Managing Forage Fish in the Mid-Atlantic
A White Paper to Inform the Mid-Atlantic Council

Mid-Atlantic Fishery Management Council
Philadelphia, PA
Initial Review
8 October 2014

E. Houde, S. Gaichas, R. Seagraves
MAFMC EAFM Activities

- Council developing an Ecosystem Approach to Fishery Management Guidance Document (PFMC approach)
- A non-regulatory umbrella document intended to guide Council policy with respect to ecosystem considerations across existing FMPs
Ecosystem Guidance Document Development

- Council formed EAFM working group to develop guidance document and background information necessary to inform the process
- Current member expertise in areas of ecosystem level assessment modelling, habitat, social/economics and fishery management; need to add……..
- NEFSC/Pop Dy Branch and GARFO(NEPA)
EAFM Guidance Document Focus

1. Forage/low trophic level species considerations
2. Species interactions (predation, competition) and their effects on sustainable harvest policy
3. Incorporation of social and economic considerations in OY specifications/EAFM
EAFM Guidance Document Focus (cont.)

4. Effects of systematic changes in oceanographic conditions on abundance and distribution of fish stocks; ramifications for assessment and management

5. Incorporation of habitat conservation and management objectives in the current management process (including water quality issues)
Focus on science related to assessment and management of forage species

Discuss where in the process these issues should be handled including stock assessments, ABC control rules, OY specification

Discussion will inform EAFM Guidance Document
White Paper Development

- White papers under development for each EAFM area of emphasis
- Allows for review of science and discussion of policy implications
- Synthesis and integration of white papers will form EAFM Guidance Document (plus additional background information)
*Brief* Review of Forage Fish Workshop

All materials available:
http://www.mafmc.org/workshop/forage-fish-workshop
What Are Forage Fish?

- Crucial species in food webs
- Small, often schooling pelagic species
- Sardines, anchovies, sand eels, krill, herring...
- Feed on plankton and transfer energy to upper trophic levels

Economic Value of Forage Fish

<table>
<thead>
<tr>
<th>Economic Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct value of commercial catch</td>
<td>$5.6 b.</td>
</tr>
<tr>
<td>Supportive commercial value</td>
<td>$11.3 b.</td>
</tr>
<tr>
<td>Total global commercial value</td>
<td>$16.9 b.</td>
</tr>
</tbody>
</table>

Key Recommendations

- Focus on predators
- Consider spatial & temporal management
- Cut forage fishing in half and leave twice as much fish in the ocean compared with conventional management in many ecosystems.
- Tailor management to available information
For consideration:

- Indicators and reference points
- Are there any rules of thumb, e.g., $F < M$, Biomass threshold, hockey-stick (Restrepo, Lenfest) rules, appropriate $F$ and $B$ levels.
- Can predator demand be indexed from stock assessments of predators?
- What indices of ecosystem state are available that are indicative of predator demand and prey availability?
- Can energetics modeling be useful to estimate demand?
- What about ecosystem modeling? Strategic or tactical?
- What decisions and regulations could be implemented by managers in the short term?
Forage Fish Workshop, April 2013: Latour

Data/modeling strategies

Analytical gradient

Largely single-species BRPs

Group/guild BRPs

Pure single-species assessment

Multiple coordinated single-species assessments

Single-species assessments with explicit \( M_2 \) or climate

Multispecies assessments

Aggregated biomass analyses

Entire ecosystem model

Natural mortality (M)

- Forage stocks: more attention focused on natural mortality

Accounting vs. Managing

How is \( M \) treated analytically?

- Guestimate; constant over age & time
- Empirical single-species estimate; may/not be age & time varying
- \( M \), modeled; partial suite of predators; may/not be age & time varying
- \( M \), modeled; 'complete' suite of predators; age & time varying

Probability of Overfishing

\[ P^* = 0.40 \]

\[ P^* < 0.35 \]
Forage Fish Workshop, April 2013: Gaichas

Changes from 40+ Years data
Spring and Fall each year
Outline: Forage Fish White Paper

• Introduction/background
  – Role of forage fish in marine ecosystems
  – Definition of “forage” fish

• Forage species management considerations

• Identifying Mid-Atlantic forage species
  – Based on definition: currently fished and unfished
  – Based on predator diets: fish, mammals, turtles, birds

• Mid-Atlantic food web description

• Potential ABC/OFL framework for forage species

• Potential management measures for currently unfished forage species
Role of forage fishes in marine ecosystems

The ocean food web

Along the U.S. West Coast, most major fish, mammal and seabird species rely on forage fish for food – a group of about 30 species of small schooling fish. Scientists increasingly recognize that maintaining this small group of fish is key to ocean health.

**Fisheries**
- Chinook salmon
- Albacore tuna
- Sturgeon
- Yelloweye rockfish

**Marine Mammals**
- California sea lion
- Pacific white-sided dolphin
- Humpback whale

**Seabirds**
- Brown pelican
- Pomarine jaeger
- Horned puffin
- Caspian tern
- Common murre

**Forage Fish**
- Pacific herring
- Pacific jack mackerel
- Pacific sardine
- Eulachon (smelt)
- Northern anchovy

**Zooplankton**
- Copepod
- Seastar larva
- Fish larva
- Radiolarian
- Ostracod
- Comb jelly

**Phytoplankton**
- Microscopic plants

Source: OCEANA; “FORAGE FISH: Feeding the California Current Large Marine Ecosystem,” Marine Forage Species Management off the U.S. West Coast, October 2011

MARK NOWLIN / THE SEATTLE TIMES
• Small throughout lifespan

• Major prey throughout lifespan
  – For fish, marine mammals, birds
  – >5% of diet, 5 or more years
  – High mortality due to consumption

• Central in food webs, highly productive
  – Trophic level between 2 and 4
  – Many trophic links, energy conduit
  – Production >1/100th; biomass >1/1000th of system primary production

• Often
  – Schooling, pelagic
  – High recruitment variability
Forage species management considerations
SSC National Workshop IV: EBFM and Forage Fish Issues

- Need better ways to estimate forage biomasses
- Need better ways to estimate predator demand
- Determining M2 is important
- Ecosystem forage buffers vs single-species buffers?
Forage biomass and predator demand estimation: “Leave one third for the birds”

Cury et al. 2011
COASTAL PELAGIC SPECIES FISHERY MANAGEMENT PLAN

AS AMENDED THROUGH AMENDMENT 13

PACIFIC FISHERY MANAGEMENT COUNCIL
7700 NE AMBASSADOR PLACE, SUITE 101
PORTLAND, OR 97220
(503) 820-2280
(866) 806-7204
WWW.PCOUNCIL.ORG

SEPTEMBER 2011

ECOSYSTEM INITIATIVE 1: PROTECTING UNFISHED AND UNMANAGED FORAGE FISH SPECIES

OF THE U.S. PORTION OF THE CALIFORNIA CURRENT LARGE MARINE ECOSYSTEM

PACIFIC FISHERY MANAGEMENT COUNCIL
7700 NE AMBASSADOR PLACE, SUITE 101
PORTLAND, OR 97220
(503) 820-2280
(866) 806-7204
WWW.PCOUNCIL.ORG
MARCH 2014

http://www.pcouncil.org/wpcontent/uploads/I1a_ATT1_Eco_Initiative1_forage_APR2014BB.pdf
Consider Human Benefits

- Directed fisheries and inter-fishery linkages
  - Herring and lobster
  - Changing consumer tastes: slow food
- Cultural importance
- Prey value
  - High valued fisheries
  - Endangered/Protected species
    - Whale watching
      - by beachgoers as pods feed on large aggregations
      - On whale watch boats
...and Human Responses

- Does decreasing forage fish landings increase fishing pressure on other susceptible species?
  - Effort pushed into less well managed/new fishery?
- Are there differential impacts due to seasonal migrations?
- How to handle potential increased market demand due to increased consumer interest in eating low on the food chain?
- All trade-offs must be carefully weighed
Forage species of the Mid Atlantic

1. By definition
2. By predator type
   a. list predators
   b. what do they eat?
## 1. Mid Atlantic Forage Fishes (by definition)

<table>
<thead>
<tr>
<th>Common name</th>
<th>Species</th>
<th>Fished Y/N</th>
<th>Mean Annual Landings (mt) (2008-2012)</th>
<th>Management Authority</th>
<th>Bycatch Important Y/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic herring</td>
<td>Clupea harengus</td>
<td>Y</td>
<td>82,422.4</td>
<td>NEFMC/ASMFC</td>
<td>Y</td>
</tr>
<tr>
<td>Atlantic menhaden</td>
<td>Brevoortia tyrannus</td>
<td>Y</td>
<td>210,776.0</td>
<td>ASMFC</td>
<td>N</td>
</tr>
<tr>
<td>Atlantic mackerel</td>
<td>Scomber scombrus</td>
<td>Y</td>
<td>12,003.2</td>
<td>MAFMC</td>
<td>Y</td>
</tr>
<tr>
<td>Butterfish</td>
<td>Peprilus triacanthus</td>
<td>Y</td>
<td>244.1</td>
<td>MAFMC</td>
<td>Y</td>
</tr>
<tr>
<td>Alewife</td>
<td>Alosa pseudoharengus</td>
<td>Y</td>
<td>605.2</td>
<td>ASMFC</td>
<td>Y</td>
</tr>
<tr>
<td>Blueback herring</td>
<td>Alosa aeslintalis</td>
<td>Y</td>
<td>6.2</td>
<td>ASMFC</td>
<td>Y</td>
</tr>
<tr>
<td>Longfin squid</td>
<td>Doryteuthis pealii</td>
<td>Y</td>
<td>9,892.0</td>
<td>MAFMC</td>
<td>Y</td>
</tr>
<tr>
<td>Illex squid</td>
<td>Illex illecebrosum</td>
<td>Y</td>
<td>11,227.5</td>
<td>MAFMC</td>
<td>Y</td>
</tr>
<tr>
<td>Bay anchovy</td>
<td>Anchoa mitchilli</td>
<td>N</td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Striped anchovy</td>
<td>Anchoa hepetus</td>
<td>N</td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Silver anchovy</td>
<td>Engraulis eurystole</td>
<td>N</td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Round herring</td>
<td>Etrumeus teres</td>
<td>N</td>
<td></td>
<td></td>
<td>N ?</td>
</tr>
<tr>
<td>Thread herring</td>
<td>Opisthonema oglinum</td>
<td>Y</td>
<td>0</td>
<td></td>
<td>Y, small</td>
</tr>
<tr>
<td>Spanish sardine</td>
<td>Sardinella aurita</td>
<td>Y</td>
<td>0</td>
<td></td>
<td>Y, small</td>
</tr>
<tr>
<td>Sand lance</td>
<td>Ammodypus americanus and A. dubius</td>
<td>N</td>
<td>0</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Atlantic silverside</td>
<td>Menidia menidia</td>
<td>Y</td>
<td>6.4</td>
<td></td>
<td>N</td>
</tr>
</tbody>
</table>
2a. Mid Atlantic predator list—fish

**MAFMC managed**
- Spiny dogfish
- Summer flounder
- Monkfish
- Butterfish
- Scup
- Atl. mackerel
- Bluefish
- Black sea bass
- Tilefish

**ESA listed**
- Atlantic sturgeon
- Shortnose sturgeon

**Highly Migratory**
- Large coastal sharks
- Pelagic sharks
- Billfish
- Tunas

**Other managed**
- Little skate
- Spotted hake
- Silver hake
- Fourspot flounder
- Windowpane
- Atlantic herring
- Winter skate
- Smooth dogfish
- Red hake
- Winter Flounder
- Weakfish
- Clearnose skate
- Ocean pout
- Blueback herring
- Yellowtail flounder
- N. Searobin

**Witch flounder**
- Rosette skate
- Spot
- Atlantic croaker
- Gulf Stream flounder
- Sea raven
- Cusk eel
- Longhorn sculpin
- Striped bass
- American shad
2a. Mid Atlantic predator list—all others

**Baleen Whales**
- Fin whale
- Humpback whale
- Sei whale
- Minke whale
- N Atlantic right whale

**Toothed Whales**
- Pilot whale
- White-sided dolphin
- Common dolphin
- Bottlenose dolphin
- Harbor porpoise

**Dolphins**
- Common dolphin
- Bottlenose dolphin
- Harbor porpoise

**Seals**
- Harbor seal
- Gray seal

**Sea Turtles**
- Loggerhead
- Leatherback
- Kemp’s ridley

**Pelagic seabirds**
- Herring gull
- Great black-backed gull
- Laughing gull
- Bonaparte's gull
- Black-legged kittiwake

**Coastal birds**
- Great cormorant
- Double-crested cormorant
- Loons
- Brown pelican
- American bittern
- Great blue heron
- Great egret
- Snowy egret
- Tricolored heron
- Little blue heron
- Green heron
- Black-crowned night-heron
- Common merganser
- Red-breasted merganser
- Osprey
- Black skimmer

**Pelagic seabirds continued**
- Northern gannet
- Northern fulmar
- Wilson's storm-petrel
- Leach's storm-petrel
- Great shearwater
- Cory's shearwater
- Manx shearwater
- Audubon's shearwater
- Sooty shearwater
- Common tern (spring)
- Royal tern
- Razorbill

**Bald eagle**
2b. Mid Atlantic major forage by predator

**All fish in NEFSC database, including MAFMC managed**
- Crabs and shrimp
- Amphipods
- Other zooplankton
- Fish (incl. unid.)
  - Anchovies
  - Hakes
  - Sandlance
  - Herrings
- Molluscs
  - Unid. cephalopods
  - Loligo sp.
  - Bivalves
- Annelids
- Ctenophores

**Highly migratory fish**

*Large coastal sharks:*
- Fish (unid, bluefish, summer flounder)
- Skates/rays/sharks
- Crabs

*Large pelagics:*
- Squids (incl. Illex sp.)
- Fish (unid, mackerel, butterfish, bluefish, hakes, sandlance)

**ESA listed fish**
- Annelids
- Shrimp
- Other benthic invertebrates
2b. Mid Atlantic major forage, by predator

**Baleen Whales**
- Krill
- Herrings
- Other zooplankton
- Sandlance
- Large gadids
- Mackerels
- Other fish

**Toothed Whales and Dolphins**
- Squids
- Mackerels
- Other fish
- Small gadids
- Herrings
- Mesopelagics

**Seals**
- Other fish
- Sandlance
- Small gadids
- Flatfish
- Herrings
- Large gadids
- Squids

**Sea Turtles**
- Crabs
- Fish (scavenged?)
- Ctenophores and jellyfish
2b. Mid Atlantic major forage, by predator

**Pelagic seabirds**

*Gulls*: fish, offal and fish scavenged from commercial fishing operations, euphausiids

*Shearwaters*: fish (sandlance, saury), squids

*Storm petrels and Phalaropes*: zooplankton, fish eggs and larvae

*Gannets*: fish (menhaden, mackerel, saury)

*Fulmars*: euphausiids, squids

**Coastal birds**

Fish and crustaceans; extremely varied diet along salinity gradients

*Osprey, Cormorants and Pelicans*—Menhaden, herring, estuarine fish (mullet, drums, anchovy...
Key forage of managed fish

1. Summer flounder
2. Bluefish
Summer flounder diet (NEFSC database)

- Cephalopods
- Unid fish
- Mackerels
- Herrings
- Hakes and cods
- Porgies and pinfish
- Unid crabs/shrimp
- Butterfish
- Anchovy
- Sandlance
- Cusk-eels
- Unid
- Searobins
- Flounders
- Drums
- All others
Bluefish diet (NEFSC database)

- Anchovies
- Unid fish
- Butterfish
- Cephalopods
- Bluefish
- Herrings
- Sandlance
- Porgies and pinfish
- Hakes and cods
- Eelpouts
- Unid
- Drums
- Ctenophores
- Flounders
- Unid crabs/shrimp
- Mackerels
- Seaborins
- All others
Food webs of the Mid Atlantic

1. Energy flow
2. Predators and prey of commercial forage
3. Key fishery links
Potential ABC/OFL framework for forage species

Questions for Sarah?
Managed Forage Species

- Atlantic mackerel
- Long-finned squid
- Illex squid
- Butterfish

All in one FMP!
Exploited Forage Stocks

- NS1 advises to maintain forage stocks at levels higher than $B_{msy}$ to protect ecosystem structure and function
- Implications for biological reference points
Exploited Forage Stocks
BRP Options

- Maintain MSA based reference points and potentially apply additional buffers
- Define “ecological reference points”- biological reference points modified based on ecological importance and scientific uncertainty
- Currently little or no National guidance on how to implement either approach
Forage OFL/ABC Control Rules

- Maintain existing MSA based OFL definition (F_{msy} or proxy) and add additional buffers

One option: ABC based on P* = P* - f(M gradient)
### Potential Ecosystem-Based Reference Points for Forage Fishes

#### Mortality-based reference points

<table>
<thead>
<tr>
<th>Equation</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F = M )</td>
<td>Beverton 1990</td>
</tr>
<tr>
<td>( F = 0.87 M )</td>
<td>Zhou et al. 2012</td>
</tr>
<tr>
<td>( F = 0.67 M )</td>
<td>Patterson 1992</td>
</tr>
<tr>
<td>( F_{ERP} = (0.2, 0.5 \text{ or } 0.75) F_{MSY} )</td>
<td>Lenfest 2012</td>
</tr>
</tbody>
</table>

#### Biomass-based reference points

<table>
<thead>
<tr>
<th>Equation</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( B_{ERP} = 0.75 B_0 )</td>
<td>FAO 2003, Smith et al. 2011</td>
</tr>
<tr>
<td>( B_{ERP} = (0.8, 0.4, \text{ or } 0.3) B_0 )</td>
<td>Lenfest 2012</td>
</tr>
</tbody>
</table>
Managed Forage Species

Modified Council Risk Policy

Can the MAFMC Develop a Forage Policy?
Maintain minimum biomass threshold for FS

- In addition to fishing mortality control rule, specify minimum biomass at which directed fishery would be greatly reduced or closed (PFMC includes this provision in the CPS FMP)

- Originally included in mackerel ABC control rule but removed after 1996 MSA compliance amendments
BRPs for Forage Species

- No simple answer as to how to specify BRPs for forage species
- EAFM document should evaluate social and economic tradeoffs as well as complex biological considerations and environmental influences on FS
- Guidance document should provide comprehensive framework to evaluate BRP control rules for managed FS
Potential management alternatives for unfished forage species

- No Action
- Ecosystem Component Species
- Develop a Forage Species Plan
- Declare Moratoria on New Forage Fisheries
Unfished Forage Species:
No action

- Monitor abundance in surveys
- No management actions unless major changes in abundances occurred
- Landings and discards could be tracked.
Ecosystem Component Species

- Following NS1 guidance, unfished forage species, or a complex of species, could be declared EC species in FMPs (prey for managed species or bycatch in the managed fishery)
- EC species not included as managed species in the FMPs, but abundances and habitats monitored
- Council adjust measures in FMPs in response to changes in abundance of the forage species complex or key species in that complex
- Being proposed by the Pacific Fishery Management Council (PFMC 2014)
Develop a Forage Species “Plan”

- Need to consider FS role in supporting managed MAFMC species, but also within context of greater ecosystem.
- Not an FMP but a mechanism that could allow tracking of abundance of ecosystem forage species biomass complex.
- Would help address questions related to adequacy of forage base in Mid-Atlantic ecosystems.
Declare Moratoria on New Forage Fisheries

- Anticipating potential development of new fisheries on forage species, declare moratoria.
- Fisheries still could be developed, but it would insure formal processes are followed before a fishery could be initiated, including need for stock assessments, determination of effects on existing fisheries, FMPs, and the ecosystem.
- The North Pacific Fishery Management Council has declared moratoria for several forage species.
- Pacific Fishery Management Council Ecosystem Initiative 1
PFMC Ecosystem Initiative 1

- Prohibiting new directed commercial fishing on forage species until the Council has had an adequate opportunity to assess the scientific information relating to any proposed fishery and to consider potential impacts to existing fisheries, fishing communities, and the greater marine ecosystem.
PFMC Ecosystem Initiative 1

- Modifications to its four FMPs (CPS, Groundfish, HMS, Salmon)
- Designation of FS as ecosystem component species (bycatch or prey)
- New directed EEZ fishing for these species would be prohibited (some *di minimus* landing allowed)
White Paper Deficiencies

- analysis of social and economic considerations/tradeoffs (Smith)
- climate and physical drivers on population dynamics of FS complicates estimation of BRPs (Hare)
- incorporate NEAMAP food habits data to identify forage species from inshore waters (identify additional FS)
Next steps

- Incorporate Council feedback and modify white paper
- Second review at future Council meeting (if necessary)
- Fully develop white paper to form module of EAFM Guidance Document (i.e., living document)
Questions?