AMBON: Arctic Marine Biodiversity Observing Network

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Core themes and what we have learned

- **Observation**: Close current gaps in taxonomic and spatial coverage in biodiversity observation on the Chukchi shelf.

- **Integration**: Integrate with past and ongoing research programs on US Arctic shelf into Arctic biodiversity observation network.

- **Demonstration**: Demonstrate at a regional level how a MBON could be developed in other regions and ecosystems.

- **Pan-Arctic linkages**: Link with other programs on pan-Arctic level.
**Core themes**

**Observation**

**AMBON field sampling**

2015

2017
• New baselines for microbial size fraction
• > 10,000 molecular species of microbes (OTUs)

→ Microbial community strongly structured by habitat (left) and region (right).
Observation

Community ordinations, AMBON 2015 (65 stations)

- Benthic communities primarily associated with **sediment gradients** and **bottom water type**
- Zooplankton & seabirds associated with bottom waters (*not* surface)
- South → North gradient
- Modest to strong correlations among communities
- **Key species** link communities

Mantel correlations among communities

<table>
<thead>
<tr>
<th></th>
<th>Infauna</th>
<th>Epifauna</th>
<th>Fish</th>
<th>Zooplankton</th>
<th>Seabirds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infauna</td>
<td>&lt;0.001</td>
<td>0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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<tr>
<td>Epifauna</td>
<td>0.504</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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<tr>
<td>Fish</td>
<td>0.157</td>
<td>0.414</td>
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<td>&lt;0.001</td>
<td>0.032</td>
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<tr>
<td>Zooplankton</td>
<td>0.448</td>
<td>0.352</td>
<td>0.185</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Seabirds</td>
<td>0.373</td>
<td>0.331</td>
<td>0.080</td>
<td>0.414</td>
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</tr>
</tbody>
</table>
Integrate with past and ongoing research programs on US Arctic shelf into Arctic biodiversity observation network
Integration

→ Connecting short-term (cruise) with long-term (mooring) observations

www.chukchiecosystemobservatory.org
Moorings provide seasonal and longer-term context for AMBON sampling.

Near-bottom temperature at the CEO site since 2015:

- **AMBON 2015**: Almost no time above 0 °C
- **AMBON 2016**: 2 months above 0 °C
- **AMBON 2017**: 3 months above 0 °C
- **AMBON 2018**: 4 months above 0 °C
Integrating AMBON data with existing time series

- Example: 10 years of zooplankton observations
  - Abundances during AMBON years within range of previously observed abundances
  - Relatively low abundances in 2016/17 (warm years)
  - Long-term increase in zooplankton biomass of Pacific origin, 1946-2012 (Ershova et al. 2015)
Building capacity and enhancing taxonomic expertise by compiling online picture identification guides for Arctic benthos

Five volumes:
- Echinodermata
- Arthropoda
- Mollusca
- Annelida
- Miscellaneous Taxa

Currently in beta-testing (NOAA collaborators)
Integrating results from AMBON with other studies on data-poor stocks

**Arctic cod life history**

- Documenting ontogenetic migrations of Arctic Cod

  Forster et al. (In Prep)

**Snow Crab assessment**

- Estimated biomass: 810,200 mt (474,000 – 1,759,200 mt)
- Updated & region-specific life history parameters
  - Maturity curves
  - Fecundity

Divine et al. (In Revision)
Integration


- Six clusters (identified by dominant species) - 5 occur in AMBON region

- Integration with DBO network (black boxes)

- Integration with other programs
  - Arctic IERP
  - NOAA surveys
  - and many more...

From: Kuletz et al. (2019) DSR II

- Core themes
- Sustainability
- Methodology
- Continuity
- Vital Stats
- Recommendations
Integration with NSPIRES (NASA) project on seascapes

Dominant Seascape: Spatial Variability

Areal extent of habitats in Beaufort Sea (top) and Chukchi Sea (bottom)
Distributed Biological Observatory: Do satellite seascapes reflect meaningful benthic patterns?

Dominant Seascape (July): DBO sites 2013 and 2014

Benthic Temp and Salinity (Depth = 40-130 m)

Integration with NSPIRES (NASA) project

Core themes

Sustainability  Methodology  Continuity  Vital Stats  Recommendations
Integrating AMBON data into national archives & data portals

Example:

- Cruise track
- 2015-17 marine mammals
- Sea surface temperature

Demonstrate at a regional level how a MBON could be developed in other regions and ecosystems.
Based on AMBON experience, developed guidelines for sampling design (Iken et al 2018)
- Developed simulation approach to evaluate alternative sampling designs for estimating species richness and abundance
- Similar analysis of trade-offs associated with different spatial coverage for seabird surveys
Pan-Arctic Linkages

Link with other programs on pan-Arctic level
Pan-Arctic Linkages

Core themes

Sustainability
Methodology
Continuity
Vital Stats
Recommendations

Pan-Arctic Linkages

Ecosystem Studies of Subarctic and Arctic Seas
ESSAS
(an IMBER program)

Pacific Arctic Group (DBO)

Circumpolar Biodiversity Monitoring Program (CBMP)

ICES/PICES/PAME Working Group on Integrated Ecosystem Assessment of the Central Arctic Ocean (Interim Report)

FisCAO: Fisheries in the Central Arctic Ocean
<table>
<thead>
<tr>
<th>Core themes</th>
<th>Sustainability</th>
<th>Methodology</th>
<th>Continuity</th>
<th>Vital Stats</th>
<th>Recommendations</th>
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</table>

Is our approach valid & sustainable?
Is our approach valid & sustainable?

Validity

• Are we sampling target communities effectively & representatively?

• Are we able to quantify uncertainties appropriately and detect signals?
Validity

- Sampling approaches validated for most communities, but some limitations remain
  - gear selectivity (e.g., fish)
  - taxonomic uncertainties (e.g., juvenile stages)
  - missing baselines (e.g., eDNA).

- Validity of approach for meeting certain performance measures (e.g., estimating species richness or species abundances within a prescribed margin of error) is being tested through a simulation approach.
Is our approach valid & sustainable?

**Sustainability**

- Costly and logistically challenging field work that is required for long-term monitoring in the Arctic may be best achieved through collaboration with other research projects
- Exploring alternative **sampling designs** through a simulation approach can help determine efficient and effective designs

### Simulating sampling under reduced designs...

1. **Select index**
   - e.g. Species richness/diversity, abundance/biomass of selected taxa
2. **Select design**
   - AMBON17
   - AMBON15
   - x-shelf
   - x-shelf, reduced
   - DBO plus
   - DBO

<table>
<thead>
<tr>
<th>Design</th>
<th>AMBON17</th>
<th>AMBON15</th>
<th>x-shelf</th>
<th>x-shelf, reduced</th>
<th>DBO plus</th>
<th>DBO</th>
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</thead>
<tbody>
<tr>
<td>x-shelf, 100%</td>
<td>N=81</td>
<td>69</td>
<td>65</td>
<td>39</td>
<td>22</td>
<td>14</td>
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<tr>
<td>x-shelf, 67%</td>
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<tr>
<td>x-shelf, 50%</td>
<td></td>
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</tr>
<tr>
<td>x-shelf, 33%</td>
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</tbody>
</table>
1. Select index  e.g. Species richness/diversity, abundance/biomass of selected taxa
2. Select design

Evaluating alternative sampling designs

3. Select sampling density

4. Compute indices & evaluate performance
Preliminary results:
- Dropping along-shelf transects associated with least ‘cost’
- Further reducing station spacing by 50% may be acceptable for some goals
- Any design with < 30 stations generally had poor performance
- Standard errors can be low for the reduced x-shelf design that dropped up to 50% of stations
- ‘DBO+’ performed well for some measures
Are there certain methodologies that should be expanded, or some that were less effective?

Methodologies to expand:
Expand year-round seasonal sampling (mooring collections):
• eDNA, passive & active acoustic, phytoplankton & zooplankton
• Spring & winter samples (e.g. under-ice sampling)
• Continue linking to larger-scale sampling for spatial variability, connectivity and shifting distributions

New methodologies to include:
• Functional diversity analysis (started for AMBON epibenthos)
• eDNA fungal diversity and biomass component (added 2017, w/ UiT, Norway)
• eDNA: molecular markers for metazoans
• Gelatinous zooplankton (started for AMBON in 2017)
Are there certain methodologies that should be expanded, or some that were less effective?

Less effective methodologies:

- Gear selectivity of small mesh trawl may limit sampling of large fishes and invertebrates
- Species identifications for some assemblages (zooplankton, infauna) very time consuming
- Mammal observations without dedicated mammal observer limit detectability and species identifications
What aspects of the project are we likely to continue going forward?

• Continued sampling of all ecosystem components important for integrated view
• Maximize sampling through collaborations with other projects
• Reduce spatial coverage or limit frequency for some components (based on simulations)
**Communication / training**
- 9 publications to date, 30 oral presentations, 17 posters
- Training for 10 graduate students (field, lab, analytical)
- Training for one post-doc

**Products actively in use**
- MBON Data Portal: 16 published datasets
- NCEI archive: 6 datasets (10 pending)
- North Pacific Pelagic Seabird Database
- Identification guide (Arctic benthos)
- Shiny App (microbial discovery)

**Engagement**
- Local stakeholders (Bering Strait)
- BOEM, NOAA, NPFMC
- Interagency Arctic Research Policy Committee (IARPC)
- Arctic Council (CAFF/CBMP, PAME)
- ICES/PICES (WGICA, Chukchi IEA)
Key recommendations to the community & federal agencies about how to construct and maintain a long-term MBON in U. S. waters to meet both scientific and natural resource managerial needs

• Develop a “minimally sufficient” sampling design, through collaborations with and by building on existing programs
  – Sampling should encompass major Chukchi Sea mater masses
  – If based on DBO lines, expand DBO line both inshore and offshore
  – Using a (slightly) reduced number of cross-shelf transects with current or reduced AMBON station spacing is most effective for multiple objectives

• Include and expand use of eDNA in any MBON design

• Continue / expand year-round sampling of biodiversity components at CEO moorings (eDNA, passive & active acoustics, particle fluxes)
Key recommendations to the community & federal agencies about how to construct and maintain a long-term MBON in U. S. waters to meet both scientific and natural resource managerial needs

- For seabirds, integrate offshore surveys with colony-based monitoring (currently minimal)
- Develop a step-wise approach to monitoring for biodiversity under challenging Arctic conditions (*adapted from Grebmeier et al., in prep*):
  1. Synthesis of historical observations to re-assess needs & priorities
  2. Develop thresholds & criteria that trigger enhanced sampling or modifications to existing sampling designs
    - Increased frequency
    - Adaptation of spatial sampling design (for example, if shifts occur)
  3. Develop new thresholds and repeat!
Observations

Thresholds exceeded?

Minimally Sufficient Sampling Design

No

Yes

Simulations

Synthesis

Define thresholds

EOV/EBV

Evaluate against thresholds

Re-evaluate design

• Increase frequency?
• Enhance spatial sampling?

Recommendations

Core themes  Sustainability  Methodology  Continuity  Vital Stats

Continuity

Core themes

Methodology

Sustainability

Vital Stats

Synthesis

Minimally Sufficient Sampling Design

Recommendations
Thank you!