Science, Service, Stewardship

# An Ecosystem Perspective for Fisheries Management

Jason Link
Woods Hole Laboratory
Northeast Fisheries Science Center (NEFSC)

July 26, 2011

NOAA FISHERIES SERVICE

NOAA
FISHERIES
SERVICE

# Acknowledgements


- Megan Tyrrell & Hassan Moustahfid
- Lenfest Ocean Program
- Bill Overholtz
- Larry Jacobsen, Larry Alade, Tim Miller, Kathy Sosebee, Jon Deroba, Joe Idoine, Gary Shepherd, Chris Legault, Liz Brooks, Lisa Hendrickson
- Lance Garrison, Pat Livingston, Rick Methot, John Field, Sarah Gaichas, Bern Megrey

NOAA FISHERIES SERVICE

## EBFM/EBM

"U.S. ocean and coastal resources should be managed to reflect the relationships among all ecosystem components, including human and nonhuman species and the environments in which they live. Applying this principle will require defining relevant geographic management areas based on ecosystem, rather than political boundaries."

U.S. Commission on Ocean Policy (2003)

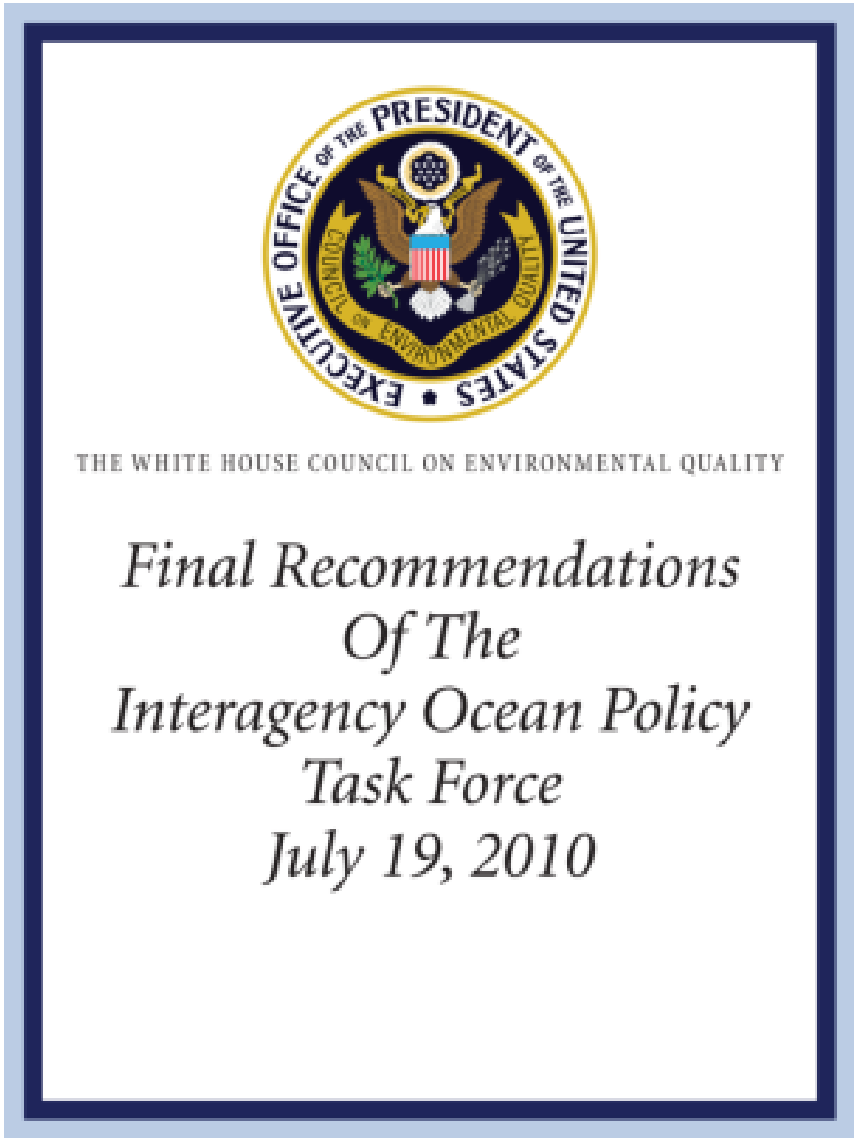
NOAA FISHERIES SERVICE

# EBFM/EBM

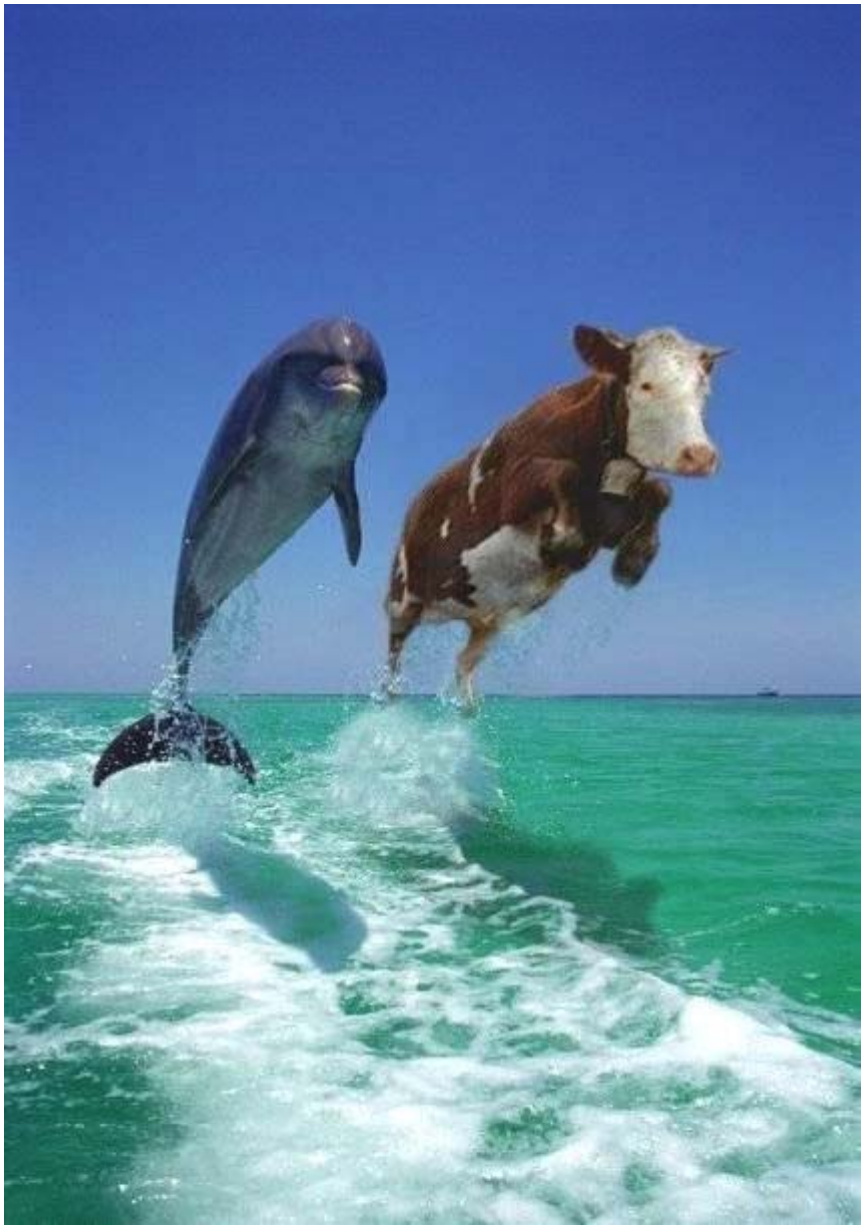
An ecosystem approach to management is geographically specified, adaptive, takes account of ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse societal objectives. Implementation will need to be incremental and collaborative.

NOAA Strategic Plan (2005)

# National Ocean Policy




On July 19, 2010, President Obama signed an Executive order implementing a new National Ocean Policy. The Policy establishes Ecosystem -Based Management as the guiding principle and marine spatial planning as a primary tool for ocean resource management in the United States.



NOAA FISHERIES SERVICE

## For EBFM/EBM, many ways ecosystem considerations can apply to LMRs. e.g.:

- System-level resilience
- Environmental effects
  - Thermal impacts
  - Chemical impacts
  - Physical impacts
- Habitat alterations
- Ecological interactions
  - Predation
  - Competition

# Ecosystem Considerations for Many Forage Stocks, e.g.- Atlantic Herring, Mackerel, Silver hake, etc.

- Highly migratory, locally dominant, spatially overlapping with many species
- Predation by protected species, commercially valuable species- odontocetes, seals, birds, fish, invertebrates
- Competition with protected or commercial species- planktivores, ichthyoplanktivores
- Predation on larvae/juvneiles of commercial species
- Large fishery potential
- Lower-intermediate trophic levels
- Very high trophic efficiency
- Horizontal flux, high biomass
- High linkage density, strong interactions for some stocks
- High exploitation rate, high historical fishery
- Temperature mediated changes in distribution, migration or production
- Demonstrably susceptible to climate change

NOAA FISHERIES SERVICE

# For LMRs (Fisheries), one key area for implementing EBFM is M2 for forage stocks

$$Z = F + M$$

$$M = M1 + M2$$

- Estimates thereof are key determinants for calculating BRPs
  - Important for evaluating status of stocks
- The issue of M & M2 has remained an important challenge
  - e.g. Brodziak et al. (2011). Estimating Natural Mortality in Stock Assessment Applications. NOAA Tech. Memo.

International Commission for the Northwest Atlantic Fisheries

Serial No. 000½
(WOW)

ICNAF Dumm. Doc. 75/2

ANNUAL MEETING - JUNE 1975

# Estimation of Unknown Natural Mortality

by

J.G. Pope

M = ?

M = ?

M = .2

M = .2

M = 0.2

EUREKA!!!

# What is a BRP?

= Biological Reference Point

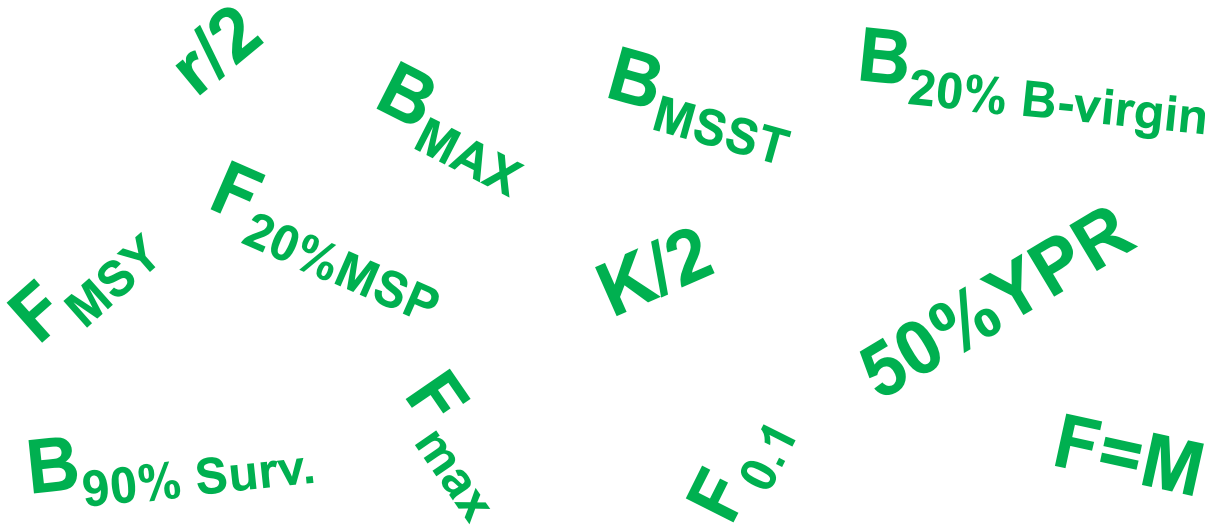
Based off of estimates of biomass or abundance, and fishing

Numerous examples, but most common in N. America are those associated with or proxied for $B_{MSY}$ or $F_{MSY}$

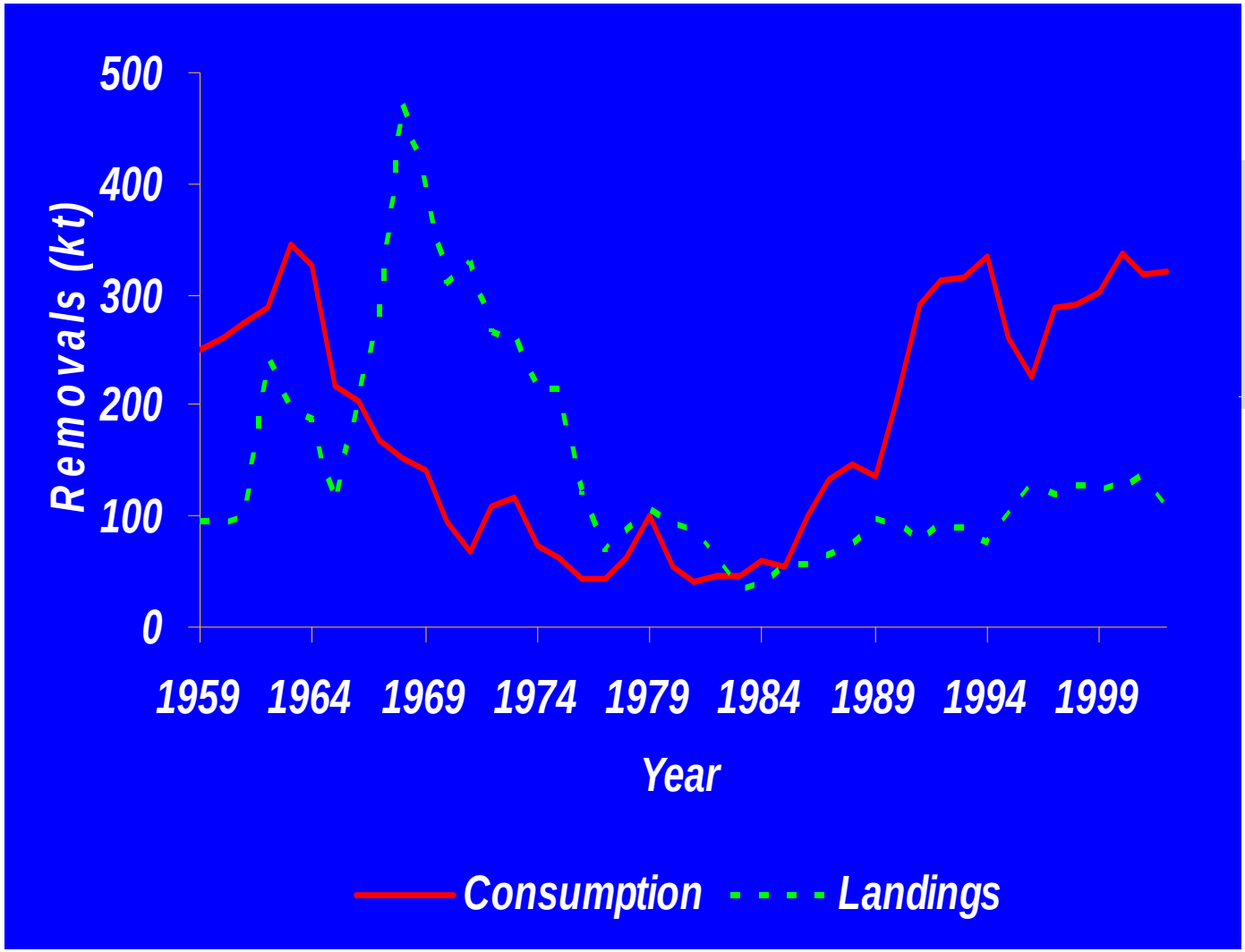
Used to determine status of a stock (overfished, rebuilt, overfishing, etc.)

Typically uses estimates of B and Catch to derive

***Strongly suspected that for forage fish, should incorporate predation accordingly***



# Common Observations

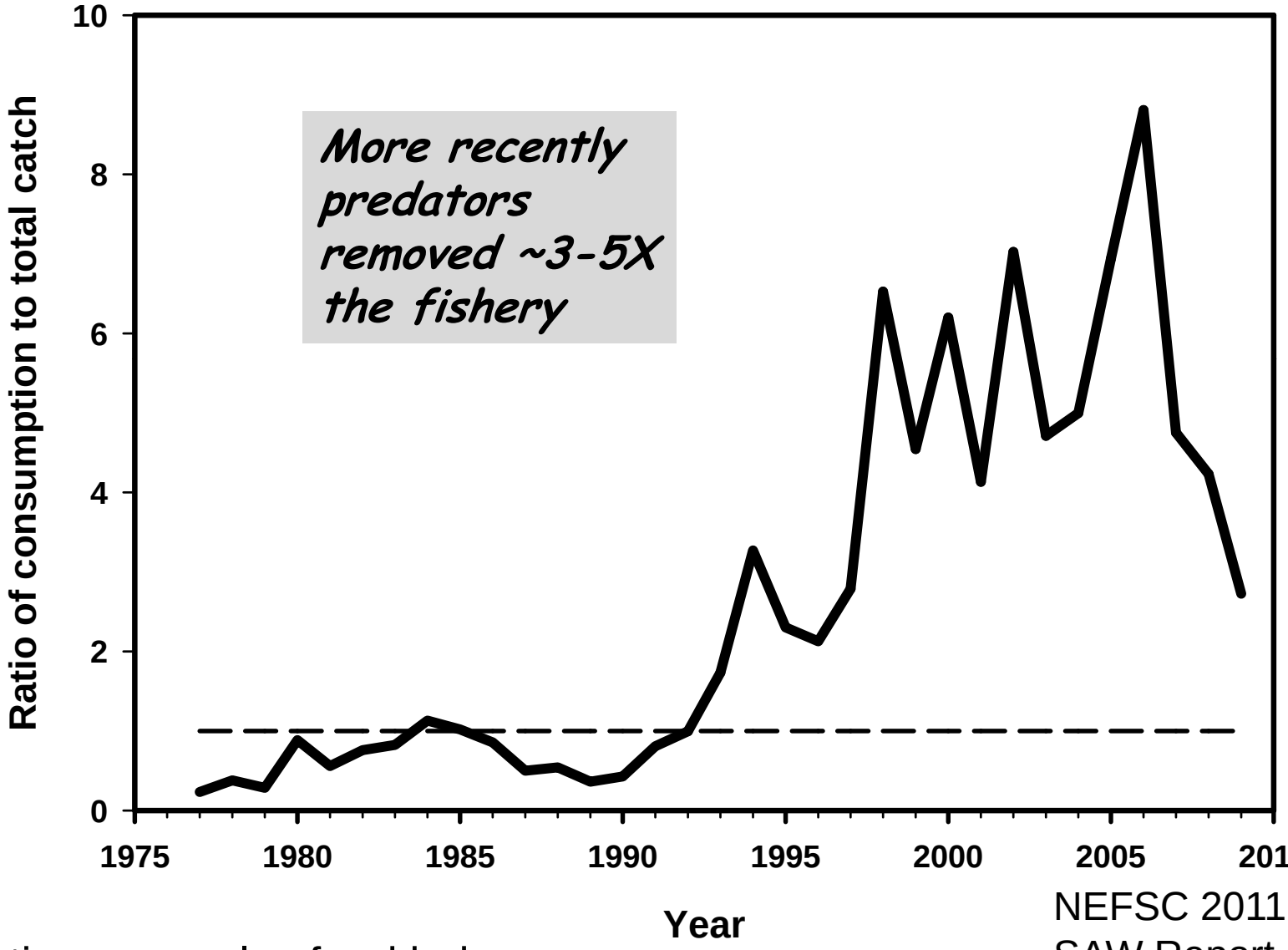



*More recently predators removed ~3X the fishery*

Removals of Atlantic herring

Overholtz & Link. 2007.
ICES J. Mar. Sci. 64:83-96.

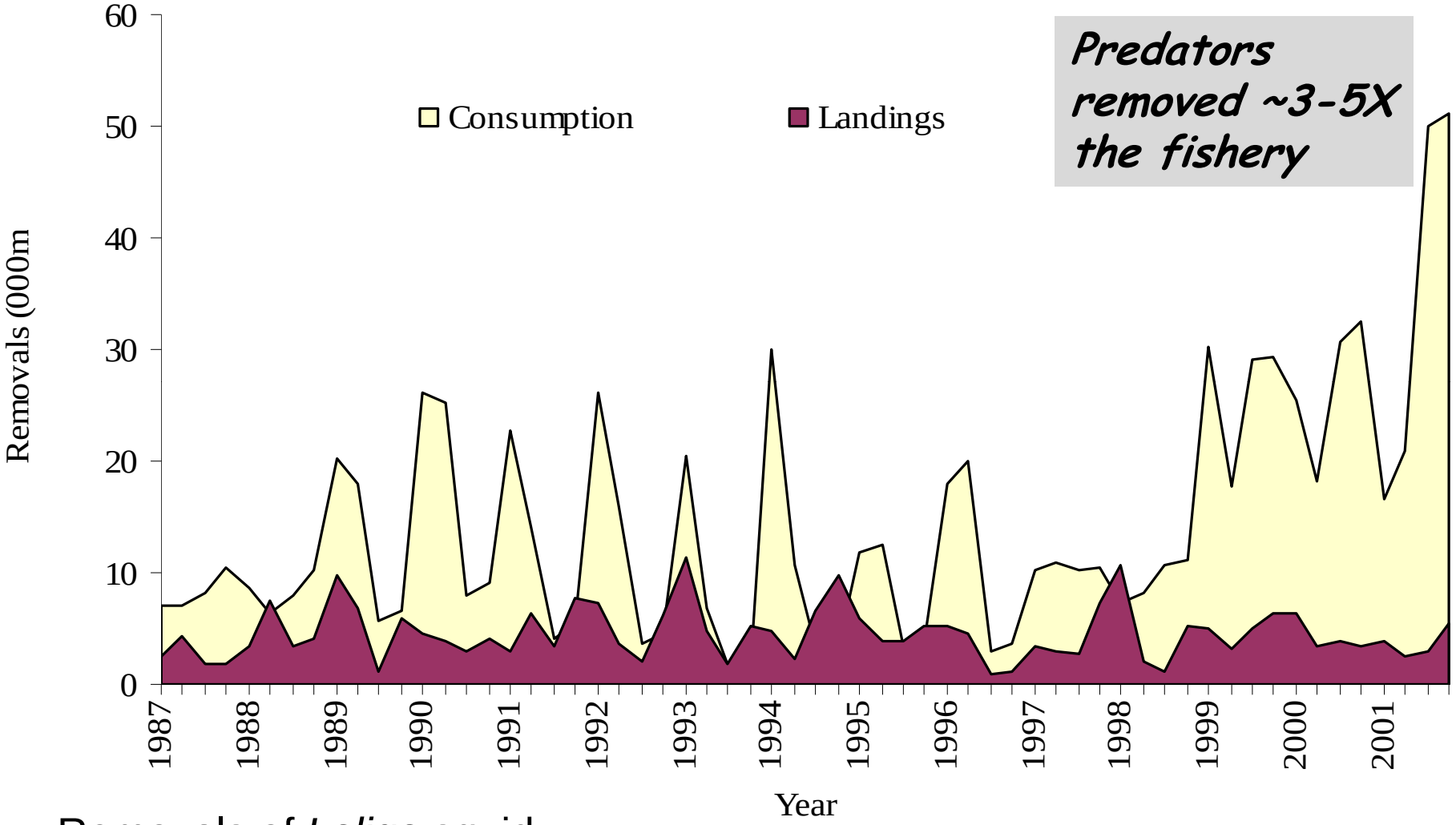
# Common Observations




Relative removals of red hake

NEFSC 2011. 51st SAW Report NEFSC CRD 11-01

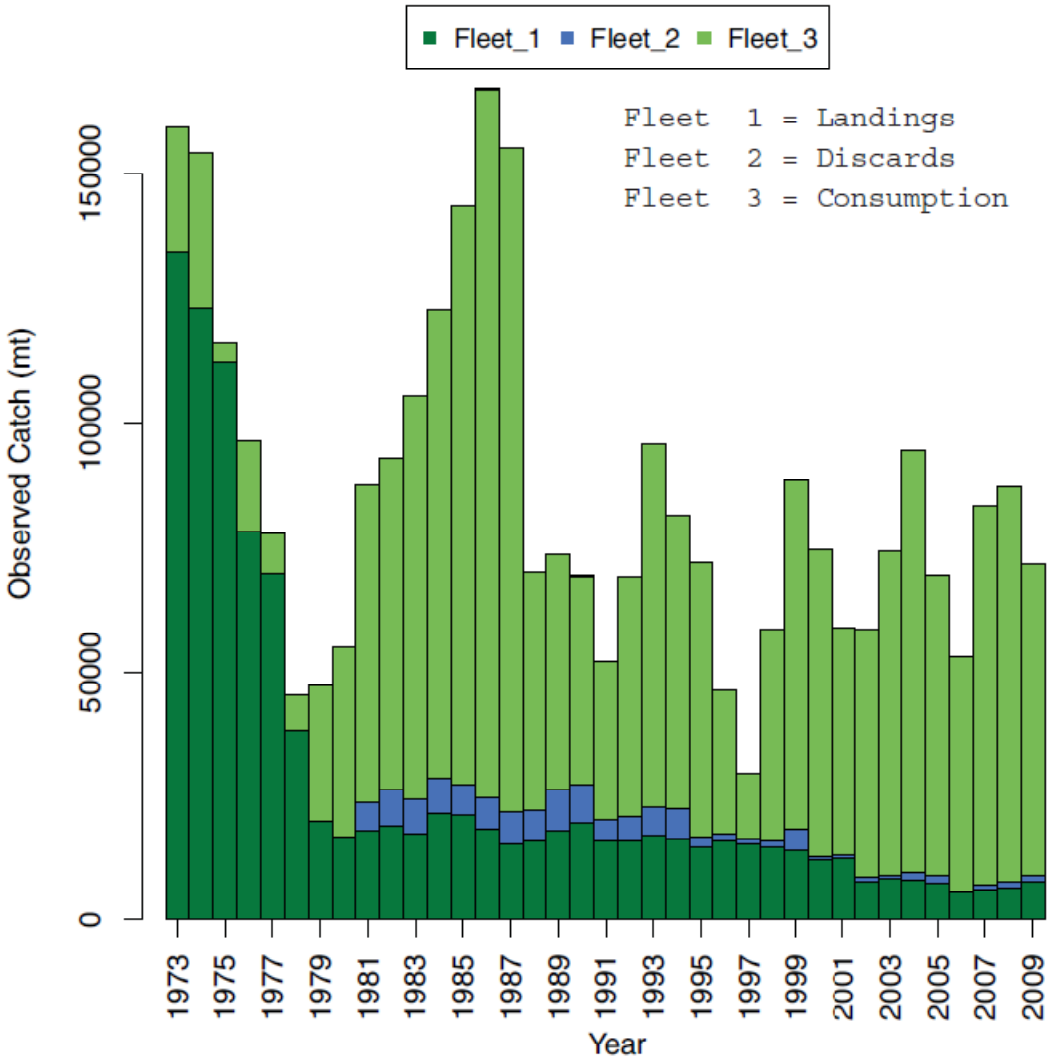
# Common Observations




Removals of *Loligo* squid

Moustahfid et al. 2008. *N. Am. J. Fish. Manag.* 29:1555-1566.

# Common Observations



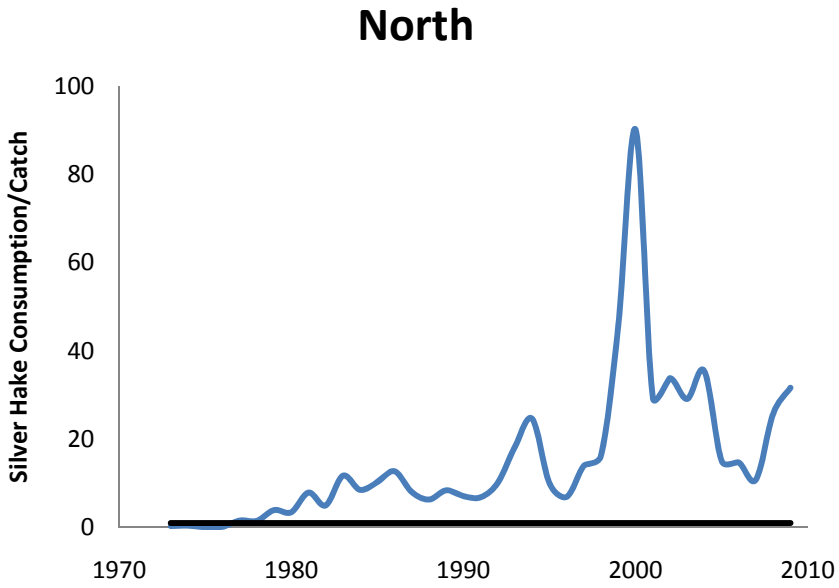

***Predation dominant source of removals***

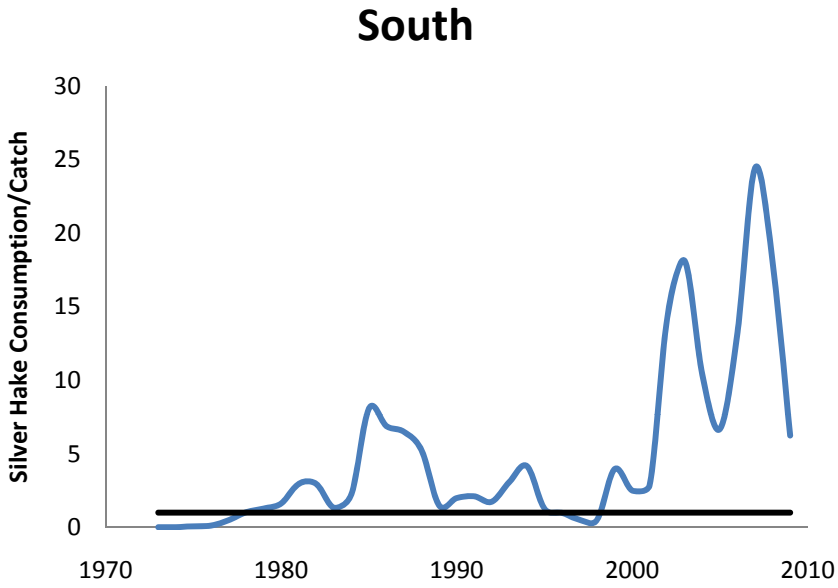
***Includes cannibalism***

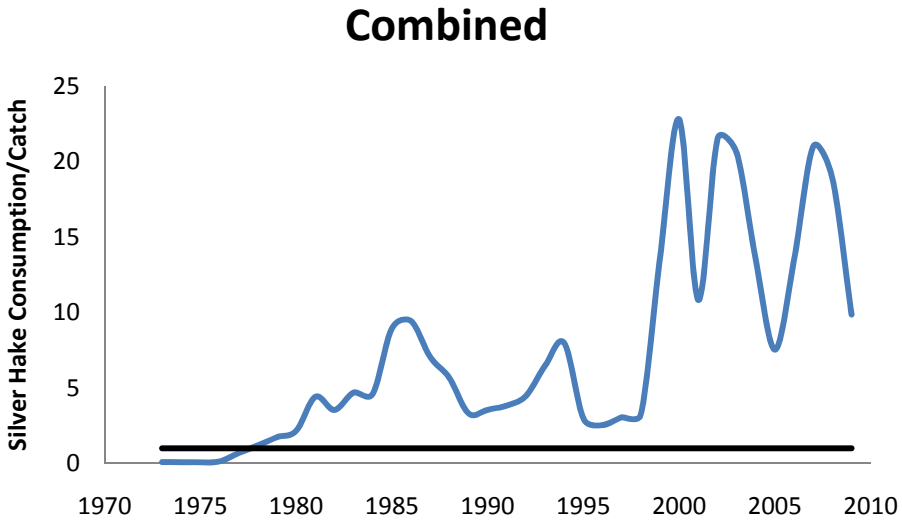
Removals for Silver hake

NEFSC 2011. 51st SAW Report NEFSC CRD 11-01

# Common Observations



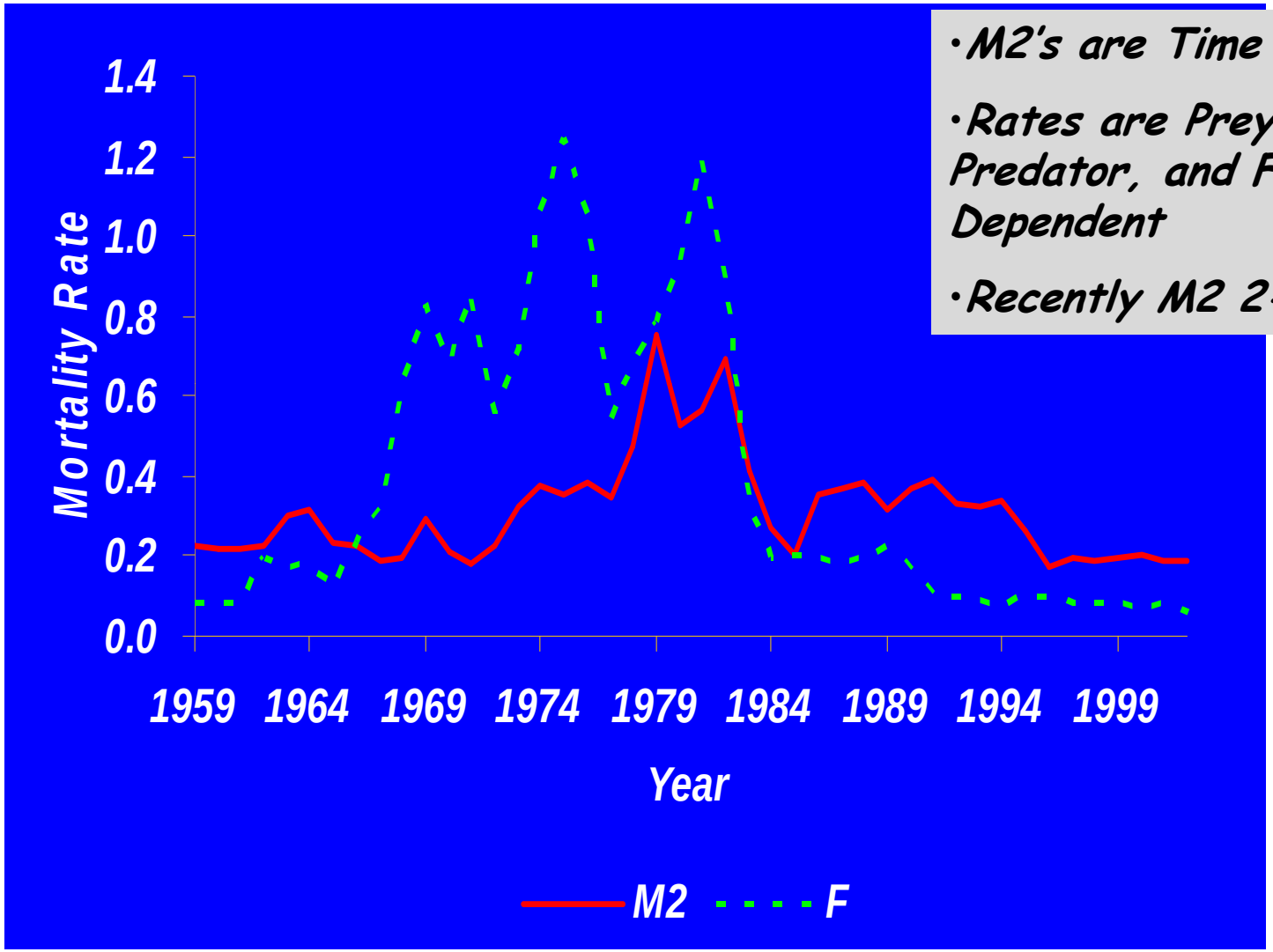




***Catch 5-20x lower than very minimal estimates of Predation***

NEFSC 2011. 51st SAW Report NEFSC CRD 11-01

Relative removals of silver hake

# Common Observations

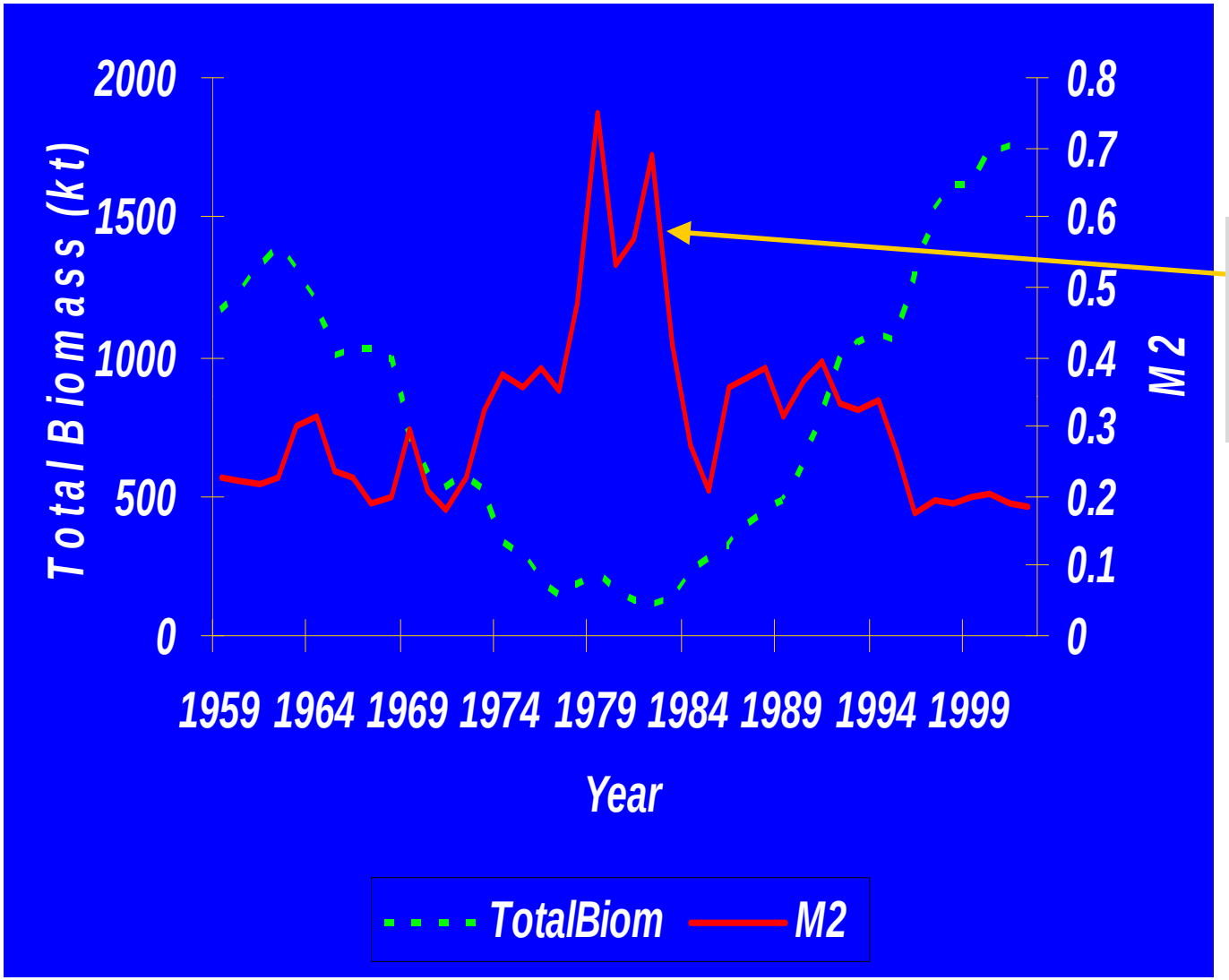



- *M2's are Time Variant*
- *Rates are Prey, Predator, and Fishery Dependent*
- *Recently M2 2-4X F*

Mortality rates (M2 & F) for Atlantic herring

Overholtz & Link. 2007.
ICES J. Mar. Sci. 64:83-96.

# Common Observations




***M2 was at its highest when herring B was the lowest***

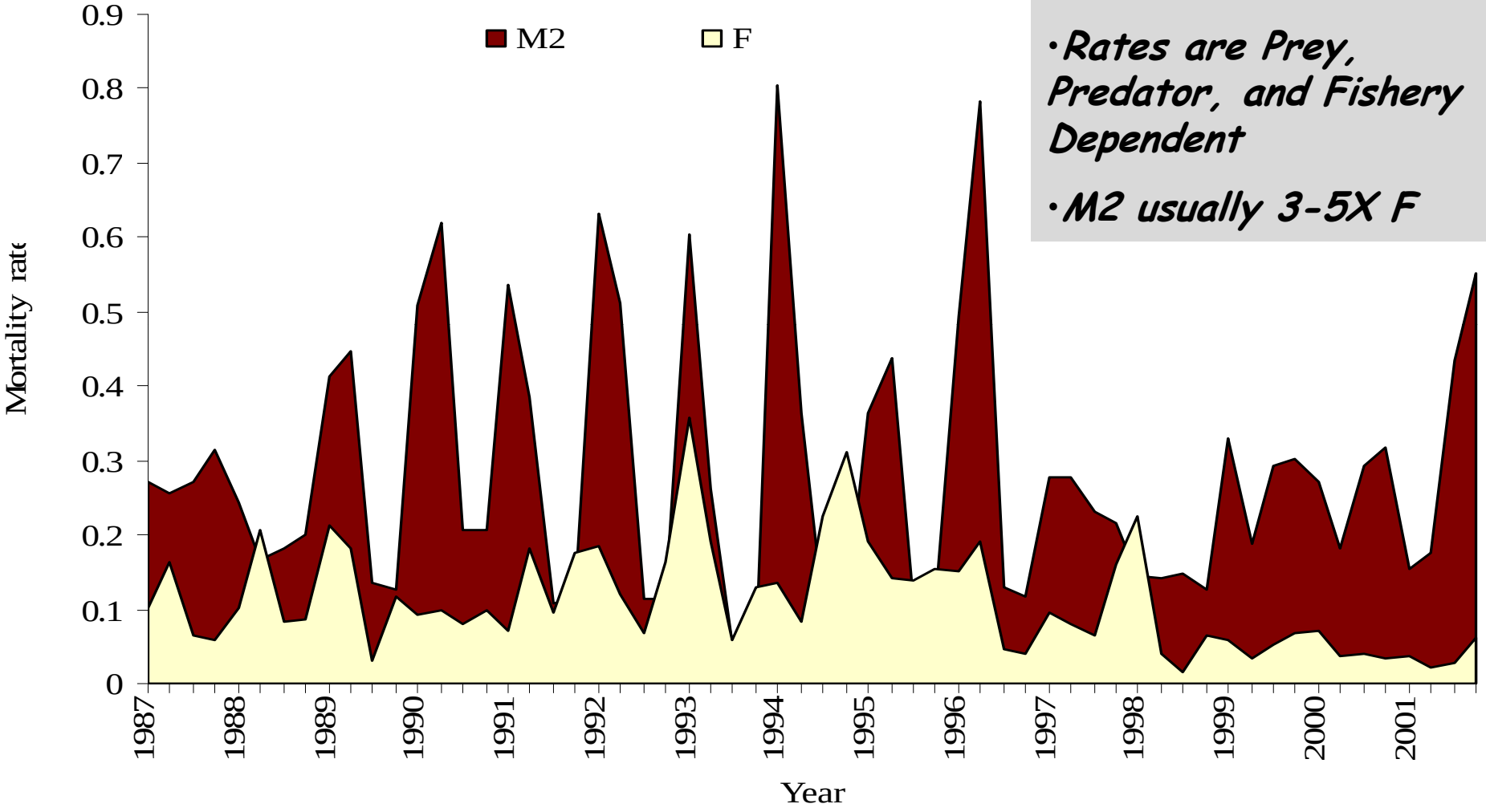
Overholtz et al. 2008. *N. Am. J. of Fish. Manag.* 28:247-257.

Atlantic herring M2 and B

Overholtz & Link. 2007. ICES J. Mar. Sci. 64:83-96.

# Common Observations

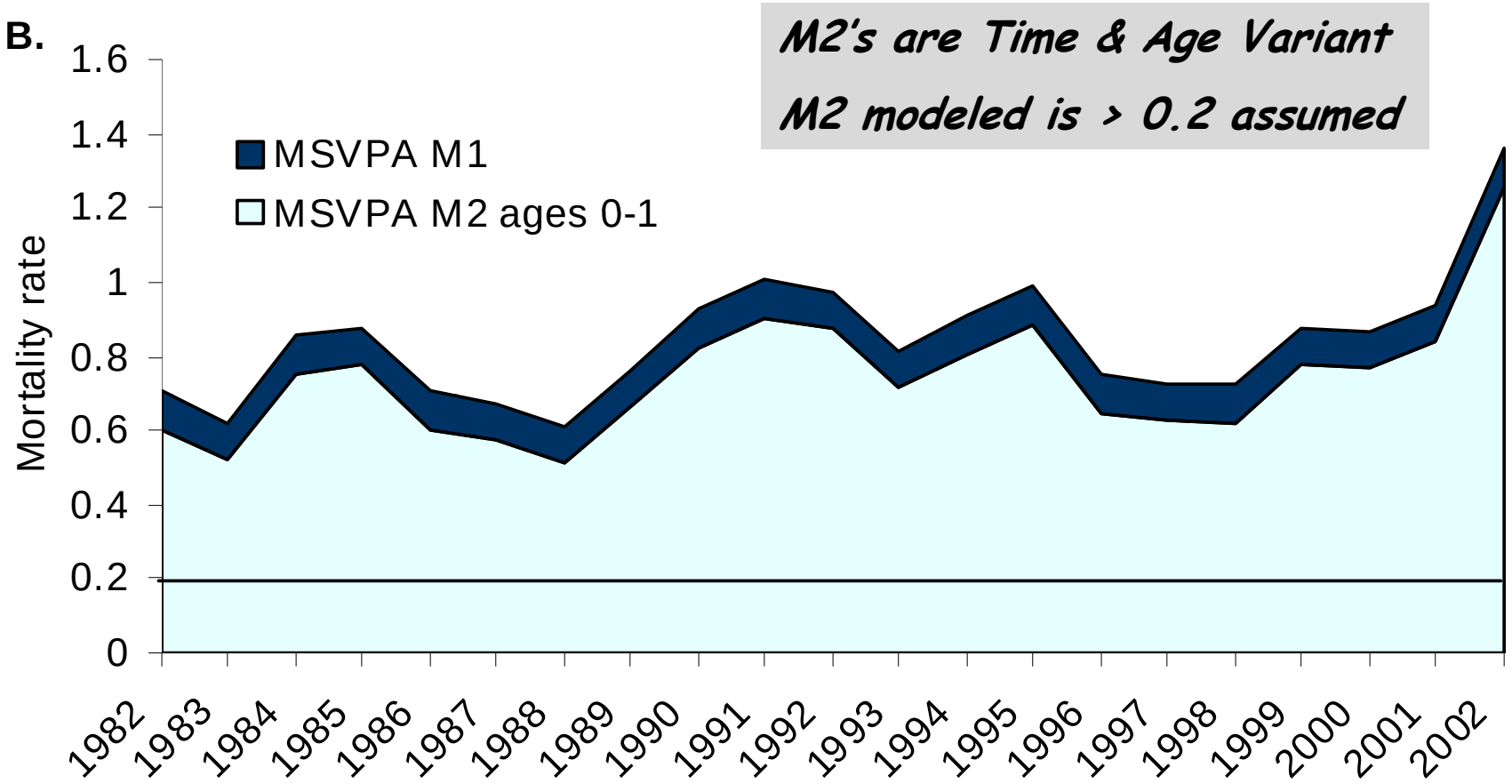
- ***M2's are Time Variant***
- ***Rates are Prey, Predator, and Fishery Dependent***
- ***M2 usually 3-5X F***




Mortality rates (M2 & F) for *Loligo* squid

Moustahfid et al. 2008. *N. Am. J. Fish. Manag.* 29:1555-1566.

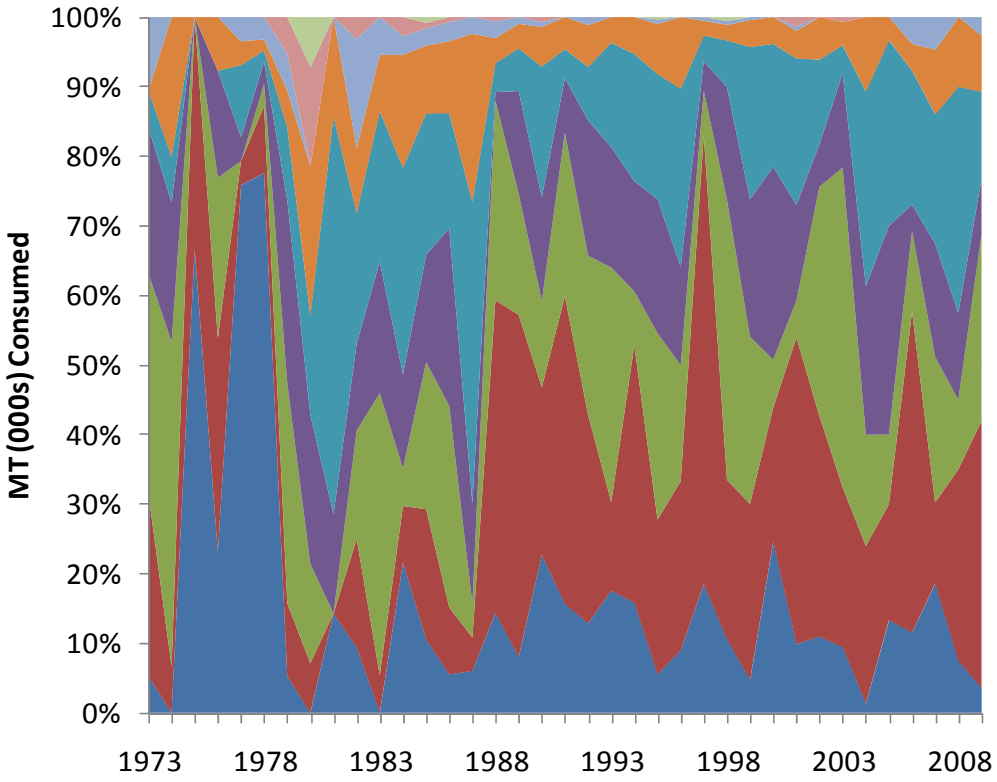
# Common Observations




Temporal variability in predation mortality on young age classes of Atlantic mackerel

Tyrrell et al. 2008. *ICES J. Mar. Sci. 65:1689-1700*

# Common Observations




***Most predation focused on < 20 cm hakes***

Proportion of silver hake consumed for various size classes.

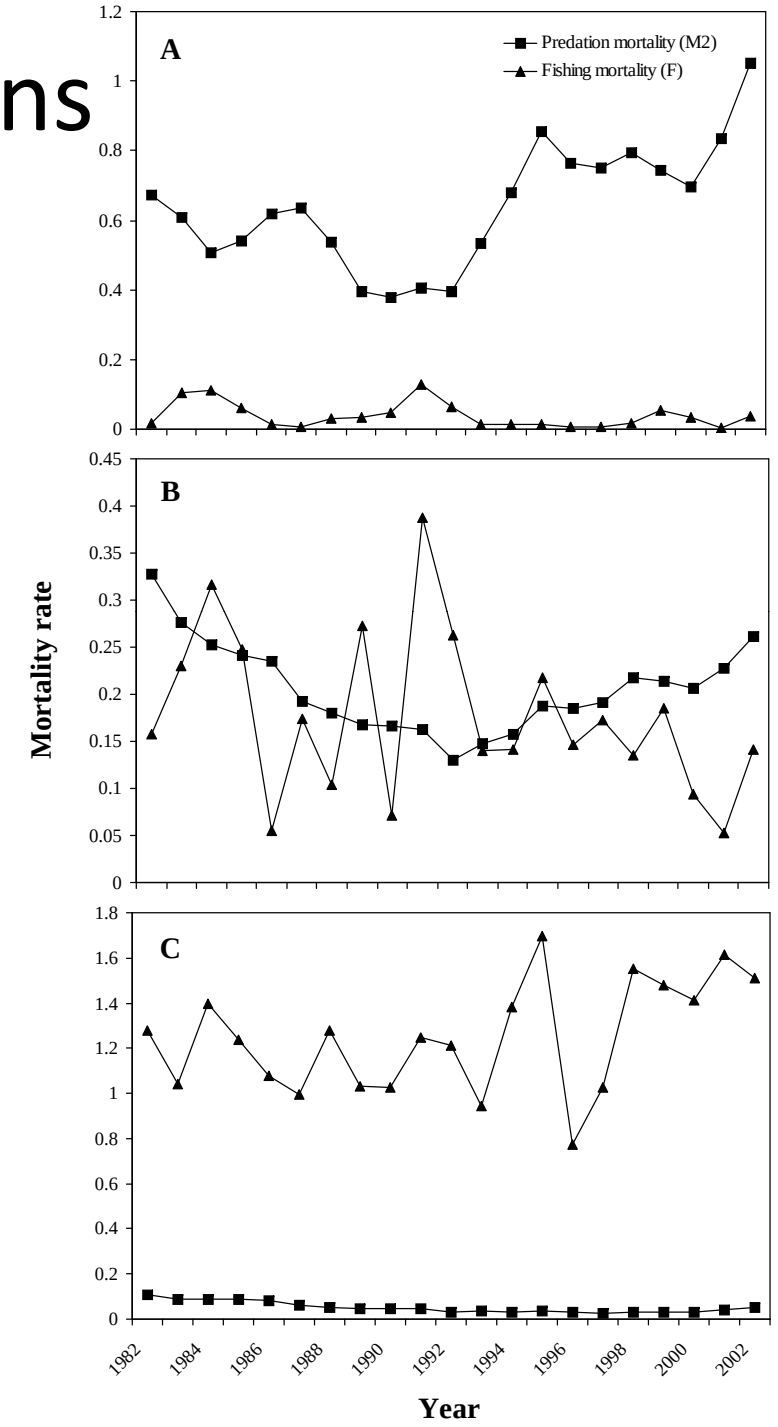
NEFSC 2011. 51st SAW Report NEFSC CRD 11-01

# Common Observations

***Most predation focused on younger ages, dampens after 2+***

***M2's are Age and Time Variant***

***M2 modeled is NE 0.2 assumed***




Mortality rates (M2 & F) for Menhaden at ages 0, 1 and 2

Garrison et al. 2008. *ICES J. Mar. Sci. 67: 856-870*

NOAA FISHERIES SERVICE

# Observations about Predation on Forage Stocks

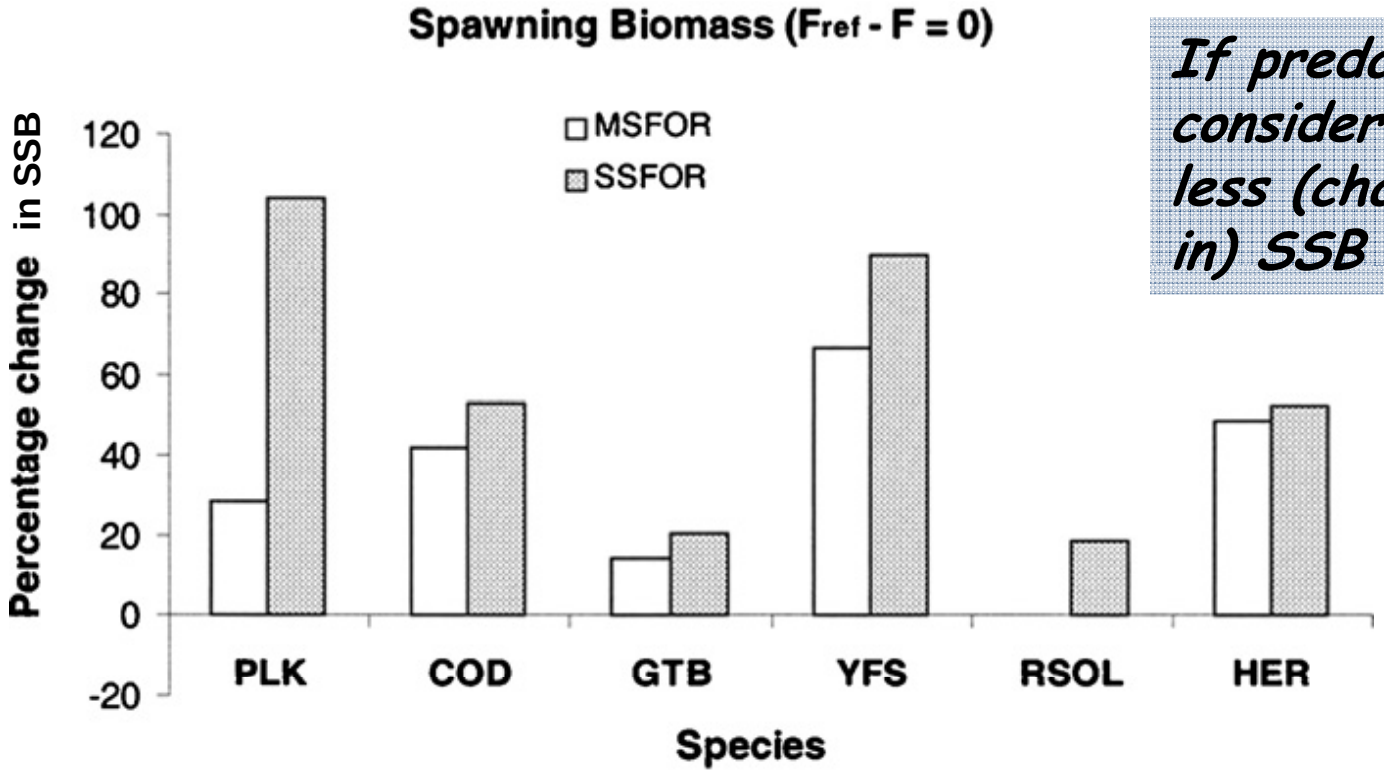
- Consumption to Catch (Landings) ratios for these stocks often >> 1
  - C/L ratio of ~1 implies that for total Z, F~M
    - Rule of thumb: worth considering at this level
  - Most C/L ratios 3-5X
- Similarly, it follows that M2 for these stocks is often >> than F
  - Most 2-4X higher

NOAA FISHERIES SERVICE

# Observations about Predation on Forage Stocks

- M2 is not:
  - 0.2,
  - age invariant,
  - nor time invariant
- M2 often focuses on younger age classes, but not always
  - Can influence recruitment successes
  - Some stocks vulnerable throughout life histories

# So what difference does it make?

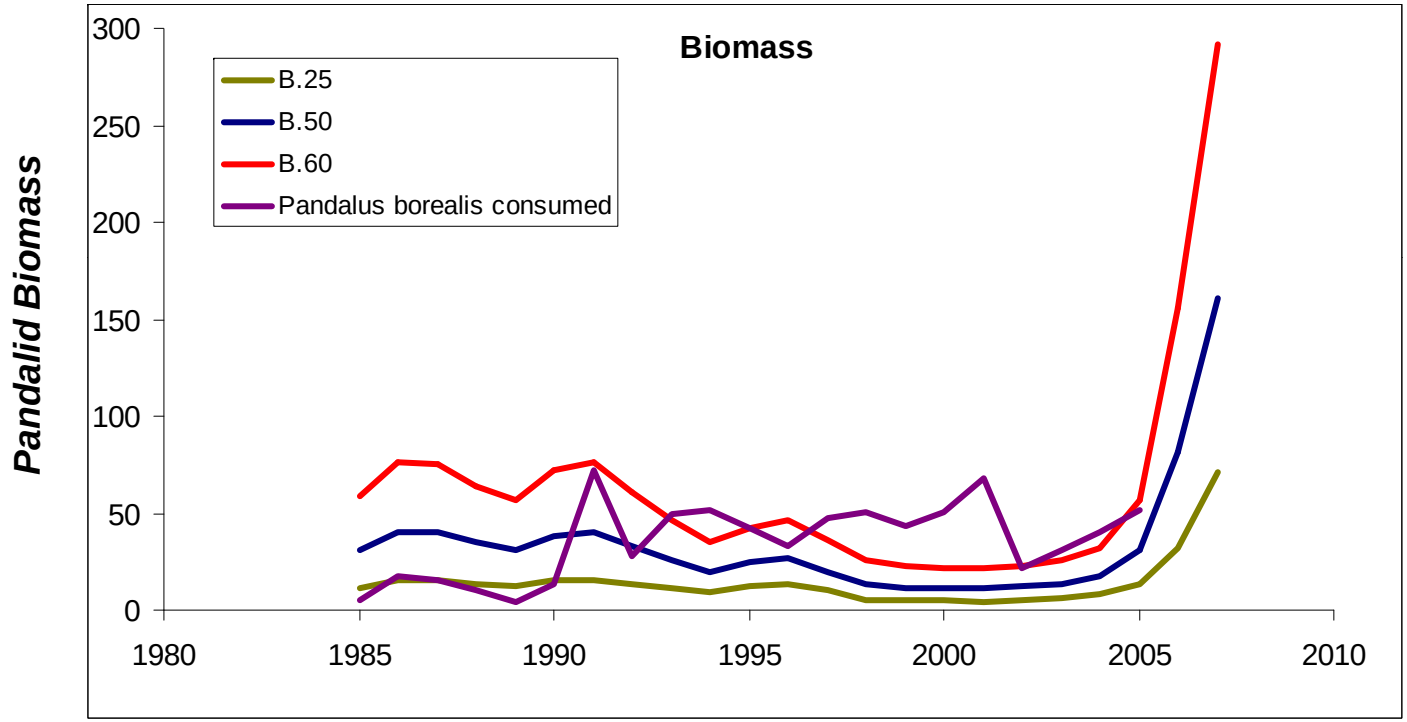



***If predators considered, less (change in) SSB***

**% change in SSB from forecasts w/ and w/o fishing**

Jurado-Molina & Livingston 2002. *N. Am. J. Fish. Manag*. 22:1164–1175

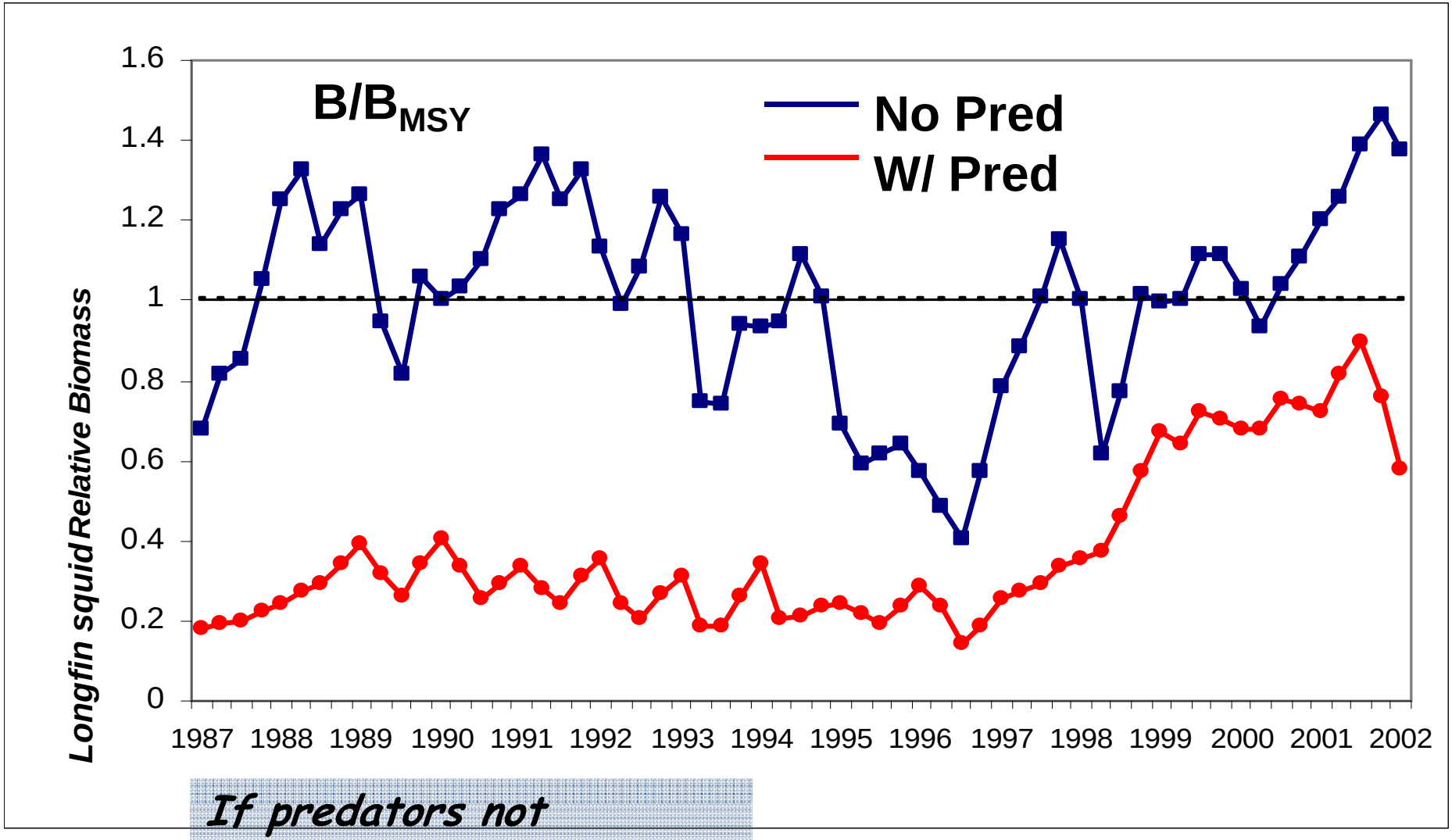
# So what difference does it make?




***Empirical estimates of B consumed by predators higher than existing modeled B; higher Ms suggested***

Link & Idoine 2009. *N. Am. J. Fish. Manag.* 29:1567-1583.

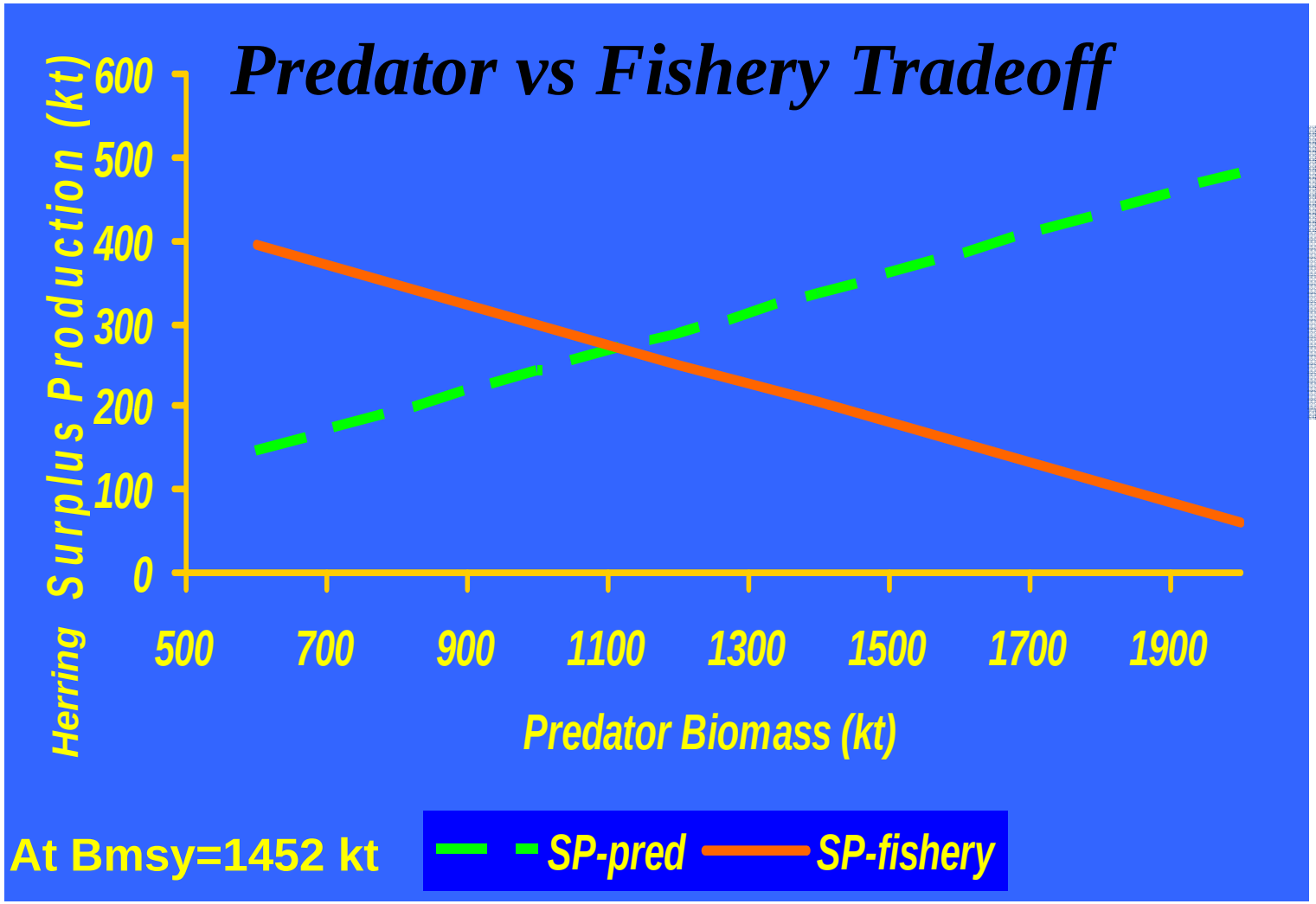
# So what difference does it make?




***If predators not considered, may actually be unknowingly below BRP***

Moustahfid et al. 2008. *N. Am. J. Fish. Manag.* 29:1555-1566.

# So what difference does it make?

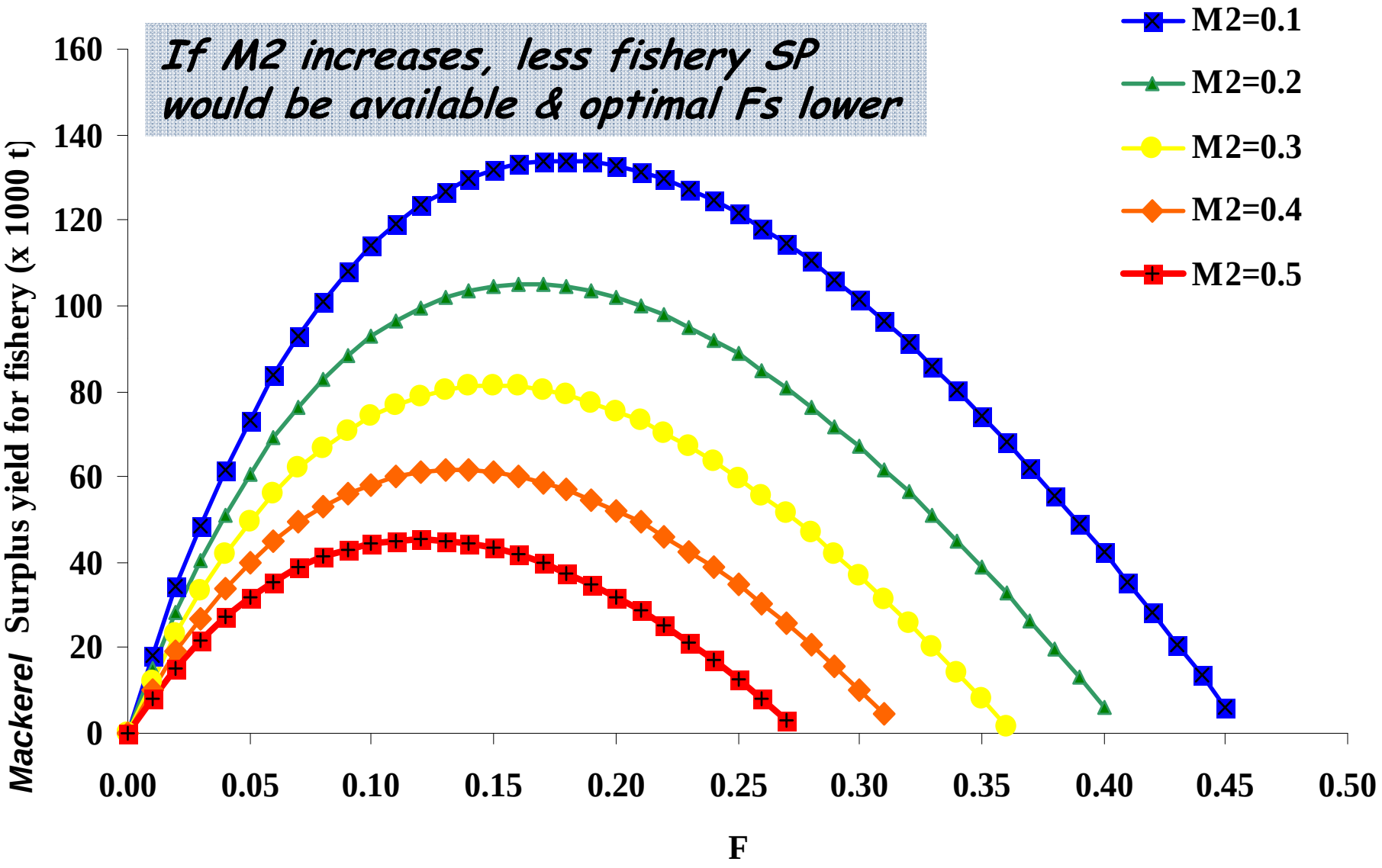



*If predators increase, less fishery SP would be available*

Overholtz et al. 2008. *N. Am. J. of Fish. Manag.* 28:247-257.

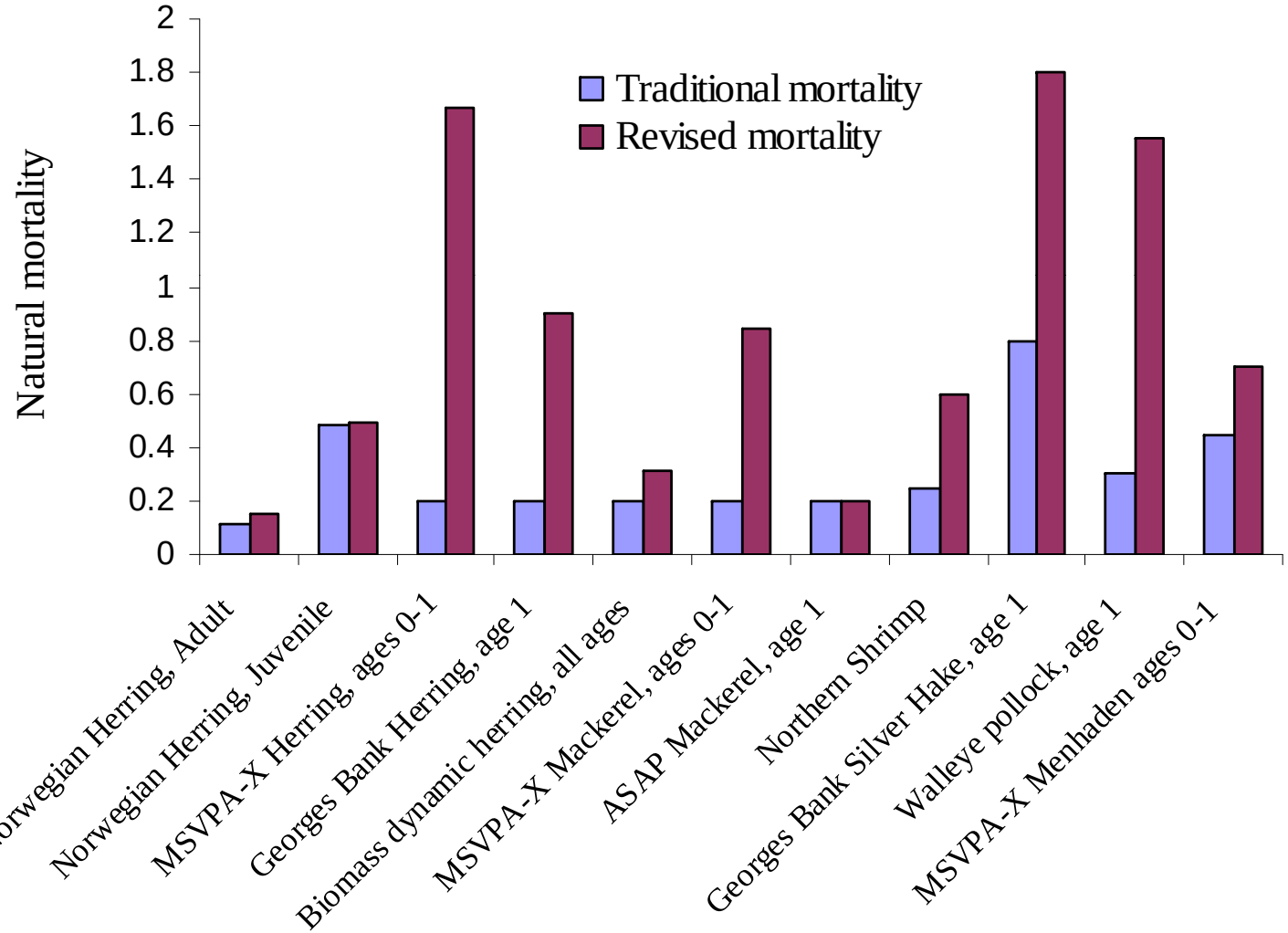
**SP available to predators and herring fishery at BMSY (1452 kt) for Predator B from 0.6-2.0 million t**

# So what difference does it make?




Moustahfid et al. 2009. *ICES J. Mar. Sci. 66: 445-454*

# So what difference does it make? From a global meta analysis



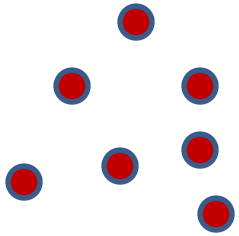

Tyrrell et al. 2011 *Fish. Res. 108:1-8*

# So what difference does it make? From a global meta analysis

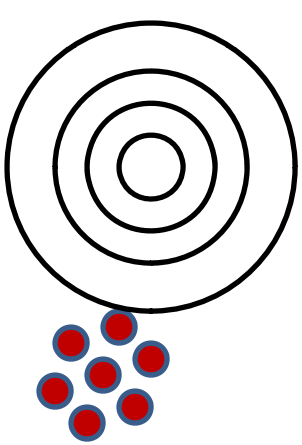
- Conundrum:
- MSY estimated w/pred included 1.5-4x higher
- But, …
- total Z higher, and allocating across “fleets” means:
- M2 higher and F lower
- Thus, lower B available for fishery harvest

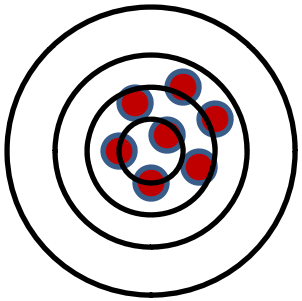
Tyrrell et al. 2011 *Fish. Res. 108:1-8*

Precision important



but Accuracy
even more so





NOAA FISHERIES SERVICE

# EBFM and the issue of Predation on Forage Stocks

- Is clearly important and clearly needs to be accounted for
  - Routinely different BRPs (both F and B), often by 20% or more
- Does yet not fully consider other elements of the ecosystem
  - Effects on ecology on the stocks shown
  - Effects of the stocks on ecology of other organism not shown here
    - food requirements for predators, tradeoffs among biota, etc. being explored with different sets of approaches

NOAA FISHERIES SERVICE

# EBFM and the issue of Predation on Forage Stocks

- Is Legal to address
  - Perhaps even required?!?

NOAA FISHERIES SERVICE

# EBFM Intersection with NS Guidelines

1. Conservation and management measures shall prevent overfishing while achieving on a continuing basis, the optimum yield from each fishery for the United States fishing industry.
    - Many Ecosystem Issues here
2. Conservation and management measures shall be based upon the best scientific information available.
    - Many Ecosystem Issues here

NOAA FISHERIES SERVICE

# EBFM Intersection with NS Guidelines

6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.
    - Some Ecosystem Issues here
7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.
    - Some efficiency Issues here

See also NSG 3 (stock area), 9 (bycatch)

NOAA FISHERIES SERVICE

# EBFM and the issue of Predation on Forage Stocks

- Is Feasible to address
  - Extant analytical tools
  - A proposed protocol
  - Doable even for data poor situations

NOAA FISHERIES SERVICE

# A Proposed Protocol for use in Stock Assessments

1. Is stock known or strongly suspected to be consumed by many other fish, mammal, bird or invertebrate predators? Is the stock or species a classic “forage species”?

   Y continue

   N stop, Calculate BRPs and stock status without predation mortality considered

NOAA FISHERIES SERVICE

# A Proposed Protocol for use in Stock Assessments

2. Does the stock also support a fishery?

   Y continue

   N population modeling is solely ecological; calculation of BRPs are not likely unless as an index or “ecosystem” species

3. Do any food habits data confirm the trophic demands on the stock?

   Y continue to direct approaches

   N continue to indirect approaches (6)

NOAA FISHERIES SERVICE

# A Proposed Protocol for use in Stock Assessments

4. Direct approaches

   Is there sufficient time series of food habits and predator abundance data to estimate, validate and calculate consumption?

   Y continue to use in various models (5)

   N continue to indirect approaches (6)

5. Insert estimates of consumptive removals into various MRM models, akin to another “fleet”

Partition mortality and estimate M2 as part of Z (where Z = F + M and M = M1 +M2)

Calculate BRPs and stock status accordingly

NOAA FISHERIES SERVICE

# A Proposed Protocol for use in Stock Assessments

6. Are there estimates of predator biomass or abundance data?

   Y continue to indirect approaches (7)

   N continue to different indirect approaches (8)

7. Fit statistical models and functional forms of consumption using predator models based on various known relationships of predator to prey abundance.

Use to inform ontogenetic (if germane) and time variant M2

Calculate BRPs and stock status accordingly

NOAA FISHERIES SERVICE

# A Proposed Protocol for use in Stock Assessments

8. Use dynamic modeling techniques and include time varying (and age varying, if appropriate) M's as informed by whatever relevant/covarying information are available

Calculate BRPs and stock status accordingly

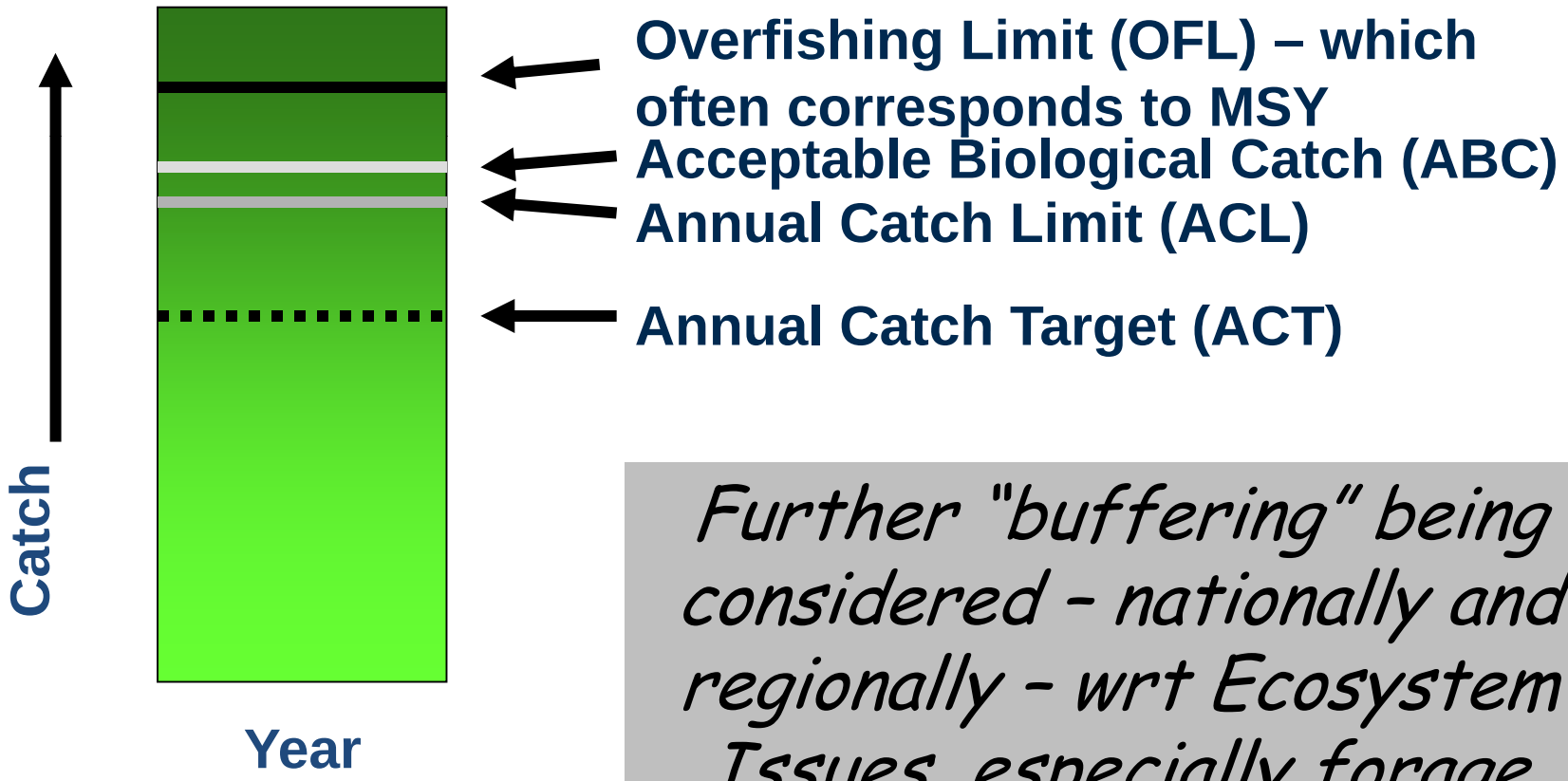
Else

Calculate BRPs and stock status without predation mortality considered

Then reduce allowable catch limits, etc. by allowing for some precautionary level of stock escapement

# EBFM Intersection with ACL setting

**Definition Framework: OFL ≥ ABC ≥ ACL > ACT**




*Further "buffering" being considered – nationally and regionally – wrt Ecosystem Issues, especially forage*

NOAA FISHERIES SERVICE

# Summary

- EBM is here, is not going away and is feasible to implement
- For LMRs, the issue of predation on forage is apt to be high profile and a good case study for EBFM
- For managing forage stocks, it has been shown that incorporating predation is important and ramifications not subtle
- There are several extant tools and approaches to address this issue