



Fisheries and Oceans
Canada

Pêches et Océans
Canada

Beaufort Regional Environmental Assessment

Marine Fishing Program:

Integrated Knowledge of Canadian Beaufort Sea Fishes & Their Ecosystems

DFO & Universities of Laval, Manitoba, Quebec (Rimouski) & Waterloo
BREA Workshop Inuvik February 2013



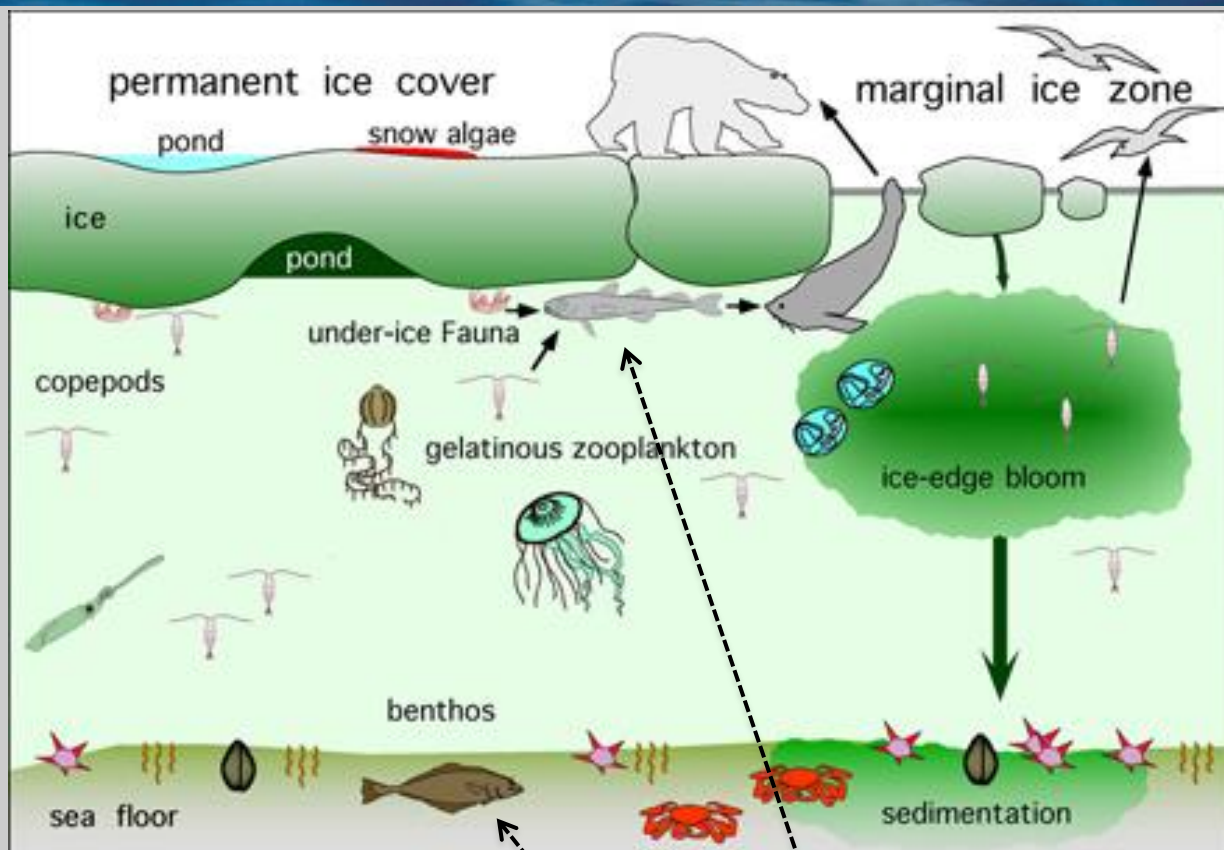
BREA Marine Fishes Project Objectives

- 1) Field survey of offshore area to 1000m+ depths to establish:**
 - a) fish occurrence and community diversity,**
 - b) habitat associations, and**
 - c) couplings (e.g., foodweb/trophic, energy pathways) within and among offshore (~50-1000m) habitats**
- 2) Establish the functional relationships within/among offshore and slope, shelf and coastal, benthic and pelagic sub-ecosystems**
- 3) Summarize existing knowledge of fish occurrences and habitat associations geo-spatially**
- 4) Link offshore research findings with past & ongoing research in the estuary, coastal and the shelf areas in Canadian & US waters [coastal research ongoing as separate project]**
- 5) Establish regional contexts for future monitoring & assessments (e.g., hydrocarbon metabolites, PAH, Hg, species diversity, habitat usage)**

First-ever systematic fish and ecosystem sampling deeper from ~150 to 1000m.



Canadian Beaufort Sea Marine Fishes: roles in the ecosystem



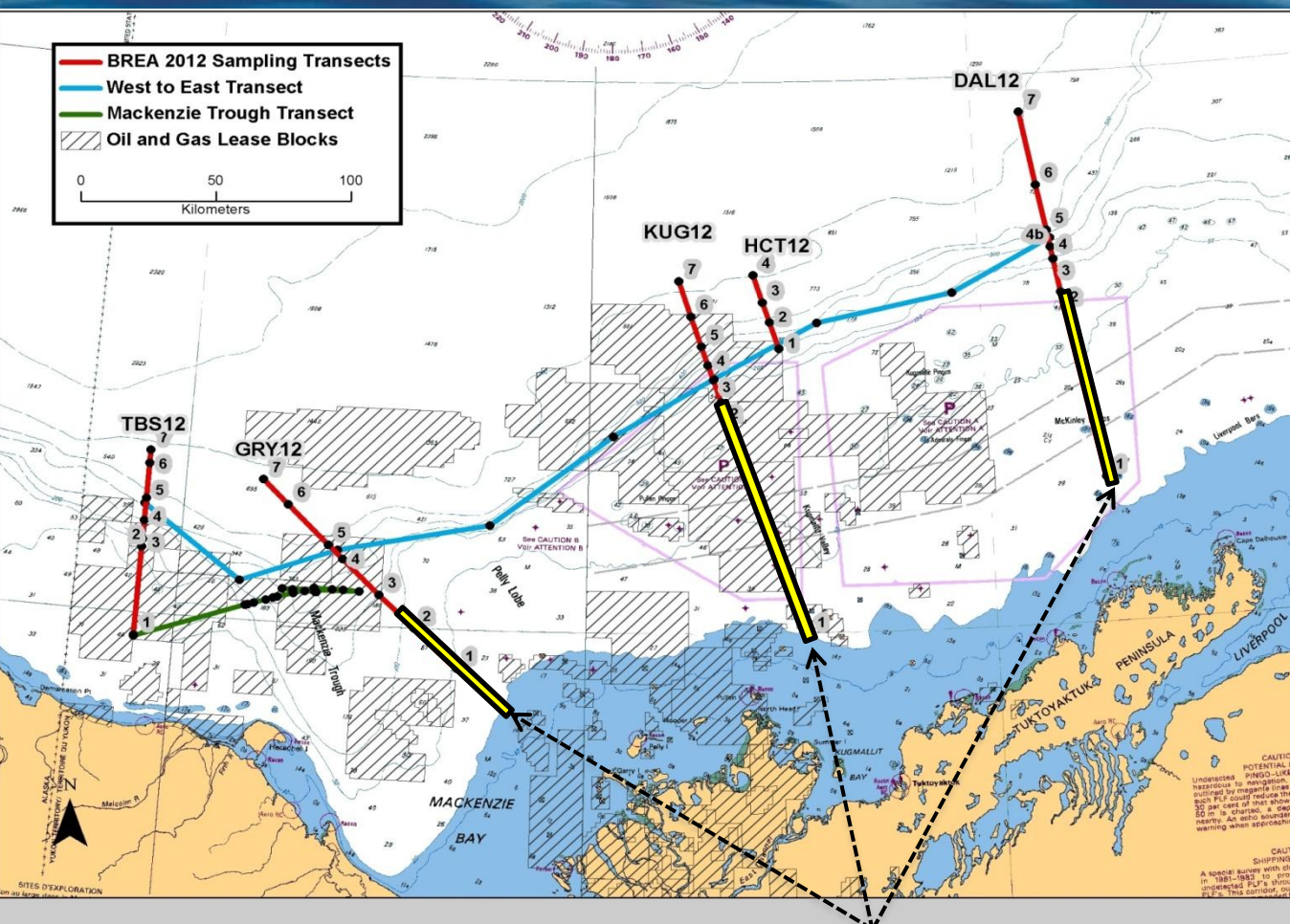
For marine fishes **GOAL** is to understand their:

- **Ecosystem Structure**
 - habitats present in water column & bottom
- **Species Composition**
 - diversity
 - relative abundance
 - biology
- **Habitat Associations**
 - which fish occur where
- **Pathways (energy)**
 - food webs
- **Linkages** between marine & coastal fishes, & to marine mammals

- fishes in water column (pelagic) habitats
- fishes in bottom habitats (benthos)
- coastal, shelf, slope and deeper areas (to 1000m depths)



2012 Field Sampling Aboard F/V Frosti



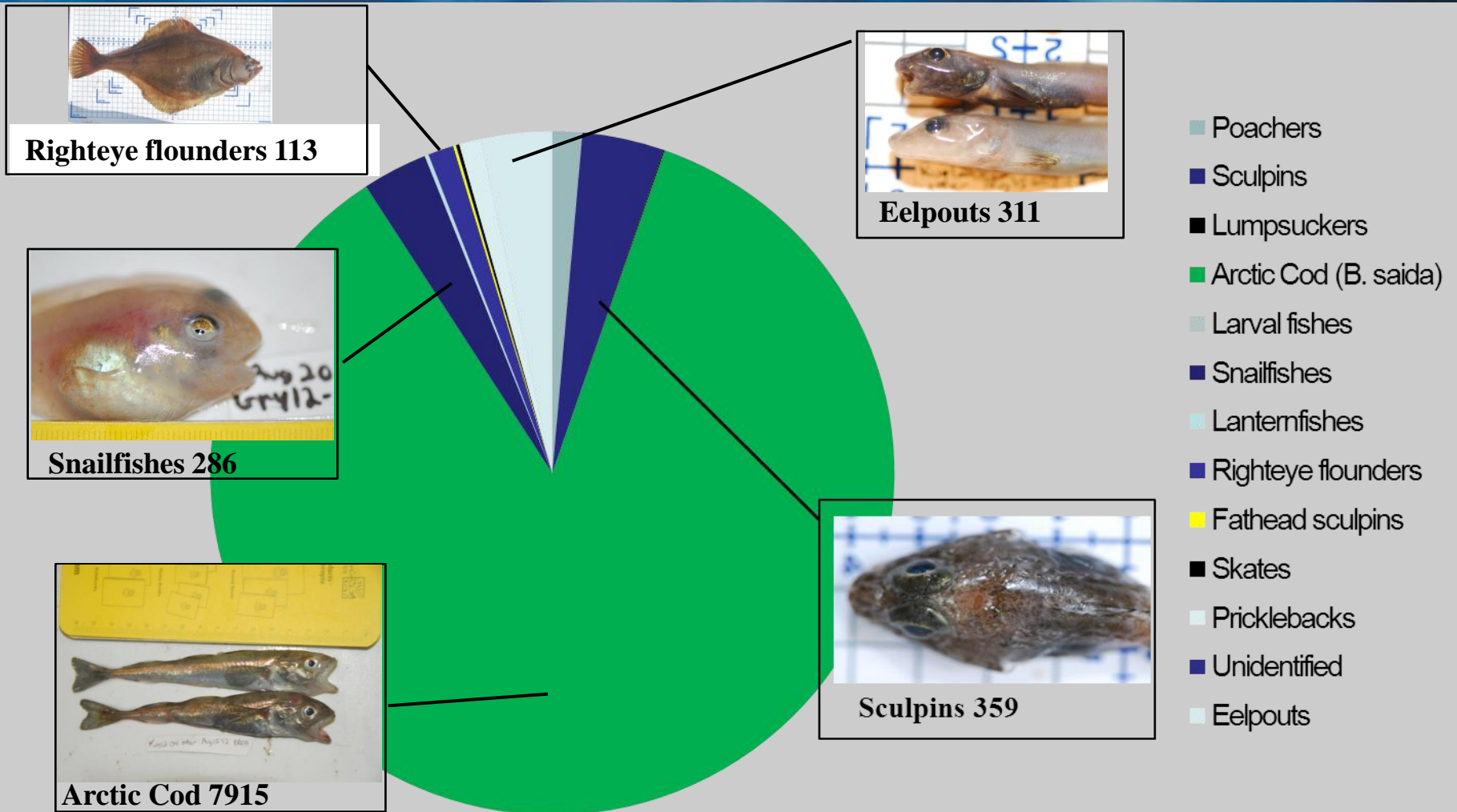
**Four main transects:
DAL12, KUG12, GRY12
and TBS12:**

- Stations along each transect at 20-40, 75, 200, 350, 500, 750, & 1000 m depths (n=28).
- Work at each station: oceanography, productivity, plankton, sediment, bottom animals & bottom fishes.
- Hydroacoustics & mid-water trawling on each main transect.
- Hydroacoustics across fish concentrations at 150-400m (blue line).

Nearshore ends of Dal12, Kug12 and Gry12 were transects sampled during Northern Coastal Marine Systems program by DFO with the *CCGS Nahidik* (2006-2009) (yellow bar).



Fishes Captured: 9258 individuals from 11 families





Some larger bottom species



Greenland Halibut



Snow Crab & Basket Starfish



Bering Flounder (new record?)



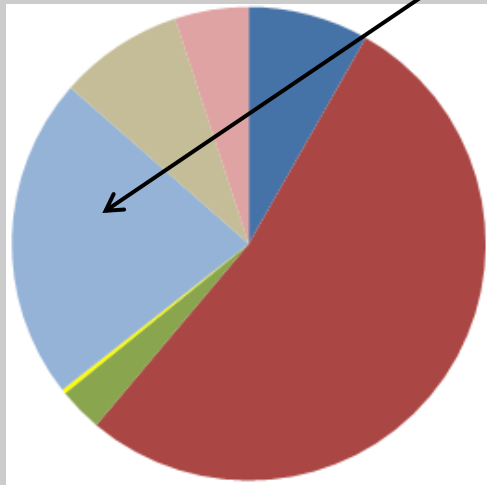
Snow Crab



Benthic Fish Diversity by Habitat

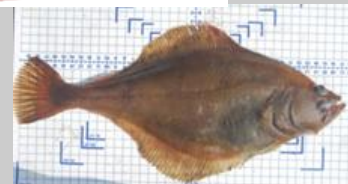
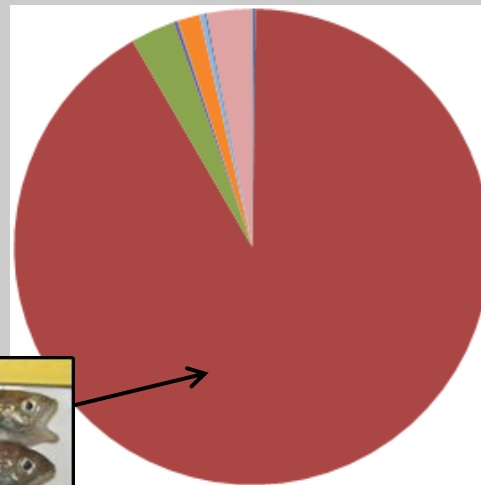
Shelf

20m - 200m



Slope

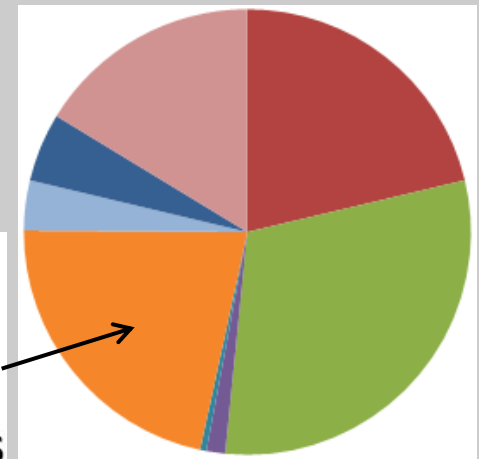
200m - 500m



Righteye Flounders

Off Slope

500m - 1000m



- Diversity of families (7,5,8) more or less even across three major zones
- Arctic cod dominate on shelf and slope
- Species composition differs: sculpins on shelf; flounders deeper
- First capture for some species in the Canadian Beaufort Sea



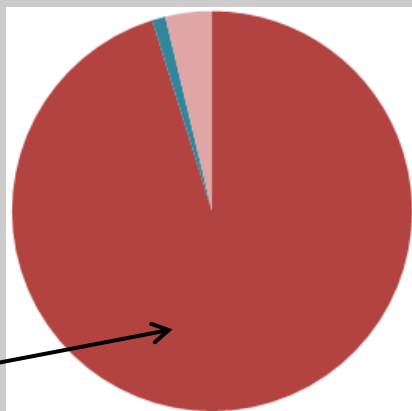


Pelagic Fish Diversity by Habitat

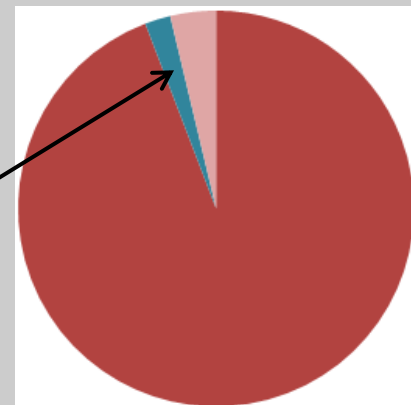
Mixed water mass
surface - <200m



Sharp Halocline
~200m - ~300m



Atlantic water mass
>300m to 1000m



- Diversity lower in pelagic than in benthic habitats (3 vs 11 families)
- Upper water column (approx. 0-60m depth) is an important habitat for larval fishes, e.g. Arctic cod, Snailfish
- First capture for some pelagic species in the Canadian Beaufort

■ Cod (B. Saida)
■ Lanternfish
■ Snailfish



Species Newly Recorded from the Area

BREA 2012 (6-9 new species, possibly others)

- Rockling (Lotidae), *Gaidropsaurus* sp? →
- Threadfin Seasnail (Liparidae), *Rhodichthyes regina* →
- Glacier Lanternfish (Myctophidae), →
- Bering Flounder (Pleuronectidae), →
- Arrowtooth Flounder (Pleuronectidae), →
- Unidentified 'Fathead Sculpin' (Psychrolutidae) →
- Zoarcidae – 3 species new to the area sampled in Nahidik shelf work (also captured in BREA)
- Several skates – possibly first records →

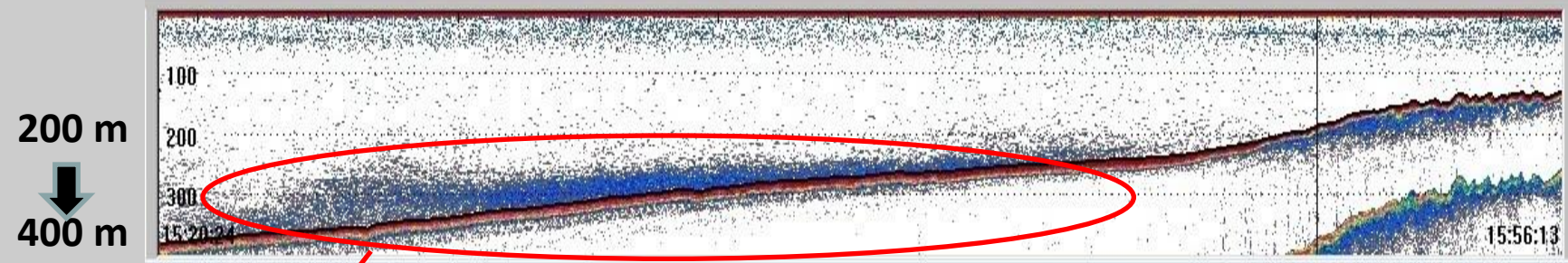


Upper two photos: internet; bottom ones BREA



Hydroacoustics – Midwater Trawl Sampling

- Detect pelagic organisms and document their assemblage and biomass within surface and bottom aggregations, with particular focus on Arctic Cod
- “Truth” targets identified on acoustic echogram with midwater fishing nets
- Work linked with Laval University (ArcticNet program – Geoffroy & Fortier)



- A near-bottom aggregation of Arctic Cod present between ~200 – 400m spanning the shelf slope along the entire southern Canadian Beaufort Shelf.
- Likely ecologically and biologically significant -- ‘Atlantic’ water masses intersect the slope, upwellings from deeper areas, and intermixing with surface ‘Mackenzie, Pacific & ice melt’ waters occur.
- Marine conditions & food ideal for Arctic Cod.



Preliminary conclusions

Knowledge pre-2012

- ~70 fish species – 20 sea-run spp, 50 marine (spot occurrences from literature), mostly shelf focused
- Relatively few pelagic marine species (assumed)
- Relatively more benthic marine species (assumed)
- Offshore fish habitat use unknown
- Arctic cod pivotal but uncertain biomass & habitat associations

New Knowledge

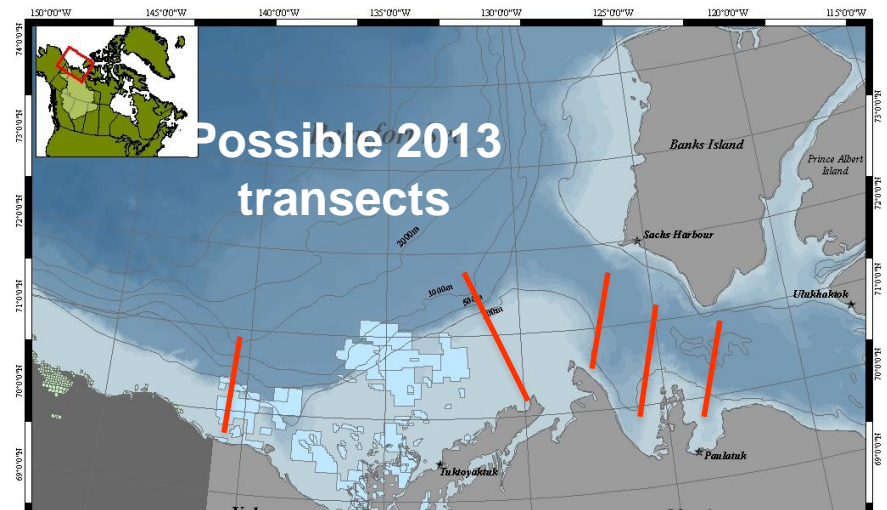
- Additional 6-9 marine species present (survey distribution knowledge)
- Habitat linkages established
- Confirmed low pelagic diversity
- Confirmed high benthic diversity
- Shelf, slope & offshore fish communities composition differs
- Cod found throughout, but highly associated with the complex slope habitat; high biomass confirmed



Where to next on fishes and other biota?

Completion 2012 Work

- Sample Processing (fish id's confirmed, biology, tissues, complete diversity analyses)
- Lab Analyses (fatty acids, energy, Hg, PAHs, water chemistry & physical oceanography)
- Linkages to past coastal & nearshore studies (data analysis)
- Linkages to coastal components (sample & data analyses)
- Collaborations (stable isotopes – U Waterloo, benthic invertebrates – U Quebec at Rimouski, genetics & energetics – U Manitoba; and Hydroacoustics Data Analysis – U Laval)



Future Work

- Planning 2013 BREA field program
 - 4-5 transects – eastern Beaufort Sea
 - Banks Island
 - Transboundary
- Linkages to Alaskan work
- Integration of relevant data into geospatial planning tools



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BREA Frosti Offshore Fishes Field Crew 2012



Back – Left to Right:

Wojciech Walkusz

Andy Majewski

Lorena Edenfield

Guillaume Meisterhans

Laure de Montety

Front – Left to Right:

Sheila Atchison

Shannon MacPhee

Charlie Reuben

Jane Eert

**(Present in Spirit: Jim
Reist & Rob Young)**

THANKS and...stay tuned.

Canada



Project Participants

DFO Participants (* = field work 2012):

- Program Management: Dr. Jim Reist, Dr. Rob Young
- Fishes: Dr. Jim Reist, Andy Majewski*, Sheila Atchison*, Charlie Ruben (deceased)*
- Benthos: Shannon MacPhee*
- Zooplankton: Dr. Wojciech Walkusz*
- Lower Trophics: Dr. Christine Michel, Guillaume Meisterhans*, Anke Reppchen
- Contaminants: Dr. Gary Stern, Dr. Gregg Tomy, Bruno Rosenberg, Joanne Delaronde, Allison MacHutchon
- Oceanography: Dr. Jane Eert*, Dr. Bill Williams
- Hydroacoustics: Dr. Svein Vagle, Stephane Gauthier, George Cronkite

• Collaborations:

- U Waterloo (Dr. M. Power, Dr. H. Swanson, one new PhD student)
- U Manitoba (Dr. M. Docker, Dr. J. Treberg, Dr. G. Anderson, Brittany Lynn (MSc) + one new MSc student)
- U Laval (M. Geoffroy (PhD), Dr. L. Fortier)
- UQAR (Dr. P. Archambault, L. de Montety*)
- U Alaska Fairbanks (Dr. B. Norcross, L. Edenfield*) & US Dept Interior – Bureau of Ocean Energy Management (K. Wedemeyer)

- Linkages to DFO Coastal work ^ = field work): Dr. Lisa Loseto^, Jim Johnson^, Tracey Loewen^ - PhD, Emily Choy^PhD + one new MSc student & Inuvialuit from each of the six communities.



BREA Marine Fishes Project – Supplemental Slides

- Additional fish collection slides
- Oceanography
- Primary production
- Pelagic plankton (secondary production)
- Benthos (secondary production)



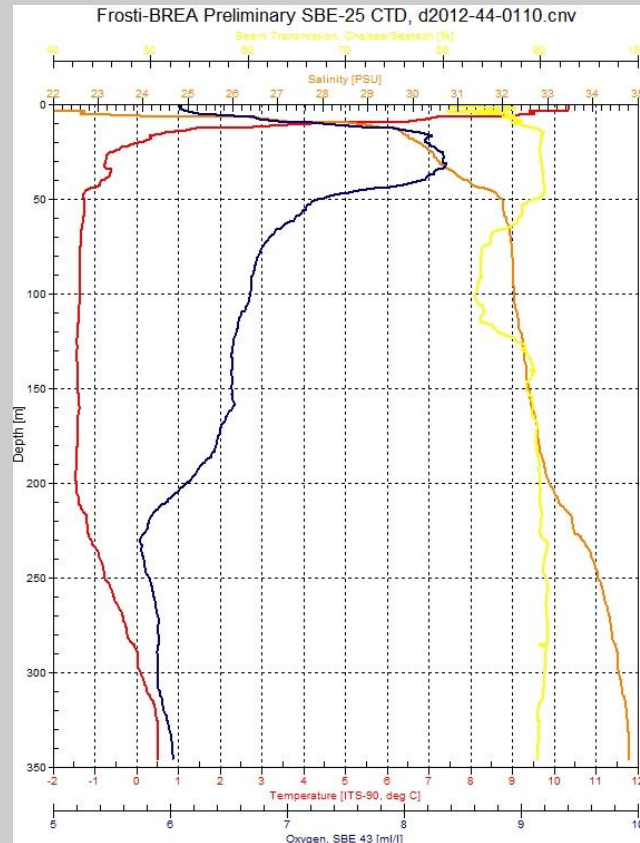
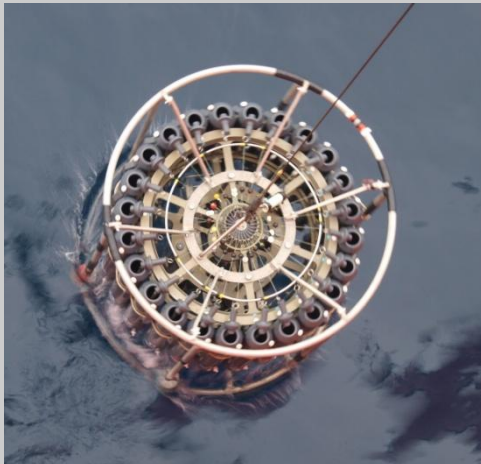


Fish Habitats: Oceanography

Temperature, salinity and chemistry of water both spatially and by depth define water masses – these are likely habitats for distinct groups of fishes.

CTD/Rosette

- electronic measurements (salinity, temperature, oxygen) of water mass characteristics by depth
- 24 separate 10L water samples for productivity measures



**Typical water properties
measured by CTD**



**Underway CTD –
records temperature
and salinity, surface
to bottom while vessel
is moving**



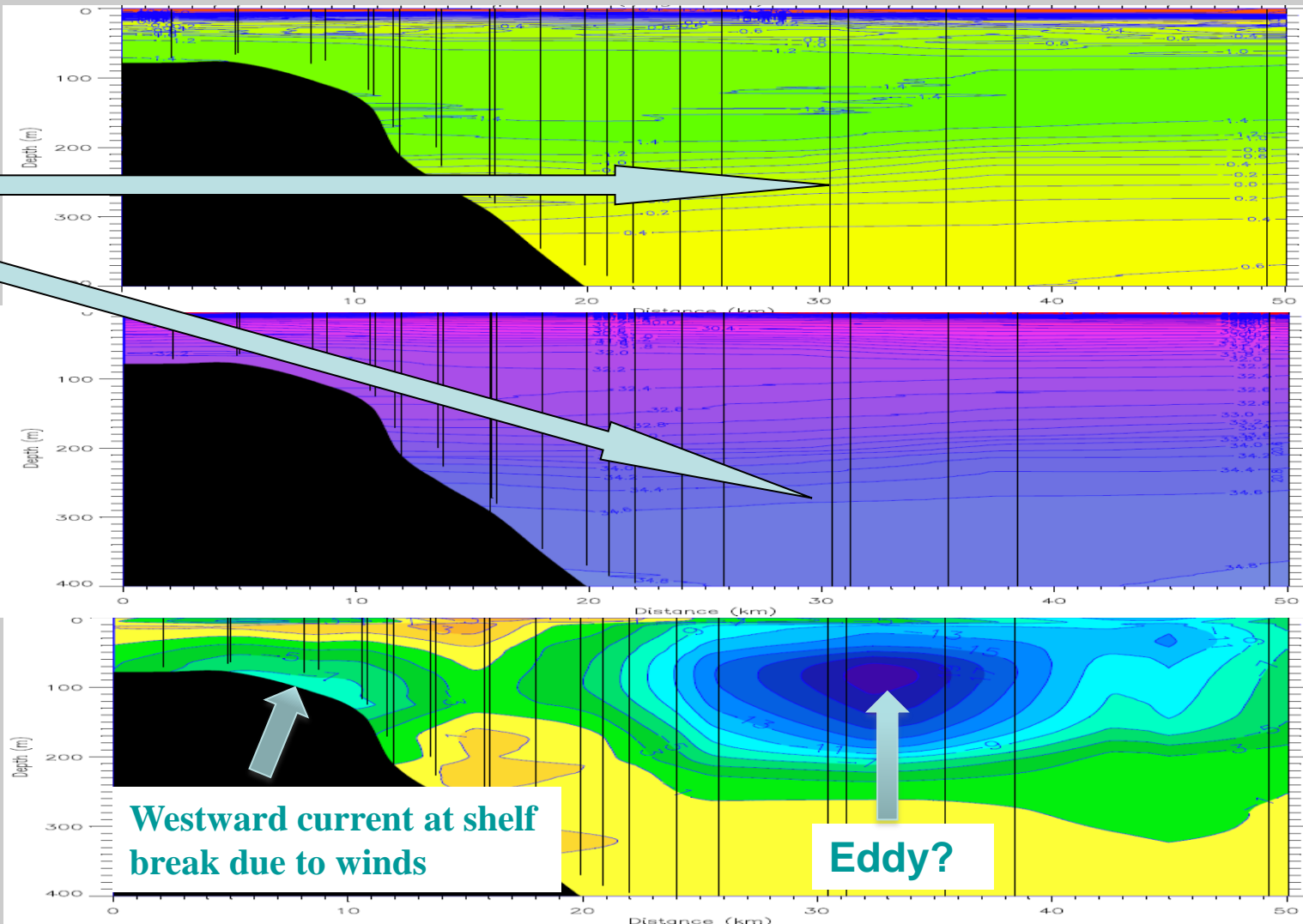
Fish Habitats: Oceanography

**Temperature:
Kug-12 transect**

**Warm, salty
water (Atlantic)
below 250m**

**Salinity: Kug-12
transect**

**Currents: Kug-12
transect (yellow is
coming toward
you, blue away)**



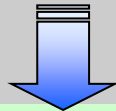


Fish Habitats: Productivity Measurements

Water samples from different depths from the CTD Rosette Analyzed

Essential Physical, chemical and biological measurements

- Nutrients profile ($\text{NO}_3 + \text{NO}_2$, PO_4 , SiOH_4)
- ^{18}O profile
- Size-fractionated chlorophyll *a* (chl *a*): total & > 5 μm
- Particulate organic carbon and nitrogen
- Stable isotopes & fatty acids at depth of chl *a* max
- Abundance of prokaryotes & eukaryotes
- Phytoplankton abundance & composition (chl *a* max)



- **Distribution & composition of lower trophic organisms including primary producers, in relation to environmental parameters – how productive is the Beaufort Sea and where is productivity concentrated?**
- **Also aids in identification of water column habitats and habitat preferences for fish usage.**

Rosette samples

- 28 Stations (4 transects)
- Up to 19 depths
- Who? G. Meisterhans (postdoct) A. Reppchen (Biologist DFO), C. Michel (PI, DFO)

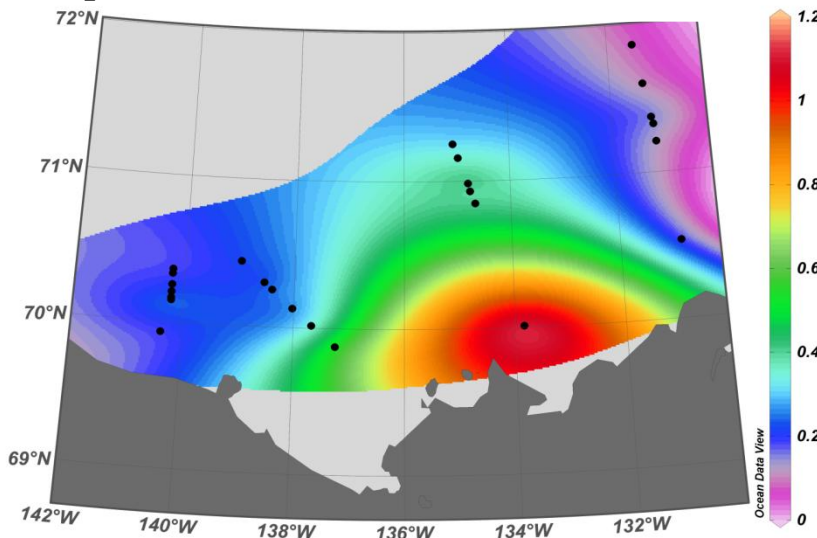




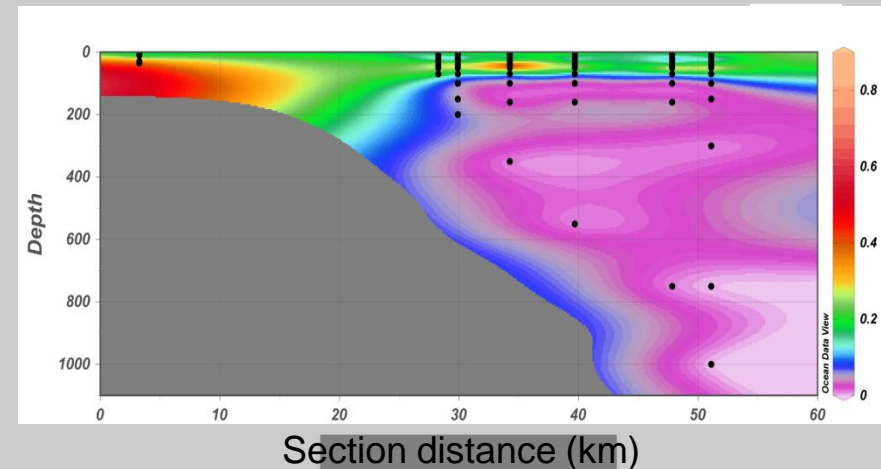
BREA Summer 2012 - Fish Habitat & Ecosystem Linkages

Preliminary results - Chl *a* distribution

Spatial Variation – Canadian Beaufort Sea



Variation by Depth - GRY Transect Line 2



- Geo-referenced maps for regional distribution of biological, chemical & physical conditions that determine fish habitat
- Critical ecosystem components, key habitats and potential sensitivities to O&G activities
- Data to support Ecosim-Ecopath model and constrain predictive models
- Key measureable parameters that can serve as indicators for monitoring & assessment of impacts and changes to the Beaufort Sea over time



Fish Habitats: zooplankton (food) and fish larvae sampling

Small-mesh nets towed in water column (pelagic zone) to capture small organisms



**MultiPlankton
sampler**



Bongo Net



**320 fish larvae collected
(1/3 Arctic cod)**



**200 zooplankton samples
collected
(mainly Copepods,
Euphausiids & Amphipods –
left to right)**



Fish Habitats: zooplankton (food) and fish larvae sampling



- All zooplankton samples to be analysed taxonomically to show spatial and vertical distribution, diversity patterns and data on food available for predators (e.g. fish, whales).
- Fish larvae to be analyzed for spatial associations.



21 individual taxa selected for creating baselines and providing ecosystem overview :

- Hg (mercury) content
- PAHs (oil/gas derivatives)
- stable isotopes (trophic interactions)
- fatty acids (trophic interactions)
- genetics (populations drift)
- energetics (energy flow)



Benthos – Epifauna (large organisms on the bottom) sample analyses

Onboard:

Sieved and sorted samples on 2 mm screen

Identification of organisms:

snowcrabs, basket stars, shrimps

Identified organisms frozen for analysis:

SI, FA, Contaminants

Unidentified specimens kept for identification



@Shannon A. MacPhee

UQAR-ISMER benthic ecology laboratory:

Epibenthic community characteristics analysis

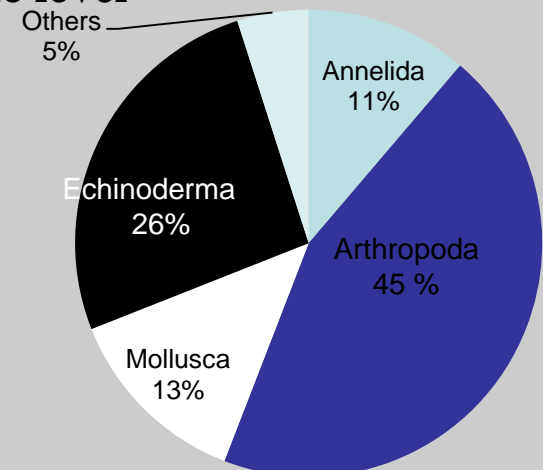
- Identification to the lowest taxonomic level
- Density
- Biomass

Preliminary results:

450 taxa

15 phyla present but 4 dominate

(arthropods, echinoderms, molluscs, annelids)



@Laure de Montety



Beaufort Sea Sediments & Infauna (organisms in the sediment) : sample collection

Sediments were collected with a benthic box corer lowered to bottom



Sediment characterization parameters and contaminants were sub-sampled from 1/2 core

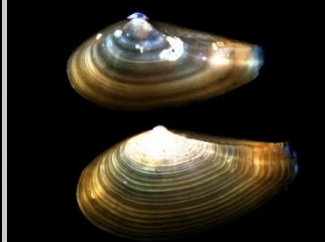


Infauna sieved from 1/2 core (mostly worm, clams & snails)





Analysis of Benthic Infauna



All Photos by Laure de Montety



Infauna Community Structure

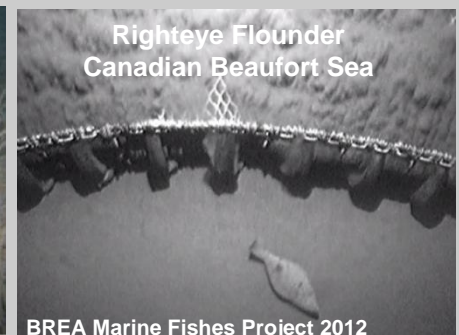


The greatest number of marine fish species in the Beaufort Sea live on or above the seafloor



Polychaete Field,
Alaska

www.afsc.noaa.gov



Righteye Flounder
Canadian Beaufort Sea

BREA Marine Fishes Project 2012

Bottom Habitat Characterization



www.fishersci.com



www.beckmancoulter.com

Particle size distribution

% Organic matter

This work describes fish benthic habitats:

- bottom composition
- linkages between animals living in the water column and on the seafloor versus those within the sediments



Collection of Large-bodied Invertebrates (with fish):

Beam trawl
3 m width \times 2-3 m height,
cod end of $\frac{1}{4}$ inches inner
mesh size



Western Otter trawl
width of doors and height recorded
for each tow,
cod end of $\frac{1}{2}$ inches inner mesh size

