Evaluating the risk of vulnerable marine ecosystems to commercial fisheries in Arctic and subarctic waters

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Nordic project on vulnerable marine ecosystems and anthropogenic activities in Arctic and sub-Arctic waters (NovasArc)

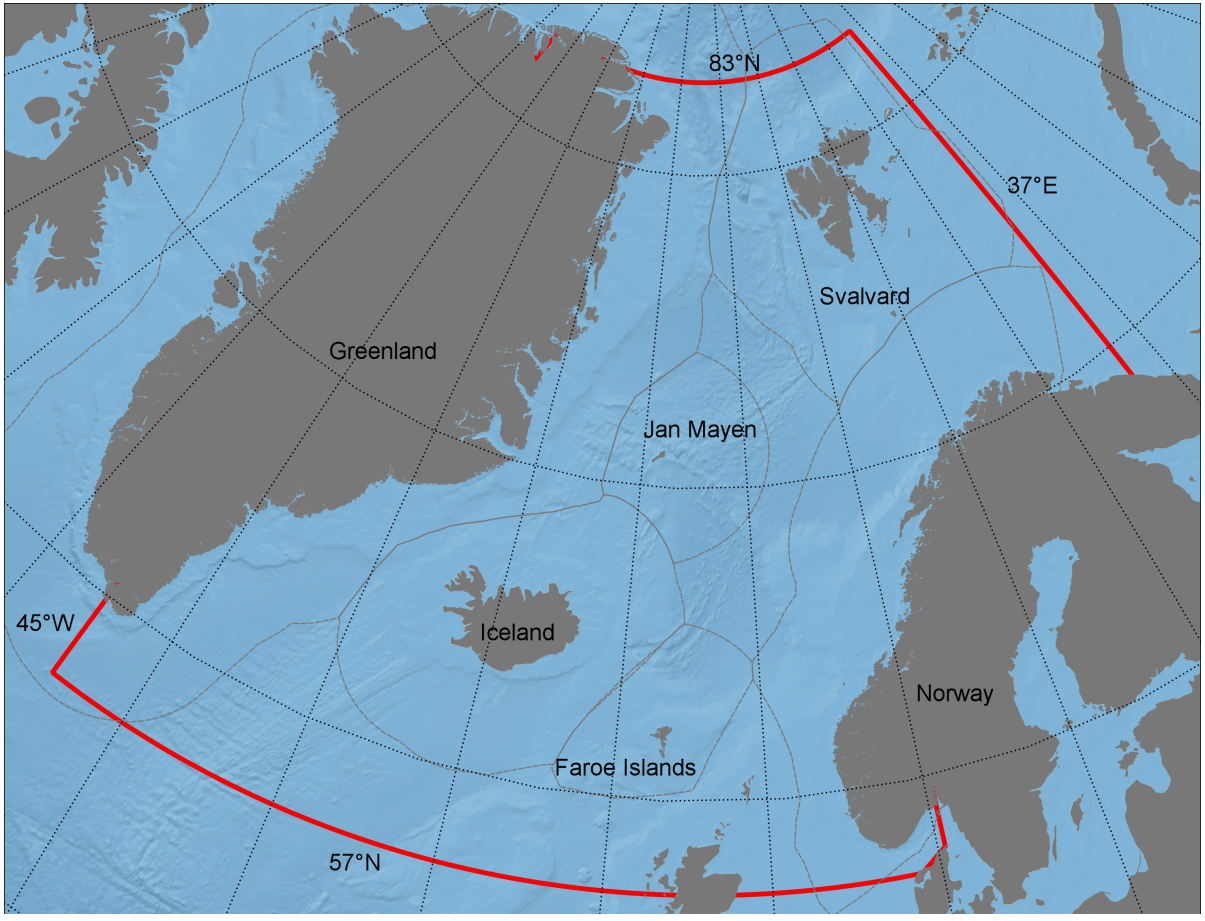
Collaboration between Institute of Marine Research (Norway, lead), the Marine and Freshwater Research Institute (Iceland) and the Faroe Marine Research Institute (Faroe Islands).

Funded by the Marine Group (HAV) and the Working Group for Fisheries (AG-Fisk) of the Nordic Counsel of Ministers.

Objectives

- Map/predict the distribution of Vulnerable Marine Habitats
- Map commercial fisheries and other antropogenic activities
- Identify potential conflict areas

Study area


83°N
37°E
Svalvard
Greenland
Jan Mayen
45°W
Iceland
Norway
Faroe Islands
57°N

Vulnerable Marine Ecosystems (VMEs)

Vulnerable Marine Ecosystems (VMEs)

- Uniqueness or rarity
- Functional significance
- Fragility
- Life history traits that difficult recovery
  - Slow growth
  - Late maturity
  - Low or unpredictable recruitment
  - Long lived
- Structural complexity
- VME indicator species: taxa that *signal* the presence of VMEs

FAO 2009 Interlational Guidelines for the Managment of Deep-Sea Fisheries in the High Seas

Soft bottom sponge aggregations

Images: MAREANO/IMR

Large sponges, including *Geodia* spp., *Stryphnus ponderosus* and *Steletta* spp.

Hard bottom sponge aggregations

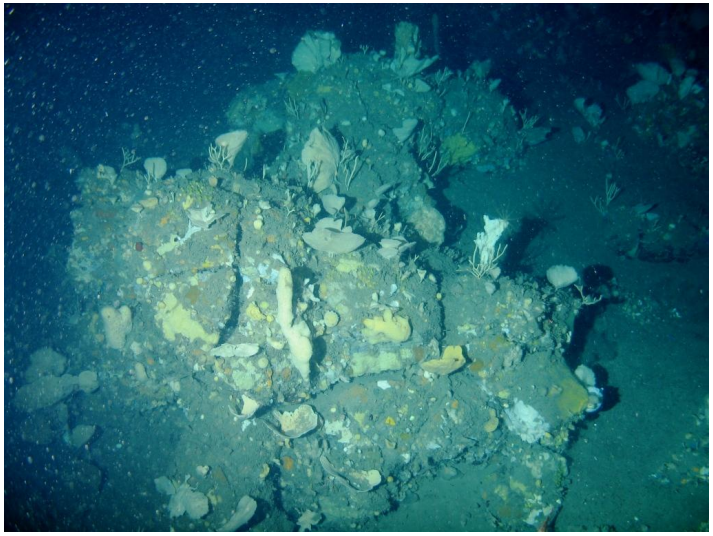


Image:MFRI

Medium sized sponges including axinellid sponges (e.g: *Phakellia* spp., *Axinella infundibulum*), *Antho dichotoma* and *Mycale lingua*.

Deep arctic sponge aggregations

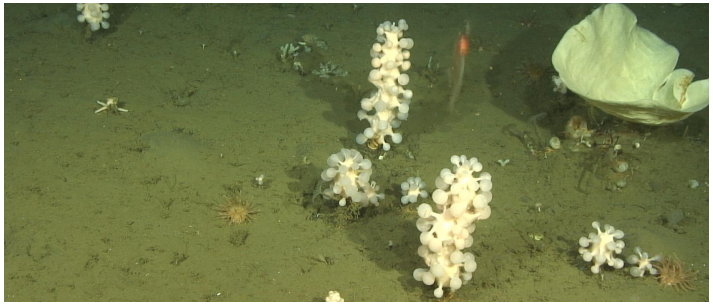


Image: MFRI

Image: MAREANO/IMR

Caulophacus arcticus, *Chondrocladia gigantea* and *Cladorhiza sp.*

Soft bottom coral gardens

Image:MAREANO/IMR

Image:MFRI

Gorgonians (*Radicipes gracilis*, *Isidella lofotensis*, *Acanella arbuscula*), and cup corals (*Caryophylla*, *Flabellum* and *Stephanocyanthus*).

Reefs

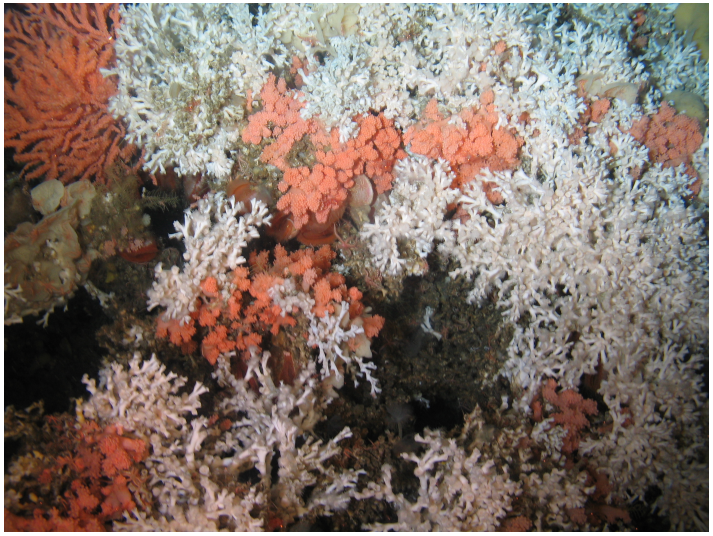


Image:MFRI

Desmophilum pertussum, *Madrepora oculata*, *Solenosmilia*. Verified from video or photographs.

Hard bottom coral gardens

Image: MAREANO/IMR

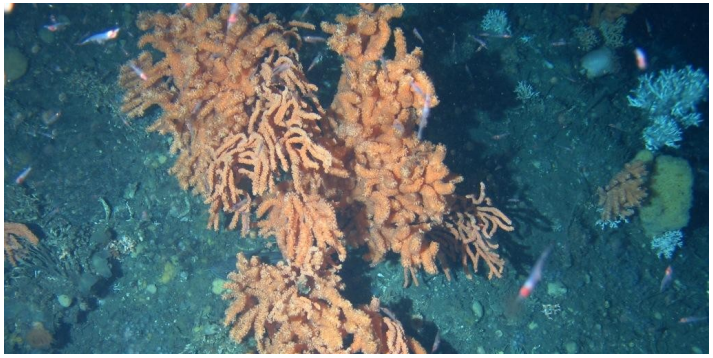


Image: MFRI

Non reefal scleractineans, gorgonians (*Primnoa*, *Paragorgia*, *Paramuriea*), Stylasterid corals, cauliflower corals.

Shelf seapen communities

Image: MAREANO/IMR

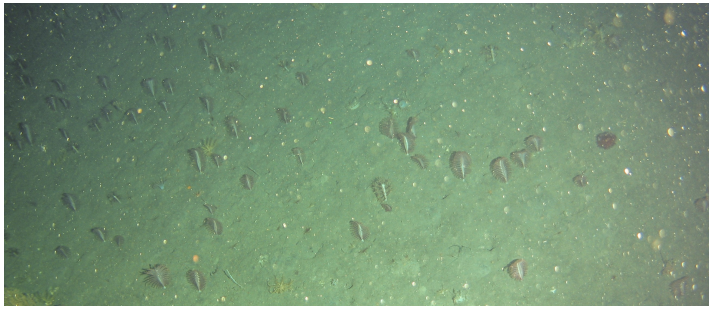


Image: MFRI

Funiculina spp., *Virgularia spp.*, *Pennatula spp.*, *Kophobelemnon spp.*

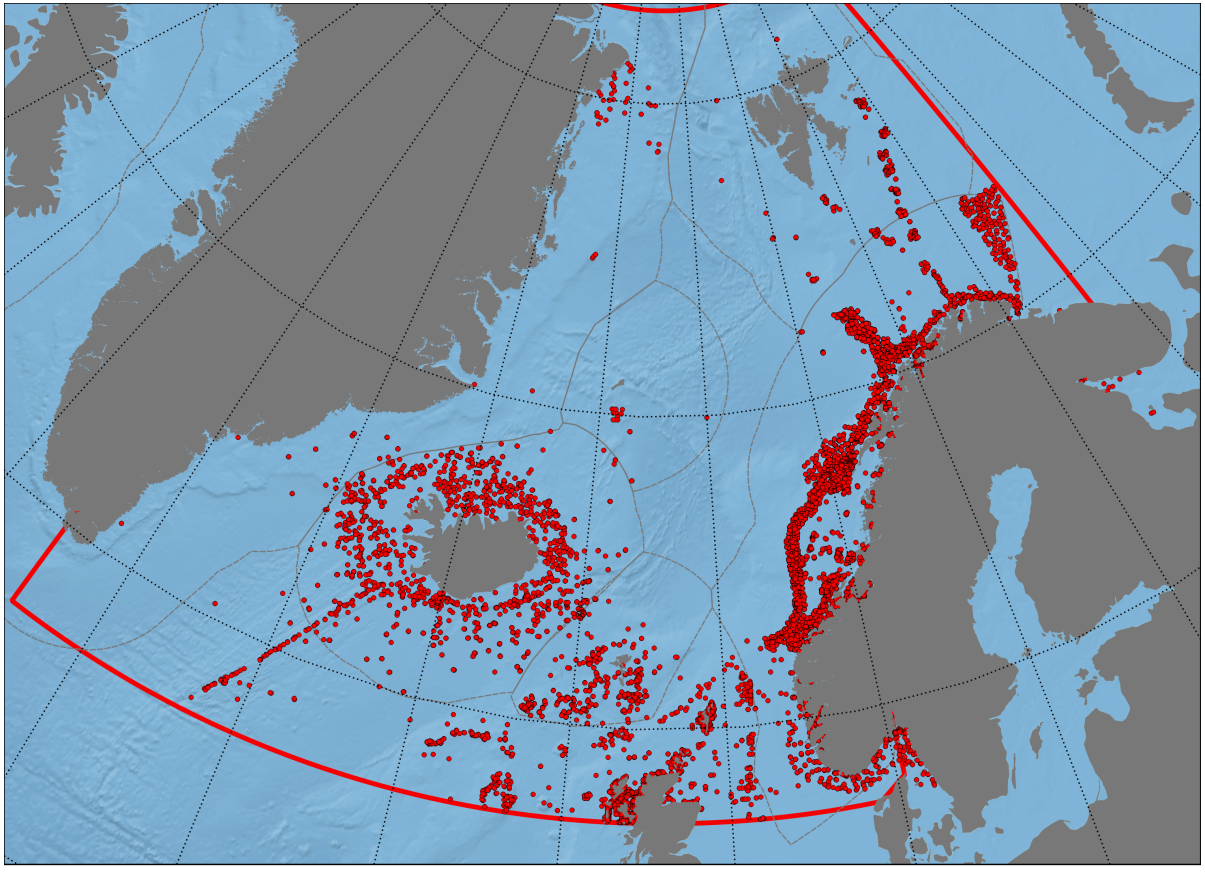
Deepwater sea seapen communities

Image:MAREANO/IMR

Umbellula spp., *Anthoptilum spp.*

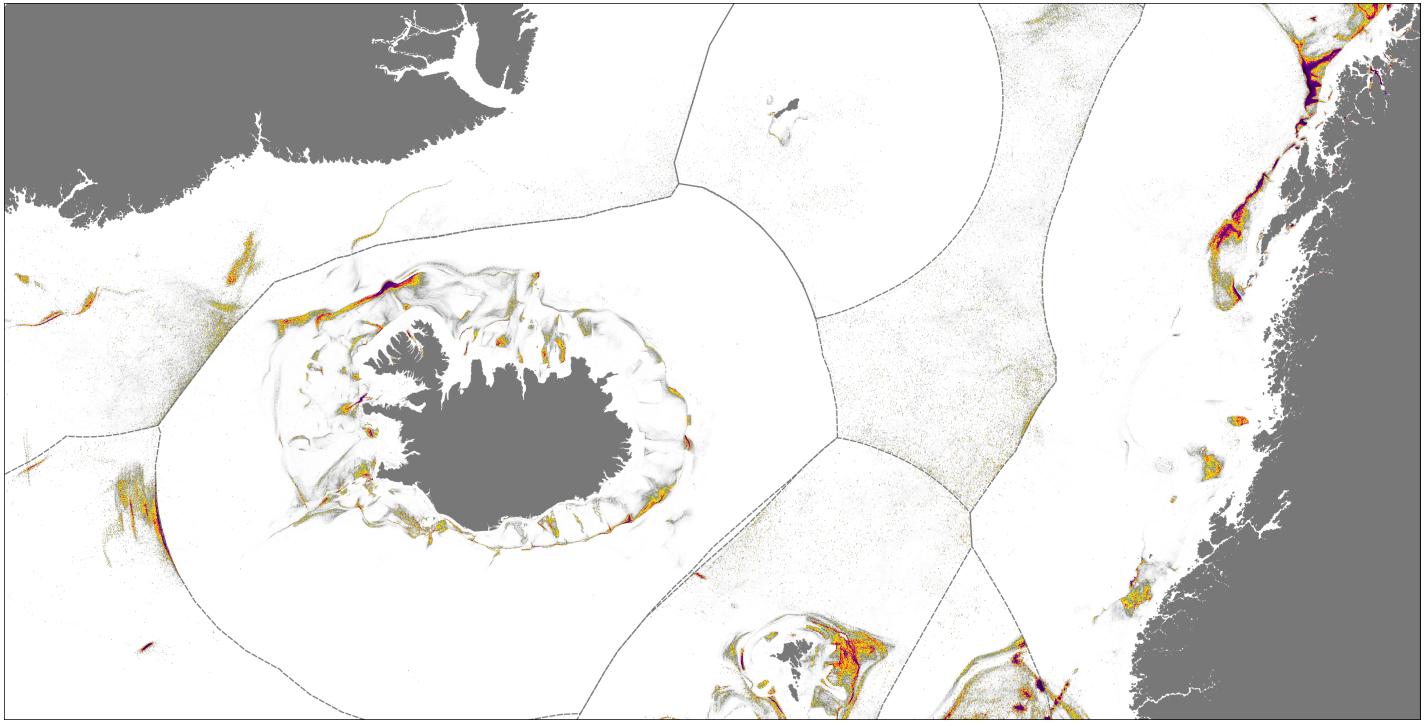
VME database

- Compiled a database with >48000 records of VME indicator species.
- Sources: habitat mapping surveys, bycatch from trawl surveys, publications, OBIS...



Fishing effort

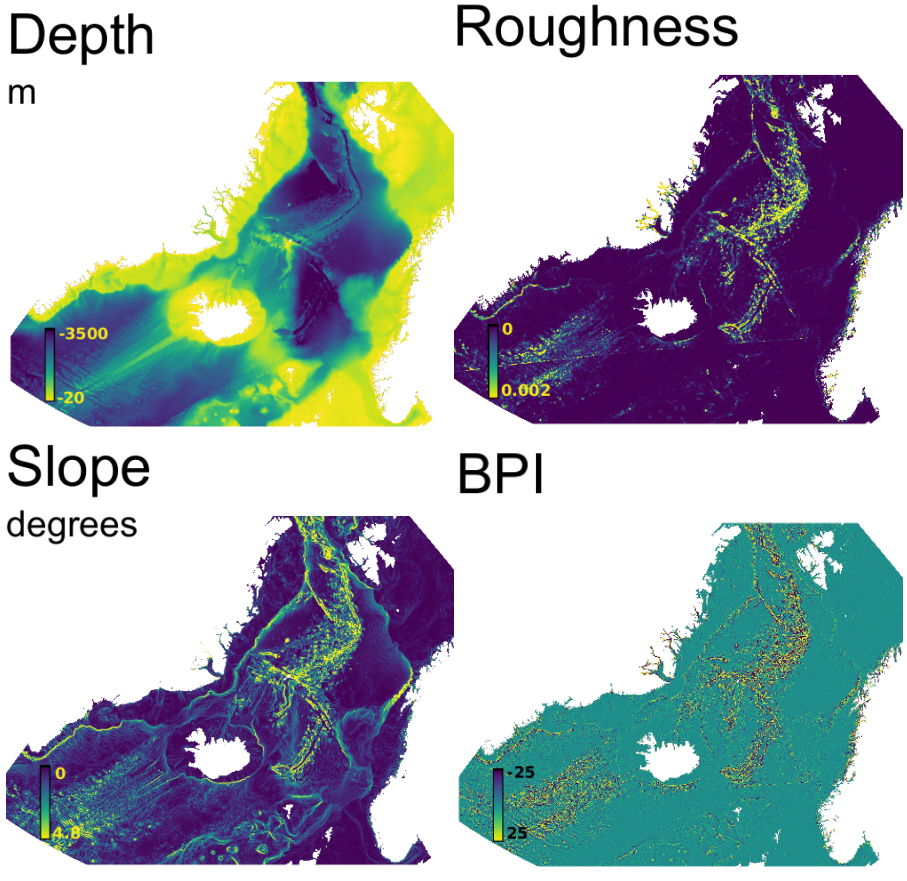
- Swept area ratio (SAR) estimates for active fishing gears contacting the bottom (2013-2015).
  - Iceland, Norway, Faroe Islands: VMS
  - Other areas: AIS data from Global Fishing Watch
- SAR computed with an adaptive grid. Resolution 150 to 2500 m.



Habitat suitability modelling

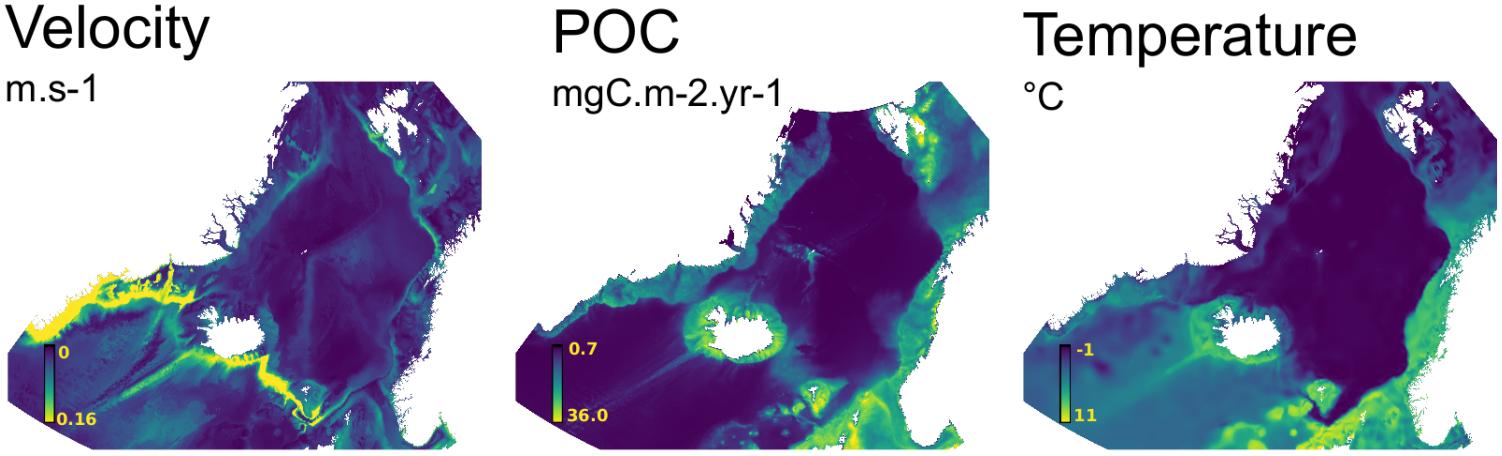
Predictors

- ETOPO 1 bathymetry (500 m)
- Terrain analysis variables at two scales (1500 and 5000 m): slope, aspect, bathimetric position index (BPI), and vector roughness.



Predictors

- Current velocity from the Global Ocean Physics Reanalysis (ECMWF)
- Surface primary productivity and particulated organic carbon (POC) in the seabed, from MODIS data.
- Bottom temperature and salinity from the NISE (Norwegian Iceland Seas Experiment) project.
- Bottom oxygen, phosphate, nitrate and silicate from the Global Ocean Biogeochemistry non-assimilative hindcast (PISCES).



Habitat suitability modelling

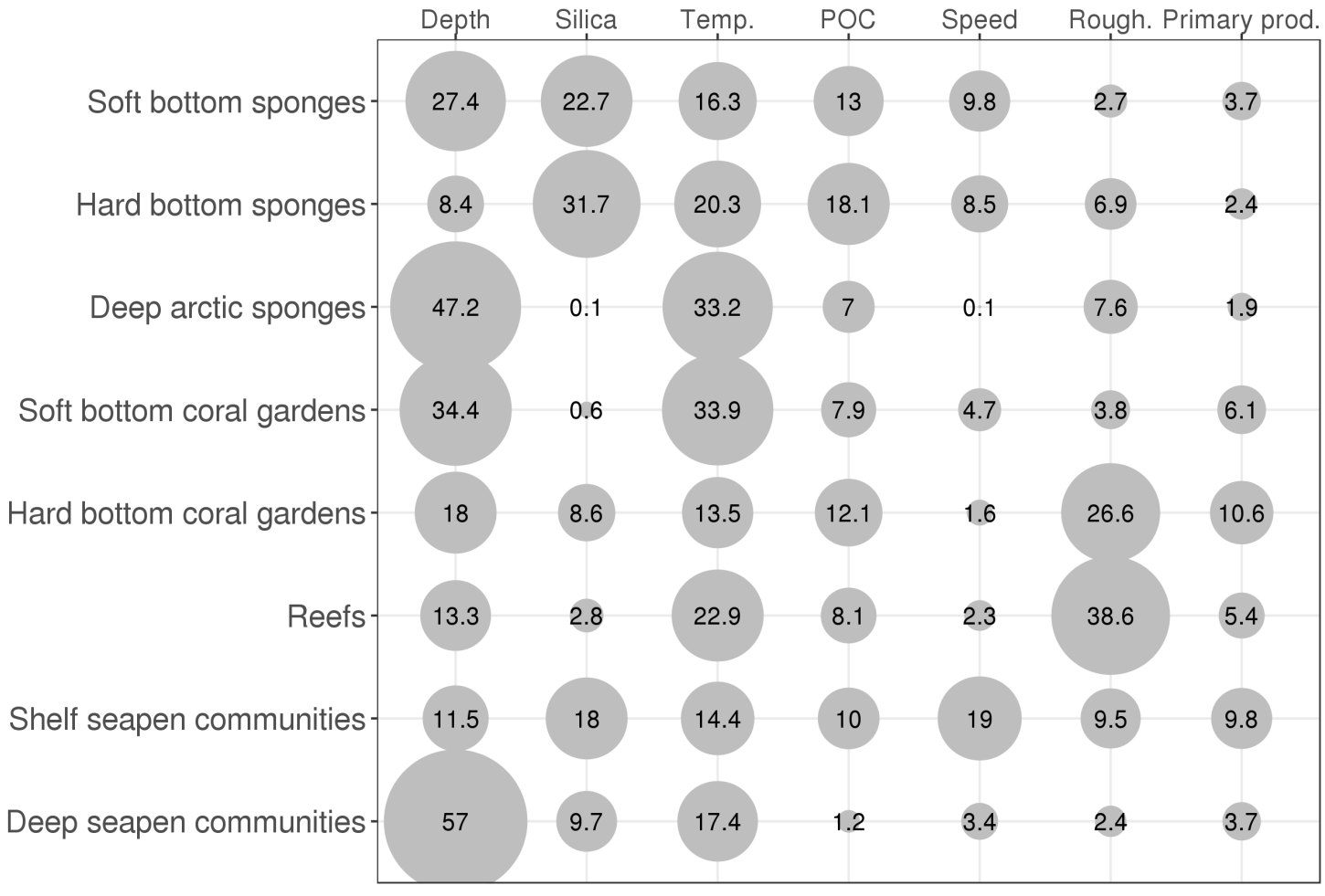
- Maximum Entropy (MAXENT)
- Model complexity selected comparing AUC and 10% OR values for all combinations of feature classes and regularization parameter values.
- Sampling bias surface: from a kernel analysis of t positions of all records in the datbase.
- A multivariate environmental similarity surface (MESS) used to identify model areas of model extrapolation.
- Absence threshold: maximizing the sum of sensitivity and specificity.
    - Cells with lower values were considered as "absences" and given a suitability value of zero.
    - Cells above the threshold values retained their value.
- Standardized to a 0-1 scale.

Image:MFRI

HSM results

VME	AUC
Soft bottom sponges	0.788
Hard bottom sponges	0.748
Deep arctic sponges	0.890
Soft bottom coral gardens	0.849
Reefs	0.935
Hard bottom coral gardens	0.750
Shelf seapen communities	0.750
Deep seapen communities	0.938

Percent contribution of main predictors



Risk analysis

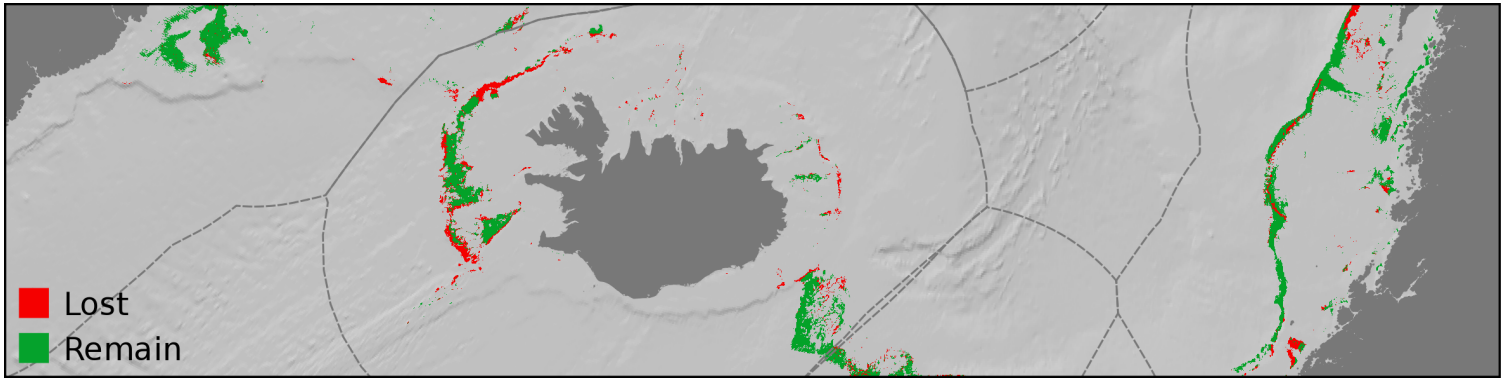
Risk analysis framework

- Spatial overlap between swept-area rato (SAR) and habitat suitability for each VME.
- Habitat suitability decreases proportionally to SAR.
- If SAR>1, suitability=0
- Here, evaluate reduction in high suitability areas (>0.8).

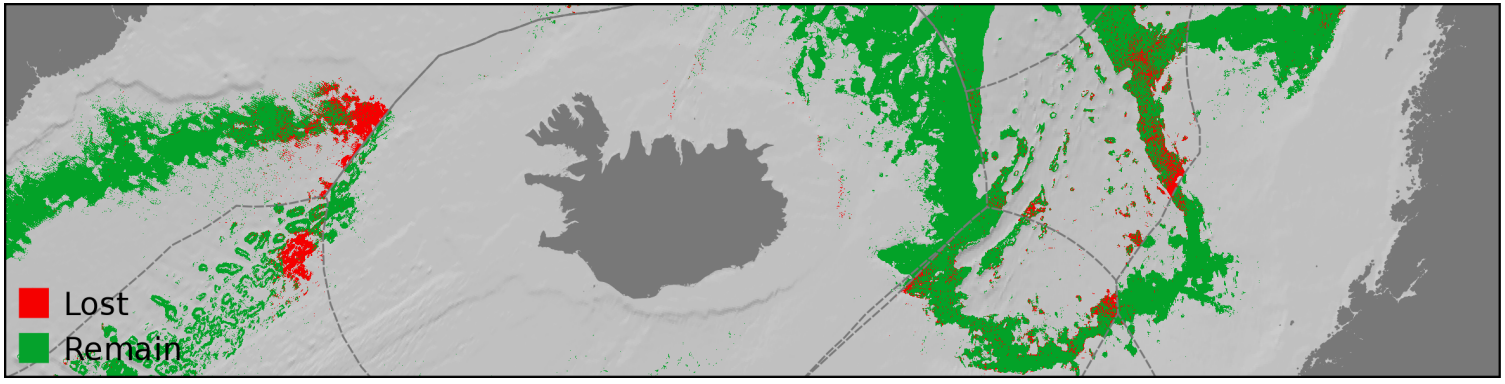
Image:MFRI

Loss of high suitability (HS) areas

Soft bottom sponges (loss = 41.7%)

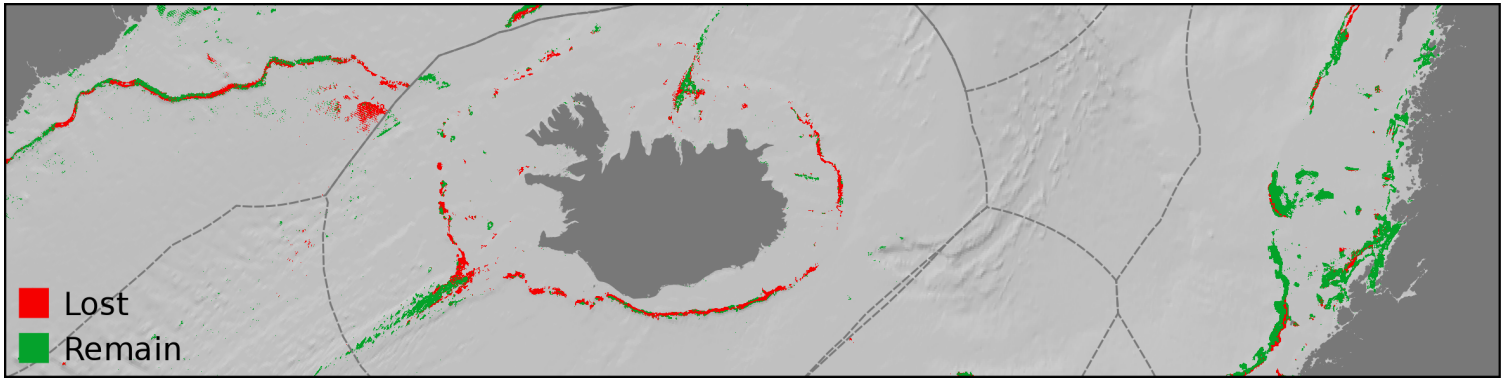


Deep arctic sponges (loss = 4.5%)

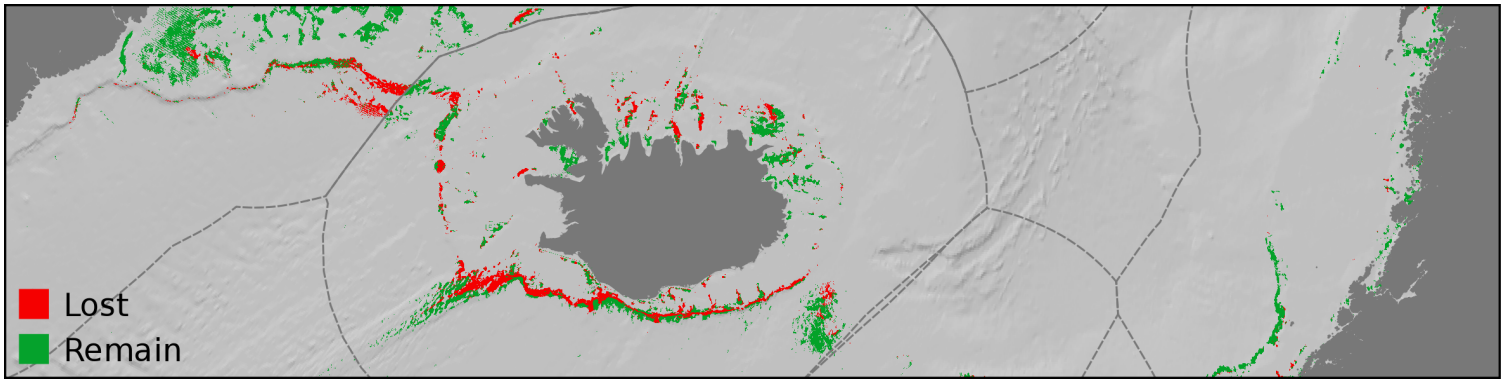


Loss of high suitability (HS) areas

Hard bottom coral garderns (loss = 21.7%)



Self seapen communities (loss = 44.6%)



Loss of high suitability (HS) areas

VME	% coverage	% loss
Soft bottom sponges	24.1	41.7
Hard bottom sponges	23.4	49.8
Deep arctic sponges	23.4	4.5
Soft bottom coral gardens	39.4	14.2
Reefs	9.6	10.5
Hard bottom coral gardens	26.9	21.7
Shelf seapen communities	28.9	44.6
Deep seapen communities	24.3	9.7

Conclusions and future steps

Conclusions

- There is a variable degreee of overlap between fishing effort and predicted suitability of VME indicators.
- For some VMEs (soft and hard bottom sponge fields, shelf seapen communities) the potential impact is high (>40%)

Future steps

- Evaluation of model overfitting: High resolution models for areas in Iceland and Norway
- Sensitivity analysis thresholds and high suitability criteria
- Model validation? Geographical bias?
- Impacts of other gears: longlines, gillnets
- Spatial planning to identify areas of high conservation value