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.
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)
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

- Righteye flounders 113
- Eelpouts 311
- Snailfishes 286
- Arctic Cod 7915
- Sculpins 359
Some larger bottom species

Greenland Halibut

Snow Crab & Basket Starfish

Bering Flounder (new record?)

Snow Crab
Benthic Fish Diversity by Habitat

- 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

Shelf
20m - 200m

Slope
200m - 500m

Off Slope
500m - 1000m

Sculpins

Arctic Cod (B. saida)

Righteye Flounders
Pelagic Fish Diversity by Habitat

- 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

**Mixed water mass**
- surface - <200m

**Snailfish**

**Sharp Halocline**
- ~200m - ~300m

**Arctic Cod (B. saida)**

**Lanternfish**

**Atlantic water mass**
- >300m to 1000m
### Species Newly Recorded from the Area

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

- **Rockling** (Lotidae), *Gaidropsaurus* sp?
- **Threadfin Seasnail** (Liparidae), *Rhodicthyes regina*
- **Glacier Lanternfish** (Myctophidae), *Benthosoma glaciale*
- **Bering Flounder** (Pleuronectidae), *Hippoglossoides robustus*
- **Arrowtooth Flounder** (Pleuronectidae), *Atheresthes stomias*
- **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
- 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
THANKS and...stay tuned.
## 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.
• 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

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)

Westward current at shelf break due to winds

Eddy?
Fish Habitats: Productivity Measurements

Water samples from different depths from the CTD Rosette Analyzed

Essential Physical, chemical and biological measurements

- Nutrients profile (NO$_3$ +NO$_2$, PO$_4$, SiOH$_4$)
- 18O profile
- Size-fractionated chlorophyll $a$ (chl $a$): total & > 5 um
- 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)
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

320 fish larvae collected (1/3 Arctic cod)

200 zooplankton samples collected (mainly Copepods, Euphausids & 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 derivates)
- stable isotopes (trophic interactions)
- fatty acids (trophic interactions)
- genetics (populations drift)
- energetics (energy flow)
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

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

Sediments were collected with a benthic box corer lowered to bottom

Infauna sieved from ½ core (mostly worm, clams & snails)

Sediment characterization parameters and contaminants were sub-sampled from ½ core
The greatest number of marine fish species in the Beaufort Sea live on or above the seafloor.

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

Infauna Community Structure

Bottom Habitat Characterization

Particle size distribution

% Organic matter
Beam trawl
3 m width × 2-3 m height, cod end of ¼ inches inner mesh size

Western Otter trawl
width of doors and height recorded for each tow, cod end of ½ inches inner mesh size

Collection of Large-bodied Invertebrates (with fish):