

UNESCO environmental DNA (eDNA) Expeditions in marine World Heritage sites

Biodiversity survey for Banc d'Arguin National Park

Interim Results Based on 50% of Samples Analyzed
Not for public distribution

UNESCO's eDNA Expeditions is a global, citizen science initiative that is conducted with the intention to measure marine biodiversity and predict the impact climate change on marine community composition across UNESCO World Heritage marine sites.

eDNA is a cost effective and minimally invasive method to measure biodiversity in any given area. Marine species continuously shed DNA into the water around them in the form of waste, mucus, or cells. By collecting this DNA from water samples, and subsequently amplifying and sequencing specific regions within these DNA strands, experts can detect a wide variety of species without removing any organisms from their environment. The amplified regions are selected depending on the scope of the study: while some markers are suitable to obtain a broad overview of biodiversity across many groups of species, other markers are particularly suited to get high resolution insight for a more specific taxonomic group. The UNESCO eDNA Expeditions initiative combines a number of markers tailored for marine vertebrates (fish, mammals, and turtles). A general marker was added to allow to detect also species from other groups such as invertebrates which can give a broader insight in the marine species diversity in a given area.

Between September 2022 and May 2023, UNESCO organized eDNA sampling campaigns in 21 marine World Heritage sites across 17 countries around the world. At every World Heritage site, about 20 samples were collected from different habitats. Over 250 young people participated in the local sampling expeditions. They were guided by local experts and park management staff, using protocols and eDNA sampling equipment provided by UNESCO.

Biodiversity inventories generated from the samples are being combined with existing species distribution data from public biodiversity databases such as the Ocean Biodiversity Information System (OBIS) in view of obtaining a comprehensive overview of marine life across marine World Heritage sites. Through the use of climate scenarios and species distribution models, an estimate will be made of the impact of climate change, in particular rising temperatures, on local biodiversity and its potential future distribution patterns.

More information about the initiative is available on the UNESCO website: <https://www.unesco.org/en/edna-expeditions>.

Results

Sampling and sample processing

eDNA sampling was conducted in Banc d'Arguin National Park in May 2023. A total of 20 samples were collected at 1 locations in the park: PNBA (Figure 1). Up to 1500 mL of seawater was filtered through filter cartridges with a 0.8 µm pore size. After sampling, the filter cartridges were flushed with preservation liquid and shipped to UNESCO. From the 20 samples, 10 have now (December 2023) been processed. A second batch of samples will be processed in January 2024. DNA from these samples was extracted and amplified, and then sent to the sequencing facility at KU Leuven in Belgium, a specialized university eDNA lab contracted by UNESCO for this work. PCR amplification was done using five primer pairs selected to capture as much biodiversity as possible in the target groups of the study: fish, mammals, and turtles. The results in this preliminary report are based on a first batch of 10 samples that were analyzed covering all locations that were sampled in the World Heritage site.

DNA sequencing

Sequencing of the DNA from 10 samples resulted in over 24 million sequence reads (Table 2), from which we collected 14394 unique sequences or ASVs. By matching those sequences with reference sequences in public databases, we were able to detect 210 species. Most of these species are vertebrates, but also species from other groups were detected, including algae, molluscs, jellyfish, crustaceans, and worms (Figure 2). Of the 210 species detected, 135 are not among the 532 species previously reported from Banc d'Arguin National Park to the UNESCO OBIS database.

reads	asvs
24416491	14394

Table 1: Reads, ASVs, and species across all samples.

locality	materialSampleID	sampleSize	reads	asvs	species
PNBA	EE0256	1500	2442075	6622	126
PNBA	EE0257	1500	3160391	8825	146
PNBA	EE0259	1500	3325472	8957	130
PNBA	EE0260	1500	2744720	6682	126
PNBA	EE0261	1500	2793104	5716	106
PNBA	EE0262	1500	2623651	8080	142
PNBA	EE0263	1500	1657943	7999	131
PNBA	EE0264	1500	1022090	6120	93
PNBA	EE0266	1500	2230473	7856	143
PNBA	EE0267	1500	2416572	7507	118

Table 2: Reads, ASVs, and species by sample.

Species identification

The marker sequences obtained from sequencing were matched with sequence reference databases built using public data available from the National Center for Biotechnology Information (NCBI). This resulted in the identification of 210 species, of which 91 fish species, 1 mammalian species, and 1 turtle species (Table 3). This represents about 37% of the species known from Banc d'Arguin National Park in the OBIS database. 14 of the detected species are listed as threatened on the IUCN Red List (Table 4). A full list of species is added at the end of this report.

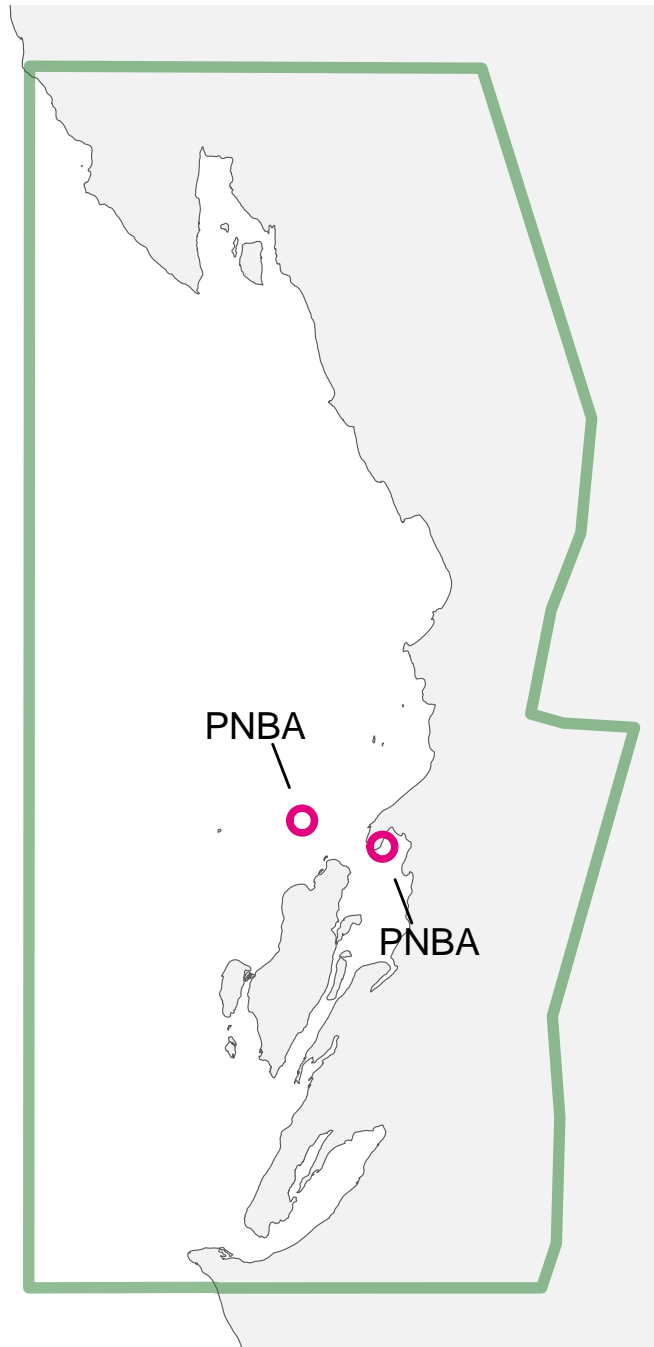


Figure 1: Map of the sampling locations.

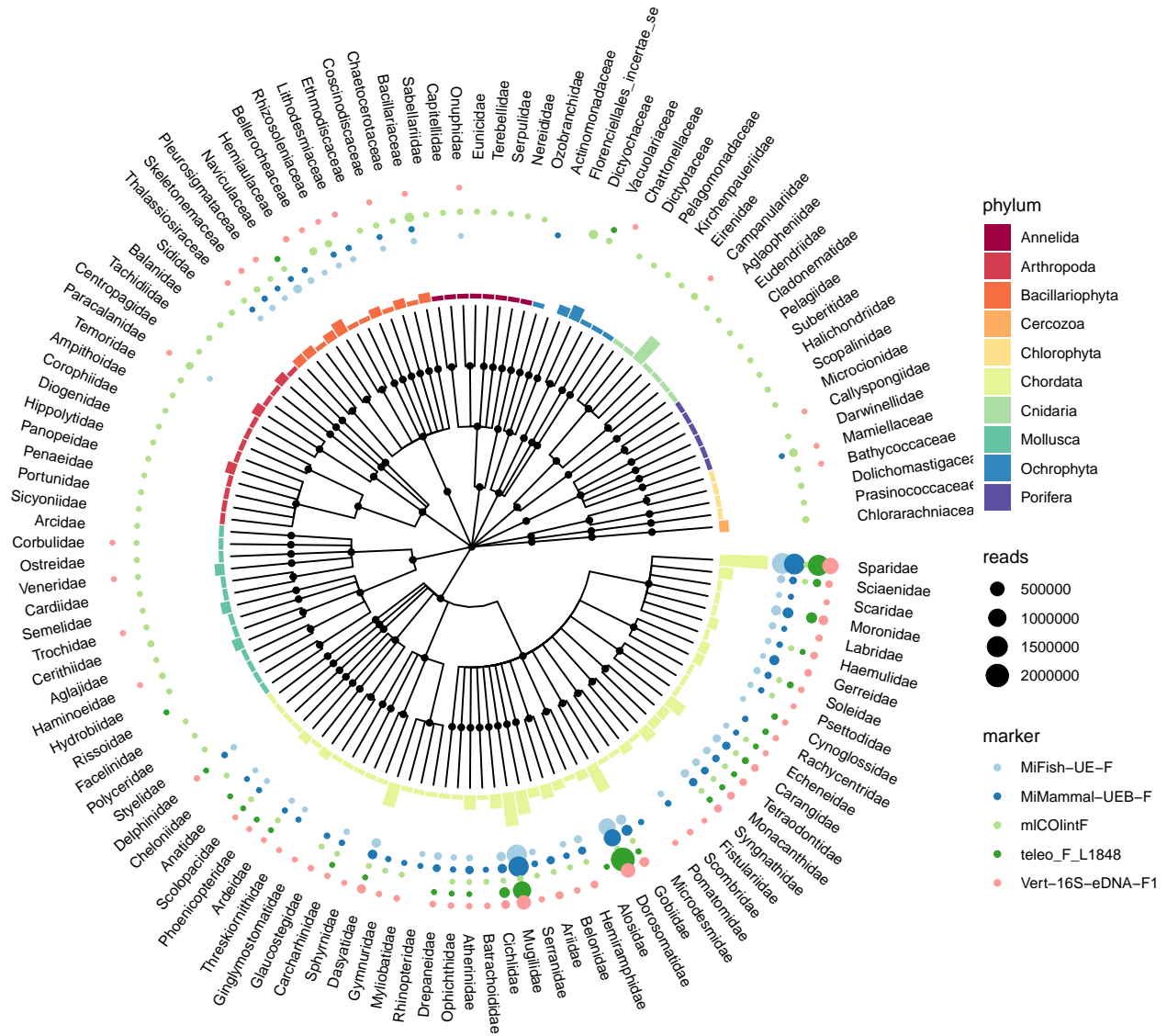


Figure 2: Number of DNA reads (bubbles) and species detected (bars) by family.

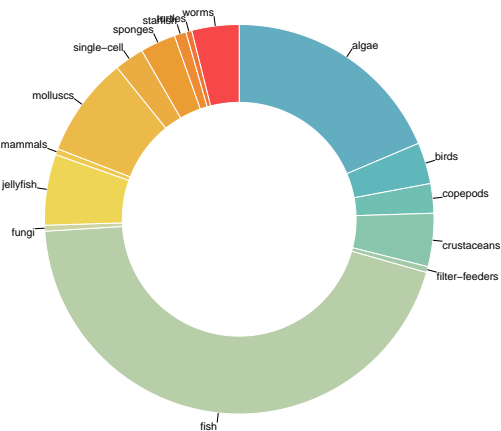


Figure 3: Distribution of detected species across groups.

group	eDNA species	total species	fraction
fish	91	246	0.37
mammals	1	4	0.25
turtles	1	2	0.50

Table 3: Number of species in the three target groups, from the OBIS database and from eDNA sampling.

category	eDNA species	total species	fraction
CR	4	7	0.57
EN	2	10	0.20
VU	8	21	0.38

Table 4: Number of species by IUCN Red List category, from the OBIS database and from eDNA sampling.

phylum	class	species	group	category	new	vernacular
Amoebozoa	Discosea	Neoparamoeba aestuarina	single-cell		yes	
Annelida	Clitellata	Ozobranchus branchiatus	worms		yes	
Annelida	Polychaeta	Capitella capitata	worms		yes	gallery worm
Annelida	Polychaeta	Diopatra neapolitana	worms		yes	
Annelida	Polychaeta	Hydroides elegans	worms			
Annelida	Polychaeta	Lygdamis muratus	worms		yes	
Annelida	Polychaeta	Marphysa sanguinea	worms		yes	red rock worm
Annelida	Polychaeta	Platynereis dumerilii	worms		yes	comb-toothed nereid
Annelida	Polychaeta	Terebella lapidaria	worms		yes	
Arthropoda	Branchiopoda	Penilia avirostris			yes	
Arthropoda	Copepoda	Euterpina acutifrons	copepods		yes	
Arthropoda	Copepoda	Isias clavipes	copepods		yes	
Arthropoda	Copepoda	Paracalanus indicus	copepods		yes	
Arthropoda	Copepoda	Paracalanus quasimodo	copepods		yes	
Arthropoda	Copepoda	Temora turbinata	copepods		yes	
Arthropoda	Malacostraca	Ampithoe longimana	crustaceans		yes	
Arthropoda	Malacostraca	Callinectes marginatus	crustaceans		yes	
Arthropoda	Malacostraca	Diogenes arguensis	crustaceans		yes	
Arthropoda	Malacostraca	Hippolyte leptocerus	crustaceans		yes	
Arthropoda	Malacostraca	Latreutes fucorum	crustaceans		yes	slender Sargassum shrimp, crevette des Sargasses
Arthropoda	Malacostraca	Monocorophium acherusicum	crustaceans		yes	
Arthropoda	Malacostraca	Panopeus africanus	crustaceans			
Arthropoda	Malacostraca	Penaeus notialis	crustaceans			southern pink shrimp, crevette rose du Sud
Arthropoda	Malacostraca	Sicyonia carinata	crustaceans			
Arthropoda	Thecostraca	Amphibalanus amphitrite			yes	
Arthropoda	Thecostraca	Balanus trigonus			yes	
Ascomycota	Dothideomycetes	Cladosporium herbarum	fungi		yes	
Bacillariophyta	Bacillariophyceae	Bellerrochea polymorpha	algae		yes	
Bacillariophyta	Bacillariophyceae	Chaetoceros socialis	algae		yes	
Bacillariophyta	Bacillariophyceae	Coscinodiscus granii	algae		yes	
Bacillariophyta	Bacillariophyceae	Coscinodiscus wailesii	algae		yes	
Bacillariophyta	Bacillariophyceae	Cylindrotheca closterium	algae		yes	
Bacillariophyta	Bacillariophyceae	Ethmodiscus punctiger	algae		yes	
Bacillariophyta	Bacillariophyceae	Eucampia striata	algae		yes	
Bacillariophyta	Bacillariophyceae	Eucampia zodiacus	algae		yes	
Bacillariophyta	Bacillariophyceae	Hemiaulus sinensis	algae		yes	
Bacillariophyta	Bacillariophyceae	Lithodesmioides polymorpha	algae		yes	
Bacillariophyta	Bacillariophyceae	Lithodesmium undulatum	algae		yes	
Bacillariophyta	Bacillariophyceae	Navicula minima	algae		yes	
Bacillariophyta	Bacillariophyceae	Navicula ramosissima	algae		yes	
Bacillariophyta	Bacillariophyceae	Pleurosigma strigosum	algae		yes	
Bacillariophyta	Bacillariophyceae	Pseudo-nitzschia cuspidata	algae		yes	
Bacillariophyta	Bacillariophyceae	Skeletonema menzelii	algae		yes	
Bacillariophyta	Bacillariophyceae	Skeletonema pseudocostatum	algae		yes	
Bacillariophyta	Bacillariophyceae	Sundstroemia setigera	algae		yes	
Bacillariophyta	Bacillariophyceae	Thalassiosira profunda	algae		yes	
Bacillariophyta	Bacillariophyceae	Thalassiosira rotula	algae		yes	
Bryozoa	Gymnolaemata	Bugula neritina	filter-feeders		yes	Common bugula, Brown bryozoan, bugule brune
Cercozoa	Chlorarachnea	Bigelowiella natans	single-cell		yes	
Cercozoa	Chlorarachnea	Chlorarachnion reptans	single-cell		yes	

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phylum	class	species	group	category	new	vernacular
Chlorophyta	Mamiellophyceae	Bathycoccus prasinus	algae		yes	
Chlorophyta	Mamiellophyceae	Dolichomastix tenuilepis	algae		yes	
Chlorophyta	Mamiellophyceae	Micromonas pusilla	algae		yes	
Chlorophyta	Pyramimonadophyceae	Prasinoderma coloniale	algae		yes	
Chordata	Ascidiacea	Botrylloides niger				Black synascidia , Synascidie noire
Chordata	Aves	Anas platyrhynchos	birds	LC	yes	mallard, canard colvert
Chordata	Aves	Ardea cinerea	birds	LC	yes	
Chordata	Aves	Calidris canutus	birds	NT		red knot, bécasseau maubèche
Chordata	Aves	Egretta garzetta	birds	LC		little egret, aigrette garzette
Chordata	Aves	Limosa lapponica	birds	NT		bar-tailed godwit, barge rousse
Chordata	Aves	Phoenicopterus ruber	birds	LC		greater flamingo, flamant des Caraïbes
Chordata	Aves	Platalea leucorodia	birds	LC		Eurasian spoonbill, spatule blanche
Chordata	Elasmobranchii	Aetomylaeus bovinus	fish	CR		
Chordata	Elasmobranchii	Dasyatis chrysonota	fish	NT	yes	
Chordata	Elasmobranchii	Dasyatis tortonesei	fish	DD	yes	
Chordata	Elasmobranchii	Ginglymostoma cirratum	fish	VU		nurse shark, requin nourrice
Chordata	Elasmobranchii	Glaucostegus cemiculus	fish	CR		
Chordata	Elasmobranchii	Gymnura altavela	fish	EN		spiny butterfly ray
Chordata	Elasmobranchii	Hypanus americanus	fish	NT	yes	
Chordata	Elasmobranchii	Hypanus rudis	fish	CR		
Chordata	Elasmobranchii	Rhinoptera bonasus	fish	VU	yes	cownose ray
Chordata	Elasmobranchii	Rhizoprionodon acutus	fish	VU		milk shark
Chordata	Elasmobranchii	Sphyrna lewini	fish	CR	yes	scalloped hammerhead
Chordata	Elasmobranchii	Taeniurops grabatus	fish	NT		
Chordata	Mammalia	Tursiops truncatus	mammals	LC		bottlenose dolphin, grand dauphin
Chordata	Teleostei	Aldrichetta forsteri	fish	LC	yes	
Chordata	Teleostei	Atherina boyeri	fish	LC		big-scale sand-smelt, joel
Chordata	Teleostei	Atherina hepsetus	fish		yes	Mediterranean sand smelt, siouclet
Chordata	Teleostei	Atherina presbyter	fish	LC		sand smelt, athérine
Chordata	Teleostei	Bathygobius casamancus	fish	LC	yes	
Chordata	Teleostei	Bathygobius fuscus	fish	LC	yes	dusky frill-goby
Chordata	Teleostei	Belone belone	fish	LC	yes	sea needle, aiguille
Chordata	Teleostei	Caranx rhonchus	fish	LC		false scad, comète coussut
Chordata	Teleostei	Caranx senegallus	fish	LC	yes	
Chordata	Teleostei	Carlarius latiscutatus	fish	LC		
Chordata	Teleostei	Carlarius parkii	fish	LC		
Chordata	Teleostei	Chelon auratus	fish	LC		
Chordata	Teleostei	Chelon dumerili	fish	DD		
Chordata	Teleostei	Chelon richardsonii	fish		yes	
Chordata	Teleostei	Chloroscombrus chrysurus	fish	LC		Atlantic bumper
Chordata	Teleostei	Coptodon guineensis	fish	LC		
Chordata	Teleostei	Coptodon zillii	fish	LC	yes	
Chordata	Teleostei	Cynoglossus senegalensis	fish	NT		Senegalese tonguesole, sole-langue sénégalaise
Chordata	Teleostei	Dalophis imberbis	fish	LC	yes	
Chordata	Teleostei	Dicentrarchus punctatus	fish	LC		spotted sea-bass, bar moucheté
Chordata	Teleostei	Diplodus bellottii	fish	LC		
Chordata	Teleostei	Diplodus kotschy	fish		yes	
Chordata	Teleostei	Diplodus puntazzo	fish	LC	yes	sharp snout bream, sar à museau pointu
Chordata	Teleostei	Diplodus sargus	fish	LC		white seabream, sar commun du Maroc
Chordata	Teleostei	Diplodus vulgaris	fish	LC		two banded sea bream, sar à tête noire

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phylum	class	species	group	category	new	vernacular
Chordata	Teleostei	Drepane africana	fish	LC	yes	
Chordata	Teleostei	Echeneis naucrates	fish	LC		sharksucker
Chordata	Teleostei	Ephippion guttifer	fish	LC		
Chordata	Teleostei	Epinephelus aeneus	fish	NT		white grouper, mérou blanc
Chordata	Teleostei	Epinephelus marginatus	fish			dusky grouper, mérou noir
Chordata	Teleostei	Ethmalosa fimbriata	fish	LC		Bonga shad
Chordata	Teleostei	Eucinostomus melanopterus	fish	LC		flagfin mojarra
Chordata	Teleostei	Fistularia tabacaria	fish	LC		bluespotted cometfish
Chordata	Teleostei	Gobius niger	fish	LC		black goby, gobie noir
Chordata	Teleostei	Gobius paganellus	fish	LC	yes	rock goby, gobie paganel
Chordata	Teleostei	Halobatrachus didactylus	fish	LC		
Chordata	Teleostei	Hemiramphus balao	fish	LC	yes	balao
Chordata	Teleostei	Hemiramphus brasiliensis	fish	LC		ballyhoo halfbeak
Chordata	Teleostei	Hippocampus kuda	fish	VU	yes	spotted seahorse
Chordata	Teleostei	Lithognathus mormyrus	fish	LC		striped seabream, marbre
Chordata	Teleostei	Megalaspis cordyla	fish	LC	yes	torpedo scad
Chordata	Teleostei	Microdesmus longipinnis	fish	LC	yes	pink wormfish
Chordata	Teleostei	Mugil bananensis	fish	LC	yes	
Chordata	Teleostei	Mugil capurrii	fish	LC		
Chordata	Teleostei	Mycteroperca rubra	fish	LC		comb grouper, badèche rouge
Chordata	Teleostei	Neochelon falcipinnis	fish	DD		
Chordata	Teleostei	Nicholsina usta	fish	LC		emerald parrotfish
Chordata	Teleostei	Pagellus bogaraveo	fish	NT	yes	blackspot seabream, daurade rose
Chordata	Teleostei	Pagrus caeruleostictus	fish	LC		bluespotted seabream, pagre à points bleus
Chordata	Teleostei	Pogonias cromis	fish	LC	yes	blackdrum
Chordata	Teleostei	Pomadasys incisus	fish	LC		
Chordata	Teleostei	Pomadasys perotaei	fish	LC		
Chordata	Teleostei	Pomatomus saltatrix	fish	VU		blue fish, tassergal
Chordata	Teleostei	Pomatoschistus microps	fish	LC		common goby, gobie buhotte
Chordata	Teleostei	Porogobius schlegelii	fish	LC	yes	
Chordata	Teleostei	Psettodes bennettii	fish	DD		
Chordata	Teleostei	Psettodes erumei	fish	DD	yes	Indian spiny turbot
Chordata	Teleostei	Pseudotolithus senegallus	fish	VU		
Chordata	Teleostei	Rachycentron canadum	fish	LC	yes	cobia, mafou
Chordata	Teleostei	Sardina pilchardus	fish	LC	yes	European pilchard, sardine commune
Chordata	Teleostei	Sardinella maderensis	fish	VU		shortbody sardine, grande allache
Chordata	Teleostei	Sarotherodon melanotheron	fish	LC		blackchin tilapia
Chordata	Teleostei	Sciaena umbra	fish	NT		brown meagre, maigre
Chordata	Teleostei	Scomberomorus concolor	fish	VU	yes	Gulf sierra
Chordata	Teleostei	Scomberomorus tritor	fish	LC		
Chordata	Teleostei	Serranus cabrilla	fish	LC		comber, serran chevrette
Chordata	Teleostei	Serranus scriba	fish	LC		painted comber, serran écriture
Chordata	Teleostei	Solea senegalensis	fish	DD		Senegal sole, Sole du Sénégal
Chordata	Teleostei	Solea solea	fish	DD		Dover sole, sole
Chordata	Teleostei	Sparus aurata	fish	LC		gilthead, dorade royale
Chordata	Teleostei	Sphoeroides spengleri	fish	LC		bandtail puffer
Chordata	Teleostei	Spondyliosoma cantharus	fish	LC		Black Sea-bream, brème de mer
Chordata	Teleostei	Stephanolepis hispidus	fish			
Chordata	Teleostei	Stephanolepis setifer	fish	LC	yes	pygmy filefish
Chordata	Teleostei	Symphodus bailloni	fish	LC		

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phylum	class	species	group	category	new	vernacular
Chordata	Teleostei	Syngnathus acus	fish	LC	yes	greater pipefish, syngnathe aiguille
Chordata	Teleostei	Syngnathus typhle	fish	LC		deep-snouted pipefish, siphonostome
Chordata	Teleostei	Tylosurus acus	fish	LC		agujon needlefish
Chordata	Teleostei	Tylosurus crocodilus	fish	LC	yes	houndfish
Chordata		Chelonia mydas	turtles	EN		green turtle, tortue verte
Cnidaria	Hydrozoa	Aglaophenia pluma	jellyfish			podded hydroid
Cnidaria	Hydrozoa	Campanularia hincksii	jellyfish		yes	
Cnidaria	Hydrozoa	Cladonema radiatum	jellyfish		yes	aquarium medusa
Cnidaria	Hydrozoa	Clytia gracilis	jellyfish		yes	
Cnidaria	Hydrozoa	Clytia noliformis	jellyfish		yes	
Cnidaria	Hydrozoa	Eudendrium capillare	jellyfish		yes	
Cnidaria	Hydrozoa	Eutima gracilis	jellyfish		yes	
Cnidaria	Hydrozoa	Kirchenpaueria pinnata	jellyfish		yes	fine feather-hydroid
Cnidaria	Hydrozoa	Laomedea angulata	jellyfish		yes	sea grass sea fir
Cnidaria	Hydrozoa	Obelia bidentata	jellyfish		yes	doubletoothed hydroid
Cnidaria	Hydrozoa	Obelia dichotoma	jellyfish			sea thread hydroid
Cnidaria	Scyphozoa	Chrysaora africana	jellyfish		yes	
Cryptophyta	Cryptophyceae	Hemiarma marina			yes	
Echinodermata	Asteroidea	Astropecten africanus	starfish		yes	
Echinodermata	Ophiuroidea	Amphipholis squamata	starfish		yes	dwarf brittle star
Entoprocta		Pedicellina cernua			yes	
Haptophyta	Coccolithophyceae	Emiliania huxleyi	algae		yes	
Haptophyta	Coccolithophyceae	Gephyrocapsa oceanica	algae		yes	
Mollusca	Bivalvia	Abra alba	molluscs		yes	white furrow shell, syndesmye blanche
Mollusca	Bivalvia	Callista chione	molluscs		yes	brown callista, vernis
Mollusca	Bivalvia	Ostrea stentina	molluscs		yes	
Mollusca	Bivalvia	Parvicardium exiguum	molluscs		yes	little cockle
Mollusca	Bivalvia	Polititapes aureus	molluscs		yes	golden carpet shell, palourde jaune
Mollusca	Bivalvia	Senilia senilis	molluscs			
Mollusca	Bivalvia	Varicorbula gibba	molluscs		yes	European clam
Mollusca	Gastropoda	Bittium reticulatum	molluscs		yes	needle whelk
Mollusca	Gastropoda	Camachoaglaja africana	molluscs		yes	
Mollusca	Gastropoda	Cingula trifasciata	molluscs		yes	
Mollusca	Gastropoda	Cratena peregrina	molluscs		yes	
Mollusca	Gastropoda	Haminoea orbignyana	molluscs		yes	
Mollusca	Gastropoda	Haminoea orteai	molluscs		yes	
Mollusca	Gastropoda	Jujubinus striatus	molluscs		yes	grooved top-shell
Mollusca	Gastropoda	Peringia ulvae	molluscs		yes	common mudflat snail
Mollusca	Gastropoda	Polycera aurantiomarginata	molluscs		yes	
Mollusca	Gastropoda	Steromphala umbilicaris	molluscs		yes	
Myxozoa	Dinophyceae	Biecheleria cincta	single-cell		yes	
Myxozoa	Dinophyceae	Heterocapsa rotundata	single-cell		yes	
Ochrophyta	Dictyochophyceae	Octactis octonaria	algae		yes	
Ochrophyta	Dictyochophyceae	Pseudochattonella farcimen	algae		yes	
Ochrophyta	Dictyochophyceae	Pseudopedinella elastica	algae		yes	
Ochrophyta	Dictyochophyceae	Vicicitus globosus	algae		yes	
Ochrophyta	Pelagophyceae	Aureococcus anophagefferens	algae		yes	
Ochrophyta	Phaeophyceae	Canistrocarpus cervicornis	algae			
Ochrophyta	Raphidophyceae	Chattonella marina	algae		yes	
Ochrophyta	Raphidophyceae	Chattonella subsalsa	algae		yes	

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phylum	class	species	group	category	new	vernacular
Ochrophyta	Raphidophyceae	Fibrocapsa japonica	algae		yes	
Ochrophyta	Raphidophyceae	Heterosigma akashiwo	algae		yes	
Porifera	Demospongiae	Callyspongia (Cladochalina) plicifera	sponges		yes	
Porifera	Demospongiae	Chelonaplysilla delicata	sponges		yes	
Porifera	Demospongiae	Clathria (Clathria) prolifera	sponges		yes	
Porifera	Demospongiae	Halichondria (Halichondria) bowerbanki	sponges		yes	Bowerbank's halichondria
Porifera	Demospongiae	Scopalina canariensis	sponges		yes	
Porifera	Demospongiae	Terpios gelatinosus	sponges		yes	
Rhodophyta	Florideophyceae	Amphiroa beauvoisii	algae			
Rhodophyta	Florideophyceae	Hypnea cornuta	algae		yes	