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

Biodiversity survey for French Austral Lands and Seas

Interim Results
Not for public distribution

Credit: Sébastien Motreuil, IPEV

About eDNA Expeditions

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 extracting this DNA from water samples, and subsequently multiplying and sequencing specific regions within these DNA strands, a wide variety of species can be detected without removing any organisms from their environment. The regions in the DNA targeted for sequencing 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 such as fish. The UNESCO eDNA Expeditions initiative combines a number of markers tailored for marine vertebrates (fish, mammals, and turtles). A general marker was added to also allow detection of 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 and a press kit are available on the UNESCO website: https://www.unesco.org/en/edna-expeditions.

Results

Sampling and sample processing

eDNA sampling was conducted in French Austral Lands and Seas in December 2022. A total of 21 samples were collected at 5 locations in the park covering different habitats: amsterdam, armor, baie_des_swains, ile_haute, and suhm (Figure 1). Up to 1,560 mL of seawater was filtered through filter cartridges containing a filter with a 0.8 µm pore size. After sampling, the filter cartridges were flushed with preservation liquid and shipped to UNESCO. DNA from the samples was extracted and amplified, and subsequently 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.

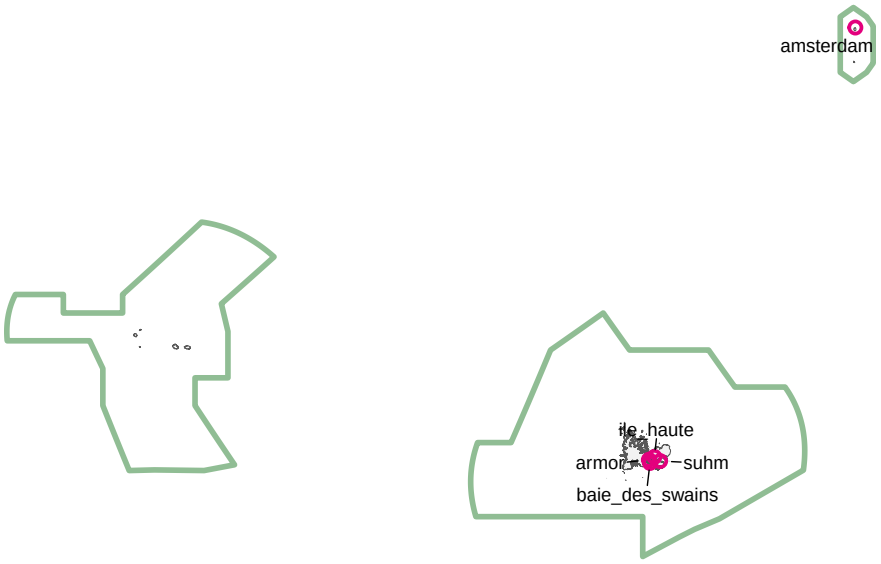

Figure 1: Map of the sampling locations.

DNA sequencing

Sequencing of the DNA from 21 samples resulted in over 39 million sequence reads, from which we collected 15,418 unique sequences or ASVs (Tables 1 and 2).

reads	asvs
39212295	15418

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

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 177 species, including 33 fish species, 4 mammalian species, and 4 turtle species (Table 3). Species from other groups, such as algae, echinoderms, worms, molluscs, and sponges, were also detected (Figures 2 and 3). This number of species detected represents about 10% of the 3,172 species known from French Austral Lands and Seas in the OBIS database. Of the 177 species detected, 93 are not among the species previously reported from French Austral Lands and Seas to the UNESCO OBIS database. 4 of the

locality	materialSampleID	sampleSize	reads	asvs	species
Armor Kerguelen	EE0087	1500	1323896	2090	18
French Austral Lands and Seas	EE0001	1560	2961225	5182	63
French Austral Lands and Seas	EE0004	1560	3449634	4833	58
French Austral Lands and Seas	EE0017	1560	1544660	482	2
French Austral Lands and Seas	EE0019	1560	2735974	3776	54
French Austral Lands and Seas	EE0127	1500	1452668	513	8
Ile Haute - Kerguelen	EE0013	1500	2309689	3848	49
Ile Haute - Kerguelen	EE0015	1500	1935299	3781	44
Ile Haute - Kerguelen	EE0018	1500	2460092	3926	61
Ile Haute - Kerguelen	EE0147	1500	831979	2278	34
Kerguelen - Armor	EE0005	1500	253073	243	2
Kerguelen - Armor	EE0007	1500	956963	3302	48
Kerguelen - Armor	EE0016	1500	1849373	3550	47
Kerguelen - Baie des Swains	EE0003	1500	1769300	2303	50
Kerguelen - Baie des Swains	EE0006	1500	1968998	2670	42
Kerguelen - Baie des Swains	EE0010	1500	2876392	3637	71
Kerguelen - Baie des Swains	EE0022	1500	2946911	480	7
Kerguelen - Suhm	EE0008	1500	1128457	1446	13
Kerguelen - Suhm	EE0011	1500	1602548	3217	54
Kerguelen - Suhm	EE0020	1500	1283787	3477	49
Kerguelen - Suhm	EE0021	1500	1571377	2125	25

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

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.

group	eDNA species	total species	fraction
fish	33	337	0.10
mammals	4	30	0.13
turtles	0	1	

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	0	1	
EN	1	13	0.08
VU	3	19	0.16

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

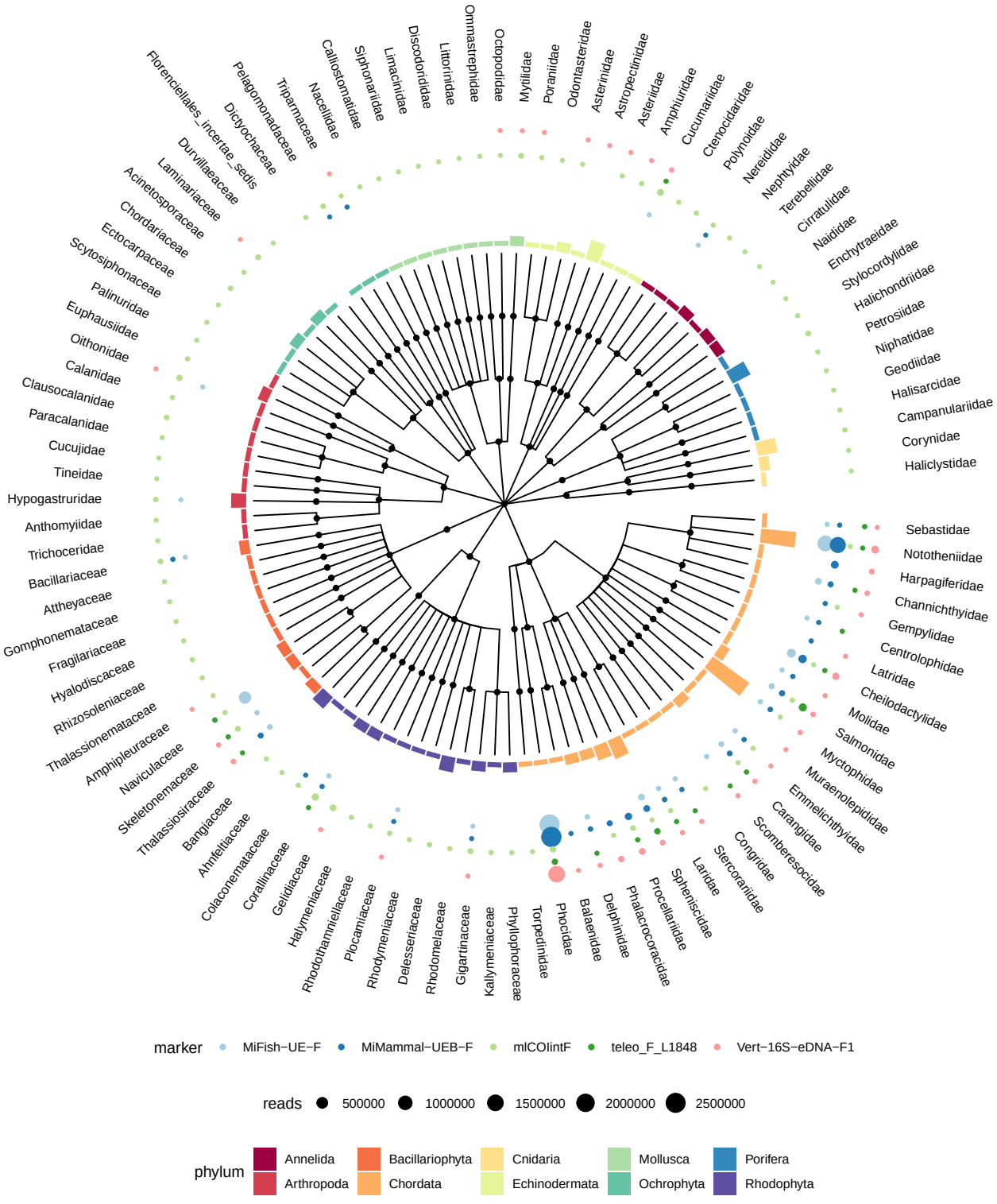

Figure 2: Number of DNA reads (bubbles) and species detected (bars) by family.

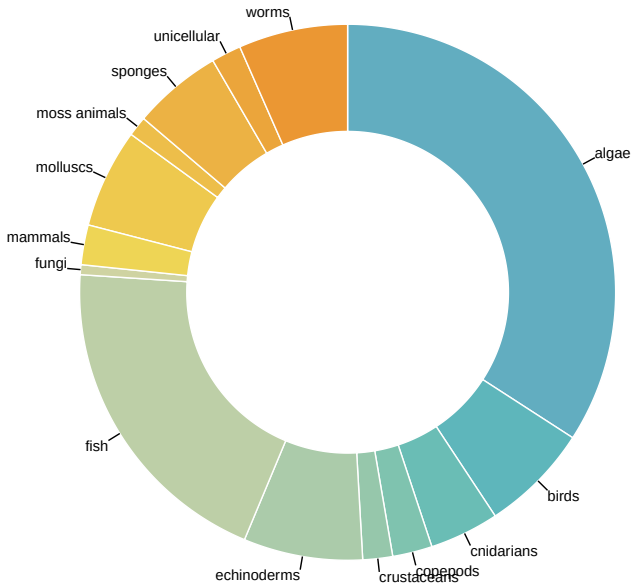

Figure 3: Distribution of detected species across groups.

phylum	class	species	group	category	new	vernacular
Amoebozoa	Discosea	Parvamoeba rugata	unicellular		yes	
Annelida	Clitellata	Cognettia varisetosa	worms		yes	
Annelida	Clitellata	Limnodrilus hoffmeisteri	worms		yes	
Annelida	Clitellata	Lumbricillus antarcticus	worms		yes	
Annelida	Clitellata	Tubifex tubifex	worms		yes	river worm
Annelida	Polychaeta	Aglaophamus trissophyllus	worms			
Annelida	Polychaeta	Amphitrite kerguelensis	worms			
Annelida	Polychaeta	Artacama crassa	worms		yes	
Annelida	Polychaeta	Cirratulus balaenophilus	worms		yes	
Annelida	Polychaeta	Harmothoe magellanica	worms			
Annelida	Polychaeta	Perinereis vallata	worms			
Arthropoda	Copepoda	Calanus simillimus	copepods			
Arthropoda	Copepoda	Ctenocalanus citer	copepods		yes	
Arthropoda	Copepoda	Mecynocera clausi	copepods			
Arthropoda	Copepoda	Oithona similis	copepods			
Arthropoda	Hexapoda	Ceratophysella denticulata			yes	
Arthropoda	Hexapoda	Fucellia tergina				
Arthropoda	Hexapoda	Hypogastrura purpurescens			yes	
Arthropoda	Hexapoda	Hypogastrura viatica				
Arthropoda	Hexapoda	Opogona omoscopa			yes	
Arthropoda	Hexapoda	Oryzaephilus surinamensis			yes	
Arthropoda	Hexapoda	Trichocera maculipennis			yes	
Arthropoda	Malacostraca	Euphausia vallentini	crustaceans			
Arthropoda	Malacostraca	Jasus paulensis	crustaceans	DD		St. Paul rock lobster
Arthropoda	Malacostraca	Thysanoessa gregaria	crustaceans		yes	
Bacillariophyta	Bacillariophyceae	Attheya longicornis	algae		yes	
Bacillariophyta	Bacillariophyceae	Cylindrotheca closterium	algae		yes	
Bacillariophyta	Bacillariophyceae	Frustulia vulgaris	algae		yes	
Bacillariophyta	Bacillariophyceae	Gomphonema parvulum	algae			
Bacillariophyta	Bacillariophyceae	Grammonema striatula	algae		yes	
Bacillariophyta	Bacillariophyceae	Halamphora calidilacuna	algae		yes	
Bacillariophyta	Bacillariophyceae	Navicula glaciei	algae		yes	
Bacillariophyta	Bacillariophyceae	Navicula minima	algae		yes	
Bacillariophyta	Bacillariophyceae	Nitzschia palea	algae		yes	
Bacillariophyta	Bacillariophyceae	Podosira stelligera	algae		yes	
Bacillariophyta	Bacillariophyceae	Skeletonema dohrnii	algae		yes	
Bacillariophyta	Bacillariophyceae	Sundstroemia setigera	algae		yes	
Bacillariophyta	Bacillariophyceae	Thalassionema nitzschioides	algae			
Bacillariophyta	Bacillariophyceae	Thalassiosira nordenskioeldii	algae		yes	
Bacillariophyta	Bacillariophyceae	Thalassiosira rotula	algae		yes	
Bigyra	Bicoecea	Cafeteria roenbergensis			yes	
Bryozoa	Gymnolaemata	Antarctothoa dictyota	moss animals		yes	
Bryozoa	Gymnolaemata	Austrothoa yagana	moss animals		yes	
Chlorophyta	Mamiellophyceae	Bathycoccus prasinos	algae		yes	
Chlorophyta	Mamiellophyceae	Micromonas commoda	algae		yes	
Chlorophyta	Mamiellophyceae	Micromonas pusilla	algae		yes	
Chlorophyta	Pyramimonadophyceae	Prasinoderma coloniale	algae		yes	
Chlorophyta		Chloroparvula pacifica	algae		yes	
Chordata	Aves	Aptenodytes patagonicus	birds	LC		king penguin, manchot royal
Chordata	Aves	Daption capense	birds	LC		Cape petrel, damier du Cap

Continued on next page

phylum	class	species	group	category	new	vernacular
Chordata	Aves	Eudyptes chrysocome	birds	VU		western rockhopper penguin, gorfou sauteur
Chordata	Aves	Eudyptes filholi	birds			Southern rockhopper penguin, Gorfou de Filhol
Chordata	Aves	Halobaena caerulea	birds	LC		blue petrel, prion bleu
Chordata	Aves	Larus dominicanus	birds	LC		kelp gull, goéland dominicain
Chordata	Aves	Leucocarbo atriceps	birds	LC		
Chordata	Aves	Leucocarbo chalconotus	birds	VU	yes	Otago shag
Chordata	Aves	Pterodroma hasitata	birds	EN	yes	black-capped petrel, Pétrel diablotin
Chordata	Aves	Pygoscelis papua	birds	LC		gentoo penguin, Manchot papou
Chordata	Aves	Stercorarius skua	birds			great skua, stercoraire brun
Chordata	Elasmobranchii	Tetronarce macneilli	fish			
Chordata	Mammalia	Cephalorhynchus commersonii	mammals	LC		piebald dolphin, jacobite
Chordata	Mammalia	Eubalaena australis	mammals	LC		southern right whale, baleine du Cap
Chordata	Mammalia	Mirounga leonina	mammals	LC		southern elephant seal
Chordata	Mammalia	Orcinus orca	mammals	DD		killer-trasher, orque
Chordata	Teleostei	Channichthys rhinoceratus	fish			unicorn icefish
Chordata	Teleostei	Diaphus effulgens	fish	LC		Headlight fish
Chordata	Teleostei	Diaphus ostenfeldi	fish	LC		
Chordata	Teleostei	Electrona carlsbergi	fish	LC		
Chordata	Teleostei	Gnathophis capensis	fish	LC		
Chordata	Teleostei	Gobionotothen acuta	fish			triangular notothen
Chordata	Teleostei	Gobionotothen gibberifrons	fish		yes	humped rockcod
Chordata	Teleostei	Gonichthys cocco	fish	LC	yes	
Chordata	Teleostei	Gymnoscopelus braueri	fish	LC		
Chordata	Teleostei	Gymnoscopelus microlampas	fish	LC		
Chordata	Teleostei	Harpagifer antarcticus	fish		yes	Antarctic spiny plunderfish
Chordata	Teleostei	Helicolenus dactylopterus	fish	LC	yes	bleumouth rockfish, sébaste chèvre
Chordata	Teleostei	Hygophum hanseni	fish	LC		
Chordata	Teleostei	Hygophum proximum	fish	LC		Firefly lanternfish
Chordata	Teleostei	Latris lineata	fish			
Chordata	Teleostei	Lindbergichthys nudifrons	fish		yes	
Chordata	Teleostei	Mola mola	fish	VU	yes	ocean sunfish, poisson-lune
Chordata	Teleostei	Muraenolepis marmorata	fish			
Chordata	Teleostei	Nemadactylus macropterus	fish			
Chordata	Teleostei	Notothenia coriiceps	fish			yellowbelly rockcod
Chordata	Teleostei	Notothenia rossii	fish			marbled rockcod
Chordata	Teleostei	Pagothenia borchgrevinki	fish		yes	bald notothen
Chordata	Teleostei	Paranotothenia magellanica	fish			Maori cod
Chordata	Teleostei	Plagiogeneion rubiginosum	fish	LC		
Chordata	Teleostei	Salmo trutta	fish	LC		brown trout, truite brune
Chordata	Teleostei	Salvelinus fontinalis	fish			brook trout, saumon de fontaine
Chordata	Teleostei	Schedophilus velaini	fish	LC		
Chordata	Teleostei	Scomberesox saurus	fish	LC		saury, aiguille de mer
Chordata	Teleostei	Seriola lalandi	fish	LC		yellowtail, sériole chicard
Chordata	Teleostei	Symbolophorus barnardi	fish	LC		
Chordata	Teleostei	Thyrsites atun	fish			snoek
Chordata	Teleostei	Trachurus murphyi	fish	DD	yes	Chilean jack mackerel
Cnidaria	Hydrozoa	Campanularia lennoxensis	cnidarians		yes	
Cnidaria	Hydrozoa	Clytia gracilis	cnidarians		yes	
Cnidaria	Hydrozoa	Coryne eximia	cnidarians		yes	
Cnidaria	Hydrozoa	Obelia geniculata	cnidarians			knotted thread hydroid, obélie

Continued on next page

phylum	class	species	group	category	new	vernacular
Cnidaria	Hydrozoa	Silicularia rosea	cnidarians			
Cnidaria	Hydrozoa	Stauridiosarsia producta	cnidarians		yes	
Cnidaria	Staurozoa	Depastromorpha africana	cnidarians		yes	
Cryptophyta	Cryptophyceae	Chroomonas placoidea			yes	
Echinodermata	Asteroidea	Anasterias antarctica	echinoderms		yes	
Echinodermata	Asteroidea	Anasterias suteri	echinoderms		yes	
Echinodermata	Asteroidea	Cycethra verrucosa	echinoderms			
Echinodermata	Asteroidea	Diplasterias brucei	echinoderms			
Echinodermata	Asteroidea	Diplasterias meridionalis	echinoderms			
Echinodermata	Asteroidea	Glabraster antarctica	echinoderms			
Echinodermata	Asteroidea	Macroptychaster accrescens	echinoderms			
Echinodermata	Asteroidea	Odontaster penicillatus	echinoderms			
Echinodermata	Asteroidea	Parvulastra exigua	echinoderms			
Echinodermata	Echinoidea	Aporocidaris milleri	echinoderms			Miller's sea urchin, oursin de Miller
Echinodermata	Holothuroidea	Staurocucumis liouvillei	echinoderms			
Echinodermata	Ophiuroidea	Amphipholis squamata	echinoderms			dwarf brittle star
Foraminifera	Globothalamea	Virgulinella fragilis				
Haptophyta	Coccolithophyceae	Emiliania huxleyi	algae		yes	
Haptophyta	Coccolithophyceae	Phaeocystis antarctica	algae		yes	
Mollusca	Bivalvia	Aulacomya atra	molluscs			
Mollusca	Bivalvia	Mytilus edulis	molluscs			blue mussel, moule commune
Mollusca	Cephalopoda	Octopus vulgaris	molluscs	LC		common octopus, pieuvre
Mollusca	Cephalopoda	Todarodes filippovae	molluscs	LC		Antarctic flying squid
Mollusca	Gastropoda	Jorunna tomentosa	molluscs		yes	white jorunna
Mollusca	Gastropoda	Laevilitorina caliginosa	molluscs			
Mollusca	Gastropoda	Limacina helicina	molluscs		yes	
Mollusca	Gastropoda	Margarella antarctica	molluscs		yes	
Mollusca	Gastropoda	Nacella macquariensis	molluscs		yes	
Mollusca	Gastropoda	Siphonaria fuegiensis	molluscs		yes	
Myzozoa	Dinophyceae	Heterocapsa rotundata	unicellular		yes	
Myzozoa	Dinophyceae	Karenia mikimotoi	unicellular		yes	
Nemertea	Pilidiophora	Parborlasia corrugatus	worms			
Ochrophyta	Bolidophyceae	Triparma laevis	algae		yes	
Ochrophyta	Dictyochophyceae	Florenciella parvula	algae		yes	
Ochrophyta	Dictyochophyceae	Octactis speculum	algae		yes	
Ochrophyta	Dictyochophyceae	Pseudochattonella farcimen	algae		yes	
Ochrophyta	Pelagophyceae	Aureococcus anophagefferens	algae		yes	
Ochrophyta	Phaeophyceae	Durvillaea antarctica	algae			
Ochrophyta	Phaeophyceae	Ectocarpus fasciculatus	algae		yes	
Ochrophyta	Phaeophyceae	Laminaria pallida	algae			
Ochrophyta	Phaeophyceae	Macrocystis pyrifera	algae			
Ochrophyta	Phaeophyceae	Microspongium stilophorae	algae		yes	
Ochrophyta	Phaeophyceae	Myrionema strangulans	algae		yes	
Ochrophyta	Phaeophyceae	Petalonia tenella	algae		yes	
Ochrophyta	Phaeophyceae	Pylaiella washingtoniensis	algae		yes	
Oomycota	Peronosporea	Eurychasma dicksonii	fungi		yes	
Porifera	Demospongiae	Amorphinopsis fenestrata	sponges		yes	
Porifera	Demospongiae	Geodia libera	sponges		yes	
Porifera	Demospongiae	Halichondria (Halichondria) panicea	sponges			breadcrumb sponge
Porifera	Demospongiae	Halisarca dujardinii	sponges			soft horny sponge, éponge de Dujardin

Continued on next page

phylum	class	species	group	category	new	vernacular
Porifera	Demospongiae	Hemigellius fimbriatus	sponges		yes	
Porifera	Demospongiae	Hymeniacidon gracilis	sponges		yes	
Porifera	Demospongiae	Hymeniacidon perlevis	sponges			crumb-of-bread sponge
Porifera	Demospongiae	Petrosia (Strongylophora) durissima	sponges		yes	
Porifera	Demospongiae	Stylocordyla chupachups	sponges		yes	
Rhodophyta	Bangiophyceae	Neoporphyra haitanensis	algae		yes	
Rhodophyta	Bangiophyceae	Porphyra capensis	algae			
Rhodophyta	Bangiophyceae	Wildemania amplissima	algae		yes	
Rhodophyta	Florideophyceae	Acrosorium ciliolatum	algae		yes	
Rhodophyta	Florideophyceae	Ahnfeltia plicata	algae			
Rhodophyta	Florideophyceae	Asterfilopsis piurana	algae		yes	
Rhodophyta	Florideophyceae	Callophyllis atrosanguinea	algae			
Rhodophyta	Florideophyceae	Colaconema daviesii	algae		yes	
Rhodophyta	Florideophyceae	Corallina ferreyrae	algae		yes	
Rhodophyta	Florideophyceae	Gelidium capense	algae			
Rhodophyta	Florideophyceae	Gelidium micropterum	algae		yes	
Rhodophyta	Florideophyceae	Gymnogongrus turquetii	algae			
Rhodophyta	Florideophyceae	Iridaea cordata	algae			
Rhodophyta	Florideophyceae	Jania sagittata	algae		yes	
Rhodophyta	Florideophyceae	Neuroglossum multilobum	algae		yes	
Rhodophyta	Florideophyceae	Ophidocladus simpliciusculus	algae		yes	
Rhodophyta	Florideophyceae	Phitymophora amansioides	algae			
Rhodophyta	Florideophyceae	Plocamium suhrii	algae			
Rhodophyta	Florideophyceae	Polyopes constrictus	algae		yes	
Rhodophyta	Florideophyceae	Rhodoglossum revolutum	algae		yes	
Rhodophyta	Florideophyceae	Rhodothamniella floridula	algae		yes	
Rhodophyta	Florideophyceae	Rhodymenia wilsonis	algae		yes	