

eDNA Expeditions biodiversity survey of Everglades National Park

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Introduction

Environmental DNA Expeditions is a global, citizen science initiative that will help measure marine biodiversity, and the impacts climate change might have on the distribution patterns of marine life, across UNESCO World Heritage marine sites.

Ocean species shed DNA into the water around them. The genetic material from waste, mucus or cells in one liter of water can determine the species richness in a given area, without the need to actually extract organisms from their environment. The cost effective, ethical nature of eDNA sampling has the potential to revolutionize knowledge about ecosystems and species

diversity and to inspire the next generation of ocean researchers.

eDNA sampling was conducted in Everglades National Park in April 2023, by filtering up to 1800 ml of seawater through filter cartridges with a 0.8 µm pore size. 20 samples were collected at five locations in the park: Trout Creek, North Eagle Creek, Crocodile Dragover, Whip Ray, and Captain. From these 20 samples, a first batch of 11 samples covering all sites has been processed. DNA from these samples was extracted and amplified, and then sent to the sequencing facility.

Results

Sampling and DNA sequencing

Sequencing of the DNA from 11 samples resulted in over 20 million sequence reads. From these reads we were able to collect 12,507 unique sequences or ASVs. Matching those sequences with reference sequences in

public databases, we were able to detect 194 species. A total of 2566 are known from Everglades National Park in the OBIS database. Of the 193 species detected, 77 are not known from the park in OBIS.

	reads	species	asvs
	20627859	194	12507

locality	materialSampleID	reads	species	asvs	sampleSize
Captain	EE0386	1715884	33	1261	1500
Captain	EE0391	1504564	77	5480	1800
Captain	EE0402	1768280	73	5873	1800
Crocodile Dragover	EE0389	1542386	64	5174	1500
Crocodile Dragover	EE0390	2070296	67	5042	450
North Eagle Key	EE0388	1586226	43	2831	1500
Trout Creek	EE0403	1854506	86	3590	1500
Whip Ray	EE0387	2902938	78	3101	1800

Whip Ray	EE0404	2195910	97	5838	1800
Whip Ray	EE0405	1994942	97	4808	1800
Whip Ray	EE0406	1491927	103	4685	1800

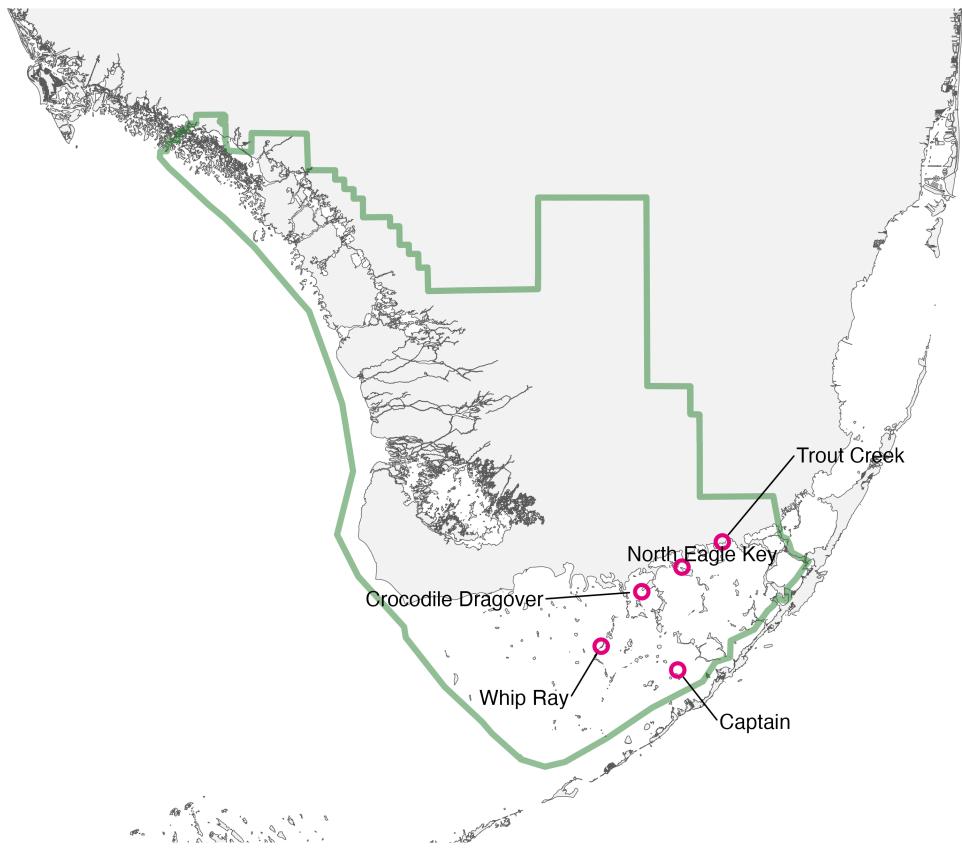


Figure 1: Map of eDNA sampling locations





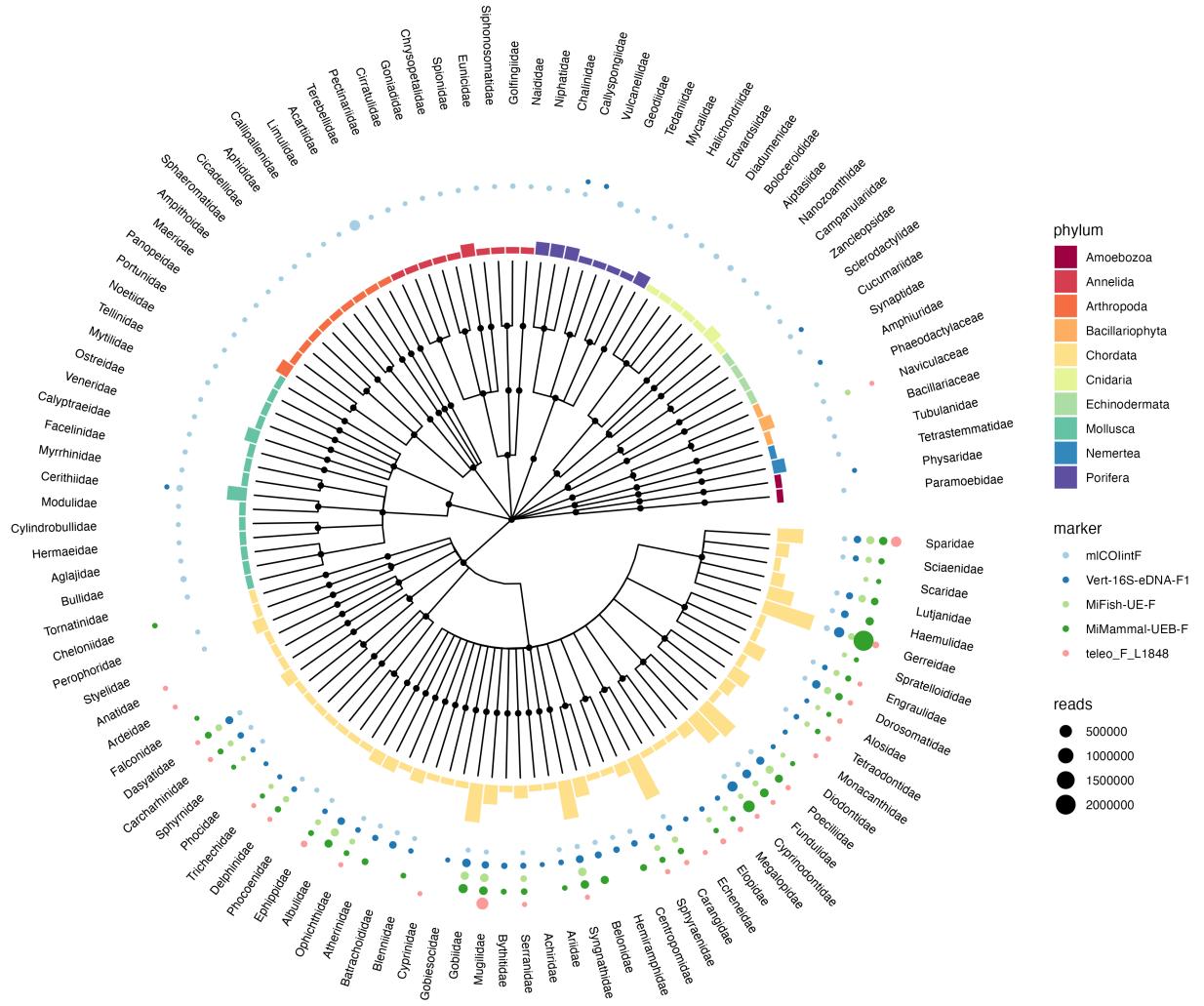


Figure 2: Number of DNA reads and species detected by family

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Species detection



(a) *Sphyrna tiburo*



(b) *Hypanus rufus*



(c) *Epinephelus itajara*

Figure 3: Some of the detected fish species.

Appendix: species list

phylum	class	species	category	new	vernacular
Amoebozoa	Dicosea	<i>Neoparamoeba aestuarina</i>	yes	yes	
Amoebozoa	Myxogastrea	<i>Craterium leucocephalum</i>	yes	yes	
Annelida	Ciliata	<i>Thalassodrilides gurwitschi</i>	yes	yes	red rock worm
Annelida	Polychaeta	<i>Marpheya sanguinea</i>	yes	yes	
Annelida	Polychaeta	<i>Bhawania godei</i>	yes	yes	
Annelida	Polychaeta	<i>Glycinde multidens</i>	yes	yes	
Annelida	Polychaeta	<i>Polydora websteri</i>	yes	yes	
Annelida	Polychaeta	<i>Prionospio steenstrupi</i>	yes	yes	
Annelida	Polychaeta	<i>Timarete caribous</i>	yes	yes	ice cream cone worm
Annelida	Polychaeta	<i>Pectinaria gouldii</i>	yes	yes	medusa worm
Annelida	Polychaeta	<i>Loimia medusa</i>	yes	yes	
Annelida		<i>Golfingia (Golfingia) elongata</i>	yes	yes	
Annelida		<i>Siphonosoma cumanense</i>	yes	yes	
Arthropoda	Copepoda	<i>Acartia (Acanthacarta) tonsa</i>	yes	yes	
Arthropoda	Hexapoda	<i>Rhopalosiphum padi</i>	yes	yes	
Arthropoda	Hexapoda	<i>Macrosteles quadrilineatus</i>	yes	yes	
Arthropoda	Malacostraca	<i>Cymadusa compta</i>	yes	yes	
Arthropoda	Malacostraca	<i>Elaasmopus nkaf</i>	yes	yes	
Arthropoda	Malacostraca	<i>Neopanope packardi</i>	yes	yes	
Arthropoda	Malacostraca	<i>Callinectes sapidus</i>	yes	yes	
Arthropoda	Malacostraca	<i>Portunus sanguinolentus</i>	yes	yes	
Arthropoda	Malacostraca	<i>Paracerceis caudata</i>	VU		
Arthropoda	Merostomata	<i>Limulus polyphemus</i>	VU		
Arthropoda	Pycnogonida	<i>Callipallene brevirostris</i>	VU		
Ascomycota	Dothideomycetes	<i>Cladosporium herbarum</i>	yes	yes	
Ascomycota	Eurotiomycetes	<i>Aspergillus versicolor</i>	yes	yes	
Bacillariophyta	Bacillariophyceae	<i>Cylindrotheca closterium</i>	yes	yes	
Bacillariophyta	Bacillariophyceae	<i>Haslea crucigera</i>	yes	yes	
Bacillariophyta	Bacillariophyceae	<i>Navicula minima</i>	yes	yes	
Bacillariophyta	Bacillariophyceae	<i>Phaeodactylum tricornutum</i>	yes	yes	
Bryozoa	Gymnolaemata	<i>Bugula rochae</i>	yes	yes	
Bryozoa	Gymnolaemata	<i>Anathia evelinae</i>	yes	yes	
Cercozoa	Chlorarachnea	<i>Chlorarachnion reptans</i>	yes	yes	
Chlorophyta	Mamiellophyceae	<i>Dolichomastix tenuilepis</i>	yes	yes	
Chlorophyta	Mamiellophyceae	<i>Micromonas pusilla</i>	yes	yes	
Chordata	Asciidae	<i>Ecteinascidia styeloides</i>	yes	yes	
Chordata	Asciidae	<i>Botrylloides niger</i>	yes	yes	
Chordata	Asciidae	<i>Botrylloides simodensis</i>	yes	yes	
Chordata	Aves	<i>Anas poecilorhyncha</i>	yes	yes	
Chordata	Aves	<i>Ardea cinerea</i>	yes	yes	
Chordata	Aves	<i>Falco sparverius</i>	yes	yes	
Chordata	Elasmobranchii	<i>Negaprion brevirostris</i>	VU		
Chordata	Elasmobranchii	<i>Sphyrna tiburo</i>	EN		
Chordata	Elasmobranchii	<i>Hypanus americanus</i>	NT		
Chordata	Elasmobranchii	<i>Hypanus rufus</i>	CR	yes	

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phylum	class	species	category	new	vernacular
Chordata	Mammalia	<i>Mirounga leonina</i>		yes	southern elephant seal
Chordata	Mammalia	<i>Tursiops truncatus</i>	VU	yes	bottlenose dolphin, grand dauphin
Chordata	Mammalia	<i>Neophocaena phocaenoides</i>	VU	yes	Indian dolphin, marsouin aptere
Chordata	Mammalia	<i>Trichechus manatus</i>	VU	yes	West Indian manatee
Chordata	Teleostei	<i>Chaetodipterus faber</i>	NT	yes	Atlantic spadefish
Chordata	Teleostei	<i>Abuia glossodonta</i>		yes	roundjaw bonefish
Chordata	Teleostei	<i>Albula vulpes</i>		yes	bonefish
Chordata	Teleostei	<i>Myrophis punctatus</i>		yes	speckled worm eel
Chordata	Teleostei	<i>Myrophis vafer</i>		yes	Pacific worm eel
Chordata	Teleostei	<i>Atherinomorus stipes</i>		yes	hardhead silverside
Chordata	Teleostei	<i>Opsanus beta</i>		yes	Gulf toadfish
Chordata	Teleostei	<i>Opsanus tau</i>		yes	oyster toadfish
Chordata	Teleostei	<i>Strongylura notata</i>		yes	redfin needlefish
Chordata	Teleostei	<i>Strongylura timucu</i>		yes	timucu
Chordata	Teleostei	<i>Tylosurus crocodilus</i>		yes	houndfish
Chordata	Teleostei	<i>Chirodorus atherinoides</i>		yes	hardhead halfbeak
Chordata	Teleostei	<i>Chasmodes bosquianus</i>		yes	striped blenny
Chordata	Teleostei	<i>Centropomus undecimalis</i>		yes	common snook
Chordata	Teleostei	<i>Sphyraena barracuda</i>		yes	great barracuda
Chordata	Teleostei	<i>Sphyraena jello</i>		yes	pickhandle barracuda
Chordata	Teleostei	<i>Caranx cryos</i>		yes	blue runner, carangue coubalí
Chordata	Teleostei	<i>Caranx ignobilis</i>		yes	common jack, carangue crevalle
Chordata	Teleostei	<i>Caranx latus</i>		yes	giant trevally
Chordata	Teleostei	<i>Oligoplites saurus</i>		yes	horse-eye jack
Chordata	Teleostei	<i>Seiene vomer</i>		yes	leatherjack
Chordata	Teleostei	<i>Trachinotus carolinus</i>		yes	lookdown
Chordata	Teleostei	<i>Echeneis naucrates</i>		yes	pompano
Chordata	Teleostei	<i>Brevoortia tyrannus</i>		yes	sharksucker
Chordata	Teleostei	<i>Harengula jaguana</i>		yes	mossbunker
Chordata	Teleostei	<i>Opisthonema oglinum</i>		yes	scaled sardine
Chordata	Teleostei	<i>Anchoa mitchilli</i>		yes	Atlantic thread herring
Chordata	Teleostei	<i>Jenkinsia lamprotaenia</i>		yes	bay anchovy
Chordata	Teleostei	<i>Carassius auratus</i>		yes	dwarf herring
Chordata	Teleostei	<i>Cyprinodon variegatus</i>		yes	goldfish, gible
Chordata	Teleostei	<i>Floridichthys carpio</i>		yes	sheepshead minnow
Chordata	Teleostei	<i>Fundulus confluentus</i>		yes	goldspotted killifish
Chordata	Teleostei	<i>Fundulus grandis</i>		yes	marsh killifish
Chordata	Teleostei	<i>Fundulus xenicus</i>		yes	Gulf killifish
Chordata	Teleostei	<i>Lucania goodei</i>		yes	rainwater killifish
Chordata	Teleostei	<i>Lucania parva</i>		yes	pike killifish
Chordata	Teleostei	<i>Belonesox belizanus</i>		yes	mosquitofish
Chordata	Teleostei	<i>Gambusia affinis</i>		yes	eastern mosquitofish
Chordata	Teleostei	<i>Gambusia holbrooki</i>		yes	mangrove gambusia
Chordata	Teleostei	<i>Gambusia rhizophorae</i>			

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phylum	class	species	category	new	vernacular
Chordata	Teleostei	<i>Poecilia latipinna</i>			sailfin molly
Chordata	Teleostei	<i>Poecilia sphenops</i>		yes	Mexican molly
Chordata	Teleostei	<i>Elops saurus</i>			ladyfish
Chordata	Teleostei	<i>Megalops atlanticus</i>	VU		tarpon
Chordata	Teleostei	<i>Diapterus auratus</i>			Irish mojarra
Chordata	Teleostei	<i>Eucinostomus argenteus</i>			silver mojarra
Chordata	Teleostei	<i>Eucinostomus gula</i>			Jenny mojarra
Chordata	Teleostei	<i>Eucinostomus jonesii</i>			slender mojarra
Chordata	Teleostei	<i>Eucinostomus melanopterus</i>			flagfin mojarra
Chordata	Teleostei	<i>Eugerres plumieri</i>			striped mojarra
Chordata	Teleostei	<i>Gerris cinereus</i>			yellowfin mojarra
Chordata	Teleostei	<i>Ulaema lefroyi</i>			
Chordata	Teleostei	<i>Haemulon aurolineatum</i>			tomtate grunt
Chordata	Teleostei	<i>Haemulon parra</i>			sailors choice
Chordata	Teleostei	<i>Haemulon plumieri</i>			grunt
Chordata	Teleostei	<i>Haemulon sciurus</i>			bluestriped grunt
Chordata	Teleostei	<i>Lutjanus argentimaculatus</i>			river snapper
Chordata	Teleostei	<i>Lutjanus griseus</i>			grey snapper
Chordata	Teleostei	<i>Nicholsina usta</i>			emerald parrotfish
Chordata	Teleostei	<i>Cynoscion nebulosus</i>			spotted weakfish
Chordata	Teleostei	<i>Pogonias cromis</i>			blackdrum
Chordata	Teleostei	<i>Archosargus probatocephalus</i>			sheepshead
Chordata	Teleostei	<i>Archosargus rhomboidalis</i>			Western Atlantic seabream
Chordata	Teleostei	<i>Diplodus kotschyi</i>	yes		
Chordata	Teleostei	<i>Lagodon rhomboides</i>			pinfish
Chordata	Teleostei	<i>Gobiesox strumosus</i>			skilletfish
Chordata	Teleostei	<i>Gobiosoma bosc</i>			naked goby
Chordata	Teleostei	<i>Gobiosoma ginsburgi</i>			seabard goby
Chordata	Teleostei	<i>Gobiosoma robustum</i>			code goby
Chordata	Teleostei	<i>Lophogobius cyprinoides</i>			crested goby
Chordata	Teleostei	<i>Microgobius gulosis</i>			clown goby
Chordata	Teleostei	<i>Microgobius microlepis</i>			banner goby
Chordata	Teleostei	<i>Mugil cephalus</i>			grey mullet, muge
Chordata	Teleostei	<i>Mugil curema</i>			silverside mullet
Chordata	Teleostei	<i>Mugil rubrioculus</i>			
Chordata	Teleostei	<i>Ocilia cavorum</i>			key brotula
Chordata	Teleostei	<i>Epinephelus itajara</i>			itajara
Chordata	Teleostei	<i>Epinephelus lanceolatus</i>			giant grouper
Chordata	Teleostei	<i>Trinectes maculatus</i>			hogchoker
Chordata	Teleostei	<i>Ariopsis felis</i>			hardhead catfish
Chordata	Teleostei	<i>Anarchopterus criniger</i>			fringed pipefish
Chordata	Teleostei	<i>Hippocampus zosterae</i>			dwarf seahorse
Chordata	Teleostei	<i>Syngnathus floridae</i>			dusky pipefish
Chordata	Teleostei	<i>Syngnathus fuscus</i>			northern pipefish
Chordata	Teleostei	<i>Syngnathus schlegeli</i>	yes		Seaweed pipefish

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phylum	class	species	category	new	vernacular
Chordata	Teleostei	<i>Syngnathus scovelli</i>			Gulf pipefish
Chordata	Teleostei	<i>Chilomycterus schoepfii</i>		yes	striped burrfish
Chordata	Teleostei	<i>Stephanolepis cirrhifer</i>			File fish
Chordata	Teleostei	<i>Stephanolepis hispida</i>			
Chordata	Teleostei	<i>Sphaerooides maculatus</i>			
Chordata	Teleostei	<i>Sphaerooides parvus</i>			puffer
Chordata	Teleostei	<i>Sphaerooides spengleri</i>			least puffer
Chordata	Teleostei	<i>Caretta caretta</i>	VU		bandtail puffer
Cnidaria		<i>Exaiptasia diaphana</i>			loggerhead sea turtle, tortue Caouanne
Cnidaria	Anthozoa	<i>Boloceroides mcmurrichi</i>			
Cnidaria	Anthozoa	<i>Diadumene leucoloma</i>			
Cnidaria	Anthozoa	<i>Edwardsia longicornis</i>			
Cnidaria	Anthozoa	<i>Nanozoanthus harenaceus</i>			
Cnidaria	Hydrozoa	<i>Zancleopsis dichotoma</i>			
Cnidaria	Hydrozoa	<i>Clytia hemisphaerica</i>			
Cnidaria	Hydrozoa	<i>Obelia bidentata</i>			
Ctenophora	Tentaculata	<i>Valicula multififormis</i>			
Echinodermata	Holothuroidea	<i>Leptosynapta tenuis</i>			
Echinodermata	Holothuroidea	<i>Thyonella gemmata</i>			
Echinodermata	Holothuroidea	<i>Sclerodactyla briareus</i>			
Echinodermata	Ophiuroidea	<i>Amphipholis squamata</i>			
Gnathostomulida		<i>Gnathostomula mediterranea</i>			
Mollusca	Bivalvia	<i>Arcopsis adamsi</i>			
Mollusca	Bivalvia	<i>Ametilla mitchelli</i>			
Mollusca	Bivalvia	<i>Brachidontes exustus</i>			
Mollusca	Bivalvia	<i>Crassostrea virginica</i>			
Mollusca	Bivalvia	<i>Anomalogardia puella</i>			
Mollusca	Bivalvia	<i>Chione cancellata</i>			
Mollusca	Gastropoda	<i>Philinopsis pusa</i>			
Mollusca	Gastropoda	<i>Bulla arabica</i>			
Mollusca	Gastropoda	<i>Acteocina canaliculata</i>			
Mollusca	Gastropoda	<i>Crepidula convexa</i>			
Mollusca	Gastropoda	<i>Learchis poica</i>			
Mollusca	Gastropoda	<i>Dondice occidentalis</i>			
Mollusca	Gastropoda	<i>Bittium varium</i>			
Mollusca	Gastropoda	<i>Cerithium eburneum</i>			
Mollusca	Gastropoda	<i>Cerithium muscarum</i>			
Mollusca	Gastropoda	<i>Modulus modulus</i>			
Mollusca	Gastropoda	<i>Cylindrobulla beaui</i>			
Mollusca	Gastropoda	<i>Cyerce antillensis</i>			
Mollusca	Gastropoda	<i>Amphidinium massartii</i>			
Myzozoa	Dinophyceae	<i>Tetrastemma elegans</i>			
Nemertea	Hoplonemertea	<i>Tetrastemma wilsoni</i>			
Nemertea	Hoplonemertea	<i>Tubulanus riceae</i>			
Nemertea	Palaeonemertea	<i>Phoronis psammophila</i>			

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phylum	class	species	category	new	vernacular
Porifera	Demospongiae	<i>Callyspongia</i> (<i>Cladochalina</i>) <i>aculeata</i>		yes	
Porifera	Demospongiae	<i>Callyspongia</i> (<i>Cladochalina</i>) <i>diffusa</i>		yes	
Porifera	Demospongiae	<i>Cladocroce burapha</i>		yes	
Porifera	Demospongiae	<i>Haliclona</i> (<i>Halichoclona</i>) <i>vandoesti</i>		yes	
Porifera	Demospongiae	<i>Gelliodes wilsoni</i>		yes	
Porifera	Demospongiae	<i>Pachychalina tenera</i>		yes	
Porifera	Demospongiae	<i>Mycale</i> (<i>Carmia</i>) <i>fibrexilis</i>		yes	
Porifera	Demospongiae	<i>Tedania</i> (<i>Tedania</i>) <i>ignis</i>		yes	
Porifera	Demospongiae	<i>Anorphinopsis fenestrata</i>		yes	
Porifera	Demospongiae	<i>Halichondria</i> (<i>Halichondria</i>) <i>melanadocia</i>		yes	
Porifera	Demospongiae	<i>Geodia neptuni</i>		yes	
Porifera	Demospongiae	<i>Poecillastra laminaris</i>		yes	
Rhodophyta	Florideophyceae	<i>Acanthosiphonia echinata</i>		yes	