Working Paper 5.1
Feb. 22, 2008

Recommended Modeling Approaches by Stock: Initial Proposals for Consideration by the GARM III Review Panel

A Working Paper in Support of Term of Reference 5

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GARM-III 2008 Models Meeting
Woods Hole, MA
25-29 February 2008

Introduction

This Working Paper provides a review of initial recommendations of the chapter authors for preferred assessment models. The appropriate assessment model for each stock is influenced by attributes of the species and their fisheries, and the ability of the model to capture the salient features of the stock dynamics. Before 1995 the selection of models for Northeast groundfish was less complicated because fishing mortality greatly exceeded natural mortality and incoming cohorts were quickly fished out. VPA-ADAPT models worked well for age structured stocks and stage based models such as the Collie-Sissenwine model worked well for others. Various management measures reduced fishing mortality and altered the spatial pattern of fisheries. In particular, large closed areas on Georges Bank differentially affected more sedentary species which would benefit from the reductions in F afforded those fish which remained in closed areas. Increases in abundance for some stocks such as Georges Bank yellowtail flounder and haddock were dramatic. As population age structure broadened, the importance of model features such as plus groups became more important as the number of ages in the plus group increased. Model assumptions that were tenable under high F became less so with reduced F.

Closure areas redistributed and concentrated fishing effort in open areas, possibly altering the relationship between a unit of fishing effort and its effect on population mortality. Other management measures such as trip limits may have increased discard rates on some stocks and years. Limited re-openings of some closure areas may also have induced changes in population structure by intensifying mortality on some cohorts and stocks.

Superimposed on these changes were reductions in average size at age for many species. Such changes, if they apply to the entire population, imply that more individual fish are killed per ton of landings. Hence, intended reductions in fishing mortality with lower quota could be offset by smaller average size of landed fish. The cumulative effects of these changes are difficult to evaluate

Methods

No formal model selection procedure was implemented. Instead individual analysts reviewed their stocks and made decisions that reflect a reasonable compromise between available information, systematic problems, and the flexibility of alternative models.

Table 1 summarizes the relevant model selection attributes for each stock. A primary consideration is the availability of age data. Forward projecting models can incorporate age information for all, or part of a time series. This potentially allows analysts to extend the time period of the assessment back to periods when landings were much greater.

Some insights into the applicability of models can be gained by reviewing the six panel plots for each stock. (See Appendix 2). When the relationship between replacement ratio and relative F are strongly correlated one can infer that the population's rate of growth is responsive to the rate of removal. In turn this suggests that parametric models may be

applicable. Disparities that arise at the end of a time series are also important and may be indicative of process changes that lead to retrospective patterns.

These recommendations herein will be reconsidered during the meeting as the results of alternative models and simulation tests are reviewed by the Review Panel.

Some important data issues relevant to model selection

- Statistical analyses of the properties of the fishery independent surveys are relevant to the application of forward projection models which utilize information on the precision of the measurement error. (A brief summary is in Appendix 1.
- Initial investigations of the variability in landings at age were conducted at the GARM Data meeting in October 2007. Further work on this aspect of variability in landings may be relevant to the selection of models that accommodate such variations.
- Discards and measures of precision can be estimated for 1989-2007. Prior to 1989, estimates of discards are based on alternative assumptions. To ensure comparability over the entire time series, discussions on the relative merits of imputation methods or plausible scenarios may be valuable.
- The joint effects of variation in the estimates in total discards and landings may need attention since the covariance of the discard estimates is dependent on the estimated landings.
- Results of historical calibration experiments have typically been applied in many but not all species in NEFSC survey time series. Use of models that explicitly allow for estimation of such factors may be relevant to model selection.
- Methods for the estimation of uncertainty of numbers at age in a complex survey sampling design were not resolved at the GARM Data Meeting.
- The data summaries are preliminary. In particular, discard estimates may be revised as the individual analysts review the underlying data in more detail.

Summary Recommendations for Assessment Models

A. Georges Bank Cod

Further evaluation of a forward projecting model, such as SS2 or ASAP would need to be conducted, since the preliminary formulations of SS2 also show retrospective patterns. The ability of the software to produce data for projections and BRP would also need to be evaluated.

B. Georges Bank Haddock

Consider the application of forward projection model, with a focus on ASAP.

C. Georges Bank Yellowtail Flounder

Use the forward projection model ASAP

D. Southern New England Yellowtail Flounder

Use the forward projection model ASAP

E. Cape Cod-Gulf of Maine Yellowtail Flounder

Use the forward projection model ASAP

F. Gulf of Maine Cod

We propose that the NOAA/NFT model, ASAP, be compared against VPA to evaluate the feasibility of changing to this model for the GARM-III assessment.

G. Witch Flounder

Continue to use VPA model until other models are fully explored. Preliminary estimates of discards based on a combined ratio of discarded witch flounder and kept of all species are currently being derived for 1989 to 2007.

H. Gulf of Maine/Georges Bank American Plaice

Until evaluations of other models i.e. forward projecting models are conducted, it would be most practical to apply the VPA model.

I. Gulf of Maine Winter Flounder

The present SCALE and VPA model configurations are presently both producing unreliable results.

J. Southern New England Winter flounder

Continue use of VPA

K. Georges Bank Winter Flounder

Update catch at age and move from ASPIC to VPA

L. White Hake

Consider application of forward projection model using SS2 or ASAP

M. Georges Bank/Gulf of Maine Pollock

The current assessment is based on An Index Model (AIM) which incorporates age-aggregated information on exploitation (commercial landings) and resource biomass (Autumn NEFSC biomass index). An age-based assessment may be possible for this region if the age structure of all of the commercial landings can be attributed to SA 5&6. This must include the non-USA components (Canadian and DWF) that were substantial since the early 1960s. This objective may be difficult to achieve because extensive borrowing of Canadian age length keys from Subarea 5 to was required to derive the age composition of the DWF catch in the 1960s and 1970s (Mayo et al. 1989) which was estimated on a stock-wide basis.

N. Gulf of Maine/ Georges Bank Acadian Redfish

Given the results of the considered RED and STATCAM models and comparisons with the FSCTPD model we recommend either STATCAM Alternative 2 or 3 models for the Gulf of Maine- Georges Bank Acadian redfish stock assessment.

O. Ocean Pout

Continue to use survey biomass and relative exploitation for stock determination. With preliminary estimates of discards back to 1970, the use of catch (landings + discards) could be explored for relative exploitation.

P. Gulf of Maine/Georges Bank Windowpane Flounder

Use AIM

Q. Southern New England – Mid-Atlantic Windowpane Flounder

Use AIM

R. Gulf of Maine Haddock

Update catch at age and move from AIM to VPA

S. Atlantic Halibut

A stock reduction analysis, relying mainly on the commercial time series of data, may be a reasonable approach for assessing this data-poor stock.

Table 5.1 (See file:
WP 5.1 Table 5.1 – Species attributes for model selection.pdf)

Table 5.2 Summary of Model attributes and features for assessment tools currently in the NOAA Fisheries Toolbox

Model feature: Ability to Handle the following :	AIM	ASPIC	SCALE	VPA-ADAPT	STATCAM	ASAP	SS2
Data/ Observation Error							
Pooled Indices	●	●	●	☯	●	●	●
Total landings	●	●	●		●	●	●
Total Discards	●	●			●	●	●
Total Catch (Landings+Discards)	●	●	●		●	●	●
Address variation in CAA, DAA, CAL, DAL					●	●	●
Catch at age CAA				●	●	●	●
Catch at Length CAL			●				●
Changes in average weight/length				●		●	●
Process/Model Specification							
Stock Recruitment Function						●	●
Sexual Dimorphism in growth rates			●				●
Spatial Heterogeniety							●
Incorporate long term historical landings			●		●	●	●
Handle gaps in age or length information	●	●	●		●	●	●
Multiple Fleets					●	●	●
Handle differences between sexes			●				●
Variable ages for Plus group over time					●	●	●
Variations in natural mortality over age and years				●	●	●	●
Retrospective Analyses	●	●	☯	●	☯	●	☯
Independently estimate temporal changes in catchability for surveys				☯		●	●
Variations in survey catchability.				☯		●	●
Address variations in biological sampling intensity over time					☯	●	●
Consider measurement error for individual times series observations.						●	●
Uncertainty/Forecasting/BRPs							
MCMC						●	●
Model complexity	❍	☯	☯	☯	●	●	●
Sensitivity to arbitrary weighting factors	☯	❍	●	☯	●	●	●
Bootstrap	●	●		●			●
Estimation of BRP for F	●	●			●	●	●
Estimation of BRP for SSB		●			●	●	●
Linkage to external/internal forecasting program	●			●		●	●
Stochastic Forecasting for mixed harvest policies				●		●	●
Process/Model Specification							
Software Availability	●	●	●	●	☯	●	●
Large user group	❍	●	❍	●	❍	☯	●
Need for External support	☯	❍	☯	❍	●	☯	●
Feasiblity Index within next 8 weeks (L,M,H)	●	●	☯	●	☯	●	☯

NA	L	M	H
	❍	☯	●

Solid circles can also indicate presence of a feature.
Open and partially open circles indicate Low and Medium, respectively

Appendix 1. Data availability and survey analyses.

The NFT Visual Report Designer may be a useful tool for highlighting availability of data for model development and for highlighting basic trends, and cohort specific patterns. Fig. 1 summarizes basic data trends for catch and survey data Since all time series are expressed as ranks, it is possible to address coherency irrespective of scale. To avoid over interpretation of patterns associated with small changes over time, a measure of relative dispersion, expressed as the range of the median is provided for each time series. Fig. 2 illustrates these principles for age based data. One advantage of this display method is that it can identify strong cohorts.

Fishery-independent surveys are typically summarized in terms of annual means and less often in terms of variances. Analyses were undertaken to examine some additional properties of the NEFSC bottom trawl surveys relevant to their use as tuning indices. These measure include the degree of concentration of the stocks as measured by the Gini Index. The Gini index is a dimensionless value ranging from 0 to 100 that expresses the degree of departure from a uniform distribution. Stocks with a high degree of clustering have indices near 100; a uniformly distributed species would have an index of zero. Differences among species are of interest but trends over time may be important indicators of changing patterns of stock abundance. Result in Fig. 3. illustrate apparent trends of increasing concentration for GOM and GB Cod and trends for GB and SNE yellowtail flounder. Gulf of Maine and SNE Winter flounder, and Pollock also have increasing trends in the Gini Index over time.

The utility of fishery independent measures of catch at age (numbers) depends strongly on the coherence of cohort across years and the precision of the estimates. Survey estimates of mean number per tow and coefficients of variation were computed for each species for the fall and spring surveys for all surveys since 1963. Results of these surveys are present in Fig. 4 and 5. Each box represents the distribution of the Gini index, the mean number per tow, the CV of the mean number per tow and the survey design effect. The design effect is a measure of the improvement in the precision of the survey estimate compared to a simple random sample (Smith and Gavaris 19xx). The CV plots and design effect summaries are important for detection of trends. Median CV estimates for spring and fall typically are less than 30% with the notable exception of halibut- an uncommon species in the Northeast. Median design effect estimates (Fig. 4-5) were almost always above zero. Overall it appears that the survey is generally doing better than a random sample yielding about a 25% reduction in variance.

Reference :

Smith, S. J. and Gavaris, S. 1993. `Improving the precision of _sh abundance estimates of Eastern Scotian Shelf cod from bottom trawl surveys', North American Journal of Fisheries Management 13: 35-47.

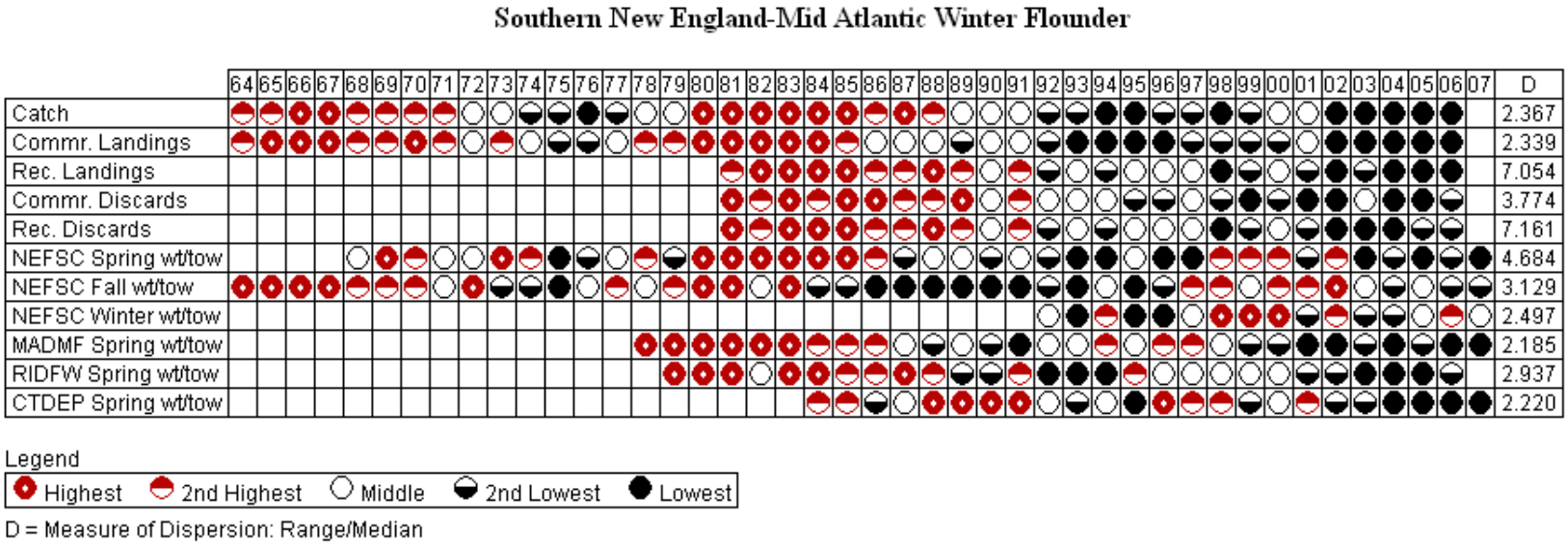
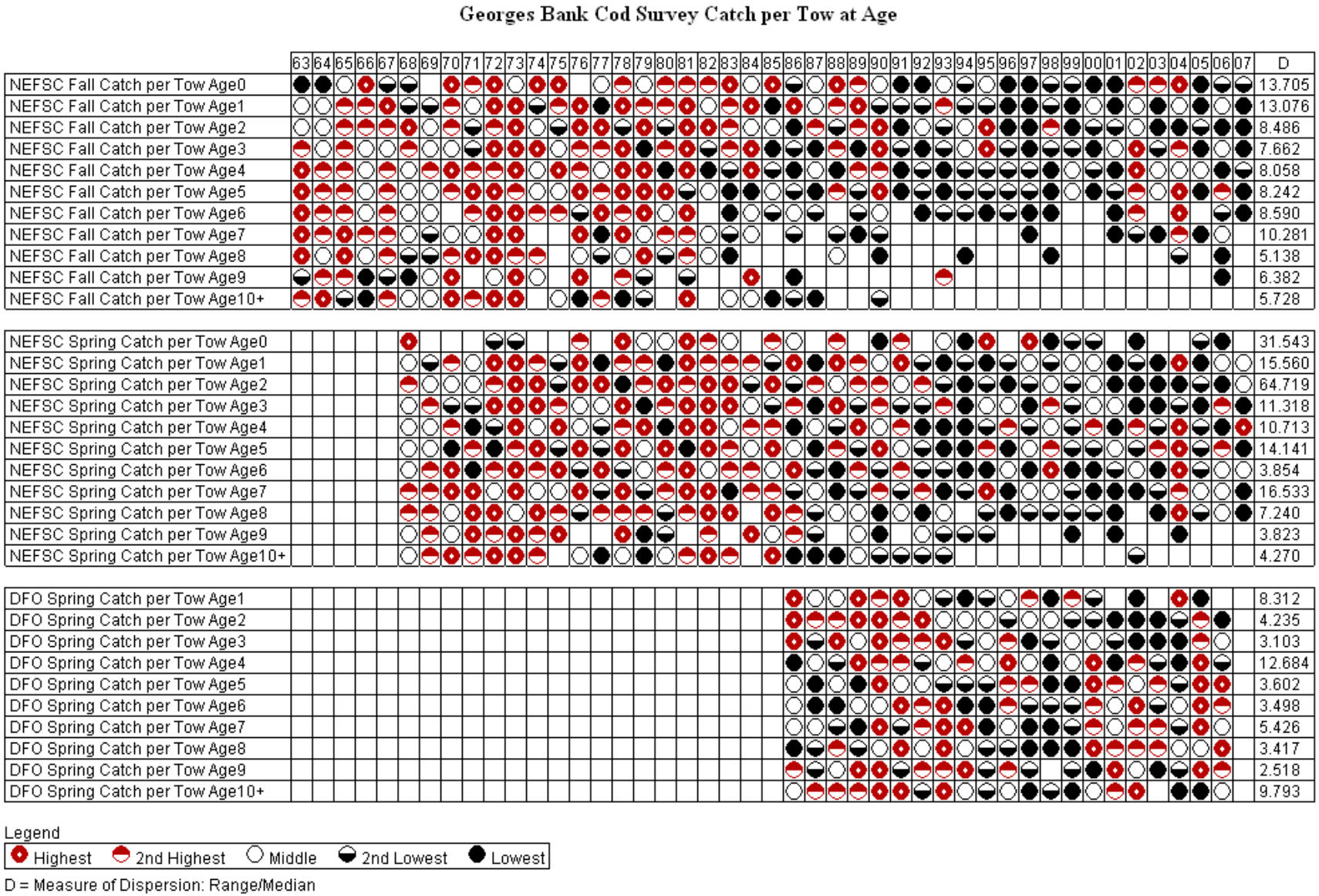
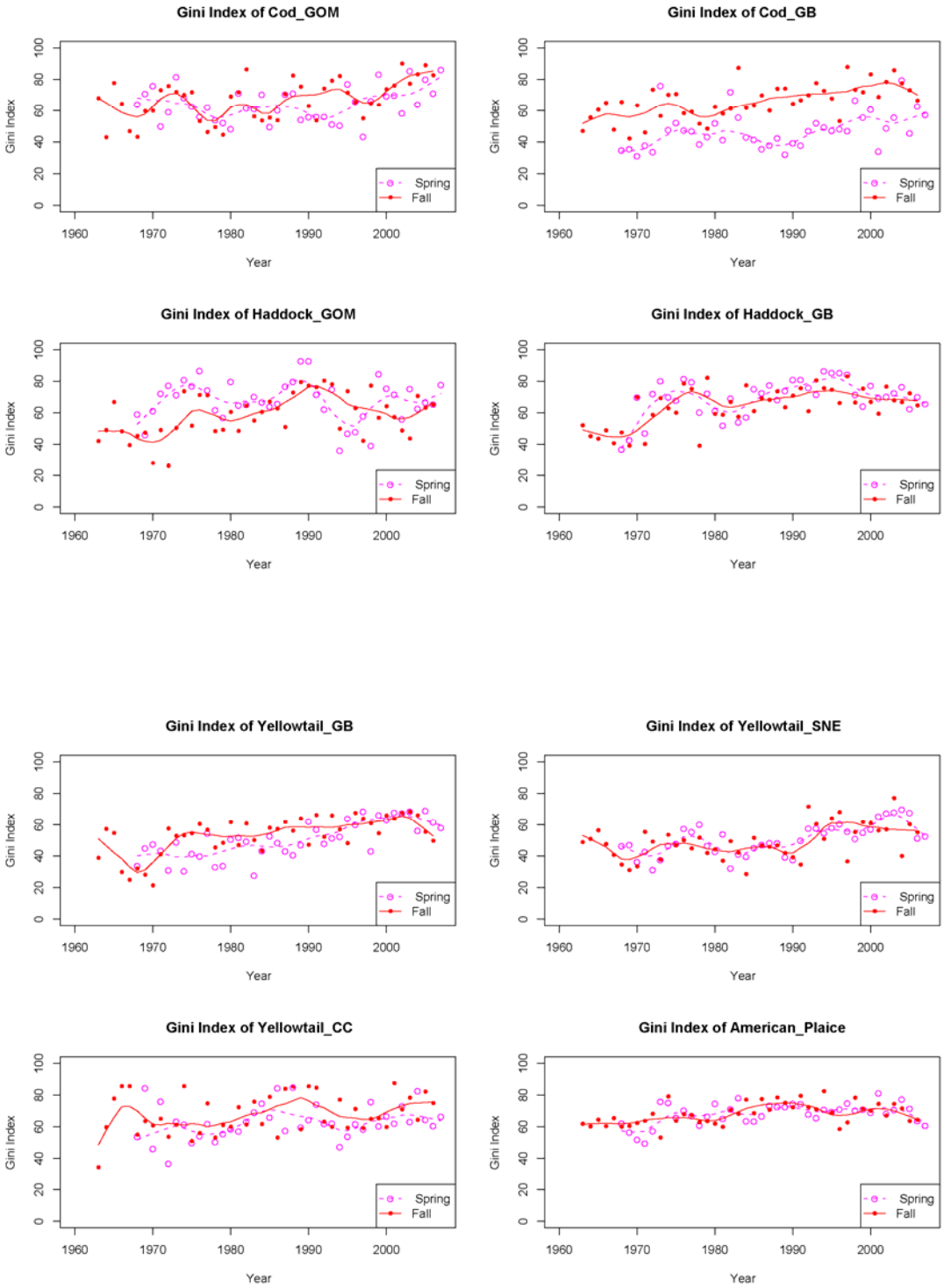
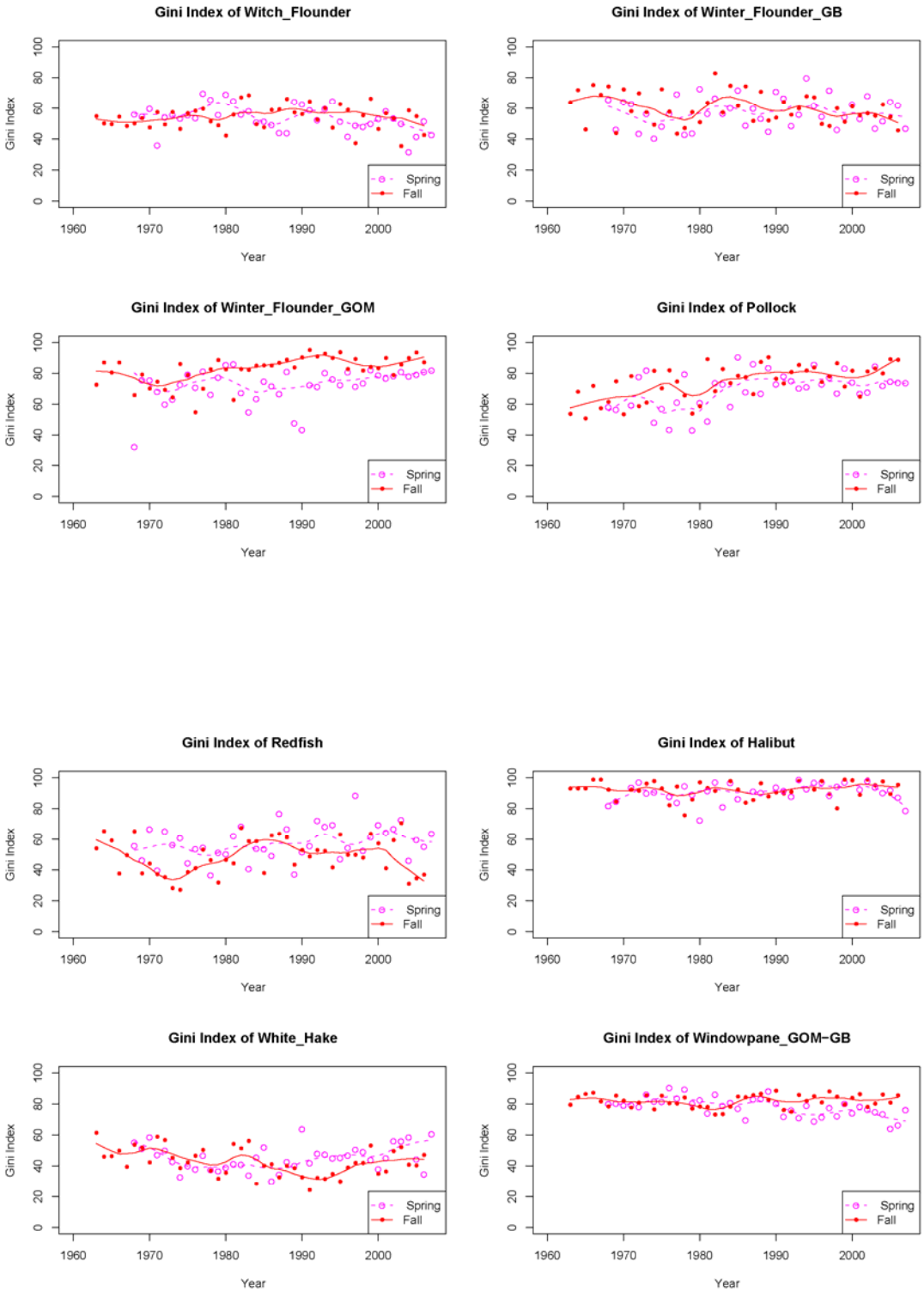


Fig. 1. Summary of trends in catch, landings, discards and fishery independent abundance abundance indices for Southern New England-MidAtlantic Winter Flounder, 1964-2007.

Figure 2. NEFSC autumn, NEFSC spring, and DFO spring survey catch at age for Georges Bank cod, ages 1-10+.




Gini Index of Cod_GOM
Gini Index of Cod_GB
Gini Index of Haddock_GOM
Gini Index of Haddock_GB
Gini Index of Yellowtail_GB
Gini Index of Yellowtail_SNE
Gini Index of Yellowtail_CC
Gini Index of American_Plaice
Gini Index
Year
Spring
Fall
0
20
40
60
80
100
1960
1970
1980
1990
2000


Gini Index of Witch_Flounder
Gini Index of Winter_Flounder_GB
Gini Index of Winter_Flounder_GOM
Gini Index of Pollock
Gini Index of Redfish
Gini Index of Halibut
Gini Index of White_Hake
Gini Index of Windowpane_GOM-GB
Gini Index
Year
Spring
Fall
0
20
40
60
80
100
1960
1970
1980
1990
2000

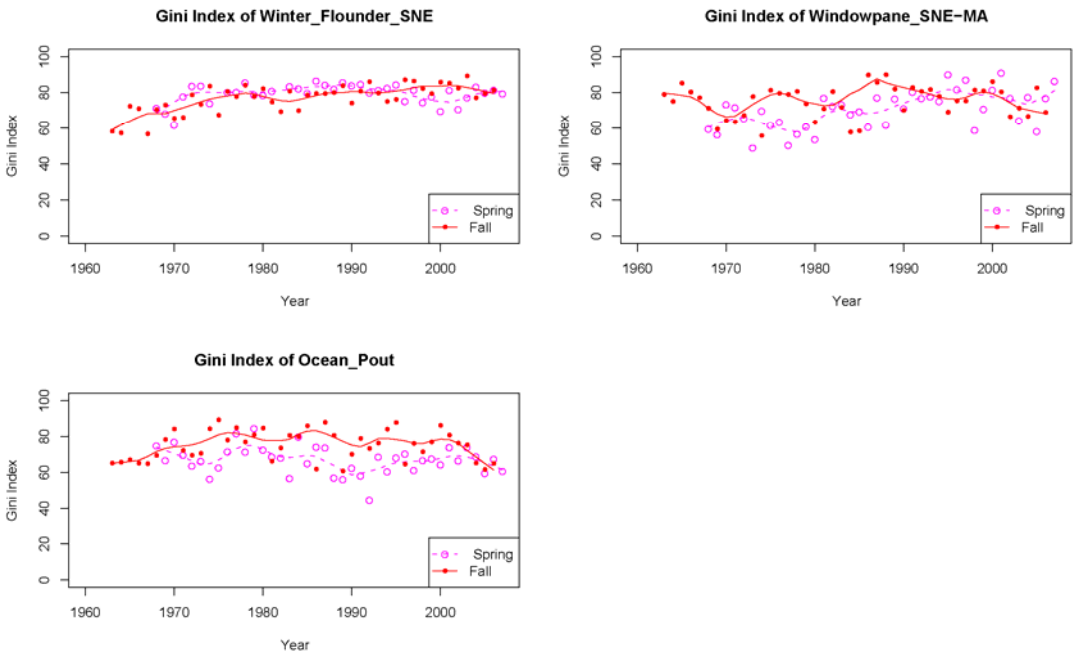


Fig 3 Summary of temporal trends in Gini Indices for NEFSC fall (1963-2007) and spring (1968-2007) bottom trawl surveys for 19 groundfish stocks. Response variable is number per tow.

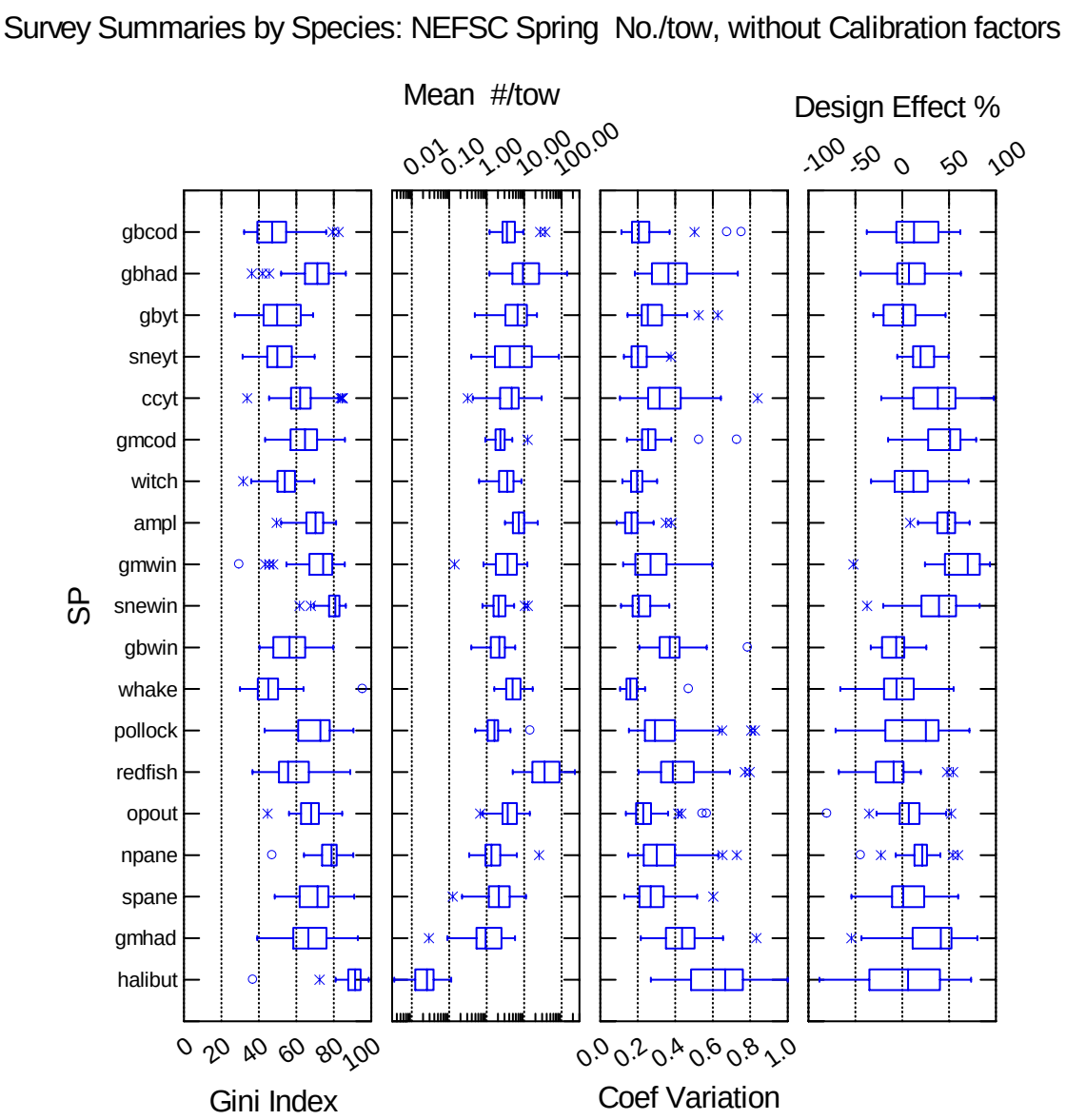


Fig 4. Box plots of Gini indices, survey means and CV, and Design effects for 19 stocks sampled in the NEFSC Spring bottom trawl survey. Each box represents incorporates data from 1968 to 2007

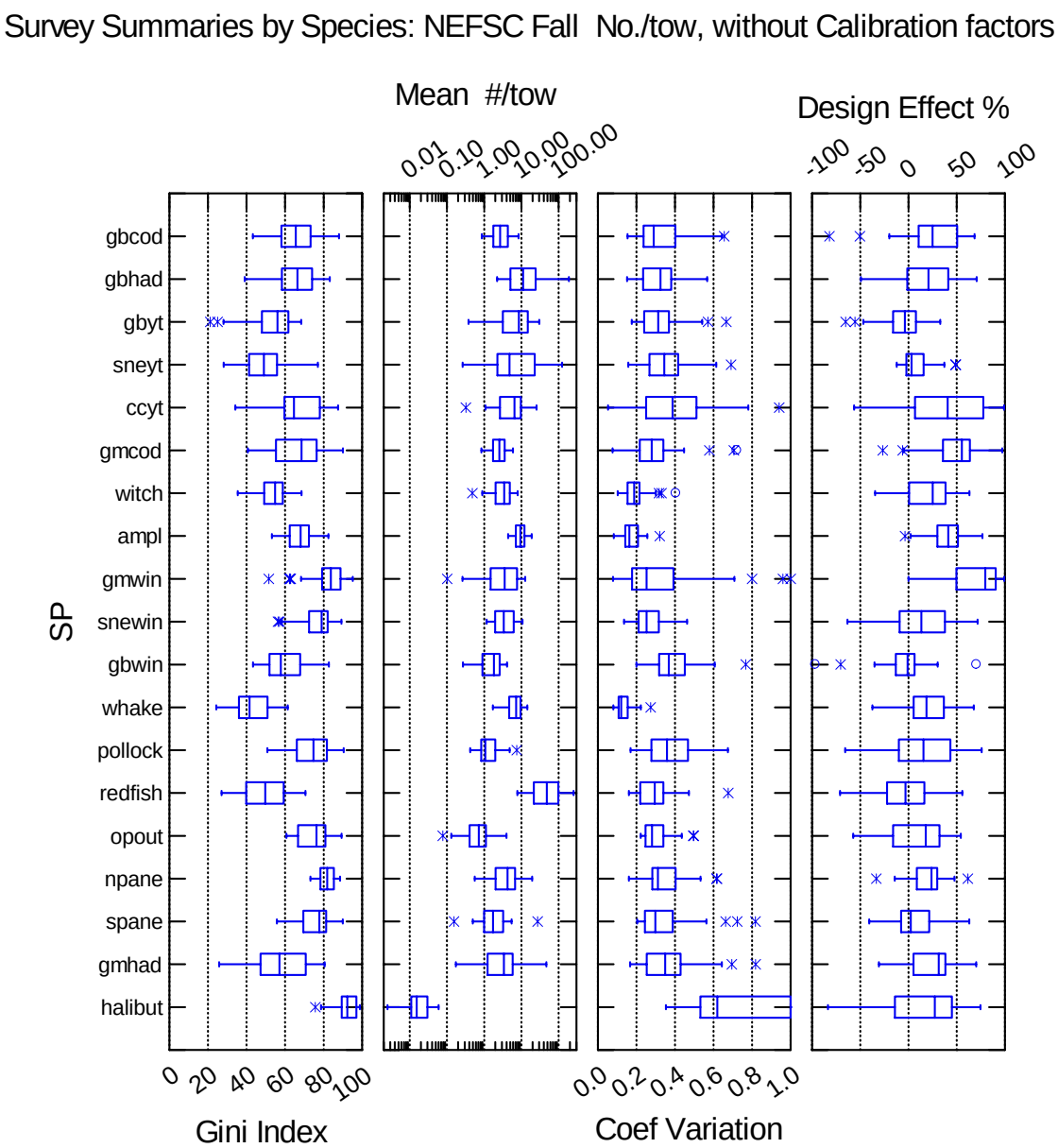


Fig. 5. Box plots of Gini indices, survey means and CV, and Design effects for 19 stocks sampled in the NEFSC Fall bottom trawl survey. Each box represents incorporates data from 1963 to 2007.

Appendix 2: Six-Panel Plots of Catch, Relative F, and Replacement Ratios

The relationships among the catches, abundance indices, relative F, replacement ratios and time are summarized in a series of six-panel plots for each stock (19) and survey type (fall, spring) in WP1.1. The panels are aligned to facilitate interpretation of the stock dynamics and to allow for a standard approach for comparison among stocks. For the purposes of this report, relative F is expressed as the ratio of total catch in year t to the average survey index I in years t-1 to t+1.

$$relF_{j,s,t} = \frac{C_{s,t}}{\left(\frac{I_{j,s,t-1} + I_{j,s,t} + I_{j,s,t+1}}{3} \right)} \qquad (1)$$

The replacement ratio is defined as the ratio of the current relative stock to the average of the preceding 5 years. At an empirical level it simply expresses the relative rate of growth or decline of the total population as a ratio of the current value to a smooth of previous values. A theoretical interpretation can be applied using Leslie matrices but that justification will be described in greater detail at the GARM Biological Reference Points Meeting in April 2008.

$$\Psi_t = \frac{I_t}{\sum_{j=1}^{A} \phi_j \; I_{t-j}} \qquad where \quad \phi = 0.2$$

The general approach for the replacement ratio was described and peer-reviewed in GARM I in March 2002 (NEFSC 2002. Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. National Marine Fisheries Service, Woods Hole, MA)

Figure 6 is a detailed application of the model to Gulf of Maine haddock (an updated version of this graphic is provided in WP 1.1). An additional feature of this application is that an external measure of target stock size is incorporated. This aspect was NOT included in the analyses done for all species in WP 1.1)

The top four panels illustrate the interelationships among ln(**relF**$_t$), ln($\mathbf{\Psi}_{,t}$), $\mathbf{I_t}$, and time **t**. The variables share axes such that the temporal and phase plane interactions are easily followed. The bottom two panels illustrate the temporal patterns between catch $\mathbf{C_t}$ and ln(**relF**$_t$). Two of the panels warrant special consideration. The upper left panel plots ln($\mathbf{\Psi_t}$) vs ln(**relF**$_t$). The strength of the linear association can be inferred from the shape of the confidence ellipse (or principle component) surrounding the points. When the association is strong the ellipse will be long and narrow; when the association is weak the ellipse will approach a circle. The diagonal line represents the robust regression

estimate and the dashed horizontal line represents the replacement ratio of 1.0. The intersection of the diagonal line with the replacement line represents the estimate of $\mathbf{relF_{threshold}}$. The intersection of the regression line with a horizontal line at a replacement ratio of 1.1 (not shown) represents the estimate of $\mathbf{relF_{target}}$

The middle left panel represents the phase plane relationship between the log of the survey, $\mathbf{ln(I_t)}$ and the ln($\mathbf{relF_{,t}}$). Each point is labeled with the survey year and the points are connected to illustrate the temporal sequence. If the population declines with increases in fishing mortality and increases when the fishing mortality is reduced, the population should move up and down a linear isocline. In many species it is interesting to note that the return path for biomass, when F is reduced, tends to deviate sharply from the decline path. This general result may suggest that the rebuilding of stocks will be less predictable than the path of decline. In particular, the influence of truncated age structures on reproduction may be important and certainly, the presence of strong year classes will have a substantial, yet unpredictable influence on stock rebuilding.

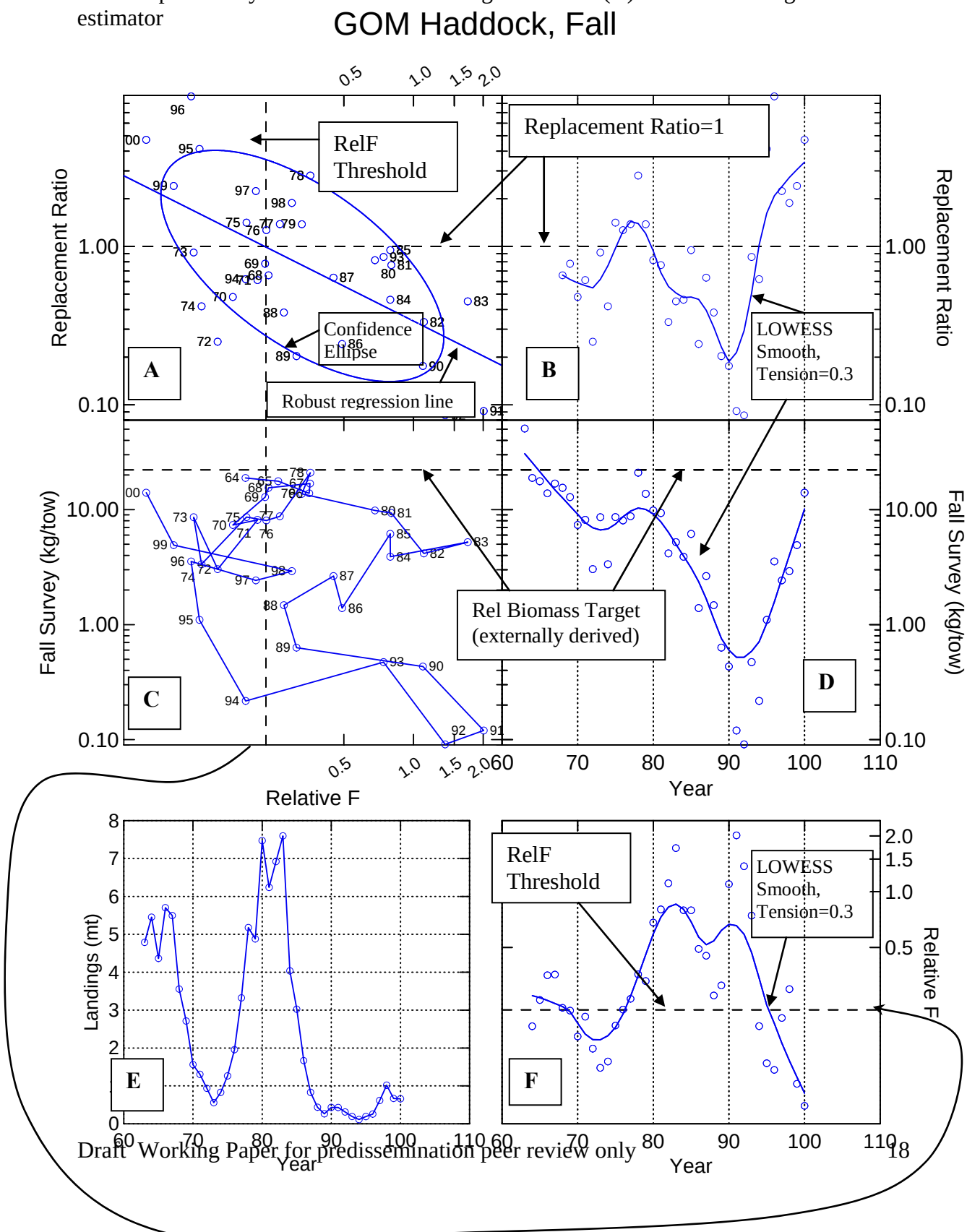



Figure 6. Annotated six-panel plot depicting trends in relative biomass, landings, relative fishing mortality rate (landings/index) and replacement ratios for Gulf of Maine haddock, using NMFS fall survey and commercial landings. Horizontal dashed (---) lines represent replacement ratios = 1 in (A) and (B). The confidence ellipse in (A) has a nominal probability level of 0.68. The diagonal line in (A) uses a robust regression estimator