Research Requirements of an Ecosystem Approach to Fisheries

A Scotian Shelf Case Study

Mike Sinclair, Bob O'Boyle & Tana Worcester
Bedford Institute of Oceanography
Canada
Outline

- EAF - related issues specific to Eastern Scotian Shelf
  - Will not discuss industry - industry issues
    - E.g. fisheries & petroleum conflicts

- Research priorities for EAF in this area for next 3 - 5 years

- Broader research implications of regional experience
Eastern Scotian Shelf

Atlantic Canadian 'lab' since 1998
Approach

- **Types of Issues**
  - Impact of fishery on ecosystem
  - Impact of ecosystem on fishery
  - Multispecies management (manipulation of ecosystem)

- **Sources of Issues**
  - ESSIM Management Plan
  - Ecosystem Status Report for ESSIM Area
  - Paper prepared for SCOR 2004 Paris Symposium
  - Scotia-Fundy Fishing Industry Roundtable

- **Classified issues using Canada's nationally established conservation objectives**
  - Biodiversity
  - Productivity
  - Habitat

Challenge of interpreting causality & cumulative effects
DFO Conservation Objectives

Traditional Fisheries Management

Intent is for Fisheries Management to address all objectives
Approach (cont'd)

- For each objective, management question posed & associated research identified

- Assessed probability that research can resolve issue in 3 - 5 years
  - Is it tractable?

- Judged scope of research effort (who can do?)
  - Institute (BIO & St. Andrew's Biological Station)
  - Atlantic Coast (Newfoundland Shelf to Gulf of Maine)
  - Global (International collaboration)
# Identification of Issues & 'Ecosystem Components' in ESSIM Area

<table>
<thead>
<tr>
<th>National Conservation Objective</th>
<th>Fisheries</th>
<th>Oil &amp; Gas</th>
<th>Transport</th>
<th>Military</th>
<th>Other Stakeholders (NGOs &amp; Public)</th>
<th>Specific Ecosystem Components on ESS related to the Issues</th>
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</thead>
<tbody>
<tr>
<td>Maintain communities</td>
<td>Modification of Bottom habitat</td>
<td>Effects on Benthic Biota</td>
<td>Impact of Explosives on Bottom Diversity</td>
<td>Protection of Fragile Benthic Communities i.e. Coral and in Gully</td>
<td>Diversity of the benthic community, the coral community and the high diversity benthic community in the Gully</td>
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<tr>
<td>Maintain populations</td>
<td>Maintenance of Population Richness within Management units</td>
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<td>Genetic Diversity of populations under Human Pressure</td>
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<tr>
<td>Maintain primary production</td>
<td></td>
<td>Impact of Produced Water Discharges on Primary Productivity</td>
<td>Impact of pollution on Primary Productivity</td>
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<td>Productivity of Base of Food Chain</td>
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<tr>
<td>Maintain trophic structure</td>
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<td>Productivity of Each Trophic Level (incl. Forage species) and Energy Transfer along Food Chain</td>
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<tr>
<td>Maintain mean generation times of populations</td>
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<td>Drilling Waste and Noise (seismic &amp; acoustic) Effects on fish larvae, fish and shellfish</td>
<td>Impact of oily discharges on Seabirds</td>
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<td>Harvesting of Krill</td>
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<td>Conserve ecosystem’s physical features - critical bottom scope</td>
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<tr>
<td>Conserve ecosystem’s physical features - water column properties</td>
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<td>Sediment Quality</td>
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<tr>
<td>Conserve ecosystem’s chemical features - water quality</td>
<td>Fishing Noise Impacts on Ecosystem</td>
<td>Seismic Impacts on Ecosystem</td>
<td>Shipping Noise Impacts on Ecosystem</td>
<td>Military Noise Impacts on Ecosystem</td>
<td>Overall Sound Environment</td>
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<tr>
<td>Conserve ecosystem’s chemical features - biota quality</td>
<td>Ship-source Pollution</td>
<td>Produced Water Discharge, Contaminant Biodegradation &amp; Biotransformation</td>
<td>Oil Pollution</td>
<td>Ship-Source Pollution</td>
<td>Overall Chemical Environment</td>
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<td>Conserve ecosystem’s chemical features - biota quality</td>
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<td>Physiological Processes of Biota</td>
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Management Needs
Georges Bank Fisheries

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<tr>
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<th>GF</th>
<th>HF</th>
<th>SF</th>
<th>L/CF</th>
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<tr>
<td><strong>Productivity</strong></td>
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<tr>
<td><strong>Primary</strong></td>
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<td>Limit alteration of <em>essential nutrient concentrations</em> affecting primary production</td>
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<td><strong>Community</strong></td>
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<tr>
<td>Limit <em>trophic level catch biomass</em> with respect to trophic demands of higher levels</td>
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<tr>
<td>Limit <em>total catch biomass</em> within system production capacity</td>
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<td><strong>Population</strong></td>
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<tr>
<td>Keep <em>fishing mortality</em> moderate</td>
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<td>Permit sufficient <em>spawning biomass</em> to evade exploitation</td>
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<td>Promote positive <em>biomass change</em> when biomass is low</td>
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<td>Manage % <em>size/age/sex</em> of capture</td>
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<td>Prevent disturbing <em>activity in spawning areas/seasons</em></td>
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<td>Manage <em>discarded catch</em></td>
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<tr>
<td><strong>Biodiversity</strong></td>
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<td><em>Biotope/seascape</em></td>
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<tr>
<td>Limit % <em>area disturbed</em> of seascape/biotope types</td>
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<td><em>Species</em></td>
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<td>Limit incidental <em>bycatch or mortality</em></td>
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<td>Minimize <em>change in distribution</em> of invasive species</td>
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<tr>
<td><em>Population</em></td>
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<tr>
<td>Distribute population <em>component catch as a % of component biomass</em></td>
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<tr>
<td><strong>Habitat</strong></td>
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<tr>
<td><em>Bottom</em></td>
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<tr>
<td>Limit % <em>area disturbed</em> of habitat types</td>
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<td><em>Water Column</em></td>
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<tr>
<td>Limit <em>amounts of contaminants, toxins and waste</em> introduced in habitat</td>
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<td>Minimize <em>amount of lost of gear</em></td>
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<td>Control <em>noise level/frequency</em> with respect to species of risk</td>
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Biodiversity Issues

- Can fisheries management & industry respond to large scale ecosystem community changes?

- What can be done to recover species at risk?

- How should species-at-risk be monitored?

- Do present management practices allow accurate discard & by-catch estimates?

- Should fisheries management be concerned about population substructure?
Can fisheries management & industry respond to large scale ecosystem community changes?

- Investigate biogeographic characteristics of fish/invertebrate communities & how these respond to circulation/mixing
  - Revisit 1990s East Coast of North America Strategic Assessment Project (ECNASAP)
Species Scale Distributions

Identified transitions in bottom communities consistent with circulation & mixing patterns

Movement in transition zones in response to North Atlantic Oscillation (NAO)

Mahon et. al. 1998
When NAO Positive

Tendency for Northern Transition Zone to move South & Southern Transition Zones to move North

Are these patterns Predictable?
- Determine if **snow crab & shrimp** are sustainable populations or Gulf extension during cold conditions.

  Tractability: Low  
  Scale: Institute

- Determine what is controlling the invasion rate of **Codium**.

  Tractability: Low  
  Scale: Institute
What can be done to recover species at risk?

- Survivorship of leatherback turtles released from large pelagic longlines
  
  Tractability: High
  Scale: Institute

- Juvenile mortality & location of porbeagle pupping grounds
  
  Tractability: Medium
  Scale: Coast

- Prediction of life history characteristics of data poor species
  
  Tractability: Medium
  Scale: Institute
How should species-at-risk be monitored?

- Investigate whether bottom trawl surveys provide reliable indicators of abundance
  - Cusk hard to sample but show dramatic decline in abundance; is this real or due to contraction to preferred habitat?

Issues with other species (e.g. Barndoor Skate)

Tractability: Medium
Scale: Coast
Barndoor Skate & Surveys

Size is Important

Trawl Survey

Immature Skate

Mature Skate

Longline Survey

Longline Survey samples all size groups
Trawl Survey samples predominantly immature skate

Monitoring species at risk requires consistent time series of Spawners
Do present management practices allow accurate discard & by-catch estimates?

- Impact of discarding on non-commercial species

- Estimation of discard & by-catch in ESS fisheries
  - May 2006 workshop uncovered significant data issues

Also Productivity Issue
Should fisheries management be concerned about population substructure?

Prior to 1984, ESS cod composed of spring & fall spawning components

Determine if re-establishment of spring spawning component necessary for recovery?

Similar questions for other species
E.g. What is link between ESS and Bay of Fundy Herring?

Tractability: Low
Scale: Institute
Productivity Issues

- What are management implications of systematic removal of large fish on ecosystem functioning?

- What is minimum Spawning Stock Biomass for Scotian Shelf stocks?

- Have current harvest practices caused growth reduction in gadoids?

- Does management need to consider impact of climate change?
What are management implications of systematic removal of large fish on ecosystem functioning?

- ESS ecosystem regulation
  - bottom - up or top - down?
  - Frank et al (2003) suggests top - down

Tractability: Low  
Scale: Global
Determine source & impact of high M on cod

Similar pattern seen in other depleted finfish (e.g. wolffish & skate)

Are these species in predator traps?

Survey Z

Tractability: Low
Scale: Coast
Role of grey seals

- Determine what population processes (e.g., density-dependent) regulate seals

Roughly 700,000t of prey consumed each year compared to 6,000t 40 yr ago

Tractability: Medium
Scale: Coast
Investigate food requirements & consumption estimates of apex predators (seals, sea birds, etc)

ESS Cod consumed using 3 different model assumptions

- Constant
- Variable
- Constrained

Constant consumption based on QFASA estimates of cod in seal diets
Are current seal consumption estimates accurate?

- Issues with stomach samples
  - Biased towards small prey?
  - Fishermen observe cod belly bites

- Issues with fatty acid analysis
  - Reproducible?
What is minimum Spawning Stock Biomass for Scotian Shelf stocks?

- Determine long-term changes in SSB
  - ESS Cod good example of Pauly's 'Shifting Baseline Syndrome'
Have current harvest practices caused growth reduction in gadoids?

- Determine relative roles of environment & genetic selection on haddock growth

Scotian Shelf

NE Atlantic

Weight (kg) at Age 7

Tractability: Low
Scale: Institute
Does management need to consider impact of climate change?

- Trends in fish recruitment in relation to climate change
  - Link between timing of spring phytoplankton bloom & ESS haddock recruitment

Tractability: Low
Scale: Coast

Also Productivity Issue
Habitat Issues

- Are fishery closures & gear restrictions adequate to protect benthic habitat?
- Can impacts of climate change on habitat be predicted?
Are fishery closures & gear restrictions adequate to protect benthic habitat?

- Determine if benthic community spatial patterns can be predicted from geological, oceanographic & biological observations

- Determine proportion of each benthic habitat type that needs to be protected
  - Sensitivity of benthic communities

Tractability: Medium
Scale: Global
Influence of geology, oceanography & biology on life history traits

Scope for Growth

- High Productivity (Benign)
- Low Productivity (Adverse)

- Lowest Risk to Impact
- Highest Risk to Impact

Areas of Potentially Higher Sensitivity

- Nova Scotia
- New Brunswick

- Depth
- Grain size
- Current
- Wave height/period

- Food Availability
- Water temperature
- Variability in temperature
- Oxygen Saturation
- Stratification

Scope for Growth

- Disturbance
  - Stable
  - Disturbed

Lowest Risk to Impact

- Highest Risk to Impact

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- New Brunswick

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Lowest Risk to Impact

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- Stratification
Determine relationship between size & location of protected areas & benthic community conservation

Current Closures
Can impacts of climate change on habitat be predicted?

- Mechanism whereby climate change influences ESS oceanography
  - Impacts on benthic & pelagic habitat

- Implications of North Atlantic Oscillation (NAO)

Tractability: Low
Scale: Coast
• Linkage of Scotian Shelf with larger North Atlantic atmospheric system
  • Different response to NAO north & south of Halifax

• Periodic? Predictable?
## Summary of Tractability & Scale

<table>
<thead>
<tr>
<th>Tractability</th>
<th>Scale</th>
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<tbody>
<tr>
<td>High</td>
<td>Institute 12</td>
</tr>
<tr>
<td>Medium</td>
<td>Coast 6</td>
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<tr>
<td>Low</td>
<td>Global 3</td>
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### Implications

- **Management of ecosystem**
  - Knowledge won’t be available in 3 – 5 years

- **Management of research**
  - Considerable progress can be made at institute level
  - Partnerships at regional & global scale required for several key issues
Emergent Research Issues requiring international collaboration

- Link biodiversity to productivity & resilience

- Ecosystem regulation (bottom - up & top - down)

- Link between habitat type & sensitivity

- Spatial scales of connectivity between benthic communities
Shortfalls of Approach

- **Focus on needs by conservation objective**
  - Requires prioritization of management issues
  - Misses ecosystem level synthesis

- **Need for**
  - ‘Ecological Risk Analysis’
    - Qualitative / Quantitative
  - Contextual ecosystem modeling
    - Eg. Atlantis, Ecopath with Ecosim (EwE)
Thank You!