ACCOUNTING FOR HABITAT DEPENDENT SPECIES DISTRIBUTION SHIFTS IN MARINE FISH POPULATION ASSESSMENTS: A case study with Atlantic Butterfish
Outline

- The tortured path to the problem & the role of cooperative research
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- Statement of the problem?
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Approach: Regional Habitat Models

NOAA US Fishery Data
Spatial grain = 11km

Ocean Observations + Physical Models

Niche Models

Regional Habitat Projection
Sometimes a management problem finds you

“Make a habitat model you can use to reduce butterfish bicatch in longfin squid fishery”

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Ecologists
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(NOAA/NMFS/NEFSC)
Laura Palamara (Rutgers)
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**Fisheries Management**
Jason Didden (MAFMC)

**Human Dimensions**
Steven Gray (U Hawaii)
Hypothesis:
Combining fishermen & scientists’ knowledge within an Operational Ocean Observing System should:

(1) Increase chance of accurately capturing ecosystem dynamics & key driving processes at appropriate space-time scales

(2) enable adaptive decision making at scales matching those of the ecosystem
Field evaluation of prototype operational habitat model (ver 2.0)

Model nowcast
based on surface observations

Predicted habitat: 2010-09-01 12:00:00

Catch & environmental data & analysis

F/V Karen Elizabeth

Cape Hatteras

Cape Cod

New Jersey
Lessons learned

1) Habitat model has coarse spatial extent & grain like the NMFS survey data used to make it
   - grain ~ 40 km$^2$
   - Fine scale habitat associations not well described
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3) Animals abundant in habitats under or un-sampled in NMFS assessment surveys
   - Seasonally productive inshore & offshore fringes of ecosystem where rates of mixing & nutrient enrichment high
   - Where triggers for ecological processes including migration may be changing rapidly with climate change
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• 3) Animals abundant in habitats under or un-sampled in assessment surveys
  - Seasonally productive inshore & offshore fringes of ecosystem where rates of mixing & nutrient enrichment high
  - Where triggers for ecological processes including migration may be changing rapidly with climate change
If survey-based indices are used to estimate population size, catchability is used to scale population size.

Catchability $Q = \text{availability } \rho \ast \text{detectability } \delta$

Proportion of population in survey space-time frame

Proportion of fish occupying station caught in net
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OpenOcean Study Group

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Simulate thermal habitat

Niche model: nonlinear extension of Boltzmann-Arrhenius equation (mechanistic basis in enzyme kinetics)

Water temperature hindcast from oceanographic model

1958-2007
Daily Temperature
~7 km Resolution

From Enrique Curchitser, Rutgers
Out of sample validation of niche model, ocean model & niche model coupled to ocean model

\( N \text{ in situ temps \& catch} = 16,883 \text{ (year<2008)} \)
Calculate proportion of thermal habitat suitability surveyed to inform estimate of population availability

\[
\rho_h = \sum_{k=1}^{o} \frac{H_{j,i} \times \text{Area of sample strata}_k}{\sum_{j=1}^{n} H_{j,i} \times \text{Area}_j} \frac{p}{\sum_{j=1}^{n} H_{j,i} \times \text{Area}_j}
\]

Habitat Suitability Index
HSI
Good habitat

Poor habitat
Substitute in catchability equation

Available thermal habitat surveyed for availability of population to survey $\rho$

Dave Richardson’s
Maximum bounds to catchability
2014 ASAP stock assessment model for Atlantic butterfish with & without habitat based availability estimate (H)
2014 Atlantic Butterfish assessment
Catchability estimate (informed by method) allowed calculation of reference points & establishment of quota. From MAFMC draft environmental assessment of specs:

• Since 2002 butterfish an **incidental fishery**

• 2014 first year of a small directed fishery with limit of **3,200 mt**.

• If limit is caught at 2013 average prices ($1,481 mt), revenues would be ~ **$4.7 million**.

• Average limit for 2015-2017 would be **21,408 mt** under proposed 2015 specifications. Could translate into **$31.7 million** additional ex-vessel revenues at 2013 prices.

• It is not clear that fishery will land limits or price will remain near $1,481/mt at higher landings, so **$31.7 million** is an “**upper end**” possibility.
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What the index does

- Model based representation of dynamic habitat effects on survey observation process.

- Estimates amount of habitat sampled relative to amount estimated to have been there during survey.
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- Estimates amount of habitat sampled relative to amount estimated to have been there during survey

What the index does not do

- Does not address habitat effects on demographic processes & productivity.

- Like all models it’s a cartoon of reality not reality

Hopefully it captures essential characteristics
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- The tortured path to the problem & the role of cooperative research
- Statement of the problem?
- What was the solution?
- What the index does and does not do?
- Does it matter?
- It matters when:

population size in assessments is scaled using fishery independent survey data
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population size in assessments is scaled using fishery independent survey data

Analyzing surveys for habitat effects on population demographics & productivity for forecasting. Need to account for habitat dependent observation error
Fall NEFSC Survey

$m = -1.311 , p = 0.622$
Spring NEFSC Survey
Spring NEFSC Survey

\[ m = 6.40, \ p = 0.0002 \]
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