NOAA FISHERIES

Northeast Fisheries Science Center

Index-based Modeling Approaches
TOR 1 Modeling Approaches

By

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Term of Reference I: Modeling Approaches

Does the Center apply a suitable scientific/technical approach to fishery stock assessment modeling?

With such abundant time series data, why use index methods?

- Poor data quality in landings (e.g. mixed species)
- Difficulties in deriving reliable ages
- Problems of model fit (e.g. severe retrospective patterns)
- Short time series of reliable data
- One way trips and well below virgin biomass
- Model resistant stocks—a halfway house while the new models/data are being developed

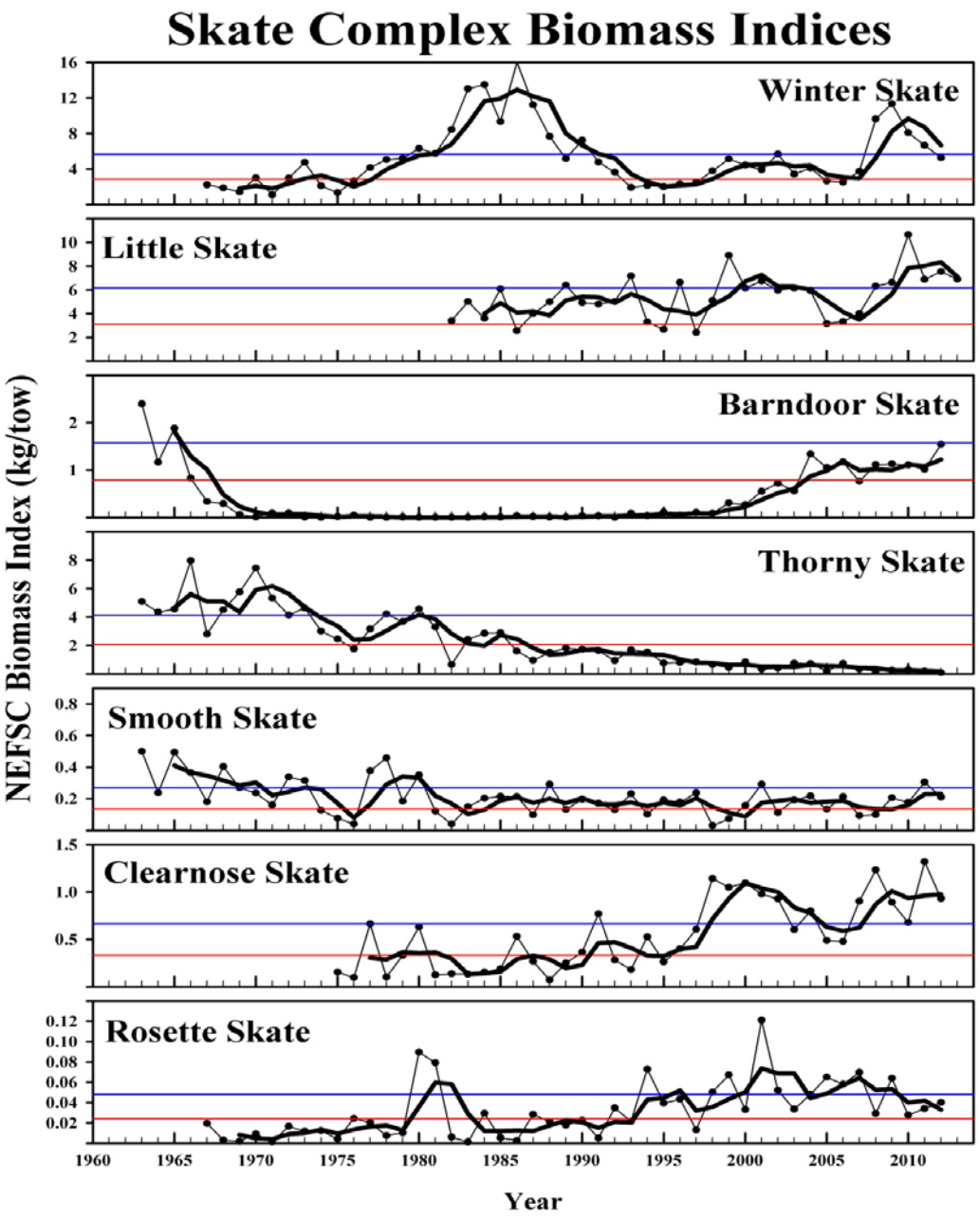
Some Examples of Index Models

Skates	Georges Bank Yellowtail Flounder	Butterfish	Gulf of Maine Winter Flounder
Control chart	AIM Kalman Filter	Envelope Plots	Swept Area

Not Yet Applied: SURBA (Beare et al. 2005) or other ICES type approaches

Control Chart for Skates

- Relative biomass is proxy for stock status with upper and lower bounds defined by historical comparisons.
- Rate of change in biomass is a proxy for F.
- Trigger for action varies by stock but ranges from -20% to -60%



AIM: An Index Method

Relative F and Replacement Ratio

- Comparison of relative abundance indices with externally defined reference points
- Find a relative exploitation rate that should lead to either no change in population size or an increase if desired. E.g., rebuilding, risk analyses, etc.

$$relF_t = \frac{C_t}{\left(\frac{I_t + I_{t-1} + I_{t-2}}{3}\right)} \qquad (1)$$

Relative F: Ratio of Catch to 3 year moving average of survey indices

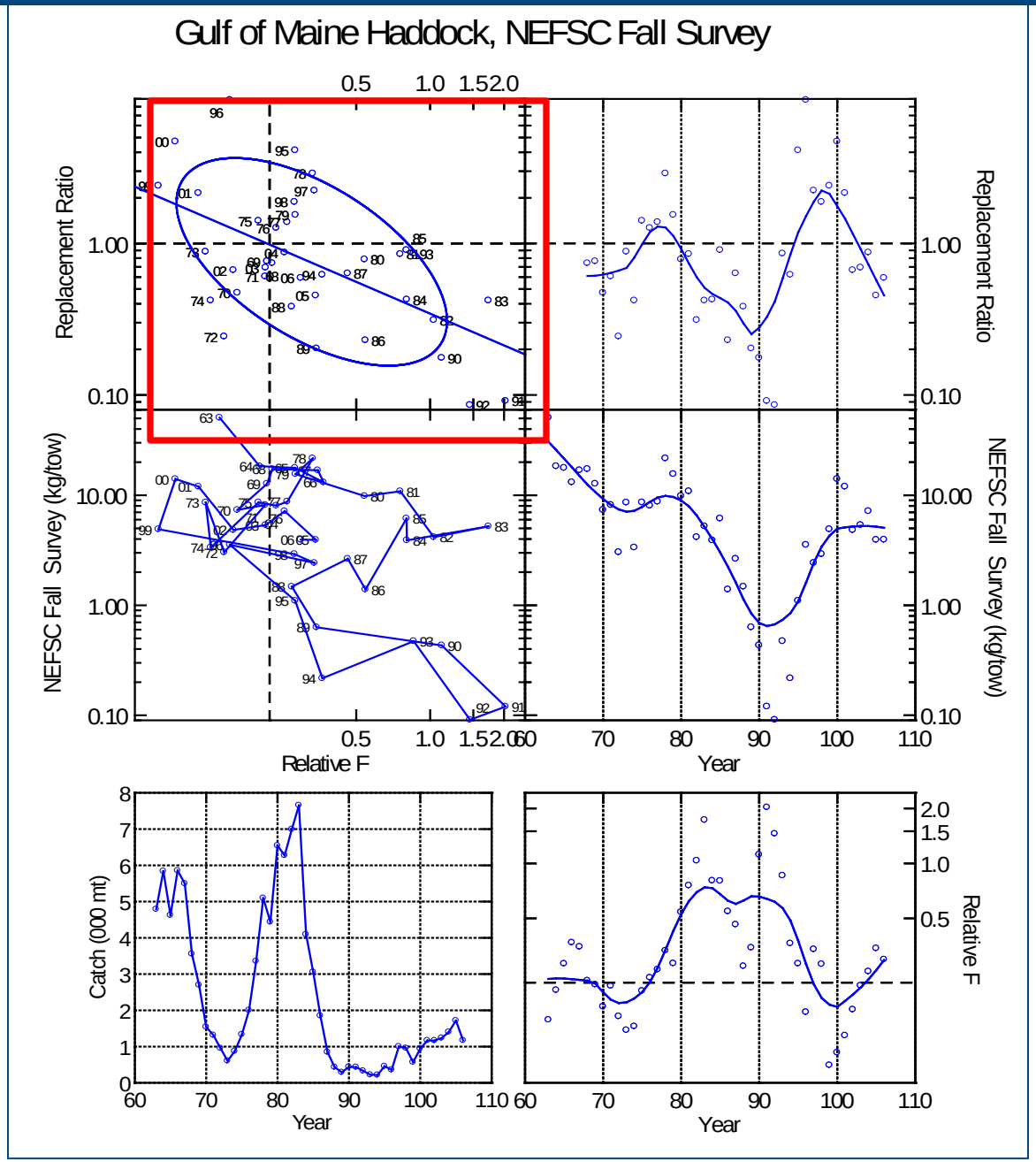
$$\Psi_t = \frac{I_t}{\sum_{j=1}^{A} I_{t-j} / A} \qquad (2)$$

Replacement Ratio: Ratio of current measure of relative abundance to average of previous relative abundance indices.

Simple question—for what range of relative F is the replacement ratio near one?

From 2008 GARM III, Gulf of Maine Haddock, Fall Survey, 1963-2007.

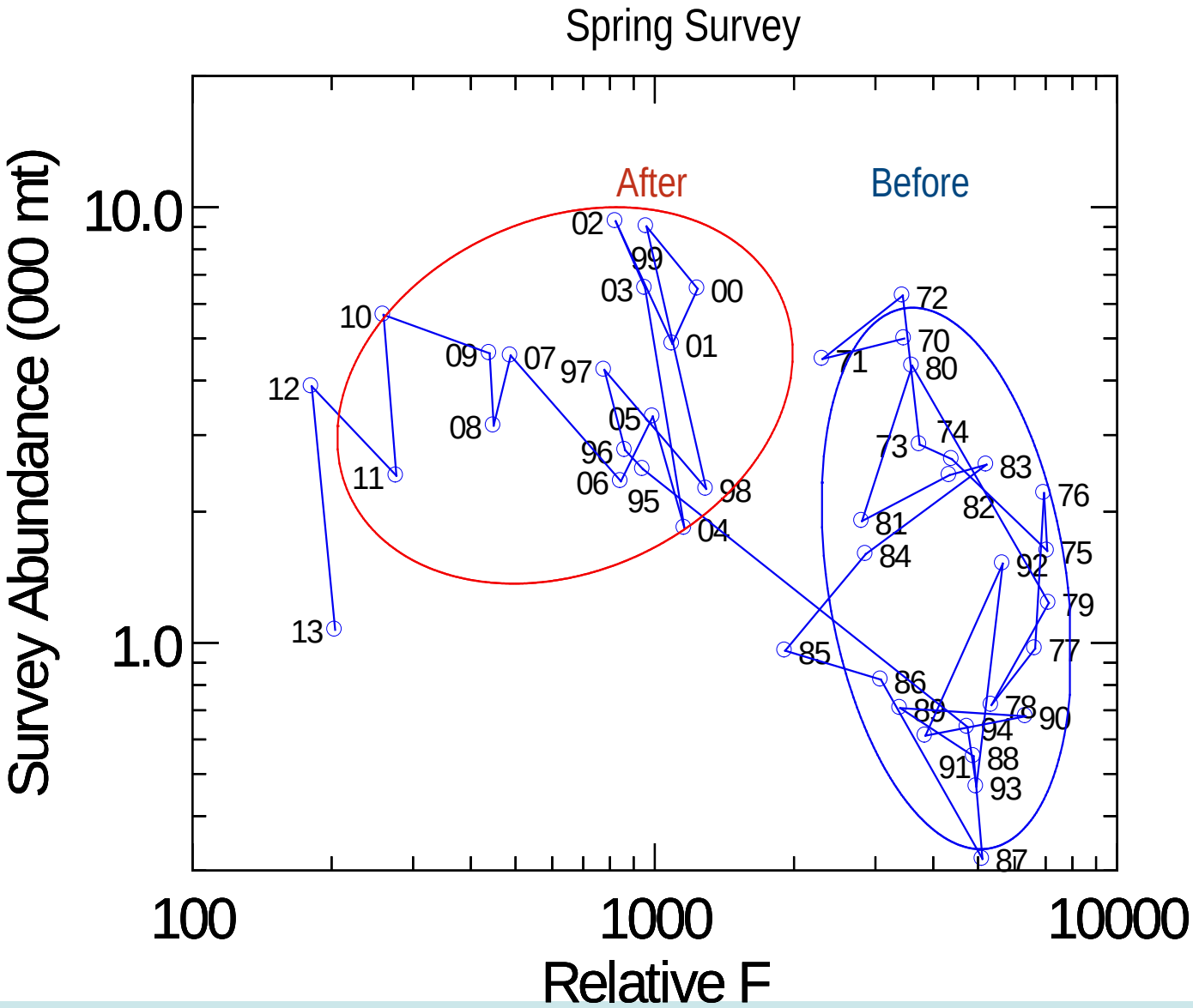
Note relatively good fit between Replacement ratio and relative F



New Math

2 variables +
2 functions =
6 plots

Georges Bank Yellowtail Flounder : Trouble along the isocline



Comparison of behaviors before and after 1994

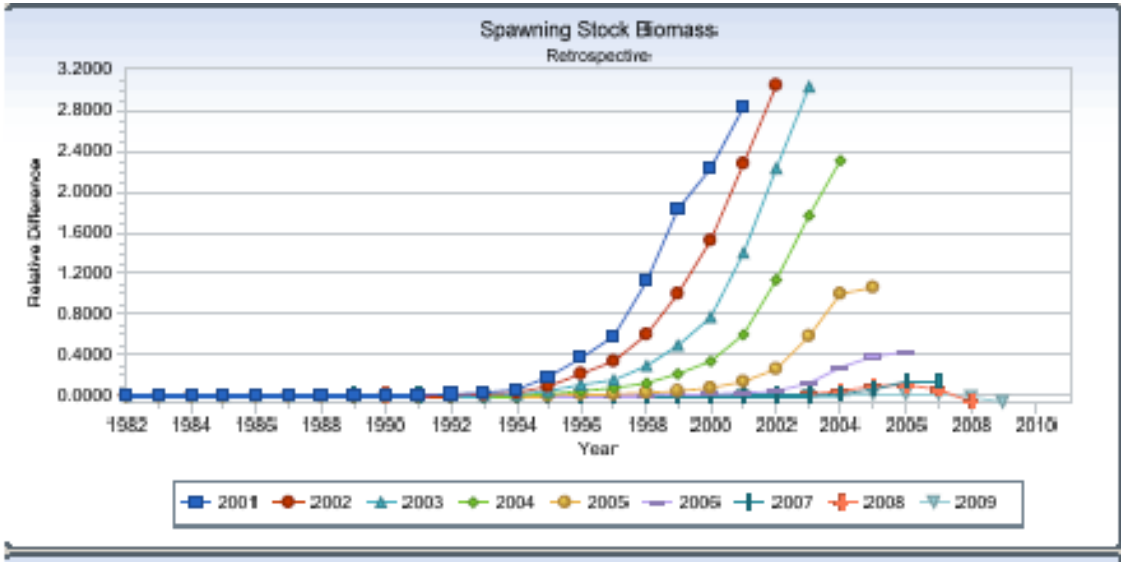
Swept Area Computation: Multiple Surveys

Gulf of Maine winter flounder, 2011—Retrospective problems

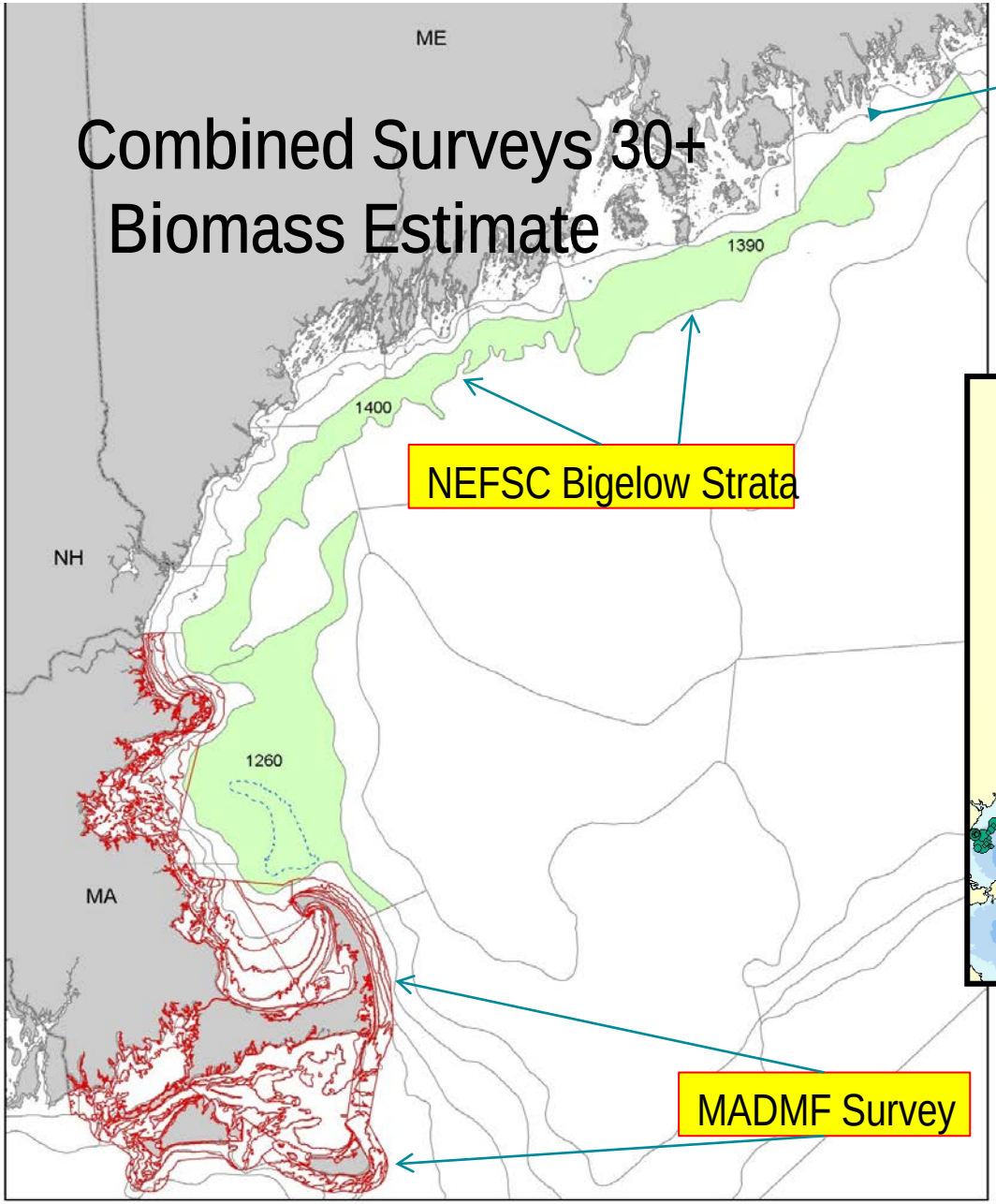
Piecewise construction of swept area biomass estimates to derive catch advice

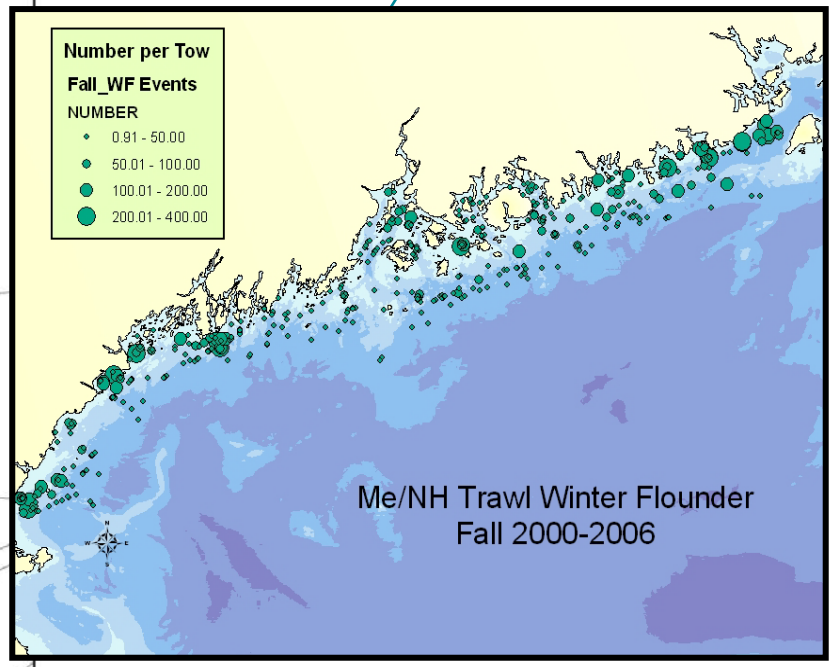
Comparison of possible exploitation rates for range of catch alternatives and assumed catchability values

Comparison with YPR-based reference points



Combined Surveys 30+ Biomass Estimate



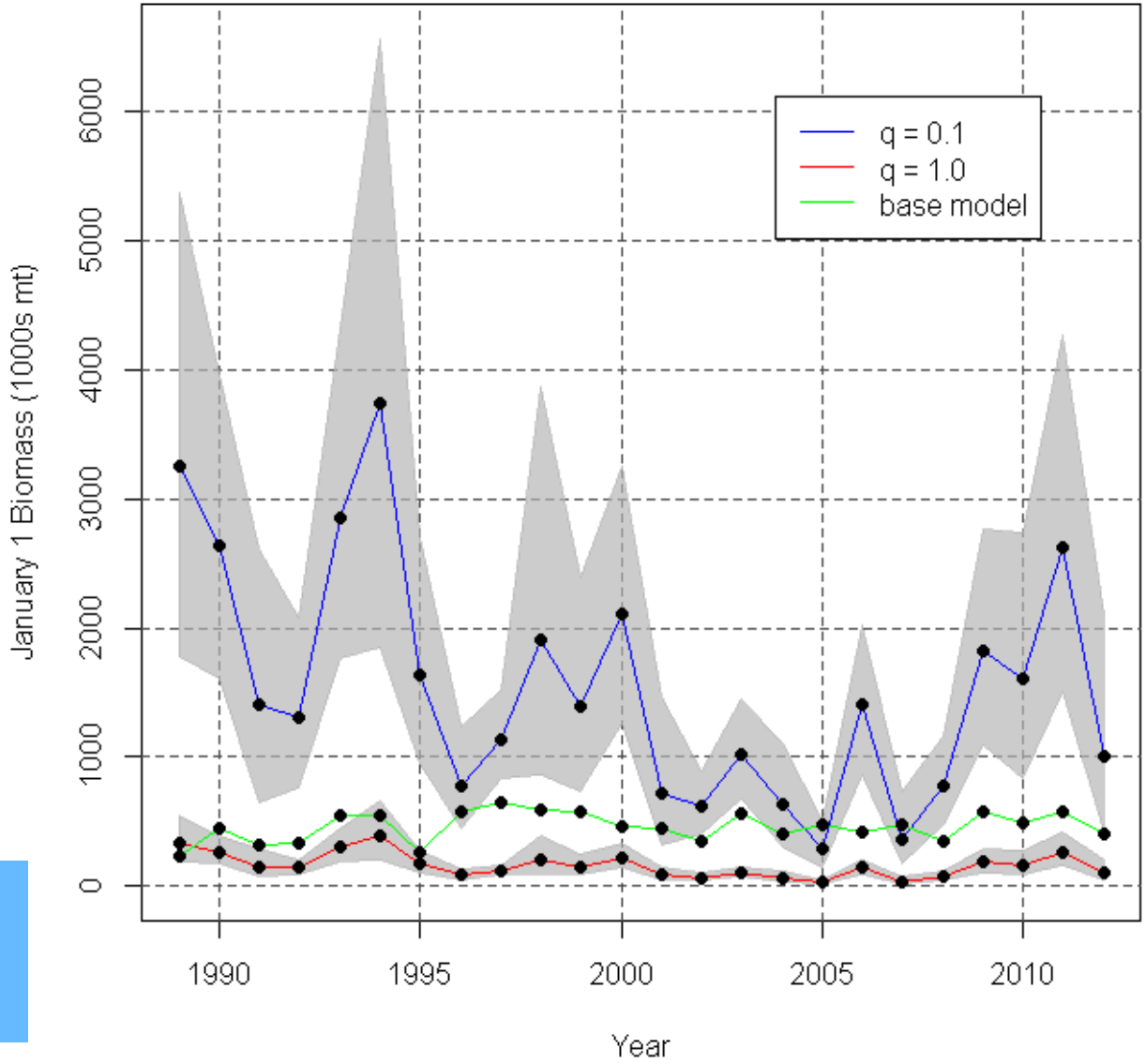


Gulf of Maine Winter Flounder 2011 : Implications of varying catches on exploitation rates for 4 assumed levels of catchability.

Q = 0.4	Catch	Bigelow Spring	Bigelow Fall	MDMF Spring	MDMF Fall	Combined Spring	Combined Fall
ABC	238	0.07	0.02	0.08	0.06	0.04	0.02
3yr avg	344	0.10	0.03	0.12	0.09	0.06	0.03
	500	0.14	0.05	0.17	0.13	0.08	0.04
	800	0.23	0.08	0.28	0.22	0.13	0.06
Q = 0.6							
ABC	238	0.10	0.03	0.12	0.10	0.06	0.03
3yr avg	344	0.15	0.05	0.18	0.14	0.09	0.04
	500	0.21	0.07	0.26	0.20	0.13	0.06
	800	0.34	0.12	0.41	0.32	0.20	0.10
Q = 0.8							
ABC	238	0.14	0.05	0.16	0.13	0.08	0.04
3yr avg	344	0.20	0.07	0.24	0.19	0.12	0.06
	500	0.28	0.10	0.35	0.27	0.17	0.08
	800	0.45	0.16	0.55	0.43	0.27	0.13
Q = 1							
ABC	238	0.17	0.06	0.21	0.16	0.10	0.05
3yr avg	344	0.24	0.08	0.30	0.23	0.14	0.07
	500	0.36	0.12	0.43	0.34	0.21	0.10
	800	0.57	0.19	0.69	0.54	0.33	0.16

Envelope Analysis for Butterfish: SARC 58

Comparison of the envelope measure of butterfish stock biomass with ASAP model-based estimates.



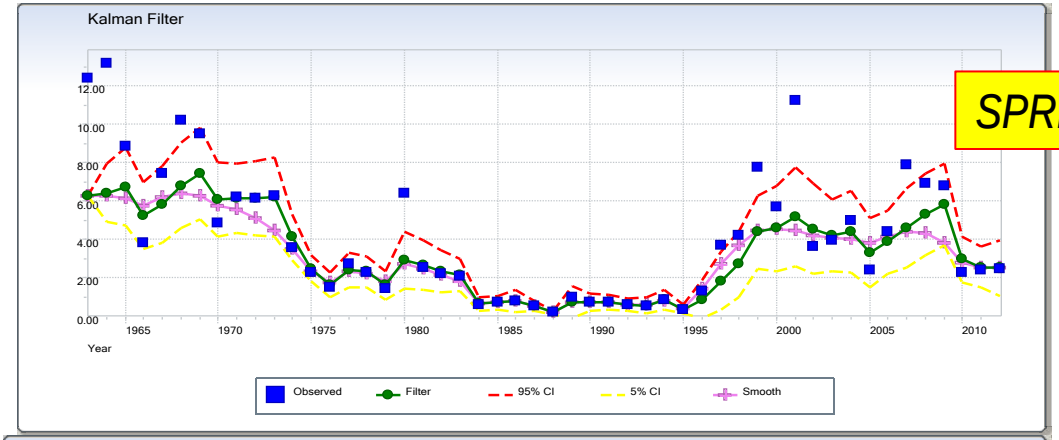
2014 Benchmark Assessment for Butterfish: SARC 58

Kalman Filter—Limited application

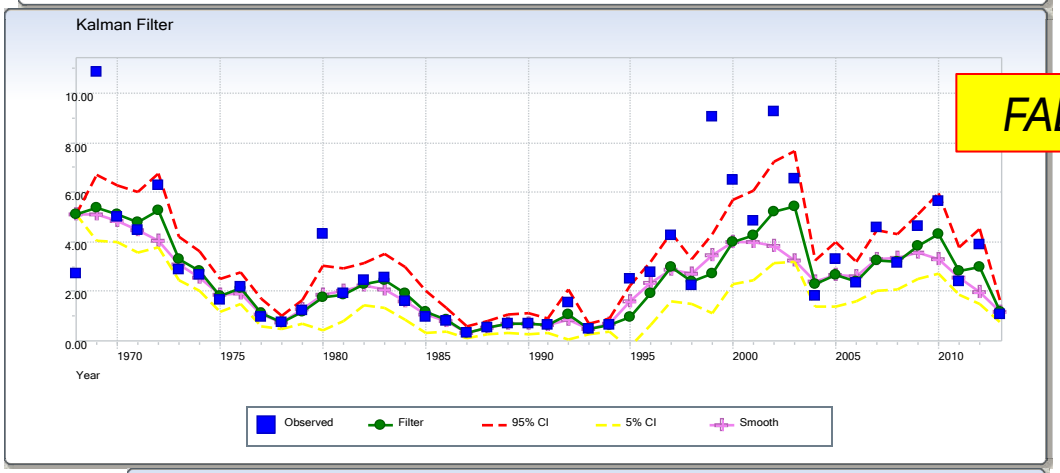
Useful as a way of explicitly considering measurement error in survey estimation

Does not require formal ARIMA model identification

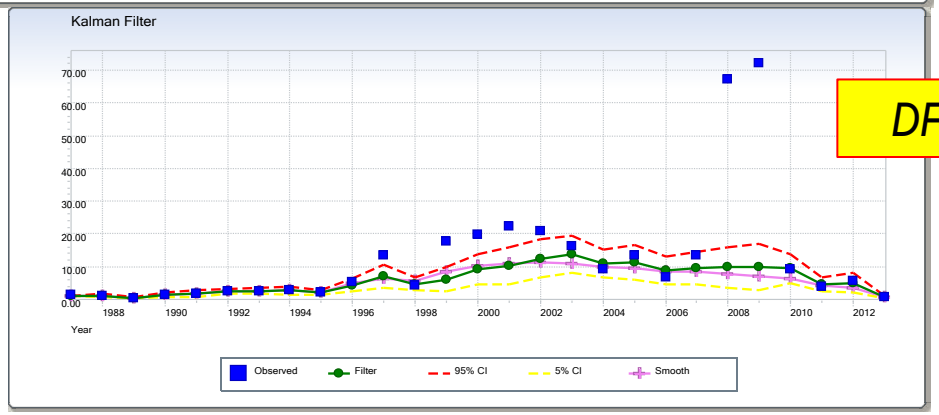
Does not impose arbitrary smoothing parameters (eg. n-point moving averages, Lowess tension, # knots, etc.)



SPRING



FALL

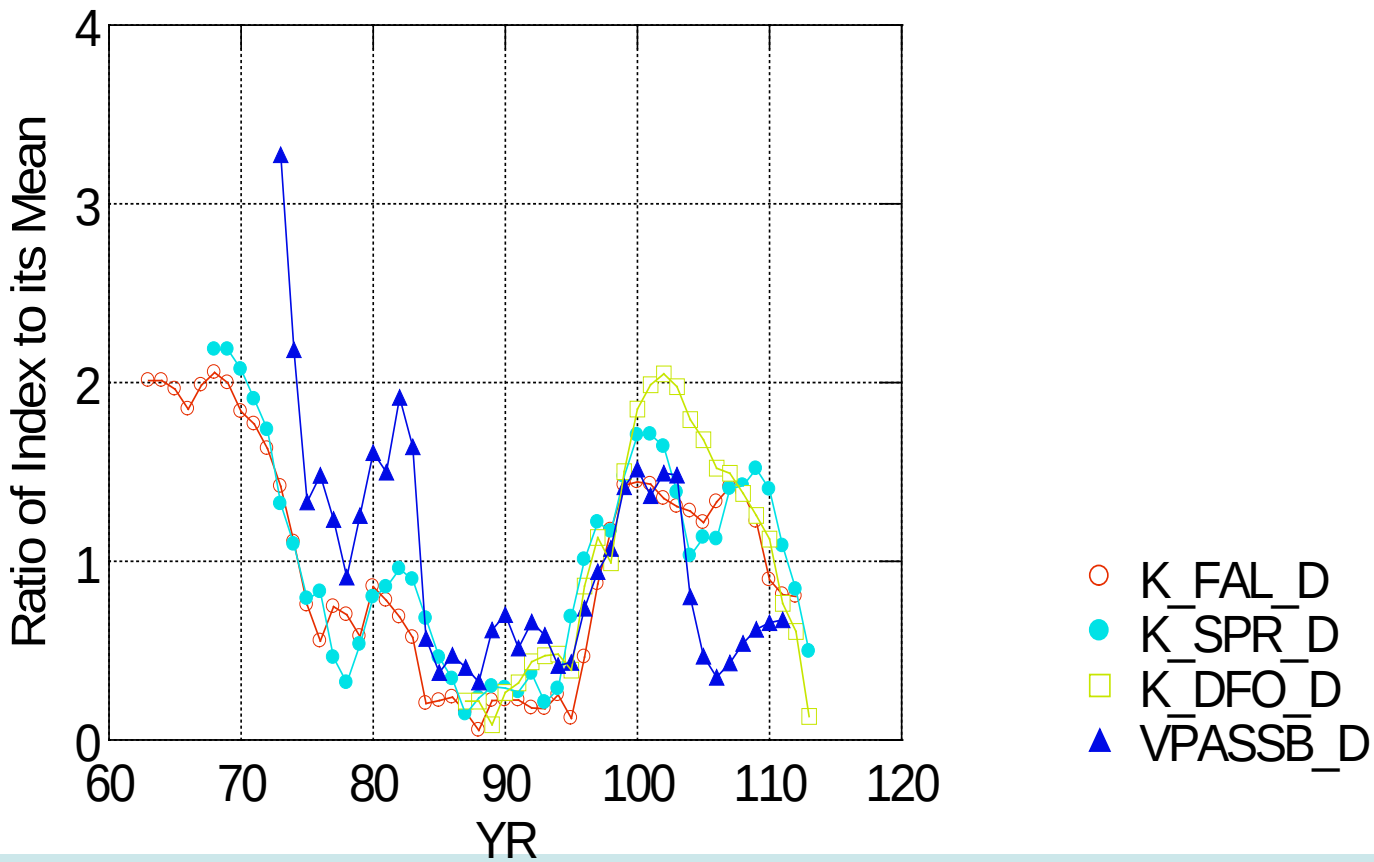


DFO

Georges Bank Yellowtail flounder, 2014, TRAC Benchmark

Summary of Kalman filter and VPA estimates of Georges Bank yellowtail flounder abundance

Comparison of Kalman Filter with VPA Estimates (X/mean)



Strengths

Methods are simple to apply

Often provide information useful for catch advice

Can serve as a diagnostic for other models and a check on more complex models

Serve as a halfway house while better models are under development or improved data streams are being collected

Could be useful for Management Strategy Evaluation and development of robust harvest policies

Challenges

- Too simple for their own good
- Multiple causes can give rise to similar patterns, so models are vulnerable
- Undetected changes in processes can be problem. Example—changes in selectivity for pollock
- Can they be used to bridge years between assessments

Solutions

Continue development as indicators of stock status and fishing mortality

Couple with gear research to reduce uncertainty in the range of assumed catchability estimates

Use as diagnostics in more complex models

Questions?