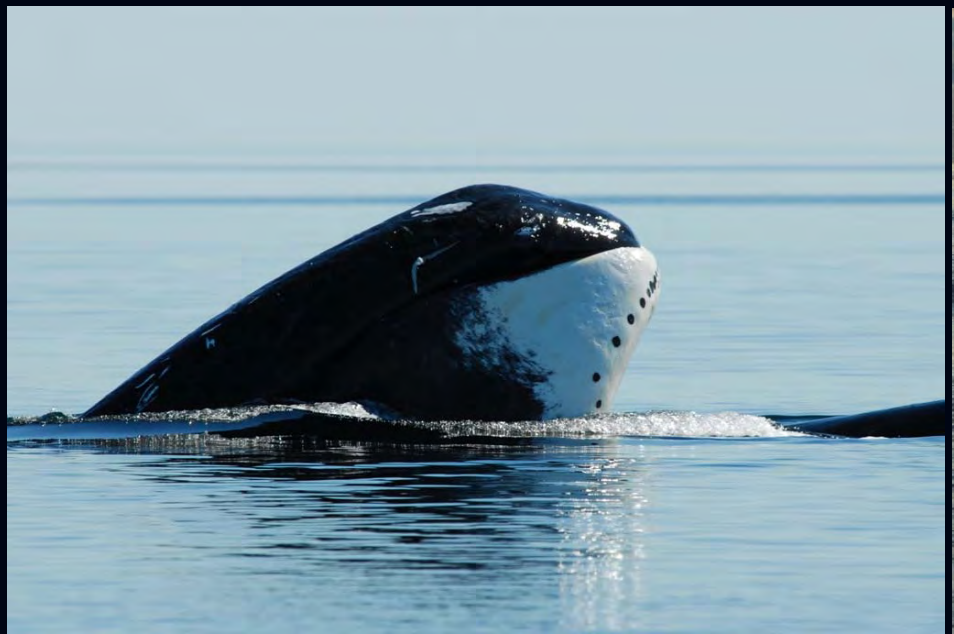
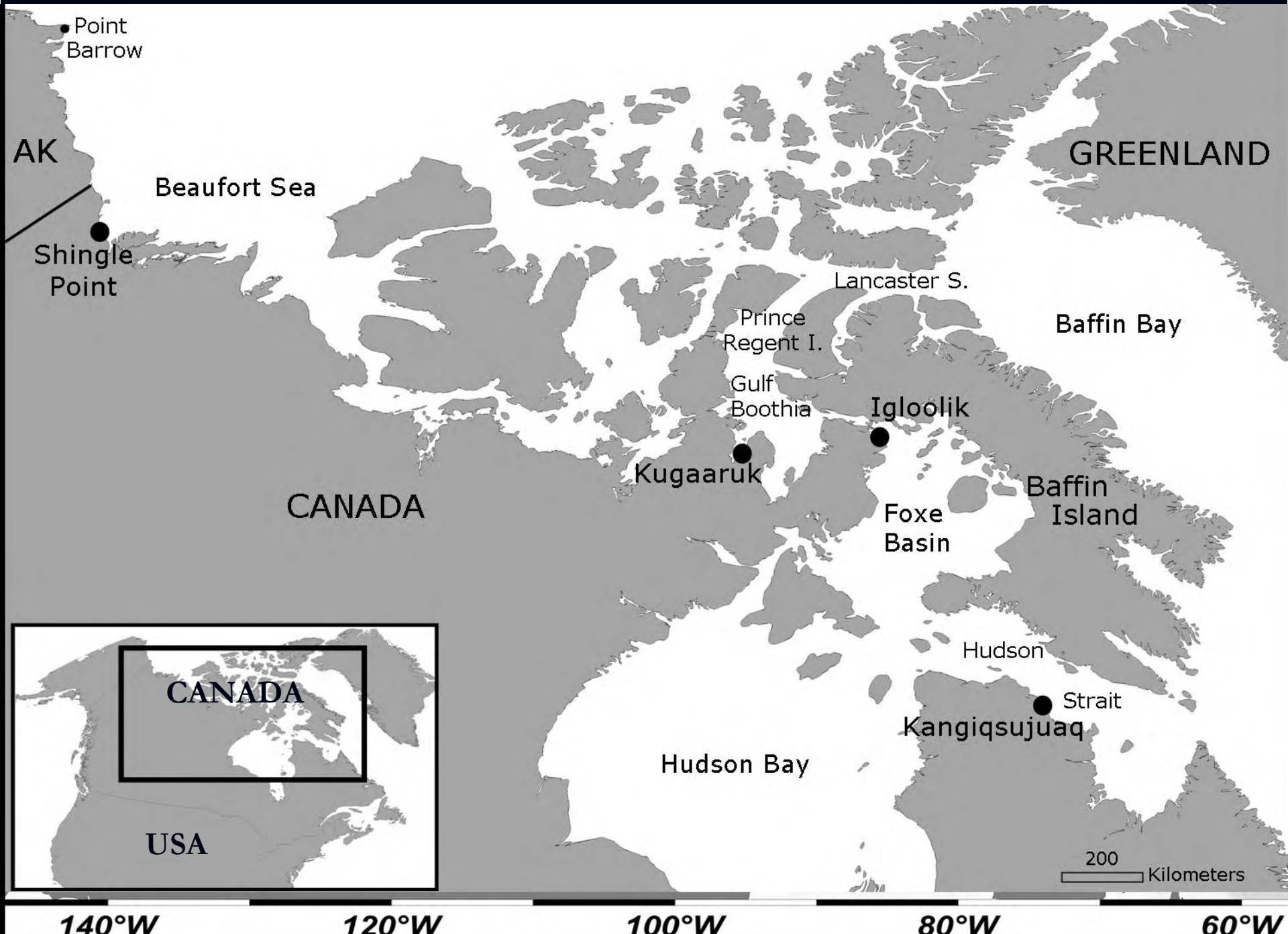
# BOWHEAD WHALE

- Largest baleen whale in the Arctic

- Only mysticete whale endemic to the Arctic

- Thick blubber and skin with no dorsal fin



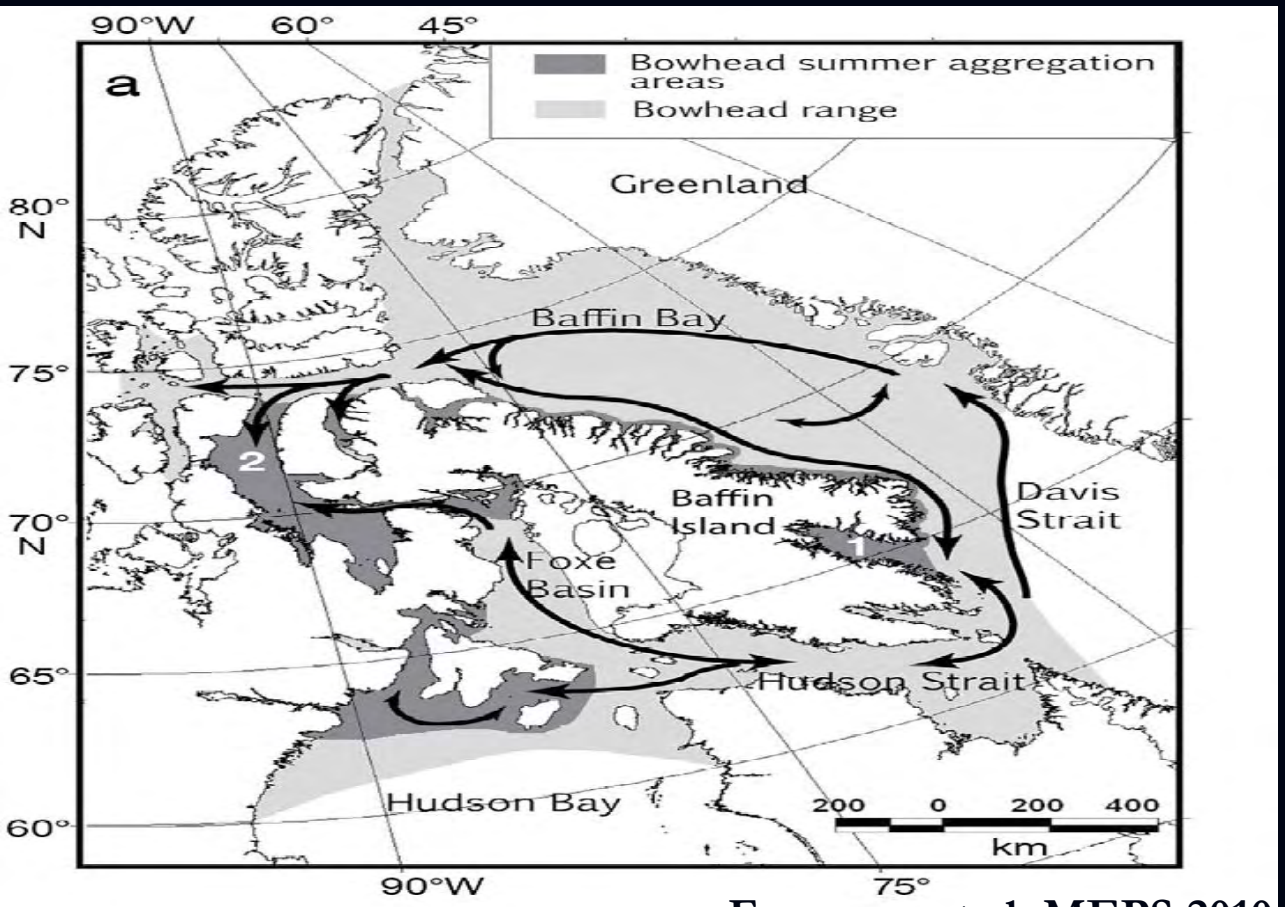

Point Barrow
AK
Beaufort Sea
GREENLAND
Shingle Point
Lancaster S.
Prince Regent I.
Baffin Bay
Gulf Boothia
Igloolik
Kugaaruk
CANADA
Baffin Island
Foxe Basin
Hudson
Strait
Kangiqsujuaq
Hudson Bay
CANADA
USA
200
Kilometers
140°W
120°W
100°W
80°W
60°W

# DISTRIBUTION

Bowhead whales are widely distributed all over the Eastern Canadian Arctic.

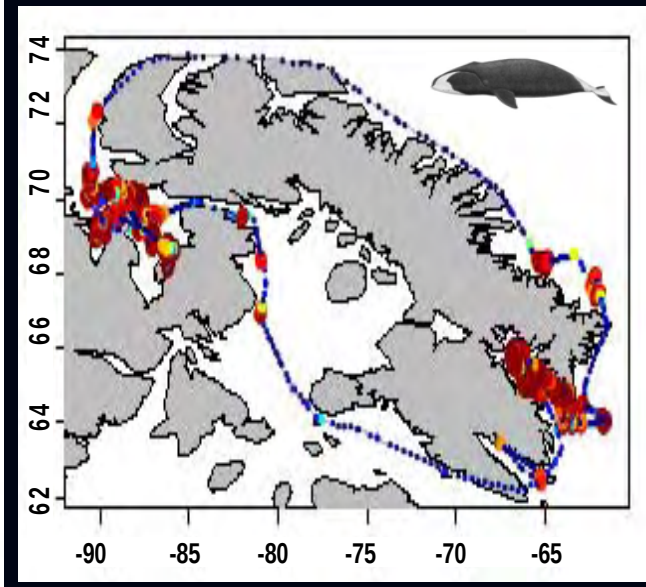
Sea ice is a major factor influencing seasonal distribution.

Population range and summer areas




Ferguson et al. MEPS 2010

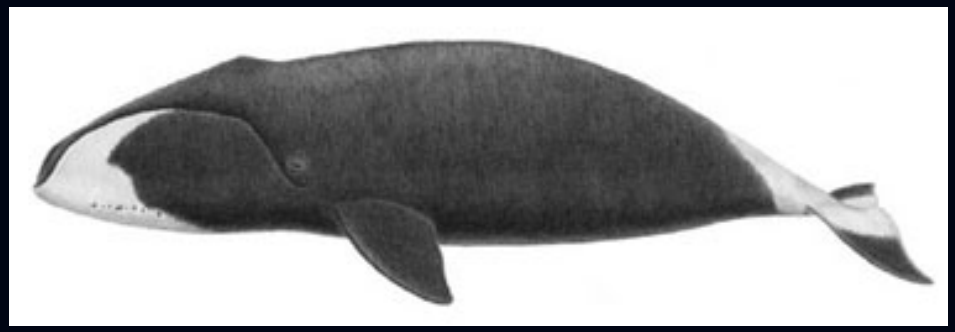
One bowhead individual movement over 8 months

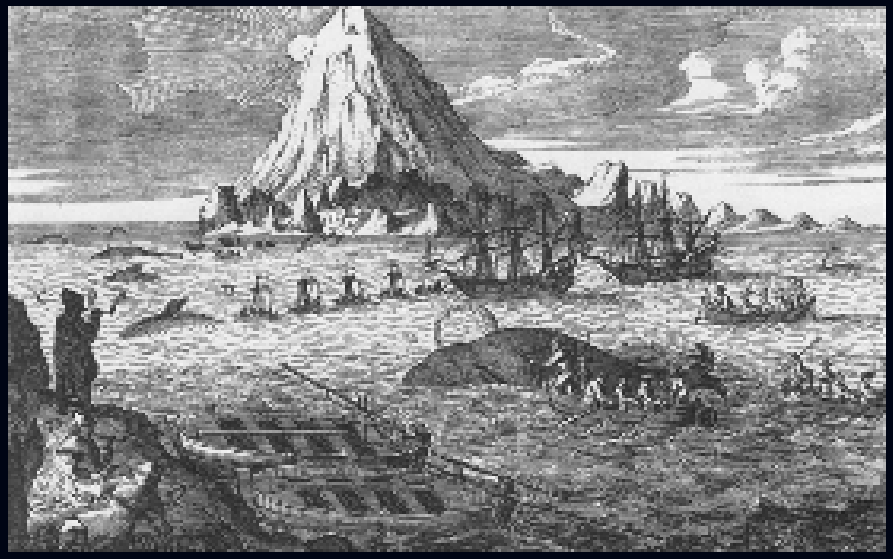



Pomerleau et al. ESR 2011 (In Review)

# Eastern Canada-West-Greenland Bowhead Population

- Special Concern in Canada
- Current estimation ~6,000 individuals.





**Bowhead whales are still at risk of becoming threatened or endangered**

- Extremely low natural growth rate and low fecundity
- Climate change
- Increase human activities and predation exposure

# Potential impacts of climate change on foraging success

- Changes in ice regime → Trophic coupling between primary production, zooplankton and higher trophic levels

- Warming ocean temperature → Sea ice extent
  Structure of water masses
  Prey abundance & distribution

- More warmer-water zooplankton species are expanding their range northward (Beaugrand *et al.* 2009)

**It is unknown how the foraging success of bowhead whales will be impacted by changes in the Arctic environment.**

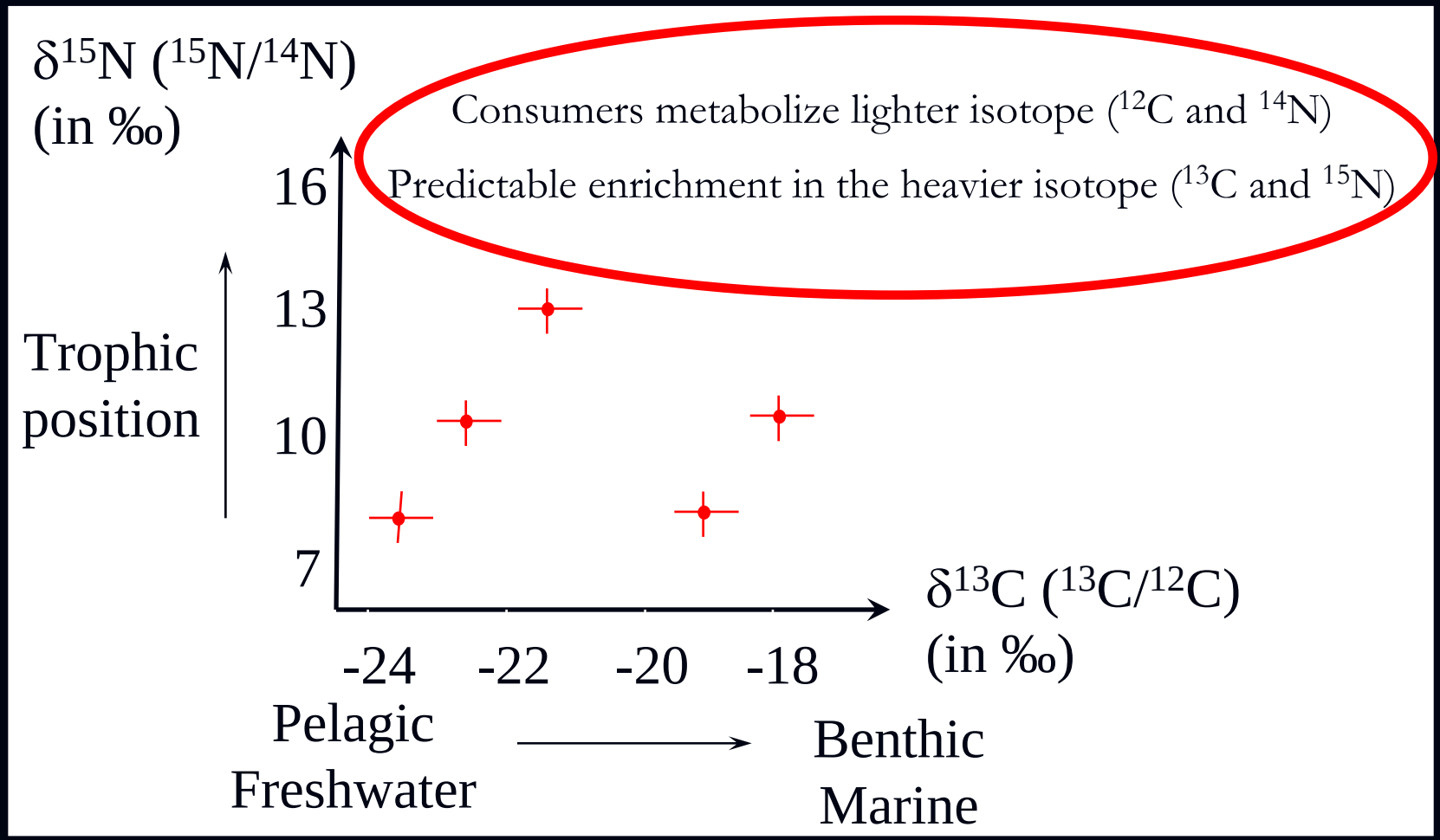
Do bowhead whales occupy a narrow feeding niche?

Are they vulnerable to changes in abundance of preferred prey?

# Stable Isotopes (SI)

- Tracers in environmental studies

- Major tool in feeding ecology to study trophic structure of ecosystems



# Stable Isotopes (SI)

$^{15}N/^{14}N$ ($\delta^{15}N$): Determine trophic level in a food chain, trophic relationships.

$^{13}C/^{12}C$ ($\delta^{13}C$): Indicates carbon sources, provide information on spatial habitat use, detect energy flow in the food web (Fry 1998).

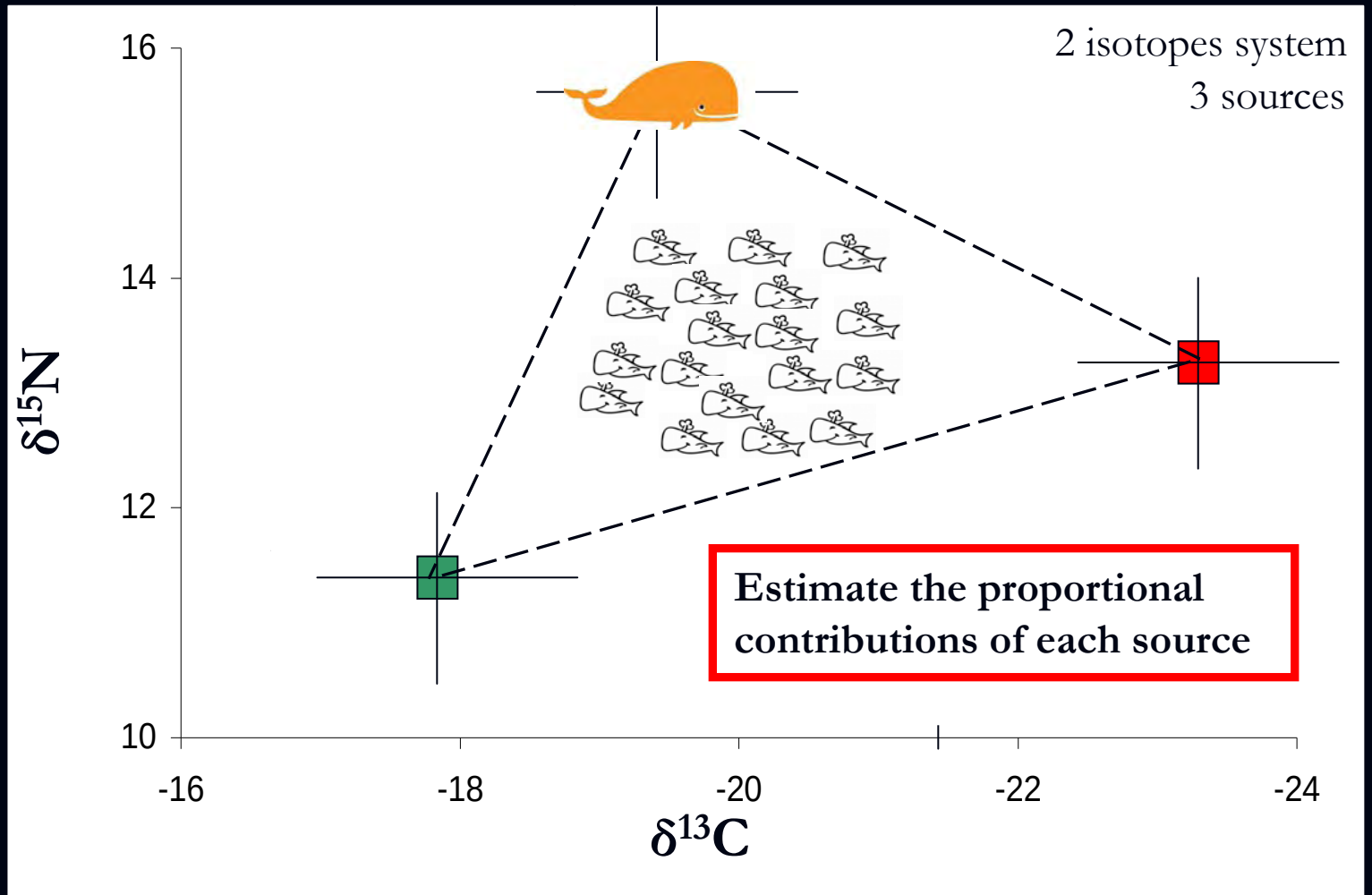
Advantages to the stable isotopes approach in dietary reconstruction studies of free ranging marine mammals include:

- Non-invasive technique
- Time-integrated diet (e.g. 70-75 days for skin)
- Reflect ingested and assimilated food

# Stable isotopes mixing model

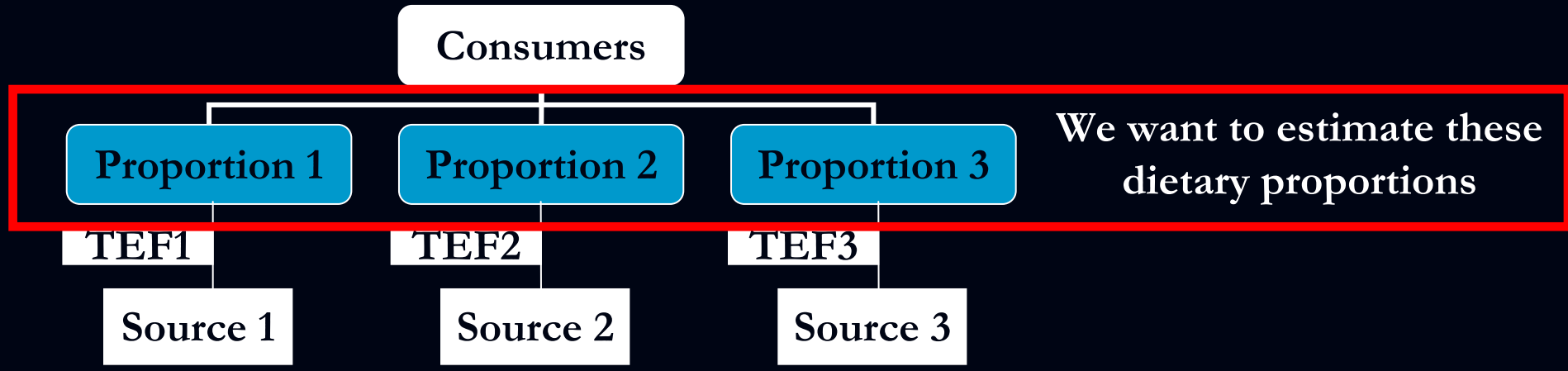
## Basic example

### (Phillips and Gregg 2003 - IsoSource )



# Bayesian stable isotopes mixing model

Determine the proportional contribution of sources (zooplankton) to a mixture (bowhead) based on their respective $\delta^{13}C$ and $\delta^{15}N$.




ROBUST TECHNIQUE:

- Take into account the substantial and multiple sources of uncertainty in all parameters
- Large number of sources
- Incorporate variability as input parameters (i.e. TEF)
- Flexible and customizable
- You get an honest representation of the estimate of diet proportions

SIAR package (R) (Parnell et al. 2010 PlosOne)
MixSIR (equivalent package - Matlab) (Moore & Semmens 2008)

# OBJECTIVES

## Identify primary prey species of the bowhead whales

1) Examining diet using stable isotope ratios of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$)

2) Examining the stomach contents from four bowhead whales



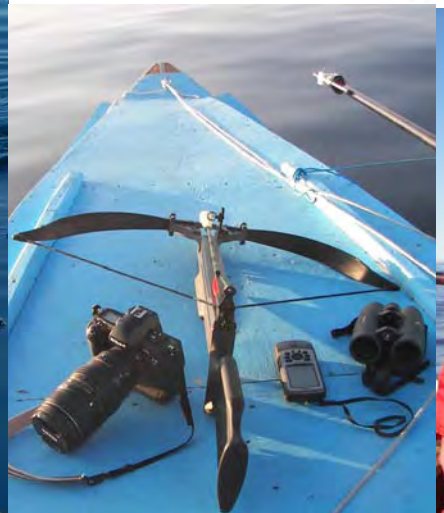


# Sample collection – Whales

Bowhead whale skin biopsies collected with a crossbow.

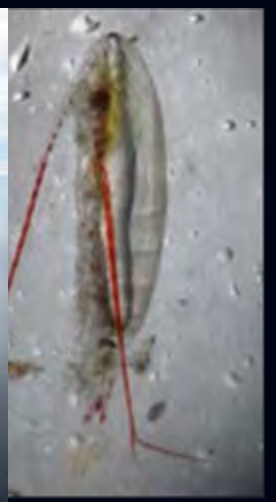
190 skin biopsies (2007-2009)

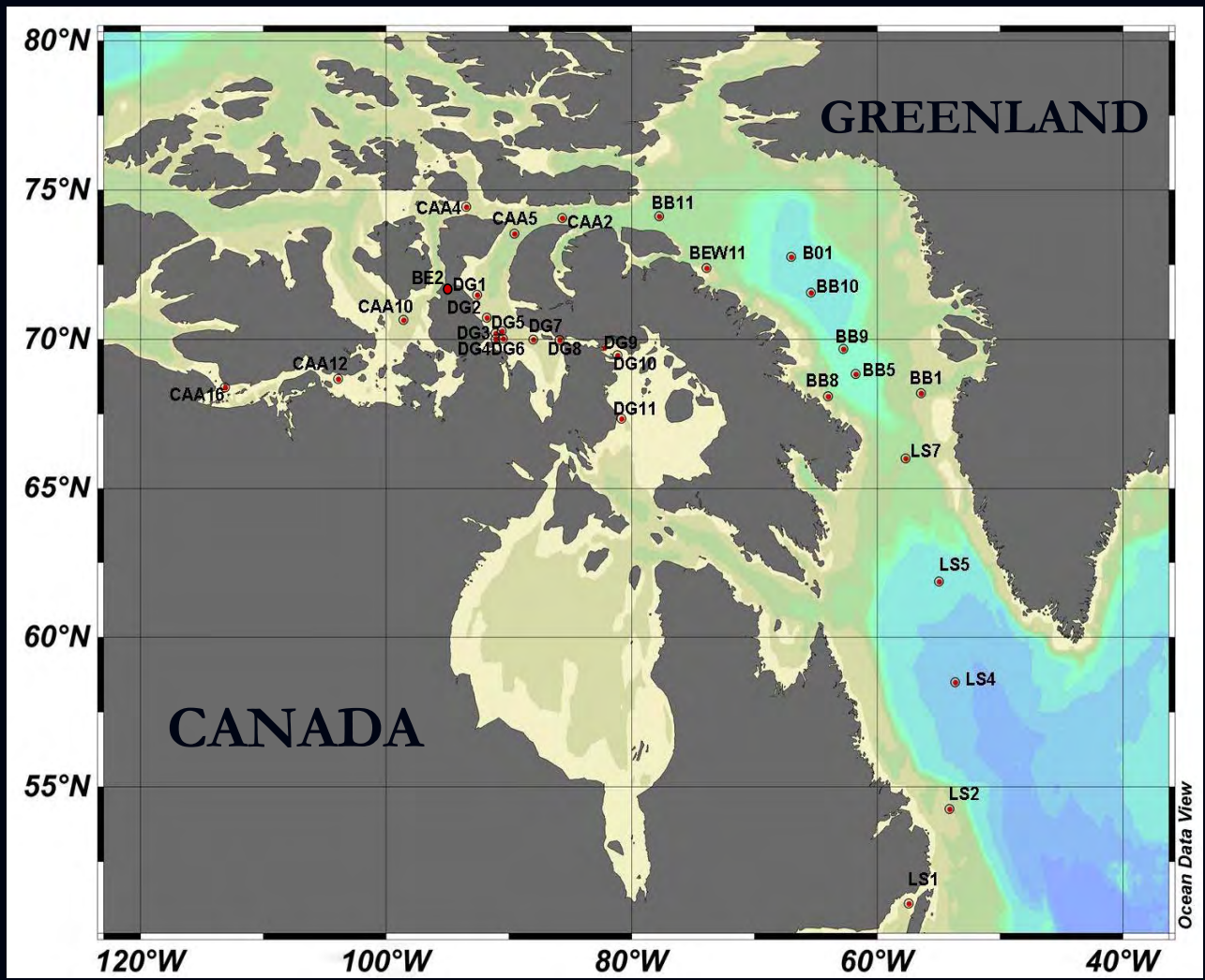
The majority of the samples from Igloolik, Foxe Basin.

# Sample collection - Zooplankton

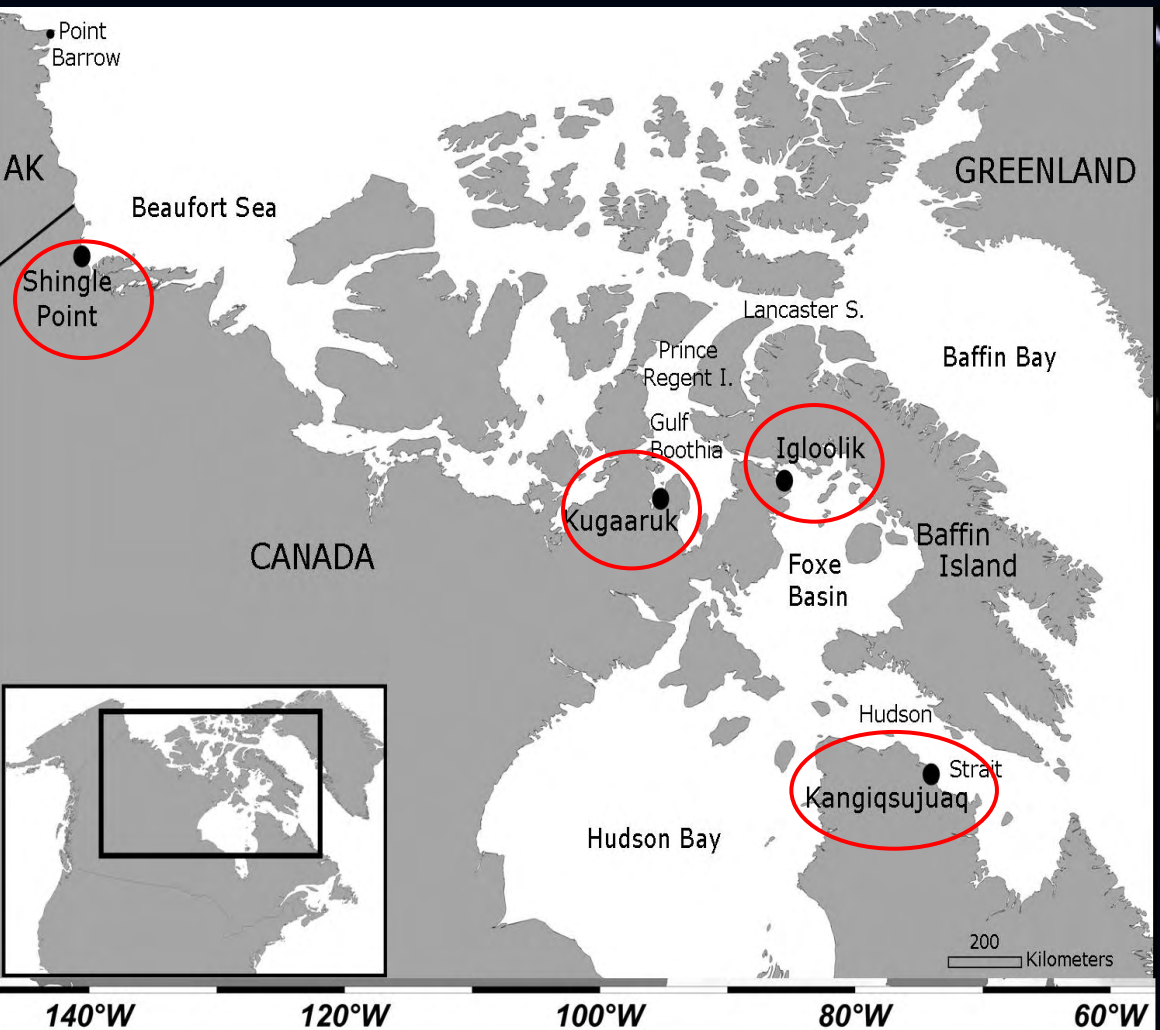
Zooplankton samples were collected at 25 stations (2007-2009) using a set of vertically towed bongo nets.





# Sample collection - Stomachs

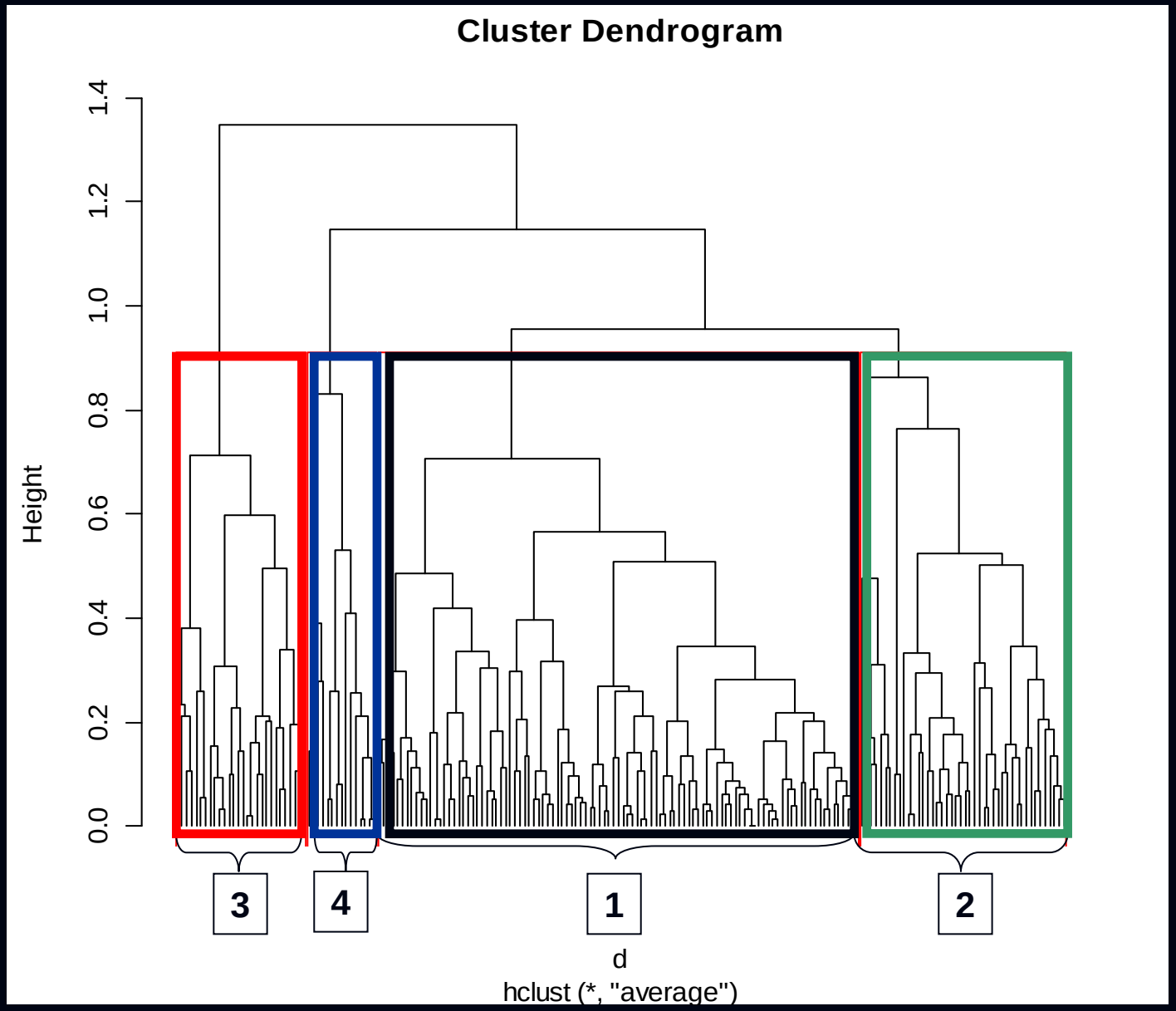
Four stomach samples were collected by Inuit during subsistence harvests in the Canadian Arctic.

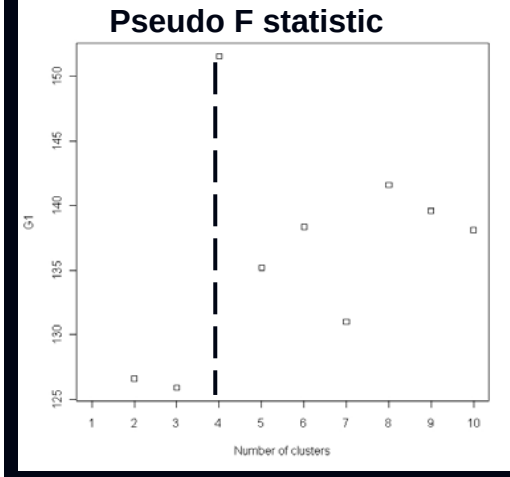


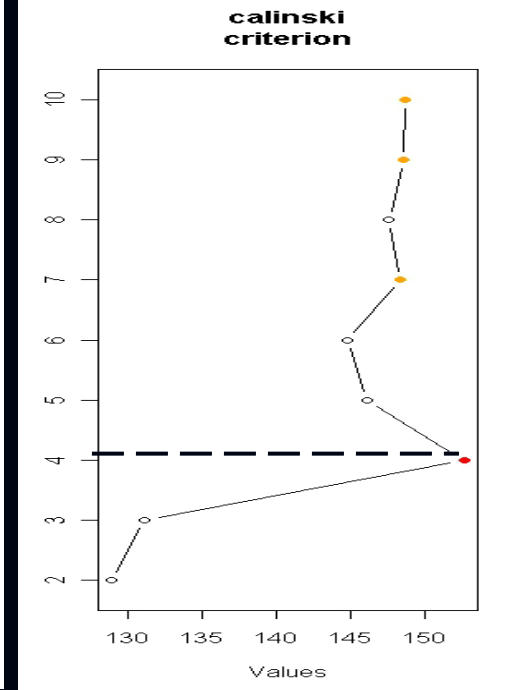

Each sample was thawed, drained and rinsed on a 250 $\mu$m sieve.

Pomerleau et al. 2010

# Consumer (Bowhead whale) Groups

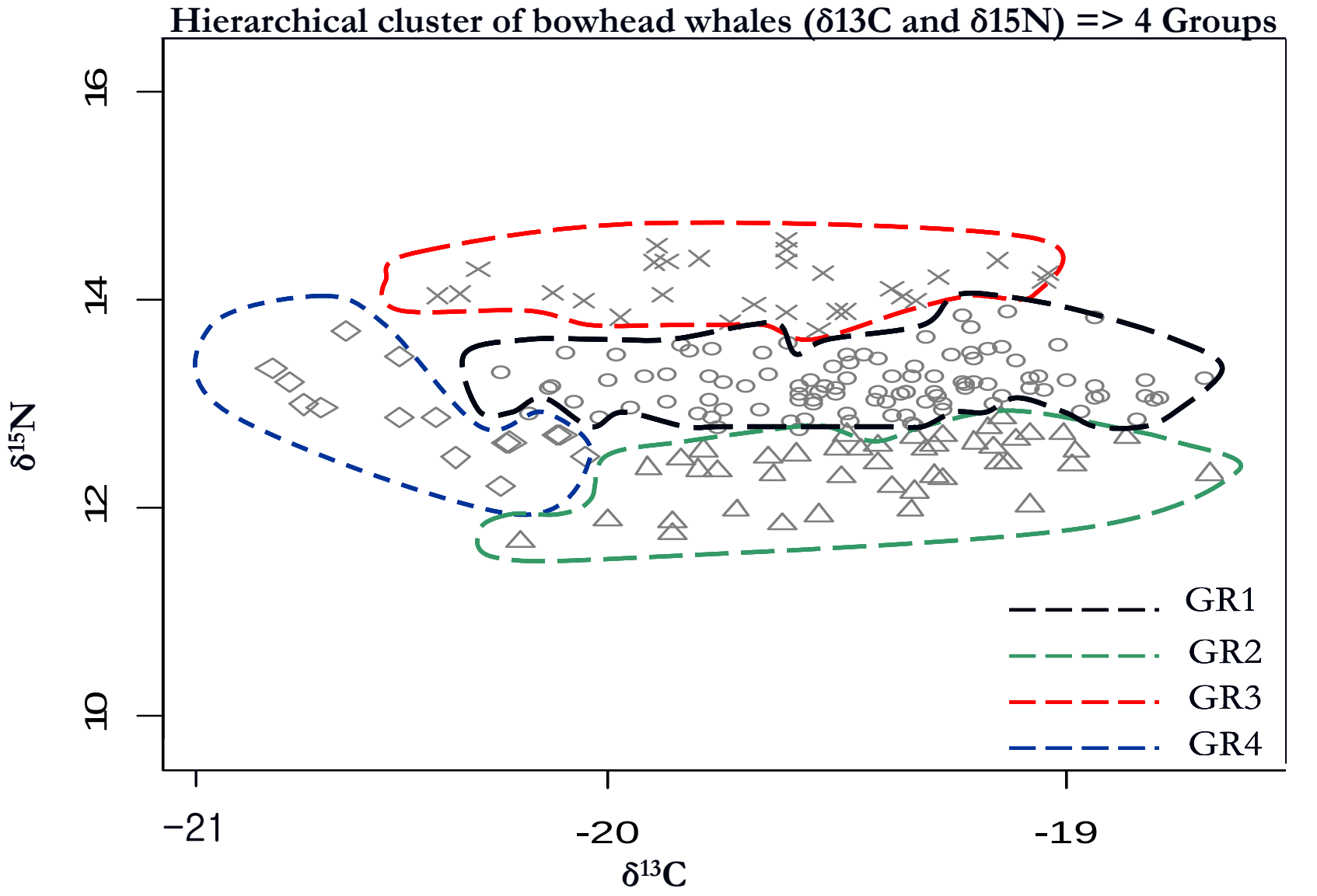


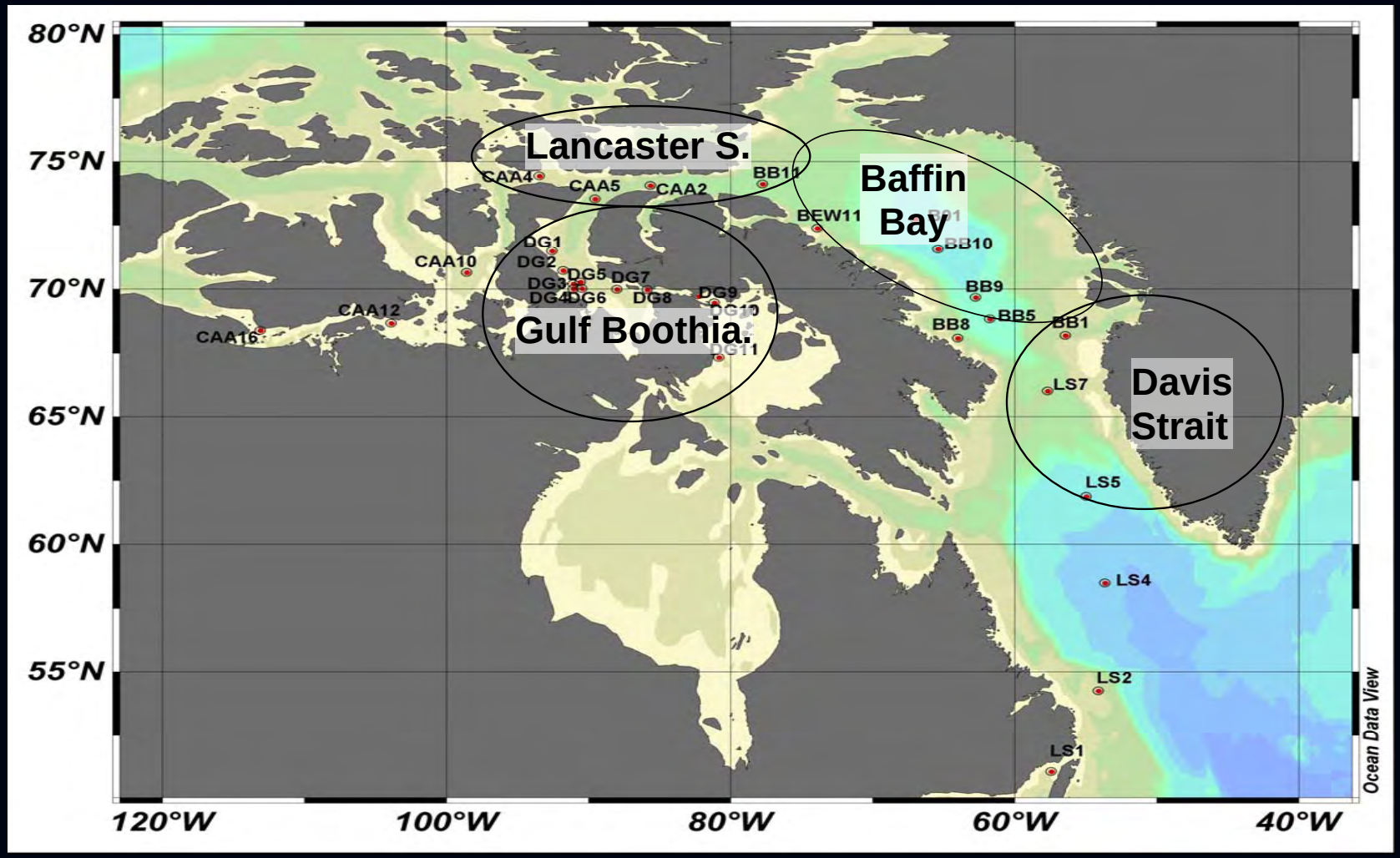

Hierarchical cluster of bowhead whales ($\delta^{13}C$ and $\delta^{15}N$) => 4 Groups

# Consumer (Bowhead whale) Groups



# Sources (Zooplankton) Groups

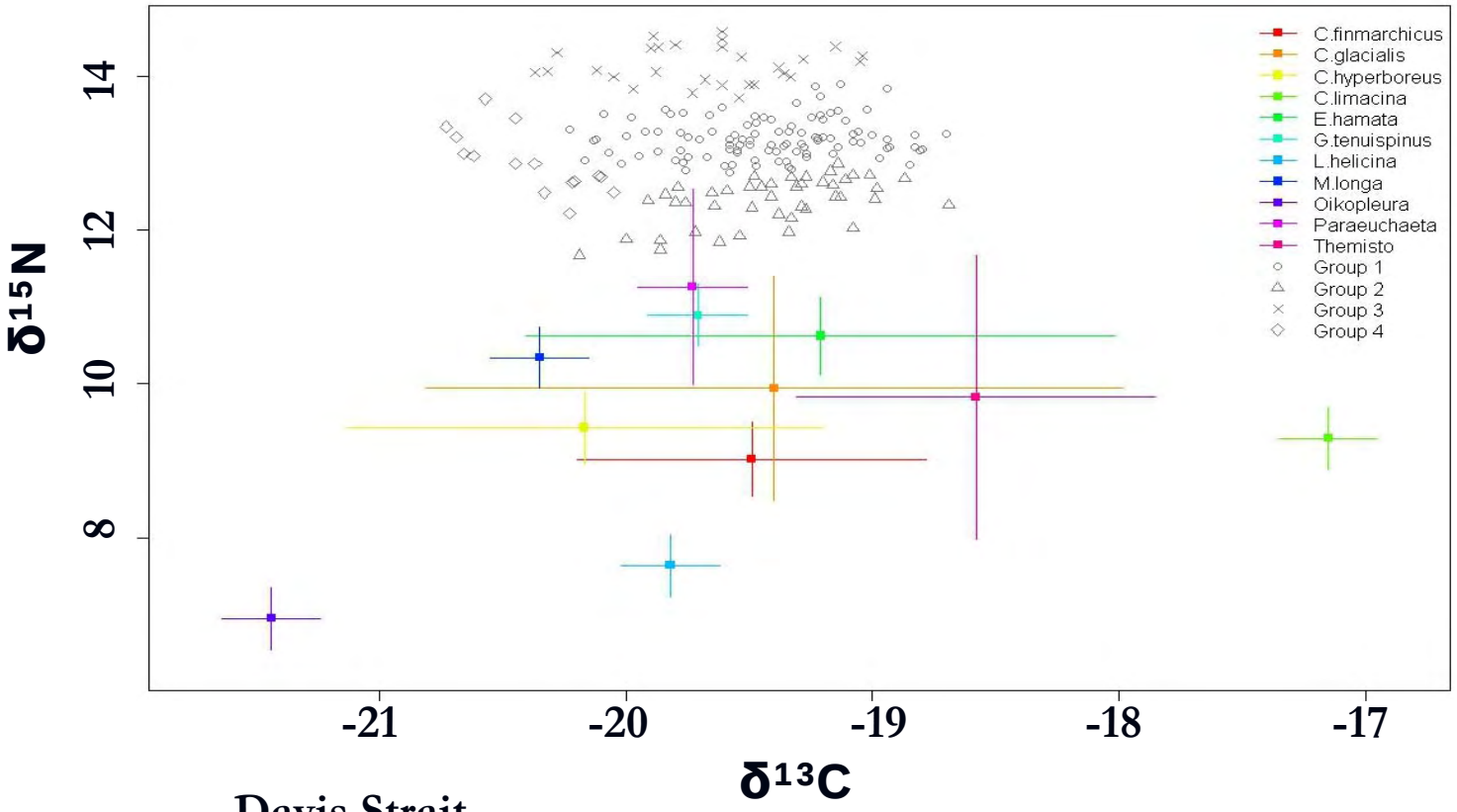
Based on physical properties (temperature and salinity) and species composition (abundance) => 4 Groups




Pomerleau C., Winkler G, Ferguson SH, Nelson J, Sastrii A, Vagle S. (In prep)

# RESULTS
# Bayesian mixing model

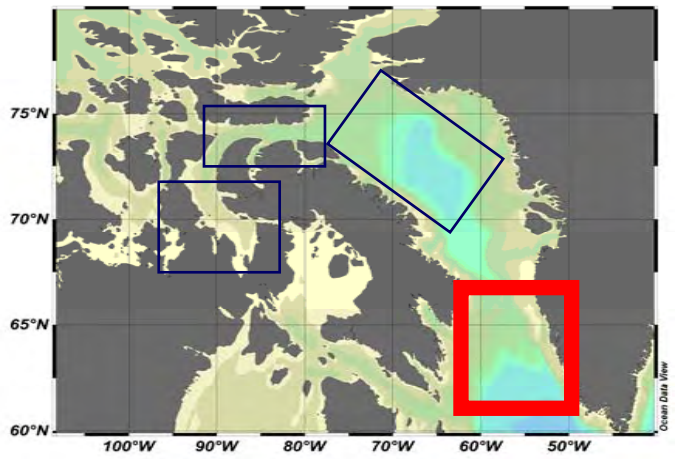
# Raw isotopic data plot of $\delta^{13}C$ vs. $\delta^{15}N$




Davis Strait

Not a feeding area

Davis Strait

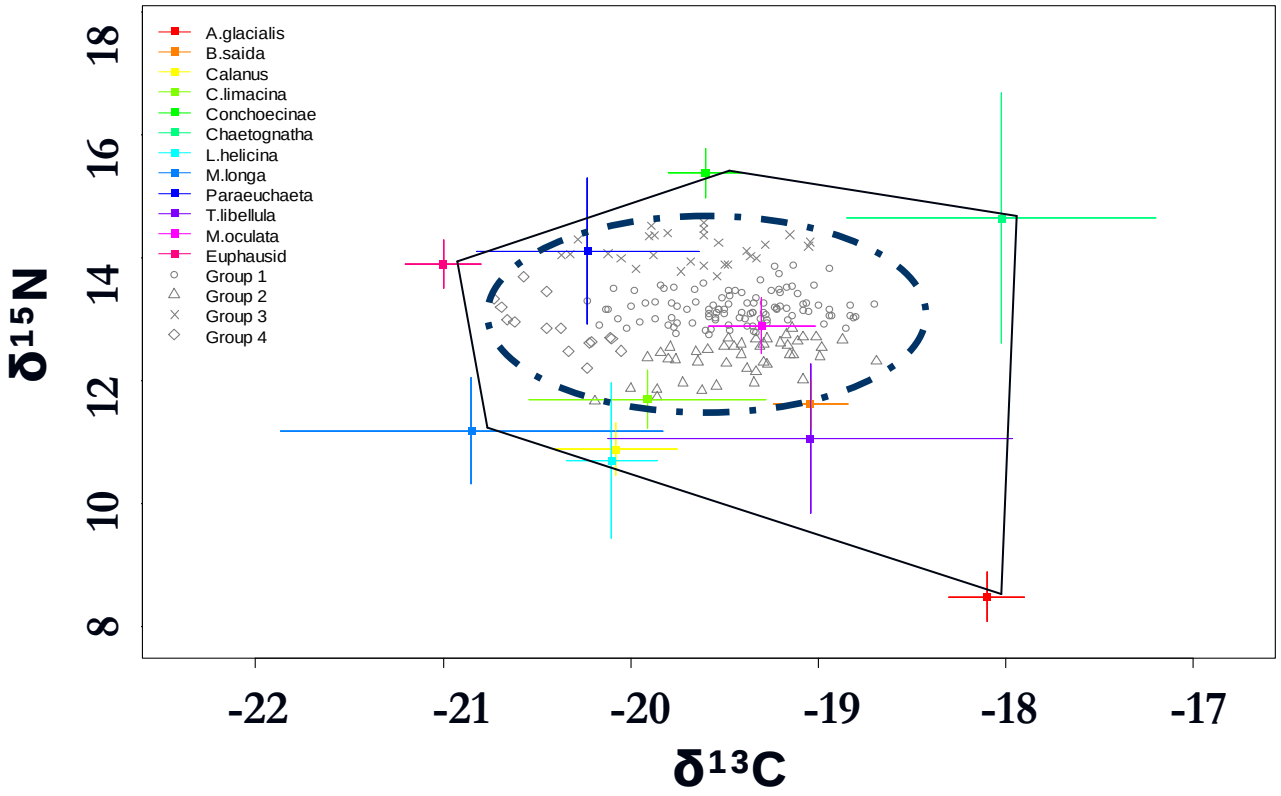



**Bowhead whale isotopic signatures are outside the prey values (TEF already integrated).**

**Signatures of prey sources failed to explain the consumer signatures.**

**Not a feasible solution.**

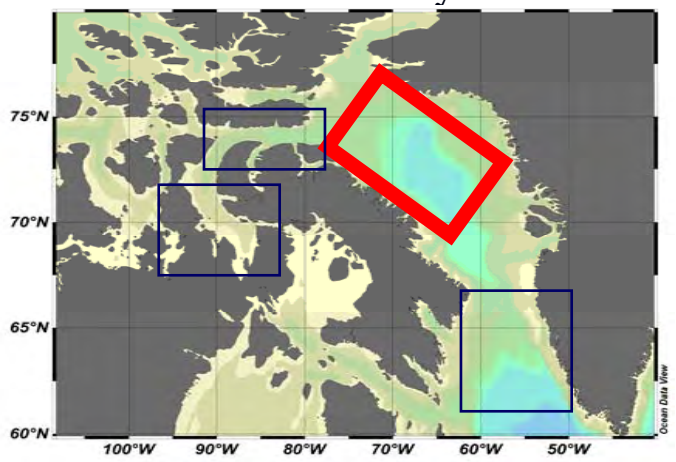
## Raw isotopic data plot of $\delta^{13}C$ vs. $\delta^{15}N$




Baffin Bay

Possible feeding area

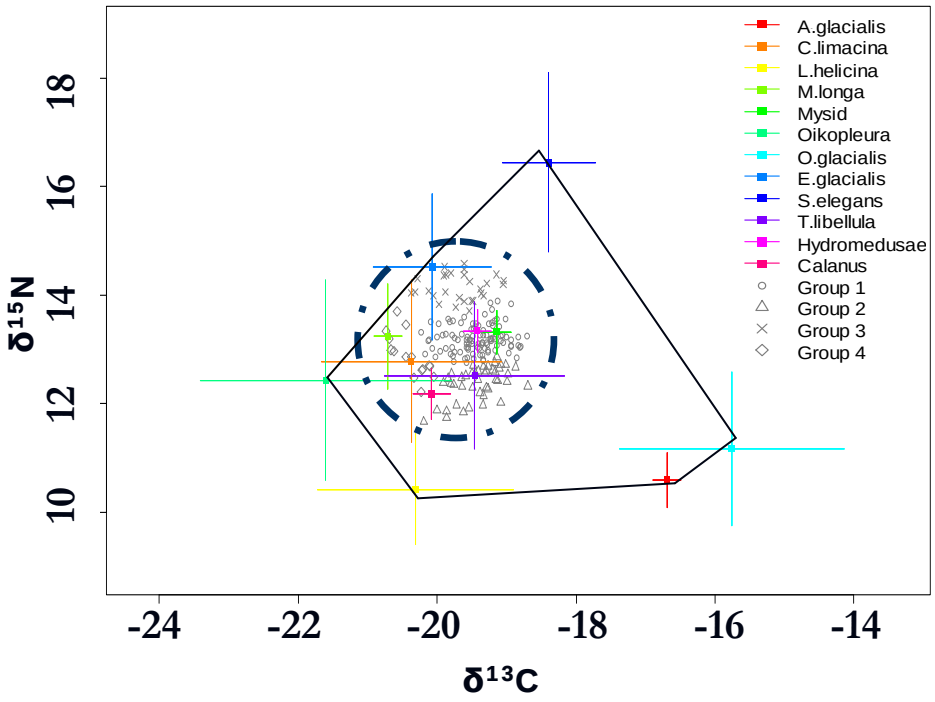
Baffin Bay

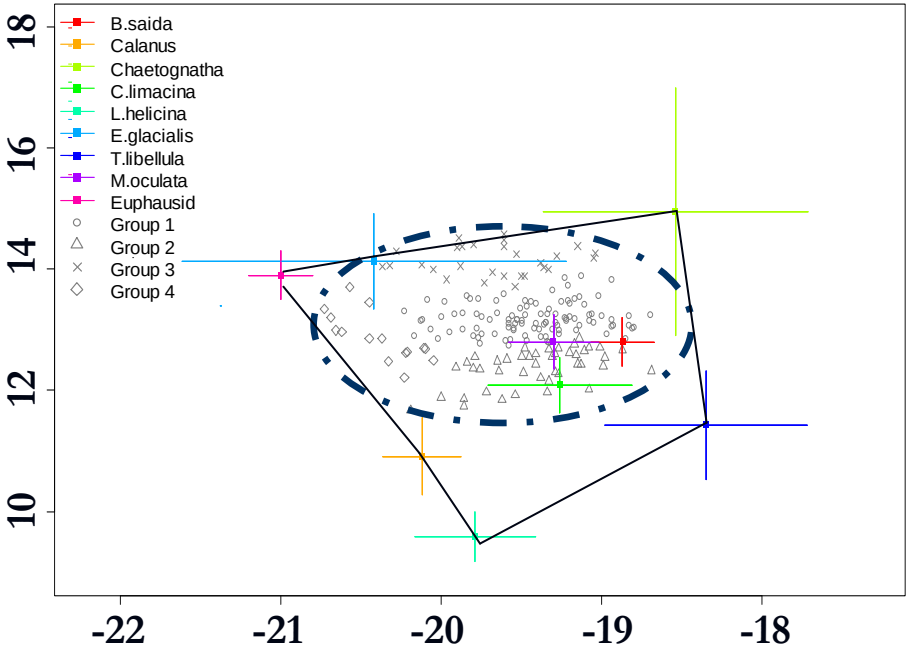



**Bowhead whale isotopic signatures (blue circle) are inside the prey "polygon" (geometry of the mixing space).**

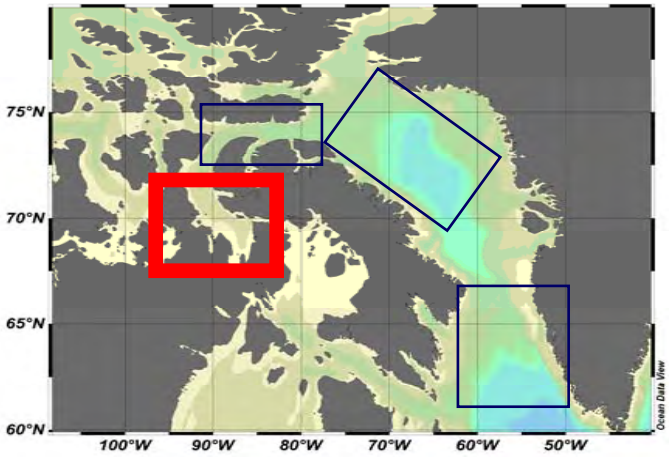
**This predator-prey diet scenario is a feasible solution.**

# Raw isotopic data plot of $\delta^{13}C$ vs. $\delta^{15}N$

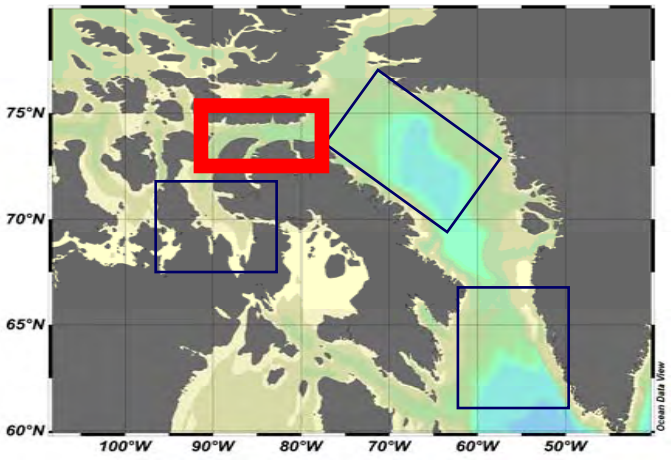


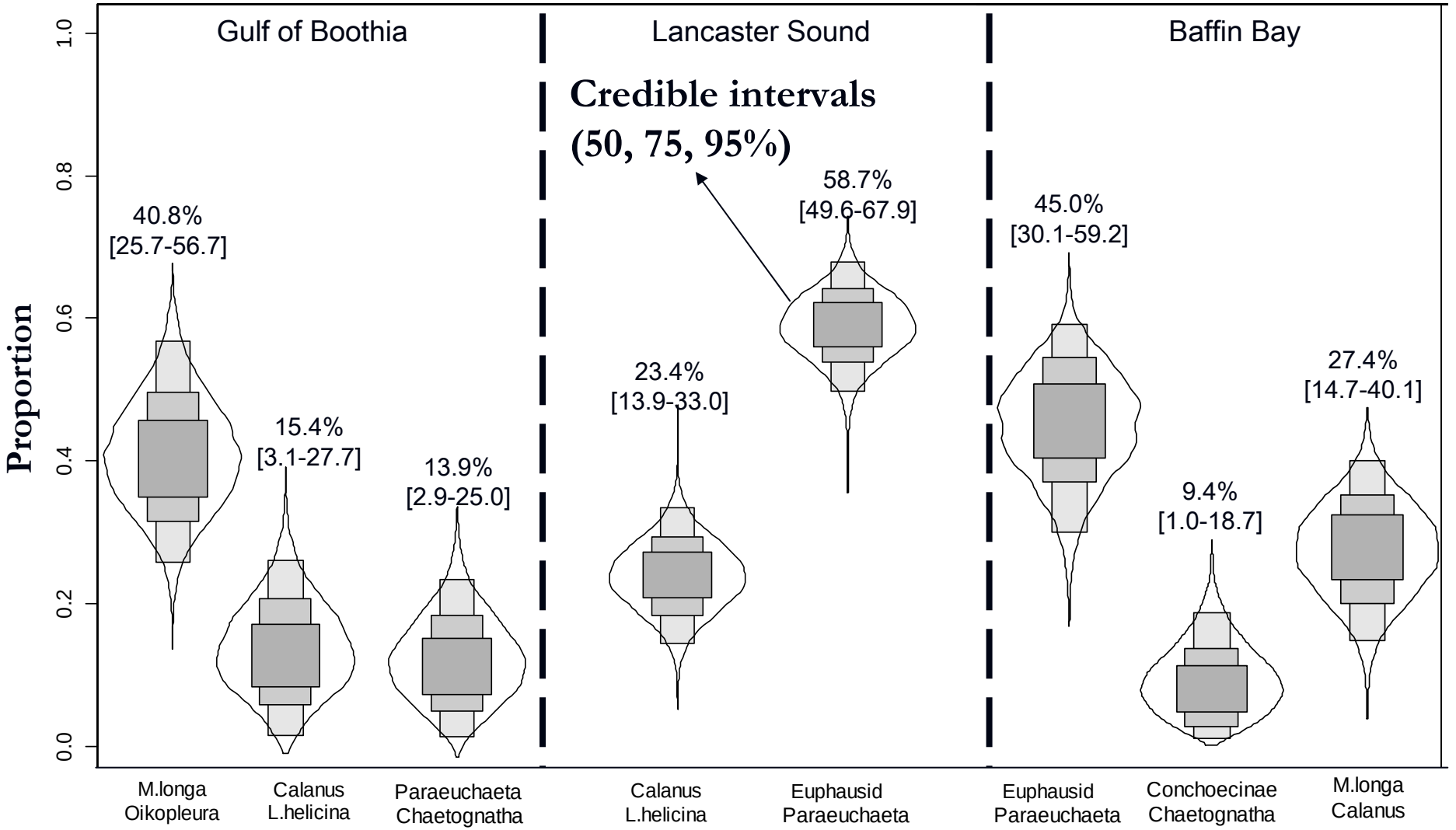

## Gulf of Boothia




## Lancaster Sound

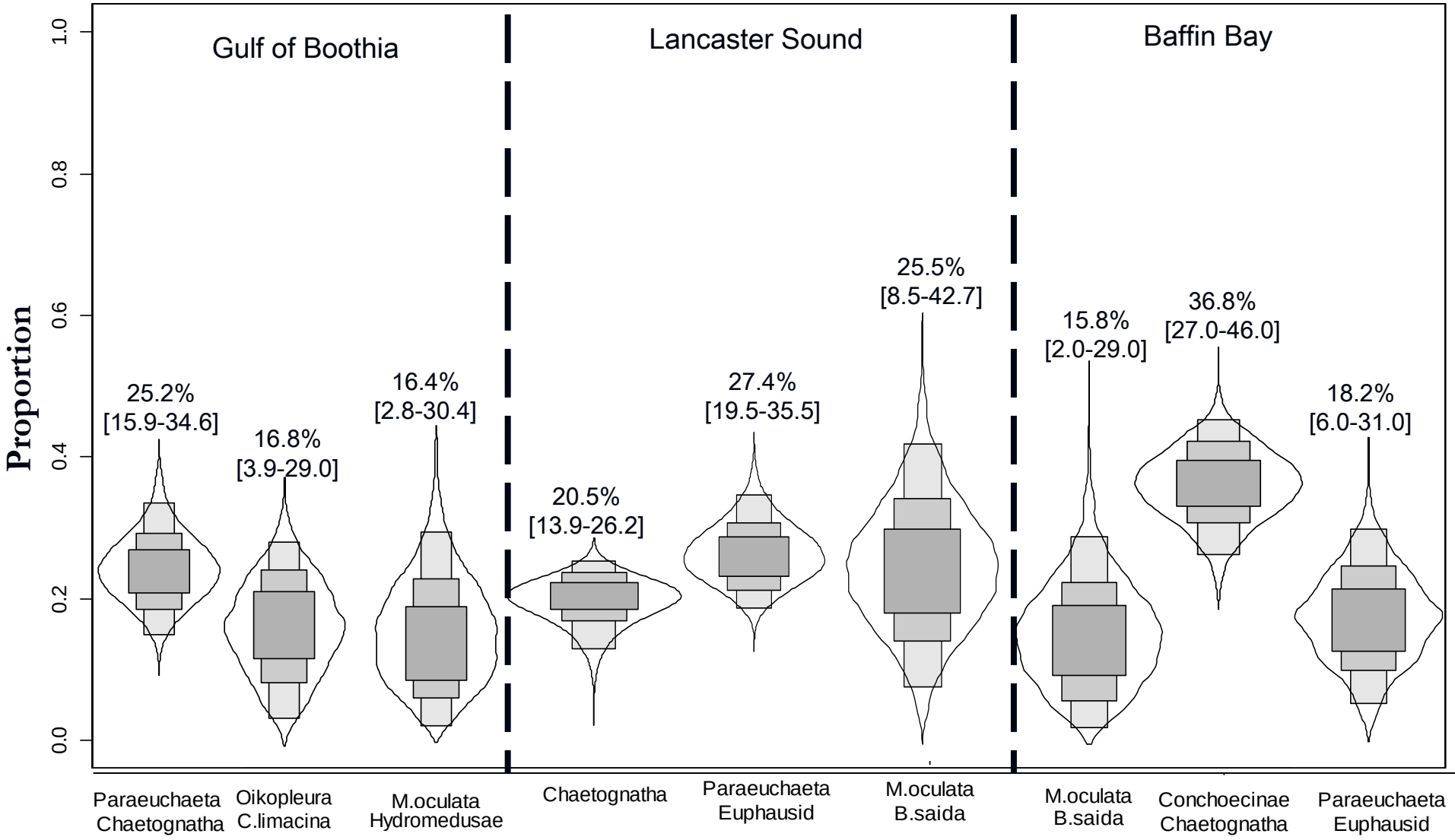


# BOWHEAD WHALE GROUP 4



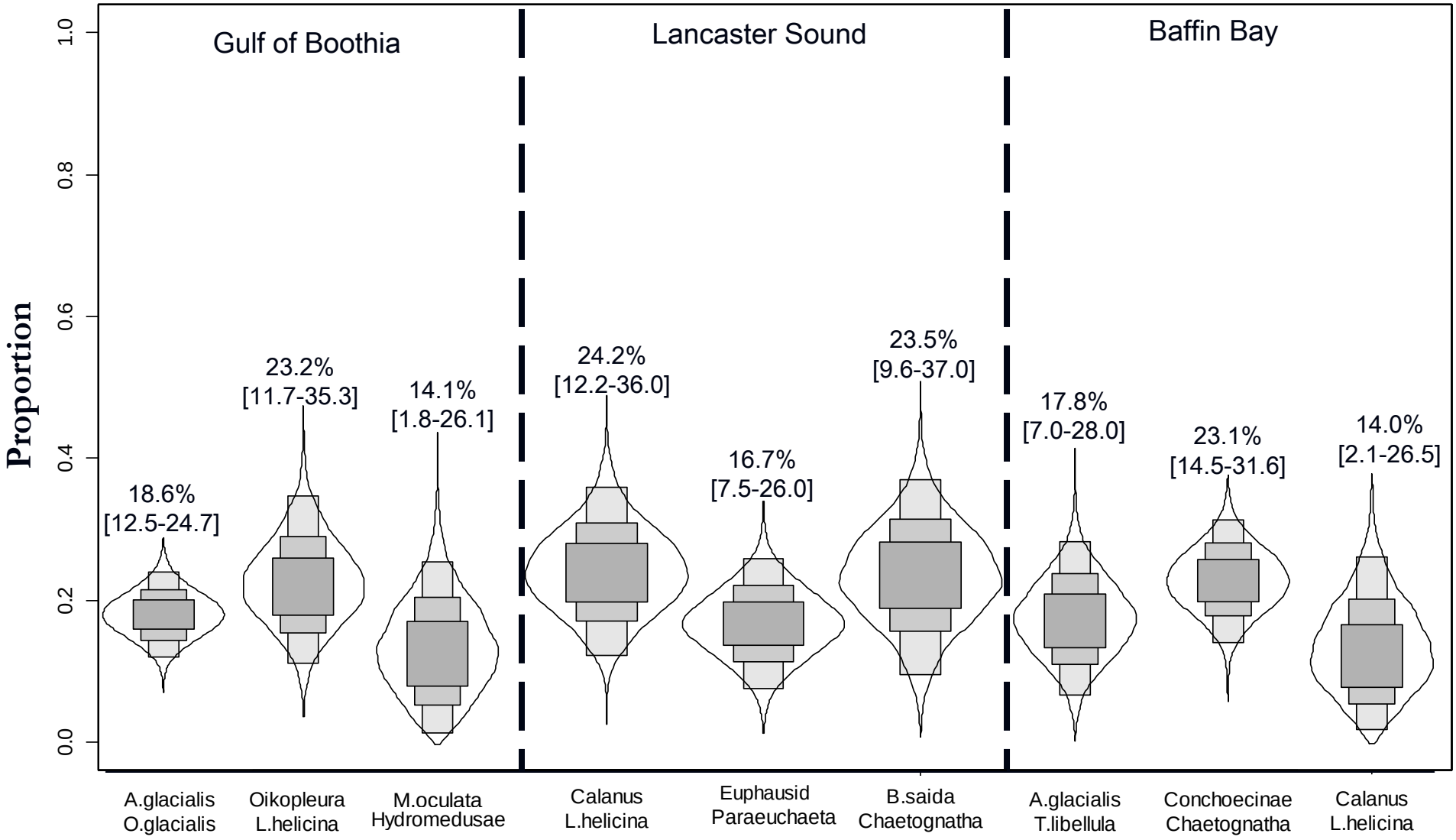

**Euphausid, *Calanus* sp., *Paraeuchaeta* sp., and *Metridia longa* are the most important prey items**

# BOWHEAD WHALE GROUP 1



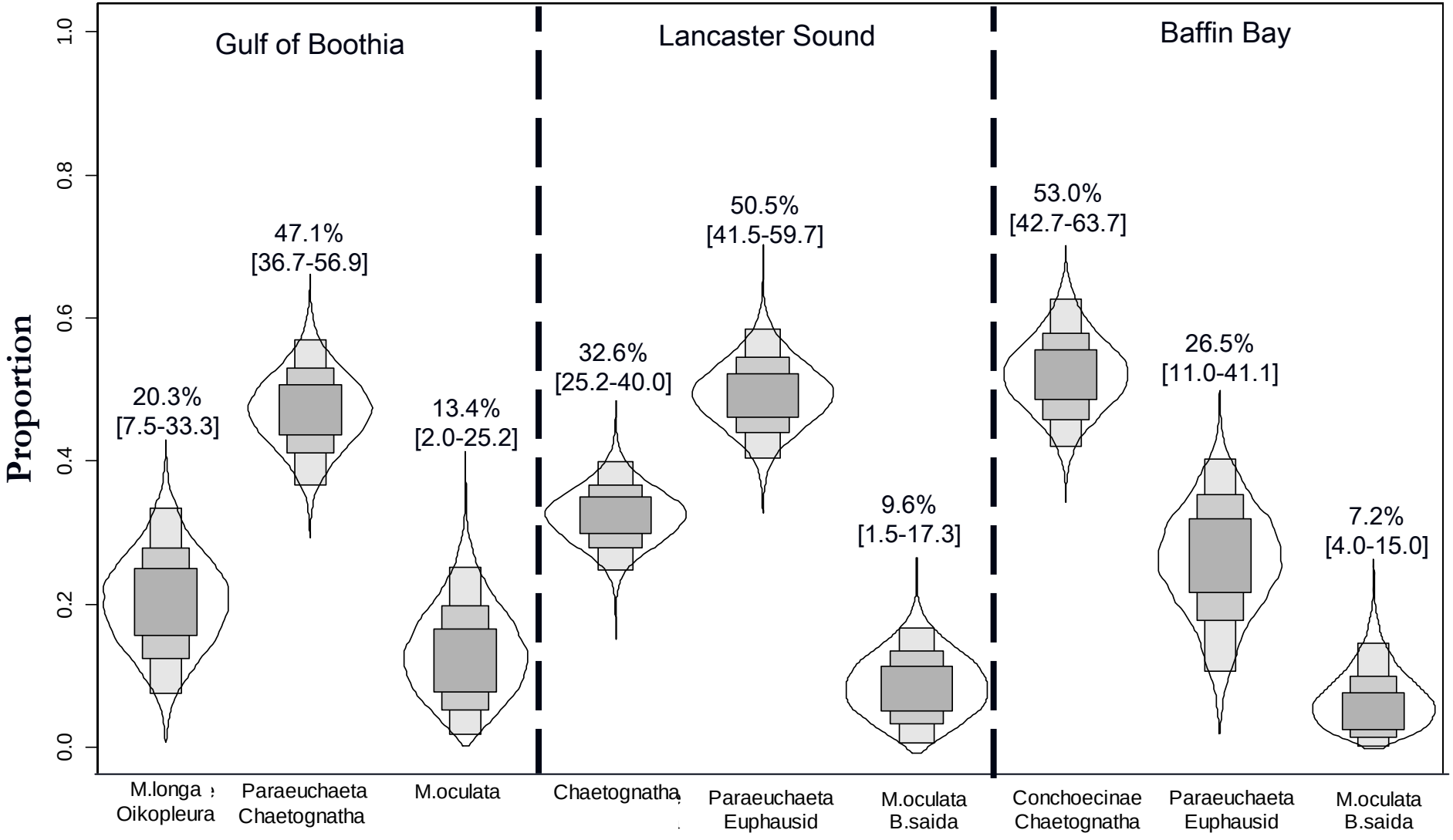

***Mysis oculata*, *Euphausid*, *Paraeuchaeta* sp. and Chaetognath are the most important prey items**

# BOWHEAD WHALE GROUP 2




***Apherusa glacialis*, *Calanus* sp., *Limacina helicina* and Chaetognath are the most important prey items**

# BOWHEAD WHALE GROUP 3



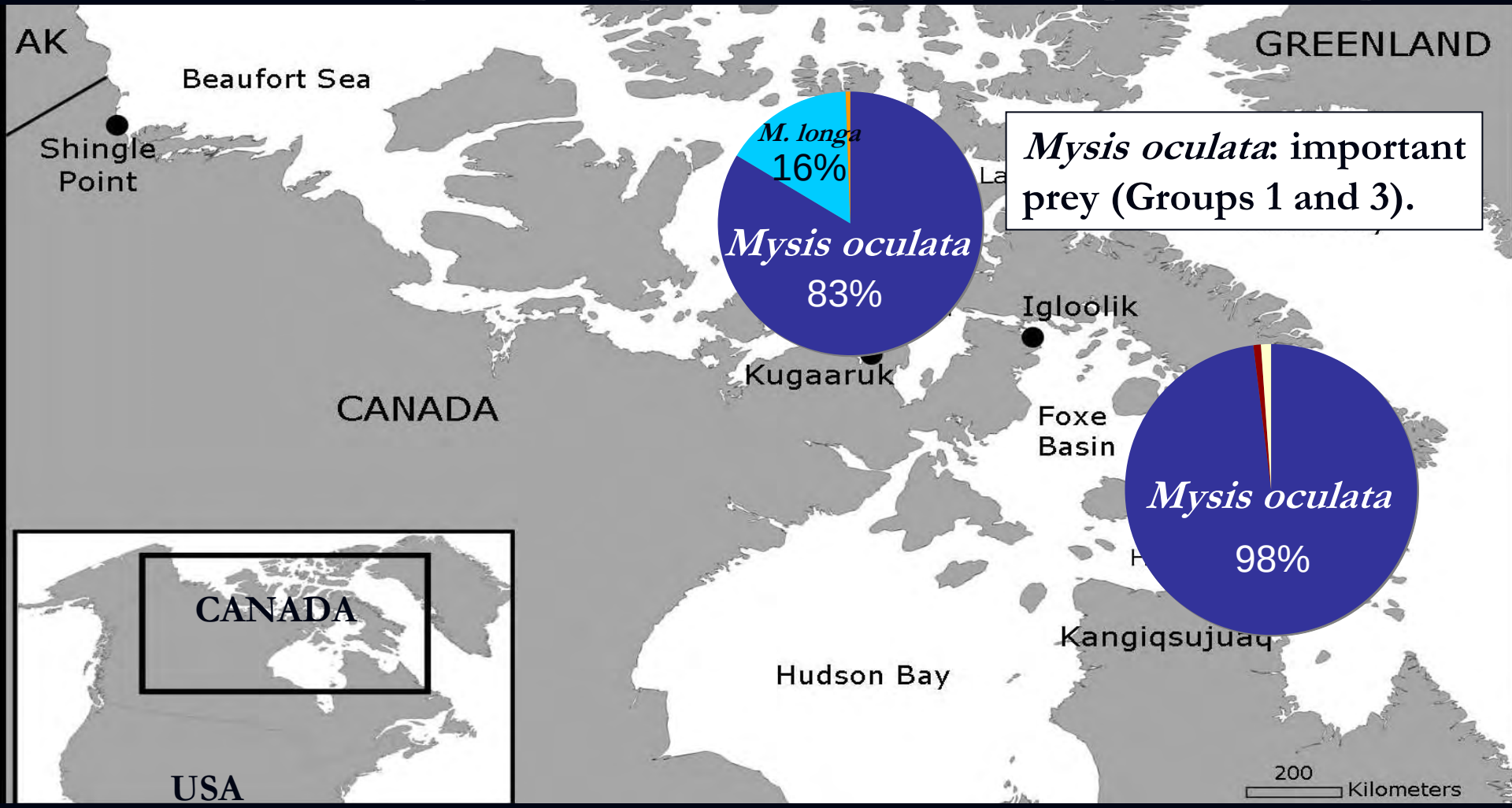

**Euphausid, Chaetognath, *Paraeuchaeta* sp., *Mysis oculata* are the most important prey items**

# RESULTS
# Stomach contents

All four whales had food in their stomachs.

*Mysis oculata* dominated two whale samples (Kugaaruk & Kangiqsujuaq).

Also found: *Onisimus* sp., *Themisto* sp., *Calanus* sp., benthic isopods and decapods




Pomerleau et al. (2010)

# CONCLUSION

1) Specialization within bowhead whales.

2) For a given group, targeted prey are the same regardless of the region exploited.

3) Davis Strait appears not to represent an important feeding ground for bowhead whales in late spring or early summer.

4) Lancaster Sound, Baffin Bay and Gulf of Boothia are all regions where bowhead whales may feed during summer.