

Active acoustics mapping of fish: an answer to the mystery of the missing Arctic cod?

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Summer distribution of Arctic cod in the Canadian Beaufort Sea

- The Beaufort Regional Environmental Assessment (BREA) has recognized knowledge on fish populations and distributions as one of the main data gaps for the Canadian Beaufort Sea.
- Two projects were funded by BREA regarding this issue:
 - 1) The fisheries acoustics program (Université Laval; 2011-2013)
 - 2) Fish diversity and habitat program (Fisheries and Oceans Canada, Winnipeg; 2011-2013)
- In 2012, both programs were conducted concomitantly.

BREA fisheries acoustics program

Main objective:

Detect pelagic fish (mainly Arctic cod) in the Canadian Beaufort Sea and document their distribution, size, and migration patterns



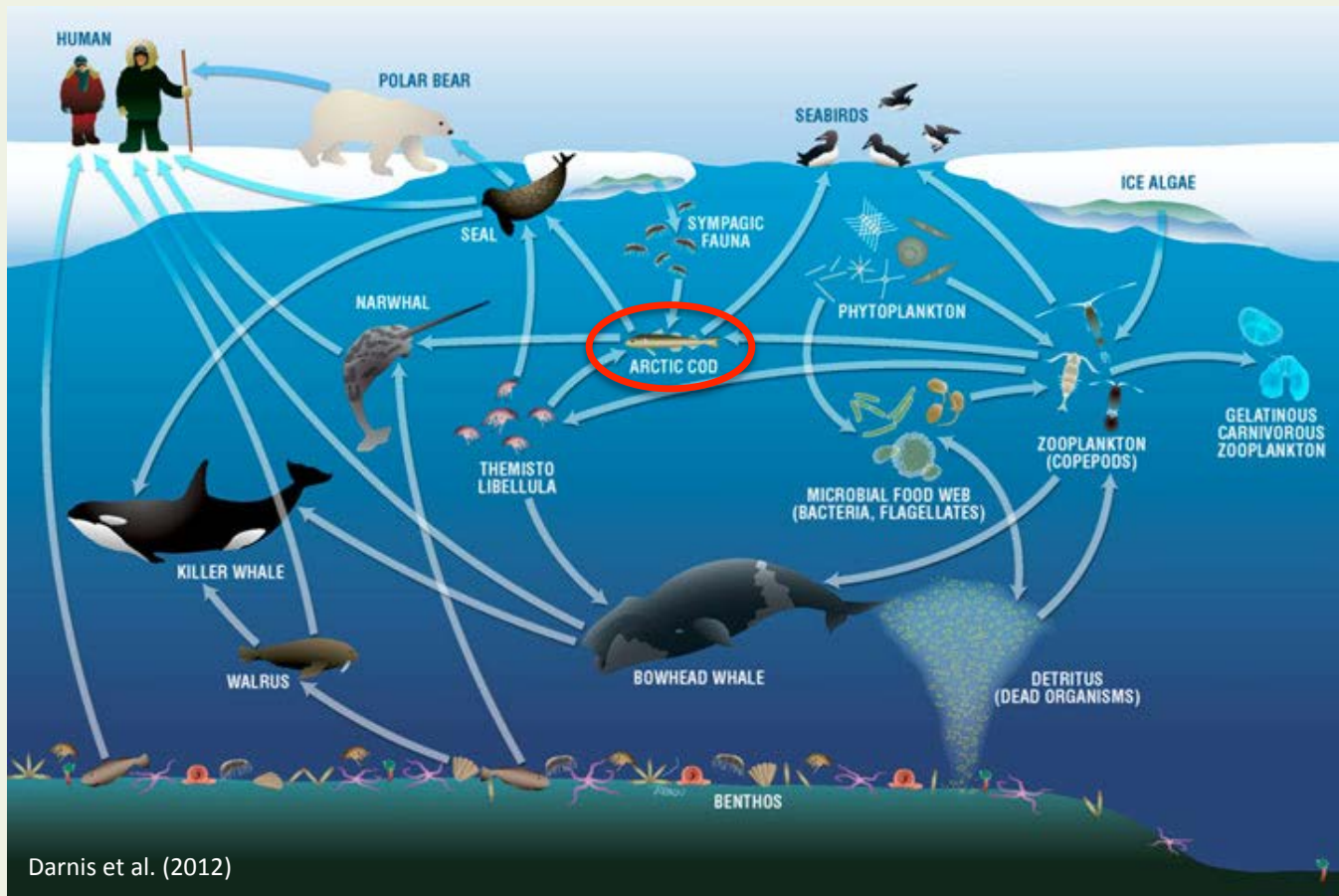
Fisheries and Oceans
Canada



Aboriginal Affairs and
Northern Development Canada

Why study Arctic cod?

- Key species of the Arctic marine ecosystem
- In some areas, Arctic cod funnels 75% of the energy between lower trophic levels and top predators

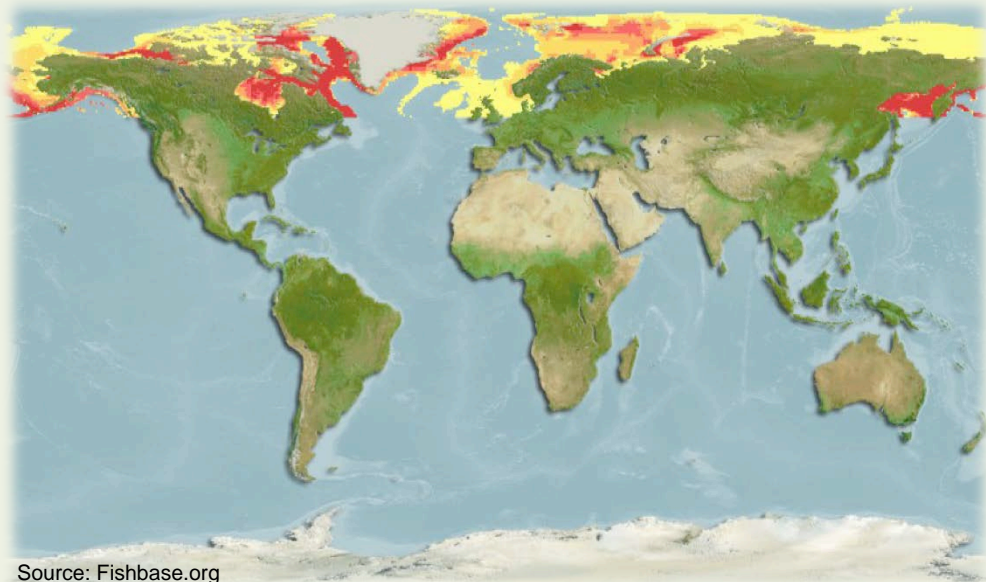


Arctic cod

- Gadidae
- Maximum length of 30 cm
- Maximum reported age : 7 years
- Circumpolar distribution



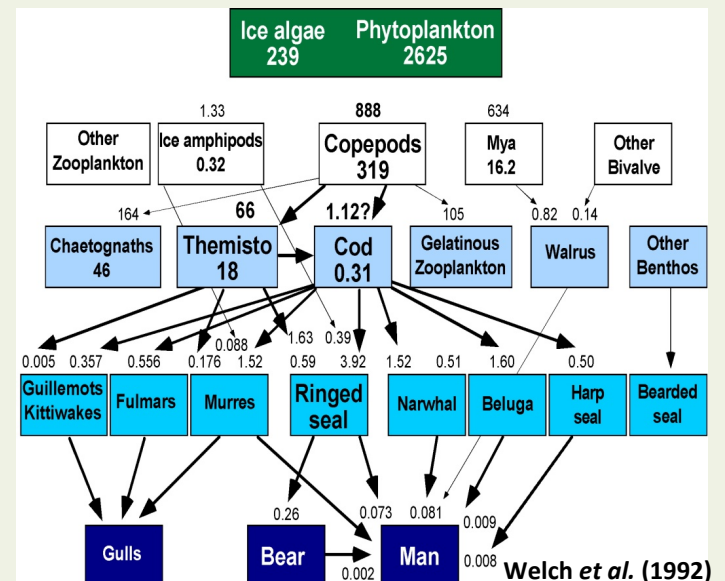
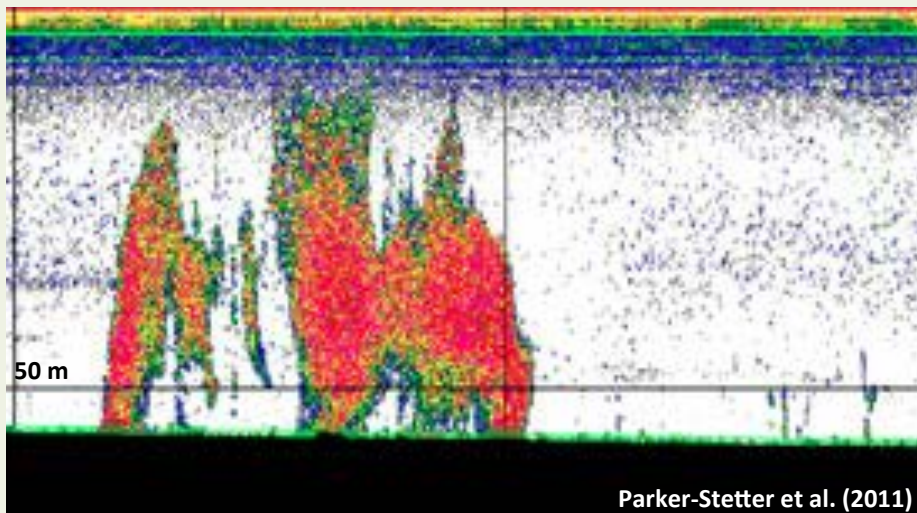
Source: Fishbase.org



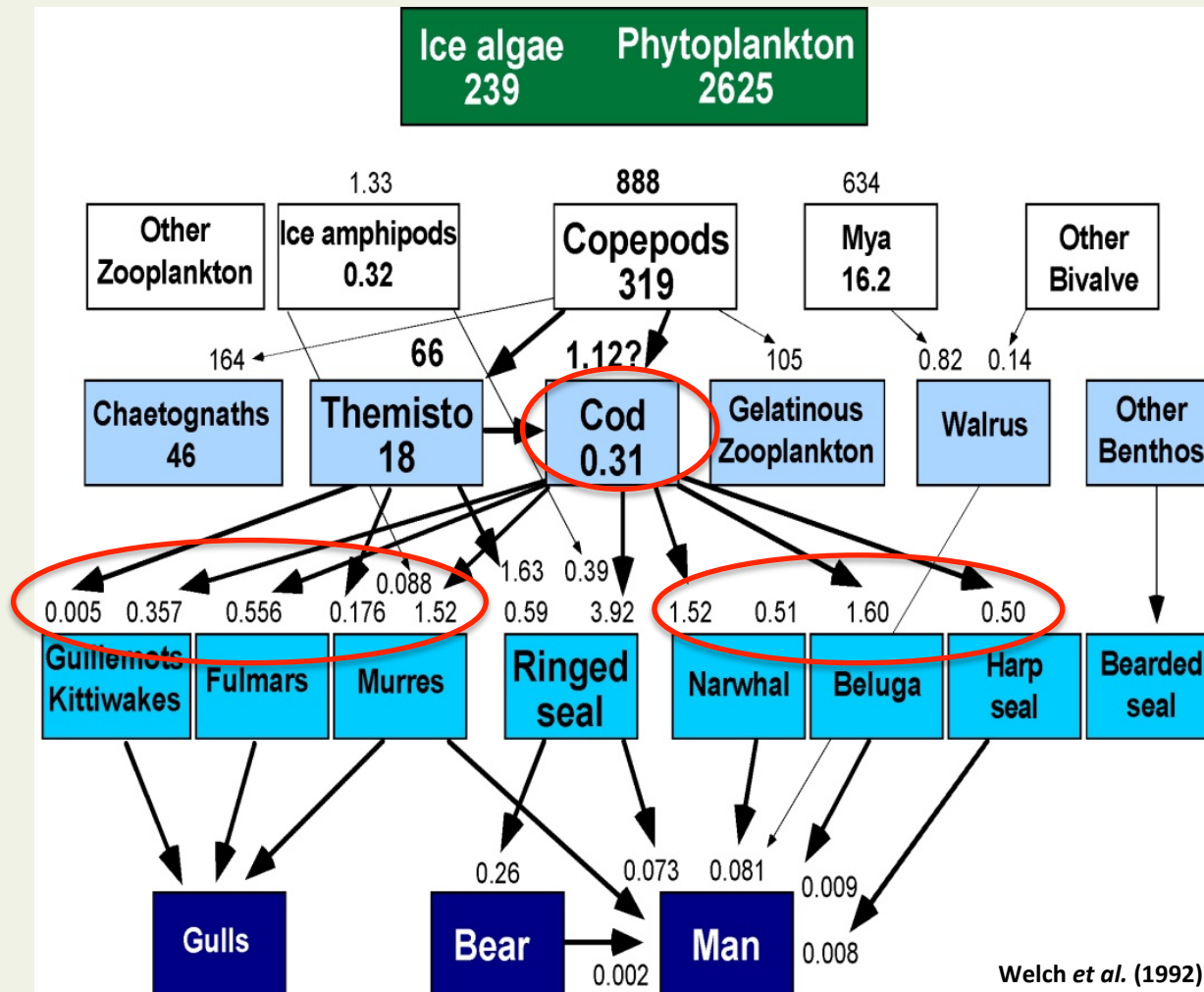
Source: Fishbase.org

Coastal distribution and the mystery of the missing cod

- 1) Coastal schools of adult Arctic cod were previously detected during the ice-free season in the Canadian Archipelago (e.g. Welch et al. 1992) and in the U.S. Beaufort Sea (Parker-Stetter et al. 2011)
- 2) At a regional scale, biomass within these schools cannot support the energy requirements of its predators. Additional aggregations of Arctic cod must exist somewhere else

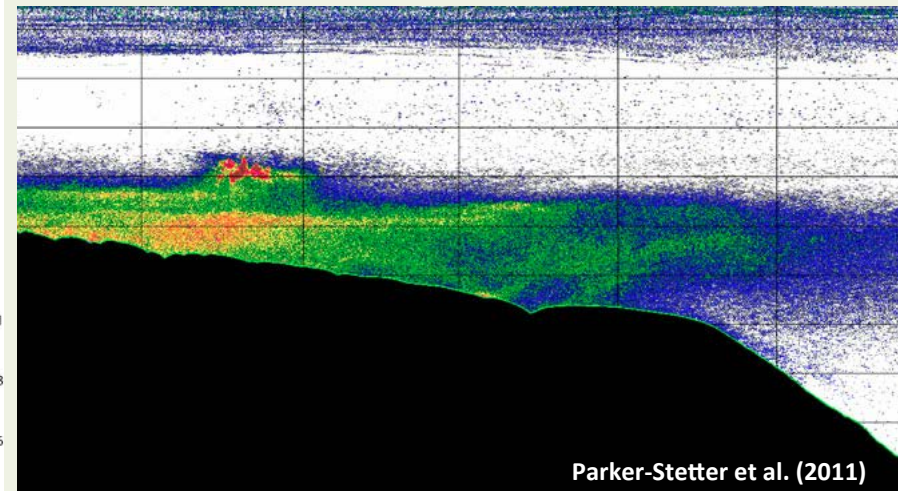
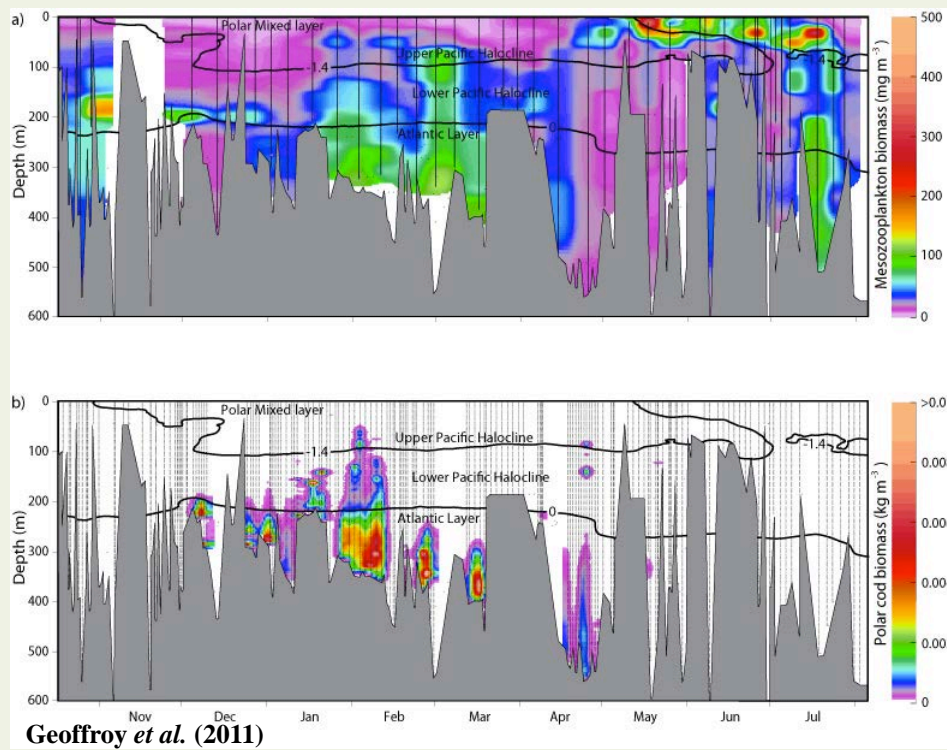


Coastal distribution and the mystery of the missing cod

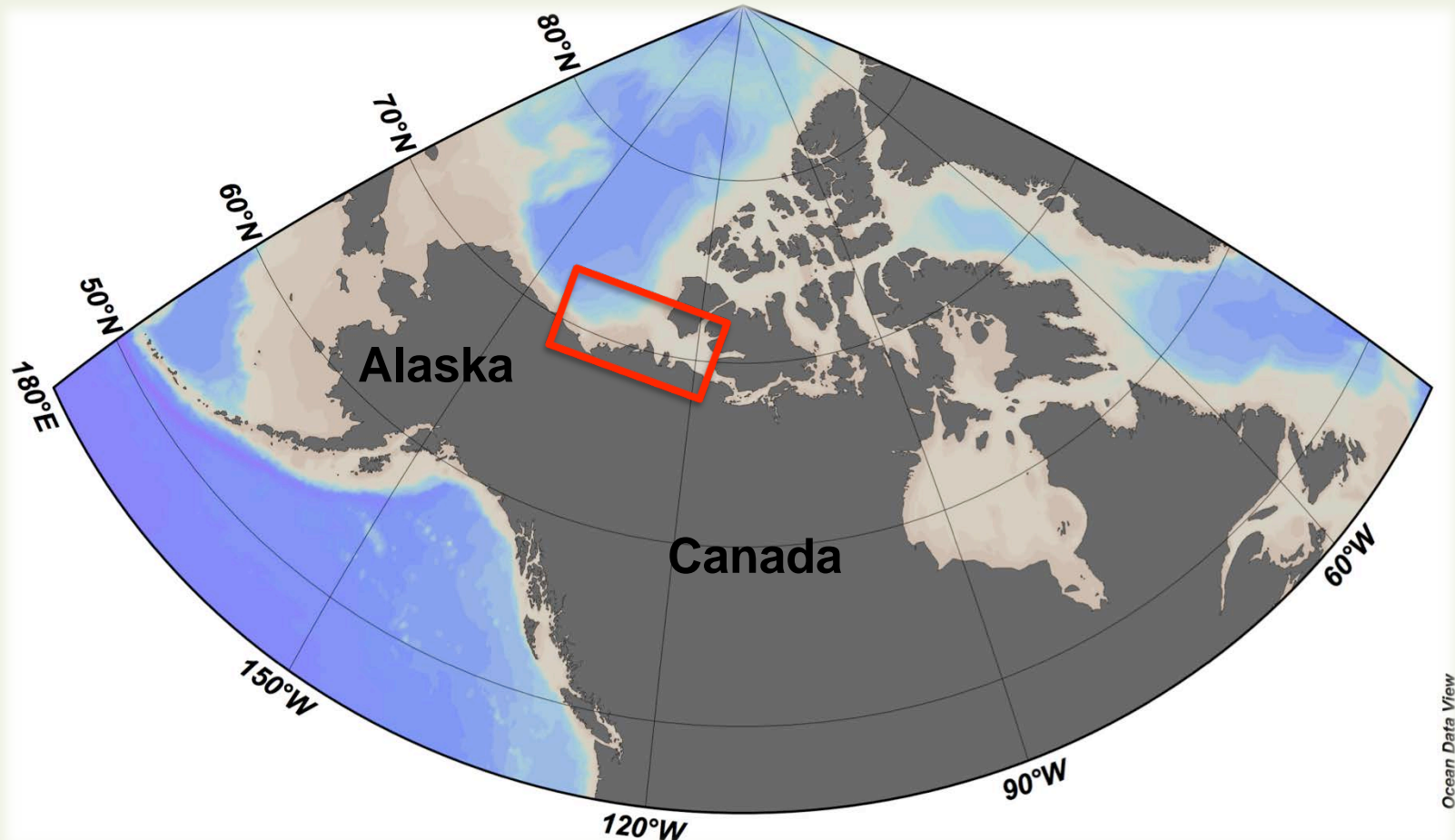


Partial answers from previous studies

- Winter aggregations over the continental slope during winter, in the southeastern Beaufort Sea (Amundsen Gulf). In the Atlantic Layer, to follow their zooplankton prey (Benoit et al. 2008, 2010; Geoffroy et al. 2011)
- Aggregations over the continental slope in the U.S. Beaufort Sea (Parker-Stetter et al. 2011)
- Limited information is available on the summer distribution of polar cod in the Canadian Beaufort Sea (e.g., CASES 2003-2004; DFO - NCMS 2003-2009)

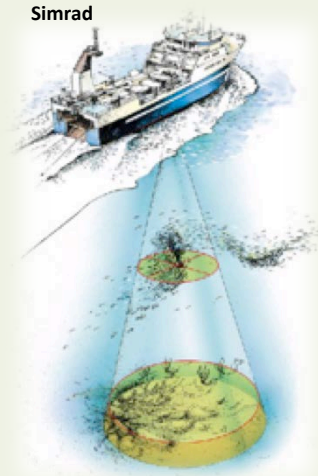
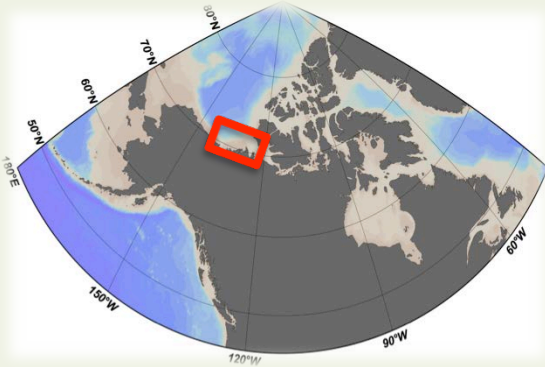


Summer acoustic surveys (2009-2012)

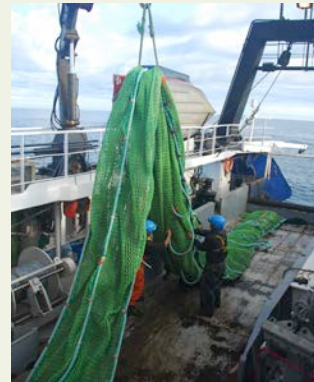
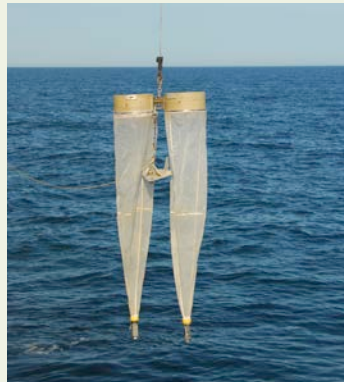


**Amundsen Gulf and Canadian Beaufort Sea
(August-September)**

Summer acoustic surveys (2009-2012)

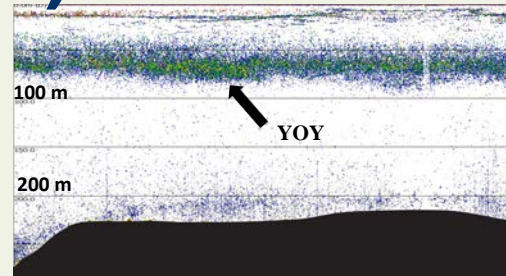


- Amundsen Gulf and Canadian Beaufort Sea
- Multifrequency (38, 120, 200 kHz) Simrad EK60 echosounder and 74 ichthyoplankton net deployments in the Amundsen Gulf and Beaufort Sea from the CCGS *Amundsen* (2009-2011)
- Echosounder, 40 ichthyoplankton net deployments and 90 mesopelagic and benthic net deployments in the Beaufort Sea from the F/V *Frosti* in 2012

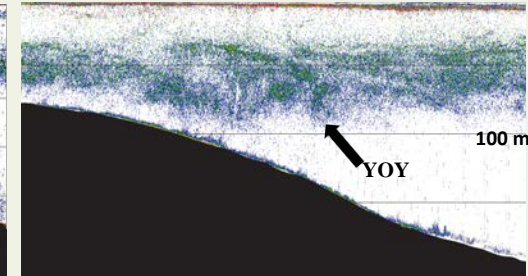


Results: Arctic cod vertical distribution during the ice-free season (2009-2012)

1. Epipelagic aggregation of young-of-the-year (YOY), mainly Arctic cod (**89% of the 3309 YOY sampled** within 100 m from 2009 to 2011; **66% of the YOY in 2012**, except for one station)

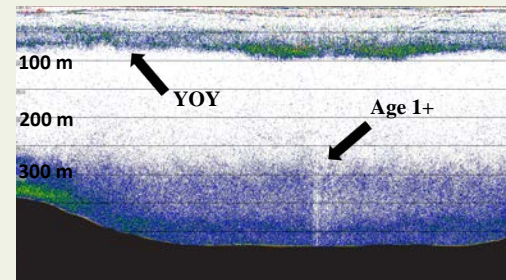


Amundsen Gulf (2011)

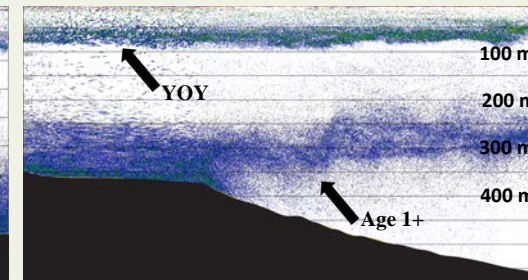


Mackenzie Shelf (2012)

2. Age 1+ Arctic cod aggregation in the Pacific-Atlantic halocline, from 200 m to 400 m (**90% of the 6439 fish sampled** with mesopelagic and benthic trawls at depth >100 m in 2012)



Amundsen Gulf (2011)



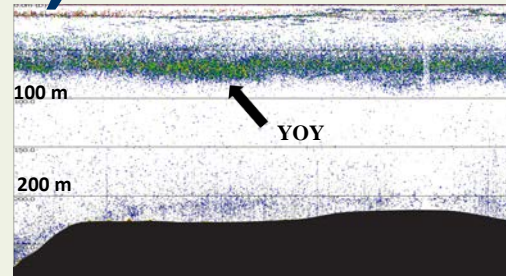
Mackenzie Slope (2012)



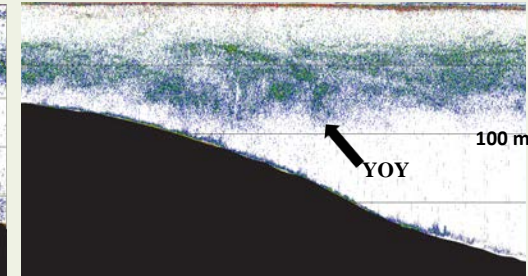
Photo: Fisheries and Oceans Canada

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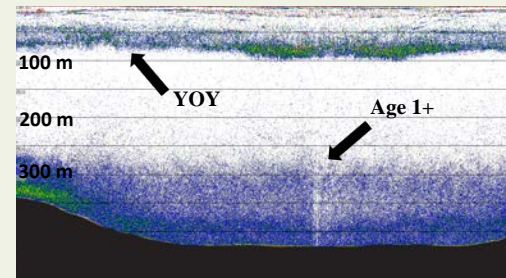


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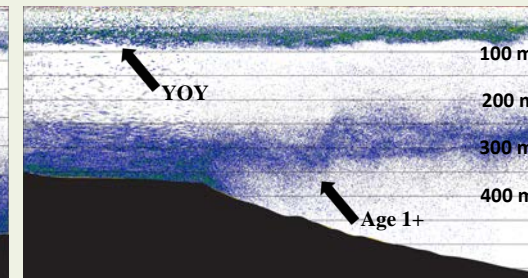


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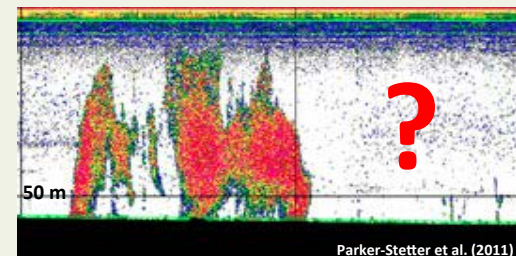


Amundsen Gulf (2011)



Mackenzie Slope (2012)

3. No shallow water coastal schools, as in the U.S. Beaufort Sea, were observed



Parker-Stetter et al. (2011)

Results: No surface schools

- New SX90 fisheries sonar aboard the CCGS *Amundsen*
- 290 hours of sonar surveys in 2011
- No surface schools were detected

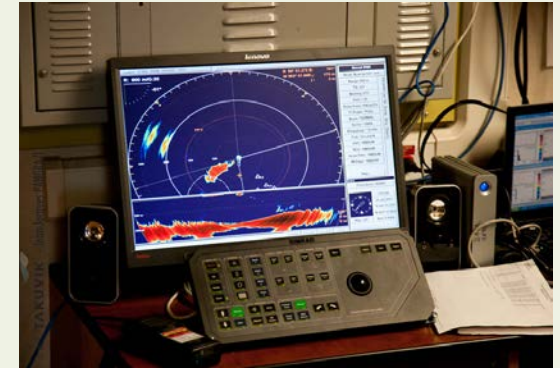
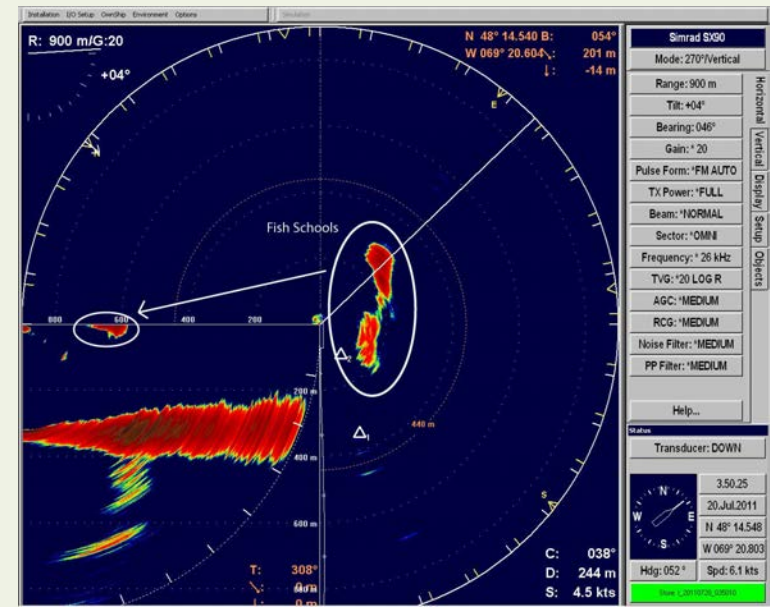
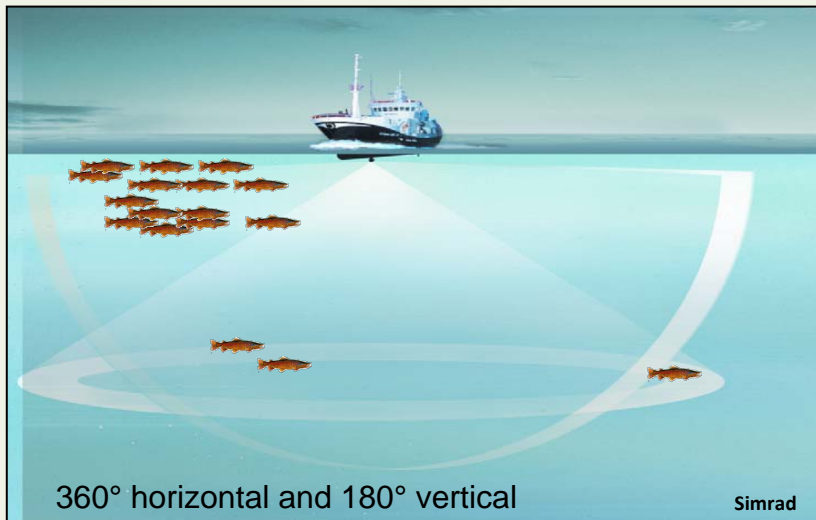


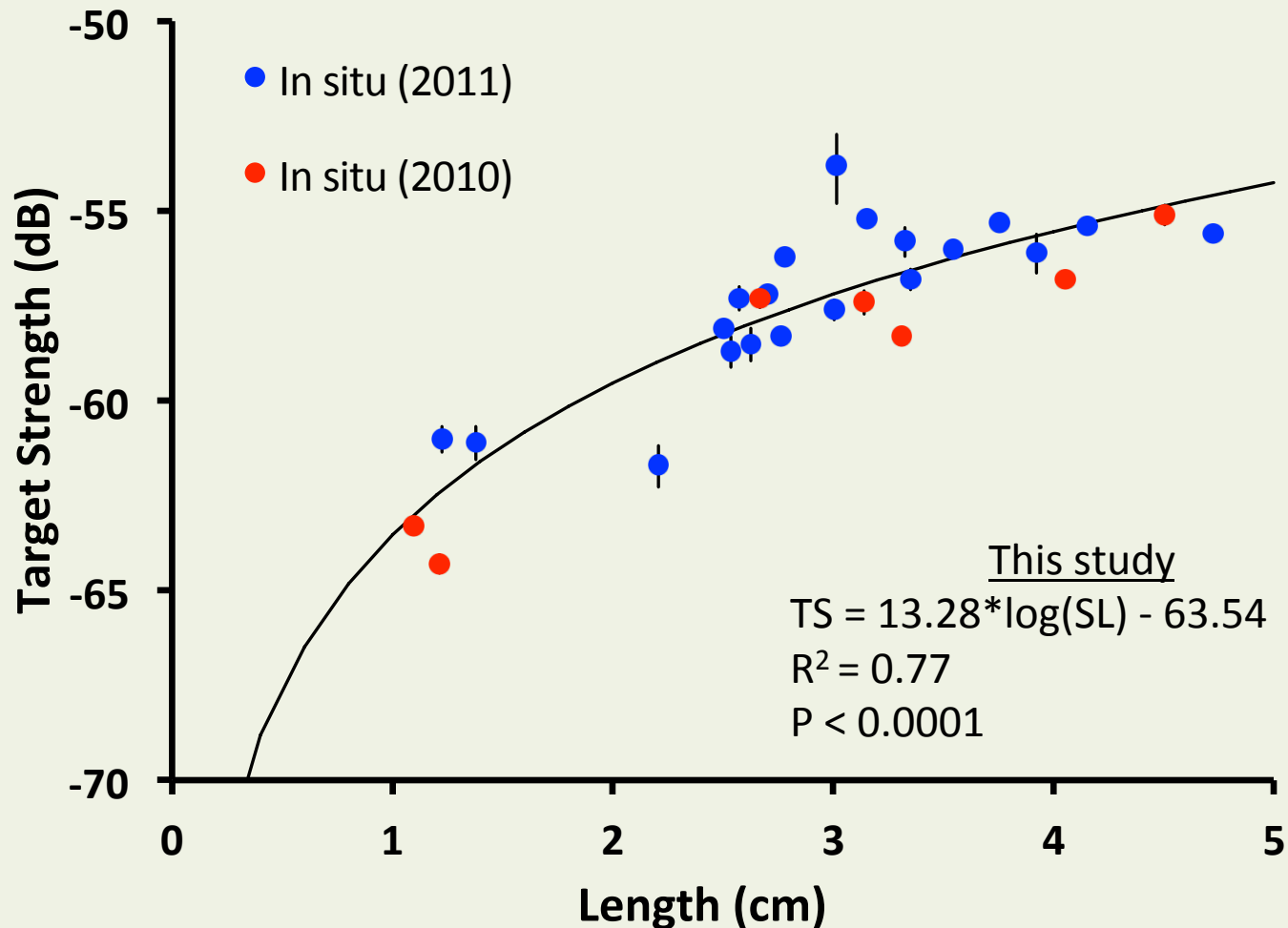
Photo: J.J. Pangrazi



SX90 sonar

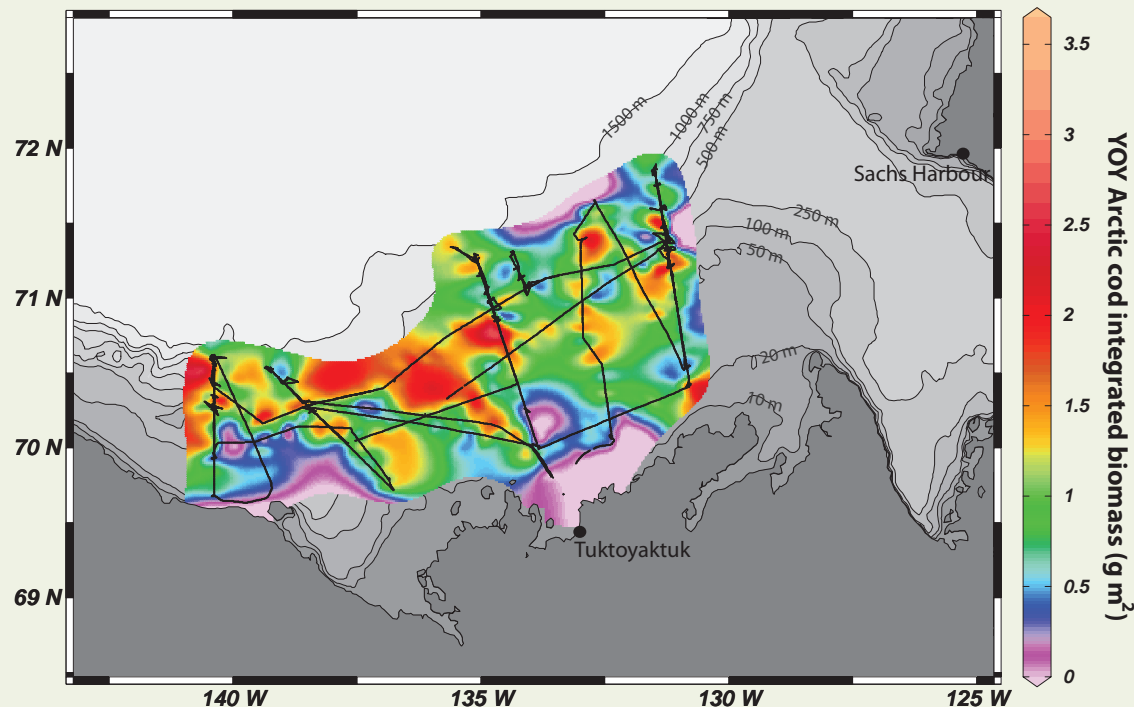
Results: Relationship for biomass calculations

Target Strength - Length relationship of YOY Arctic cod sampled in 2010 and 2011



Results: YOY Arctic cod spatial distribution during the ice-free season (2012)

- Parallel transects and echovalidation by net sampling in 2012 allowed the mapping of the spatial distribution of YOY and Age 1+ Arctic cod based on hydroacoustic data
- A resolution of 0.25 NM long by 3 m deep

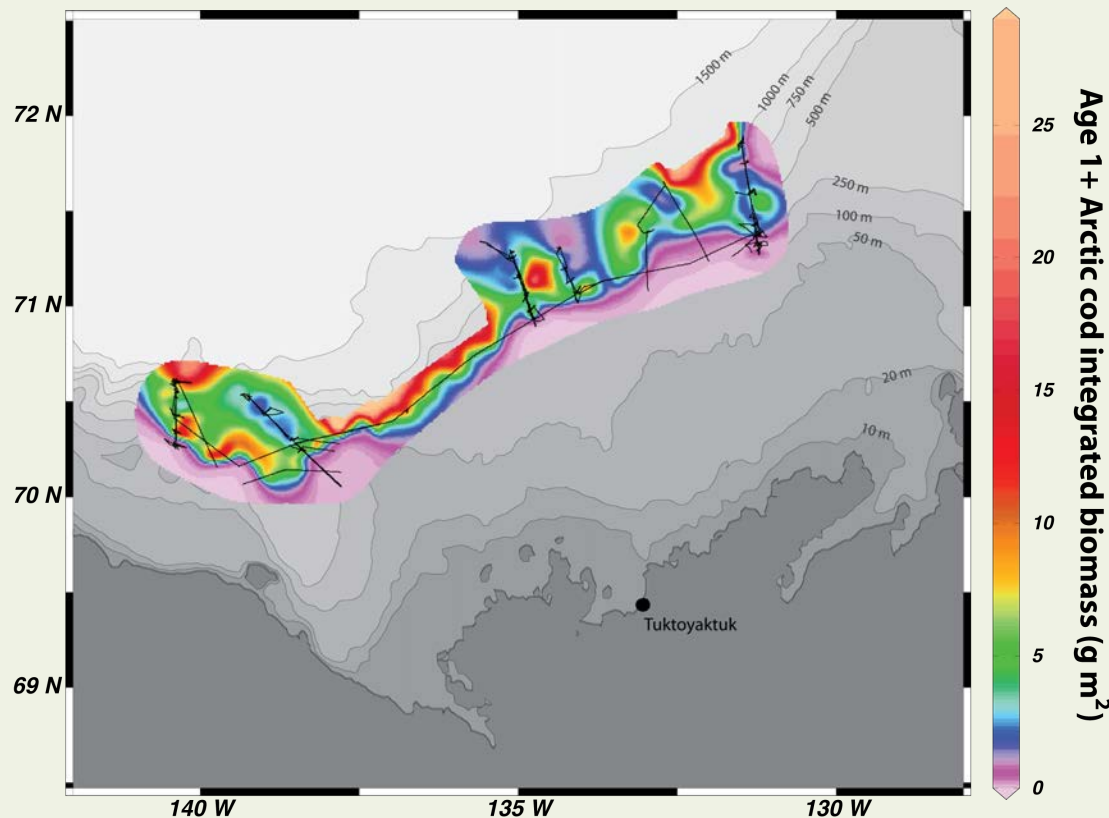


- Quasi-uniform distribution of YOY over the continental shelf and slope, from 10 to 1400 m and possibly further offshore

Results: Age 1+ Arctic cod spatial distribution during the ice-free season

(2012)

- Age 1+ Arctic cod over the entire continental slope, from 200 to 1400 and possibly further offshore
- Higher biomass at bottom depths of 350 and 1000 m



The continental slope

- The distribution of YOY and adult Arctic cod over the continental slope overlaps with several oil exploration lease blocks

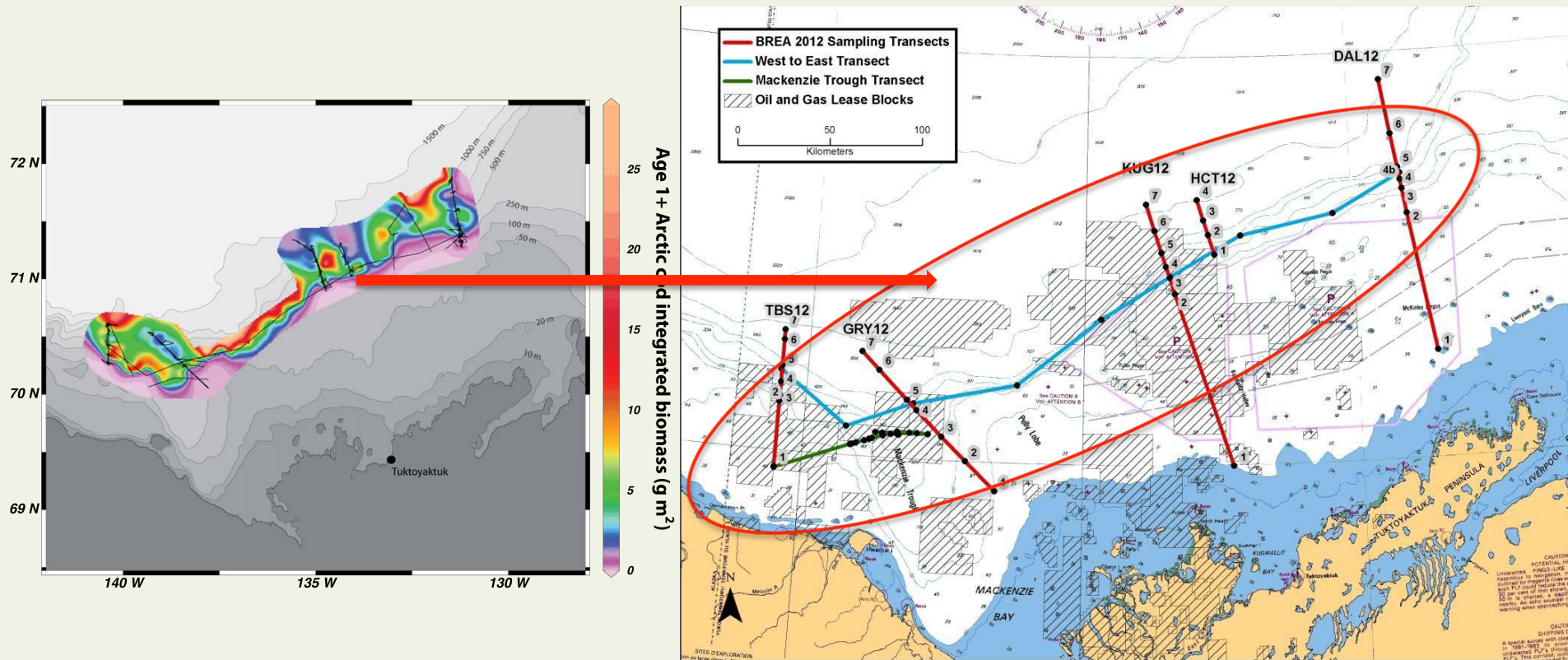


Image: Fisheries and Oceans Canada

Summary and conclusions

- 1. Arctic cod is the most abundant pelagic fish species over the shelf and slope of the Canadian Beaufort Sea: 90% of the 6439 fish sampled below 100 m in 2012**
- 2. There is a clear segregation between YOY (<100 m) and Age 1+ Arctic cod (> 200 m)**
- 3. Recent studies reported adult Arctic cod aggregations over the slope in fall and winter (Benoit et al. 2008, 2010; Geoffroy et al. 2011). Validation of the echoes during this study proves that Age 1+ Arctic cod are also distributed over the slope during the ice-free season**
- 4. The distribution of YOY and adult Arctic cod overlaps with oil exploration lease blocks**

Future surveys (2013)

- Same echosounder aboard the F/V *Frosti*
- Additional acoustic transects with the CCGS *Amundsen*



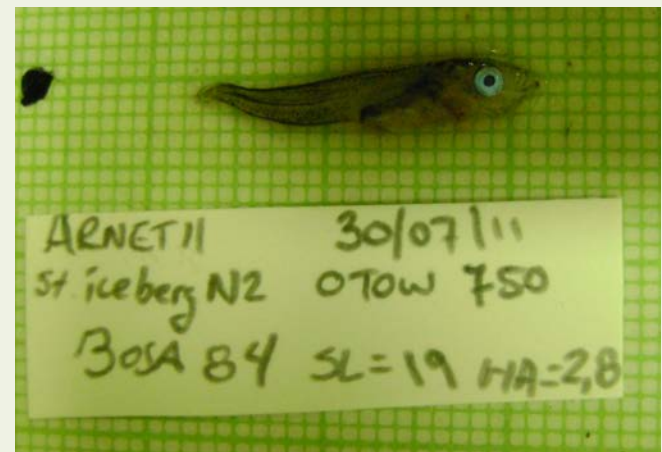
Photo: Fisheries and Oceans Canada



Photo: Martin Fortier

Future research and analysis

- More accurate biomass estimations based on new Target-Strength (TS)-Length and Weight-Length relationships for adult fish
- Test if the biomass of the slope aggregations can sustain energetic requirements of predators
- Document the coastal distribution (*Nahidik* and *Amundsen's* barge data)



Coastal distribution: local knowledge



Photos: Vancouver Aquarium (Helen Drost)

- Any local fisheries?
- Any coastal schools observed near the communities?

Acknowledgements

We thank the officers and crew of the CCGS *Amundsen* and F/V *Frosti* for their dedication and professionalism. The calibration of the echosounder in 2012 was conducted with the help of Georges Cronkite and Stéphane Gauthier from the Pacific Biological Station. Several technician and colleagues contributed to the sample collection from 2009 to 2012. This project is financially supported by Aboriginal Affairs and Northern Development Canada throughout the BREA project, ArcticNet, the *Amundsen* Program, and Fisheries & Oceans Canada. Imperial Oil Resources Ventures Limited and BP Exploration Operating Company Limited partly funded ship time from 2009 to 2011. The NOAA graciously lent the transducers used during the 2012 survey. This is a contribution to the Canada Research Chair on the Response of Arctic Marine Ecosystems to Climate Change.

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