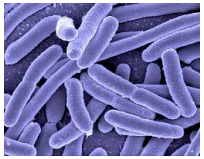
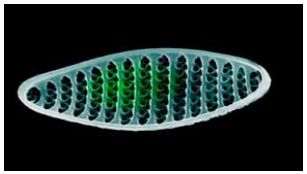
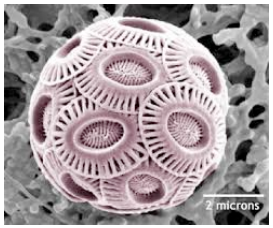
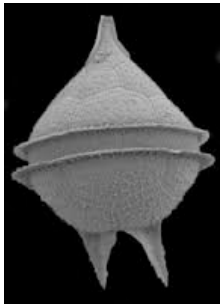
Novel approaches to understand changes in marine ecosystems









Dr. Ian Salter - Havstovan / iNOVA

granskingarráðið

Novel approaches to understand changes in marine ecosystems

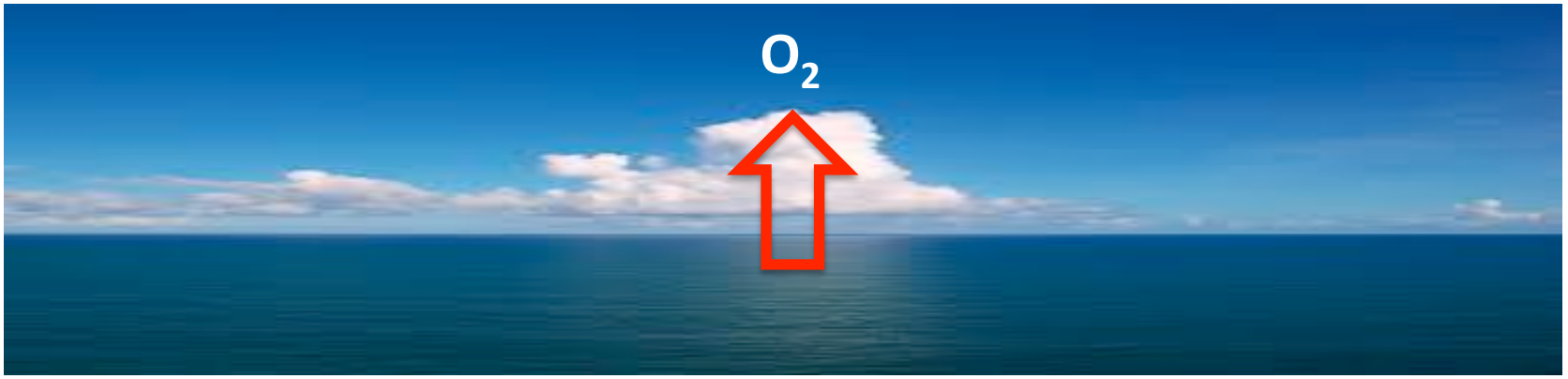
Bill Anders

Novel approaches to understand changes in marine ecosystems

Bill Anders

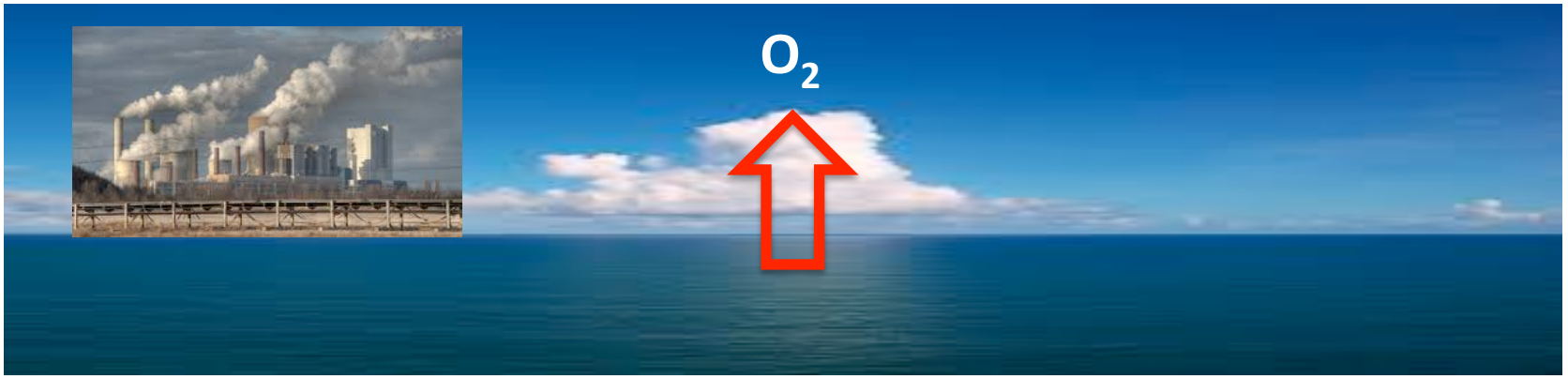
"How inappropriate to call this planet Earth when it is quite clearly Ocean" Arthur C. Clarke

Novel approaches to understand changes in marine ecosystems



Today, approximately 50% of global photosynthesis is carried out in the ocean

Novel approaches to understand changes in marine ecosystems



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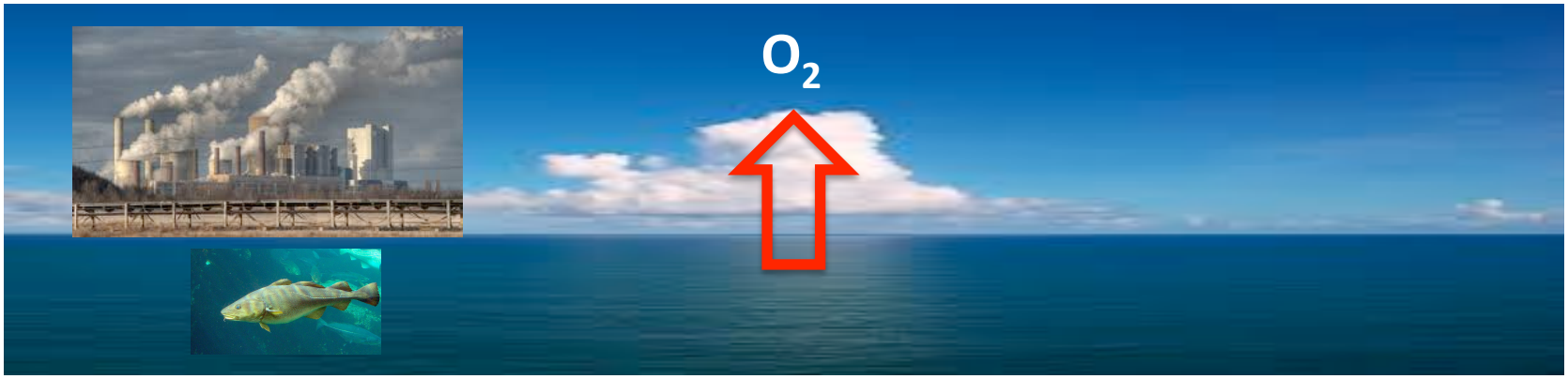

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170-200 Mio. tonnes of fish caught or farmed

$1/5^{th}$ of global protein consumption

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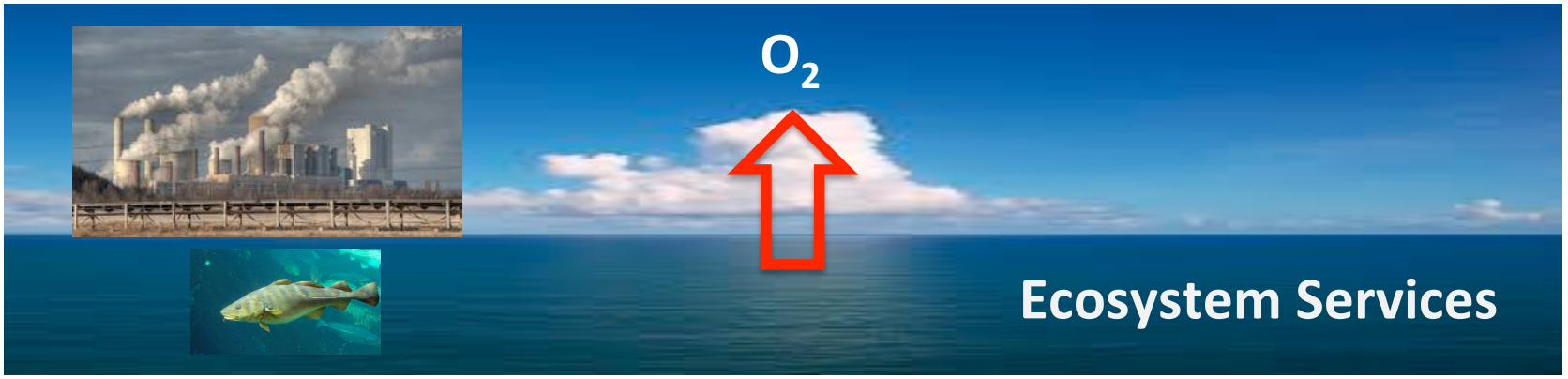

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As of 2014, 170 Mio tonnes of fish caught or farmed

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We know conditions in the oceans are changing rapidly:

Increases in temperature

Changes in nutrient concentrations

Increases in Ocean acidity

These will influence ocean ecosystems and the services they provide

How can we possibly study ocean ecosystems?

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Environmental DNA

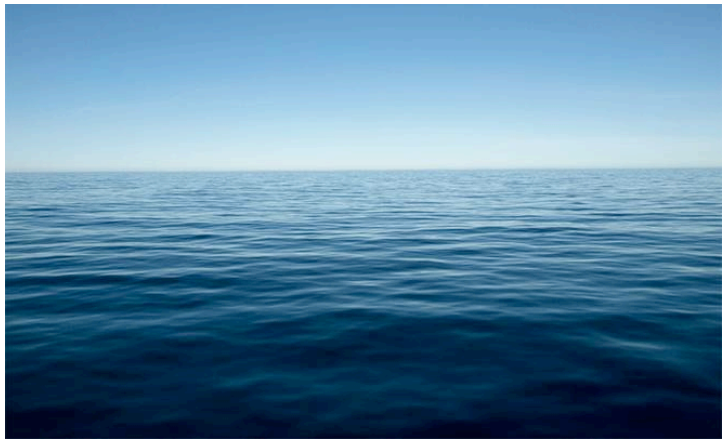
Novel approaches to understand changes in marine ecosystems

What is environmental DNA ?

All DNA that can be recovered from an environmental sample.

- Microscopic organisms isolated by filtration
- Free DNA molecules (physically separated from the organism)

Skin
Tissue
Mucuos
Saliva
Sperm
Secretions
Eggs
Urine
Faeces
Blood
Decomposing tissue



Environmental Forensics

What was where and
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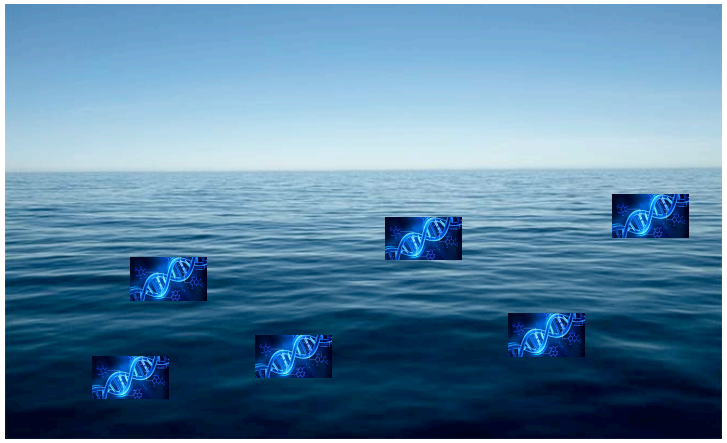

Environmental Forensics

What was where and at what time?

How can we use this Environmental DNA?

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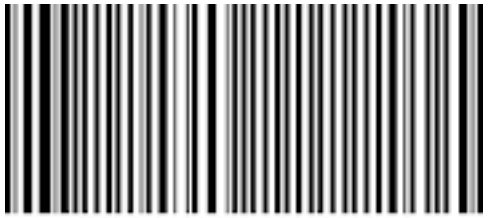
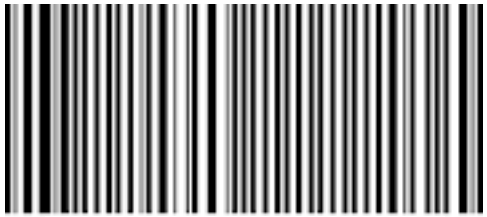
Metabarcoding

A way to identify species from the DNA encoded in their genes

Uses a very short DNA sequence from a standard part of the genome the same way a supermarket scanner uses the black lines of the UPC barcode to identify products





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Novel approaches to understand changes in marine ecosystems

Metabarcoding

Reference databases linking DNA barcodes to taxonomic assignments

BOLD SYSTEMS | Databases | Taxonomy | Identification | Workbench | Resources

Kingdoms of Life Being Barcoded

Print

Specimen Records : 7,053,018 | Specimens with Barcodes : 5,342,766 | Species with Barcodes : 263,132

Search Taxonomy

Animals:

- Acanthocephala [588]
- Annelida [55591]
- Arthropoda [5553106]
- Brachiopoda [200]
- Bryozoa [2668]
- Chaetognatha [589]
- Chordata [529777]
- Cnidaria [17981]
- Cycliophora [326]
- Echinodermata [39447]
- Gnathostomulida [18]
- Hemichordata [117]
- Mollusca [136884]
- Nematoda [14015]
- Nemertea [1914]
- Onychophora [690]
- Platyhelminthes [16367]
- Porifera [3760]
- Priapulida [43]
- Rotifera [9637]
- Sipuncula [657]
- Tardigrada [1949]
- Xenoturbellida [7]

Plants:

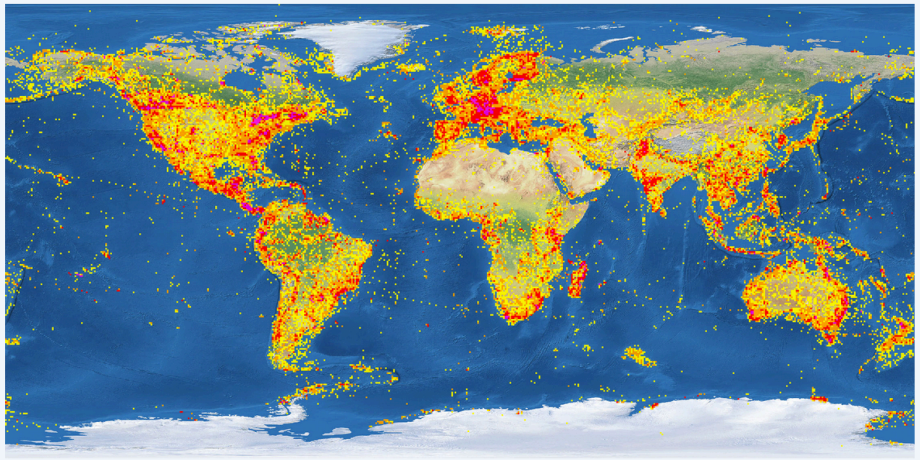
- Bryophyta [10896]
- Chlorophyta [12267]
- Lycopodiophyta [945]
- Magnoliophyta [333646]
- Pinophyta [6862]
- Pteridophyta [10429]
- Rhodophyta [47982]

Fungi:

- Ascomycota [83086]
- Basidiomycota [53726]
- Chytridiomycota [277]
- Glomeromycota [3523]
- Myxomycota [226]
- Zygomycota [3137]

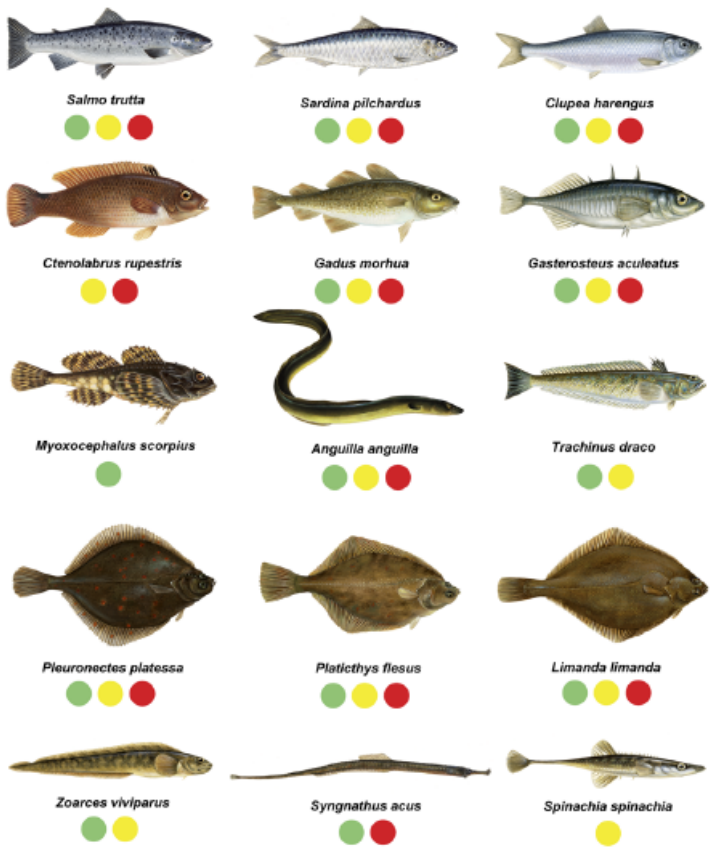
Protists:

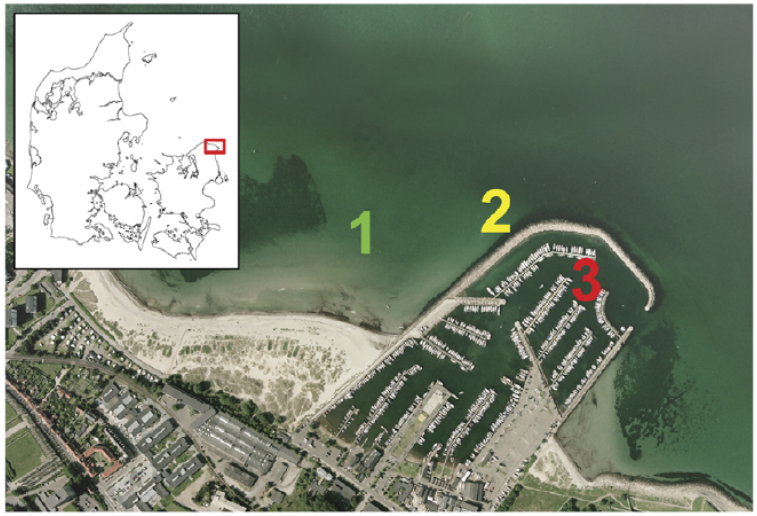
- Chlorarachniophyta [67]
- Ciliophora [706]
- Heterokontophyta [6195]
- Pyrrophycophyta [2282]



Novel approaches to understand changes in marine ecosystems

Some of the early demonstrations of this approach have been with marine fish



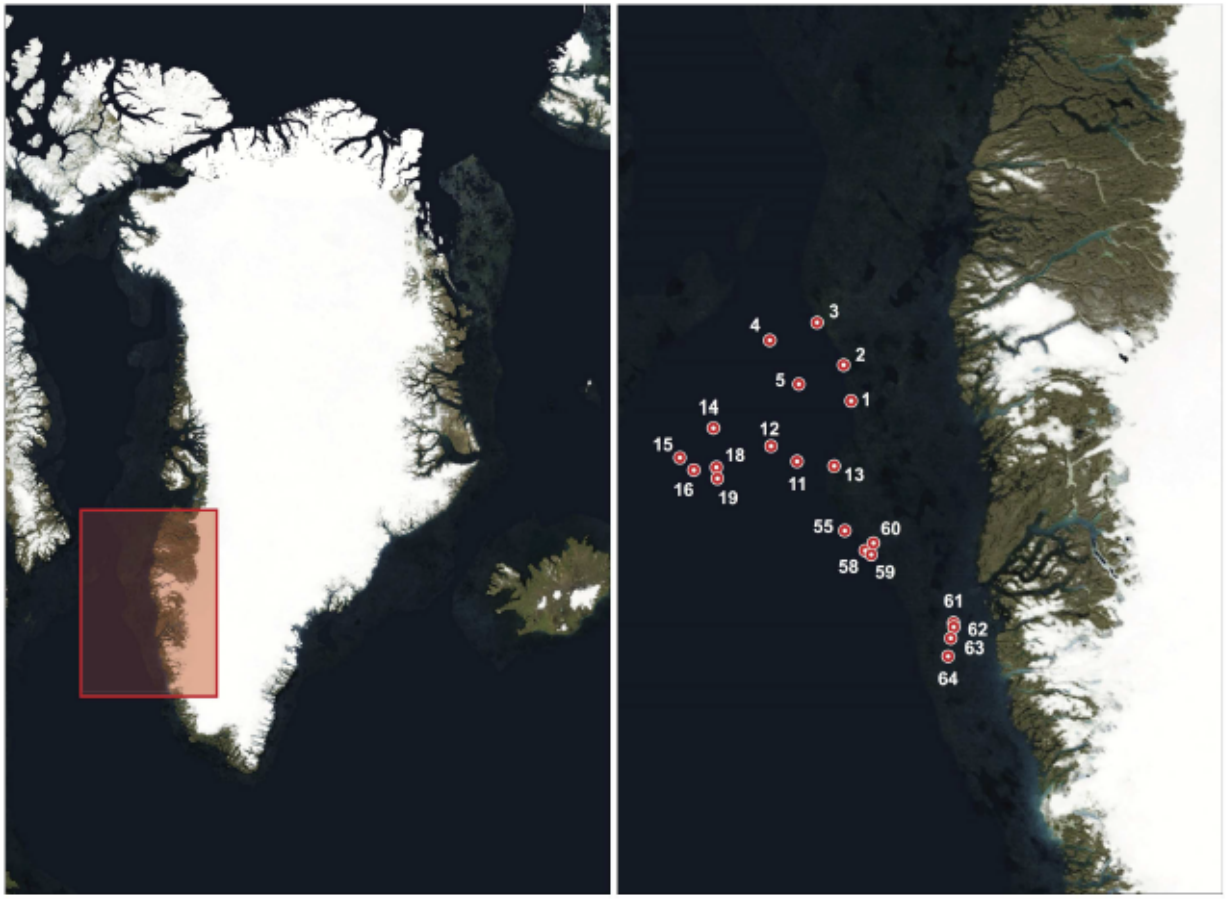


Detection of diverse marine fish fauna using eDNA in seawater

Thomson et al. 2012 PLoSONE

Novel approaches to understand changes in marine ecosystems

How does eDNA analysis perform in the field ?



1.5 litre water samples

Collected prior to Bottom-trawl

Thomsen et al. 2016 PLoSONE

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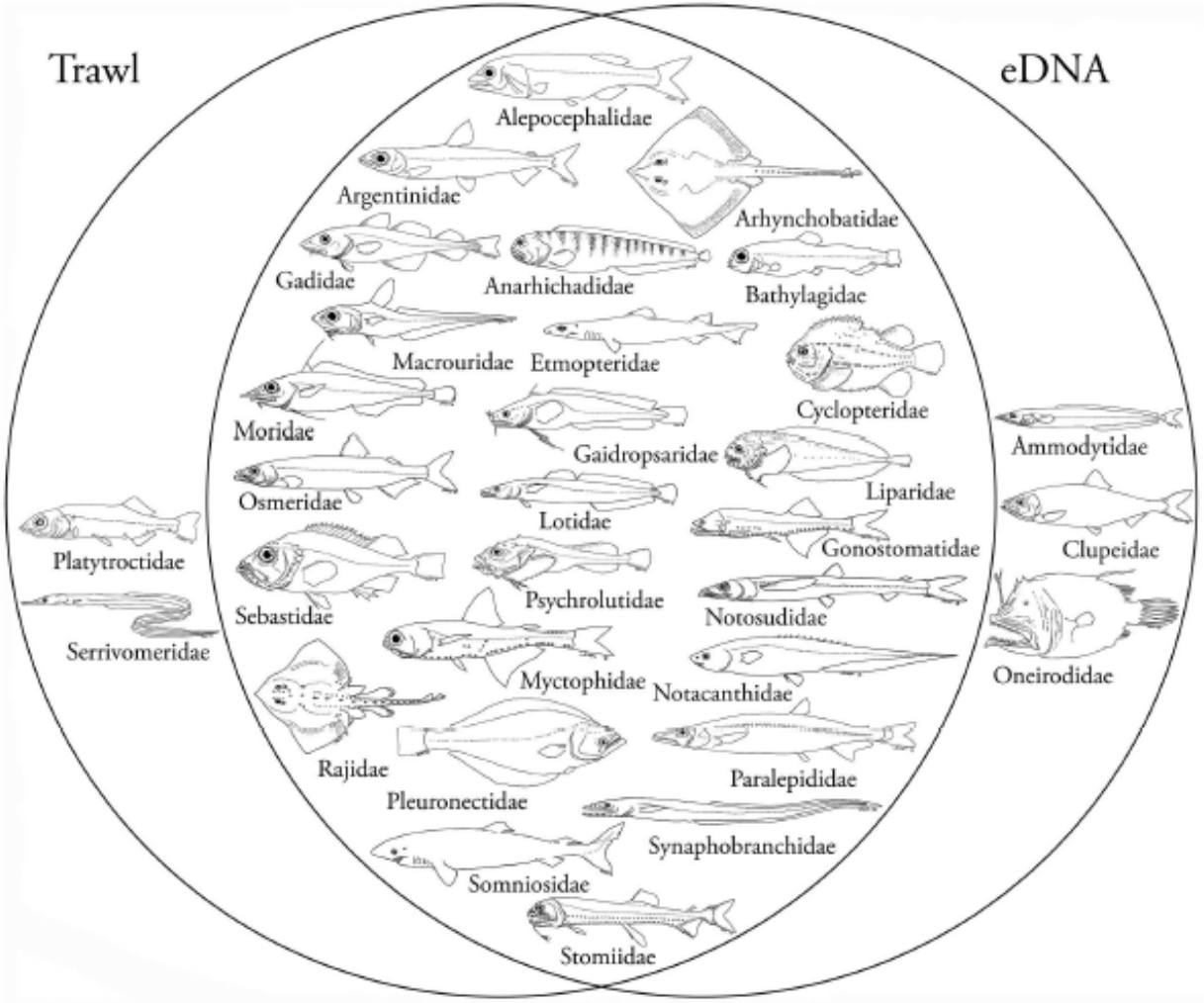

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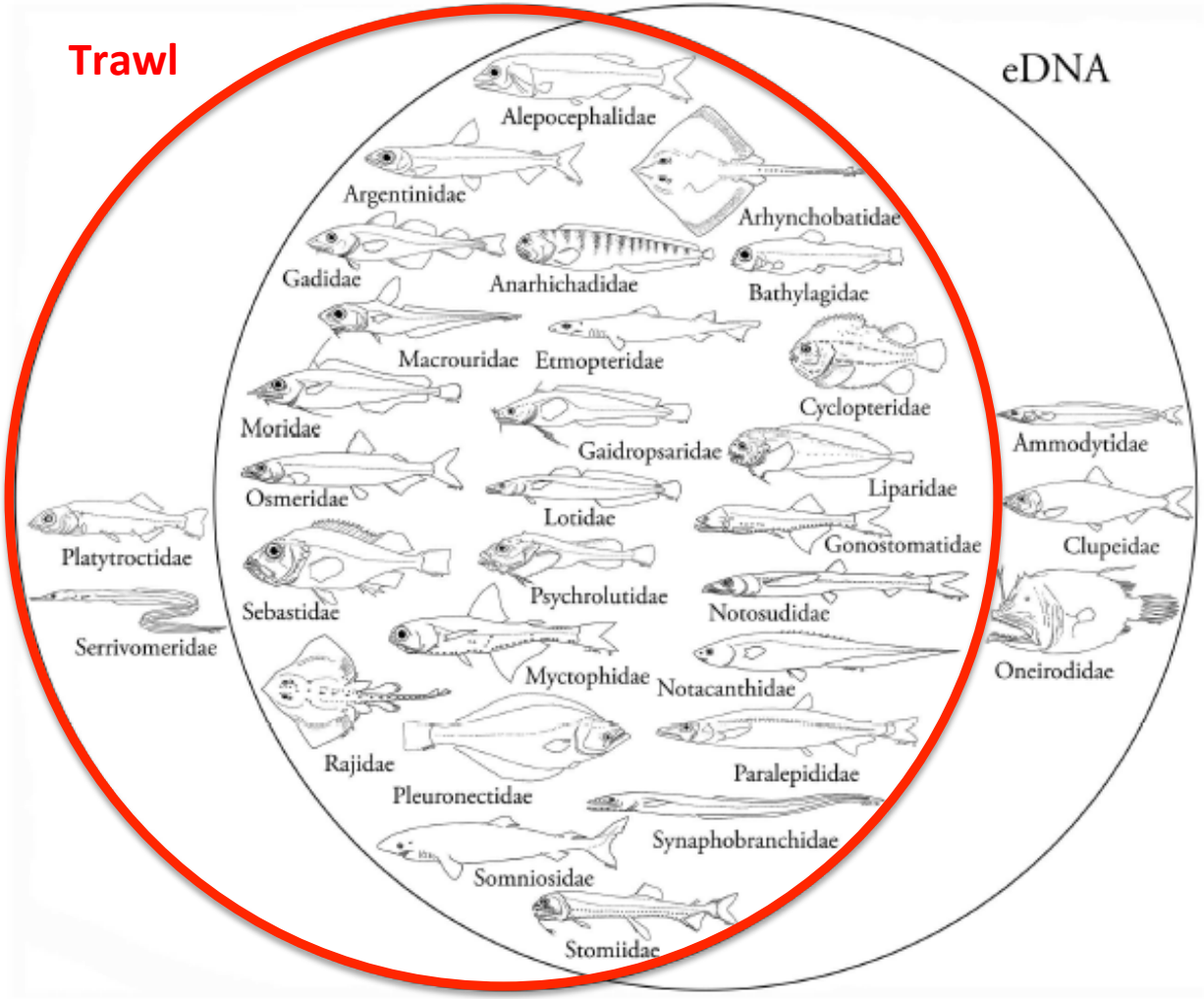

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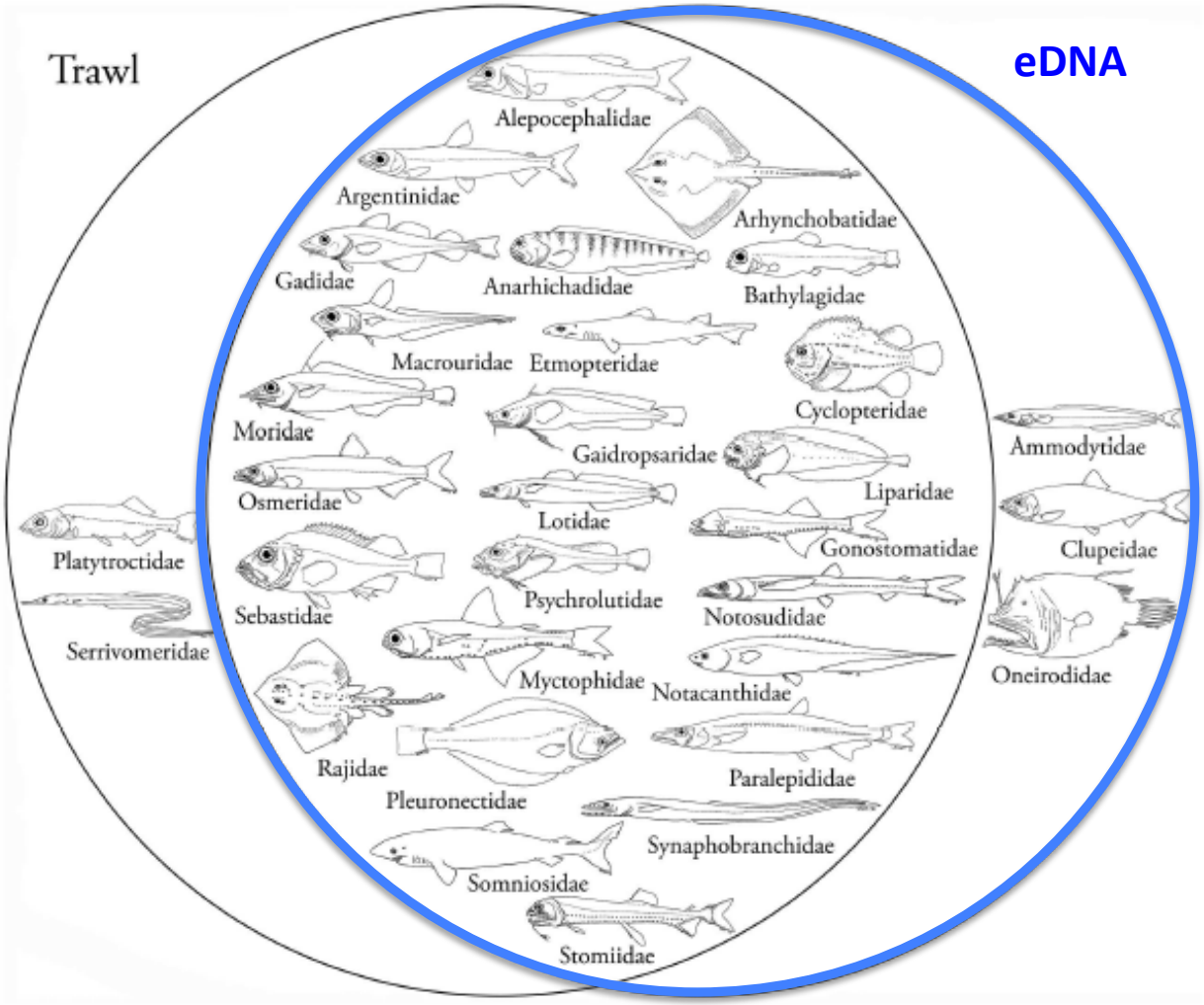

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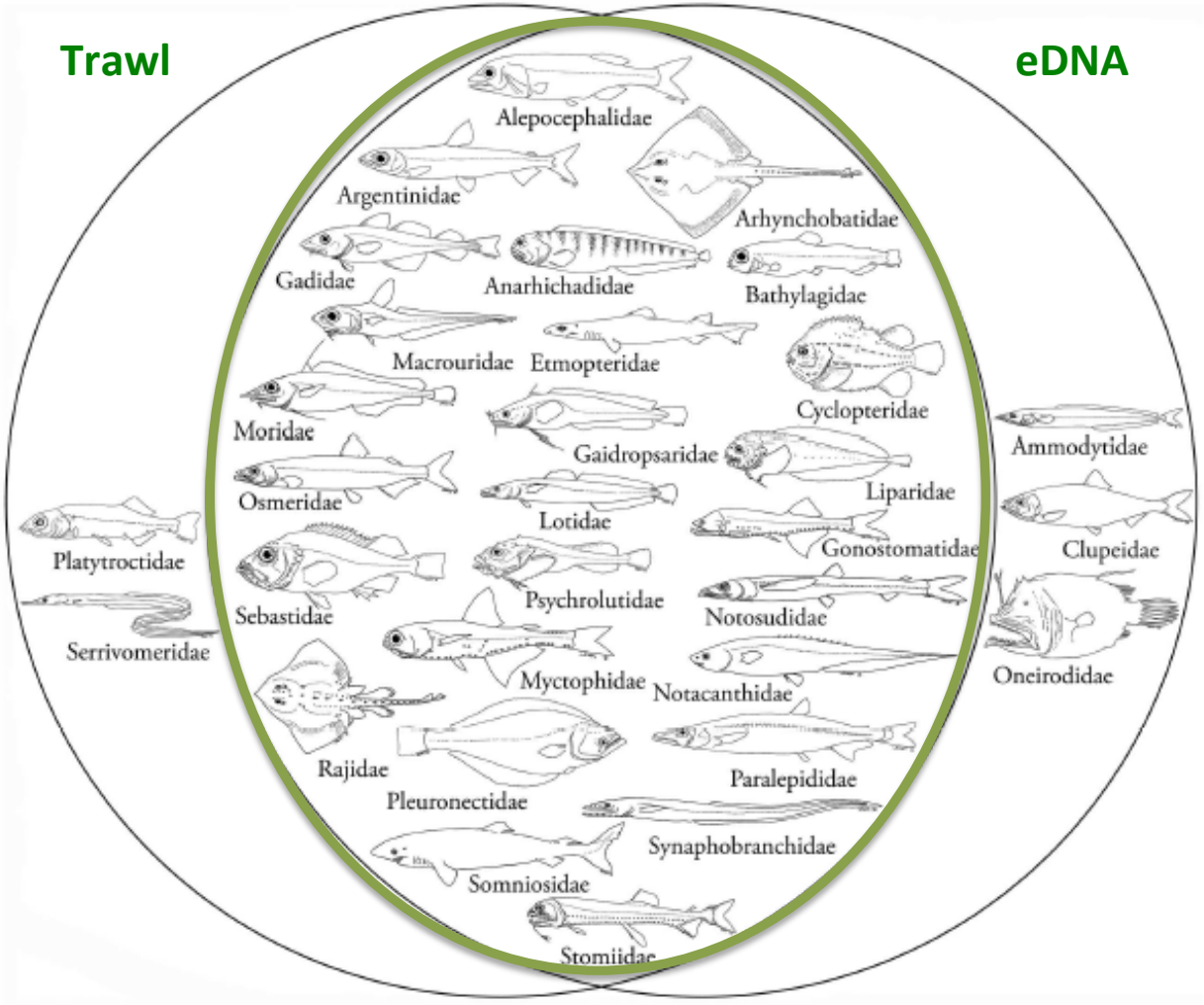

26 of 28

>90% Detection rate

Thomsen et al. 2016 PLoSONE

Novel approaches to understand changes in marine ecosystems

eDNA performs well for presence / absence of species

- Ecological models
- Invasive species
- Pathogens and parasites (Salmon Louse)
- Feeding ecology

How about relationships with biomass?

Intuitively > Organism > eDNA

Depends on production mechanisms of environmental DNA

Degradation mechanisms of environmental DNA

Environmental DNA and its application to aquatic Science and ecosystem studies

1. **COD-e-DNA (Fiskivinnuroyndir) September 2017-September 2019**

A complimentary approach to Atlantic Cod Stock assessment on the Faroe Bank using environmental DNA

2. **FAMEOS (Granskingar ráðið) January 2018 – December 2020**

*Towards a **FA**roese **M**arine **E**cosystem **O**bserving **S**ystem (FAMEOS) – integrating environmental DNA-based estimates of diversity with essential ocean measurements*

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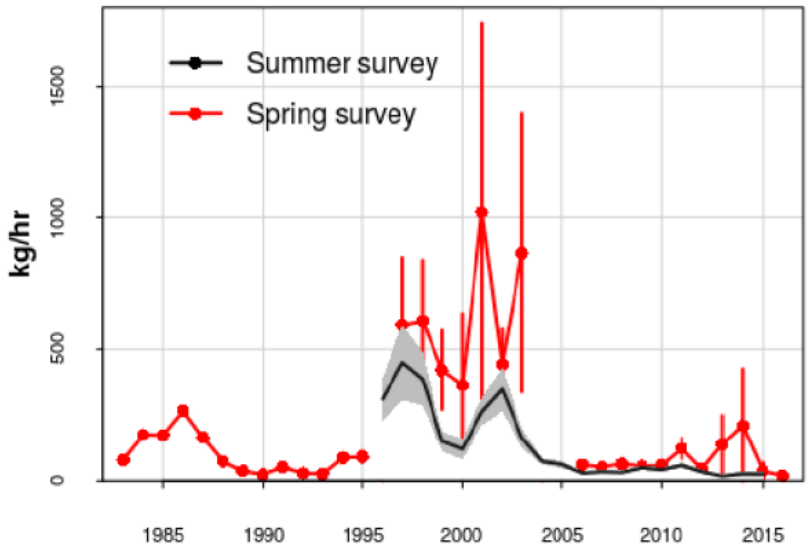
COD-e-DNA



Decline of catch per unit effort have Significantly declined since 2005, leading to a management decision to close the fishery In 2009.

ICES Working group report, 2016

Objectives

- Compare biomass in trawls with eDNA from seawater for Atlantic Cod

- Determine degradation rates of Cod DNA in natural samples

- Production rates of DNA from cod specimens in aquarium

- Compare total fish diversity in trawls with metabarcoding of fish DNA

Novel approaches to understand changes in marine ecosystems

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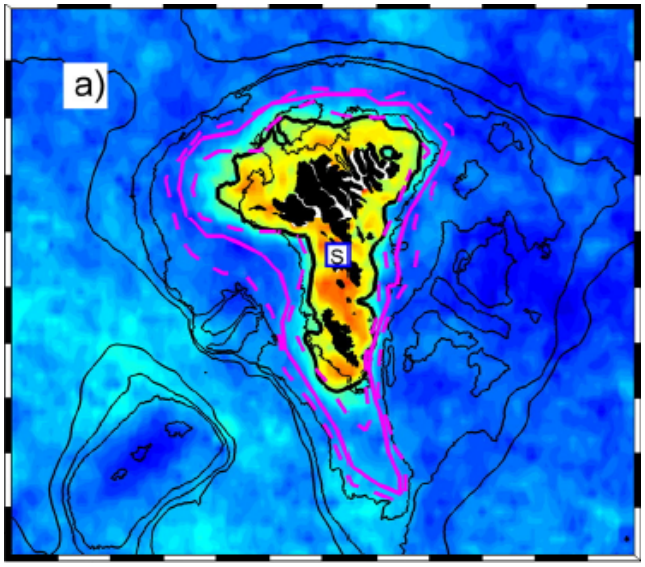


Figure: S. Eliasen, Havstovan

Weekly samples taken at station Skopun (Havstovan)

Skopun is representative of wider shelf area due to strong tidal mixing

Important chemical variables already measured Temp, Salinity, nutrients.

Couple with an eDNA sampling scheme

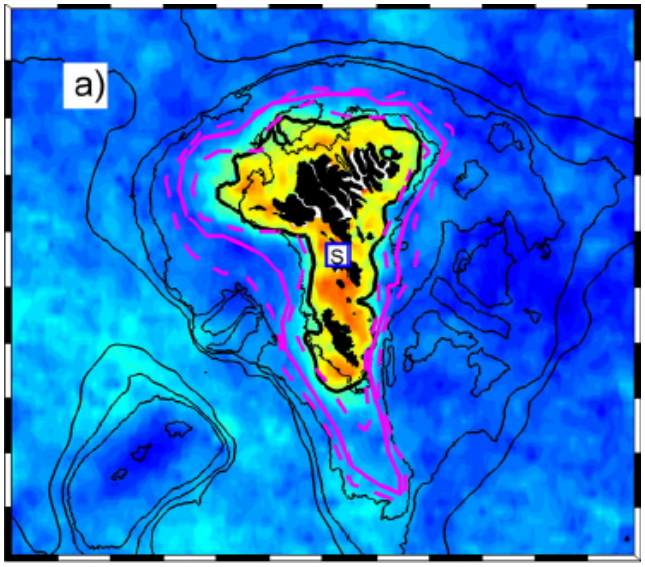
Main Objectives

Describe entire ecosystem diversity to establish baselines of coastal diversity

Use statistical analyses to describe food-web interactions

Establish a DNA archive – monitor for pathogens/parasites and invasive species

Citizen Science – Faroese coastal sampling day



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FAMEOS

Describe entire ecosystem diversity to establish baselines of coastal diversity

UNESCO

IOC

UNEP

The Global Ocean Observing System

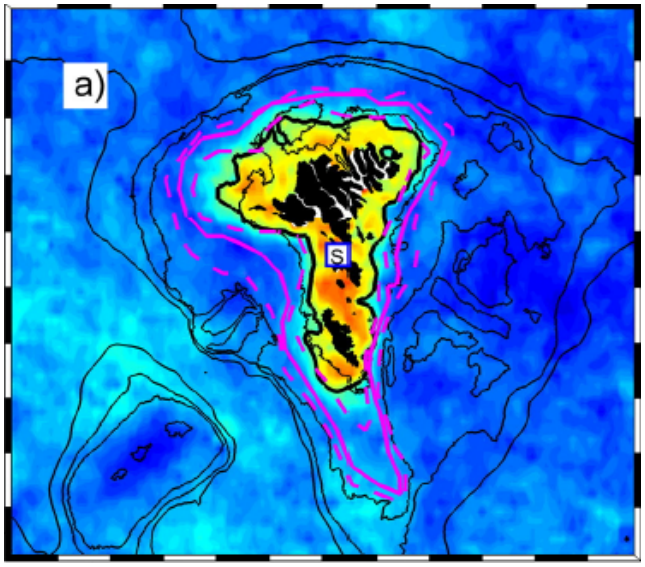
GOOS

"Critical to develop observing systems that integrate physical, chemical and biological elements to characterise coastal ecosystems and understand the societal consequences of natural and anthropogenic pressure…"

Describe entire ecosystem diversity to establish baselines of coastal diversity

UNESCO | IOC | UNEP | The Global Ocean Observing System GOOS

"Sustained observations are lacking, particularly biodiversity, and this significantly limits the capacity to report on changes in status and guide management decisions…"



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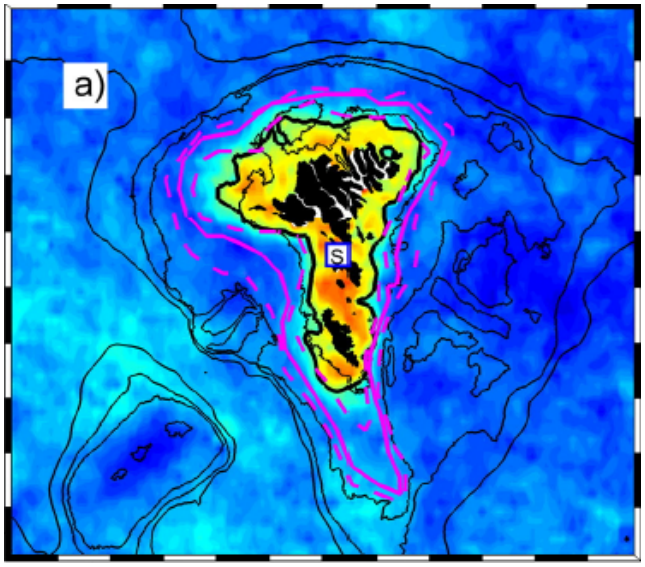

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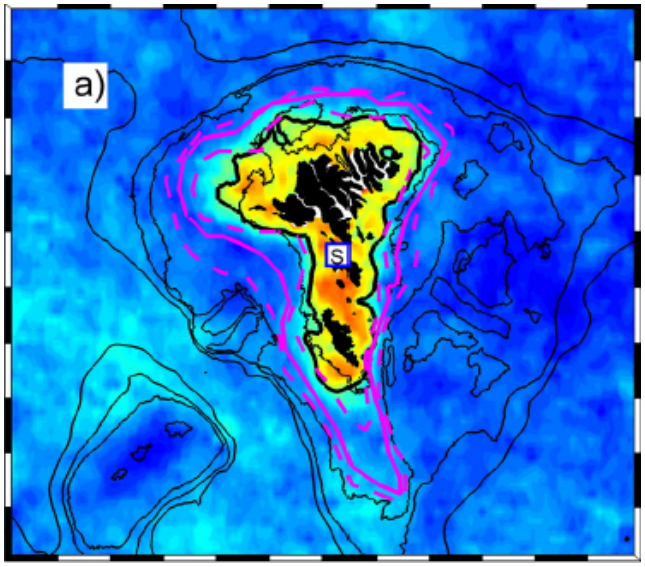

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Ocean Sampling Day

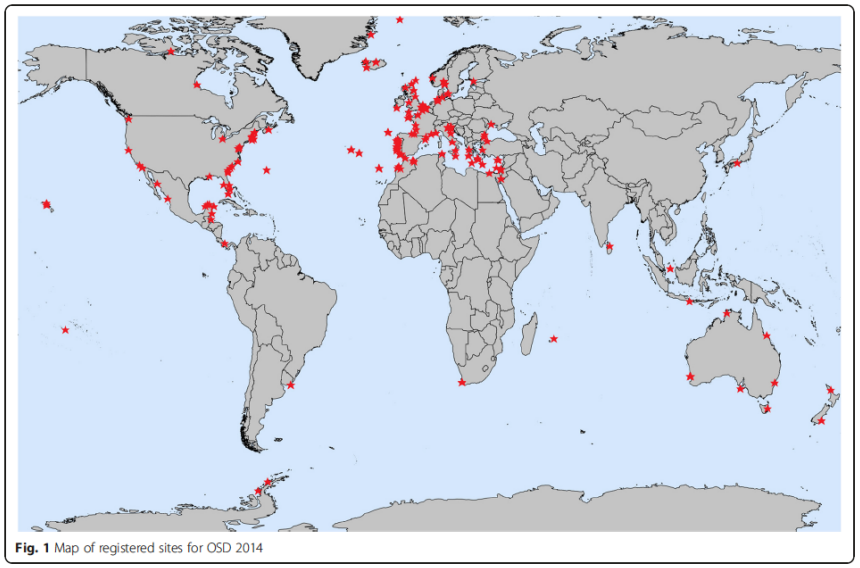

Fig. 1 Map of registered sites for OSD 2014

Globally-coordinated effort to sample microbial diversity in the World's Oceans

Kopf et al. GigaScience (2015) 4:27
DOI 10.1186/s13742-015-0066-5

COMMENTARY Open Access

The ocean sampling day consortium

Anna Kopf[1,2†], Mesude Bicak[3†], Renzo Kottmann[1], Julia Schnetzer[1,2], Ivaylo Kostadinov[2], Katja Lehmann[4], Antonio Fernandez-Guerra[1,3], Christian Jeanthon[5], Eyal Rahav[6], Matthias Ullrich[2], Antje Wichels[7], Gunnar Gerdts[7], Paraskevi Polymenakou[8], Giorgos Kotoulas[8], Rania Siam[9], Rehab Z Abdallah[9], Eva C Sonnenschein[10], Thierry Cariou[5], Fergal O'Gara[11,12], Stephen Jackson[10], Sandi Orlic[14], Michael Steinke[15], Julia Busch[16], Bernardo Duarte[17], Isabel Caçador[17], João Canning-Clode[17,18], Oleksandra Bobrova[19], Viggo Marteinsson[20], Eyjolfur Reynisson[20], Clara Magalhães Loureiro[21], Gian Marco Luna[22], Grazia Marina Quero[22], Carolin R Löscher[23], Anke Kremp[24], Marie E DeLorenzo[25], Lise Øvreås[26], Jennifer Tolman[27], Julie LaRoche[27], Antonella Penna[28], Marc Frischer[29], Timothy Davis[30], Barker Katherine[31], Christopher P Meyer[31], Sandra Ramos[32], Catarina Magalhães[32], Florence Jude-Lemeilleur[33], Ma Leopoldina Aguirre-Macedo[34], Shiao Wang[35], Nicole Poulton[36], Scott Jones[37], Rachel Collin[38], Jed A Fuhrman[39], Pascal Conan[40], Cecilia Alonso[41], Noga Stambler[42,43], Kelly Goodwin[44], Michael M Yakimov[45], Federico Baltar[46], Levente Bodrossy[47], Jodie Van De Kamp[47], Dion MF Frampton[47], Martin Ostrowski[48], Paul Van Ruth[49], Paul Malthouse[49], Simon Claus[50], Klaas Deneudt[50], Jonas Mortelmans[50], Sophie Pitois[51], David Wallom[3], Ian Salter[40,52], Rodrigo Costa[53], Declan C Schroeder[54], Mahrous M Kandil[55], Valentina Amaral[41], Florencia Biancalana[57], Rafael Santana[41], Maria Luiza Pedrotti[56], Takashi Yoshida[58], Hiroyuki Ogata[58], Tim Ingleton[60,64], Kate Munnik[61], Naiara Rodriguez-Ezpeleta[62], Veronique Berteaux-Lecellier[63], Patricia Wecker[63], Ibon Cancio[65], Daniel Vaulot[5], Christina Bienhold[1,52], Hassan Ghazal[67,68], Bouchra Chaouni[68,71], Soumya Essayeh[67], Sara Ettamimi[68,70], El Houcine Zaid[71], Noureddine Boukhatem[68], Abderrahim Bouali[68], Rajaa Chahboune[67,72], Said Barrijal[72], Mohammed Timinouni[74], Fatima El Otmani[75], Mohamed Bennani[74], Marianna Mea[2], Nadezhda Todorova[77], Ventzislav Karamfilov[77], Petra ten Hoopen[78], Guy Cochrane[78], Stephane L'Haridon[79], Kemal Can Bizsel[80], Alessandro Vezzi[81], Federico M Lauro[82], Patrick Martin[83], Rachelle M Jensen[84], Jamie Hinks[82], Susan Gebbels[85], Riccardo Rosselli[81], Fabio De Pascale[81], Riccardo Schiavon[81], Antonina dos Santos[59], Emilie Villar[13], Stéphane Pesant[87], Bruno Cataletto[88], Francesca Malfatti[88], Ranjith Edirisinghe[89], Jorge A Herrera Silveira[35], Michele Barbier[92], Valentina Turk[93], Tinkara Tinta[93], Wayne J Fuller[94], Ilkay Salihoglu[94], Nedime Serakinci[94], Mahmut Cerkez Ergoren[94], Eileen Bresnan[98], Juan Iriberri[65], Paul Anders Fronth Nyhus[100], Edvardsen Bente[101], Hans Erik Karlsen[102], Peter N Golyshin[103], Josep M Gasol[104], Snejana Moncheva[105], Nina Dzhembekova[105], Zackary Johnson[106], Christopher David Sinigalliano[44], Maribeth Louise Gidley[44,107], Adriana Zingone[108], Roberto Danovaro[108,109], George Tsiamis[110], Melody S Clark[111], Ana Cristina Costa[21], Monia El Bour[99], Ana M Martins[21,95], R Eric Collins[96], Anne-Lise Ducluzeau[96], Jonathan Martinez[97], Mark J Costello[86], Linda A Amaral-Zettler[90,91], Jack A Gilbert[69,73,76,90], Neil Davies[2,66], Dawn Field[2,3] and Frank Oliver Glöckner[1,2*]

Kopf et al. 2015 Gigascience

Taking the pulse of the Faroese shelf ecosystem

Citizen Science

Organise a Faroese Coastal Sampling Day

Snapshot of diversity on the Faroese Shelf

Novel approaches to understand changes in marine ecosystems

Summary

Environmental DNA is an emerging approach that has the potential to transform ecosystem studies

Quick, cheap, no taxonomic expertise required

Spatial and temporal scales enhanced

Non-destructive for habitats

DNA can be archived long-term for retrospective studies

Establish this approach specifically to the Faroe Islands

RESEARCH PARK iNOVA - *A new way to do science*

HAVSTOVAN
FAROE MARINE RESEARCH INSTITUTE

Takk Fyri

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