

# Utilizing environmental DNA-based metabarcoding to quantify mesopelagic fish diversity in the Southern Ocean

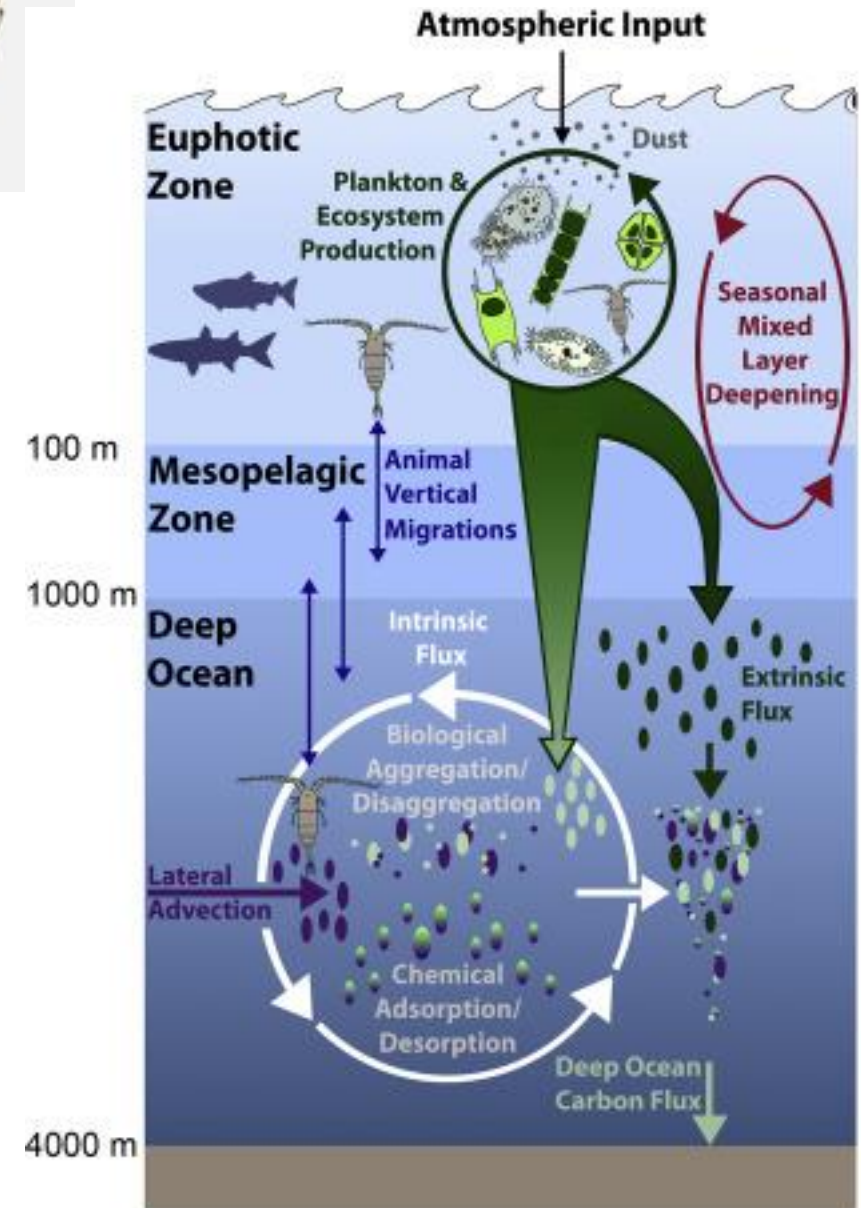
Zifang Liu, Rupert A. Collins, Charles Baillie, Jennifer J. Freer, Ryan A. Saunders, Geraint A. Tarling, Stefano Mariani, Martin J. Genner



## Background



- Mesopelagic fish in the Southern Ocean: are **fundamental** to food webs (Saunders et al. 2018; Dornan et al. 2022), as well as, key component of the oceanic **biological carbon pump** (Saba et al. 2021; Dornan et al. 2022).
- However, uncertainty regarding key aspects of their biology, including their distributions and abundance over time, space and depth, and relevance to food webs of the region (Saunders et al. 2019).
- Capture-based net survey methods, which can lead to underestimates of abundance due to net avoidance behaviour at sampled locations (Saunders et al. 2019).

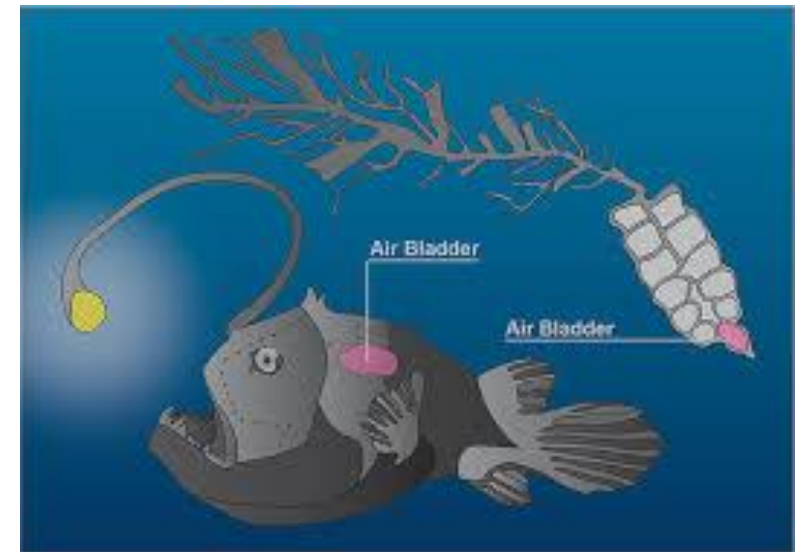
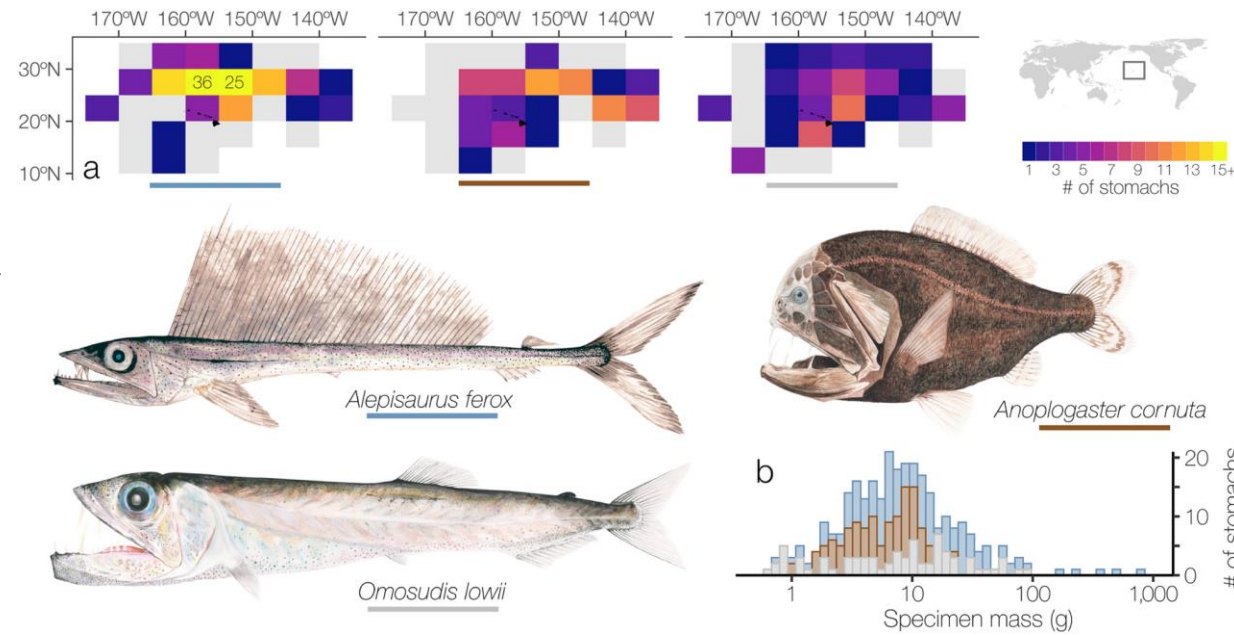


# Background

- Acoustic approaches have been implied to study the **biomass** (Portner et al., 2023), but **species composition information** still needs to be groundtruthed with sampling methods that provide species-level abundance and biomass information.



- Environmental DNA is known to be a promising biomonitoring tool, at the meantime, few tested cases have been carried out in an open ocean, especially in the most mystery ecosystem – the Southern Ocean.



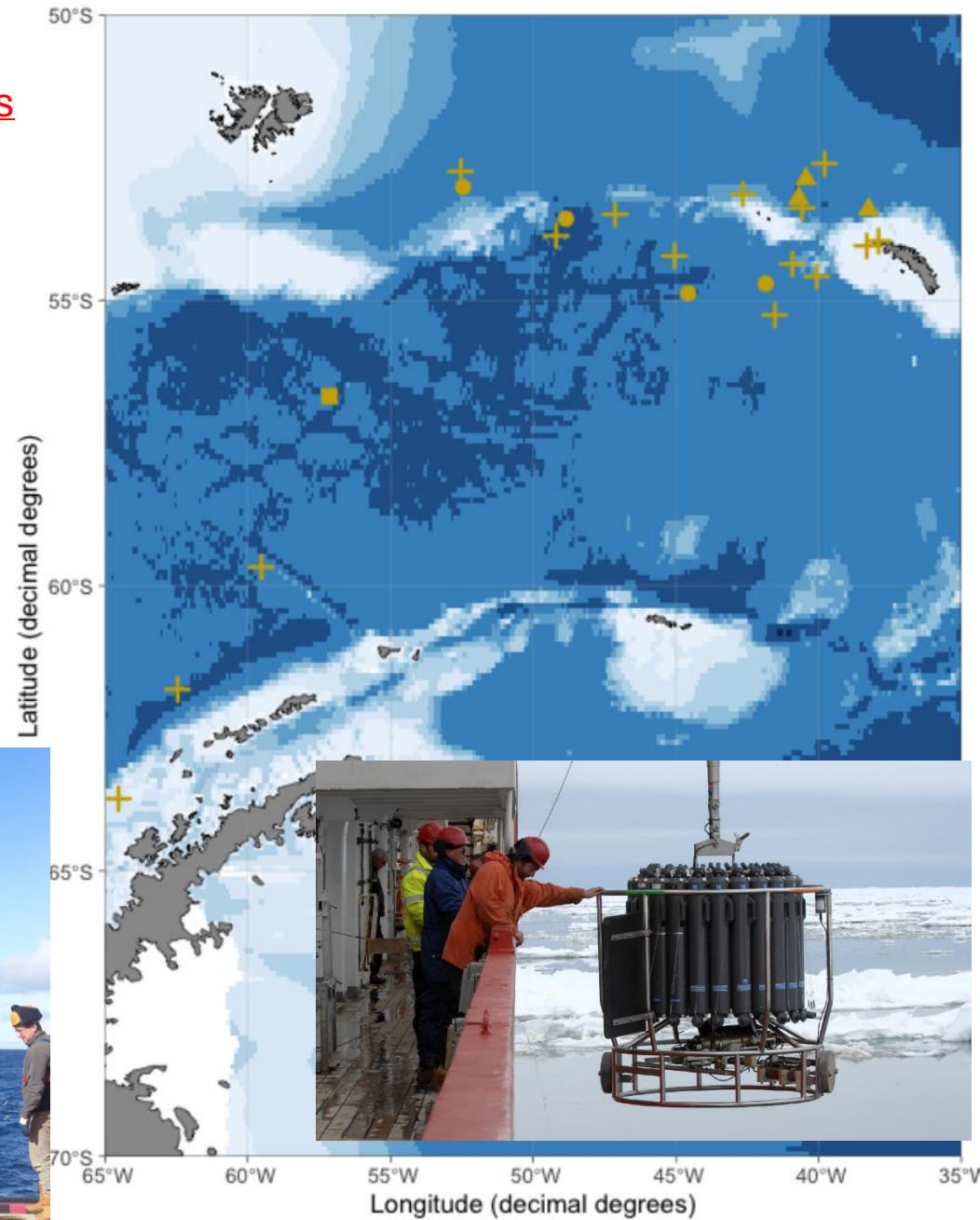
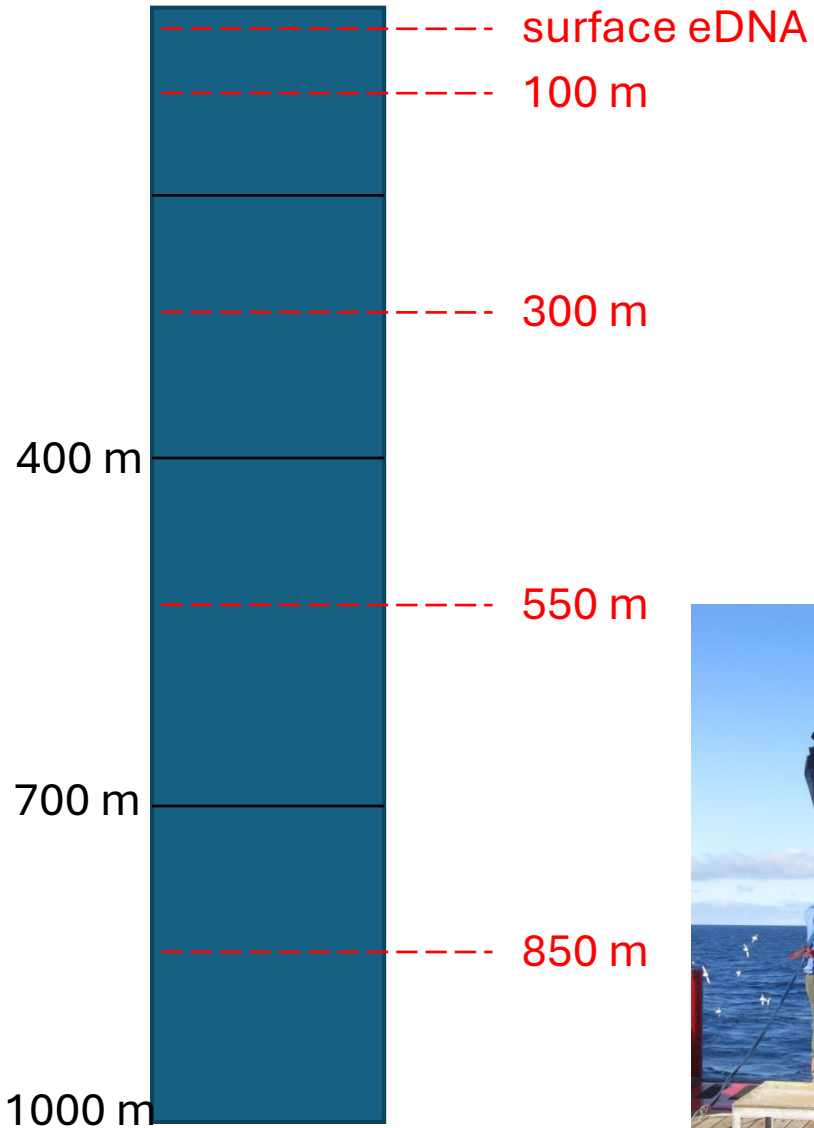
## Key Questions

- The groundtruth of mescopelagic fish composition.
- To test the ability of eDNA to detect fishery stock in gradient depth.
- To test reliability of eDNA metabarcoding to reliably reflect the relative abundance of species in the local communities.

# Sampling

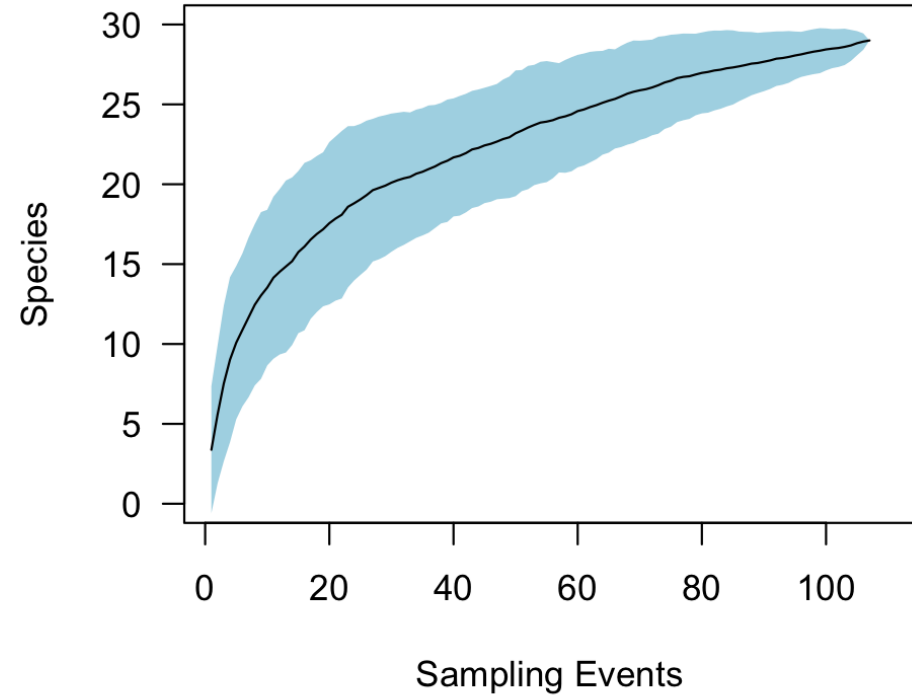
RMT25

CTD bottles for eDNA filters



# eDNA sequencing

Filtering Step	Library 1	Library 2	Total Number
Paired-end merge	6,230,305	9,630,694	15,860,999
High Alignment Score	4,315,828	7,371,439	11,687,267
Demultiplex	3,443,171	6,091,183	9,534,354
Dereplicate	3,443,171	6,091,183	9,534,354
Trim primers	3,443,171	6,091,183	9,534,354
Remove outsize and low replicates	2,955,049	5,419,485	8,374,534
Remove PCR/sequencing errors	2,176,430	3,992,451	6,168,881
Taxonomy assigned	146,502	945,459	1,091,961
Reads retained from focal samples	146,502	50,552	197,054



# eDNA sequencing

SampleID	EventID	Description	Taxon	Reads
lib1_H09	BAS-2016.12.16-E21-04	Field Negative	Arctocephalus gazella	1
lib2_H12	BAS-2016.12.22-Und-01	Field Negative	Arctocephalus gazella	5
lib2_A05	BAS-2016.12.27-E73-02	Field Negative	Balaenoptera bonaerensis	1
lib2_A05	BAS-2016.12.27-E73-02	Field Negative	Electrona antarctica	2
lib2_A05	BAS-2016.12.27-E73-02	Field Negative	Gymnoscopelus fraseri	1
lib1_D10	BAS-2016.12.30-E94-02	Field Negative	Gymnoscopelus fraseri	1
lib1_D10	BAS-2016.12.30-E94-02	Field Negative	Gymnoscopelus nicholsi	2
lib1_D10	BAS-2016.12.30-E94-02	Field Negative	Krefttichthys anderssoni	1
lib1_D10	BAS-2016.12.30-E94-02	Field Negative	Lampridae	1
lib1_H06	BAS-2017.01.03-E134-02	Field Negative	Notothenia rossii	1
lib2_G03	BAS-2017.01.03-E134-03	Field Negative	Arctocephalus australis	1
lib2_G03	BAS-2017.01.03-E134-03	Field Negative	Balaenoptera physalus	2
lib2_G03	BAS-2017.01.03-E134-03	Field Negative	Electrona antarctica	2
lib2_G03	BAS-2017.01.03-E134-03	Field Negative	Gymnoscopelus fraseri	1
lib2_G03	BAS-2017.01.03-E134-03	Field Negative	Krefttichthys anderssoni	1
lib2_G03	BAS-2017.01.03-E134-03	Field Negative	Protomyctophum bolini	1
lib2_G03	BAS-2017.01.03-E134-03	Field Negative	Trematomus lepidorhinus	1
lib2_G06	BAS-2017.01.05-E150-04	Field Negative	Arctocephalus gazella	1
lib2_F08	BAS-2017.01.06-E170-03	Field Negative	Balaenoptera bonaerensis	1
lib2_F08	BAS-2017.01.06-E170-03	Field Negative	Balaenoptera physalus	1
lib2_F08	BAS-2017.01.06-E170-03	Field Negative	Electrona antarctica	1
lib2_F08	BAS-2017.01.06-E170-03	Field Negative	Krefttichthys anderssoni	1
lib2_F08	BAS-2017.01.06-E170-03	Field Negative	Notothenia coriiceps	1
lib2_F08	BAS-2017.01.06-E170-03	Field Negative	Protomyctophum bolini	1713
lib2_F08	BAS-2017.01.06-E170-03	Field Negative	Trematomus lepidorhinus	3
lib2_C02	BAS-2017.01.06-Und-01	Field Negative	Arctocephalus gazella	1
lib2_C02	BAS-2017.01.06-Und-01	Field Negative	Bathylagidae	1
lib2_C02	BAS-2017.01.06-Und-01	Field Negative	Gymnoscopelus fraseri	1
lib1_E08	BAS-2017.01.09-Und-01	Field Negative	Aethotaxis mitopteryx	1
lib1_E08	BAS-2017.01.09-Und-01	Field Negative	Krefttichthys anderssoni	1
lib1_D04	BAS-2017.01.09-Und-02	Field Negative	Arctocephalus gazella	2
lib1_D04	BAS-2017.01.09-Und-02	Field Negative	Balaenoptera bonaerensis	1
lib1_D04	BAS-2017.01.09-Und-02	Field Negative	Krefttichthys anderssoni	1
lib1_D04	BAS-2017.01.09-Und-02	Field Negative	Patagonotothen ramsayi	1
lib1_A02	BAS-2017.01.10-Und-01	Field Negative	Arctocephalus australis	2
lib1_A02	BAS-2017.01.10-Und-01	Field Negative	Electrona antarctica	1
lib1_A02	BAS-2017.01.10-Und-01	Field Negative	Krefttichthys anderssoni	1
lib1_A02	BAS-2017.01.10-Und-01	Field Negative	Patagonotothen ramsayi	2

SampleID	EventID	Description	Taxon	Reads
lib1_H12	BLANK	Empty well/barcode	Krefttichthys anderssoni	1
lib1_A12	BLANK	Empty well/barcode	Krefttichthys anderssoni	1
lib1_F12	BLANK	Empty well/barcode	Krefttichthys anderssoni	1
lib1_A12	BLANK	Empty well/barcode	Lagenorhynchus sp.	1
lib1_E12	BLANK	Empty well/barcode	Notothenia rossii	1
lib1_F12	BLANK	Empty well/barcode	Notothenia rossii	3
lib1_G12	BLANK	Empty well/barcode	Notothenia rossii	4
lib2_E04	EXT_01	Extraction negative	Krefttichthys anderssoni	1
lib2_H10	EXT_02	Extraction negative	Arctocephalus australis	1
lib2_H10	EXT_02	Extraction negative	Balaenoptera bonaerensis	1
lib2_H10	EXT_02	Extraction negative	Balaenoptera physalus	1
lib2_H10	EXT_02	Extraction negative	Gymnoscopelus fraseri	1
lib2_H10	EXT_02	Extraction negative	Notothenia rossii	1
lib2_H10	EXT_02	Extraction negative	Trematomus lepidorhinus	3
lib1_F03	EXT_03	Extraction negative	Arctocephalus gazella	1
lib1_F05	EXT_04	Extraction negative	Arctocephalus gazella	1
lib1_B11	EXT_06	Extraction negative	Aethotaxis mitopteryx	2
lib1_B11	EXT_06	Extraction negative	Krefttichthys anderssoni	1
lib1_B11	EXT_06	Extraction negative	Notothenia rossii	2
lib1_A08	EXT_07	Extraction negative	Arctocephalus gazella	2
lib1_A08	EXT_07	Extraction negative	Krefttichthys anderssoni	1
lib1_A08	EXT_07	Extraction negative	Notothenia coriiceps	1
lib2_D10	PCR-BLANK-03	PCR Negative	Balaenoptera bonaerensis	1
lib2_D10	PCR-BLANK-03	PCR Negative	Electrona antarctica	1
lib1_C11	PCR-BLANK-05	PCR Negative	Notothenia rossii	5
lib1_H12	BLANK	Empty well/barcode	Krefttichthys anderssoni	1
lib1_A12	BLANK	Empty well/barcode	Krefttichthys anderssoni	1
lib1_F12	BLANK	Empty well/barcode	Krefttichthys anderssoni	1
lib1_A12	BLANK	Empty well/barcode	Lagenorhynchus sp.	1
lib1_E12	BLANK	Empty well/barcode	Notothenia rossii	1
lib1_F12	BLANK	Empty well/barcode	Notothenia rossii	3
lib1_G12	BLANK	Empty well/barcode	Notothenia rossii	4

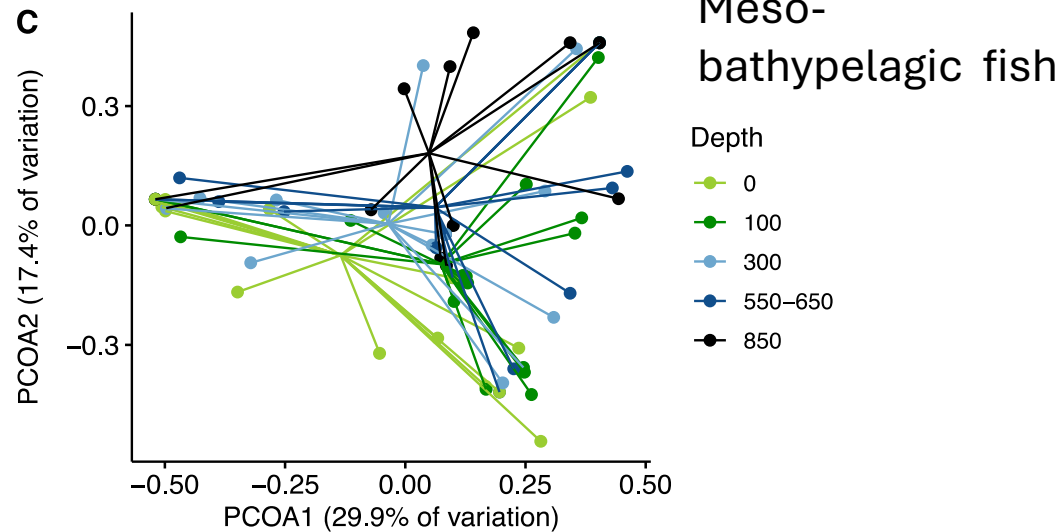
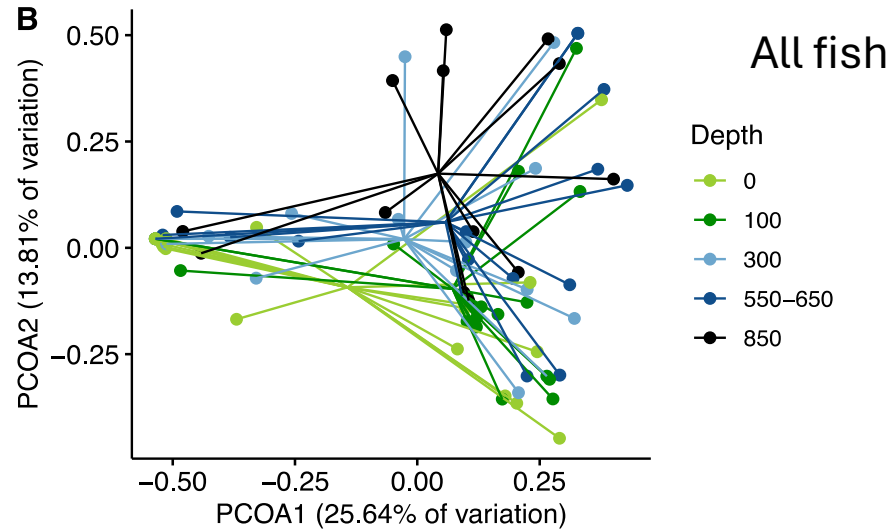
# eDNA sequencing

Taxon	Common name	Family	Total reads
Pogonophryne sp.	Plunderfish	Artedidraconidae	570
Borostomias antarcticus	Snaggletooth	Stomiidae	758
Stomias boa	Boa dragonfish	Stomiidae	730
Parachaenichthys charcoti	Charcot's dragonfish	Bathydraconidae	1612
Bathylagidae	Deep-sea smelts	Bathylagidae	20778
Centrolophidae	Medusafish	Centrolophidae	2146
Chaenocephalus aceratus	Blackfin icefish	Channichthyidae	1789
Champsocephalus exox	Pike icefish	Channichthyidae	1283
Cyclothone pseudopallida	Slender bristlemouth	Gonostomatidae	251
Harpagifer antarcticus	Antarctic spiny plunderfish	Harpagiferidae	1977
Lampridae	Moonfish	Lampridae	8834
Microstomatidae	Pencil smelts	Microstomatidae	1419
Electrona antarctica	Antarctica lanternfish	Myctophidae	17906
Electrona carlsbergi	Electron subantarctic lanternfish	Myctophidae	3824
Gymnoscopelus fraseri	Fraser's lanternfish	Myctophidae	8454
Gymnoscopelus nicholsi	Nichol's lanternfish	Myctophidae	14896
Krefflichthys anderssoni	Rhombic lanternfish	Myctophidae	17114
Lampanyctus achirus	Lantern fish	Myctophidae	1593
Lampichthys procerus	Blackhead lanternfish	Myctophidae	16
Protomyctophum bolini	Bolin's lanternfish	Myctophidae	3359
Protomyctophum sp.	Lanternfishes	Myctophidae	28
Aethotaxis mitopteryx	Longfin icedevil	Nototheniidae	5759
Dissostichus eleginoides	Patagonian toothfish	Nototheniidae	2816
Notothenia coriiceps	Black rockcod	Nototheniidae	6187
Notothenia rossii	Marbled rockcod	Nototheniidae	15263
Patagonotothen ramsayi	Longtail southern cod	Nototheniidae	18034
Trematomus lepidorhinus	Slender scalyhead	Nototheniidae	20
Amblyraja georgiana	Antarctic starry skate	Rajidae	48

- A total of 28 species recovered.
- These eDNA reads were dominated by meso-bathypelagic taxa, which comprised 66.11% of the reads of all fishes.
- Other abundant taxa in the eDNA reads were marbled rockcod (*N. rossii*; a demersal icefish), longtail southern cod (*P. ramsayi*; a benthopelagic icefish) and a representative of the genus *Lampris* (opahs, pelagic lampriforms) identified only to genus level.



# Fish community structure by depth in eDNA samples

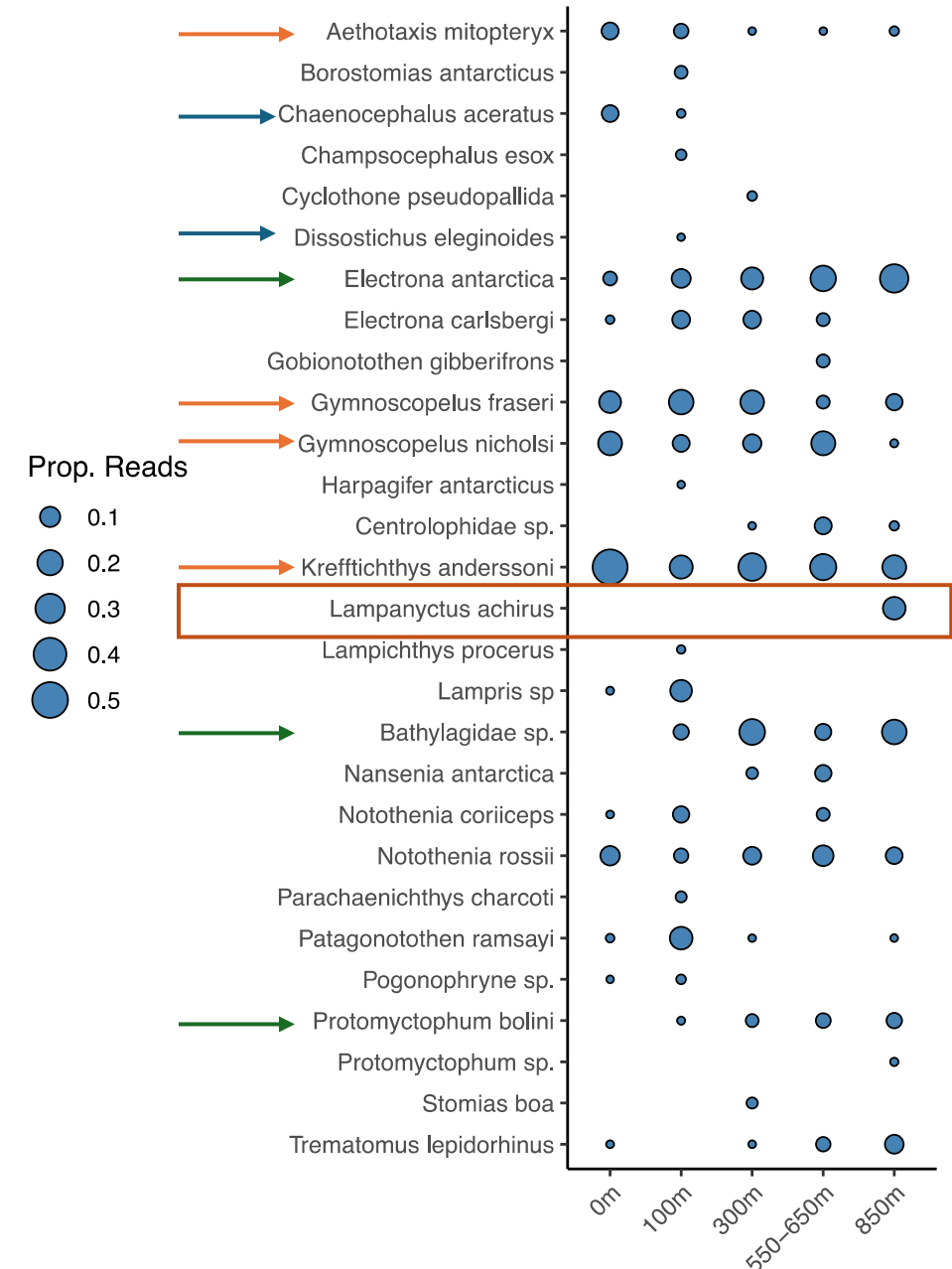


Dataset	Factor	Df	SS	r <sup>2</sup>	F	P
All fishes (eDNA)	Depth	4	2.758	0.08578	1.9557	<b>0.003</b>
	Station	6	4.009	0.12467	1.8948	<b>0.001</b>
	Residual	72	25.387	0.78955		
	Total	82	32.154	1		
Meso-bathypelagic fishes (eDNA)	Depth	4	2.5281	0.08862	1.8978	<b>0.009</b>
	Station	6	3.6871	0.12924	1.8452	<b>0.005</b>
	Residual	67	22.3136	0.78214		
	Total	77	28.5288	1		

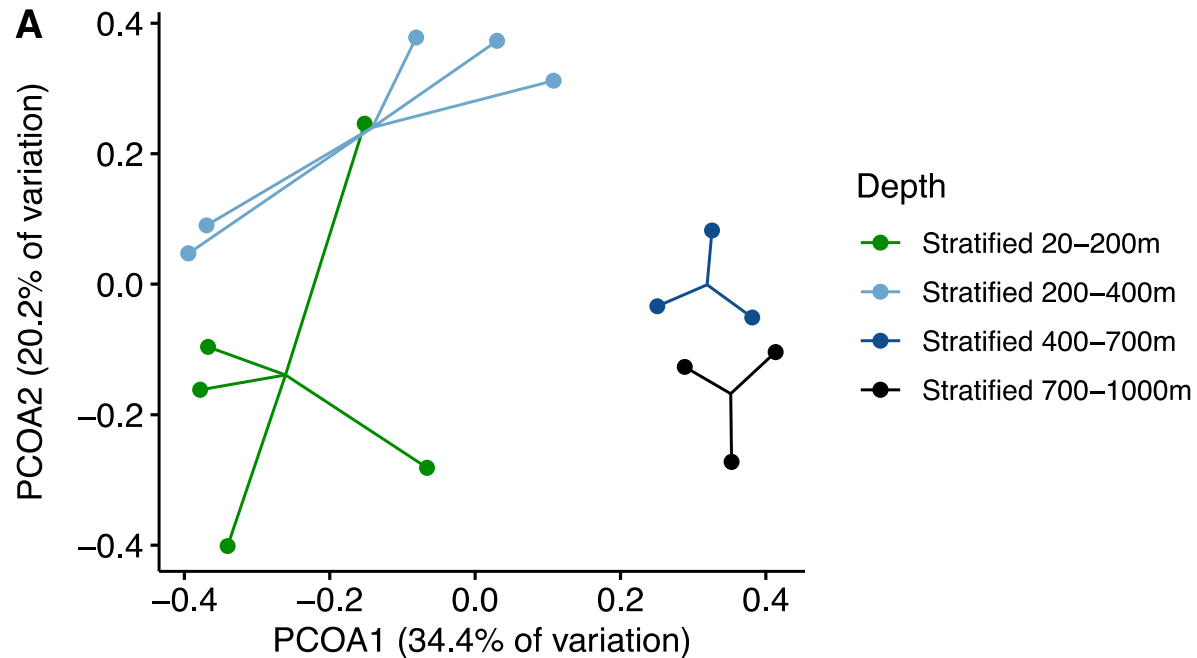
Dataset	Depth 1	Depth 2	SS	r <sup>2</sup>	F	P
All fishes (eDNA)	0m	100m	0.951	0.056	2.133	<b>0.005</b>
	0m	300m	0.703	0.049	1.588	<b>0.050</b>
	0m	550-650m	0.944	0.062	2.189	<b>0.011</b>
	0m	850m	0.942	0.069	2.163	<b>0.004</b>
	100m	300m	0.477	0.030	1.025	0.429
	100m	550-650m	1.009	0.060	2.227	<b>0.001</b>
	100m	850m	0.710	0.047	1.544	<b>0.040</b>
	300m	550-650m	0.627	0.044	1.392	0.128
	300m	850m	0.318	0.026	0.693	0.863
550-650m	850m	0.660	0.050	1.488	0.081	
Meso-bathypelagic fishes (eDNA)	0m	100m	0.734	0.047	1.617	<b>0.033</b>
	0m	300m	0.584	0.041	1.279	0.150
	0m	550-650m	0.663	0.043	1.477	0.086
	0m	850m	0.726	0.054	1.602	<b>0.022</b>
	100m	300m	0.454	0.032	0.968	0.500
	100m	550-650m	0.848	0.054	1.842	<b>0.009</b>
	100m	850m	0.583	0.044	1.249	0.160
	300m	550-650m	0.667	0.047	1.440	0.063
	300m	850m	0.304	0.026	0.644	0.968
	550-650m	850m	0.640	0.049	1.389	0.087

# Fish community structure by depth in eDNA samples

- Exploring the changes in the proportion of species within reads across sampling depths revealed relative **increases** in some species with increasing depth such as the myctophids *E. antarctica* and *P. bolini*, and deep-sea smelts (Bathylagidae). **Green**
- Notably some species were exclusively found in samples from deep waters including the myctophid *L. achirus*.
- There were also **declines** in the proportions of reads some species including the myctophids *G. fraseri* and the pelagic icefish *A. mitopteryx*. **orange**
- There were also examples of deep water or demersal taxa being found in surface waters, including Patagonian toothfish (*D. eleginoides*), black icefish (*C. aceratus*), Antarctic dragonfish (*P. charcoti*) and barbeled plunderfish (*Pogonophryne* sp.). **Blue**



# Fish community structure by depth in net catches

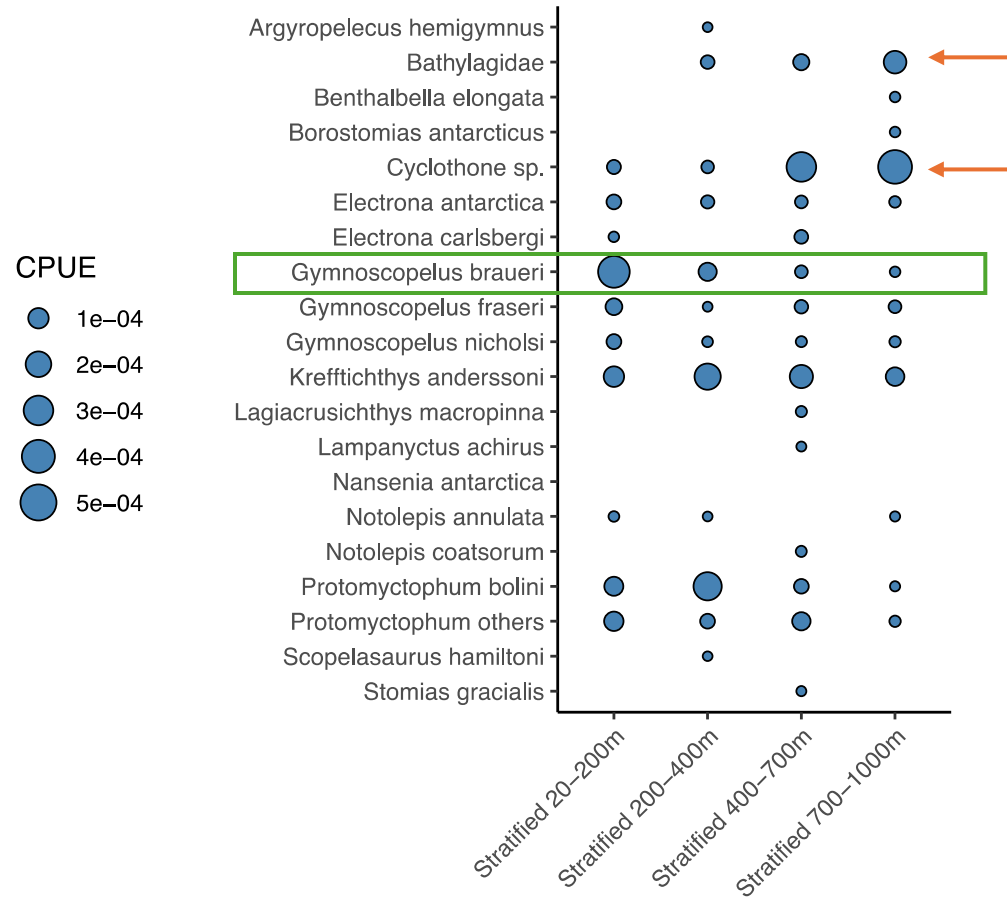


Dataset	Depth 1	Depth 2	SS	r2	F	P
Meso-bathypelagic fishes (RMT)	20-200m	200-400m	0.534	0.266	2.897	<b>0.034</b>
	20-200m	400-700m	0.694	0.394	3.906	<b>0.019</b>
	20-200m	700-1000m	0.811	0.392	3.868	<b>0.019</b>
	200-400m	400-700m	0.557	0.341	3.101	<b>0.018</b>
	200-400m	700-1000m	0.804	0.388	3.802	<b>0.017</b>
	700-1000m	400-700m	0.112	0.115	0.522	0.700

Dataset	Factor	Df	SS	r <sup>2</sup>	F	P
Meso-bathypelagic fishes (RMT)	Site	4	1.1714	0.28274	1.7552	0.035
	Depth	3	1.6369	0.39509	3.2702	<b>&lt; 0.001</b>
	Residual	8	1.3348	0.32218		
Total		15	4.1431	1		

- Significant difference on fish composition among depth strata, but not found below 700m depth.

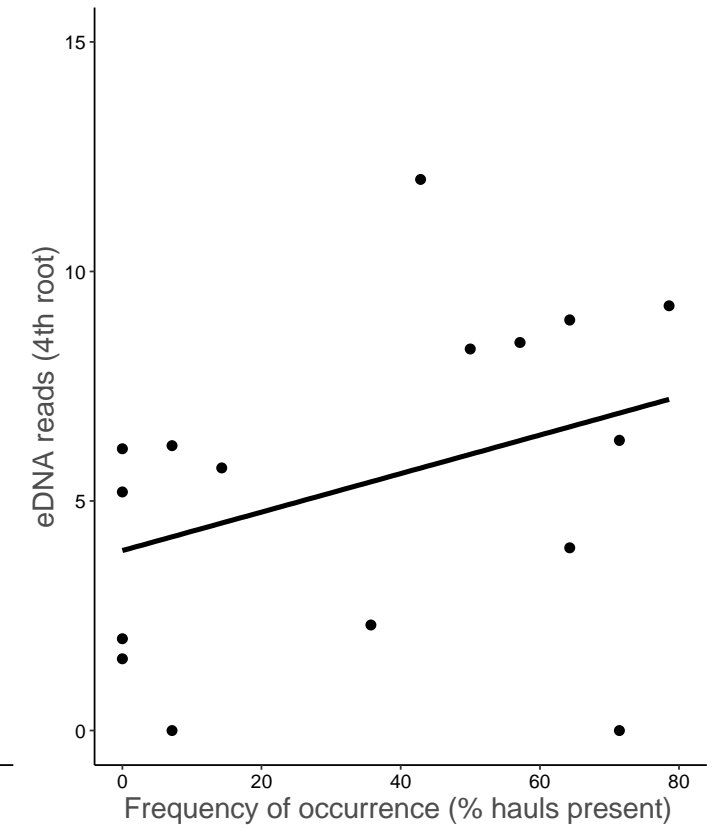
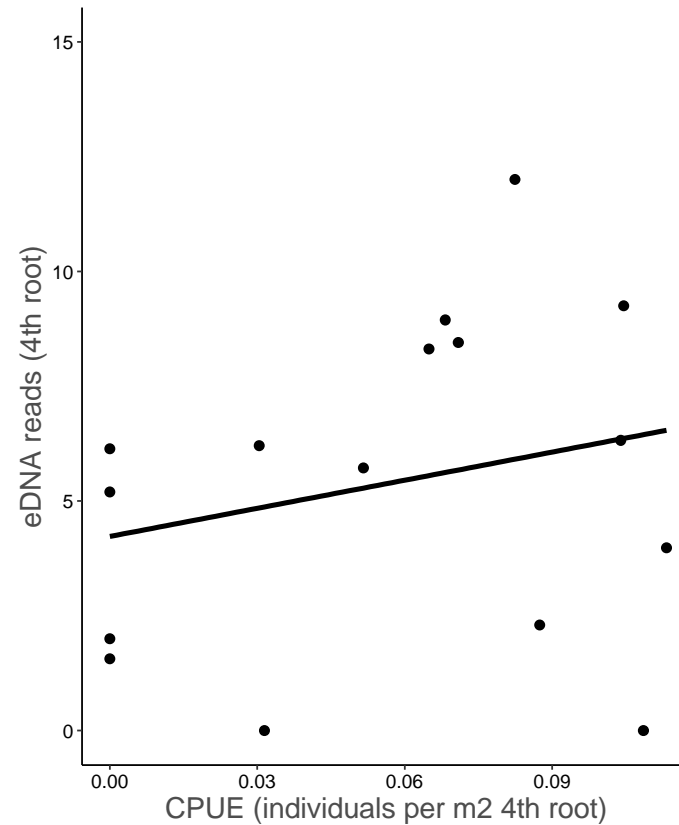
# Fish community structure by depth in net catches



- Myctophid dominated, comprising 74.43% of the CPUE on average.
- Myctophidae were broadly distributed across depth zones, except for *G. braueri* that declined in abundance with increasing depth.
- The bathypelagic taxa including the deep-sea smelts (Bathylagidae), pearleyes (*B. elongata* and *L. macropinna*) and bristlemouths (*Cyclothone sp.*) were primarily found in the samples from greater than 400m depth.

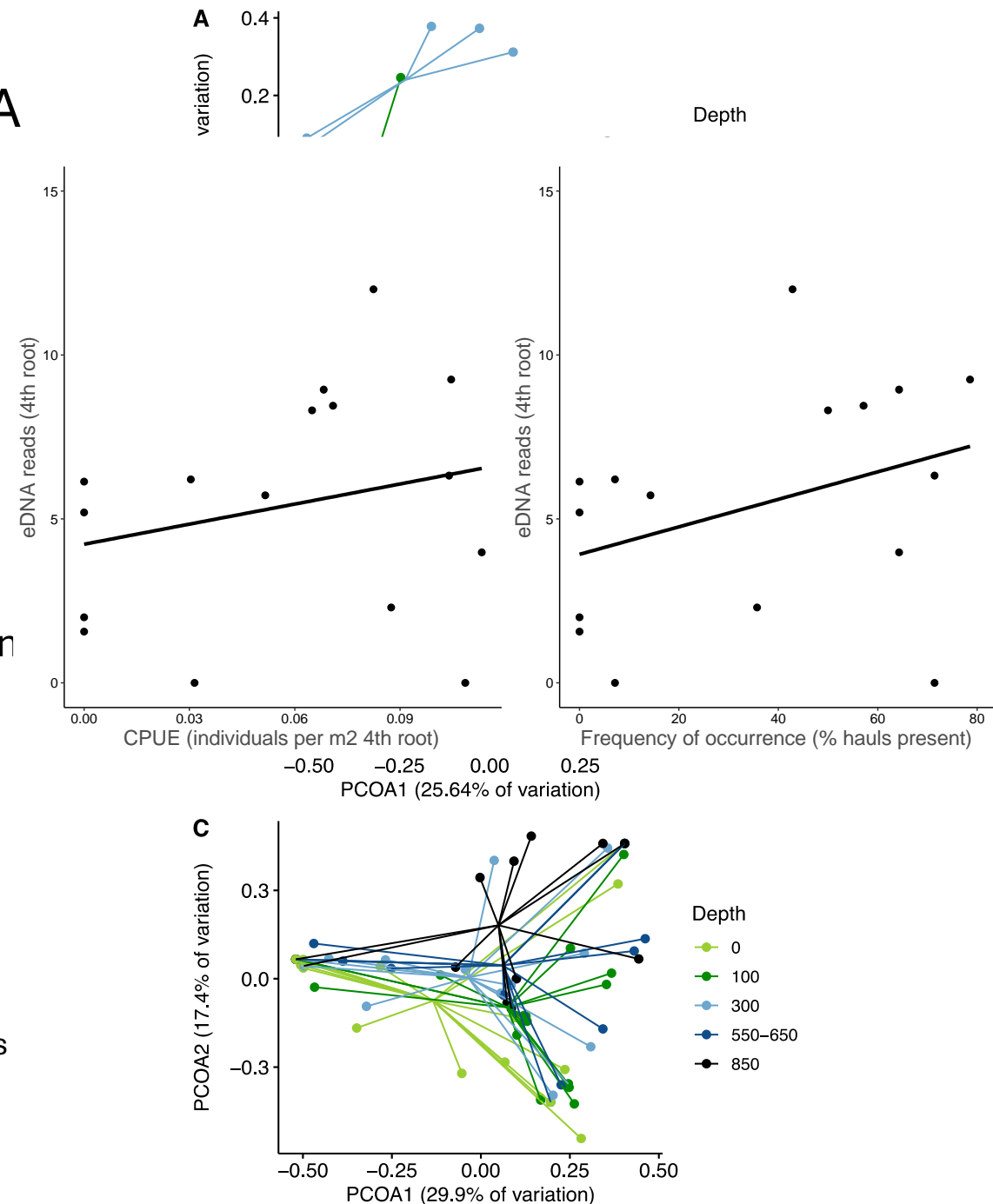
# Associations between species abundance in net samples and eDNA reads

- We found a non-significant positive association between CPUE in net surveys and eDNA reads ( $F_{1,14} = 0.8823$ ,  $r^2 = 0.059$ ,  $P = 0.365$ ).
- A non-significant positive association between frequency of occurrence of species in net surveys and eDNA reads ( $F_{1,14} = 2.10$ ,  $r^2 = 0.131$ ,  $P = 0.169$ ).



# Inferring mesopelagic fish abundance from eDNA data

- **No** clear segregation of the species by depth zones as we see in net capture data.
- **No** evidence of a link between the abundance of fish captured in RMT trawl nets and eDNA abundance.
- ☐ This decoupling of fish abundance from eDNA may be linked to mixing and transport of eDNA in the water column
  - Recent modelling work has suggested these effects may be relatively modest (Allan et al. 2021)
- ✓ Could be driven by the diurnal vertical migrations of many mesopelagic fishes.
  - eDNA degrades at an exponential rate, it has a half-life of 1-2 days in temperate conditions (Collins et al. 2018)
- ✓ eDNA contributions of the ichthyoplankton may break down expected positive associations.
  - December-January when ichthyoplankton, including pelagic myctophids and demersal notothenioids, are reliably present (Loeb et al. 1993; Saunders et al. 2017).



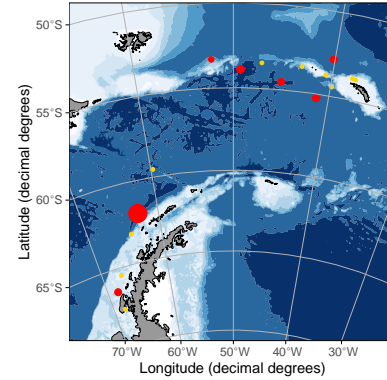
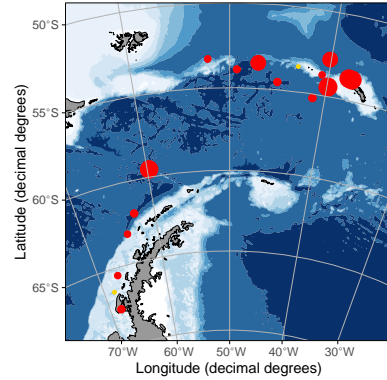
# Requirements for reference library

- Only **22.63%** of these had appropriate sequences of our target 12S region of the mitochondrial genome available for inclusion in our analyses, including from NCBI Genbank and SRA databases.
- Some sequences aligned to wrong organisms exist widely across NCBI databases.

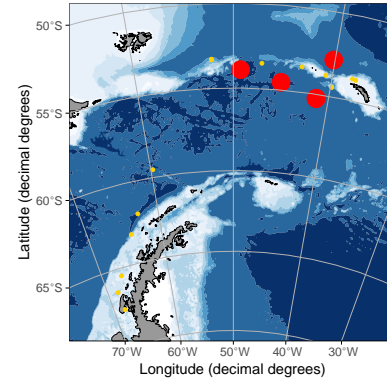
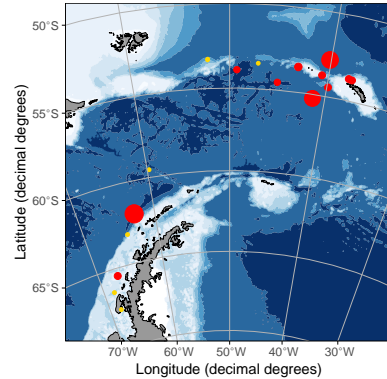
Scientific Name	Family	Order	Class	In the reference
Acanthodraco dewitti	Bathydraconidae	Notothenioidei	Actinopteri	NO
Achiropsetta tricholepis	Achiropsettidae	Pleuronectiformes	Actinopteri	NO
Aethotaxis mitopteryx	Nototheniidae	Notothenioidei	Actinopteri	GENBANK
Akarotaxis nudiceps	Bathydraconidae	Notothenioidei	Actinopteri	GENBANK
Alepisaurus brevirostris	Alepisauridae	Alepocephaliformes	Actinopteri	NO
Alepocephalus australis	Alepocephalidae	Alepocephaliformes	Actinopteri	NO
Alepocephalus bicolor	Alepocephalidae	Alepocephaliformes	Actinopteri	GENBANK
Alepocephalus productus	Alepocephalidae	Alepocephaliformes	Actinopteri	GENBANK
Alepocephalus tenebrosus	Alepocephalidae	Alepocephaliformes	Actinopteri	SRA
Amblyraja georgiana	Rajidae	Rajiformes	Elasmobranchii	GENBANK
Amblyraja taaf	Rajidae	Rajiformes	Elasmobranchii	NO
Anotopterus pharao	Anotopteridae	Aulopiformes	Actinopteri	NO
Antimora rostrata	Moridae	Gadiformes	Actinopteri	GENBANK
Arctozenus risso	Paralepididae	Aulopiformes	Actinopteri	NO
Argyropelecus aculeatus	Sternoptychidae	Stomiiformes	Actinopteri	GENBANK
Argyropelecus affinis	Sternoptychidae	Stomiiformes	Actinopteri	GENBANK
Argyropelecus gigas	Sternoptychidae	Stomiiformes	Actinopteri	GENBANK
Argyropelecus hemigymnus	Sternoptychidae	Stomiiformes	Actinopteri	NO
Argyropelecus sladeni	Sternoptychidae	Stomiiformes	Actinopteri	GENBANK
Artedidraco glareobarbatus	Artedidraconidae	Notothenioidei	Actinopteri	NO
Artedidraco lonnbergi	Artedidraconidae	Notothenioidei	Actinopteri	NO
Artedidraco mirus	Artedidraconidae	Notothenioidei	Actinopteri	NO
Artedidraco orianae	Artedidraconidae	Notothenioidei	Actinopteri	NO
Artedidraco shackletoni	Artedidraconidae	Notothenioidei	Actinopteri	NO
Artedidraco skottsbergi	Artedidraconidae	Notothenioidei	Actinopteri	GENBANK
Bathydraco antarcticus	Bathydraconidae	Notothenioidei	Actinopteri	NO
Bathydraco joannae	Bathydraconidae	Notothenioidei	Actinopteri	NO
Bathydraco macrolepis	Bathydraconidae	Notothenioidei	Actinopteri	NO
Bathydraco marri	Bathydraconidae	Notothenioidei	Actinopteri	NO
Bathydraco scotiae	Bathydraconidae	Notothenioidei	Actinopteri	NO
Bathylagus antarcticus	Bathydraconidae	Notothenioidei	Actinopteri	NO
Bathylagus gracilis	Bathydraconidae	Notothenioidei	Actinopteri	NO
Bathylagus tenuis	Bathydraconidae	Notothenioidei	Actinopteri	NO
Bathyraja eatonii	Arhynchobatidae	Rajiformes	Elasmobranchii	GENBANK
Bathyraja irrasa	Arhynchobatidae	Rajiformes	Elasmobranchii	NO
Bathyraja maccaini	Arhynchobatidae	Rajiformes	Elasmobranchii	NO
Bathyraja meridionalis	Arhynchobatidae	Rajiformes	Elasmobranchii	NO
Bathyraja murrayi	Arhynchobatidae	Rajiformes	Elasmobranchii	NO
Benthalbella elongata	Scopelarchidae	Aulopiformes	Actinopteri	NO
Benthalbella macropinna	Scopelarchidae	Aulopiformes	Actinopteri	NO
Borostomias antarcticus	Stomiidae	Stomiiformes	Actinopteri	NO

# Marine mammal “molecular bycatch”

*Arctocephalus gazella*



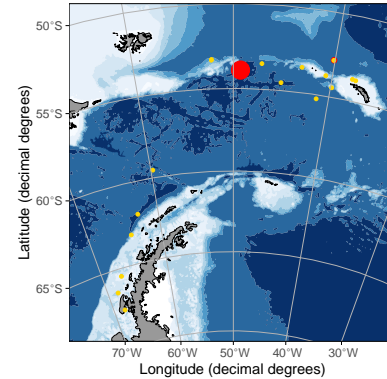
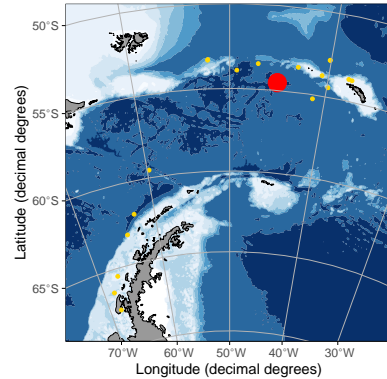
*Balaenoptera physalus*



*Balaenoptera bonaerensis*



*Hyperoodon sp.*



*Eubalaena australis*



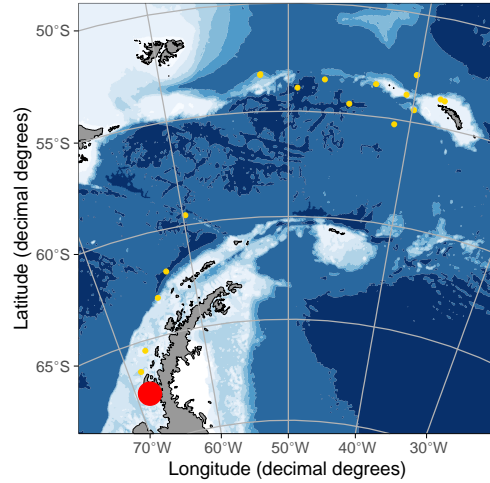
*Lagenorhynchus sp.*



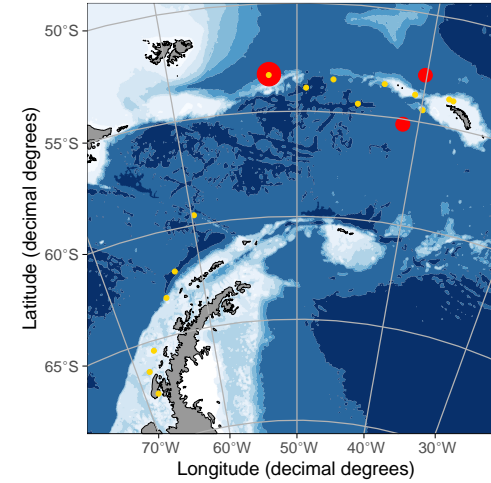
Most pictures are supplied by BSA. Some are downloaded from open resources, pasted without editing.

# Marine mammal “molecular bycatch”

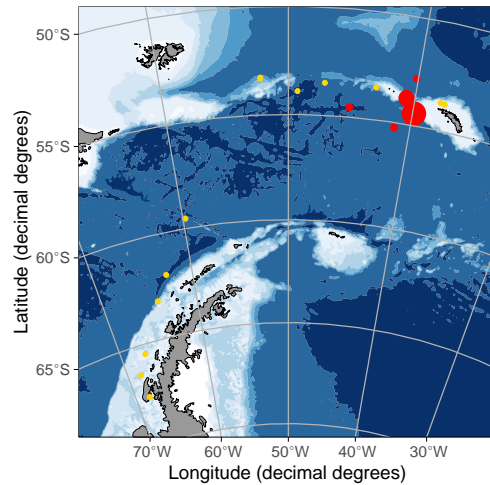
*Leptonychotes weddellii*



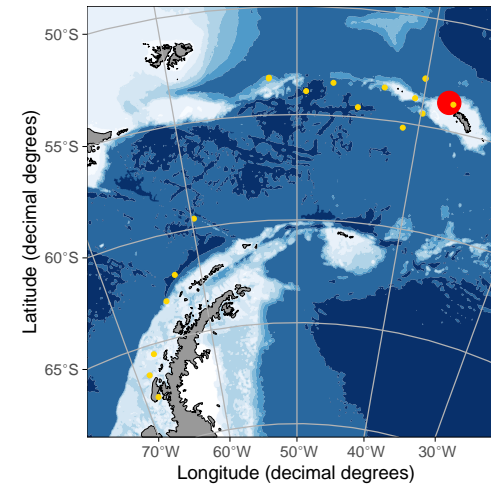
*Lobodon carcinophaga*



*Megaptera novaeangliae*



*Mirounga leonina*



# Concluding remarks

- This study has demonstrated the ability of eDNA to detect the mesopelagic fish diversity across space and provide insight into the geographic distribution of mammals.
- The whole sampling and experimental strategy should be improved, such as, avoiding ichthyoplankton, increasing water volume, sequencing depth and etc.
- Moreover, it seems likely that with primers that specifically target marine mammals a greater coverage of their diversity could be achieved.
- A comprehensive reference libraries of target eDNA sequences will benefit considerably. This needs to be a priority if the potential of eDNA-based methods for monitoring and management of vertebrate species in the Southern Ocean is to be realized.

# Acknowledgement

Thanks to: all my co-authors and crews in JR16003!



Scholarship

Funding & collaboration:



Natural Environment Research Council



**Thank you for your time and attention!!**

I am marine biologist + an *elasmobranchii* enthusiast, interested in marine conservation, eDNA and population genetics.

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Twitter: @Zifang04



# Sampling

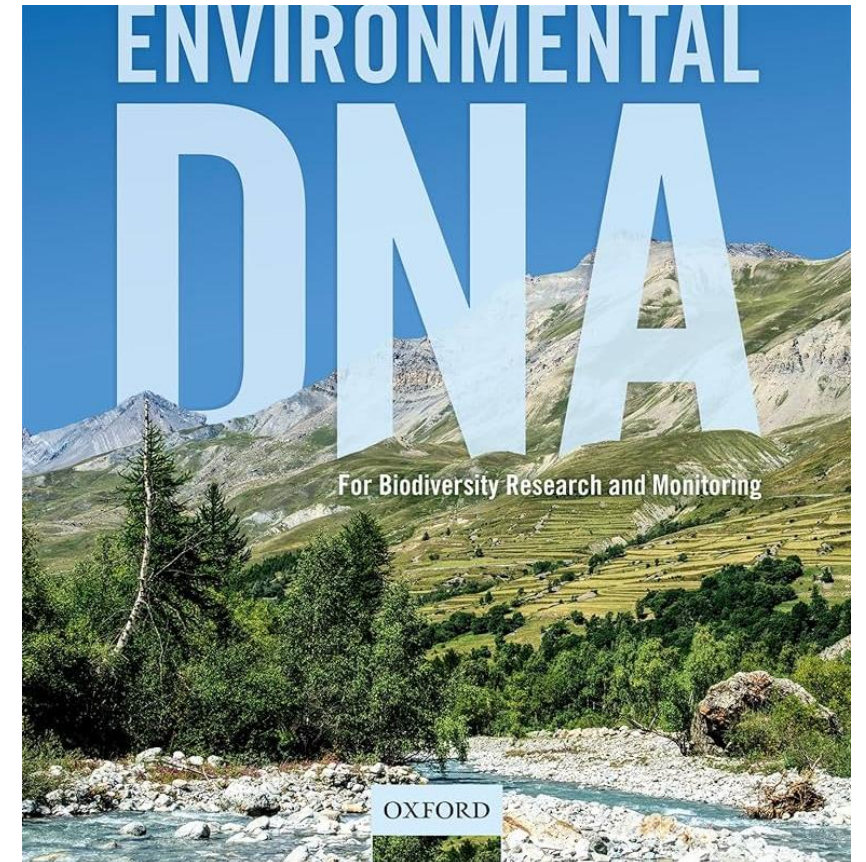


CTD bottles +  
Sterivex: 0.22 $\mu$ m for microbials  
0.45 $\mu$ m for vertebrates  
Peristaltic pump



# Experiments

- Primer: tele02: AA<sup>A</sup>ACTCGTGCCAGCCACC;  
GGGTATCTAATCCCAGTTTG
- Tag: 2-4N+6ATCG, minimize annealing temperature difference
- Library preparation: T-A tailing
- Illumina Miseq Sequencing Reagent Kit v2



# Bioinformatics and downstream analysis

- reference library: crabs + rfishbase
- demultiplexing : cutadapter + Vsearch
- denoise: DADA2
- merge+ dereplicating: vsearch
- taxonomy assignment: blast+ vsearch
- hellinger (vegan)
- Bray-cuirts (vegan)
- Functional diversity (fundiversity)

# Database

```

>5247e150d14abf351bf2742199b812f4;size=101789
GCGGTCATACGAGTGAGCCCAGCGGATAATCAGCGGCGTAAAGAGTGGTTAGGGACCCCGCGACTAAAGCTAAACGCCCGCAGAGCCGTTATACGCATC
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```

ydou & Lipp, 2018).

select all 9 sequences selected

[GenBank](#)   [Graphics](#)   [Distance tree of results](#)   [MSA Viewer](#)

	Description	Scientific Name	Max Score	Total Score	Query Cover	E value	Per. Ident	Acc. Len	Accession
<input checked="" type="checkbox"/>	<a href="#">Electrona antarctica mitochondrial DNA, almost complete genome</a>	<a href="#">Electrona antarct...</a>	291	291	100%	3e-74	98.19%	18228	<a href="#">AP012248.1</a>
<input checked="" type="checkbox"/>	<a href="#">Gymnoscopelus braueri ZMUC:Fisk:P-8388 mitochondrial gene for 12S rRNA, partial sequence</a>	<a href="#">Gymnoscopelus ...</a>	291	291	100%	3e-74	98.19%	174	<a href="#">LC579035.1</a>
<input checked="" type="checkbox"/>	<a href="#">Electrona antarctica ZMUC:Fisk:P-7552 mitochondrial gene for 12S rRNA, partial sequence</a>	<a href="#">Electrona antarct...</a>	291	291	100%	3e-74	98.19%	174	<a href="#">LC579029.1</a>
<input type="checkbox"/>	<a href="#">Gymnoscopelus nicholsi mitochondrial DNA, almost complete genome</a>	<a href="#">Gymnoscopelus ...</a>	259	259	98%	1e-64	95.12%	15718	<a href="#">AP012250.1</a>
<input type="checkbox"/>	<a href="#">Gymnoscopelus nicholsi ZMUC:Fisk:P-7806 mitochondrial gene for 12S rRNA, partial sequence</a>	<a href="#">Gymnoscopelus ...</a>	259	259	98%	1e-64	95.12%	174	<a href="#">LC579037.1</a>

# The reason...

## Gymnoscopelus braueri ZMUC:Fisk:P-8388 mitochondrial gene partial sequence

GenBank: [LC579035.1](#)

[FASTA](#) [Graphics](#)

[Go to:](#)

LOCUS LC579035 174 bp DNA linear VRT 23-OCT-2020  
DEFINITION Gymnoscopelus braueri ZMUC:Fisk:P-8388 mitochondrial gene for 12S rRNA, partial sequence.  
ACCESSION LC579035  
VERSION LC579035.1  
KEYWORDS .  
SOURCE mitochondrion Gymnoscopelus braueri  
ORGANISM [Gymnoscopelus braueri](#)  
Eukaryota; Metazoa; Chordata; Craniata; Vertebrata; Euteleostomi; Actinopterygii; Neopterygii; Teleostei; Neoteleostei; Myctophata; Myctophiformes; Myctophidae; Gymnoscopelus.  
REFERENCE 1  
AUTHORS [Miya, M.](#), Sado, T. and Fukuchi, T.  
TITLE Reference data for MiFish metabarcoding analysis  
JOURNAL Unpublished  
REFERENCE 2 (bases 1 to 174)  
AUTHORS Miya, M., Sado, T. and Fukuchi, T.  
TITLE Direct Submission  
JOURNAL Submitted (31-AUG-2020) Contact: Masaki Miya Natural History Museum & Institute, Chiba, Department of Zoology; 955-2 Aoba-cho, Chuo-ku, Chiba, Chiba 260-8682, Japan  
COMMENT Reference data for MiFish metabarcoding analysis.



# The reason...

## Electrona antarctica mitochondrial DNA, almost complete g

GenBank: AP012248.1

[FASTA](#) [Graphics](#)

Go to:

LOCUS AP012248 18228 bp DNA circular VRT 26-OCT-2018  
DEFINITION Electrona antarctica mitochondrial DNA, almost complete genome.  
ACCESSION AP012248  
VERSION AP012248.1  
KEYWORDS .  
SOURCE mitochondrion Electrona antarctica  
ORGANISM [Electrona antarctica](#)  
Eukaryota; Metazoa; Chordata; Craniata; Vertebrata; Euteleostomi;  
Actinopterygii; Neopterygii; Teleostei; Neoteleostei; Myctophata;  
Myctophiformes; Myctophidae; Electrona.  
REFERENCE 1  
AUTHORS Poulsen,J.Y., Byrkjedal,I., Willassen,E., Rees,D., Takeshima,H.,  
Satoh,T.P., Shinohara,G., Nishida,M. and Miya,M.  
TITLE Mitogenomic sequences and evidence from unique gene rearrangements  
corroborate evolutionary relationships of myctophiformes  
(Neoteleostei)  
JOURNAL BMC Evol. Biol. 13, 111 (2013)  
PUBMED [23731841](#)  
REMARK Publication Status: Online-Only  
REFERENCE 2 (bases 1 to 18228)  
AUTHORS Poulsen,J.Y.  
TITLE Direct Submission  
JOURNAL Submitted (22-JUL-2011) Contact:Jan Yde Poulsen Greenland Institute of  
Natural Resources, Department of Fish and Shellfish; Kivioq 2,  
PB 570, 3900 Nuuk 3900, Greenland  
FEATURES



## Spatial patterns of species recorded in surface reads

- We found no clear association between community composition between the more northeasterly sites (north of 55°S and east of 58°W) and the southeasterly sites (south of 52°S and west of 58°W) in the vicinity of the Antarctic Peninsula (Permanova F1,40 = 1.371, P = 0.226).

