From Then to Now and Into the Future: Scientific Research in Support of the Protection of Vulnerable Marine Ecosystems and Management of Deep-Sea Fisheries

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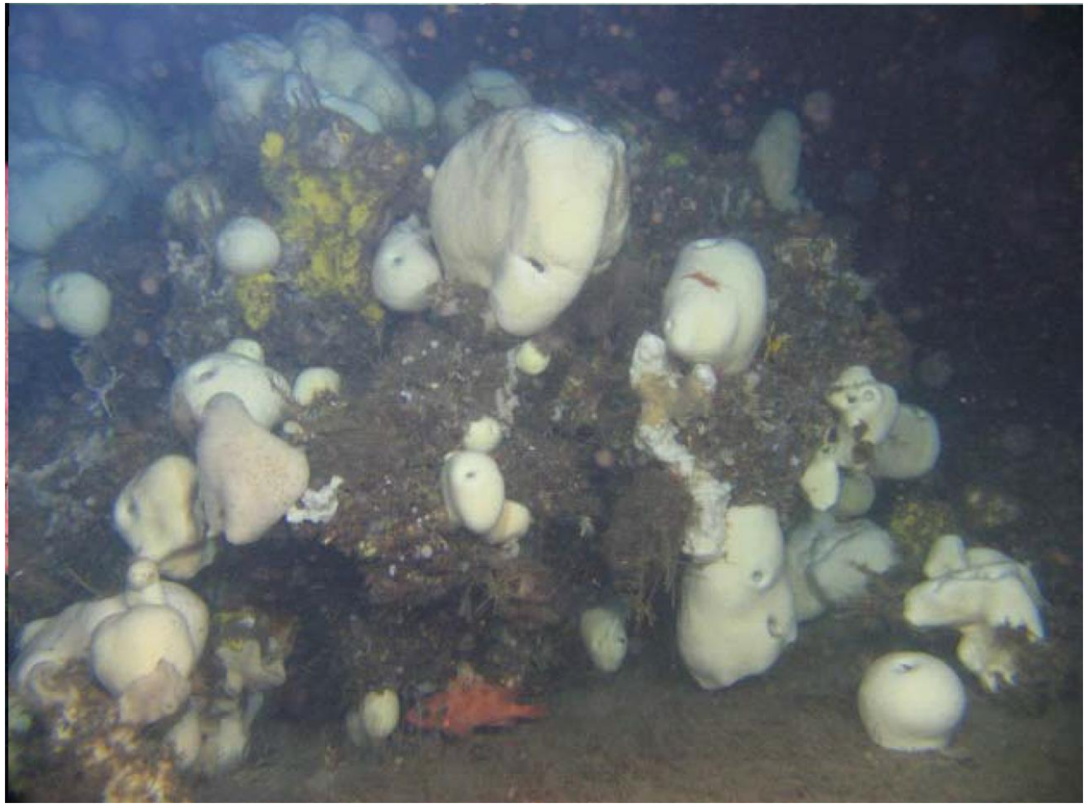
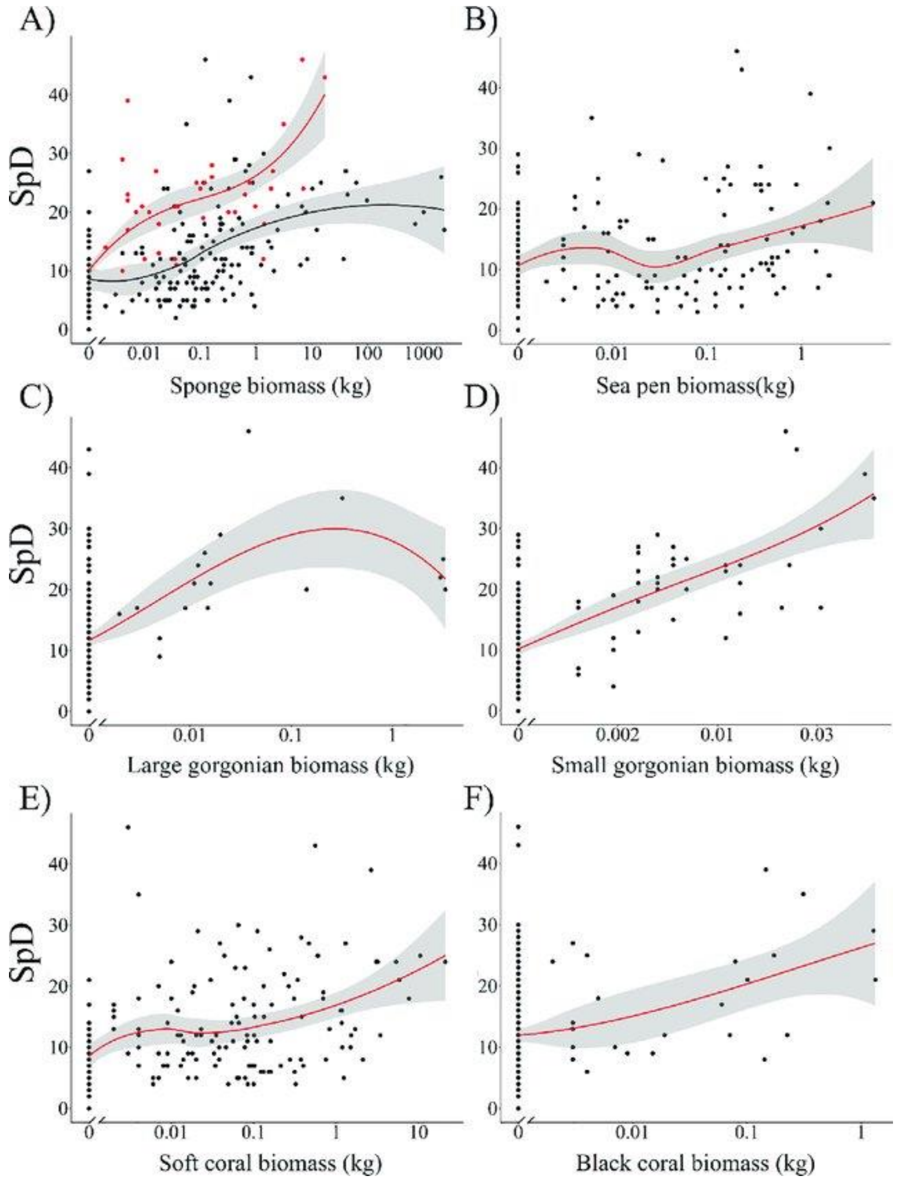
"… recognizing the immense importance and value of deep sea ecosystems and the biodiversity they contain; " A/RES/61/105 para 80



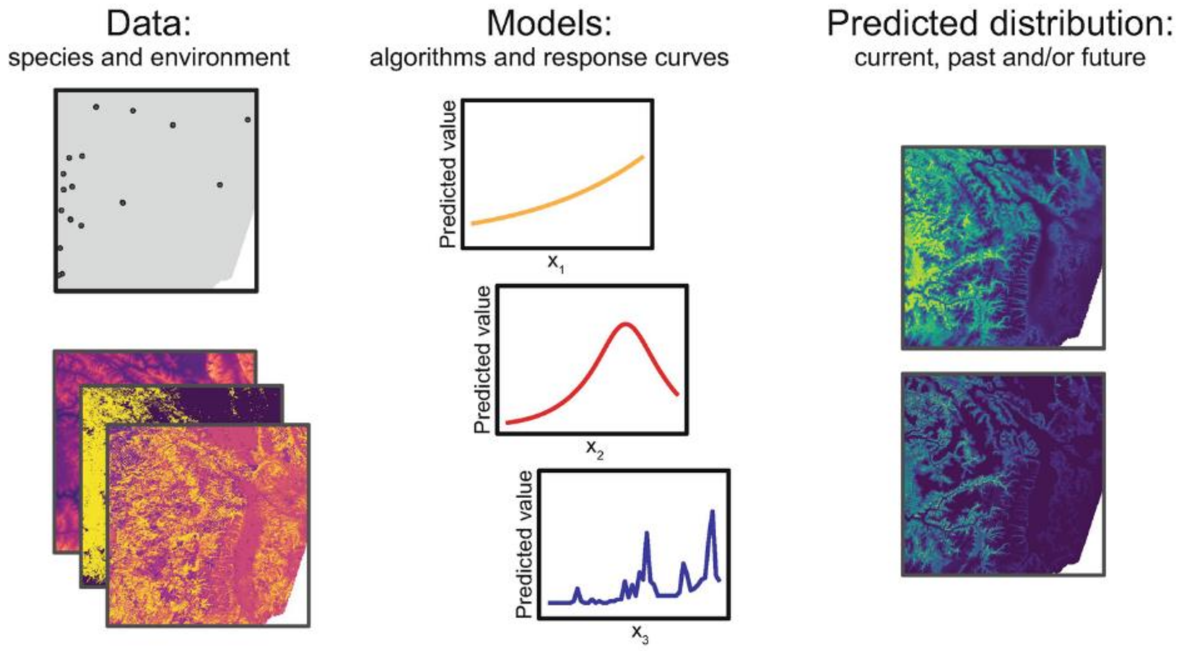
Murillo et al. 2020. Ecological Indicators 112: 106135.

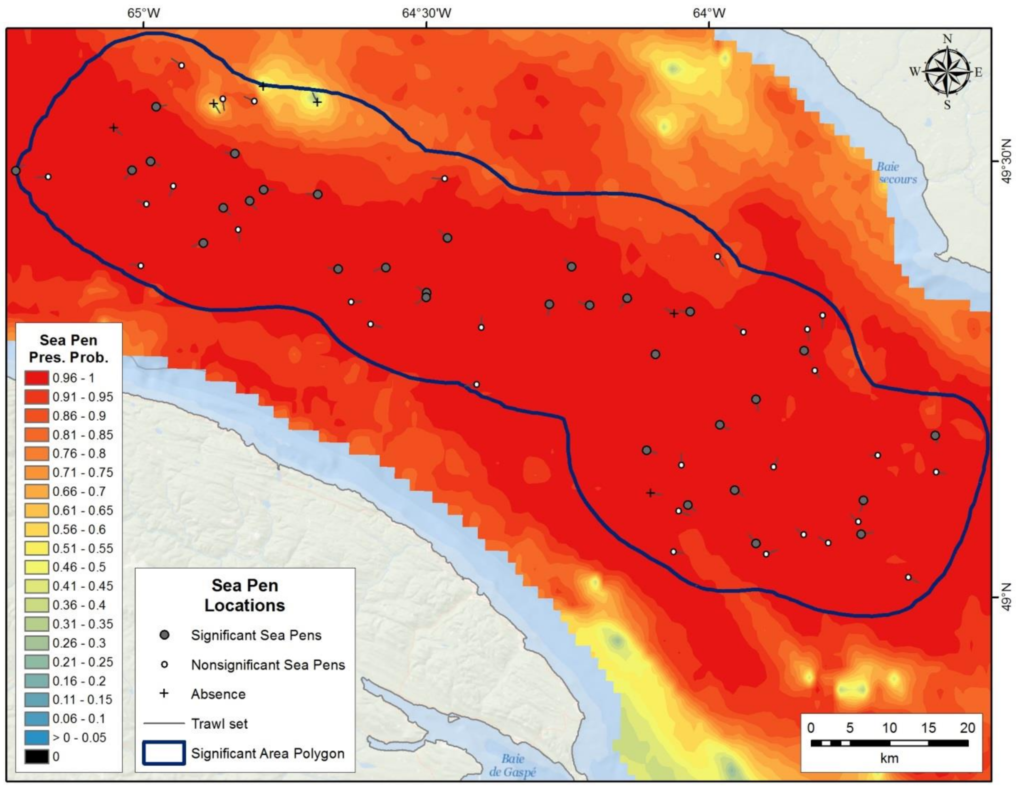


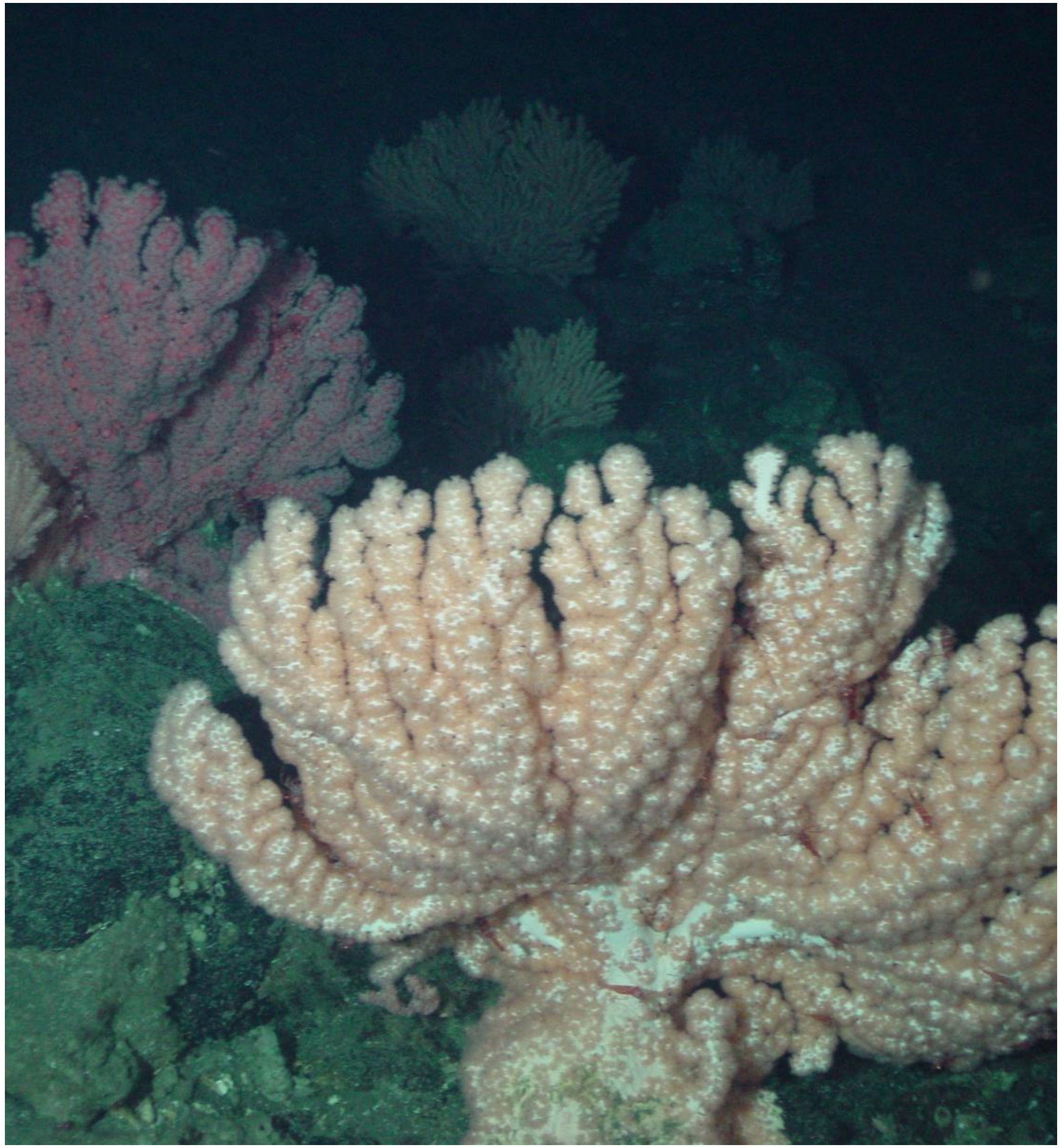
“ (b) Conduct further marine scientific research and use the best scientific and technical information available to identify where vulnerable marine ecosystems are known to occur or are likely to occur“ A/RES/64/72 para 119

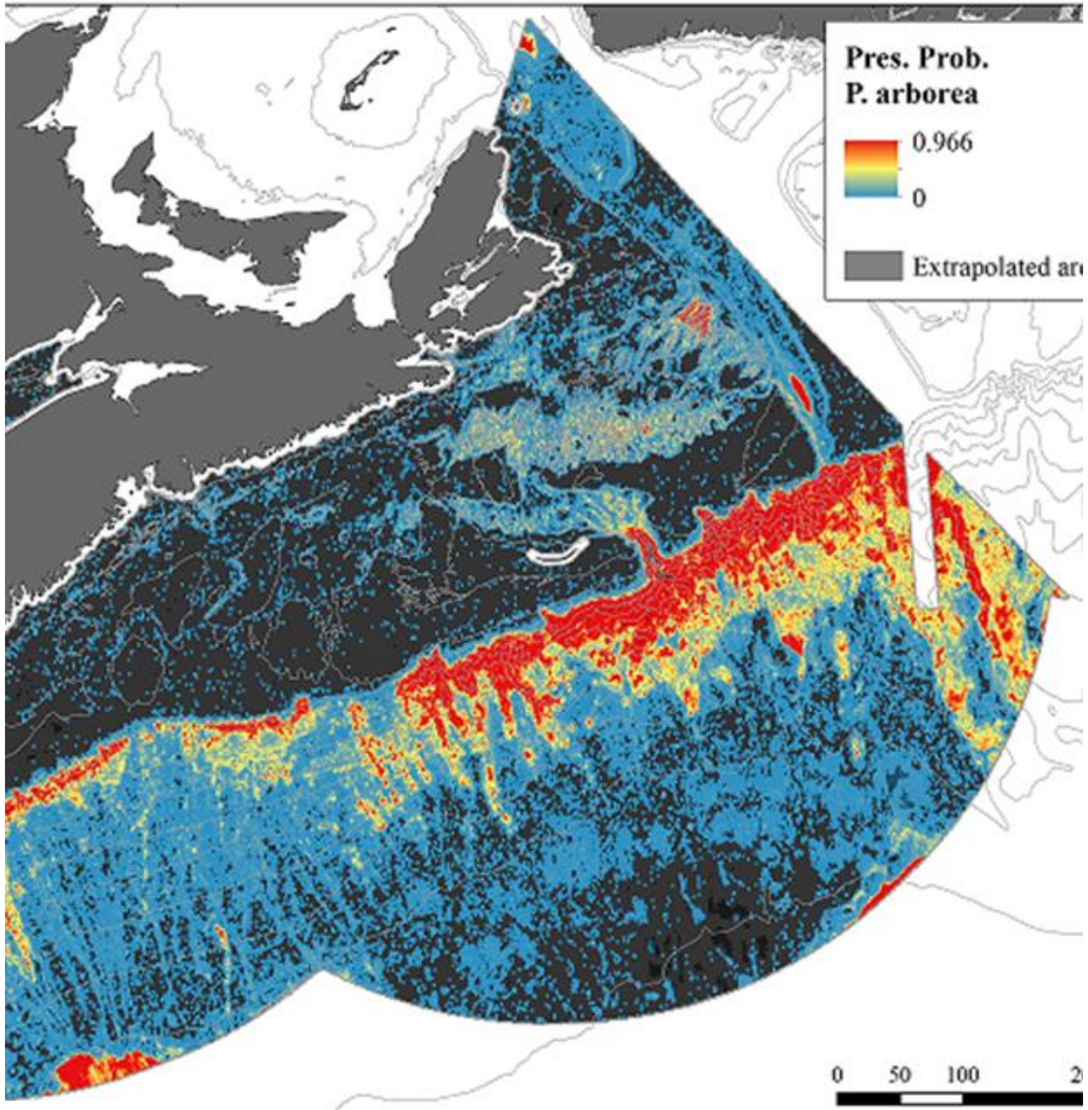
Distribution Modeling

- Relative probability of occurrence between known occurrences
- Interpolate predictions to new areas
- “Where species are known or likely to occur”







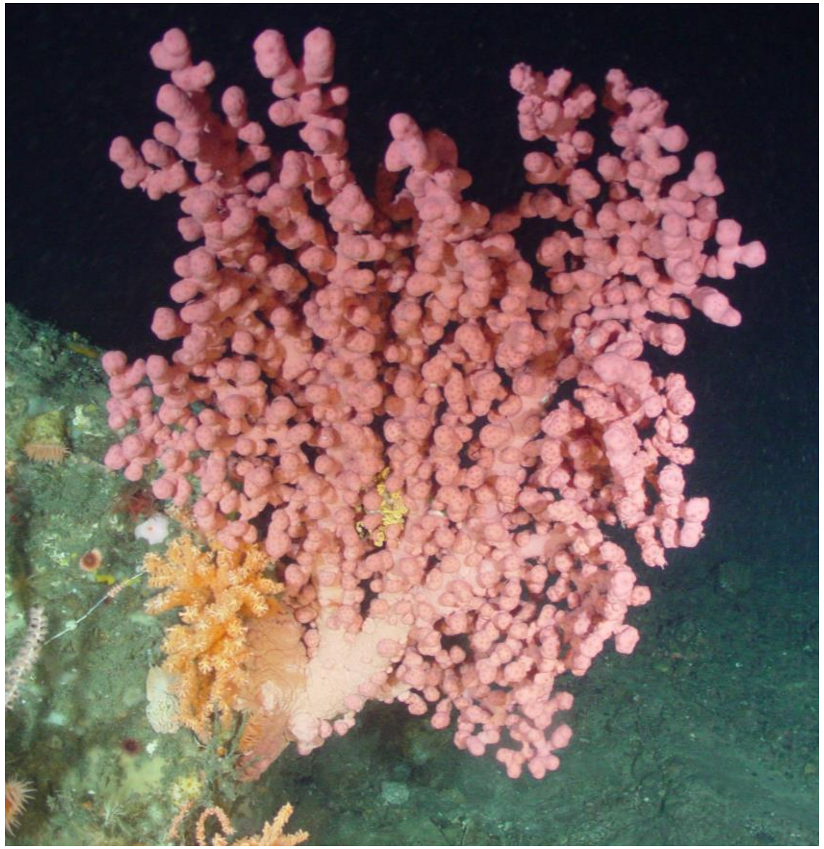


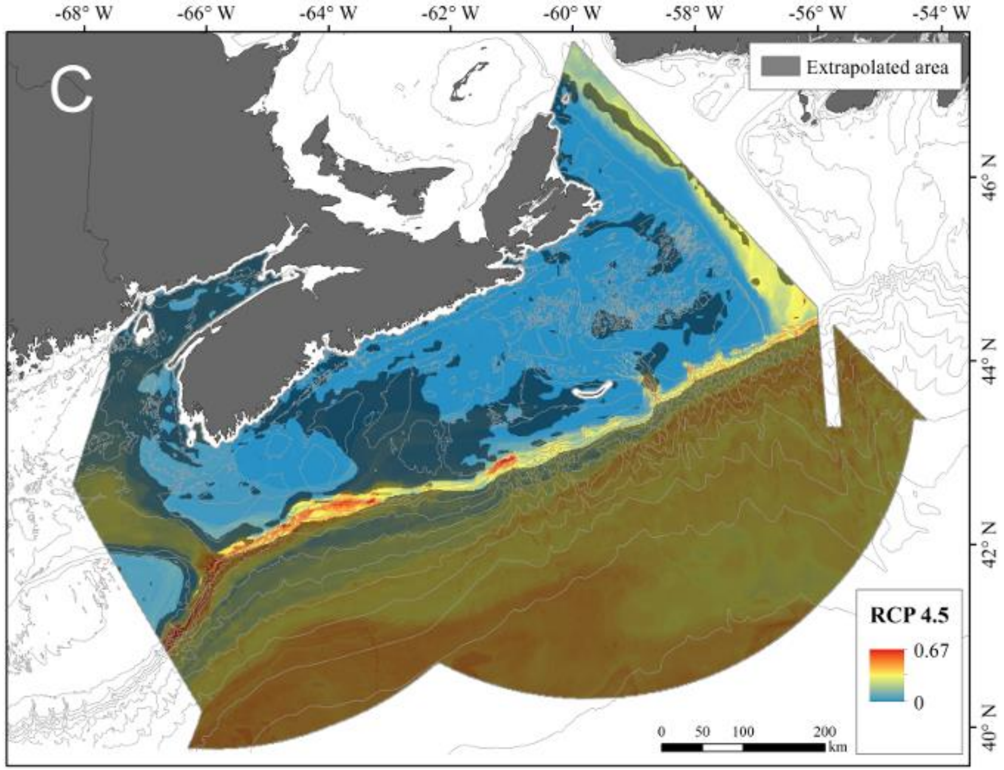
Wang et al. (2022) Frontiers in Marine Science 9: 863693

The Effects of Climate Change

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

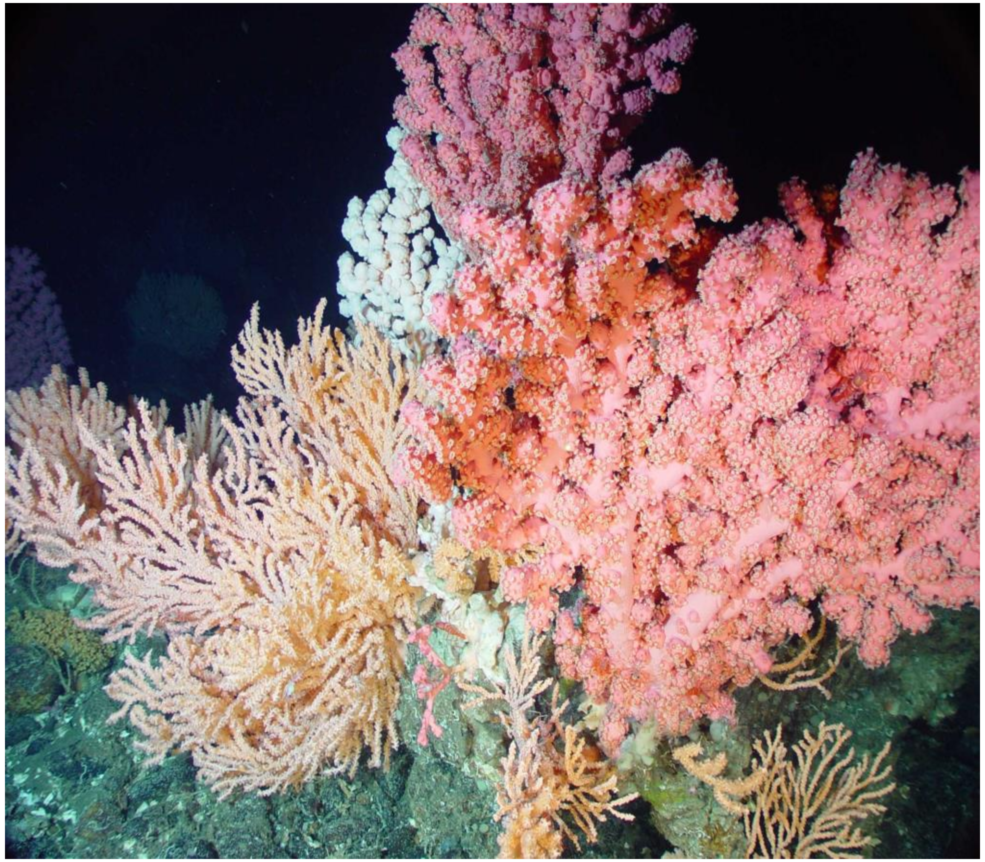
Predictions of Distribution to Mid-Century (2045-2065) and Beyond

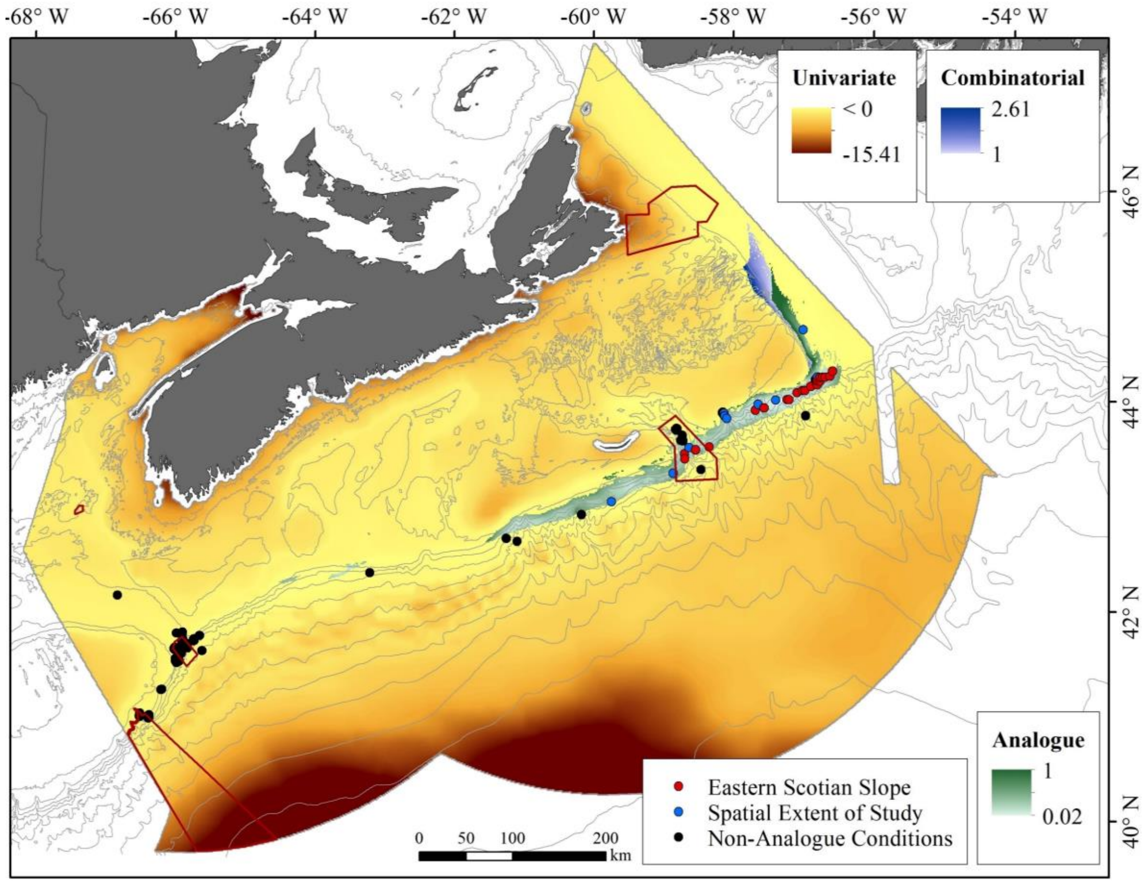




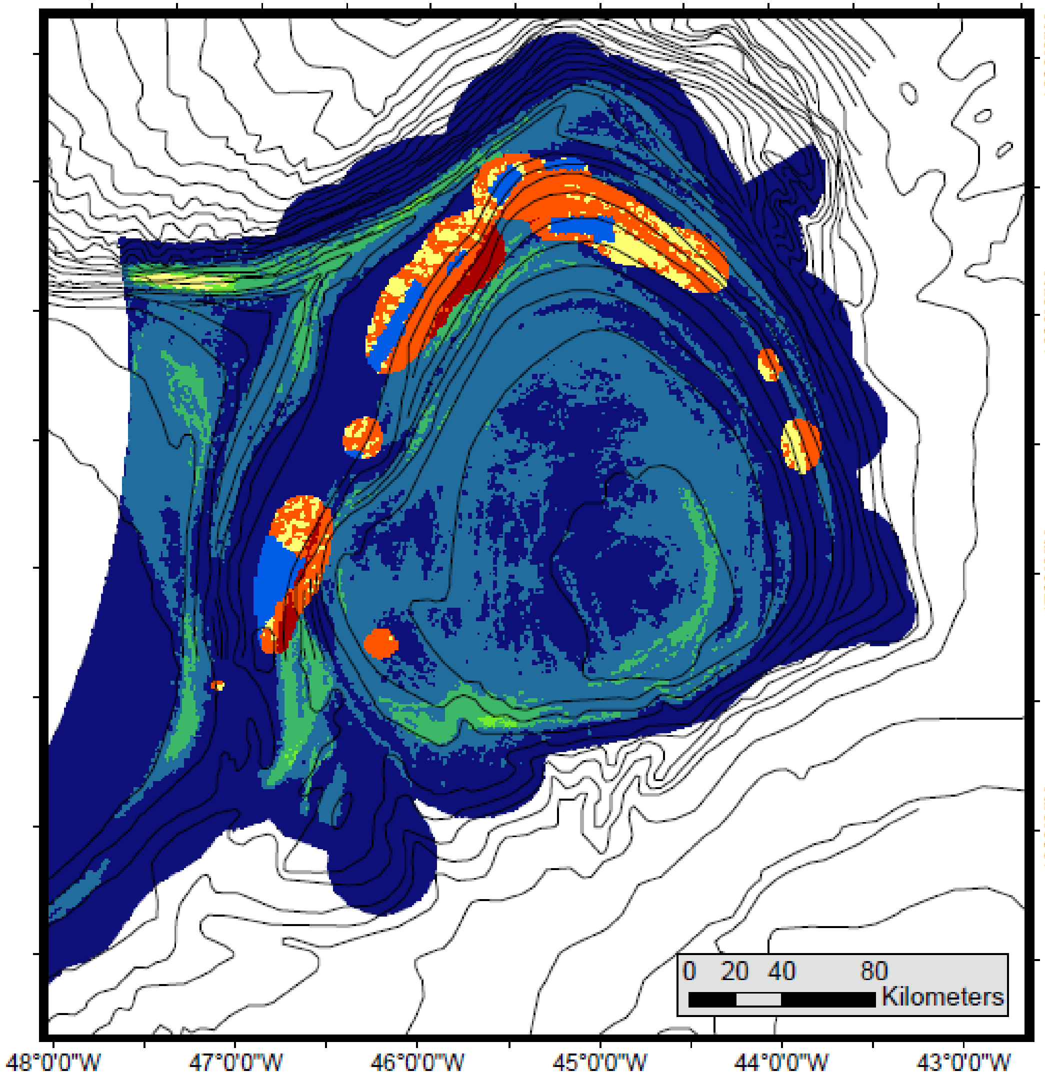
Wang et al. (2022) Frontiers in Marine Science 9: 863693

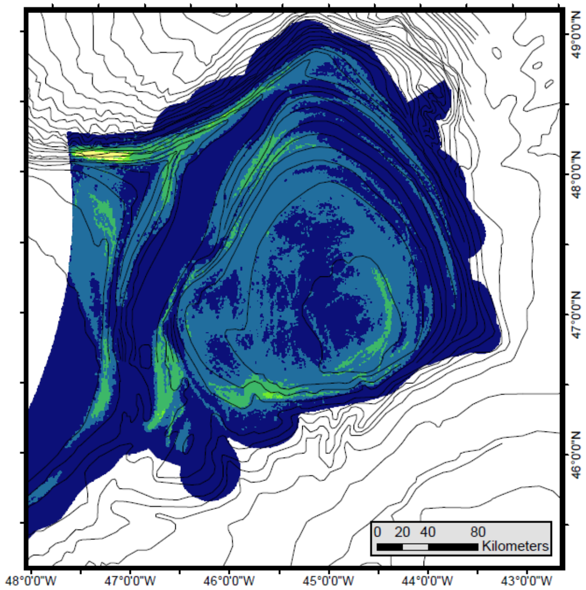
Identification of Climate Refugia





“171. Calls upon States to take action immediately… to continue to implement the 2008 International Guidelines … in order to sustainably manage fish stocks and protect vulnerable marine ecosystems … from fishing practices with significant adverse impacts on vulnerable marine ecosystems, recognizing the immense importance and value of deep sea ecosystems and the biodiversity they contain as documented in the First Global Integrated Marine Assessment“ A/RES/71/123





200m contour (GEBCO)

Sea Pens (cut-off = 95%)

Class

- At Risk
- Impacted (above cut-off)
- Impacted (below cut-off)
- Protected or outside FF

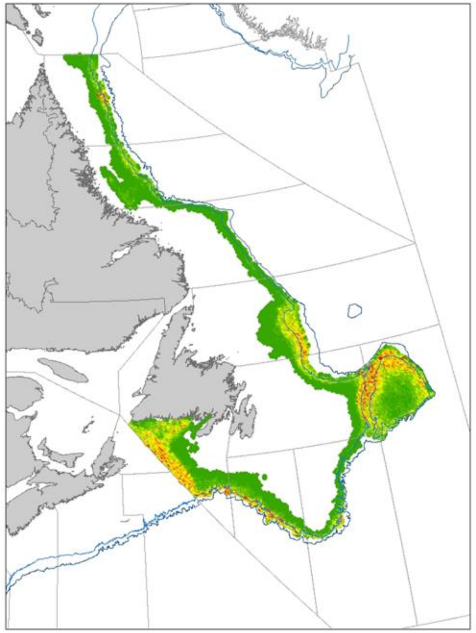
Fishing Effort (2010-19 mean)

KM Trawled per year

- 0 - 0.5
- 0.5 - 10.0
- 10.0 - 50.0
- 50.0 - 100.0
- 100.0 - 154.3

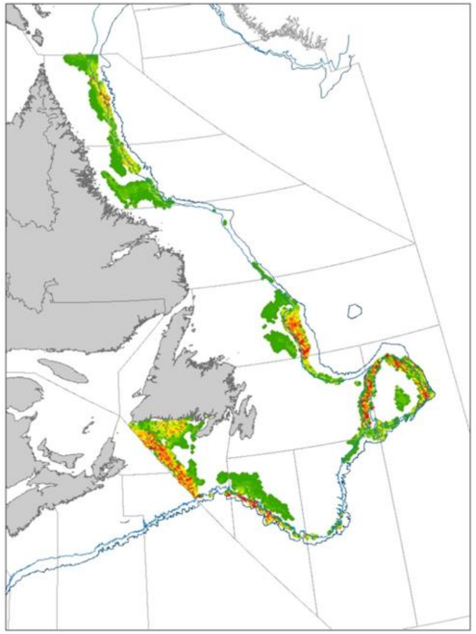
NAFO Scientific Council WG-ESA 2021 Kenny et al.

Agent-based Modeling

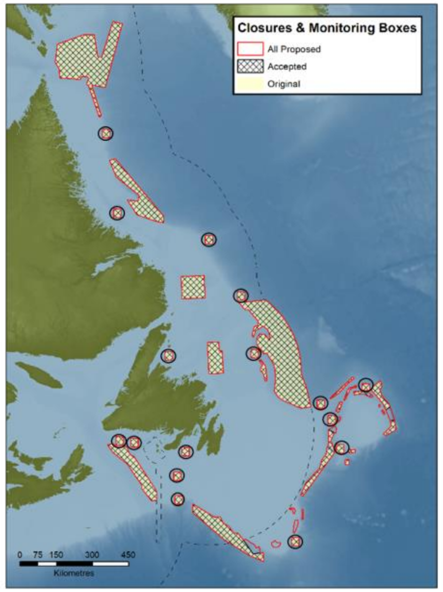


Before Fishing

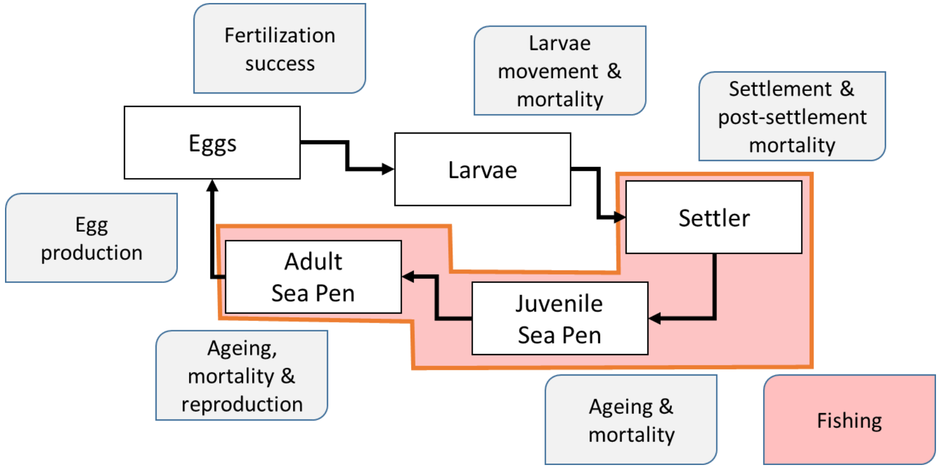
After Fishing



Evaluation of Closures and recovery times

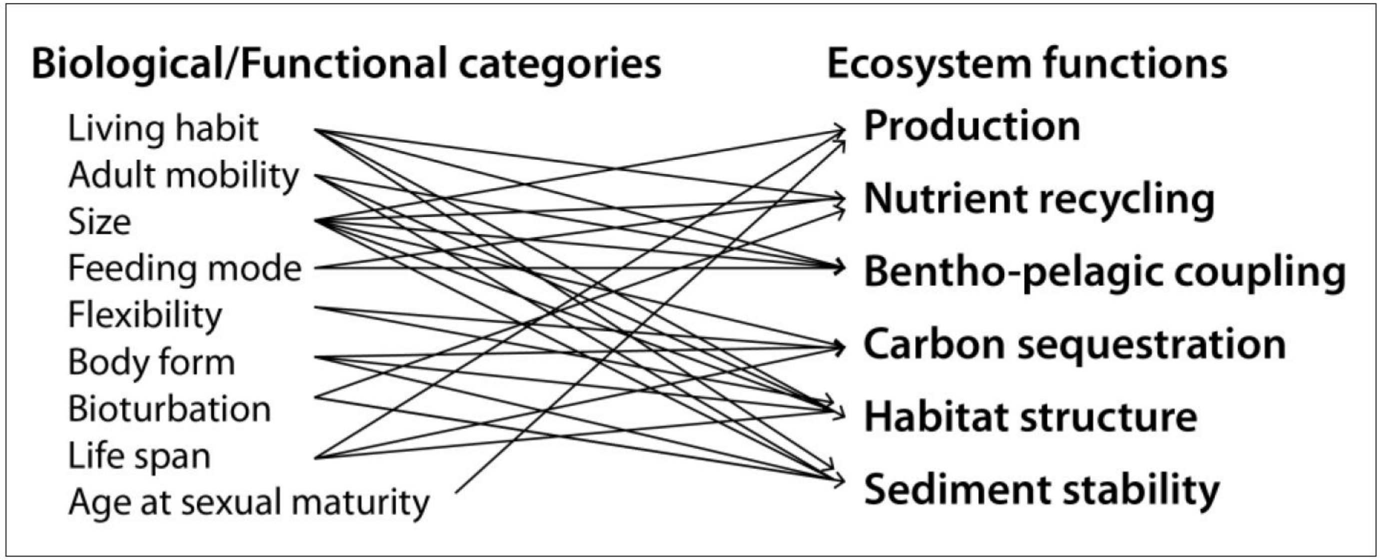


Simulating a Sea Pen Life Cycle with Fishing Impacts in Space and Time

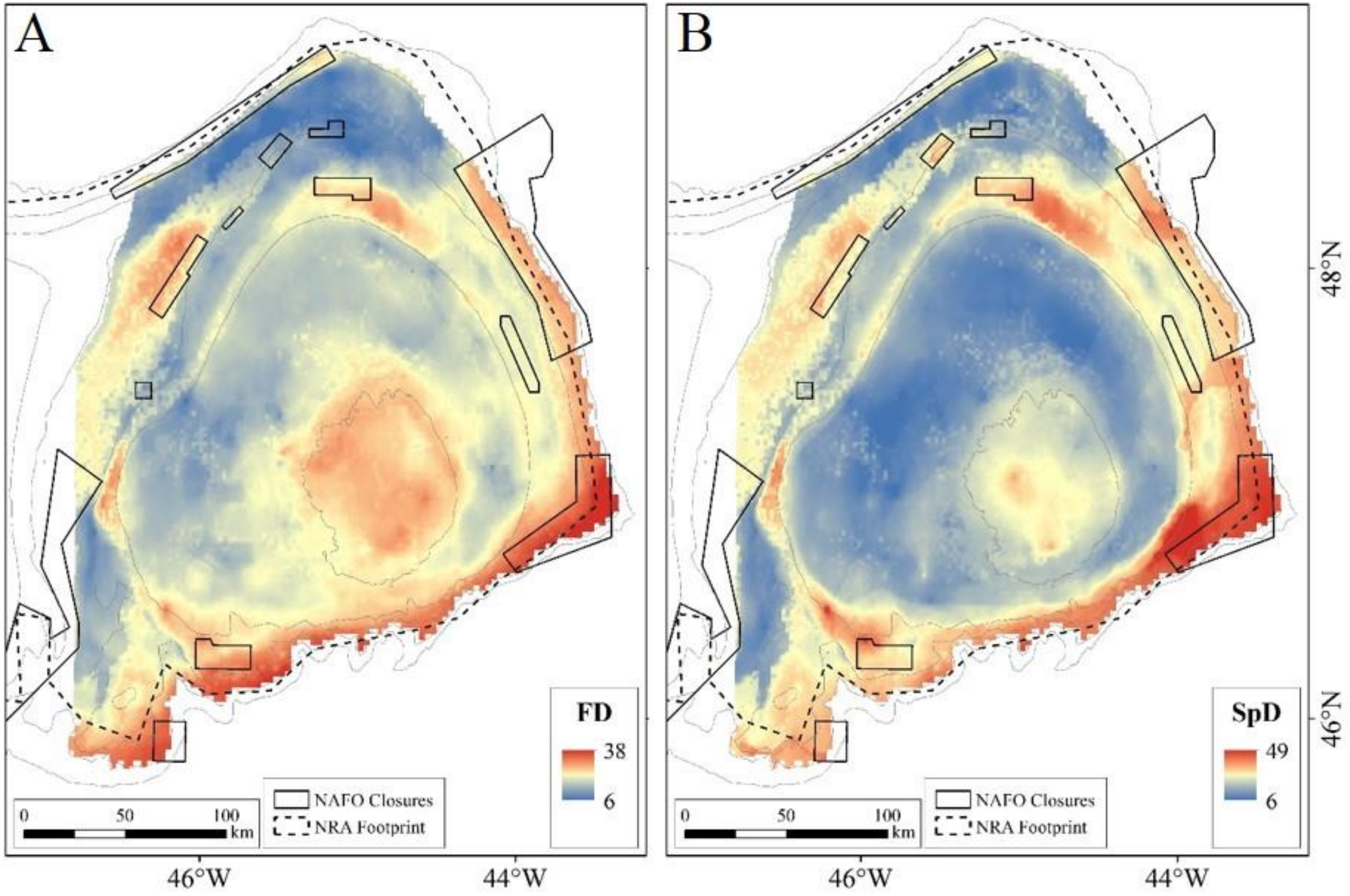


NAFO Scientific Council WG-ESA 2020-2021 Koen-Alonso et al.

Mapping of Ecosystem Functions

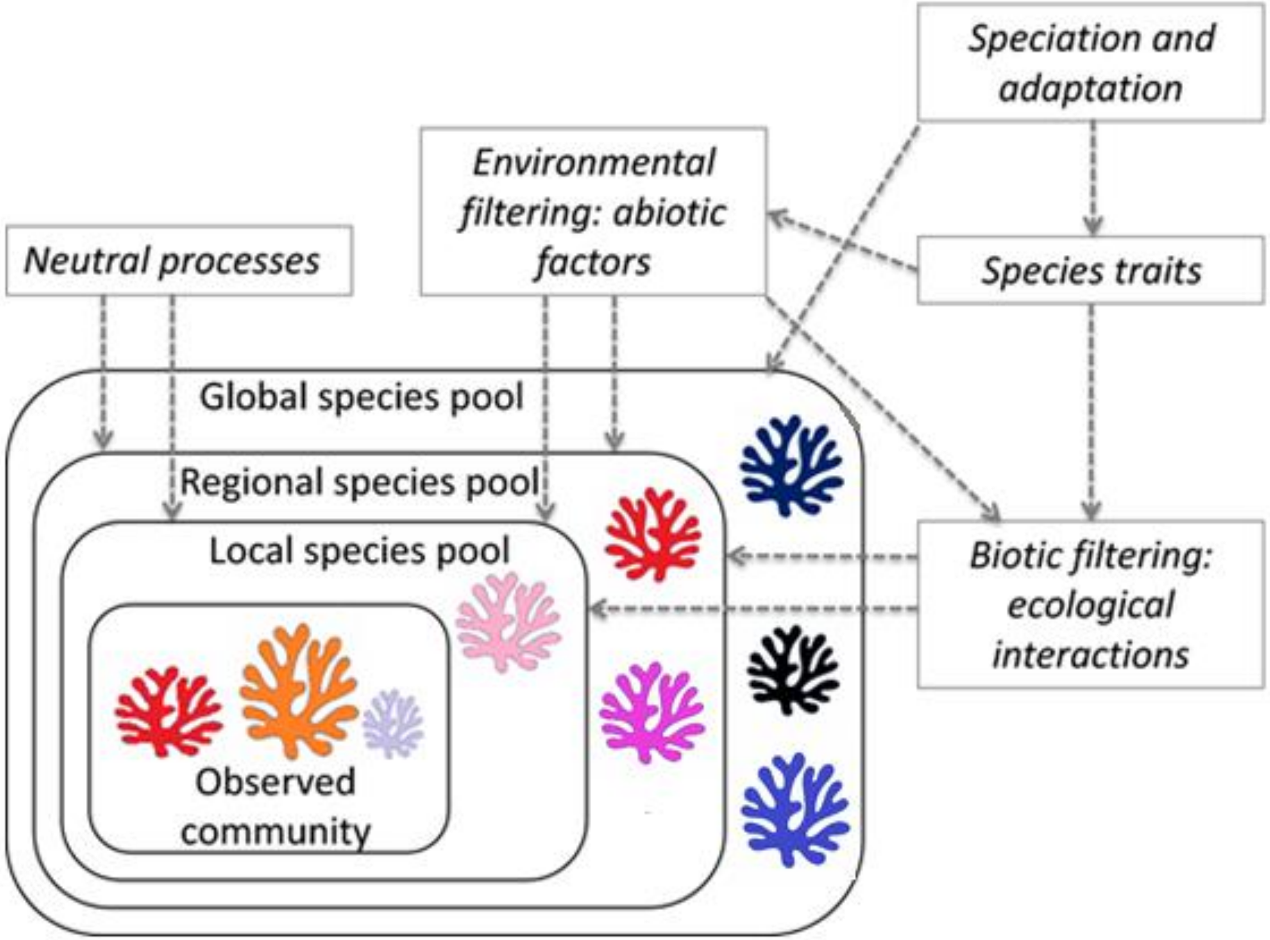


Predicted Fric (Functional Diversity) | Predicted Species Density

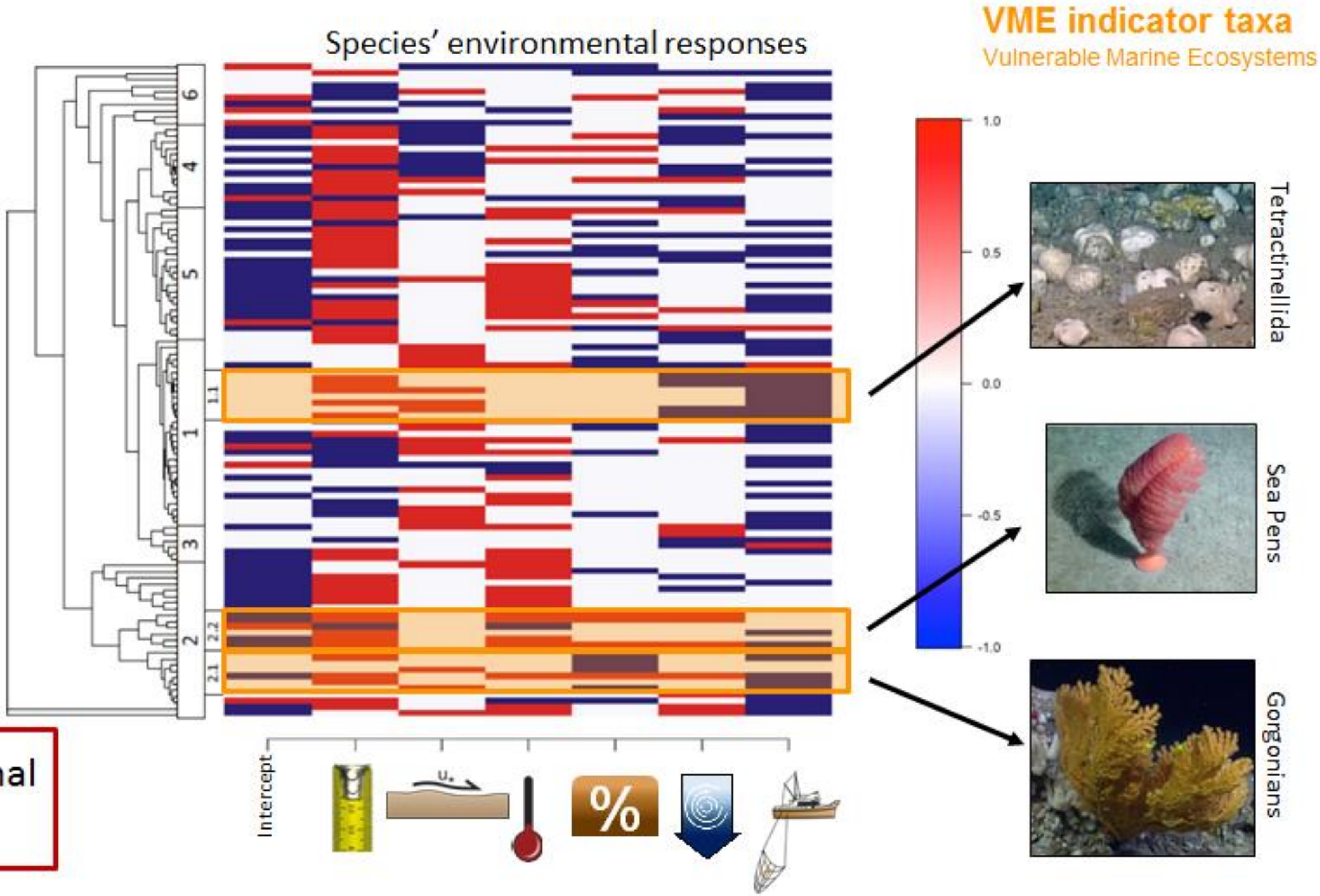


Murillo et al. (2020) Ecological Indicators 112: 106135.

Joint Species Distribution Models

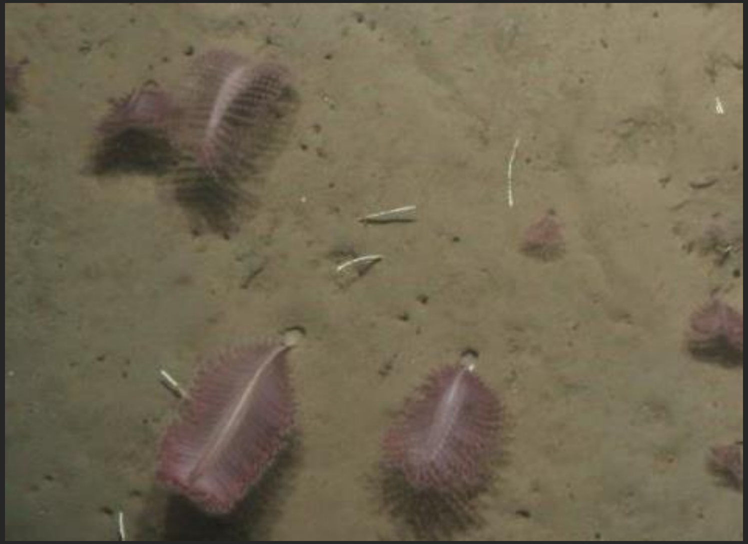


Modified from: Ovaskainen et al. 2017. Ecology Letters 5, 561-576

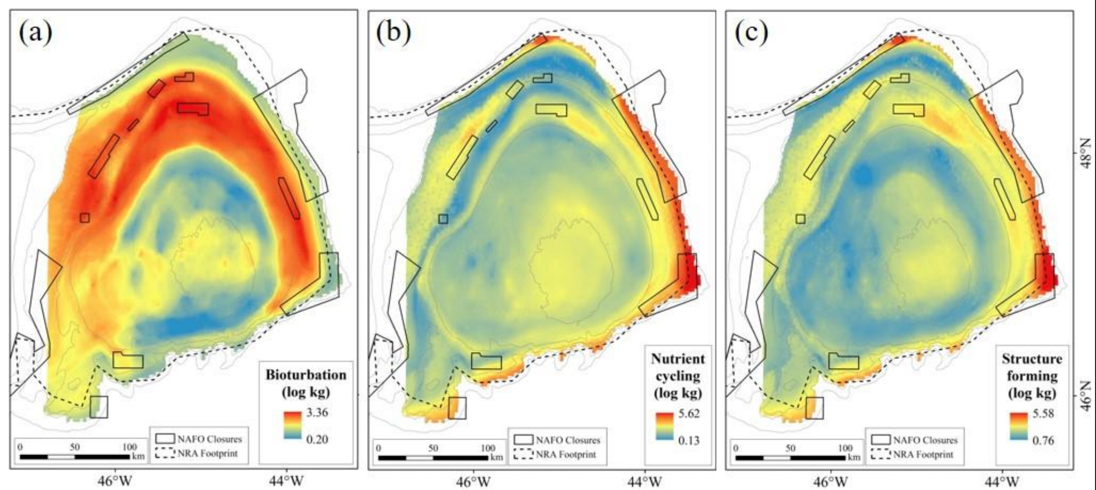


Phylogenetic signal
$\rho = 0.58$

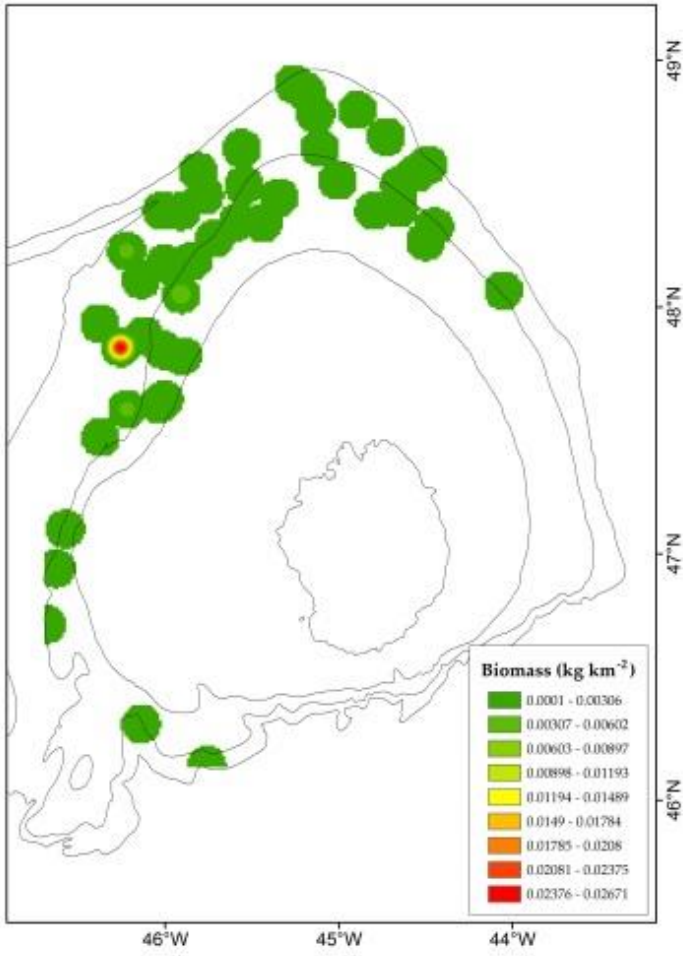
Murillo et al. (2020) Diversity and Distributions 26 (4): 460-478



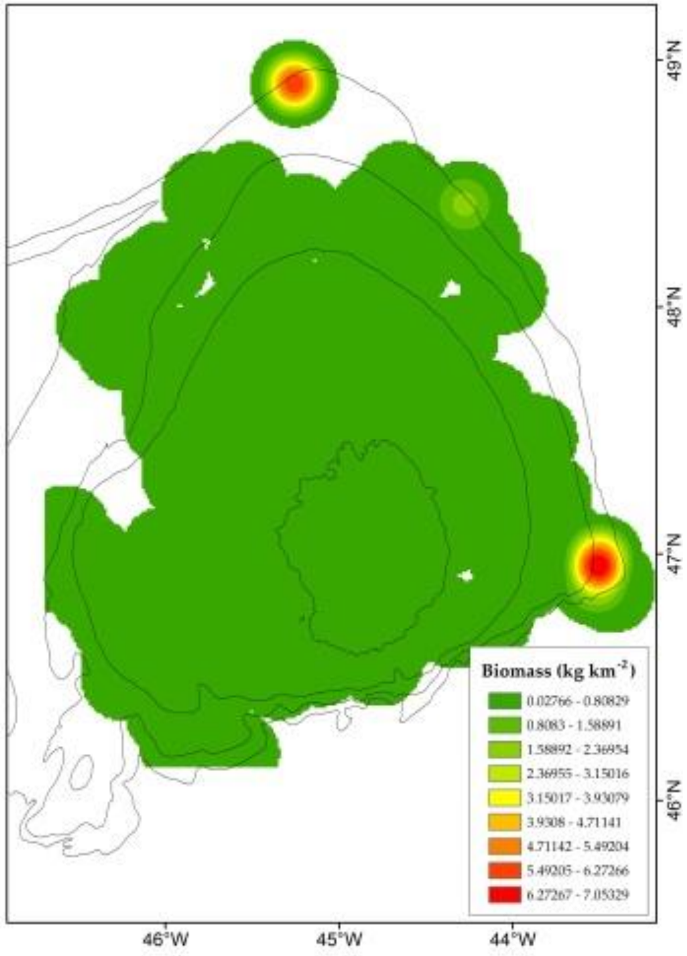
Bioturbation Nutrient Cycling Habitat Provision



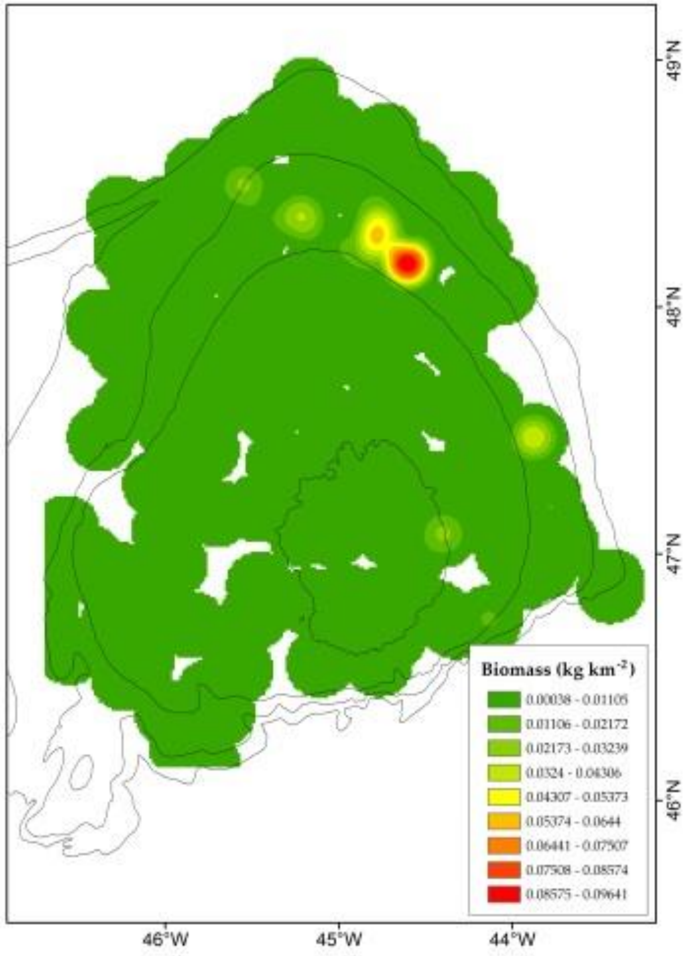
Murillo et al. (2020) Diversity and Distributions 26 (4): 460-478



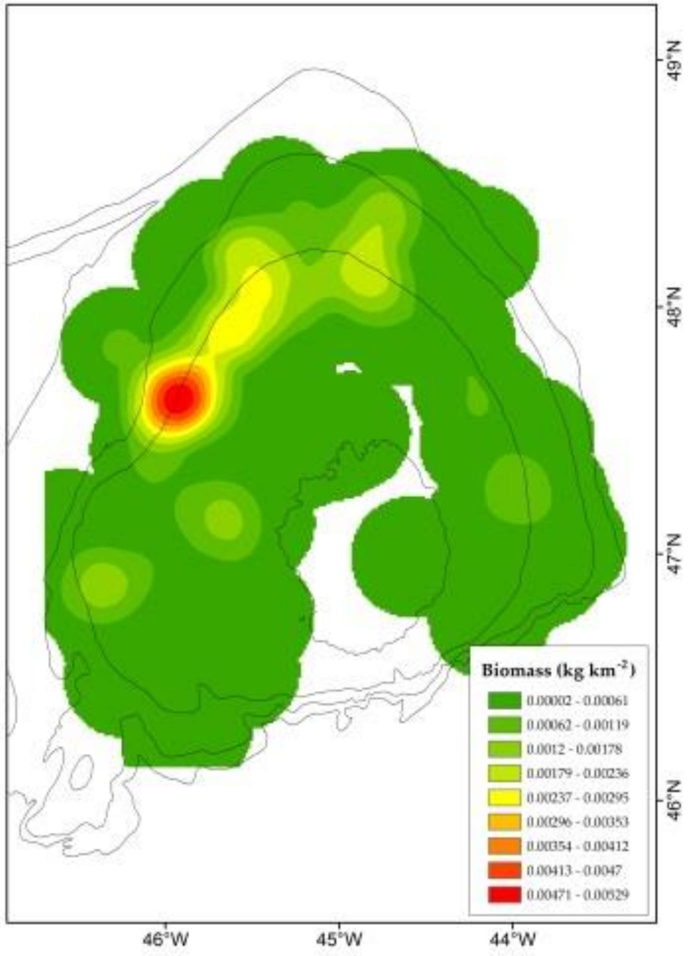
Surface Deposit Feeders



Active Filter Feeders



Passive Filter Feeders



Benthic predators

Benthic-Pelagic Coupling

http://paws.wcu.edu/dperlmutr/sponge%20type.JPG

SponGES

Geodia barretti can filter up to 1,000 litres of water per kilogram of tissue each day. Other species have filtration rates of up to 20,000 litres water kg-1 h-1 [dry wt].

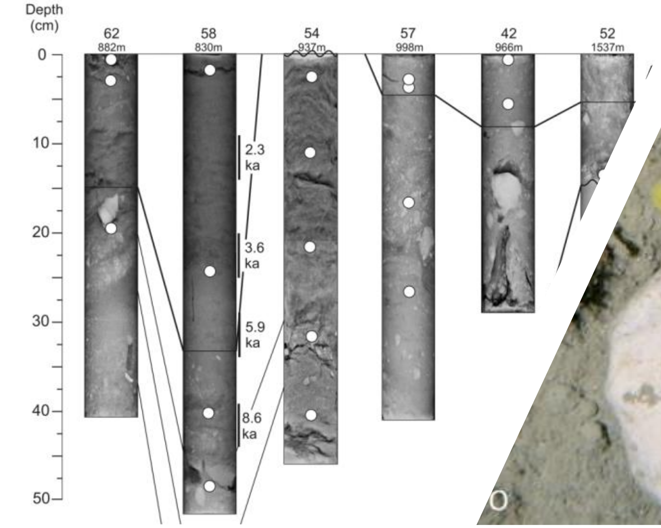
Sponges can remove up to 95% of bacteria and particles from the water and 90% of dissolved organic carbon (DOC).

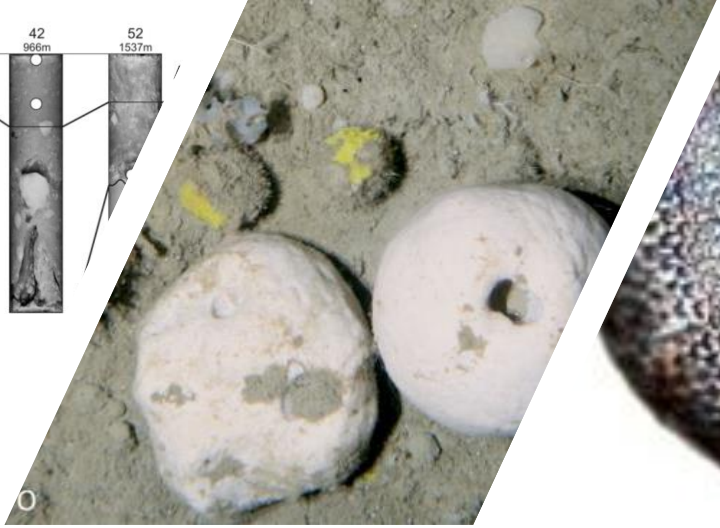
Pham et al. (2019) estimated that the sponge grounds in the Flemish Cap area filter **56,143 million litres** of seawater **daily**. An Olympic-sized pool holds **2.5 million litres** of water!

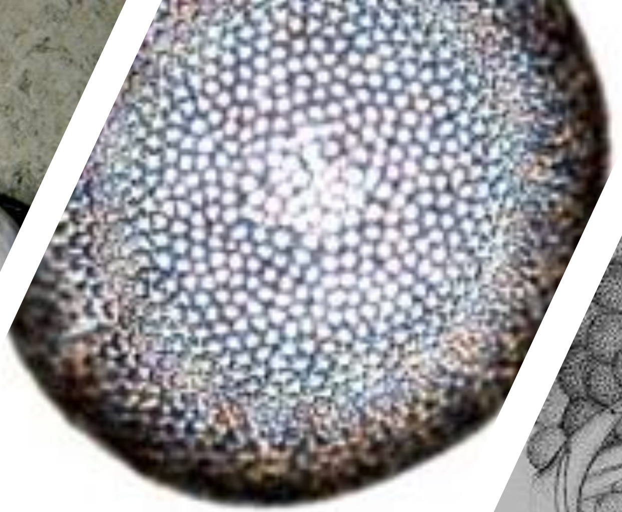
The filtering capacity of the Toronto Ashbridges Bay Treatment Plant is up to **818 million litres day^{-1}**

Pham et al. (2019). Nature Scientific Reports 9: 15843

SponGES

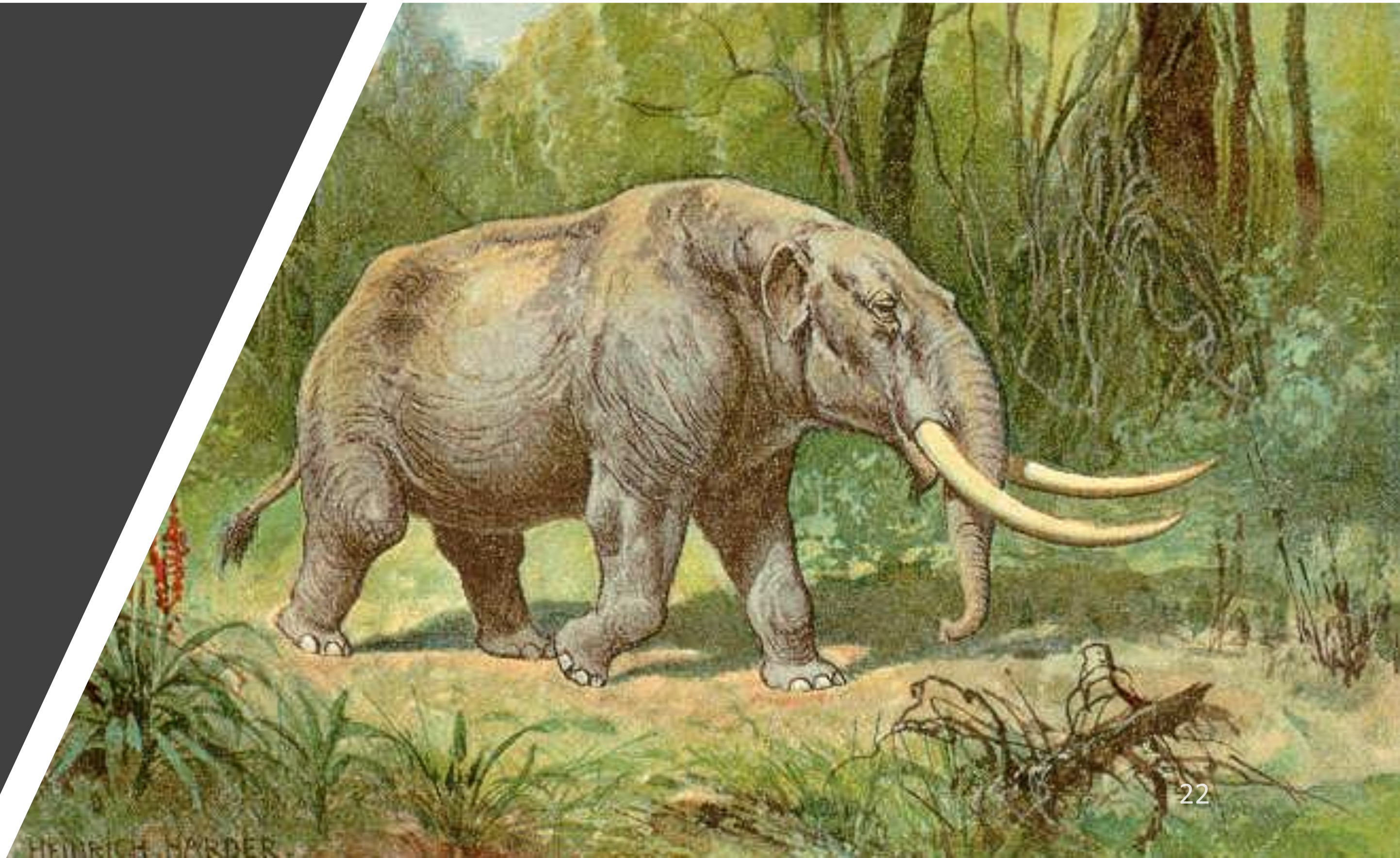




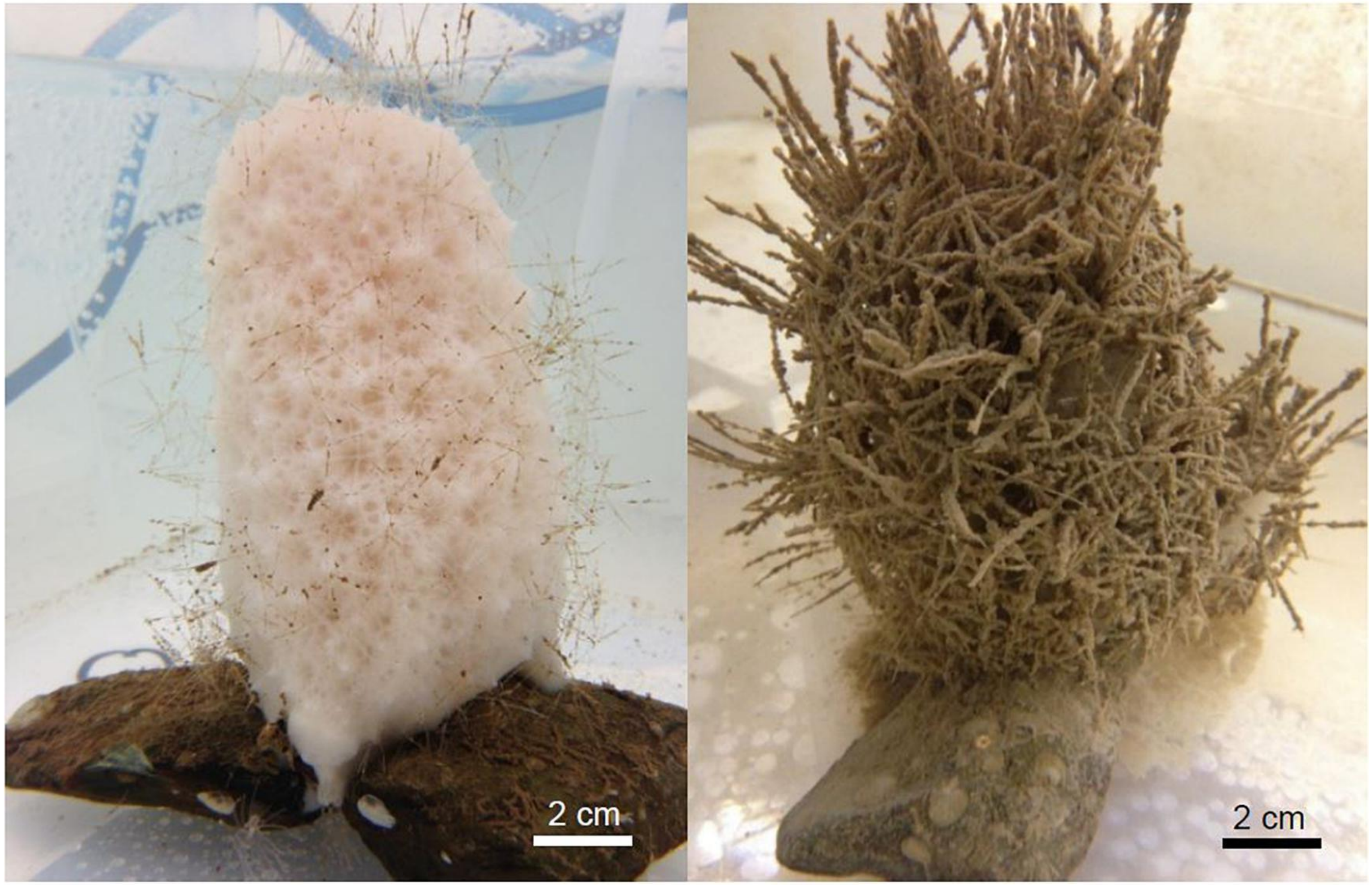


Sediment core samples reveal Sponge Grounds 17,000 BP

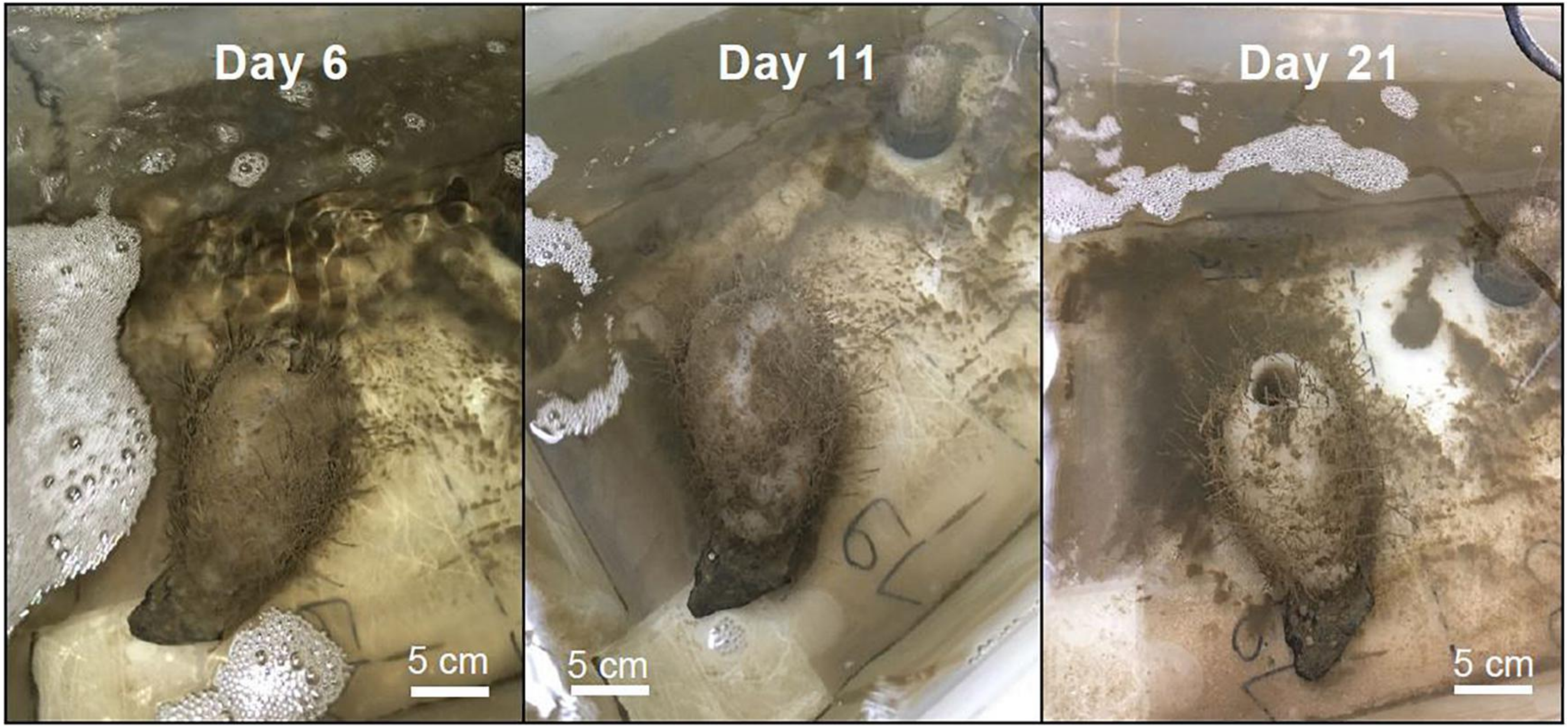
Single long core on Flemish Cap showed that *Geodia* sponges present 130,000 years ago



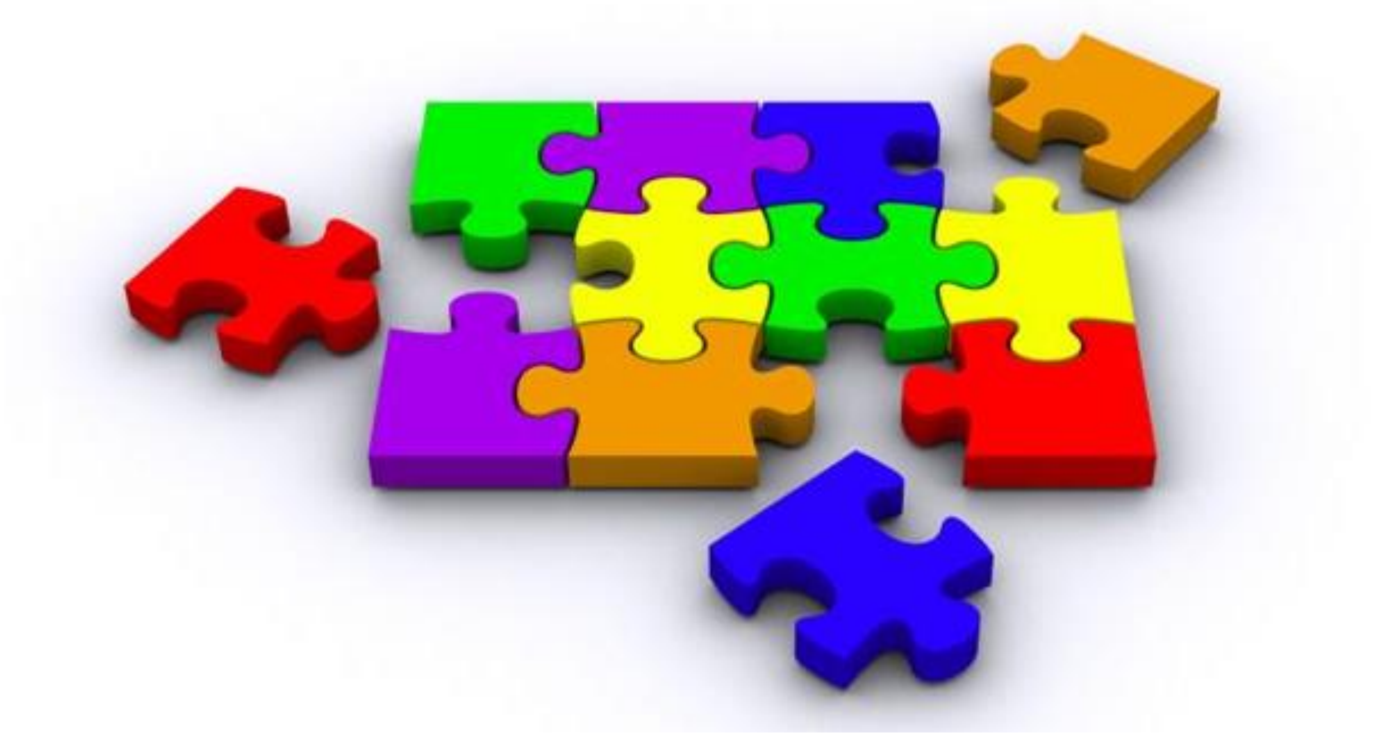
Impacts of Sediment Plumes on Sponges



Wurz et al. (2021) Front. Mar. Sci., 24 March 2021



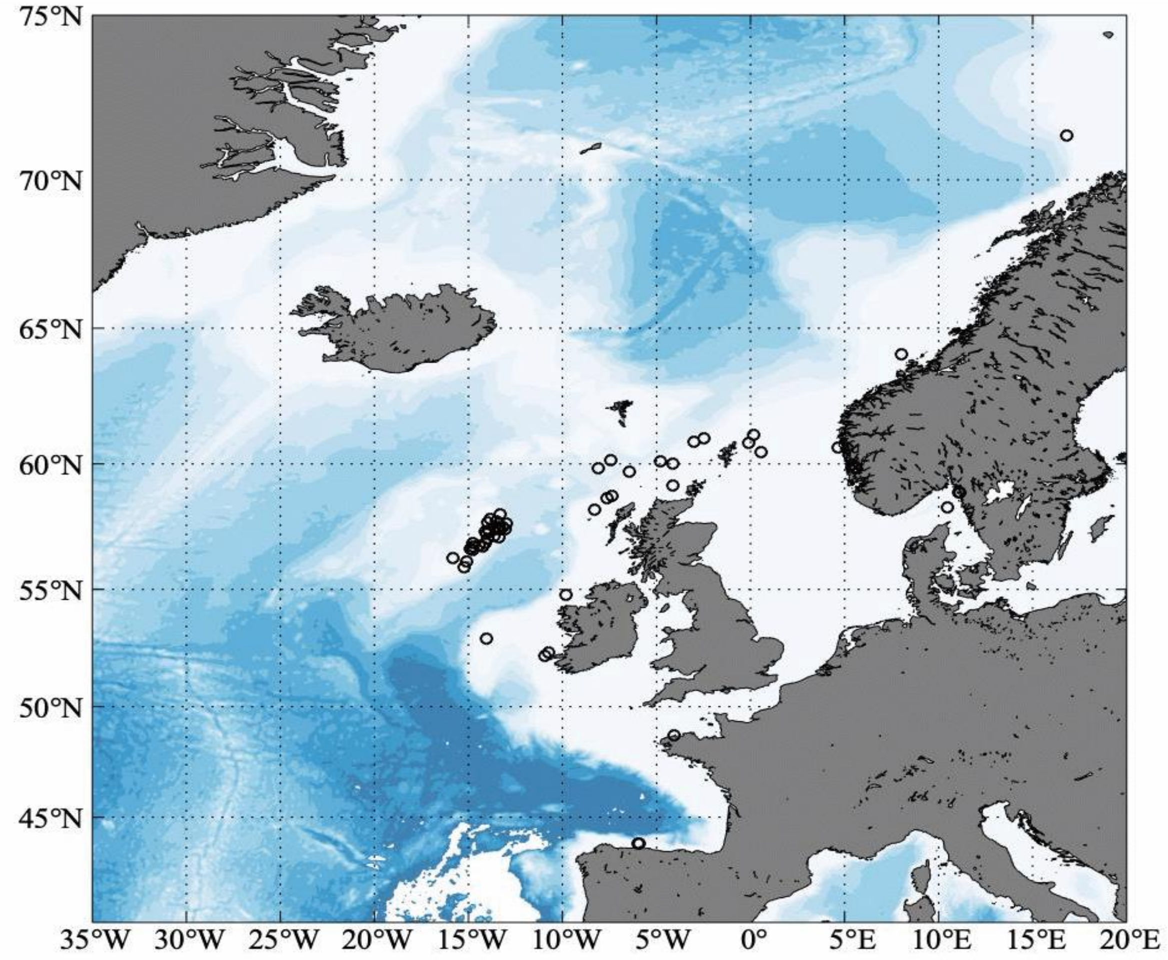
Wurz et al. (2021) Front. Mar. Sci., 24 March 2021




THE OTHER WAY
THIS WAY
THAT WAY


CHANGES
AHEAD

Connectivity - Lagrangian Particle Tracking Models



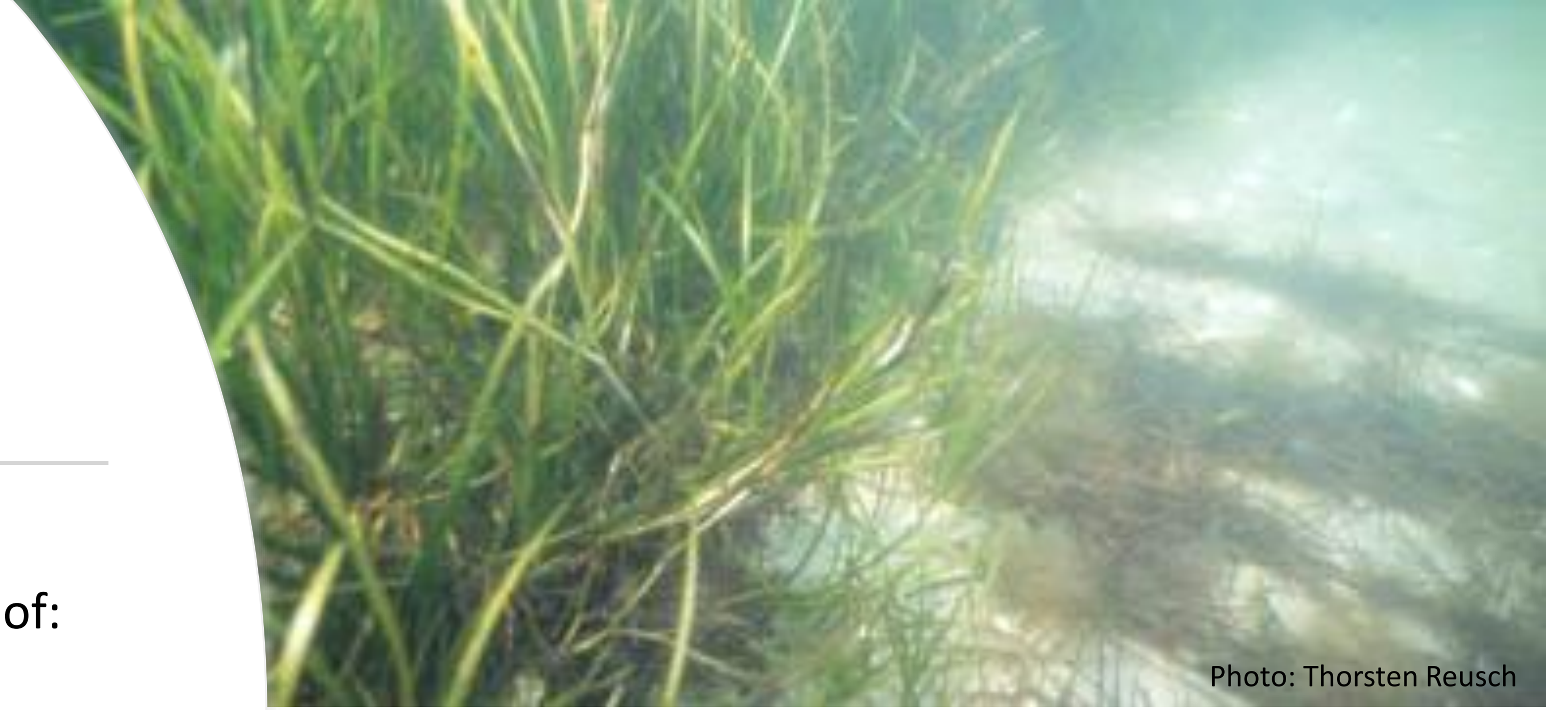
Taboada et al. (2022) Molecular Ecology (Submitted)

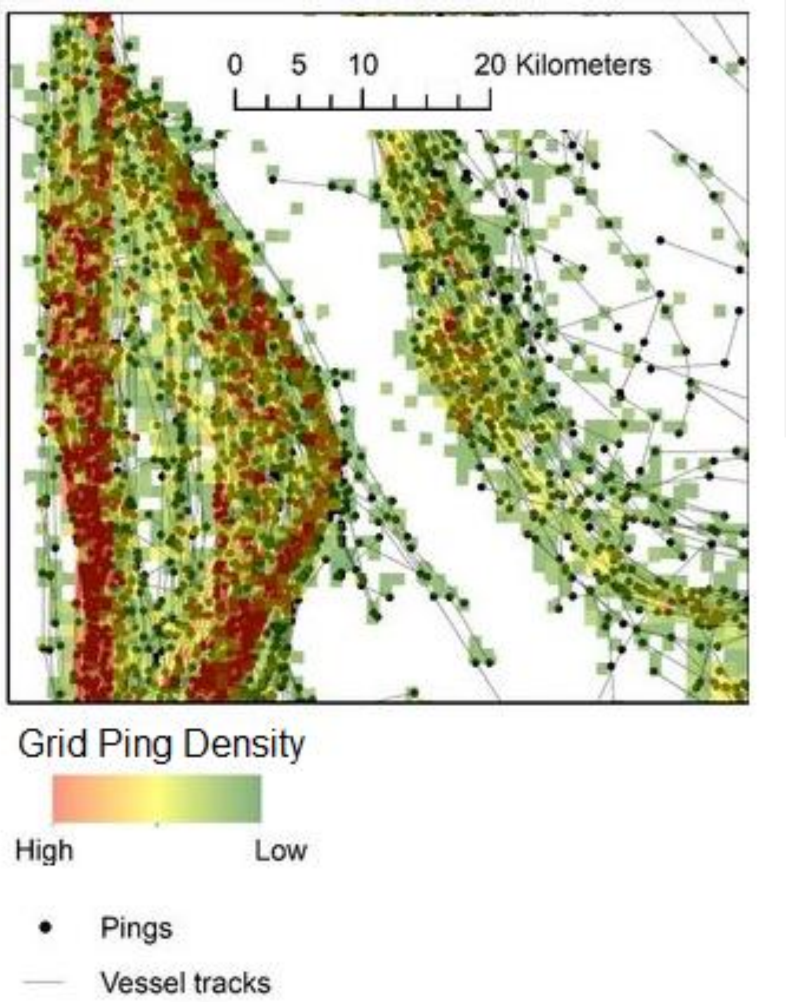
Habitat Configuration and Closed Area Networks

Habitat configuration includes properties of:

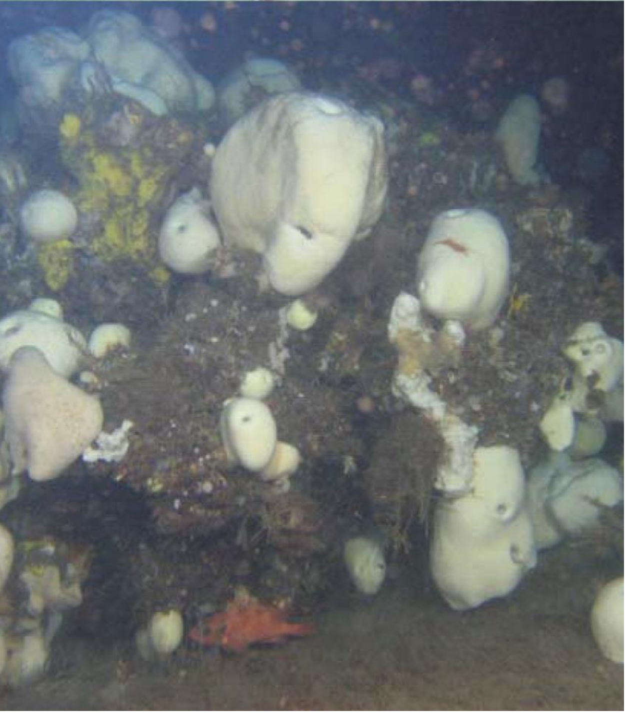
- Total habitat area
- Patch size
- Patch number
- Amount of edge
- Degree of isolation (connectivity)

Andrén, H. 1994. Oikos 71: 355–366.

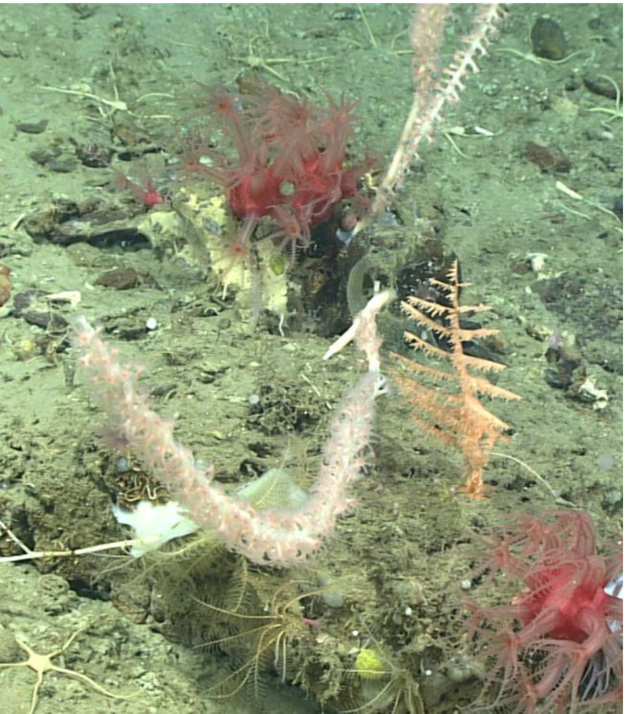




Habitat Fragmentation and SAI



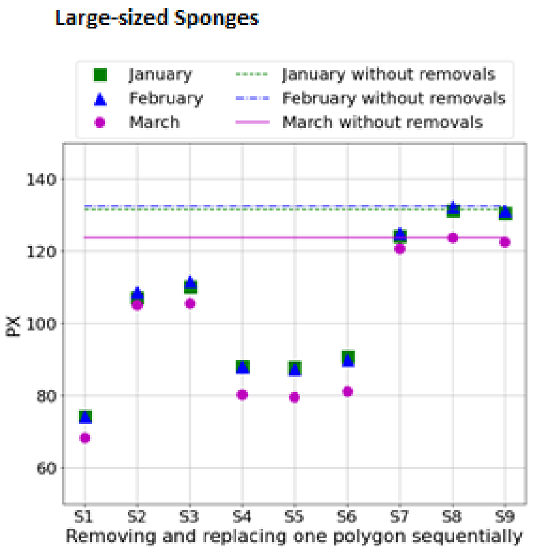


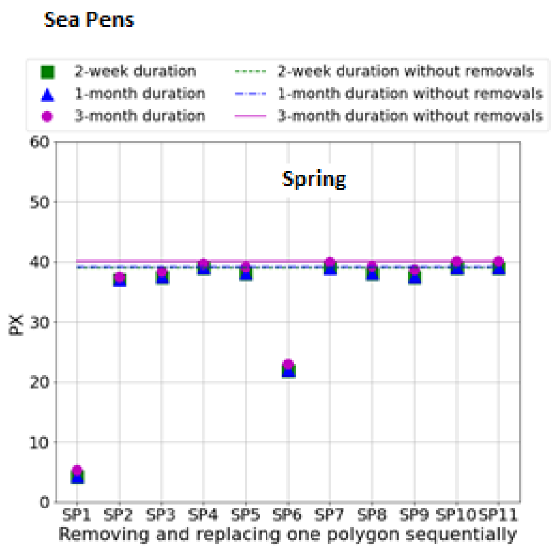


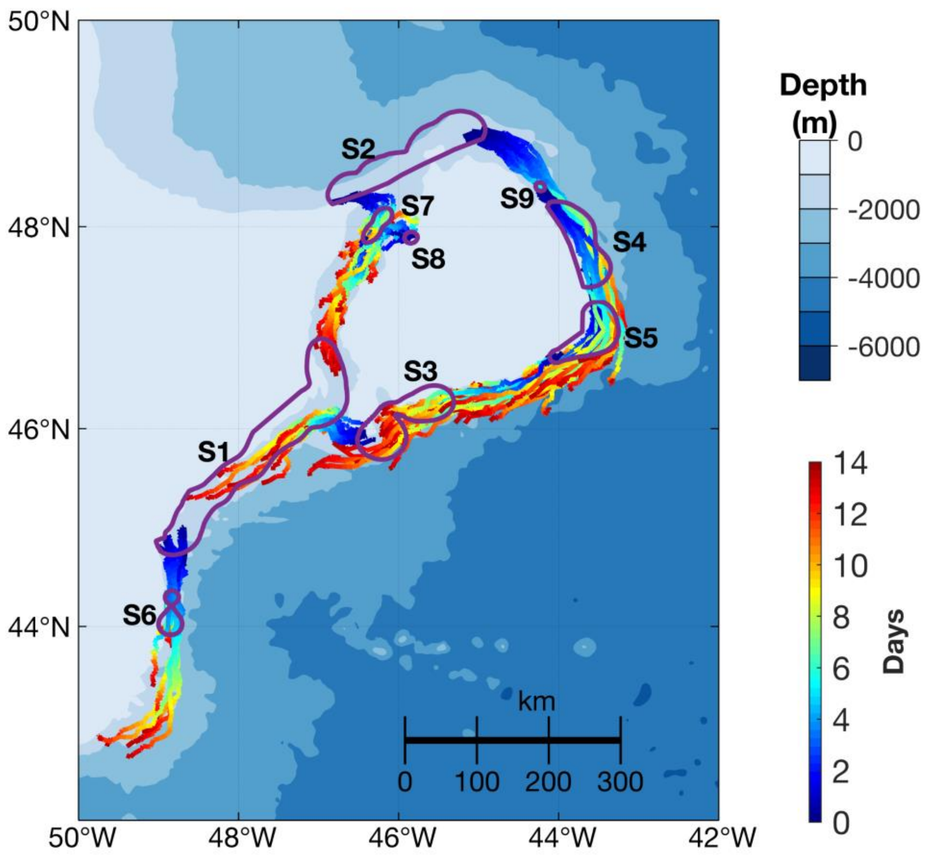

Seven Focal Benthic Habitats

- Foundation species (structure-forming)
- Locally enhance biodiversity
- Vulnerable marine ecosystems
- Deep-sea habitats (200-2000 m)
- Passive larval dispersal (lecithotrophic, short PLD)
- Bottom currents > 10 cm s^{-1}

Simulations of Habitat Loss







Fish Use of Vulnerable Marine Ecosystems

Correspondence

Sponges as natural environmental DNA samplers

Stefano Mariani[1,2,*], Charles Baillie[1], Giuliano Colosimo[3], and Ana Riesgo[4]

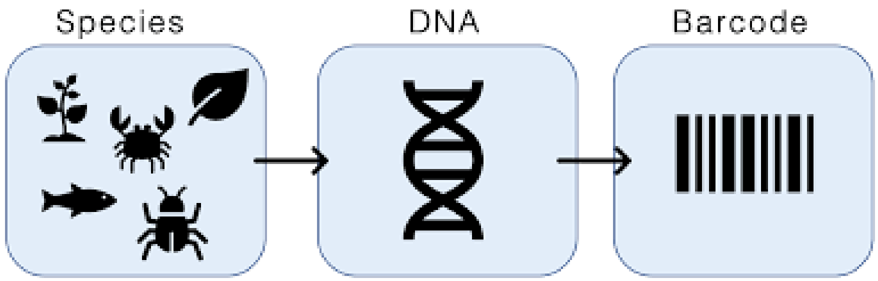
At a time of unprecedented impacts on marine biodiversity, scientists are rapidly becoming persuaded by the potential of screening large swathes of the oceans through the retrieval, amplification and sequencing of trace DNA fragments left behind by marine organisms; an approach known as 'environmental DNA' (eDNA) [1]. In trying to circumvent the many challenges associated with water filtration and DNA isolation from environmental samples, significant investment is being made in high-tech solutions, such as automated underwater vehicles and robots [2]. Here, instead, we explored a simpler, alternative option, based on the recovery of eDNA from sponges (phylum Porifera), the planet's most effective water-filterers. We obtained sponge samples from Mediterranean and Antarctic surveys, extracted total DNA from their tissues, and obtained tens of thousands of fish DNA reads via metabarcoding, which were able to clearly distinguish samples from the two regions. One Antarctic sample yielded hundreds of reads from chinstrap penguin (*Pygoscelis antarcticus*) and Weddell seal (*Leptonychotes weddellii*). We argue that this 'natural sampler DNA' (nsDNA) approach is poised to become a powerful, affordable, universal tool for aquatic biodiversity monitoring globally.

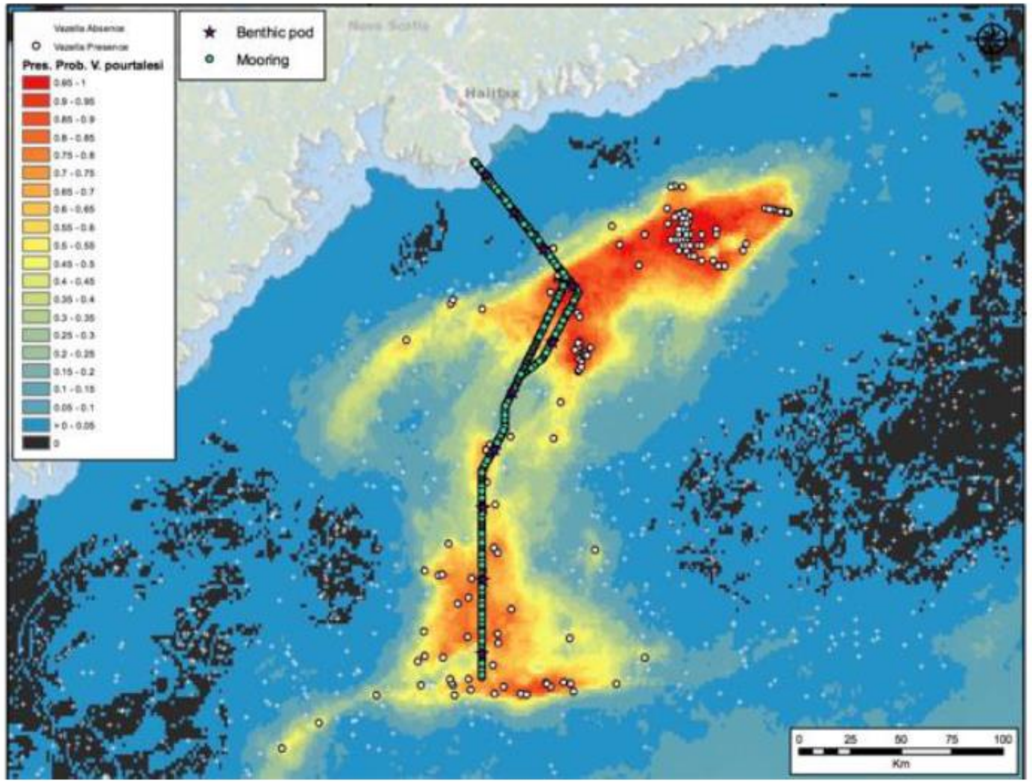
In just a few years, eDNA metabarcoding has surged as a novel, revolutionary approach to biodiversity monitoring [3], and despite the caveats and unknowns inherent to every new method [4], overwhelming evidence indicates greater speed and efficacy in taxon detection, compared with traditional 'catch-and-see' techniques [5]. Most recently, researchers are turning to automation and robotics [2] in the attempt to streamline filtration, DNA isolation and detection, and to screen larger volumes of water, which is paramount in large ecosystems like the

litres of water in one day [6] — that is about 1000-fold the sampling effort normally achieved through current rosette-based sampling in marine habitats. The sponge tissue naturally traps and concentrates the particles from which environmental DNA is isolated, effectively acting as a natural filter. We hypothesized that by extracting DNA from sponge samples and subjecting it to metabarcoding for a fish-specific 12S mtDNA marker [7], we would be able to recover

a 12S amplicon library, and sequenced in parallel. The nine samples yielded 246,910 reads (around 0.02% of the total run), and recovered at least 31 metazoan taxa, of which 22 could be identified at least to the Family level or below (Supplemental Information). These comprised five typically Antarctic Notothenioid species, including black rockcod (*Notothenia coriiceps*), emerald rockcod (*Trematomus bernacchii*) and Antarctic toothfish (*Dissostichus mawsoni*), as well as

Current Biology 29, R395–R402, June 3, 2019 © 2019 The Authors. Published by Elsevier Ltd. R401





LIVERPOOL JOHN MOORES UNIVERSITY

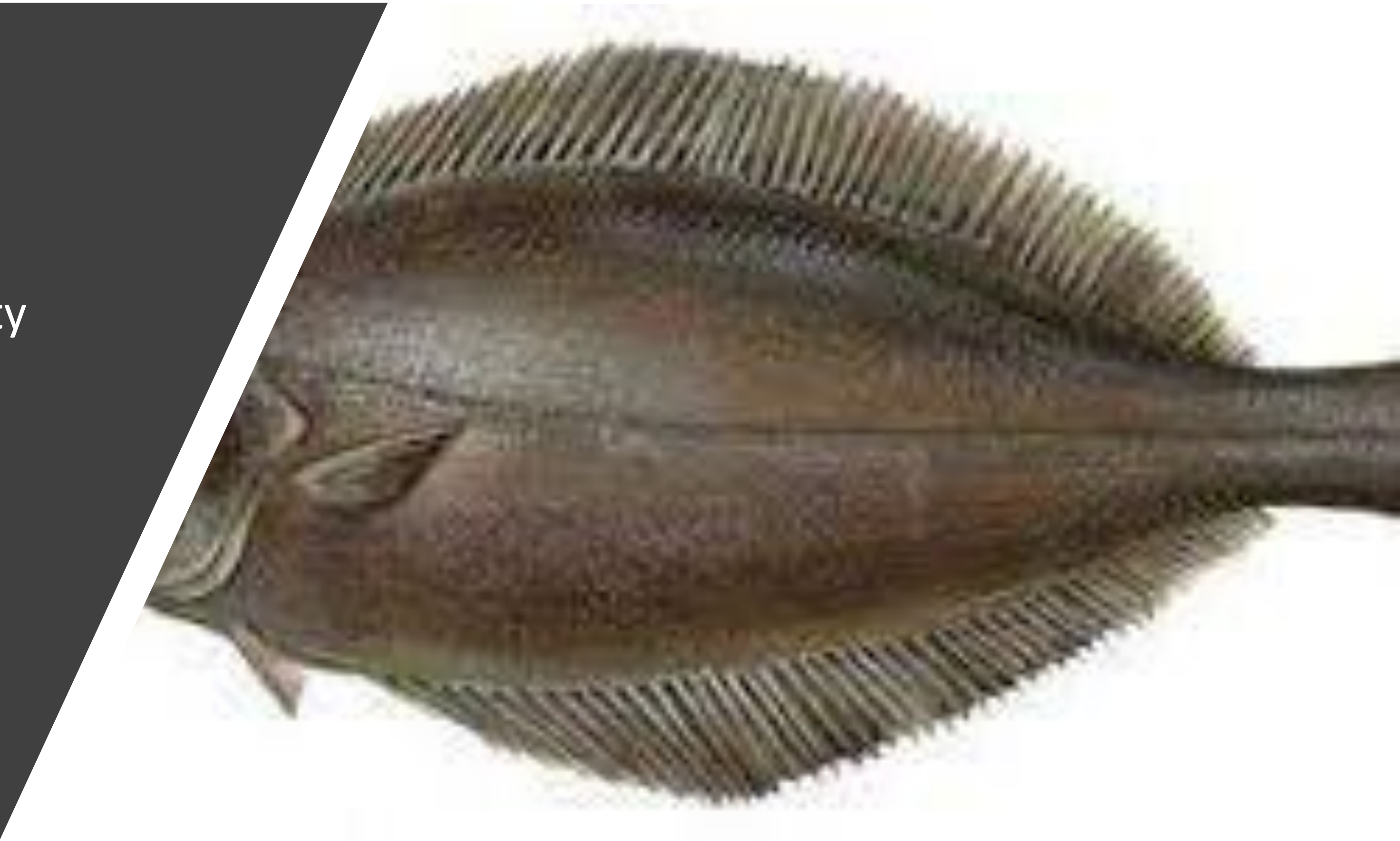
Fisheries and Oceans Canada / Pêches et Océans Canada

mncn

OCEAN TRACKING NETWORK

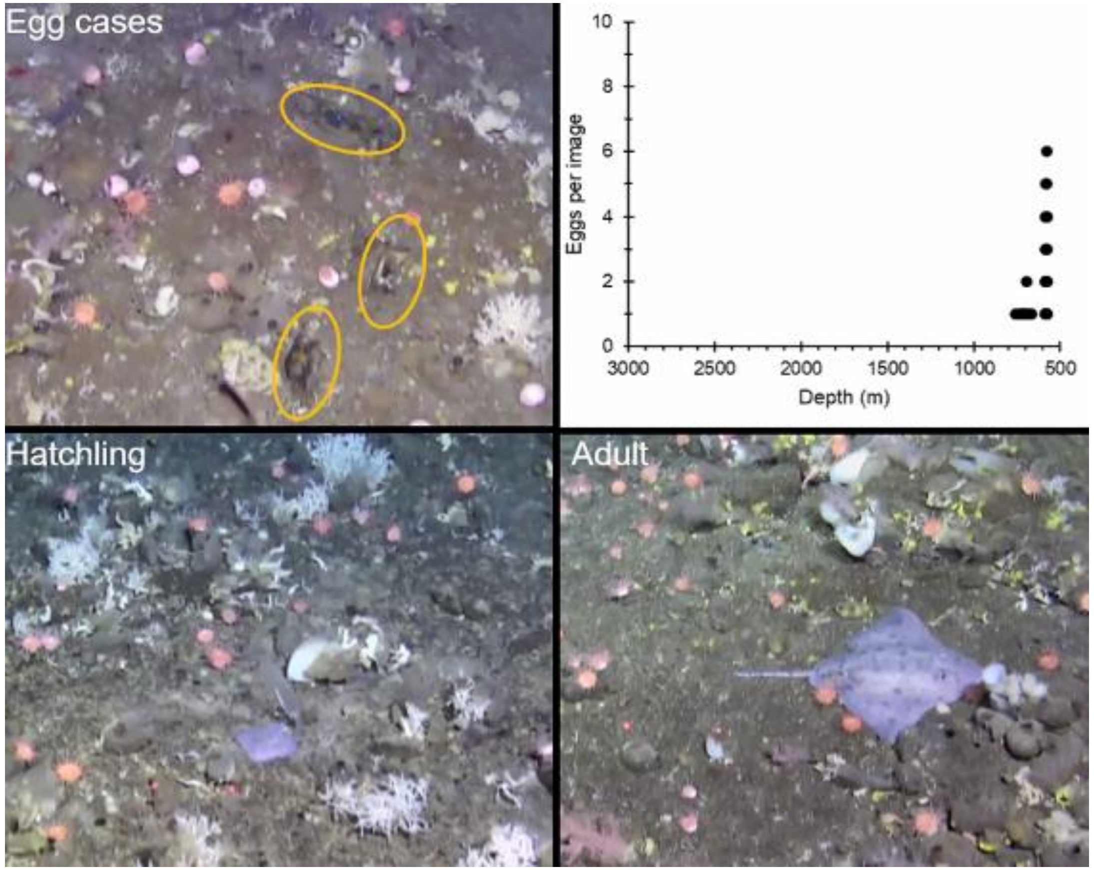



Vazella specimens used to optimize the methodology, revealed trapped biodiversity of approx. 20 species (7 cetaceans, including blue whale).



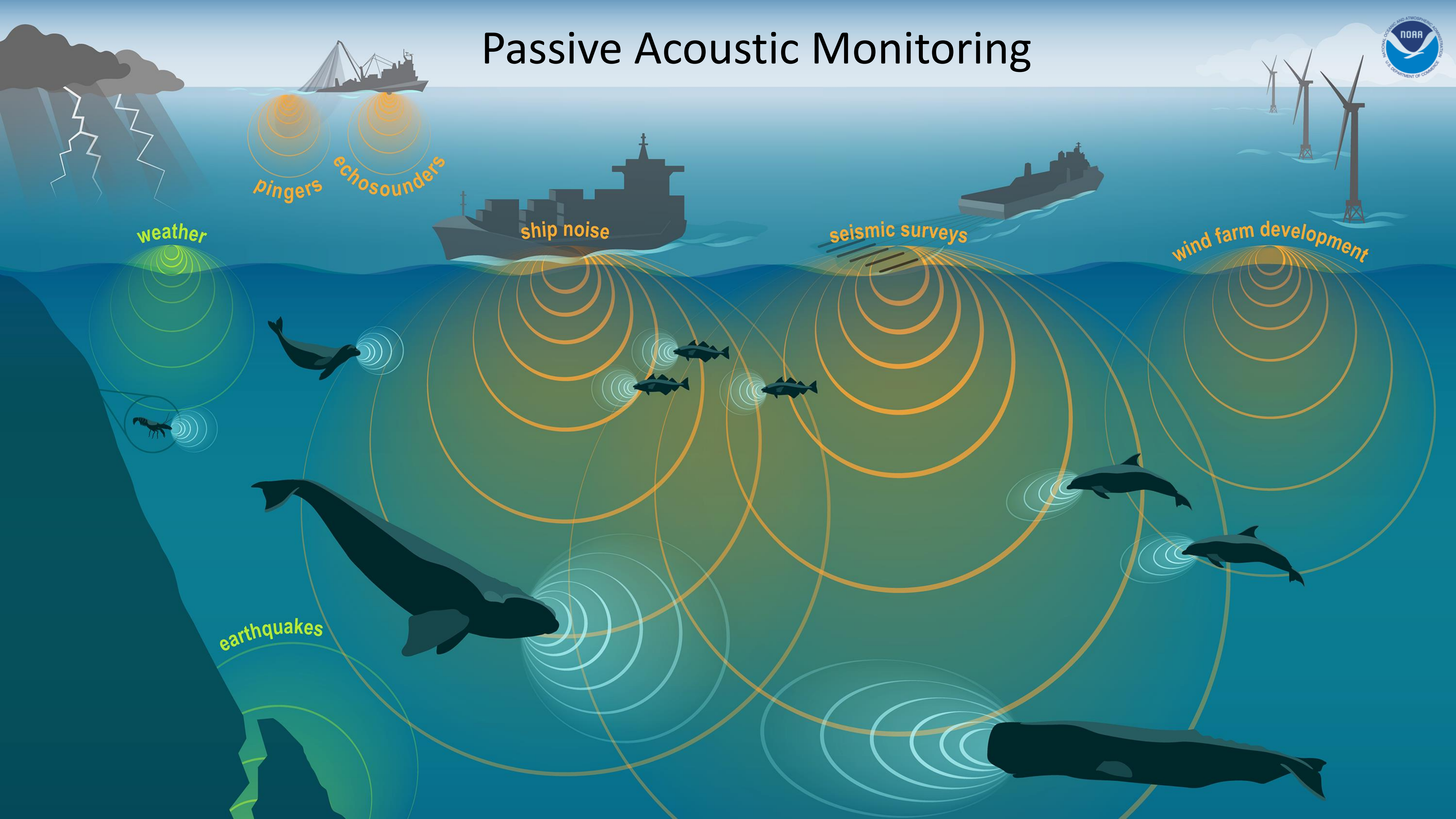
Fish Use of Vulnerable Marine Ecosystems

Amblyraja hyperborea (Collett, 1879). Arctic skate.

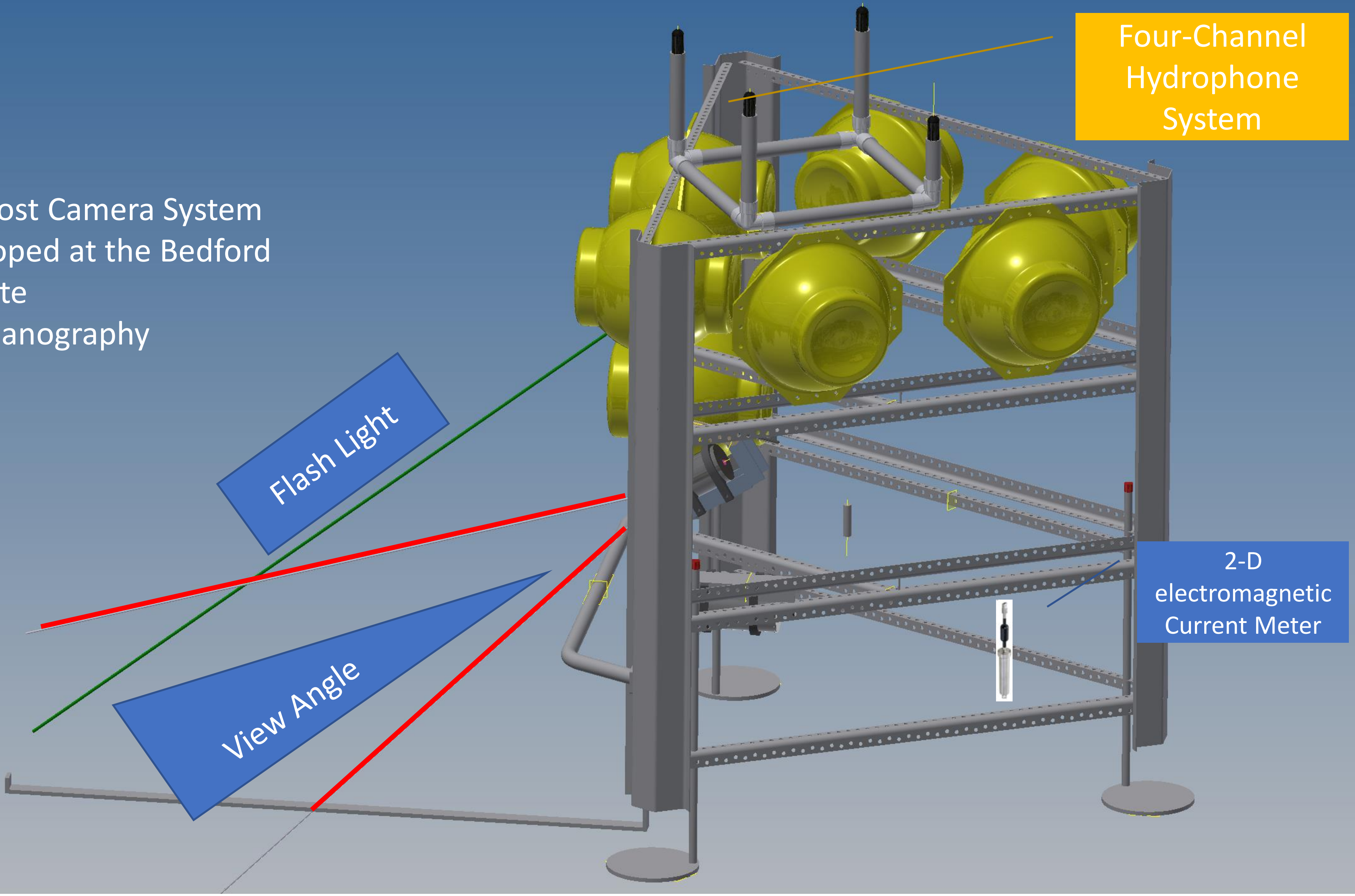


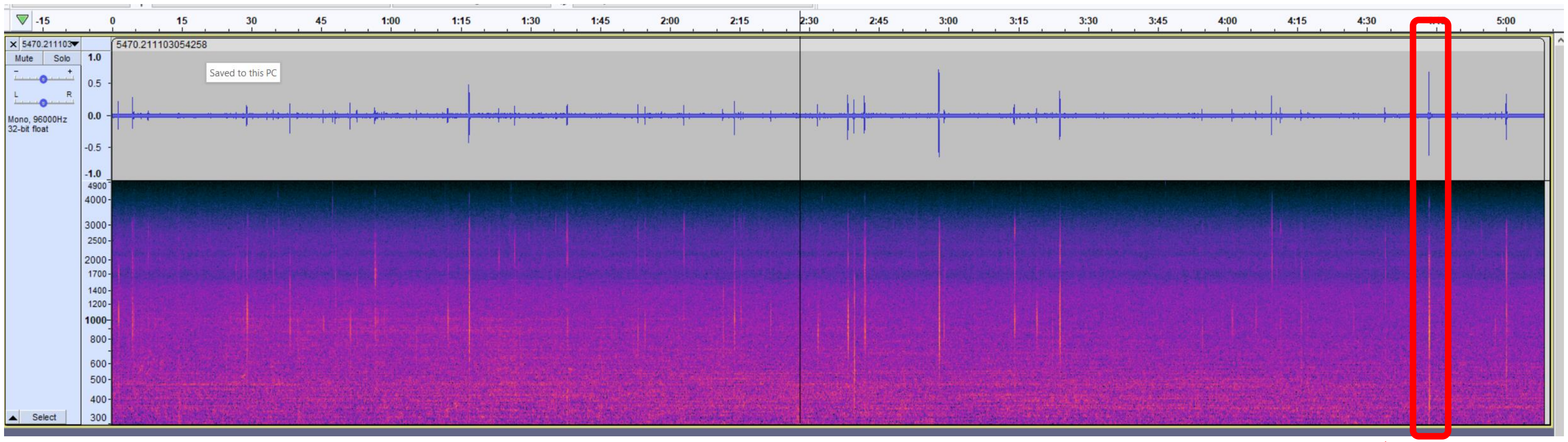
Meyer, H. (2022) PhD Thesis, University of Bergen


Passive Acoustic Monitoring

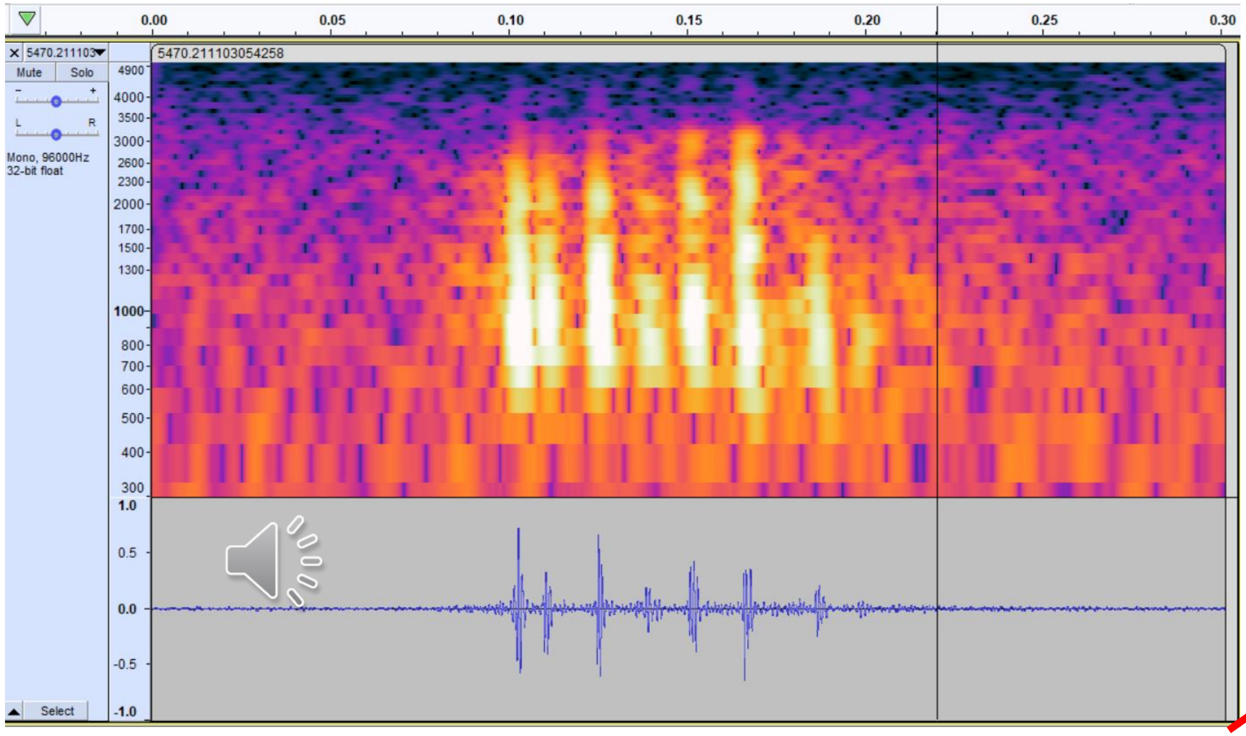


Low-Cost Camera System
Developed at the Bedford
Institute
of Oceanography





Fish Grunt Sound from Lander#1- Zoomed in (0.30 Second)



Play Speed is reduced 5 times from original soundtrack.


Blue Shark

OCEAN
TRACKING NETWORK


Atlantic Salmon


Bluefin Tuna


Thank you - Merci beaucoup