The Beaufort Regional Environmental Assessment Marine Fishes Project:

Updates to the Diversity of Marine Fishes in the Western Canadian Arctic

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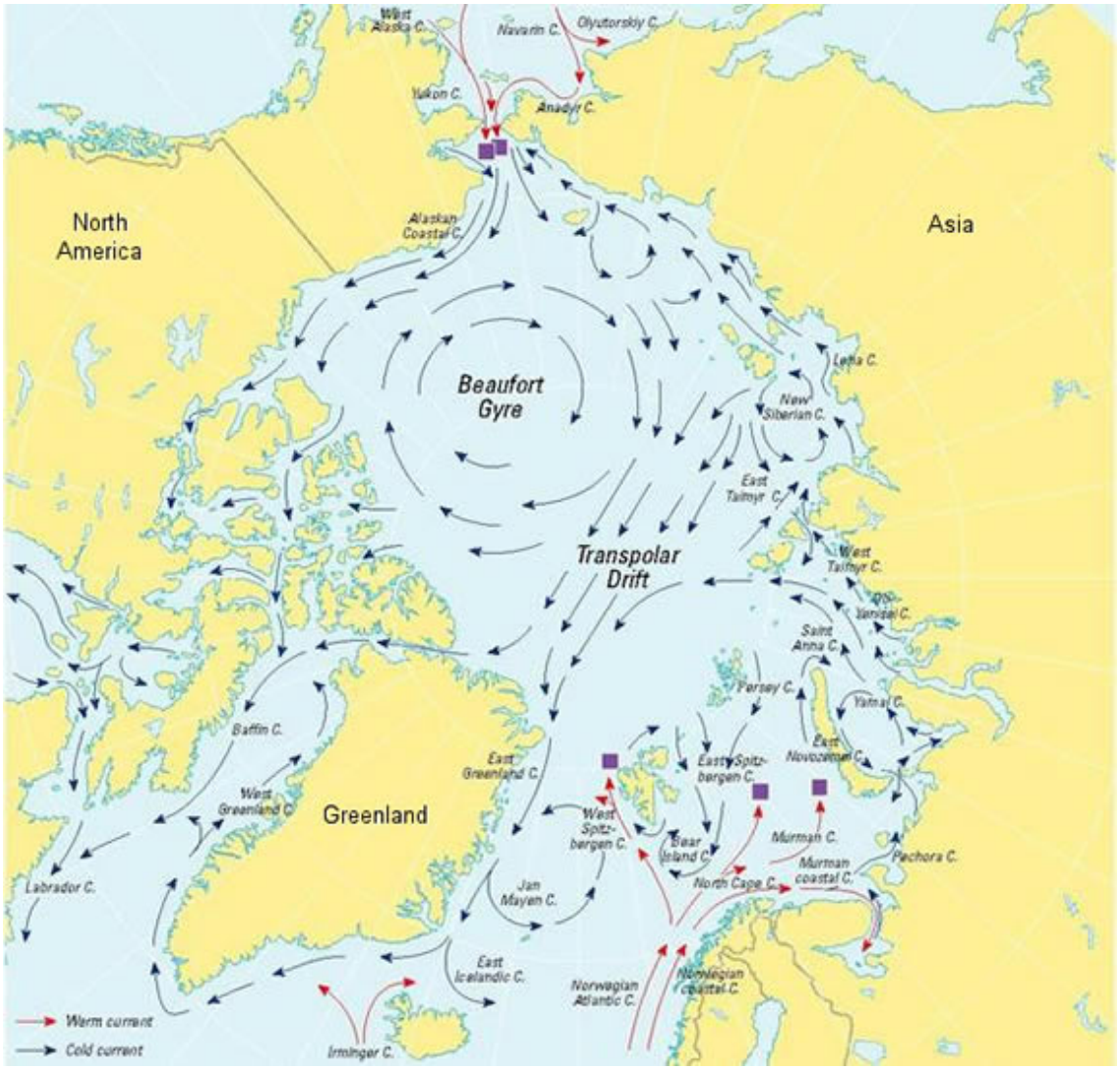
Presentation Outline

- The Canadian Beaufort Sea – Amundsen Gulf Ecozone
- Regional diversity of marine fishes to 2011
- Need for a baseline biodiversity assessment
- The Beaufort Regional Environmental Assessment Marine Fish Project (BREA)
- Updates to the regional diversity of marine fishes & comparison to the Arctic Ocean overall
- Summary and objectives for future work

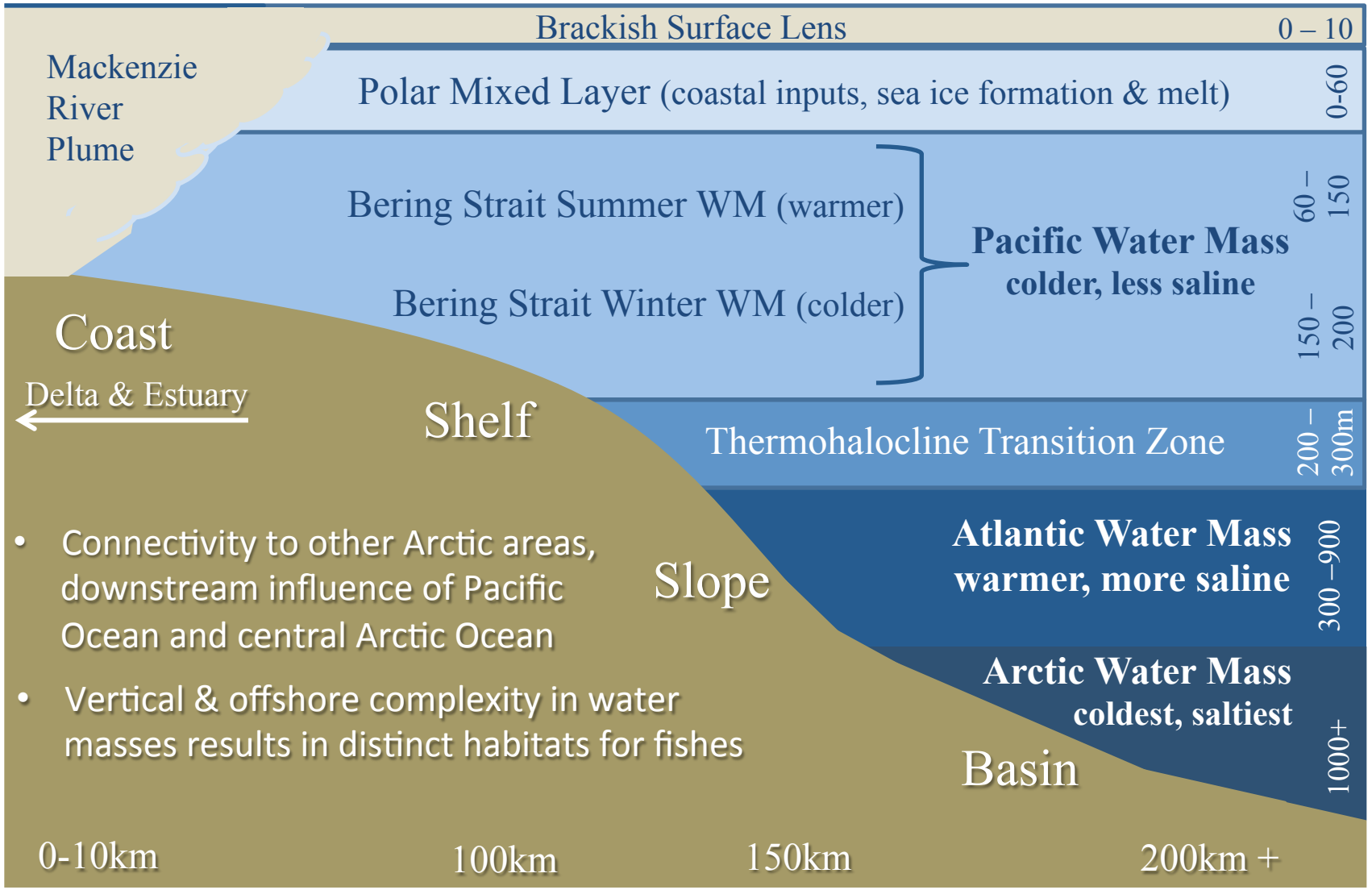
The Canadian Beaufort Sea & Amundsen Gulf Ecozone



- Extends from Yukon-Alaska border east to Coronation Gulf
- Large, wide shelf, 476, 000km^2
- Relatively shallow-slope to ~200m depth at shelf break, drops off to >1000m depth
- Highly dynamic system
- Perennial sea ice, highly seasonal environment
- Influence of Mackenzie River, largest river in Canada
- Complex circulation patterns & distribution of water masses

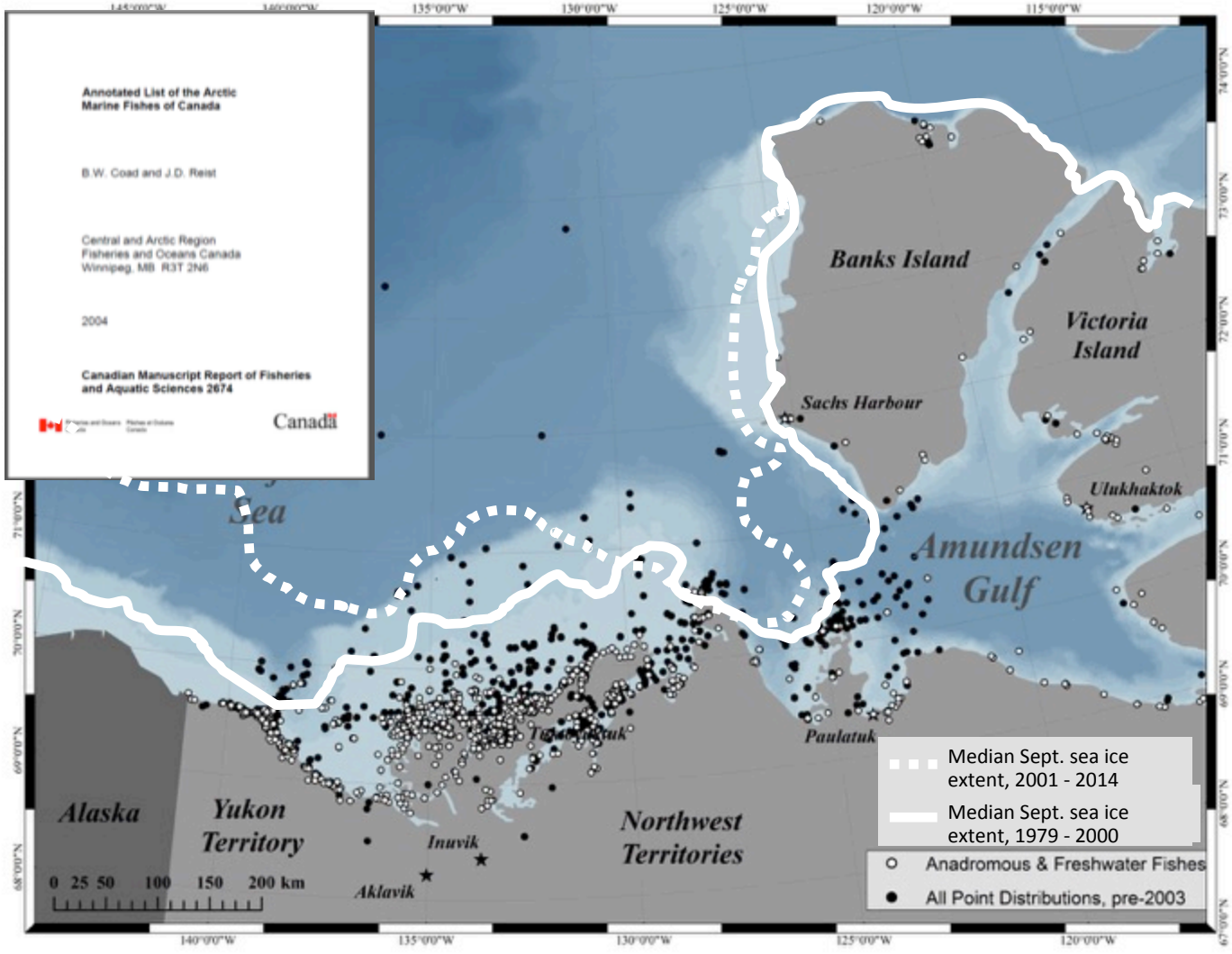
AMAP 1998

….Marine Habitats relevant to Fishes & Their Ecosystems



Baseline Biodiversity of Marine Fishes to 2003

- Majority of fish occurrence records prior to 2003 result from periodic surveys or research projects in coastal & nearshore habitats (all open water)
- Small number of ice-based activities in shallow open water
- Species complement for Canadian Beaufort Sea & Amundsen Gulf pre-2003 was 68 spp (48 marine + 20 coastal anadromous)
- Point occurrences shown include 39, 924 records



Ice data are averaged, smoothed September sea ice extent polylines available from NSIDC

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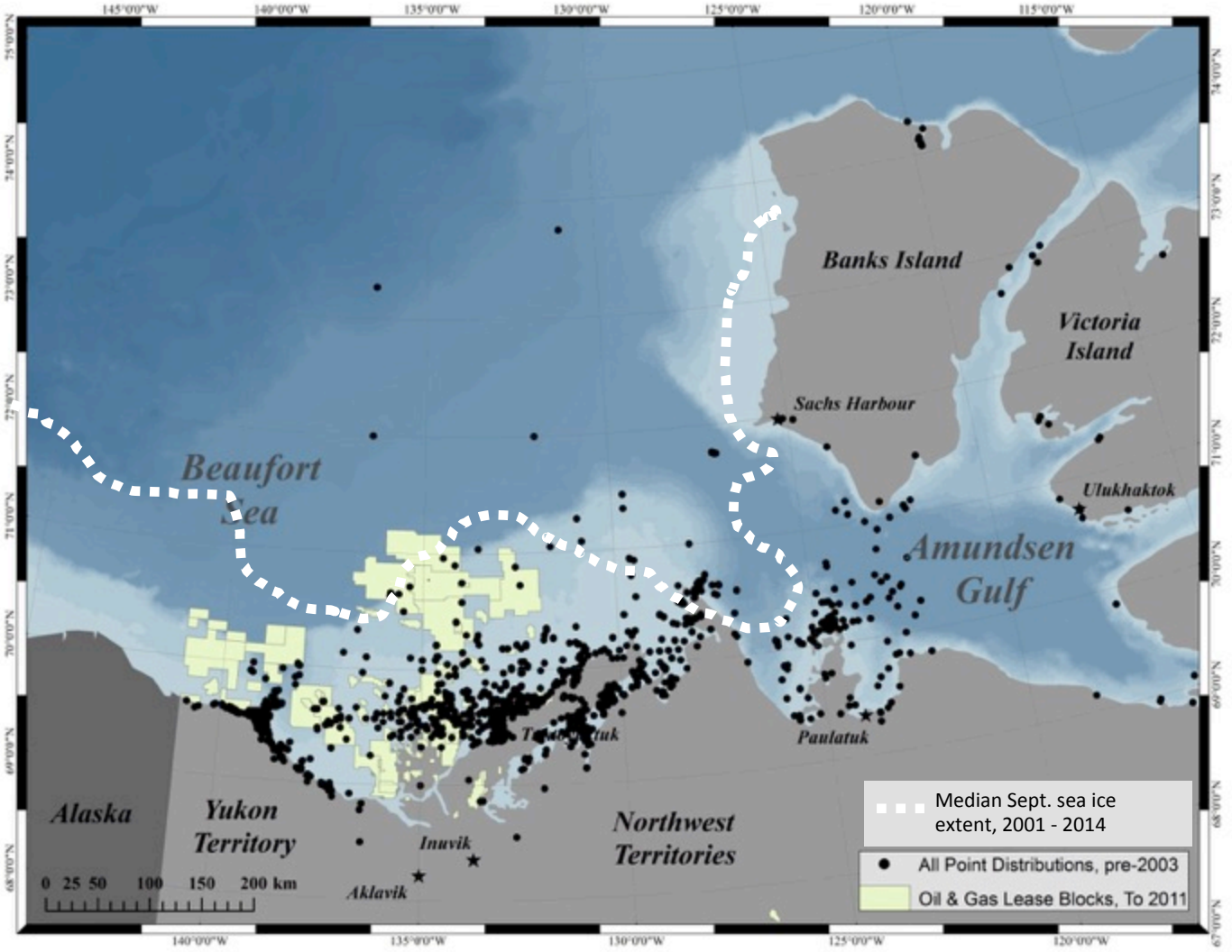
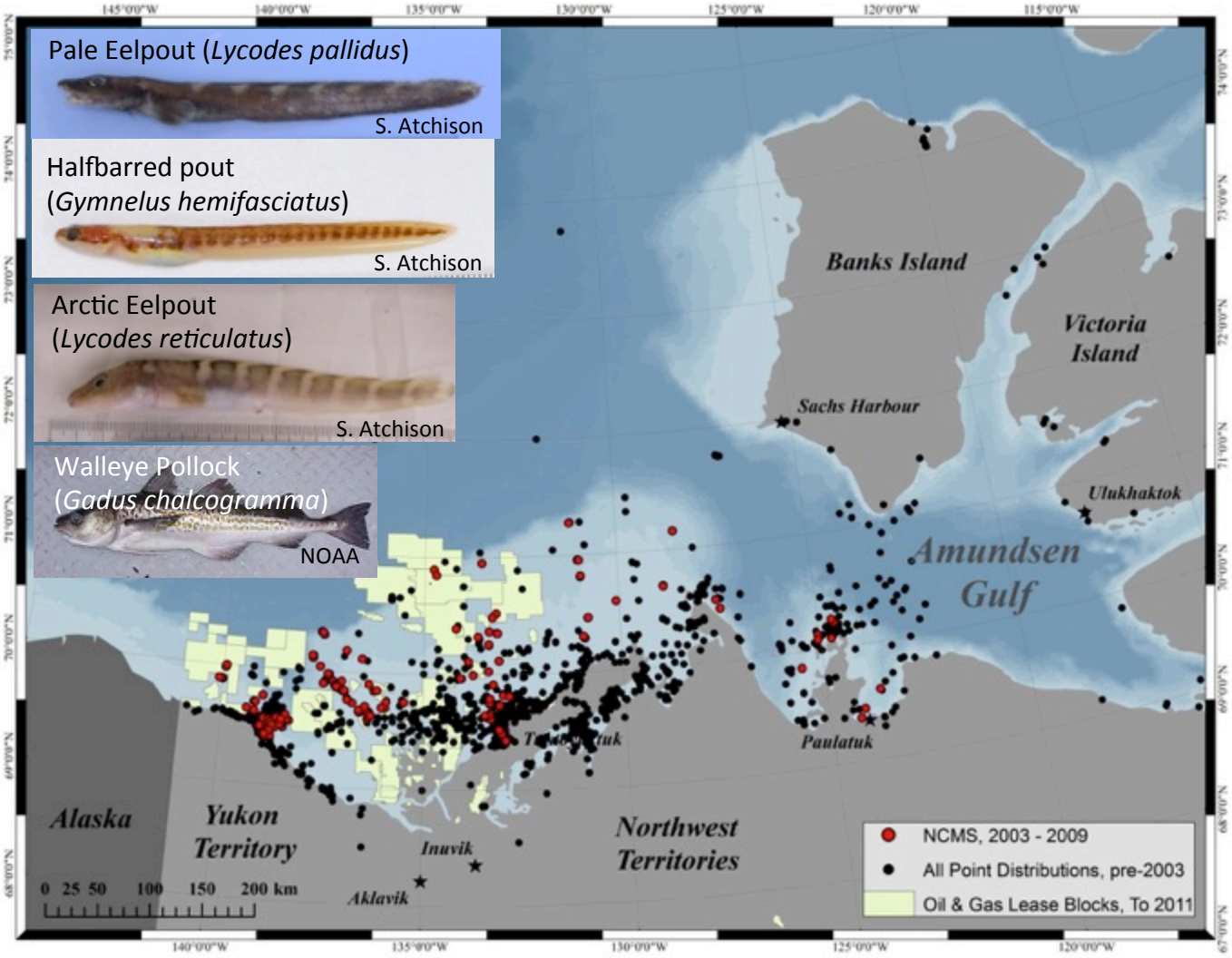


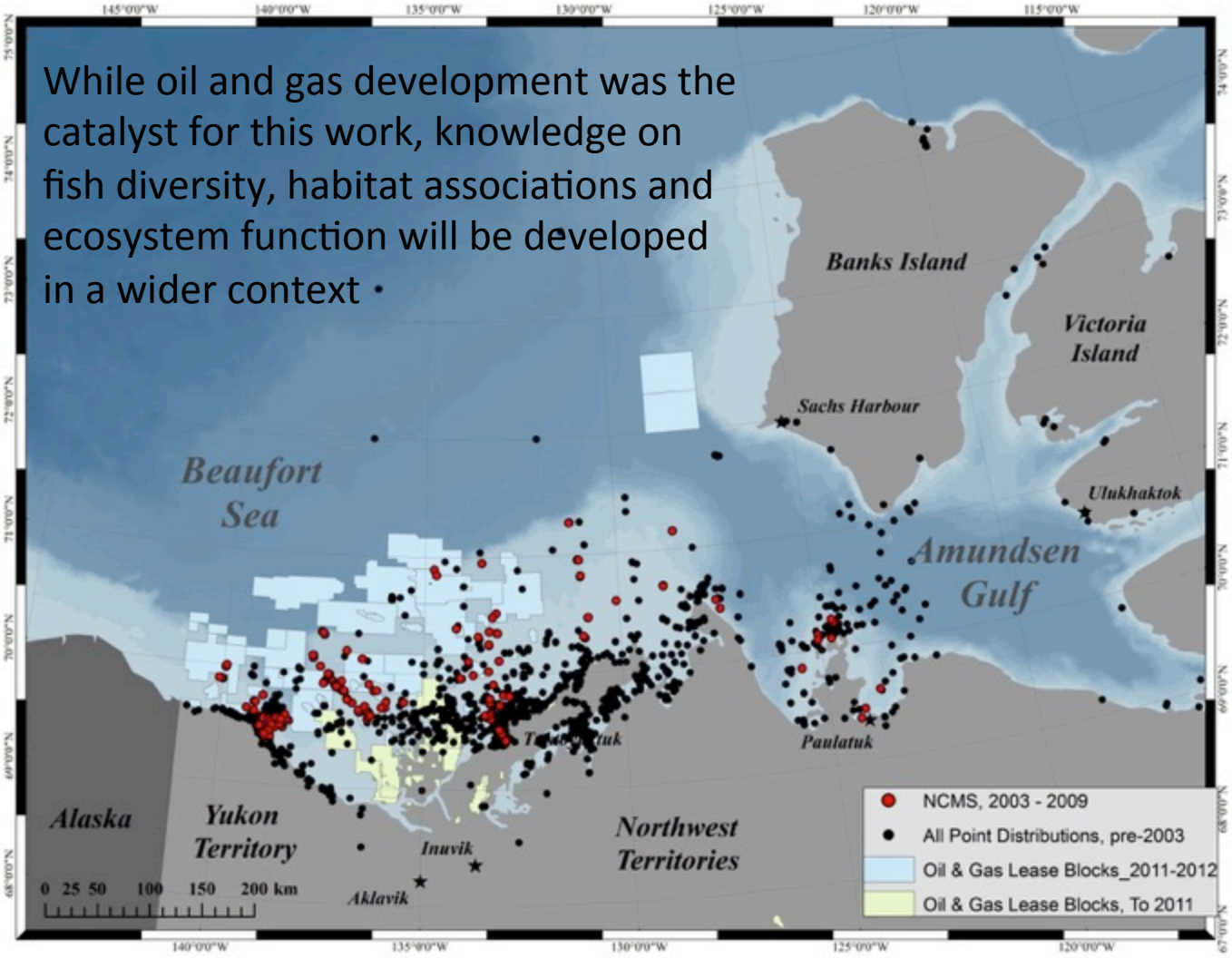
Baseline Biodiversity of Marine Fishes to 2003

- From 2003-2009, Fisheries and Oceans Canada conducted the Northern Coastal Marine Studies (NCMS)
- NCMS focused on the Mackenzie shelf, extending work from 20-150 m depths at shelf edge
- NCMS research added 566 new point occurrence records and 4 new species for an updated inventory of 52 marine fishes



Baseline Biodiversity of Marine Fishes to 2003

- New lease blocks awarded at locations farther offshore along the outer shelf, slope, and off southwest Banks Island
- Need to understand diversity and distribution of marine fishes, habitats, and ecosystem processes to detect response to change
- Prompted a comprehensive survey of the deeper waters of the southern Canadian Beaufort Sea



Beaufort Regional Environmental Assessment Marine Fishes Project

F/V Frosti, 41m chartered commercial stern trawler

Banks Island

Victoria Island

Sachs Harbour

Ulukhaktok

Amundsen Gulf

Paulatuk

Tuktoyaktuk

Yukon Territory

Inuvik

Aklavik

Northwest Territories

2012: 5 weeks in southern Canadian Beaufort Sea – sampled from 40 -1000m

0 25 50 100 150 km

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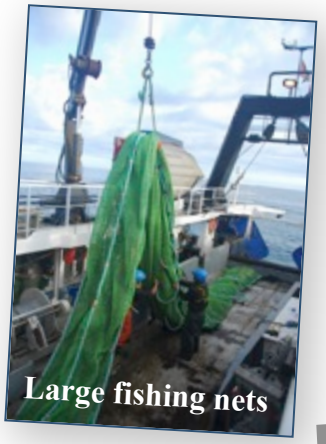
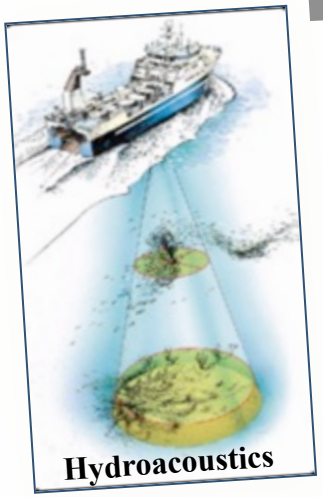
- **2013**: 6 weeks in southern & eastern Beaufort Sea, Amundsen Gulf & Darnley Bay – 20 -1500m
- **2014**: 5 weeks in northern Beaufort Sea & Amundsen Gulf – 40-500m..limited by sea ice

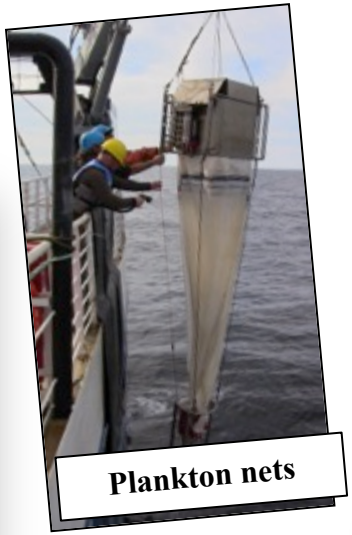
Comprehensive Sampling of Fishes and Habitats

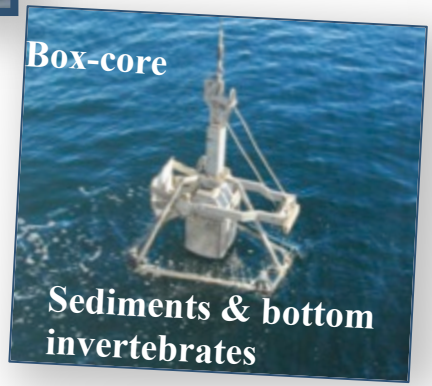
Fishes





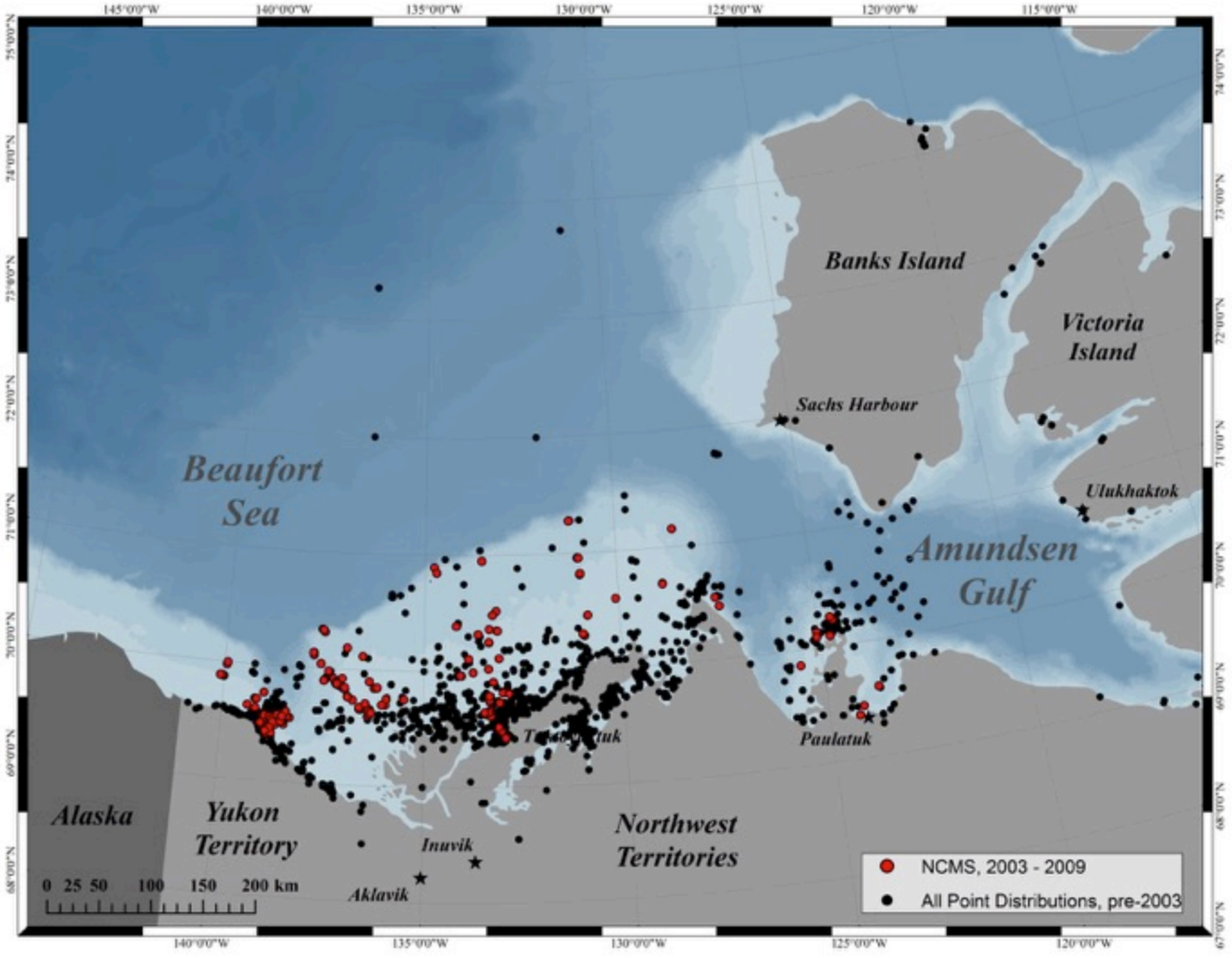
Habitats & Foodweb





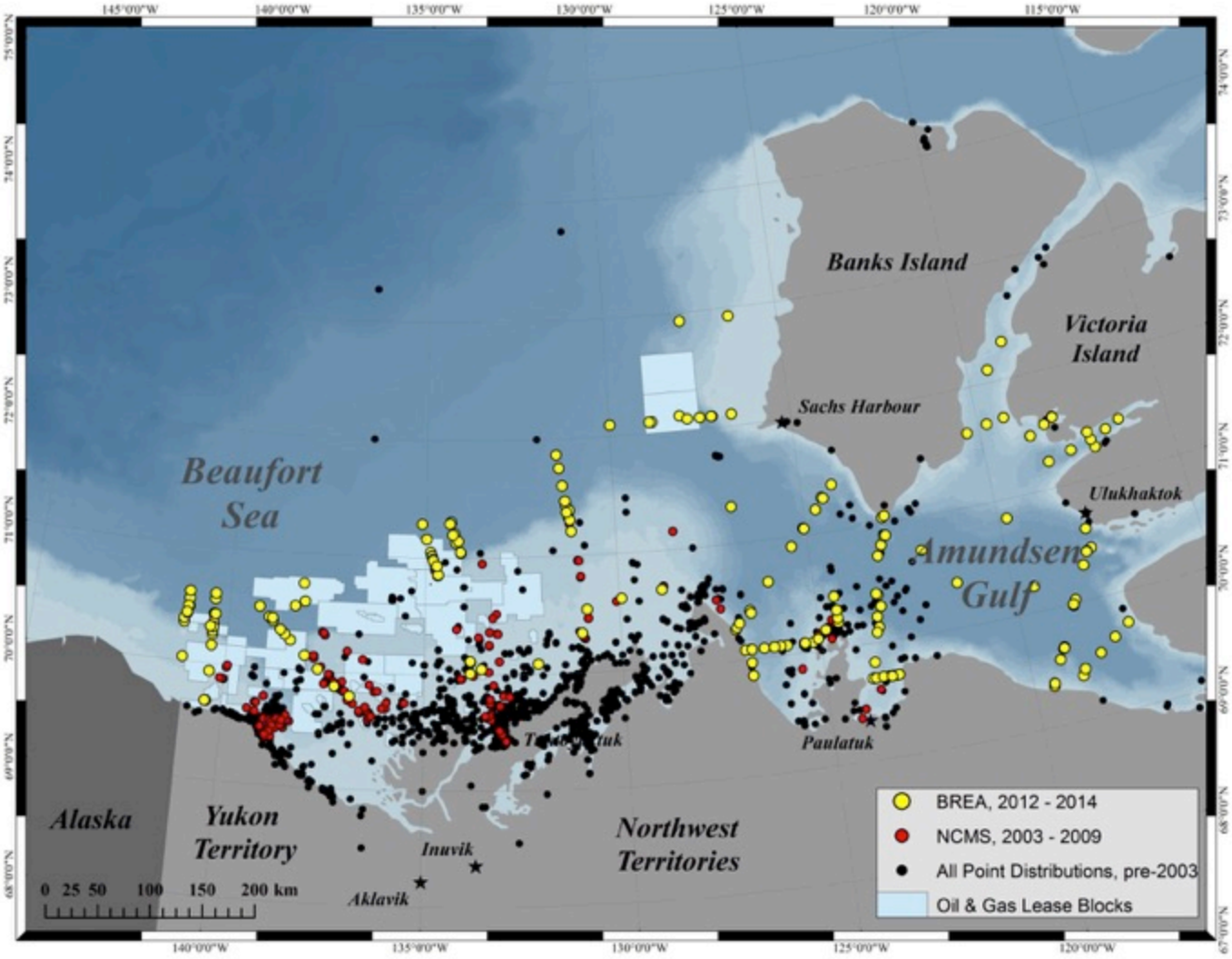
Baseline Biodiversity of Marine Fishes to 2003

- All marine fish point occurrences prior to 2012, revisited

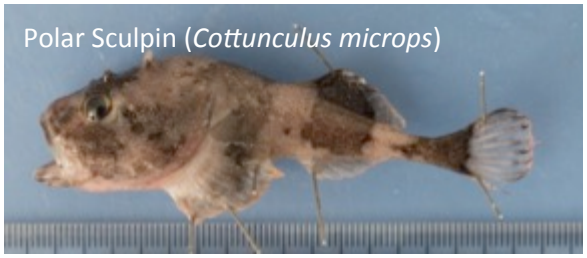


Baseline Biodiversity of Marine Fishes to 2014

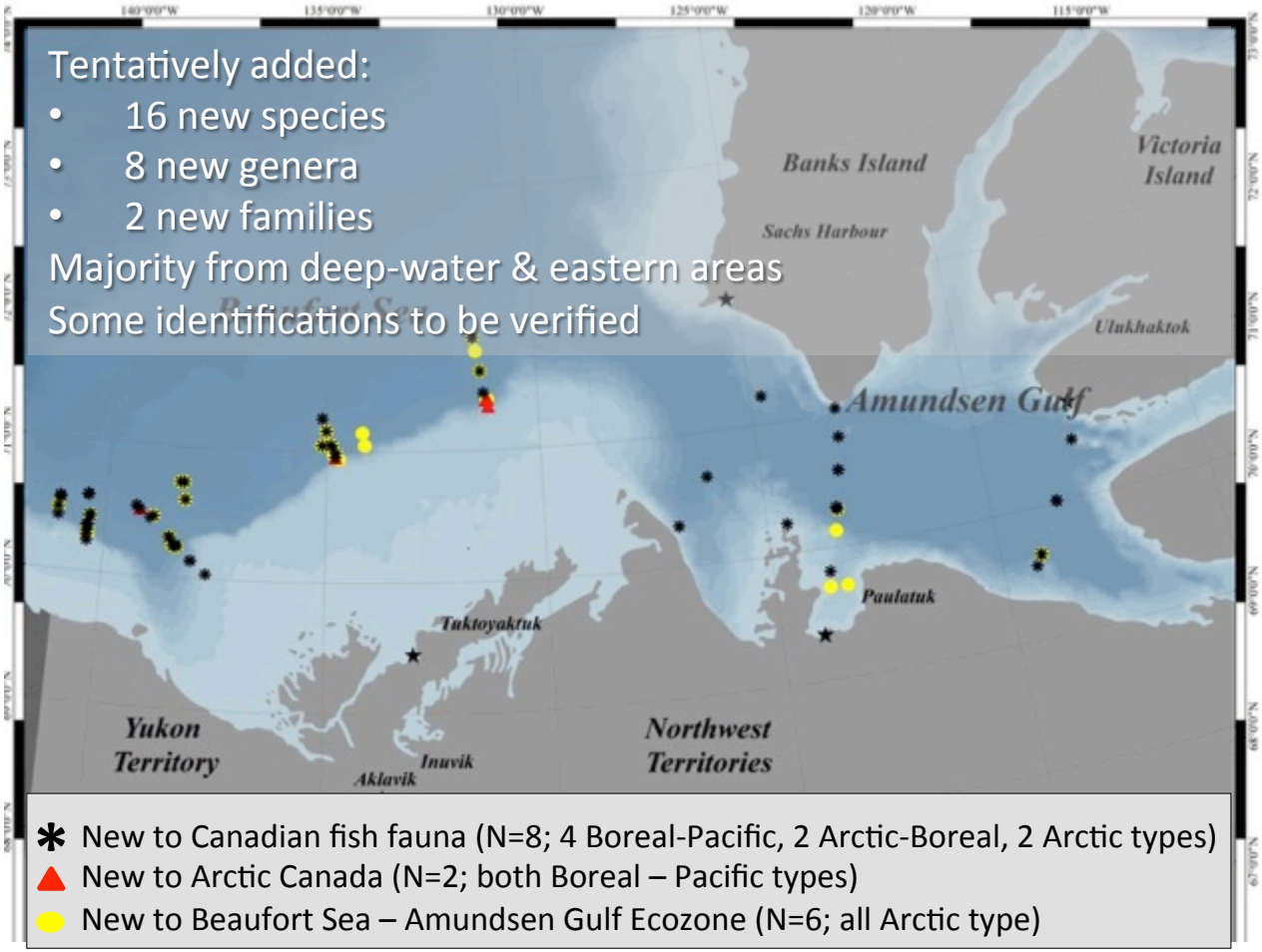
- BREA Marine Fishes Project extended work offshore to 1515m depths & east into Amundsen Gulf
- From 2012 – 2013, added 16 more spp. (mostly deep water, offshore, & eastern)
- Total fish diversity now 68 marine spp. (+20 coastal anadromous)
- 2014 findings are unknown as yet (eastern & northern Amundsen Gulf, to 73°N off western Banks Island)
- Added at least 689 new records



New Marine Fishes Occurrences, 2012 & 2013

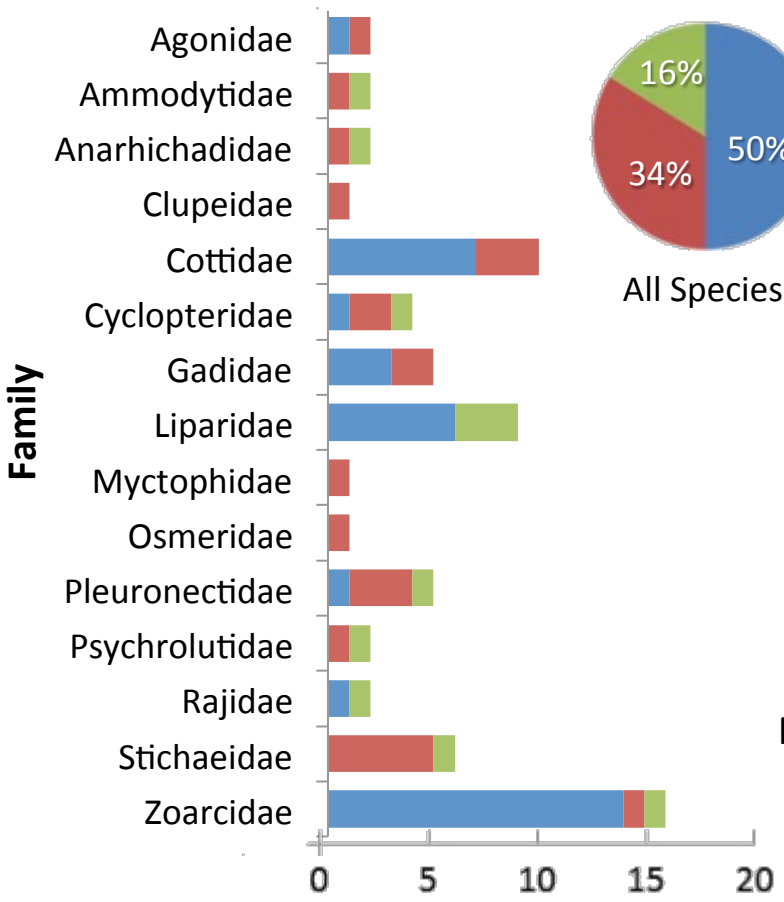


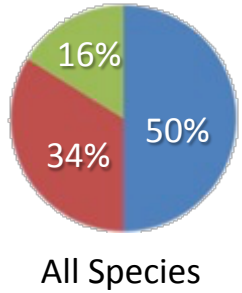
All Photos by S. Atchison, DFO

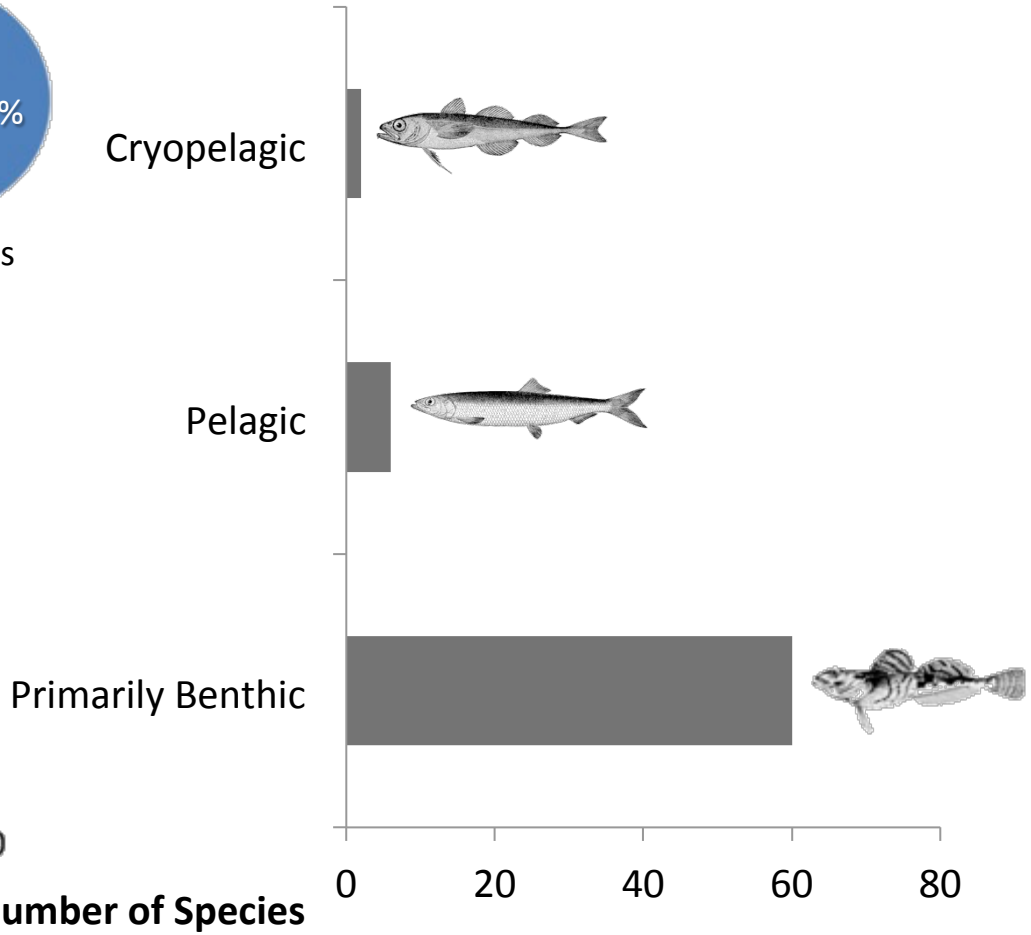


New Arctic or subarctic species reported from several areas likely represent both altered distributions resulting from climate change and previously occurring but unsampled species

Zoogeographic Affiliation & Vertical Habitat Use of Marine Fishes





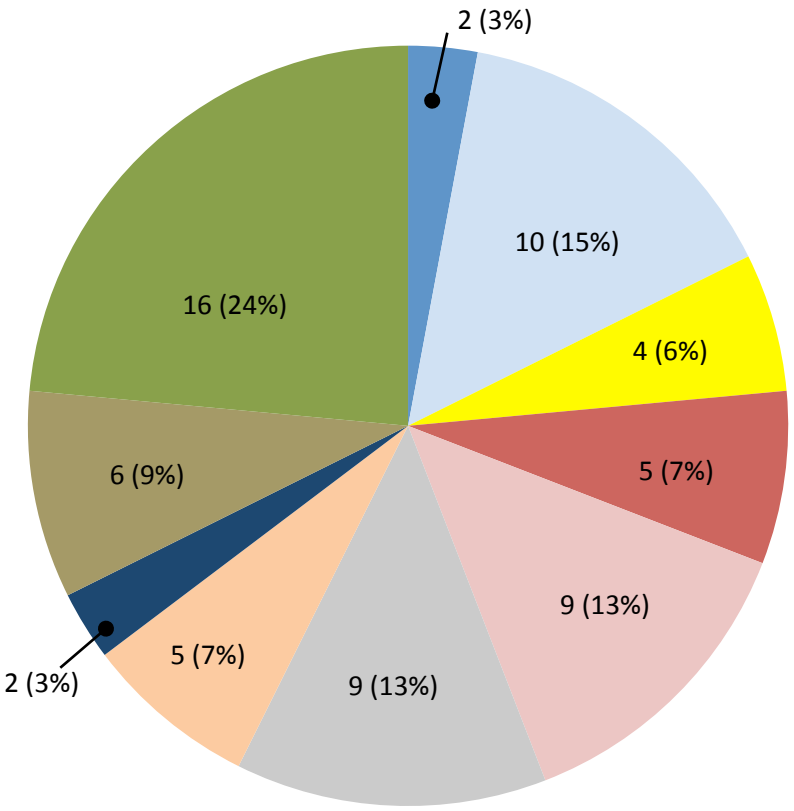


Arctic Arctic – Boreal Boreal

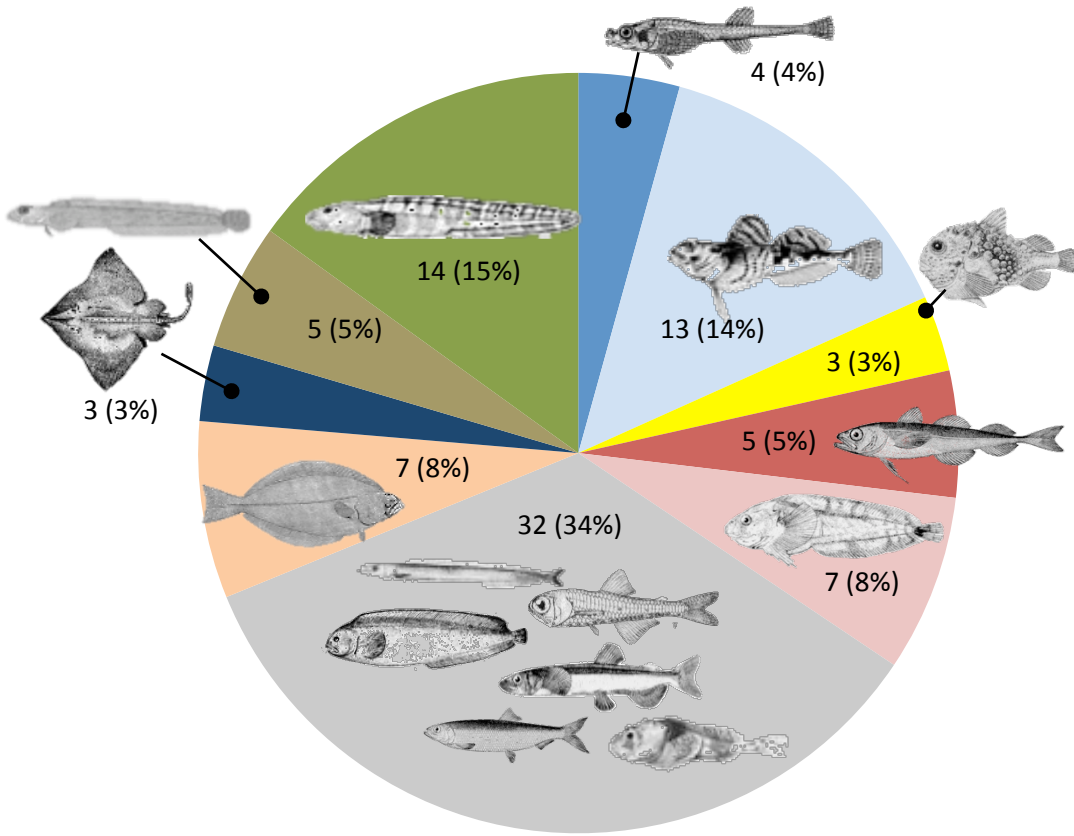
Geographic ranges and habitats from:
Mecklenburg et al. (2002, 2011) and Chernova (2011)

Proportion of Marine Fish Species Richness by Family

Canadian Beaufort Sea – Amundsen Gulf Ecozone



Whole Arctic



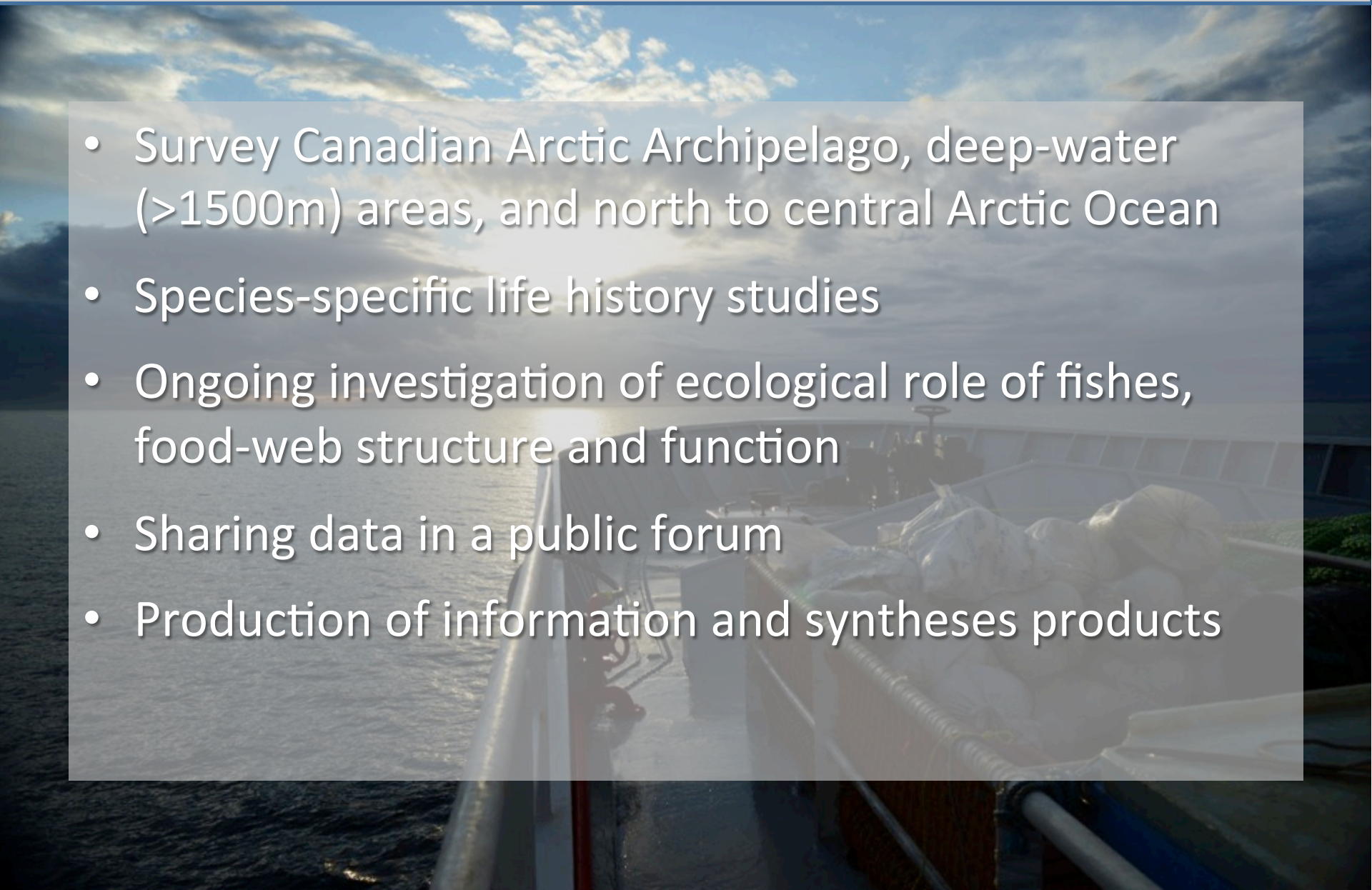
- Poachers
- Sculpins
- Lumpsuckers
- Cods
- Snailfishes
- Other
- Right-eye Flounders
- Skates
- Pricklebacks
- Eelpouts

Photos from Mecklenburg et al. Fishes of Alaska (2002)
Whole Arctic Diversity from Mecklenburg et al. (2011)

Summary & Implications

- First comprehensive ecosystem sampling by a large-scale trawling vessel in the western Canadian Arctic
  - Wide spatial and some temporal coverage
- Establishing baseline fish biodiversity , with linkages to habitats
  - Context for development but also biodiversity syntheses, e.g. under the Circumpolar Biodiversity Monitoring Plan
- Developing regional approach with Alaskan colleagues & establishing linkages to the central Arctic Ocean and other shelf seas (Chukchi Sea, Canadian Archipelago)
- Determining trophic pathways and linkages between pelagic & benthic, and nearshore & offshore habitats

Future Work is Needed…



- Survey Canadian Arctic Archipelago, deep-water (>1500m) areas, and north to central Arctic Ocean
- Species-specific life history studies
- Ongoing investigation of ecological role of fishes, food-web structure and function
- Sharing data in a public forum
- Production of information and syntheses products

Fisheries and Oceans Canada | Pêches et Océans Canada

Thank you!

Aboriginal Affairs and Northern Development Canada

• Funding: BREA, ESRF, IGC, DFO (multiple internal sources) & ArcticNet.

• MFP PIs (DFO): J. Reist, A. Majewski, W. Walkusz, C. Michel & B. Williams.

• University Linkages: Waterloo (M. Power, H. Swanson); Quebec at Rimouski (P. Archambault); Laval (L. Fortier); Manitoba – Biological Sciences (J. Treberg, M. Docker); Manitoba – Centre for Earth Observation (G. Stern); (NSERC leverage).

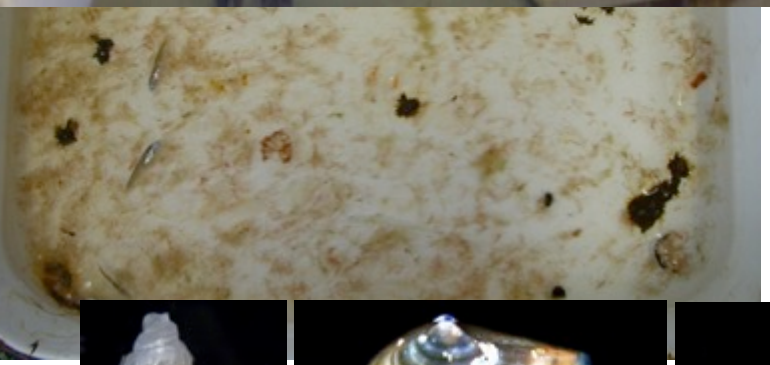
• Coastal Linkages: DFO (L. Loseto); UofM (G. Anderson, N. Halden, G. Davoren),

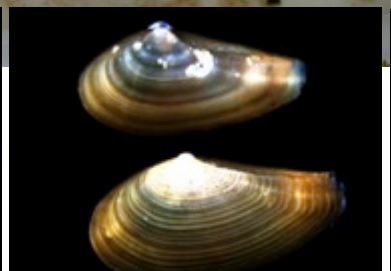
2013

2014

Government of Canada, co-management partners, many university partners, field crews, ships crew and owners of the *F/V* Frosti

Extra Slides Follow



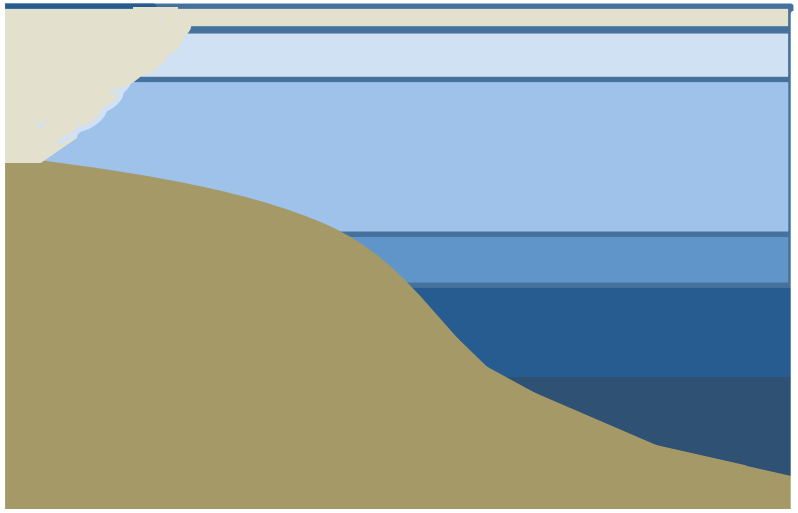


Linkages to ABA recommendations

- Recommendation 3: Advance and advocate ecosystem-based management efforts in the Arctic as a framework for cooperation, planning and development.
- Recommendation 5: creation of EBSAs
- Recommendation 12: Evaluate ecological services
- Recommendation 13: Increase and focus inventory, long-term monitoring and research efforts to address key gaps in scientific knowledge identified in this assessment to better facilitate the development and implementation of conservation and management strategies.
- 14 – recognize TEK
- 15 – promote trainings
- 17 – develop communication and outreach tools

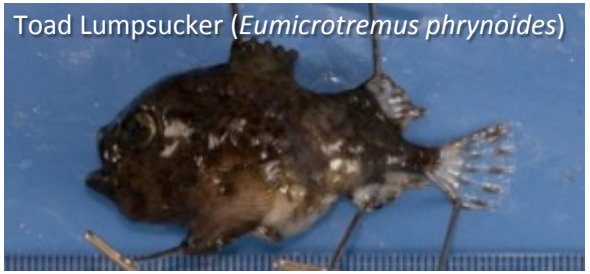
Key Research Themes

1. Biodiversity & habitat associations (esp. fishes)
2. Linkages within ecosystems (trophic patterns & foodwebs)
3. Coupling among ecosystems (pelagic-benthic, coast-offshore) – biotic, energetic & water mass
4. Variability – spatial (area), over depths & temporal (inter-annual)
5. Regional Scale Context for marine system:
   - Distributions of key biota
   - Predictability vs Variability
   - Baselines & context for Environmental Impact Assessments
   - Knowledge for management
6. International – Linked with Alaskan researchers & Canadian delivery for CBMP & Central Arctic Ocean High Seas



List of New Marine Fish Occurrences

- New to the Beaufort Sea – Amundsen Gulf Ecozone (N=6; all with Arctic distributions)
  - Glacier Lanternfish (*Benthosema glaciale*) – Arctic
  - Doubleline Eelpout (*Lycodes eudipleurostictus*) – Arctic
  - Scalebelly Eelpout (*Lycodes squamiventer*) – Arctic
  - Black Seasnail (*Paraliparis bathybius*) – Arctic
  - Threadfin Seasnail (*Rhodicthys regina*) – Arctic
  - Checkered Wolf Eel (*Lycenchelys kolfhoffi*) – Arctic


Toad Lumpsucker (*Eumicrotremus phrynoides*)

- New to Arctic Canada (N=2 currently known from Pacific region with Boreal – Pacific distributions)
  - Flathead Sole (*Hippoglossoides elassodon*) – Boreal Pacific
  - Tadpole Snailfish (*Nectoliparis pelagicus*) – Boreal Pacific

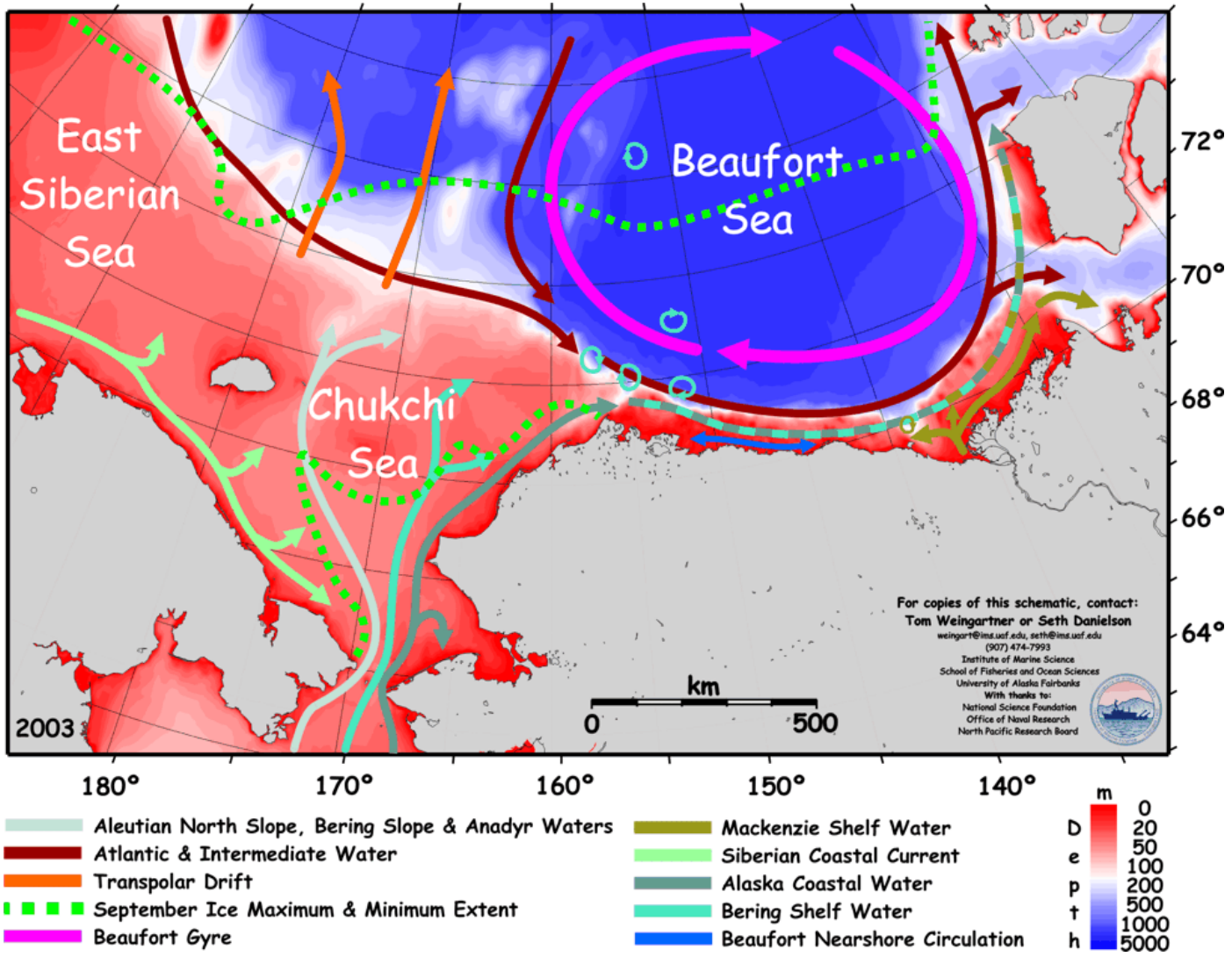
- New to the Canadian marine fish fauna (N=8; 4 Boreal-Pacific; 2 Arctic-Boreal; , 2 A
  - Everyday Snailfish (*Careproctus mollis*) – Boreal-Pacific
  - Salmon Snailfish (*Careproctus rastrinus*) – Boreal-Pacific
  - Polar Sculpin (*Cottunculus microps*) – Arctic–boreal (Atlantic)
  - Toad Lumpsucker (*Eumicrotremus phrynoides*) –Arctic-Boreal (Pacific)
  - Docked Snailfish (*Lethotremus muticus*) – Boreal-Pacific
  - Adolf's Eelpout (*Lycodes adolfi*) –Arctic
  - Archer Eelpout (*Lycodes sagittarius*) – Arctic
  - Soft Sculpin (*Psychrolutes sigalutes*) – Boreal-Pacific


Flathead Sole (*Hippoglossoides elassodon*)

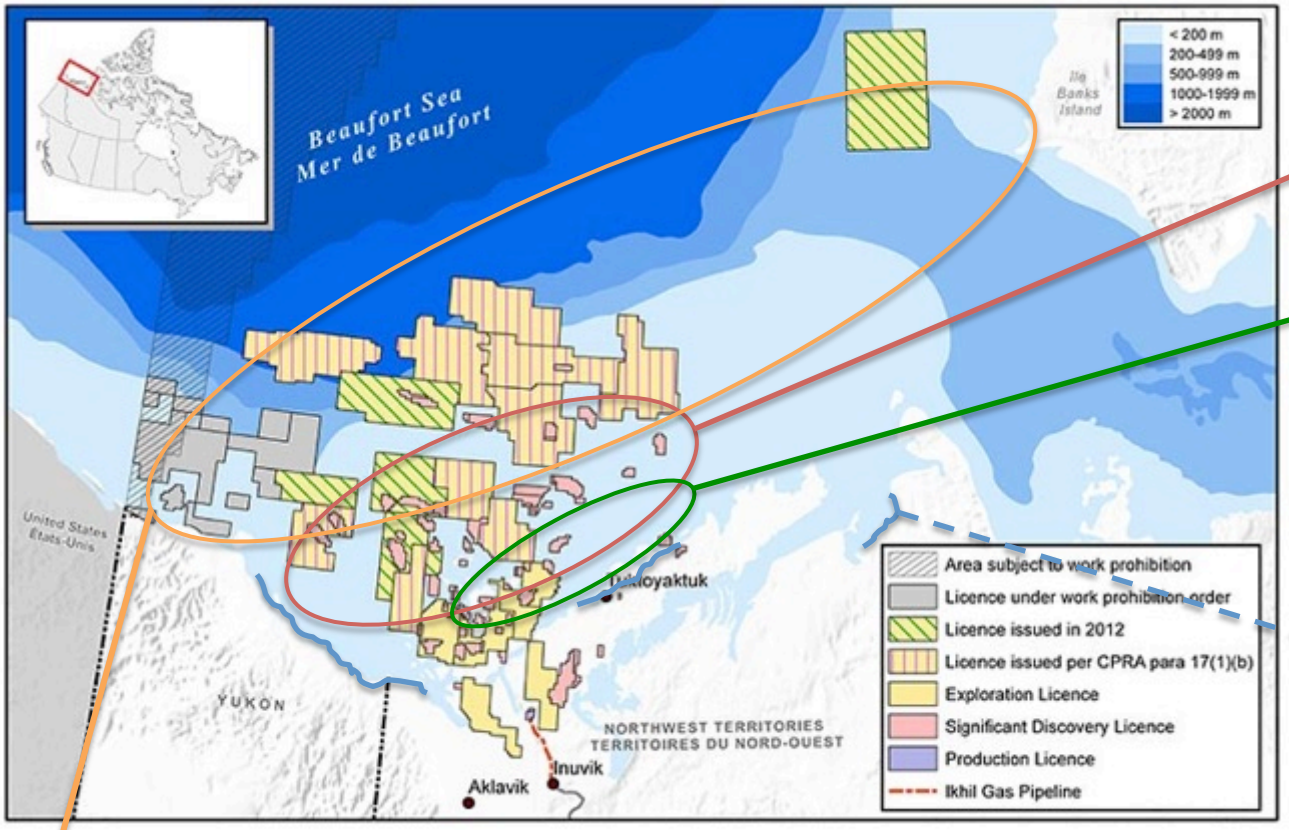
New Families (N=2): Myctophidae; Psychrolutidae

New genera (N=8): *Cottunculus, Lethotremus, Lycenchelys, Psychrolutes* New genera: *Benthosema, Nectoliparis, Paraliparis, Rhodicthys*

Canadian Beaufort Sea: A complex mix of source waters (fresh & Pacific surface, Atlantic mid-depth, Arctic bottom) and…



Canadian Beaufort Sea Bathymetry, Leases & Previous Fish Studies



Fish Research in Area

- 2003-2009 – Northern Coastal Marine Studies (5-150m on shelf)
- 1981-1987 – **Northern Oil & Gas Action Program & Beaufort Sea Project** Marine Studies (10-100m on shelf) including the 1955-1975 FRB Arctic Unit Beaufort Sea work
- 1970-present – nearshore & coastal (0-5m) assessments of anadromous & marine fish communities

Priority Research Gap: persistent summer sea ice & absence of suitable vessel precluded work on **offshore deepwater fishes**, their biodiversity & ecological relationships especially in deep waters – BREA Marine Fishes Project (2011-2015) designed to fill gap.

Marine Fishes Project Design & Components

- **2012**: 5 weeks in southern Canadian Beaufort Sea (+2 weeks transit to and from area) – 1000m
- **2013**: 6 weeks in southern & eastern Beaufort Sea, Amundsen Gulf & Darnley Bay – 1500m
- **2014**: 5 weeks in northern Beaufort Sea & Amundsen Gulf – 500m..ICE
- **Fishing vessel based work**: on-to-off shore transects 20 to 1000+m; 7 shelf, slope & deep stations on transect
  - Benthic trawling for fishes
  - Oceanography & lower trophics
  - Zooplankton & ichthyoplankton
  - Benthic habitats – epifauna & infauna
  - Hydroacoustic assessment & midwater trawling of aggregations
  - Samples & data for follow-on research
- 22 DFO staff, 2 pdf's, 5 university linkages, 8 grad students (+)
- Direct linkages with ongoing DFO coastal program focused upon 3 estuarine & 3 marine sites

Name: F/V *Frosti* (1979)
Home Port: Richmond B.C.
Length: 40 m, Beam: 8 m, Draft: 5 m
Horsepower: 1200, Gross Tonnage: 454
Retrofitted: side crane, wet/dry labs, hydroacoustics system
Accommodation: 8 science crew, 6 ship crew

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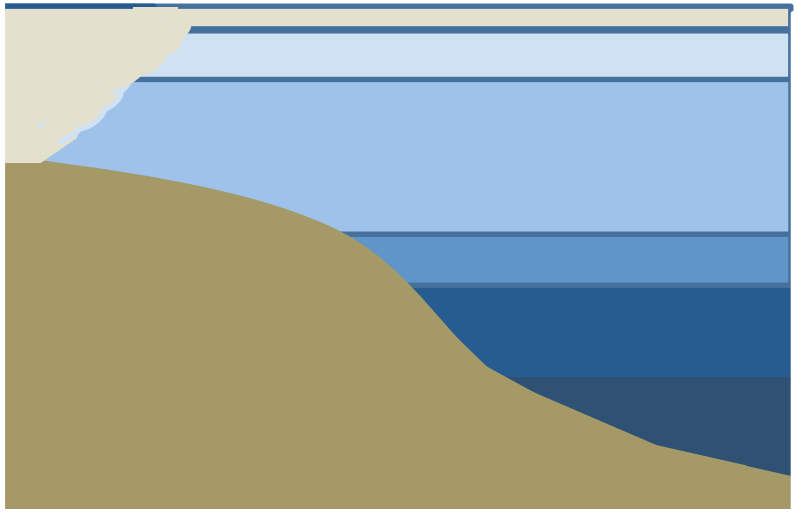
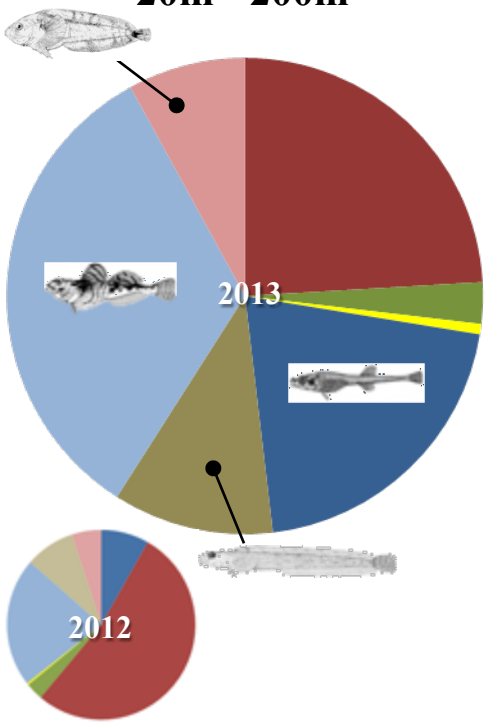
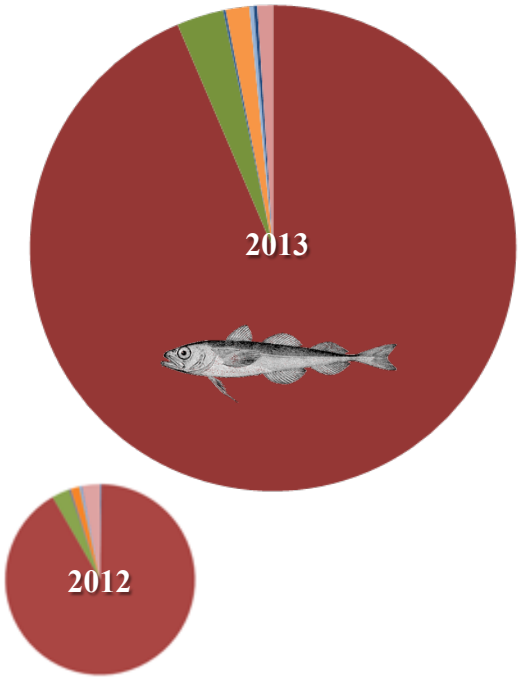


Benthic Fish Habitat Associations:
Species Composition, Canadian Beaufort Shelf , Slope & Off Slope

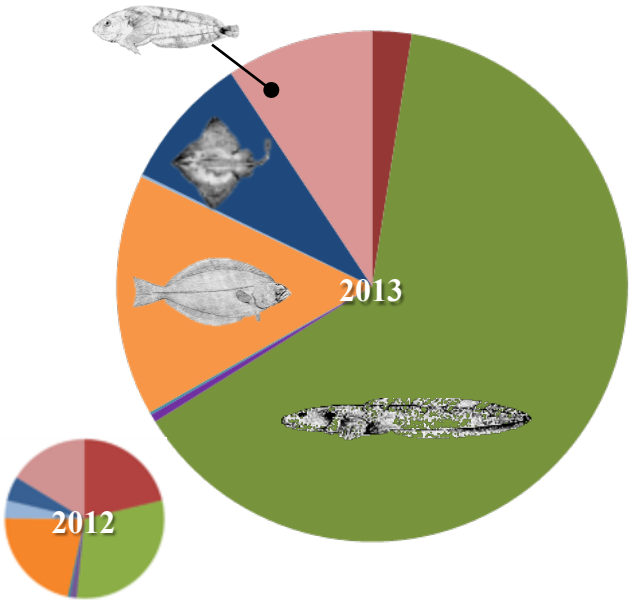
Shelf
20m - 200m



Slope
200m - 500m



Off Slope
500m - 1500m



Legend

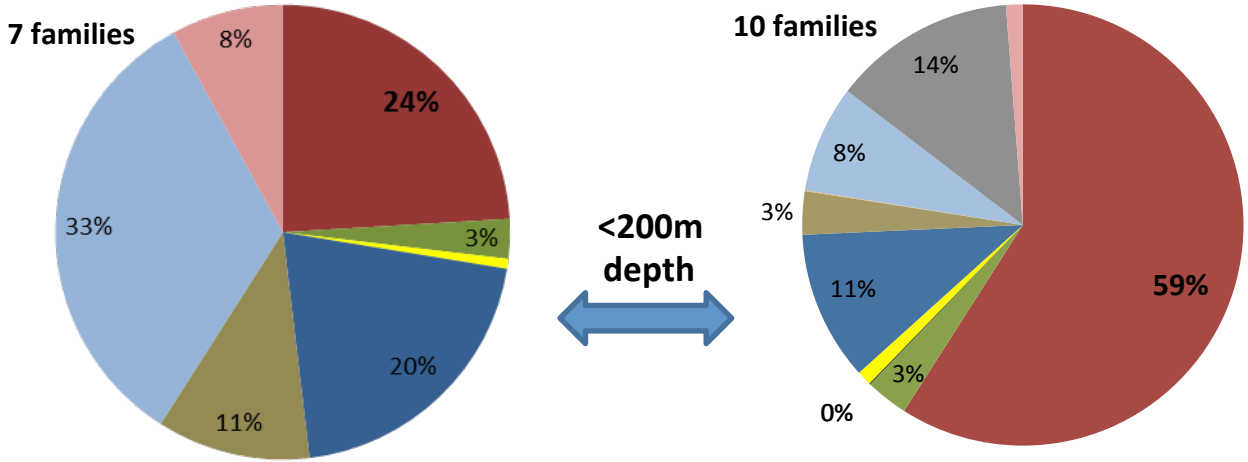
- Cods
- Eelpouts
- Fathead sculpins
- Lanternfishes
- Lumpsuckers
- Poachers
- Pricklebacks
- Righteye flounders
- Sculpins
- Skates
- Snailfishes

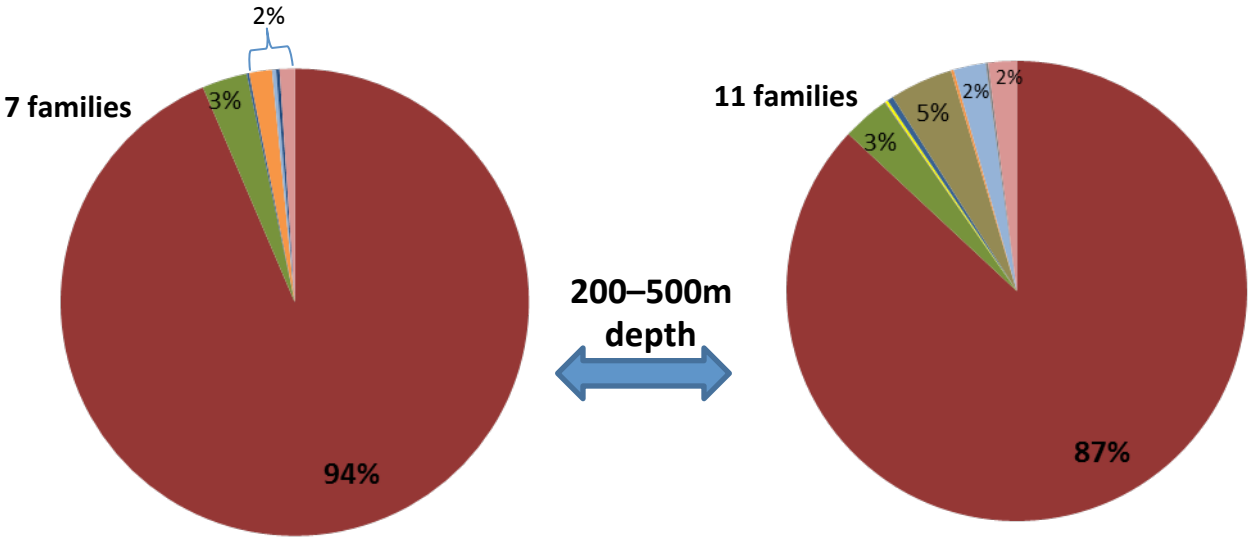
- Diversity of families (7,7,8) more or less even across three major zones.
- Arctic cod numerically dominate on slope.
- Species composition differs: e.g., sculpins on shelf; flounders deeper.
- Relative abundances within habitats ***may*** differ year to year.

Benthic Fish Diversity by Region :
Species Composition , Canadian Beaufort Sea – Amundsen Gulf

Canadian Beaufort Shelf

Amundsen Gulf





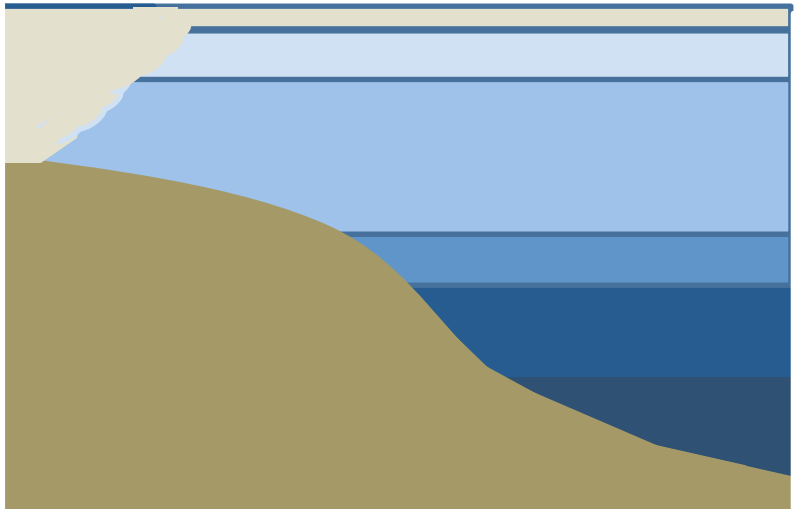
- Diversity of families more or less even across depth zones in both areas.
- Diversity highest in Amundsen Gulf.
- Arctic cod numerically dominant on slope (200-500m)
- Species composition differs between areas and across habitats: e.g., Capelin in Amundsen Gulf; species differences within family groups.

Legend

- Cods
- Eelpouts
- Fathead sculpins
- Herrings
- Lanternfishes
- Lumpsuckers
- Poachers
- Pricklebacks
- Righteye flounders
- Sculpins
- Skates
- Smelts
- Snailfishes

General Patterns of Marine Fish Diversity

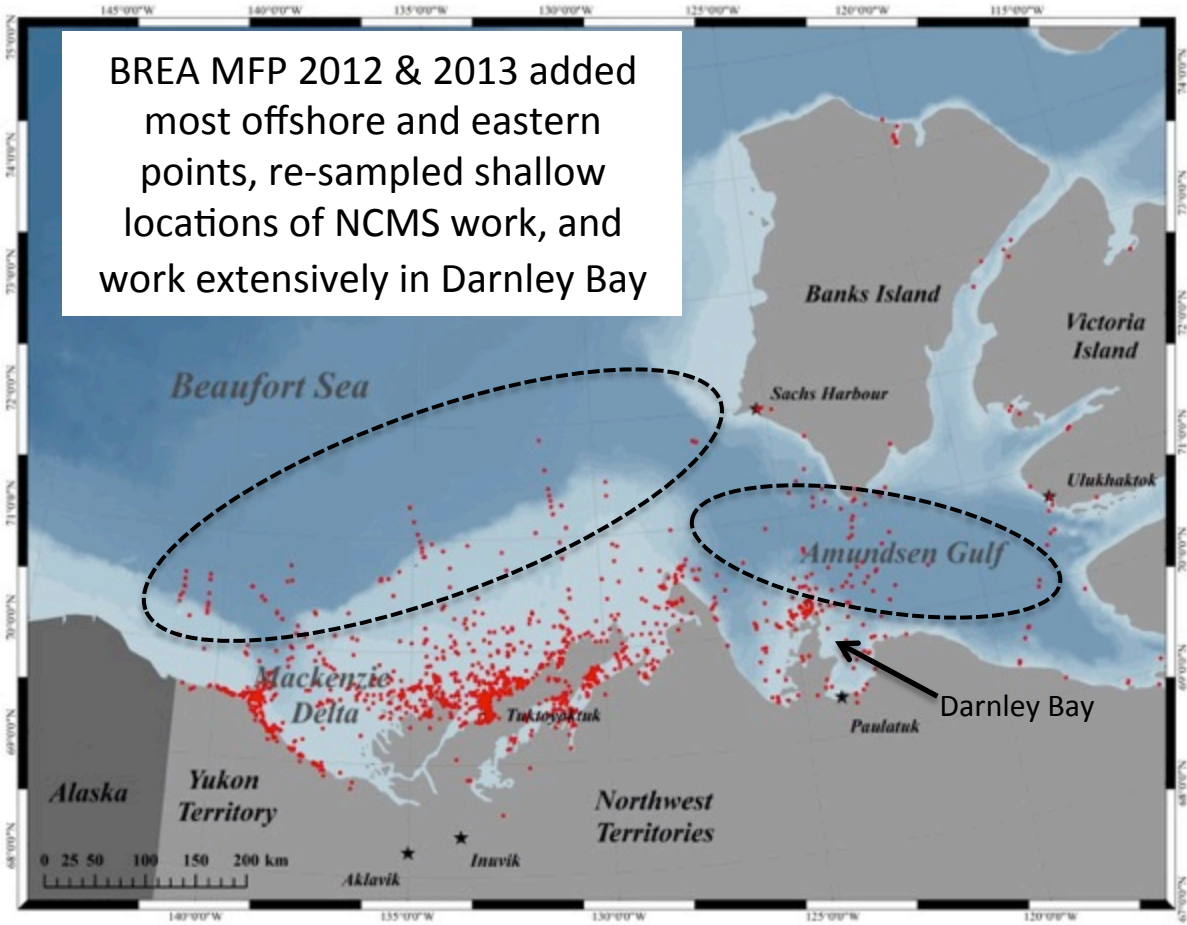
- Majority of fishes are benthic
- Arctic Cod are ubiquitous
- Diversity is relatively high on the extensive shelves, particularly that near the Mackenzie River estuary
- Diversity declines beyond 200m depths and becomes very low (1-2 species) at depths greater than 1200m



- Diversity is higher in the east (Amundsen Gulf) than in the west (Beaufort Sea)
- Gradients in species richness from warmer, subarctic waters to colder, Arctic waters, implies high potential for species expanding into Arctic waters as temperatures increase
- Diversity of marine fishes decreases northwards and westward
- Diversity also appears to decrease with latitude in the Arctic Ocean generally

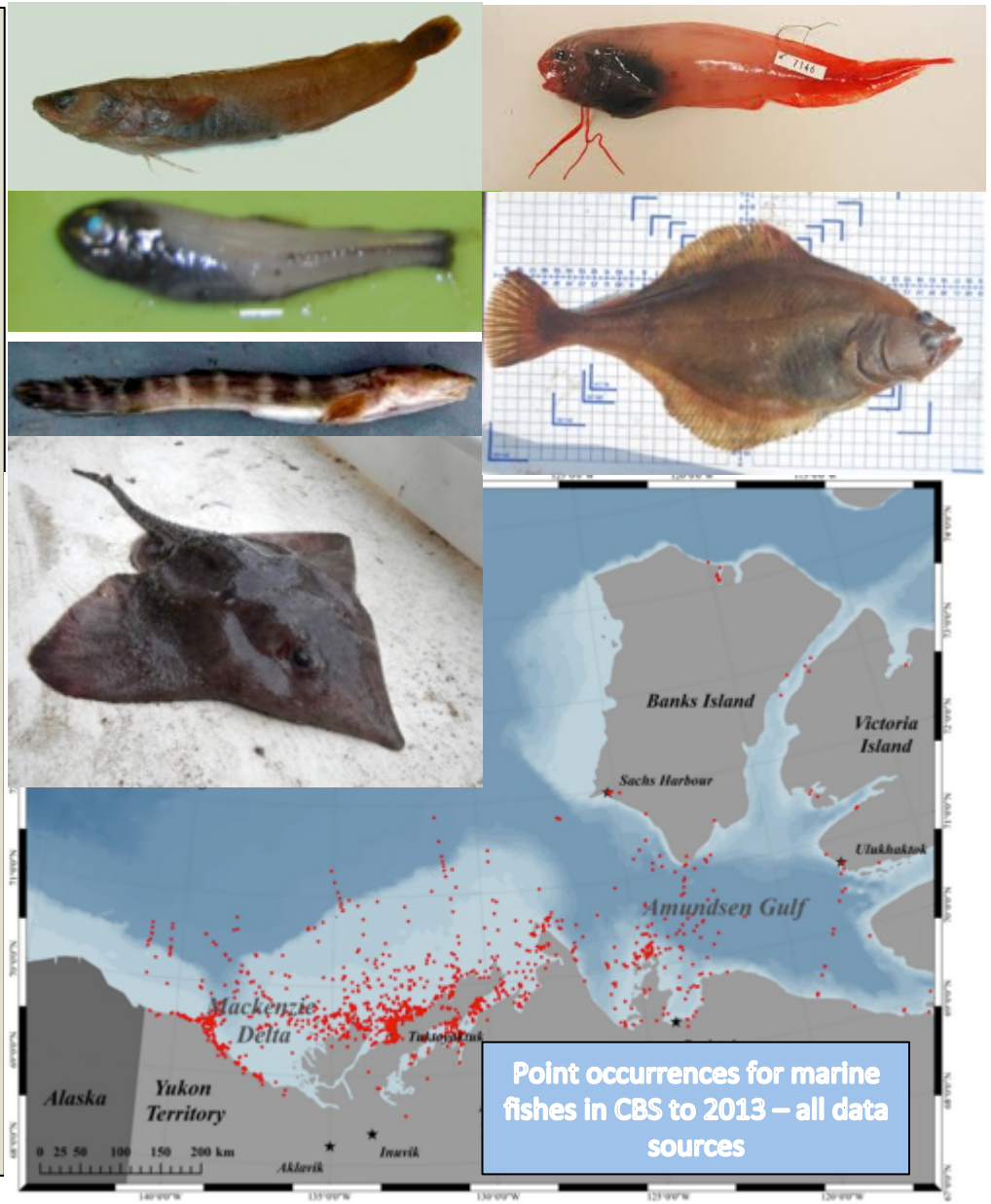
Update to point locations for all marine fishes known for Canadian Beaufort Sea to 2014

- Majority of fish occurrence records prior to 2003 result from periodic surveys or research projects in coastal & nearshore habitats (all open water) and a very small number of ice-based activities mostly in shallow open water
- Species complement for CBS & Amundsen Gulf pre-2003 was 68 spp (48 marine + 20 coastal anadromous)
- 2003-2009, DFO AARD conducted the Northern Coastal Marine Studies (NCMS) on the Mackenzie shelf extending work from 20-150 m depths at shelf edge
- **NCMS research added 4 spp**
- 2012 & 2013 field years of BREA Marine Fishes Project led by DFO AARD extended work offshore to 1515m depths
- **BREA MFP research added 15 more spp.** to 2013 (mostly deep water & offshore)
- **Total fish diversity for CBS now is 67 marine spp (+20 coastal anadromous)**
- 2014 findings are unknown as yet (eastern & northern Amundsen Gulf, to 73ºN off western Banks Island)



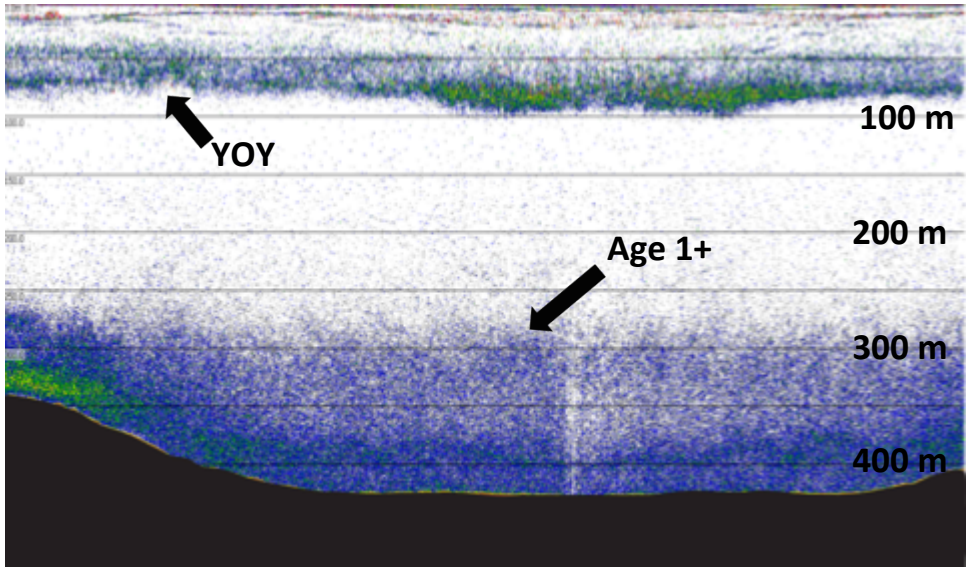
New Knowledge – Fish Biodiversity

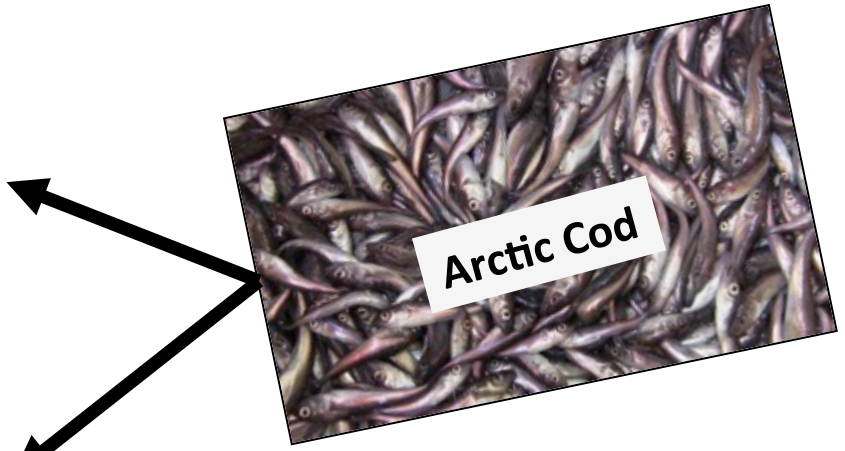
- Prior to 2003, 48 marine fishes known from CBS
- 2003-2009 Nahidik work added 4 spp
- 15 additional spp added in 2012 & 2013; now **67 marine spp** total
- Majority (n=62) are demersal/benthic in habit; few (n=5) pelagic species (Arctic Cod occupies both habitats)
- Most taxa in depths >400m have Atlantic water affinities; Pacific taxa <400m
- Distributional knowledge vastly increased especially offshore and areas >200m
- Biology, habitat use & trophic associations of fishes starting to be understood (stable isotopes, fatty acids)
- Fish community structured spatially (along shelf) & by depth (water masses, bottom type)
- Arctic Cod is most significant (numerically & biomass); occupies a key habitat (200-450m along slope drop-off) throughout the entire area in 2012 & 2013, but absent in 2014



Preliminary Hydroacoustics – Interannual Variability

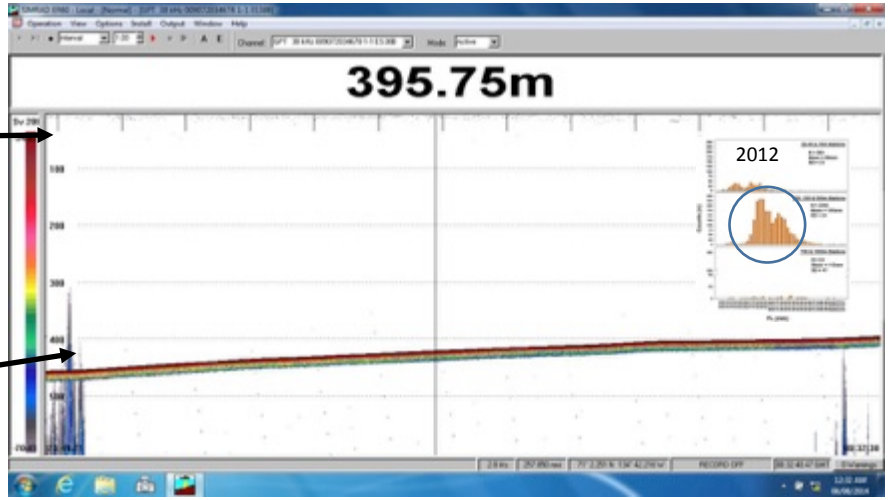
2012 & 2013: high concentration along shelf break from Alaskan border east to Amundsen Gulf





Canadian Beaufort Shelf-slope 2014

- **Weaker surface signal than in previous years (where have all the cod gone?)**
- **Benthopelagic layer not apparent in 2014**
  - **Primarily large Arctic Cod in net benthic catches; 1yo in pelagic catches**
  - **Age 2 and 3 Arctic Cod not prevalent as in past years**



Emerging Pressures and Need for Baseline Biodiversity Assessment

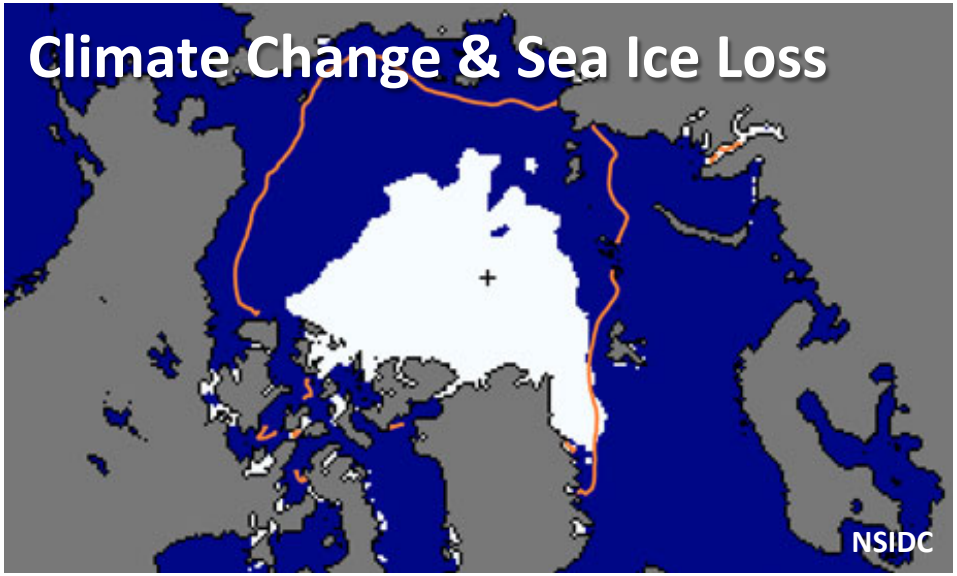
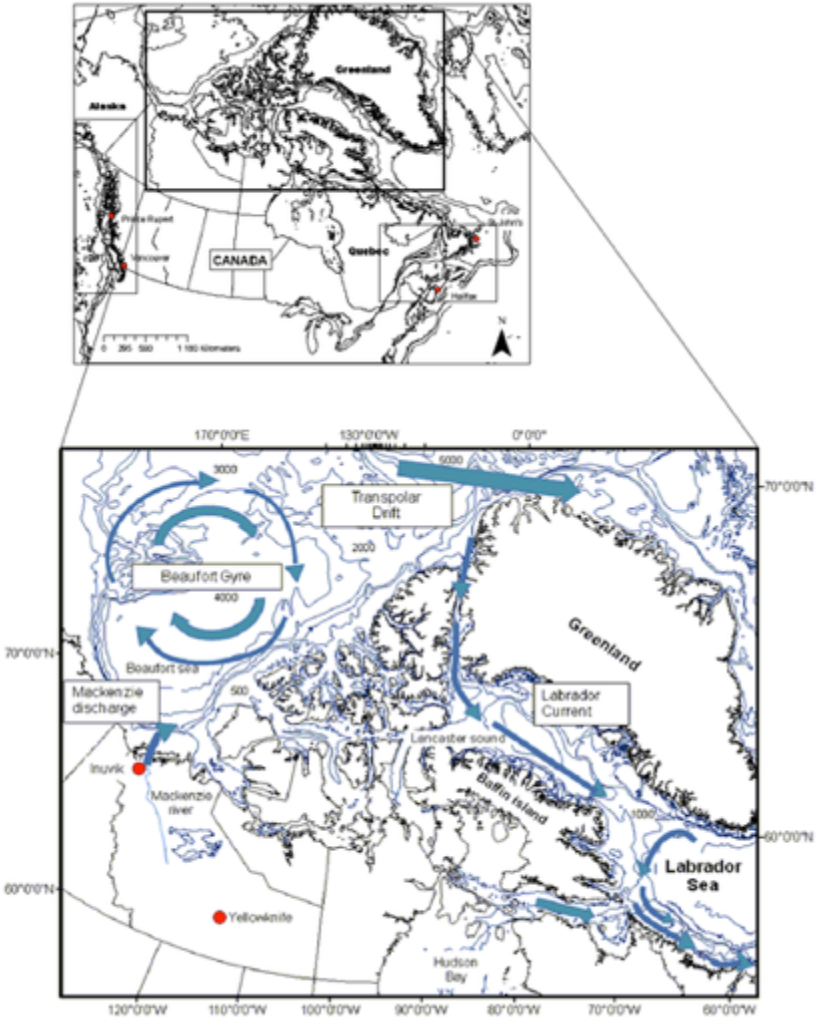


Figure 1. Location and general circulation patterns for the Canadian Arctic province.



Archambault P, Snelgrove PVR, Fisher JAD, Gagnon J-M, et al. (2010) From Sea to Sea: Canada's Three Oceans of Biodiversity. PLoS ONE 5(8): e12182. doi:10.1371/journal.pone.0012182
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0012182

Summary – Where we are now

Present & Immediate Future

- Improved knowledge, understanding & key baselines – write up…
- Ecosystems are coupled – pelagic-benthic and coastal-offshore (?) so local effects may cumulate & transfer – continue lab work…
- Spatial variability in CBS is high both across depth and areas – write up…
- Inter-annual variability (at least in short-lived key biota) is high – more research needed…
- Some changes appear to be recent & possibly associated with climate change (new Pacific fishes in area)
- Some areas, ecosystem components & habitats unique and/or dynamic in space & time – predictability ???

Gaps & Follow-on Issues

- Cause-effect understanding uncertain (CVC likely driving some changes) – change vs variability
- Consequences & expectations from multiple stressors – how to account and manage for these?
- North, deeper areas and many embayments remain un-surveyed
- Many 'unique' areas not surveyed – hard bottom/gravel locations, kelp forests in east, gas vent/methane seep communities
- 'Downstream' areas not surveyed – M'Clure Strait-Viscount Melville Sd; Dolphin & Union Strait-Coronation Gulf