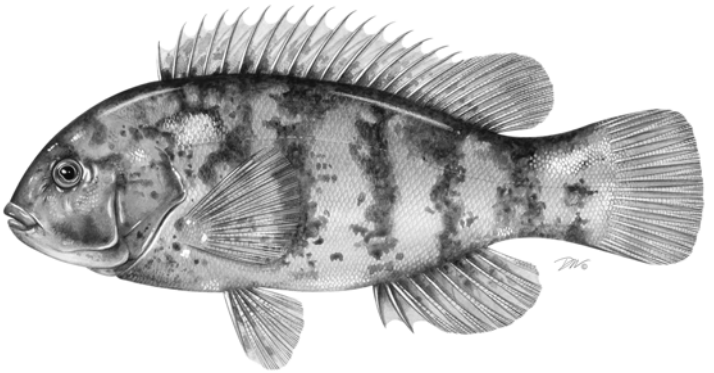
Stock Assessment Report No. 06-02
of the

Atlantic States Marine Fisheries Commission

Terms of Reference & Advisory Report
to the Tautog Stock Assessment Peer Review



January 2006

Working towards healthy, self-sustaining populations for all Atlantic coast fish species or successful restoration well in progress by the year 2015

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to the Tautog Stock Assessment Peer Review

Conducted on
November 10-11, 2005
Providence, Rhode Island

Prepared by the
ASMFC Tautog Stock Assessment Review Panel

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Preface

Summary of the ASMFC Peer Review Process

The Stock Assessment Peer Review Process, adopted in October 1998 and revised in 2002 and 2005 by the Atlantic States Marine Fisheries Commission (ASMFC or Commission), was developed to standardize the process of stock assessment reviews and validate the Commission's stock assessments. The purpose of the peer review process is to: (1) ensure that stock assessments for all species managed by the Commission periodically undergo a formal peer review; (2) improve the quality of Commission stock assessments; (3) improve the credibility of the scientific basis for management; and (4) improve public understanding of fisheries stock assessments. The Commission stock assessment review process includes an evaluation of input data, model development, model assumptions, scientific advice, and a review of broad scientific issues, where appropriate.

The Benchmark Stock Assessments: Data and Assessment Workshop and Peer Review Process report outlines options for conducting an external peer review of Commission managed species. These options are:

1. The Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) conducted by the National Marine Fisheries Service (NMFS), Northeast Fisheries Science Center (NEFSC).

2. The Southeast Data and Assessment Review (SEDAR) conducted by the National Marine Fisheries Service, Southeast Fisheries Science Center (SEFSC).

3. The Transboundary Resources Assessment Committee (TRAC) reviews stock assessments for the shared resources across the USA-Canada boundary and is conducted jointly through the National Marine Fisheries Service and the Canada Department of Fisheries and Oceans (DFO).

4. A Commission stock assessment review panel conducted by 3-4 stock assessment biologists (state, federal, university). The Commission review panel will include scientists from outside the range of the species to improve objectivity.

5. A formal review using the structure of existing organizations (i.e. American Fisheries Society, International Council for Exploration of the Sea, or the National Academy of Sciences).

Twice annually, the Commission's Interstate Fisheries Management Program (ISFMP) Policy Board prioritizes all Commission managed species based on

species Management Board advice and other prioritization criteria. The species with highest priority are assigned to a review process to be conducted in a timely manner.

In November 2005, the Commission convened a Stock Assessment Peer Review Panel comprised of members who had expertise in stock assessment methods. The review for the Tautog stock assessment was conducted at the Hotel Providence in Providence, Rhode Island from November 9-10, 2005. Prior to the Review Panel meeting, the Atlantic States Marine Fisheries Commission provided the Review Panel Members with an electronic copy of the 2005 Tautog Stock Assessment, and copies of the 2001 Tautog Stock Assessment and Addendum III to the ASMFC Fishery Management Plan for Tautog.

The review process consisted of an introductory presentation of the completed 2005 assessment, followed by general questions. This was followed by work sessions in which more specific questions concerning details of the assessment document and related work were addressed, and in which reports from several of the individual States were presented. The final day involved a closed-door meeting of the Review Panel during which the documents and presentations were reviewed and a report prepared.

The report of the Review Panel is structured to closely follow the terms of reference provided to the stock assessment team.

Acknowledgements

The Atlantic States Marine Fisheries Commission thanks all of the individuals who contributed to the development of the Tautog stock assessment and the Terms of Reference and Advisory Report. The Commission extends its appreciation to the Tautog Stock Assessment Peer Review Panel (Dr. Thomas Miller - Chair, Chesapeake Biological Laboratory; Dr. Yan Jiao, Virginia Tech University; Mr. Mike Murphy, Florida Fish and Wildlife Conservation Commission; and Dr. Michael Prager, National Marine Fisheries Service, Beaufort Laboratory) for their efforts evaluating the stock assessment and developing this Terms of Reference and Advisory Report.

The Commission and the Tautog Review Panel thanks the ASMFC Tautog Technical Committee and Stock Assessment Subcommittee (SASC) members who developed the consensus stock assessment report, especially Paul Caruso (Massachusetts Division of Marine Fisheries) for his dedication to the completion of the stock assessment, serving as Chair of the SASC, and presenting the report to the Tautog Review Panel. We would also like to thank Mr. Najih Lazar, Rhode Island Department of Environmental Management, Marine Fisheries Section, Mr. Jeffrey Brust, New Jersey Bureau of Marine Fisheries, and Dr. John Hoenig, Virginia Institute of Marine Science for their useful and clear presentations relating to the available data and the new assessment.

The Tautog Review Panel would like to thank Lydia Munger and Patrick Kilduff from the ASMFC for logistical and administrative support during the peer review and preparation of the report.

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Terms of Reference for the Tautog Stock Assessment Peer Review

A. Summarize recreational and commercial landings by region and state from MA to VA.

Recreational and commercial landings of tautog (*Tautoga onitis*) for 1982-2003 were appropriately documented by state within the report. Recreational landings were the dominant sector in most years in most states, accounting for an average of 92% coastwide landings (Fig. 1). The remainder of the removals was comprised of recreational discard and commercial landings.

Estimates of the number landed by the recreational sector were derived from the National Marine Fisheries Service's (NMFS) Marine Recreational Fisheries Statistics Survey (MRFSS) reported Type A+B1 catches by state and wave. Proportional standard errors of the estimated recreational catch by each state often greater than 20%. This suggests there is a considerable degree of uncertainty in the true value of recreational landings. Massachusetts, New York and New Jersey dominated the reported recreational harvests, accounting for between 30 – 70% of the total coastwide recreational harvests. The total removals in the recreational fishery were derived by combining recreational catches with an estimate of the mortality of released fish. The discard mortality rate was estimated as 2.5% of the MRFSS Type B2 releases. The Review Panel noted that this rate of discard mortality was low compared to other fisheries. Additionally, the mortality rate estimate was based on a single study (Simpson and Gates 1999) in a single region over a limited period of time. The degree to which this estimate reflects coastwide mortality levels throughout the time period of concern is unclear. The Review Panel further noted that even at this low rate, based on the last five years data, the estimated discard mortality accounts for approximately 5% total removals for this species (Fig. 1). The current level of releases in the recreational fishery is high, likely as a result of implementation of minimum size limits in the recreational fishery, such that in the most recent years, two to four times as many fish are caught and released as are retained. This translates into an increase in the importance of discard mortality.

Estimates of removals in the commercial fishery were based upon reports of the weight of tautog landed. Concern was noted that estimates of commercial landings early in the time series, before states implemented appropriate reporting procedures, may have been biased low. No information on discard mortality in the commercial fishery was available, and thus the assessment assumed there was no commercial discard mortality. This assumption introduces an unquantifiable source of error into the assessment. However, the Review Panel felt that the magnitude of this error is likely to be small. The reported commercial landings were expanded to numbers using the mean weight in the recreational fishery. This approach requires the assumption that there is no difference in selectivity

between commercial and recreational sectors. The approach was justified by the assessment team based on the considerable overlap in time, space and gear between the recreational and commercial sectors. However, the Review Panel noted that no data were presented to verify this assumption.

B. Summarize length composition and available age-length data to the highest level of resolution, based on the accuracy of the data.

Length compositions were derived from a combination of sources. Data came from the estimates of size distributions in MRFSS Type A catches. Sampling intensity varied considerably over the time series. Initial increases in sampling intensity in the first half of the series reflects increased efforts by states to collect length information. Subsequent declines in sampling intensity reflect declines in the recreational harvest available for characterization. Additional length distribution information in the recreational fishery, especially for tautog caught and released alive, came from specific fisheries in New York, New Jersey and Virginia. These surveys were of limited temporal and spatial extent.

Expansion occurred at one of two different scales. In some cases, expansion to size- or age-distribution was possible at the state level. However, an adequate level of sampling was not always available for individual states. Accordingly, the assessment team employed data from a mixture of all possible data to generate aggregate age-length keys for a northern region (Massachusetts to New York), and a southern region (New Jersey to North Carolina). The separation was justified on the basis of the differences in the distribution of likely tautog habitat in the two regions, and on the potential for differences in growth dynamics.

The length distributions were then applied to the recreational landings and discards, and commercial harvest to develop estimates of total removals at length. For the recreational landings, the expansion was conducted at the state level. For the recreational discards, the expansion was conducted at the regional level.

The Review Panel felt that the assessment team conducted appropriate expansion of length compositions. However, the Review Panel noted that the low sampling intensity for biological characteristics in the different fishery sectors means that the precision of the final length composition in the total removals is limited.

Age determination was based on opercular annular structures. A standard of 200 opercula samples per state per year has been established, with samples distributed ideally evenly across observed length classes. However, this level of sampling has not always been met by individual states. Age sampling in all fishery sectors was insufficient to develop sector and/or state-specific or annual age-length keys. For the early years in the time series, the assessment team developed multiyear

age length keys specific to 4-5 year periods for each region. More recently, increases in sampling have allowed biennial and even annual age-length keys to be developed. The Review Panel noted this improvement in data availability and recommended that the states continue to strive to develop annual age-length keys.

The Assessment indicated that the age-length keys have changed over time. However, the Review Panel was not able to inspect the age-length keys to determine the extent of these changes.

Evidence presented in the Assessment was equivocal regarding both latitudinal variation in size at age and sex-specific differences in growth coastwide. The Review Panel noted that age validation studies for this species are lacking. Indeed, recent, but as yet unreviewed, evidence from Virginia suggests the potential for considerable latitudinal variation in size-at-age. Thus, there exists the potential for differences in interpretation of size-at-age among the states and regions which would have substantial consequences for the current assessment.

C. Summarize all available indices of stock abundance by state.

Indices of abundance were developed for fishery-independent trawl surveys conducted by each state for use in the coastwide assessment. The design, spatial and temporal extent of these surveys differs. The Massachusetts survey provides annual weighted stratified mean number of fish per tow for a stratified survey conducted south of Cape Cod during the spring. The Rhode Island fishery-independent survey indices are a combination of non-overlapping seasonal and monthly trawling stations in state waters providing annual mean numbers of fish. The Connecticut survey is a monthly trawl survey in Long Island Sound that estimates the geometric mean number of fish per tow. New York conducts a small-gear, seasonal trawl survey in Peconic Bay in shallow water providing a geometric mean number of age-1 tautog. New Jersey surveys coastal waters with an otter trawl during January /February, April, June, August, and October using a depth stratified design and providing annual stratified mean number per tow by age. Further details were often available in the state-specific reports appended to the assessment document. Some of these reports described additional surveys that were not considered adequate for use in the coastwide assessment.

The Review Panel found that the list of surveys used in the coastwide assessment appeared to contain all of the appropriate surveys available for the assessment. It was somewhat reassuring that all surveys in general showed a coherent pattern, beginning at high levels of relative abundance before declining in the 1980s and 1990s and then increasing since about 2000. A fishery-dependent survey based on tautog-directed angler catches did not show the recent increase but these data were not used in the assessment analysis. The Review Panel agreed that it was appropriate not to use the MRFSS CPUE as an index of abundance in this assessment. However, the Review Panel noted that future assessments should

review this finding, and considering using MRFSS CPUE if it can be shown to be reliable.

The Review Panel did question the application of the fishery-independent data as indices of abundance within the analysis. All of the surveys were conducted by trawl, a gear that cannot be used effectively over the high-relief habitats preferred by tautog. Trawls likely encounter tautog sporadically during periods of movement to spawning grounds or during their migration to nearshore or offshore overwintering sites. The Review Panel suggested the use of statistical techniques, like general linear models, to remove the seasonal and environmental effects associated with differing availability. Also, given the species affinity for non-trawlable bottom, a non-linear relationship between the survey indices and tautog abundance should be considered as an assessment sensitivity run.

Additionally, the Review Panel expressed concerns over a lack of standardization apparent in some surveys. The Review Panel noted changes in vessel during the course of the surveys conducted in several states. Ideally gear and vessel changes should be avoided unless absolutely necessary, as they can jeopardize the long-term value of the data set unless careful inter-calibration studies are conducted.

D. Estimate age composition of recreational and commercial landings and indices using age data from the states MA - VA.

The estimation of the age composition of the commercial and recreational removals has been reviewed in previous sections of the report. We reiterate that the Review Panel felt that the assessment team had appropriately analyzed the age composition of removals, but note that the precision of these compositions is not well described due to the low intensity of sampling for biological characteristics of removals.

Fishery-independent survey indices were converted to age-specific indices by expanding the annual survey estimate by an estimated age-structure of the survey catch. This was accomplished in different ways by each State. Most States applied the aggregate commercial /recreational /survey age-length key to survey abundances. However, in Connecticut, survey age-structure was estimated using a survey-based key. The New York survey indices were grouped into two length-specific bins recognizable for age-0, age-1 and older-adult age groups. The Review Panel was concerned about the accuracy of the age-structure estimated for the surveys. Examination of age-structured survey abundances indicated that surveys may not track age composition reliably, so that surveys may more accurately reflect the abundance of groups of ages only. The Review Panel discussed whether the lack of internal consistency in individual surveys with regard to age reflected a lack of strong interannual variation in recruitment, or whether the pattern resulted from interannual variability in availability of fish to

the survey gear. The Review Panel could not resolve the contribution of each potential explanation to the pattern observed.

E. Provide estimates of stock status and trends and fishing mortality on a coastwide and regional basis, and if possible for each state.

The 2005 Tautog Stock Assessment contained estimates of stock status, trends and fishing mortality rates both on a coastwide basis and at the level of individual states. Analyses conducted at both levels were reviewed.

The development of a coastwide assessment presupposes a single coastwide stock. The Assessment team presented evidence from tagging studies conducted at several locations along the coast that would indicate low vagility of individual fish within short time periods (i.e., less than two years). These data might suggest the presence of substock structure and thus the potential for regional variability in vital rates and fishery characteristics. The Review Panel noted that if such structure exists, consolidated management of multiple substocks could lead to a situation in which some substocks are overexploited while others are not.

The Stock Assessment Team utilized a coastwide Virtual Population Analysis (VPA) to estimate trends in abundance, spawning stock biomass, recruitment and fishing mortality. The Review Panel concluded that, of the assessment work in the Assessment Report, the coastwide VPA provided the best available scientific foundation for management. The VPA estimated population abundances in 11 real age classes and a final plus group. The Review Panel believed that the use of a plus group for ages 12 onward was appropriate. The analysis used aggregate estimates of catches- and weights-at-age for 1982- 2003, and an initial partial recruitment vector. Fifty-one, age-specific tuning indices, derived from the fishery-independent surveys, were used in fitting the VPA model to the available data. A catch-weighted fishing mortality rate (F), based on ages 8-10, was estimated by the VPA.

The VPA results indicated that population abundance declined approximately fourfold from 1982 to 1996. Subsequently, and likely as a result of management action to restrict catches, population abundances have increased, but not to the levels seen at the beginning of the time series. Predicted catch-weighted Fs varied between $0.15 < F < 0.65$ over the same period. There was evidence of a decline in catch-weighted F between 1994 and 1996, presumably as a result of management action.

A retrospective analysis did not indicate any significant issues with VPA sensitivity to recent survey and catch estimates. However, the comparison of the abundance of the plus age group when calculated by either backward projection or forward projection differed substantially. The differences were most apparent

for that since 1994, suggesting that it may result from incomplete passage of age classes through the model.

Despite the Review Panel's acceptance of the overall VPA, the Panel did identify several concerns with the analysis.

- The Review Panel noted that dividing state survey into indices representing single ages will increase variance in estimated abundance at age, especially as the ageing is uncertain. An alternative model structure or configuration that utilizes indices of age-groups (such as cohort models that estimate selectivity curves by index and age) might simplify the assessment.
- The VPA assumed a proportional relationship between survey abundance and population abundance. As discussed above, the surveys potentially may not be proportional to abundance. Thus, the Review Panel questioned the reliability of the use of the proportionality assumption in the VPA.
- The assessment document presents estimates of the terminal F in 2003. Given the uncertainty in the catch-at-age and the inherent uncertainty in terminal F estimates in VPAs generally, the Review Panel recommended that an average fully-recruited F over the last few years be used to characterize the current level of fishing.
- The VPA-estimated stock and recruitment relationship appears relatively linear. Recruitment levels appear more stable than they are in many stocks. The Review Panel noted that this apparent stability may be due in part to imprecision of ageing, which tends to dilute the influence of strong year classes. However, if the stock-recruit relationship is reliable, the relationship indicates that current stock sizes would need to be approximately doubled to give average levels of recruitment. The Review Panel felt that a plot of the time series of annual recruitments would be beneficial.
- VPAs assume perfect catch-at-age data as an input. As we have noted above, there is uncertainty in both the level of removals by the various fishery sectors, and their expansion to catches-at-age. This uncertainty propagates into the VPA results. Other age-structured models that do not carry the assumption of accurate and precise catch at age data should be considered for future assessments.

The Review Panel noted many inconsistencies between the tables and figures in the Assessment report. For example, estimated numerical stock abundances (ASMFC 2005 - Fig. 9) were orders of magnitude less than harvests, suggesting a scaling factor was left off of figures. Additionally, the estimated numerical abundances were of a similar magnitude to the reported stock biomass (ASMFC 2005 Figs. 9 & 10), which would imply each fish weighs 1 MT. The tick marks on many figures do not line up with the corresponding x-axis values (usually year), nor with points in the graphs, which makes the figures difficult to interpret. Finally, spawning stock biomasses at the beginning of the time series were greater than total stock biomasses (ASMFC 2005 Figs. 10 & 11). Greater

attention to detail in preparation and presentation of figures and tables is warranted prior to release of the assessment document.

Several of the State reports attached as appendices to the coastwide assessment provided state-specific estimates of status and fishing mortality rates. Because of the potential for substock structure in this species, the Review Panel encourages the continued development and refinement of State-specific assessments to complement the coastwide assessment. Although the approaches used differed among the individual states, the individual State reports indicate that they appear not be overfishing their components of the population. However, Panel expressed several concerns regarding the comparability of the F estimates developed in the State reports and that developed from the coastwide VPA. There were, for example, differences between the partial recruitment vectors employed by the different states and the coastwide assessment. In particular, catch curve analysis, which was used by many state to estimate their Fs, can be extremely sensitive to the choice of ages consider fully recruited. Simulations conducted by the Review Panel indicated that inclusion of younger ages always biased the estimated F values downward and that the error in the selection of age classes was not detectable by eye as deviations from the fitted straight line. Furthermore, it is well known that if recruitment is declining over time, a "cross-sectional" catch curve will underestimate F. The Review Panel recommends that extreme caution be employed when comparing analyses that employ different assumptions regarding the pattern of fishing.

The Rhode Island report differed from the other state reports in that it used a biomass dynamic model (production model) to estimate status and trends in the fishery. The Review Panel views use of an additional model as a positive step in the assessment. However, the Review Panel expressed the following concerns regarding the application of the biomass dynamic model in the Rhode Island report. First, several of the indices used are young of year indices. The Review Panel questioned the appropriateness of such indices as indicators of total stock abundance. As the young of year indices showed a marked increased toward the end of the time series, they tended to influence the entire analysis toward a less exploited state. Second, the decline in the University of Rhode Island Graduate School of Oceanography (URIGSO) trawl index in the first two decades seems incompatible with the model structure assumed and the imputed fishery catches in that time period, in that the abundance index was declining steadily while imputed removals were near zero. Finally, converting F estimates from biomass dynamic models to corresponding F estimates in numbers is always challenging, partly because of the conversion of numbers to weight, partly because selectivity vectors are different (and in the biomass dynamic model unknown), and partly because of differences in other model assumptions.

F. Evaluate biological reference points using appropriate models and updated information.

The Tautog fishery is managed to achieve an $F_{40\%}$ spawning per recruit (SPR) target. The Review Panel noted that the value of F which results in 40% SPR will vary according to the partial recruitment of the stock to the different fishery sectors, which may vary both temporally and spatially. Indeed, the VPA indicates that the partial recruitment vector does vary temporally. The Review Panel believed that it would be more direct to report fishery status in terms of realized SPR rather than equivalent F.

The Review Panel further believes that if management responsibility for this species further devolves to the States, calculation of regional or State-specific SPRs will be critical to the evaluation of status of fisheries for this species. This was evident in comparing the results of State assessment which report Fs based on different (and sometimes poorly defined) partial recruitment vectors.

G. Review stock status and fishing mortality with respect to the biological reference points.

The coastwide VPA indicates that the 2003 coastwide F for tautog (0.2999 yr^{-1}) is marginally above the target (F=0.29 yr^{-1}). The variability in the partial recruitment vector for these fisheries will impact the calculation of the 40% SPR target. The VPA results do not provide information on realized fishing intensity relative to the target other than for the final year. However, terminal Fs are somewhat higher than 0.29 yr^{-1} in the four preceding years, which suggest that on average the target fishing mortality rate may have been exceeded in recent years.

The Review Panel observed that calculation of the realized SPR as a part of the VPA would provide more direct information of the status of the fishery relative to the target, and would further provide the possibility of bootstrapping the status of the fishery relative to the target which would represent an improvement of advice to managers. This may require minor modifications to the VPA software. Also, the Review Panel recommended that a target be developed based on the average partial recruitment vector, rather than a point estimate for an individual year.

H. Research Recommendations

Issue: Estimates of vital rates and fishery characteristics come from limited geographic range and are not regularly updated.

1. Studies to quantify and validate size-at-age by state should be conducted and calibrated. Improvements in our understanding of size-at-age coastwide would greatly improve estimates of partial recruitment.

2. Studies to quantify and validate maturity-at-age by state should be conducted and calibrated. Improvements in our understanding of maturity-at-age are necessary for coastwide and state-specific evaluation of status and biological reference points.
3. Studies of discard mortality should be updated and conducted on a broader spatial basis.
4. Studies to improve knowledge of the biological characteristics of the commercial harvest would improve overall estimates of catch-at-age
5. Studies of the recruitment and mortality of the first few age classes should be conducted. Independent estimates of recruitment are currently lacking for this species, and thus the extent of recruitment variability cannot be assessed independently of model results.

Issue: Sensitivity of VPA results to model assumptions has been insufficiently characterized

6. The application of alternative model approaches to the tautog fishery should be explored. Virtual population analyses assume no error in the catch-at-age data, yet for tautog there is considerable uncertainty in the levels of absolute removals, and the characteristics of these removals. Development of forward projecting statistical catch-at-age models, or length-based models should be encouraged.
7. Studies to explore the sensitivity of model results to the assumed level of discard mortality should be conducted. The Review Panel has noted concerns over the low rate of discard mortality assumed in the current VPA. Sensitivity analyses of the importance of this assumption on estimated status and trends would be beneficial.
8. Studies to explore the sensitivity of model results to the assumed proportionality between survey indices and abundance together with the weighting of the individual survey indices should be conducted. Sensitivity analyses of the importance of these assumptions on estimated status and trends would be beneficial.
9. Studies should be conducted to confirm that the biological characteristics of fish harvested in the commercial and recreational fisheries are equal.

Issue: Conclusions of State-specific and coastwide assessments diverge

10. States should consider developing their own spawning potential per recruit (SPR) estimates based on data on maturity, growth and partial recruitment, specific to their own waters that can be compared against state-specific fisheries exploitation patterns.
11. Simulation studies of the sensitivity of catch-curve analyses to misspecification of partial recruitment, recruitment variability and similar factors should be conducted. Catch curve analyses were a

prominent feature of many State reports, yet the reliability of these methods to provide estimates of current status is unclear.

Issue: Fishery-independent surveys as an indicator of abundance

12. Intercalibration studies are critical when gear and or vessels are changed during surveys. The Review Panel noted vessel changes during the course of the surveys conducted in several states. Ideally gear and vessel changes should be avoided when possible. In the absence of calibration studies, it is unclear whether changes in survey indices reflect changes in underlying abundance or changes in methodology.
13. Exploration of the application of general linear models (GLM) or other statistical methods to survey time series should be conducted. Survey indices currently appear to reflect differential availability of fish to survey gear, rather than differences in abundance from year to year. Incorporation of environmental factors into the analysis of survey data using GLM techniques may improve the reliability of survey indices.

Issue: Relationship of 40% SPR to maximum sustainable yield (MSY) is unknown

14. An analytical study should be conducted to compare the current target of F40% SPR to an MSY-based target computed from average recent partial recruitments. Such a study would provide information on the appropriate SPR to adopt as a target to meet the Commission's management objectives.

Advisory Report

A. Stock Status

Tautog is currently experiencing fishing mortality rates, estimated on a coastwide basis, that are marginally above the management target.

B. Stock Identification and Distribution

Tautog ranges along the Atlantic coast from South Carolina to Nova Scotia (Collette and Klein-MacPhee 2002). Genetic information cannot distinguish separate stocks within this range. However, information from tagging studies indicates that movement of fish within the stock is extremely limited. This information, combined with their reproductive behaviors, gives rise to the clear potential for substock structure.

C. Management Unit

The management unit is the coastwide tautog population from Massachusetts to North Carolina. However, biological information indicates that it would be appropriate to subdivide the management unit should data become available to conduct assessments on a smaller geographic scale.

D. Removals (Landings and Discards)

Removals in this species are dominated by the recreational harvest, ranging from approximately seventy-six percent in Rhode Island to almost one hundred percent in Delaware, and averaging ninety-two percent for all states for the 1982 - 2004 time series (Table 1). From 1982-2003, recreational landings of tautog (estimated as MRFSS Type A+B1 in numbers) from Massachusetts to Virginia declined from approximately 3 million fish (1982-1992) to 0.9 million (2000-2004 – Fig. 1). Most of the decline evident in the recreational landing time series likely results from the implementation of minimum size limits in the fishery in the mid 1990s. The recreational landings are dominated by landings from Massachusetts, New York and New Jersey (Fig. 2). With the advent of minimum size limits, releases in the recreational fishery increased, so that by the 2000s two to four times as many fish were released as landed. Despite the rate of release mortality being estimated as only 2.5%, the large number of releases translates to a sizeable discard mortality in the recreational fishery (Fig. 1). In the final years of the time series the fraction of total removals that came from recreational discard mortality and the commercial removals were equivalent (Fig. 1).

E. Data and Assessment

Tautog was assessed via a coastwide VPA analysis. The Review Panel concluded that the coastwide assessment provided the best available scientific foundation for management. The Review Panel noted, however, that there is strong evidence for substock structure, which complicates the application of coastwide standards to local fisheries. Additional state-specific assessments were conducted, but were not sufficiently refined at this time to form the basis for management.

F. Biological Reference Points

Tautog is currently managed by a coastwide target fishing mortality rate set to ensure 40% of the virgin spawning potential ratio is maintained. This is currently estimated to be $F=0.29\ yr^{-1}$. No limit reference points or biomass-based reference points have been established

G. Fishing Mortality

Coastwide, catch-weighted fishing mortality rates were estimated from the VPA. Fishing mortality rates have been consistently above the target rate in 17 of 24 years for which estimates are available. Catch-weighted fishing mortality rates were considerably higher than the target rate until the mid 1990s when management action to limit recreational harvest lead to a reduction in Fs. The 2003 catch-weighted fishing mortality rate ($F=0.299\ yr^{-1}$) was marginally higher than the target. The average of the last three years catch-weighted F was $F=0.389\ yr^{-1}$, indicated that overfishing is likely still occurring.

H. Recruitment

Fishery-independent surveys do not provide reliable recruitment indices for tautog. Accordingly, the only information available on patterns of tautog recruitment comes the results of the VPA analysis. Based on estimates of abundance of age-1 tautog from the VPA, recruitments declined steadily from 1982- 1996 (Fig. 3). Recruitments appear to have recovered since the time series low in 1996 (Fig. 3). However, it should be noted that the estimates in the final years of the time series are likely of low precision.

I. Spawning Stock Biomass

Spawning stock biomass was estimated in the coastwide VPA. The VPA estimates indicate that SSB has declined more than threefold over the time period 1982-2003 (Fig. 4). Estimates of numbers-at-age in the VPA appear to be reflective of trends in fishery-independent surveys. Accordingly, there is some

empirical support to suggest the trend observed in VPA-based estimates of SSB may indeed be reflective of true population trends.

J. Bycatch

Bycatch of this species is likely to be limited because of the dominance of the highly targeted recreational fishery in the total removals.

K. Sources of Information

Atlantic States Marine Fisheries Commission. 2005. Tautog Stock Assessment Report for Peer Review. ASMFC Stock Assessment Report No. 05-02 (Supplemental). Washington, DC.

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Simpson, D.G. and M. Gates, 1999. Studies in Conservation Engineering, Job 4. In: A Study of Marine Recreational Fisheries in Connecticut. Final Report. Pp 121 – 127. CT DEP Marine Fisheries Office, Old Lyme, CT.

L. Tables

Table 1. The pattern of removals (numbers) in the tautog fishery by sector for 1982 – 2004. Removals represent removals from Massachusetts – Virginia as estimated by MRFSS and as reported to individual States. Removals attributed to discards were calculated assuming a 2.5% mortality rate of tautog that were reported as released alive.

Year	Recreational Landings	Recreational Discard Mortalities	Commercial Landings
1982	2,971,422	7,322	146,164
1983	2,659,994	16,908	192,871
1984	2,116,432	16,199	254,356
1985	2,498,968	17,918	416,087
1986	7,008,374	27,566	387,539
1987	3,322,249	35,144	437,384
1988	3,026,526	31,017	346,874
1989	2,512,986	26,618	418,920
1990	2,477,131	30,939	439,703
1991	2,922,315	56,416	380,004
1992	2,578,373	40,186	353,022
1993	2,237,418	49,278	263,878
1994	1,170,673	36,989	148,507

1995	1,639,290	52,565	130,720
1996	1,053,034	28,942	115,144
1997	689,027	26,989	84,759
1998	348,488	34,962	60,165
1999	679,751	57,063	55,525
2000	847,043	43,147	62,187
2001	789,112	50,807	86,486
2002	1,496,637	79,301	99,436
2003	719,038	41,974	96,889
2004	719,038	54,460	76,029

M. Figures

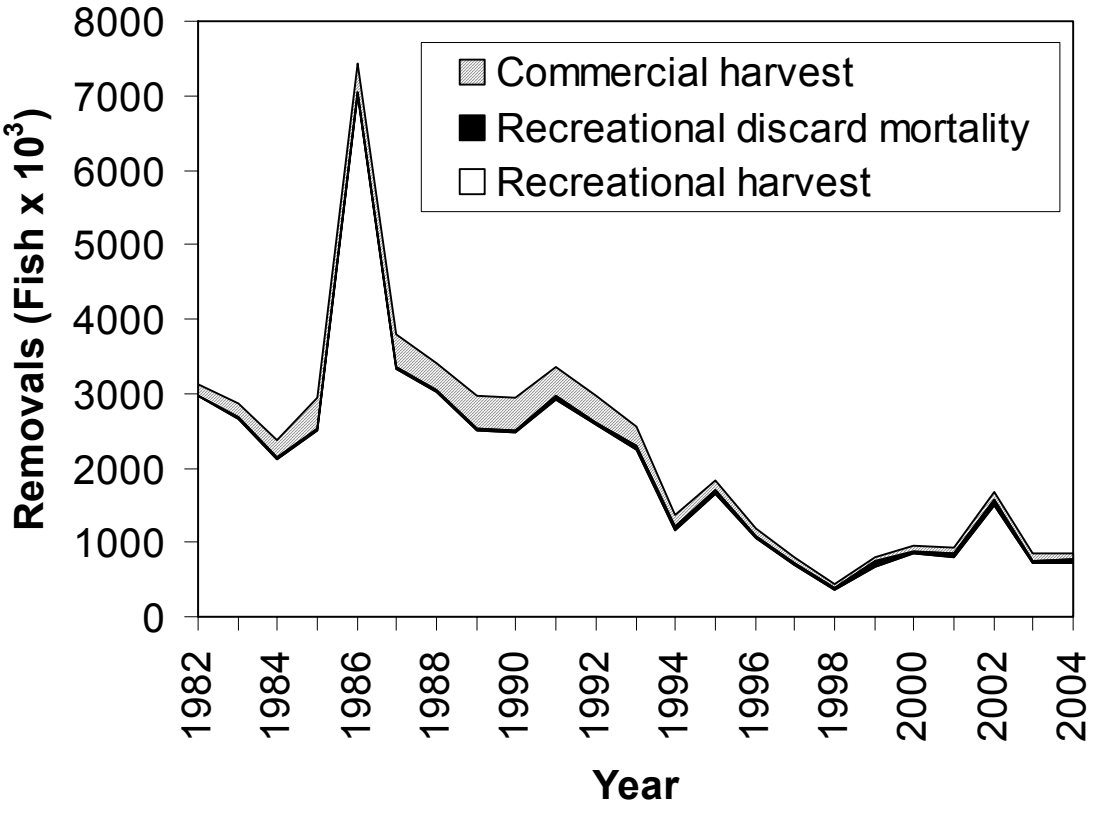

Figure 1. Time series of removals in the coastwide tautog fisheries

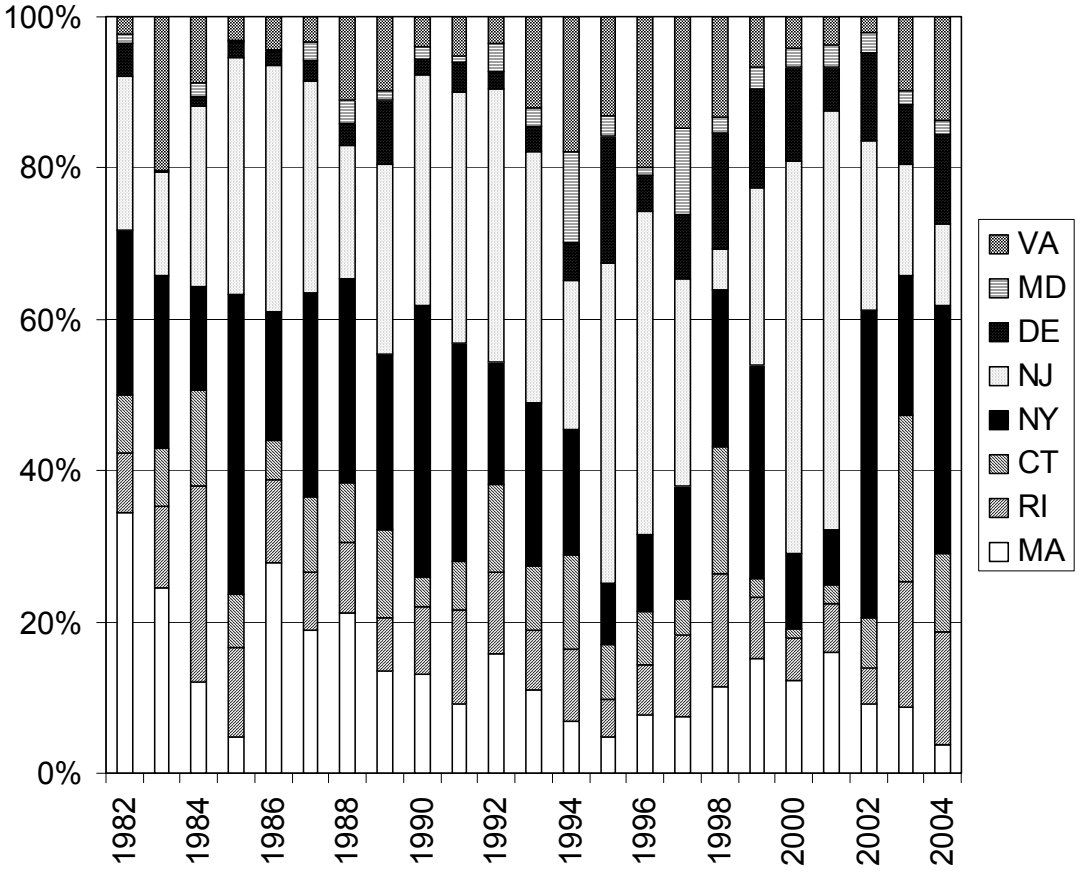

Figure 2. Proportional contribution to tautog recreational catches by individual States for the period 1982-2004

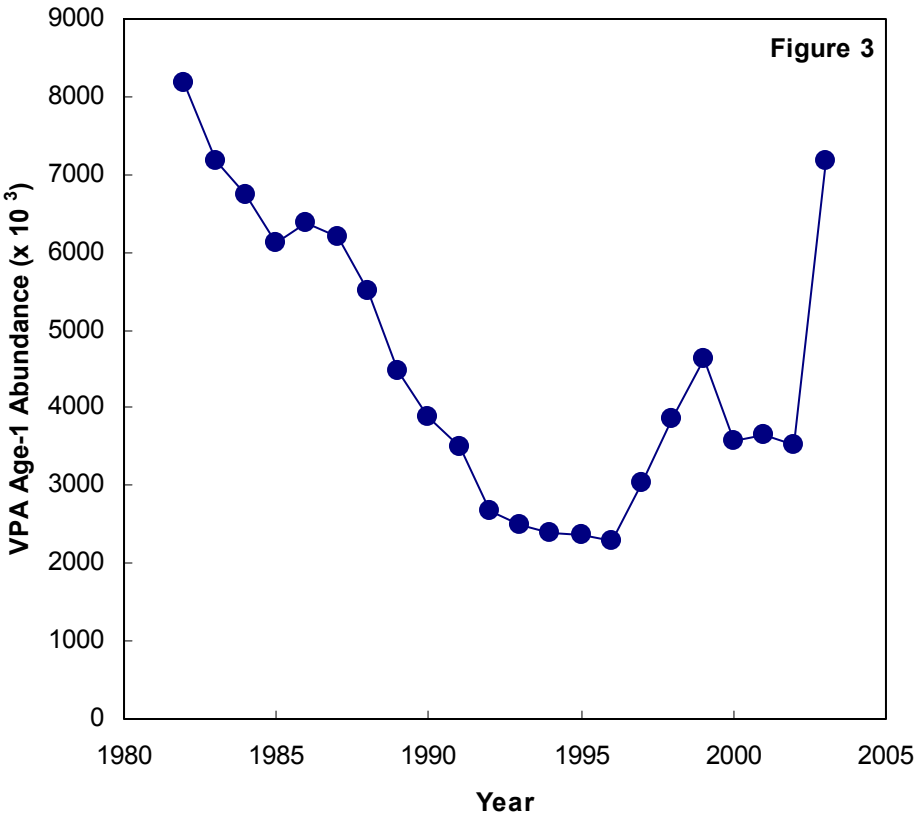

Figure 3. Time series of recruitments of tautog, in thousands of fish, estimated from the abundance of age-1 fish in the coastwide VPA.

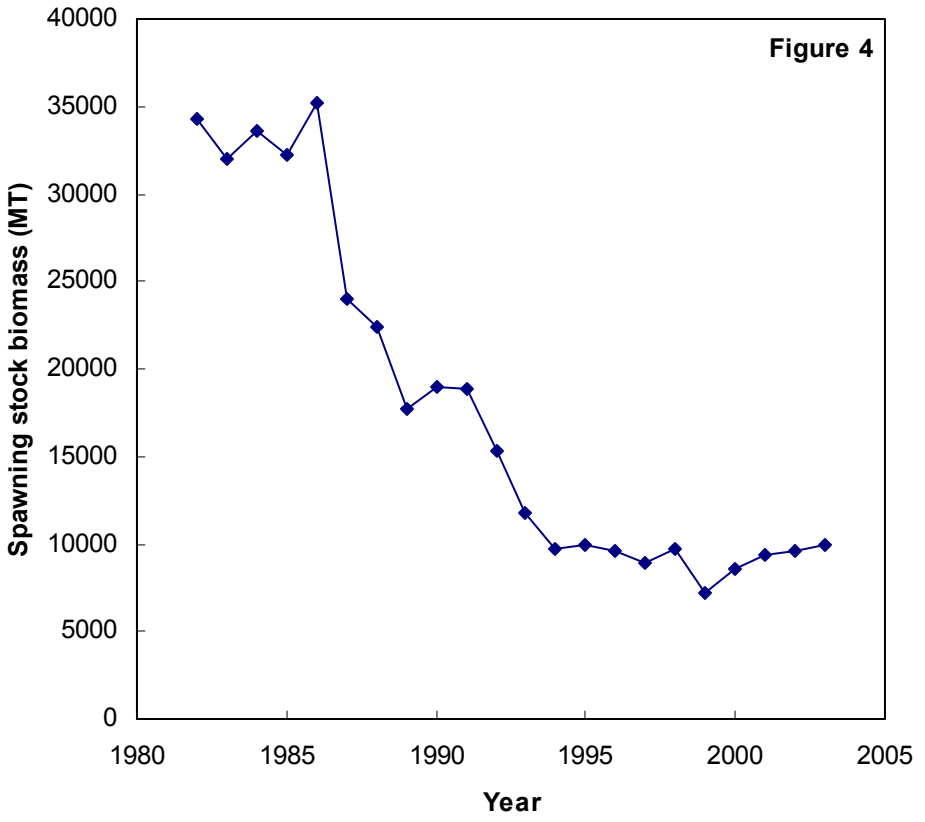

Figure 4. Time series of tautog spawning stock biomass (mt) estimated by a coastwide VPA