Preliminary Results from a Hudson Bay Ecosystem Model
Estimating mid trophic levels

Session T24B
Hudson Bay: New Findings and Direction for Future Study
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My Background

• Thesis: “Effects of Climate Change on Top Predators in Polar Ecosystems”
• Case Studies: Hudson Bay and Antarctic Peninsula
• Model start to 1970’s values (Initial parameters)
  – Linking data from other researchers in Hudson Bay
• Dynamic model runs from 1970’s to present
  – Catch trends
  – Abundance trends
• Forecasting under various climate change scenarios
This Project

• Estimate biomass for unknown species
• Use of Ecopath with Ecosim modelling program
  – Based on trophic interactions (food web)
  – How much prey is needed to support top predators
  – Ecopath: Initial snapshot of ecosystem
    (1 year average)
“As we know,
There are known knowns.
There are things we know we know.
We also know
There are known unknowns.
That is to say
We know there are some things
We do not know.
But there are also unknown unknowns,
The ones we don't know
We don't know”
Known Knowns
(Things we know fairly well)
- Mammal species
- Marine Mammal #
- Marine Mammal Diet
- Primary Production
- Marine Mammal Catches

Known Unknowns
(Things we know we don’t know)
- Fish species (relative proportions)
- Fish #’s
- Fish Diets
- Zooplankton #’s
- Zooplankton Diet

How can we use models to learn about the unknowns?
Mass balance: cutting the pie

Source: Villy Christensen
Parameters Needed

For Each Functional Group: (yearly average)

- Biomass $B$
- Production/Biomass (Total Mortality) $P/B$
- Consumption/Biomass $Q/B$
- Diet Composition $DC$
- Catches (if needed)
- Catch/ biomass trends over time
Ecopath with Ecosim

Main Equations

Production = predation + fishery + biomass accumulation + net migration + other mortality
Consumption = production + unassimilated food + respiration

For each functional group (species group)
1). B, P/B, Q/B, Diet Composition, ...
2). B, P/B, Q/B, Diet Composition, ...
3). B, P/B, Q/B, Diet Composition, ...

-Need 3 of 4 parameters for each functional group to solve linear equations simultaneously

(Walters and Christensen)
Hudson Bay Model: 39 functional groups

15 marine mammals groups
10 fish groups
6 zooplankton groups
5 benthos groups
Seabirds
Cephalopods
Primary Production
Detritus
Hudson Bay Food Web
## Data Sources

### Marine Mammals
- Biomass from surveys (Dept of Fisheries and Oceans)
- Production based on life history and survival (Barlow & Boveng 1991)
- Consumption based on energetics and prey species (Hunt et al. 2000)

### Zooplankton
- Estimate biomass based on composition and total biomass (Harvey et al. 2001)

### Phytoplankton
- Production from other model projections
  - NOAA Geophysical Fluid Dynamics Laboratory (GFDL)

### Fish
- Using production and consumption parameters from same species elsewhere
“Pedigree” of data

(B) High precision sampling
(P,Q) Same species in same system
(B) Low precision sampling
(P,Q) Same species in similar system
(P,Q) Similar species in same system
(P,Q) Similar species in similar system
(B) Approximate
(P,Q) Empirical relationship

Value from another model
Guesstimate: expert guess
Estimated by Ecopath: missing parameter

MC routines: CV proportional to data quality
Estimating Biomass: Plankton

Zooplankton Biomass Estimates

Biomass (Tons/km²)

- Mesozooplankton
- Euphausids
- Copepods
- Crustaceans
- Other Mesozooplankton
- Microzooplankton
- Meso-Worms
- Echinoderms
- Polychaetes
- Other Benthos
Estimating Biomass: Fish
Interpreting Results
Minimum Biomass Required t/km2 (or g/m2)

• Fish (all species)
  – Hudson Bay: 2.4
  – Ionian Sea 6.43
  – Antarctic Peninsula 4.32

• Zooplankton (all species)
  – Hudson Bay 32
  – Ionian Sea 4
  – Antarctic Peninsula 48
  – Newfoundland 68

• Benthos (all species)
  – Hudson Bay 35
  – Ionian Sea 28
  – Antarctic Peninsula 60

Ionian Model (Piroddi 2008) Newfoundland Model (Heymans 2003)
Lessons Learned

• Parameters of mid-trophic level species
  – biomass
• Pedigree analysis: where data for the region are limited
• Better data needed
  – Phytoplankton
  – Zooplankton
  – Fish
  – Benthos
Future Focus

Personal Research

• Currently fitting model to data for last 30 years
• Incorporating catch and abundance trends
• Linking model to climate change scenarios
• Primary production to temperature

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