**Breakout 3, Day 2.**

**Research foci in coastal and open ocean settings**

**KEY QUESTIONS that emerged from discussion:**

1. **What are the spatial and temporal variations in the magnitude of trophic linkages in the N. Atl/Arctic system?**
2. **What controls the timing of ‘events’ in the annual cycle in the N Atl/ Arctic system?**
3. **What are the effects of coupled multi-scale physical processes on the structure of N Atl/Arctic food webs?**
4. **How will biogeography, life history and behavior be influenced by environmental change and impact food webs?**

**Fleshing it out…**

**What are the spatial and temporal variations in the magnitude of trophic linkages in the N. Atl/Arctic system?**

1. Fishing pressure can result in trophic cascades by restructuring the food web. What are the consequences for carbon flux?
2. What sort of processes impacts the flow of carbon to the meso-pelagic layers?
3. How does plankton size structure influence trophic and elemental transfer?
4. Parasites, viruses?

**What controls timing of ‘events’ in the annual cycle?**

1. What controls the timing of the initial diatom spring bloom and the emergence of *Calanus* from diapause?
2. How do the controls on timing of events vary geographically and with climate change?
3. How could changes in timing of events affect events later in the annual cycle (does the magnitude of the fall  bloom affect timing or magnitude of the *Calanus* population in the spring)?
4. Timing of diatom flux? Doesn`t fit the paradigm of Si runs out and then they sink. What are nutritional changes associated with Si limitation?
5. What is the role of prior events on spring bloom? (Fall Fe. Limitation? Depth of winter mixed layer? Changing ocean temperature).
6. Bloom phenology: role of fronts, winds, eddies, deep winter mixing, in setting stage. Do the mechanisms for bloom initiation vary inter-annually and regionally?
7. Role of top down pressure (in regulating bloom phenology – e.g. what triggers Calanus emergence from diapause?)
8. Where and when do seed populations come from? - What defines the variability of the annual spring bloom system of the North Atlantic and the Arctic? Is it chaotic, spatially variable, how does it get seeded, do the seed population matter, and how does the timing vary and why?

**What are the effects of coupled multi-scale physical processes on the structure of N Atl/Arctic food webs?**

1. What is the relative importance of local vs. remote forcings?
2. How do riverine and shelf / ocean exchanges influence food webs?
3. What are the roles of meso- and submeso-scale patchiness in the food webs?
4. What are the relative roles of local vs remote forcing? Understand the mechanistic links between and within lower trophic levels.
5. Does all patches bloom? How do you scale up information that is spatially heterogeneous? We care about the patches because that’s where the processes occur and our understandings of these are criteria for our ability to perform predictive responses.
6. What are we missing by not knowing the whole life cycle?

**How will biogeography, life history and behavior be influenced by environmental change and impact food webs?**

1. Do we understand these well enough to understand how they will be affected by climate change?
2. How do different life-history strategies (e.g. timing of emergence of Calanus from diapause) impact fitness?
3. What is the "biogeography" of life-history strategies?
4. How does behaviour (e.g ???) shape community structure and carbon transfer?

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Separate issue???

How will climate change, fishing or other external pressures impact the

taxonomic and functional biogeography of multiple trophic levels, from

bacteria to fish?

- Potential drivers include:

Changes in resource supply

Changes in circulation and connectivity

Physiological stressors (e.g. temperature, pH, ...)

Human influence

1. How will life – history strategies be influenced by environmental change?

2. Biogeographic shifts in response to climate change

3. What are we missing by not knowing the whole life cycle?

**Notes from the Food web dynamics and community structure**

We like to address both the coast and open ocean together and not as separate entities. One reason being that e.g. fisheries is tightly coupled to both the coast and the open ocean

Trophic cascades

What defines the variability of the annual spring bloom system of the North Atlantic and the Arctic? Is it chaotic, spatially variable, how does it get seeded, do the seed population matter, and how does the timing vary and why?

How does calanus impact the foodweb and how does the variability of the spring bloom affect the zooplankton?

Spring bloom dynamics differ across the North Atlantic with diatom blooms that support one foodweb system while the little diatom bloom supports a different foodweb system. The initiation of the blooms differ and the control mechanisms may vary. What terminates the bloom? Can the export of the carbon be predicted to deeper levels of the water column?

Mechanisms between trophic levels may be missing to provide a better understanding of trophic interactions. How does mixotrophs affect the structure?

Historically, we have been using idealized size-based models. Potentially, we could incorporate trait-based approach and provides a promising link between trophic levels.

Different fatty acids of zooplankton, but otherwise small differences makes it difficult to separate copepods in models and perhaps size-based approach is a better starting point to understand community structure.

Migration and behavior of zooplankton is extremely important to understand the transfer between trophic levels and spatial variability.

Do we have enough information on the current foodweb structure? Is there a foodweb model for the North Atlantic?

Do we need to model every single species but could we focus on keyplayers? A questions is what happens when one of the key species disappears?

GAPS:

1. Mechanisms between trophic levels

2. What role does behavior play in carbon transfer between trophic levels

3. Where do seed populations come from?

4. Is there a food web for all of North Atlantic

5. What are the relative roles of in-situ vs external forcing

6. What is the role of prior events on spring bloom?

There are different mechanisms that can initiate the flow of energy such as stratification, melting ice, mixing, …

Understanding the zooplankton grazing dynamics is key

How much do the past affect the future? Next year can potentially be determined by conditions the previous year. Copepod blooms are dependent on how many copepods that went into diapause previous year.

To understand the effects of a process on the system you need information of all key processes that makes up the system. This means multi-ship involvement for simultaneous studies.

Do we know the food web processes well enough to parameterize processes using autonomous measurements?

We need a 10-year vision on where we want to go: we would like to measure size-spectra + a few more things that combined with modeling can provide a continuous/autonomous source of information. We can envision a sweep of instruments that can help us. Basically, what are the instruments we need to put on autonomous vehicles to measure the size-spectra, transport, export of lower trophic level biology that can provide us with a measure the amount of carbon available to higher trophic levels and how much is exported out.

How do you study the connection between changes in climate and consequences for the biology between the North Atlantic and the Arctic?

The bio-geographical shifts of marine resources have a tremendous effect on human well-being

How does plankton size structure influence trophic and elemental transfer?

The presence of mixed layer eddies coupled with fronts leads to earlier plankton blooms. Wind can help maintain the fronts – inter-annual changes in wind could lead to changes in timing of blooms. Do the mechanisms for bloom initiation vary inter-annually and regionally?

How important is patchiness to bloom dynamics?

Timing of diatom flux