L. Atlantic Wolffish -2010 Groundfish Update
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1. Background

Atlantic wolffish was most recently assessed in 2008 as part of the Northeast Data Poor Stocks Working Group (NDPSWG 2009). The NDPSWG Peer Review Report indicated that there are three main issues which combine to make wolffish a "data poor" species, including concerns over which geographical regions to include in developing and assessing population status relative to BRPs, over the reliability of survey data as indices of population abundance and over life history parameters for the species within the northwestern Atlantic Ocean (NDPSWG 2009). Atlantic wolffish continue to be a data poor species.

Atlantic wolffish in the Gulf of Maine and Georges Bank regions inhabit the southern edge of the species distribution. Analyses for this update were limited to the stock component completely within US waters. Catchability is believed to be low in Northeast Fisheries Science Center (NEFSC) trawl surveys due to the habitat preference of wolffish for rough topography. Atlantic wolffish are long-lived (22+ years), late maturing, and of low fecundity. Males guard the eggs in nests in the fall. Larger wolffish have typically been caught in the spring survey compared to the fall, perhaps due to mating and nest guarding behavior making them less available to survey gear. All fishery independent survey indices show a declining trend in abundance over the time series with slight improvement in recent years. Confounding the recent trends in all wolffish indices is the lack of any reliable calibration coefficients for changes in research survey vessels and survey gear. The commercial catch has also declined steadily since 1983 and possession of Atlantic wolffish is currently prohibited. Atlantic wolffish were added to Northeast Multispecies Fishery Management Plan, Amendment 16, by the New England Fishery Management Council (Federal Register 2010).

A forward projection model, Statistical Catch At Length (SCALE), which tunes to the size and age data from trawl survey recruitment and adult indices, total catch, and catch size distributions along with overall growth information was accepted by the Peer Review Panel as a basis for determining the biological reference points (BRPs) for Atlantic wolffish (Miller et al 2009). In 2008 overfishing status was uncertain and the stock was considered overfished (Table L1).

Commercial and recreational fisheries data and fishery independent data has been updated for use in the model. BRPs have also been updated using the guidance from the Peer Review Panel Report. Biological reference points for the F 50% proxy were not updated. BRPs were estimated for two commercial selectivity regimes and for three knife edge maturity cutoffs. There is preliminary biological evidence to support the 40 cm knife edge L50 maturity cutoff (Atlantic Wolffish Appendix 1, Personal Communication McBride 2012). Sensitivity analyses are presented to evaluate the effects on SCALE model results through changes in swept area biomass due to vessel/gear changes, adding length frequency data for discarded fish in 2010, and comparing commercial discard mortality rates at 100% and 10%.

1. Fishery

Commercial Landings

Landings and Total Catch

NMFS Commercial Fishery Databases contain historical and current catch and effort information of Atlantic wolffish, 1963 - 2010. Data presented here are only from fishery statistical reporting areas that are completely or almost entirely within US territorial waters throughout the time series (Figure L1). US landings increased until it peaking in 1983 at 1,100 metric tons (mt) and then decline steadily until 2009 (last full fishing year), where landings were 33.41 mt (Figure L2 and Table L2). In the US, Atlantic wolffish were harvested primarily as bycatch in the otter trawl fishery. As of May 2010 commercial and recreational harvest for Atlantic wolffish has been closed in an effort to improve stock biomass. Landings in 2010 were at a time series low of 2.69 mt. Over all years and areas, percent commercial landings of wolffish were dominated by otter trawl gear (90.98%), followed by fixed gillnets (4.29%) and bottom tending longlines (3.2%) (Figure L3). Comparing landings in the Gulf of Maine and Georges Bank regions shows relatively no change in otter trawl landings but some shifting of fixed gill net and bottom tending longlines to scallop dredge and pelagic longline gears (Table L3, Figure L3).

Reported US commercial wolffish landings come primarily from fishery statistical areas 513, 514, 515, 521 and 522 (Figure L4, Table L4). Landings have fluctuated between statistical areas over time and spatial differences may be difficult to interpret due to management actions, such as permanent closures and rolling time closures, in the Gulf of Maine. Commercial landings in the US GBK/GOM region appear to be contracting into a single statistical reporting area, 514 (Table L4, Figure L4).

Commercial Discards

Commercial fishery discards from the Northeast Fisheries Observer Program database were updated for the period 1989-2010 from US only statistical areas based on the Standardized Bycatch Reporting Methodology combined ratio estimation (Wigley et al 2007). Discards have been a small component of the overall catch of Atlantic wolffish for the majority of the time series (Figure L2, Table L2). The maximum estimated discards in any one year was 26.98 mt in 1989, which is the first year of discard estimates (Table L2). Otter trawls account for 93.6% of the total discarded wolffish from all years. Discards appear to be increasing in the gillnet sector, which reported approximately 18.9% of the total wolffish discarded for 2009, the last full year of commercial fishing (Table L5). Discards estimates in 2010 are relatively high as a result of management action.

Recreational Landings

Recreational landings data were updated from the MRFSS database (Figure L5, Table L6). Landings are reported in total number of fish and total weight per year. Landings include both A and B1 fish, these are fish permanently removed from the population. B2 fish are discarded live and are assumed to have survived. Adjusted

landings were developed because average weight of an individual wolffish was highly variable. Average weight (kg) was calculated based on the reported numbers of landed fish (A + B1) divided by the reported landed weight (kg). A grand mean was updated from average weights and used in the new adjusted landings values. Adjusted landing are less variable than the original MRFSS reported values and are likely to describe the recreational portion of total catch. Recreational landings have become more significant in recent years as commercial landings have steadily declined (Figure L2, Table L2). The recreational component of total catch makes up approximately 22% of the total catch and is nearly 1/4 as large as the commercial landings for 2009 (Table L2). Recreational landings are extremely low in 2010 as possession of Atlantic wolffish was also prohibited in the recreational sector as of May 2010.

Total Catch

Total Catch is comprised of reported landings, estimates of commercial discards from the primary fishery sectors and recreational catch from US waters as previously described (Figure L2, Table L2). Recreational catches begin in 1981 and discard estimates begin in 1989. Discard mortality has been assumed to be 100% in the commercial sector. Total US catch peaked in 1983 with 1,112 mt and has decreased steadily reaching a low of 17.47 mt in 2010. The 2010 total catch is dominated by the commercial discard component, 14.3 mt, followed by 2.7 mt of landings, and 0.5 mt of recreational landings.

Commercial Landings – Length Frequencies

Fishery observers collect length samples at sea opportunistically providing information on the size structure of the population for Atlantic wolffish. Observer lengths have been collected since 1989. Starting in May, 2010 At-Sea Monitors (ASM) began to collect fishery dependent information aboard commercial fishing vessels including length data for Atlantic wolffish. Sample sizes from early in the time series are low but have exceeded 100 lengths per year during 2003-2007 and in 2010 (Table L7). Commercial lengths presented are from kept fish only for all years except 2010 when kept and discards were combined. Kept and discards for 2010 were combined because all Atlantic wolffish after May, 2010 were required to be discarded. Of the 268 fish sampled in 2010 only 7 were kept and 261 discarded. Discarded observer length data are sparse from 1989-2009, maximum of 18 wolffish in a year, and therefore not reported. Median length has been variable over time but increased slightly during the 2003-2007 period indicating that larger fish were being harvested (Figure L6). Since 2008 median length has trended down. Commercial lengths from port samples have been taken irregularly during the span of the commercial fishery. A significant amount of samples were collected during 1982 – 1985 and have also been taken consistently during 2001-2009. Few port samples were obtained in 2010 as landing this species was not allowed after May 1st. Commercial port sample length distributions were plotted by year (Figure L7). An increase in median length was seen during the 2001 – 2007 time period but has since been on a downward trend. The median increased from 75 cm in 2001 to 84 cm in 2007 and has declined back to 80 cm in 2010 (Table L8). A pooled length dataset was created for port sample and observer and At-Sea monitor data. The pooled data also showed a declining trend on the median length of Atlantic wolffish after 2007 (Figure8, Table L9). In 2009 the NDPSWG reported that there was little evidence of any truncation of length frequency over time. This still appears true as the range of commercial lengths is the same although median length for observer-ASM

and port samples has decreased recently. A subset of the pooled data is used as input into the observed catch length frequency distribution of the SCALE model. Some years were omitted from the model due to low sample sizes or skewed length distributions.

2. Research Bottom Trawl Surveys

Biomass and abundance indices

Atlantic wolffish are encountered infrequently on NEFSC bottom trawl surveys. The NDPSWG Report indicated that there is uncertainty over the degree to which the NEFSC surveys provide a reliable index of the population (NDPSWG, 2009). Strata used in wolffish analyses were limited to offshore areas completely or almost completely within US waters (Figure L9). In 2009 the RSV Bigelow replaced the RV Albatross IV for conducting resources surveys. Calibration coefficients for Atlantic wolffish indices are not available as the species was only encountered in 3 pairs of tows between the Bigelow and Albatross (Miller et al, 2010).

In general the NEFSC spring and fall bottom trawl survey indices show abundance and biomass of Atlantic wolffish has declined over the last two to three decades (Figure L10). The spring survey typically encountered higher abundance and biomass than the fall survey and was considered the preferred index by the Data Poor Working Group in 2008 for assessing resource trends. Survey differences may be attributed to wolffish being less available to the sampling gear while nest guarding in the fall (Rountree, R.A. 2002). Inter-annual variability among both surveys has been high. Zero catches have been observed in the spring (2005, 2006, 2008) and fall surveys (2007). Spring and fall indices of abundance and biomass show increasing trends since 2008 but these are difficult to interpret without vessel calibration coefficients.

The current spring biomass is at low levels in relation to the time series (Table L10, Figure L10). The spring biomass index from 1968 to 1988 averaged 0.786 kg/tow and varied between 0.38 and 1.44 kg/tow. Since the mid to late 1980's the resource has steadily declined. The average spring biomass index for 1989-2010 was 0.15 kg/tow and ranged from 0 to 0.42 kg/tow. CV's for the spring biomass are high, averaging 50% over the full time series. The fall biomass index shows little trend over time and is relatively low over most of the time series, which may be prescribed to availability issues during mating (Figure L11) (NDPSWG, 2009). A large peak of biomass appears in 1981 but is not seen again in subsequent years. Since the mid 1990's wolffish biomass has fluctuated with a declining trend. Current stratified mean biomass for the fall index is low but has increased slight since the last assessment in 2007 (Table L11, Figure L11). The MADMF spring has also declined over time and suffers from frequent zero catches in last decade (Table L12, Figure L12)

Abundance indices in spring and fall surveys show a declining trend in stratified mean number per tow since the mid 1990's to 2008. Recent estimates of abundance appear to be increasing slightly but care should be used when interpreting these non-calibrated survey results. 3-year centered moving average plots of abundance and biomass helps reduce the inter-annual variability within the indices and depicts an overall declining trend in the resource until 2009, when a slight positive response is detected (Figures L10 & L11).

Spring and fall percent positive Atlantic wolffish catch were plotted by year (Figures 10 & 11). This type of index for species rarely captured can be a good indicator of how frequently rare events occur over time. These indices indicate that the number of survey tows catching at least one wolffish has decreased with time in both the spring and fall until recent. The spring percent positive tows index shows an almost continuous declining trend since the late 1970's/early 1980's, averaging around 12% and dropping to approximately 2% in 2007 with a slight improvement in 2010 (Table L10). The fall index appears relatively stable from the mid 1970's through the early 1990's, fluctuating around 6 %. It then declines quickly from 1994 to 1996 and becomes relatively stable again at low levels near 2 % until 2007 where it reaches zero. Since 2007 fall percent positive has also increased slightly (Table L11).

Spring and fall indices and population estimates are also calculated for the adult component (40+ cm) of the resource (Table L13, Figure L13). Because calibration coefficients are not available the annual swept area estimates are calculated using the tow footprint of the corresponding vessel and gear configuration times the total survey area coverage. The Albatross tow footprint is estimated at 0.012 square nautical miles the Bigelow tow footprint is estimated at 0.007 nmi^2. The area coverage of survey strata used to assess Atlantic wolffish is 25,911 nmi^2. Bigelow swept area estimates are calculated for the 2009 and 2010 data points; all other years are Albatross swept area units. Swept area abundance estimates are used as input into the SCALE model.

Maturity

Atlantic wolffish maturity schedules for the Gulf of Maine are not well understood at present. A logistic maturity ogive was developed for female Atlantic wolffish based on spring and fall survey vessel data in 2008 (Figure L14) (NDPSWG, 2009). L_{50} was estimated at approximately 35 cm from these data. This L_{50} for female wolffish is lower than estimates reported in Newfoundland (65cm) and Iceland (75cm) where females containing second generation eggs were considered immature (Templeman 1986; Gunnarsson et al. 2006). These L50 estimates from these different regions provided the range of knife edge maturity cutoffs for determining biological reference points.

Gonad histology samples have been collected since 2009, including 33 female wolffish. Preliminary analysis by the NEFSC Population Biology Branch indicate that size at maturity in Gulf of Maine Atlantic wolffish is lower than in studies from Newfoundland-Labrador and Iceland, approximately 40 cm (Atlantic Wolffish Appendix 1, Personal Communication R. McBride, 2012). While sample size is small and these analyses are preliminary they may help narrow the range of biological reference points needed to determine the status of Atlantic wolffish.

4. Assessment

SCALE Model
Background

Incomplete or lack of age-specific catch and survey indices often limits the application of a full age-structured assessment (e.g. Virtual Population Analysis and many forward projecting age-structured models). Stock assessments will often rely on the

simpler size/age aggregated models (e.g. surplus production models) when age-specific information is lacking. However the simpler size/age aggregated models may not utilize all of the available information for a stock assessment. Knowledge of a species growth and lifespan, along with total catch data, size composition of the removals, recruitment indices and indices on numbers and size composition of the large fish in a survey can provide insights on population status using a simple model framework.

The Statistical Catch At Length (SCALE) model, is a forward projecting age-structured model tuned with total catch (mt), catch at length or proportional catch at length, recruitment at a specified age (usually estimated from first length mode in the survey), survey indices of abundance of the larger/older fish (usually adult fish) and the survey length frequency distributions (NOAA Fisheries Toolbox 2008a). The model parameter estimates are fishing mortality and recruitment in each year, fishing mortality to produce the initial population (Fstart), logistic selectivity parameters for each year or blocks of years and Qs for each survey index.

The SCALE model was developed as an age-structured model that does NOT rely on age-specific information on a yearly basis. The model is designed to fit length information, abundance indices, and recruitment at age which can be estimated by using survey length slicing. However the model does require an accurate representation of the average overall growth of the population which is input to the model as mean lengths at age. Growth can be modeled as sex-specific growth and natural mortality or growth and natural mortality can be model with the sexes combined. The SCALE model will allow for missing data.

Model Input and Base Model Results

A base SCALE model run was developed by balancing the need to keep inputs as similar to the previously accepted model as possible and from guidance derived from the NDPSWG Peer Review Panel Report (NDPSWGR, 2009, Miller et al, 2009). The SCALE model has been updated for this assessment using 1968-2010 data from NEFSC spring and fall trawl surveys, Massachusetts Division of Marine Fisheries (MADMF) spring trawl survey, and an age 1 (1-7cm) recruitment index from the NEFSC spring survey (Table L14). Only one recruitment index exists in the SCALE model (Figure L15). The recruitment index suffers from zero catches in many years and at times in blocks of several years. A 40+ cm index was developed from the NEFSC spring, NEFSC fall and the MADMF spring survey (Table L13, Figure L13). All three surveys show an overall declining trend in abundance with the indices also suffering from zero catches at the end of the time series. Zero catches were a major concern of the NDPSWG Peer Review Panel (Miller et al 2009). The survey length frequency distributions are limited due to the low numbers of wolffish caught in the surveys. The adult abundance indices are scaled to swept area units, the approximate area of survey coverage divided by the average coverage of a survey tow, in the SCALE model and include non-calibrated estimates (2009-2010) when vessel and gear changes occurred in 2009 (Table L15). The area swept estimates can provide some insight from estimated survey efficiencies using the estimated Qs in the SCALE model (Table L15). The recruitment index (1-7cm) was not affected by swept area adjustments as no age 1 wolffish were captured in the spring. Total catch is reported as commercial landings, estimated commercial discards, and estimated recreational harvest from 1968 – 2010. Commercial discard mortality is assumed at 100%.

Age information did not change during this update. Mean lengths at age and variation in mean length at age were based on fish collected during the 1980s from Nelson and Ross (1992). A Gompertz relationship had the best fit using all ages. We have re-estimated a von Bertalanffy relationship using data limited to fish older than 4 with L-infinity fixed at 110 cm (Figure L16). The mean lengths from Nelson and Ross's Gompertz relationship for fish younger than age 5 were also used in the SCALE model. The mean lengths from the younger fish do not have a large effect on the SCALE model results. In the final growth model we fixed L-infinity (110) at a slightly higher value than what was estimated by the Gompertz (98.9) model because few larger and older fish exist in Nelson and Ross's study and the SCALE model had difficultly predicting larger fish that are in seen in the catch length frequency distributions. The assumed variation around the mean lengths at age can be seen in Figure L17. Nelson and Ross's oldest fish was 22 years. The age matrix was dimensioned from ages 1 to 30 with an assumed natural mortality of 0.15.

Zero catches were set to missing in the SCALE model. Setting zeros to the smallest value in the time series appears to have a large unsubstantiated influence on the model results. The age-1 recruitment series was given a relatively low weight (Table L16). Setting the weight to high on the recruitment index will force SCALE to fit the recruitment index very closely but the model is less constrained in estimating recruitment for years where recruitment information is missing which can produce unrealistic results. The age-1 index was used more as a guide with setting the penalty on recruitment variation. The penalty on recruitment variation was set high enough to produce recruitment variation within the bounds of what was observed in the recruitment index. The model has to estimate a declining trend in recruitment to fit the decline in the 40+ cm indices and the declining trend in the catch since 1983. The recruitment index was used as guidance on whether recruitment failure has occurred for the wolffish stock.

The catch length frequency distributions are an important component of the SCALE model and were updated for this assessment. Observer trawl kept length sampling and port samples where combined to characterize the catch size distributions. Catch length frequency information exists from 1982 to 1985 and from 2001 to 2010. 2010 catch length distributions include lengths of discarded wolffish from the ASM databasee. A single selectivity block was used due to insufficient commercial length samples over the time series. Commercial length distributions have declined slightly over the last few years.

The lack of data prevents the SCALE model from estimating a reliable logistic selectivity curve. The SCALE model estimates a very flat selectivity curve that produces a L-50 at very large sizes. There is a tradeoff in the SCALE model between the estimated selectivity and fishing mortality rates. Two different selectivity regimes were chosen to determine its influence of stock status determination as was previously conducted in the 2008 assessment (Figure L18) (NDPSWGR, 2009). Run one had a relativity flat selectivity curve which was allowed to hit the L-50 bound of 90 cm. Run two was setup to hit the slope parameter bound of 0.15 which produces a steeper selectivity function with a lower L-50 estimate. Results of the two selectivity runs are summarized in Figures 19-22 and Table L16.

The SCALE model time series starts in 1968 with the beginning of the NEFSC spring index. The SCALE model estimates virgin conditions at the beginning of the time

series with a low Fstart estimate (0.001) in 1968 when the catch was low. Strong retrospective patterns were not apparent in the 2008 or in the current assessment for the SCALE model run2 (Slope = 0.15) (Figure L23.) (NDPSWG, 2009).

SCALE model results are optimistic in the current assessment. Total biomass and exploitable biomass show an increasing trend while catch and estimates of fishing mortality are at series lows (Figure L24). Caution should be used when interpreting trends in estimated biomass as the increase may be the result of the combination of extremely low catch and slight increase in non-calibrated survey abundance.

5. Biological Reference Points

Non-parametric biological reference points (BRP) were re-estimated for both the selectivity L-50 = 90 run (Run 1) and the slope = 0.15 run (Run 2) within the SCALE model using $F_{40\%}$ as a Proxy for F_{MSY} (Table L17). Reference points were not re-estimated for the $F_{50\%}$ proxy as the 2009 NDPSWG Peer Review Panel indicated that $F_{40\%}$ was reasonable and justifiable. A range of knife edge maturities values were used in estimating the BRPs. Maturity as 40+ cm fish was used to correspond to NEFSC survey maturity results and the 65+ cm and 75+ cm cutoffs correspond to studies in Labrador and Iceland (NDPSWG, 2009). Based on reference points from both SCALE model runs, the wolfish stock in 2010 is at a low biomass (48% to 72% of B_{MSY}) but has improved since 2008 (Table L17). The overfished status is dependent upon SCALE model selectivity and size at 50% maturity. Under both selectivity regimes a small (40+ cm) L50 maturity cutoff indicates the resource is not overfished. For both selectivity regimes and the large L50 maturity cutoff (75 cm) the resource is overfished. Status is split at the 65 cm maturity cutoff; for run 1 (L50 = 90cm) status is overfished and for run 2 (Slope = 0.15) the resource is not overfished. Overfishing is not occurring in all model runs as the F_{2010} to F_{MSY} ratios range from 7% to 14% (Table L17, Figure L25). MSY ranges from 272-301 mt and SSB_{MSY} are likely between 1,590-2,032 mt.

Sensitivity Analysis

Sensitivity of Swept Area Estimates in SCALE model

Sensitivity analyses are presented to evaluate the effects on SCALE model results through changes in the swept area abundance estimates due to vessel/gear changes, adding length frequency data for discarded wolffish in 2010, and comparing commercial discard mortality rates at 100% and 10%. A fourth sensitivity was added during the course of the Groundfish Update meeting to examine the use of a proxy Bigelow to Albatross calibration coefficient for Atlantic wolffish.

Swept Area Abundance

Fishery independent survey indices (numbers per tow) are converted into swept area estimates for use in the SCALE model. Estimates come from NEFSC spring and fall time series beginning in 1968 and through 2010. A vessel change occurred in 2009, where the RSV Bigelow replaced the R/V Albatross IV. Conversion factors are not available for Atlantic wolffish as too few fish were encountered during the Albatross/Bigelow calibration exercises (Miller et al. 2010). The spring Massachusetts DMF index is also

used in the SCALE model but is not affected by the Albatross/Bigelow calibration. Swept area calculations for the survey time series were done according to the appropriate fishing gear configurations for each research vessel. The Albatross IV survey gear has a swept area scalar equal to 0.0112 and the FRV H. B. Bigelow is equal 0.007 (Table L15). The swept area footprint of the Bigelow is approximately 40% smaller than the Albatross therefore more Bigelow tows may be conducted per same unit area. This scaling factor results in higher swept area indices for the Bigelow when compared to the Albatross (Table L18).

Results of this sensitivity analysis indicate that swept area scaling differences have only a minimal effect on SCALE model output. The base model for all the sensitivity analyses was the steep sloped selectivity curve (slope =0.15 – run 2), commercial catch length frequencies including discarded wolffish from 2010, commercial discard mortality assumed at 100% and swept area survey indices scaled to the appropriate vessel, 1968-2008 Albatross and 2009-2010 Bigelow (HB runs). The base model was compared to a nearly identical model run, which differed only in that the spring and fall survey indices were scaled to the Albatross IV survey gear footprint for all years, 1968-2010 (A4 runs) (Table L13). SCALE model outputs analyzed were total biomass, exploitable biomass, and fishing mortality. Total biomass appears to be most sensitive among the SCALE outputs examined. The largest differences in total biomass occur in the early part of the time series, 1968-1975, and the conclusion of the time series, 2001-2010 (Table L18, Figure L26). Differences in total biomass between Bigelow swept area and Albatross swept area model runs for 2001-2010 are on the order of 15 to 254 metric tons per year or 2 to 16%. Differences in exploitable biomass appear less sensitive to changes in swept area calculations than total biomass and also peak at the end of the time series in 2010 with 10.5% difference (Table L18). Estimates of fishing mortality do not appear to be sensitive to changes in the calculations of swept area indices. Percent differences in F estimates were largest at -12.5% in 2010 when F was extremely low, estimated Bigelow = 0.024 vs ALIV = 0.027 (Table L19, Figure L27). Fishing mortality values are higher for the base run during the years of peak commercial catches through 2000.

Total biomass estimates differ very slightly between the base model run and the final 2009 NDPSWG model run. Input differences to the models include using kept and discarded commercial length frequency data for 2010 and using the Bigelow swept area estimates for 2009 and 2010 spring and fall survey indices in the base model run. The total biomass estimates from the NDPSWG assessment model are nearly identical to the base model run and no significant differences are detectable (Figure L28). Estimates of fishing mortality are also nearly identical (Figure L28).

Combining Commercial Length Frequency 2010 Kept and Discards.

In May of 2010 commercial landings of Atlantic wolffish was no longer permitted due to management action to help rebuild this stock. Commercial length frequency information is critical for the SCALE model to project the population dynamics for this species. Although it was not the practice in the 2008 Atlantic wolffish assessment, length data were combined between discarded and kept catch dispositions for the 2010 commercial catch length data. During the 2001-2010 time frame port samplers, commercial fishery observers and At Sea Monitors have taken length data to describe the distribution of the commercial landings (Figure L29). Up until 2010, hundreds of length samples were available in the “kept” catch disposition to be input into the SCALE model.

In 2010 only 55 lengths are classified as "kept". When kept and discarded wolffish are combined 316 lengths are available to describe the catch data in 2010.

A sensitivity analysis was conducted to determine the extent of any differences in the SCALE model output estimates by the addition of discarded length frequency data in 2010 year only. The base model SCALE run 2 (slope = 0.15) with Bigelow swept area, with kept and discarded wolffish in 2010 and commercial discards assumed at a 100% mortality rate. The sensitivity runs differed by not having the discarded fish included in 2010. A total of 261 discarded fish from the Observer and At Sea Monitoring database were added to the 55 kept wolffish. Discarded and kept commercial length frequencies are similar when plotted but sample size is very low in the 2010 kept category (Figure L30) Also compared in the figure is the 2009 kept wolffish distribution from port samples and observers. These distributions have a similar modes and ranges and were considered a good fit for a data poor species.

No difference in model output was detected due the addition of discarded length frequency data. Results of the sensitivity show both total and exploitable biomass increased very slightly in the base model run as a result of adding a more complete 2010 length frequency distribution to the SCALE model (Figure L31). The average percent change between kept/discarded and kept only for total biomass was +0.76% and the maximum percent change was +1.2%. Percent change of exploitable biomass was more variable. The maximum percent increase was 5.7% and the exploitable biomass increased on average 3.5% (Table L20). The effect of additional discard length frequency information was also minimal on fishing mortality estimates from SCALE model runs.

Commercial Discard Mortality

A sensitivity analysis was conducted on the effects of choosing a low discard mortality rate for Atlantic wolffish. The base run and previous assessments assumed 100% discard mortality. A 10% mortality rate was chosen to compare results from the SCALE model based on an otter trawl study in Canada (Grant et al, 2005).

No difference in model output was detected due changing the commercial discard mortality rate to 10%. Results of the sensitivity show both total and exploitable biomass increased by as much as 71 and 56 metric tons resulting in a 2.5 and 4.2% increase in total and exploitable biomass for 1989 respectively (Table L20, Figure L32). The effect was minimal due to the low amount of estimated commercial discards in the fishery compared to the commercial landings. The greatest change was seen in 1989, the first year of commercial discard estimates.

Proxy Bigelow to Albatross Calibration Coefficient

A Bigelow to Albatross calibration coefficient is not available for Atlantic wolffish. Using non-calibrated survey indices was believed to be inappropriate by the Groundfish Update Review Panel 2012. It was suggested that a proxy species, Ocean pout *Zoarces americanus*, be used to calibrate the NEFSC spring and fall survey indices. Other species lacking Bigelow to Albatross calibration have adopted similar methodology using proxy species. Atlantic wolffish and ocean pout are related and from the same suborder, Zoarcoidei. They share similar body type, long and eel-like, and have similar reproductive

strategies, including low fecundity, multi-generation oocytes and nest guarding. They inhabit similar environs, preferring rocky habitat in the Gulf of Maine region. Ocean pout are found further south than Atlantic wolffish, their range extending into the Mid-Atlantic Bight region of the Northeast continental shelf.

Ocean pout were captured in a total of 100 calibration tows aboard both the FRV Bigelow and RV Albatross IV. Of those 100 tows they were encountered 32 times on both the Bigelow and Albratross in the spring. A beta-binomial calibration coefficient was estimated at 4.575 with a standard error of 0.45 (Miller et al. 2010). This value was used as a proxy calibration coefficient to estimate the number of Bigelow fish in Albatross units.

Comparisons were made between the base run (slope 0.15) and ocean pout proxy run, all other SCALE model inputs were kept the same. Both the spring and fall swept area indices were reduced by incorporating the ocean pout calibration coefficient (Figures 33-34). The age-1 recruitment index for the ocean pout proxy run shows a lower recruitment than the base model run at the end of the time series (Figure L35). The total biomass projected by the ocean pout proxy SCALE model were significantly less than the base model run (Figure L36).

Biological reference points for the 40 cm and 65 cm knife edge maturity cutoffs were developed using the ocean pout proxy run for Atlantic wolffish. The Review Panel was presented with preliminary maturity findings that indicated the size at maturity in the Gulf of Maine is lower than in Canadian or Icelandic waters (Atlantic Wolffish Appendix 1, McBride Personal Communication 2012). The sensitivity run indicates that the wolffish stock is currently overfished but overfishing is not occurring for both of the knife edge maturity cutoffs examined (Table L22, Figure L37). SSB_{2010} is between 371 and 505 mt and F_{2010} is at 0.069. For status determination, the Peer Review Panel recommended adopting the SCALE model run that used, as a proxy, the ocean pout survey calibration coefficient (Table L23).

Projections

Projections were not conducted for Atlantic wolffish due to the data poor condition of the resource. The NDPSWG Peer Review Panel believed that projections would be unreliable due to the occurrence of zero catches in the survey indices and should not be undertaken (Miller et al, 2009).

Stock: Atlantic wolffish *Anarhichas lupus*

Conclusions:

SSB in 2010 is estimated to be 505 mt
F in 2010 is estimated to be 0.07
Revised estimates of the biological reference points based on a $F_{40\%}$ proxy are:
SSB_{msy} proxy= 1756 mt,
F_{msy} proxy = 0.33, and
MSY proxy= 261 mt.

Based on the preferred run the Atlantic wolffish stock is presently overfished with current SSB being at 29% of SSB_{MSY} and overfishing is not occurring (F_{2010} is only 21% of F_{MSY}).

Atlantic wolffish continues to be considered a data poor species and was previously assessed and reviewed at the DPSWG in 2008.

The "overfished" status remains unchanged since the 2008 assessment. The overfishing status has changed from "unknown" to "overfishing not occurring".

The results are based on a forward projection model, Statistical Catch At Length (SCALE), which was used in the 2008 assessment and approved by the DPSWG.

The assessment update included the selection of a single cutoff size of maturation (40 cm) and the application of the ocean pout Bigelow to Albatross IV conversion factor to the wolfish survey indices. The non-parametric biological reference points (BRP) were re-estimated for both the selectivity L-50= 90 and the slope = 0.15 run (Run 2) within the SCALE model using F40% as a Proxy for FMSY.

Atlantic Wolffish. Summary of Assessment Information

Atlantic Wolffish	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Avg	Min	Max	YrRange
Comm Landings (mt)	236	146	123	117	114	80	63	49	33	3	361	3	1100	1964-2010
Comm discards (mt)	6.5	13.1	3.8	1.6	1.3	1.5	0.8	1.8	1.5	14.3	6.0	0.1	27.0	1989-2010
Rec Landings (mt)	17.0	10.0	24.7	12.7	10.9	18.2	13.1	11.8	10.1	0.5	15.3	0.5	38.4	1981-2010
Catch (mt)	259	169	152	131	126	100	77	63	45	17	374	17	1112	1964-2010
SSB (mt)	808	729	704	655	594	521	490	492	482	505	2443	482	4577	1968-2010
Recruitment (000's)	79.20	86.01	95.59	76.86	60.71	110.02	300.07	301.87	301.85	301.85	360.79	60.71	1596.74	1968-2010
F full	0.970	0.665	0.635	0.600	0.633	0.475	0.330	0.363	0.220	0.069	0.471	0.035	1.209	1968-2010

Panel Comments

The work that is presented is accepted by the Review Panel for determining stock status and providing catch advice.

The Panel reviewed the DPSWG report and concluded that the WG recommended using the model run with the slope =0.15 (Run 2 in 2008 report). The panel agreed and proceeded with this recommendation.

The Panel reviewed three options of the cut off length of maturity (40 cm, 65 cm and 75 cm) which were from the DPSWG (2009) and concluded that based on visual observations of gonads and limited histological evidence, currently the 40 cm knife edge maturity is a more appropriate description of wolfish maturity in US waters. Although concerns were expressed about the low sample size of histological data, the analysis repeated with the 65 cm maturity cutoff resulted in the same conclusions regarding the status of the stock. A preliminary run of a logistic curve through the available maturity data indicated that the two smallest sizes at maturity (40 and 65cm) are more likely than the 75 cm size at maturity.

The panel noted that the direct use of uncalibrated survey indices derived from Bigelow in 2009-2010 was inappropriate. Due to the lack of Bigelow to Albatross calibration estimate for wolffish, the panel agreed to use an ocean pout conversion factor (4.58) as a proxy for Atlantic wolffish. When the Bigelow series can be treated as its own tuning series, the conversion factor will become unnecessary.

The Panel expressed concerns that the surveys have reached the limit of wolffish detectability due to the significant decline in abundance which is expressed in increased occurrence of zero values in observations. The treatment of zeroes in the survey data as missing data may introduce a non-negligible bias in population estimates.

References

Federal Register. 2010. Magnusson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast (NE) Multispecies Fishery; Amendment 16; Final Rule. Federal Register, 75(68) (09 April 2010): 18262–18353.

Grant, S.M., W. Hiscock, and P. Brett. 2005. Mitigation of capture and survival of wolffish captured incidentally in the Grand Bank yellowtail flounder otter trawl fishery. Centre for Sustainable Aquatic Resources, Marine Institute of Memorial University of Newfoundland, Canada. P-136, xii + 68p.

Gunnarsson A, Hjorleifsson E, Thorarinsson K, Marteinsdottir G. 2006. Growth, maturity and fecundity of wolffish (*Anarhichas lupus* L.) in Icelandic waters. J Fish Biol. 68: p 1158-1176.

Miller TJ, Das C, Politis PJ, Miller AS, Lucey SM, Legault CM, Brown RW, Rago PJ. 2010. Estimation of Albatross IV to Henry B. Bigelow calibration factors. Northeast Fish Sci Cent Ref Doc. 10-05; 233p.

Miller, T., R. Muller, B. O'Boyle, and A. Rosenberg. 2009. Report by the Peer Review Panel for the Northeast Data Poor Stocks Working Group. 20 January 2009. 34 pp.

Nelson, G. A., and M. R. Ross. 1992. Distribution, growth and food habits of the Atlantic wolffish *Anarhichas lupus*) from the Gulf of Maine-Georges Bank region. J. Northw. Atl. Fish. Sci. 13: p 53-61.

NOAA Fisheries Toolbox Version 3.0, 2008 a. Statistical Catch at Length Program, version 1.0.3. [Internet address: http://nft.nefsc.noaa.gov/].

Northeast Data Poor Stocks Working Group (NDPSWG). 2009. The Northeast Data Poor Stocks Working Group Report, December 8-12, 2008 Meeting. Part A. Skate species complex, deep sea red crab, Atlantic wolffish, scup, and black sea bass. Northeast Fisheries Science Center Reference Document, 09-02. 496 pp.

Rountree, R.A. 2002. Wolffishes. Family Anarhichadidae. Pages 485-496. In: Collette B.B., and G. Klein-MacPhee. (eds.). Bigelow and Schroeder's Fishes of the Gulf of Maine. 3rd Edition. Smithsonian Institution Press, Washington, D.C. 748 p.

Templemann W. 1986. Some biological aspects of Atlantic wolffish (*Anarhichas lupus*) in the Northwest Atlantic. J NW Atl Fish Sci. 7: p 57-65.

Wigley SE, Rago PJ, Sosebee KA, Palka DL. 2007. The analytical component to the Standardized Bycatch Reporting Methodology omnibus amendment: sampling design and estimation of precision and accuracy. NESFC Ref Doc. 07-09;156.

Tables

Table L1. 2008 Biological reference points from the Data Poor Stocks Working Group Report.

SCALE run	1			2		
Selectivity	L50 = 90			slope = 0.15		
Length of maturity	40cm	65cm	75cm	40cm	65cm	75cm
F_{MSY} proxy	F40%	F40%	F40%	F40%	F40%	F40%
F_{MSY}	0.686	0.486	0.374	0.319	0.233	0.185
YPR	0.872	0.839	0.799	0.861	0.817	0.771
SSB per Recruit	6.098	5.432	4.846	6.098	5.430	4.838
Initial Recruits (000s)	355	355	355	361	361	361
MSY (mt)	310	298	284	311	295	278
SSB_{MSY} (mt)	2,167	1,931	1,722	2,202	1,961	1,747
SSB_{07} (mt)	890	656	475	998	753	562
F_{07}	0.413	0.413	0.413	0.158	0.158	0.158
SSB_{07}/SSB_{MSY}	41%	34%	28%	45%	38%	32%
F_{07}/F_{MSY}	60%	85%	111%	50%	68%	86%

Table L2. Updated commercial landings, recreational landings, commercial discards and total catch.

Year	Commercial Landings	Commercial Discards	MRFSS Landings	Total Catch
1964	114.325			114.325
1965	166.511			166.511
1966	174.424			174.424
1967	149.584			149.584
1968	116.224			116.224
1969	163.283			163.283
1970	154.828			154.828
1971	172.795			172.795
1972	243.940			243.940
1973	242.634			242.634
1974	352.789			352.789
1975	313.118			313.118
1976	401.932			401.932
1977	393.763			393.763
1978	605.240			605.240
1979	656.494			656.494
1980	826.463			826.463
1981	671.613		0.82	672.433
1982	760.400		23.53	783.932
1983	1099.924		12.12	1112.039
1984	935.314		13.42	948.735
1985	879.963		16.24	896.199
1986	789.792		7.37	797.164
1987	665.128		38.38	703.509
1988	505.586		9.19	514.777
1989	466.840	26.983	20.85	514.677
1990	378.156	2.629	29.69	410.474
1991	446.563	1.948	17.16	465.674
1992	430.919	19.177	10.93	461.022
1993	467.222	13.378	20.47	501.068
1994	455.389	0.107	18.88	474.371
1995	449.805	5.769	20.81	476.389
1996	347.980	4.534	12.55	365.060
1997	301.767	7.821	20.57	330.155
1998	286.841	2.247	17.14	306.225
1999	242.748	0.351	8.69	251.793
2000	191.341	0.545	12.63	204.512
2001	235.998	6.470	16.97	259.437
2002	145.577	13.104	10.00	168.680
2003	123.053	3.825	24.66	151.539
2004	116.953	1.577	12.68	131.206
2005	114.040	1.306	10.92	126.269
2006	80.051	1.451	18.18	99.679
2007	63.323	0.838	13.10	77.257
2008	49.443	1.756	11.79	62.985
2009	33.409	1.451	10.09	44.953
2010	2.685	14.263	0.53	17.474

Table L3. Percent Landings by Major Gear Groups in the Georges Bank, Gulf of Maine and Combined regions - 1968-2010

Gear Groups	GBK	GOM	Grand Total
DANISH SEINE	0.07	0.29	0.29
DREDGE, SCALLOP,SEA	3.52	0.31	0.39
GILL NET, FIXED OR ANCHORED	1.27	4.37	4.30
HANDLINE	0.15	0.24	0.24
LONGLINE, BOTTOM	1.29	3.23	3.18
LONGLINE, PELAGIC	2.12	0.03	0.08
POT/TRAP, LOBSTER INSH NK	0.02	0.03	0.03
POT/TRAP, LOBSTER OFFSH NK	0.04	0.03	0.03
TRAWL,OTTER,BOTTOM,FISH	91.52	90.97	90.98
TRAWL,OTTER,BOTTOM,SHRIMP	<0.01	0.50	0.49
Grand Total	100	100	100

Table L4. Updated percent of US Commercial Landings of Atlantic Wolffish by Statistical Area and Year.

Year	512	513	514	515	521	522	525	526	537	Grand Total
1964	3.12 %	4.04%	37.04 %	3.23%	27.92 %	19.68 %	4.20 %	0.76 %	0.00 %	100%
1965	8.06 %	3.35%	29.81 %	0.92%	29.43 %	25.04 %	0.72 %	2.64 %	0.04 %	100%
1966	1.04 %	5.00%	40.12 %	0.98%	30.95 %	16.79 %	1.47 %	3.60 %	0.05 %	100%
1967	1.45 %	17.26 %	35.79 %	1.27%	29.84 %	13.21 %	0.49 %	0.70 %	0.00 %	100%
1968	1.72 %	10.96 %	32.65 %	0.55%	37.79 %	12.71 %	2.55 %	0.97 %	0.10 %	100%
1969	0.86 %	12.90 %	43.91 %	1.74%	24.19 %	14.83 %	1.31 %	0.26 %	0.01 %	100%
1970	1.12 %	11.05 %	41.51 %	1.25%	31.19 %	13.03 %	0.19 %	0.63 %	0.03 %	100%
1971	1.85 %	8.25%	42.71 %	1.63%	26.40 %	16.68 %	0.85 %	1.08 %	0.54 %	100%
1972	1.07 %	8.43%	33.76 %	0.31%	32.09 %	17.60 %	2.50 %	3.95 %	0.28 %	100%
1973	0.74 %	10.16 %	42.75 %	0.80%	33.97 %	8.85%	1.32 %	1.41 %	0.00 %	100%
1974	0.74 %	8.16%	37.03 %	0.21%	37.61 %	12.80 %	1.21 %	2.21 %	0.02 %	100%
1975	1.36 %	10.36 %	41.55 %	2.50%	33.34 %	9.56%	0.60 %	0.50 %	0.23 %	100%
1976	1.70 %	12.99 %	34.29 %	1.53%	32.27 %	13.75 %	1.06 %	2.40 %	0.00 %	100%
1977	1.34 %	10.35 %	37.32 %	2.02%	41.23 %	6.41%	0.58 %	0.69 %	0.06 %	100%
1978	3.72 %	14.36 %	35.43 %	2.38%	34.24 %	8.90%	0.32 %	0.52 %	0.13 %	100%
1979	3.10 %	17.31 %	28.33 %	3.09%	36.69 %	10.71 %	0.16 %	0.62 %	0.00 %	100%
1980	2.94 %	21.78 %	21.63 %	7.24%	33.58 %	11.75 %	0.49 %	0.57 %	0.00 %	100%
1981	3.99 %	22.81 %	24.84 %	6.61%	28.62 %	11.73 %	0.39 %	0.80 %	0.21 %	100%
1982	7.88 %	22.65 %	23.83 %	10.27 %	26.92 %	7.67%	0.35 %	0.19 %	0.24 %	100%
1983	4.65 %	25.89 %	28.50 %	13.92 %	19.84 %	6.35%	0.22 %	0.57 %	0.06 %	100%
1984	4.46 %	28.29 %	16.08 %	16.53 %	23.95 %	9.41%	0.70 %	0.49 %	0.09 %	100%
1985	6.17 %	25.18 %	14.83 %	19.47 %	26.63 %	7.09%	0.21 %	0.35 %	0.05 %	100%
1986	8.92 %	25.29 %	14.59 %	18.43 %	24.31 %	7.10%	0.78 %	0.52 %	0.06 %	100%
1987	5.90 %	25.24 %	17.55 %	18.22 %	25.56 %	6.91%	0.18 %	0.42 %	0.01 %	100%
1988	5.82 %	26.09 %	15.76 %	9.69%	32.96 %	8.31%	0.26 %	1.10 %	0.00 %	100%
1989	6.39 %	22.29 %	11.77 %	8.76%	41.19 %	8.01%	0.10 %	1.37 %	0.13 %	100%
1990	7.90 %	29.96 %	15.65 %	8.59%	29.71 %	5.04%	0.83 %	2.01 %	0.30 %	100%
1991	6.10	24.38	16.46	16.73	25.43	9.08%	0.33	1.19	0.29	100%

	%	%	%	%	%		%	%	%	
1992	5.76 %	24.47 %	15.62 %	18.07 %	23.35 %	10.60 %	0.49 %	1.24 %	0.40 %	100%
1993	3.73 %	20.37 %	15.57 %	20.63 %	19.52 %	17.47 %	0.82 %	1.47 %	0.42 %	100%
1994	4.33 %	18.88 %	15.46 %	15.30 %	28.57 %	15.70 %	0.39 %	1.19 %	0.19 %	100%
1995	2.26 %	14.93 %	20.68 %	17.80 %	28.22 %	14.38 %	0.30 %	1.04 %	0.39 %	100%
1996	2.16 %	15.08 %	25.99 %	13.79 %	28.99 %	12.18 %	0.63 %	0.97 %	0.21 %	100%
1997	1.82 %	13.56 %	24.11 %	11.09 %	33.51 %	13.71 %	0.54 %	0.43 %	1.22 %	100%
1998	1.87 %	9.26%	35.38 %	10.09 %	29.87 %	11.24 %	0.43 %	1.58 %	0.28 %	100%
1999	1.18 %	9.36%	18.41 %	7.92%	41.21 %	17.37 %	0.83 %	2.65 %	1.07 %	100%
2000	1.53 %	13.69 %	29.24 %	8.74%	29.32 %	14.39 %	0.91 %	0.59 %	1.61 %	100%
2001	0.96 %	9.95%	19.13 %	5.80%	34.24 %	26.32 %	0.83 %	0.59 %	2.19 %	100%
2002	1.36 %	11.85 %	28.66 %	6.18%	35.34 %	14.20 %	1.02 %	0.27 %	1.13 %	100%
2003	1.91 %	14.17 %	36.01 %	5.83%	29.50 %	7.83%	1.17 %	0.25 %	3.32 %	100%
2004	3.89 %	17.18 %	40.12 %	7.06%	24.36 %	4.65%	0.18 %	0.06 %	2.50 %	100%
2005	2.56 %	20.20 %	40.86 %	12.90 %	15.75 %	6.39%	0.65 %	0.66 %	0.03 %	100%
2006	2.56 %	17.07 %	42.67 %	8.32%	19.93 %	8.64%	0.29 %	0.10 %	0.41 %	100%
2007	3.61 %	15.44 %	39.34 %	9.69%	23.03 %	7.82%	0.73 %	0.33 %	0.01 %	100%
2008	2.38 %	13.95 %	52.38 %	4.18%	21.61 %	4.99%	0.17 %	0.06 %	0.29 %	100%
2009	2.27 %	9.39%	63.52 %	5.23%	13.13 %	5.29%	0.64 %	0.34 %	0.20 %	100%
2010	0.00 %	9.00%	62.96 %	6.33%	6.43%	13.84 %	1.44 %	0.00 %	0.00 %	100%
Grand Total	4.10 %	19.25 %	24.82 %	10.26 %	29.12 %	10.67 %	0.59 %	0.93 %	0.26 %	100%

Table L5. Commercial discard estimates from major gear components in US waters only, 1989-2010.

	Metric Tons				Percent Discards			
YEAR	LL	OT	GN	Grand Total	LL	OT	GN	Grand Total
1989	0.00	26.98	0.00	26.98	0.00	100.00	0.00	100.00
1990	0.00	2.63	0.00	2.63	0.00	100.00	0.00	100.00
1991	0.00	1.95	0.00	1.95	0.00	100.00	0.00	100.00
1992	0.51	18.67	0.00	19.18	2.66	97.34	0.00	100.00
1993	0.00	13.38	0.00	13.38	0.00	100.00	0.00	100.00
1994	0.00	0.11	0.00	0.11	0.00	100.00	0.00	100.00
1995	0.00	5.77	0.00	5.77	0.00	100.00	0.00	100.00
1996	0.00	4.53	0.00	4.53	0.00	100.00	0.00	100.00
1997	0.00	7.11	0.71	7.82	0.00	90.91	9.09	100.00
1998	0.00	2.25	0.00	2.25	0.00	100.00	0.00	100.00
1999	0.00	0.35	0.00	0.35	0.00	100.00	0.00	100.00
2000	0.00	0.49	0.06	0.54	0.00	89.28	10.72	100.00
2001	0.00	6.47	0.00	6.47	0.00	100.00	0.00	100.00
2002	0.00	13.10	0.00	13.10	0.00	100.00	0.00	100.00
2003	0.00	3.67	0.15	3.82	0.00	96.01	3.99	100.00
2004	0.00	1.34	0.23	1.58	0.00	85.28	14.72	100.00
2005	0.00	1.22	0.09	1.31	0.00	93.37	6.63	100.00
2006	0.03	1.42	0.00	1.45	1.90	98.10	0.00	100.00
2007	0.01	0.69	0.14	0.84	0.65	82.16	17.19	100.00
2008	0.000	1.102	0.654	1.76	0.00	62.74	37.26	100.00
2009	0.055	1.122	0.274	1.45	3.79	77.32	18.89	100.00
2010	2.173	8.697	3.393	14.26	15.24	60.98	23.79	100.00
Grand Total	2.77	123.05	5.71	131.53	2.11	93.55	4.34	100.00

Table L6. Recreational landings estimates from MRFSS data updated through 2010

Year	HARVEST (TYPE A + B1)	Num PSE	Weight (TYPE A + B1) (kg)	Wkl PSE	Weight (TYPE A + B1) (mt)	Mean Weight (TYPE A + B1) (kg)	Ave Wt per fish (wt / #'s)	Weight Adjusted (kg)	Weight Adjusted (mt)
1981	334	99.9						820.80	0.82
1982	9576	58.6	4952	0	4.952	2.1	0.52	23532.77	23.53
1983	4930	38.7	16776	39.3	16.776	3.4	3.40	12115.35	12.12
1984	5461	30.9	12740	47.3	12.74	2.4	2.33	13420.27	13.42
1985	6607	33	14428	33.5	14.428	2.2	2.18	16236.53	16.24
1986	3000	44.4						7372.42	7.37
1987	15618	28.5	31733	32.4	31.733	2.9	2.03	38380.83	38.38
1988	3740	32.8	3748	3.3	3.748	2.8	1.00	9190.95	9.19
1989	8486	28.1	21415	34.1	21.415	2.9	2.52	20854.13	20.85
1990	12081	33.2	9628	21.1	9.628	2.6	0.80	29688.75	29.69
1991	6984	31.8	14250	41.8	14.25	3.5	2.04	17163.00	17.16
1992	4446	52.6	4985	71.3	4.985	3.7	1.12	10925.93	10.93
1993	8329	28.4	11969	66.6	11.969	1.8	1.44	20468.30	20.47
1994	7681	27.7	10526	32.1	10.526	1.7	1.37	18875.86	18.88
1995	8470	26.1	32287	27	32.287	3.8	3.81	20814.81	20.81
1996	5105	27.5	10391	34	10.391	2.6	2.04	12545.41	12.55
1997	8369	28	37474	40.1	37.474	4.5	4.48	20566.60	20.57
1998	6974	32.2	19760	37.9	19.76	3	2.83	17138.43	17.14
1999	3538	31.1	4741	45.6	4.741	1.8	1.34	8694.54	8.69
2000	5138	27.1	11592	29.9	11.592	3	2.26	12626.50	12.63
2001	6905	21.4	15628	30.4	15.628	3.2	2.26	16968.86	16.97
2002	4069	34.2	17996	35.6	17.996	4.5	4.42	9999.46	10.00
2003	10035	22.3	42207	5.4	42.207	4.4	4.21	24660.76	24.66
2004	5158	31.4	9573	11.6	9.573	2.5	1.86	12675.65	12.68
2005	4445	23.7	14955	20.3	14.955	3.4	3.36	10923.47	10.92
2006	7397	31.8	28614	12.5	28.614	3.9	3.87	18177.94	18.18
2007	5329	31.7	15253	36.5	15.253	2.9	2.86	13095.88	13.10
2008	4796	42.1	12506	40.9	12.506	2.6	2.61	11786.05	11.79
2009	4107	41.8	11565	54	11.565	2.8	2.82	10092.85	10.09
2010	214	61.2	648	69.6	0.648	3.5	3.03	525.90	0.53
					grand mean =	**3.01**	**2.46**		

Table L7. Observer and At-Sea monitor Length Summary Statistics by Year, 1989 and 1991-2010.

year	n	mean	sd	median	min	max	range	skew	kurtosis	se
1989	4	74.25	5.91	72	70	83	13	0.69	3.56	2.95
1991	9	81.89	13.25	77	70	114	44	1.48	4.93	4.42
1992	70	49.14	10.93	45.5	39	80	41	1.3	0.62	1.31
1993	20	63.8	11.9	60	49	86	37	0.63	-0.81	2.66
1994	23	74	8.97	73	58	95	37	0.13	-0.15	1.87
1995	12	71.67	13.91	68.5	54	102	48	0.78	0.81	4.02
1996	23	73.57	11.02	75	42	94	52	-0.75	2.11	2.3
1997	12	81	8.6	83.5	70	92	22	-0.15	-1.95	2.48
1998	19	85.58	9.89	89	67	99	32	-0.54	-0.64	2.27
1999	5	80.2	12.24	83	65	92	27	-0.18	-2.58	5.47
2000	50	77.3	7.19	77	60	89	29	-0.72	0.51	1.02
2001	73	75.88	10.81	76	52	96	44	-0.54	-0.06	1.27
2002	35	83.11	10.07	83	68	105	37	0.44	-0.28	1.7
2003	175	74.42	13.19	77	31	113	82	-0.58	1.14	1
2004	245	74.23	12.43	75	41	115	74	-0.01	0.08	0.79
2005	260	80.4	11.35	81	29	107	78	-0.82	1.99	0.7
2006	151	83.07	11.81	83	58	111	53	0	-0.57	0.96
2007	124	82.49	11.18	83	52	105	53	-0.52	0.17	1
2008	45	81.33	12.44	80	60	112	52	0.39	-0.24	1.85
2009	24	74.33	13.31	78.5	53	99	46	-0.17	-1.21	2.72
2010	268	75.73	13.51	76	37	115	78	-0.15	0.15	0.83

Table L8. Commercial Port Sample Summary Statistics by Year, 1981-1986, 1994, 2001-2010

year	var	n	mean	sd	median	min	max	range	skew	kurtosis	se
1981	2	13	86.77	12.32	85	63	110	47	0.17	0.53	3.42
1982	2	354	71.71	15.35	69	45	114	69	0.56	-0.4	0.82
1983	2	1349	78.25	14.46	78	42	128	86	0.53	0.57	0.39
1984	2	445	76.1	12.76	76	51	130	79	0.57	0.56	0.6
1985	2	729	76.98	11.86	77	47	119	72	0.26	0.3	0.44
1986	2	106	85.03	10.92	86.5	57	100	43	-0.79	0.1	1.06
1994	2	18	80.22	15.27	78.5	59	106	47	0.16	-1.16	3.6
2001	2	176	76.59	10.12	75	59	110	51	0.8	0.82	0.76
2002	2	297	76.34	10.3	76	38	104	66	-0.06	0.46	0.6
2003	2	473	76.88	11.07	76	52	109	57	0.24	-0.62	0.51
2004	2	1142	80.9	10.64	81.5	50	115	65	-0.11	-0.25	0.31
2005	2	453	81.27	10.01	82	54	110	56	-0.1	-0.54	0.47
2006	2	896	83.03	10.36	83	37	111	74	-0.3	0.55	0.35
2007	2	816	83.56	10	84	51	108	57	-0.25	-0.25	0.35
2008	2	410	81.92	11.66	83	52	114	62	-0.31	-0.39	0.58
2009	2	210	80.63	11.19	81	40	112	72	-0.18	0.54	0.77
2010	2	47	77.77	11.07	80	48	100	52	-0.55	0.38	1.61

Table L9. Commercial Port Samples, Observer and At-Sea monitor Length Summary Statistics by Year, 1981-1986, 1989, 1991-2010.

year	n	mean	sd	median	min	max	range	skew	kurtosis	se
1981	13	86.77	12.32	85	63	110	47	0.17	0.53	3.42
1982	354	71.71	15.35	69	45	114	69	0.56	-0.4	0.82
1983	1349	78.25	14.46	78	42	128	86	0.53	0.57	0.39
1984	445	76.1	12.76	76	51	130	79	0.57	0.56	0.6
1985	729	76.98	11.86	77	47	119	72	0.26	0.3	0.44
1986	106	85.03	10.92	86.5	57	100	43	-0.79	0.1	1.06
1989	4	74.25	5.91	72	70	83	13	0.69	3.56	2.95
1991	9	81.89	13.25	77	70	114	44	1.48	4.93	4.42
1992	70	49.14	10.93	45.5	39	80	41	1.3	0.62	1.31
1993	20	63.8	11.9	60	49	86	37	0.63	-0.81	2.66
1994	41	76.73	12.38	77	58	106	48	0.51	-0.22	1.93
1995	12	71.67	13.91	68.5	54	102	48	0.78	0.81	4.02
1996	23	73.57	11.02	75	42	94	52	-0.75	2.11	2.3
1997	12	81	8.6	83.5	70	92	22	-0.15	-1.95	2.48
1998	19	85.58	9.89	89	67	99	32	-0.54	-0.64	2.27
1999	5	80.2	12.24	83	65	92	27	-0.18	-2.58	5.47
2000	50	77.3	7.19	77	60	89	29	-0.72	0.51	1.02
2001	249	76.38	10.31	75	52	110	58	0.35	0.58	0.65
2002	332	77.05	10.47	77	38	105	67	0	0.46	0.57
2003	648	76.22	11.72	76	31	113	82	-0.13	0.38	0.46
2004	1387	79.72	11.26	80	41	115	74	-0.18	-0.07	0.3
2005	713	80.95	10.52	82	29	110	81	-0.44	0.8	0.39
2006	1047	83.04	10.57	83	37	111	74	-0.24	0.33	0.33
2007	940	83.42	10.16	84	51	108	57	-0.31	-0.14	0.33
2008	455	81.87	11.72	83	52	114	62	-0.23	-0.39	0.55
2009	234	79.98	11.56	81	40	112	72	-0.24	0.32	0.76
2010	315	76.03	13.18	77	37	115	78	-0.21	0.19	0.74

Table L10. NEFSC Spring survey abundance, biomass and proportion positive tows of Atlantic wolffish. 2009 and 2010 data were collected aboard the RSV Bigelow.

YEAR	stratified mean number	CV mean num	80% Lower CI (boot)	80% Upper CI (boot)	stratified mean weight	CV mean wt	80% Lower CI (boot)	80% Upper CI (boot)	Total Number Tows	Number Positive Tows	Prop Positive
1968	0.074832	45.48	0.036	0.121	0.379935	55.73	0.1351	0.6373	93	6	0.065
1969	0.146360	28.17	0.097	0.194	1.110400	49.88	0.5031	1.7424	96	11	0.115
1970	0.184209	31.46	0.118	0.253	1.123650	41.92	0.609	1.6872	98	9	0.092
1971	0.139439	29.97	0.093	0.189	0.601683	35.00	0.3554	0.8468	105	11	0.105
1972	0.337351	46.62	0.178	0.5	0.509674	51.96	0.2093	0.8063	101	7	0.069
1973	0.139069	47.41	0.064	0.221	0.866688	53.63	0.3491	1.4008	94	7	0.074
1974	0.528880	36.50	0.309	0.76	1.109440	33.52	0.6819	1.5368	93	14	0.151
1975	0.140400	44.37	0.071	0.206	0.924290	64.32	0.2774	1.6191	100	11	0.110
1976	0.102373	30.76	0.067	0.141	0.530604	35.88	0.3131	0.743	111	12	0.108
1977	0.223311	32.02	0.144	0.309	0.619603	33.08	0.3644	0.8656	116	17	0.147
1978	0.304785	30.19	0.198	0.416	1.169070	43.18	0.591	1.8358	111	18	0.162
1979	0.211721	35.75	0.126	0.307	0.712763	26.92	0.486	0.9534	166	19	0.114
1980	0.297972	38.32	0.167	0.429	0.696510	38.02	0.3884	0.9988	117	13	0.111
1981	0.305932	46.66	0.147	0.465	0.627849	33.29	0.4031	0.897	98	10	0.102
1982	0.186281	23.14	0.138	0.236	0.680649	32.86	0.4366	0.9567	100	18	0.180
1983	0.127162	42.00	0.071	0.198	0.737782	55.36	0.2809	1.2037	98	8	0.082
1984	0.122841	30.12	0.082	0.168	0.474255	38.21	0.2758	0.6884	95	10	0.105
1985	0.284045	32.31	0.183	0.39	0.741842	37.75	0.46	1.0459	92	11	0.120
1986	0.237597	26.27	0.165	0.31	1.438940	33.92	0.8924	1.9864	97	12	0.124
1987	0.247225	31.44	0.158	0.328	0.913709	31.67	0.6102	1.2462	93	11	0.118
1988	0.198091	35.76	0.119	0.282	0.541849	48.12	0.2585	0.8353	92	10	0.109
1989	0.274190	36.84	0.165	0.394	0.403499	41.00	0.2224	0.5986	89	9	0.101
1990	0.059452	46.92	0.031	0.092	0.166516	53.53	0.0729	0.2727	92	5	0.054
1991	0.052251	46.54	0.025	0.081	0.360148	48.66	0.1783	0.5756	89	5	0.056
1992	0.139869	47.46	0.067	0.221	0.114772	54.99	0.0464	0.1957	90	5	0.056
1993	0.127671	36.81	0.076	0.177	0.420072	50.72	0.173	0.6702	90	8	0.089
1994	0.206584	36.59	0.118	0.299	0.138898	44.91	0.0708	0.2104	91	9	0.099
1995	0.123460	41.29	0.065	0.182	0.196500	50.15	0.0928	0.3283	91	5	0.055
1996	0.106639	39.70	0.059	0.157	0.167041	62.52	0.0408	0.2933	87	7	0.080
1997	0.045510	59.10	0.016	0.079	0.041146	61.60	0.011	0.0713	91	3	0.033
1998	0.037444	55.52	0.014	0.061	0.104679	65.70	0.0234	0.1893	114	4	0.035
1999	0.039134	44.72	0.016	0.055	0.059484	49.34	0.0282	0.0939	92	3	0.033
2000	0.030916	79.67	0	0.062	0.208352	74.13	0.0714	0.4109	93	2	0.022
2001	0.034004	55.47	0.016	0.058	0.063016	64.57	0.0233	0.1097	93	3	0.032
2002	0.059240	39.79	0.032	0.088	0.084007	60.52	0.0277	0.1573	95	6	0.063
2003	0.092651	49.40	0.039	0.147	0.181660	44.35	0.0817	0.2628	89	5	0.056
2004	0.015708	63.25	0.008	0.024	0.000031	74.16	0	0.0001	90	2	0.022
2005	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-
2007	0.024351	75.09	0.008	0.049	0.009262	94.80	0	0.0185	90	2	0.022
2008	-	-	-	-	-	-	-	-	-	-	-
2009	0.149162	45.34	0.066	0.227	0.062343	52.69	0.026	0.1071	123	6	0.049
2010	0.083825	38.69	0.046	0.123	0.108849	56.95	0.0403	0.178	110	5	0.045

Table L11. NEFSC Fall survey abundance, biomass and proportion positive tows of Atlantic wolffish. 2009 and 2010 data were collected aboard the RSV Bigelow.

YEAR	stratified mean number	CV mean num	80% Lower CI (boot)	80% Upper CI (boot)	stratified mean weight	CV mean wt	80% Lower CI (boot)	80% Upper CI (boot)	Total Number Tows	Number Positive Tows	Prop Positive
1963	0.031086	62.91	0.0091	0.0548	0.004032	75.44	0.0001	0.0079	79	3	0.038
1964	0.087940	48.56	0.0376	0.1382	0.185740	92.49	0.0014	0.37	86	5	0.058
1965	0.305541	50.91	0.1496	0.5042	0.296804	39.57	0.1682	0.4424	91	8	0.088
1966	0.333844	51.00	0.148	0.5197	0.169165	43.50	0.0889	0.2494	88	6	0.068
1967	0.088979	64.41	0.0277	0.1558	0.232514	81.78	0.0332	0.4428	97	4	0.041
1968	0.146726	38.24	0.0896	0.2096	0.407058	36.47	0.2463	0.5859	97	8	0.082
1969	0.009391	100.00	0	0.0188	0.033808	100.00	0	0.0676	97	1	0.010
1970	0.076562	55.34	0.0307	0.1287	0.357788	56.11	0.132	0.5836	100	4	0.040
1971	0.121017	45.52	0.06	0.1856	0.161766	59.00	0.0544	0.2842	106	6	0.057
1972	0.129339	46.45	0.0627	0.2038	0.161805	68.88	0.0334	0.2931	100	6	0.060
1973	0.341706	35.12	0.2087	0.4861	0.133042	44.25	0.0712	0.2053	99	8	0.081
1974	0.229524	78.51	0.0356	0.4295	0.096172	87.88	0.0074	0.1854	102	4	0.039
1975	0.038254	33.87	0.0235	0.0539	0.032399	37.84	0.018	0.0491	112	8	0.071
1976	0.069622	66.81	0.0236	0.125	0.046311	50.97	0.0206	0.073	99	4	0.040
1977	0.042050	37.78	0.0216	0.062	0.084916	45.43	0.0427	0.1328	135	7	0.052
1978	0.472066	26.94	0.3203	0.6332	0.536890	23.46	0.386	0.6951	218	26	0.119
1979	0.054341	29.26	0.0343	0.0759	0.102655	42.93	0.0509	0.1658	234	13	0.056
1980	0.139714	35.14	0.0843	0.1953	0.180163	42.34	0.0968	0.2711	98	7	0.071
1981	0.260816	47.79	0.1147	0.4069	1.137620	76.64	0.2151	2.1505	97	6	0.062
1982	0.048125	44.86	0.0226	0.0729	0.191943	83.03	0.0235	0.376	99	5	0.051
1983	0.247228	35.61	0.1432	0.343	0.334220	37.16	0.1954	0.4889	97	10	0.103
1984	0.039978	53.20	0.0163	0.0637	0.071304	69.63	0.0033	0.1309	95	3	0.032
1985	0.188415	45.86	0.0952	0.2822	0.319381	51.58	0.1343	0.5011	95	8	0.084
1986	0.096276	38.06	0.0528	0.1368	0.368753	42.40	0.1935	0.5423	94	6	0.064
1987	0.035614	38.70	0.0208	0.0504	0.063314	36.06	0.0363	0.089	91	4	0.044
1988	0.114253	35.12	0.0639	0.1649	0.102314	43.31	0.0538	0.1524	93	8	0.086
1989	0.135309	48.01	0.065	0.2057	0.106517	52.35	0.0433	0.1768	90	6	0.067
1990	0.105232	57.78	0.0383	0.1732	0.214463	67.51	0.0541	0.3981	92	5	0.054
1991	0.133637	43.30	0.0675	0.2067	0.295392	44.90	0.145	0.4696	91	7	0.077
1992	0.131571	36.59	0.0762	0.1866	0.183606	47.47	0.0869	0.2886	89	8	0.090
1993	0.194925	55.98	0.0739	0.3193	0.411690	68.61	0.098	0.7345	89	6	0.067
1994	0.112726	48.72	0.0495	0.1762	0.279722	55.88	0.1192	0.4698	91	6	0.066
1995	0.148715	80.03	0.0217	0.2826	0.266597	66.64	0.0876	0.4863	95	4	0.042
1996	0.007827	100.00	0	0.0157	0.014088	100.00	0	0.0282	92	1	0.011
1997	0.073725	56.51	0.0283	0.1202	0.208050	57.88	0.0702	0.3346	93	4	0.043
1998	0.013045	100.00	0	0.0261	0.007175	100.00	0	0.0143	104	1	0.010
1999	0.052009	44.09	0.027	0.0804	0.185929	44.72	0.0882	0.2829	110	6	0.055
2000	0.006947	100.00	0	0.0139	0.025009	100.00	0	0.05	92	1	0.011
2001	0.044447	51.89	0.0172	0.0717	0.122631	52.62	0.0492	0.1961	94	4	0.043
2002	0.028729	71.01	0.013	0.0575	0.071735	74.40	0.0241	0.1428	89	2	0.022
2003	0.079503	71.86	0	0.1446	0.084381	73.54	0	0.1627	91	2	0.022
2004	0.014774	70.84	0.0069	0.0287	0.020610	99.77	0	0.0412	88	2	0.023
2005	0.046081	67.49	0.0078	0.0835	0.019457	95.09	0.0001	0.0389	90	3	0.033
2006	0.042326	52.45	0.0163	0.0684	0.001579	65.90	0.0004	0.0029	102	3	0.029
2007	-	-	-	-	-	-	-	-	-	-	-
2008	0.105453	75.17	0.0163	0.1953	0.147088	64.57	0.04	0.2675	93	3	0.032
2009	0.169910	57.54	0.0614	0.2874	0.034842	53.41	0.014	0.0576	99	7	0.071
2010	0.119737	56.64	0.0425	0.1983	0.126993	84.06	0.0021	0.2519	97	3	0.031

Table L12. Stratified mean and proportion positive indices of Atlantic wolffish for the spring MA DMF resource survey.

YEAR	stratified mean number	CV mean num	80% Lower CI (boot)	80% Upper CI (boot)	stratified mean weight	CV mean wt	80% Lower CI (boot)	80% Upper CI (boot)	Total Number Tows	Number Positive Tows	Prop Positive
1978	0.09035	38.79	0.051600	0.129900	0.32664	43.88	0.17890	0.48700	95	6	0.06
1979	0.07601	42.10	0.044200	0.106600	0.29359	53.15	0.14470	0.45440	100	6	0.06
1980	0.10386	29.25	0.071900	0.138000	0.43393	26.85	0.30470	0.55890	98	10	0.10
1981	0.01518	71.92	0.000000	0.030400	0.03514	72.58	0.00000	0.06490	97	2	0.02
1982	0.05409	37.68	0.029700	0.075600	0.24120	44.30	0.12460	0.35400	95	6	0.06
1983	0.12744	58.94	0.049100	0.208600	0.29530	59.70	0.10570	0.49600	94	5	0.05
1984	0.06037	34.86	0.038700	0.083700	0.30701	40.90	0.16970	0.44890	99	6	0.06
1985	0.04965	78.88	0.012500	0.099300	0.27943	71.08	0.00000	0.53040	93	2	0.02
1986	0.02637	45.38	0.014200	0.036000	0.08916	68.30	0.03950	0.14170	94	3	0.03
1987	0.02810	59.06	0.012000	0.044200	0.18470	71.29	0.08040	0.28900	97	3	0.03
1988	0.02182	58.71	0.009000	0.034600	0.18189	59.11	0.07560	0.28820	91	3	0.03
1989	0.05696	49.38	0.030000	0.084700	0.47100	54.10	0.22150	0.71630	94	5	0.05
1990	0.00927	100.00	0.000000	0.018500	0.02597	100.00	0.00000	0.05190	95	1	0.01
1991	0.00900	100.00	0.000000	0.018000	0.07021	100.00	0.00000	0.14040	98	1	0.01
1992											
1993	0.00964	100.00	0.000000	0.019300	0.12048	100.00	0.00000	0.24100	88	1	0.01
1994											
1995	0.00742	100.00	0.000000	0.014800	0.00445	100.00	0.00000	0.00890	97	1	0.01
1996	0.01237	100.00	0.000000	0.024700	0.16076	100.00	0.00000	0.32150	101	1	0.01
1997	0.01637	71.34	0.007100	0.027800	0.01473	71.34	0.00640	0.02310	98	2	0.02
1998											
1999											
2000	0.00618	100.00	0.000000	0.012400	0.01669	100.00	0.00000	0.03340	97	1	0.01
2001											
2002											
2003	0.00618	100.00	0.000000	0.012400	0.03895	100.00	0.00000	0.07790	96	1	0.01
2004											
2005											
2006	0.01806	71.83	0.007400	0.028700	0.11315	73.41	0.04080	0.19480	100	2	0.02
2007											
2008	0.01855	57.74	0.009300	0.027800	0.11964	66.77	0.03520	0.20400	103	2	0.02
2009											
2010											

Table L13. The adult (40+ cm) index of abundance and population abundance estimates using swept area adjustments for the Albatross, Bigelow and MADMF surveys. Population estimates for the Albatross, 2009-2010 in (), are adjusted Bigelow mean number per tow values.

	Spring	ALIV	HB	Fall	ALIV	HB	Spr	MADMF
Year	40+ str mean num / tow	40+ str mean N population estimate	40+ str mean N population estimate	40+ str mean num / tow	40+ str mean N population estimate	40+ str mean N population estimate	40+ str mean num / tow	40+ str mean N population estimate
1963	-	-	-	0	0	-		
1964	-	-	-	0.020230	46802	-		
1965	-	-	-	0.081600	188780	-		
1966	-	-	-	0.072020	166617	-		
1967	-	-	-	0.034200	79121	-		
1968	0.074860	173187	-	0.099350	229844	-		
1969	0.120430	278613	-	0.009390	21724	-		
1970	0.137260	317549	-	0.069620	161065	-		
1971	0.096310	222811	-	0.036770	85067	-		
1972	0.075740	175223	-	0.050440	116692	-		
1973	0.122560	283540	-	0.053310	123332	-		
1974	0.165360	382557	-	0.023490	54344	-		
1975	0.096410	223043	-	0.013050	30191	-		
1976	0.096850	224061	-	0.027940	64639	-		
1977	0.078220	180961	-	0.035550	82244	-		
1978	0.273040	631673	-	0.175390	405762	-	0.09035	43061
1979	0.140130	324188	-	0.030890	71463	-	0.07601	36226
1980	0.203730	471326	-	0.083670	193569	-	0.09765	46540
1981	0.188510	436115	-	0.226900	524929	-	0.01518	7235
1982	0.102280	236623	-	0.027910	64569	-	0.05409	25779
1983	0.119340	276091	-	0.117440	271695	-	0.11324	53970
1984	0.113030	261493	-	0.023710	54853	-	0.05073	24178
1985	0.177350	410296	-	0.067980	157271	-	0.04963	23654
1986	0.206280	477225	-	0.096270	222719	-	0.01673	7974
1987	0.160860	372147	-	0.035630	82429	-	0.01909	9098
1988	0.094410	218416	-	0.031330	72481	-	0.02182	10399
1989	0.142120	328792	-	0.058030	134251	-	0.05696	27147
1990	0.043790	101307	-	0.038860	89902	-	0.00927	4418
1991	0.044810	103667	-	0.076250	176403	-	0.009	4289
1992	0.078390	181354	-	0.093200	215617	-	0	0
1993	0.096710	223737	-	0.180110	416681	-	0.00964	4594
1994	0.089420	206872	-	0.097080	224593	-	0	0
1995	0.056640	131036	-	0.126120	291776	-	0.00742	3536
1996	0.056110	129809	-	0.007830	18115	-	0.01236	5891
1997	0.030630	70862	-	0.066780	154494	-	0.01636	7797
1998	0.037430	86594	-	0.006520	15084	-	0	0
1999	0.039150	90573	-	0.047680	110307	-	0	0
2000	0.030930	71556	-	0.006950	16079	-	0.00618	2945
2001	0.023490	54344	-	0.044460	102857	-	0	0
2002	0.031320	72458	-	0.028720	66443	-	0	0
2003	0.054810	126802	-	0.024100	55755	-	0.00618	2945
2004	0	0	-	0.006950	16079	-	0	0
2005	0	0	-	0.006950	16079	-	0	0
2006	0	0	-	0.000000	0	-	0.01806	8607
2007	0.007830	18115	-	0.000000	0	-	0	0
2008	0	0	-	0.024100	55755	-	0.01854	8836
2009	0.029340	(67878)	108604	0.032310	(74749)	119598	0	0
2010	0.019560	(45252)	72403	0.033720	(78011)	124817	0	0

Table L14. SCALE model input data updates and general model configuration.

Main Parameter Configuration of the SCALE Model Base Run

Input data	**Parameters**	**Update Status**
General Parameters	Years - 1968-2010, 30 Ages, 1 Selectivity Block, 1 Recruitment Index, 3 Adult Indices, 1 Survey with LF, 145 Length bins	Addition of 2008-2010 – all else same as 2008 assessment
Biological Data	Mean Lengths at Age	Same as 2008 assessment - modified growth from Nelson & Ross Study
Catch Length Frequency	Observed Catch LF Distributions	Updated - same 1968-2007 - new data for 2008-2010 - 2010 includes kept and discard LFs
Fishery Data	Total Catch in Weight (mt)	Updated – small changes 1968-2007 via recalculation of recreational landings- new values for 2008-2010 - same 100% discard mortality all years
Recruitment Indices	NEFSC spring age 1	Updated - same 1968-2007 - no new data for 1-7 cm 2008-2010
Swept area survey indices	NEFSC spring 40+	Updated - same 1968-2007 - new values for 2008-2010, 2009-2010 swept area scaled to Bigelow
	NEFSC fall 40+	Updated - same 1968-2007 - new values for 2008-2010, 2009-2010 swept area scaled to Bigelow
	MADMF spring 40+	Updated - same 1978-2007 - no new catch for 2008-2010
Survey Length Frequencies	Observed LF Distribution	Updated - same 1968-2007 - new data for 2009-2010 - 2008 no catch
Selectivity	Selectivity Bounds	Same as 2009 assessment Slope = 0.15 preferred by NDPSWG Peer Review Panel

Table L15. Updated SCALE model survey area coverage, estimated average survey tow coverage, total area divided by the survey footprint and the survey efficiency Q estimates for run 1 and 2. *MADMF survey was not affected by vessel change from Albatross to Bigelow.

Atlantic Wolffish	Vessel	NEFSC Spr Age 1	NEFSC Spr 40+	NEFSC Fall 40+	MADMF* 40+
survey area (nm^2)		25,911	25,911	25,911	1,833
Avg tow area swept	ALIV	0.0112	0.0112	0.0112	0.003846
	HB	0.007	0.007	0.007	
Tow duration	ALIV	30 min	30 min	30 min	20 min
	HB	20 min	20 min	20 min	
total area / tow area swept	ALIV	2,313,482	2,313,482	2,313,482	476,573
	HB	3,701,571	3,701,571	3,701,571	
Q L50 = 90 (run 1)		0.142	0.194	0.104	0.012
Q Slope = 0.15 (run2)		0.144	0.186	0.099	0.011

Table L16. Diagnostics from the Atlantic wolffish SCALE model runs. Run 1 was allowed to hit the L50 bound on the selectivity and run 2 hit the selectivity slope bound of 0.15.

SCALE Model Run	1			2		
	L_{50} = 90			slope = 0.15		
	Weight	Qs	Residuals or Parameters	Weight	Qs	Residuals or Parameters
total objective function			262.99			265.39
total catch	10		0.21	10		0.21
catch len freq 1+	500		14.21	500		12.77
Variation in recruit penalty	2		13.56	2		14.46
NEFSC Spr 1 Age-1 1968-2007	2	0.142	8.80	2	0.144	8.94
NEFSC Spr 40+ 1968-2007	12	0.194	6.21	12	0.186	6.34
MDMF Spr 40+ 1978-2007	3	0.012	9.87	3	0.011	9.79
NEFSC Fall 40+ 1968-2007	3	0.104	27.96	3	0.099	28.09
NEFSC Spr 40+ len freq	5		13.94	5		13.91
Fstart			0.021			0.001
recruitment year 1 (1968, 000s)			356			362
Selectivity Alpha (L50) 1982-1984			90			72.86
Selectivity Beta (slope) 1982-1984			0.095			0.15

Table L17. Updated biological reference points for Atlantic wolffish for 2 selectivity regimes and 3 knife edge maturity cutoffs. Run 2 was considered the preferred model.

SCALE run	1			2		
Selectivity	L_{50} = 90			slope = 0.15		
Length of maturity	40cm (L_{50} = 90)	65cm (L_{50} = 90)	75cm (L_{50} = 90)	40cm (slope = 0.15)	65cm (slope = 0.15)	75cm (slope = 0.15)
F_{MSY} proxy	$F_{40\%}$	$F_{40\%}$	$F_{40\%}$	$F_{40\%}$	$F_{40\%}$	$F_{40\%}$
F_{MSY}	0.740	0.520	0.398	0.341	0.248	0.196
YPR	0.878	0.848	0.810	0.867	0.827	0.784
SSB per Recruit	5.934	5.268	4.686	5.828	5.156	4.582
Initial Recruits (000s)	342	342	342	347	347	347
MSY (mt)	301	290	277	301	287	272
SSB_{MSY} (mt)	2,032	1,804	1,605	2,022	1,789	1,590
SSB10 (mt)	1,335	892	652	1,463	1,006	759
F_{10}	0.057	0.057	0.057	0.024	0.024	0.024
SSB_{10}/SSB_{MSY}	66%	49%	41%	72%	56%	48%
F_{10}/F_{MSY}	8%	11%	14%	7%	10%	12%

Table L18. Sensitivity of SCALE Model output, Total and Exploitable Biomass (mt), due to swept area indices adjustments. The base run was HB and the sensitivity run was A4.

Year	**HB** Total Biomass	**A4** Total Biomass	**HB** Exploitable Biomass	**A4** Exploitable Biomass	**HB – A4** Differ Tot Bio	**HB – A4** Differ Exp Bio	**HB v A4** % Change Tot Bio	**HB v A4** % Change Exp Bio
1968	5,647	5,533	4,284	4,219	114	65	2.02	1.53
1969	5,539	5,425	4,183	4,117	114	66	2.06	1.57
1970	5,397	5,284	4,047	3,982	113	66	2.09	1.62
1971	5,280	5,169	3,929	3,863	111	66	2.11	1.67
1972	5,173	5,066	3,805	3,739	107	66	2.07	1.73
1973	5,029	4,929	3,633	3,567	101	66	2.01	1.82
1974	4,929	4,836	3,477	3,411	93	66	1.89	1.90
1975	4,797	4,718	3,243	3,178	79	65	1.65	2.00
1976	4,802	4,738	3,086	3,026	63	60	1.32	1.95
1977	4,772	4,722	2,898	2,847	51	51	1.06	1.76
1978	4,926	4,896	2,776	2,739	30	37	0.61	1.35
1979	4,927	4,915	2,550	2,533	12	17	0.24	0.65
1980	4,978	4,976	2,413	2,421	2	-8	0.04	-0.34
1981	4,880	4,888	2,262	2,292	-8	-30	-0.16	-1.31
1982	4,913	4,929	2,308	2,350	-16	-41	-0.33	-1.79
1983	4,843	4,865	2,363	2,415	-22	-52	-0.46	-2.18
1984	4,429	4,460	2,207	2,273	-32	-66	-0.72	-3.01
1985	4,113	4,146	2,133	2,207	-34	-75	-0.82	-3.51
1986	3,738	3,771	1,967	2,043	-33	-76	-0.89	-3.87
1987	3,298	3,331	1,715	1,786	-32	-71	-0.98	-4.14
1988	2,936	2,967	1,452	1,515	-30	-63	-1.03	-4.34
1989	2,785	2,811	1,352	1,407	-26	-55	-0.94	-4.05
1990	2,523	2,549	1,188	1,237	-26	-49	-1.04	-4.15
1991	2,452	2,475	1,168	1,212	-23	-44	-0.93	-3.80
1992	2,325	2,345	1,084	1,124	-20	-40	-0.86	-3.70
1993	2,228	2,245	957	994	-17	-37	-0.76	-3.90
1994	2,044	2,057	792	827	-13	-35	-0.64	-4.48
1995	1,827	1,838	685	717	-10	-32	-0.57	-4.63
1996	1,543	1,551	602	627	-8	-25	-0.51	-4.11
1997	1,384	1,388	583	603	-4	-20	-0.31	-3.42
1998	1,244	1,244	531	546	-1	-15	-0.06	-2.92
1999	1,141	1,138	465	477	3	-11	0.31	-2.44
2000	1,084	1,075	415	423	9	-8	0.80	-1.93
2001	1,083	1,069	419	425	15	-6	1.34	-1.36
2002	1,026	1,003	400	402	23	-2	2.22	-0.45
2003	1,033	1,000	436	433	32	3	3.14	0.60
2004	1,033	986	467	458	47	10	4.55	2.11
2005	1,052	987	504	486	65	18	6.19	3.58
2006	1,080	990	530	502	89	28	8.28	5.28
2007	1,147	1,026	563	524	121	39	10.56	6.89
2008	1,264	1,105	615	565	159	50	12.58	8.08
2009	1,422	1,218	681	618	204	63	14.31	9.25
2010	1,628	1,374	777	696	254	81	15.59	10.48

Table L19. Sensitivity of fishing mortality estimates due to swept area indices adjustments.

Year	HB K + D Fmult	A4 K + D Fmult	HB v A4 diff in F	HBv A4 % change
1968	0.029	0.030	-0.001	-3.45
1969	0.042	0.043	-0.001	-2.38
1970	0.042	0.042	0.000	0.00
1971	0.048	0.049	-0.001	-2.08
1972	0.070	0.071	-0.001	-1.43
1973	0.073	0.074	-0.001	-1.37
1974	0.113	0.116	-0.003	-2.65
1975	0.106	0.108	-0.002	-1.89
1976	0.141	0.144	-0.003	-2.13
1977	0.142	0.145	-0.003	-2.11
1978	0.242	0.245	-0.003	-1.24
1979	0.285	0.285	0.000	0.00
1980	0.400	0.394	0.006	1.50
1981	0.349	0.341	0.008	2.29
1982	0.375	0.364	0.011	2.93
1983	0.535	0.512	0.023	4.30
1984	0.463	0.442	0.021	4.54
1985	0.495	0.470	0.025	5.05
1986	0.543	0.514	0.029	5.34
1987	0.580	0.547	0.033	5.69
1988	0.467	0.442	0.025	5.35
1989	0.616	0.582	0.034	5.52
1990	0.460	0.438	0.022	4.78
1991	0.505	0.481	0.024	4.75
1992	0.561	0.535	0.026	4.63
1993	0.773	0.734	0.039	5.05
1994	0.990	0.934	0.056	5.66
1995	1.194	1.130	0.064	5.36
1996	0.884	0.846	0.038	4.30
1997	0.817	0.788	0.029	3.55
1998	0.773	0.750	0.023	2.98
1999	0.751	0.734	0.017	2.26
2000	0.607	0.597	0.010	1.65
2001	0.775	0.770	0.005	0.65
2002	0.519	0.523	-0.004	-0.77
2003	0.462	0.478	-0.016	-3.46
2004	0.361	0.379	-0.018	-4.99
2005	0.320	0.342	-0.022	-6.88
2006	0.239	0.261	-0.022	-9.21
2007	0.156	0.171	-0.015	-9.62
2008	0.115	0.129	-0.014	-12.17
2009	0.074	0.082	-0.008	-10.81
2010	0.024	0.027	-0.003	-12.50

Table L20. Sensitivity of SCALE Model output, Total and Exploitable Biomass (mt), due to changes in commercial length frequency between model runs. The base run included kept and discarded length data for the 2010 year only and the sensitivity run had only kept length data for all years.

Year	**Base K+D** Total Biomass	**K only** Total Biomass	**Base K+D** Exploitable Biomass	**K only** Exploitable Biomass	**K+D – K** Differ Tot Bio	**K+D – K** Differ Exp Bio	**K+D v K** % Change Tot Bio	**K+D v K** % Change Exp Bio
1968	5,647	5,622	4,284	5,622	25	60	0.44	1.40
1969	5,539	5,514	4,183	5,514	25	59	0.44	1.42
1970	5,397	5,373	4,047	5,373	24	59	0.45	1.45
1971	5,280	5,257	3,929	5,257	24	58	0.45	1.48
1972	5,173	5,150	3,805	5,150	24	57	0.46	1.51
1973	5,029	5,006	3,633	5,006	23	56	0.47	1.55
1974	4,929	4,905	3,477	4,905	24	55	0.48	1.59
1975	4,797	4,773	3,243	4,773	24	54	0.50	1.67
1976	4,802	4,776	3,086	4,776	26	54	0.53	1.76
1977	4,772	4,745	2,898	4,745	27	54	0.57	1.88
1978	4,926	4,896	2,776	4,896	30	56	0.62	2.01
1979	4,927	4,894	2,550	4,894	33	60	0.68	2.37
1980	4,978	4,942	2,413	4,942	35	70	0.71	2.91
1981	4,880	4,843	2,262	4,843	36	80	0.75	3.52
1982	4,913	4,877	2,308	4,877	36	88	0.73	3.79
1983	4,843	4,808	2,363	4,808	35	92	0.72	3.89
1984	4,429	4,395	2,207	4,395	33	89	0.75	4.02
1985	4,113	4,081	2,133	4,081	31	83	0.76	3.87
1986	3,738	3,709	1,967	3,709	30	73	0.79	3.72
1987	3,298	3,271	1,715	3,271	27	63	0.83	3.68
1988	2,936	2,911	1,452	2,911	26	56	0.88	3.85
1989	2,785	2,761	1,352	2,761	25	54	0.89	4.00
1990	2,523	2,500	1,188	2,500	23	52	0.92	4.36
1991	2,452	2,430	1,168	2,430	22	49	0.89	4.23
1992	2,325	2,304	1,084	2,304	20	44	0.87	4.06
1993	2,228	2,209	957	2,209	19	40	0.85	4.15
1994	2,044	2,026	792	2,026	18	39	0.86	4.88
1995	1,827	1,811	685	1,811	16	38	0.86	5.62
1996	1,543	1,529	602	1,529	13	33	0.87	5.53
1997	1,384	1,372	583	1,372	12	29	0.89	4.96
1998	1,244	1,232	531	1,232	12	24	0.96	4.60
1999	1,141	1,129	465	1,129	12	21	1.05	4.61
2000	1,084	1,072	415	1,072	12	21	1.13	5.03
2001	1,083	1,071	419	1,071	12	22	1.14	5.29
2002	1,026	1,014	400	1,014	12	23	1.18	5.67
2003	1,033	1,021	436	1,021	12	24	1.13	5.50
2004	1,033	1,022	467	1,022	11	25	1.07	5.31
2005	1,052	1,042	504	1,042	10	25	0.95	4.99
2006	1,080	1,071	530	1,071	9	24	0.80	4.61
2007	1,147	1,139	563	1,139	8	23	0.68	4.01
2008	1,264	1,257	615	1,257	7	20	0.59	3.30
2009	1,422	1,414	681	1,414	8	19	0.57	2.77
2010	1,628	1,619	777	1,619	9	20	0.57	2.55

Table L21. Sensitivity of SCALE Model output, Total and Exploitable Biomass (mt), due to assumed discard mortality rates. The base run was 100% discard mortality and the sensitivity run was 10% discard mortality.

Year	**Base 100** Total Biomass	**10%** Total Biomass	**Base 100** Exploitable Biomass	**10%** Exploitable Biomass	**100 – 10** Differ Tot Bio	**100 – 10** Differ Exp Bio	**100 v 10** % Change Tot Bio	**100 v 10** % Change Exp Bio
1968	5,647	5,594	4,284	4,244	53	40	0.95	0.93
1969	5,539	5,485	4,183	4,143	53	40	0.96	0.96
1970	5,397	5,344	4,047	4,008	53	40	0.99	0.99
1971	5,280	5,227	3,929	3,889	54	40	1.01	1.02
1972	5,173	5,120	3,805	3,765	54	40	1.04	1.05
1973	5,029	4,976	3,633	3,593	54	40	1.07	1.10
1974	4,929	4,875	3,477	3,437	54	40	1.09	1.15
1975	4,797	4,743	3,243	3,203	54	40	1.13	1.23
1976	4,802	4,747	3,086	3,046	55	40	1.14	1.30
1977	4,772	4,717	2,898	2,858	56	40	1.17	1.38
1978	4,926	4,870	2,776	2,736	57	40	1.15	1.44
1979	4,927	4,869	2,550	2,511	58	39	1.18	1.54
1980	4,978	4,918	2,413	2,375	60	38	1.20	1.58
1981	4,880	4,818	2,262	2,225	62	37	1.26	1.63
1982	4,913	4,848	2,308	2,270	65	38	1.32	1.66
1983	4,843	4,776	2,363	2,323	67	41	1.38	1.73
1984	4,429	4,362	2,207	2,164	67	43	1.51	1.95
1985	4,113	4,045	2,133	2,086	67	47	1.64	2.18
1986	3,738	3,671	1,967	1,917	67	50	1.80	2.54
1987	3,298	3,230	1,715	1,662	69	53	2.08	3.11
1988	2,936	2,866	1,452	1,397	70	55	2.39	3.81
1989	2,785	2,714	1,352	1,296	71	56	2.56	4.16
1990	2,523	2,485	1,188	1,159	38	29	1.51	2.43
1991	2,452	2,414	1,168	1,141	38	26	1.55	2.24
1992	2,325	2,285	1,084	1,059	39	25	1.69	2.30
1993	2,228	2,203	957	945	25	12	1.12	1.25
1994	2,044	2,028	792	788	16	3	0.76	0.44
1995	1,827	1,806	685	678	21	7	1.15	1.06
1996	1,543	1,524	602	595	19	7	1.24	1.22
1997	1,384	1,366	583	575	18	8	1.30	1.34
1998	1,244	1,230	531	526	13	5	1.06	0.96
1999	1,141	1,127	465	460	14	6	1.22	1.20
2000	1,084	1,067	415	408	17	7	1.54	1.78
2001	1,083	1,064	419	410	19	9	1.76	2.20
2002	1,026	1,009	400	392	17	8	1.64	2.02
2003	1,033	1,025	436	434	7	2	0.70	0.46
2004	1,033	1,028	467	467	5	1	0.51	0.13
2005	1,052	1,046	504	503	6	1	0.53	0.16
2006	1,080	1,073	530	528	6	1	0.58	0.22
2007	1,147	1,140	563	562	7	1	0.60	0.23
2008	1,264	1,256	615	613	8	2	0.66	0.31
2009	1,422	1,413	681	679	9	2	0.66	0.27
2010	1,628	1,617	777	775	11	2	0.67	0.29

Table L22. A comparison of biological reference points estimated using the base run (slope 0.15) and the ocean pout ("op") sensitivity run SCALE model output.

SCALE run	**Base Run** slope = 0.15			**Sensitivity Run** slope = 0.15 op conversion 4.58		
Selectivity						
Length of maturity	40cm	65cm	75cm	40cm	65cm	
F_{MSY} proxy	F40%	F40%	F40%	F40%	F40%	
F_{MSY}	0.341	0.248	0.196	0.334	0.243	
YPR	0.867	0.827	0.784	0.864	0.824	
SSB per Recruit	5.828	5.156	4.582	5.818	5.155	
Initial Recruits (000s)	347	347	347	302	302	
MSY (mt)	301	287	272	261	249	
SSB_{MSY} (mt)	2,022	1,789	1,590	1,756	1,556	
SSB_{2010} (mt)	1,463	1,006	759	505	371	
F_{2010}	0.024	0.024	0.024	0.069	0.069	
SSB_{2010}/SSB_{MSY}	72%	56%	48%	29%	24%	
F_{2010}/F_{MSY}	7%	10%	12%	21%	28%	-

Table L23. Accepted SCALE model run for wolffish, which assumed the same survey vessel conversion coefficient as for ocean pout.

Year	Recruitment (mt)	SSB (mt)	Total Biomass (mt)	Fmult
1968	302	4,577	4,702	0.035
1969	657	4,467	4,596	0.050
1970	340	4,323	4,458	0.050
1971	170	4,198	4,349	0.058
1972	1,597	4,069	4,258	0.084
1973	350	3,932	4,140	0.089
1974	805	3,855	4,070	0.141
1975	997	3,666	3,993	0.133
1976	977	3,678	4,054	0.177
1977	666	3,771	4,068	0.177
1978	571	3,924	4,288	0.295
1979	331	3,983	4,349	0.336
1980	497	4,112	4,419	0.446
1981	204	4,113	4,346	0.378
1982	830	4,201	4,389	0.383
1983	346	4,175	4,345	0.529
1984	310	3,807	3,984	0.455
1985	223	3,493	3,689	0.485
1986	230	3,130	3,333	0.548
1987	806	2,766	2,902	0.574
1988	322	2,456	2,580	0.501
1989	505	2,283	2,425	0.612
1990	162	2,026	2,222	0.467
1991	148	1,963	2,171	0.526
1992	225	1,902	2,053	0.571
1993	204	1,854	1,973	0.776
1994	252	1,736	1,812	1.020
1995	181	1,530	1,611	1.209
1996	197	1,266	1,356	0.928
1997	129	1,110	1,199	0.833
1998	112	986	1,071	0.824
1999	84	891	963	0.879
2000	72	820	881	0.725
2001	79	808	854	0.970
2002	86	729	767	0.665
2003	96	704	737	0.635
2004	77	655	688	0.600
2005	61	594	629	0.633
2006	110	521	557	0.475
2007	300	490	527	0.330
2008	302	492	532	0.363
2009	302	482	541	0.220
2010	302	505	599	0.069

Figures

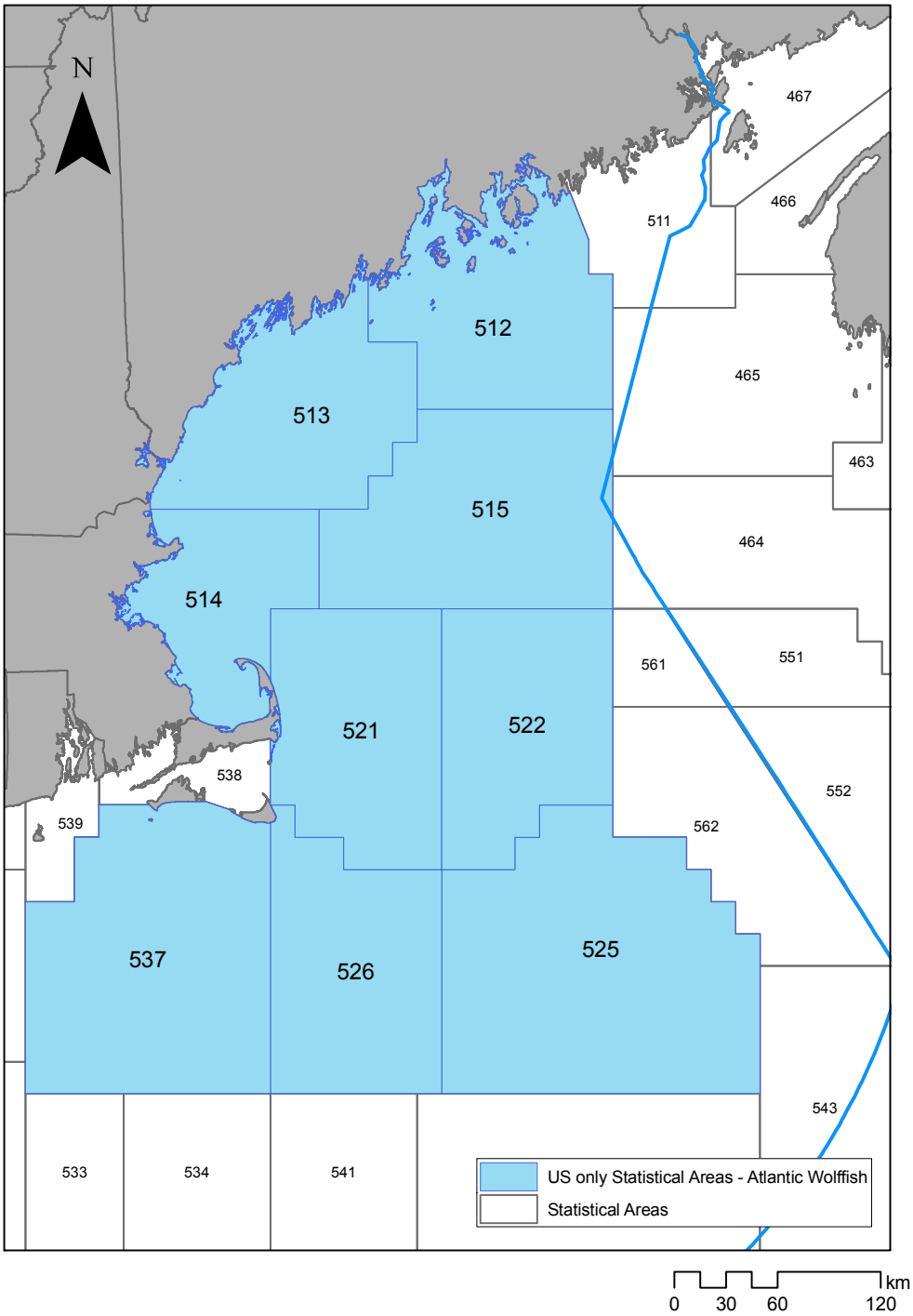


Figure L1. Fishery statistical areas used for Atlantic wolffish landings and discard estimates.

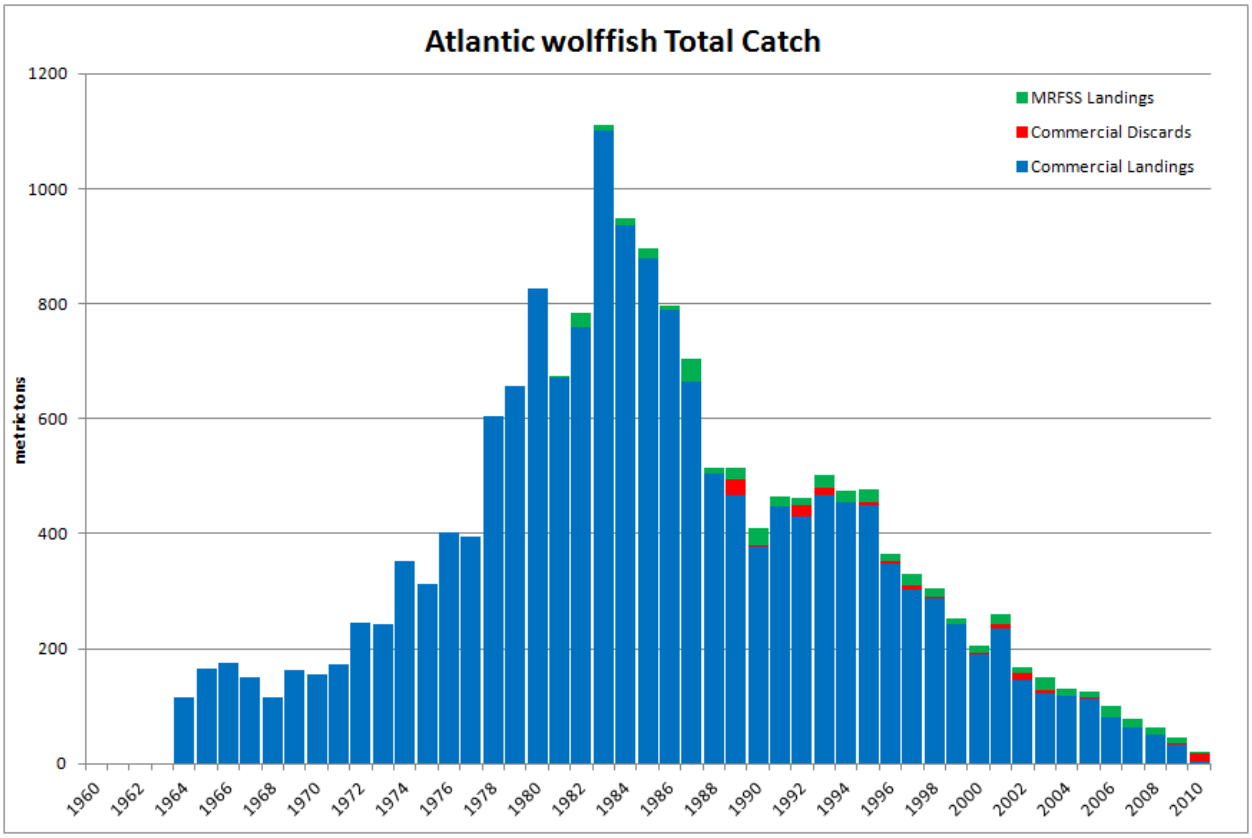


Figure L2. Updated commercial landings, recreational landings, commercial discards and total catch.

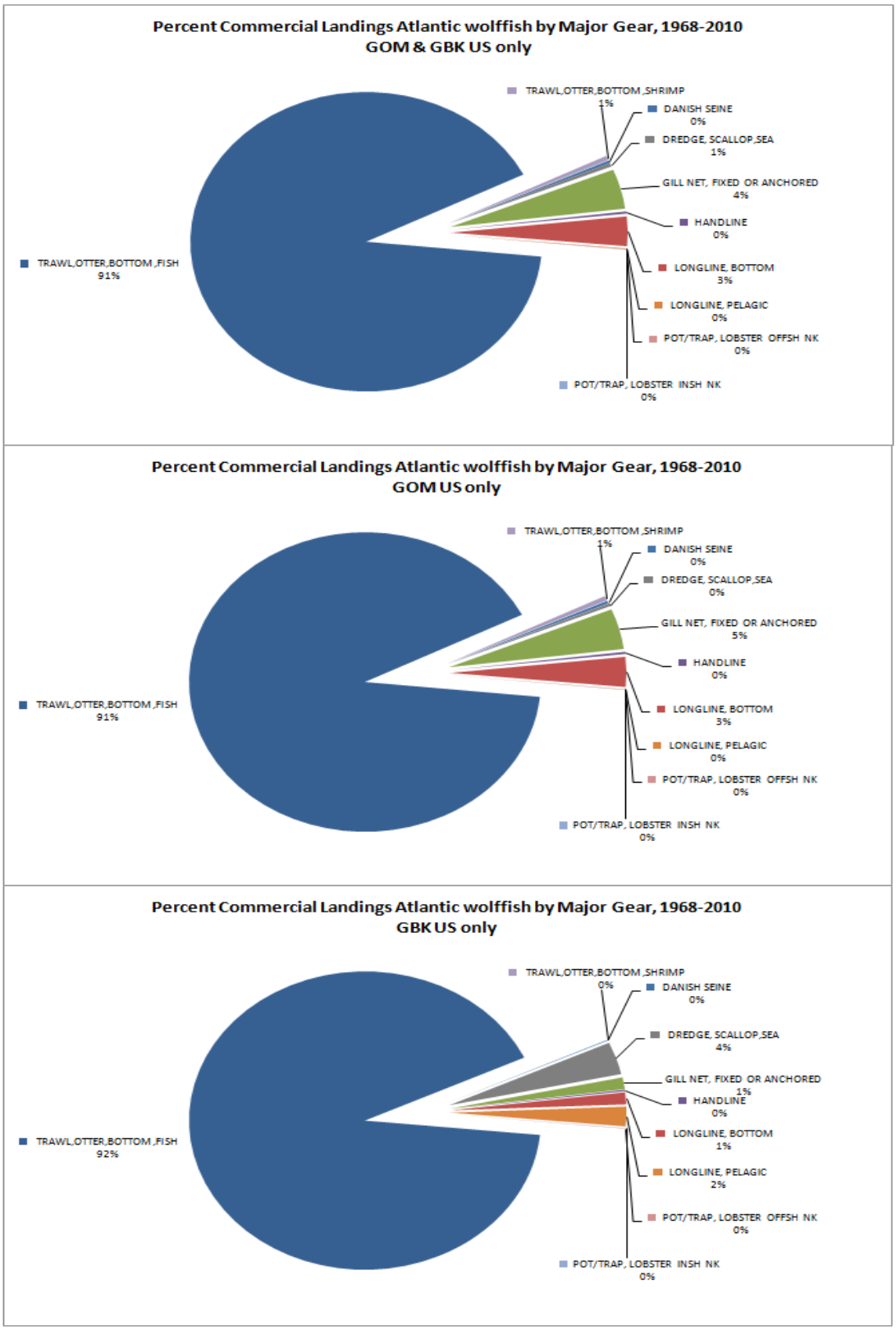


Figure L3. Updated commercial landings of Atlantic wolffish by major gear types and region, 1968-2010.

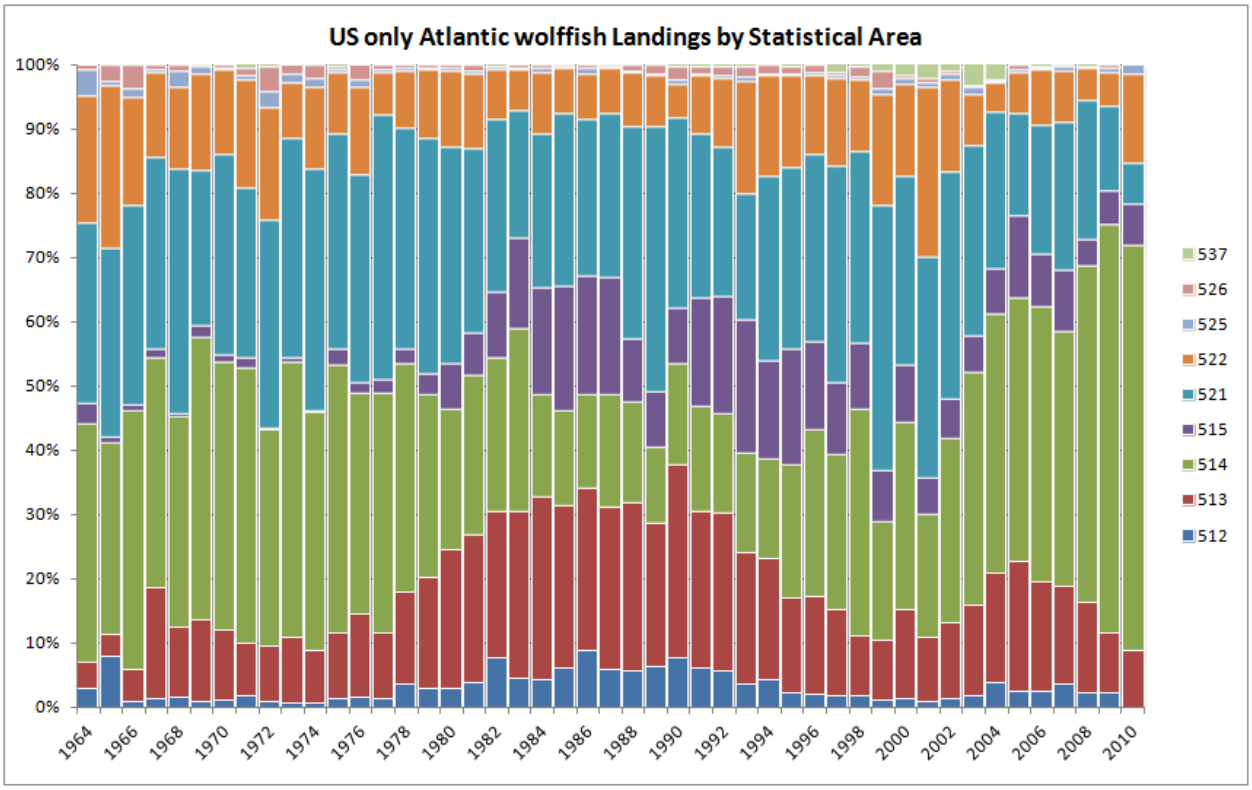


Figure L4. Updated commercial landings by statistical area.

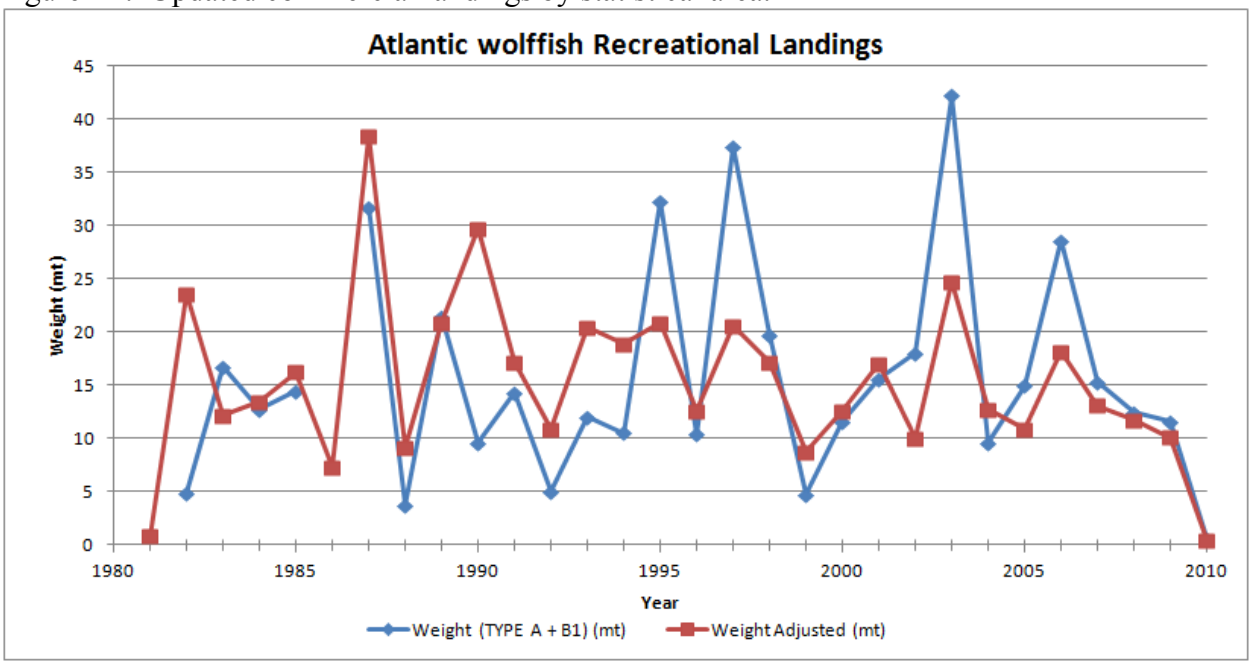


Figure L5. Updated recreational landings from MRFSS data.

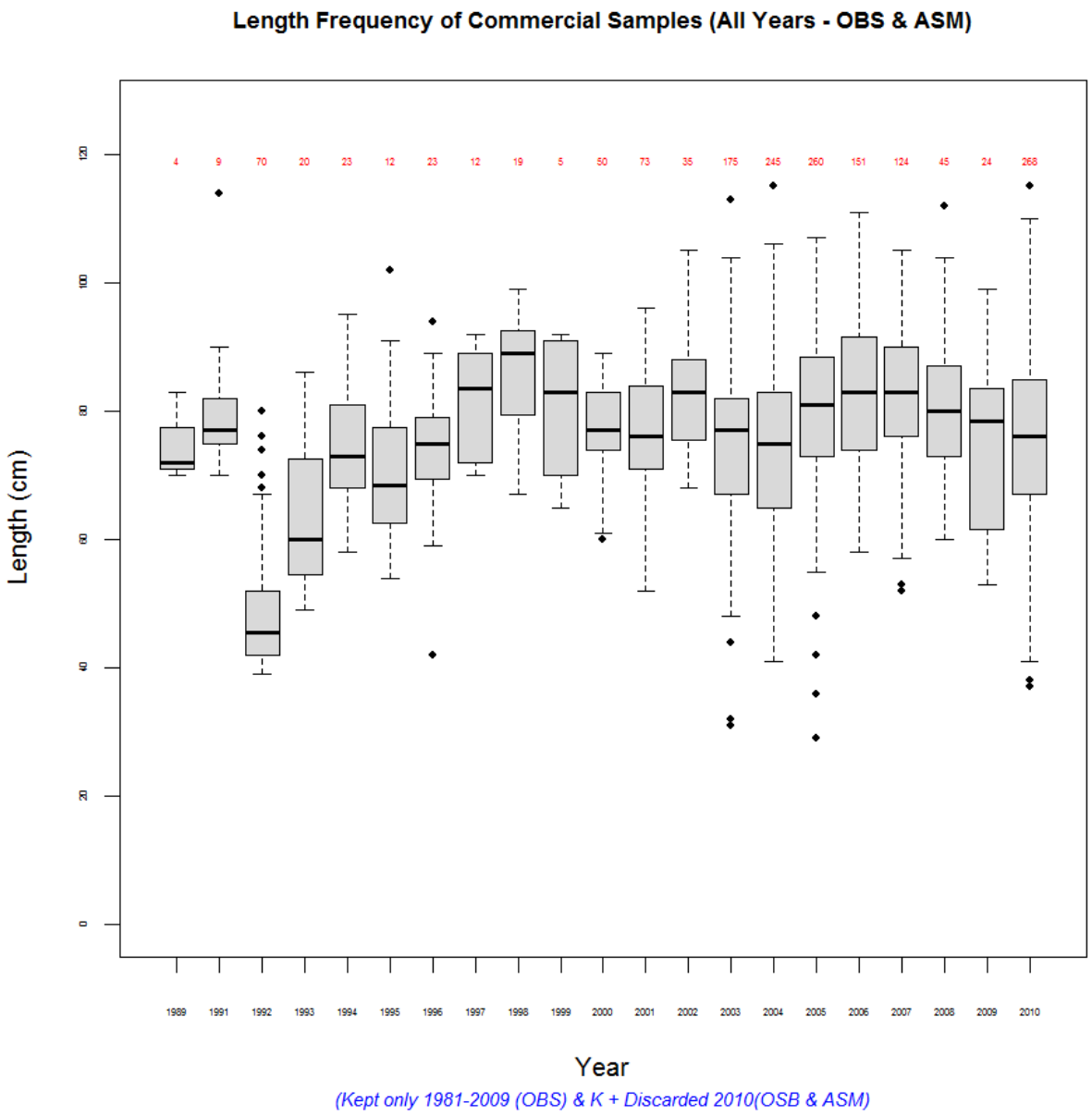


Figure L6. Boxplots of observer length frequency data by year. Mean number at length is shown by the solid black line in the boxplot. Sample size is shown in red at the top of the graph. Observer data is from kept fish only until 2010 when kept and discarded fish are combined.

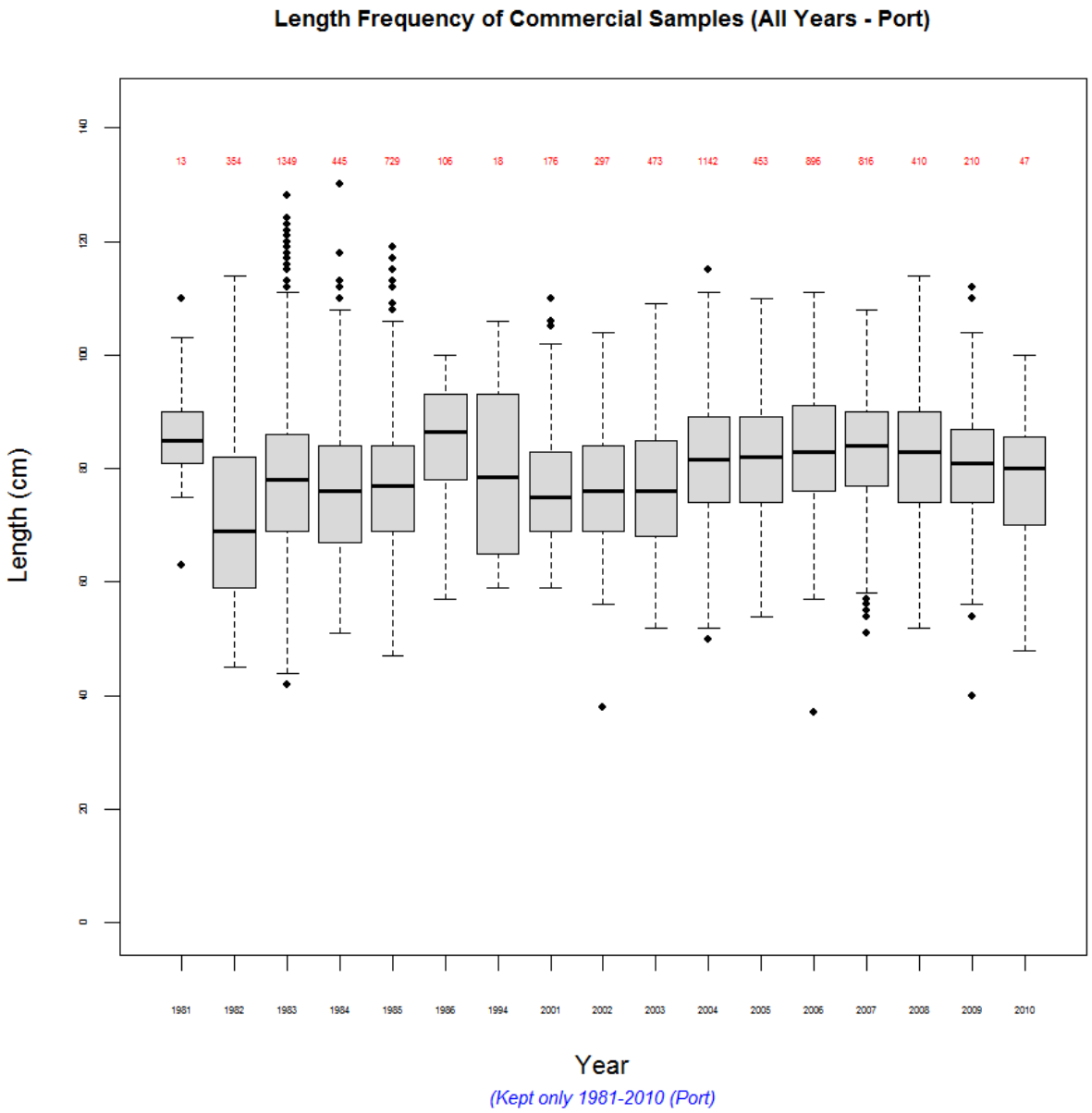


Figure L7. Boxplots of commercial port length frequency data by year. Mean number at length is shown by the solid black line in the boxplot. Sample size is shown in red at the top of the graph.

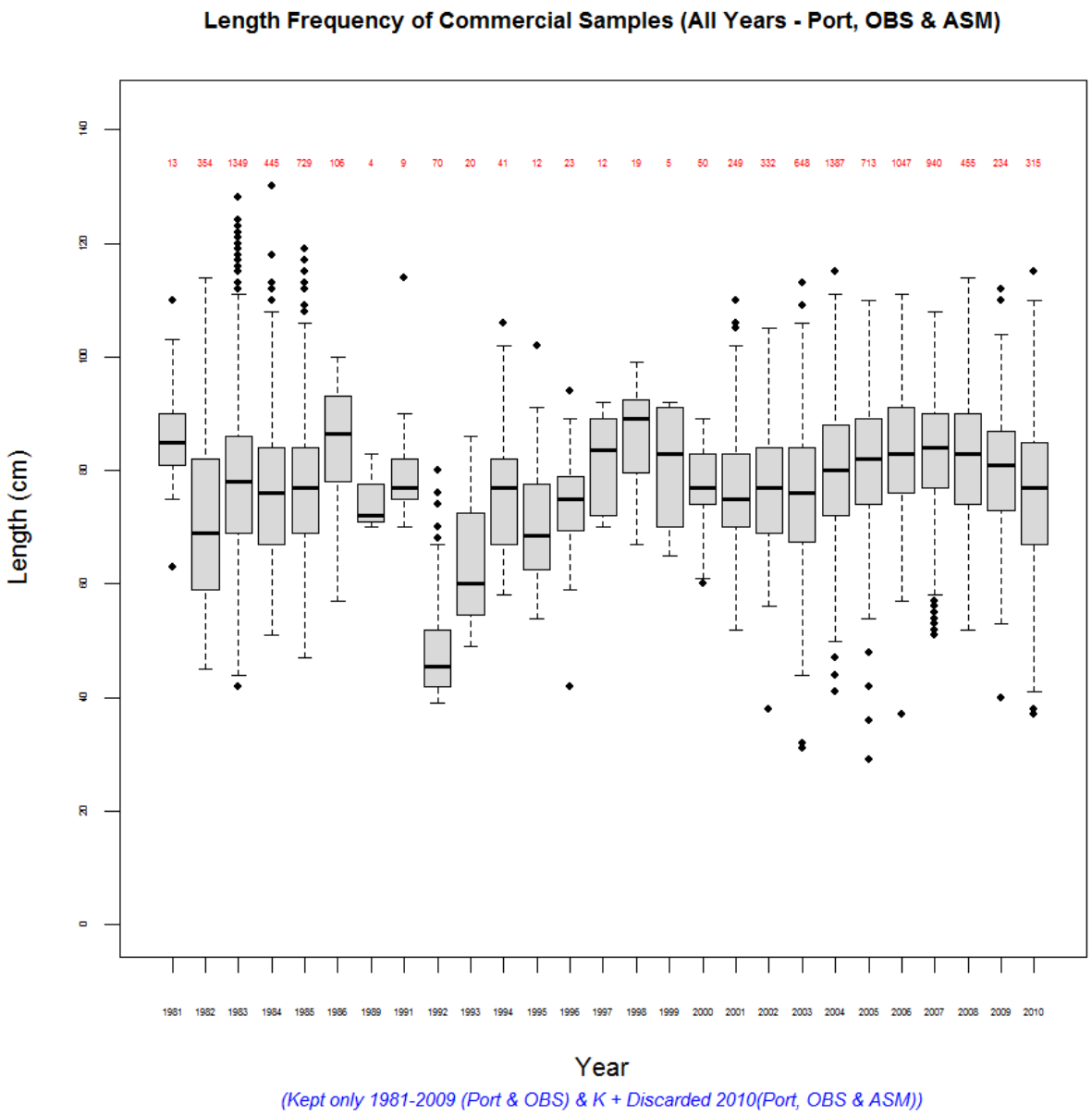


Figure L8. Combination boxplots of observer and port sample length frequency data by year. Mean number at length is shown by the solid black line in the boxplot. Sample size is shown in red at the top of the graph. Observer data is from kept fish only until 2010 when kept and discarded fish are combined.

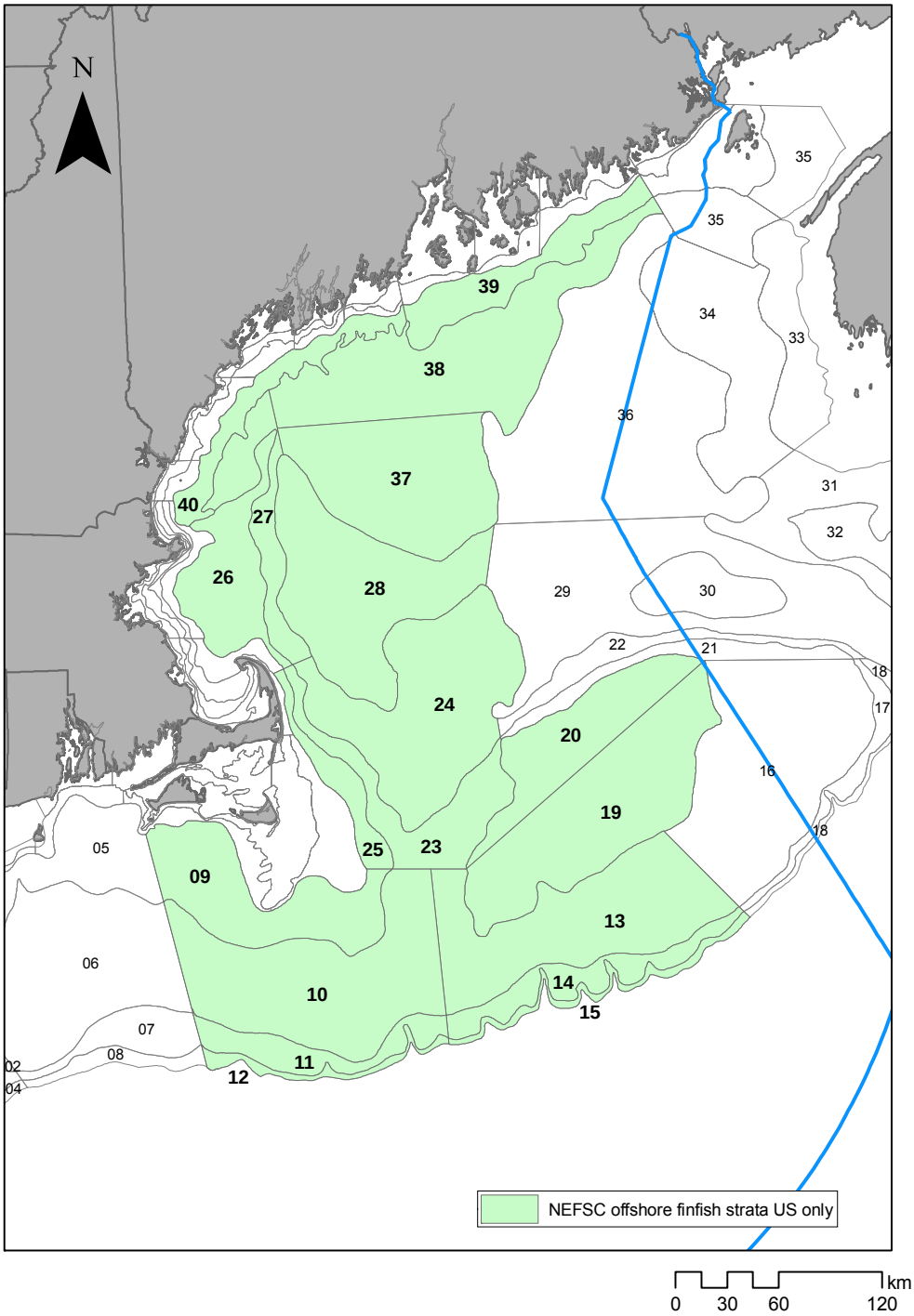


Figure L9. NEFSC survey strata used to assess Atlantic wolffish in the 2008 and 2010 assessments.

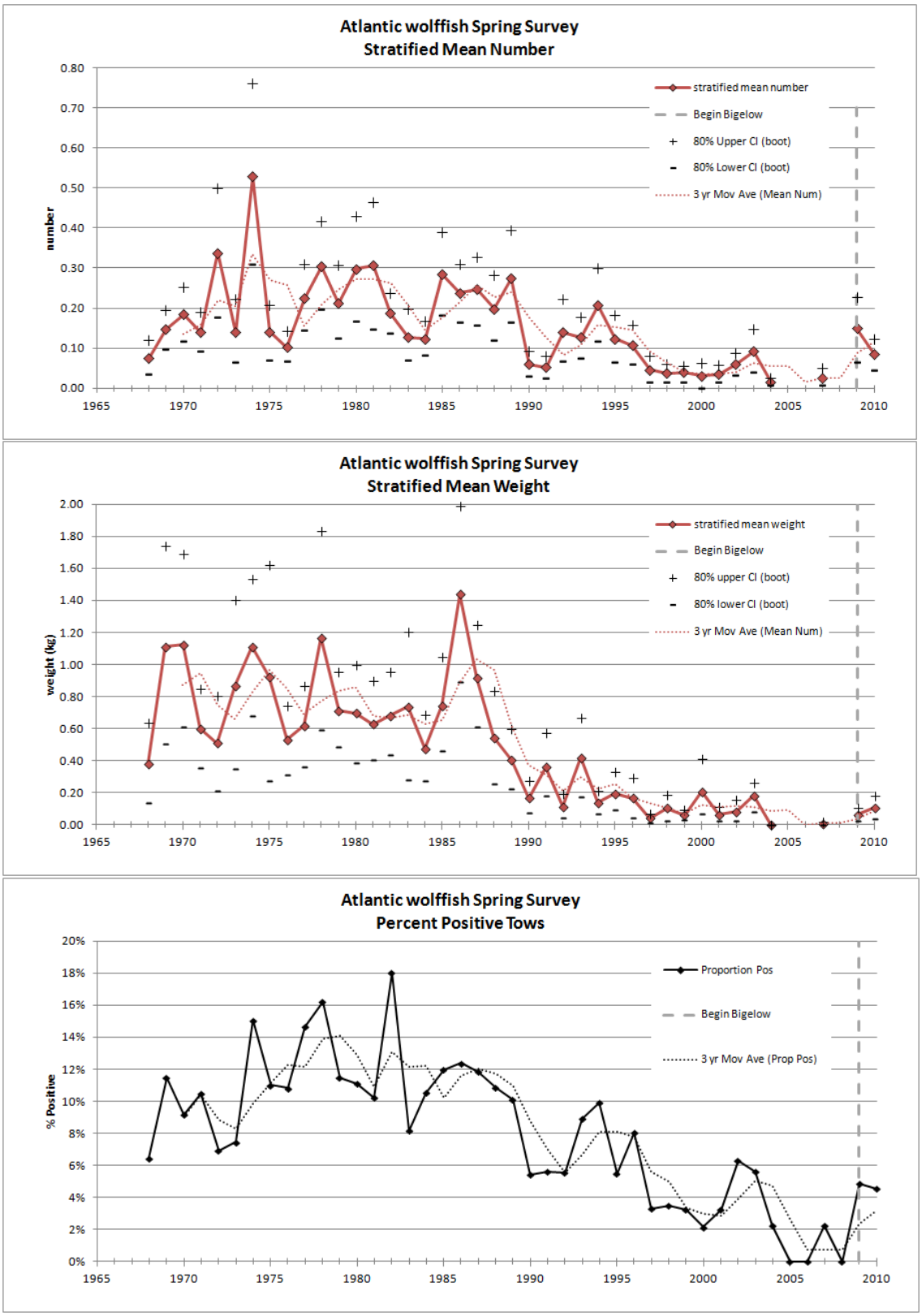


Figure L10. Updated NEFSC spring abundance, biomass and percent positive indices for Atlantic wolffish.

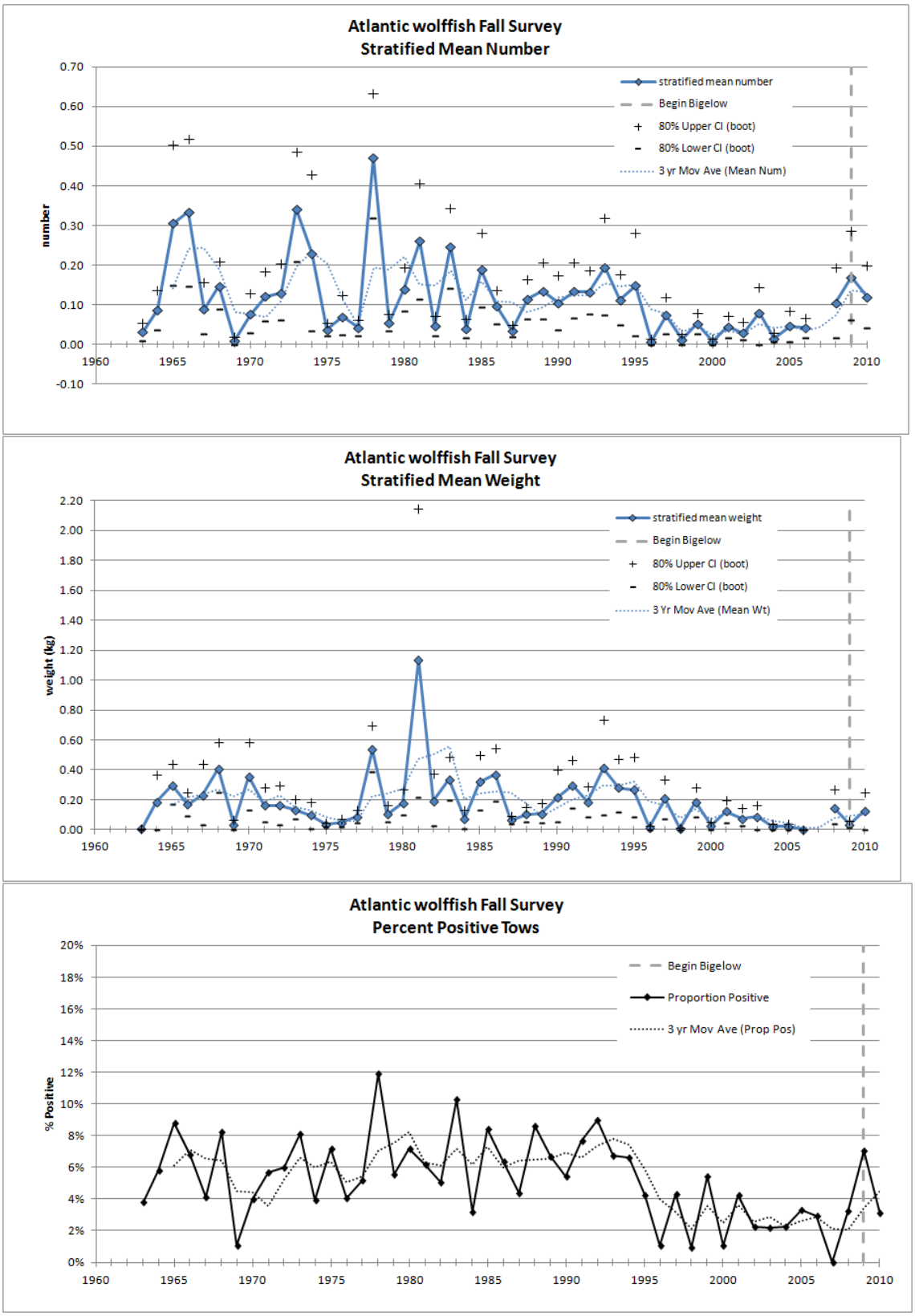


Figure L11. Updated NEFSC fall abundance, biomass and percent positive indices for Atlantic wolffish.

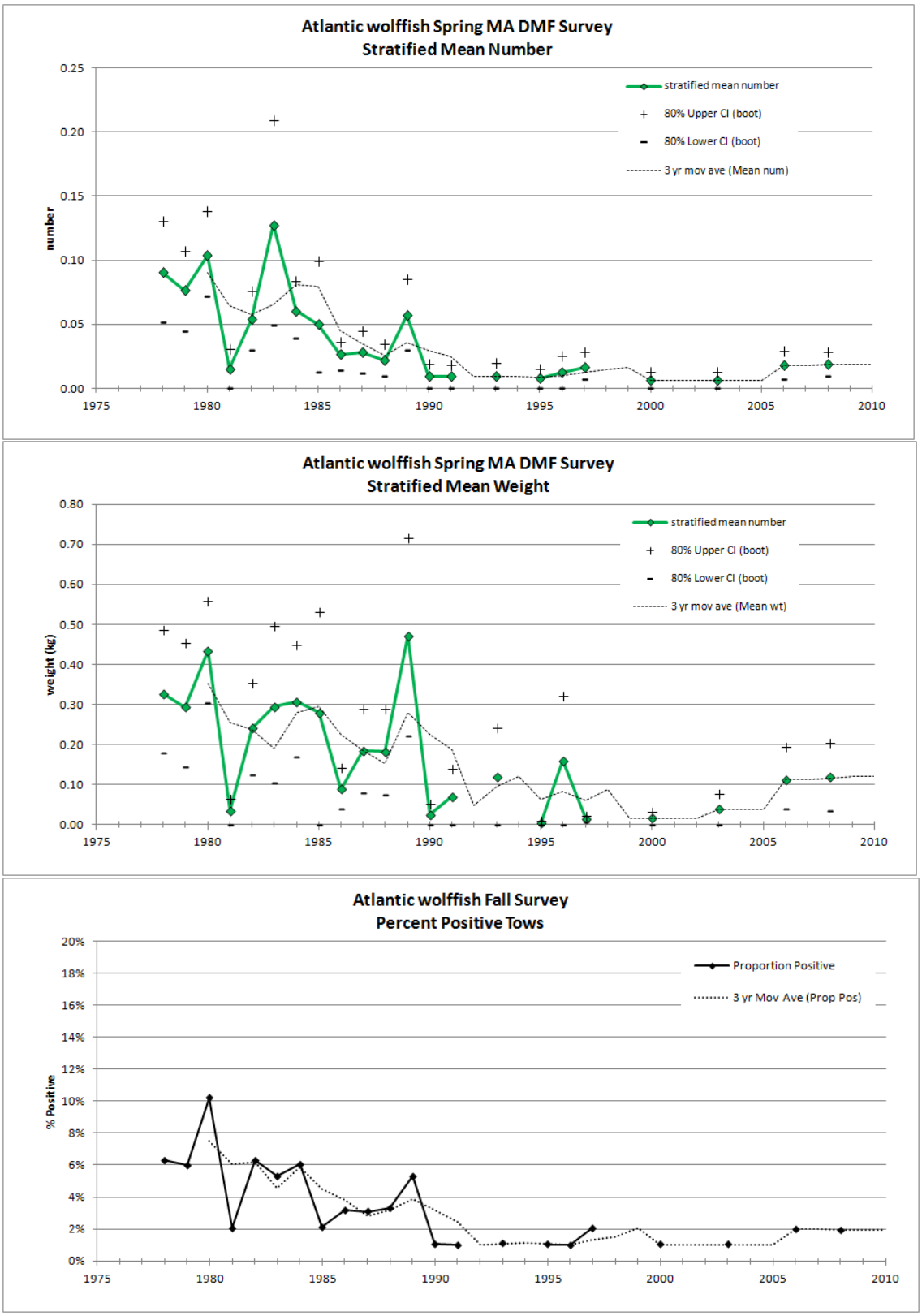


Figure L12. Updated NEFSC fall abundance, biomass and percent positive indices for Atlantic wolffish.

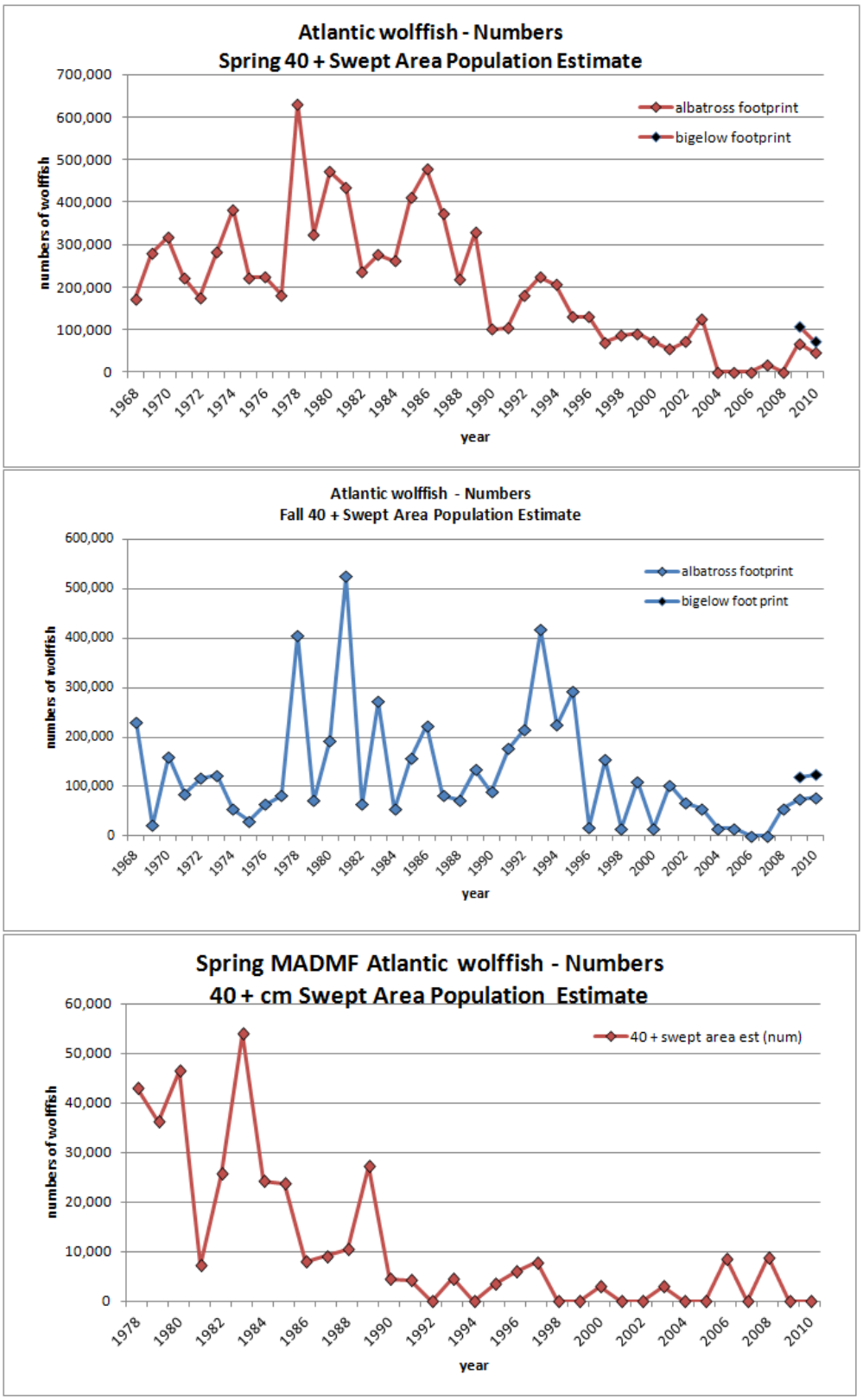


Figure L13. Updated NEFSC spring/fall and MADMF adult (40+ cm) abundance indices for Atlantic wolffish.

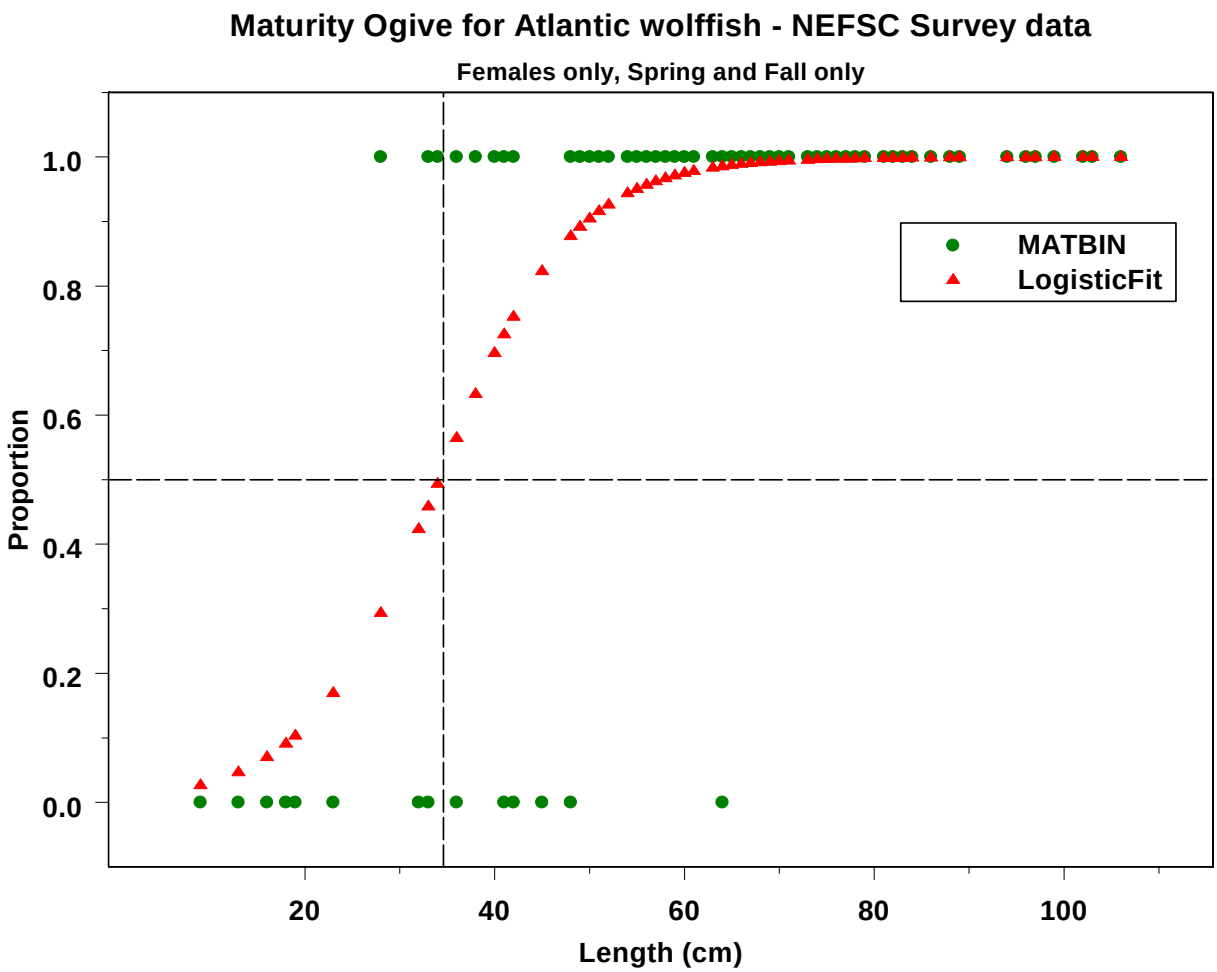


Figure L14. Maturity ogive for female Atlantic wolffish from NEFSC spring and fall data, all years.

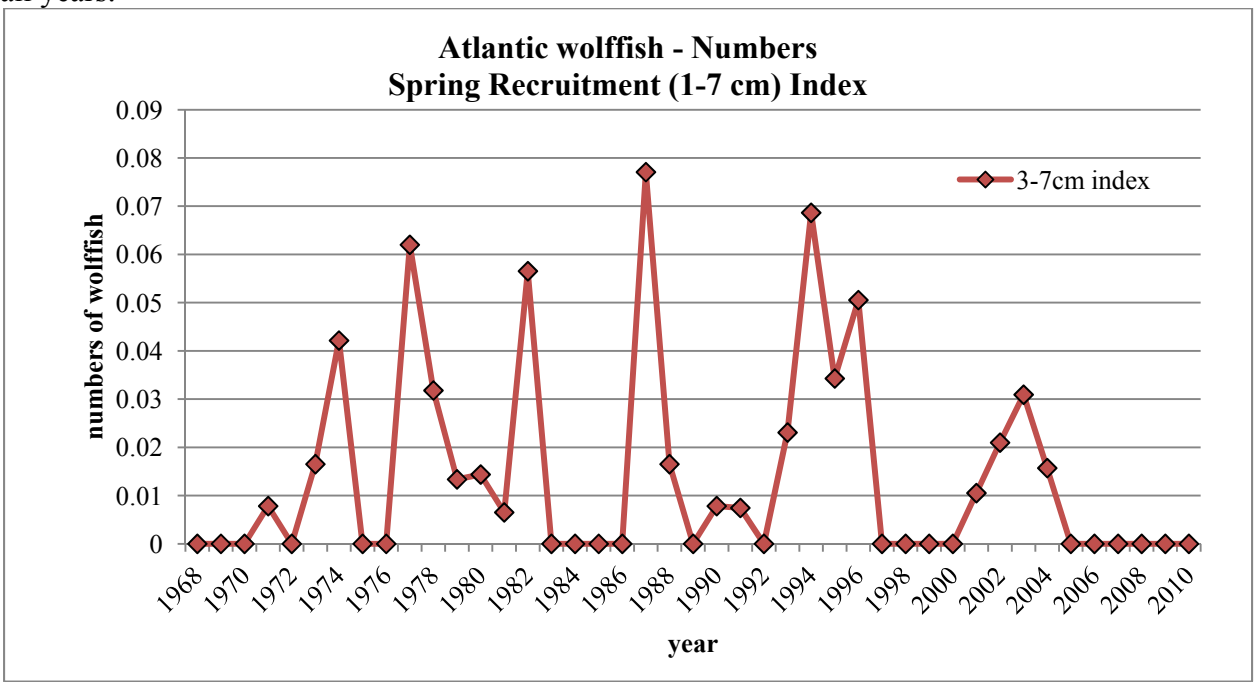


Figure L15. NEFSC spring survey recruitment index for Atlantic wolffish, 1-7 cm = Age 1.

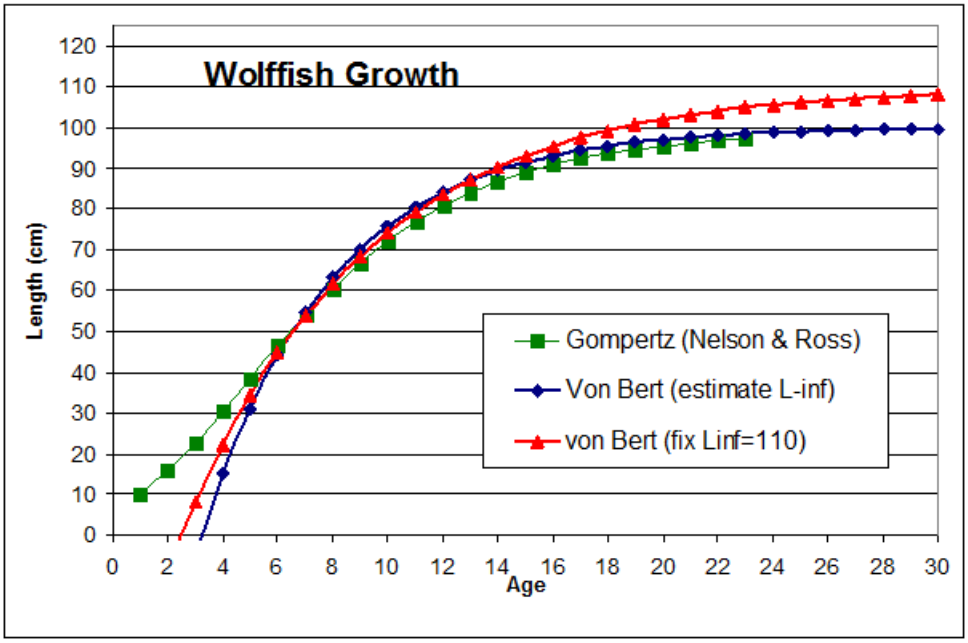


Figure L16. Wolffish estimated growth from Nelson and Ross (1992), von Bertalanffy model limited to 5+ fish, and von Bertalanffy model limited to 5+ fish with fixed L-infinity at 110 cm.

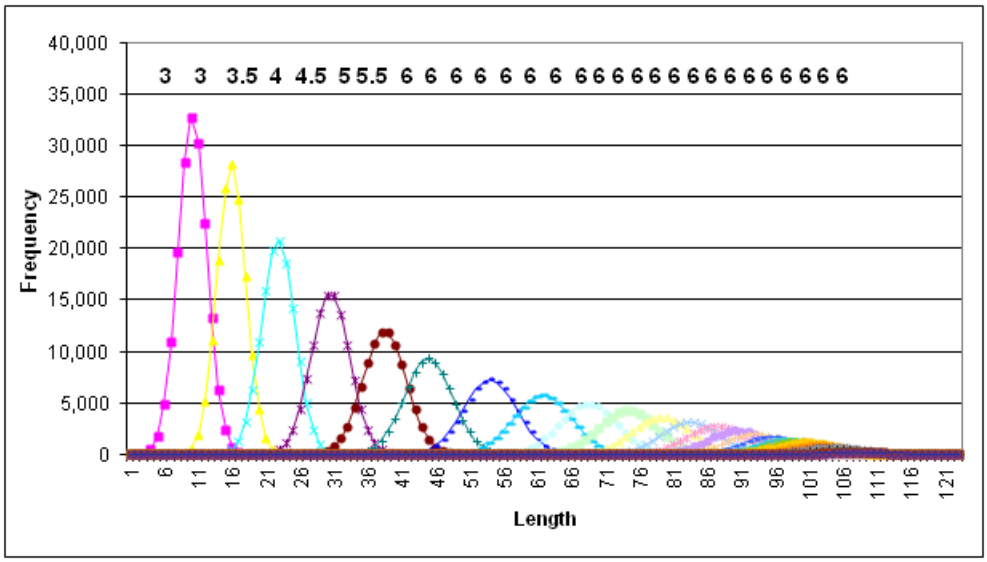


Figure L17. Mean lengths at age distributions assumed for wolffish growth. The input standard deviation is given in the top row of numbers. Ages greater than 7 had a standard deviation of 6.

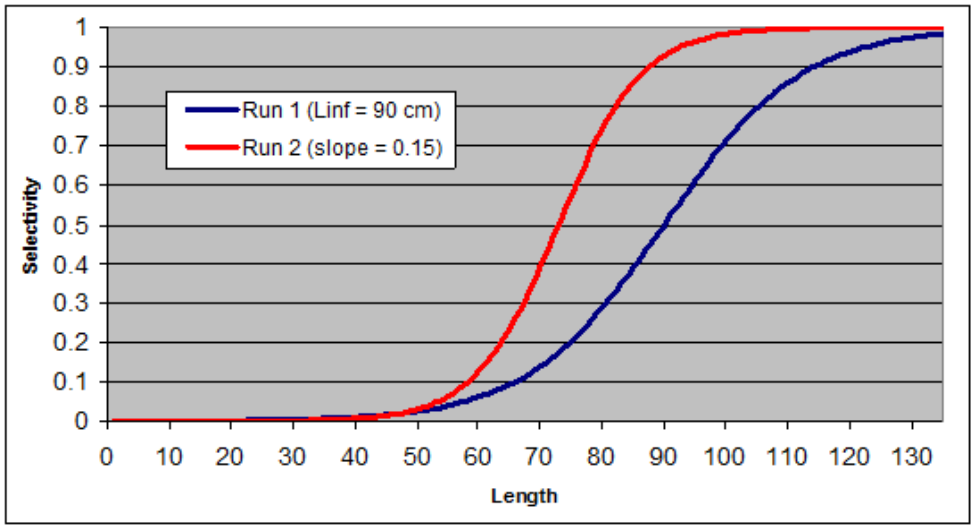


Figure L18. SCALE run 1 selectivity was allowed to hit the L-infinity bound of 90 cm which estimates a relatively flat selectivity curve. SCALE run 2 hits the slope bound of 0.15 which estimated a lower L-infinity.

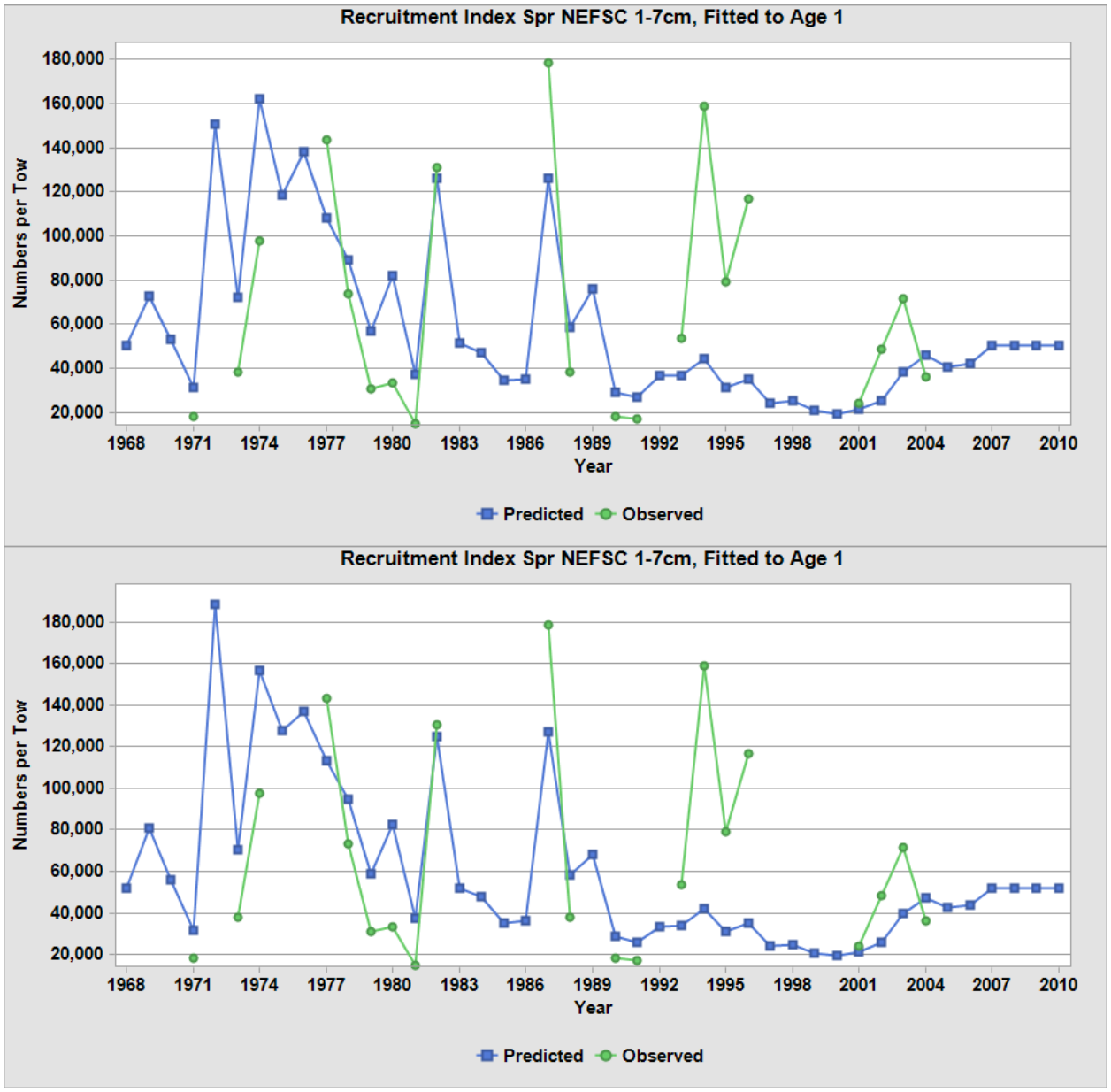


Figure L19. SCALE run 1 (L-infinity = 90 cm) top and SCALE run 2 (Slope = 0.15) fit to the NEFSC spring age-1 recruitment index.

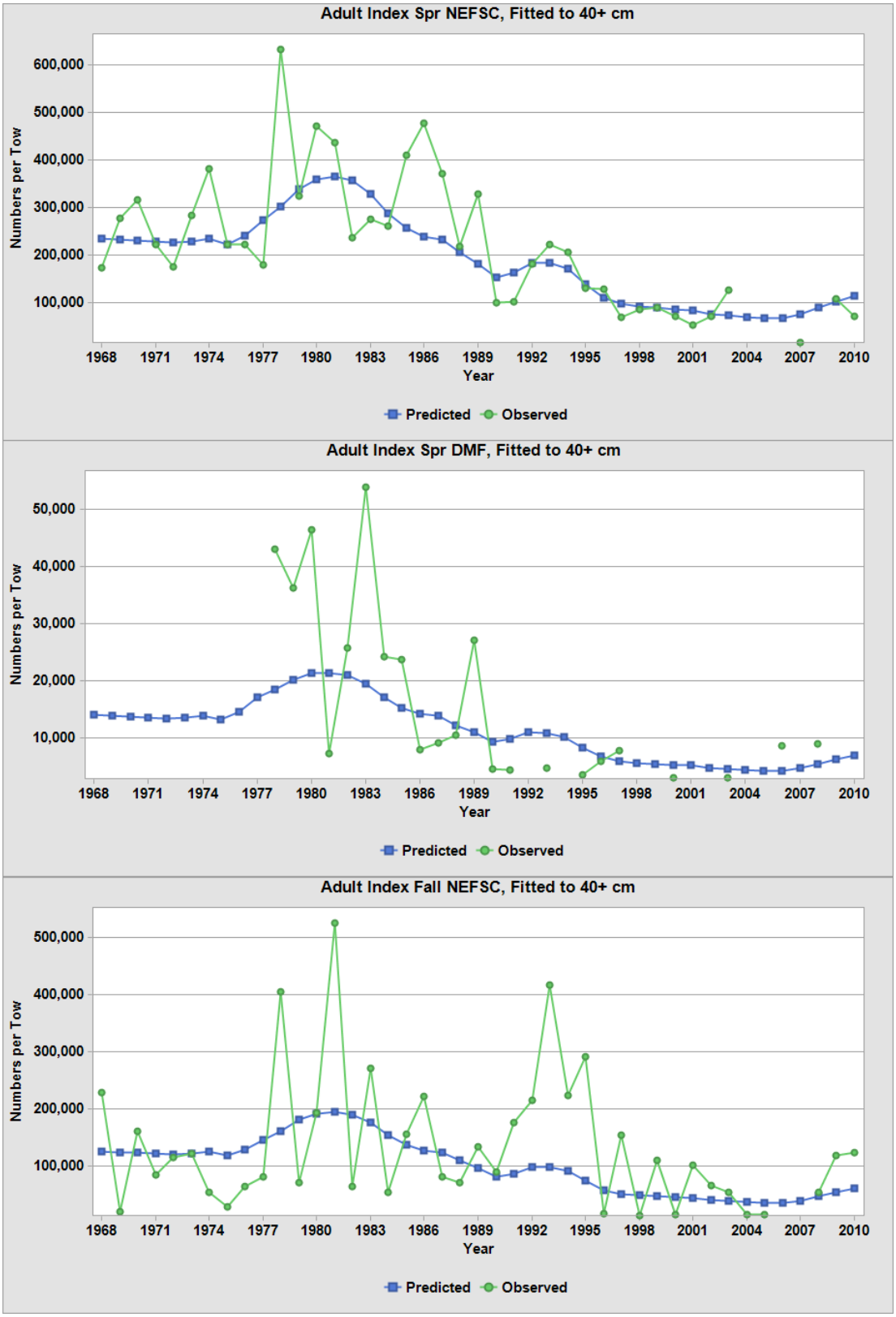


Figure L20. SCALE model fit to the NEFSC spring 40+ cm, MDMF 40+ cm, and NEFSC fall 40+ cm indices.

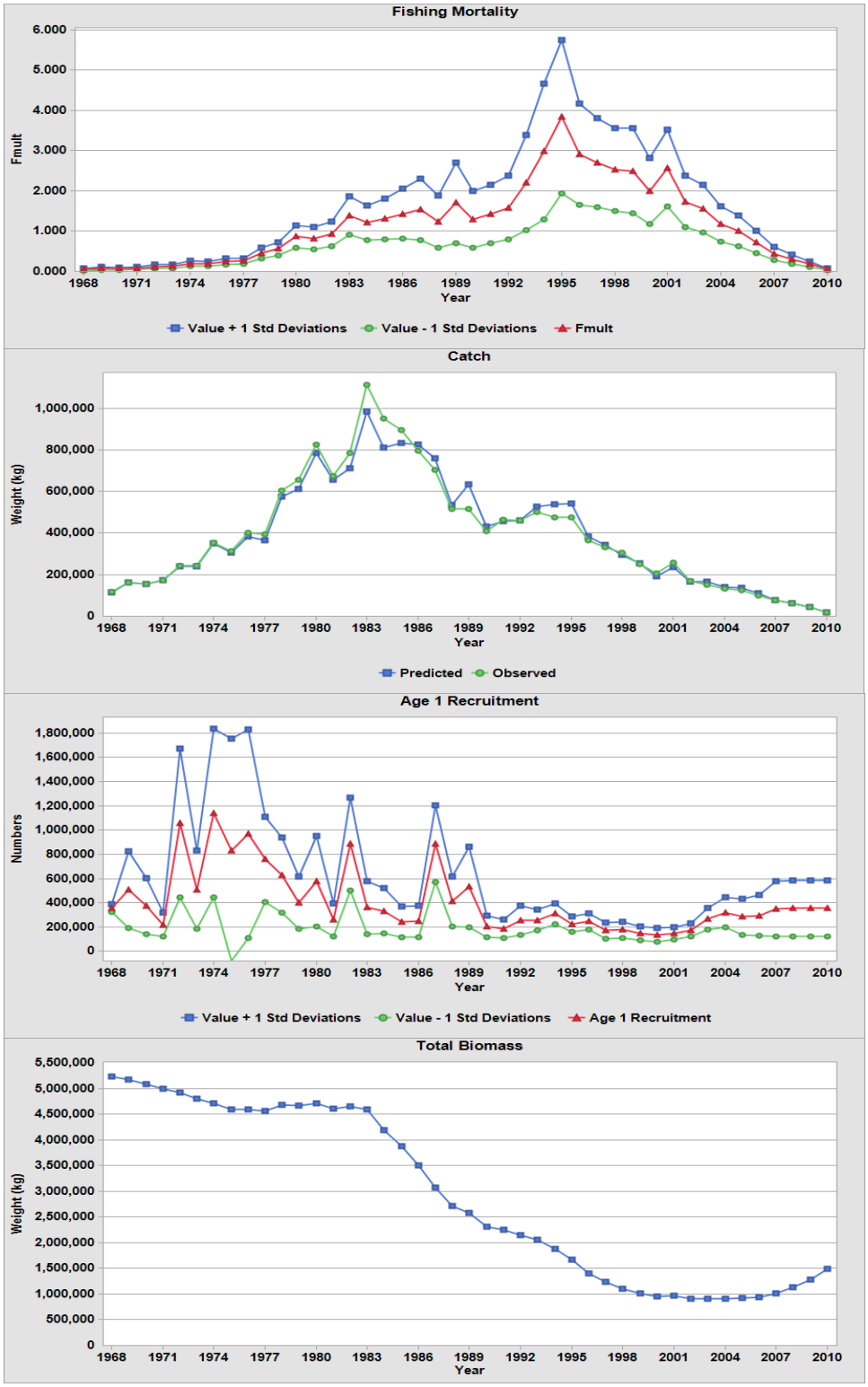


Figure L21. Run 1 (L-infinity = 90 cm) F, fit to the catch, recruitment and total biomass. Plus 1 and minus 1 standard deviations are shown on F and recruitment.

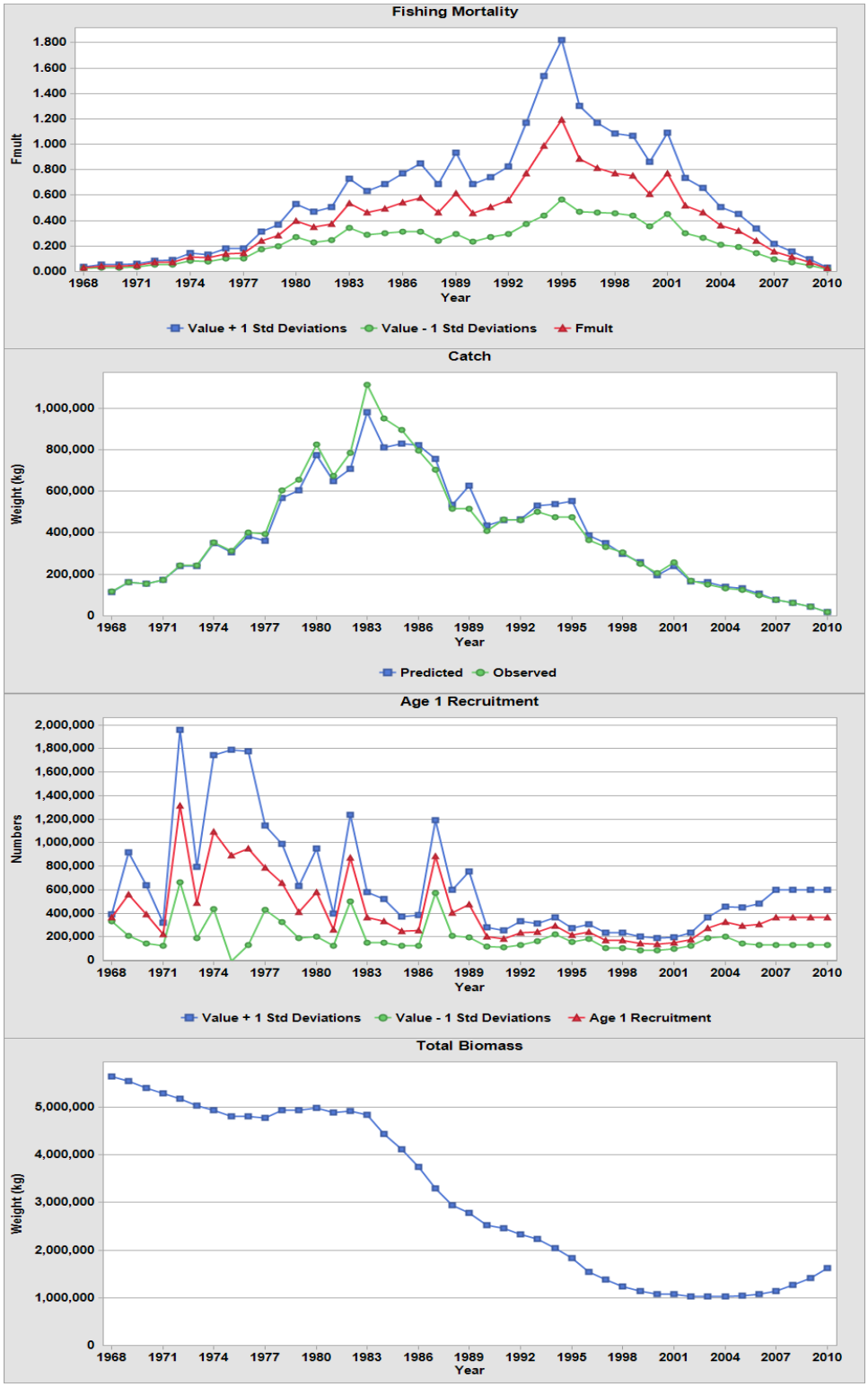


Figure L22. Run 2 (Slope = 0.15) F, fit to the catch, recruitment and total biomass. Plus 1 and minus 1 standard deviations are shown on F and recruitment.

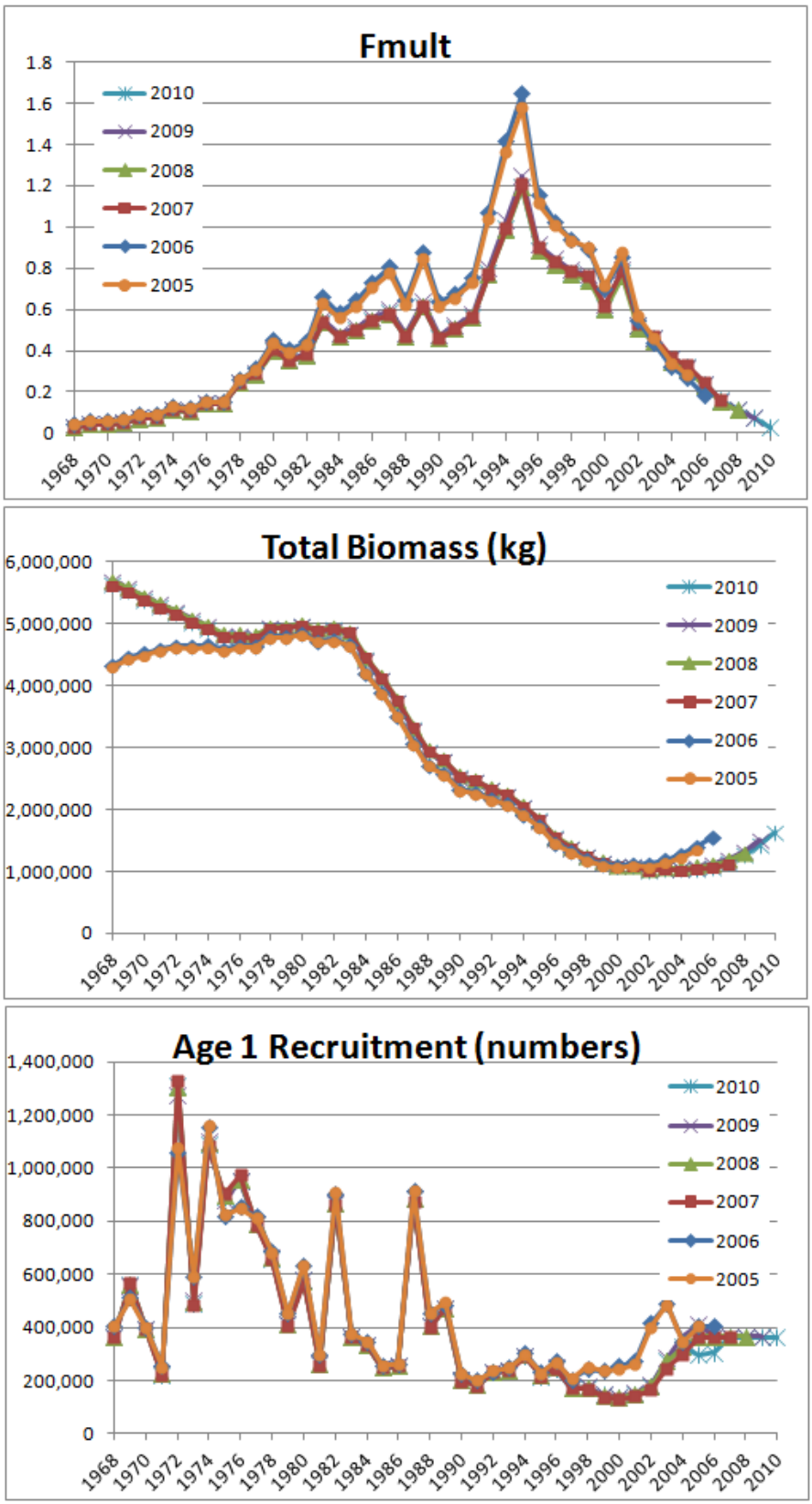


Figure L23. Run 2 (slope = 0.15) retrospective on F, total biomass and age-1 recruitment.

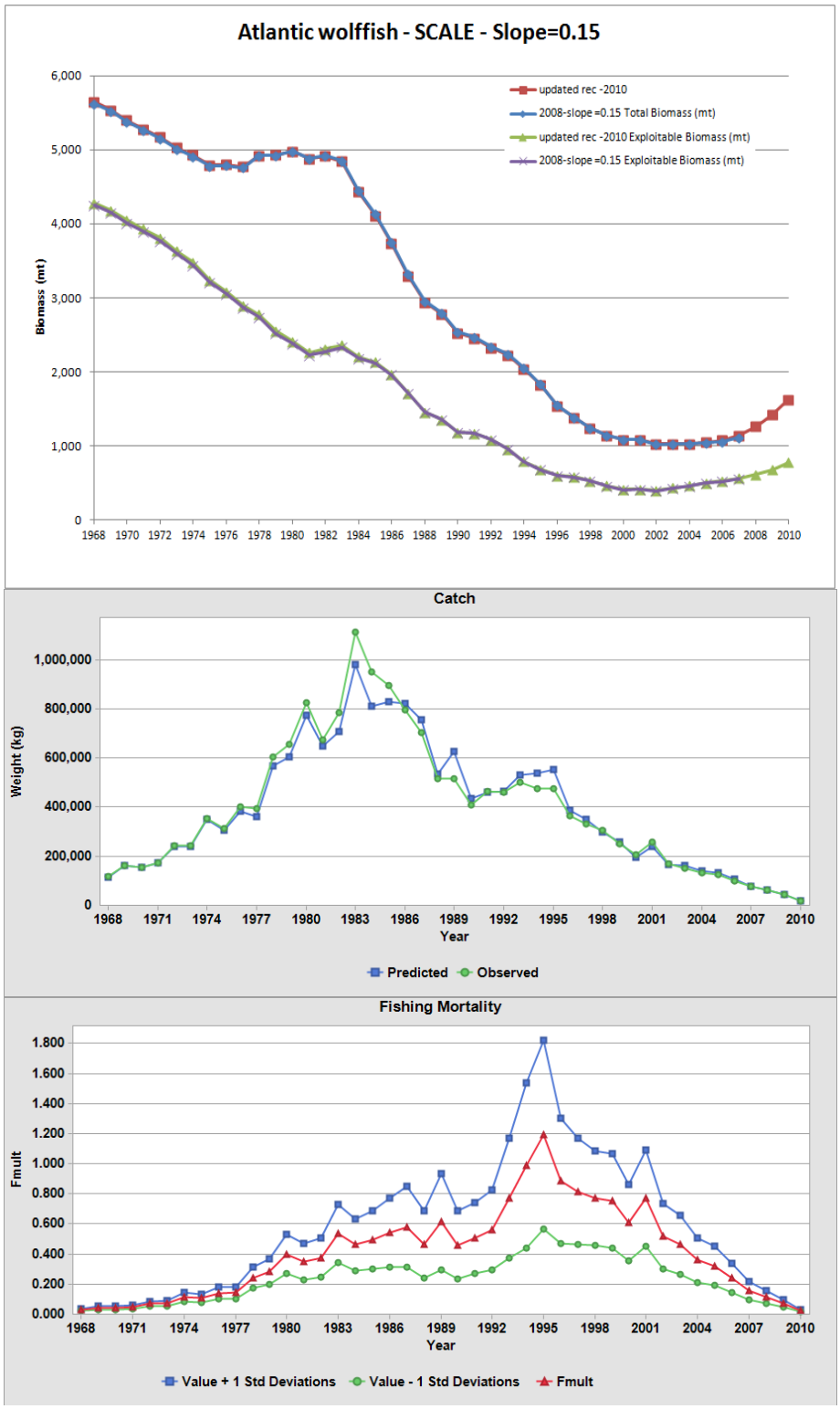


Figure L24. SCALE model run 2 (Slope = 0.15) results for total and exploitable biomass, catch, and fishing mortality.

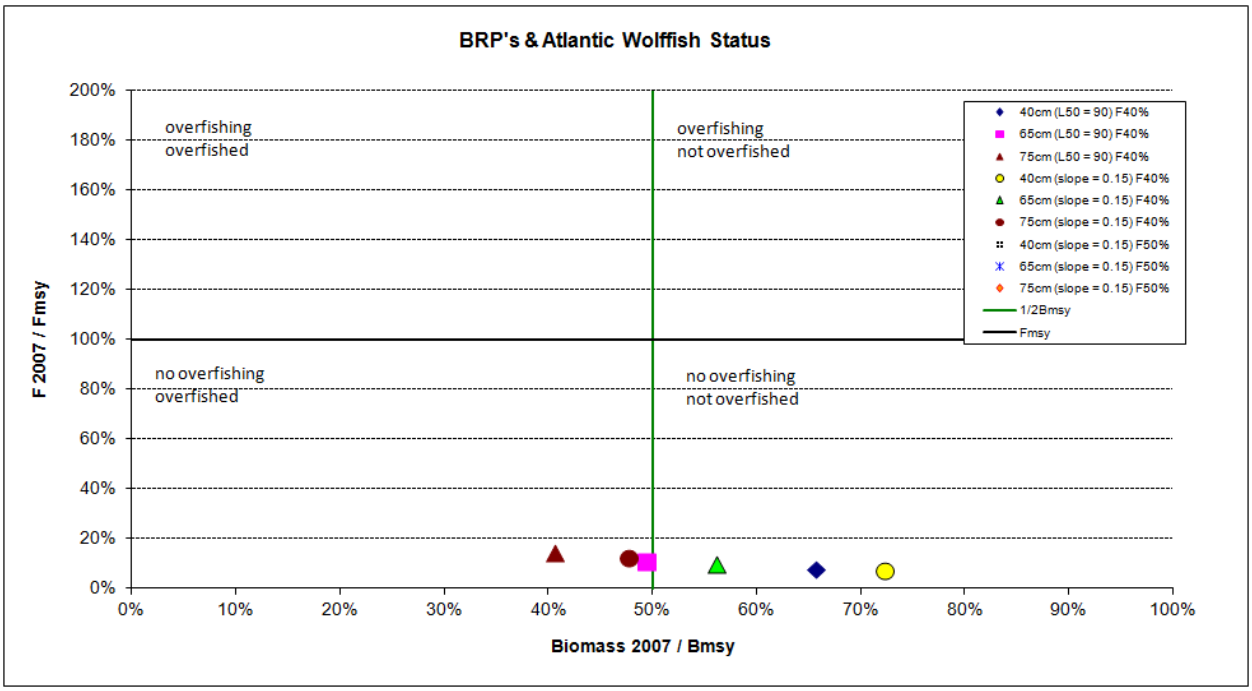


Figure L25. Atlantic wolffish biological reference points and status in 2010.

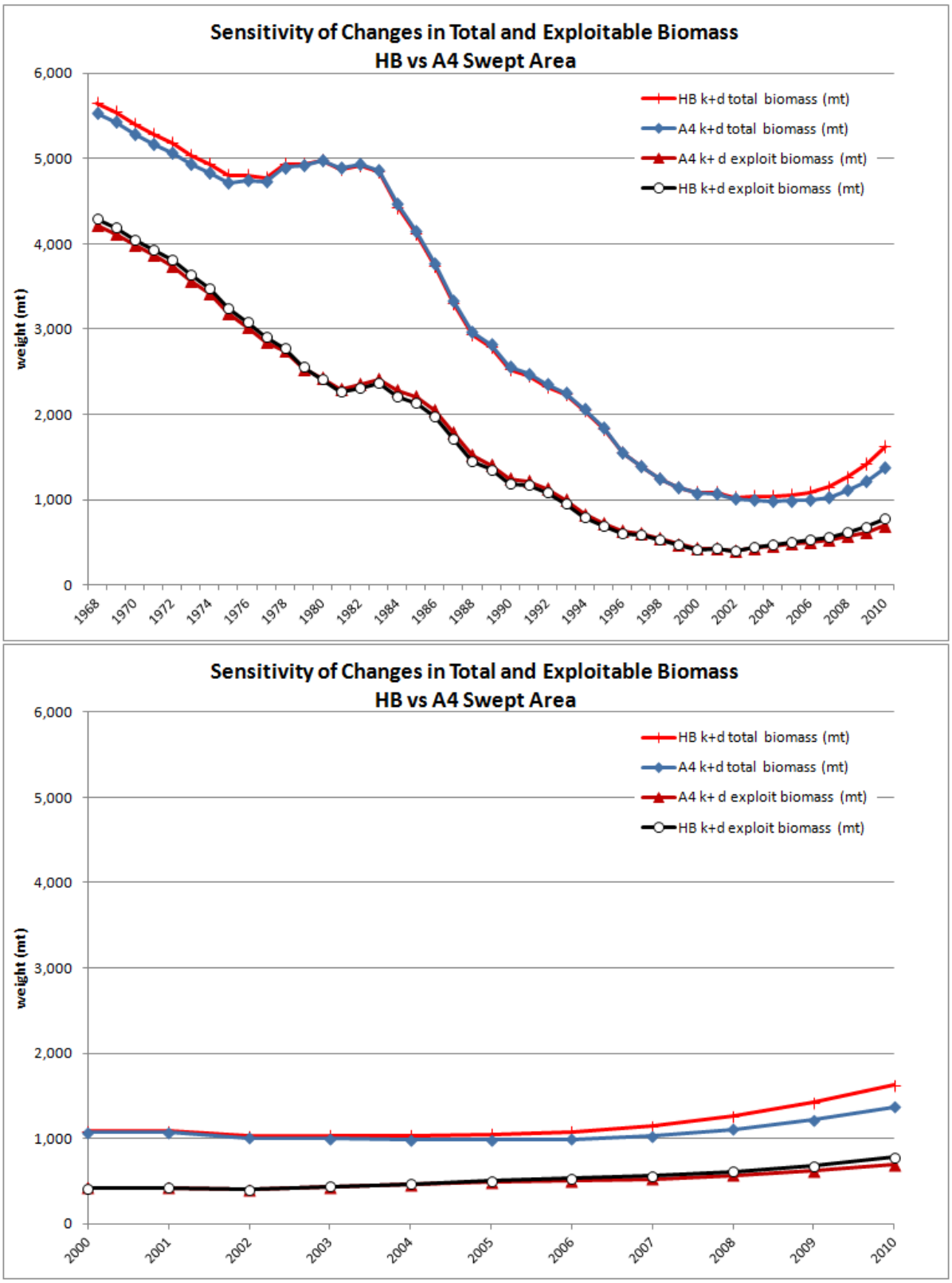


Figure L26. A comparison of changes in total biomass estimated by the SCALE model due to changes in the swept area abundance input for the Bigelow and the Albatross IV.

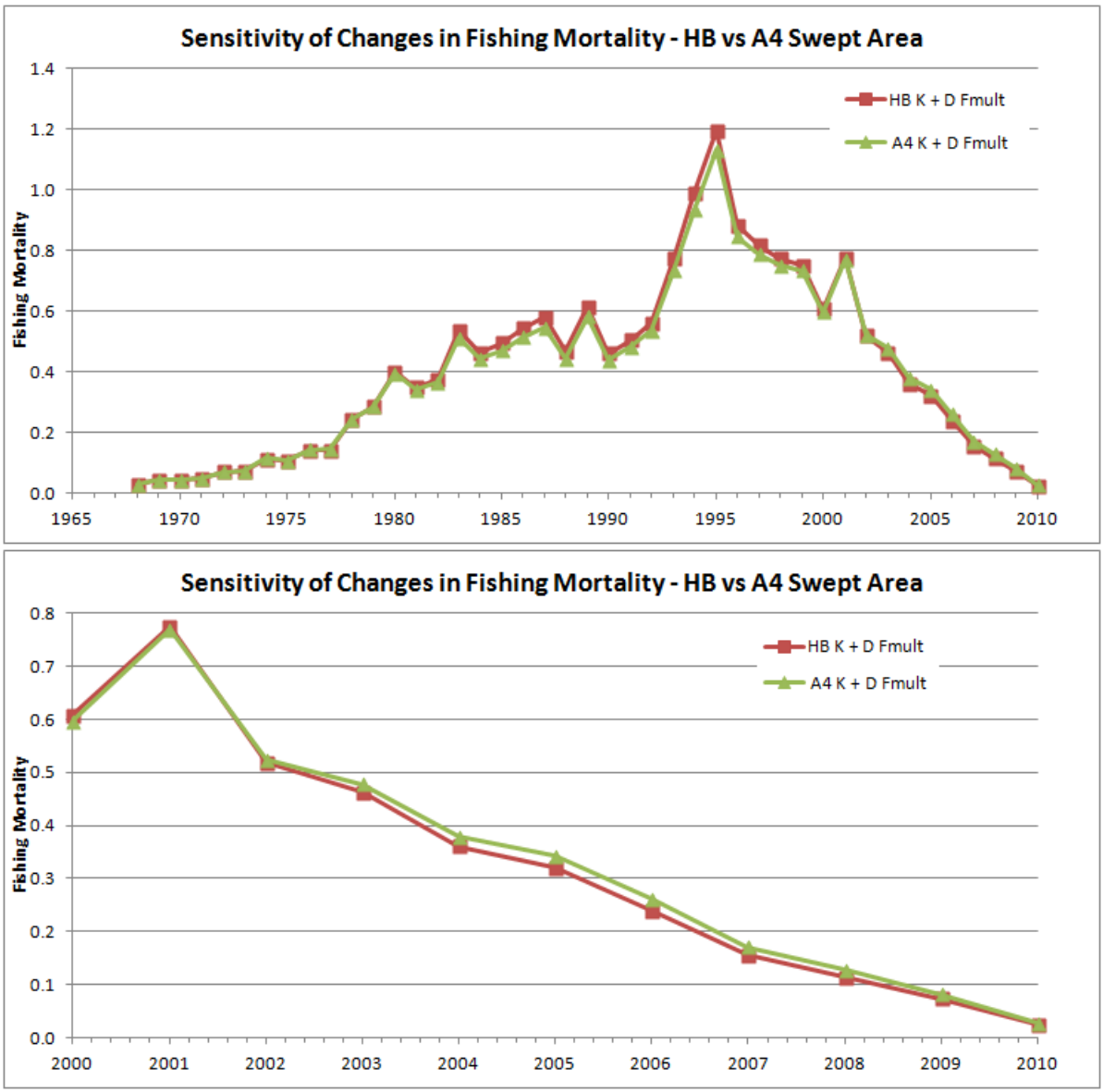


Figure L27. A comparison of changes in fishing mortality estimated by the SCALE model due to changes in the swept area abundance input for the Bigelow and the Albatross IV.

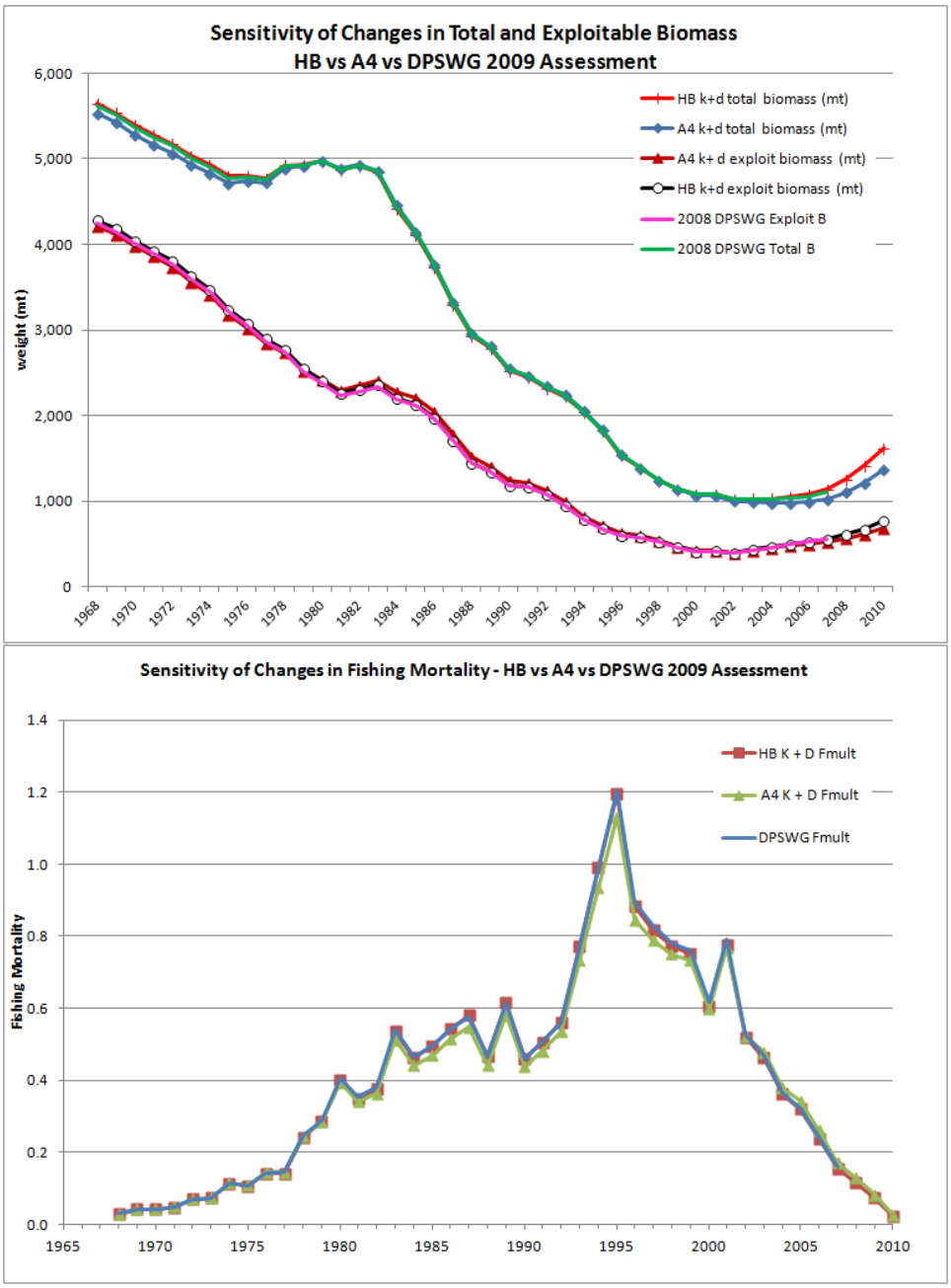


Figure L28. A comparison between the 2009 NDPSWG model results and the of changes in total and exploitable biomass and fishing mortality estimated by the SCALE model due to changes in the swept area abundance input for the Bigelow and the Albatross IV.

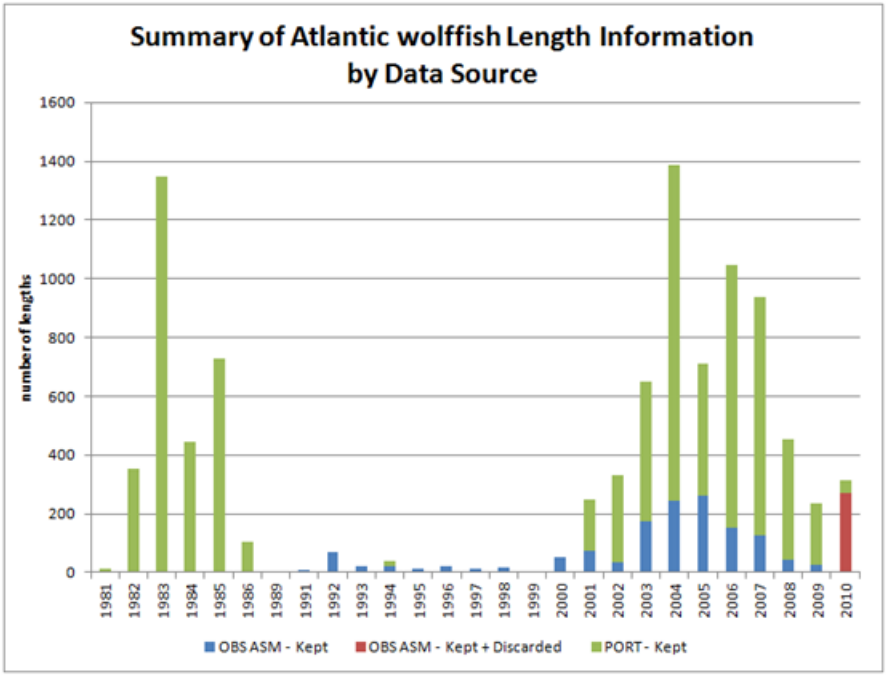


Figure L29. Commercial length frequency data used in the SCALE model by data source. Only the 2010 year includes length information from discarded wolffish.

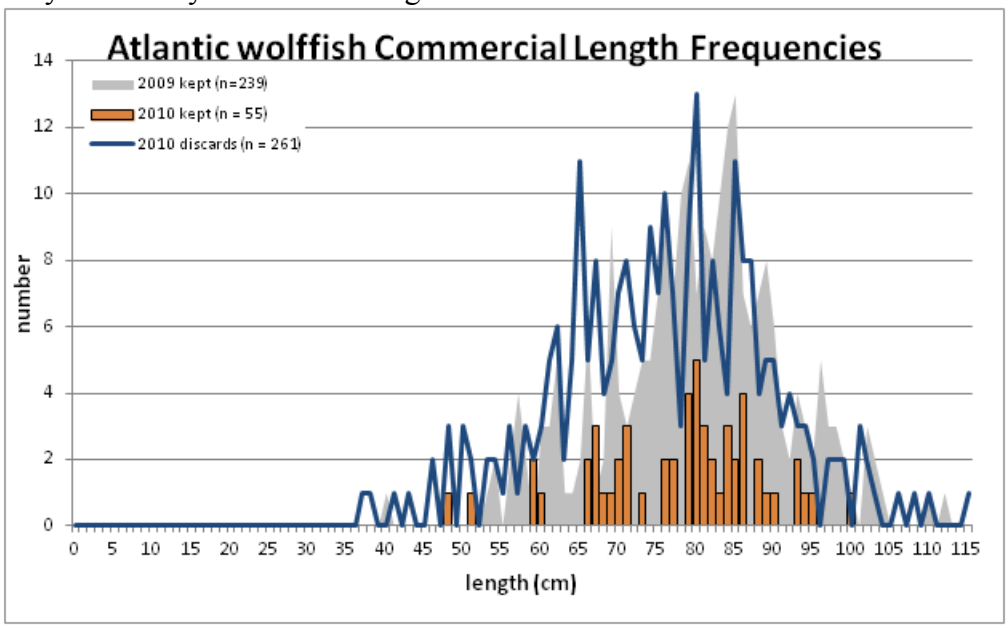
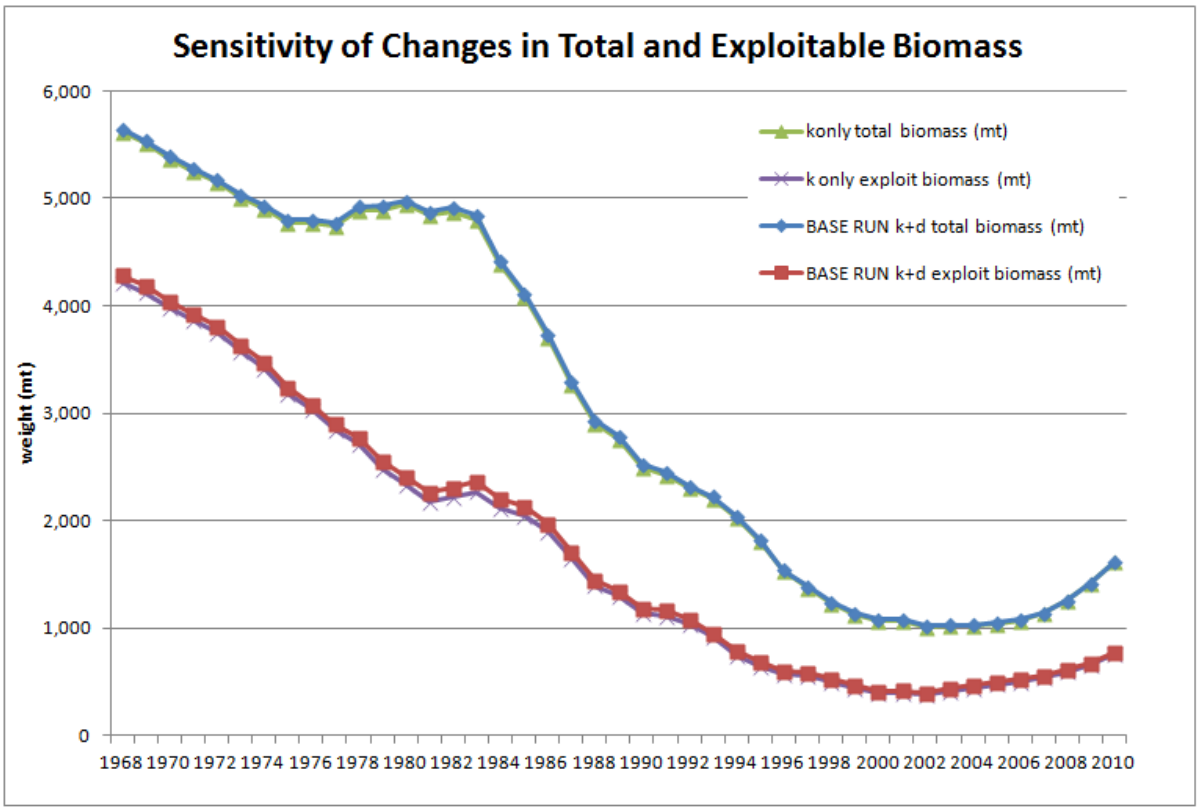


Figure L30. Length frequency comparisons of 2009 kept, 2010 kept and 2010 discarded commercial Atlantic wolffish.



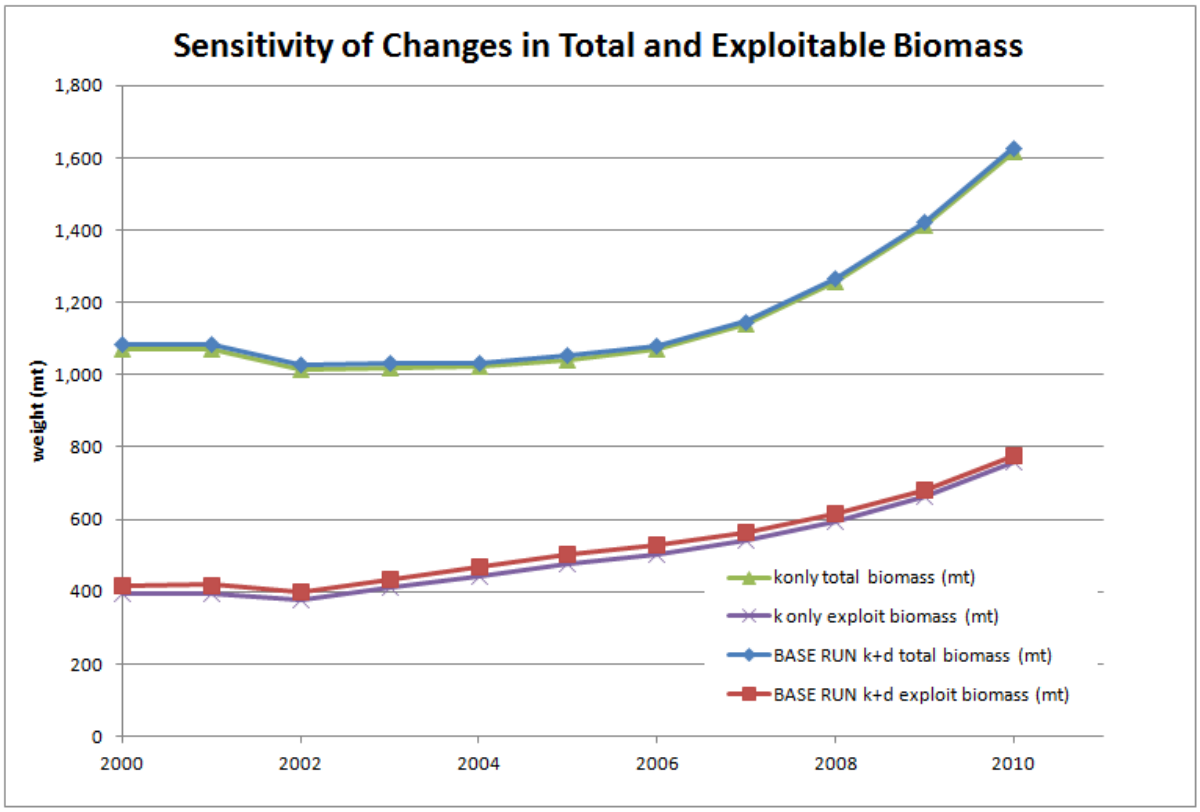


Figure L31. A comparison of changes in the total and exploitable biomass estimated by the SCALE model due to changes in the 2010 length frequency distribution.

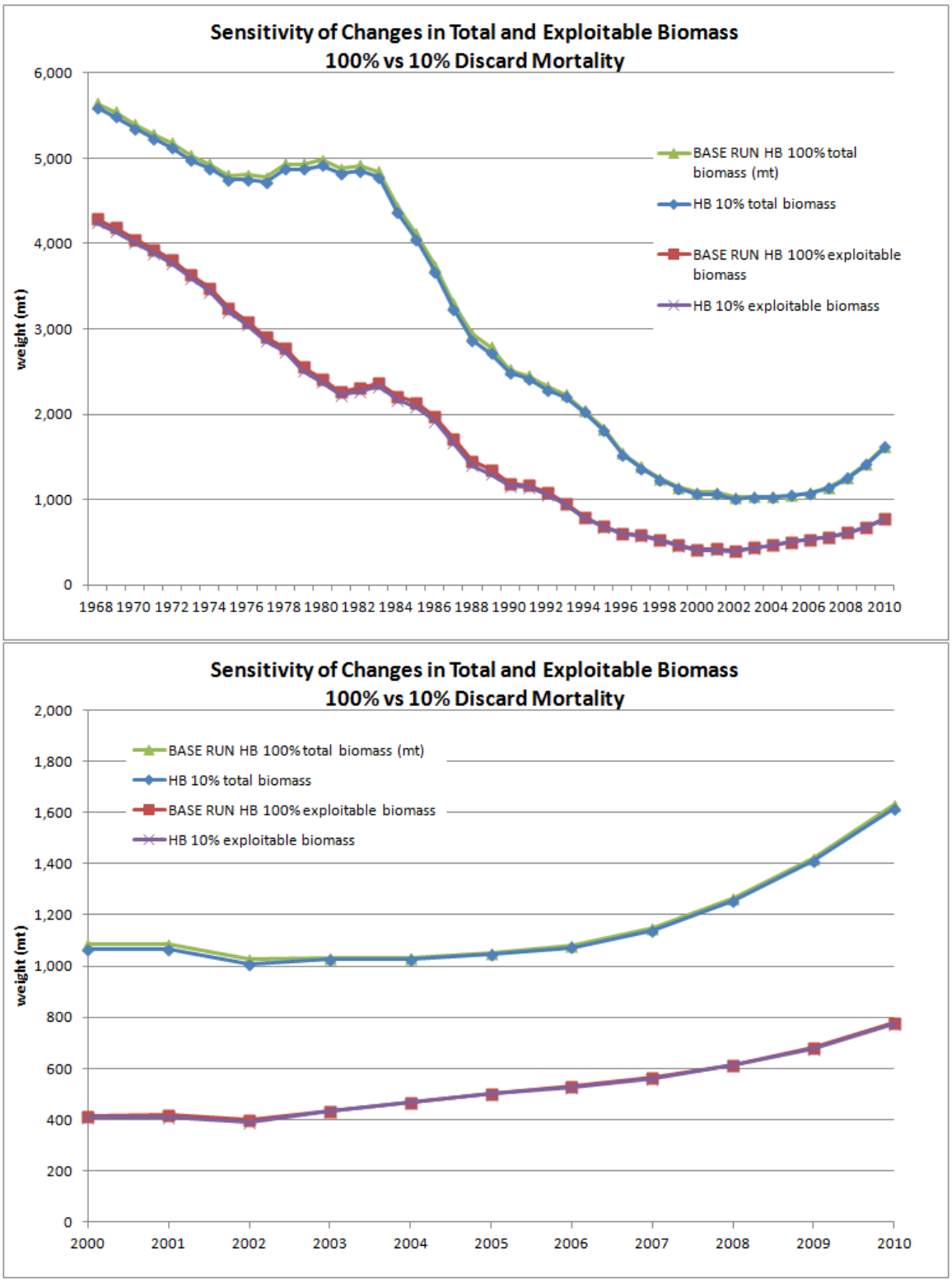


Figure L32. A comparison of changes in the total and exploitable biomass estimated by the SCALE model due to changes to assumed discard mortality rates (BASE run 100% vs discard mortality 10%). Bottom graph scaled to the end of the time series.

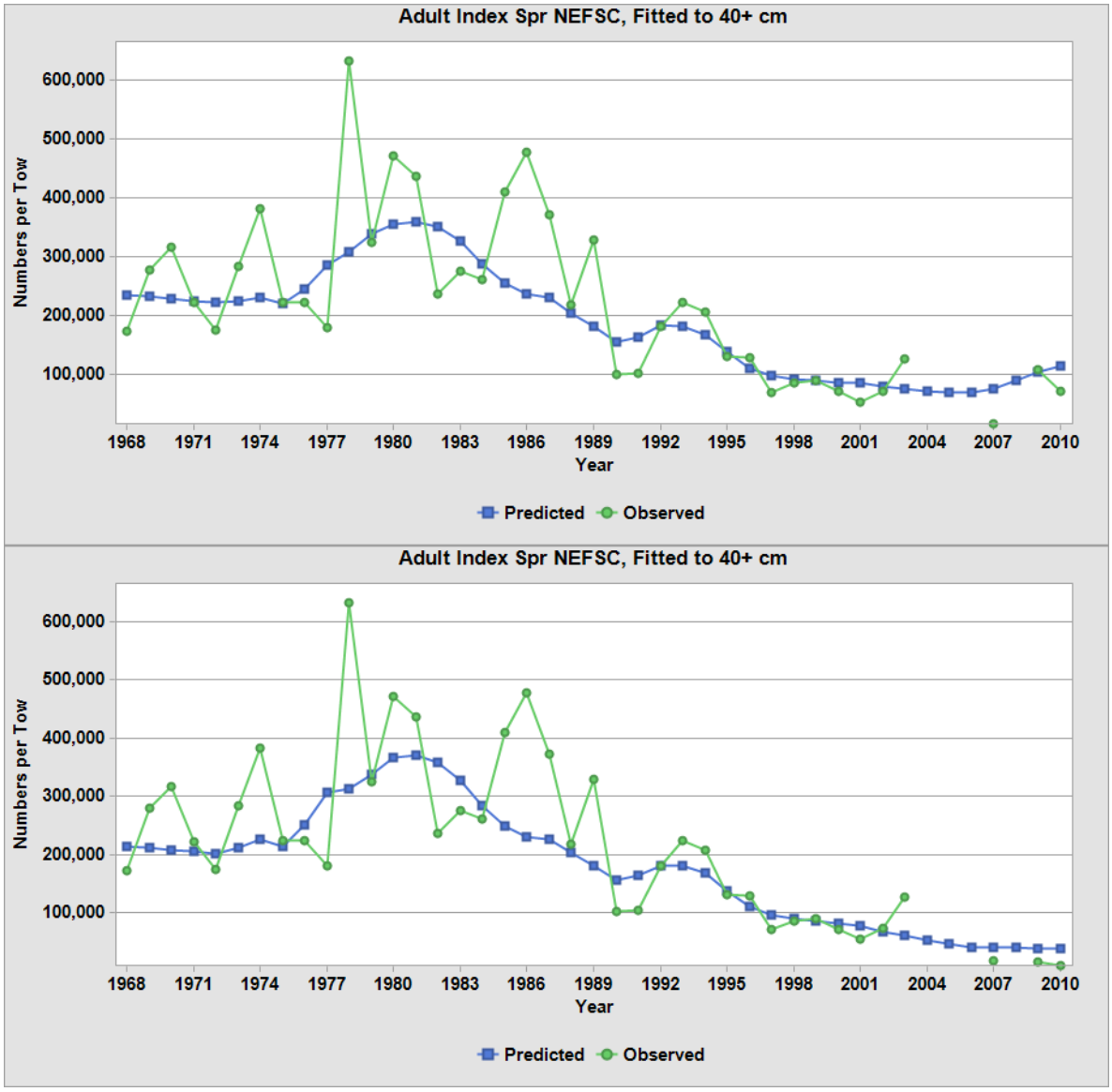


Figure L33. A comparison of spring survey indices (swept area units) from the NEFSC. The top panel is the Atlantic wolffish base run and the bottom is the ocean pout proxy run using the 4.575 Bigelow to Albatross calibration coefficient.

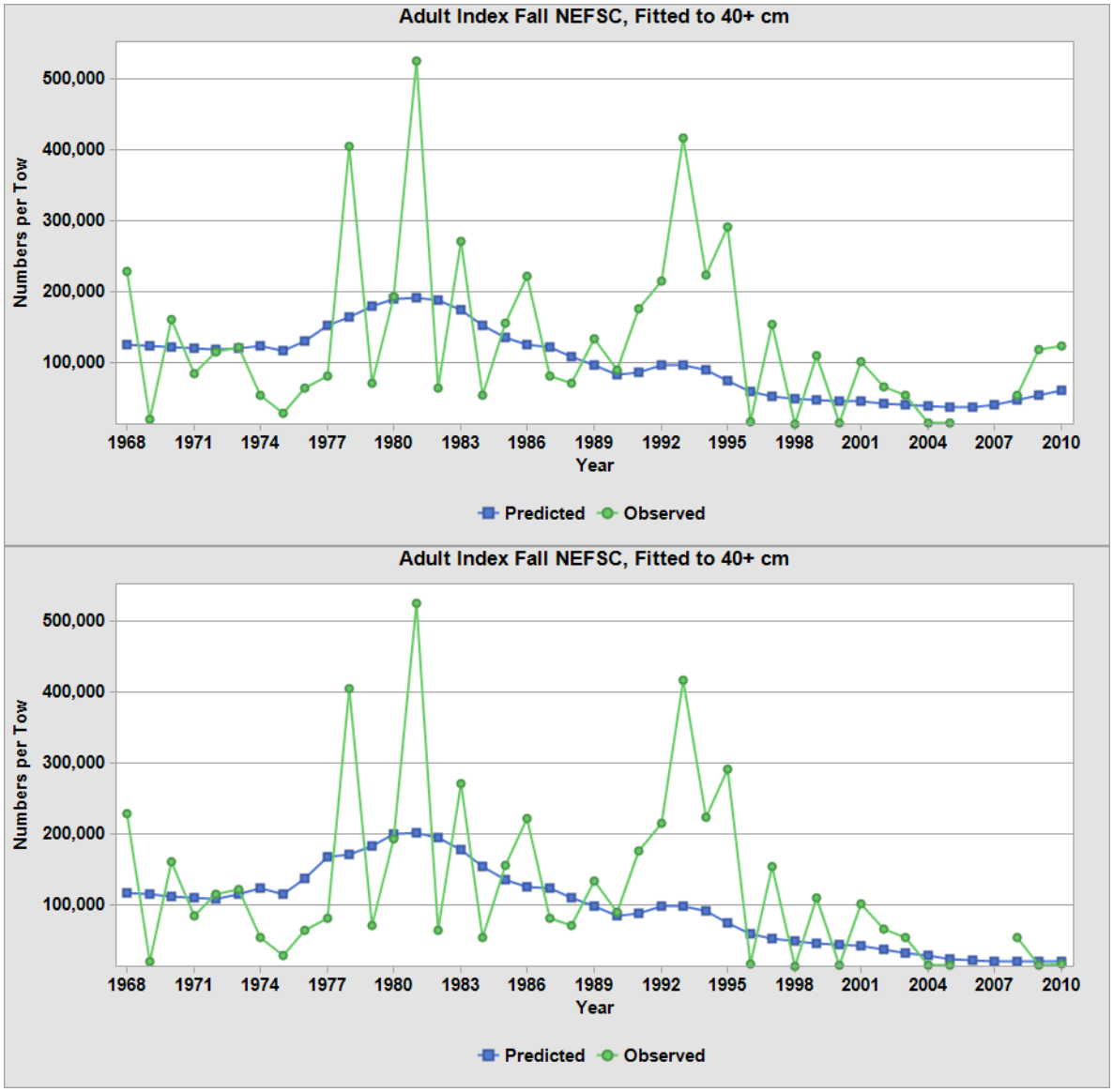


Figure L34. A comparison of fall survey indices (swept area units) from the NEFSC. The top panel is the Atlantic wolffish base run and the bottom is the ocean pout proxy run using the 4.575 Bigelow to Albatross calibration coefficient.

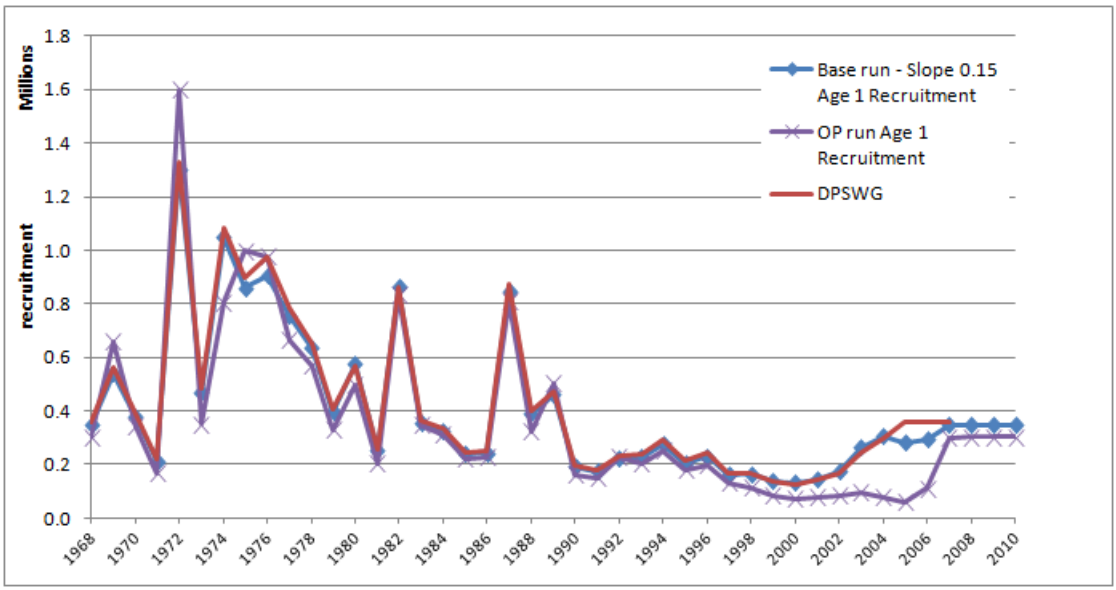


Figure L35. Estimated age 1 recruitment of Atlantic wolffish from the SCALE model showing the base run, 2008 DPSWG preferred run and the ocean pout proxy run.

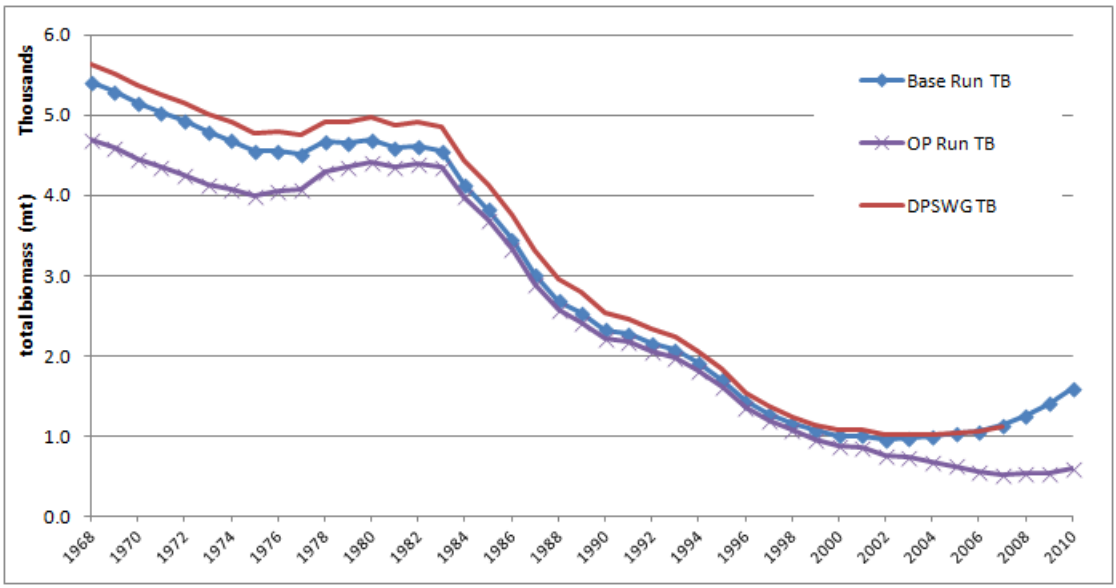


Figure L36. Estimated total biomass of Atlantic wolffish from the SCALE model showing the base run, 2008 DPSWG preferred run and the ocean pout proxy run.

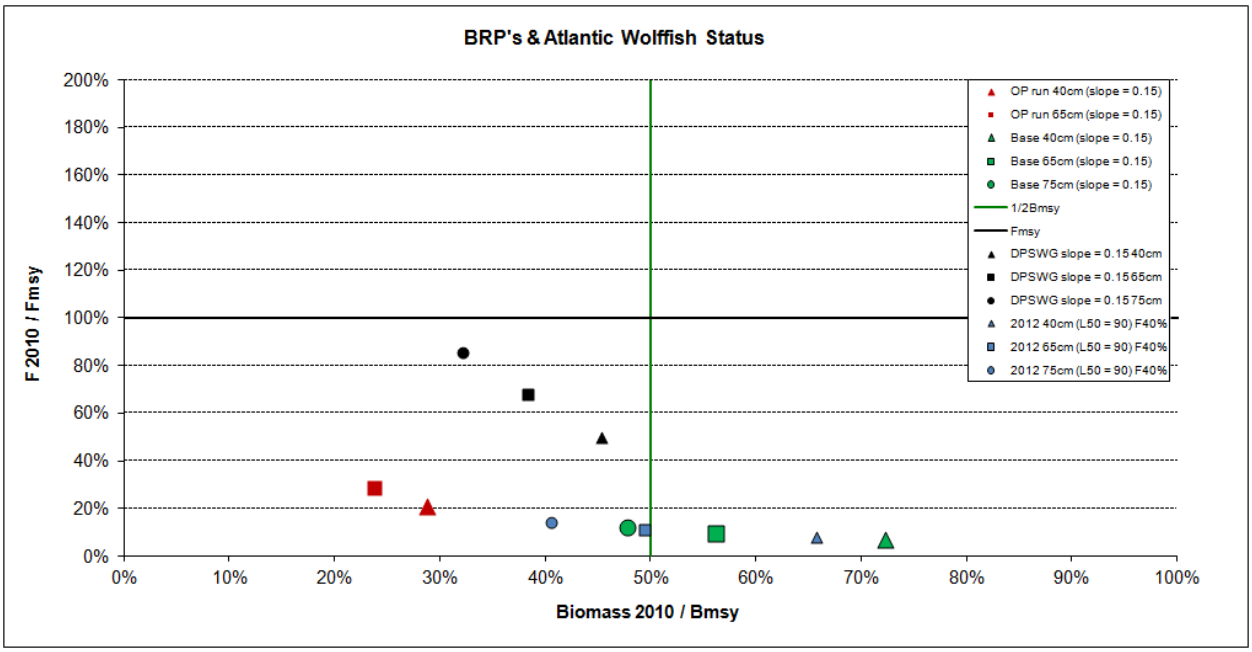


Figure L37. A comparison of biological reference points developed for the ocean pout proxy run, base runs and 2008 DPSWG preferred run (slope 0.15).

Atlantic Wolffish Appendix 1

Appendix Table L1. Number of wolffish collected by year (2009, 2010), season (spring, autumn), and sex (female, male, or unknown) from NEFSC groundfish surveys (FSV Bigelow). Sex was determined from gonad histology. A section of gonad tissue was excised from the middle of one lobe of the gonad, fixed in 10% buffered formalin, preserved and dehydrated later in an increasing series of ethyl alcohol, embedded in paraffin, sectioned to 5 microns, and stained with Schiff's Mallory Trichrome. Three fish were not identified by sex because the tissue sampled was not from the gonad.

Appendix Figure L1. Size frequency of wolffish with respect to maturity, based on the examination of gonad histology from 33 females. Histology slides were examined by one reader (R. McBride, NEFSC) three times at 40-100 x. Fish were scored mature if the tissue contained vitellogenic oocytes or there was evidence of previous spawning. Fish size is total length (TL) in centimeters.

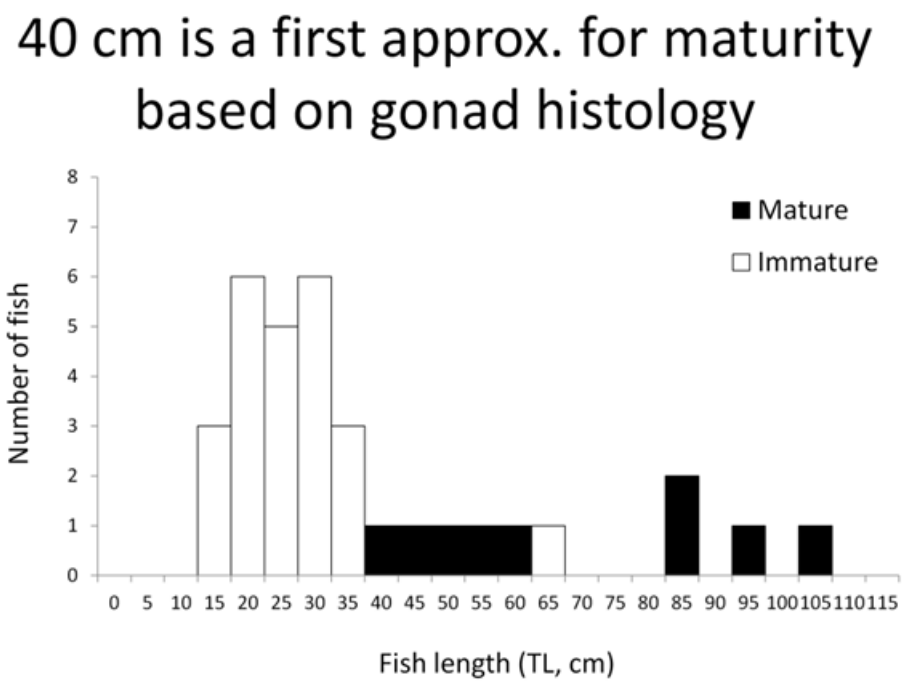
Atlantic Wolffish Appendix 1.

Sample size (NEFSC groundfish survey)

Year	Season	Females	Males	Unknown
2009	Spring	12	8	
2009	Autumn	5	3	
2010	Spring	12	9	3
2010	Autumn	4	4	
	Total	**33**	**24**	**3**

Small sample size (33 females)
but very detailed (gonad histology)

Appendix Table L1. Number of wolffish collected by year (2009, 2010), season (spring, autumn), and sex (female, male, or unknown) from NEFSC groundfish surveys (FSV Bigelow). Sex was determined from gonad histology. A section of gonad tissue was excised from the middle of one lobe of the gonad, fixed in 10% buffered formalin, preserved and dehydrated later in an increasing series of ethyl alcohol, embedded in paraffin, sectioned to 5 microns, and stained with Schiff's Mallory Trichrome. Three fish were not identified by sex because the tissue sampled was not from the gonad.



Appendix Figure L1. Size frequency of wolffish with respect to maturity, based on the examination of gonad histology from 33 females. Histology slides were examined by one reader (R. McBride, NEFSC) three times at 40-100 x. Fish were scored mature if the tissue contained vitellogenic oocytes or there was evidence of previous spawning. Fish size is total length (TL) in centimeters.