Challenges for Making the Bridge between Ecologists and Decision-Makers a Two-Way Street: One Ecologist's Perspective

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Important Points For Today

- Fisheries science is applied ecology.
- Indeed fisheries scientists, like wildlife biologists, were the first conservation biologists.
- Studies in fisheries science often at the spatial scale of populations while studies in ecology are often at the scale of individual animals within habitats.
- Both approaches yield valuable insight.
- However, results of small scale studies are often minimized in terms of development of alternatives in the management arena because they do not explicitly comport with population-scale results.
- Need to resolve this issue to understand all of the logical choices available to solve problems.
Integrate and synthesize studies of fish from scales of individuals living within a landscape (incl. bioenergetics) to interacting communities across biogeographic regions ...
NOAA 2015 Report to Congress

40% of overfished stocks nationally (no HMS)

Impaired populations of key species of economic and ecological importance
Despite many manipulations to control F and recover exploited populations, including use of closed areas, overfishing and overfished status persists.

Other things we need to know??
Mixed species & mixed gear fisheries - a management challenge
Fishing effects on fish habitat ...

The Effects of Fishing on Fish Habitat

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Global analysis of response and recovery of benthic biota to fishing

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Spatial variation in effort: important places?

Map 40 – Spatial distribution of realized adverse effects from generic otter trawl gear type timesteps: 2000, 2005, and 2009. All panels use the same color scale. The maps give an annual snapshot of adverse effects, summing impacts from previous years fishing where the habitat has not fully recovered combined with new impacts.

Adverse effects, square kilometers per grid:

- 0 - 16
- 17 - 44
- 45 - 82
- 83 - 133
- 134 - 203
- 204 - 294
- 295 - 406
- 407 - 551
- 552 - 893
- 894 - 1712

*2000 had highest per grid cell adverse effect values of all three years, and is therefore used as the baseline. All years are plotted on the same scale.

NEFMC. 2014. Omnibus EFH Amendment 2. Draft DEIS.
Gradient of Habitat Complexity and Recovery Time

Figure 1. Conceptual model of the relationship between vulnerability to fishing gear (structural complexity and recovery time) and habitat availability for the Northeast region.

Prioritizing Complexity

But each species does not use all available habitats.

But habitats with longest recovery times are not the only ones in need of protection – space-time patterns of use may be important!
Figure 2. Comparison of the spawner–recruit relationship (a) where survival to spawning is a simple function of fishing and natural mortality, and recruitment is an inevitable consequence of egg production, and (b) where spawner abundance is vital, but spawning also depends on an adult refugium, and recruitment success of the juveniles is subject to sequential risk/bottlenecks during migration between stage-specific habitats (from Caddy, 2008).
Fish-Habitat Perspective

• Sampling tools we use operate within variable space-time domains as well.
• Important to link sampling approach to the scale of the process of interest ... at least to provide inference for interpreting other data sources.

Domains based on sample unit size-time

Low recruitment a consequence of many factors

Recruitment and 3+ biomass

GB
Atlantic cod

- Since 1995, adult population biomass (ages 3+) has fluctuated between 5,900 mt and 18,800 mt. The estimated adult population biomass at the beginning of 2015 was about 10,000 mt.

- Recruitment at age 1 has been low in recent years. The 2003 and 2010 year classes are estimated to be the highest recruitments since 1998. The current estimate of the 2013 year class is about two-thirds of the 2003 and 2010 year class based on the 2015 assessment.
Threshold pattern but process(es)?

The current biomass is well below 25,000 mt. When biomass is above this threshold, there is a better chance for higher recruitment.
• Habitat associations can be defined across gradients of space and time, based on multiple factors, and those factors can be dynamic within different space-time domains!

Figure modified from one stolen from John Manderson, NMFS. Not sure where he got it from?
Fish-Habitat Perspective

- Fishery independent surveys designed on a human, not an ecological time and space scale.
- Narrow space-time resolution to detect important elements of dynamics and other drivers.

Figure modified from one stolen from John Manderson, NMFS. Not sure where he got it from?
Micro-Habitats: Physical Substrata

Piled Boulder

Rippled Sand

Pebble-Cobble

Mud

Photos P. Auster et al. except upper right
Micro-Habitats: Biogenic Structure

- Boulder with Anemone
- Sand with Amphipod Tubes
- Mud-draped Gravel with Sponge
- Shell and Shell Fragments

Photos P. Auster et al., NURC, UConn
Seafloor habitat and a suite of interactions ...

Species & habitat dependent

- Biogenic – geologic complexity
- Disturbance to seafloor habitats
- Larval-pelagic juvenile settlement
- Predation intensity - risk
- Realized prey abundance
- Competitor dominance
- Spawning success
Seafloor habitat and a suite of interactions ...

Habitat dependent

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- Predation intensity - risk
- Realized prey abundance
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- Spawning success
Biological elements in and out of WGOM are dynamic - not successional

Tamsett-Verkade, Auster and Lindholm unpublished
Mismatch between perspectives on habitat impact-recovery and patterns of use by fish

- Current focus on habitats with long recovery times - like biogenic reefs, gravel with dense epifauna (y)
- Misses the linkage between patterns of habitat use (and functional role) by fish and timing of impacts (w, m).
  - Movement between diurnal shelter and nocturnal feeding habitats (d)
    - Diaz et al. 2003, Auster et al. 2005
  - Patch size patterns and dynamics of settlement into habitats (w, m)
  - Functional role of aggregating prey linked to bioenergetics of feeding, growth and fecundity (m)
    - Auster et al. 1996, Bradshaw et al. 2003
  - Biophysical elements of spawning habitat (w, m)
Shape?
- Species
- Settings
- Dynamics

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Biogenic – geologic complexity
Disturbance to seafloor habitats
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Spawning success
Seafloor habitat and a suite of interactions …
Habitat is not just physical habitat ... but it helps
Research to Support Management

This is all knowable
... we just gotta wanna!!
Link small spatial-scale
processes to management scale.
Geospatial approaches useful.
Scenario-building useful.
Geospatial analysis of habitat use in yellowtail flounder *Limanda ferruginea* on Georges Bank

Jose J. Pereira¹,*, Eric T. Schultz², Peter J. Auster³

<table>
<thead>
<tr>
<th>Model</th>
<th>Geographical range</th>
<th>Local density</th>
<th>Local fitness</th>
<th>Spatiotemporal variation in fitness</th>
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<tbody>
<tr>
<td>CDM</td>
<td>Increases with N</td>
<td>Constant over N</td>
<td>Constant over N</td>
<td>Spatial variance at high N</td>
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<tr>
<td>PDM</td>
<td>Constant over N</td>
<td>Constant proportion of N</td>
<td>Constant over N</td>
<td>Spatial variance at high N</td>
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<tr>
<td>BM</td>
<td>Increases with N</td>
<td>Increases with N(^a)</td>
<td>Decreases with N</td>
<td>No change in spatial variance with N</td>
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</tbody>
</table>

\(^a\)The increase may be more pronounced if fish follow a Beverton-Holt stock-recruitment relationship.

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<table>
<thead>
<tr>
<th>Season</th>
<th>Area (km(^2))</th>
<th>P</th>
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<tbody>
<tr>
<td></td>
<td>Low period</td>
<td>High period</td>
</tr>
<tr>
<td>Fall</td>
<td>3966</td>
<td>8676</td>
</tr>
<tr>
<td>Spring</td>
<td>3844</td>
<td>7907</td>
</tr>
</tbody>
</table>

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**Figure 1:**

- **A** and **B**: Maps showing the distribution of low and high abundance areas.

- **Graph:**
  - X-axis: Year 1968-2006
  - Y-axis: CPUE (kg tow\(^{-1}\))
  - Graph types: Spring (O), Fall (●)

**Equation:**

\[ y = 3.02x - 5.16 \]

**R²:** 0.94
Role of a large marine protected area for conserving landscape attributes of sand habitats on Georges Bank (NW Atlantic)

James Lindholm¹,³,*, Peter Auster¹, Page Valentine²
Compensation and recovery of feeding guilds in a northwest Atlantic shelf fish community

P. J. Auster¹,*  J. S. Link²

NEUS Shelf
Coastal kelp forest
GoMaine - Steneck et al

SBNMS - Incze & Auster unpub
Habitat and habitat bottlenecks?

Fig. 3. Effect of substrate rugosity of a transect on postsettlement survival of age 0+ cod. Survival is calculated as the percentage of all fish settling onto a given transect that survived until the end of the experiment.

Top right: http://coz.southernfriedscience.com/?p=65
Others P. Auster
Multi-scale approaches
Cells contain “local species” and implicitly represent a single habitat type. Size of cell to be determined. Cells combine to form a mosaic of similar and different habitats such that they represent a landscape feature (e.g., a ridge, a bank). Inputs and outputs vary based on characteristics of adjacent cells (species composition and processes as well as physical location such as depth-related oceanographic regime).
Advective

Mobile

Human Activities

inputs

services

Modulation by human and landscape-specific processes

Attributes/inputs/services

Habitat/Community

Net effects at landscape or feature scale

Ecosystem-multiple landscapes

Investigations data => models

gradually inform

Management monitoring => decisions
Where are we now and where do we need to go?

Integrate use of cross-scale tools and information

... to produce **data and information** products for management
Use scenario analysis approaches

Scenario Analysis Gives us a View of Multiple Possible Futures

- Critical Uncertainty 1
  - Extreme Negative State
  - Extreme Positive State

- Critical Uncertainty 2
  - Extreme Negative State
  - Extrem Positive State

Discontinuity

Empirical data, past performance

Observable quantity

Past
Present
Future

Scenario Driver

Scenario A
Scenario B
Scenario C
Scenario D
Scenario E
Integrating the invisible fabric of nature into fisheries management

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Edited by Stephen R. Carpenter, University of Wisconsin–Madison, Madison, WI, and approved December 3, 2013 (received for review August 2, 2013)

Overfishing and environmental change have triggered many severe and unexpected consequences. In some cases, new ones have become established, fundamentally transforming ecosystems to those that are highly sensitive to cycles of booms and busts, and thus less manageable. We contend that the failure of fisheries management to recognize and respond to these changes is due to a lack of appreciation for the nature, strength, complexity, and underlying mechanisms of the processes that lead to unexpected shifts. We argue that fisheries science and management must follow this lead and develop new tools to assess how human activities interact with and disrupt other processes that could sustain ecosystems in which fisheries are a top trophic level.
Management Under Uncertainty

There are no recipes!

- Apply ecological theory and empirical results across space and time.
  - Harmonize variable space-time perspectives on habitat and species interactions.
- Manage fisheries to minimize effects on attributes of landscape and species interactions.
  -- closed areas AND fishing “windows” to assess actions
- Use available information to infer elements of the environment sensitive to disturbance.
  -- use both space and time domains to parse impacts
  -- don’t require overwhelming confirmation of elements but use what we know and test effects of interventions.
- Collect data in a collaborative manner to assess outcomes.
  -- measure of success can’t just be more fish (biod counts too)!
  -- take multi-species nature of fishery into account

This is the ecological part. Someone down the hall needs to deal with policy, management, social and economic issues.
Words of Wisdom

"Not everything that counts can be counted, and not everything that can be counted counts."
William Bruce Cameron

"We don’t know everything, but we do know some things."
paraphrasing some really rude lyrics by Dr. Dre
Thank You

"That's all Folks!"
Abstract Title:
Challenges for Making the Bridge between Ecologists and Decision-Makers a Two-Way Street: One Ecologist's Perspective

Co-authors (if any):

Presentation Summary:
There is a need to improve two-way information flow across the science-management bridge to better develop a research agenda explicitly to improve decision-making in the short term. Examples from research are used to illustrate problems and propose solutions.

Presentation Abstract:
The essential fish habitat (EFH) provisions of the Magnuson-Stevens Act provide a pathway to apply our current knowledge of habitat and landscape ecology for managed species and communities to problems of conserving those attributes of the environment that mediate populations of managed species exploited by fisheries. Using this knowledge to develop and implement management actions to minimize the effects of fisheries is a primary goal. The process that plays out in the fisheries management realm produces a necessary top-down tension between risks and benefits (e.g., fisheries access vs habitat conservation) for how new knowledge is applied, but the focus of acquiring new knowledge (i.e., research) is generally a bottom-up exercise. Based on this ecologist's perspective (i.e., as one who has been directly involved across research, policy and management processes) I suggest we need to improve two-way information flow across the science-management bridge to better develop a research agenda explicitly to improve decision-making in the short term. Examples based on EFH for Atlantic cod, Acadian redfish and black sea bass off the eastern United States are used to illustrate problems and propose solutions.