758)	European Barracuda,	LC						
Sphyrna zygaena (Linnaeus, 1758)	Smooth Hammerhead	LC						
Spicara maena (Linnaeus, 1758)	Blotched Picarel	LC						X
Spicara smaris (Linnaeus, 1758)	Picarel	LC						
Sudis hyalina (Rafinesque, 1810)	Barracudina	LC						
Symphodus cinereus (Bonnaterre, 1788)	Grey Wrasse	LC						
Symphodus mediterraneus (Linnaeus, 1758)	Axillary Wrasse	LC						
Symphodus melops (Linnaeus, 1758)	Corkwing Wrasse	LC						
Symphodus ocellatus (Forsskål, 1775)	Ocellated Wrasse	LC						
Symphodus roissali (Risso, 1810)	Five-spotted Wrasse	LC						
Symphodus rostratus (Bloch, 1791)	Long snouted wrasse	LC						
Symphurus ligulatus (Cocco, 1844)	Elongate Tonguesole	LC						
Symphurus nigrescens (Rafinesque, 1810)	Tonguesole	LC						
Synodus saurus (Linnaeus, 1758)	Atlantic Lizardfish	LC						
Tetrapturus belone (Rafinesque, 1810)	Mediterranean Shortbill Spearfish	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Thalassoma pavo (Linnaeus, 1758)	Ornate Wrasse	LC						
Thorogobius ephippiatus (Lowe, 1839)	Leopard-spotted Goby	LC						
Trachinotus ovatus (Linnaeus, 1758)	Pompano	LC						
Trachinus draco (Linnaeus, 1758)	Greater Weever	LC						
Trachipterus trachypterus (Gmelin, 1789)	Mediterranean Dealfish	LC						
Trachurus mediterraneus (Steindachner, 1868)	Mediterranean Horse Mackerel	LC						
Trachurus picturatus (Bowdich, 1825)	Blue Jack Mackerel	LC						
Trachurus trachurus (Linnaeus, 1758)	Atlantic Horse Mackere	LC						
Tripterygion melanurum (Guichenot, 1850)		LC						
Tripterygion tripteronotum (Risso, 1810)		LC						
Trisopterus capelanus (Lacepède, 1800)	Capelin	LC						
Tylosurus acus (Lacepède, 1803)	Agujon Needlefish	LC						
Uranoscopus scaber (Linnaeus, 1758)	Atlantic Stargazer	LC						
Valenciennellus tripunctulatus (Esmark, 1871)	Constellationfish	LC						
Vinciguerria attenuata (Cocco, 1838)	Slender Lightfish	LC						
Vinciguerria poweriae (Cocco, 1838)	Power's Deep-water Bristle-mouth Fish	LC						
Zebrus zebrus (Risso, 1827)	Zebra Goby	LC						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Campogramma glaycos (Lacepède, 1801)	Vadigo	DD						
Heptranchias perlo (Bonnaterre, 1788)	Sharpnose Sevengill Shark	DD						
Nerophis maculatus (Rafinesque, 1810)	Spotted Pipefish	DD						
Pegusa lascaris (Risso, 1810)	Sand Sole	DD						
Pomatoschistus canestrini (Ninni, 1883)	Atlantic Wreckfish	DD	x	Annex II		Annex II		X
Synapturichthys kleinii (Risso, 1827)	Klein's Sole,	DD						
Syngnathus phlegon (Risso, 1827)	Pelagic Spiny Pipefish	DD						
Syngnathus tenuirostris (Rathke, 1837)	Narrow-snouted Pipefish	DD						
Anthias anthias (Linnaeus, 1758)	Swallowtail Seaperch	DD						
Belone belone (Linnaeus, 1760)	Garfish	DD						
Carapus acus (Brünnich, 1768)	Pearl Fish	DD						
Cepola macrophthalma (Linnaeus, 1758)	Red Bandfish	DD						
Ctenolabrus rupestris (Linnaeus, 1758)	Goldsinny Wrasse	DD						
Deltentosteus collonianus (Risso, 1820)	Toothed goby	DD						
Gobius cobitis (Pallas, 1814)	Giant Goby	DD						
Gobius cruentatus (Gmelin, 1789)	Red-mouthed Goby	DD						
Gobius paganellus (Linnaeus, 1758)	Rock goby	DD						
Lappanella fasciata (Cocco, 1833)	Iris Wrasse	DD						

Latin name	English name	IUCN/CRO	Habitats Directive	Bern Convention	Bonn Convention	Barcelona Convention	Law on nature protection	Law on marine fisheries
Lobotes surinamensis (Bloch, 1790)	Atlantic Tripletail	DD						
Microlipophrys nigriceps (Vinciguerra, 1883)	Black-headed Blenny	DD						
Millerigobius macrocephalus (Kolombatovic, 1891)		DD						
Mola mola (Linnaeus, 1758)	Ocean Sunfish,	DD						
Molva macrophthalma (Rafinesque, 1810)	Spanish Ling	DD					X	X
Ophichthus rufus (Rafinesque, 1810)	Rufus Snake Eel,	DD						
Ophidion rochei (Müller, 1845)		DD						
Pagrus caeruleostictus (Valenciennes, 1830)	Bluespotted Seabream	DD						
Parablennius zvonimiri (Kolombatovic, 1892)	Zvonimir's blenny	DD						
Pomatoschistus marmoratus (Risso, 1810)	Marbled goby	DD						
Pomatoschistus quagga (Heckel, 1837)	Quagga goby	DD						
Raja undulata (Lacepède, 1802)	Undulate skate	DD						
Stomias boa (Risso, 1810)	Boa Dragonfish	DD						
Stromateus fiatola (Linnaeus, 1758)	Blue Butterfish	DD						
Trigloporus lastoviza (Bonnaterre, 1788)	Rock Gurnard	DD						
Zu cristatus (Bonelli, 1819)	Scalloped Ribbonfish	DD						
Epinephelus caninus (Valenciennes, 1843)	Dogtooth Grouper	DD/LC						

A total of 344 fish species are listed after cross-referencing between various lists and legislation available for the Adriatic. Fifteen of them are listed like Critically Endangered both in IUCN and Croatian Red list, while *Acipenser sturio* is considered Regionally Extinct in Adriatic according to Croatian Red list. Almost all of those fifteen species are protected by Law on marine fisheries and mariculture, and are considered in Bern, Bonn and Barcelona Conventions. Fifteen species have the status of Endangered species in the Adriatic and the Mediterranean, three of them are protected by Law on marine fisheries and mariculture (*Mobula mobular*, *Cetorhinus maximus*, *Rostroraja alba*), and several are considered in Bern, Bonn and Barcelona Conventions. As Vulnerable are listed 14 species, of which only *Oxynotus centrina* and *Galeorhinus galeus* are protected by Law on marine fisheries and mariculture. The species *Pomatoschistus tortonesei* is protected by two documents in national legislation (Law on nature protection and Law on marine fisheries and mariculture), but is not listed on any other relevant lists due to a fact that it was recorded only once in the Adriatic Sea, in the Boka Kotorska Bay. According to Croatian Red list 29 species in Croatia have the Nearly Threatened status, while according to IUCN Red list 11 species have the Nearly Threated status in the Mediterranean. Other species listed in Table 1 are listed as a species with Least Concern or Data Deficient status.

The *IUCN Red List Categories and Criteria* (IUCN 2012) are designed to determine a relative risk of extinction of species, with the main purpose of cataloguing and highlighting those taxons that are facing a higher risk of extinction. The IUCN Red List provides taxonomic, distribution, ecological, threat and conservation status information on species that have been evaluated using the IUCN Categories and Criteria.

The IUCN Red List has 8 extinction risk categories, and those categories are based on a set of quantitative criteria linked to

population trends, size and structure, and species' geographic ranges. Those 8 categories are: Extinct species (EX), Extinct in the Wild (EW), Critically Endangered species (CR), Endangered species (EN), Vulnerable species (VU), Near Threatened species (NT), Least Concern species (LC) and Data Deficient species (DD) (Figure 1). On a regional or national level two additional categories should be considered: Regionally Extinct species (RE) and Not Applicable (NA) (IUCN Red List Regional Guidelines).

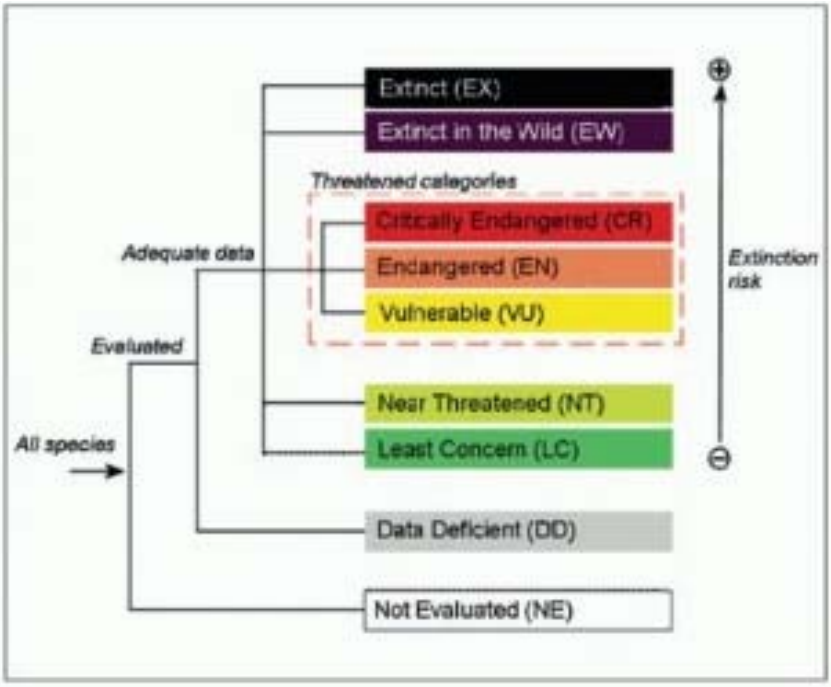

Figure 1. The IUCN Red List categories

Regarding Extinct species, the IUCN recognizes two categories: Extinct (EX) and Extinct in the Wild (EW). Species is considered

Extinct (EX) when there is no reasonable doubt that the last individual has died, or when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form. Species is **Extinct in the Wild (EW)** when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form. Additionally, one more category should be considered at regional level, **Regionally Extinct (RE)** species, when a species is extinct in the chosen geographic area of study, though it still exists elsewhere.

In the Adriatic Sea there are no fish species that are considered Extinct on a global level, but according to the Red Book of Marine species of Croatia (Jardas *et al.*, 2008) some of them are considered Regionally Extinct in Croatian sea: cartilaginous species smoothback angelshark *Squatina oculata*, and two bony species, sturgeon *Acipenser sturio* and meagre *Argyrosomus regius*.

In a group of Threatened species there are three categories: **Critically endangered (CR), Endangered (EN) and Vulnerable (VU)**. There are five criteria that are used to classify some species in one of the mentioned categories. Those criteria are based on a population size, negative trends in population size and distribution range, number of mature individuals in a population and on a VPA analysis (Table 2).

Table 2. Group of categories of threatened species and subcategories with criteria for estimation of endangerment of extinction (IUCN Standards and Petitions Subcommittee, 2014)

A. Population size reduction. Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

	Critically Endangered	Endangered	Vulnerable
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%

A1 Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND have ceased.

A2 Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction projected, inferred or suspected to be met in the future (up to a maximum of 100 years) *[(a) cannot be used for A3].*

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

based on any of the following:

(a) direct observation *[except A3]*
(b) an index of abundance appropriate to the taxon
(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality
(d) actual or potential levels of exploitation
(e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)

	Critically Endangered	Endangered	Vulnerable
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented **OR** Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** area, extent and/or quality of habitat; **(iv)** number of locations or subpopulations; **(v)** number of mature individuals			
(c) Extreme fluctuations in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** number of locations or subpopulations; **(iv)** number of mature individuals			

C. Small population size and decline

	Critically Endangered	Endangered	Vulnerable
Number of mature individuals	< 250	< 2,500	< 10,000
AND at least one of C1 or C2			
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future):	25% in 3 years or 1 generation (whichever is longer)	20% in 5 years or 2 generations (whichever is longer)	10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions:			
(a) **(i)** Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(ii) % of mature individuals in one subpopulation =	90–100%	95–100%	100%
(b) Extreme fluctuations in the number of mature individuals			

D. Very small or restricted population

	Critically Endangered	Endangered	Vulnerable
D. Number of mature individuals	< 50	< 250	**D1.** < 1,000
D2. *Only applies to the VU category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.	-	-	**D2.** typically: AOO < 20 km² or number of locations ≤ 5

E. Quantitative Analysis

	Critically Endangered	Endangered	Vulnerable
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate.

3. Protection measures

In order to protect fish species various conservation and protection measures have been implemented in the Mediterranean and Adriatic Seas. Since the highest impact on fish is related to fisheries activities, numerous fishing restricted measures are implemented or proposed for implementation on national level. Adriatic countries are members of General Fisheries Commission for the Mediterranean (GFCM), and are obliged to implement regulations adopted by the GFCM. Additionally, Italy, Slovenia and Croatia are members of the European Union (EU) and are obliged to implement regulations enforced by the European Commission (EC). One of the regulations adopted by the GFCM, which applies to the Adriatic Sea, is ban of deep-water fisheries, meaning **fishing operations below the depth limit of 1.000 meters are forbidden.** The Jabuka Pit is protected as an important spawning and nursery area for demersal species since 2017, and has been proclaimed as **Fisheries Restricted Area**, meaning that professional fisheries using bottom set nets, bottom trawls, longlines and traps, as well as the recreational fishery is prohibited in this area (GFCM Recommendation 41/2017/3). This measure reduces pressure on highly vulnerable deep-water species, many of which are seriously threatened in and outside the Mediterranean. According to the GFCM and EC regulation, **driftnets are forbidden** in the Adriatic Sea, which highly reduces by-catch and incidental catch of many vulnerable and endangered species, mostly cartilaginous species.

One of the most important and most effective protection measures is designation of **Marine Protected Areas (MPA)**. MPAs approach considers the ecosystem as a whole, rather than using the more traditional species-specific management practices (Lubchenco *et al*., 2003). Marine protected areas allow for the conservation of species and their biophysical environments, and may therefore be an effective way to safeguard ecosystem services. When carefully

designed and managed, MPAs can increase fish species richness (Tunesi & Molinari, 2005), and allow recovery of the original fish assemblage compositions in coastal waters providing benefits both to ecosystems and to humans (Halpern & Warner, 2002; Halpern, 2003; Gell & Roberts, 2003; Claudet *et al*., 2008). According to regulations plan, every country has to have a minimum of 10% of marine area in national waters proclaimed and protected as an MPA. This goal of 10% of marine area planned as MPAs has not been reached in the Mediterranean, where currently less than 8% is protected as MPAs. Additional problem is that those MPAs are independent entities and are not ecologically connected, usually there is significant distance between them and more integrated approach is needed in management of MPAs in the Mediterranean and the Adriatic Seas.

Since the Adriatic Sea represents a separate and enclosed basin of the Mediterranean, many **temporal and spatial closures related to fishing activities** have recently started to be enforced. According to recommendations and regulations of GFCM based on stock assessments for shared stocks in Adriatic, new temporal and spatial closures on fishing activities are enforced for small pelagic fish species whose stocks are overfished, such as sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*)(GFCM Recommendation 40/2016/3).

Additionally to those protection measures, there are international conventions that are relevant to the conservation and management of the Mediterranean marine fish fauna.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (**CITES**) creates the international legal framework for the prevention of trade in endangered species of wild fauna and flora and for the effective regulation of international trade in other species which may become threatened in the absence of such regulation. **The Bern Convention** on the Conservation of European Wildlife and Natural Habitats aims to conserve wild flora and fauna and their natural habitats, especially where the cooperation of several

states is required. The main aim of **the EC Habitats Directive** is to promote the maintenance of biodiversity. In the framework of **Barcelona Convention** for the Protection of the Marine Environment and the Coastal Region of the Mediterranean a specific Action Plan for the Conservation of Cartilaginous Fishes (Chondrichthyans) in the Mediterranean was approved. The Convention on the Conservation of Migratory Species of Wild Animals, also known as CMS or the **Bonn Convention**, is an intergovernmental treaty conducted through the United Nations Environmental Programme. CMS parties strive towards strictly protecting the migratory species threatened with extinction by conserving or restoring their habitats and by mitigating obstacles that might endanger them.

4. Flagship species

4.1. Concept of flagship species

Numerous threats and pressures on the environment lead to rapid loss of biodiversity and calls for urgent measures for biodiversity protection. Conservation biology is the management of nature and of Earth's biodiversity with the aim of protecting species, their habitats, and ecosystems from excessive rates of extinction and the erosion of biotic interactions. Conservation biology is usually defined as a holistic science (Soulé, 1985), but biodiversity management often has to call for practical objectives. Conservation history shows that it is impossible to measure or monitor all biodiversity, and even more when considering its state and dynamics, so ecologists need proxies (Williams & Gaston, 1994). With purpose of protection of biodiversity and raising people's awareness and collecting funds, many shortcuts have been designed in conservation management, like "choosing one species to protect them all", by choosing "indicator species", "keystone species", "umbrella species" or "flagship species". Despite the same aim of all these terms there are

some differences in their meaning, and their use should be carefully chosen at least in academic circles. Standard definition of "indicator species" is biological entities, such as gene frequencies, populations, species, species assemblages and communities that might function as surrogates or proxies for other forms of biodiversity and/or reflect changes in ecosystem patterns or processes (Lindenmayer, 2000). "Keystone species" is a species having impact on many others, often far beyond, what might have been expected from a consideration of their biomass or abundance (Simberloff, 1998), they are usually top predators or engineer species. "Umbrella species" are those whose area of occupancy or home range are large enough and whole habitat requirements are wide enough that, if they are given a sufficiently large area for their protection will bring other species under their protection (Heywood, 1995). "Flagship species" are popular charismatic species that serve as a symbol and rallying points to stimulate conservation awareness and action (Heywood, 1995), or a species that has become a symbol and leading element of entire conservation campaign (Simberloff, 1998).

Flagship species, a prime example of a surrogate, are primarily intended to promote public awareness and to raise funds for conservation (Veŕıssimo *et al*., 2011). In contrast, the protection of umbrella species is expected to benefit a wide range of co-occurring species (Roberge & Angelstam, 2004; Caro, 2010). Accordingly, the main criteria for selecting flagship species should be based on sociocultural considerations, whereas umbrella species should be chosen principally based on ecological criteria (Caro, 2010; Veŕıssimo *et al*., 2011).

With an increasing number of species that need protection and with very tight budget available for conservation measures it is very important to make the right choice for flagship species. Several authors state that flagship species must fulfil different criteria for a desired conservation action. In selection process of flagship species

for a desired conservation action various combinations of ecological, phenotypic, cultural and policy-related traits must be taken into consideration (Dietz *et al.*, 1994; Caro & O'Doherty, 1999; Bowen-Jones & Entwistle, 2002; Farjon *et al.*, 2004; Home *et al.*, 2009; Veríssimo *et al.*, 2009). Following recommendation of Kalinkat *et al.* (2016), the main criteria for selecting flagship species should be based on sociocultural considerations. Beside all of mentioned criteria's, almost all authors agree that the most important criteria is that flagship species must be charismatic. Flagship species such as giant pandas, tigers, endangered whales and dolphins, rhinoceros, elephants, marine turtles and great apes attracts funding to protect more species in same habitat.

4.2. Aquarium Boka flagship species

As a pre-requirement for selection of flagship species for Aquarium Boka, the species has to be well recognized regionally (in the South Adriatic) and in particular locally (in Montenegro). On the other hand, it was avoided selection of species which are already exploited as flagship species by other Adriatic aquaria or environmental organizations, like WWF, IUCN or UNEP.

In first step of the process of selection flagship species, project team has composed list of six criteria for selection of the flagship species, following defined pre-requirements and literature recommendations. Selected criteria are as follows: 1. Vulnerability status; 2. Visual identity of species; 3. Importance for local community; 4. The attractiveness of the species; 5. Economic valuing, and 6. Gastronomic value (character). Second step was to apply defined criteria on 8 well known fish species as candidate flagship species for Aquarium Boka (Table 3) considering them as most known locally and with the highest sociocultural considerations among other species (Pešić *et al.*, 2018).

Table 3. List of candidate flagship fish species

Scientific name	***English name***	***Local name***
Mullus barbatus	Red mullet	Barbun, Trlja od blata
Pagellus erythrynus	Common Pandora	Arbun, Rombun
Merluccius merlucius	Hake	Oslić, Luc
Zeus faber	John dory	Kovač, Šanpjer
Sardine pilchardus	Sardine	Srdela, Gavica
Engraulis encrasicolus	Anchovy	Inćun, Sardun
Argyrosomus regius	Meagre	Hama
Epinephelus marginatus	Dusky grouper	Kirnja

After definition of relevant stakeholders (including fisherman, representatives of local community, relevant scientists from the region, etc.) questionaries' were distributed to them in order to obtain their opinion/answers how well candidate species meets given criteria according to 4 level score (1. Species doesn't meet criteria at all; 2. Species meet criteria in small extent; 3. Species meet criteria in high extent; 4. Species fully meets criteria). Values from 60 questionnaires for each species and each criterion was calculated and averaged in order to obtain average value in each field of the table and to obtain final score for each candidate species (Table 4).

Table 4. Results of interviews and final score for each candidate species

Criteria / Species	***Vulnerability status***	***Visual identity***	***Importance for local community***	***Attractiveness of the species***	***Economic value***	***Gastronomic character***	***Final score***
Mullus barbatus	3.1	2.7	3.2	1.8	3.2	3.6	2.9
Pagellus erythrynus	2.5	2.9	2.6	2.2	2.8	3.0	2.6
Merluccius merluciu s	3.2	1.9	3.2	1.8	3.4	3.4	2.8
Zeus faber	3.8	3.9	3.6	3.8	4.0	4.0	3.8
Sardine pilchardus	2.6	1.3	3.2	1.6	2.2	3.2	2.3
Engraulis encrasicolus	2.6	1.9	3.2	1.4	2.2	2.8	2.3
Argyrosomus regius	3.9	3.6	2.8	3.2	4.0	4.0	3.6
Epinephelus marginatus	3.9	3.7	2.6	3.3	4.0	4.0	3.6

Based on all questionnaires the highest value of the final score was obtained for species John Dory (*Zeus faber*) – 3.8, followed by final scores of 3.6 for Meagre (*Argyrosomus regius*) and Dusky grouper (*Epinephelus marginatus*), respectively. Other candidate species

obtained lower final scores due to low values obtained for criteria of visual identity and attractiveness of species. These findings correspond to definition of “flagship species” by different authors which defines them as “known charismatic species that serve as a symbol or focus point to raise environmental consciousness” (Samways *et al.,* 1995) or “popular charismatic species that serve as symbols and rallying points to stimulate conservation awareness and action” (Heywood, 1995). John Dory represents important species for coastal area of Montenegro, this species is categorized as a high-quality fish (1st class fish) with high economic value (25 euros/kg at the market) and there is high demand for this species at restaurants. Species has very characteristic visual identity, body is laterally compressed, olive-yellow colour with a large dark spot on each side, and long spines on the dorsal fin. The dark spot is used to flash an 'evil eye' if danger approaches. This eye spot on the side of its body also confuses prey, which are scooped up in its big mouth. Numerous legends about name of this fish exists, according to one the apostle Peter grabbed the fish with his hands. He caught the fish, and in the places where he touched her fingers, black spots remained. From there, this fish got the name of St. Peter's fish. In Italian the species is called “pesce San Pietro”, and as the eastern coast of the Adriatic was under direct Italian influence for centuries, the local population adopted the name, shortened it and turned it into "šanpjer".

5. Conclusions and recommendations

Fish are among the most endangered marine species due to their high economic importance for humanity, which is why they are the subject of fisheries, and in most cases under overfishing. According to the last census in the Adriatic Sea there are 407 fish species and subspecies recorded (Jardas, 1996). Meanwhile, that number has grown up to 449, which is about 66% of all species and subspecies recorded in the Mediterranean (Dulčić & Dragičević, 2011). However, some of the findings for some species (at least 20 of them) are very old and unreliable, and some rare Adriatic fish were found only once or only a few times, or the observation was dubious for some reason. Most of the south Adriatic basin has not been sufficiently explored in terms of its ichthyofauna, particularly not at depths greater than 500 m. Every year new species are recorded in the Adriatic, and actual number of species that inhabit Adriatic or breed there is still unknown.

After comparison and cross-referencing of two legal documents governing protection status of fish in Montenegro (Law on Nature Protection (Official Gazette of Montenegro 18/16) and Law on Marine Fisheries and Mariculture (Official Gazette of Montenegro 56/09, 47/15)), IUCN Red List of Threatened species for the Mediterranean, European Red List of marine fishes (Nieto *et al.*, 2015) and Red Book of Marine Fishes of Croatia (Jardas *et al.*, 2008), a list of Adriatic species was prepared. Fifteen species are listed as Critically Endangered both in IUCN and Croatian Red list, while *Acipenser sturio* is considered Regionally Extinct in the Adriatic, according to Croatian Red list, and fifteen species have the status of Endangered species in the Adriatic and Mediterranean. According to Croatian Red list, 29 species in Croatia have Nearly Threatened status, while, according to IUCN Red list, the Nearly Threated status in Mediterranean is assigned to 11 species. Other species listed are listed as a species with Least Concern or Data Deficient status.

Marine fishes are facing numerous pressures. Fisheries is the most direct and most negative pressure on fish species worldwide. Of more than 400 fish species in the Adriatic, 120 species have high commercial and economic importance and are target species in fisheries. Beside these 120 species, there is high number of other species that are not directly targeted by fishermen but are accidentally caught as by-catch or as discard. Habitat degradation and marine pollution caused by numerous human activities on land and sea, appearance of allochtonous and invasive species, climate changes, are all pressures that have an effect on marine fishes, directly and indirectly, through changes in food chains, acidification of water, competition for food and for free niches, and many other ways.

In order to protect marine fishes and their populations numerous protection measures have been established across the Mediterranean and Adriatic Sea, most of them related to fisheries. International protection measures in force in the Adriatic Sea are: forbidden fisheries at depths greater than 1,000 m; Jabuka/Pomo Pit protected as Fisheries Restricted Area; driftnets are forbidden; temporal and spatial closures and reduction of fishing effort for small pelagic species, etc. In addition to international protection measures, there are also measures established at national level, of which the most effective are Marine Protected Areas, an approach that considers the ecosystem as a whole. Currently in there are no Marine Protected Areas established in Montenegro, but several locations area have been studied and are considered for this purpose (Katič, Platamuni, Ratac, Stari Ulcinj).

As one of the newer approaches to protection of species in the last decades, the concept of "Umbrella species" or "Flagship species" became more popular. This concept aims to promote public awareness and to raise funds for conservation with the end purpose of protecting biodiversity. John Dory (*Zeus faber*) has been chosen as a "Flagship species" for Aquarium Boka based on a questionaries with relevant stakeholders. John Dory is an important species for

coastal area of Montenegro, categorized as a high-quality fish (1st class fish) with high economic value (25 euros/kg at the market) and there is high demand for this species at restaurants. The species has very characteristic visual identity, the body is laterally compressed, olive-yellow in colour with a large dark spot on each side, and long spines on the dorsal fin. All this makes it very recognizable and unique.

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