



Fisheries and Oceans
Canada

Pêches et Océans
Canada

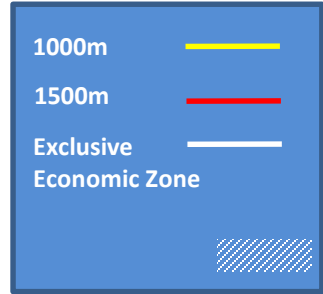
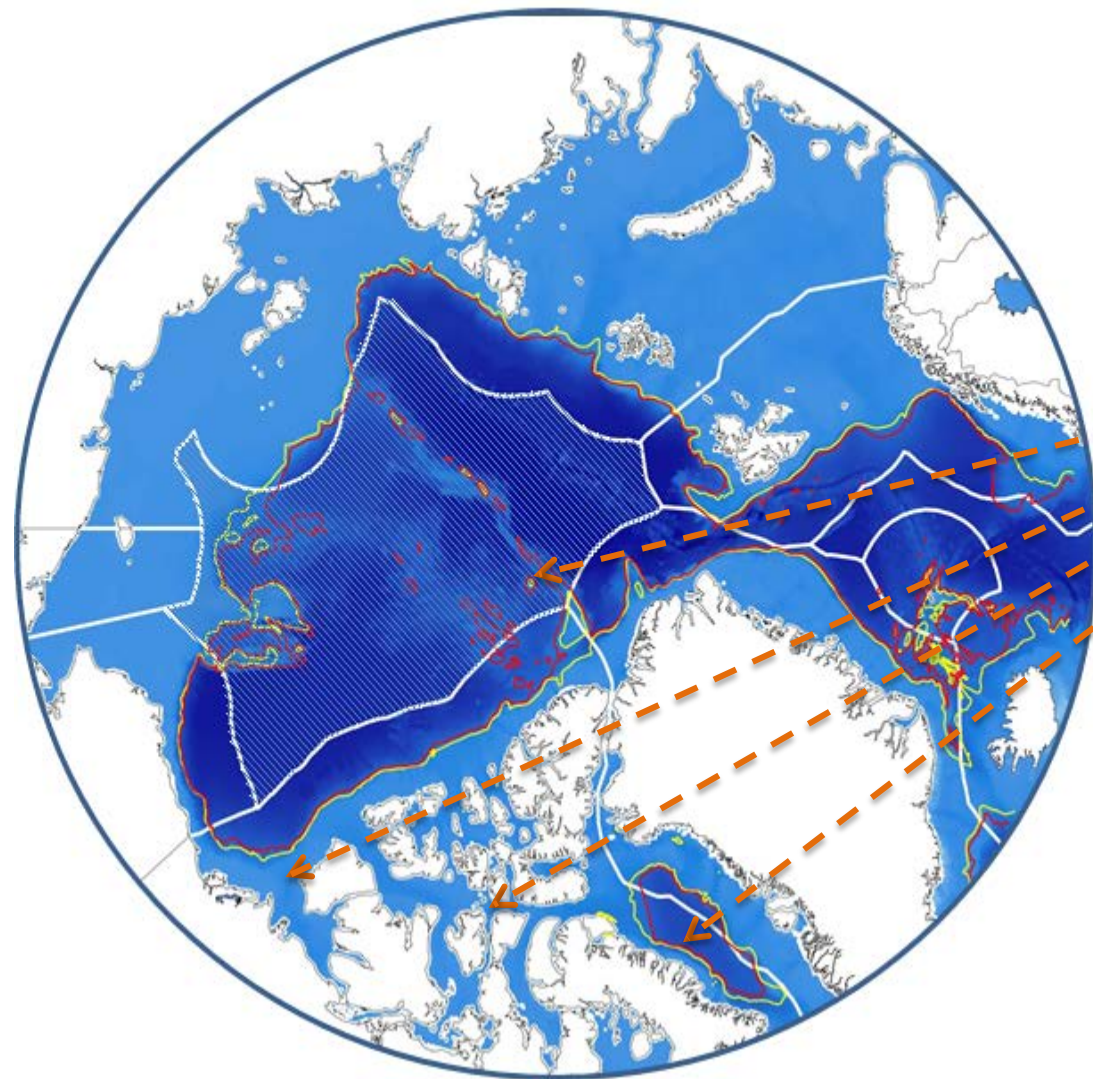
Canada: Recent Research, Monitoring and Synthesis Activities

Update to Arctic Fisheries Research Workshop
Seattle, April 2015

Synthesized and presented by Jim Reist

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Arctic Ocean Bathymetry & Exclusive Economic Zones



Areas of Canadian Activities

- Central Arctic Ocean
- Beaufort Sea (western)
- Archipelago (central)
- Baffin Bay/Davis Strait (east)

Types of Canadian Activities

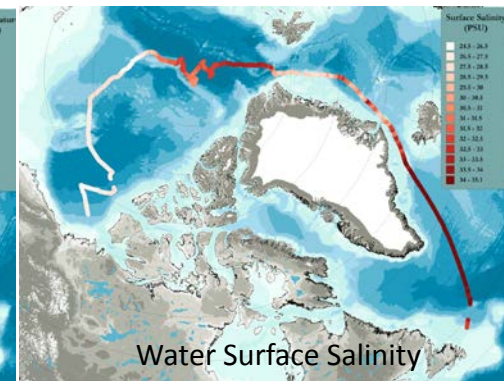
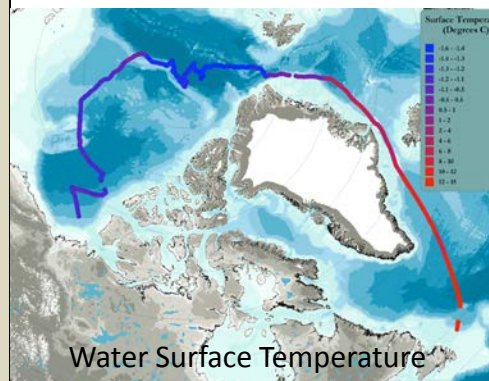
- Research
- Monitoring
- Synthesis & Integration
- Data delivery (international)

Delivery to:

- Fishery/Habitat co-managers
- Oceans Managers
- National/international forums

Research Activities I: CAO Oceanographic Data Collection (Eert/Cooper – DFO IOS)

- Physical and geochemical measurements during CCGS Louis S. St. Laurent polar mission (Aug-Sept 2014) to determine water mass distribution and ocean circulation.
- 126 expendable CTD (XCTD) casts as part of Pan-Arctic Climate Investigation (JAMSTEC/DFO).
- CTD/rosette casts (ROS) at 2 stations (46 water bottles to be analyzed for TIC, pCO₂, salinity, oxygen, nutrients, CDOM, Bacteria, Barium, O-18).
- Underway Measurements: seawater loop system (salinity, temperature, chlorophyll, CDOM, oxygen saturation); data on geo-position, weather, sonder depths and ice (cameras).



Research Activities II: Lower Trophic Level (Michel & Niemi, DFO – Winnipeg)

- Beaufort Sea (2012-2014): Water Mass Description (nutrients, O₁₈, POM, fatty acids, stable isotope tracers); primary productivity (chlorophyll, DOC, microbes) – inter-annual variability and estimates of productivity in Canadian Beaufort Sea.
- Primary production in high Arctic:
 - SUBICE (under-ice blooms) in Chukchi Sea (Arrigo, Stanford) 2014 to determine fate of ice-associated production to microbial systems (i.e., potential re-direction of energy away from higher-trophic levels).
 - TRANSSIZ preparations for May 2015 seasonal sea ice transit (Svalbard area) aboard *Polarstern* (AWI Germany) – cryo-pelagic-benthic coupling on Barents Shelf and Nansen basin (better prediction of primary production in ice-free Arctic Ocean).
- Canadian Arctic Archipelago (2010-2013) – 100 ice stations for production and food web linkages in first- and multi-year ice:
 - production in this multi-year sea ice is orders of magnitude HIGHER than in the Beaufort Sea.

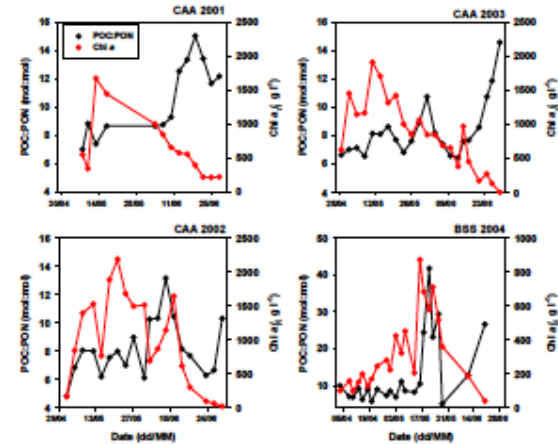


Figure 1. Seasonal trends in sea-ice C:N and chlorophyll a biomass (Chl a) for the CAA and BSS. Note change in scales for the BSS.

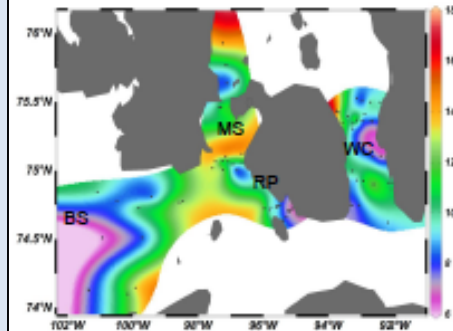


Figure 3. Spatial variability in sea-ice C:N in Barrow Strait (BS), Resolute Passage (RP), McDougall Sound (MS) and Wellington Channel (WC) in the CAA. Samples collected 1-20 May 2010-2013.



Figure 4. Variability in density and species composition of bottom ice algae with corresponding C:N ratios of A) 7.8, B) 9.6 and C) 13 (*Melosira* dominated). Samples from CAA 2012.

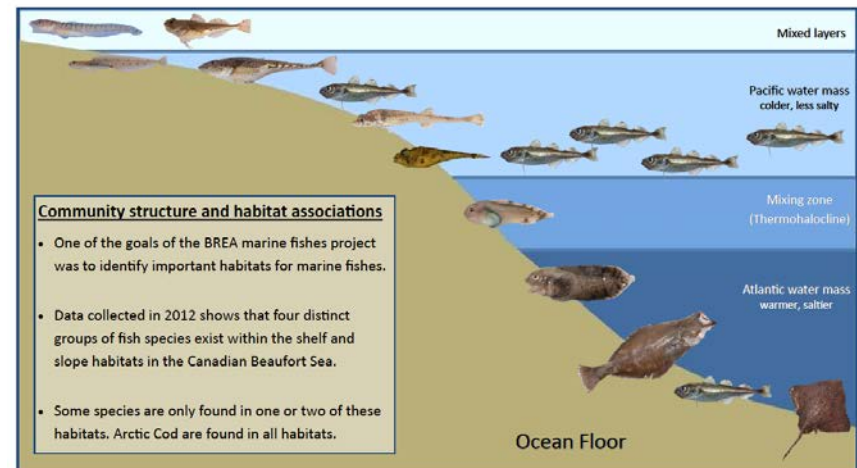
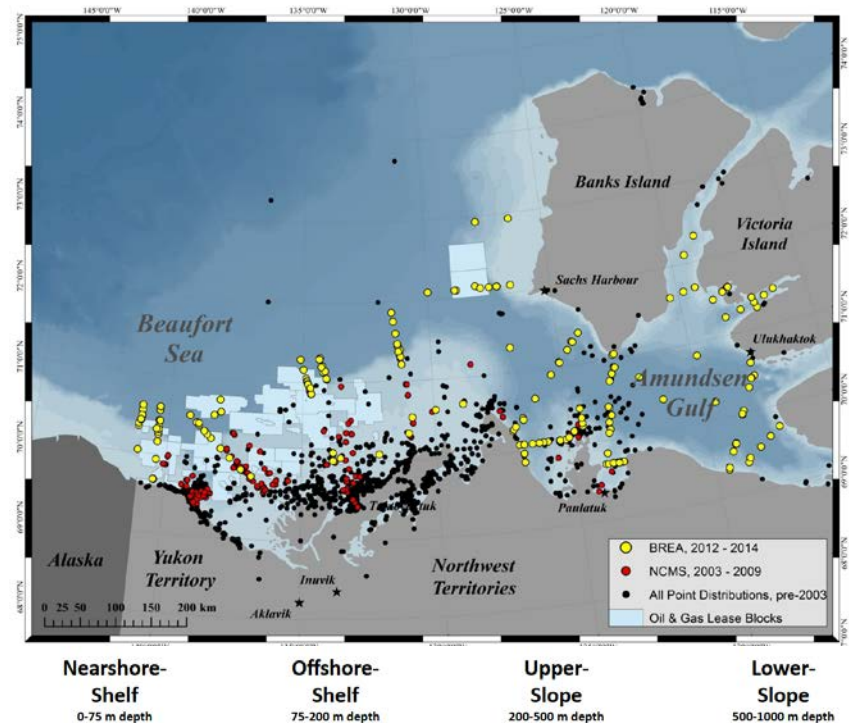
Research Activities III: Beaufort Regional Environmental Assessment – Marine Fishes Program (Reist) & Coastal (Reist/Loseto)

• Offshore Marine Fishes:

- Fish (bottom trawl, hydroacoustic biomass, midwater trawl), plankton & benthos diversity, pelagic & benthic (substrate) habitats, ecosystem function & couplings with shelf (<150m) & coastal ecosystems.
- 2012-2014 (4-6 week field seasons) sampling Beaufort Sea & Amundsen Gulf from ~40-1000m (+1515m depth sampling).
- Increased geographic, offshore & deep water spatial coverage (fishes, plankton, epifauna & infauna); inter-annual variability for several key transects.
- Incremented known marine fish diversity from 52 to 68 (+20 anadromous) species.
- Marine fish community is depth-structured.
- Inter-annual variability in Arctic Cod biomass and habitat usage (ice associated?).
- Wind- and ice-moderated(?) upwellings along slope concentrate biota in key areas.

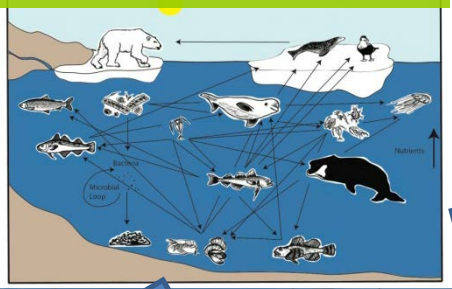
• Coastal Studies (fishes, MM, habitat):

- Six coastal sites (3 estuarine/3 marine) assessed (and monitored – capelin increasing in abundance) to link with off-shore studies.



Linking Coastal and Offshore Ecosystems – Loseto et al.

Beaufort Sea Ecosystem Model



Off Shore Fish



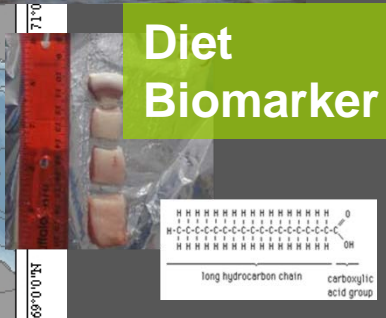
Opportunistic Beluga and cod



Beluga Habitat Use and Characterization



Diet Biomarker



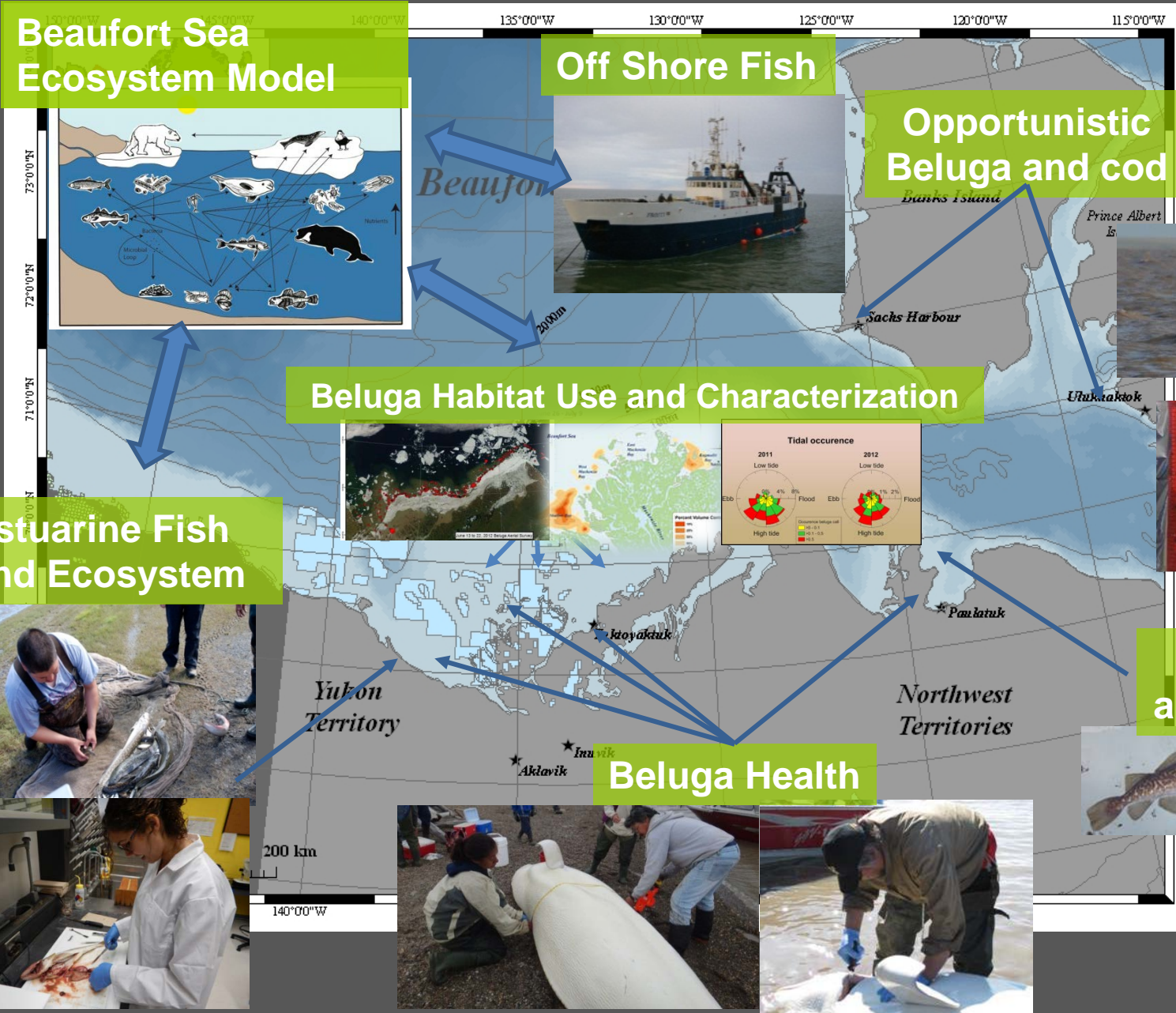
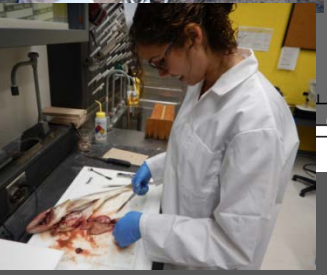
Estuarine Fish and Ecosystem



Marine Fish and Ecosystem



Beluga Health



Research Activities IV: Multi-species surveys Baffin Bay/Davis Strait (Treble/Hedges)

- Annual bottom trawl survey (with Greenland Institute Natural Resources):
 - Assess Greenland Halibut and shrimp stocks in Canadian part of BB-DS (100-1500m) (NAFO Area 0A & Hudson Strait - shrimp)
 - Greenland Halibut time series from 1999
 - Catch and biological data on other demersal fishes and invertebrates collected
 - Salinity and temperature data collected
 - Data, once verified, are shared on Ocean Biogeographic Information System (OBIS)
 - Distribution, abundance and biological data on focal species incorporated into NAFO Scientific Council and Canadian Science Advisory Secretariat reports.



Research Activities V: Inshore surveys Eastern Arctic (Hedges et al.)

Scott Inlet (Clyde River)

- Greenland Halibut - test fishing, biological data into stock assessment activities
- Tracking - Greenland Halibut, Greenland Shark & Arctic Skate (Ocean Tracking Network & DFO)

Cumberland Sound

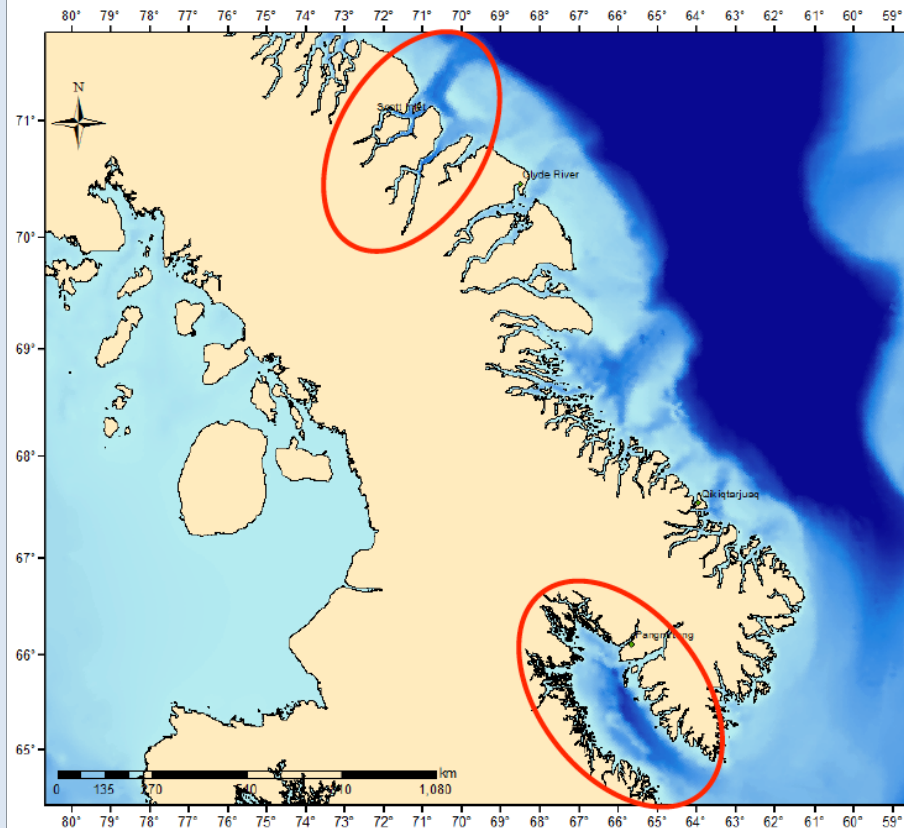
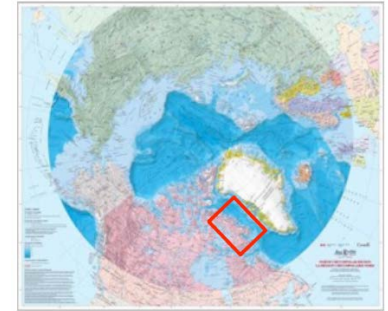
- Community-based commercial winter Greenland Halibut fishery; developing summer fishery (depth-stratified long-line survey)
- Greenland Halibut movements (Ocean Tracking Network & DFO)
- Capelin on southern Baffin Island: population abundance and range changes (?)

Expand Inshore Fisheries Research

- Assessments in western areas
- Biodiversity surveys in northern & western areas

Greenland Halibut (other research)

- Otolith microchemistry - verify aging and Sr evacuation rates to verify life history assumptions for other species
- Genetic re-analysis of North Atlantic panmixis (Roy et al. 2014, Can. J. Fish. Aquat. Sci.)



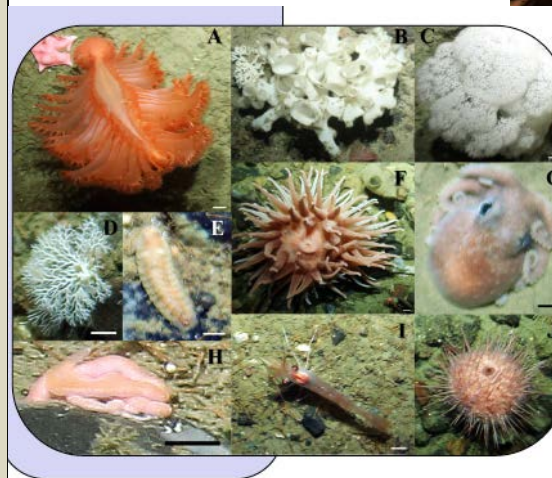
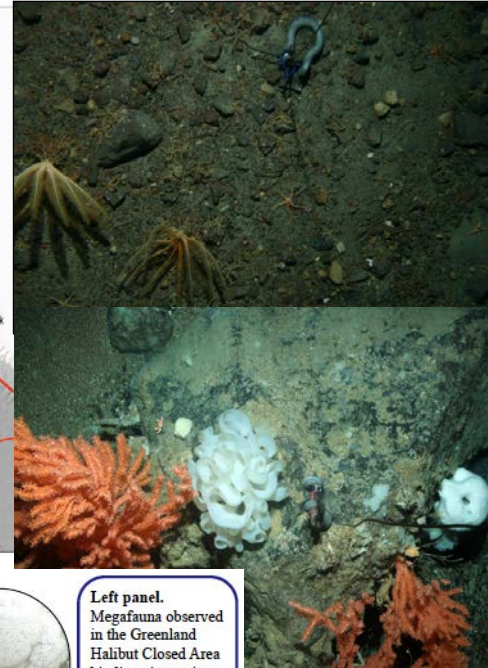
Activities VI: Baffin Bay Benthic Biodiversity Research & Monitoring (Kenchington et al. BIO)

Benthic Productivity & Sea-birds

- Lancaster Sound (Marmen et al.) – 2012 comparison of benthos in areas without & with sea-bird colonies (diversity not affected but productivity may differ).

Benthic Diversity Monitoring

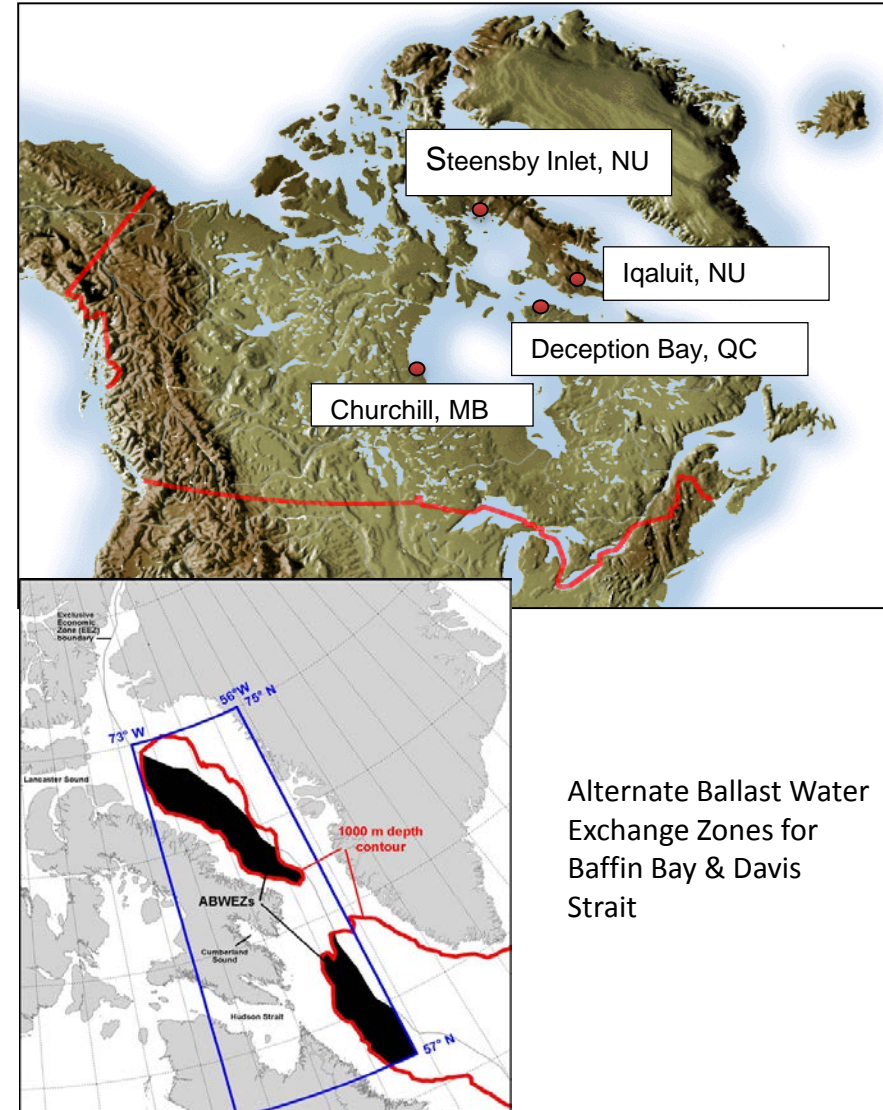
- Circumpolar Biodiversity Monitoring Protocols (photographic transects and grabs, 2013) in area closed to bottom trawling (low disturbance).
- Spatial diversity and density estimated, taxon photos and identification to lowest taxonomic level with confirmation through DNA barcoding.
- Data to be uploaded to Arctic Council Data Portal (see Canadian CBMP protocol).



Left panel.
Megafauna observed in the Greenland Halibut Closed Area biodiversity stations. A) sea pen *Pennatula borealis* and sea star *Ceramaster granularis*, B) sponge *Asconema foliata*, C) nephtheid soft coral, D) unknown stalked bryozoan, E) scale worm, F) unknown anemone, G) unknown octopus, H) unknown nemertean, I) pandalid shrimp, J) urchin of the genus *Echinus*.

Activities VII: Marine Aquatic Invasive Species Research & Monitoring (Howland et al. 2012-present)

- **Baseline knowledge:**
 - Early detection of non-indigenous organisms in Arctic Ports (Canadian Aquatic Invasive Species Network)
 - Inventory existing biota & compare to existing information (??any changes) incl. multi-species environmental DNA (eDNA)
 - ~20% identified taxa were newly reported for the location but origins is uncertain (unsampled vs introduced)
- **Invertebrate AIS Risk & Climate Change:**
 - Modeling of risk (i.e., vector, biology) linked to ecology (and projected changes)
 - 8 species have potential high risk for range extension and/or invasion
- **Ecological Risks of Ballast Water Exchange:**
 - Existing eastern areas are high risk with new suggested areas beyond 1000m
 - No feasible areas in Beaufort Sea area.
- **Ballast Water as an AIS Pathway:**
 - Churchill & Deception Bay – examination of ballast water from arriving ships



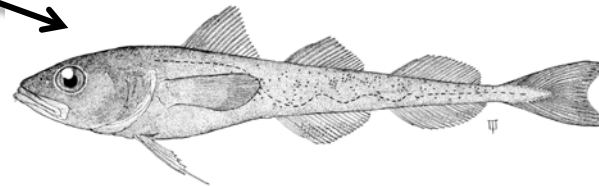
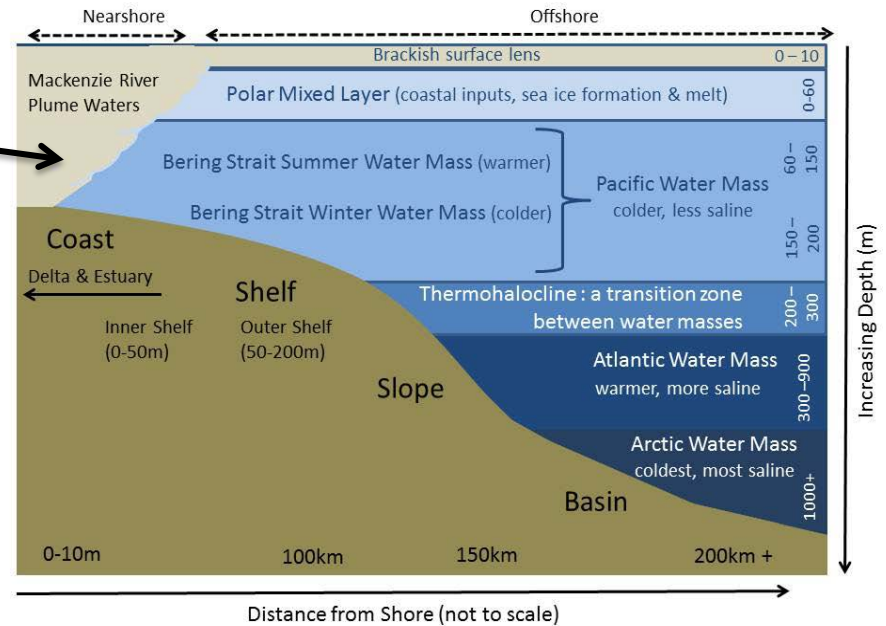
Synthesis & Integration Activities (Reist)

- **Canadian Domestic Waters:**

- Distribution, diversity & habitat associations of marine fishes in Canadian Beaufort Sea (DFO MS report as draft, publication in late 2015)
- Marine Fishes of Arctic Canada – Coad & Reist, book (final draft in revision presently): identification keys, illustrations, descriptions & point distributions; plus bibliography (electronic) and published data base of distributions (late 2015 date).

- **Central Arctic Ocean (CAO):**

- Fishes of CAO (abundance, roles, Canadian shelf linkages)
 - Benthic ecosystem of CAO (bottom types, benthos)
 - Fishes & benthos of Chukchi Cap
- (all as draft contract reports; to be integrated and synthesized, publication in 2016)



Arctic Cod in Arctic Canada; Coad & Reist



Recent International Reporting – a sampling

International Research Reporting

- Arctic Biodiversity Assessment (Fishes & Marine Ecosystems)
<http://www.arcticbiodiversity.is>
- Arctic Biodiversity Congress (Dec 2014)
 - Fish research in Beaufort Sea & Baffin Bay/Davis Strait
 - Benthos in Baffin Bay/Davis Strait
 - <http://www.arcticbiodiversity.is/congress>
- Gordon Polar Marine Conference (March 2015)
 - C:N ratios in sea ice & water column
 - <https://www.grc.org/programs.aspx?id=14833>
- Marine Fishes in Arctic Report Card (2013) http://www.arctic.noaa.gov/report13/marine_fish.html
- Polar Biology 2015? Special Issue on Arctic/Polar Cod (4 papers from Canada)
- Arctic Ocean Acidification
 - <http://www.amap.no/documents/doc/amap-assessment-2013-arctic-ocean-acidification/881>

Other Canadian Activities (non-governmental)

The following organizations conduct research in the Canadian (and global Arctic); although activities are not enumerated here, linkages exist between them and DFO; linkages also exist between DFO scientists and various universities.

- ArcticNet:
 - <http://www.arcticnet.ulaval.ca>
 - Various publications; data archived through Polar Data Catalogue
- Ocean Tracking Network:
 - 4.10. Fish and marine mammal interactions in the high Arctic
 - 4.11. Deep-water Arctic marine fishes: Developing commercial fisheries and interactions with marine mammals
 - 4.13. Tracking anadromous adult salmonids in Canada's three oceans to evaluate the sustainability of catch-and-release angling practices – behavioural and physiological perspectives on estuarine fisheries
 - <http://oceantrackingnetwork.org>
- Canadian Healthy Oceans Network:
 - <http://chone.marinebiodiversity.ca>

Data Delivery & Monitoring

Data Delivery

(project-specific from research & commercial stock assessment & monitoring programs)

- Polar Data Catalogue:
 - Beaufort Sea Marine Fishes (i.e., metadata and first-order data) – usually <6 months
 - <https://www.polardata.ca>
- By-catch Data: OBIS, <http://www.iobis.org>
- Stock Assessment Data/reports: NAFO, <http://www.nafo.int>
- Internal DFO data reports:
 - Detailed 2nd (biological) and 3rd order (e.g., lab analyses of trophic markers) – no longer than 2 years (or before)
- Other Internal DFO reports:
 - Technical Reports
 - Manuscript Reports

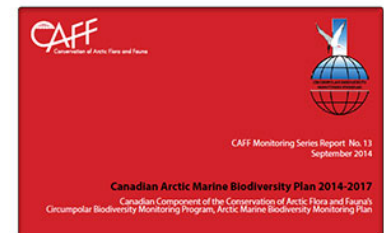
(Data, Technical & Manuscript reports available at <http://waves-vagues.dfo-mpo.gc.ca/waves-vagues/>)

 - Canadian Science Advisory Secretariat (formal advisory documents) (available at <http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm>)
- Other:
 - Arctic Council Data Portal - <http://arcticdata.is>

Circumpolar Biodiversity Monitoring Program – Canadian Arctic Marine Biodiversity Plan (Watkins et al.)

- Focal Ecosystem Components: sea-ice biota, plankton, benthos, fishes, sea-birds & marine mammals.
- Regional ecosystem-based approach: Beaufort Shelf, Lancaster Sound, Western Hudson Bay, Hudson Strait, Southeast Baffin Bay, Nares Strait/North Baffin Bay.
- Linkages to ongoing Marine Expert Networks (e.g., marine fishes) – ‘State of the Arctic Marine Biodiversity (SAMBR)’ writing workshop.
- Nelson, R.J. 2012. Development of indicators for Arctic Marine Biodiversity Monitoring in Canada. Canadian Science Advisory Secretariat Research Document 2012/123

CAFF Monitoring Series Report
No. 13, Sept. 2014.
<http://www.caff.is/marine/marine-monitoring-publications/278-canadian-arctic-marine-biodiversity-plan-2014-2017>

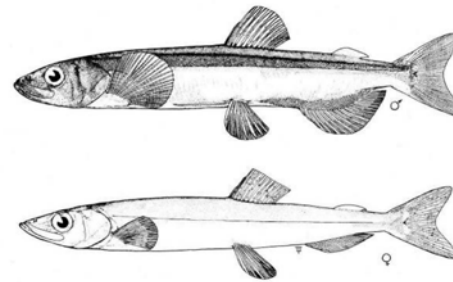


Biological Evidence of Possible Changes in Arctic Ocean

- Anecdotal reports:
 - Walrus in Western Arctic in 2014 (Darnley Bay);
 - Narwhal in western Archipelago;
 - eastern & western Arctic bowheads now have potential in contact in central archipelago.
- Pacific salmons in Mackenzie River (west):
 - increased frequency of vagrant occurrences;
 - population increase of the only natal species (Chum);
 - Pink Salmon occurrence in eastern Greenland waters in 2012 (PhD student/monitoring).
- Atlantic salmon occurrence on central & northern Baffin Island 2012 & 2014
- 2-10 marine fish species in CBS may be due to increased variability in underlying system (i.e., 6 were boreal-pacific types; two others are boreal-arctic types).
- Increased abundance (& occurrence ?) of capelin in some western Arctic areas.

BUT

- Vagrant occurrence does not equal established reproducing populations, and
- Many baselines are simply too limited (either do not exist or too short time series) to be valid for establishing occurrences as resulting from climate change (although variability is perhaps increasing).



Capelin in Arctic
Canada; Coad & Reist



Ongoing and Future Plans

- **Ongoing work:**

- Most activities summarized above are continuing: regular publication & data analysis/delivery.
- BREA – Marine Fishes Project: data analysis & complete delivery over next two years.

- **New Initiatives:**

- BREA Marine Fishes Project II: seeking funding to extend it (further offshore, north & east), but....

- **Central Arctic Ocean (JPSRM):**

- Canada endorses the concept and suggests further development of both the approach & detailed planning.
- Key research questions need to be developed, agreed to, and developed into an organized approach.
- Development of a time line for research activities would facilitate planning, funding acquisition and approvals.

- **With respect to CAO fish populations, the three possibilities are:**

- Limited now, commercially unviable in future (habitat, productivity, accessibility constraints)
- Limited now, but future potential (may become viable? – after colonization and/or population expansion)
- Stocks are present now

- **Key Research & Monitoring Questions:**

- Fishes & macrobenthos presently in accessible areas and depths of CAO (and fringing seas) – inventory, density & biomass.
- Present ecosystem structure & function that supports these components in CAO.
- Linkages and relationships of these to EEZ fringing seas (biotic exchanges) and/or pelagic sea-ice system.
- Anticipated changes in medium-term future.
- Consequences of exploitation and development (e.g., shipping) to the components.
- Which easily obtained pelagic parameters (e.g., if any from ice-breakers) can be used as proxy estimates of CAO demersal ecosystem.

A Conceptual Approach to Areas becoming Accessible – Chukchi Sea

- Chukchi Cap Area – shelf to deep waters (2000m)
- Paired Fishing Vessel with Ice-breaker support
- Scientists from all A5 countries involved; costs shared
- Fishing Vessel Activities:
 - Benthic trawling to 2000m
 - Mid-water trawling
 - Hydroacoustics – biomass
 - Plankton – multiple depths
 - Camera-benthic sled assessment
- Ice-breaker Science Activities:
 - CTD Rosette: chemistry, nutrients etc.
 - Benthic box-core: benthos, infauna
 - Plankton – surface
 - Multi-beam sonar
 - ROV Video bottom assessment

