

# Indicators of vulnerable marine ecosystems in the Arctic Ocean

Vassily Spiridonov<sup>1</sup>, Boris Solovyev<sup>2,3</sup>, Irina Onufrenya<sup>3</sup>, William Meritt<sup>4</sup>

<sup>1</sup>Shirshov Institute of Oceanology of Russian Academy of Sciences;

<sup>2</sup>Severtsov Institute of Ecology and Evolution of Russian Academy of Sciences;

<sup>3</sup>WWF Russia

<sup>4</sup>WWF Canada

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# Vulnerable marine ecosystems, criteria

- Uniqueness or rarity – an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include:
  - habitats that contain endemic species;
  - habitats of rare, threatened or endangered species that occur only in discrete areas; or nurseries or discrete feeding, breeding, or spawning areas.
- Functional significance of the habitat
- Fragility – an ecosystem that is highly susceptible to degradation by anthropogenic activities
- Life-history traits of component species that make recovery difficult
- Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features



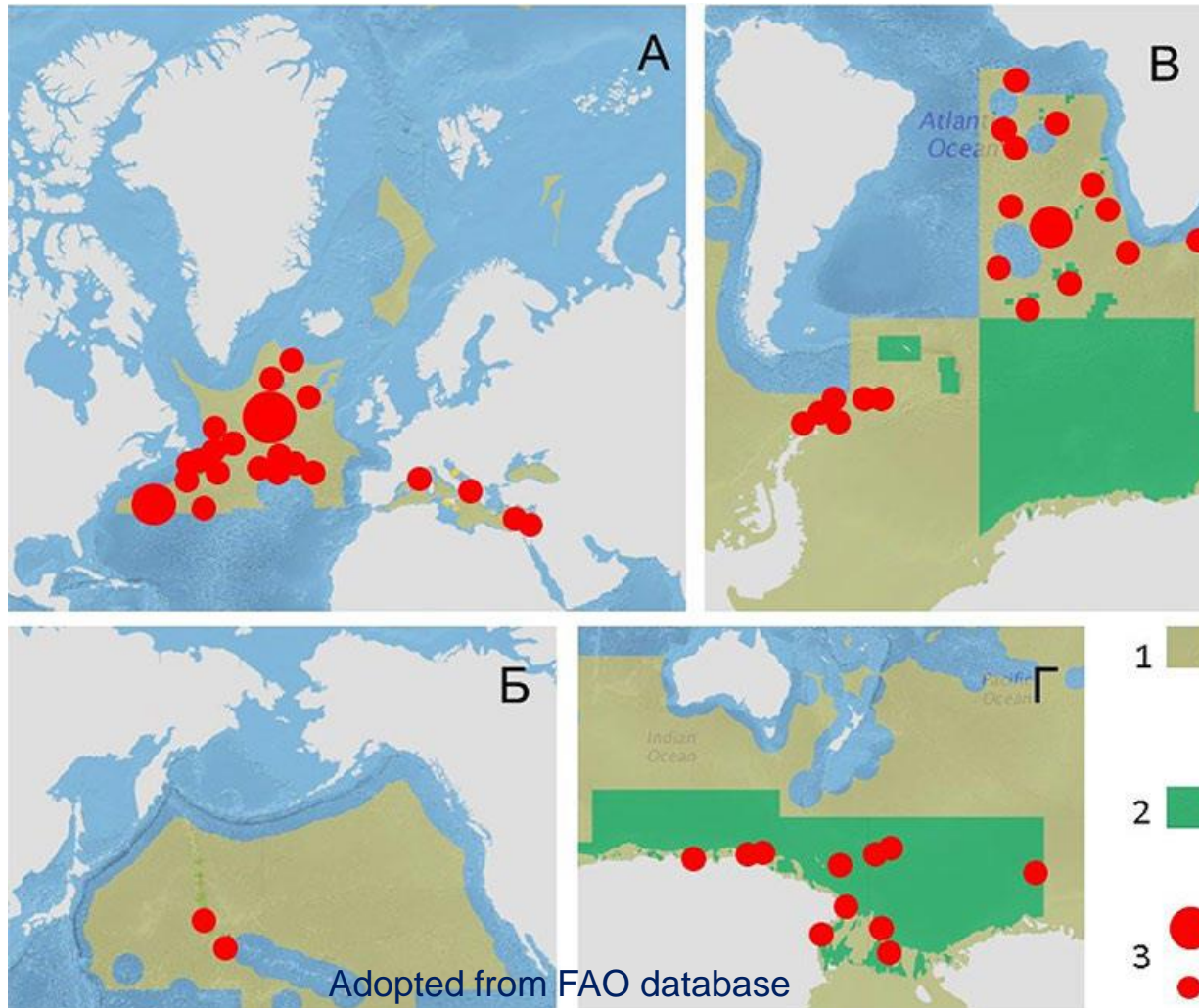
INTERNATIONAL GUIDELINES  
FOR THE MANAGEMENT OF DEEP-SEA FISHERIES  
IN THE HIGH SEAS

DIRECTIVES INTERNATIONALES  
SUR LA GESTION DE LA PÊCHE PROFONDE  
EN HAUTE MER

DIRECTRICES INTERNACIONALES  
PARA LA ORDENACIÓN DE LAS PESQUERÍAS  
DE AGUAS PROFUNDAS EN ALTA MAR



# VME are becoming an important tool in the practice of Regional Fishery Management Organizations



Areas with different regimes of bottom fisheries in the jurisdictions of particular international conventions on fisheries and protection of marine living resources.

A: North Atlantic, zones of NEAFC, NAFO, and General Commission for Fisheries in Mediterranean.

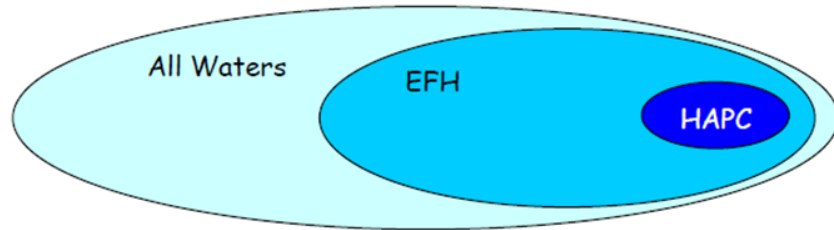
Б: North Pacific, the North Pacific Fisheries Organization zone;  
 Б: South Atlantic, zones of South-East Atlantic Fisheries Organization and CCAMLR;  
 Г: South Pacific and Pacific part of Antarctic, zones of South Pacific Fisheries Commission and CCAMLR.

1: zones of international fisheries conventions;  
 2: areas within conventions zones, where bottom trawling is allowed; areas and separate underwater rises where bottom fishery is closed following the vulnerable marine ecosystems criteria

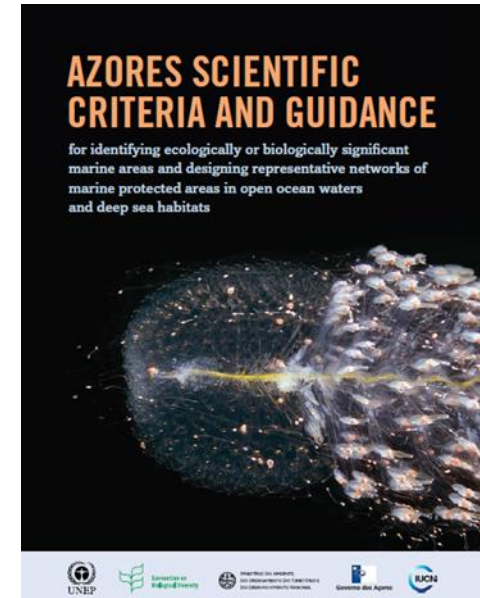
Adopted from FAO database in Spiridonov et al. 2019

# Evolution of the approach and criteria, and related notions

- Magnuson-Stevens Fishery Conservation and Management Act, US Legislation: essential fish habitat, EFH (1996)
- Habitat of particular concern, HAPC



- Vulnerable habitats, OSPAR
- Ecologically and Biologically Significant Areas



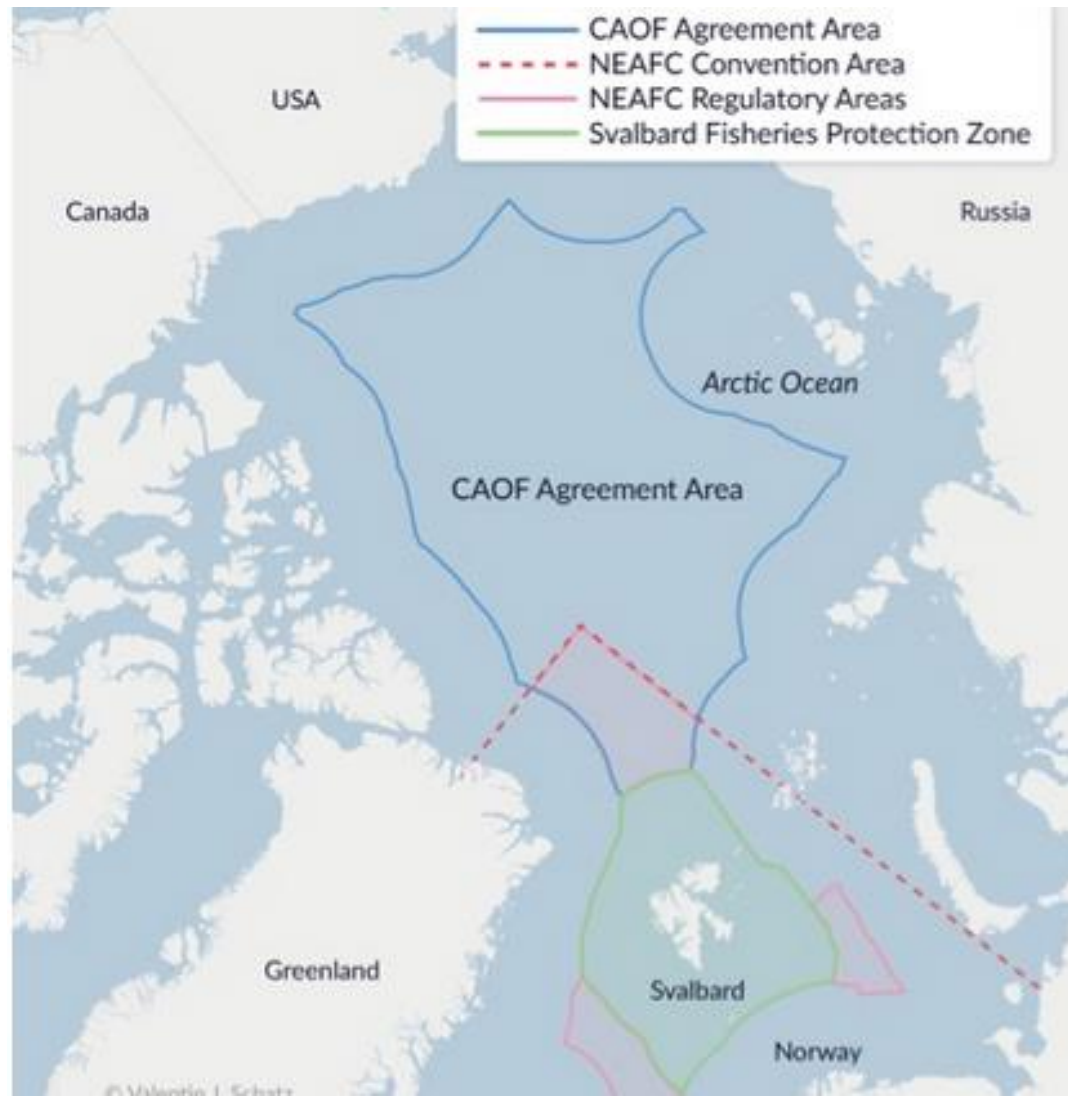
# Our review and analysis of VME and related notions

- VMEs are only parts of integral marine ecosystems
- They are in fact bottom biotopes and communities forming by habitat-making organisms (aedificators), such as deep-water corals, sponges, mollusks and some other taxa building biogenic structures
- In the new areas they may be searched by indicator taxa or indicator habitat, or better by both indicators

“Vulnerable marine ecosystems” and related notions in the practice of marine environmental management: conceptions, terminology and possibilities of application for the conservation of the marine environment and biological resources of the Russian seas

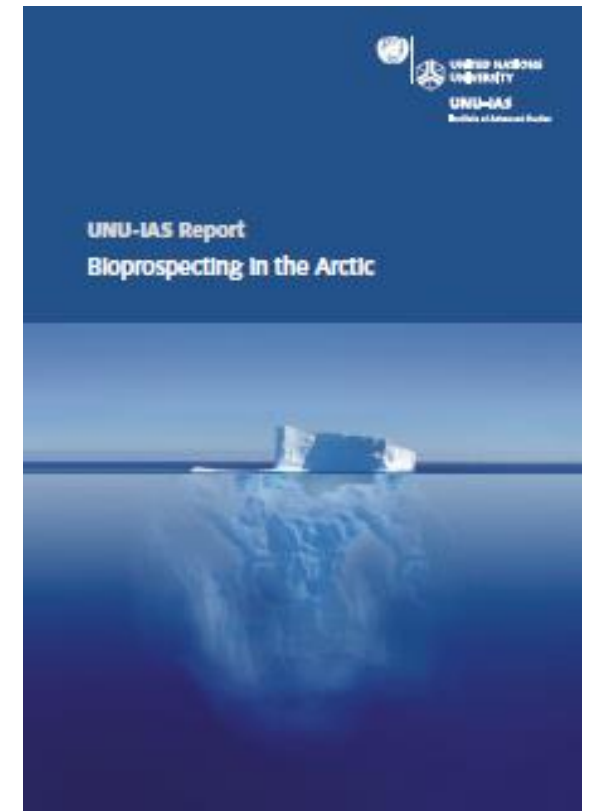
*V.A. Spiridonov<sup>1</sup>, A.V. Vinnikov<sup>2</sup>, A.V. Golenkevich<sup>2</sup>, A.A. Mays<sup>3</sup>*

# Agreement to Prevent High Seas Unregulatory Fisheries in the Arctic Ocean (CAOF)



# Are there VMEs in the CAOF area?

- It is not a purely scientific issue
- Although nobody currently seems to fish in the CAOF area where VME may be present
- This is also an issue of potential bioprospecting



# The present study attempts to identify possible VME sites in the Arctic Ocean within the PAMPAN (Pan-Arctic Marine Protected Area Network ) project of WWF

## Why PAMPAN?

- Urgency – climate change, increasing human pressure, very few existing MPAs
- Opportunity – a sustainability minded region
- Framework

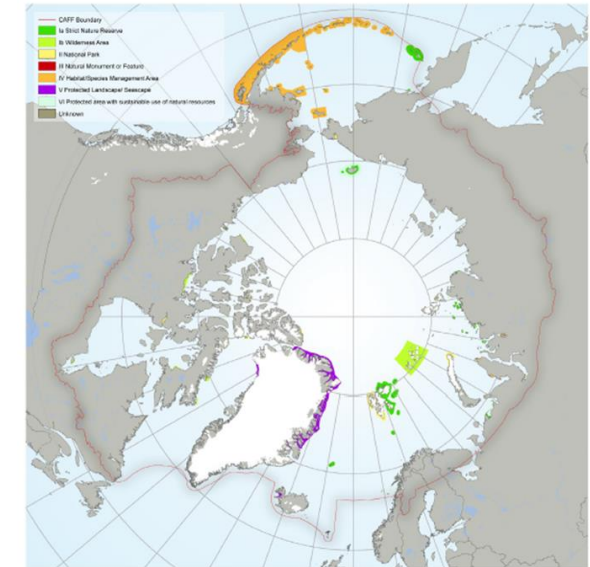
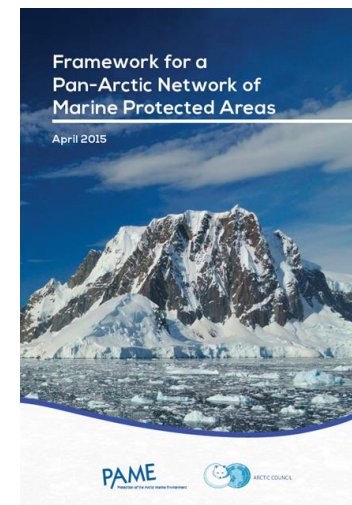


Figure 6. Marine protected areas in the Arctic classified according to their IUCN Management Category, 2016.



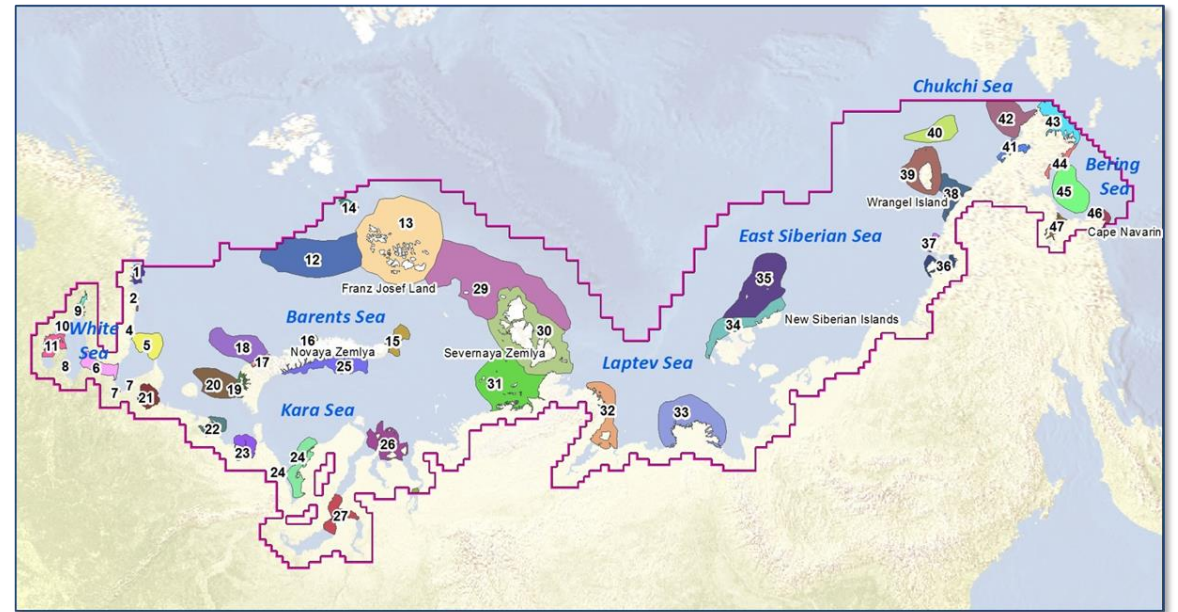
### Framework for a Pan-Arctic Network of Marine Protected Areas

A Network of Places and Natural Features  
Specially-managed for the Conservation  
and Protection of the Arctic Marine Environment



# We use taxonomic and geomorphological indicators of VME and integrate them in systematic conservation planning using MARXAN tool

- For examples how this works see
- Recently published study for the Russian Arctic
- Where 47 conservation priority areas has been identified



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## SUPPLEMENT ARTICLE

### Identifying a network of priority areas for conservation in the Arctic seas: Practical lessons from Russia

Boris Solovyev<sup>1</sup> | Vassily Spiridonov<sup>2</sup> | Irina Onufrenya<sup>3</sup> | Stanislav Belikov<sup>4</sup> | Natalia Chernova<sup>5</sup> | Dmitry Dobrynin<sup>6</sup> | Maria Gavrilov<sup>7</sup> | Dmitry Glazov<sup>1</sup> | Yuri Krasnov<sup>8</sup> | Svetlana Mukharamova<sup>9</sup> | Anatoly Pantyulin<sup>10</sup> | Nikita Platonov<sup>1</sup> | Anatoly Saveliev<sup>9</sup> | Mikhail Stishov<sup>3</sup> | Grigory Tertitski<sup>11</sup>

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## SUPPLEMENT ARTICLE

### Importance of oceanographical background for a conservation priority areas network planned using MARXAN decision support tool in the Russian Arctic seas

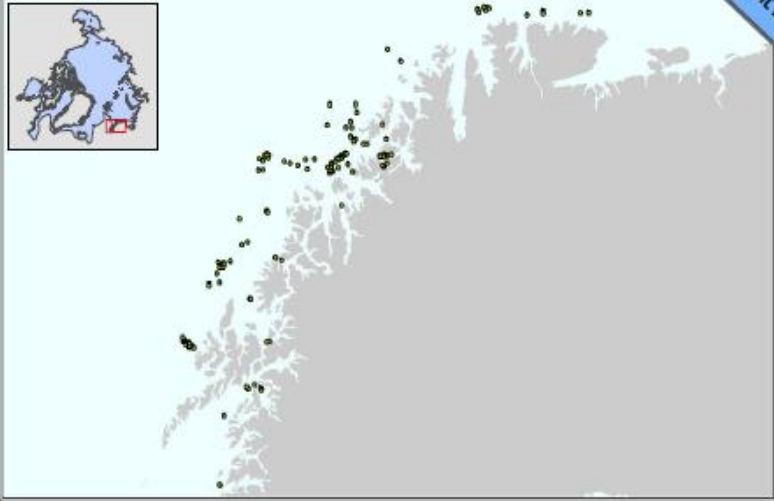
Vassily Spiridonov<sup>1</sup> | Boris Solovyev<sup>2</sup> | Ekaterina Chuprina<sup>3</sup> | Anatoly Pantyulin<sup>4</sup> | Alexei Sazonov<sup>4</sup> | Andrei Nedospasov<sup>1</sup> | Svetlana Stepanova<sup>4</sup> | Stanislav Belikov<sup>5</sup> | Natalia Chernova<sup>6</sup> | Maria Gavrilov<sup>7</sup> | Dmitry Glazov<sup>2</sup> | Yuri Krasnov<sup>8</sup> | Grigory Tertitskiy<sup>9</sup> | Irina Onufrenya<sup>10</sup>

# Distinctive benthic Conservation Features (VME indicators underlined)

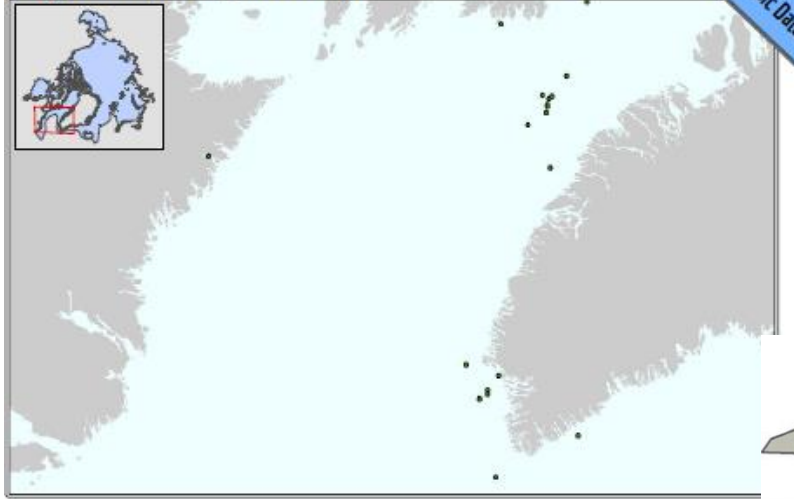
- Fragmented (High-Arctic) seagrass communities
- (With representation of low-Arctic seagrass communities)
- Fragmented High-Arctic kelp forests (with representation of low-Arctic kelp forests)
- Benthic hotspots: persistent areas of elevated benthic biomass which are important for marine mammals and sea ducks
- Cold water coral communities
- Cold seep and mud volcanoes biotopes and communities
- Hydrothermal vent biotopes and communities
- Seamounts biotopes and communities

# Cold-water coral communities

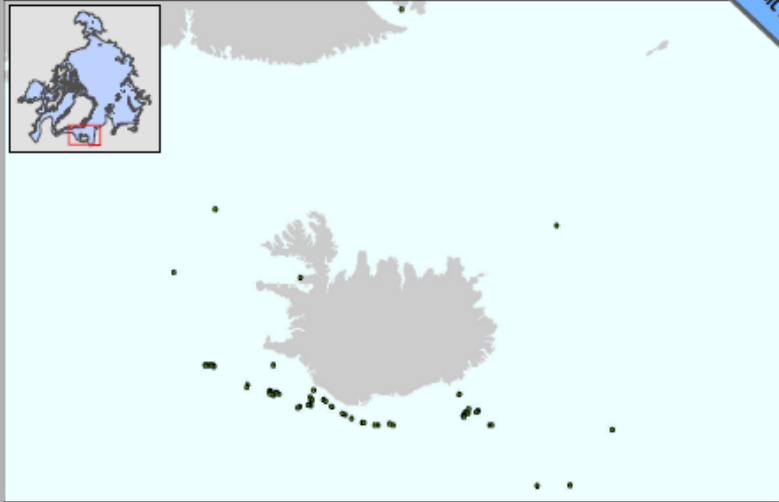
7134\_cold corals\_Barents.shp



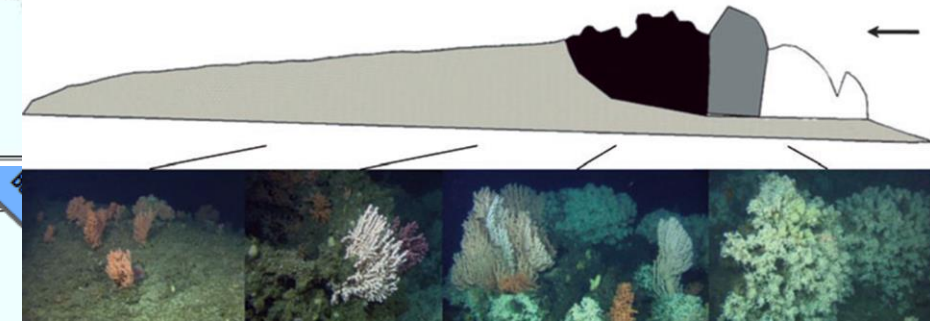
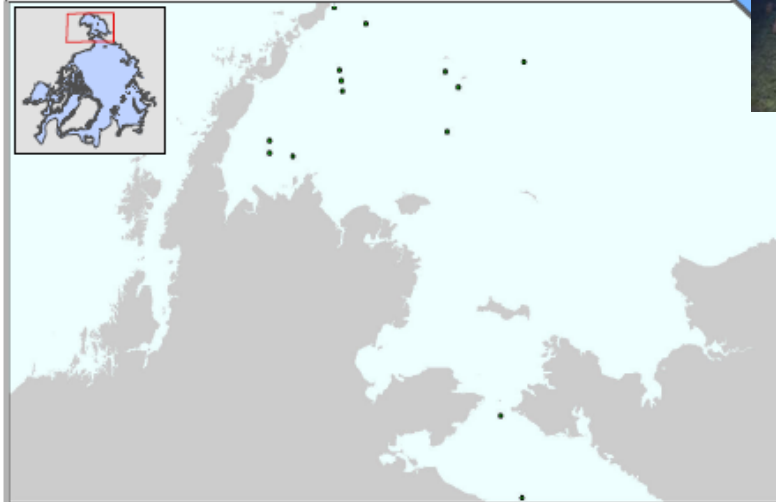
7135\_cold corals\_Canada\_Greenland.shp



7137\_cold corals\_Iceland\_E\_Greenland.shp



7138\_cold corals\_Pacific.shp



Cold-water reef scheme from  
Buhl-Mortensen et al., 2010

# Cold seeps and mud volcanoes biotopes and communities

- Cold seeps and mud volcanoes are expected in the areas of seismic activity
- Map shows known so far cold seeps and mud volcanoes as CFs
- They are characterized by hemoautotrophic production of organic matter,
- Specific prokaryotic biota and benthic fauna,
- Increased diversity and biomass of ambient benthic communities

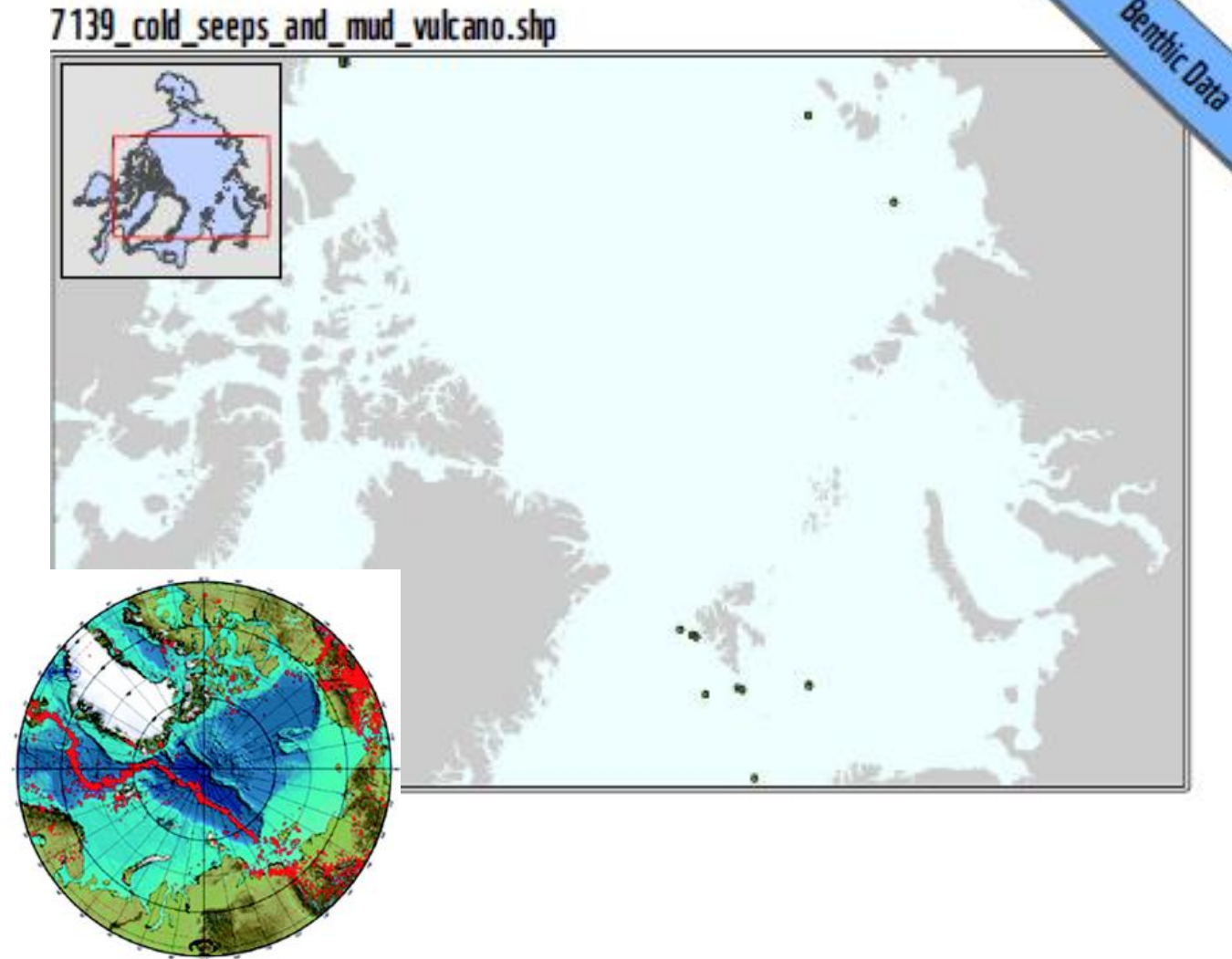
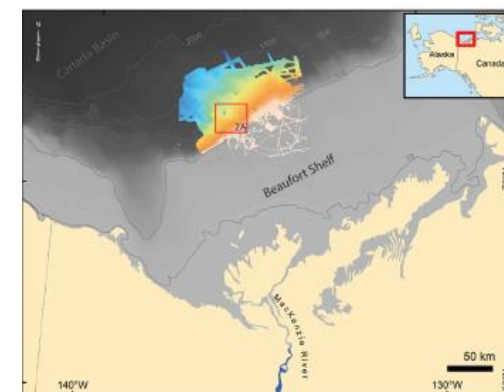
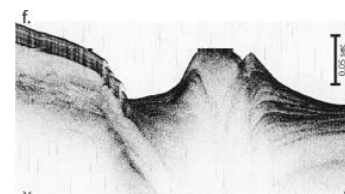
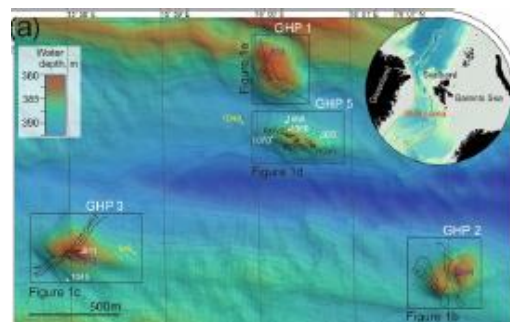
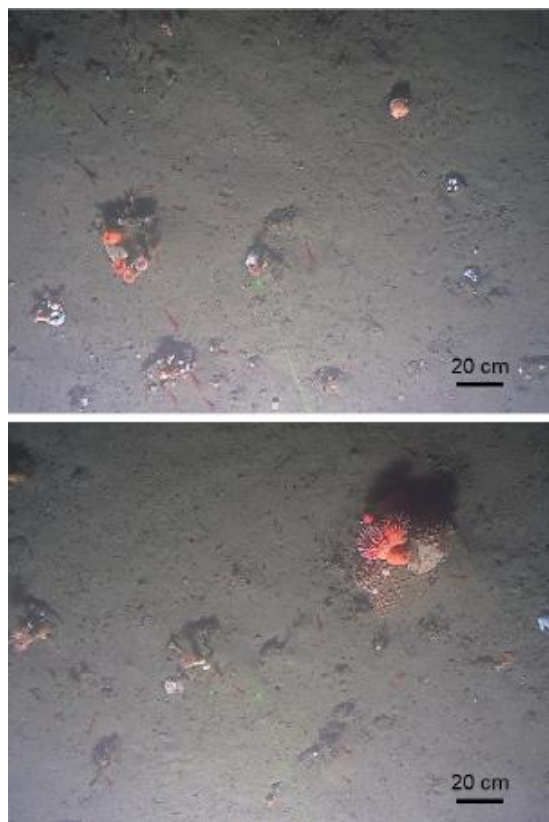


Fig. 3. Scheme of seismic situation in the Arctic (Bogoyavlenskii, 2012).

# Examples:



## Geochemistry, Geophysics, Geosystems

### RESEARCH ARTICLE

10.1002/2015GC005928

### Active mud volcanoes on the continental slope of the Canadian Beaufort Sea

#### Key Points:

- Active mud volcanoes expel methane on the continental slope of the Beaufort Sea

C. K. Paul<sup>1</sup>, S. R. Dallimore<sup>2</sup>, D. W. Caress<sup>1</sup>, R. Gwiazda<sup>1</sup>, H. Melling<sup>3</sup>, M. Riedel<sup>2</sup>, Y. K. Jin<sup>4</sup>, J. K. Hong<sup>4</sup>, Y.-G. Kim<sup>4</sup>, D. Graves<sup>1</sup>, A. Sherman<sup>1</sup>, E. Lundsten<sup>1</sup>, K. Anderson<sup>1</sup>, L. Lundsten<sup>1</sup>, H. Villinger<sup>5</sup>, A. Kopf<sup>6</sup>, S. B. Johnson<sup>1</sup>, J. Hughes Clarke<sup>7</sup>, S. Blasco<sup>8</sup>, K. Conway<sup>2</sup>, P. Neelands<sup>2</sup>, H. Thomas<sup>1</sup>, and M. Côté<sup>2</sup>

### Geophysical and geochemical controls on the megafaunal community of a high Arctic cold seep

Arunima Sen<sup>1</sup>, Emmelle K. L. Åström<sup>1</sup>, Wei-Li Hong<sup>1,2</sup>, Alexey Portnov<sup>1,3</sup>, Malin Waage<sup>1</sup>, Pavel Serov<sup>1</sup>, Michael L. Carroll<sup>1,4</sup>, and JoLynn Carroll<sup>4</sup>

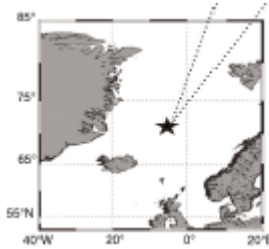
# Hydrothermal biotopes and communities

- Nearly all known Arctic hydrotherms are located along Arctic Mid-Ocean Ridge (Gakkel Ridge)
- Their biotic characteristics are not known
- Biotic assemblages may be similar to the single studied hydrotherm with black smokers at Mohn Ridge (Norwegian Sea)

7140\_vents.shp



# Example: Mohn Ridge hydrothermal site



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doi: 10.3354/meps10050

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## Faunal trophic structure at hydrothermal vents on the southern Mohn's Ridge, Arctic Ocean

Andrew K. Sweetman<sup>1,2,7,\*</sup>, Lisa A. Levin<sup>3</sup>, Hans T. Rapp<sup>2,4</sup>,  
Christoffer Schander<sup>2,4,5,6,\*</sup>

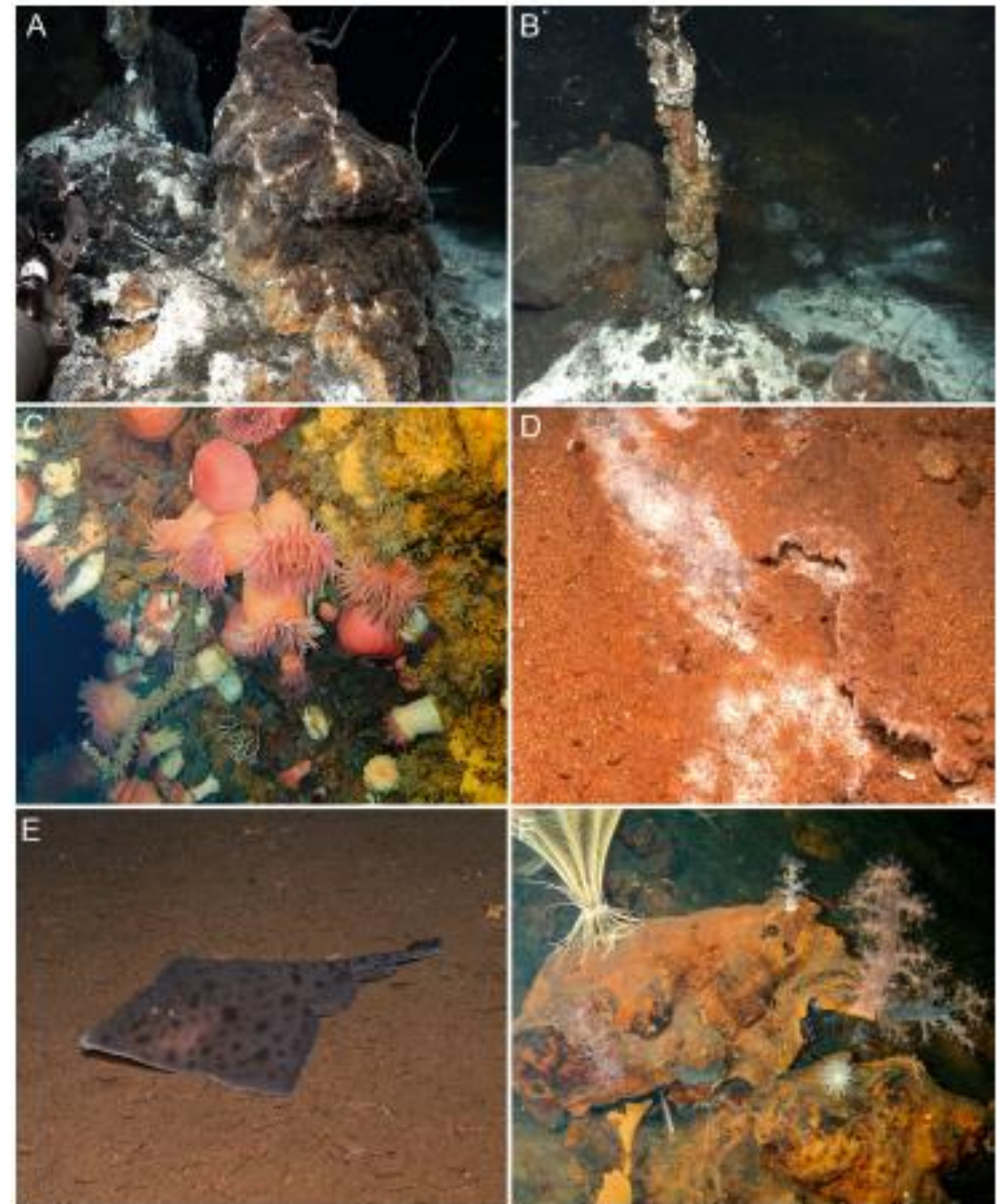
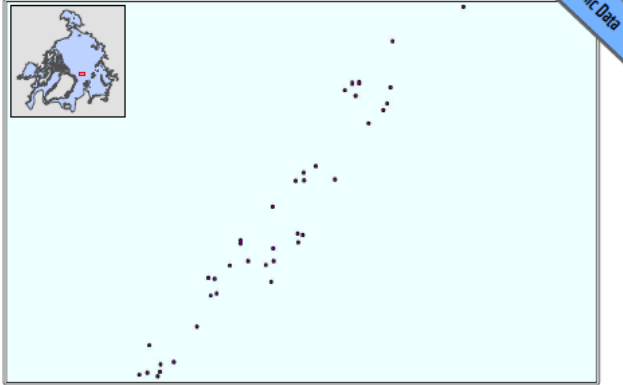


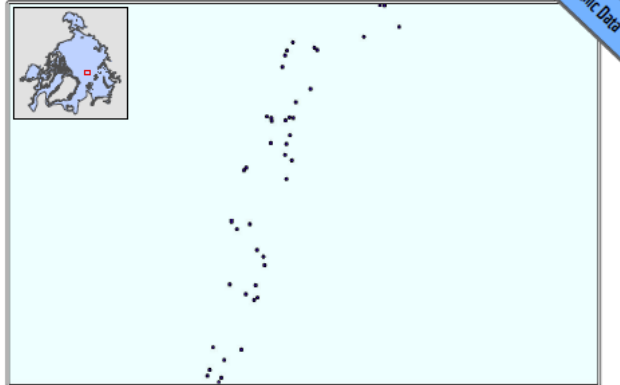
Fig. 2. Sampling locations at the southern Mohn's Ridge vent fields (for details of sites see Table 1). Trollvöggen: (A,B) high temperature (HT) venting through active chimneys (Troll-HT), (C) low temperature (LT) venting, low-activity chimney structure with very rich epifauna (Troll-LT), (D) sediments with more diffuse LT venting (Troll-LT), and (E) no visible signs of hydrothermal activity (Troll-NHT). Gallionsalle Garden: (F) LT venting and iron deposits (Gall-LT)

# Rift and flank seamounts of the main zones of Gakkel Ridge

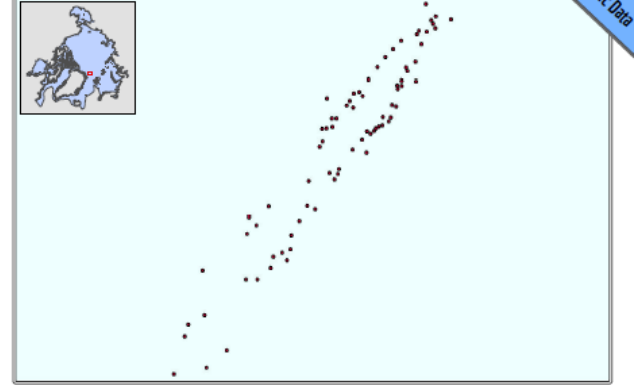
7145\_centralflank\_mounts\_LL.shp



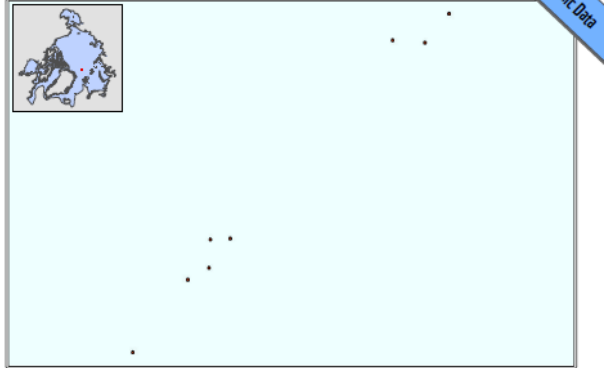
7147\_eastflank\_mounts\_LL.shp



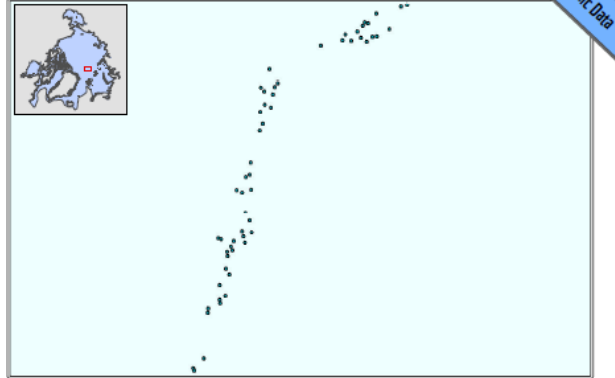
7149\_westflank\_mounts\_LL.shp



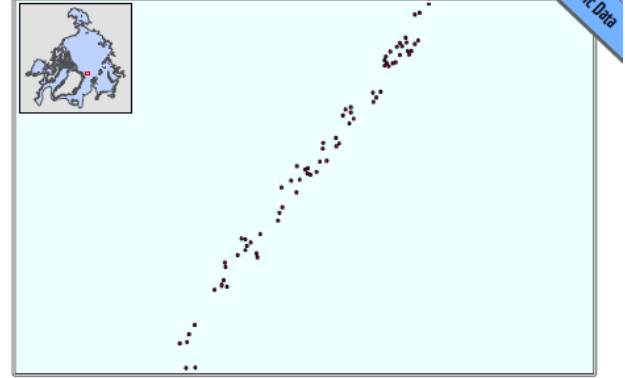
7146\_centralrift\_mounts\_LL.shp



7148\_eastrift\_mounts\_LL.shp



7150\_westrift\_mounts\_LL.shp





# Only Karasik Seamount has been studied biologically so far (Boetius, Purser, 2017)

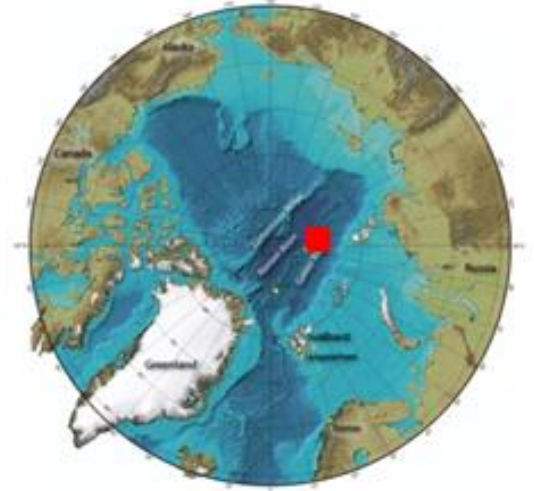


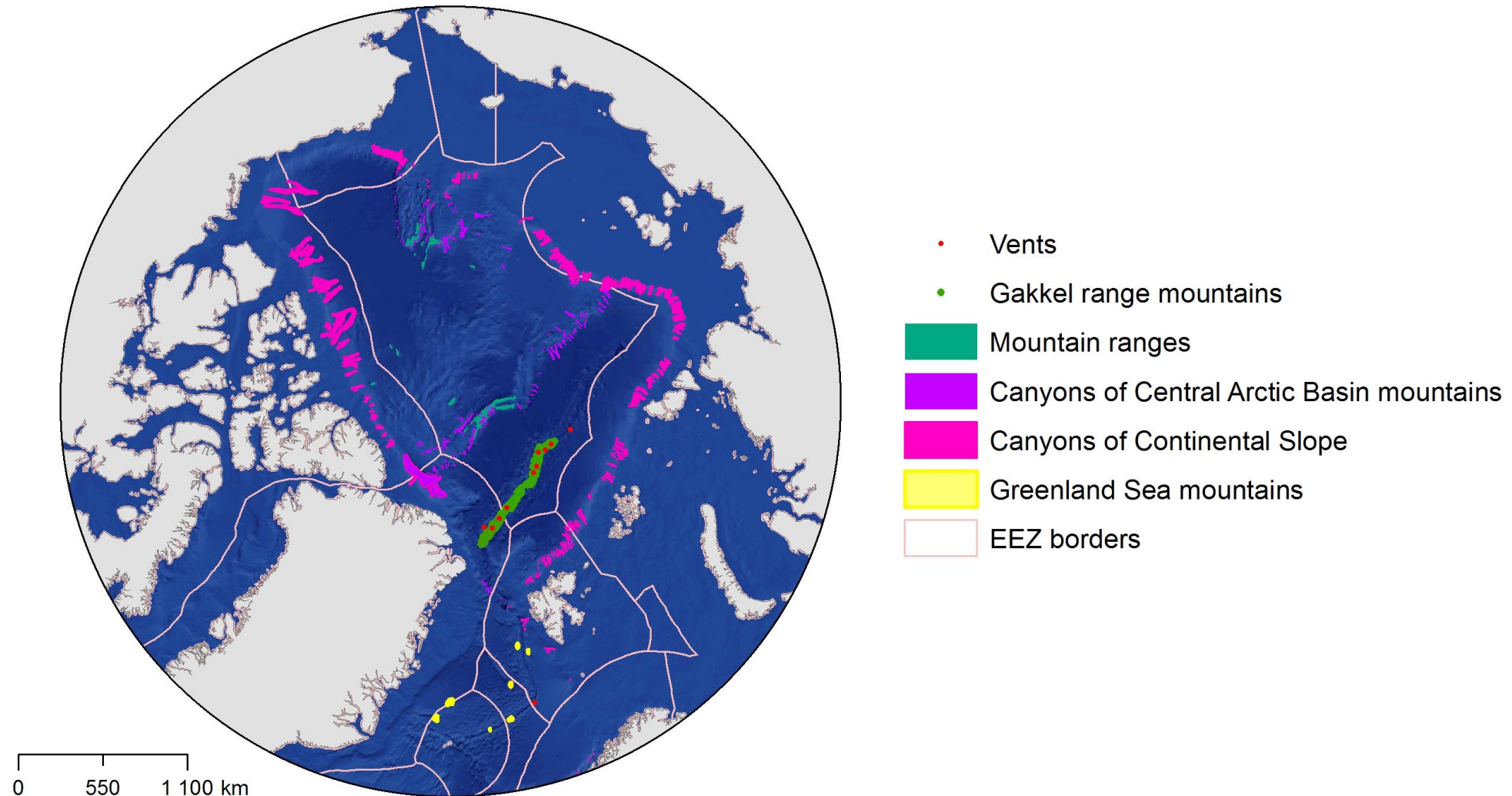
Photo: Sponge concentrations at Karasik Seamount; courtesy Dr. Antje Boetius (Alfred Wegener Institute for Polar and Marine Research;)

# We also use benthic biotopes\* classification (geomorphic structures possibly supporting VME are underlined)

- **Shelves and margins**
  - **Inflow shelves**
    - **Coastal domains**
    - **Large fjords, lagoons and bays with specific oceanographical regimes**
    - **Shelf plains**
    - **Shelf banks**
    - **Glacial troughs**
    - **Slopes**
    - **Canyons**
  - **Interior shelves (subdivisions similar to above)**
  - **Outflow shelves (subdivisions similar to above)**
  - **Semi-enclosed shelf basins (i.e. White Sea, Hudson Bay)**
- **Deep Basins**
  - **Ridges (other than Mid-Ocean (Gakkel) Ridge)**
  - **Isolated seamounts**

\*The notion “biotope” here is used in the original meaning of Dahl (1908) (see also Beklemishev et al., 1972); the word “habitat” can be used, if readers feel more familiar with it. Although this is not a scientific term and lacks definition

# Combined VME-related geo-data



# Conclusions

- Identification of VME should be considered within CAOOF research plan
- There are very few proven indications of VME within CAOOF area
- However, several geomorphological features may host communities, meeting VME criteria (FAO, 2009), i.e. hydrothermal sites, seamounts, and canyons
- The data gathered in PAMPAN, and the expected results of PAMPAN should contribute for planning further research in the CAOOF area



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