Breakout 3 – Group 4 + 5

- Ecosystem health and biodiversity
- Human implications, management, and adaptation strategies

Setting the stage

- We cannot separate out basin-scale processes from processes on the coast.
- The Galway declaration is not an Arctic-sub-polar initiative.
- View humans as drivers for pressures.
- Need coupling of systems/models so that we work in an INTEGRATED manner joining physical oceanographers, geochemists, ecologists, managers.
- What issues need a basin-scale analysis, and what issues would benefit from a combined /complimentary approach (building on national or regional projects/analyses).
- **Link back to the physical and biogeochemical system**

Overarching science questions

- *How will marine ecosystem structure and function including feedbacks respond to environmental change in climate, ocean physics, biogeochemistry and human pressures?*

- *What are the interactions between humans and changing arctic and Atlantic marine systems considering perspectives of health, wellbeing and impacts, and how should these inform sustainable management practices.*

DRIVERS (DPSIR) of knowledge gaps

- Climate change
- Ocean Acidification
- Hypoxia
- Reduced sea ice
- Increased demand for resources and space
- Changed demography on the coast
- Growing human population

PRESSURE/STATE of knowledge gaps

- Warming oceans
- Reduces ice cover makes arctic accessible to shipping, oil, gas etc
- Increased storm risks
- Arctic more accessible - more tourists - more ships
- Increased shipping
- ballast-water discharge
- Increased petroleum extraction
- Increased renewable energy development/production
- Increased sub-sea mining
- Increased aquaculture
- human infrastructure (installations creating connectivity, from petroleum, renewables, aquaculture installations and similar)
- Increased extraction in frontier areas (previously ice-covered)
- Going deeper: oil/gas, mineral extraction, fisheries, aquaculture
- Increasing and redistribution coastal developments
- Invasive humans (eg. Tourism or other new access into new areas

IMPACTS of knowledge gaps

- Ecosystem:
  - Changing food webs,
  - shifting biogeographic boundaries
  - invasive species
  - Cumulative/synergistic impacts.
- Humans:
  - Health/safe food /safe recreation
    - pathogens
    - HAB (poisonous shellfish),
    - stinging jellyfish,
    - stinking beaches,
  - Economic/social impacts
    - CC as a food-security issue
    - changing fishing patterns/opportunities,
    - changes in coastal community structure,
    - coastal infrastructure,
    - Security of coastal settlements
      - Acute (storms, tsunamis etc)
      - Chronic (coastal erosion, flooding, sea-level rise, waves)

RESPONSES of knowledge gaps

- Better ballast-water regulation,
- Marine Spatial Planning (eg. offshore installations, pipelines, shipping, aquaculture sites, conservation zones, fishing zones)
- Changes in community structure and culture of indigenous people – responses to changes in ice cover, permafrost, changes in biogeography

Research foci

Photo: TDL Wenneck

Shifting biogeographic boundaries

- What are the implications of climate change on food-webs especially in relation to shelf - open ocean connection?
- How is the coastal fish production impacted by changes in the oceanic areas?
- What is the impact of heat distribution on a basin-scale on the distribution of zooplankton/fish/whales?
- What are the implications for whale-watching/fisheries
- How is energy routed through the food-web? What are the changes to this routing likely to be?
- How are changes in nutrients changing the O_2 levels on the shelf, and in turn affecting the productivity and distribution of fish stocks and other ecosystem components?
- What are the implications for genetic diversity and evolutionary adaption?
- What are the health, social, cultural and economic, impacts on coastal communities from biogeographic shifts?
  - Eg. how will fishermen who are used to fishing certain species respond to a new target species?
  - How communities avoid, mitigate or adapt to change?

Environmental and human effects of resource / space use / extractions

- What are the ecological implications of increased space demands/use from shipping, renewable energy, fisheries, aquaculture etc?
- Ecological implications of increased harvest at lower trophic levels and at mesopelagic communities?
- Ecological implications of deep-water mineral extractions
- How are new off-shore deep-water human activities affected by climate change?
- How can we develop tools, methods etc to understand the trade-offs? (eg. Social, economic, cultural, health and ecological trade-offs)

Extreme - risk events

- How do we identify vulnerable ecosystem / vulnerable human communities? (in relation to extreme events as well as in relation to longer-term impacts from climate change)
- How to assess, quantify and predict the risks / consequences of accidents (e.g. spill, shipwrecks, nuclear events)
- How to assess, quantify and predict the risks of extreme weather/environmental events and their resultant effects on coastal communities/ ecosystems?
- Research – what observation systems would we need to monitor extreme events (e.g. spills) in real-time?
- How can we communicate risk and uncertainty to the community?

Carbon Quotas /Carbon Balance

- How is the carbon pump changing including the links between the shelf and open-ocean, and how does this impact on the contribution to the climate regulation service?
- What is the role of higher trophic levels in the carbon cycle? *[Biogeochemical models need to be linked to fish/fisheries models.]*
- What impacts would human activities (extractions) have on the carbon pump service? (eg. Fishing at lower trophic levels or in new places, on mesopelagics)
- What are the trade-offs in ecosystem functions and services under varying exploitation/use patterns (eg. Harvest or not to harvest mesopelagics, changes in physical circulation/carbon cycling)?
- What are the trade-offs between exploitation food/feed resources and maintaining charismatic species?

Metrics of ecosystem health

- At a Basin-scale:
  - What monitoring do we need to develop to assess the health of the open ocean and what can rely on the monitoring along the shelves?
  - How can a suite or a single metric / indicator of ecosystem health be developed?
  - How to set targets, boundaries and reference points? What are the uncertainties of the assessments?
  - How to extrapolate / scale up from small spatial and temporal scale, few samples?
  - What observations, how many observations do we need to evaluated ecosystem health?
  - System integrity, resiliency to change?

To the future of trans-Atlantic science!

Photo: TDL Wenneck