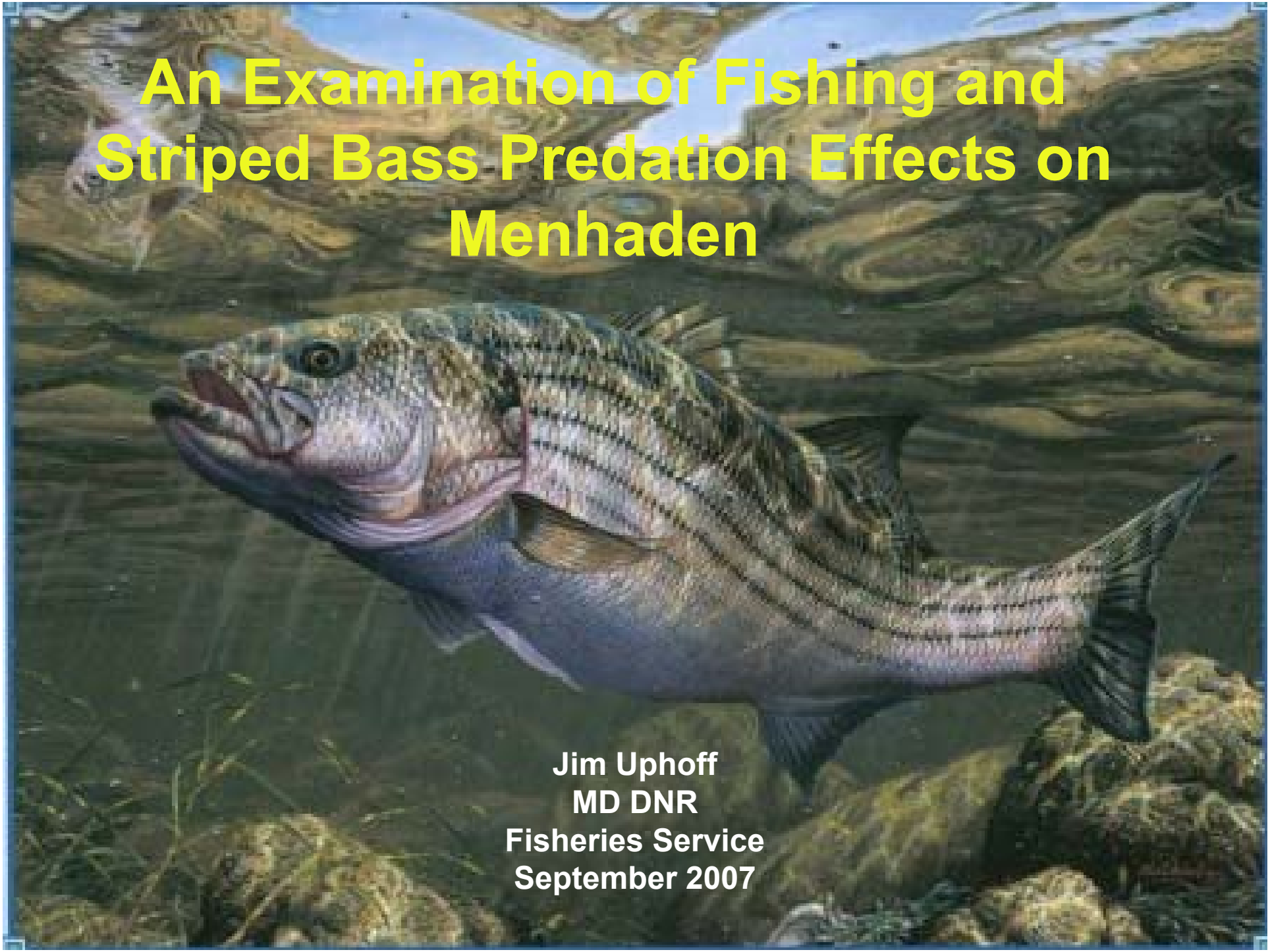
An Examination of Fishing and Striped Bass Predation Effects on Menhaden



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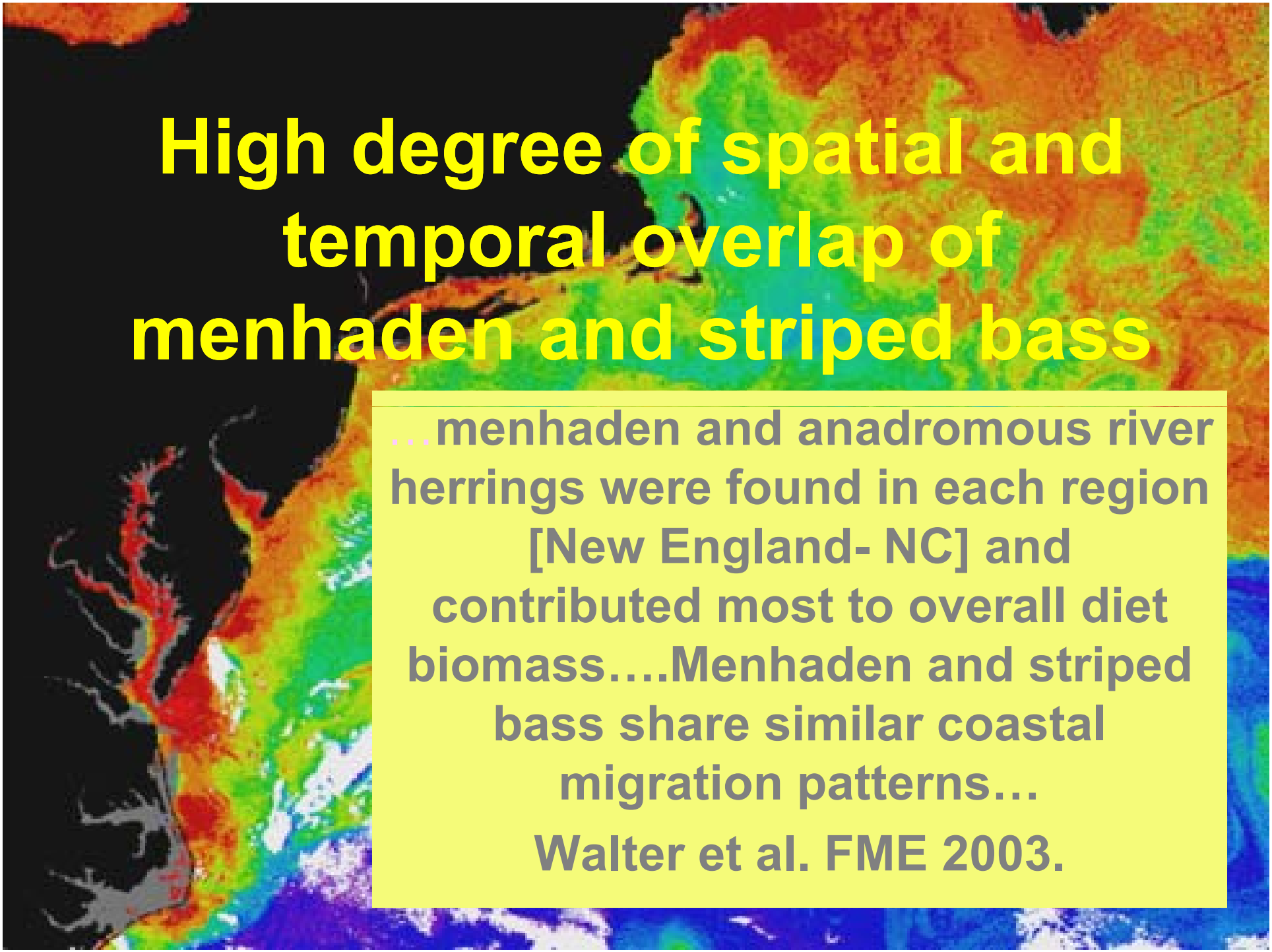
Empirical, Statistical, Model Approach

- ***Empirical – (biological)***
  - ***Motive* - Does predator consume candidate species?**
  - ***Means* - Is gape of large enough to consume prey of all sizes?**
  - ***Opportunity* - Temporal and spatial match between predator and prey?**
- ***Statistical***
  - ***Regression and correlation***
- ***Model***
  - ***Production models***
  - ***Single species vs predator-prey addition***

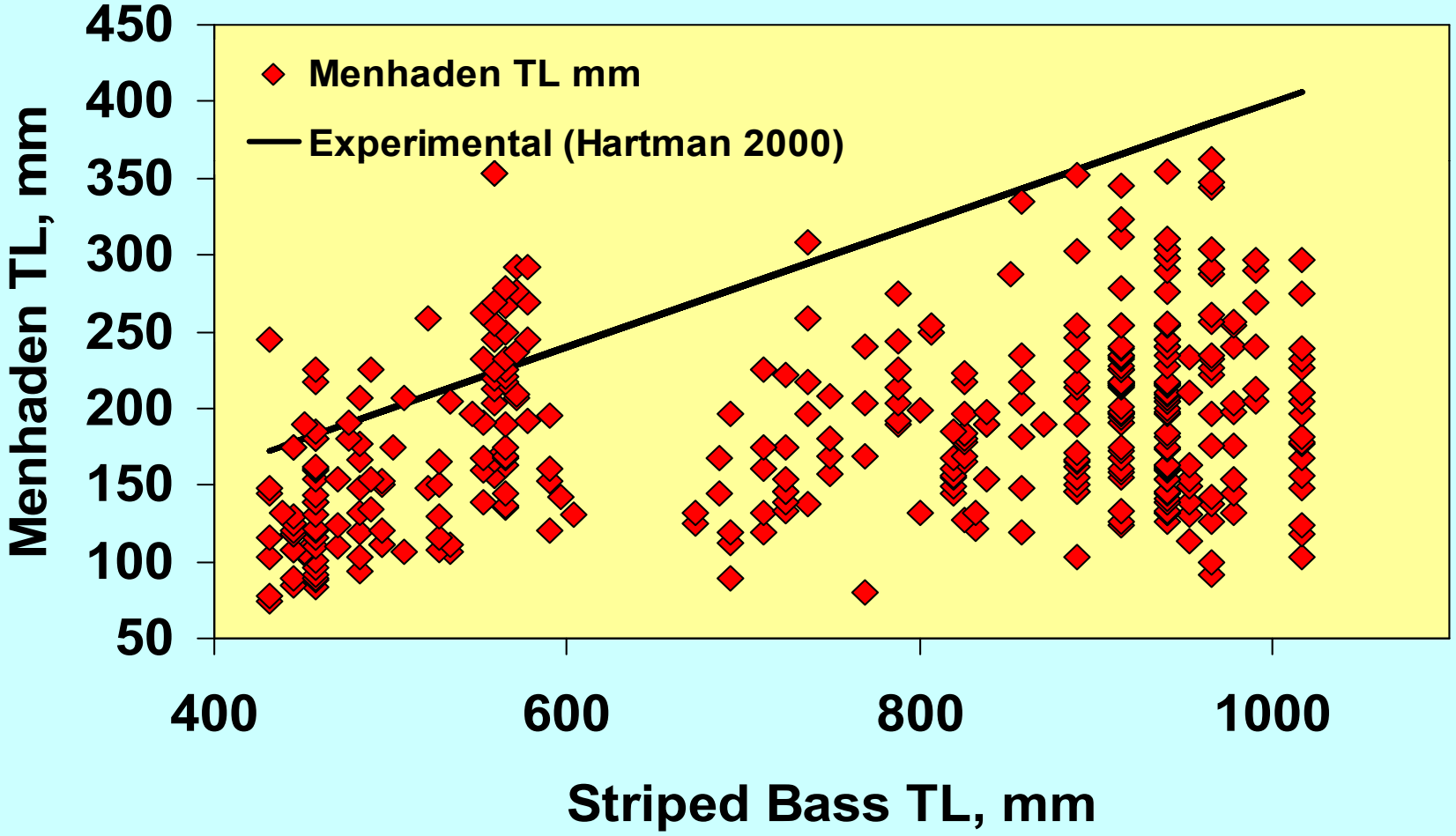


High degree of spatial and temporal overlap of menhaden and striped bass

…menhaden and anadromous river herrings were found in each region [New England- NC] and contributed most to overall diet biomass….Menhaden and striped bass share similar coastal migration patterns…

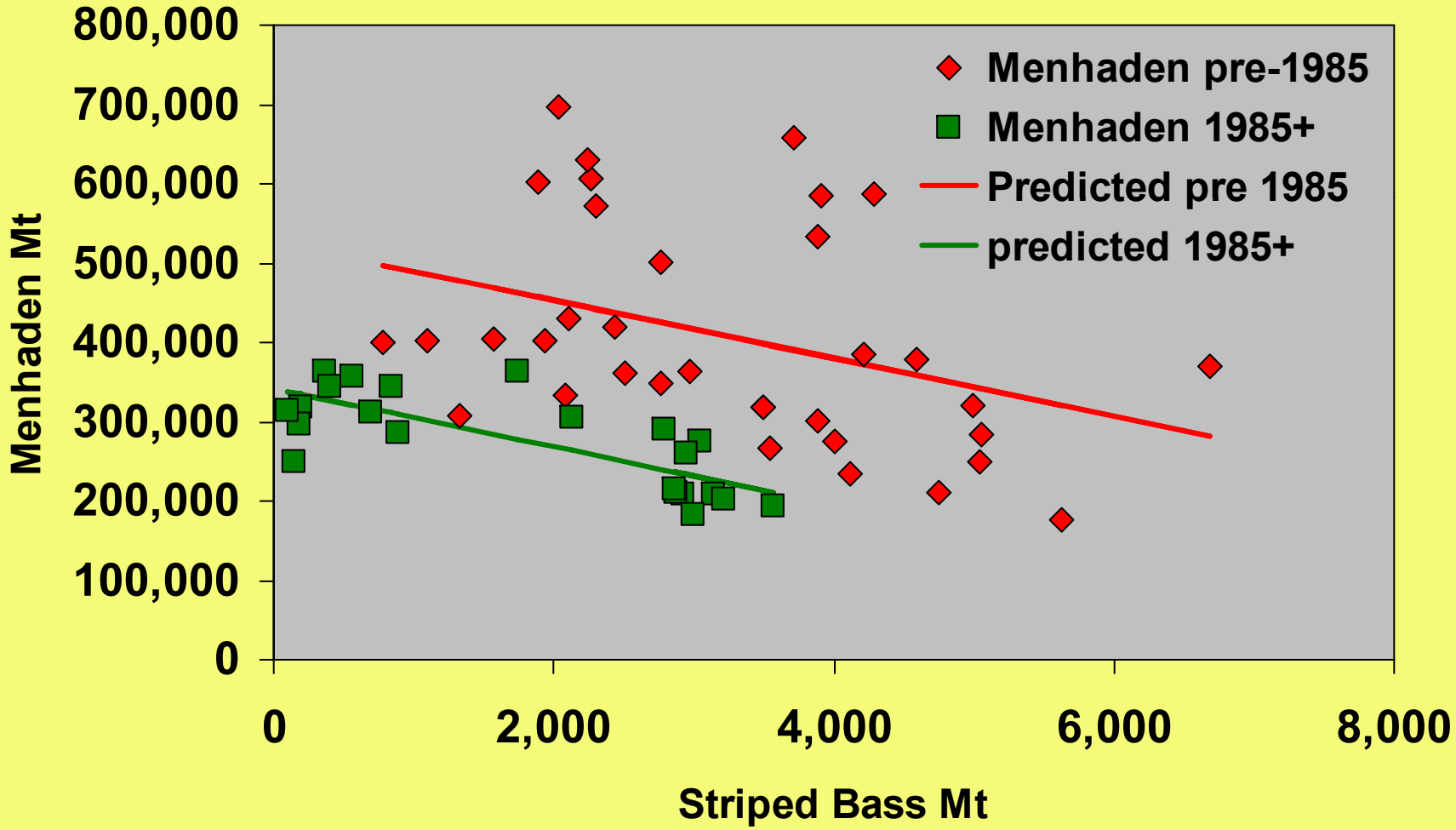
Walter et al. FME 2003.

Length of striped bass versus length of menhaden consumed in MD Bay April 2006 - February 2007 (CBEF & ECU). Corresponds to all ages of menhaden.

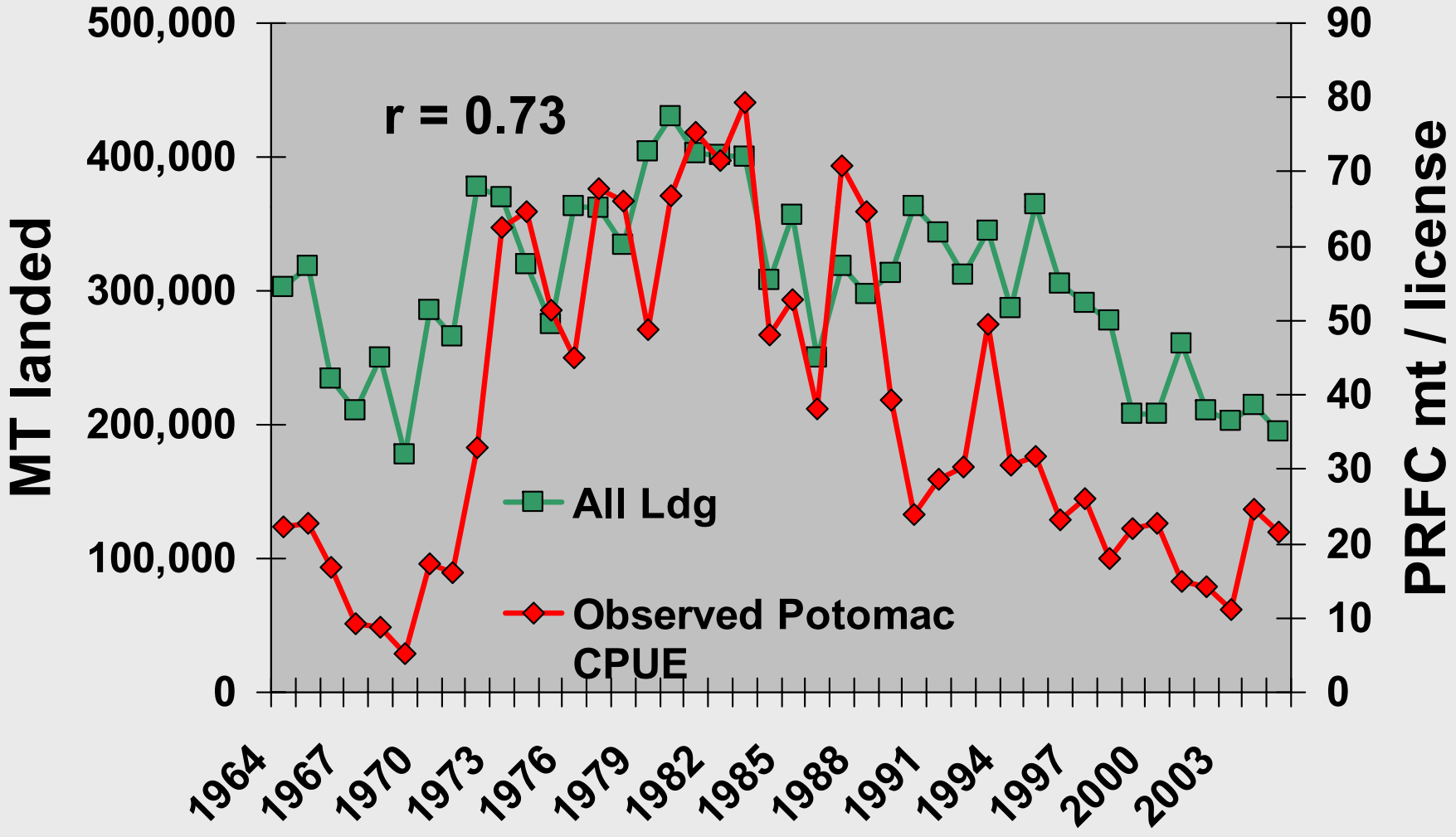


Categorical regression of commercial landings. Menhaden vs striped bass landings with lightly regulated (1950-1984) and regulated bass period categories (1985-2005).

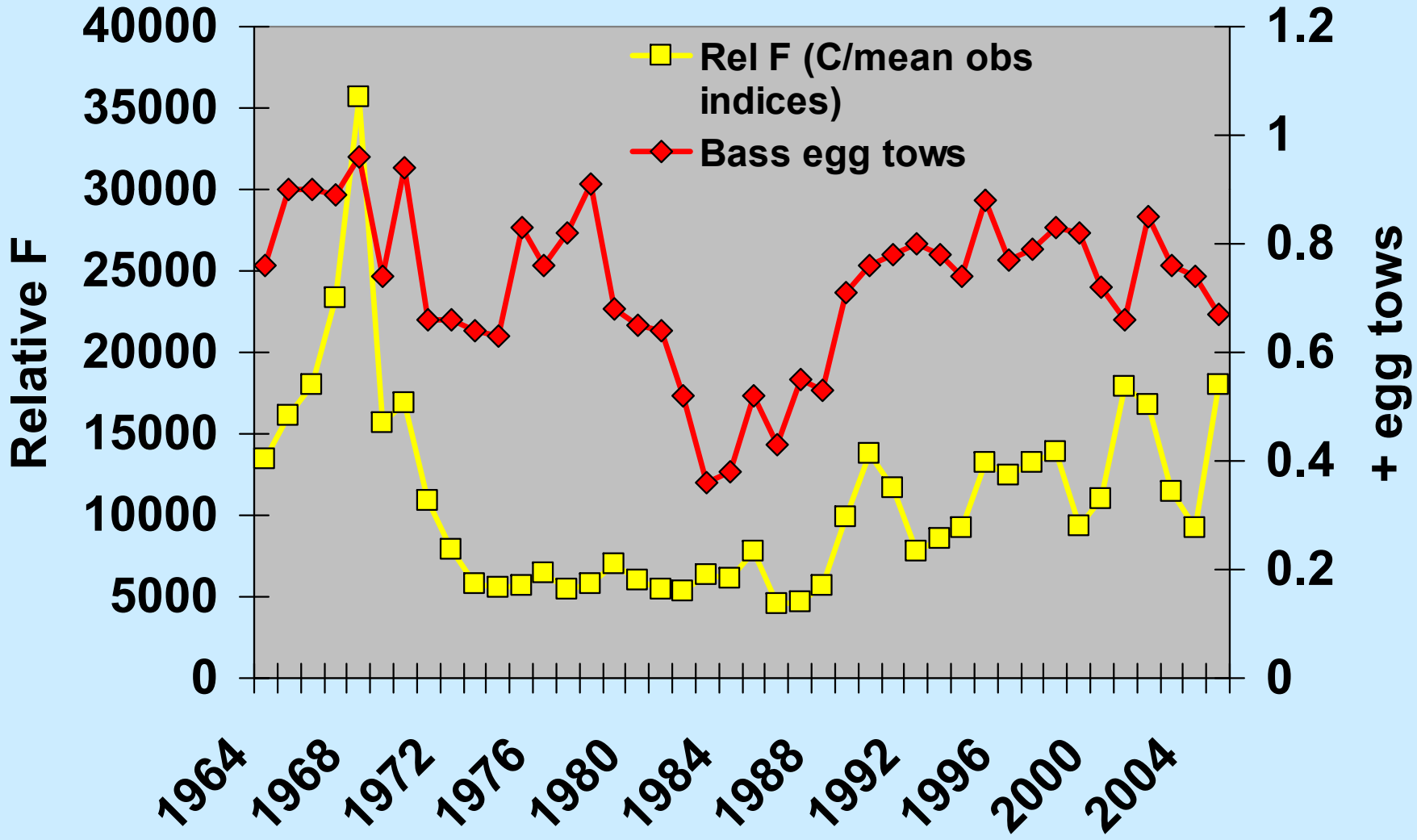
All terms significant $P<0.001$, $r^2 = 0.38$



Atlantic menhaden: Atlantic Coast landings and PRFC mt / license index



Atlantic Coast Menhaden Relative F and striped bass egg tows (age 6+ biomass index)

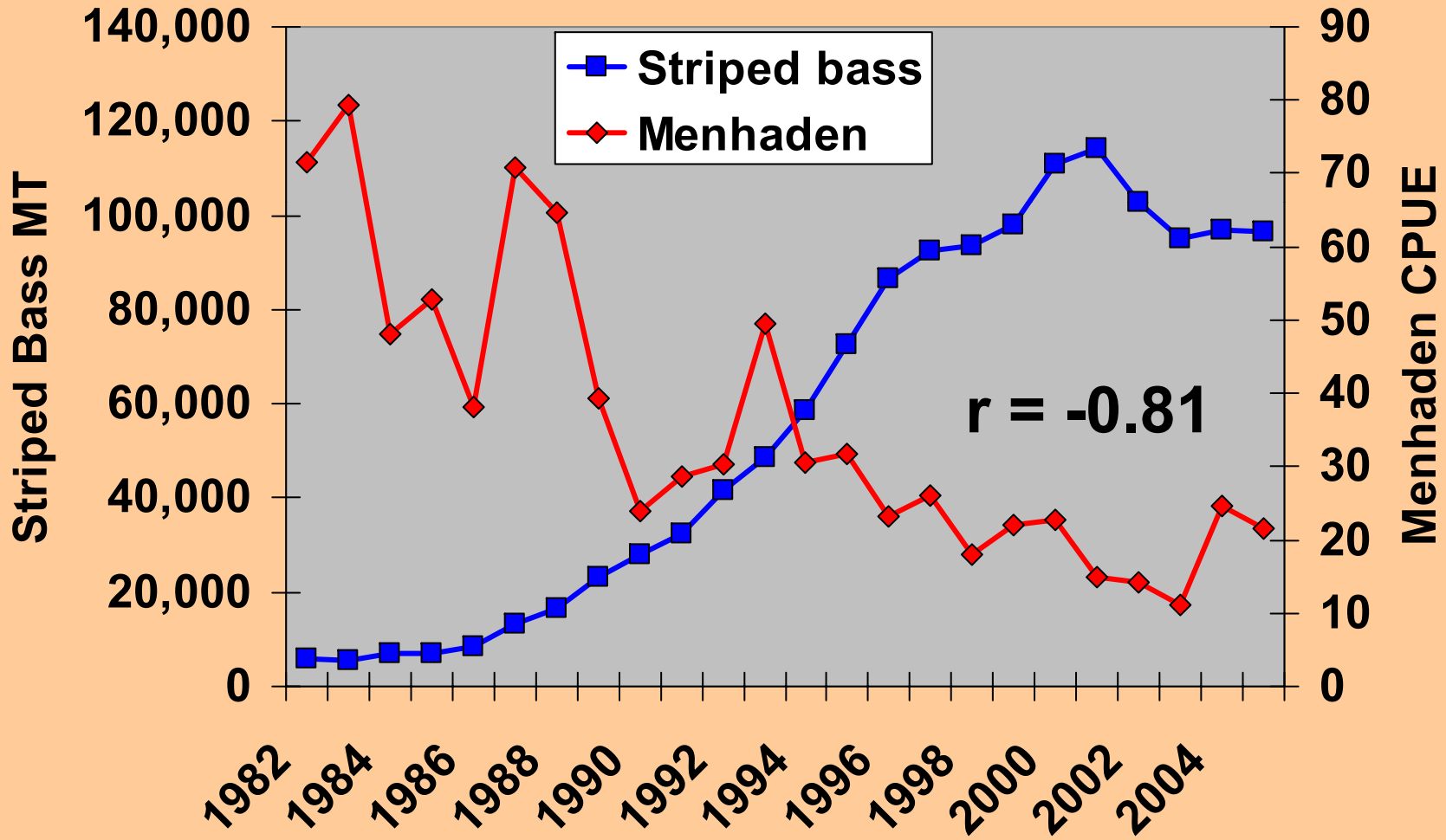


Correlations of menhaden relative abundance, menhaden relative F, and relative large striped bass biomass, 1964-2005

	MT / PRFC license	Bass Egg tows
Menhaden Relative F	-0.75	+0.58
Bass Egg tows	-0.55	

Bluefish & weakfish positively correlate w/ menhaden & negatively w/ bass

Menhaden relative biomass index and striped bass biomass (ages 2+) from VPA



Could menhaden M have changed?
Steele and Henderson Predator-Prey Model
Logistic biomass dynamic model with predation.
Does a predator make a difference?

INPUTS	DETAILS
• Menhaden catch per license index • Harvest • Striped bass biomass	• Spreadsheet • Logistic with type III predator fc • Evolver genetic algorithm super-solver • Bootstrapping or jacknife • Sensitivity analyses (time-blocks removed)

Steele Henderson Model: Biomass dynamic model with additional non-equilibrium M

$$B_t = B_{t-1} + rB_{t-1}\,(1-(B_{t-1} / K)) - C_{t-1} - D_{t-1} + \varepsilon;$$

D_{t-1} = predation deaths based on type III predator-prey function

$$[(cP_{t-1}(B_{t-1})^2)/(A^2+(B_{t-1})^2)];$$

where c = maximum per capita consumption and

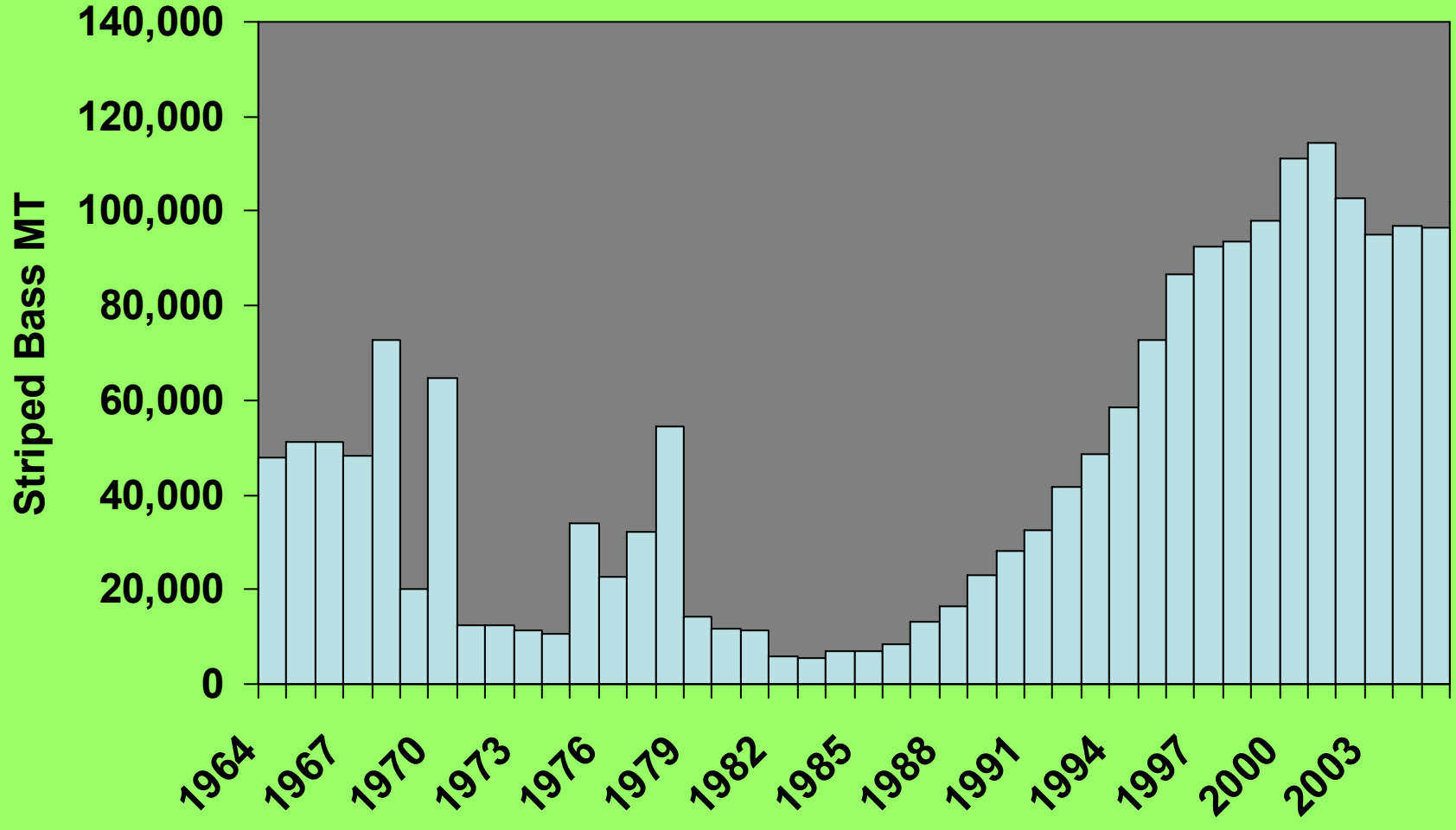
A = prey biomass where predator satiation begins.

Estimating F&M

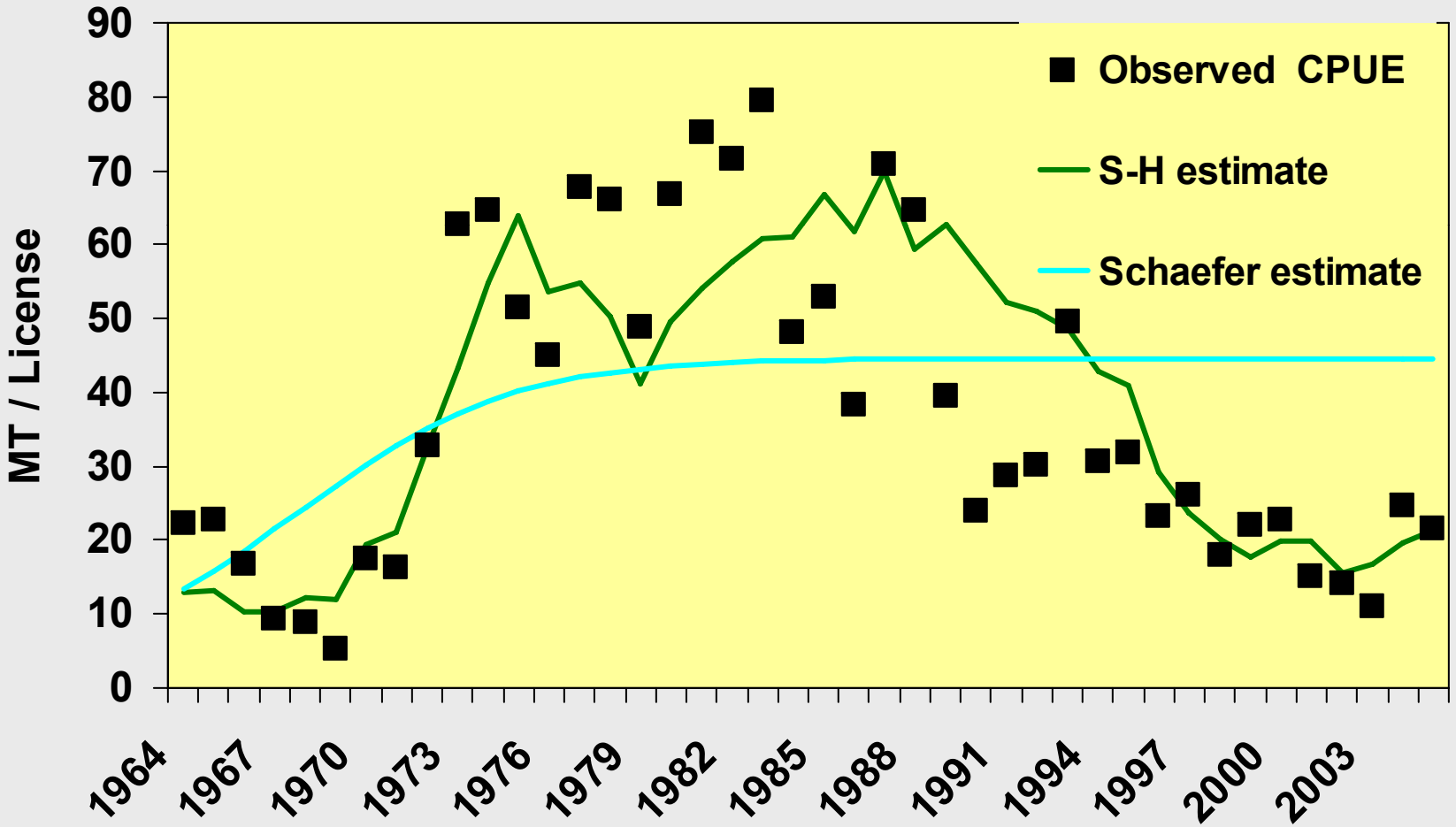
- Estimate q (catchability) as I_t / B_t, (I = index) use
- B_t * mean q for estimated I_t.
- Minimize $\ln(I_t) - \ln(\text{estimated } I_t)$

- $F = C_{t-1} / ((B_{t-1} + B_t) / 2)$
- $M = D_{t-1} / ((B_{t-1} + B_t) / 2)$

Biomass of striped bass, ages 2+. VPA biomass from 1982-2005 & 1964-1981 biomass predicted from egg tows vs VPA (1964-1981 rescaled by S-H model to adjust for regulations).



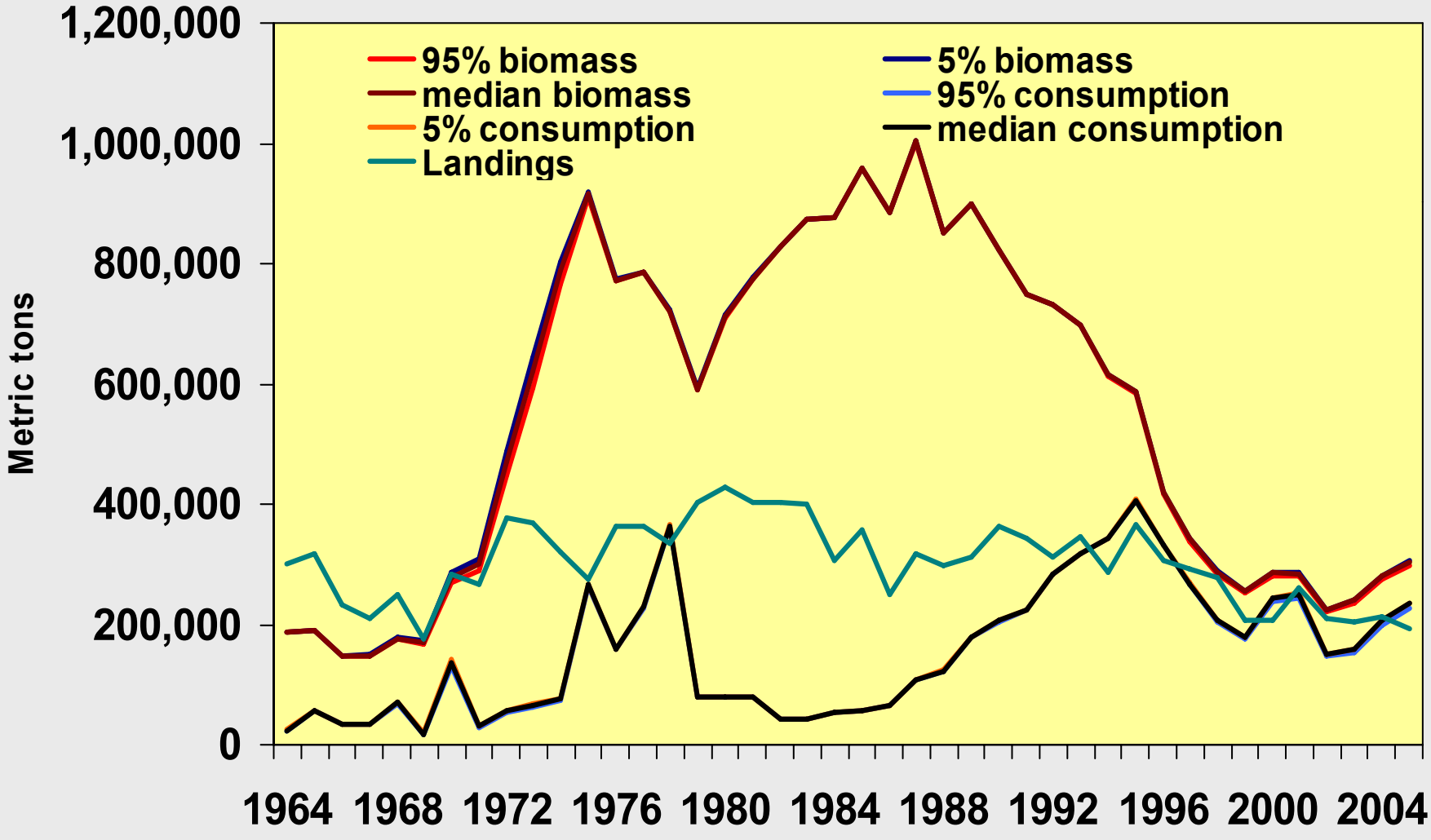
Fit of logistic models of menhaden with and without striped bass predation



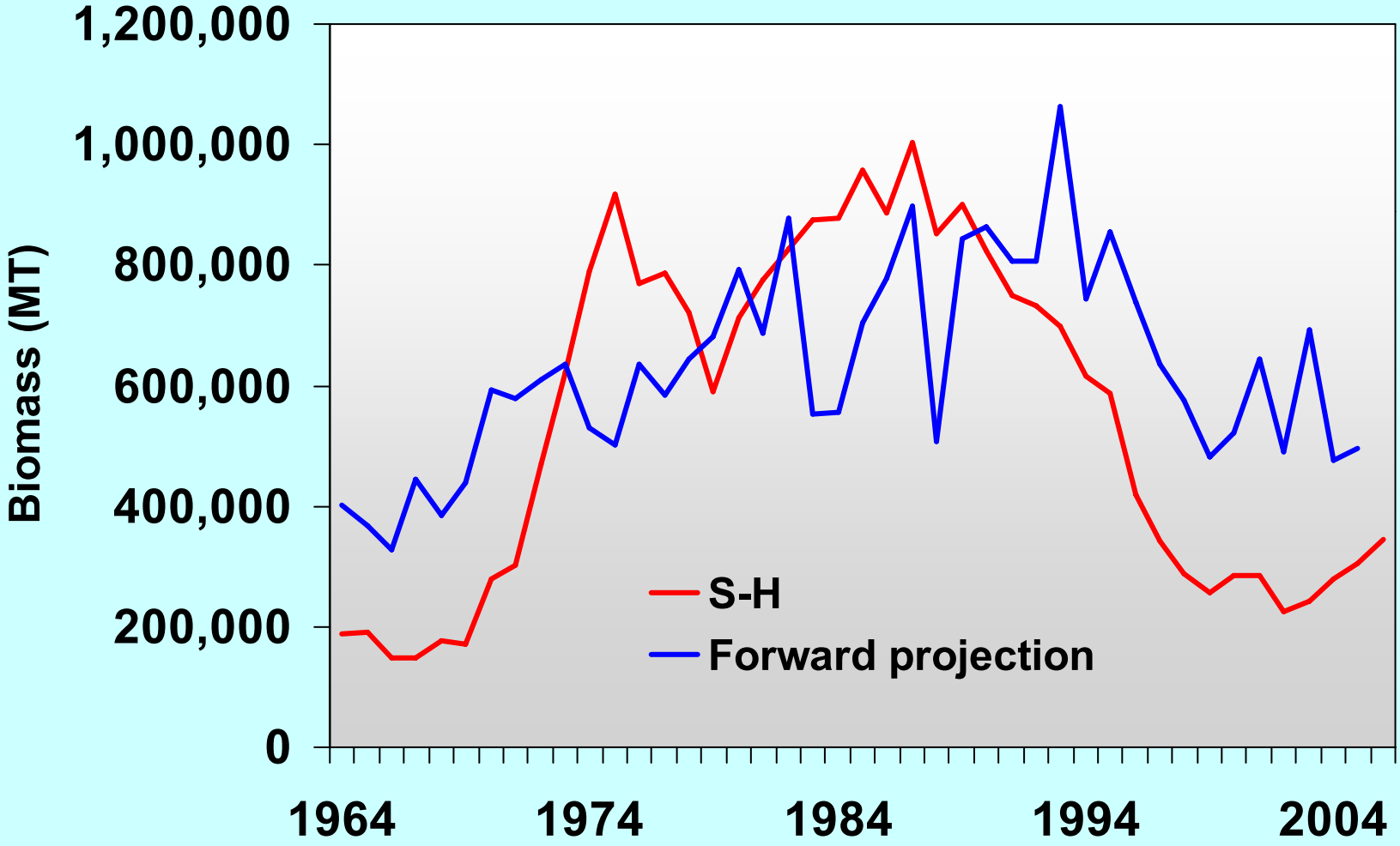
Parameters and fit of logistic Steele-Henderson and Schaefer models

Parameter	Steele-Henderson	Schaefer
r	2.10	0.27
K (mt)	$1.15 * 10^6$	$3.49 * 10^9$
c (max per capita)	10.8	
A (mt, bass satiation)	$5.67 * 10^5$	
R-square	0.66	0.15
AICc	-311	-224

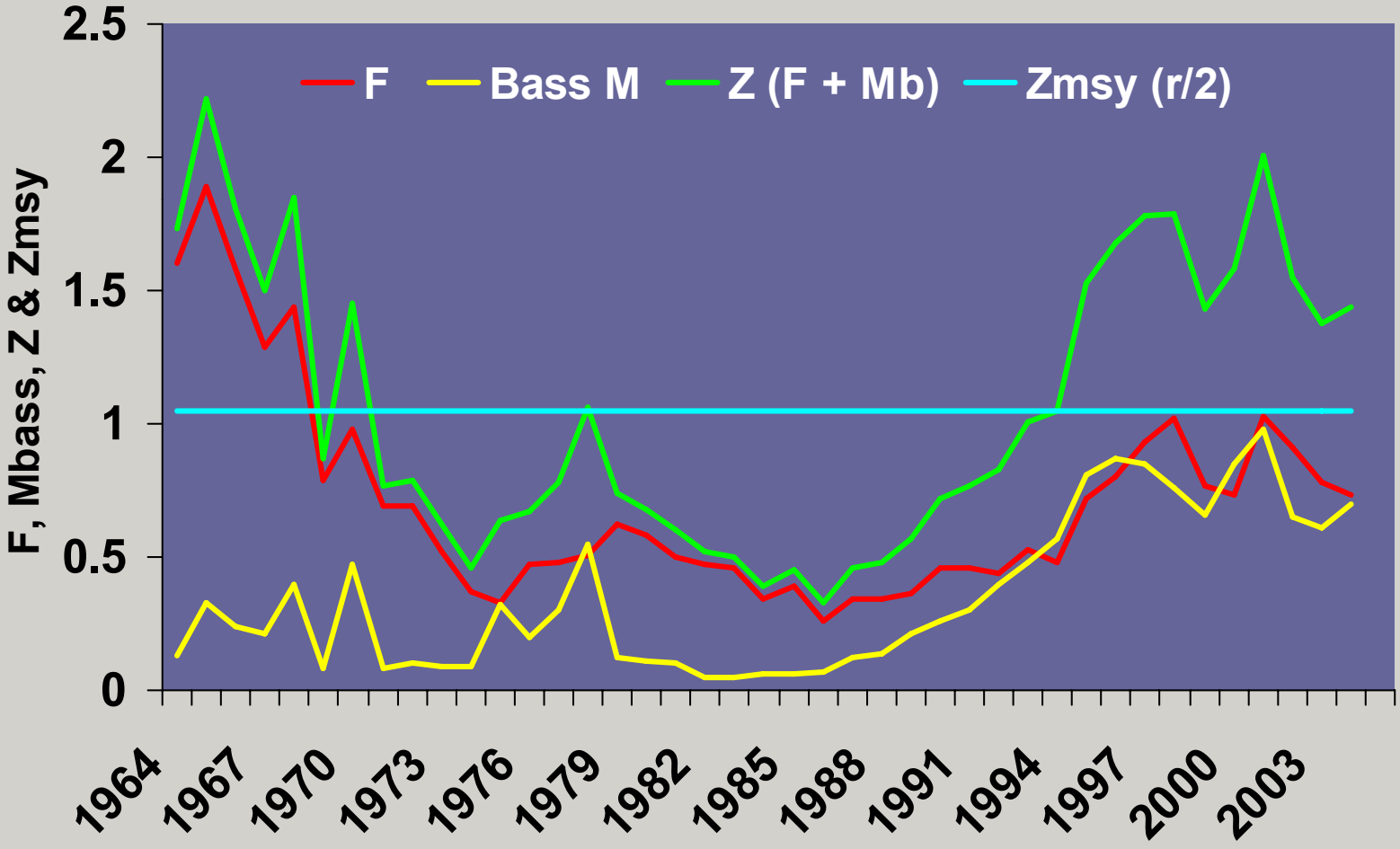
90% confidence intervals of biomass and striped bass consumption estimated by jack-knifing and landings



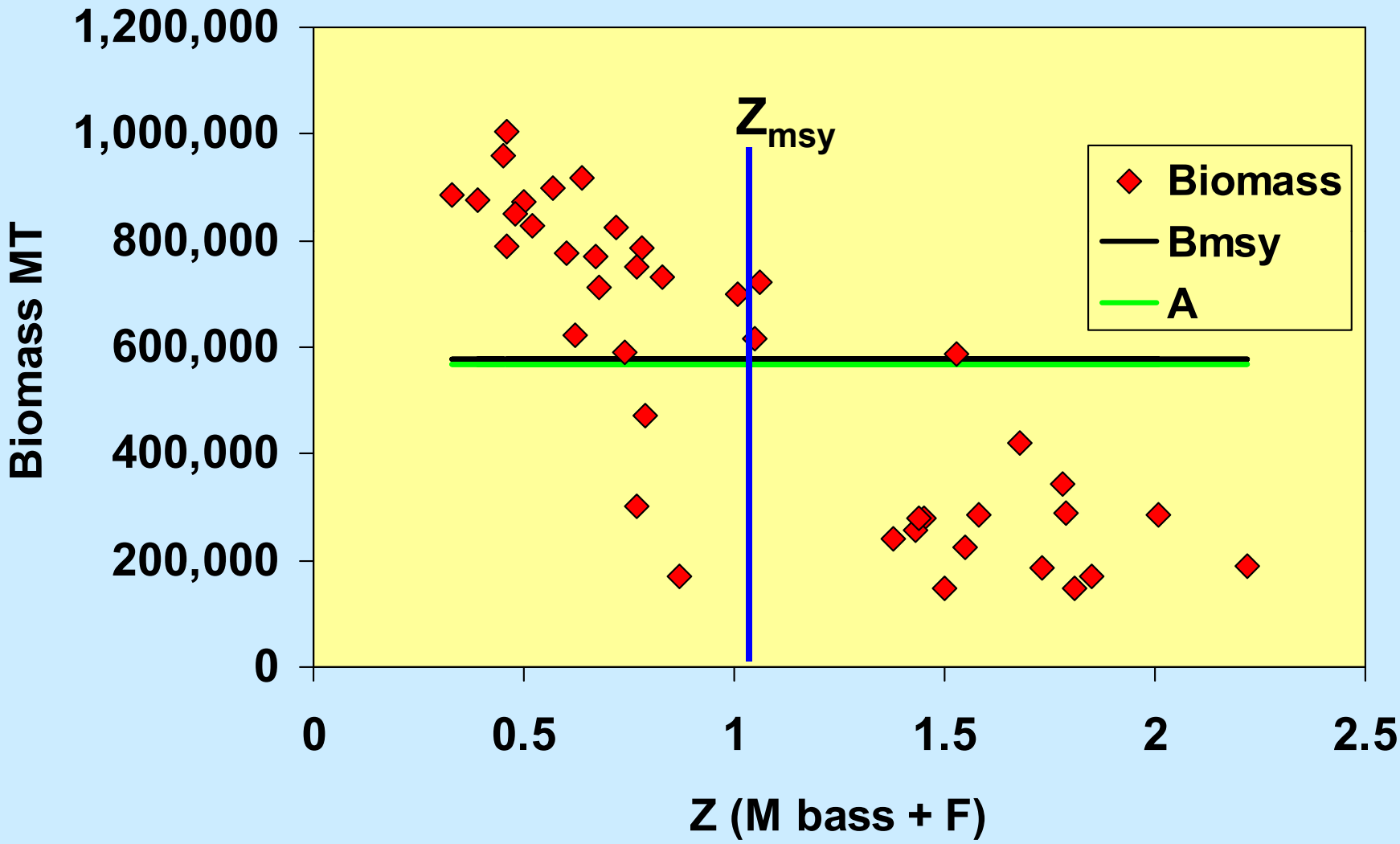
Biomass comparison – ASMFC single species forward projection and Steele-Henderson. Medians are very close. Early and late differences reflect high striped bass periods.



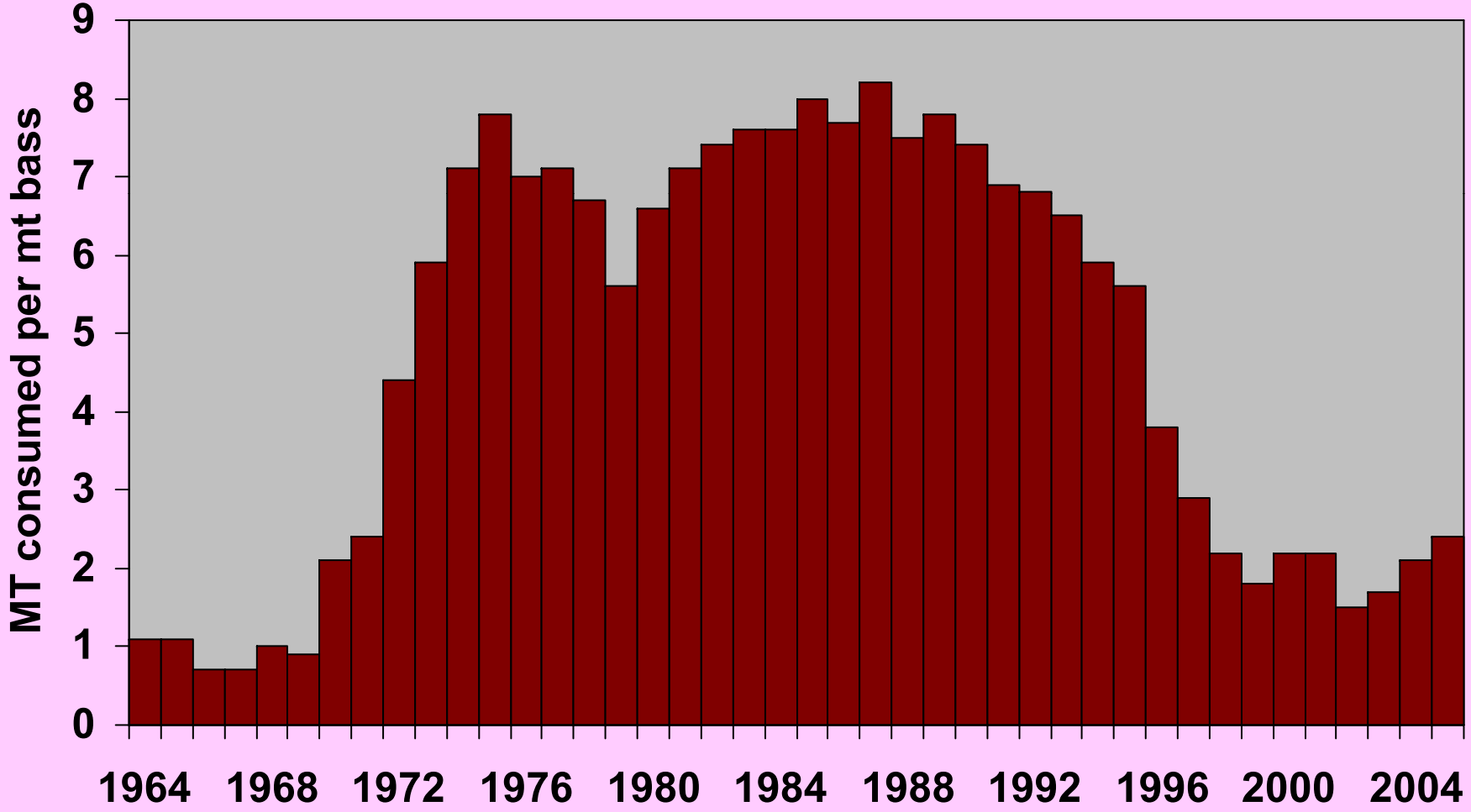
F, bass-related M, Z (F + M_{bass}), and Z_{msy} from the menhaden-striped bass Steele Henderson model.



Total mortality versus menhaden biomass



Steele-Henderson menhaden consumption per bass



Comparison of striped bass consumption patterns between coastal Steele-Henderson (S-H) and Chesapeake bioenergetics models (BE).

1990-1992 Hartman and Brandt (1995)
1998-2000 Overton (2003)