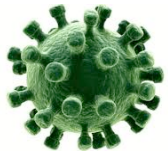
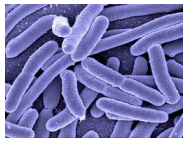
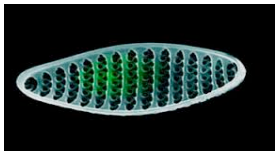
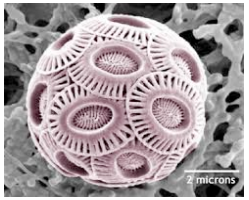
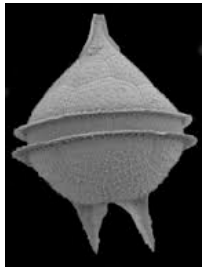
Environmental DNA as a novel approach for studying marine ecosystems in Faroese waters









Ian Salter, Havstovan

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FAROE MARINE RESEARCH INSTITUTE

What is environmental DNA?

Environmental Forensics

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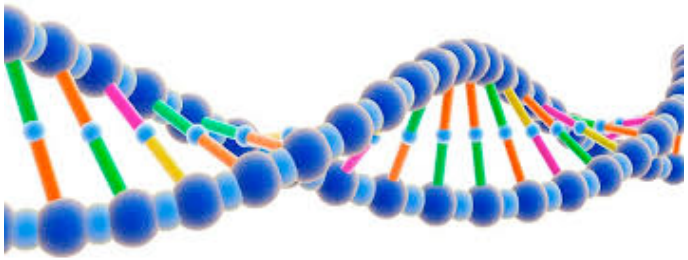
What is environmental DNA?

Criminal Forensics



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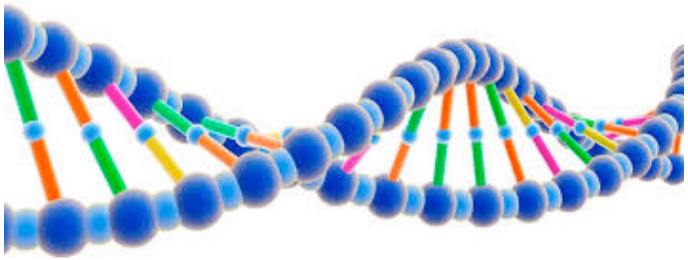

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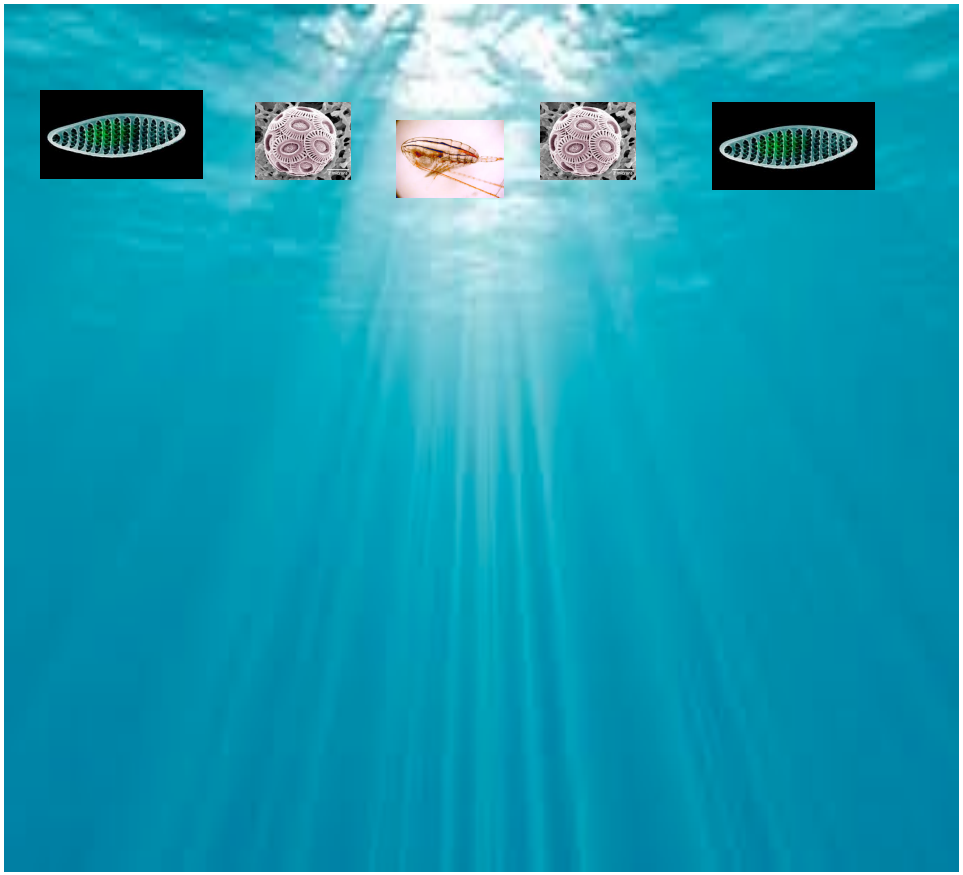

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What is environmental DNA?

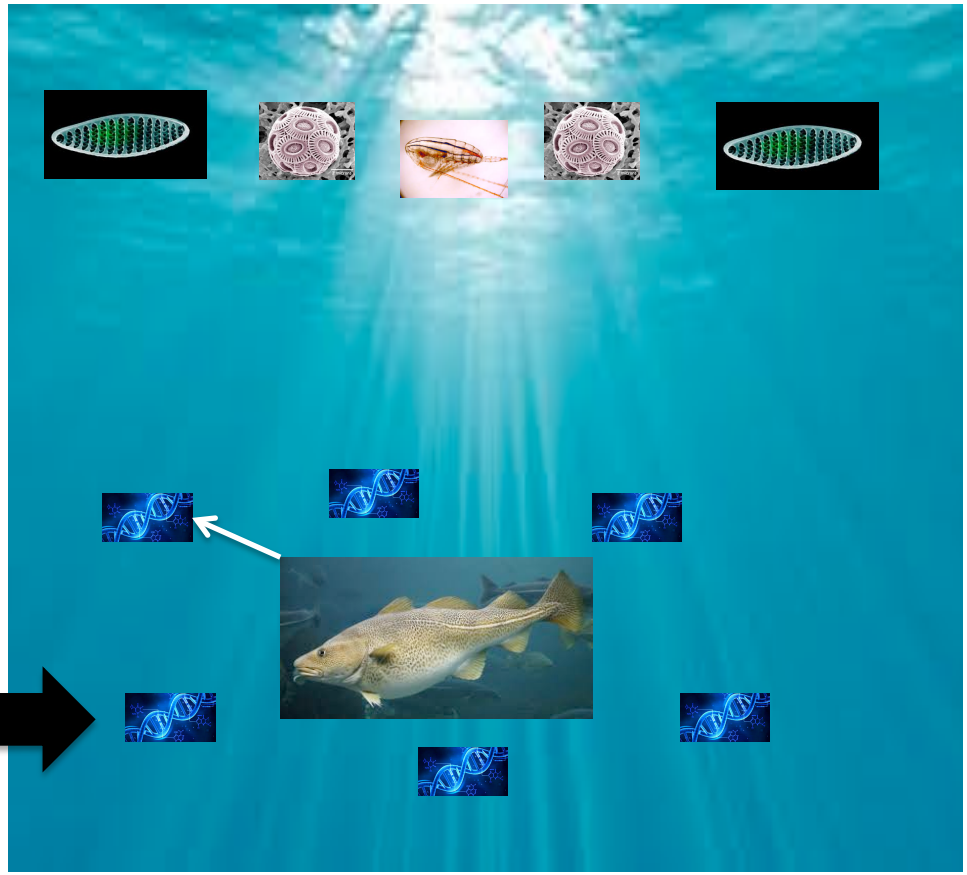
Skin cells and mucous,

sperm, eggs, secretions,

faeces, urine, blood

etc..

Environmental Forensics



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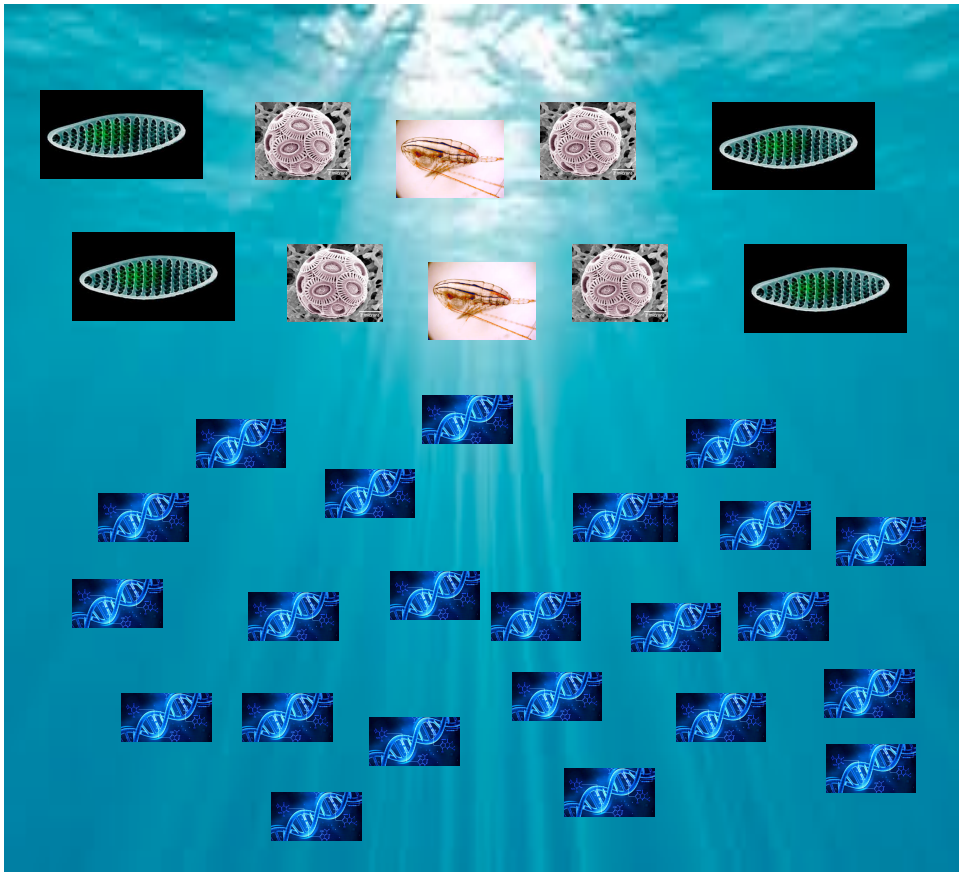
What is environmental DNA?

Every litre of seawater is like a "DNA-soup"

Environmental Forensics



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How can we use environmental DNA?

How can we use this "soup" of environmental DNA in seawater to learn something about ocean ecosystems?

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How can we use environmental DNA?

We can use DNA molecules to describe species inventories

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Uses short sequences of DNA from genes present in all animals, but different depending on the species – fingerprint

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MIKLAGARÐUR

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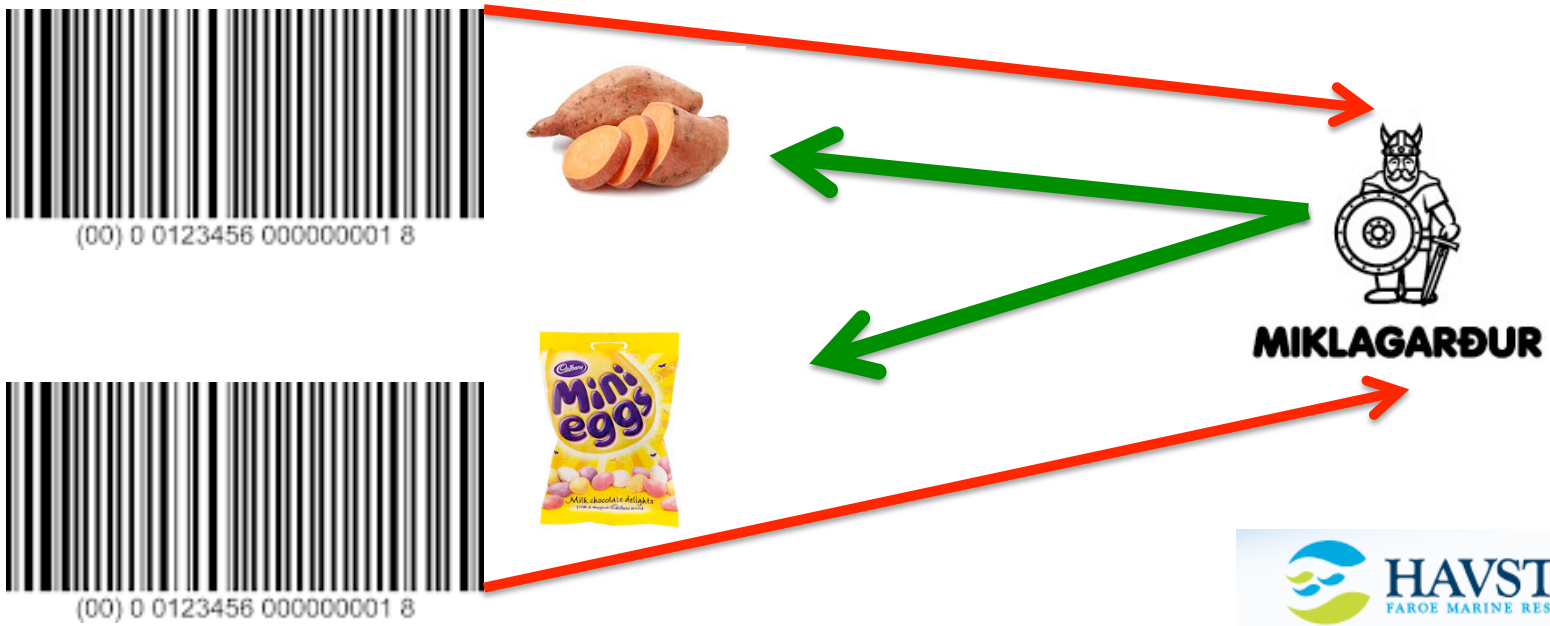

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Metabarcoding

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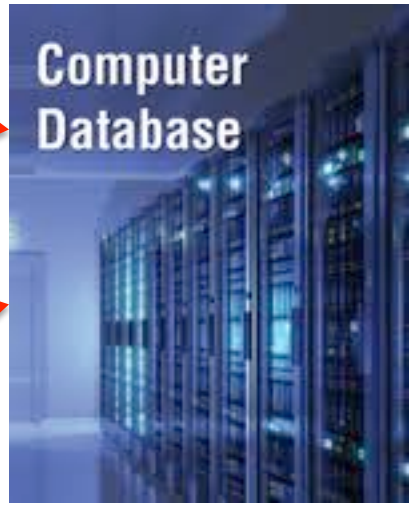

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How can we use environmental DNA?

BOLDSYSTEMS DATABASES IDENTIFICATION TAXONOMY WORKBENCH RESOURCES LOGIN

TAXONOMY

Kingdoms of Life Being Barcoded

SEARCH TAXONOMY

7,826,119	5,803,721	268,055
Specimen Records	Specimens with Barcodes	Species with Barcodes

Animals:

- Acanthocephala [588]
- Annelida [58603]
- Arthropoda [6282571]
- Brachiopoda [226]
- Bryozoa [2776]
- Chaetognatha [589]
- Chordata [551571]
- Cnidaria [18451]
- Cycliophora [326]
- Echinodermata [40678]
- Gnathostomulida [18]
- Hemichordata [163]
- Mollusca [139953]
- Nematoda [14173]
- Nemertea [2178]
- Onychophora [690]
- Platyhelminthes [16723]
- Porifera [3840]
- Priapulida [44]
- Rotifera [9743]
- Sipuncula [757]
- Tardigrada [1985]
- Xenoturbellida [7]

Plants:

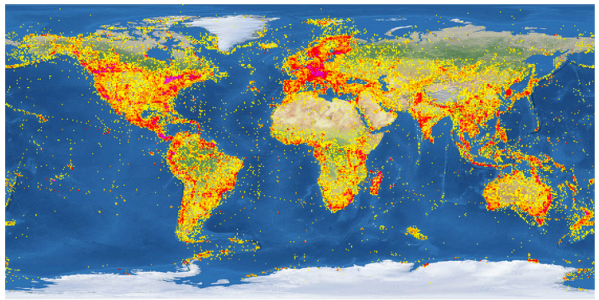
- Bryophyta [11214]
- Chlorophyta [14677]
- Lycopodiophyta [1129]
- Magnoliophyta [338188]
- Pinophyta [6870]
- Pteridophyta [10475]
- Rhodophyta [49214]

Fungi:

- Ascomycota [83592]
- Basidiomycota [54951]
- Chytridiomycota [277]
- Glomeromycota [3516]
- Myxomycota [226]
- Zygomycota [3137]

Protists:

- Chlorarachniophyta [67]
- Ciliophora [706]
- Heterokontophyta [6195]
- Pyrrophycophyta [2281]



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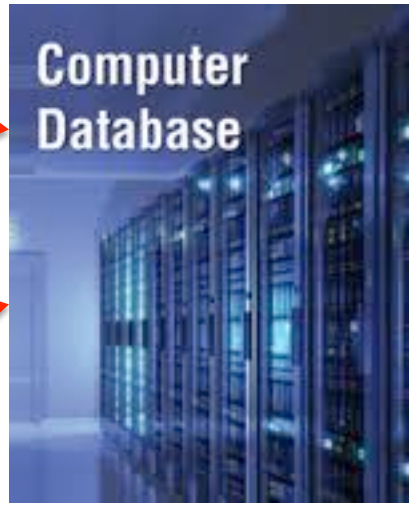

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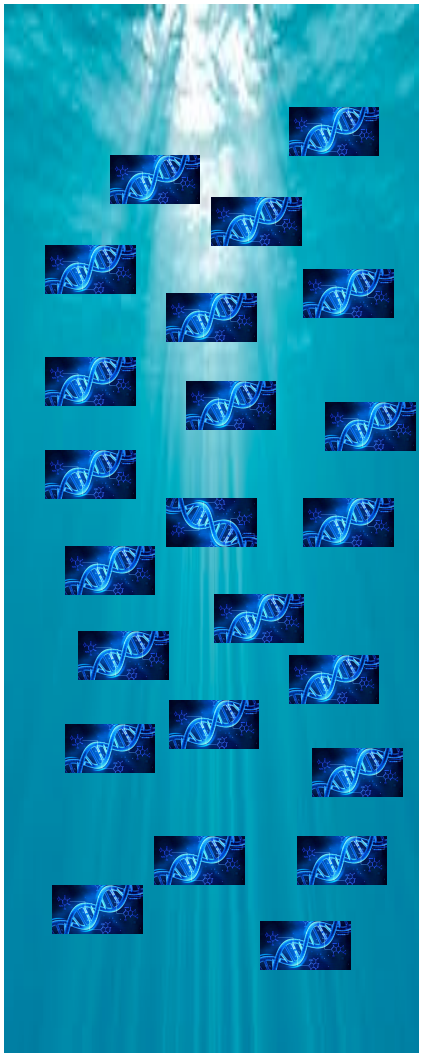
How can we use environmental DNA?

DNA soup



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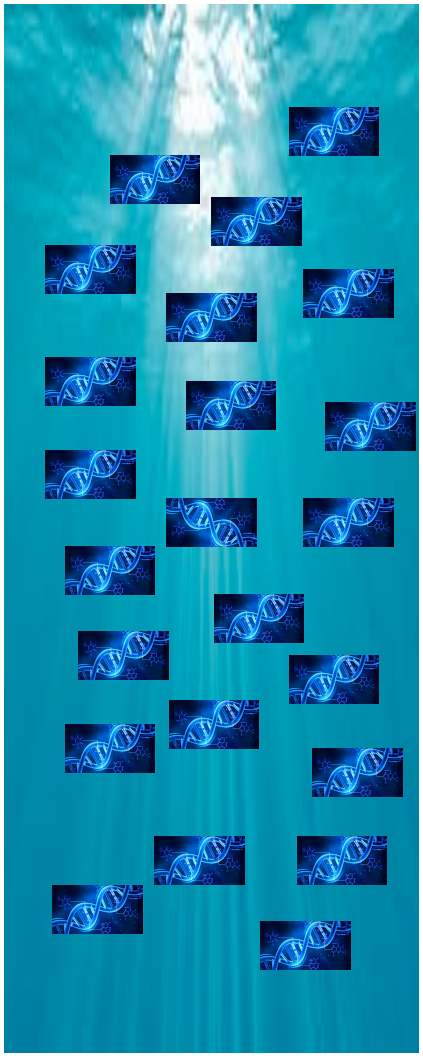
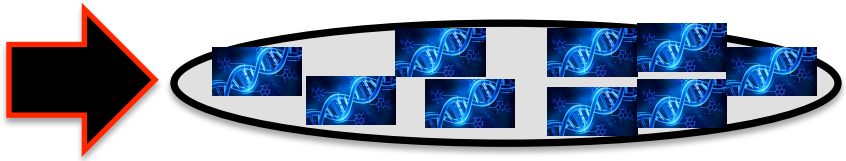


Collect and extract DNA



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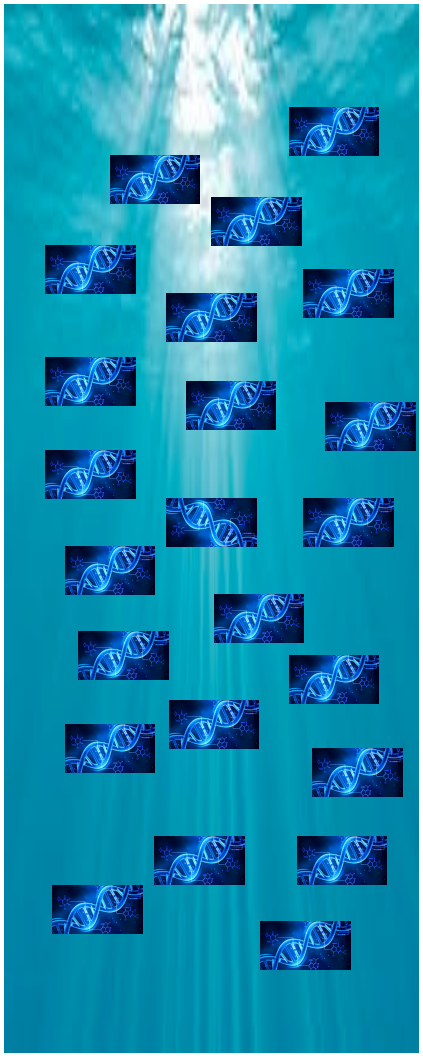

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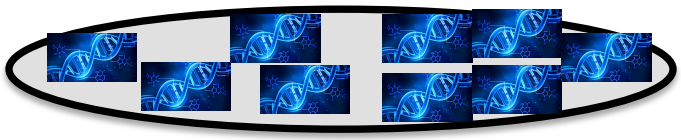

DNA sequencer

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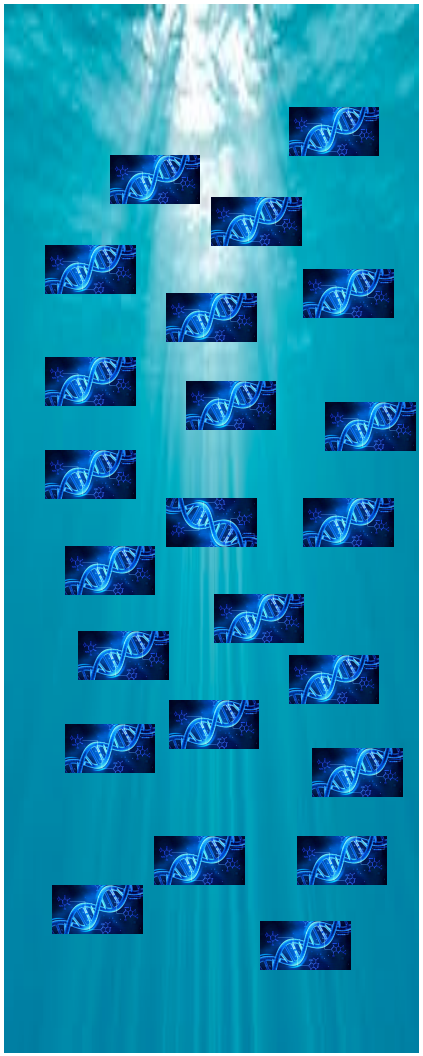

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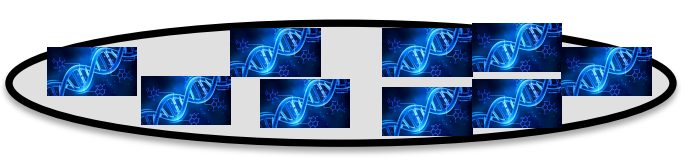
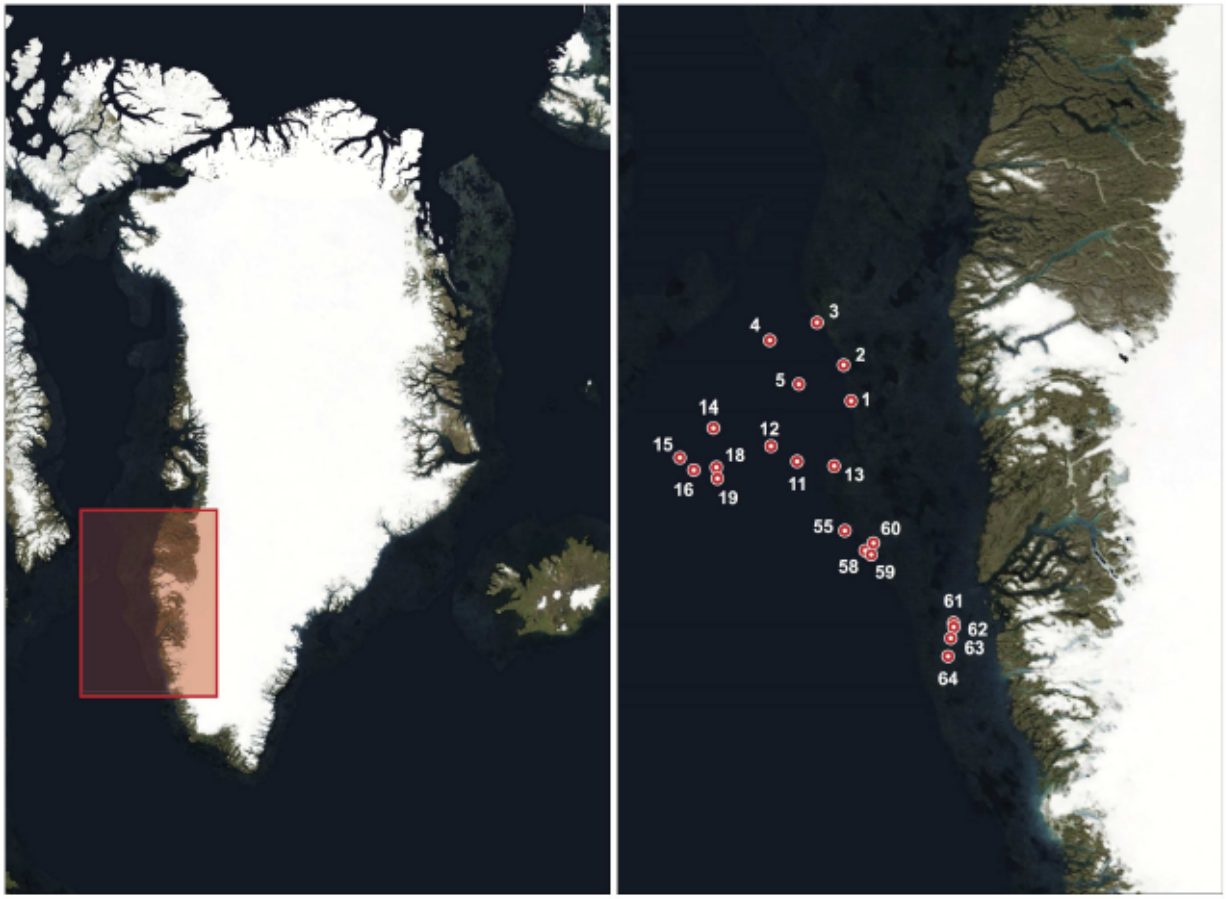


DNA sequencer

Species inventory

Passive Monitoring of bottom fish communities

How well does eDNA monitoring perform in reality?



Bottom trawl samples

Thomsen et al. 2016 PLoSONE

eDNA Monitoring of bottom fish communities

How well does eDNA monitoring perform in reality?

2 litre

Thomsen et al. 2016 PLoSONE

1 hour bottom trawl

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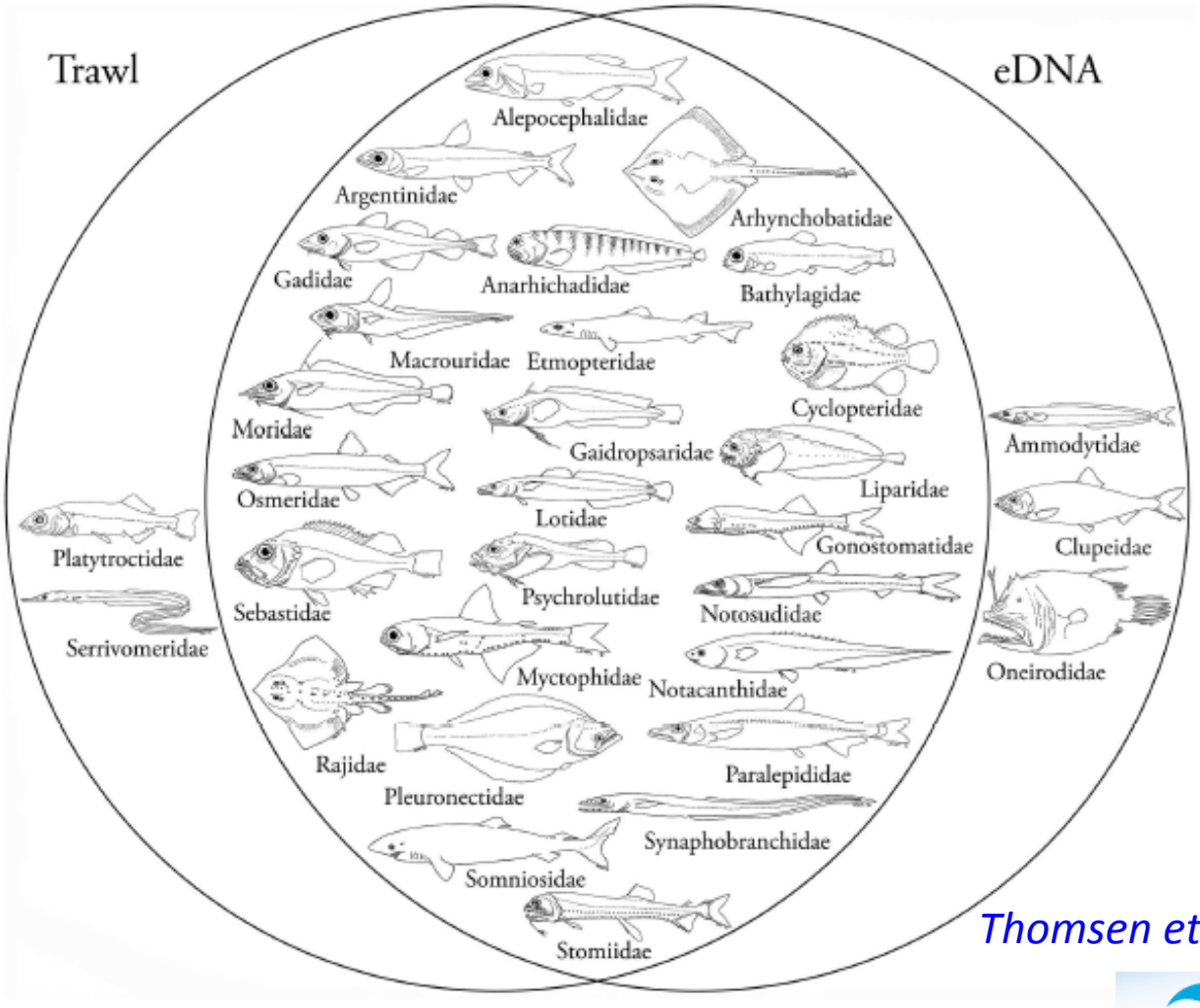
eDNA Monitoring of bottom fish communities



Thomsen et al. 2016 PLoSONE

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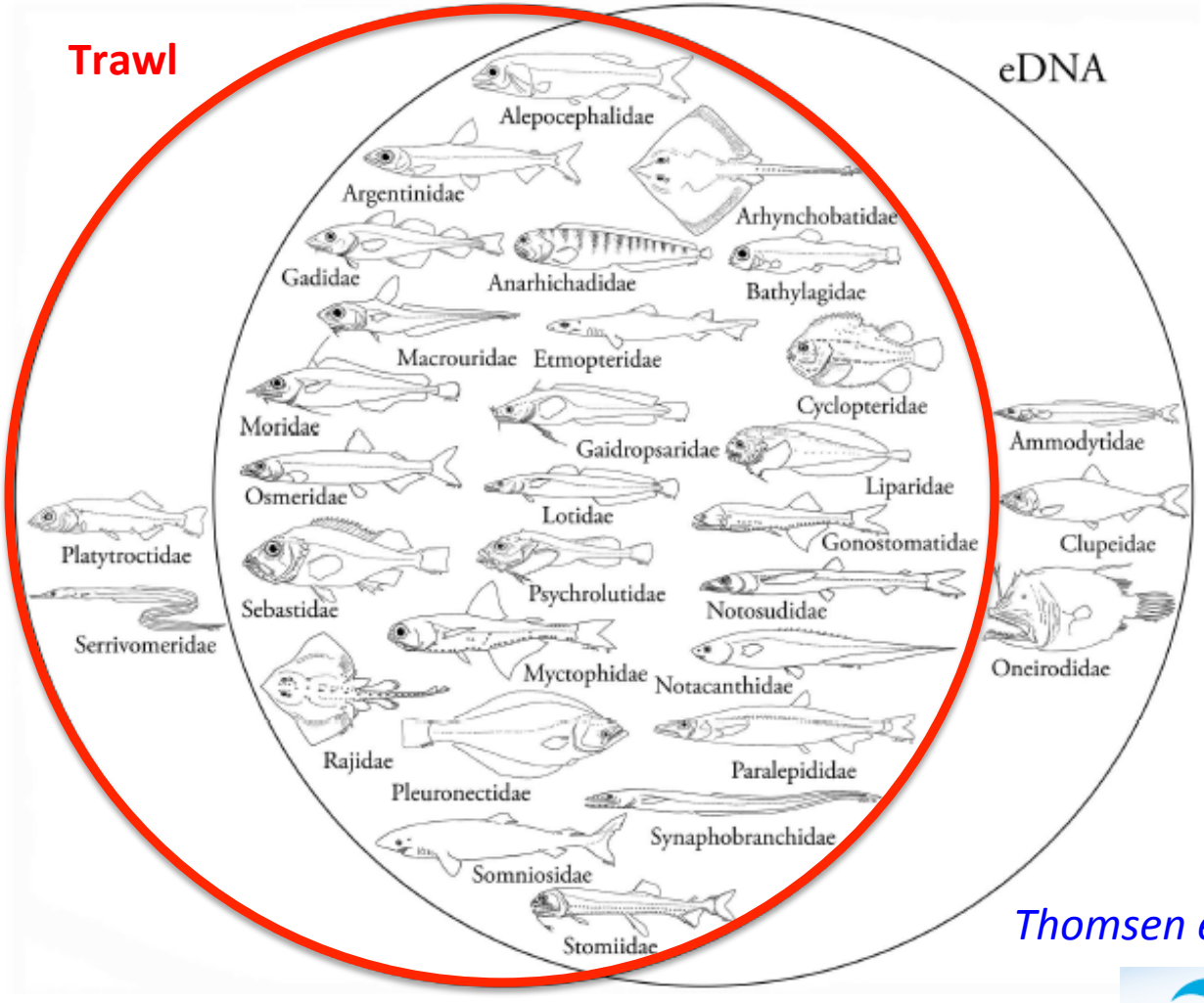

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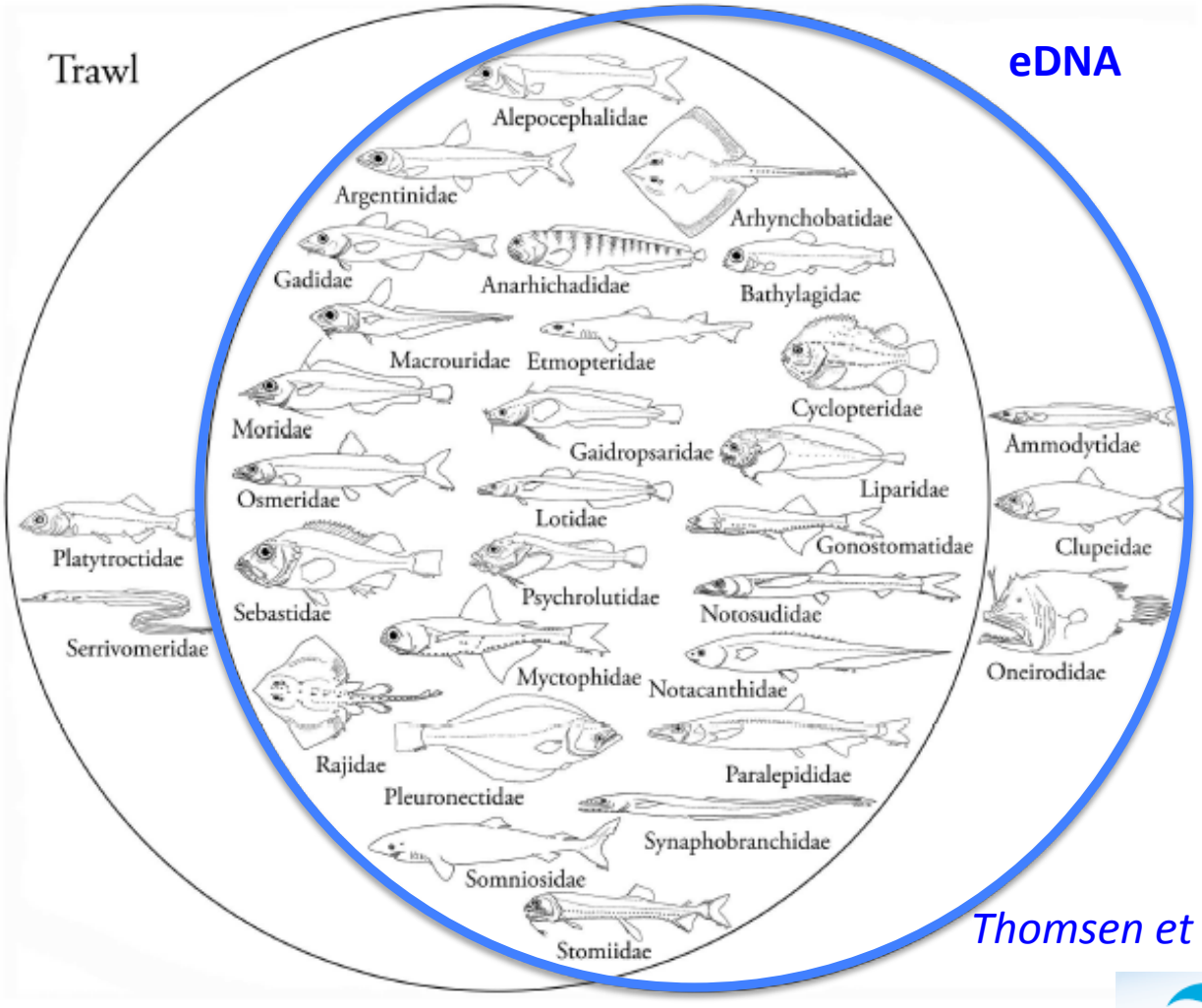

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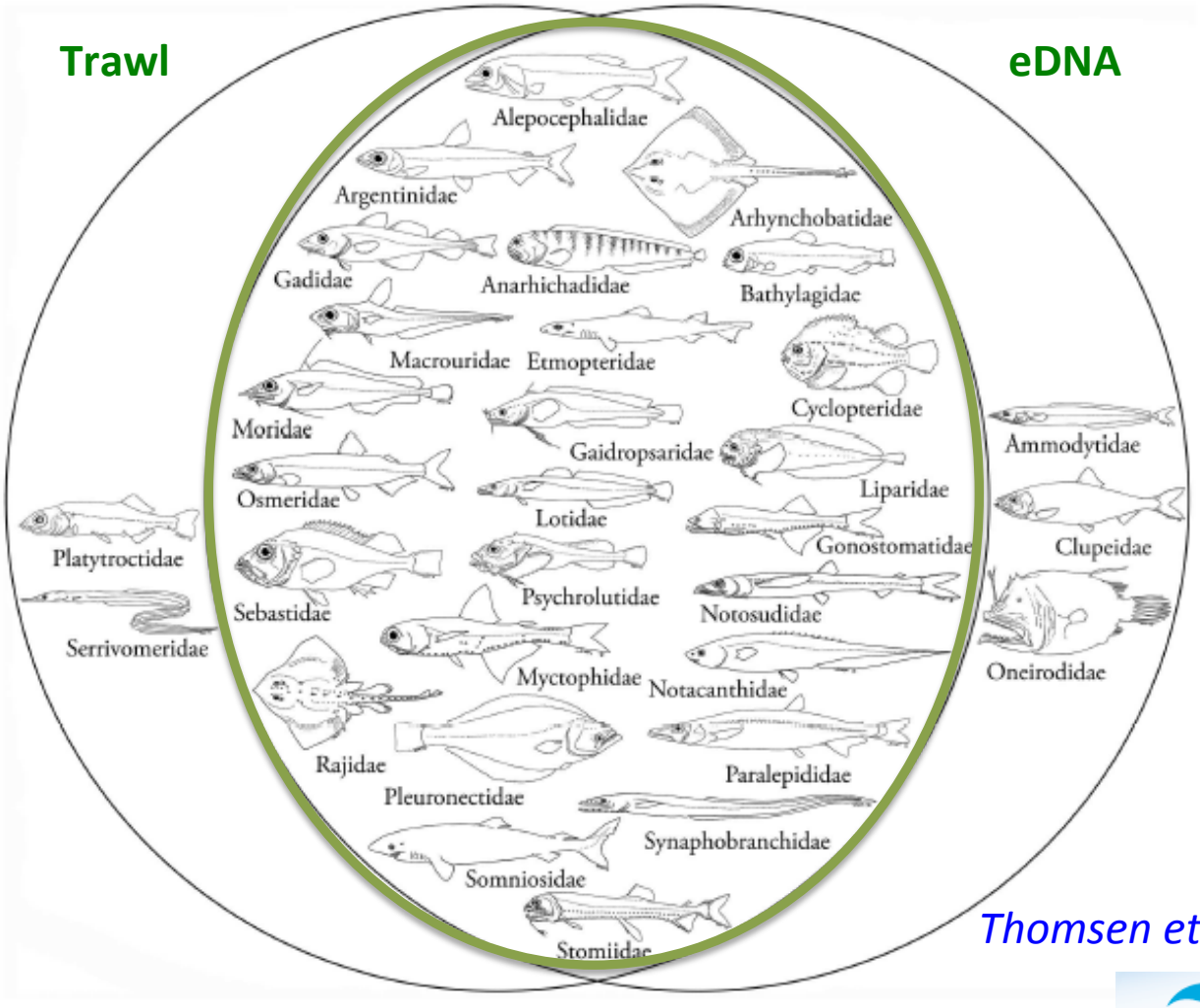

26 of 28

>93% Detection rate

Thomsen et al. 2016 PLoSONE

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eDNA Monitoring of bottom fish communities

eDNA monitoring works very well for describing presence of different species

Incredibly useful for invasive species monitoring, pathogens, species distribution modeling etc.

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How about as a quantitative approach?

Does the concentration of cod DNA in seawater reflect the biomass of cod in a given location?

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eDNA monitoring of bottom fish communities

COD-e-DNA (Fisheries Ministry)
October 2017 - October 2019

Relationship between cod biomass and cod DNA copies on the Faroese Bank

Compare cod biomass from trawls with cod DNA molecules in seawater samples

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eDNA monitoring of entire ecosystems

1-2 Litres Seawater

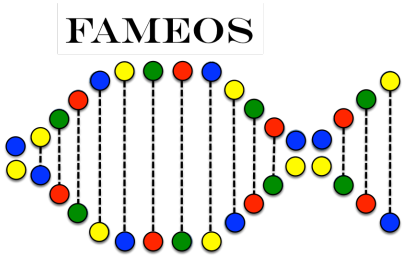
Marker Genes	Ecosystem dynamics
16S Ribosomal	Species distribution
18S Ribosomal	Biogeography
COI Mitochondria	Diversity
12S Mitochondria	Food-web structure
COI Mitochondria	Invasive species

eDNA monitoring of entire ecosystems

FAMEOS (Faroese Research Council)

January 2018 – December 2019

Faroese Marine Ecosystem Observing Study



Faroese Marine Ecosystem Observing Study

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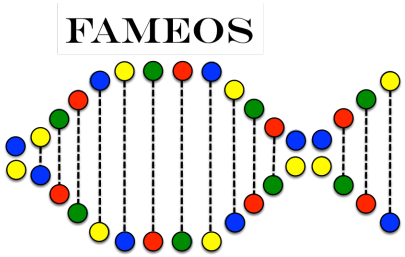

Faroese Marine Ecosystem Observing Study

Integrating environmental-DNA based estimates of diversity with essential ocean variables

eDNA monitoring of entire ecosystems

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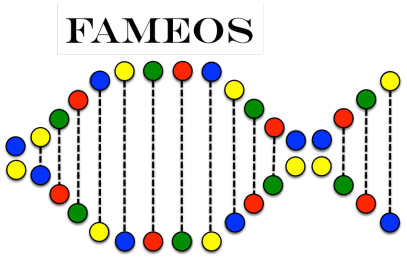


Faroese Marine Ecosystem Observing Study

Integrating environmental-DNA based estimates of diversity with essential ocean variables

Objectives

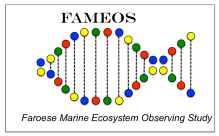
Time-series monitoring program of marine biodiversity and ecosystem dynamics in Faroese waters

Establish a robust baseline to understand the effects of climate variability and anthropogenic pressures

FAMEOS

Faroese Marine Ecosystem Observing Study

Ian Salter (ians@hav.fo) (Havstovan); Sólva Jacobsen (Havstovan); Durita Sørensen (Havstovan); Eilif Gaard (Havstovan); Katja Metfies (AWI, Germany); Halina Tegetmeyer (Uni. Bielefeld, Germany).



Rationale

The biology of the oceans is critical for our survival. It provides half of the oxygen we breathe, absorbs our CO_2 emissions and forms the basis of a marine food-web that provides 1/6th of the protein we consume globally. Natural and anthropogenic pressures are changing the physical and chemical properties of the oceans in a way that is likely to impact ecosystem structure. This is especially relevant in the Faroe Islands that has such a strong cultural and economic dependence on it's marine environment. It is now considered critical to develop observing systems that integrate physical, chemical and biological components to characterize baselines of marine ecosystem health. Sustained measurements of biodiversity within structured observation frameworks are currently lacking, limiting our capacity to report on changes in their status. FAMEOS aims to develop an observing system in Faroese waters that integrates DNA-based estimates of ecosystem structure and biodiversity with essential ocean variables.

Essential Ocean Variables

Essential Ocean Variables (EOVs) are observation parameters that are able to describe the changing physical and chemical state of our oceans

They are selected by panels of experts that represent supranational organizations such as UNESCO and UNEP and form part of a common Global Ocean Observing System (GOOS)

UNEP

UNESCO

The Global Ocean Observing System GOOS

Biodiversity

MBON Marine Biodiversity Observation Network

international BARCODE OF LIFE

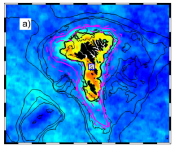
ipbes Science and Policy for People and Nature

Biodiversity underpins almost every aspect of human development. It helps produce food, clean water, regulates climate and controls disease transmission.

Biodiversity is being rapidly degraded.

Keeping track of and protecting our planets biodiversity is one of the United Nations Sustainable Development Goals (SDGs).

Phase 1 – Coastal Observations



Weekly monitoring at station Skopun (S)

Representative of shelf ecosystem due to strong tidal mixing

Image courtesy of Sólva Eliasen

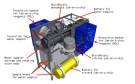
Samples will be collected for following parameters:

Existing parameters	New parameters
Temperature	^{13}C and ^{15}N
Salinity	$CaCO_3$ and SiO_2
Nutrients	Cytometry
Chlorophyll	Microbial DNA
Plankton	Macrobial DNA

Phase 2 - Technology Corner

FerryBox: Underway monitoring systems on ships of opportunity (RV Norrona)

FlowCam: Semi-automated image recognition systems for phytoplankton



Autonomous Samplers: Takes and preserves water samples for later analysis

Future Perspectives

FAMEOS will run for three years from January 2018 to December 2020. It is intended to form the basis for launching a sustained marine biodiversity observation program. Future initiatives will extend FAMEOS to include novel sampling platforms like ships of opportunity and autonomous sensor and sampler platforms.

granskingarráðið THE FAROESE RESEARCH COUNCIL

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RESEARCH PARK iNOVA

Thank you for your attention

granskingarráðið
THE FAROESE RESEARCH COUNCIL

Fiskimálaráðið

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- A new way to do science