WITCH FLOUNDER APPENDICES

APPENDIX B1 Sweep Study Working Paper with supporting information

APPENDIX B2 Replacement Yield (RY) Model Working Paper

APPENDIX B3 Statistical Catch At Age (SCAA) Model Working Paper

APPENDIX B4 Virtual Population Analysis (VPA) Model Input

APPENDIX B5 Age structured Assessment Program (ASAP) Model Input

APPENDIX B6 Collection of Slides provided during SARC Discussion

APPENDIX B1

Empirical estimates of maximum catchability of Witch Flounder *Glyptocephalus cynoglossus L.* on the Northeast Fisheries Science Center Fall bottom trawl survey

Authors in Alphabetical Order: Jon Hare[1], John Hoey[2], John Manderson[1,2], Michael Martin[3], Phil Politis[3], David Richardson[1,2], Chris Roebuck[4],

1 Oceans and Climate Branch, Northeast Fisheries Science Center
2 Cooperative Research Branch, Northeast Fisheries Science Center
3 Ecosystem Surveys Branch, Northeast Fisheries Science Center
4 Fishing Vessel Karen Elizabeth, Point Judith RI

ABSTRACT

For fisheries research surveys the catchability coefficient (q) defines the relationship between a survey index and population size. Typically, catchability is estimated within a stock assessment model. However, in many situations an empirical estimate of survey gear catchability can provide important information to scale population size during an assessment. We used a gear comparison study with a twin trawler to develop an estimate of maximum catchability of Witch Flounder on the Northeast Fisheries Science Center bottom trawl survey. On average, catch rates in the experimental chain sweep gear were about 4-fold the catch rates of the rockhopper sweep gear used on the standard survey. Both day:night differences and length-specific differences were evident in relative catch efficiencies of the two sweeps. Two separate analytical techniques (beta-binomial models & bootstrapping) provided very similar results; indicating that on a relative scale, the chain sweep was more efficient than the rockhopper sweep during daylight hours and at catching small individuals. Age-specific maximum catchability for the rockhopper survey gear was developed on the assumption of 100% efficiency of the chain sweep between the wings. An asymptote of maximum catchability for the NEFSC survey was reached at age-7 and at a value of 0.291 if survey data is entered into a stock assessment model as Bigelow swept area biomass or 0.056 if entered as Albatross swept area biomass.

INTRODUCTION

Flatfish are dorsoventrally flattened and use cryptic coloration and inactivity on the seafloor or burial in sediments as tactics to evade predators. Flatfish use vision to detect predators at short distances and typically remain within ½ a body length of the seabed when they take flight (Ryer, 2010). Following a brief period of swimming they often resettle on the substrate and may rebury. Their short reactive distance and intimate association with the seabed makes them uniquely susceptible to bottom trawling and specialized trawls have been developed to efficiently capture flatfish (Ryer and Barnett 2006, Ryer 2008, Ryer et al. 2010, Underwood et al. 2015). Flatfish are generally more susceptible to bottom trawls with sweeps that maintain contact with the seabed throughout their length. On commercial trawls, sweeps may also be extended by adding bridles between the net and doors that promote herding of flatfish from beyond net wings.

Fisheries independent bottom trawl surveys are used to assess the size and condition of marine populations, including flatfishes. In multi-species surveys, sampling gear is not optimized for any particular species, but rather is designed to provide representative samples that allow indices of abundance, size and age to be developed for many species. Unlike specialized flatfish trawls, survey trawls often utilize sweeps with discs or other modifications that allow nets to be towed across a wide variety of habitats, even seafloor habitats with complex physical structures. Survey nets may also utilize short bridles that minimize herding and decrease variability in swept area.

Indices of abundance at age and size derived from fisheries independent bottom trawl surveys are scaled to population size using the survey catchability (q) parameter. Catchability is typically estimated internally within population assessment models that incorporate fisheries landings, survey-based estimates of population trends and age structure and life history parameters. However, under many circumstances empirical estimates of survey catchability can provide important information to an assessment, either as a diagnostic of assessment model accuracy or as a direct input into the assessment model. Two sources of observation error are accounted for by the catchability parameter. These are detectability (δ), the proportion of organisms present at a sampling site detected with the sampling method (also termed gear efficiency), and availability, (ρ), the proportion of a population falling within the space-time frame of the survey:

$$q = \delta * \rho$$

Catchability is used in equations to estimate population biomass B_t at time t based on tow swept area in the following manner:

$$B_t = \frac{A}{aq} \mathrm{I}_t$$

Where I_t is the index of stratified mean biomass per sample, a is the area covered by the average sample (e.g. swept area of the tow) and A is the area covered by the survey. The following equation, with the explicit inclusion of detectability and availability, is equivalent:

$$W_t = \frac{A}{a\delta\rho} \mathrm{I}_t$$

Absolute values of detectability are difficult to estimate because accurate abundances of animals in the field are usually not available. However, maximum bounds on detectability can be established by comparing relative abundances (i.e. fish/km^2) of organisms caught in a scientific survey gear versus a gear optimized for a given target species or group of species. Because trawls used in most fishery independent surveys are not specifically designed to maximize capture of flatfish, field comparison of detectability in survey trawls and trawls specialized for the capture of flatfish with respect to sweep differences (but not bridle length) could be used to estimate maximum bounds on detectability, which can then be used to inform population assessments.

The analysis of controlled gear efficiency studies has greatly improved over the last twenty years beginning with the introduction of binomial models conditioned on the total catch of the gears being compared (Fryar, 1991, Millar, 1992). Further improvements have included the addition of smoothed non-parametric size effects through the use of GAM modelling, allowing a greater range of functional forms of this relationship (Munro and Somerton 2001; Fryer et al. 2003; Holst and Revill 2009) and accounting for within-pair extra-binomial variation through the use of beta-binomial models (Miller, 2013).

Witch flounder, *Glyptocaphalus cynoglossus L* , is a pleuronectid flatfish that ranges in the Western North Atlantic from North Carolina USA, to the Gulf of Saint Lawrence and Grand Banks, Canada and in the Eastern North Atlantic from Northern Spain to Norway. The animals mature at between 4 and 10 years of age at lengths of approximately 30 cm,. The animals prefer temperatures of ~7 ^{o}C, and are most abundant at depths ranging from 45 to 370 meters , However the animals are known to occur >1000 meters deep (see: http://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/dailyupdates/dailyupdates.html). Like most pleuronectids, witch flounder are often inactive, strongly associated with soft bottom habitats, and use burial in sediments to avoid predators.

The NOAA NMFS Northeast Fisheries Science Center bottom trawl survey is the main fisheries-independent source of information describing the abundance, age structure, and condition of witch flounder (along with ~60 other species in US waters) for population assessments. Sampling in the survey is performed using a 4-Seam trawl fitted with a rockhopper sweep made of discs that elevate the footrope ~ 16 cm above the seabed and allow the net to be towed on relatively complex seabeds (Fig. 1). This net was designed with relatively short bridles to minimize herding variability by minimizing the wing to door distance while maintaining the desired mouth opening. This appears to minimize the herding by the bridles of many benthic species including most flatfish. The NEFSC trawl survey occurs in during the Fall (September-November) and Spring (February-April) over periods of approximately 2 months (μ=56 days, 35-101 days) each year.

In this study we use a field experiment to estimate the relative detectability of witch flounder in the same net fitted with the rockhopper sweep routinely used in the NEFSC bottom trawl survey and a chain sweep optimized to capture flatfish. The experiment was performed on a commercial trawler with a twin trawl rig. Our goal was to estimate the sweep efficiency of the standard NEFSC survey trawl and develop a conservative, empirical upper bound for the detectability of witch flounder that could be used for the population assessment of witch flounder on the Northeast US Continental Shelf.

MATERIALS & METHODS

Field Experiment

The field experiment was performed on the FV Karen Elizabeth, a 24 meter twin rigged fishing trawler. The twin trawl rig allowed the vessel to tow two similar nets during each tow, allowing direct comparisons of the gear efficiency (Fig. 1-3). A number of studies have used twin trawl rigs to measure the relative efficiencies of trawls and trawl configurations, including studies focused on flatfishes (Ryer et al, 2010; Engas and Godo, 1989; Walsh, 1992; Munro and Somerton, 2002; Somerton et al., 2007; Ingolfsson & Jorgensen, 2006; Krag et al., 2010). Two 400 x 12 4-Seam trawls as used on the Northeast Fisheries Science Center (NEFSC) fishery independent bottom trawl surveys (for details, see Politis, 2014), were fished on both sides of the twin rig. The inside wings and sweeps of each net were attached by 38 m bridles to the 1134 kg central clump that was towed along the bottom (Fig. 3). The outside wings and sweep of each net were attached by a 38 meter bridles to 84" type 4 Thyborøn doors (weight = 590 kg; area = 3.39 m^2). On the second leg of the field experiment, the bridles were spray painted orange to visually determine what fraction were in consistent contact with the seabed by examining them for abrasion. This allowed us to determine if net spread was the appropriate metric for the estimation of swept area. To ensure consistent trawl geometry for each net irrespective of gear differences or depth, 32 meter restrictor ropes (9/16" Polytron) were connected between each of the doors and the clump. The spreading force of the doors, which are much larger than those used the spring and fall NEFSC trawl surveys (Poly_Ice oval - weight = 550 kg, area = 2.2 m^2), ensured that the restrictor rope remained consistently taut throughout each tow and ensured a wing spread of ~ 13 m for each net. From the attachment points and the likely orientation of the gear during towing, we believe that the restrictor ropes were ~ 1 m off the seafloor at the clump and ~ 1.5 m at the doors when in fishing configuration. A trawl monitoring system was employed to monitor wing spread using spread sensors sewn into the outer portion of the wings.

The net on one side of the twin trawl was a standard NEFSC bottom trawl fitted with the rockhopper sweep (Politis, 2014). The rockhopper sweep has 30, 40.64 cm x 2.54 cm, 6.35 cm thick discs in the center of the net (total length = 890 cm) and 27, 35.56 cm x 2.54cm, 6.35 cm thick disks in each of the wings (total length = 820 cm). The net is connected to the bolchline which is then connected to the sweep with a wire traveller. The net with the rockhopper had 66, 20cm spherical floats positioned along the headrope and upper wing end extensions (Fig. 1). The net on the other side of the twin rig was fitted with a sweep specifically designed to maximize flatfish capture. The sweep was made with 2 rows of ½ inch (1.25 cm) steel chain (6cm) connected together every other link by 1/2 inch (1.25 cm) shackles (Fig. 2). The 3rd row of ⅝ inch (1.6 cm) chain of the sweep had 5 inch outer diameter x 2 inch hole diameter (12.7 cm x 5 cm) ⅜ inch (1 cm) thick disks at every second link. Every fourth link of the ⅝ chain was attached directly to the footrope of the net with a ½ inch shackle (Fig. 2). The headrope of the net with the chain sweep had 32, 20 cm spherical floats, roughly half the number of the standard survey trawl, to limit the buoyancy of the trawl and maximize seafloor contact.

Sampling was performed on two legs from August 7 through August 21, 2016 around the clock in two areas of the Gulf of Maine where witch flounder are known to occur (Fig 4). The two areas included the northern edge of Georges Bank, and an area off Cape Ann, Massachusetts. Our goal was to perform 25 tows in which witch flounder were caught in at least one net in each tow during the day and night within each region to maximize the precision of estimates of the relative detectability of the nets with the two sweeps. Tows were made in a range of sediment types that included soft mud, sand, coarse gravel and shell hash. Standard tow speed (3 kts) and duration (20 minutes) for the NEFSC survey tows were used and tows were therefore approximately 1nm (1.852 km) long. The scope table used for the NEFSC survey was modified to allow trawl wire in 25 fathom increments, rather than the more precise increments available on the Bigelow. An area of approximately 24,076 m^2 (13m*1852m) was swept by each net during each tow. GPS data were recorded every second aboard the vessel. Temperature and depth sensors (Star Oddi, DST centi-TD) were mounted on the center of the headrope and footrope of each net during leg 2. At the approximate midpoint of sampling in each 7 day leg, the sides on which the nets with sweeps were fished on the twin trawl rig were switched.

All flatfish, skates, and scallops collected in each net in each tow were independently sorted and weighed. The lengths of all flatfish, cod, and monkfish captured in each net were measured when fewer than approximately 150 individuals were present in the catch for that species, otherwise the catch were randomly sub-sampled for length.

Estimates of sweep efficiency by length and day/night were derived via two different methods:

1) The data were fitted under differing assumptions about the mean relative catch efficiency using either the binomial or beta-binomial distribution to model variation both within and between pairs by fish length. The relative performance of the models was compared using Akaike's information criterion (AIC; Akaike 1973).

2) Mean catch ratios with bootstrapped confidence intervals were calculated and a maximum estimate of catchability was derived.

Binomial/Beta-binomial data analysis

The objective of this analysis was to derive a model-based estimate of sweep efficiency for all lengths of fish captured in the experiment. The start of each tow was defined as the winch lock time and the end of the tow was defined as the haul back time. Mean net spread for each tow was estimated from the net mensuration data. For tows where net spread information was not available, net spread was estimated via a generalized additive model (GAM) using depth, mean vessel speed and sweep type as predictor variables. The distance fished was estimated by first smoothing the gps data with a cubic spline smoother and summing the distances between the smoothed points. The area swept for each tow was calculated as the mean net spread*distance fished. A catch per unit effort (CPUE in numbers) by length was then calculated for each tow.

All of the CPUE length data were then fit following the methods of Miller (2013). A total of 5 conditional binomial (Table 4) and 8 conditional beta-binomial models (Table 5) were fit to the data. The relative performance of all model fits was compared using marginal AIC. The best performing model was selected as the candidate for further analysis. The CPUE length data were then designated as either day or night using the time of the mid-point of the tow for both location and time information as calculated from the AstroCalc4R package (Jacobsen et al, 2011). A similar analysis as described above was performed on each of these subsets of the data and the best performing model chosen.

Development of a maximum estimate of catchability

The objective of this analysis was to develop a maximum estimate of catchability that could be input into the stock assessment model or alternatively could be used to develop a minimum estimate of spawning stock biomass in future analyses. Since the comparative experiment occurred in August which has oceanographic conditions much more similar to the fall versus spring bottom trawl survey, we focused our analyses on obtaining a catchability parameter that could be applied to the NEFSC fall trawl survey. Furthermore, we focused on developing maximum estimates of catchability by age-class, as the assessment models use abundance-at-age data from the surveys rather than abundance-at-length data.

The first step of the analysis involved calculating length-specific (1 cm interval) catch ratios of the chain sweep relative to the rockhopper sweep from the comparative gear experiment. These analyses were done separately for daytime and nighttime tows, with the "suncycle" function in Matlab used to designate tows as daytime or nighttime. We used bootstrapping to develop confidence intervals around these estimates. Paired nets were maintained with the bootstrapping and median ratios and 95% confidence intervals are presented.

Most flatfish exhibit significant night:day catch ratios in the NEFSC trawl survey that will dictate how the comparative gear experiment is analyzed. For example, windowpane is a species for which the night:day ratio on the survey often exceeds the daytime experimental gear:survey gear ratio. In this case the detectability of the daytime experimental tows does not exceed that of the nighttime survey tows. For a species such as windowpane the comparative gear experiment should thus focus on establishing the maximum detectability of the nighttime survey tows (assuming the nighttime comparative gear tows are 100% efficient) and should use the survey data to estimate the relative detectability of the daytime survey tows relative to the nighttime survey tows.

For witch flounder on the NEFSC trawl survey the night:day catch ratio is lower than many flatfish (≈1.4 Night:Day 2009-2014 Fall; 30 cm+ fish) and is similar to the chain sweep: rockhopper sweep efficiency difference between the daytime and nighttime (1.5). We thus assumed that the daytime and nighttime tows with the chain sweep were both equally 100% efficient. The maximum efficiency of the 24-hour survey tows is thus a weighted average of the nighttime efficiency differences of the chain to rockhopper sweep and the daytime efficiency differences of the chain to rockhopper sweep. The average number of daytime and nighttime tows on the fall trawl survey in the strata used for the witch flounder serves as weighting factors.

To obtain estimates of age-specific maximum catchability of the survey on the R/V Bigelow the relative abundance at length of each age-class on the NEFSC fall trawl survey was combined with the length-specific maximum catchability estimates. For the 2009-2015 fall trawl survey on the R/V Bigelow, the stratified mean number per tow at length (strata: 22-30 & 36-40) was first calculated for each year. An age-length key was developed for each year and was applied to the stratified mean number at length to estimate the length-distribution for each age class. To obtain the maximum catchability at age the relative proportion at length for each age class and year was multiplied by the maximum catchability at length for each of the 1000 bootstrap runs of the comparative trawl survey analysis. These products were then summed. The median and 95% confidence intervals of these 1000 bootstrap runs across 7 years are reported as are the annual values.

RESULTS

We successfully completed 118 twin trawl tows of both trawls from August 7 – 21, 2016 (total number of tows = 125). Fifty eight successful tows were made on the west side of Georges Bank during the first leg of the cruise (Aug 7-14; Fig. 4). Three successful tows were also made just east of Cape Cod during this leg. During the second leg of the cruise (Aug 14-21), 57 successful tows were made in the area east of Cape Anne, Massachusetts. Depths of the tows ranged from 40-152 meters.

Spread data indicated that both nets maintained very close to the desired 13 m wing spread on all successful tows. This observation confirmed that the two trawls were maintaining consistent geometry regardless of depth or differential pressure exerted on the trawls due to differences in either sweep or floatation. The chain sweep was much more susceptible to hanging as anticipated, and all but one of the tows with unacceptable performance were due to problems with the chain sweep trawl capturing bottom substrate (rocks, mud etc.).

Witch flounder were the most common and abundant of the 17 species quantitatively sampled during the experiment. They accounted for over 36% of the total measured biomass and were present at all of the sites where tows were performed. American plaice, goosefish, and several skate species were also relatively common). Biomass collected in the chain sweep was higher than the rockhopper sweep for all species occurring in more than 3 tows.

A total of 53,495 witch flounder were caught during the 118 representative tows of the twin trawl, with 43,789 caught in the net with the experimental chain sweep and 10,706 caught in the net with the rockhopper sweep used during the standard NEFSC trawl survey (Table 1). These catch ratios were similar between the leg of the survey that sampled Georges Bank and the leg of the survey that sampled the western Gulf of Maine. Notable length-specific differences were evident in the relative catch rates of the two sweeps during both the day and night (Table 3, Figs. 6-10). The ratio of chain sweep to rockhopper sweep catches were highest for the smallest length classes during both the daytime and nighttime.

Binomial/beta-binomial analysis results

The best fitting model for all data combined is presented in Figure 7. The best fitting model for this data set was beta-binomial model BB3 (Table 4-5). This models also provided the best fit for nighttime tows (Figure 8), while daytime tows were best fit with model BB7 (Figure 8). The results from the binomial/ beta-binomial analysis showed an overall sweep efficiency of .231 for witch flounder for the standard NEFSC rockhopper gear, assuming the chain sweep was 100% efficient. The daytime efficiency estimate was .193, while the nighttime ratio estimate was .271, indicating a catch ratio of ~1.4:1 between day and night catches.

Bootstrapping analysis results

During the Fall, the NEFSC trawl survey on the R/V Bigelow catches on average 1.4 fold the number of witch flounder (30 cm+) during nighttime tows versus during daytime tows. For similarly sized fish the chain sweep was 4.80-fold more efficient than the rockhopper during the daytime and 3.12-fold more efficient than the rockhopper during the nighttime, a difference of 1.53-fold. This implies that the chain sweep had a similar efficiency during both nighttime and daytime. We thus proceeded with an analysis that assumed the chain sweep was 100% efficient during both nighttime and daytime tows. During the fall bottom trawl survey, the Gulf of Maine (strata 22-30 and 36-40) is typically sampled after the fall equinox when there are more nighttime hours than daytime hours. Since the start of the Bigelow time series, ≈43% of tows have been during the day and 57% at night in the Gulf of Maine strata. We used these two values as weighting factors in calculating an aggregate 24-hour estimate of the maximum catchability of the rockhopper gear used during the NEFSC trawl survey; this procedure had the effect of downweighting the higher catch ratio daytime tows.

The maximum catchability of the rockhopper gear increased with age from Age 3 to Age 7 (Table 6 and Figure 11). The maximum catchability was nearly constant for Age 7 to Age 11+ fish. For Age-7 fish the maximum catchability of the rockhopper gear used on the Bigelow was 0.291 with 95% confidence intervals of 0.264-0.321. The calibration of Albatross to Bigelow is 3.257 across all age classes for the number of fish per tow. An Albatross tow sampled 1.6 fold the area of a Bigelow tow (0.038 km^2 versus 0.024 km^2), and thus the Rockhopper net used on the Bigelow survey is estimated to be 5.2-fold as efficient as the net used on the Albatross survey. For Age-7 fish the maximum catchability of the Albatross gear was 0.056 with 95% confidence intervals of 0.051-0.062. All other age classes had lower maximum catchabilities. This maximum catchability value of Age-7 fish not differ much on an interannual basis using annual age-length keys and stratified mean numbers at length.

DISCUSSION

With some notable exceptions (e.g. acoustic surveys, camera surveys of scallops, egg surveys), the primary goal of research surveys is to provide an index of abundance rather than an absolute estimate of abundance. One function of a stock assessment model is to integrate a diverse set of data to determine the scale of the population. However, a variety of factors can make for imprecise scaling of population levels including inaccurate catch data, low fishing mortality rates over the time series, uncertain and time-varying natural mortality, and time-varying catchability on the research survey leading to biased estimates of trend. In these cases, external information can serve a role in population scaling, even if only to establish minimum estimates on stock biomass.

The purpose of this analysis was to establish a maximum bound on catchability of the NEFSC fall trawl survey and data which could be used to obtain a minimum bound on the estimate of spawning stock biomass. We report values of catchability in both Bigelow units and Albatross units. The standard for most NEFSC stock assessments has been to convert the Bigelow trawl survey data to the equivalent values for the Albatross trawl survey. Assuming swept area biomass estimates are the input to the stock assessment, the catchability numbers output by the assessment models are for a tow with the net used on the Albatross survey. For witch flounder, a constant calibration factor across length classes of 3.257 is used to convert the N tow^{-1} of fish on the Bigelow survey to the equivalent for the Albatross survey. Importantly, a Bigelow tow, in addition to catching more witch flounder per tow, is also sampling a smaller area than an Albatross tow (0.024 km^2 vs 0.038 km^2), a factor that needs to be considered in analyses of catchability. The Albatross maximum catchabilities are thus a factor of 5.2 (3.257*(0.038/0.024)) less than the Bigelow maximum catchabilities. Similarly catchabilities output by the stock assessment model with Albatross swept areas as the input need to be multiplied by 5.2 to obtain the estimated Bigelow survey catchability. If the calibration factors were to be changed in future work (e.g. length specific catchabilities), these changes would need to be accounted for in these analyses of maximum Albatross catchability.

The primary data used in this analysis came from an experiment using a twin trawler and many of the standard tow protocols for the NEFSC survey on the R/V Bigelow. The experimental net used on the other side of twin trawler was similar to the standard bottom trawl survey trawl used on the R/V Bigelow but with roughly half number of floats was reduced and the sweep was modified to optimize flatfish catch by reducing the ability of individuals to pass under the net. As has been shown for past experiments, these modifications resulted in an increased catch rate of flatfish in general. All analyses of this data were based on the assumption that modifying the sweep resulted in the experimental net being 100% efficient (i.e., every fish encountered between the wings of the net is caught), an assumption which is almost certainly incorrect based on previous observations of escapement for a number of flatfish species.

The decision on what value of catchability to input into a stock assessment model depends on the selectivity pattern for the associated survey. The maximum catchability calculated based on the experimental tows increased with age until reaching an asymptote at 0.291 in Bigelow units (0.056 in Albatross units) at Age-7. The Age-7 maximum catchability is recommended as an input to the assessment model. Age-7 maximum catchability is also the highest value for any age class, and thus its use is conservative. A q of 0.291 corresponds to the chain sweep being estimated to be 3.43-fold more efficient than the rockhopper. This value is lower than the catch ratio of 3.99 across all tows on the twin trawl experiment. There are two reasons for this. First, the experimental survey sampled more tows during the day when catch ratios are higher, whereas the analyses used a weighting factor based on the fall survey which samples more nighttime tows in the Gulf of Maine. Second, the aggregate catch ratio includes smaller fish that, on a relative basis, were sampled more effectively by the chain sweep, whereas the recommended q-value is for larger fish more likely to correspond to the asymptotic selectivity of the NEFSC trawl survey.

The analyses presented here assume that bridle herding did not occur, and thus that wing swept area, rather than the door swept area, is the appropriate measure of the area swept by a tow. Herding is a known phenomena for flatfish and many other species when certain types of gear are used (Ramm and Xiao 1995, Somerton and Munro 2001, Somerton et al. 2007, Rose et al. 2009). Our decision to use wing swept area was based on two factors. First, the gear used on the Bigelow survey was specifically designed to minimize herding. On the experimental work, the bridles used during the tows were painted to evaluate whether they were making contact with the bottom and thus were potentially herding flatfish; abrasion from bottom contact would result in the paint wearing off. The paint was not observed to wear off during the tows consistent with the design of the gear and previous work. The second factor underlying our decision to use wing swept area was that published behavioral studies in both the field and lab have indicated reduced and minimal herding of flatfish during nighttime tows (Ryer 2008, Ryer et al. 2010). Most published examples of herding are from daytime studies (Somerton et al 2007, Underwood et al 2015). Use of wing swept area for nighttime tows is consistent with those results. The reason for minimal herding at night is the tendency of fish to rise off the bottom in low light levels rather than engage in directional swimming near to the seafloor as they do during herding at higher light levels (Main and Sangster, 1981; Walsh, 1988, 1991; Walsh and Hickey, 1993; Casey and Myers, 1998; Cadrin and Westbrook, 2004; Ryer and Barnett 2006). This differential behavior is likely to underlie the higher catch rates in survey gear of many flatfish during the night.

The towing of the standard survey bottom trawl differed in a few ways from its deployment on the spring and fall bottom trawl surveys, but we believe that these differences did not have a significant effect on the results. The use of larger doors and the restrictor rope served to fix the net geometry which is likely the biggest potential source of variability in comparative trawl catches. This setup also allowed us to avoid many of the potential problems due to the rather large size difference of the Bigelow and the Karen Elizabeth. The use of the restrictor rope is not believed to have influenced flatfish behavior in front of the trawl as flatfish have been shown to generally not react to trawling induced stimuli until they are in in very close proximity or even contacted by the fishing gear (Ryer et al, 2010). The spread data indicated that the restrictor rope remained taut throughout the towing process (setting, towing, hauling back), so we believe it likely that the restrictor rope was almost always at least 1 m off the bottom at all times. All information indicates that bridle herding was very minimal for flatfish, and therefore the possibility of an increase in herding due to an increase in mud clouds from the use of larger doors was likely a non-factor in the catches that we observed. Similarly, the use of the clump instead of a door was likely not a factor for similar reasons. The use of a modified scope table was likely a very small difference as the amount of wire out never differed (+/-) by more than 13 fm from what the Bigelow scope table prescribes.

A concern raised in previous work is that the results of gear comparison experiments, which are often logistically constrained to certain seafloor types or time of year, may not be broadly applicable to other regions or seasons. We assumed 100% efficiency of the chain sweep in the analyses with the goal of obtaining a maximum efficiency. A catch ratio higher than what we observed in another area would suggest even lower rockhopper catchabilities in that area. In this case the maximum efficiency would be an overestimate. Similarly, if the catch ratios were lower in another unsampled area but the catchabilities of the rockhopper survey gear were assumed to be constant across space, the results would also be valid. Where this caveat is relevant is if the catchabilities of the survey rockhopper gear vary spatially- temporally, and the gear comparison experiment occurred in a low catchability area or time of year for the rockhopper sweep, that is not an equally (on a relative scale) low catchability area for the chain sweep. Empirical data on spatially varying survey catchabilities of the rockhopper sweep is not available. Over the course of the experiment, the gear were towed on a variety of habitats including mud, cobble, shell hash and sand. Additionally, the two study areas in the western Gulf of Maine and northern edge of Georges Bank had similar catch ratios for both the daytime and nighttime tows (Table 2). The study was obviously constrained in the time of year in which the work was conducted and temperature has been shown to play a role in catchability for other fish species (Winger et al., 1999; Swain et al., 2000). There is also some evidence that catchability may also be related to density in some species (Godo et al, 1999). We were able to sample in a variety of flatfish densities and the catch ratios remained remarkably consistent so we see no evidence of this behavior in the current study.

The two analyses that were performed differed in several substantial ways from the treatment of the raw data (area-swept estimated vs. raw catches), the analytical methods utilized, and the methodology to derive final results. The fact that the two independent analyses found very similar results (Fig. 10) increases the probability that the results presented here are robust.

References

Akaike, H. 1973. Information theory and the maximum likelihood principle. In 2nd International Symposium on Information Theory. Edited by B.N. Petrov and F. Csaki. Akademiai Kiado, Budapest. pp. 267–281.

Burnett, J., Ross, M.R., Clark, S.H. 1992. Several Biological Aspects of the Witch Flounder (*Glyptocephalus cynoglossus* (L.)) in the Gulf of Maine-Georges Bank Region. Journal of Northwest Atlantic Fisheries Science. 12: 15-25.

Cadrin, S.X. and A.D. Westwood. 2004. The use of electronic tags to study fish movement: a case study with yellowtail flounder off New England. ICES CM 2004/K:81, 34 pp.

Casey, J. M., and R. A. Myers. 1998. Diel variation in trawl catchability: is it as clear as day and night? Can. J. Fish. Aquat. Sci. 55:2329–2340.

Engas, A. and O.R. Godo.1989.The effect of different sweep lengths on the length composition of bottom-sampling trawl catches. J. Cons. Int. Explor. Mer, 45:263-268.

Fryer, R.J. 1991. A model of between-haul variation in selectivity. ICES J. Mar. Sci. 48(3): 281–290.

Fryer, R.J., Zuur, A.F., and Graham, N. 2003. Using mixed models to combine smooth size-selection and catch-comparison curves over hauls. Can. J. Fish. Aquat. Sci. 60(4): 448–459.

O. R. Godø, S. J. Walsh, and A. Engas 1999. Investigating density-dependent catchability in bottom-trawl surveys ICES Journal of Marine Science, 56: 292–298.

Holst, R., and Revill, A. 2009. A simple statistical method for catch comparison studies. Fish. Res. 95(2–3): 254–259.

Ingolfsson O. and T. Joergensen. 2006. Escapement of gadoid fish beneath a commercial bottom trawl: Relevance to the overall trawl selectivity. Fish. Res. 79:303-312.

Jacobsen, L., A. Seaver, and J. Tang. 2011. AstroCalc4R: Software to Calculate Solar Zenith Angle; Time at sunrise, Local Noon, and Sunset; and Photosynthetically Available Radiation Based on Date, Time, and Location. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 11-14; 10 p.

Krag, L.A., Holst,R., Madsen, N., Hansen, K., and Frandsen, R.P. 2010. Selective haddock (Melanogrammus aeglefinus) trawling—avoiding cod (Gadus morhua) bycatch. Fish. Res. 101:20–26

Main, J., and Sangster, G. I. 1981. A study of the fish capture process in a bottom trawl by direct observations from a towed underwater vehicle. Scottish Fisheries Research Report No. 23. 23 pp.

Politis, P.J., Galbraith, J.K., Kostovick,P. Brown, R.W.. 2014. Northeast Fisheries Science Center bottom trawl survey protocols for the NOAA Ship Henry B. Bigelow. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 14-06; 138 p.

Millar, R.B. 1992. Estimating the size-selectivity of fishing gear by conditioning on the total catch. J. Am. Stat. Assoc. 87(420): 962–968.

Miller, T. J. 2013. A comparison of hierarchical models for relative catch efficiency based on paired-gear data for US Northwest Atlantic fish stocks. Can. J Fish Aq. Sci. 70: 1306–1316.

Munro, P.T., and Somerton, D.A. 2001. Maximum likelihood and non-parametric methods for estimating trawl footrope selectivity. ICES J. Mar. Sci. 58(1):220–229.

Munro, P.T. and D.A. Somerton. 2002. Estimating net efficiency of a survey trawl for flatfishes. Fish. Res. 55:267-279.

Ramm, D. C. and Xiao, Y. 1995. Herding in groundfish and effective pathwidth of trawls. Fish. Res. 24:243-259.
Rose, C.S., Gauvin, J.R. and Hammond, C.W. 2009. Effective herding of flatfish by cables with minimum seafloor contact. Fishery Bulletin. 108: 136-144.
Ryer, C. H. and Barnett L.A.K, 2006. Influence of illumination and temperature upon flatfish reactivity and herding behavior: Potential implications for trawl capture efficiency. Fisheries Research. 81:242-250.
Ryer, C. H. 2008. A review of flatfish behavior relative to trawls. Fish. Res. 90:138-146.
Ryer, C. H., Rose, C. S., and Iseri, P. J. 2010. Flatfish herding behavior in response to trawl sweeps: a comparison of diel responses to conventional sweeps and elevated sweeps. Fish. Bull. (Seattle) 108:145-154.
Somerton, D. A. and Munro, P. 2001. Bridle efficiency of a survey trawl for flatfish. Fish. Bull. (Seattle) 99:641-652.
Swain, D. P., Poirier, G. A., and Sinclair, A. F. 2000. Effect of water temperature on catchability of Atlantic cod (Gadus morhua) to the bottom-trawl survey in the southern Gulf of St Lawrence. – ICES Journal of Marine Science, 57: 56–68.
Somerton, D. A., Munro, P. T., and Weinberg, K. L. 2007. Whole-gear efficiency of a benthic survey trawl for flatfish. Fish. Bull. 105:278-291.
Underwood, M.J., Winger, P.D., Ferno, A. and Engas, A. 2015. Behavior-dependent selectivity of yellowtail flounder (*Limanda ferruginea*) in the mouth of a commercial bottom trawl. Fishery Bulletin 113: 430-441.
Walsh, S. J. 1988. Diel variability in trawl catches of juvenile and adult yellowtail flounder on the Grand Banks and the effects on resource assessment. North American Journal of Fisheries Management 8: 373-381.
Walsh, S. J. 1991. Diel variation in availability and vulnerability of fish to a survey trawl. Journal of Applied Ichthyology, 7: 147–159.
Walsh, S.J. 1992. Size-Dependent selection at the footgear of a groundfish survey trawl. N. Amer. J. Fish. Man. 12:625-633.
Walsh, S. J., and Hickey, W. M. 1993. Behavioural reactions of demersal fish to bottom trawls at various light conditions. ICES Marine Science Symposium, 196: 68–76.
Winger, P. D., He, P., and Walsh, S. J. 1999. Swimming endurance of American plaice (Hippoglossoides platessoides) and its role in fish capture. ICES Journal of Marine Science, 56:252-265

Table 1: Summary data on Witch Flounder (*Glyptocephalus cynoglossus*) catches from the twin trawl experiment aboard the F/V Karen Elizabeth in August of 2016.

	Tows	Rockhopper Sweep Total N	Chain Sweep Total N	Total Catch
Night	43	5,893	19,152	**25,045**
Day	74	4,813	23,637	**28,450**
Total	**117**	**10,706**	**42,789**	**53,495**

Table2 : Total catch numbers and chain sweep to rockhopper catch ratios for tows made during the daytime and at night for each of the two legs of the survey

	Day		Night	
	Leg 1 Georges Bank	Leg 2 WGOM	Leg 1 Georges Bank	Leg 2 WGOM
Chain	9,035	14,592	9,013	10,149
Rockhopper	1,747	3,070	2,653	3,236
Ratio	5.17	4.75	3.40	3.14

Table 3: Summary data on Witch Flounder (*Glyptocephalus cynoglossus*) catches at length from the twin trawl experiment aboard the F/V Karen Elizabeth in August of 2016.

	Night		Day		Total	
Length	Chain Sweep	Rockhopper Sweep	Chain Sweep	Rockhopper Sweep	Chain Sweep	Rockhopper Sweep
<25	254	37	264	33	518	70
25	95	15	129	23	224	38
26	188	47	200	39	388	86
27	539	138	542	84	1081	222
28	759	203	859	172	1618	375
29	1229	291	1223	213	2452	504
30	1428	422	1630	294	3058	716
31	1666	521	1958	363	3624	884
32	1867	500	2073	381	3940	881
33	1604	470	2053	364	3657	834
34	1795	527	2059	417	3854	944
35	1376	473	1673	321	3049	794
36	1434	475	1722	408	3156	883
37	953	277	1119	265	2072	542
38	980	348	1259	300	2239	648
39	667	244	787	236	1454	480
40	697	235	971	238	1668	473
41	370	146	698	155	1068	301
42	303	134	568	119	871	253
43	266	119	526	120	792	239
44	179	86	380	68	559	154
45	147	61	319	57	466	118
46	128	32	213	51	341	83
47	77	24	160	26	237	50
48	54	23	100	28	154	51
49	27	12	74	15	101	27
50	19	10	29	9	48	19
>50	51	23	49	14	100	37

Table 4. Description of relative catch efficiency (ρ)parameterizations for conditional binomial models
fit to data (From Miller 2103)

Model	log(ρ)	Across-pair effects	Pair-specific random effects
BI_0	β_0	Intercept	None
BI_1	$\beta_0 + \delta_{0,j}$	Intercept	Intercept
BI_2	$\mathbf{X}_f^T\boldsymbol{\beta} + \mathbf{X}_r^T\boldsymbol{b}$	Intercept and cubic spline smoother of size	None
BI_3	$\mathbf{X}_f^T\boldsymbol{\beta} + \mathbf{X}_r^T\boldsymbol{b} + \delta_{0,j}$	Intercept and cubic spline smoother of size	Intercept
BI_4	$\mathbf{X}_f^T(\boldsymbol{\beta}_f + \boldsymbol{\delta}_j) + \mathbf{X}_r^T(\boldsymbol{b} + \boldsymbol{\epsilon}_j)$	Intercept and cubic spline smoother of size	Intercept and cubic spline smoother of size

Table 5. Description of relative catch efficiency (ρ)and dispersion (ϕ) parameterizations for conditional beta-binomial models fit to data (From Miller 2103)

Model	log(ρ)	log(ϕ)	Across-pair effects	Pair-specific random effects
BB_0	β_0	γ_0	Intercepts for mean and dispersion	None
BB_1	$\beta_0 + \delta_{0,j}$	γ_0	Intercepts for mean and dispersion	Intercept for mean
BB_2	$\mathbf{X}_f^T\boldsymbol{\beta} + \mathbf{X}_r^T\boldsymbol{b}$	γ_0	Mean and dispersion intercepts and cubic-spline smoother of size for mean	None
BB_3	$\mathbf{X}_f^T\boldsymbol{\beta} + \mathbf{X}_r^T\boldsymbol{b}$	$\mathbf{X}_f^T\gamma + \mathbf{X}_r^T\mathbf{g}$	Intercepts and cubic-spline smoothers of size for mean and dispersion	None
BB_4	$\mathbf{X}_f^T\boldsymbol{\beta} + \mathbf{X}_r^T\boldsymbol{b} + \delta_{0,j}$	γ_0	Mean and dispersion intercepts and cubic-spline smoother of size for mean	Intercept for mean
BB_5	$\mathbf{X}_f^T\boldsymbol{\beta} + \mathbf{X}_r^T\boldsymbol{b} + \delta_{0,j}$	$\mathbf{X}_f^T\gamma + \mathbf{X}_r^T\mathbf{g}$	Intercepts and cubic-spline smoothers of size for mean and dispersion	Intercept for mean
BB_6	$\mathbf{X}_f^T(\boldsymbol{\beta}_f + \boldsymbol{\delta}_j) + \mathbf{X}_r^T(\boldsymbol{b} + \boldsymbol{\epsilon}_j)$	γ_0	Mean and dispersion intercepts and cubic-spline smoother of size for mean	Intercept and cubic spline smoother for mean
BB_7	$\mathbf{X}_f^T(\boldsymbol{\beta}_f + \boldsymbol{\delta}_j) + \mathbf{X}_r^T(\boldsymbol{b} + \boldsymbol{\epsilon}_j)$	$\mathbf{X}_f^T\gamma + \mathbf{X}_r^T\mathbf{g}$	Intercepts and cubic-spline smoothers of size for mean and dispersion	Intercept and cubic spline smoother for mean

Table 6: Age specific maximum catchabilities (q) for the R/V Bigelow survey using the Rockhopper sweep based on the results of the twin trawl experiment. Medians and 95% confidence intervals are presented. R/V Albatross catchabilities are scaled to R/V Bigelow catchabilities using the constant calibration factor across lengths of 3.257 for N fish tow^{-1} and the difference in swept area between the two survey tows (1.6; 0.024 km^2 for the Bigelow and 0.038 km^2 for the Albatross). Age 7 is bolded as it corresponds to the highest maximum q of any age group and may make a suitable input for constraining the assessment model

	Bigelow	Albatross
Age 3	0.170 (0.118-0.228)	0.033 (0.023-0.044)
Age 4	0.235 (0.207-0.264)	0.045 (0.040-0.051)
Age 5	0.252 (0.226-0.281)	0.048 (0.043-0.054)
Age 6	0.281 (0.255-0.312)	0.054 (0.049-0.060)
Age 7	0.291 (0.264-0.321)	0.056 (0.051-0.062)
Age 8	0.273 (0.233-0.311)	0.052 (0.045-0.060)
Age 9	0.255 (0.199-0.305)	0.049 (0.038-0.059)
Age 10	0.251 (0.192-0.309)	0.048 (0.037-0.059)
Age 11+	0.287 (0.149-0.499)	0.055 (0.029-0.096)

Figure 1. Schematic Drawing of the center section of the rockhopper sweep used on the standard NEFSC bottom trawl

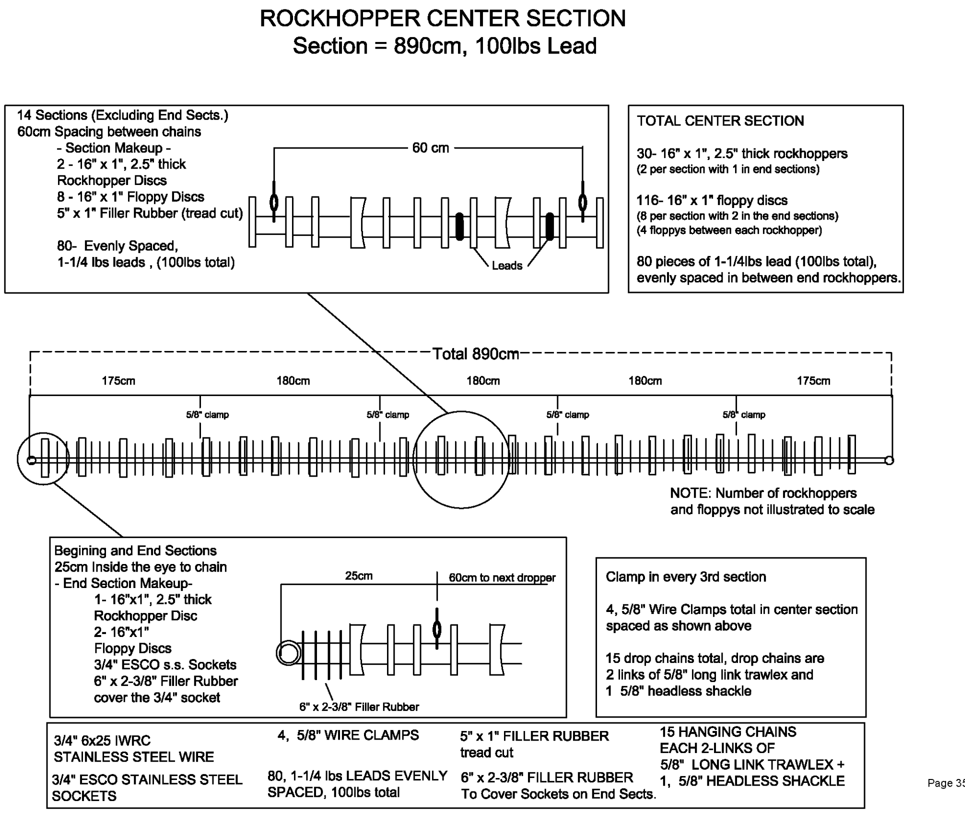


Figure 2. Schematic drawing of the chain sweep used on the experimental net

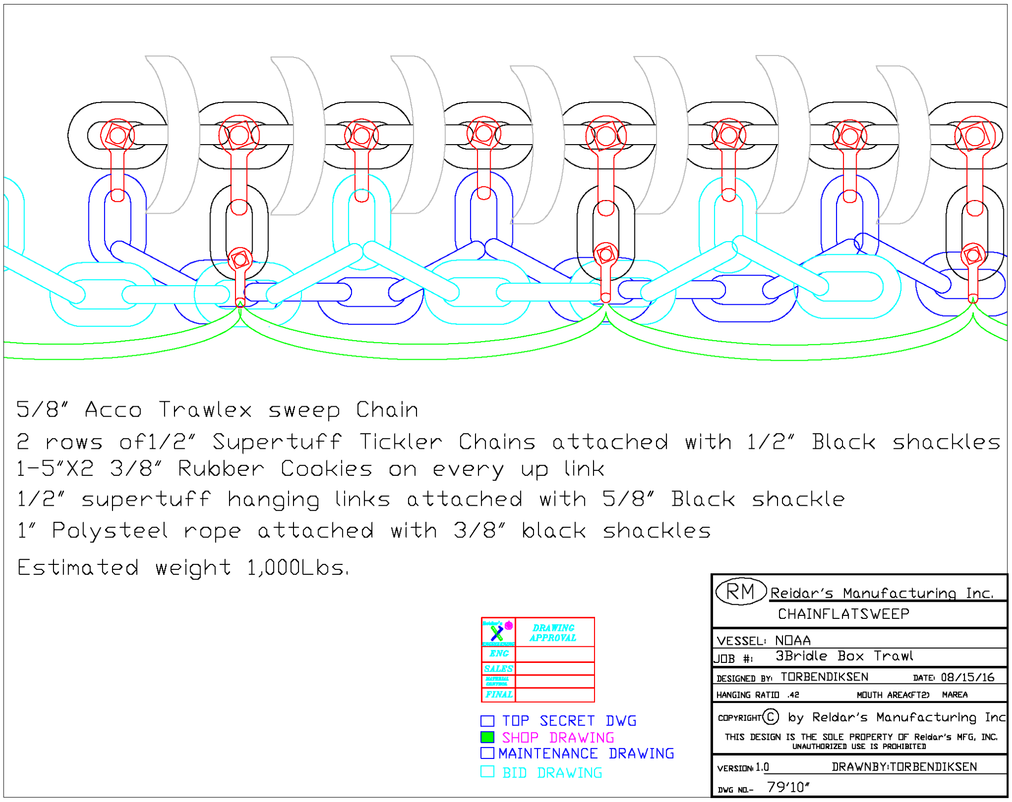
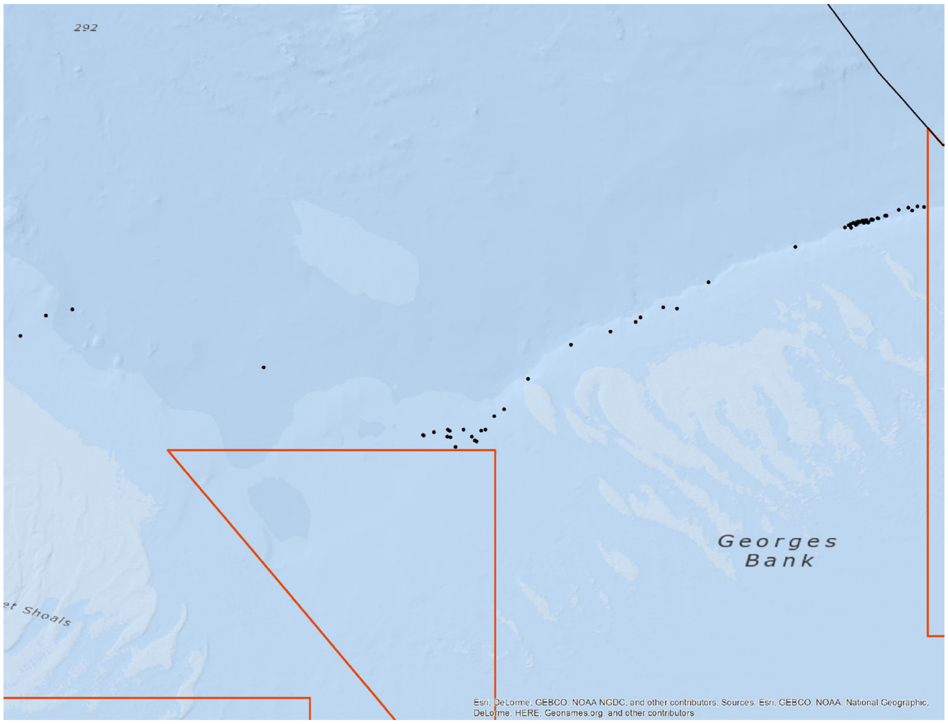


Figure 3. Photo of the rockhopper sweep (left), chain sweep (right) and the clump (center) during the twin trawl experiment.

Figure 4. Tow locations during Leg 1 and Leg 2 of the sweep efficiency study



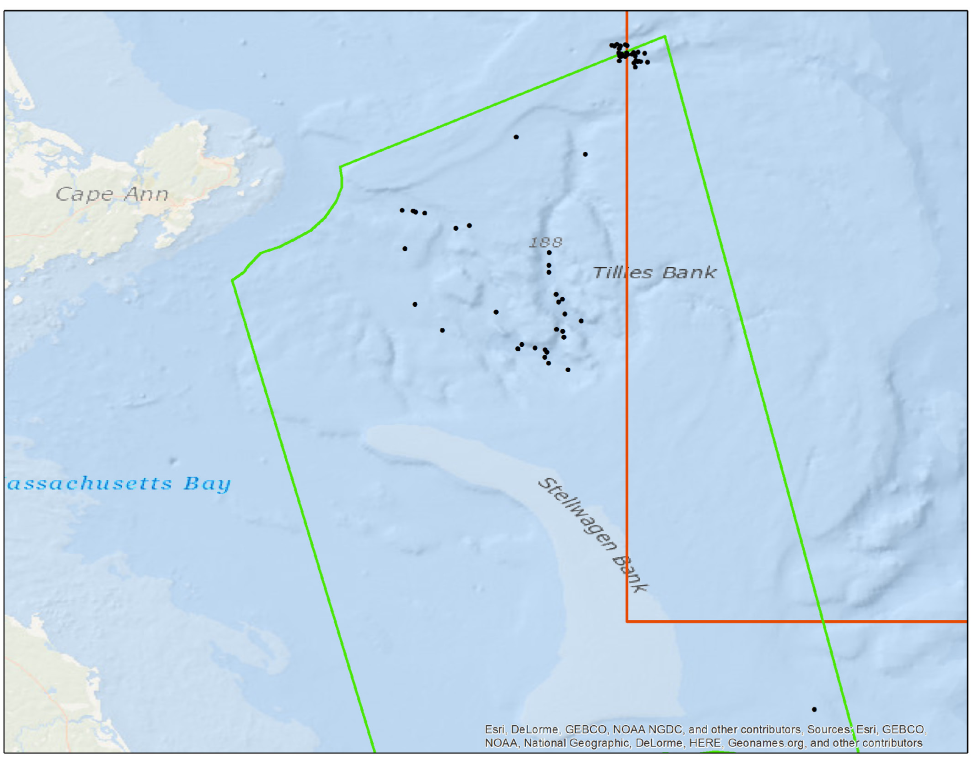


Figure 5. The proportion of all witch flounder captured with the chain sweep for each tow. Red points indicate day tows, while black points indicate night tows.

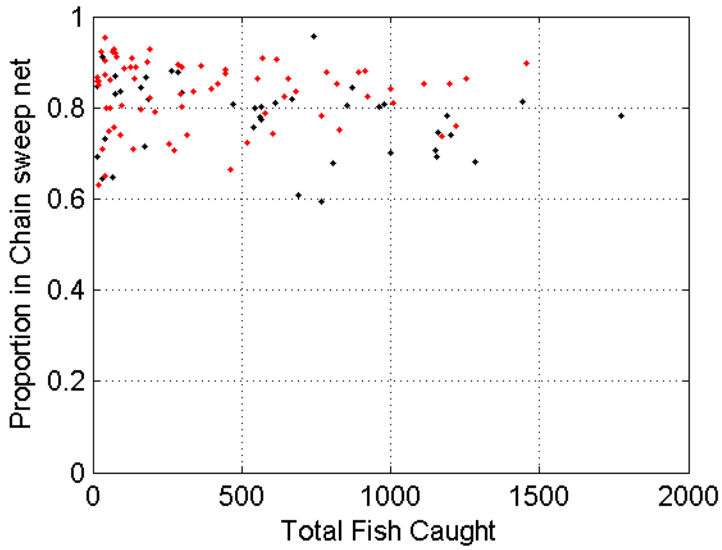


Figure 6. Estimated raw length data expressed as proportion of total witch flounder caught.

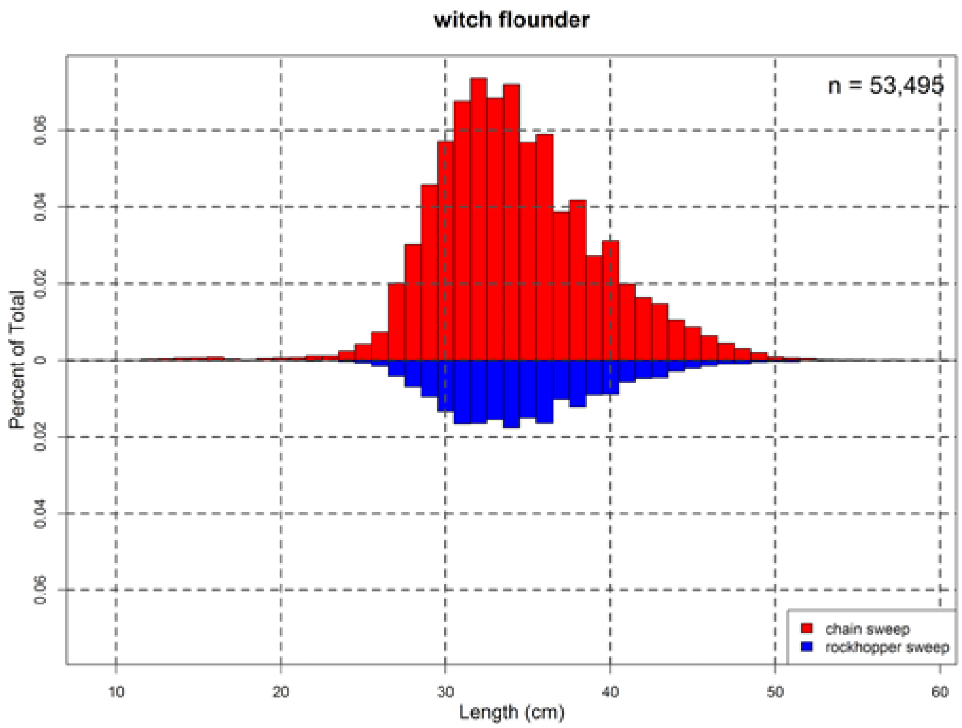


Figure 7. Best model fit for binomial/beta-binomial data analysis using all length CPUE data. The blue area represents 95% confidence intervals

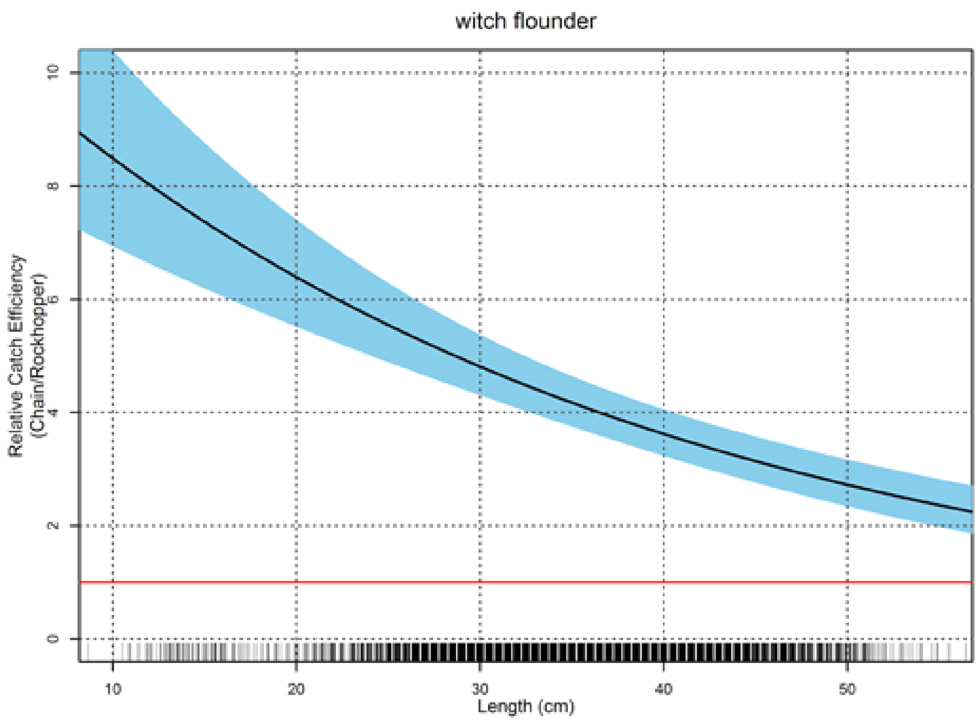


Figure 8. Best model fit for binomial/beta-binomial data analysis using night (top) and day (bottom) length CPUE data only. The blue area represents 95% confidence intervals.

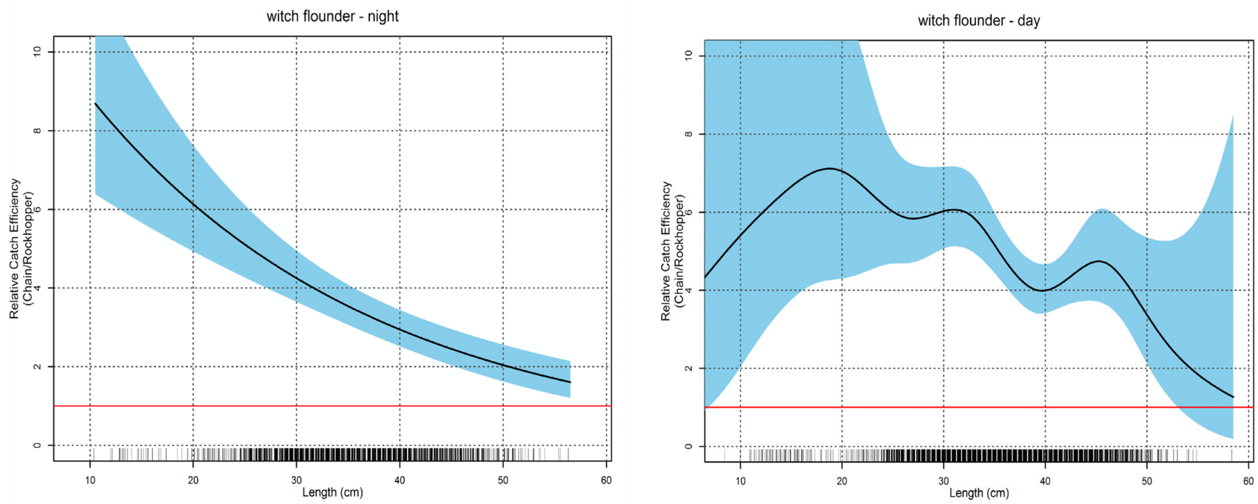


Figure 9: Ratio of chain sweep to rockhopper sweep catches by centimeter length bin during daytime and nighttime tows. Median and 95% confidence intervals of 1000 bootstraps are presented.

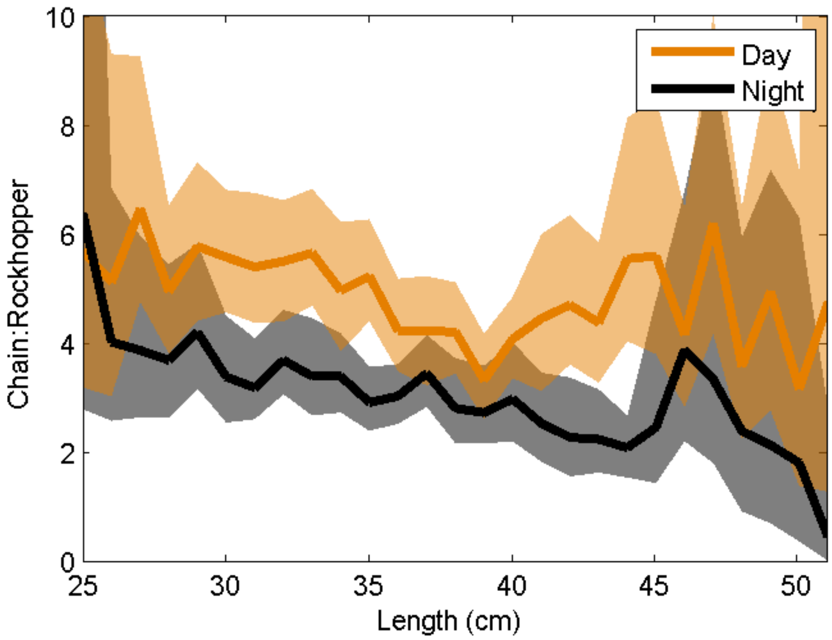


Figure 10: Comparison of the two analytical techniques used to estimate relative gear efficiency by length for both daytime and nighttime tows. See Figures 8 and 9 for details.

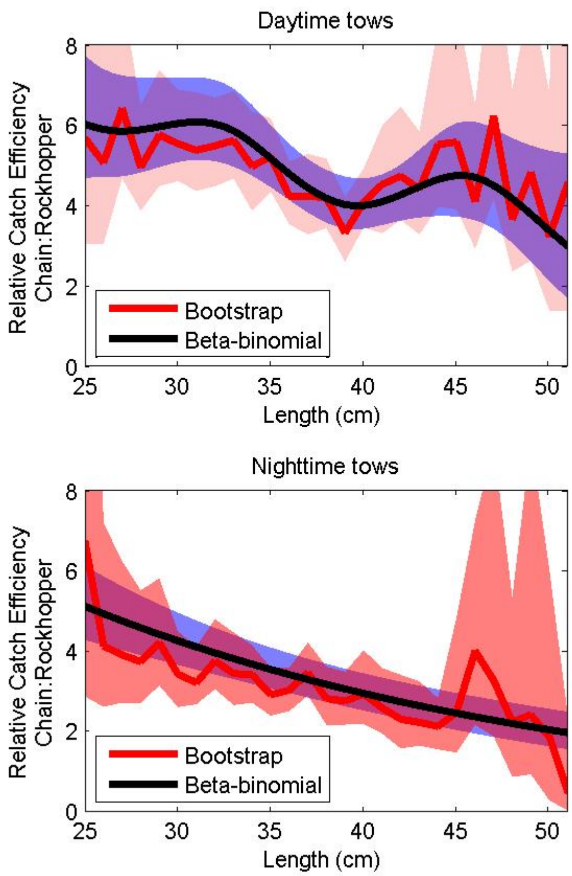
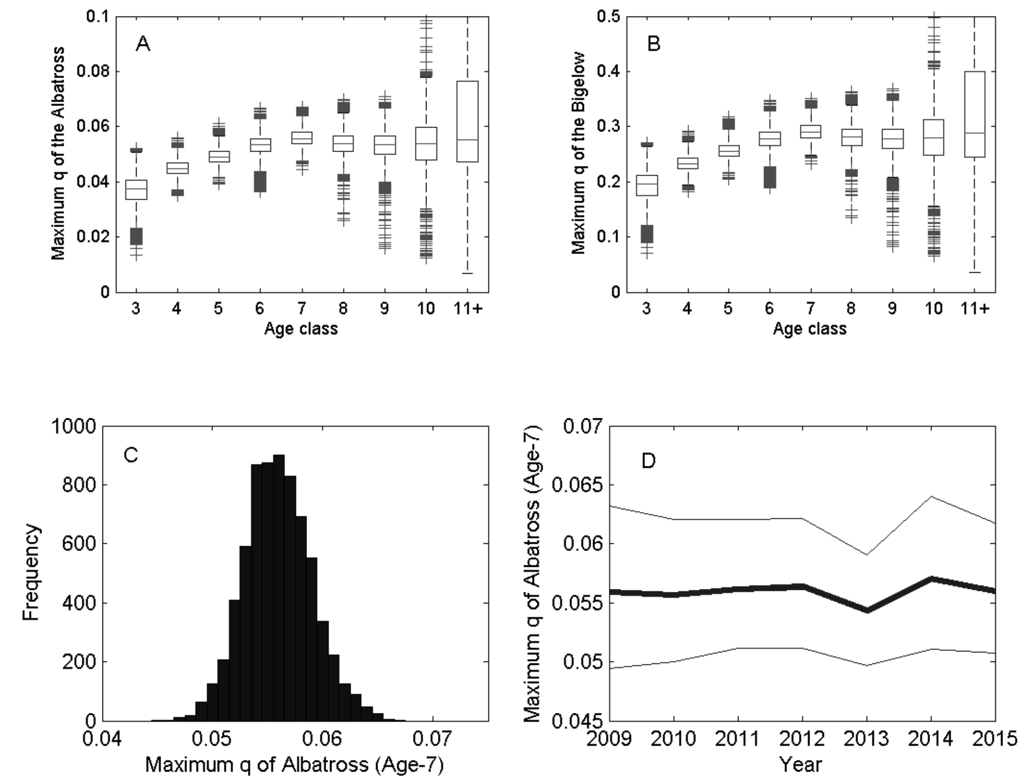


Figure 11: Boxplots of maximum catchability by age class for the A) Albatross tows and B) Bigelow tows. C) Histogram of maximum catchability for Age-7 witch flounder for the fall trawl survey. D) Median and 95% confidence intervals of Age-7 catchability using annual age-length key and stratified mean numbers at length.



Supporting information to the Sweep Study working paper

The relationship between a trawl survey index, catchability and population biomass is generally defined using the following equation:

$$B_t = \frac{1}{q} * \frac{I_t\, A}{a}$$

Where:

I_t: Index value at year t (kg tow^{-1})
B_t: Biomass of the population at year t (kg)
q: catchability
a: area covered by a single trawl (km^2 tow^{-1})
A: area covered by the survey (km^2)
$I_t A/a$=Swept area biomass

This same equation can be specified for both Bigelow and Albatross Units

$$B_t = \frac{1}{q_{Alb}} * \frac{I_{t,Alb}\, A}{a_{Alb}} = \frac{1}{q_{Big}} * \frac{I_{t,Big}\, A}{a_{Big}}$$

The Area covered by the survey cancels out.

$$\frac{1}{q_{Alb}} * \frac{I_{t,Alb}}{a_{Alb}} = \frac{1}{q_{Big}} * \frac{I_{t,Big}}{a_{Big}}$$

Multiply both sides by $q_{Bigelow}$

$$\frac{q_{Big}}{q_{Alb}} * \frac{I_{t,Alb}}{a_{Alb}} = \frac{I_{t,Big}}{a_{Big}}$$

Multiply both sides by $a_{Albatross}$

$$\frac{q_{Big}}{q_{Alb}} * \frac{I_{t,Alb}}{1} = \frac{I_{t,Big} * a_{Alb}}{a_{Big}}$$

Divide both sides by $I_{t,Alb}$

$$\frac{q_{Big}}{q_{Alb}} = \frac{I_{t,Big}}{I_{t,Alb}} * \frac{a_{Alb}}{a_{Big}}$$

For witch flounder the calibration factor for an individual tow of the Albatross and Bigelow is:

$$I_{t,Big} = 3.257 * I_{t,Alb}$$

This can be substituted into the above equation

$$\frac{q_{Big}}{q_{Alb}} = \frac{3.257 * I_{t,Alb}}{I_{t,Alb}} * \frac{a_{Alb}}{a_{Big}}$$

The $I_{t,Alb}$ cancels out:

$$\frac{q_{Big}}{q_{Alb}} = 3.257 * \frac{a_{Alb}}{a_{Big}}$$

The area of an Albatross tow is 0.038km^2 and the area of a Bigelow tow is 0.024

$$a_{Alb} = 0.038$$

$$a_{Big} = 0.024$$

Substituting those in

$$\frac{q_{Big}}{q_{Alb}} = 3.257 * \frac{0.038}{0.024} = 5.157$$

This is the ratio of catchabilities assuming data is entered into an assessment model as Albatross Swept area numbers (or biomass). That is a catchabilty of 0.2 for the Albatross would be equivalent to a catchability of 1.30 on the Bigelow.

Appendix B2

Replacement Yield Model Assessments of Gulf of Maine-Georges Bank Witch Flounder

Doug S. Butterworth and Rebecca A. Rademeyer

October 2016

Introduction

The "replacement yield" (RY) assessment model is the simplest possible form of an age-aggregated dynamic surplus production model approach. The underlying rationale is that if a resource has been without trend in abundance over a period of time, the (average) annual sustainable yield from the resource over that period is given by the average annual catch. The term "replacement yield" is often used in this context rather than "sustainable yield", with the two being equivalent in an "average over time" sense, as technically RY is that catch which will leave (a specified component of) the resource biomass at the end of a year unchanged from the level at which it started that year. The approach extends naturally to a situation where the resource is trending up or down, in which case the RY will be either greater or less than the past average catch, and to an extent that depends on the size of the trend and the size of the underlying biomass.

This is formalised through a dynamic surplus production model in which the annual natural resource growth is taken to be a constant (here denoted by RY). Only limited information is used to then estimate RY: a time series of catches and of one or more indices of abundance (desirably with associated measures of precision). There are various ways possible to effect the estimation, with the one used here set out in Annex A, together with the specific data considered for implementation in this case. A key consideration is how to handle "estimation" of the index constant of proportionality to biomass q**.** Occasionally there is sufficient contrast in the data to estimate q directly, though more usually some prior has to be assumed or a fixed input value is used (with sensitivity to that value explored). In this application, where the survey indices of abundance available reflect swept area estimates of biomass in terms of tons, the approach has been to set q for those surveys equal to a fixed value on input (which is taken to be the same for both the autumn and spring surveys in question, with the choice q=1 implying those estimates to be unbiased).

The choice of the length of the period of years of data for which the approach is applied involves a trade-off. Since in reality there can be longer term trends in the natural growth of a resource over time, ideally one would want to use a short recent period only to get an RY estimate corresponding closely to that which applies at present. However, the shorter the series, the greater the variance of the RY estimate, so that some compromise decision needs to be made.

By construction the MSY concept is not built into the approach. It could equally be applied to a resource with present abundance either well above or well below B_{MSY}, and would provide the same output for both. In principle that might not be desirable; in practice however, that aspect is moot as in the circumstances where such an approach might be applied, one would generally be fairly uncertain as to on which side of B_{MSY} the resource biomass was. Regarding MSY-related reference points, at a stretch one might consider the RY estimate a surrogate for MSY. At a further stretch, since the approach provides a time series of (age-aggregated) biomass estimates, one could take the average biomass over the period considered as a surrogate for B_{MSY} , and then the corresponding surrogate for F_{MSY} (considered as an exploitation rate) would be given simply by MSY/ B_{MSY}.

Results and Discussion

Results from the application of the approach to Gulf of Maine-Georges Bank witch flounder are provided in Table 1 for three choices of period (from 1982, from 1996 and from 2006), four choices (1, 2, 3 and 4) for *q*, and with and without inclusion of the LCPUE series as well as the NEFSC survey abundance series. Plots of the model-estimated indices of abundance to show how well they fit the corresponding data are shown in Figures 1-6 for the six combinations of three periods x two data-choice scenarios (with and without LPUE data). Note that "fits" are shown to the LPUE data even when these data are not included – this is because a *q* value for the LPUE series is still implied in such cases (and provided by the limit of including the LPUE data in the likelihood, but with a vanishingly small weight).

Results for RY across these combinations show a number of the features that might have been expected:

- The longer the period the lower the SE.
- Including the extra (LPUE) series reduces the SE.

Features specific to this case are:

- Except for the shortest period considered (that starting in 2006 which is unable to discriminate), the negative log likelihoods for the fits favour *q*=1. These correspond to smaller estimates for RY compared to those for larger *q* values.
- The estimates of RY decrease as the period considered for the computations is reduced in length, suggesting that resource productivity may be lower more recently than further back in time.
- RY estimates that take account also of the LPUE data are larger.

As far as the period *vs* precision trade-off is concerned, the variability in the data is such that when only those from 2006 onwards are considered (see Figures 5 and 6), unsurprisingly standard error estimates for RY are so high as to make them of questionable value. On the other hand, the trend in the RY estimates with period length is such as to query use of the estimates from 1982 onwards. Over the set of results shown then, the best estimates would seem to be those for the intermediate period from 1996 onwards, and for *q*=1. Those yield RY (SE) estimates of 2.09 (0.72) and 1.20 (0.87) thousand tons for respective inclusion and exclusion of the LPUE index data.

Table 1: RY analysis results with Hessian-based CV in parenthesis (except for RY for which SE are given in parenthesis and italics). Estimates of biomass and RY are given in thousand mt (i.e. kt).

(Table is shown on following page due to size constraints)

	1982, with LPUE				1982, no LPUE			
	q=1	q=2	q=3	q=4	q=1	q=2	q=3	q=4
-lnL_total	50.80	51.70	53.61	56.02	15.96	16.98	18.60	20.53
-lnL_surv1	8.93	9.42	10.21	11.16	8.67	9.25	10.10	11.09
-lnL_surv2	7.41	7.86	8.63	9.59	7.29	7.73	8.50	9.43
-lnL_LPUE	34.46	34.42	34.76	35.27	-	-	-	-
-lnL_q1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-lnL_q2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RY	2.57 *(0.30)*	2.69 *(0.17)*	2.73 *(0.12)*	2.75 *(0.09)*	2.23 *(0.41)*	2.52 *(0.22)*	2.63 *(0.15)*	2.69 *(0.11)*
q1	1.00	2.00	3.00	4.00	1.00	2.00	3.00	4.00
q2	1.00	2.00	3.00	4.00	1.00	2.00	3.00	4.00
B_{1982}	40.99 (0.16)	27.93 (0.12)	23.82 (0.10)	21.87 (0.08)	47.34 (0.18)	30.74 (0.15)	25.24 (0.12)	22.58 (0.10)
B_{1996}	22.04 (0.16)	10.56 (0.16)	6.99 (0.16)	5.29 (0.16)	23.49 (0.17)	11.04 (0.17)	7.07 (0.18)	5.18 (0.17)
B_{2006}	18.88 (0.19)	8.54 (0.22)	5.35 (0.24)	3.84 (0.26)	16.84 (0.21)	7.34 (0.26)	4.47 (0.29)	3.14 (0.31)
B_{2015}	31.75 (0.17)	22.43 (0.13)	19.58 (0.11)	18.24 (0.09)	26.56 (0.24)	19.73 (0.18)	17.85 (0.13)	17.01 (0.11)
B_{2015}/B_{1982}	0.77 (0.28)	0.80 (0.22)	0.82 (0.18)	0.83 (0.15)	0.56 (0.38)	0.64 (0.30)	0.71 (0.23)	0.75 (0.19)
B_{2015}/B_{1996}	1.44 (0.20)	2.12 (0.19)	2.80 (0.18)	3.45 (0.17)	1.13 (0.30)	1.79 (0.27)	2.53 (0.24)	3.29 (0.22)
B_{2015}/B_{2006}	1.68 (0.08)	2.63 (0.11)	3.66 (0.15)	4.75 (0.18)	1.58 (0.12)	2.69 (0.13)	3.99 (0.18)	5.42 (0.22)

	1996, with LPUE				1996, no LPUE			
	q=1	q=2	q=3	q=4	q=1	q=2	q=3	q=4
-lnL_total	29.31	30.73	32.60	34.74	8.16	9.13	10.48	12.12
-lnL_surv1	5.06	5.87	6.82	7.87	5.02	5.82	6.78	7.83
-lnL_surv2	3.62	3.86	4.36	5.07	3.15	3.31	3.70	4.28
-lnL_LPUE	20.63	21.01	21.41	21.80	-	-	-	-
-lnL_q1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-lnL_q2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RY	2.09 *(0.72)*	2.17 *(0.44)*	2.22 *(0.36)*	2.27 *(0.32)*	1.20 *(0.87)*	1.59 *(0.53)*	1.72 *(0.43)*	1.79 *(0.40)*
q1	1.00	2.00	3.00	4.00	1.00	2.00	3.00	4.00
q2	1.00	2.00	3.00	4.00	1.00	2.00	3.00	4.00
B_{1982}	-	-	-	-	-	-	-	-
B_{1996}	27.06 (0.30)	15.53 (0.31)	11.72 (0.32)	9.75 (0.34)	35.81 (0.30)	21.05 (0.30)	16.42 (0.30)	14.27 (0.32)
B_{2006}	19.01 (0.21)	8.34 (0.24)	5.06 (0.26)	3.55 (0.28)	18.91 (0.22)	8.09 (0.25)	4.75 (0.28)	3.22 (0.31)
B_{2015}	27.47 (0.28)	17.58 (0.25)	14.77 (0.24)	13.67 (0.22)	19.42 (0.39)	12.13 (0.37)	9.95 (0.37)	8.99 (0.37)
B_{2015}/B_{1982}	-	-	-	-	-	-	-	-
B_{2015}/B_{1996}	1.02 (0.50)	1.13 (0.51)	1.26 (0.52)	1.40 (0.54)	0.54 (0.62)	0.58 (0.63)	0.61 (0.64)	0.63 (0.67)
B_{2015}/B_{2006}	1.45 (0.24)	2.11 (0.26)	2.92 (0.27)	3.86 (0.29)	1.03 (0.40)	1.50 (0.43)	2.10 (0.47)	2.79 (0.51)

	2006, with LPUE				2006, no LPUE			
	q=1	q=2	q=3	q=4	q=1	q=2	q=3	q=4
-lnL_total	13.07	13.08	13.09	13.11	3.15	3.14	3.13	3.13
-lnL_surv1	1.89	1.88	1.87	1.87	1.79	1.78	1.77	1.76
-lnL_surv2	1.31	1.32	1.32	1.33	1.36	1.36	1.37	1.37
-lnL_LPUE	9.86	9.88	9.90	9.92	-	-	-	-
-lnL_q1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-lnL_q2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RY	0.71 *(1.28)*	0.90 *(0.65)*	0.96 *(0.44)*	0.99 *(0.34)*	0.18 *(1.57)*	0.62 *(0.80)*	0.77 *(0.54)*	0.84 *(0.41)*
q1	1.00	2.00	3.00	4.00	1.00	2.00	3.00	4.00
q2	1.00	2.00	3.00	4.00	1.00	2.00	3.00	4.00
B_{1982}	-	-	-	-	-	-	-	-
B_{1996}	-	-	-	-	-	-	-	-
B_{2006}	20.83 (0.37)	10.91 (0.36)	7.61 (0.35)	5.97 (0.34)	23.40 (0.41)	12.21 (0.39)	8.49 (0.38)	6.64 (0.37)
B_{2015}	16.96 (0.41)	8.69 (0.40)	5.94 (0.40)	4.56 (0.39)	14.69 (0.50)	7.52 (0.49)	5.13 (0.48)	3.93 (0.48)
B_{2015}/B_{1982}	-	-	-	-	-	-	-	-
B_{2015}/B_{1996}	-	-	-	-	-	-	-	-
B_{2015}/B_{2006}	0.81 (0.61)	0.80 (0.60)	0.78 (0.59)	0.76 (0.58)	0.63 (0.76)	0.62 (0.75)	0.60 (0.73)	0.59 (0.72)

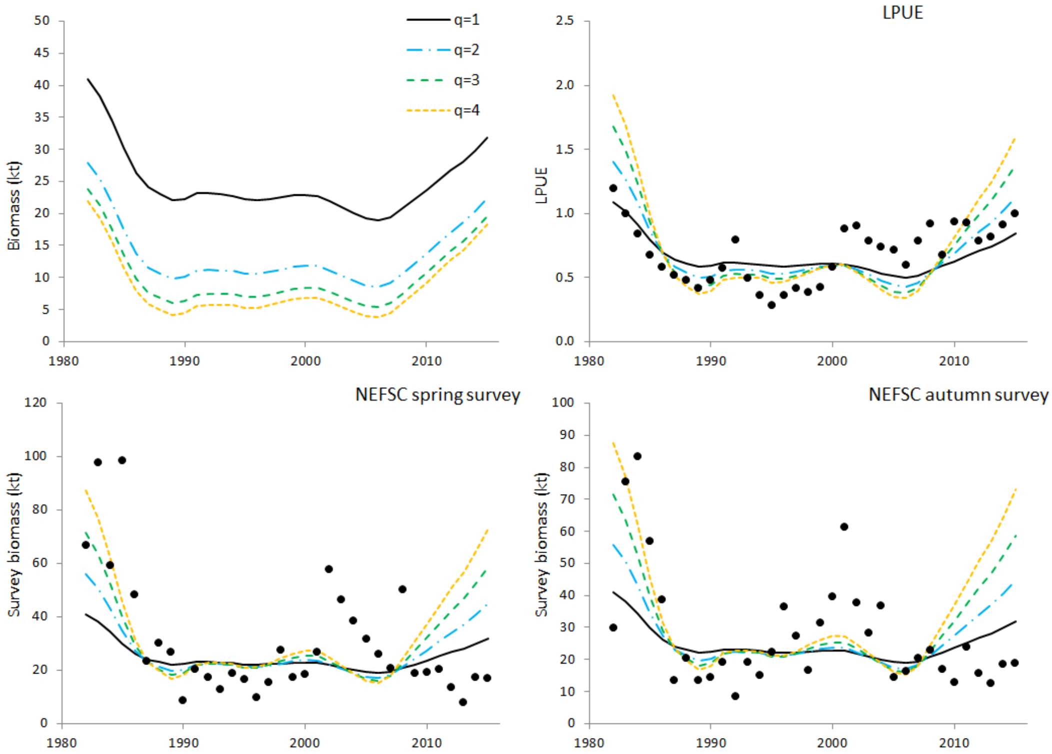


Figure 1: Plots of the estimated biomass trajectories and fits to the abundance indices for the "With LPUE, 1982 start" scenario.

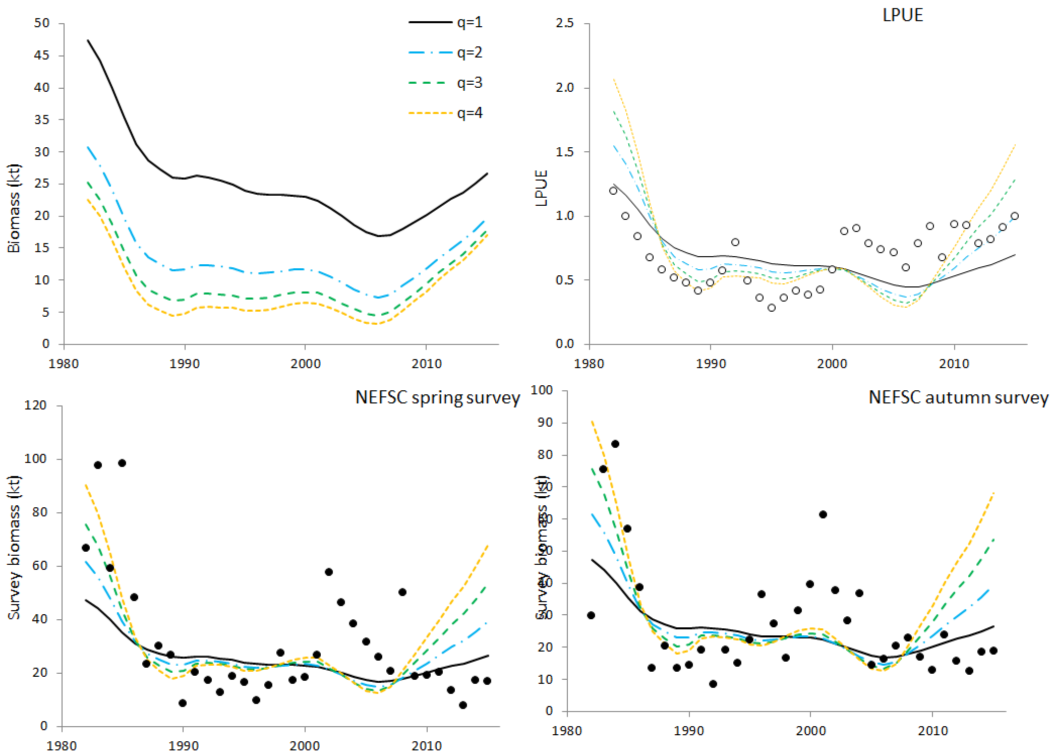


Figure 2: Plots of the estimated biomass trajectories and fits to the abundance indices for the "No LPUE, 1982 start" scenario. Note that the fits shown to the LPUE index are implied by an estimate of q^{LPUE} external to the basic model fitting procedure.

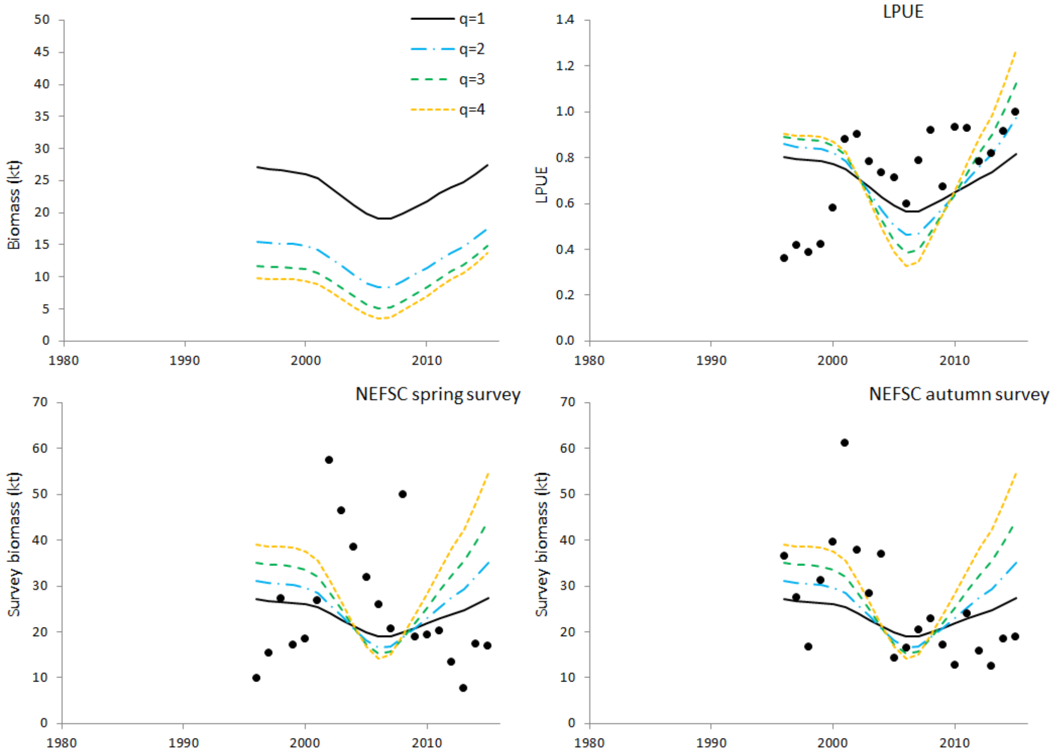


Figure 3: Plots of the estimated biomass trajectories and fits to the abundance indices for the "With LPUE, 1996 start" scenario.

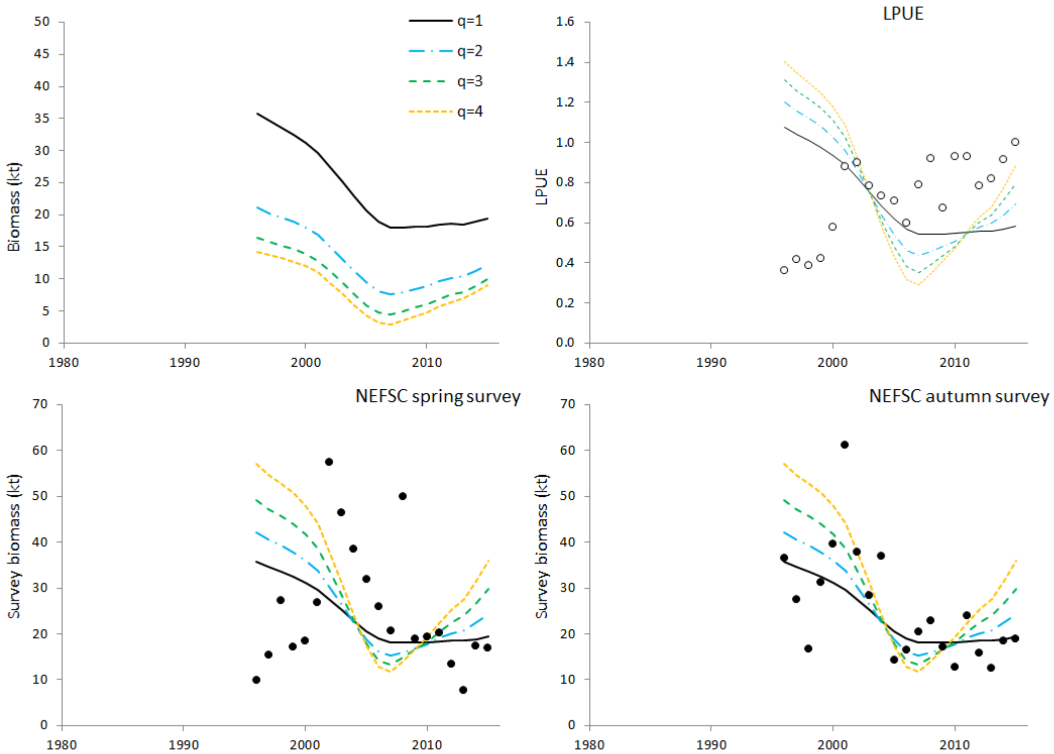


Figure 4: Plots of the estimated biomass trajectories and fits to the abundance indices for the "No LPUE, 1996 start" scenario.

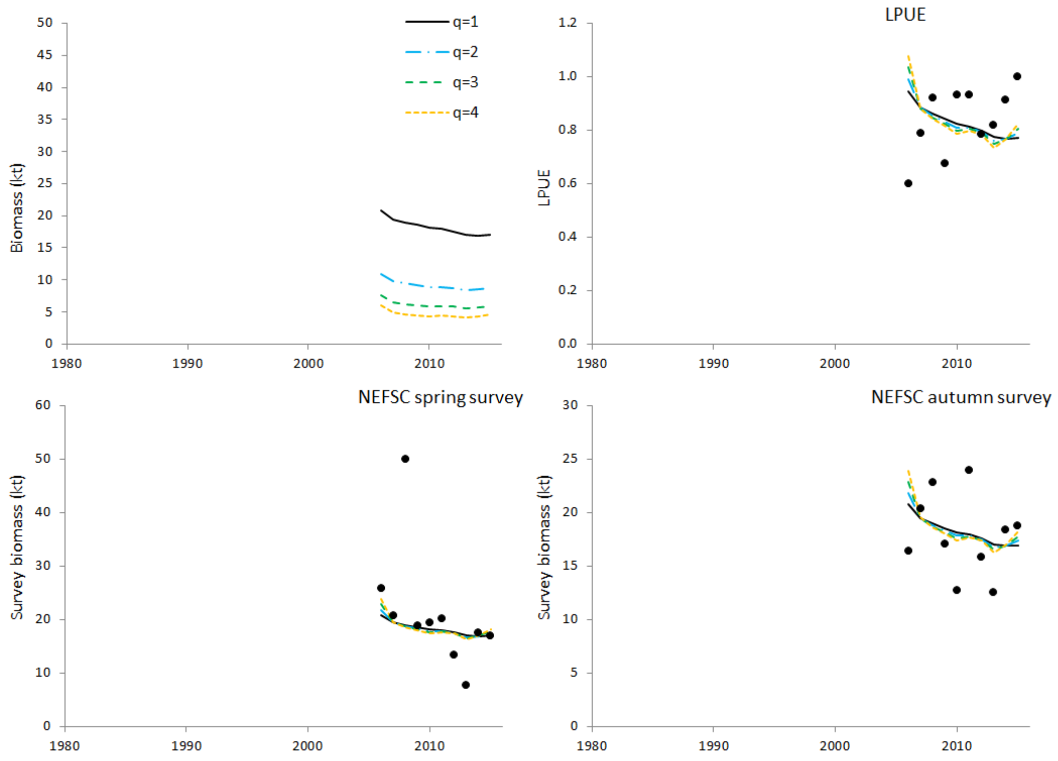


Figure 5: Plots of the estimated biomass trajectories and fits to the abundance indices for the "With LPUE, 2006 start" scenario.

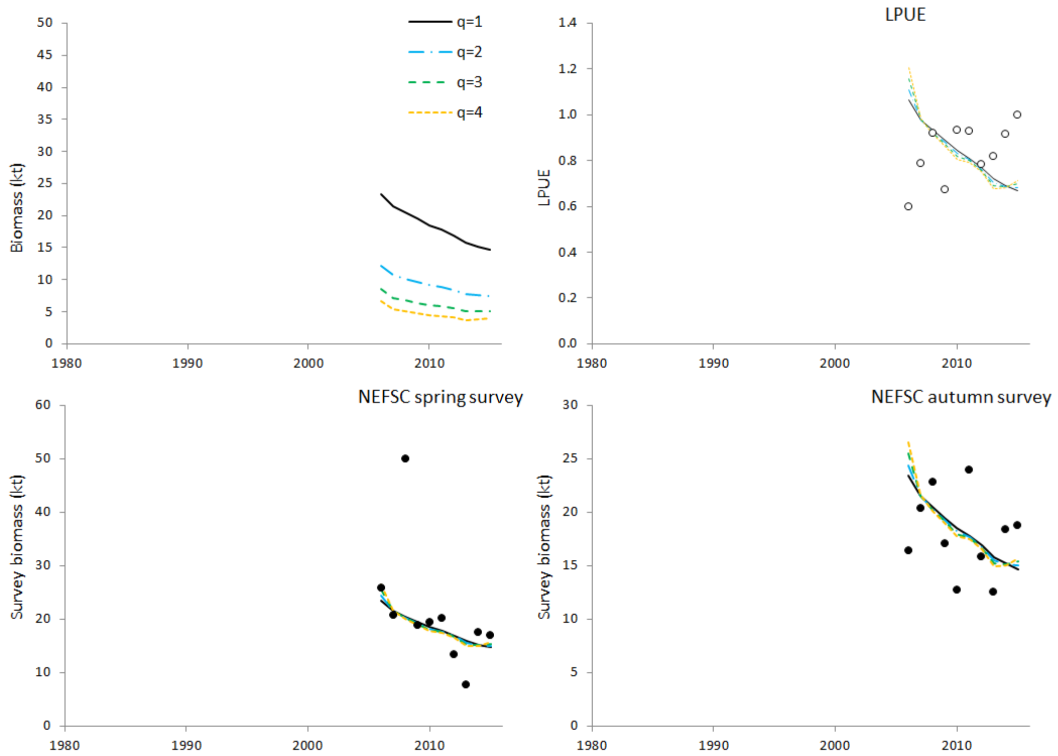


Figure 6: Plots of the estimated biomass trajectories and fits to the abundance indices for the "No LPUE, 2006 start" scenario.

APPENDIX B2: ANNEX A - REPLACEMENT YIELD MODEL

THE POPULATION DYNAMICS

The resource dynamics are modelled by the following equation:

$$B_{y+1} = B_y + RY - C_y \qquad \text{(A.1)}$$

where:

B_y is the biomass at the start of year y,

C_y is the catch in year y, and

RY is the replacement yield in year y, which is assumed to be constant over the period considered.

THE LIKELIHOOD FUNCTION

The model is fitted to survey abundance indices. Contributions by each of these to the negative of the log-likelihood ($-lnL$) are as follows.

Survey abundance data

The likelihood is calculated assuming that the observed abundance indices are log-normally distributed about their expected value:

$$I_y^i = \hat{I}_y^i e^{\varepsilon_y^i} \quad \text{or} \quad \varepsilon_y^i = ln(I_y^i) - ln(\hat{I}_y^i) \qquad \text{(A.2)}$$

where:

I_y^i is the abundance index for year y and survey series i,

$\hat{I}_y^i = \hat{q}^i \hat{B}_y$ is the corresponding model estimated value,

$\hat{q}^i$ is a constant of proportionality (catchability) for abundance index i, and

ε_y^i is the observation error for survey i in year y, which is assumed to be normally distributed: $N\left(0, \left(\sigma_y^i\right)^2\right)$.

For the surveys, an estimate of the CV is available for each survey and the associated σ_y^i are given by $ln\left(1 + \left(CV_y^i\right)^2\right)$, where the CV_y^i are the coefficients of variation of the resource abundance estimate for index i for year y. These CVs are input and include the additional variance estimated in the SCAA Final BC (see Appendix B3). They are given in Table A1.

The contribution of the survey abundance data to the negative of the log-likelihood function (after removal of constants) is then given by:

$$-lnL^{surv} = \sum_{iy} \left\{ ln(\sigma_y^i) + \frac{(\varepsilon_y^i)^2}{2(\sigma_y^i)^2} \right\} \qquad \text{(A.3)}$$

LPUE data

As for the survey abundance data, the likelihood is calculated assuming that the LPUE index is lognormally distributed about its expected value:

$$I_y^{LPUE} = \hat{I}_y^{LPUE} e^{\varepsilon_y^{LPUE}} \quad \text{or} \quad \varepsilon_y^{LPUE} = ln(I_y^{LPUE}) - ln(\hat{I}_y^{LPUE}) \qquad \text{(A.4)}$$

where

I_y^{LPUE} is the LPUE index in year y,
$\hat{I}_y^{LPUE} = \hat{q}^{LPUE}\hat{B}_y$ is the corresponding model estimate, where
$\hat{q}^{LPUE}$ is the constant of proportionality for the LPUE index.

The contribution of the LPUE index data to the negative of the log-likelihood function (after removal of constants) is then given by:

$$-lnL^{LPUE} = \sum_y \left\{ ln\left(\sigma_y^{LPUE}\right) + \frac{\left(\varepsilon_y^{LPUE}\right)^2}{2\left(\sigma_y^{LPUE}\right)^2} \right\} \qquad \text{(A5)}$$

The coefficient of proportionality $\hat{q}^{LPUE}$ for is estimated by its maximum likelihood value:

$$ln\hat{q}^{LPUE} = \frac{1}{n_{LPUE}} \sum_y \left(lnI_y^{LPUE} - ln\hat{B}_y\right) \qquad \text{(A6)}$$

_q_ prior

A very tight prior is included for the catchability coefficient q^i for each survey abundance index i so that these are basically fixed:

$$ln\left(q^i\right) \sim N\left(lnq^{mean}, \sigma^2_{lnq^{mean}}\right) \qquad \text{(A.7)}$$

with $\sigma_{\sigma^2_{lnq^{mean}}} = 0.05$.

Table A1: Total catch (mt), NEFSC spring and autumn surveys swept area biomass estimates (mt) and LPUE each with CV. These CVs are from SCAA final BC results for the NEFSC series (see Appendix B3) and from a corresponding fit with LPUE replacing those series in the log likelihood.

	Total catch	NEFSC spring survey		NEFSC autumn survey		LPUE (40% trips)	
	(mt)	Swept area biomass (mt)	CV	Swept area biomass (mt)	CV	LPUE	CV
1982	5309	66648	0.554	29789	0.531	1.193	0.320
1983	6409	97751	0.575	75553	0.553	0.998	0.320
1984	6937	59375	0.532	83373	0.509	0.842	0.320
1985	6339	98269	0.543	56893	0.520	0.674	0.320
1986	4788	48131	0.531	38766	0.508	0.582	0.320
1987	3644	23230	0.558	13325	0.535	0.521	0.320
1988	3451	30193	0.558	20356	0.536	0.481	0.320
1989	2425	26554	0.552	13404	0.529	0.415	0.320
1990	1744	8441	0.591	14297	0.570	0.476	0.320
1991	2571	20499	0.566	19156	0.543	0.569	0.320
1992	2752	17210	0.539	8512	0.516	0.794	0.320
1993	2806	12836	0.537	19260	0.514	0.497	0.320
1994	3115	18974	0.556	15028	0.533	0.362	0.320
1995	2718	16664	0.535	22291	0.511	0.282	0.320
1996	2393	9894	0.535	36430	0.511	0.362	0.320
1997	2254	15468	0.573	27418	0.551	0.417	0.320
1998	2306	27318	0.537	16771	0.513	0.387	0.320
1999	2490	17210	0.547	31335	0.524	0.423	0.320
2000	2749	18535	0.526	39647	0.502	0.580	0.320
2001	3406	26808	0.533	61160	0.509	0.878	0.320
2002	3470	57529	0.547	37801	0.523	0.901	0.320
2003	3551	46399	0.532	28336	0.509	0.785	0.320
2004	3370	38405	0.523	36859	0.499	0.734	0.320
2005	2917	31803	0.547	14300	0.523	0.711	0.320
2006	2075	25883	0.526	16414	0.502	0.600	0.320
2007	1210	20759	0.534	20349	0.510	0.787	0.320
2008	1136	50009	0.566	22852	0.543	0.921	0.320
2009	1157	18828	0.528	17070	0.504	0.675	0.320
2010	912	19329	0.526	12727	0.502	0.931	0.320
2011	1071	20238	0.520	23917	0.496	0.930	0.320
2012	1258	13454	0.522	15827	0.498	0.785	0.320
2013	811	7767	0.525	12539	0.501	0.819	0.320
2014	675	17430	0.530	18353	0.506	0.914	0.320
2015	585	16896	0.528	18792	0.504	1.000	0.320

Appendix B3

Exploratory Catch-at-Age Assessments of Gulf of Maine-Georges Bank Witch Flounder

Doug S. Butterworth and Rebecca A. Rademeyer

October 2016

Summary

Exploratory Statistical Catch-at-Age assessments of the Gulf of Maine-Georges Bank witch flounder stock indicate possibly unrealistically high q values (in the range of 3-5) for surveys, suggesting substantial herding by the net. If q is forced to be lower, the primary lack of fit that arises originates from the larger numbers of 11+ fish predicted compared to observed for the spring survey. All of treating the *Albatross* and *Bigelow* abundance index series as independent, including LPUE data, and forcing a lower value for q suggest the resource at present to be larger and of better status relative to pristine. Even if both the first two of these factors are incorporated, however, a strong retrospective pattern remains. During the meeting, a further base case run was developed to mimic the specifications agreed for the ASAP base case run as closely as possible, and some sensitivities to that also run. Of interest is that for a combination of the sensitivity factors (allowing selectivity doming, including LPUE data and downweighting the proportions-at-age data) the retrospective pattern is considerably reduced (especially for spawning biomass), the survey indices are fit better, and values of q drop, approaching 3.

Introduction

The initial section of this paper provides exploratory assessments of the Gulf of Maine-Georges Bank witch flounder stock. Their purpose is not to advocate a specific "best assessment" choice, but rather to show the sensitivity of results to some key factors under discussion relating to assumptions and input choices for this assessment. These include the following.

- Whether to assume a change in survey catchability in the mid-1990s.
- The catchability difference between the *Albatross* and the *Bigelow*.
- The use of LPUE data.
- The large estimates of survey catchability q under standard model assumptions.

A subsequent section reports on further analyses developed during the October SAW WG meeting in the light of discussions there.

Data and Methodology

The data used for the assessments reported in this paper are as kindly provided by Susan Wigley (NEFSC) for the period 1982-2015 and are given in Annex A.

The algebraic details of the methods used for the SCAA assessments are similar to those of previous assessments of New England groundfish by the authors (e.g. Butterworth and Rademeyer 2012), and are set out in Annex B. Important assumptions for Base Case assessment model runs are as follows.

- The Baranov catch equation is used.
- Natural mortality M is age-independent and equal to 0.15.
- Recruitment is independent of spawning stock size (i.e. an extreme case of the Beverton-Holt relationship with steepness h =1), and assumed log normal variability of a magnitude

specified as σ_R = 0.5 in a penalty function added to the negative log likelihood minimised in the model fitting process.

- A parsimonious parametrisation of the starting numbers-at-age estimated in the model fit.
- Essentially free estimation of both commercial and survey selectivity-at-age, except that the survey is considered flat above ages 7 and 8 for the spring and autumn surveys respectively.
- A "sqrt(p)" formulation for fitting to information on proportions-at-age in the survey and commercial catches.
- Survey indices of abundance are fitted to (selectivity-weighted) numbers (though in scenarios include the LPUE series this is fitted to mass in the form of exploitable biomass).
- Estimation of additional variation in excess of survey sampling error for the surveys.

Convenient groupings of alternative assessment runs have been attempted to aid understanding of the impacts of different changes. The first set (Table 1) considers two Base Cases – BC1 with no survey catchability change after 1994, and BC2 with such a change – as well as runs forcing the survey catchabilities to be 1 and fitting to the LPUE (the series taking 25% of the catch being witch flounder to be reflective of directed effort is used) instead of the survey abundance indices (and their age-composition data). The second set (Table 2) takes BC1 and BC2 and addresses the impact on each of including one or both of the LPUE data in the fit and treating the *Albatross* and *Bigelow* survey series as independent (i.e. taking no account of the calibration factor for their catchabilities estimated from a trawl experiment, though still assuming the same selectivities for surveys in the same season by each vessel).

Results

Table 1 lists estimates of primary parameters and management-related quantities for the Gulf of Maine-Georges' Bank witch flounder for the first set of "single factor" runs. Results for an "ASAP-test_run_2" kindly provided by Susan Wigley are also included for convenient comparison, but not intending to imply that they might be Wigley's preferred ASAP run.

Figures 1-5 give plots of fits and diagnostics for the Table 1 runs. In the interests of brevity, not all statistics are plotted for every run, and CAA comparison plots in particular have been omitted if not considered to be particularly informative. Figure1 shows results for the BC1 run for spawning biomass, recruitment at ages1 and 3, a stock-recruitment plot with a time-series of residuals, and estimated selectivities-at-age, with comparisons where straightforward to the near-equivalently specified example ASAP run. Figure 2 shows BC1 fits to abundance and CAA data. Figures 3 and 4 show similar results comparing the BC1, *q*=1 and fit to the LPUE series results, though here the fits shown to the CAA data are for the survey *q*=1 scenario. Figure 5 provides a less extensive comparison of the BC1 and BC2 set of results, where the latter allows for a survey catchability change after 1994.

Table 2 provides the results for BC1 and BC2 together with their variants that include one or both of fitting to the LPUE data and treating the *Albatross* and *Bigelow* series as without any information on relative catchability. Figures 6 (for BC1) and Figure 7 (for BC2) provide comparisons across these variants in a similar format to Figure 5.

Results for further sensitivities based on SCAA BC3 are developed as follows:

1. "SCAA BC3": *Albatross* and *Bigelow* survey series split, including LPUE.
2. "SCAA BC3 Dome surveys": Survey selectivities are freely estimated to age 11+ for both spring and autumn surveys (instead of flat from ages 7 and 8 for the spring and autumn survey respectively).

3. "SCAA BC3 W_{CAA}=0.30": Downweighting of the contribution of the CAA data (both survey and commercial) to –lnL by a multiplicative factor of 0.3 instead of 1.
4. "SCAA BC3 calibration": Addition of a term to -lnL to take account of the *Albatross/Bigelow* experimental calibration estimate as:

$$-lnL^{calib} = \sum_i \left[ln\left(q^{Big}\right) - ln\left(q^{Alb}\right) - \Delta lnq\right]^2 / 2\sigma^2_{\Delta lnq} \qquad (1)$$

with

$$\Delta lnq = ln(3.257) = 1.181$$

and

$$\sigma_{\Delta lnq} = 0.336/3.257 = 0.103$$

5. "SCAA BC3 split LPUE": the LPUE series is split into five series following major management changes which may have compromised comparability over time (the choice of break point is not always obvious, but the following approximation has been used:1982-1986, 1987-1994, 1995-2001, 2002-2009 and 2010-2015).

Table 3 lists estimates of primary parameters and management-related quantities for these further five sensitivity runs. Furthermore Hessian-based CVs are given for SCAA BC3 in Table 3. Figures 8-10 give plots of fits and diagnostics for the Table 3 runs, while Figure 11 plots the retrospective analysis for SCAA BC3.

Discussion

The discussion below is limited to listing a few key observations from the results with brief commentary.

1) The SCAA BC1 results are quite similar to those for the near equivalently specified example ASAP run, both reflecting domed commercial selectivity (Figure 1).

2) Both BC1 and BC2 indicate high survey *q* values, ranging from about 3 to 5 (Table 1), which indicates an extent of herding by the survey net whose plausibility might be open to question – hence inclusion of run forcing the survey *q* values to 1.

3) BC1 displays a systematic lack of fit to the LPUE data (not taken into account in this fit of the model), with the LPUE data being too low in the 1980s, and too high around 2010 (Figure 2).

4) Fitting to the LPUE instead of the survey index results in a larger and less depleted (relative to pristine) spawning biomass, and these effects are larger still if the survey catchabilities *q* are forced to equal 1 (Table 1 and Figure 3).

5) From the –lnL contributions in Table 1, it is clear to the main reason that the BC1 (BC2 would be similar) model fit "wants" high *q* values is in the fit to the survey CAA. Comparison of the residual plots for the CAA data in Figure 2 for BC1 and Figure 4 for *q*=1 show that this stems primarily from the spring survey, with the *q*=1 results predicting a far higher fraction of older (11+) fish.

6) BC1 (no survey catchability change in the mid-1990s) indicates a more positive recent status and trend for the resource than BC2 (Table 1 and Figure 5).

7) When the possibility of one or both of taking account of the LPUE data and treating the *Albatross* and *Bigelow* index series as independent is admitted (BC3), estimates of current spawning biomass and of status relative to pristine improve (Table 3 and Figures 6 and 7).

8) Both the domed selectivity and the downweighted CAA variants show higher current spawning biomasses and less depletion below pristine than BC3, and correspondingly lower survey *q* values which though still greater than 1 might be considered more realistic (Table 3 and Figure 8).

9) These last two variants fit the LPUE series better. The domed selectivity fit to the CAA data is slightly better for the commercial data but slightly worse for the surveys, but the downweighted CAA variant predicts too many 11+ fish for the autumn survey compared to the data (Table 3 and Figure 9).

10) The other two variants (calibration and split LPUE) show the opposite effects, with lower current spawning biomasses and greater depletion below pristine than BC3, and correspondingly higher survey *q* values (Table 3 and Figure 10).

11) Biomass related quantities for BC3 have Hessian-based CV estimates of about 20% (Table 3).

12) The retrospective pattern remains for BC3 (Figure 11).

DEVELOPED DURING SAW WG MEETING

These further runs with their results were developed and presented during the SAW WG meeting. They reflect a "final (SCAA) BC" which was structured to match the specifications for the final ASAP Base case run as closely as possible given certain different structures of these two approaches, together with some sensitivities to that run. Note that these runs do not include any survey selectivity change between 1994 and 1995.

Results

Table 4 lists estimates of primary parameters and management-related quantities for the SCAA final BC and six sensitivities to that. The sensitivities are:

- sens1: domed fishery and survey selectivities;
- sens2: domed survey only;
- sens3: dome fishery only;
- sens4: including LPUE (the 40% trips series) in the fit;
- sens5: *Bigelow/Albatross* calibration factor halved (i.e. 3.257 is reduced to 2.129, half-way towards 1) ; and
- sens6: downweighting of the CAA data in terms of output from an ASAP run, which resulted in setting W_{CAA} equal to 0.36 for commercial, 0.54 for spring survey and 0.34 for autumn survey CAA data; this is on the basis of application of an estimation procedure by Francis (2011) which attempts to take correlations amongst these data into account

Figures 12-14 provide plots of fits and diagnostics for the Table 4 runs.

Table 5 lists estimates of primary parameters and management related quantities for a further sensitivity run sens7 and two further variants to sens7, all based on the final BC. Sens7 includes dome selectivities for both the fishery and the surveys, fits to LPUE (40% trips series) and downweights the CAA data as for sens 6. Sens8 and sens9 restrict *q* to a maximum of 2 and 1 respectively.

Figures 15-17 give plots of fits and diagnostics for the Table 5 runs, while Figure 18 plots the retrospective analysis for sens7.

Discussion

Again the discussion below is limited to listing a few key observations from these within-WG-meeting results with brief commentary.

1) The first six sensitivities show little difference in results from those for the final BC. The current spawning biomass as a fraction of *K* is about 0.2, increasing slightly only for sens4 (including the LCPUE data) and for sens5 (halving the calibration factor). All survey *q* values remain above 4 (Table 4 and Figures 12-14).

2) Sens7, which includes three of the sensitivity factors together (dome selectivities for both the fishery and the surveys, fits to LPUE (40% trips series) and downweighting the CAA data as for sens6) shows more appreciable differences from the final BC: the current spawning biomass increases by about 50%, and relative to *K* from about 0.2 to 0.4. The fits to the survey indices of abundance improve, and the survey *q* values drop to approach 3 (Table 5 and Figures15-17).

3) If the survey *q* is forced to be 2 or less (sens8), the –lnL deteriorates by only some 1.5 units, the current spawning biomass is estimated to be higher still as is its ratio to *K*, and the fits to the survey indices of abundance improve still further. However the 1982 spawning biomass is estimated to be above *K*, this being primarily a reflection of estimation of a large 11+ abundance in this (assessment-commencing) year. Forcing *q* to be 1 or less (sens9) reflects all these same features to a greater extent (Table 5 and Figure 17).

4) The retrospective pattern for sens7 (Figure 18) is appreciably reduced (compared, say, to that for BC3 in Figure 11). This is particularly the case for spawning biomass for which there is very little indication of pattern, though for apical fishing mortality some systematic pattern remains.

References

Butterworth DS and Rademeyer RA. 2012. Applications of Statistical Catch-at-Age Assessment Methodology to Gulf of Maine cod, October 2012.Document presented to SAW/SARC 55 Working Group on Gulf of Maine and Georges Bank cod Modeling Meeting, 15-19 October, 2012. 40pp.

Francis RICC. 2011. Data weighting in statistical stock assessments models. Can. J. Fish. Aquat. Sci. 68: 1124-1138.

Table 1: Negative log-likelihood components and estimates of abundance and related quantities for witch flounder for the ASAP run "test_run_2", and several Base Case and "single factor" SCAA runs. Biomass units in this and all following tables are thousand mt unless otherwise indicated. For the run fitting to commercial LPUE and CAA data only, the implied *q* values for the surveys are shown in *italics*. Note that overall –lnL values are not comparable for run including the LPUE data.

	ASAP	SCAA BC1	SCAA BC2	SCAA B1 q=1	SCAA B1 CPUE only
-lnL: overall		-1634.0	-1665.0	-1508.2	-659.3
-lnL: survey		54.8	35.8	42.1	-
-lnL: LPUE		-	-	-	-0.8
-lnL: comCAA		-584.7	-583.2	-607.6	-631.7
-lnL: survCAA		-1096.7	-1107.0	-930.0	-0.1
-lnL: RecRes		37.0	34.2	33.7	19.1
-lnL: Catch		-44.5	-44.7	-46.7	-45.9
K^{sp}		31.38	28.53	78.71	43.35
B^{sp}_{1982}	24.81	23.63	24.24	89.20	35.37
B^{sp}_{2015}	6.77	6.58	4.31	58.55	21.33
B^{sp}_{2015}/K^{sp}		0.21	0.15	0.74	0.49
$B^{sp}_{2015}/B^{sp}_{1982}$	0.27	0.28	0.18	0.66	0.60
q:					
NEFSC spring: 1972-1994			2.85		*2.45*
NEFSC spring: 1995-2008	3.84	4.15	5.33	1.00	*2.77*
Bigelow spring: 2009-2015					
NEFSC aut: 1982-1994			2.70		*2.12*
NEFSC aut: 1995+	4.13	4.50	6.35	1.00	*3.03*
Bigelow aut.: 2009-2015					

Table 2: Negative log-likelihood components and estimates of abundance and related quantities for witch flounder for variants of the two Base Case SCAA runs. Note that overall –lnL values are not comparable for runs including the LPUE data.

	SCAA BC1	SCAA BC1 split Alb/Big	SCAA BC1 incl. LPUE	SCAA BC1 split Alb/Big, incl. LPUE = BC3	SCAA BC2	SCAA BC2 split Alb/Big	SCAA BC2 incl. LPUE	SCAA BC2 split Alb/Big, incl. LPUE
-lnL: overall	-1634.0	-1655.1	-1608.8	-1629.9	-1665.0	-1678.2	-1634.4	-1651.9
-lnL: survey	54.8	55.9	53.4	54.3	35.8	-	38.1	38.1
-lnL: LPUE	-	-	22.1	21.3	-	37.6	27.9	22.8
-lnL: comCAA	-584.7	-589.2	-590.4	-594.1	-583.2	-587.8	-588.4	-592.7
-lnL: survCAA	-1096.7	-1114.2	-1087.2	-1108.5	-1107.0	-1118.9	-1101.8	-1114.1
-lnL: RecRes	37.0	37.4	37.5	41.7	34.2	36.3	34.3	39.3
-lnL: Catch	-44.5	-45.1	-44.3	-44.7	-44.7	-45.3	-44.6	-45.2
K^{sp}	31.38	32.07	33.88	36.54	28.53	31.58	30.46	35.30
B^{sp}_{1982}	23.63	23.68	23.30	23.46	24.24	24.06	23.99	23.87
B^{sp}_{2015}	6.58	6.71	8.93	10.86	4.31	6.33	5.69	9.54
B^{sp}_{2015}/K^{sp}	0.21	0.21	0.26	0.30	0.15	0.20	0.19	0.27
$B^{sp}_{2015}/B^{sp}_{1982}$	0.28	0.28	0.38	0.46	0.18	0.26	0.24	0.40
q:								
NEFSC spring: 1972-1994		4.11		3.94	2.85	2.91	2.85	2.90
NEFSC spring: 1995-2008	4.15		3.85		5.33	5.45	4.87	5.14
Bigelow spring: 2009-2015		4.10		2.82		4.19		3.07
NEFSC aut: 1982-1994		4.21		3.91	2.70	2.65	2.62	2.50
NEFSC aut: 1995+	4.50		4.24		6.35	6.36	5.60	5.61
Bigelow aut.: 2009-2015		4.21		2.76		4.36		2.97

Table 3: Negative log-likelihood components and estimates of abundance and related quantities for the SCAA BC3 run and several variants thereof. Biomass units are thousand mt. For the run fitting to commercial LPUE and CAA data only, the implied *q* values for the surveys are shown in italics. For SCAA BC3, the Hessian-based CVs are given in parenthesis.

	SCAA BC3		SCAA BC3 Dome surveys	SCAA BC3 W_{CAA}=0.3	SCAA BC3 with calib. in likelihood	SCAA BC3 split CPUE
-lnL: overall	-1629.9		-1641.2	-463.0	-1580.9	-1654.8
-lnL: survey	54.3		45.4	36.7	50.6	55.1
-lnL: calib	-		-	-	14.2	-
-lnL: LPUE	21.3		9.5	-5.0	40.6	-1.8
-lnL: comCAA	-594.1		-598.5	-181.9	-586.4	-590.4
-lnL: survCAA	-1108.5		-1096.2	-288.3	-1092.2	-1109.2
-lnL: RecRes	41.7		44.5	21.9	36.6	35.9
-lnL: Catch	-44.7		-46.0	-46.3	-44.4	-44.4
K^{sp}	36.54	(0.11)	43.73	42.29	24.50	31.27
B^{sp}_{1982}	23.46	(0.07)	51.46	28.64	23.72	24.12
B^{sp}_{2015}	10.86	(0.19)	20.08	19.97	1.98	6.05
B^{sp}_{2015}/K^{sp}	0.30	(0.17)	0.46	0.47	0.08	0.19
$B^{sp}_{2015}/B^{sp}_{1982}$	0.46	(0.21)	0.39	0.70	0.08	0.25
q:						
NEFSC spring: 1972-1994 NEFSC spring: 1995-2008	3.94	(0.07)	3.35	2.43	4.04	4.06
Bigelow spring: 2009-2015	2.82	(0.17)	1.82	1.53	8.57	4.31
NEFSC aut: 1982-1994 NEFSC aut: 1995+	3.91	(0.11)	2.99	2.82	4.42	4.15
Bigelow aut.: 2009-2015	2.76	(0.19)	1.66	2.00	10.20	4.45

Table 4: Negative log-likelihood components and estimates of abundance and related quantities for witch flounder for SCAA Final BC and sens1 to sens6.

	BC	sens1	sens2	sens3	sens4	sens5	sens6
	Final BC	Dome fishery and survey	Dome survey	Dome fishery	Include 40% LPUE	Calibration factor halved	Downweighting CAA
-lnL: overall	-1686.8	-1690.5	-1686.8	-1690.5	-1650.5	-1684.4	-675.5
-lnL: survey	56.2	56.0	56.2	56.0	55.1	57.9	54.7
-lnL: LPUE	-				34.4		
-lnL: comCAA	-655.2	-658.5	-655.2	-658.5	-654.8	-655.1	-233.4
-lnL: survCAA	-1079.0	-1078.9	-1079.0	-1078.9	-1077.5	-1080.9	-481.2
-lnL: RecRes	34.8	34.8	34.8	34.8	35.4	37.2	30.0
-lnL: Catch	-43.7	-43.8	-43.7	-43.8	-43.0	-43.6	-45.6
K^{sp}	31.44	31.80	31.44	31.80	32.74	33.42	30.67
B^{sp}_{1982}	21.25	21.74	21.25	21.74	20.66	21.20	21.40
B^{sp}_{2015}	6.41	6.77	6.41	6.77	7.55	8.24	6.16
B^{sp}_{2015}/K^{sp}	0.20	0.21	0.20	0.21	0.23	0.25	0.20
$B^{sp}_{2015}/B^{sp}_{1982}$	0.30	0.31	0.30	0.31	0.37	0.39	0.29
ϕ	0.12	0.14	0.12	0.14	0.12	0.12	0.12
1982 N-at-age ($x10^6$)							
$N_{1,1982}$	17.14	17.29	17.14	17.29	16.95	17.11	16.61
$N_{2,1982}$	21.25	21.64	21.25	21.64	20.98	21.23	20.44
$N_{3,1982}$	20.28	20.76	20.28	20.76	20.02	20.26	20.27
$N_{4,1982}$	15.27	15.75	15.27	15.75	15.08	15.23	14.92
$N_{5,1982}$	9.39	9.68	9.39	9.68	9.25	9.36	9.23
$N_{6,1982}$	7.43	7.63	7.43	7.63	7.32	7.40	7.33
$N_{7,1982}$	5.79	5.93	5.79	5.93	5.72	5.77	5.74
$N_{8,1982}$	4.39	4.37	4.39	4.37	4.32	4.37	4.36
$N_{9,1982}$	3.33	3.27	3.33	3.27	3.26	3.32	3.32
$N_{10,1982}$	2.52	2.47	2.52	2.47	2.46	2.51	2.53
$N_{11+,1982}$	7.89	8.25	7.89	8.25	7.60	7.88	8.05
q:							
NEFSC spring	4.39	4.26	4.39	4.26	4.29	4.65	4.33
NEFSC autumn	4.75	4.60	4.75	4.60	4.62	5.01	4.44

Table 5: Negative log-likelihood components and estimates of abundance and related quantities for witch flounder for SCAA Final BC, and sens7 to sens9.

	BC	sens7	sens8	sens9
	Final BC	Both dome, incl. LPUE, down. CAA	sens7 + q=2	sens7 + q=1
-lnL: overall	-1686.8	-656.2	-654.7	-651.8
-lnL: survey	56.2	41.0	37.4	36.6
-lnL: LPUE	-	9.1	7.8	8.7
-lnL: comCAA	-655.2	-229.5	-223.0	-221.2
-lnL: survCAA	-1079.0	-457.6	-458.7	-458.8
-lnL: RecRes	34.8	27.2	28.5	30.0
-lnL: Catch	-43.7	-46.4	-46.7	-46.9
K^{sp}	31.44	37.13	50.72	81.92
B^{sp}_{1982}	21.25	31.85	83.36	157.22
B^{sp}_{2015}	6.41	14.78	29.98	62.93
B^{sp}_{2015}/K^{sp}	0.20	0.40	0.59	0.77
$B^{sp}_{2015}/B^{sp}_{1982}$	0.30	0.46	0.36	0.40
F_{2015}	0.138	0.071	0.047	0.026
ϕ	0.12	0.13	0.00	0.00
1982 N-at-age ($x10^6$)				
$N_{1,1982}$	17.14	16.54	20.68	30.51
$N_{2,1982}$	21.25	21.32	27.69	40.88
$N_{3,1982}$	20.28	21.35	28.47	42.36
$N_{4,1982}$	15.27	16.18	21.84	33.20
$N_{5,1982}$	9.39	10.08	14.75	27.71
$N_{6,1982}$	7.43	8.12	12.69	23.85
$N_{7,1982}$	5.79	6.50	10.93	20.53
$N_{8,1982}$	4.39	4.84	9.40	17.67
$N_{9,1982}$	3.33	3.77	8.09	15.21
$N_{10,1982}$	2.52	3.02	6.97	13.09
$N_{11+,1982}$	7.89	14.51	43.04	80.88
q:				
NEFSC spring	4.39	3.36	2.00	1.00
NEFSC autumn	4.75	3.18	1.75	0.95

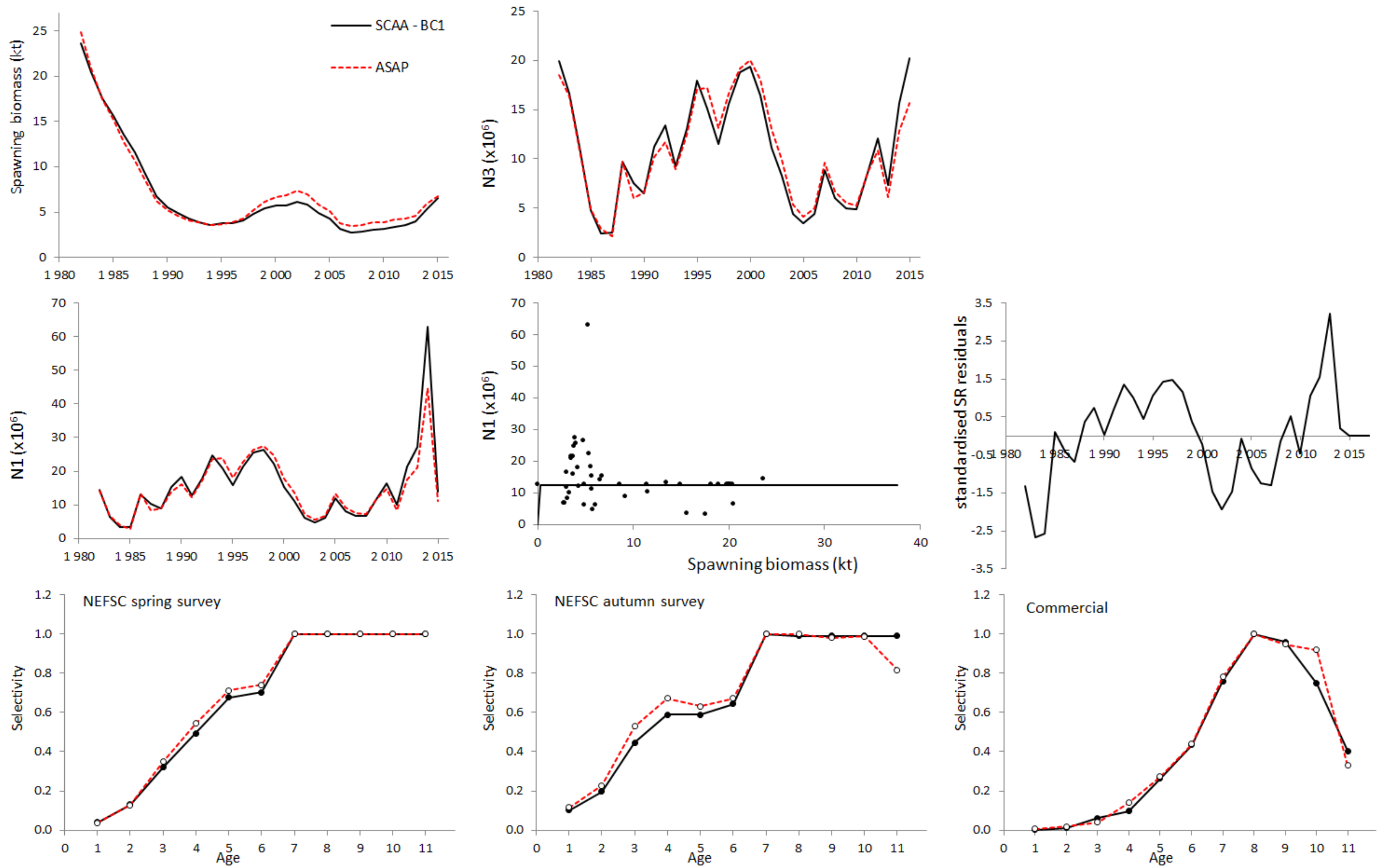


Figure 1: Comparison of the **SCAA BC1** results with the **ASAP run "test_run2"** .

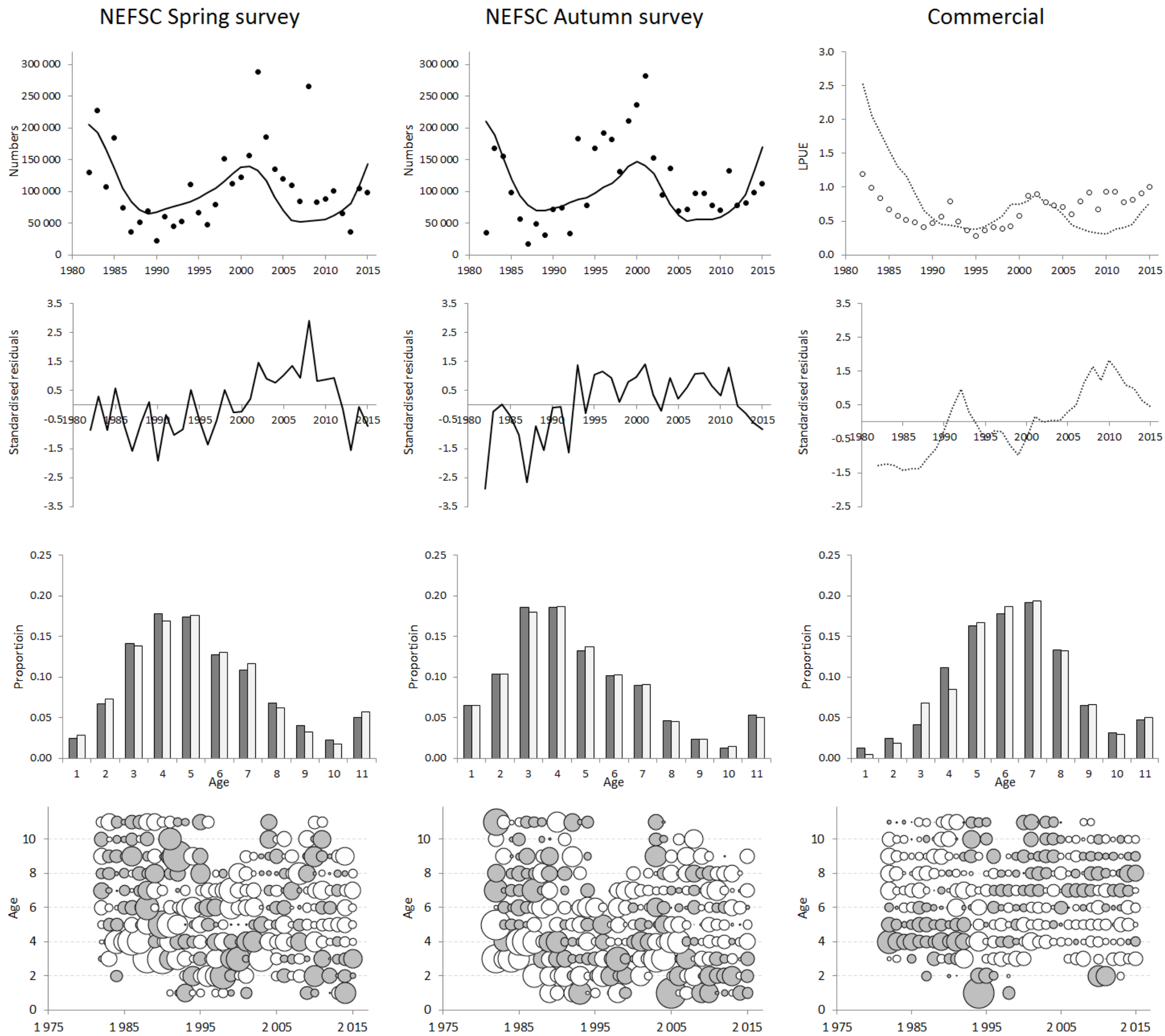


Figure 2: Fit to the survey series and survey and commercial catch-at-age data (averaged over all the years for which data is available – third row – and bubble plots of residuals, with grey bubbles representing positive residuals – bottom row) for the **SCAA BC1** run.

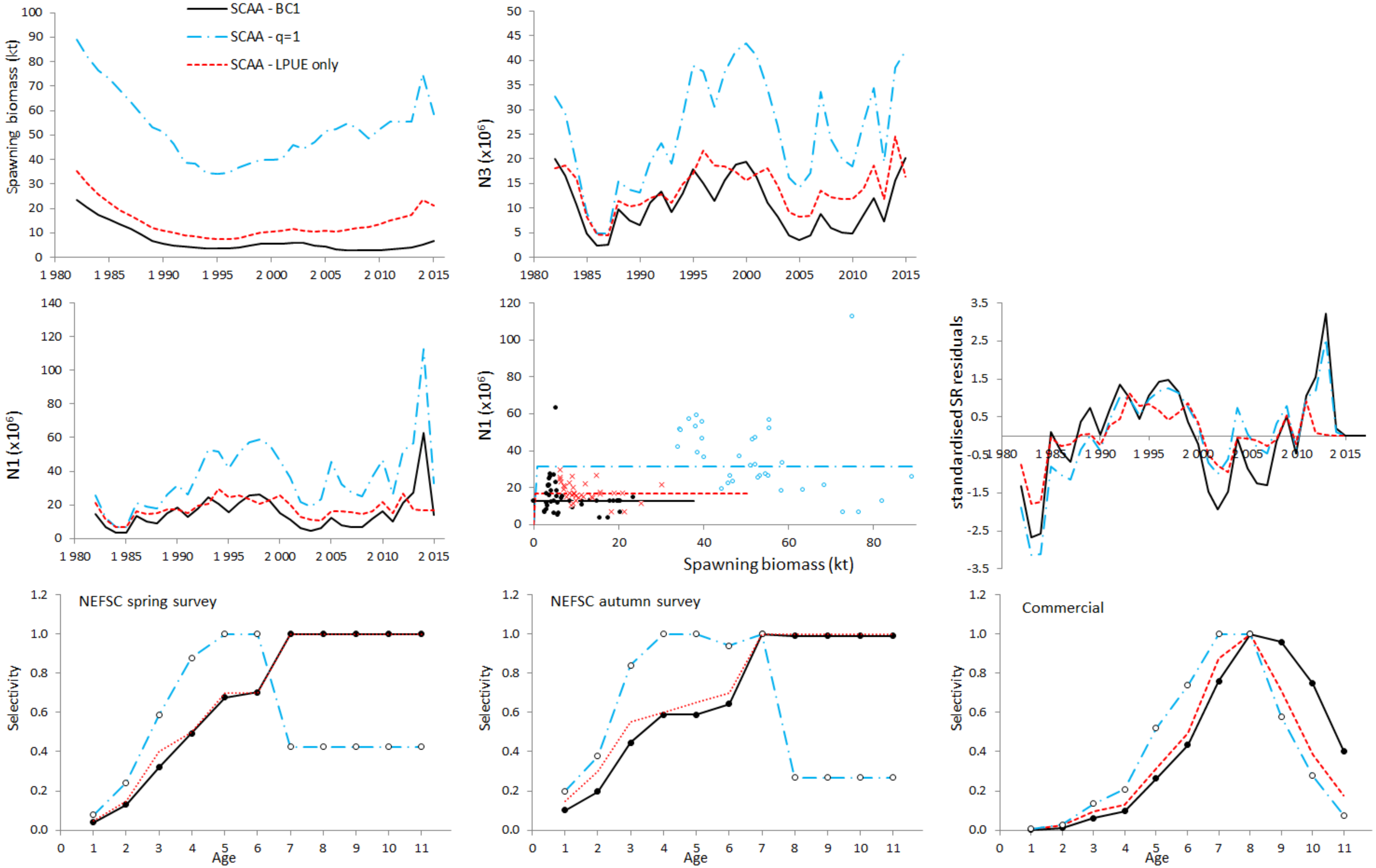


Figure 3: Comparison of the **SCAA BC1** results with the **SCAA q=1** and **SCAA LPUE only**.

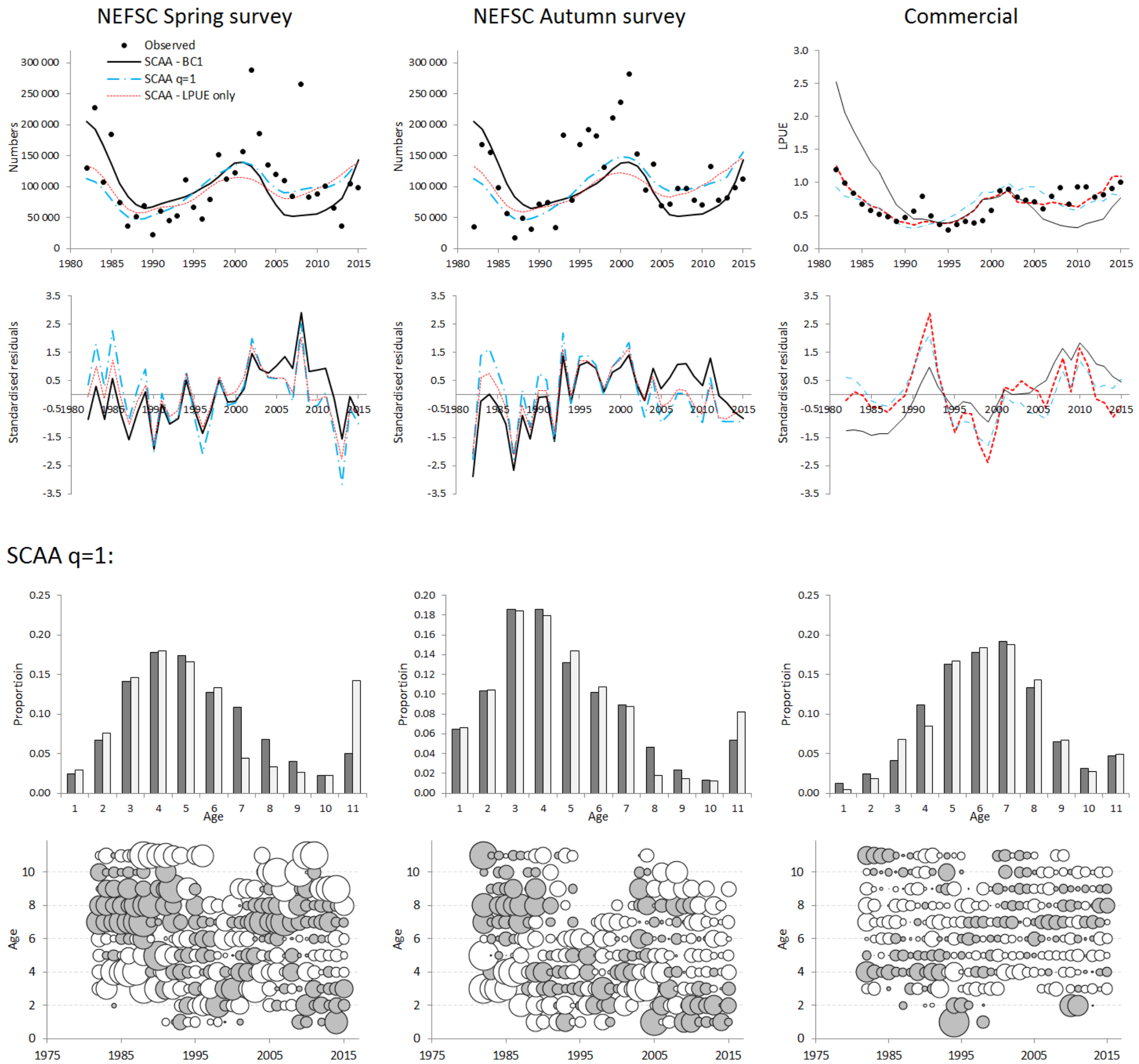


Figure 4: Fit to the survey and CPUE series for the **SCAA BC1**, **q=1** and **LPUE only** runs and survey and commercial catch-at-age data (averaged over all the years for which data is available – third row – and bubble plots of residuals, with grey bubbles representing positive residuals – bottom
row) for SCAA *q*=1.

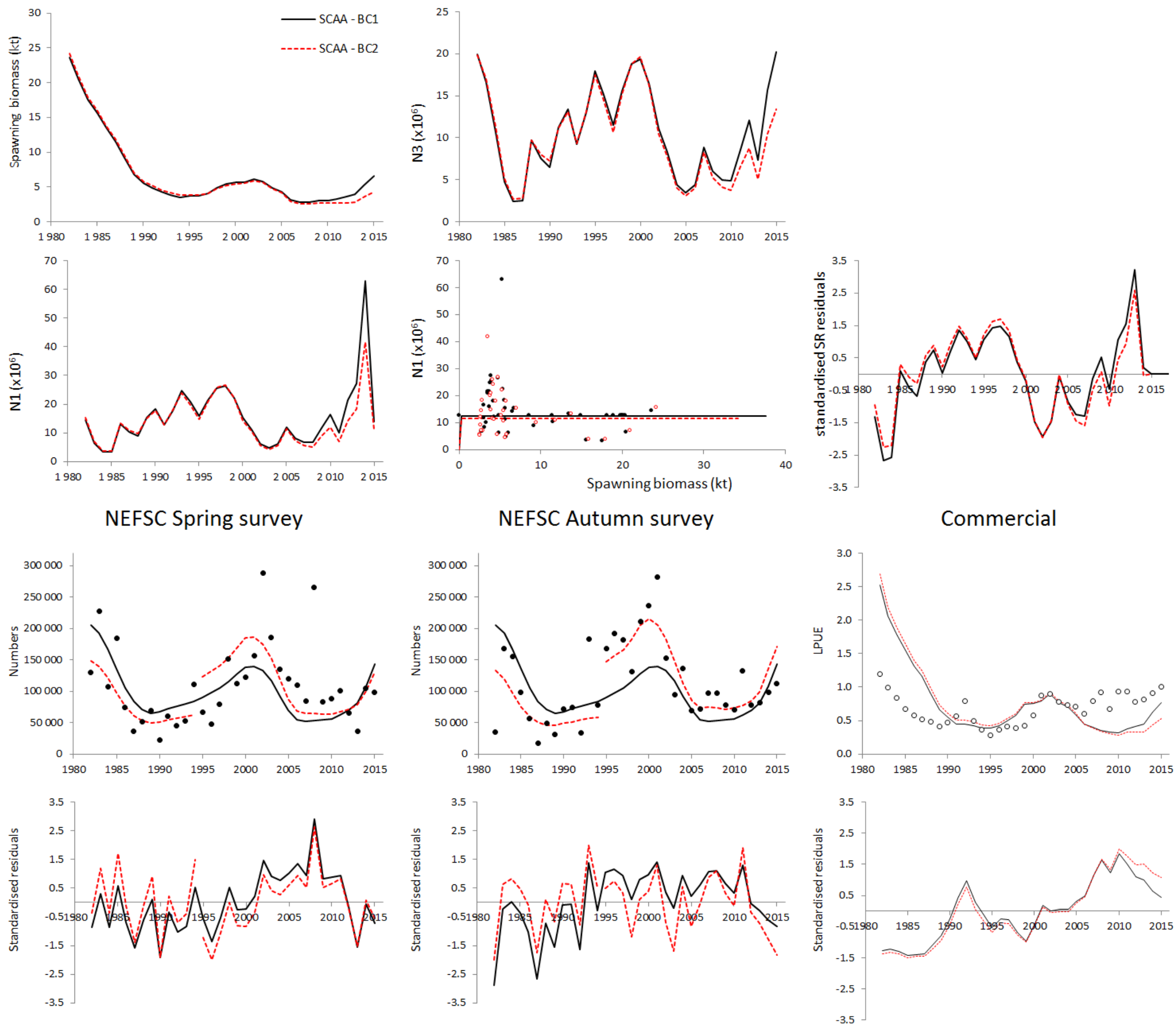


Figure 5: Comparison of the **SCAA BC1** and **SCAA BC2** results.

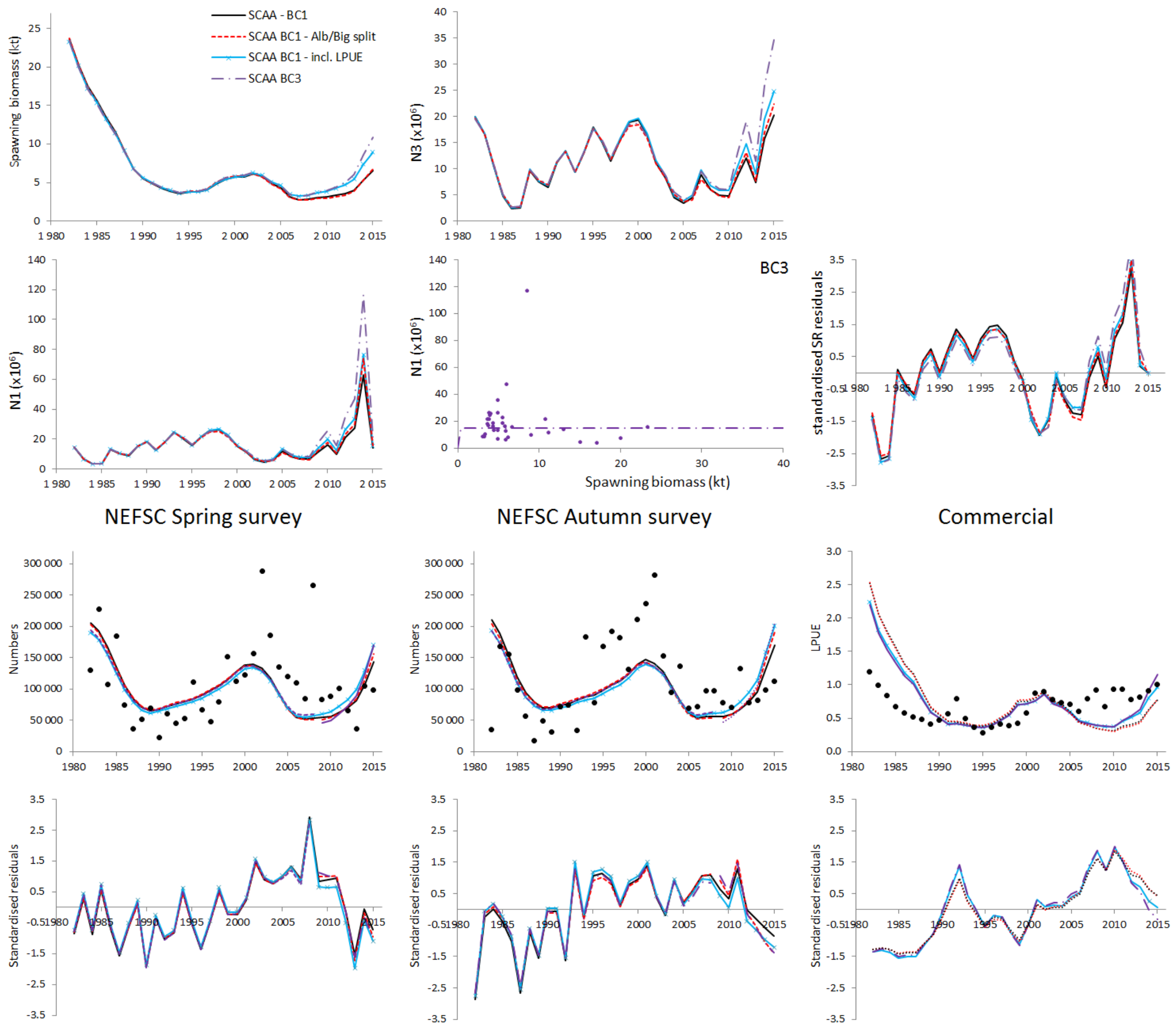


Figure 6: Comparison of the **SCAA BC1** (in black) and **Alb/Big split** (in red), **including LPUE** (in blue) and **BC3** (Alb/Big split and including CPUE, in purple) results.

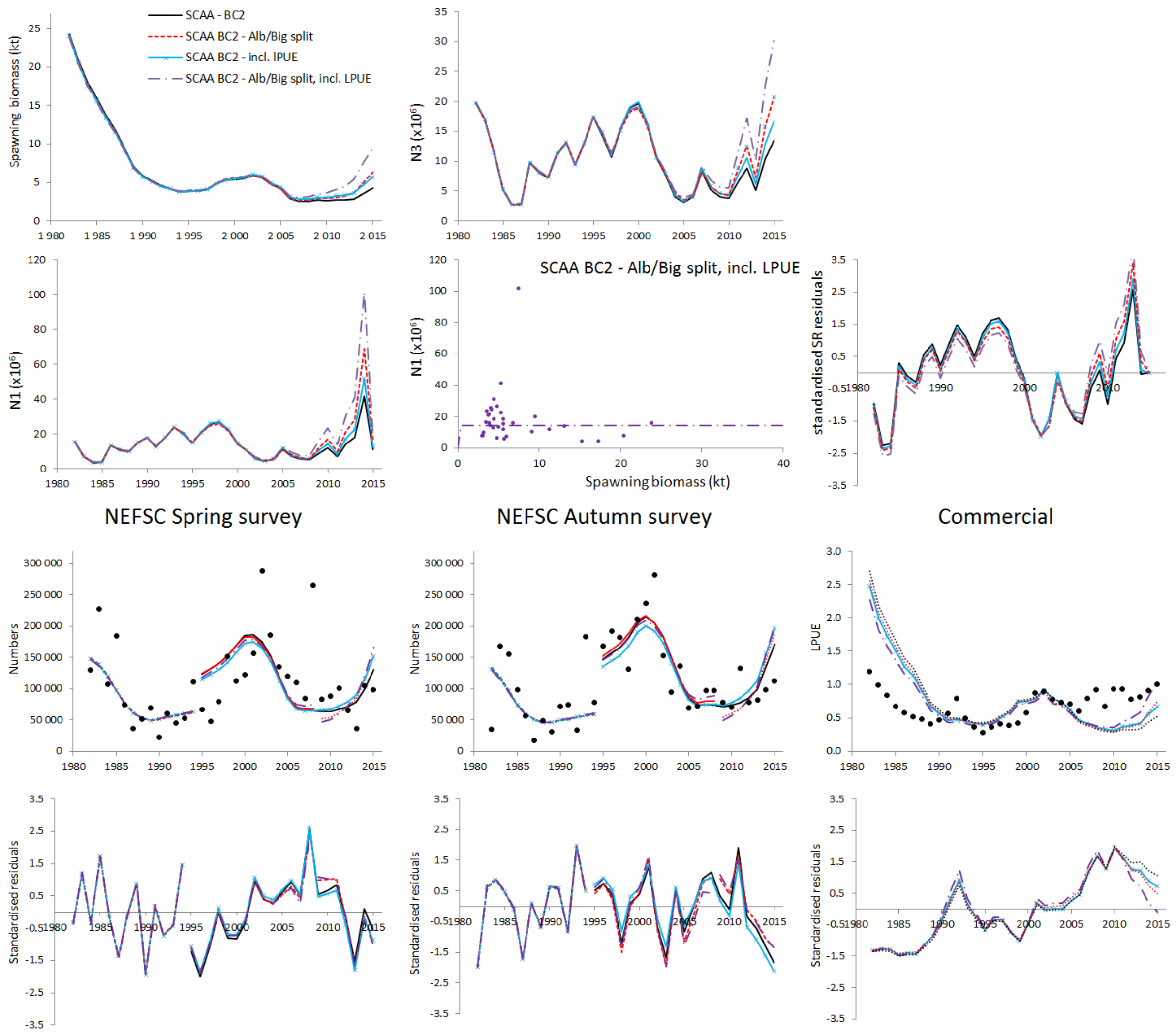


Figure 7: Comparison of the **SCAA BC2** (in black) and **Alb/Big split** (in red), **including LPUE** (in blue) and **BC3** (Alb/Big split and including CPUE, in purple) results.

Figure 8: Comparison of the **SCAA BC3** (in black) and **survey dome** (in red), and $\mathbf{W_{CAA}=0.3}$ (in blue) results.

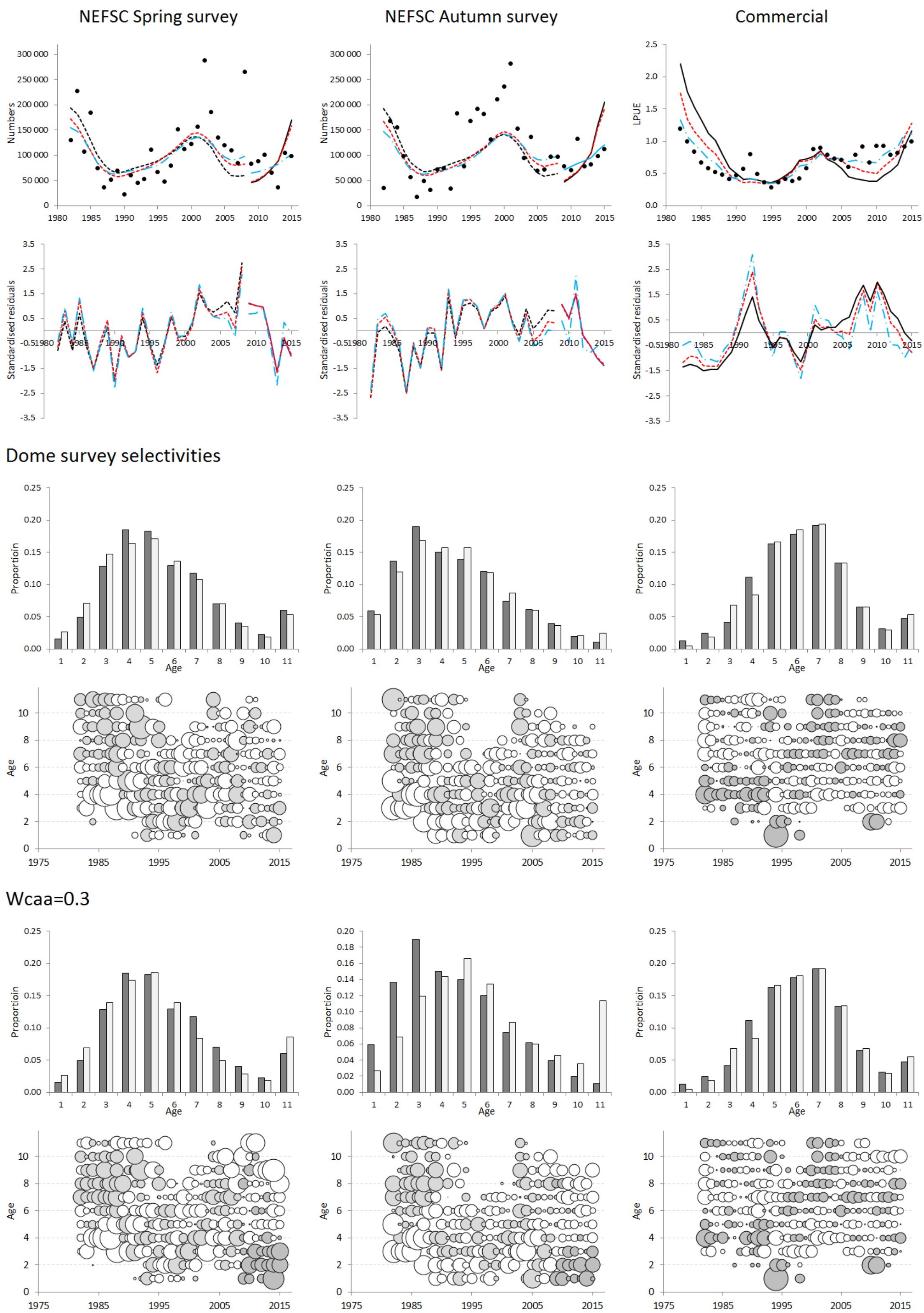


Figure 9: Fit to the survey series for **SCAA B3** (in black), with **dome survey selectivities** (in red) and **downweighting the CAA data** (W_{CAA}=0.3, in blue) and survey and commercial catch-at-age data (averaged over all the years for which data is available – third row – and bubble plots of residuals, with grey bubbles representing positive residuals – bottom row) for the **dome survey** and **downweighting the CAA data** runs.

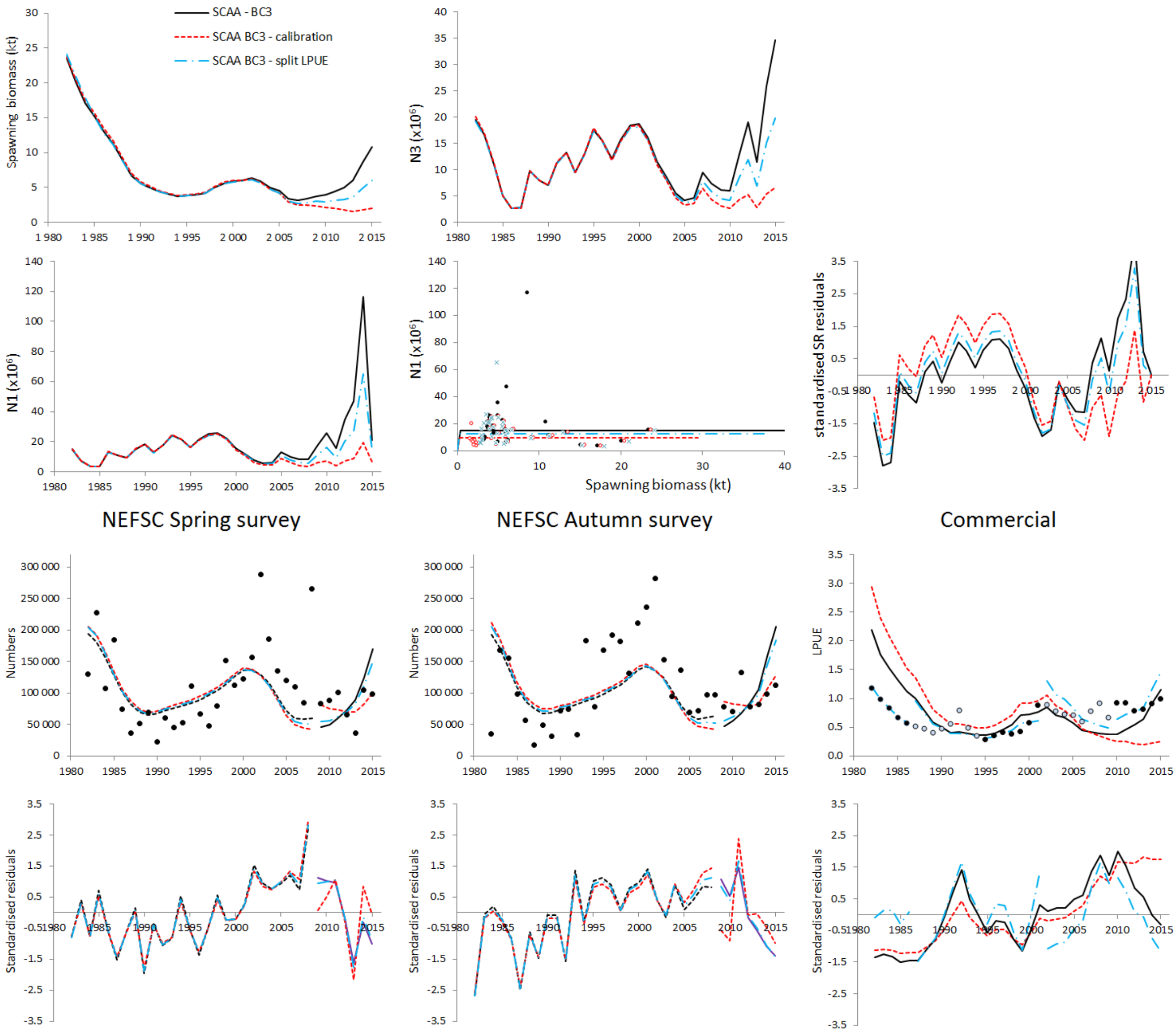


Figure 10: Comparison of the **SCAA BC3** (in black) and **calibration** (in red), and **split LPUE** (in blue) results.

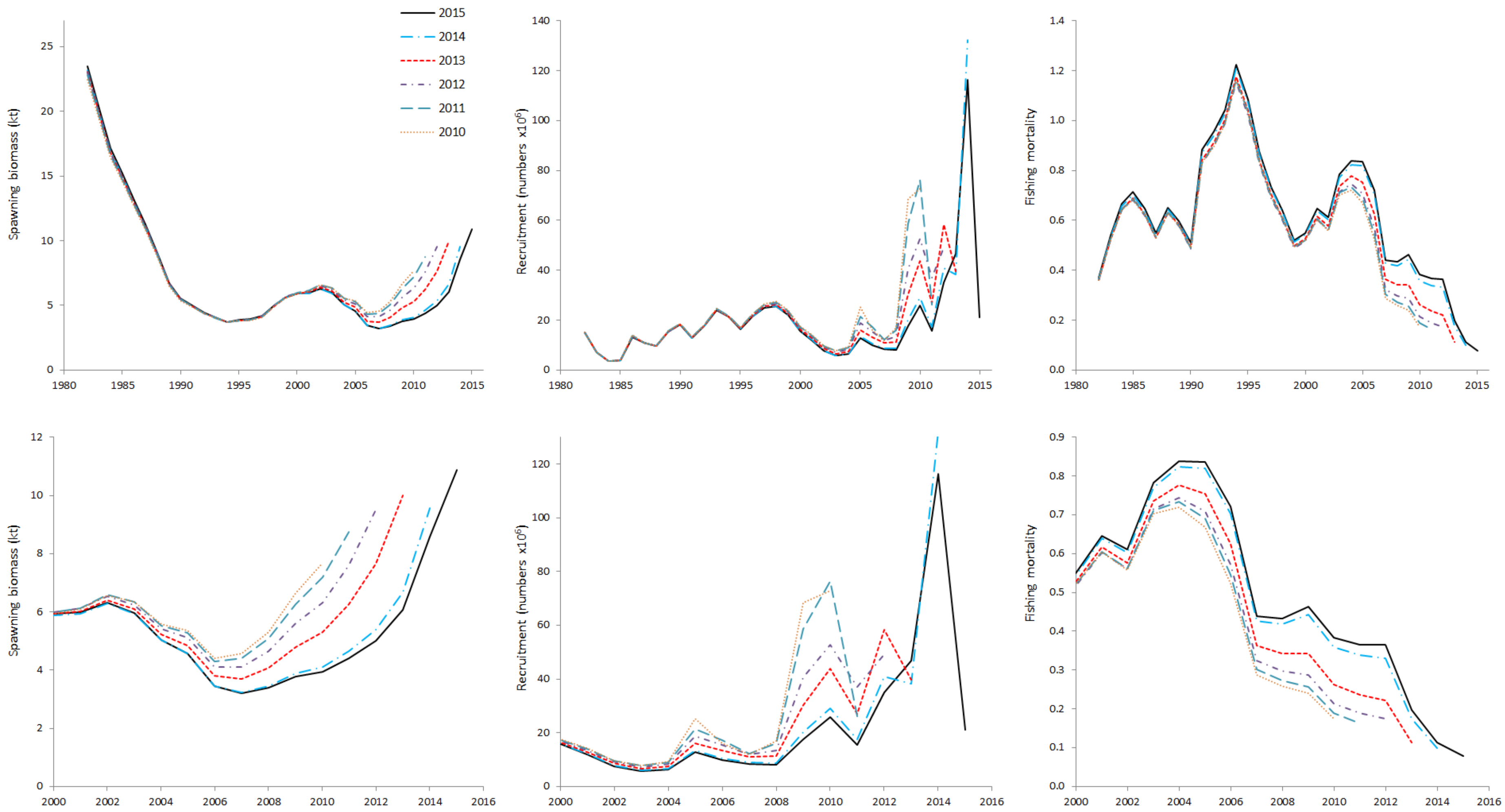


Figure 11: Retrospective plots of spawning biomass, recruitment and (apical – age 8) fishing mortality for SCAA BC3. The bottom row replicates the top row but with different scales.

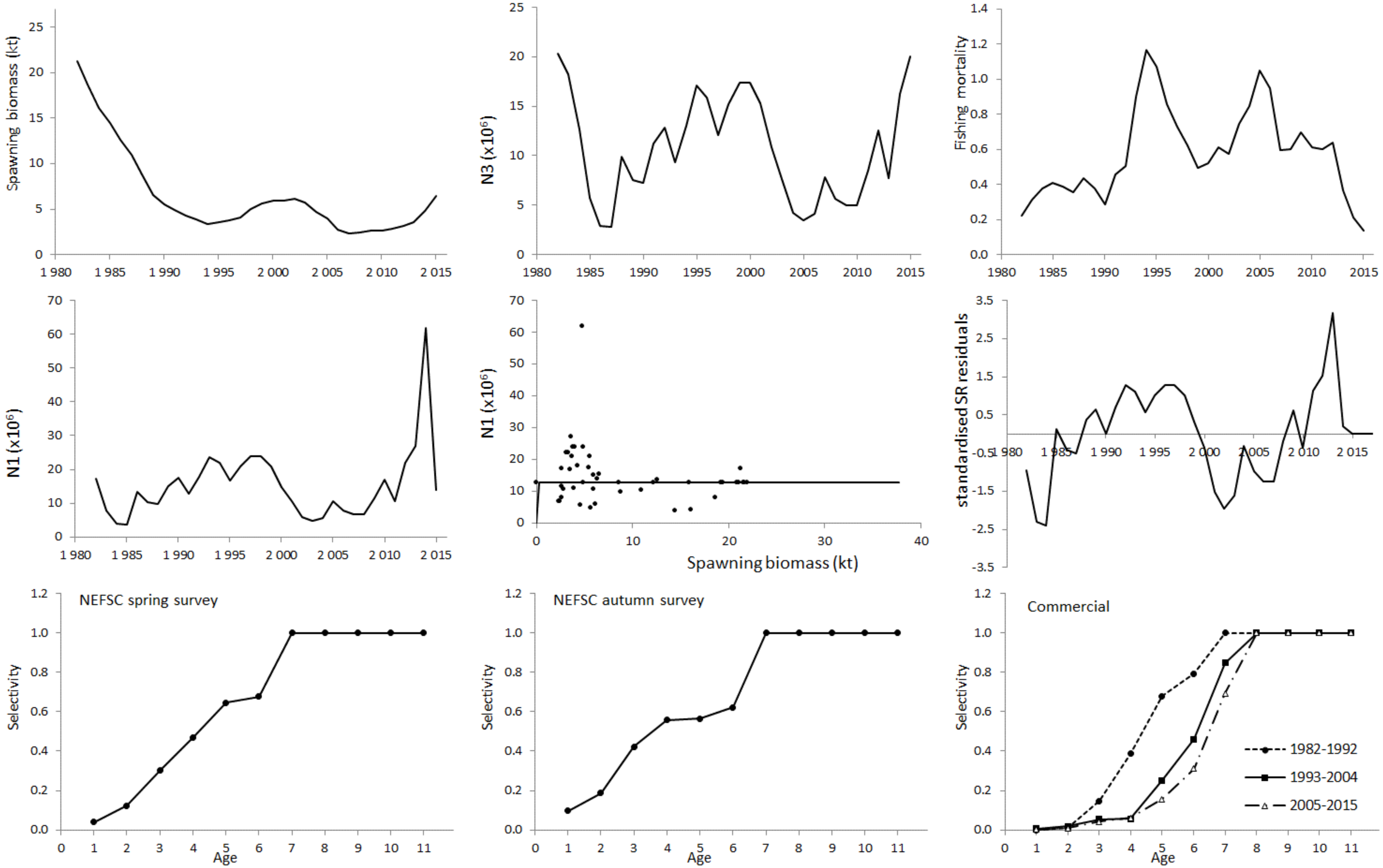


Figure 12: **SCAA Final BC** results.

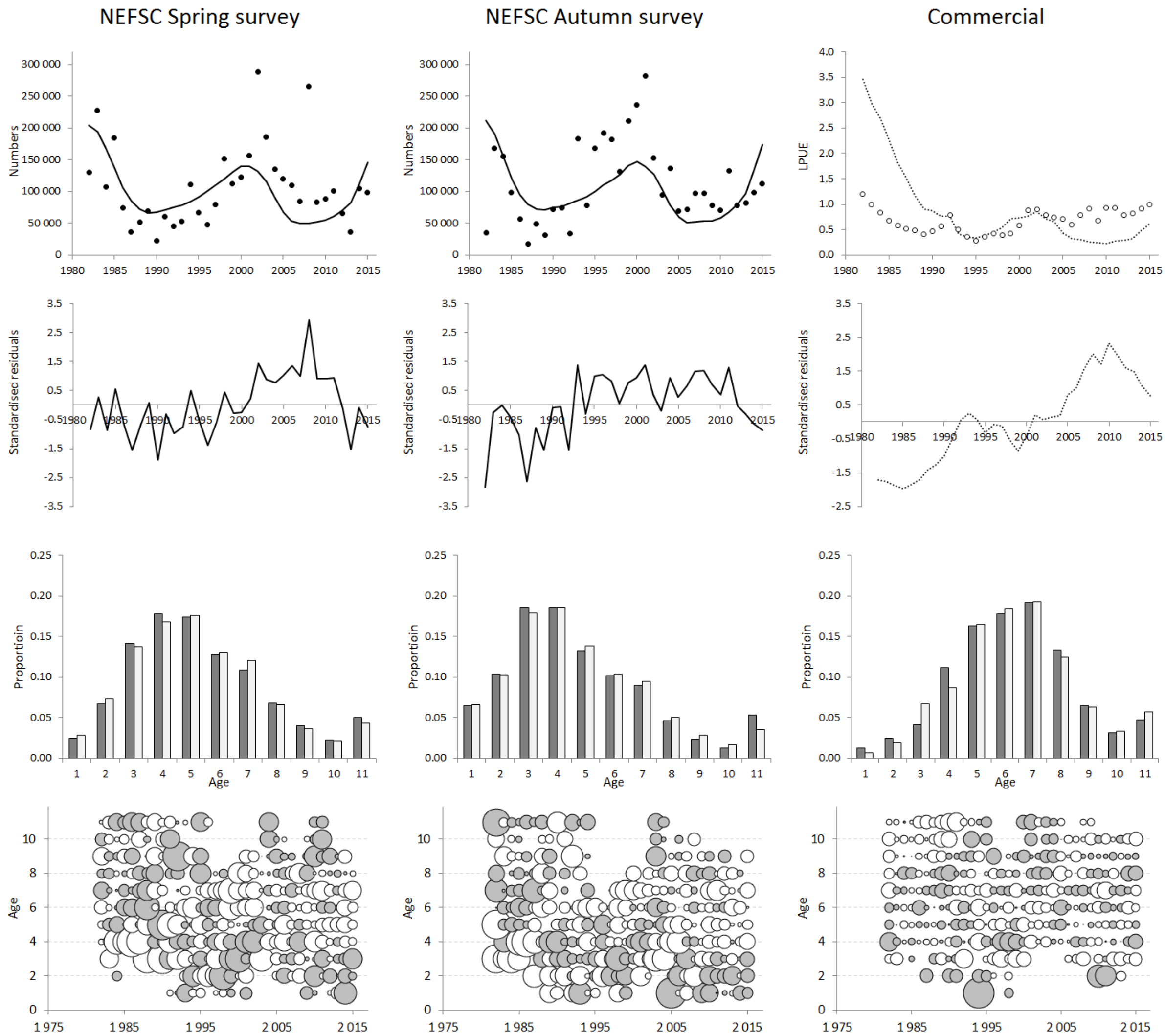


Figure 13: Fit to the survey series and survey and commercial catch-at-age data (averaged over all the years for which data is available – third row – and bubble plots of residuals, with grey bubbles representing positive residuals – bottom row) for the **SCAA Final BC** run.

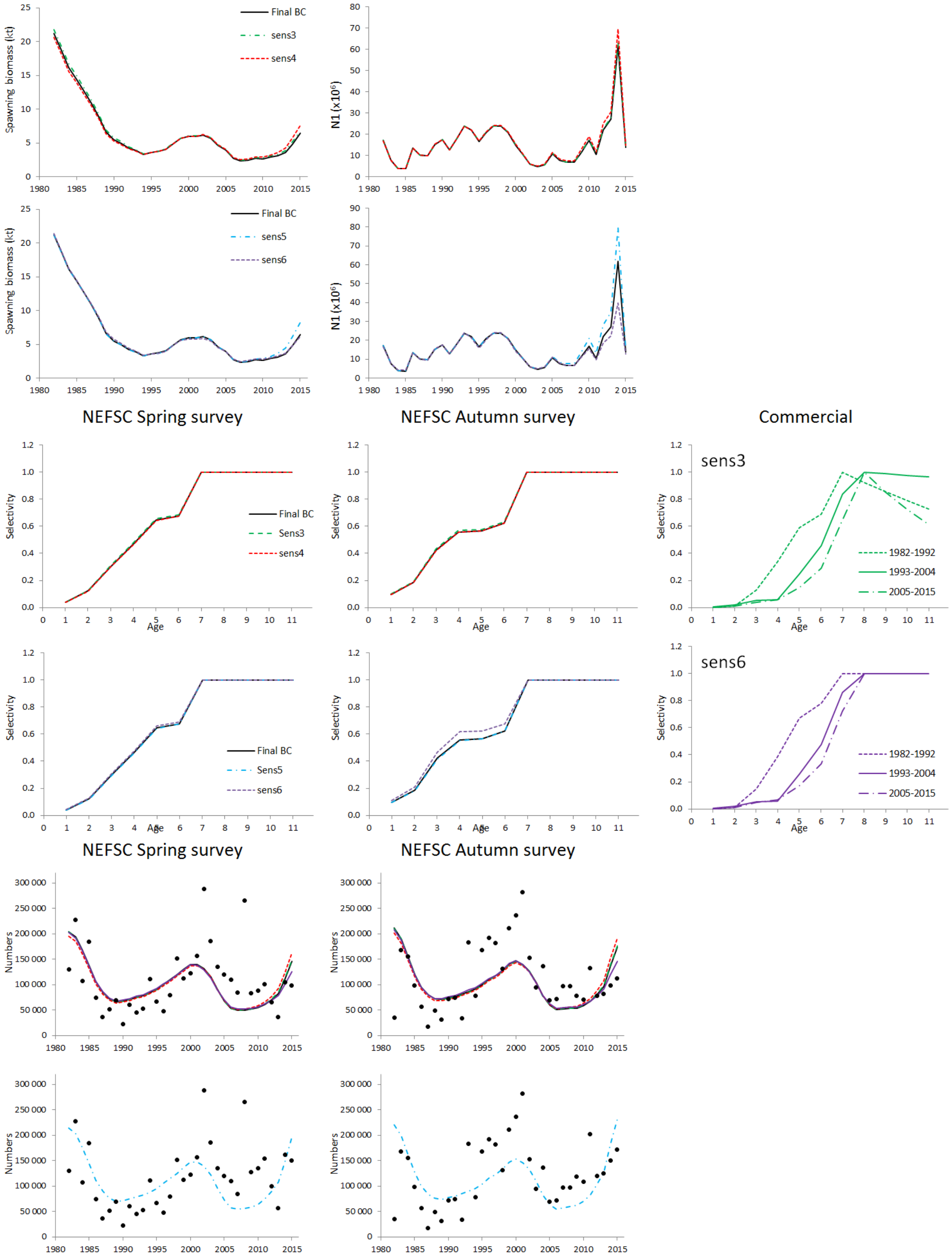


Figure 14: Comparison of the **SCAA Final BC** and four sensitivities: "sens3" (domed fishery and flat survey selectivities), "sens4" (including 40% LPUE), "sens5" (calibration factor halved) and "sens6" (downweighting the CAA data).

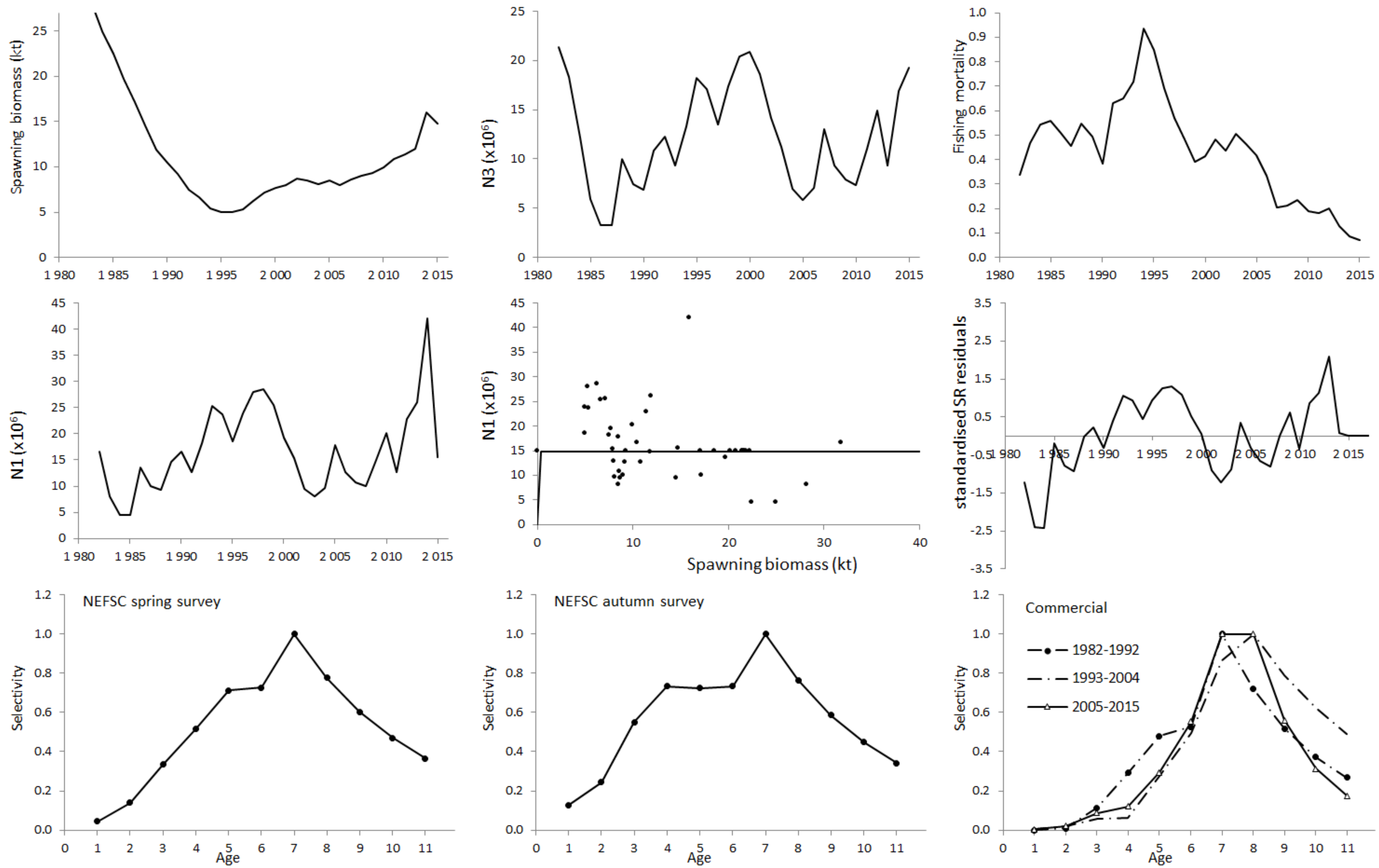


Figure 15: **SCAA sens7** (domed fishery and survey selectivities, including LPUE and downweighting the CAA data) results. Fishing mortality is apical (for age 7).

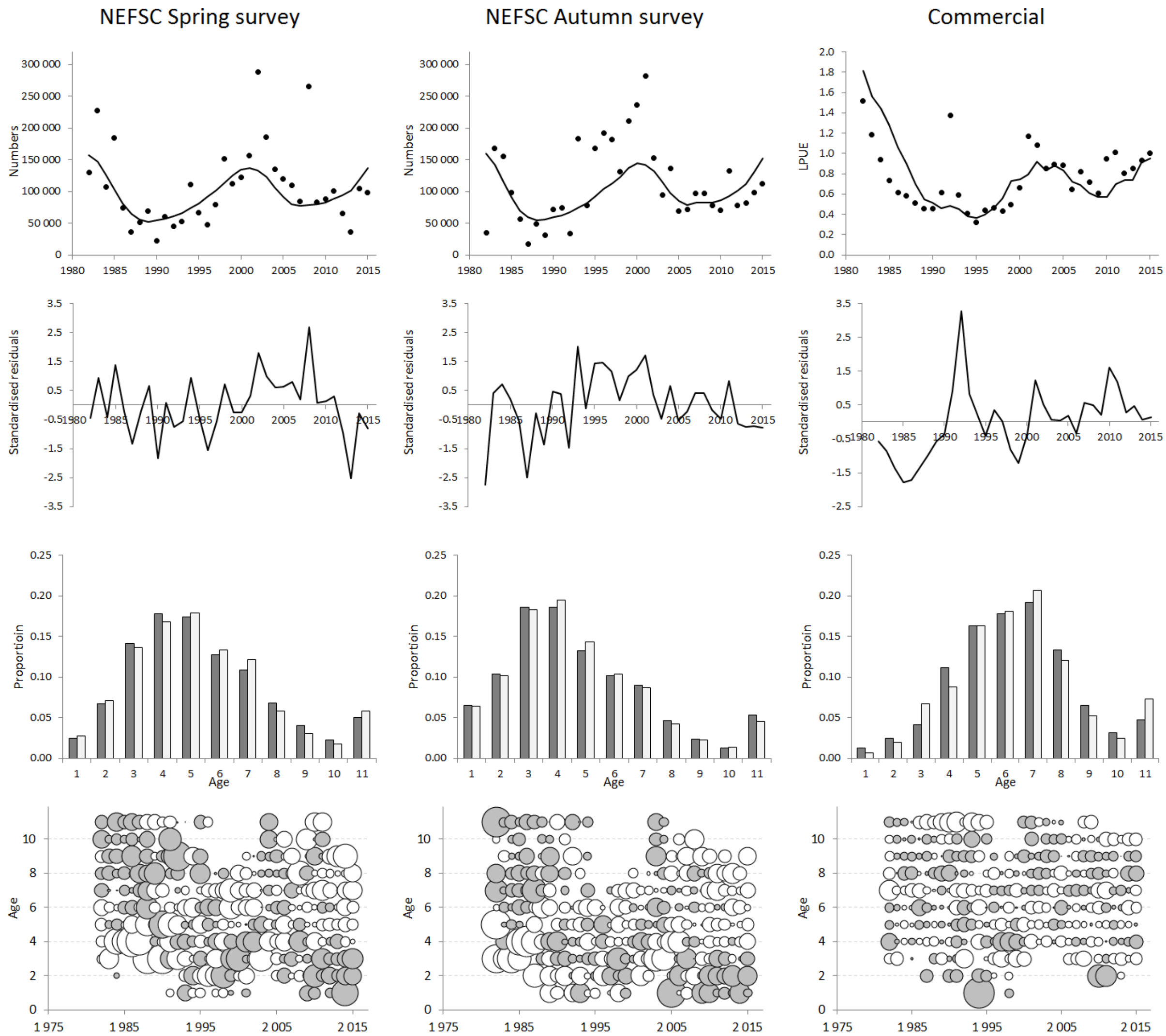


Figure 16: Fit to the survey series and survey and commercial catch-at-age data (averaged over all the years for which data is available – third row – and bubble plots of residuals, with grey bubbles representing positive residuals – bottom row) for the **SCAA sens7** run.

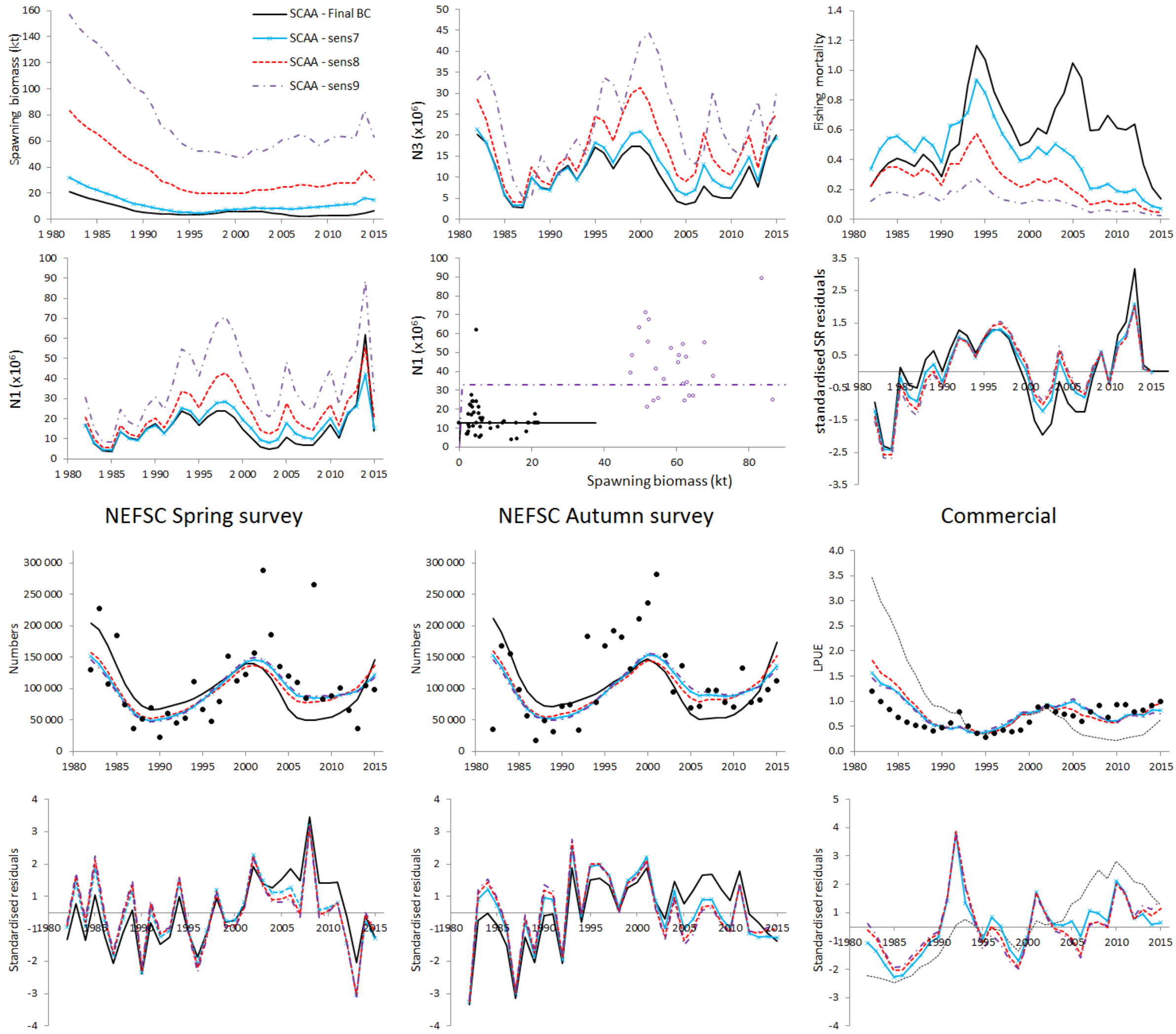


Figure 17: Comparison of the **SCAA Final BC** (in black) and **sens7** (in red, domed fishery and survey selectivities, including LPUE and downweighting the CAA data), sens8 (in blue, as sens7 but with q<=2) and sens9 (in purple, as sens7 but with q<=1) results. Fishing mortality is apical (for age 7).

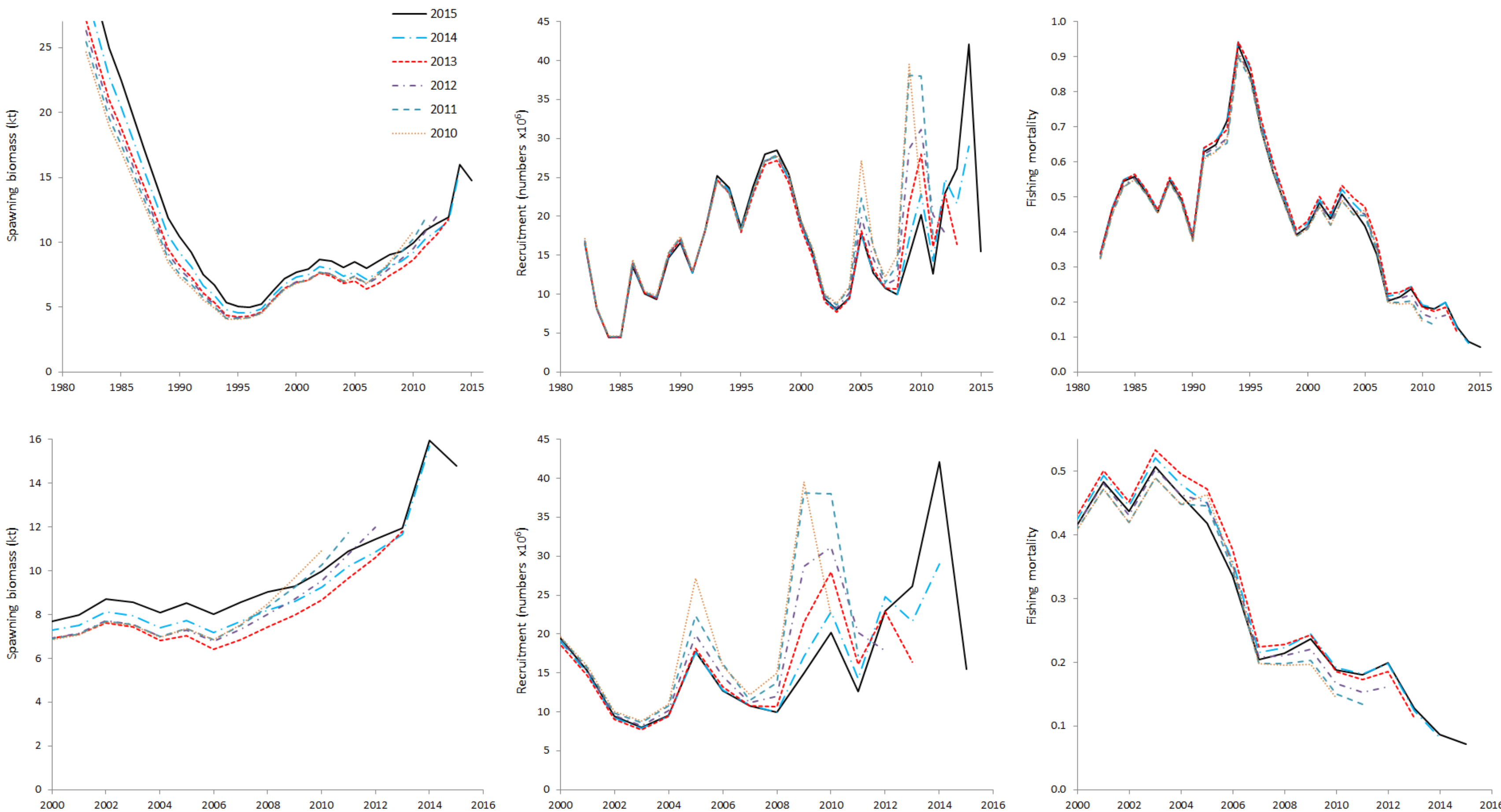


Figure 18: Retrospective plots of spawning biomass, recruitment and (apical – age 7) fishing mortality for SCAA sens7 (domed fishery and survey selectivities, including LPUE and downweighting the CAA data). The bottom row replicates the top row but with different scales.

APPENDIX B3 - Annex A - Data

Table A1: Maturity-at-age (proportions) for witch flounder.

Maturity at age					AGE						
Year	1	2	3	4	5	6	7	8	9	10	11+
1982	0.00	0.00	0.01	0.04	0.14	0.40	0.73	0.92	0.98	0.99	1.00
1983	0.00	0.00	0.01	0.06	0.20	0.51	0.82	0.95	0.99	1.00	1.00
1984	0.00	0.00	0.02	0.07	0.24	0.59	0.86	0.97	0.99	1.00	1.00
1985	0.00	0.00	0.01	0.05	0.24	0.68	0.93	0.99	1.00	1.00	1.00
1986	0.00	0.00	0.02	0.09	0.36	0.76	0.95	0.99	1.00	1.00	1.00
1987	0.00	0.02	0.08	0.30	0.68	0.91	0.98	1.00	1.00	1.00	1.00
1988	0.01	0.03	0.14	0.43	0.78	0.94	0.99	1.00	1.00	1.00	1.00
1989	0.00	0.02	0.09	0.32	0.68	0.91	0.98	1.00	1.00	1.00	1.00
1990	0.01	0.02	0.07	0.20	0.46	0.73	0.90	0.97	0.99	1.00	1.00
1991	0.01	0.02	0.07	0.17	0.38	0.64	0.84	0.94	0.98	0.99	1.00
1992	0.01	0.02	0.06	0.17	0.41	0.70	0.89	0.96	0.99	1.00	1.00
1993	0.00	0.01	0.04	0.13	0.35	0.65	0.87	0.96	0.99	1.00	1.00
1994	0.00	0.01	0.04	0.13	0.34	0.64	0.86	0.96	0.99	1.00	1.00
1995	0.00	0.01	0.03	0.13	0.42	0.78	0.95	0.99	1.00	1.00	1.00
1996	0.00	0.00	0.02	0.12	0.45	0.83	0.96	0.99	1.00	1.00	1.00
1997	0.00	0.00	0.01	0.07	0.37	0.81	0.97	1.00	1.00	1.00	1.00
1998	0.00	0.01	0.04	0.13	0.38	0.71	0.91	0.98	0.99	1.00	1.00
1999	0.00	0.01	0.04	0.14	0.36	0.67	0.88	0.96	0.99	1.00	1.00
2000	0.01	0.02	0.05	0.14	0.33	0.59	0.82	0.93	0.98	0.99	1.00
2001	0.01	0.02	0.06	0.15	0.33	0.58	0.79	0.91	0.97	0.99	1.00
2002	0.02	0.04	0.08	0.17	0.32	0.53	0.72	0.86	0.93	0.97	1.00
2003	0.02	0.04	0.09	0.17	0.31	0.49	0.68	0.82	0.91	0.96	1.00
2004	0.03	0.06	0.11	0.19	0.32	0.49	0.66	0.79	0.89	0.94	1.00
2005	0.04	0.07	0.12	0.22	0.35	0.52	0.68	0.80	0.89	0.94	1.00
2006	0.02	0.04	0.09	0.16	0.29	0.45	0.63	0.78	0.88	0.94	1.00
2007	0.02	0.04	0.08	0.17	0.32	0.52	0.71	0.85	0.93	0.97	1.00
2008	0.01	0.03	0.08	0.19	0.37	0.61	0.80	0.92	0.97	0.99	1.00
2009	0.02	0.04	0.11	0.25	0.47	0.71	0.87	0.95	0.98	0.99	1.00
2010	0.01	0.04	0.10	0.24	0.48	0.73	0.89	0.96	0.99	0.99	1.00
2011	0.02	0.05	0.13	0.29	0.53	0.75	0.89	0.96	0.98	0.99	1.00
2012	0.01	0.04	0.11	0.27	0.52	0.76	0.90	0.96	0.99	1.00	1.00
2013	0.01	0.04	0.11	0.27	0.52	0.76	0.91	0.97	0.99	1.00	1.00
2014	0.01	0.03	0.09	0.23	0.49	0.75	0.91	0.97	0.99	1.00	1.00
2015	0.01	0.03	0.09	0.23	0.49	0.75	0.91	0.97	0.99	1.00	1.00

Table A2: Catch and SSB mean weight-at-age for witch flounder in kg.

Catch mean weights					AGE						
Year	1	2	3	4	5	6	7	8	9	10	11+
1982	0.0029	0.0347	0.0847	0.1744	0.2649	0.4005	0.5499	0.7260	0.8857	0.9828	1.4054
1983	0.0078	0.0380	0.1317	0.1775	0.2370	0.4088	0.5182	0.6131	0.7948	0.9770	1.3573
1984	0.0161	0.0391	0.1192	0.2015	0.3078	0.4208	0.5390	0.6639	0.8168	0.9221	1.3393
1985	0.0163	0.0235	0.1281	0.2168	0.2940	0.4282	0.5648	0.6909	0.8419	0.9640	1.3254
1986	0.0165	0.0255	0.0910	0.1692	0.2727	0.4074	0.5331	0.6759	0.8528	0.9748	1.3208
1987	0.0151	0.0328	0.0873	0.1654	0.2618	0.4323	0.5607	0.6859	0.8282	0.9801	1.3030
1988	0.0061	0.0170	0.0629	0.1902	0.2740	0.4329	0.5376	0.6678	0.8192	0.9801	1.3255
1989	0.0123	0.0313	0.0580	0.1514	0.2395	0.4243	0.5722	0.6796	0.8179	0.9676	1.3574
1990	0.0106	0.0355	0.0580	0.2051	0.2662	0.4404	0.5849	0.6870	0.8482	1.0429	1.4527
1991	0.0139	0.0386	0.0632	0.1756	0.2885	0.3530	0.5770	0.7003	0.8347	0.9724	1.4185
1992	0.0066	0.0209	0.0961	0.2351	0.3302	0.4165	0.6042	0.7387	0.8215	0.8820	1.2430
1993	0.0086	0.0226	0.1005	0.2403	0.3302	0.4314	0.5343	0.6660	0.8820	1.0230	1.3353
1994	0.0045	0.0187	0.0736	0.2144	0.3122	0.4269	0.5260	0.6897	0.8322	0.9085	1.2636
1995	0.0074	0.0269	0.0646	0.1576	0.3001	0.4212	0.5610	0.6914	0.9080	0.9718	1.2377
1996	0.0189	0.0311	0.0607	0.1365	0.2685	0.4213	0.5542	0.7085	0.8568	0.9742	1.2295
1997	0.0234	0.0354	0.0733	0.1959	0.2771	0.3774	0.4973	0.6277	0.8611	1.0302	1.2800
1998	0.0060	0.0287	0.0830	0.1685	0.2535	0.3569	0.4874	0.5856	0.8640	0.9772	1.2088
1999	0.0062	0.0292	0.0930	0.2084	0.2829	0.3976	0.5147	0.5866	0.6324	0.9402	1.0631
2000	0.0060	0.0279	0.0810	0.1747	0.2393	0.3642	0.4512	0.5344	0.6267	0.7149	0.9296
2001	0.0060	0.0245	0.1088	0.1722	0.2415	0.3507	0.4605	0.5500	0.6448	0.6477	0.8431
2002	0.0068	0.0329	0.1024	0.2198	0.2783	0.3963	0.4728	0.5524	0.6519	0.8219	0.9400
2003	0.0072	0.0324	0.0695	0.1582	0.2437	0.3214	0.4195	0.5035	0.5658	0.6211	0.8112
2004	0.0064	0.0479	0.0986	0.2120	0.2611	0.3291	0.4333	0.5374	0.6106	0.6869	0.8701
2005	0.0188	0.0514	0.1090	0.2033	0.2859	0.3543	0.4417	0.5553	0.6323	0.7243	0.9135
2006	0.0121	0.0509	0.0975	0.1978	0.2669	0.3170	0.4532	0.5452	0.6474	0.7124	0.9272
2007	0.0154	0.0410	0.1147	0.1884	0.2495	0.3522	0.4718	0.5636	0.6783	0.7451	0.9149
2008	0.0036	0.0358	0.1241	0.1991	0.2705	0.3928	0.4754	0.5405	0.5986	0.6489	0.8268
2009	0.0402	0.0444	0.1036	0.2030	0.2652	0.3666	0.4528	0.5477	0.6222	0.7260	0.6897
2010	0.0025	0.0116	0.0808	0.1803	0.2526	0.3024	0.4256	0.4993	0.6518	0.6196	0.8102
2011	0.0024	0.0262	0.0933	0.2030	0.2469	0.3430	0.4322	0.5442	0.6483	0.7199	0.8851
2012	0.0065	0.0388	0.1402	0.1843	0.2811	0.3266	0.4382	0.5398	0.6494	0.7195	0.8828
2013	0.0245	0.0941	0.1472	0.2010	0.2669	0.3498	0.4400	0.5304	0.6313	0.6972	0.8755
2014	0.0254	0.0754	0.1319	0.1951	0.2862	0.3764	0.4812	0.5892	0.6927	0.7692	1.3769
2015	0.0264	0.0624	0.1054	0.1612	0.2751	0.3701	0.4683	0.5536	0.6564	0.7556	0.8428

SSB mean weights at age					AGE						
Year	1	2	3	4	5	6	7	8	9	10	11+
1982	0.0008	0.0178	0.0585	0.1496	0.2132	0.3521	0.5208	0.6939	0.8433	0.9330	1.4054
1983	0.0035	0.0105	0.0676	0.1226	0.2033	0.3291	0.4556	0.5806	0.7596	0.9302	1.3573
1984	0.0133	0.0175	0.0673	0.1629	0.2337	0.3158	0.4694	0.5865	0.7077	0.8561	1.3393
1985	0.0130	0.0195	0.0708	0.1608	0.2434	0.3630	0.4875	0.6102	0.7476	0.8874	1.3254
1986	0.0117	0.0204	0.0462	0.1472	0.2431	0.3461	0.4778	0.6179	0.7676	0.9059	1.3208
1987	0.0142	0.0233	0.0472	0.1227	0.2105	0.3433	0.4779	0.6047	0.7482	0.9142	1.3030
1988	0.0027	0.0160	0.0454	0.1289	0.2129	0.3366	0.4821	0.6119	0.7496	0.9010	1.3255
1989	0.0072	0.0138	0.0314	0.0976	0.2134	0.3410	0.4977	0.6044	0.7390	0.8903	1.3574
1990	0.0056	0.0209	0.0426	0.1091	0.2008	0.3248	0.4982	0.6270	0.7592	0.9236	1.4527
1991	0.0113	0.0202	0.0474	0.1009	0.2433	0.3065	0.5041	0.6400	0.7573	0.9082	1.4185
1992	0.0036	0.0170	0.0609	0.1219	0.2408	0.3466	0.4618	0.6529	0.7585	0.8580	1.2430
1993	0.0058	0.0122	0.0458	0.1520	0.2786	0.3774	0.4717	0.6343	0.8072	0.9167	1.3353
1994	0.0018	0.0127	0.0408	0.1468	0.2739	0.3754	0.4764	0.6070	0.7445	0.8952	1.2636
1995	0.0036	0.0110	0.0348	0.1077	0.2537	0.3626	0.4894	0.6031	0.7914	0.8993	1.2377
1996	0.0138	0.0152	0.0404	0.0939	0.2057	0.3556	0.4831	0.6305	0.7697	0.9405	1.2295
1997	0.0211	0.0259	0.0477	0.1090	0.1945	0.3183	0.4577	0.5898	0.7811	0.9395	1.2800
1998	0.0027	0.0259	0.0542	0.1111	0.2228	0.3145	0.4289	0.5396	0.7364	0.9173	1.2088
1999	0.0029	0.0132	0.0517	0.1315	0.2183	0.3175	0.4286	0.5347	0.6086	0.9013	1.0631
2000	0.0030	0.0132	0.0486	0.1275	0.2233	0.3210	0.4236	0.5245	0.6063	0.6724	0.9296
2001	0.0026	0.0121	0.0551	0.1181	0.2054	0.2897	0.4095	0.4982	0.5870	0.6371	0.8431
2002	0.0031	0.0140	0.0501	0.1546	0.2189	0.3094	0.4072	0.5044	0.5988	0.7280	0.9400
2003	0.0028	0.0148	0.0478	0.1273	0.2314	0.2991	0.4077	0.4879	0.5591	0.6363	0.8112
2004	0.0023	0.0186	0.0565	0.1214	0.2032	0.2832	0.3732	0.4748	0.5545	0.6234	0.8701
2005	0.0114	0.0181	0.0723	0.1416	0.2462	0.3042	0.3813	0.4905	0.5829	0.6650	0.9135
2006	0.0066	0.0309	0.0708	0.1468	0.2329	0.3010	0.4007	0.4907	0.5996	0.6712	0.9272
2007	0.0101	0.0223	0.0764	0.1355	0.2222	0.3066	0.3867	0.5054	0.6081	0.6945	0.9149
2008	0.0010	0.0235	0.0713	0.1511	0.2257	0.3131	0.4092	0.5050	0.5808	0.6634	0.8268
2009	0.0748	0.0126	0.0609	0.1587	0.2298	0.3149	0.4217	0.5103	0.5799	0.6592	0.6897
2010	0.0008	0.0216	0.0599	0.1367	0.2264	0.2832	0.3950	0.4755	0.5975	0.6209	0.8102
2011	0.0006	0.0081	0.0329	0.1281	0.2110	0.2943	0.3615	0.4813	0.5689	0.6850	0.8851
2012	0.0017	0.0096	0.0606	0.1311	0.2389	0.2840	0.3877	0.4830	0.5945	0.6830	0.8828
2013	0.0140	0.0247	0.0756	0.1679	0.2218	0.3136	0.3791	0.4821	0.5838	0.6729	0.8755
2014	0.0162	0.0430	0.1114	0.1695	0.2398	0.3170	0.4103	0.5092	0.6061	0.6968	1.3769
2015	0.0175	0.0398	0.0891	0.1458	0.2317	0.3255	0.4198	0.5161	0.6219	0.7235	0.8428

Table A3: Commercial catch-at-age (numbers) and total catch in metric tons.

	USA Commercial Catch in Numbers (1000's) at Age											
						Age						Total weight
Year	1	2	3	4	5	6	7	8	9	10	11+	(MT)
1982	0.567	5.607	569.606	2639.517	1783.427	1630.697	679.992	666.996	402.621	240.837	1581.769	5308.91
1983	0.116	6.857	450.599	2107.911	2179.089	1597.730	1607.434	986.839	741.867	511.969	1677.879	6408.60
1984	0.838	2.185	222.633	2142.118	2302.064	1761.252	1497.367	1505.305	700.016	376.358	1720.203	6936.86
1985	1.016	9.966	365.703	1556.639	2311.335	1957.652	1536.384	1254.371	608.287	401.366	1360.878	6339.35
1986	1.760	12.411	68.090	701.335	1941.511	2806.150	1582.601	842.199	415.715	223.989	760.189	4787.66
1987	33.867	143.655	55.777	334.163	813.067	1318.507	1602.784	881.442	484.684	254.450	492.585	3644.02
1988	10.788	94.742	767.854	288.380	421.124	688.357	1414.635	1168.934	405.564	268.794	600.688	3451.38
1989	17.726	90.405	192.085	1180.069	503.974	344.911	792.398	911.628	356.871	125.750	352.580	2424.98
1990	4.058	138.838	367.034	604.478	1158.980	284.554	295.391	493.800	347.107	84.961	182.239	1743.82
1991	25.191	245.711	1152.476	1595.278	2002.075	1012.933	256.209	260.502	303.311	323.813	264.151	2571.13
1992	30.959	97.582	196.151	1524.221	1531.463	1271.739	756.764	204.313	180.413	121.551	380.915	2751.97
1993	57.850	79.558	73.255	958.623	1386.252	924.061	600.316	586.487	218.566	278.058	389.811	2805.73
1994	2921.323	1061.537	100.681	738.916	2208.789	1371.979	981.975	202.511	548.804	114.695	335.580	3115.31
1995	48.454	683.181	864.719	881.761	1463.417	1912.799	879.927	284.820	103.323	282.725	162.006	2717.99
1996	104.172	163.173	390.327	678.510	1162.319	1383.912	1444.920	266.553	218.007	57.733	114.883	2392.45
1997	60.909	89.881	129.710	994.288	1189.272	1404.670	1114.704	649.761	90.470	51.734	71.978	2254.24
1998	161.398	152.609	347.466	865.764	1285.410	1486.022	1652.813	387.595	151.864	16.555	74.448	2306.24
1999	70.388	83.006	147.616	704.019	1262.546	1504.897	1224.363	783.738	260.975	38.072	75.759	2490.21
2000	101.892	78.759	132.663	497.238	708.860	1223.361	1758.267	1051.961	585.766	100.785	256.693	2748.76
2001	39.078	27.781	61.710	464.584	1315.658	1198.923	1766.246	1471.324	640.224	431.876	314.977	3406.43
2002	16.311	14.570	37.143	652.752	1210.582	1392.170	2167.130	1288.619	649.988	97.094	206.364	3470.39
2003	1.989	11.663	42.955	364.779	1300.668	1737.052	1944.153	1591.591	764.205	444.261	356.777	3550.97
2004	0.760	16.012	48.583	448.668	1408.064	1795.719	1589.928	1179.364	813.028	335.933	299.951	3370.06
2005	11.001	36.517	30.657	275.372	993.733	1996.458	1859.272	848.055	424.964	242.450	139.426	2916.83
2006	6.972	53.352	126.192	134.464	344.545	946.998	1624.709	901.303	369.128	140.072	80.217	2074.69
2007	4.753	29.889	144.450	179.640	174.494	310.973	905.672	607.730	175.451	99.340	46.482	1210.13
2008	1.200	22.313	55.445	293.238	242.925	352.223	617.315	466.765	317.030	113.232	68.711	1135.94
2009	0.622	25.127	40.691	238.696	562.298	339.983	527.421	485.433	338.646	80.674	81.078	1157.43
2010	29.169	370.005	80.707	110.936	314.626	543.392	308.355	407.329	182.763	234.229	47.800	912.33
2011	46.437	346.598	245.024	149.018	255.107	671.757	630.503	447.907	162.104	86.122	36.051	1070.97
2012	6.487	57.336	167.776	270.315	355.504	480.603	820.808	594.319	221.193	88.867	41.837	1257.51
2013	3.498	48.004	43.095	204.821	227.644	296.599	475.140	331.940	185.173	84.216	38.165	810.76
2014	1.778	19.497	134.520	104.032	220.835	181.621	280.031	337.879	136.972	48.589	27.467	675.03
2015	0.367	19.947	94.246	189.642	133.565	250.096	266.993	290.772	121.793	36.562	24.117	584.97

Table A4: Swept area NEFSC spring and autumn abundance indices, in Albacore and Bigelow units.

	SWEPT AREA (using q=0.056) ALB units				SWEPT AREA (using q=0.291) BIG units			
	NEFSC SPRING 82-15		NEFSC AUTUMN 82-15		NEFSC SPRING 09-15		NEFSC AUTUMN 09-15	
Year	number of fish (1000's)	CV	number of fish (1000's)	CV	number of fish (1000's)	CV	number of fish (1000's)	CV
1982	129606.3	0.222	35252.9	0.405				
1983	227996.6	0.270	167921.8	0.142				
1984	106806.6	0.161	155613.9	0.139				
1985	184410.5	0.193	98346.6	0.197				
1986	73755.0	0.158	56589.0	0.155				
1987	35842.4	0.232	17164.6	0.330				
1988	51019.4	0.233	48960.6	0.173				
1989	69222.5	0.217	31594.7	0.196				
1990	22280.8	0.303	71335.4	0.164				
1991	59922.2	0.250	74125.9	0.276				
1992	44844.1	0.182	33440.8	0.300				
1993	52284.2	0.177	183434.3	0.250				
1994	111366.2	0.226	78606.8	0.164				
1995	66998.9	0.169	168542.1	0.196				
1996	48353.2	0.169	191619.0	0.191				
1997	78953.1	0.267	181668.8	0.196				
1998	152102.7	0.175	131720.9	0.201				
1999	112072.3	0.205	210496.1	0.219				
2000	122631.3	0.140	235959.9	0.152				
2001	156908.6	0.163	282569.2	0.162				
2002	288301.8	0.203	153417.0	0.190				
2003	185206.3	0.161	94667.4	0.190				
2004	135215.4	0.126	135788.0	0.318				
2005	119655.8	0.203	68773.0	0.185				
2006	109855.5	0.139	72240.0	0.193				
2007	84329.7	0.165	97526.6	0.228				
2008	265119.9	0.250	97791.4	0.171				
2009	83344.3	0.147	77611.0	0.190	83585.8	0.147	77835.9	0.171
2010	87963.7	0.138	71166.0	0.169	88218.5	0.138	71372.2	0.190
2011	100384.0	0.114	132068.3	0.206	100674.8	0.114	132450.9	0.169
2012	64898.9	0.122	78020.3	0.196	65086.9	0.122	78246.3	0.206
2013	36990.5	0.134	82070.2	0.177	37097.7	0.134	82308.0	0.196
2014	105369.9	0.152	98359.0	0.168	105675.2	0.152	98644.0	0.177
2015	98629.5	0.147	112338.1	0.132	98915.2	0.147	112663.6	0.168

Table A5: Stratified mean number per tow at age of witch flounder in NEFSC spring and autumn surveys.

NEFSC SPRING 82-15 (ALB units)					Age						
Year	1	2	3	4	5	6	7	8	9	10	11+
1982	0.0442	0.0418	0.6096	0.4838	0.3766	0.2367	0.6084	0.3621	0.0932	0.2593	0.5269
1983	0.0000	0.0710	0.5312	1.2615	1.2933	0.5410	0.7163	0.6324	0.4754	0.2141	0.6712
1984	0.0000	0.1032	0.0115	0.3071	0.7774	0.4013	0.3096	0.2017	0.1961	0.1147	0.5791
1985	0.0000	0.0000	0.0167	0.4592	1.0572	1.1994	0.9077	0.4121	0.1478	0.1487	0.8335
1986	0.0000	0.0000	0.0000	0.0439	0.2403	0.5286	0.4118	0.1719	0.1942	0.0792	0.4032
1987	0.0000	0.0000	0.0000	0.0589	0.1139	0.1328	0.2595	0.1855	0.0095	0.0614	0.1862
1988	0.0228	0.0229	0.0620	0.0000	0.0724	0.3000	0.3790	0.2386	0.1372	0.0863	0.1127
1989	0.0229	0.0130	0.0360	1.0044	0.1055	0.0728	0.0812	0.3275	0.0812	0.0152	0.1858
1990	0.0081	0.0000	0.0375	0.0913	0.3196	0.0000	0.0421	0.0087	0.0504	0.0176	0.0512
1991	0.0418	0.0000	0.7803	0.1084	0.0871	0.2087	0.0329	0.1008	0.0828	0.1377	0.1036
1992	0.0545	0.0087	0.1869	0.3727	0.0852	0.1106	0.1519	0.0450	0.1486	0.0153	0.0812
1993	0.1485	0.1122	0.1373	0.4723	0.3196	0.0577	0.0854	0.0000	0.0155	0.0155	0.1055
1994	0.1073	0.6974	0.5409	0.6436	0.8104	0.1644	0.0269	0.0281	0.0704	0.0083	0.0320
1995	0.0405	0.1198	0.5812	0.3157	0.1789	0.3119	0.1162	0.1102	0.0420	0.0000	0.0665
1996	0.0168	0.0356	0.2436	0.3944	0.3456	0.2185	0.0725	0.0000	0.0000	0.0000	0.0320
1997	0.0721	0.0663	0.1521	0.6926	0.6169	0.4375	0.0842	0.0827	0.0144	0.0000	0.0000
1998	0.1121	1.0788	0.7123	0.3881	0.7980	0.7131	0.2143	0.1536	0.0758	0.0000	0.0284
1999	0.1058	0.3758	0.9738	0.7970	0.4825	0.1643	0.1824	0.0306	0.0144	0.0228	0.0000
2000	0.0065	0.2504	1.1938	0.6925	0.6595	0.2393	0.2527	0.1159	0.0000	0.0354	0.0000
2001	0.1051	0.0988	0.7126	1.4758	1.0199	0.4008	0.2930	0.1629	0.1128	0.0281	0.0000
2002	0.0229	0.0599	0.8972	2.6274	2.2633	0.8223	0.6832	0.3507	0.1915	0.1027	0.0802
2003	0.0000	0.0000	0.1498	0.8079	1.6464	1.0167	0.8686	0.3871	0.1969	0.0455	0.0855
2004	0.0092	0.0601	0.0738	0.4280	0.6485	0.8090	0.8828	0.3683	0.1581	0.1607	0.2017
2005	0.0109	0.1600	0.1464	0.2195	0.7375	0.7602	0.5744	0.3832	0.2450	0.0865	0.0392
2006	0.0435	0.4604	0.3473	0.1380	0.2072	0.6833	0.5681	0.4101	0.1451	0.0688	0.0151
2007	0.0000	0.1778	0.5707	0.2627	0.2413	0.2284	0.5462	0.1536	0.1584	0.0000	0.0306
2008	0.0109	0.3722	0.8475	2.8342	1.3407	0.6455	0.7243	0.5501	0.0882	0.0364	0.0000
2009	0.1349	0.1395	0.2897	0.4283	0.5745	0.2058	0.1552	0.2206	0.1204	0.0566	0.0172
2010	0.1389	0.4514	0.2682	0.1681	0.4199	0.4712	0.1417	0.1016	0.1849	0.0657	0.0604
2011	0.0349	0.3652	0.7009	0.2677	0.3045	0.4695	0.2827	0.1176	0.0883	0.1150	0.0744
2012	0.0894	0.1875	0.3870	0.3293	0.1559	0.2321	0.1597	0.1585	0.0753	0.0339	0.0160
2013	0.0356	0.1239	0.1391	0.2793	0.1444	0.0870	0.1090	0.0655	0.0312	0.0186	0.0055
2014	0.5757	0.4474	0.6763	0.2635	0.4316	0.2091	0.1365	0.1383	0.0823	0.0000	0.0000
2015	0.0316	0.5818	0.7549	0.4608	0.2345	0.3200	0.1516	0.1511	0.0526	0.0201	0.0127

NEFSC AUTUMN 82-15 (ALB units)					Age						
Year	1	2	3	4	5	6	7	8	9	10	11+
1982	0.0000	0.0000	0.0575	0.0131	0.0270	0.0757	0.2409	0.1323	0.0146	0.0274	0.3825
1983	0.0081	0.0109	0.5071	1.5958	0.7575	0.5480	0.4442	0.0837	0.1373	0.0730	0.5529
1984	0.0000	0.0000	0.0933	0.9437	0.9913	0.6049	0.5348	0.3097	0.1489	0.1256	0.6210
1985	0.0000	0.0086	0.0588	0.0757	0.6102	0.6840	0.4825	0.2698	0.1027	0.1222	0.3497
1986	0.0000	0.0000	0.0000	0.0510	0.2665	0.3533	0.3085	0.1598	0.1120	0.0093	0.3217
1987	0.0000	0.0229	0.0000	0.0109	0.0229	0.0457	0.1921	0.0714	0.0000	0.0086	0.1077
1988	0.0065	0.0000	0.7247	0.0545	0.0115	0.0356	0.2148	0.0484	0.0463	0.0454	0.1880
1989	0.0182	0.0182	0.0817	0.3006	0.0091	0.0211	0.0166	0.0838	0.0784	0.0237	0.0629
1990	0.0881	0.1369	0.3801	0.5379	0.1881	0.0240	0.0229	0.0229	0.0251	0.0000	0.0981
1991	0.0211	0.1776	0.6610	0.3292	0.2899	0.1449	0.0673	0.0591	0.0296	0.0518	0.0281
1992	0.0293	0.1092	0.2585	0.2236	0.0536	0.0604	0.0000	0.0000	0.0189	0.0092	0.0804
1993	0.6718	0.1542	0.5442	0.7771	0.2194	0.0579	0.0217	0.0814	0.0000	0.0192	0.0675
1994	0.1559	0.2872	0.5314	0.1652	0.3952	0.0370	0.1061	0.0000	0.0425	0.0091	0.0476
1995	0.2027	0.7643	1.6238	0.8576	0.4722	0.2291	0.0000	0.0000	0.0108	0.0545	0.0091
1996	0.0914	0.2608	0.7853	1.9876	1.3861	0.4412	0.0655	0.0648	0.0373	0.0000	0.0330
1997	0.3389	0.9789	0.5223	0.8709	0.7696	0.3831	0.3296	0.0000	0.0000	0.0000	0.0195
1998	0.0817	0.5199	1.3626	0.4652	0.3030	0.1652	0.1102	0.0425	0.0123	0.0000	0.0000
1999	0.5213	1.1781	1.5137	1.0439	0.5997	0.3634	0.2754	0.0498	0.0370	0.0094	0.0000
2000	0.0957	0.7187	1.4082	1.7460	0.6739	0.5891	0.2294	0.1517	0.0495	0.0000	0.0260
2001	0.0393	0.2105	0.9525	3.1557	1.8858	0.8130	0.6119	0.1586	0.0575	0.0556	0.0000
2002	0.0000	0.2748	0.4309	1.4752	0.9971	0.5319	0.3307	0.1485	0.0711	0.0000	0.0507
2003	0.0000	0.0383	0.0752	0.3067	0.5804	0.7696	0.3150	0.1286	0.2223	0.0828	0.1235
2004	0.0723	0.0144	0.0863	0.4529	0.9866	0.8263	0.4978	0.3550	0.0541	0.1048	0.0901
2005	0.6350	0.0868	0.0229	0.1309	0.1809	0.2693	0.3399	0.0548	0.0522	0.0117	0.0162
2006	0.1029	0.5398	0.3217	0.0460	0.1043	0.2982	0.2864	0.1379	0.0710	0.0420	0.0144
2007	0.0650	0.1615	1.2063	0.4776	0.1880	0.2198	0.2609	0.0691	0.0777	0.0000	0.0144
2008	0.0212	0.0952	0.4220	0.7936	0.2730	0.2537	0.2345	0.3022	0.0136	0.0565	0.0081
2009	0.3842	0.1863	0.1984	0.3770	0.4540	0.1534	0.1379	0.1152	0.0677	0.0043	0.0085
2010	0.4016	0.4686	0.1833	0.2115	0.1678	0.2512	0.0514	0.1162	0.0625	0.0193	0.0238
2011	0.2285	0.8690	1.0769	0.4022	0.2800	0.4395	0.1801	0.0751	0.0475	0.0604	0.0112
2012	0.2612	0.3079	0.6442	0.3154	0.1407	0.2156	0.1347	0.0571	0.0586	0.0318	0.0106
2013	0.1878	0.4858	0.1902	0.4620	0.2378	0.0420	0.1046	0.0572	0.0258	0.0045	0.0000
2014	0.6832	0.3263	0.5346	0.2361	0.3794	0.1419	0.1395	0.1402	0.0379	0.0076	0.0209
2015	0.1501	0.9330	0.8293	0.3310	0.1604	0.3086	0.1306	0.0512	0.0599	0.0140	0.0034

Table A6: >25% target LPUE

LPUE	**Trips 25**	
Year	Index	CV
1982	1.193	0.05
1983	0.998	0.05
1984	0.842	0.04
1985	0.674	0.04
1986	0.582	0.04
1987	0.521	0.05
1988	0.481	0.05
1989	0.415	0.05
1990	0.476	0.06
1991	0.569	0.07
1992	0.794	0.06
1993	0.497	0.05
1994	0.362	0.04
1995	0.282	0.05
1996	0.362	0.05
1997	0.417	0.05
1998	0.387	0.05
1999	0.423	0.04
2000	0.580	0.04
2001	0.878	0.04
2002	0.901	0.04
2003	0.785	0.04
2004	0.734	0.04
2005	0.711	0.04
2006	0.600	0.05
2007	0.787	0.05
2008	0.921	0.06
2009	0.675	0.06
2010	0.931	0.07
2011	0.930	0.06
2012	0.785	0.05
2013	0.819	0.05
2014	0.914	0.05
2015	1.000	

APPENDIX B3 - Annex B

Algebraic details of the Statistical Catch-at-Age Model

The text following sets out the equations and other general specifications of the Statistical Catch-at-Age assessment model applied to witch flounder, followed by details of the contributions to the (penalised) log-likelihood function from the different sources of data available and assumptions concerning the stock-recruitment relationship. Quasi-Newton minimization is applied to minimize the total negative log-likelihood function to estimate parameter values (the package AD Model Builder^{TM}, Otter Research, Ltd is used for this purpose).

Where options are provided under a particular section, the section concludes with a statement in **bold** as to which option was selected for the iinitial Base Case (BC) runs considered in the main text.

B.1. Population dynamics

B.1.1 Numbers-at-age

The resource dynamics are modelled by the following set of population dynamics equations:

$$N_{y+1,1} = R_{y+1} \quad \text{(B1)}$$

$$N_{y+1,a+1} = N_{y,a} e^{-Z_{y,a}} \quad \text{for } 1 \le a \le m-2 \quad \text{(B2)}$$

$$N_{y+1,m} = N_{y,m-1} e^{-Z_{y,m-1}} + N_{y,m} e^{-Z_{y,m}} \quad \text{(B3)}$$

where

$N_{y,a}$ is the number of fish of age *a* at the start of fishing year *y*,

R_y is the recruitment (number of 1-year-old fish) at the start of year *y*,

m is the maximum age considered (taken to be a plus-group, where here *m* = 11),

$Z_{y,a} = F_y S_{y,a} + M_{y,a}$ is the total mortality in year *y* on fish of age *a*, where

$M_{y,a}$ denotes the natural mortality rate for fish of age *a* in year *y* (taken here to be year- and age-independent),

F_y is the fishing mortality of a fully selected age class in year *y* , and

$S_{y,a}$ is the commercial selectivity at age *a* for year *y*.

B.1.2. Recruitment

The number of recruits (i.e. new 1-year olds) at the start of year *y* is assumed to be related to the spawning biomass by a Beverton-Holt stock-recruitment relationship, allowing for annual fluctuation about the deterministic relationship.

$$R_y = \frac{\alpha B^{sp}_{y-1}}{\beta + B^{sp}_{y-1}} e^{(\varsigma_y - (\sigma_R)^2/2)} \quad \text{(B4)}$$

where

α and β are spawning biomass-recruitment relationship parameters,

ς_y reflects fluctuation about the expected recruitment for year *y*, which is assumed to be normally distributed with standard deviation σ_R (which is input in the applications considered here); these residuals are treated as estimable parameters in the model fitting process,

B_y^{sp} is the spawning biomass at the start of year *y*, computed as:

$$B_y^{sp} = \sum_{a=1}^{m} w_y^{sp} f_{y,a} N_{y,a} e^{-Z_{y,a}\mu_{spawn}} \quad \text{(B5)}$$

where spawning for the witch flounder stock under consideration is taken to occur on the 1st of March, i.e. μ_{spawn} = 0.1667,

$f_{y,a}$ is the proportion of fish of age *a* which are (reproductively) mature in year *y* (see Table A1), and

w_y^{sp} is the mean weight of fish of age *a* that are mature in year *y* (see Table A2).

Further, for the Beverton-Holt relationship, the parameters α and β parameters are related to steepness *h* and the deterministic pristine spawning biomass B_0^{sp} by the equations:

$$\alpha = \frac{4hR_0}{5h-1} \quad \text{and} \quad \beta = \frac{B_0^{sp}(1-h)}{(5h-1)}$$

For the Base Cases, the Beverton-Holt form with *h* fixed at 1.0 has been used.

B.1.3. Total catch and catches-at-age

The total catch by mass in year *y* is given by:

$$C_y = \sum_{a=1}^{m} w_{y,a}^{mid} C_{y,a} = \sum_{a=1}^{m} w_{y,a}^{mid} N_{y,a} S_{y,a} F_y \left(1-e^{-Z_{y,a}}\right) \big/ Z_{y,a} \quad \text{(B7)}$$

where

$w_{y,a}^{mid}$ denotes the (middle of the fishing year) mean weight of fish of age *a* landed in year *y* (see Table A2),

$C_{y,a}$ is the catch-at-age, i.e. the number of fish of age *a*, caught in year *y*.

B.1.4. Initial conditions

As the first year for which data are available for witch flounder considered clearly does not correspond to the first year of (appreciable) exploitation, one cannot necessarily make the conventional assumption in the application of SCAA's that this initial year reflects a population (and its age-structure) at pre-exploitation equilibrium

For the first year (y_0) considered in the model therefore, the numbers-at-age are estimated directly for ages 1 to a^{est}, with a parameter ϕ mimicking recent average fishing mortality for ages above a^{est}, i.e.:

$$N_{y_0,a} = N_{\text{start},a} \quad \text{for } 1 \le a \le a^{est} \quad \text{(B13)}$$

and

$$N_{\text{start},a} = N_{\text{start},a-1} e^{-M_{a-1}} (1-\phi S_{y_0,a-1}) \quad \text{for } a^{est} < a \le m-1 \quad \text{(B14)}$$

$$N_{\text{start},m} = N_{\text{start},m-1} e^{-M_{m-1}} (1-\phi S_{y_0,m-1}) \big/ (1-e^{-M_m}(1-\phi S_{y_0,m})) \quad \text{(B15)}$$

where

$$S_a = \sum_f S_{y0,a}^f C_{y0}^{obs,f} \Big/ \sum_f C_{y0}^{obs,f} \quad \text{(B16)}$$

For the Base Cases a^{est}=5. Thus the abundances of the first five ages plus the value of the parameter ϕ are estimated; there is insufficient information content in the data to allow all elements of the starting numbers-at-age vector to be estimated with reasonable precision.

B.2. The (penalised) likelihood function

The model can be fit to (a subset of) fleet-specific catches, survey abundance indices, CPUE and commercial and survey catch-at-age to estimate model parameters (these may include residuals about the stock-recruitment function, facilitated through the incorporation of a penalty function described below). Contributions by each of these to the negative of the (penalised) log-likelihood ($-\ell\text{nL}$) are as follows.

B.2.1. Survey abundance data

The likelihood is calculated assuming that a survey index is lognormally distributed about its expected value:

$$I_y^{obs,i} = I_y^i \exp(\varepsilon_y^i) \quad \text{or} \quad \varepsilon_y^i = \ell\text{n}(I_y^{obs,i}) - \ell\text{n}(I_y^i) \quad \text{(B17)}$$

where

$I_y^{obs,i}$ is the survey index for survey *i* in year *y* (see Table A4),

$I_y^i = \hat{q}^i \widetilde{N}_y^i$ is the corresponding model estimate, where

$\hat{q}^i$ is the constant of proportionality (catchability) for the survey series *i*,

$$\widetilde{N}_y^i = \sum_{a=1}^{m} S_a^i N_{y,a} e^{-Z_{y,a}T^i/12}$$

where,

S_a^i is the selectivity at age for index *i*,

T^i is the month in which the survey takes place (4 and 10 for the spring and autumn surveys respectively), and

ε_y^i from $N\left(0,(\sigma_y^i)^2\right)$.

The contribution of the survey abundance data to the negative of the log-likelihood function (after removal of constants) is then given by:

$$-\ell\text{n}\, L^{\text{survey}} = \sum_i \sum_y \left\{ \ell\text{n}\left(\sqrt{(\sigma_y^i)^2 + (\sigma_{Add}^i)^2} \right) + (\varepsilon_y^i)^2 / \left[2\left((\sigma_y^i)^2 + (\sigma_{Add}^i)^2 \right) \right] \right\} \quad \text{(B18)}$$

where

σ_y^i is the standard deviation of the residuals for the logarithm of survey *i* in year *y* (which is input), and

σ_{Add}^i is the square root of the additional variance for survey series *i*, which is estimated in the model fitting procedure.

The catchability coefficient q^i for survey index *i* is estimated by its maximum likelihood value:

$$\ell n\, \hat{q}^i = 1/n_i \sum_y \left(\ln I_y^i - \ln \widetilde{N}_y^i \right) \quad \text{(B19)}$$

B.2.2. LPUE series

As for the survey indices, the likelihood is calculated assuming that the LPUE index is lognormally distributed about its expected value:

$$I_y^{obs,LPUE} = I_y^{LPUE} \exp(\varepsilon_y^{LPUE}) \quad \text{or} \quad \varepsilon_y^{LPUE} = \ell\text{n}(I_y^{obs,LPUE}) - \ell\text{n}(I_y^{LPUE}) \quad \text{(B20)}$$

where

$I_y^{obs,LPUE}$ is the LPUE index in year *y* (see Table A6),

$I_y^{LPUE} = \hat{q}^{CPUE} B_y^{\text{ex}}$ is the corresponding model estimate, where

$\hat{q}^{LPUE}$ is the constant of proportionality for the LPUE index,

$$B_y^{ex} = \sum_{a=1}^{m} w_{y,a}^{\text{mid}} S_{y,a} N_{y,a} e^{-Z_{y,a}/2} \quad \text{(B21)}$$

where,
ε_y^{LPUE} from $N\left(0,\left(\sigma^{LPUE}\right)^2\right)$,
with $\hat{\sigma}^{LPUE}$ estimated in the fitting procedure by its maximum likelihood value:

$$\hat{\sigma}^{LPUE} = \sqrt{1/n_{LPUE} \sum_y \left(\ell\text{n}(I_y^{LPUE}) - \ell\text{n}(q^{LPUE} \hat{B}_y^{ex})\right)^2} \qquad \text{(B22)}$$

The contribution of the LPUE index data to the negative of the log-likelihood function (after removal of constants) is then given by:

$$-\ell\text{n}\, L^{\text{LPUE}} = \sum_y \left\{\ell\text{n}\left(\sigma_y^{LPUE}\right) + \left(\varepsilon_y^{LPUE}\right)^2 / \left[2\left(\sigma_y^{LPUE}\right)^2\right]\right\} \qquad \text{(B23)}$$

The coefficient of proportionality q^{LPUE} for is estimated by its maximum likelihood value:

$$\ell n\, \hat{q}^{LPUE} = 1/n_{LPUE} \sum_y \left(\ln I_y^{LPUE} - \ln B_y^{ex}\right) \qquad \text{(B24)}$$

B.2.3. Commercial catches-at-age

The contribution of the catch-at-age data to the negative of the log-likelihood function under the assumption of a "sqrt(p)" formulation, which mimics a multinomial form for the error distribution by forcing a near-equivalent variance-mean relationship for the error distributions:

$$-\ell\text{n}\, L^{\text{CAA}} = W_{CAA} \sum_y \sum_a \left[\ell n\left(\sigma_{CAA}\right) + \left(\sqrt{p_{y,a}^{obs}} - \sqrt{\hat{p}_{y,a}}\right)^2 / 2\left(\sigma_{CAA}\right)^2\right] \qquad \text{(B25)}$$

where

$p_{y,a}^{obs} = C_{y,a}^{obs} / \sum_{a'} C_{y,a'}^{obs}$ is the observed proportion of fish caught in year *y* by fleet *f* that are of age *a* (see Table A3),

$\hat{p}_{y,a} = C_{y,a} / \sum_{a'} C_{y,a'}$ is the model-predicted proportion of fish caught in year *y* that are of age *a*,

where

$$C_{y,a} = N_{y,a}\; S_{y,a} F_y \left(1 - e^{-Z_{y,a}}\right) / Z_{y,a} \qquad \text{(B26)}$$

and

σ_{CAA} is the standard deviation associated with the catch-at-age data, which is estimated in the fitting procedure by:

$$\hat{\sigma}_{CAA} = \sqrt{\sum_y \sum_a \left(\sqrt{p_{y,a}^{obs}} - \sqrt{\hat{p}_{y,a}}\right)^2 \Big/ \sum_y \sum_a 1} \qquad \text{(B27)}$$

Minus and plus groups are year dependent and are chosen so that any proportion is greater than 2%.

The W_{CAA} factor can be selected on input to downweight the contributions of these data to the negative log likelihood, to account for their possible non-independence.

For the Base Cases, the sqrt(p) formulation has been used with W_{CAA} = 1 (i.e. no downweighting).

B.2.4. Survey catches-at-age

The survey catches-at-age are incorporated into the negative of the log-likelihood in an analogous manner to the commercial catches-at-age (equation (B25) where:

$p_{y,a}^i = C_{y,a}^i / \sum_{a'} C_{y,a'}^i$ is the observed proportion of fish of age *a* in year *y* for survey *I* (see Table A5),

$\hat{p}_{y,a}^i$ is the expected proportion of fish of age *a* in year *y* in the survey *i*, given by:

$$\hat{p}^{i}_{y,a} = S^{\mathrm{i}}_{a} N_{y,a} e^{-Z_{y,a}T^{i}/12} \Big/ \sum_{a'=1}^{m} S^{i}_{a'} N_{y,a'} e^{-Z_{y,a'}T^{i}/12} \quad . \qquad \text{(B28)}$$

As for the commercial data, the minus and plus groups are year dependent and are chosen so that any proportion is greater than 2%.

B.2.5. Stock-recruitment function residuals

The stock-recruitment residuals are assumed to be lognormally distributed. Thus, the contribution of the recruitment residuals to the negative of the (now penalised) log-likelihood function is given by:

$$-\ell n L^{\mathrm{pen}} = \sum_{y=y_1}^{y_2} \left[\varepsilon_y^2 / 2\sigma_{\mathrm{R}}^2 \right] \qquad \text{(B29)}$$

where

$y1$ and $y2$ are the first and last years over which these residuals are included (the full period of the assessment is used here)

ε_y from $N\left(0, (\sigma_R)^2\right)$,

σ_{R} is the standard deviation of the log-residuals, which is input.

For the Base Cases, σ_{R} has been set to 0.5.

B.2.6. Catches

$$-\ell n L^{\mathrm{Catch}} = \sum_{y} \left[\frac{\ell n\, C_y^{obs,} - \ell n\, C_y}{2\sigma_{\mathrm{C}}^2} \right] \qquad \text{(B30)}$$

where

C_y^{obs} is the observed catch in year y,

C_y is the predicted catch in year y (equation B7), and

σ_{C} is the CV input: 0.1 throughout.

B.3. Estimation of precision

Where quoted, CV's or 90% probability interval estimates are based on the Hessian.

B.4. Model parameters

B.4.1 Natural mortality

Natural mortality is taken to be age and year independent at 0.15 yr-1.

APPENDIX B4: VPA Run A2 Input file
(WITCH15_SPLIT_RUN_A2.DAT)

```
VPA/ADAPT V 3.0
##
MODEL ID
WITCH 2015 SPLIT RUN A2  (swept area q= 0.056; all in ALB units)
PARAM
34  9  78  36  8  1982  3  0  123456
PARTIAL RECRUIT
0.0128  0.0324  0.0905  0.4274  0.5685  1.0000  1.0000  1.0000
AGE ESTIMATE
3  4  5  6  7  8  9  10
STOCK ESTIMATE
10000.  10000.  10000.  10000.  10000.  10000.  10000.  9000.
STOCK MIN-MAX
1.0000E+00  1.0000E+06
F-PLUS
1.00000*34
AGES-F
8-10
AGES-SUMMARY
8-9
MFSPAWN
0.1667  0.1667
CATCH AT AGE
569.61      2639.52     1783.43     1630.70     679.99      667.00      402.62      240.84      1581.77
450.60      2107.91     2179.09     1597.73     1607.43     986.84      741.87      511.97      1677.88
222.63      2142.12     2302.06     1761.25     1497.37     1505.31     700.02      376.36      1720.20
365.70      1556.64     2311.33     1957.65     1536.38     1254.37     608.29      401.37      1360.88
68.09       701.33      1941.51     2806.15     1582.60     842.20      415.71      223.99      760.19
55.78       334.16      813.07      1318.51     1602.78     881.44      484.68      254.45      492.58
767.85      288.38      421.12      688.36      1414.64     1168.93     405.56      268.79      600.69
192.08      1180.07     503.97      344.91      792.40      911.63      356.87      125.75      352.58
367.03      604.48      1158.98     284.55      295.39      493.80      347.11      84.96       182.24
1152.48     1595.28     2002.07     1012.93     256.21      260.50      303.31      323.81      264.15
196.15      1524.22     1531.46     1271.74     756.76      204.31      180.41      121.55      380.91
73.26       958.62      1386.25     924.06      600.32      586.49      218.57      278.06      389.81
100.68      738.92      2208.79     1371.98     981.98      202.51      548.80      114.70      335.58
864.72      881.76      1463.42     1912.80     879.93      284.82      103.32      282.73      162.01
390.33      678.51      1162.32     1383.91     1444.92     266.55      218.01      57.73       114.88
129.71      994.29      1189.27     1404.67     1114.70     649.76      90.47       51.73       71.98
347.47      865.76      1285.41     1486.02     1652.81     387.59      151.86      16.55       74.45
147.62      704.02      1262.55     1504.90     1224.36     783.74      260.98      38.07       75.76
132.66      497.24      708.86      1223.36     1758.27     1051.96     585.77      100.78      256.69
61.71       464.58      1315.66     1198.92     1766.25     1471.32     640.22      431.88      314.98
37.14       652.75      1210.58     1392.17     2167.13     1288.62     649.99      97.09       206.36
42.96       364.78      1300.67     1737.05     1944.15     1591.59     764.21      444.26      356.78
48.58       448.67      1408.06     1795.72     1589.93     1179.36     813.03      335.93      299.95
30.66       275.37      993.73      1996.46     1859.27     848.05      424.96      242.45      139.43
126.19      134.46      344.54      947.00      1624.71     901.30      369.13      140.07      80.22
144.45      179.64      174.49      310.97      905.67      607.73      175.45      99.34       46.48
55.45       293.24      242.92      352.22      617.32      466.77      317.03      113.23      68.71
40.69       238.70      562.30      339.98      527.42      485.43      338.65      80.67       81.08
80.71       110.94      314.63      543.39      308.36      407.33      182.76      234.23      47.80
245.02      149.02      255.11      671.76      630.50      447.91      162.10      86.12       36.05
167.78      270.32      355.50      480.60      820.81      594.32      221.19      88.87       41.84
43.10       204.82      227.64      296.60      475.14      331.94      185.17      84.22       38.17
134.52      104.03      220.84      181.62      280.03      337.88      136.97      48.59       27.47
94.25       189.64      133.57      250.10      266.99      290.77      121.79      36.56       24.12
WEIGHT AT AGE
0.085       0.174       0.265       0.401       0.550       0.726       0.886       0.983       1.405
0.132       0.178       0.237       0.409       0.518       0.613       0.795       0.977       1.357
0.119       0.201       0.308       0.421       0.539       0.664       0.817       0.922       1.339
```

0.128	0.218	0.295	0.428	0.565	0.691	0.842	0.964	1.325
0.091	0.172	0.275	0.407	0.533	0.676	0.853	0.975	1.321
0.087	0.168	0.265	0.432	0.561	0.686	0.828	0.980	1.303
0.063	0.192	0.278	0.433	0.538	0.668	0.819	0.980	1.326
0.058	0.151	0.241	0.424	0.572	0.680	0.818	0.968	1.357
0.058	0.205	0.266	0.440	0.585	0.687	0.848	1.043	1.453
0.063	0.176	0.289	0.353	0.577	0.700	0.835	0.972	1.419
0.096	0.235	0.330	0.417	0.604	0.739	0.822	0.882	1.243
0.101	0.240	0.330	0.431	0.534	0.666	0.882	1.023	1.335
0.074	0.215	0.312	0.427	0.526	0.690	0.832	0.908	1.264
0.065	0.158	0.300	0.421	0.561	0.691	0.908	0.972	1.238
0.061	0.137	0.268	0.421	0.554	0.708	0.857	0.974	1.230
0.073	0.196	0.277	0.377	0.497	0.628	0.861	1.030	1.280
0.083	0.168	0.253	0.357	0.487	0.586	0.864	0.977	1.209
0.093	0.208	0.283	0.398	0.515	0.587	0.632	0.940	1.063
0.081	0.175	0.239	0.364	0.451	0.534	0.627	0.715	0.930
0.109	0.172	0.241	0.351	0.461	0.550	0.645	0.648	0.843
0.102	0.220	0.278	0.396	0.473	0.552	0.652	0.822	0.940
0.070	0.158	0.244	0.321	0.419	0.504	0.566	0.621	0.811
0.099	0.212	0.261	0.329	0.433	0.537	0.611	0.687	0.870
0.109	0.203	0.286	0.354	0.442	0.555	0.632	0.724	0.914
0.098	0.198	0.267	0.317	0.453	0.545	0.647	0.712	0.927
0.115	0.188	0.250	0.352	0.472	0.564	0.678	0.745	0.915
0.124	0.199	0.270	0.393	0.475	0.540	0.599	0.649	0.827
0.104	0.203	0.265	0.367	0.453	0.548	0.622	0.726	0.690
0.081	0.180	0.253	0.302	0.426	0.499	0.652	0.620	0.810
0.093	0.203	0.247	0.343	0.432	0.544	0.648	0.720	0.885
0.140	0.184	0.281	0.327	0.438	0.540	0.649	0.720	0.883
0.147	0.201	0.267	0.350	0.440	0.530	0.631	0.697	0.876
0.132	0.195	0.286	0.376	0.481	0.589	0.693	0.769	1.377
0.105	0.161	0.275	0.370	0.468	0.554	0.656	0.756	0.843
BIOMASS								
0.0587	0.1491	0.2133	0.3528	0.5210	0.6938	0.8437	0.9332	1.4050
0.1070	0.1230	0.2031	0.3292	0.4558	0.5806	0.7597	0.9304	1.3570
0.0879	0.1629	0.2341	0.3159	0.4695	0.5865	0.7077	0.8561	1.3390
0.1104	0.1611	0.2435	0.3631	0.4877	0.6103	0.7477	0.8875	1.3250
0.0670	0.1484	0.2448	0.3465	0.4776	0.6180	0.7677	0.9061	1.3210
0.0586	0.1236	0.2135	0.3447	0.4778	0.6047	0.7481	0.9143	1.3030
0.0407	0.1292	0.2161	0.3387	0.4821	0.6122	0.7496	0.9008	1.3260
0.0309	0.0975	0.2151	0.3433	0.4977	0.6048	0.7392	0.8904	1.3570
0.0333	0.1090	0.2004	0.3256	0.4980	0.6269	0.7594	0.9237	1.4530
0.0326	0.1010	0.2434	0.3064	0.5039	0.6399	0.7574	0.9079	1.4190
0.0607	0.1217	0.2410	0.3471	0.4617	0.6530	0.7586	0.8582	1.2430
0.0692	0.1518	0.2785	0.3771	0.4719	0.6342	0.8073	0.9170	1.3350
0.0506	0.1474	0.2736	0.3754	0.4761	0.6070	0.7444	0.8949	1.2640
0.0448	0.1081	0.2540	0.3624	0.4894	0.6029	0.7915	0.8993	1.2380
0.0340	0.0944	0.2058	0.3554	0.4829	0.6302	0.7695	0.9404	1.2300
0.0481	0.1093	0.1948	0.3179	0.4574	0.5898	0.7808	0.9395	1.2800
0.0524	0.1107	0.2227	0.3145	0.4285	0.5397	0.7366	0.9172	1.2090
0.0678	0.1314	0.2180	0.3173	0.4288	0.5347	0.6086	0.9012	1.0630
0.0556	0.1276	0.2230	0.3210	0.4237	0.5244	0.6067	0.6722	0.9300
0.0767	0.1180	0.2054	0.2896	0.4096	0.4980	0.5869	0.6374	0.8430
0.0820	0.1549	0.2187	0.3089	0.4075	0.5045	0.5988	0.7281	0.9400
0.0402	0.1269	0.2317	0.2987	0.4073	0.4883	0.5590	0.6363	0.8110
0.0691	0.1218	0.2031	0.2833	0.3728	0.4743	0.5549	0.6236	0.8700
0.0809	0.1418	0.2462	0.3040	0.3813	0.4902	0.5826	0.6651	0.9140
0.0708	0.1469	0.2328	0.3011	0.4005	0.4908	0.5992	0.6708	0.9270
0.0874	0.1357	0.2225	0.3066	0.3868	0.5055	0.6079	0.6943	0.9150
0.0969	0.1513	0.2253	0.3134	0.4089	0.5049	0.5812	0.6633	0.8270
0.0791	0.1587	0.2296	0.3148	0.4219	0.5102	0.5796	0.6594	0.6900
0.0512	0.1368	0.2266	0.2829	0.3954	0.4754	0.5977	0.6210	0.8100
0.0661	0.1282	0.2109	0.2946	0.3612	0.4814	0.5686	0.6852	0.8850
0.1168	0.1308	0.2388	0.2842	0.3876	0.4830	0.5942	0.6831	0.8830
0.1276	0.1677	0.2216	0.3136	0.3793	0.4818	0.5837	0.6726	0.8760
0.1195	0.1693	0.2398	0.3168	0.4103	0.5091	0.6060	0.6966	1.3770
0.0756	0.1458	0.2316	0.3253	0.4195	0.5162	0.6216	0.7238	0.8430

0.0756	0.1458	0.2316	0.3253	0.4195	0.5162	0.6216	0.7238	0.8430
SSB								
0.0587	0.1491	0.2133	0.3528	0.5210	0.6938	0.8437	0.9332	1.4050
0.1070	0.1230	0.2031	0.3292	0.4558	0.5806	0.7597	0.9304	1.3570
0.0879	0.1629	0.2341	0.3159	0.4695	0.5865	0.7077	0.8561	1.3390
0.1104	0.1611	0.2435	0.3631	0.4877	0.6103	0.7477	0.8875	1.3250
0.0670	0.1484	0.2448	0.3465	0.4776	0.6180	0.7677	0.9061	1.3210
0.0586	0.1236	0.2135	0.3447	0.4778	0.6047	0.7481	0.9143	1.3030
0.0407	0.1292	0.2161	0.3387	0.4821	0.6122	0.7496	0.9008	1.3260
0.0309	0.0975	0.2151	0.3433	0.4977	0.6048	0.7392	0.8904	1.3570
0.0333	0.1090	0.2004	0.3256	0.4980	0.6269	0.7594	0.9237	1.4530
0.0326	0.1010	0.2434	0.3064	0.5039	0.6399	0.7574	0.9079	1.4190
0.0607	0.1217	0.2410	0.3471	0.4617	0.6530	0.7586	0.8582	1.2430
0.0692	0.1518	0.2785	0.3771	0.4719	0.6342	0.8073	0.9170	1.3350
0.0506	0.1474	0.2736	0.3754	0.4761	0.6070	0.7444	0.8949	1.2640
0.0448	0.1081	0.2540	0.3624	0.4894	0.6029	0.7915	0.8993	1.2380
0.0340	0.0944	0.2058	0.3554	0.4829	0.6302	0.7695	0.9404	1.2300
0.0481	0.1093	0.1948	0.3179	0.4574	0.5898	0.7808	0.9395	1.2800
0.0524	0.1107	0.2227	0.3145	0.4285	0.5397	0.7366	0.9172	1.2090
0.0678	0.1314	0.2180	0.3173	0.4288	0.5347	0.6086	0.9012	1.0630
0.0556	0.1276	0.2230	0.3210	0.4237	0.5244	0.6067	0.6722	0.9300
0.0767	0.1180	0.2054	0.2896	0.4096	0.4980	0.5869	0.6374	0.8430
0.0820	0.1549	0.2187	0.3089	0.4075	0.5045	0.5988	0.7281	0.9400
0.0402	0.1269	0.2317	0.2987	0.4073	0.4883	0.5590	0.6363	0.8110
0.0691	0.1218	0.2031	0.2833	0.3728	0.4743	0.5549	0.6236	0.8700
0.0809	0.1418	0.2462	0.3040	0.3813	0.4902	0.5826	0.6651	0.9140
0.0708	0.1469	0.2328	0.3011	0.4005	0.4908	0.5992	0.6708	0.9270
0.0874	0.1357	0.2225	0.3066	0.3868	0.5055	0.6079	0.6943	0.9150
0.0969	0.1513	0.2253	0.3134	0.4089	0.5049	0.5812	0.6633	0.8270
0.0791	0.1587	0.2296	0.3148	0.4219	0.5102	0.5796	0.6594	0.6900
0.0512	0.1368	0.2266	0.2829	0.3954	0.4754	0.5977	0.6210	0.8100
0.0661	0.1282	0.2109	0.2946	0.3612	0.4814	0.5686	0.6852	0.8850
0.1168	0.1308	0.2388	0.2842	0.3876	0.4830	0.5942	0.6831	0.8830
0.1276	0.1677	0.2216	0.3136	0.3793	0.4818	0.5837	0.6726	0.8760
0.1195	0.1693	0.2398	0.3168	0.4103	0.5091	0.6060	0.6966	1.3770
0.0756	0.1458	0.2316	0.3253	0.4195	0.5162	0.6216	0.7238	0.8430
M MATRIX								
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150

0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
MATURITY								
0.01	0.04	0.14	0.40	0.73	0.92	0.98	0.99	1.00
0.01	0.06	0.20	0.51	0.82	0.95	0.99	1.00	1.00
0.02	0.07	0.24	0.59	0.86	0.97	0.99	1.00	1.00
0.01	0.05	0.24	0.68	0.93	0.99	1.00	1.00	1.00
0.02	0.09	0.36	0.76	0.95	0.99	1.00	1.00	1.00
0.08	0.30	0.68	0.91	0.98	1.00	1.00	1.00	1.00
0.14	0.43	0.78	0.94	0.99	1.00	1.00	1.00	1.00
0.09	0.32	0.68	0.91	0.98	1.00	1.00	1.00	1.00
0.07	0.20	0.46	0.73	0.90	0.97	0.99	1.00	1.00
0.07	0.17	0.38	0.64	0.84	0.94	0.98	0.99	1.00
0.06	0.17	0.41	0.70	0.89	0.96	0.99	1.00	1.00
0.04	0.13	0.35	0.65	0.87	0.96	0.99	1.00	1.00
0.04	0.13	0.34	0.64	0.86	0.96	0.99	1.00	1.00
0.03	0.13	0.42	0.78	0.95	0.99	1.00	1.00	1.00
0.02	0.12	0.45	0.83	0.96	0.99	1.00	1.00	1.00
0.01	0.07	0.37	0.81	0.97	1.00	1.00	1.00	1.00
0.04	0.13	0.38	0.71	0.91	0.98	0.99	1.00	1.00
0.04	0.14	0.36	0.67	0.88	0.96	0.99	1.00	1.00
0.05	0.14	0.33	0.59	0.82	0.93	0.98	0.99	1.00
0.06	0.15	0.33	0.58	0.79	0.91	0.97	0.99	1.00
0.08	0.17	0.32	0.53	0.72	0.86	0.93	0.97	0.99
0.09	0.17	0.31	0.49	0.68	0.82	0.91	0.96	0.98
0.11	0.19	0.32	0.49	0.66	0.79	0.89	0.94	0.97
0.12	0.22	0.35	0.52	0.68	0.80	0.89	0.94	0.97
0.09	0.16	0.29	0.45	0.63	0.78	0.88	0.94	0.97
0.08	0.17	0.32	0.52	0.71	0.85	0.93	0.97	0.98
0.08	0.19	0.37	0.61	0.80	0.92	0.97	0.99	0.99
0.11	0.25	0.47	0.71	0.87	0.95	0.98	0.99	1.00
0.10	0.24	0.48	0.73	0.89	0.96	0.99	0.99	1.00
0.13	0.29	0.53	0.75	0.89	0.96	0.98	0.99	1.00
0.11	0.27	0.52	0.76	0.90	0.96	0.99	1.00	1.00
0.11	0.27	0.52	0.76	0.91	0.97	0.99	1.00	1.00
0.09	0.23	0.49	0.75	0.91	0.97	0.99	1.00	1.00
0.09	0.23	0.49	0.75	0.91	0.97	0.99	1.00	1.00

SURVEY INDEX										
Spr82-94	Spr82-94	Spr82-94	Spr82-94	Spr82-94	Spr82-94	Spr82-94	Spr82-94	Spr82-94	Spr82-94	Spr82-94
Spr82-94	Spr82-94	Spr82-94	Spr82-94	Spr82-94	Spr82-94	Spr82-94	Aut82-94	Aut82-94	Aut82-94	Aut82-94
Aut82-94	Aut82-94	Aut82-94	Aut82-94	Aut82-94	Aut82-94	Aut82-94	Aut82-94	Aut82-94	Aut82-94	Aut82-94
Aut82-94	Aut82-94	Aut82-94	LPUEAS	LPUEAS	LPUEAS	LPUEAS	LPUEAS	LPUEAS	Spr95-16	Spr95-16
Spr95-16	Spr95-16	Spr95-16	Spr95-16	Spr95-16	Spr95-16	Spr95-16	Spr95-16	Spr95-16	Spr95-16	Spr95-16
Spr95-16	Spr95-16	Spr95-16	Spr95-16	Spr95-16	Aut95-15	Aut95-15	Aut95-15	Aut95-15	Aut95-15	Aut95-15
Aut95-15	Aut95-15	Aut95-15	Aut95-15	Aut95-15	Aut95-15	Aut95-15	Aut95-15	Aut95-15	Aut95-15	Aut95-15
Aut95-15										

0	1	2	3	4	5	6	7	8	9	10	11
12	13	14:11	9:11	10:11	11	1	2	3	4	5	6
7	8	9	10	11	12	13	14	15:11	10:11	11	12:11
7	8	9	10	10:11	11	0	1	2	3	4	5
6	7	8	9	10	11	12	13	14:11	9:11	10:11	11
1	2	3	4	5	6	7	8	9	10	11	12
13	14	15:11	10:11	11	12:11						
1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN
1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN
1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN
MEAN	MEAN	MEAN	MEAN	MEAN	MEAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN
1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN
1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN
1-JAN	1-JAN	1-JAN	1-JAN	1-JAN	1-JAN						
NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER
NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER
NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER

NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER
NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER
NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER
NUMBER	NUMBER	NUMBER	NUMBER	NUMBER	NUMBER						
0	1573.004145	1487.592156	21694.64541	17217.63361	13402.56473	8423.757494	21651.93941	12886.53396	3316.83227	9228.053731	
6227.957589	935.9730548	1185.091358	10402.46859	31296.37659	27979.54432	18751.49059	1067.649872	2491.183036	1067.649872	8541.19898	
15658.8648	21708.88074	16370.63138	9608.848852	9252.965561	6405.899235	7473.549107	6050.015944	1423.533163	4626.482781	17082.39796	
43061.87819	36655.97895	29182.42985	0.040	0.040	0.024	0.014	0.109	0.095	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	0	2526.771365	18904.52041	44894.67714	46026.386	19253.28603	25491.92012	22506.05931	16918.69165	7619.461256	
5911.22146	2683.360013	1903.975606	13388.3294	48425.03938	31506.34774	23886.88648	722.4430804	0	0	2046.328922	
466.207111	960.8848852	2694.036511	8573.228476	4708.335938	519.5896046	975.1202168	1138.826531	338.0891263	1405.738999	10729.88122	
15107.2457	14587.65609	13612.53587	0.088	0.054	0.041	0.028	0.121	0.093	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	0	3672.715561	409.2657844	10929.17586	27666.36703	14281.59646	11018.14668	7178.165976	6978.871333	4081.981346	
6171.016263	4156.716837	804.2962372	9477.172034	31670.05405	24691.18272	20609.20137	0	288.2654656	387.912787	18046.84168	
56791.85555	26958.15928	19502.40434	15808.33578	2978.743144	4886.277583	2597.948023	4049.951849	871.9140625	0	14754.92124	
27161.01276	22274.73517	19676.78715	0.071	0.071	0.033	0.018	0.100	0.082	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	0	0	594.3250957	16342.16071	37623.98151	42684.6419	32303.52631	14665.95041	5259.955038	5291.984534	
1558.768814	2544.565529	960.8848852	24598.65306	40214.81186	34954.85682	29662.87229	0	0	0	3320.391103	
33584.70615	35278.71062	21527.38026	19032.63839	11021.70552	5299.1022	4469.894133	2594.38919	1455.562659	4708.335938	13342.06457	
31869.34869	26570.24649	22100.35236	0.069	0.057	0.028	0.018	0.080	0.062	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	0	0	0	1562.327647	8551.875478	18811.99075	14655.27392	6117.633769	6911.253508	2818.595663	
1363.033004	2227.829401	1946.681601	8811.670281	24079.06346	17167.80995	14349.21429	0	0	306.0596301	2092.59375	
2694.036511	21715.99841	24342.41709	17171.36878	9601.731186	3654.921397	4348.893814	1021.385045	523.1484375	3174.478954	7726.226244	
20449.05389	16794.13249	12445.23868	0.082	0.044	0.022	0.012	0.051	0.040	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	0	0	0	2096.152583	4053.510682	4726.130102	9235.171397	6601.635045	338.0891263	2185.123406	
811.4139031	0	0	5815.132972	9149.759407	8811.670281	6626.546875	323.8537946	0	0	0	
1815.004783	9484.2897	12573.35666	10978.99952	5687.014987	3985.892857	330.9714605	370.1186224	761.5902423	1861.269611	8455.78699	
15765.62978	11779.73693	11448.76547	0.090	0.050	0.028	0.015	0.043	0.028	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	811.4139031	814.972736	2206.476403	0	2576.595026	10676.49872	13487.97672	8491.375319	4882.71875	3071.2728	
2989.419643	1021.385045	0	0	11964.79624	7082.077487	4010.804688	0	0	814.972736	0	
387.912787	814.972736	1626.386639	6836.518017	2541.006696	0	306.0596301	0	0	811.4139031	3021.449139	
4138.922672	4138.922672	3832.863042	0.082	0.069	0.024	0.016	0.051	0.036	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	814.972736	462.6482781	1281.179847	35744.91773	3754.568718	2590.830357	2889.772321	11655.17777	2889.772321	540.942602	
1992.946429	1975.152264	661.9429209	1982.26993	10043.02647	7153.254145	6612.311543	0	231.324139	0	25790.86209	
1939.563935	409.2657844	1266.944515	7644.373087	1722.475128	1647.739636	1615.71014	2822.154496	380.7951212	1533.856983	1953.799267	
9954.055644	8306.316008	6690.605867	0.050	0.059	0.023	0.008	0.031	0.023	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	288.2654656	0	1334.562341	3249.214445	11374.02997	0	1498.268654	309.618463	1793.651786	626.3545918	
338.0891263	405.7069515	0	1078.326371	4242.128827	2448.477041	1822.122449	6188.810427	647.7075893	647.7075893	2907.566486	
10697.85172	323.8537946	750.9137436	590.7662628	2982.301977	2790.125	843.4433992	0	911.0612245	0	1327.444675	
5872.074298	3081.949298	2238.505899	0.019	0.033	0.023	0.006	0.018	0.012	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	1487.592156	0	27769.57318	3857.774872	3099.743463	7427.284279	1170.856027	3587.303571	2946.713648	4900.512915	
637.0310906	779.3844069	0	2270.535395	11534.17746	8587.463807	3686.950893	17103.75096	3135.331792	4872.042251	13527.12388	
19142.96221	6694.1647	854.119898	814.972736	814.972736	893.2670599	0	0	323.8537946	1950.240434	1217.120855	
4384.482143	3491.215083	3491.215083	0.014	0.015	0.018	0.019	0.034	0.015	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	1939.563935	309.618463	6651.458705	13263.77025	3032.125638	3936.069196	5405.867188	1601.474809	5288.425702	544.5014349	
576.5309311	1640.621971	0	672.6194196	8722.699458	3434.273756	2889.772321	7961.109216	750.9137436	6320.487245	23523.88552	
11715.67793	10317.0566	5156.748884	2395.094547	2103.270249	1053.414541	1843.475446	1000.032047	0	0	0	
3896.922034	2843.507494	1000.032047	0.037	0.011	0.009	0.006	0.026	0.020	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0			
0	5284.866869	3993.010523	4886.277583	16808.36783	11374.02997	2053.446588	3039.243304	0	551.6191008	551.6191008	0
2434.241709	0	1320.327009	4857.80692	4306.187819	3754.568718	3434.273756	1042.738042	3886.245536	9199.583068	7957.550383	
1907.534439	2149.535077	0	0	672.6194196	327.4126276	683.2959184	0	683.2959184	1494.709821	3861.333705	
3188.714286	2861.301658	0.032	0.031	0.012	0.015	0.035	0.021	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0				
0	3818.62771	24819.3007	19249.7272	22904.6486	28840.78189	5850.721301	957.3260523	1000.032047	2505.418367	295.3831314	0
0	569.4132653	569.4132653	3939.628029	1434.209662	1138.826531	90419.2677	23908.23948	5487.720344	19367.16869	27655.69053	
7808.079401	2060.564254	772.2667411	2896.889987	0	683.2959184	1484.033323	0	405.7069515	512.4719388	3085.508131	
3085.508131	2402.212213	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0				
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	1441.327328	4263.481824	20683.93686	11235.23549	
6366.752073	11099.99984	4135.363839	3921.833865	1494.709821	0	1355.915338	1010.708546	0	0	3861.333705	
2366.623884	2366.623884	15367.0405	5548.220504	10220.96811	18911.63807	5879.191964	14064.50765	1316.768176	3775.921716	0	
1512.503986	323.8537946	0	181.5004783	0	1512.503986	3530.362245	2017.858259	1694.004464			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	597.8839286	1266.944515	8669.316964	14036.03699	
12299.32653	7776.049904	2580.153858	0	0	0	1138.826531	0	0	0	1138.826531	
1138.826531	1138.826531	18217.66566	7213.754305	27200.15992	57788.32876	30520.55102	16804.80899	8153.286193	0	0	
384.3539541	1939.563935	0	0	0	323.8537946	2647.771684	2263.41773	323.8537946			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	2565.918527	2359.506218	5412.984853	24648.47672	
21954.44021	15569.89397	2996.537309	2943.154815	512.4719388	0	0	0	0	0	512.4719388	0
0	8245.815848	3252.773278	9281.436224	27947.51483	70735.36288	49328.98294	15701.57079	2331.035555	2306.123724	1327.444675	0
1174.41486	0	0	0	2501.859534	1174.41486	1174.41486					
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	3989.45169	38392.68941	25349.5668	13811.83052	
28399.48661	25378.03747	7626.578922	5466.367347	2697.595344	0	0	0	1010.708546	0	3708.30389	
1010.708546	1010.708546	31751.90721	12060.88473	34837.41534	18587.78428	30993.8758	27388.77806	13633.88887	11729.91327	0	0
0	0	693.9724171	0	0	693.9724171	693.9724171	693.9724171				
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	3765.245217	13374.09407	34655.91486	28363.89828	
17171.36878	5847.162468	6491.311224	1089.00287	512.4719388	811.4139031	0	0	0	0	1323.885842	
811.4139031	0	22740.94228	2907.566486	18502.37229	48492.65721	16555.69069	10783.26371	5879.191964	3921.833865	1512.503986	
437.7364477	0	0	0	0	0	437.7364477	0	0			

0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	231.324139	8911.317602	42485.34726	24644.91789	
23470.50303	8516.287149	8993.170759	4124.687341	0	1259.826849	0	0	0	0	1259.826849	
1259.826849	0	11491.47146	18552.19595	41926.61049	53870.05373	37150.65673	21342.32095	12932.79879	9801.025829	1772.298788	
1316.768176	334.5302934	0	0	0	0	1651.298469	334.5302934	0			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	3740.333386	3516.126913	25360.2433	52521.25606	
36296.53683	14263.8023	10427.38042	5797.338807	4014.36352	1000.032047	0	0	0	0	5014.395568	
1000.032047	0	33542.00016	3405.803093	25577.33211	50115.48501	62137.22258	23982.97497	20965.08466	8163.962691	5398.749522	
1761.62229	0	0	925.2965561	0	0	2686.918846	925.2965561	925.2965561			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	814.972736	2131.740912	31929.84885	93504.77583	
80547.06521	29264.283	24313.94643	12480.82701	6815.165019	3654.921397	494.6777742	0	1032.061543	1327.444675	13324.27041	
6509.105389	2854.183992	0	1398.621333	7491.343272	33897.88345	112306.0901	67112.47098	28933.31154	21776.49857	5644.308992	
2046.328922	1978.711097	0	0	0	0	4025.040019	1978.711097	0			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	5331.131696	28751.81107	
58592.625	36182.65418	30912.02264	13776.24219	7007.341996	1619.268973	2145.976244	0	569.4132653	327.4126276	11669.41311	
4662.07111	3042.802136	0	0	9779.672832	15335.011	52499.90306	35485.12293	18929.43224	11769.06043	5284.866869	
2530.330198	0	1622.827806	181.5004783	0	0	4334.658482	1804.328284	1804.328284			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	327.4126276	2138.858578	2626.418686	15231.80485	
23079.03141	28790.95823	31417.37691	13107.1816	5626.514828	5719.044483	4804.424426	0	0	2373.74155	18523.72529	
12897.21046	7178.165976	647.7075893	0	1363.033004	2676.242347	10914.94053	20655.4662	27388.77806	11210.32366	4576.65912	
7911.285555	2946.713648	736.678412	1629.945472	683.2959184	1345.238839	15253.15784	7341.87229	4395.158642			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	387.912787	5694.132653	5210.131378	7811.638233	
26246.3927	27054.24777	20441.93622	13637.4477	8719.140625	3078.390466	647.7075893	0	747.3549107	0	13192.59359	
4473.452966	1395.0625	9801.025829	2573.036193	512.4719388	3071.2728	16117.95424	35111.44547	29406.63632	17715.87022	12633.85682	
1925.328603	3729.656888	2551.683195	0	0	654.8252551	8861.493941	6936.165338	3206.50845			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	1548.092315	16384.86671	12359.82669	4911.189413	
7373.901786	24317.50526	20217.72975	14594.77376	5163.86655	2448.477041	537.3837691	0	0	0	8149.72736	
2985.86081	537.3837691	4711.89477	22598.58897	3089.066964	814.972736	4658.512277	6437.928731	9583.937022	12096.47305	1950.240434	
1857.710778	416.3834503	0	0	576.5309311	0	2850.625159	992.9143814	576.5309311			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	0	6327.604911	20310.25941	9349.05405	
8587.463807	8128.374362	19438.34534	5466.367347	5637.191327	0	1089.00287	0	0	0	6726.194196	
1089.00287	1089.00287	2338.153221	3662.039063	19210.58004	11448.76547	1637.063138	3711.862723	10612.43973	10192.49745	4907.63058	
2526.771365	1494.709821	512.4719388	0	0	0	4533.953125	2007.18176	512.4719388			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.000	0.000	0.000	0.000	0.000	0.000	0	387.912787	13245.97608	30161.1089	100864.4423	
47713.2728	22972.26642	25776.62675	19577.13983	3138.890625	1295.415179	0	0	0	0	4434.305804	
1295.415179	0	0	2313.24139	5747.515147	42930.20137	16996.98597	6690.605867	7822.314732	9284.995057	2459.15354	
2765.21317	0	0	512.4719388	0	0	3277.685108	512.4719388	512.4719388			
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

```
0.000 0.000 0.000 0.000 0.000 0.000 0 4800.865593 4964.571907 10309.93893 15242.48135
20445.49506 7324.078125 5523.308673 7850.785395 4284.834821 2014.299426 316.7361288 149.4709821 145.9121492 0 6911.253508
2626.418686 612.1192602 9776.113999 754.4725765 3388.008929 15018.27487 28242.89796 9715.613839 9028.759088 8345.46317 10754.79305
484.0012755 2010.740593 0 0 288.2654656 0 2783.007334 2299.006059 288.2654656
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0.000 0.000 0.000 0.000 0.000 0.000 0 4943.218909 16064.57175 9544.78986 5982.398119
14943.53938 16769.22066 5042.866231 3615.774235 6580.282047 2338.153221 1110.355867 555.1779337 145.9121492 338.0891263 11067.97034
4487.688297 2149.535077 3352.420599 13673.03603 6630.105708 7060.72449 13416.80006 16157.1014 5459.249681 4907.63058 4099.77551
2409.329879 153.0298151 302.5007972 0 0 0 2864.860491 455.5306122 302.5007972
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0.000 0.000 0.000 0.000 0.000 0.000 0 1242.032685 12996.85778 24943.85985 9526.995695
10836.64621 16708.7205 10060.82063 4185.1875 3142.449458 4092.657844 1487.592156 419.9422832 338.0891263 402.1481186 9882.878986
6740.429528 2647.771684 1516.062819 14292.27296 16676.69101 6523.340721 7526.931601 5971.72162 8939.788265 1829.240115 4135.363839
2224.270568 686.8547513 758.0314094 88.9708227 0 0 3758.127551 1533.856983 847.0022321
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0.000 0.000 0.000 0.000 0.000 0.000 0 3181.59662 6672.811703 13772.68335 11719.23677
5548.220504 8260.05118 5683.456154 5640.750159 2679.80118 1206.444356 355.8832908 0 213.5299745 0 4455.658801
1775.857621 569.4132653 1473.356824 8131.933195 30926.25797 38325.07159 14313.62596 9964.732143 15641.07063 6409.458068 2672.683514
1690.445631 2149.535077 213.5299745 185.0593112 0 0 4238.569994 2548.124362 398.5892857
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0.000 0.000 0.000 0.000 0.000 0.000 0 1266.944515 4409.393973 4950.336575 9939.820313
5138.954719 3096.18463 3879.12787 2331.035555 1110.355867 661.9429209 0 131.6768176 0 64.05899235 1968.034598
857.6787309 195.7358099 526.7072704 9295.671556 10957.64652 22926.00159 11224.55899 5007.277902 7672.84375 4793.747927 2032.093591
2085.476084 1131.708865 0 377.2362883 0 0 3594.421237 1508.945153 377.2362883
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0.000 0.000 0.000 0.000 0.000 0.000 0 20488.20105 15922.21843 24068.38696 9377.524713
15359.92283 7441.519611 4857.80692 4921.865912 2928.919483 0 0 0 0 0 2928.919483 0
0 18096.66534 6683.488202 17288.81027 6768.900191 16441.80804 8462.904656 1494.709821 3722.539222 2035.652423 918.1788903
160.1474809 0 0 0 0 1078.326371 160.1474809 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0.000 0.000 0.000 0.000 0.000 0.000 0 1124.591199 20705.28986 26865.62962 16399.10204
8345.46317 11388.26531 5395.190689 5377.396524 1871.94611 715.3254145 284.7066327 0 0 167.2651467 3039.243304
1167.297194 451.9717793 4135.363839 24313.94643 11612.47178 19025.52073 8402.404496 13502.21205 5049.983897 4964.571907 4989.483737
1348.797672 270.471301 249.1183036 306.0596301 0 188.6181441 2363.065051 1014.267379 743.7960778
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0.000 0.000 0.000 0.000 0.000 0.000 0 3765.245217 2968.066645 26812.24713 11160.5
12957.71062 3836.421875 5017.954401 3053.478635 1078.326371 444.8541135 220.6476403 540.942602 0 0 1206.444356
761.5902423 540.942602 6608.75271 5341.808195 33203.91103 29513.40131 11779.73693 5708.367985 10982.55835 4647.835778 1822.122449
2131.740912 498.2366071 0 0 0 121.0003189 2750.977838 619.236926 121.0003189
CHECKED INDEX
4 5 6 7 8 9 10 11 18 21 22 23 24 25 26 27 28 35 46 47 48 49 50 51 52 53 60 63 64 65 66 67 68 69 70 77
CHECKED RETRO
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1
OPTIONS
1 0 0 1 1 1 0 1 0 1
XPARM
80 1
```

APPENDIX B5

ASAP INPUT FILE: Run_9Mc_FLAT_q056_5_v2.DAT (aka Run 9_5_v2)

```
# ASAP VERSION 3.0
# WITCH 2015 Run 9Mc FLAT q=0.056 5 SV indices
#
# ASAP GUI 15 AUG 2012
#
# Number of Years
34
# First Year
1982
# Number of Ages
11
# Number of Fleets
1
# Number of Sensitivity Blocks
3
# Number of Available Survey Indices
15
# Natural Mortality
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
# Fecundity Option
0
# Fraction of year that elapses prior to SSB calculation (0=Jan-1)
```

0.1667

Maturity

0.00	0.00	0.01	0.04	0.14	0.40	0.73	0.92	0.98	0.99	1.00
0.00	0.00	0.01	0.06	0.20	0.51	0.82	0.95	0.99	1.00	1.00
0.00	0.00	0.02	0.07	0.24	0.59	0.86	0.97	0.99	1.00	1.00
0.00	0.00	0.01	0.05	0.24	0.68	0.93	0.99	1.00	1.00	1.00
0.00	0.00	0.02	0.09	0.36	0.76	0.95	0.99	1.00	1.00	1.00
0.00	0.02	0.08	0.30	0.68	0.91	0.98	1.00	1.00	1.00	1.00
0.01	0.03	0.14	0.43	0.78	0.94	0.99	1.00	1.00	1.00	1.00
0.00	0.02	0.09	0.32	0.68	0.91	0.98	1.00	1.00	1.00	1.00
0.01	0.02	0.07	0.20	0.46	0.73	0.90	0.97	0.99	1.00	1.00
0.01	0.02	0.07	0.17	0.38	0.64	0.84	0.94	0.98	0.99	1.00
0.01	0.02	0.06	0.17	0.41	0.70	0.89	0.96	0.99	1.00	1.00
0.00	0.01	0.04	0.13	0.35	0.65	0.87	0.96	0.99	1.00	1.00
0.00	0.01	0.04	0.13	0.34	0.64	0.86	0.96	0.99	1.00	1.00
0.00	0.01	0.03	0.13	0.42	0.78	0.95	0.99	1.00	1.00	1.00
0.00	0.00	0.02	0.12	0.45	0.83	0.96	0.99	1.00	1.00	1.00
0.00	0.00	0.01	0.07	0.37	0.81	0.97	1.00	1.00	1.00	1.00
0.00	0.01	0.04	0.13	0.38	0.71	0.91	0.98	0.99	1.00	1.00
0.00	0.01	0.04	0.14	0.36	0.67	0.88	0.96	0.99	1.00	1.00
0.01	0.02	0.05	0.14	0.33	0.59	0.82	0.93	0.98	0.99	1.00
0.01	0.02	0.06	0.15	0.33	0.58	0.79	0.91	0.97	0.99	1.00
0.02	0.04	0.08	0.17	0.32	0.53	0.72	0.86	0.93	0.97	1.00
0.02	0.04	0.09	0.17	0.31	0.49	0.68	0.82	0.91	0.96	1.00
0.03	0.06	0.11	0.19	0.32	0.49	0.66	0.79	0.89	0.94	1.00
0.04	0.07	0.12	0.22	0.35	0.52	0.68	0.80	0.89	0.94	1.00
0.02	0.04	0.09	0.16	0.29	0.45	0.63	0.78	0.88	0.94	1.00
0.02	0.04	0.08	0.17	0.32	0.52	0.71	0.85	0.93	0.97	1.00
0.01	0.03	0.08	0.19	0.37	0.61	0.80	0.92	0.97	0.99	1.00
0.02	0.04	0.11	0.25	0.47	0.71	0.87	0.95	0.98	0.99	1.00
0.01	0.04	0.10	0.24	0.48	0.73	0.89	0.96	0.99	0.99	1.00
0.02	0.05	0.13	0.29	0.53	0.75	0.89	0.96	0.98	0.99	1.00
0.01	0.04	0.11	0.27	0.52	0.76	0.90	0.96	0.99	1.00	1.00
0.01	0.04	0.11	0.27	0.52	0.76	0.91	0.97	0.99	1.00	1.00
0.01	0.03	0.09	0.23	0.49	0.75	0.91	0.97	0.99	1.00	1.00
0.01	0.03	0.09	0.23	0.49	0.75	0.91	0.97	0.99	1.00	1.00

Number of Weights at Age Matrices

3

Weight Matrix - 1

0.0029	0.0347	0.0847	0.1744	0.2649	0.4005	0.5499	0.726	0.8857	0.9828	1.4054
0.0078	0.038	0.1317	0.1775	0.237	0.4088	0.5182	0.6131	0.7948	0.977	1.3573
0.0161	0.0391	0.1192	0.2015	0.3078	0.4208	0.539	0.6639	0.8168	0.9221	1.3393
0.0163	0.0235	0.1281	0.2168	0.294	0.4282	0.5648	0.6909	0.8419	0.964	1.3254
0.0165	0.0255	0.091	0.1692	0.2727	0.4074	0.5331	0.6759	0.8528	0.9748	1.3208
0.0151	0.0328	0.0873	0.1654	0.2618	0.4323	0.5607	0.6859	0.8282	0.9801	1.303
0.0061	0.017	0.0629	0.1902	0.274	0.4329	0.5376	0.6678	0.8192	0.9801	1.3255
0.0123	0.0313	0.058	0.1514	0.2395	0.4243	0.5722	0.6796	0.8179	0.9676	1.3574
0.0106	0.0355	0.058	0.2051	0.2662	0.4404	0.5849	0.687	0.8482	1.0429	1.4527
0.0139	0.0386	0.0632	0.1756	0.2885	0.353	0.577	0.7003	0.8347	0.9724	1.4185
0.0066	0.0209	0.0961	0.2351	0.3302	0.4165	0.6042	0.7387	0.8215	0.882	1.243
0.0086	0.0226	0.1005	0.2403	0.3302	0.4314	0.5343	0.666	0.882	1.023	1.3353
0.0045	0.0187	0.0736	0.2144	0.3122	0.4269	0.526	0.6897	0.8322	0.9085	1.2636
0.0074	0.0269	0.0646	0.1576	0.3001	0.4212	0.561	0.6914	0.908	0.9718	1.2377
0.0189	0.0311	0.0607	0.1365	0.2685	0.4213	0.5542	0.7085	0.8568	0.9742	1.2295
0.0234	0.0354	0.0733	0.1959	0.2771	0.3774	0.4973	0.6277	0.8611	1.0302	1.28
0.006	0.0287	0.083	0.1685	0.2535	0.3569	0.4874	0.5856	0.864	0.9772	1.2088
0.0062	0.0292	0.093	0.2084	0.2829	0.3976	0.5147	0.5866	0.6324	0.9402	1.0631
0.006	0.0279	0.081	0.1747	0.2393	0.3642	0.4512	0.5344	0.6267	0.7149	0.9296
0.006	0.0245	0.1088	0.1722	0.2415	0.3507	0.4605	0.55	0.6448	0.6477	0.8431
0.0068	0.0329	0.1024	0.2198	0.2783	0.3963	0.4728	0.5524	0.6519	0.8219	0.94
0.0072	0.0324	0.0695	0.1582	0.2437	0.3214	0.4195	0.5035	0.5658	0.6211	0.8112
0.0064	0.0479	0.0986	0.212	0.2611	0.3291	0.4333	0.5374	0.6106	0.6869	0.8701
0.0188	0.0514	0.109	0.2033	0.2859	0.3543	0.4417	0.5553	0.6323	0.7243	0.9135
0.0121	0.0509	0.0975	0.1978	0.2669	0.317	0.4532	0.5452	0.6474	0.7124	0.9272
0.0154	0.041	0.1147	0.1884	0.2495	0.3522	0.4718	0.5636	0.6783	0.7451	0.9149
0.0036	0.0358	0.1241	0.1991	0.2705	0.3928	0.4754	0.5405	0.5986	0.6489	0.8268

0.0402	0.0444	0.1036	0.203	0.2652	0.3666	0.4528	0.5477	0.6222	0.726	0.6897
0.0025	0.0116	0.0808	0.1803	0.2526	0.3024	0.4256	0.4993	0.6518	0.6196	0.8102
0.0024	0.0262	0.0933	0.203	0.2469	0.343	0.4322	0.5442	0.6483	0.7199	0.8851
0.0065	0.0388	0.1402	0.1843	0.2811	0.3266	0.4382	0.5398	0.6494	0.7195	0.8828
0.0245	0.0941	0.1472	0.201	0.2669	0.3498	0.44	0.5304	0.6313	0.6972	0.8755
0.0254	0.0754	0.1319	0.1951	0.2862	0.3764	0.4812	0.5892	0.6927	0.7692	1.3769
0.0264	0.0624	0.1054	0.1612	0.2751	0.3701	0.4683	0.5536	0.6564	0.7556	0.8428

Weight Matrix - 2

0.0008	0.0178	0.0585	0.1496	0.2132	0.3521	0.5208	0.6939	0.8433	0.933	1.4054
0.0035	0.0105	0.0676	0.1226	0.2033	0.3291	0.4556	0.5806	0.7596	0.9302	1.3573
0.0133	0.0175	0.0673	0.1629	0.2337	0.3158	0.4694	0.5865	0.7077	0.8561	1.3393
0.013	0.0195	0.0708	0.1608	0.2434	0.363	0.4875	0.6102	0.7476	0.8874	1.3254
0.0117	0.0204	0.0462	0.1472	0.2431	0.3461	0.4778	0.6179	0.7676	0.9059	1.3208
0.0142	0.0233	0.0472	0.1227	0.2105	0.3433	0.4779	0.6047	0.7482	0.9142	1.303
0.0027	0.016	0.0454	0.1289	0.2129	0.3366	0.4821	0.6119	0.7496	0.901	1.3255
0.0072	0.0138	0.0314	0.0976	0.2134	0.341	0.4977	0.6044	0.739	0.8903	1.3574
0.0056	0.0209	0.0426	0.1091	0.2008	0.3248	0.4982	0.627	0.7592	0.9236	1.4527
0.0113	0.0202	0.0474	0.1009	0.2433	0.3065	0.5041	0.64	0.7573	0.9082	1.4185
0.0036	0.017	0.0609	0.1219	0.2408	0.3466	0.4618	0.6529	0.7585	0.858	1.243
0.0058	0.0122	0.0458	0.152	0.2786	0.3774	0.4717	0.6343	0.8072	0.9167	1.3353
0.0018	0.0127	0.0408	0.1468	0.2739	0.3754	0.4764	0.607	0.7445	0.8952	1.2636
0.0036	0.011	0.0348	0.1077	0.2537	0.3626	0.4894	0.6031	0.7914	0.8993	1.2377
0.0138	0.0152	0.0404	0.0939	0.2057	0.3556	0.4831	0.6305	0.7697	0.9405	1.2295
0.0211	0.0259	0.0477	0.109	0.1945	0.3183	0.4577	0.5898	0.7811	0.9395	1.28
0.0027	0.0259	0.0542	0.1111	0.2228	0.3145	0.4289	0.5396	0.7364	0.9173	1.2088
0.0029	0.0132	0.0517	0.1315	0.2183	0.3175	0.4286	0.5347	0.6086	0.9013	1.0631
0.003	0.0132	0.0486	0.1275	0.2233	0.321	0.4236	0.5245	0.6063	0.6724	0.9296
0.0026	0.0121	0.0551	0.1181	0.2054	0.2897	0.4095	0.4982	0.587	0.6371	0.8431
0.0031	0.014	0.0501	0.1546	0.2189	0.3094	0.4072	0.5044	0.5988	0.728	0.94
0.0028	0.0148	0.0478	0.1273	0.2314	0.2991	0.4077	0.4879	0.5591	0.6363	0.8112
0.0023	0.0186	0.0565	0.1214	0.2032	0.2832	0.3732	0.4748	0.5545	0.6234	0.8701
0.0114	0.0181	0.0723	0.1416	0.2462	0.3042	0.3813	0.4905	0.5829	0.665	0.9135
0.0066	0.0309	0.0708	0.1468	0.2329	0.301	0.4007	0.4907	0.5996	0.6712	0.9272
0.0101	0.0223	0.0764	0.1355	0.2222	0.3066	0.3867	0.5054	0.6081	0.6945	0.9149
0.001	0.0235	0.0713	0.1511	0.2257	0.3131	0.4092	0.505	0.5808	0.6634	0.8268
0.0748	0.0126	0.0609	0.1587	0.2298	0.3149	0.4217	0.5103	0.5799	0.6592	0.6897
0.0008	0.0216	0.0599	0.1367	0.2264	0.2832	0.395	0.4755	0.5975	0.6209	0.8102
0.0006	0.0081	0.0329	0.1281	0.211	0.2943	0.3615	0.4813	0.5689	0.685	0.8851
0.0017	0.0096	0.0606	0.1311	0.2389	0.284	0.3877	0.483	0.5945	0.683	0.8828
0.014	0.0247	0.0756	0.1679	0.2218	0.3136	0.3791	0.4821	0.5838	0.6729	0.8755
0.0162	0.043	0.1114	0.1695	0.2398	0.317	0.4103	0.5092	0.6061	0.6968	1.3769
0.0175	0.0398	0.0891	0.1458	0.2317	0.3255	0.4198	0.5161	0.6219	0.7235	0.8428

Weight Matrix - 3

0.0008	0.0178	0.0585	0.1496	0.2132	0.3521	0.5208	0.6939	0.8433	0.933	1.4054
0.0035	0.0105	0.0676	0.1226	0.2033	0.3291	0.4556	0.5806	0.7596	0.9302	1.3573
0.0133	0.0175	0.0673	0.1629	0.2337	0.3158	0.4694	0.5865	0.7077	0.8561	1.3393
0.013	0.0195	0.0708	0.1608	0.2434	0.363	0.4875	0.6102	0.7476	0.8874	1.3254
0.0117	0.0204	0.0462	0.1472	0.2431	0.3461	0.4778	0.6179	0.7676	0.9059	1.3208
0.0142	0.0233	0.0472	0.1227	0.2105	0.3433	0.4779	0.6047	0.7482	0.9142	1.303
0.0027	0.016	0.0454	0.1289	0.2129	0.3366	0.4821	0.6119	0.7496	0.901	1.3255
0.0072	0.0138	0.0314	0.0976	0.2134	0.341	0.4977	0.6044	0.739	0.8903	1.3574
0.0056	0.0209	0.0426	0.1091	0.2008	0.3248	0.4982	0.627	0.7592	0.9236	1.4527
0.0113	0.0202	0.0474	0.1009	0.2433	0.3065	0.5041	0.64	0.7573	0.9082	1.4185
0.0036	0.017	0.0609	0.1219	0.2408	0.3466	0.4618	0.6529	0.7585	0.858	1.243
0.0058	0.0122	0.0458	0.152	0.2786	0.3774	0.4717	0.6343	0.8072	0.9167	1.3353
0.0018	0.0127	0.0408	0.1468	0.2739	0.3754	0.4764	0.607	0.7445	0.8952	1.2636
0.0036	0.011	0.0348	0.1077	0.2537	0.3626	0.4894	0.6031	0.7914	0.8993	1.2377
0.0138	0.0152	0.0404	0.0939	0.2057	0.3556	0.4831	0.6305	0.7697	0.9405	1.2295
0.0211	0.0259	0.0477	0.109	0.1945	0.3183	0.4577	0.5898	0.7811	0.9395	1.28
0.0027	0.0259	0.0542	0.1111	0.2228	0.3145	0.4289	0.5396	0.7364	0.9173	1.2088
0.0029	0.0132	0.0517	0.1315	0.2183	0.3175	0.4286	0.5347	0.6086	0.9013	1.0631
0.003	0.0132	0.0486	0.1275	0.2233	0.321	0.4236	0.5245	0.6063	0.6724	0.9296
0.0026	0.0121	0.0551	0.1181	0.2054	0.2897	0.4095	0.4982	0.587	0.6371	0.8431
0.0031	0.014	0.0501	0.1546	0.2189	0.3094	0.4072	0.5044	0.5988	0.728	0.94
0.0028	0.0148	0.0478	0.1273	0.2314	0.2991	0.4077	0.4879	0.5591	0.6363	0.8112
0.0023	0.0186	0.0565	0.1214	0.2032	0.2832	0.3732	0.4748	0.5545	0.6234	0.8701

```
0.0114	0.0181	0.0723	0.1416	0.2462	0.3042	0.3813	0.4905	0.5829	0.665	0.9135
0.0066	0.0309	0.0708	0.1468	0.2329	0.301	0.4007	0.4907	0.5996	0.6712	0.9272
0.0101	0.0223	0.0764	0.1355	0.2222	0.3066	0.3867	0.5054	0.6081	0.6945	0.9149
0.001	0.0235	0.0713	0.1511	0.2257	0.3131	0.4092	0.505	0.5808	0.6634	0.8268
0.0748	0.0126	0.0609	0.1587	0.2298	0.3149	0.4217	0.5103	0.5799	0.6592	0.6897
0.0008	0.0216	0.0599	0.1367	0.2264	0.2832	0.395	0.4755	0.5975	0.6209	0.8102
0.0006	0.0081	0.0329	0.1281	0.211	0.2943	0.3615	0.4813	0.5689	0.685	0.8851
0.0017	0.0096	0.0606	0.1311	0.2389	0.284	0.3877	0.483	0.5945	0.683	0.8828
0.014	0.0247	0.0756	0.1679	0.2218	0.3136	0.3791	0.4821	0.5838	0.6729	0.8755
0.0162	0.043	0.1114	0.1695	0.2398	0.317	0.4103	0.5092	0.6061	0.6968	1.3769
0.0175	0.0398	0.0891	0.1458	0.2317	0.3255	0.4198	0.5161	0.6219	0.7235	0.8428
# Weights at Age Pointers
1
1
1
1
2
3
# Selectivity Block Assignment
# Fleet 1 Selectivity Block Assignment
1
1
1
1
1
1
1
1
1
1
1
2
2
2
2
2
2
2
2
2
2
2
2
3
3
3
3
3
3
3
3
3
3
3
# Selectivity Options for each block 1=by age, 2=logisitic, 3=double logistic
1  1  1
# Selectivity Block #1 Data
0.0128	3	0	0.001
0.0324	3	0	0.001
0.0905	2	0	0.001
0.4274	2	0	0.001
0.5685	1	0	0.001
1	1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
```

```
1	-1	0	0.001
1	-1	0	0.001
0	-1	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0
# Selectivity Block #2 Data
0.0128	3	0	0.001
0.0324	3	0	0.001
0.0905	2	0	0.001
0.4274	2	0	0.001
0.5685	1	0	0.001
1	1	0	0.001
1	1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
# Selectivity Block #3 Data
0.0128	3	0	0.001
0.0324	3	0	0.001
0.0905	2	0	0.001
0.4274	2	0	0.001
0.5685	1	0	0.001
1	1	0	0.001
1	1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
# Fleet Start Age
1
# Fleet End Age
11
# Age Range for Average F
8  9
# Average F report option (1=unweighted, 2=Nweighted, 3=Bweighted)
1
# Use Likelihood constants? (1=yes)
0
# Release Mortality by Fleet
0
# Catch Data
# Fleet-1 Catch Data
0.566518513	5.606896798	569.5981556	2639.481958	1783.403138	1630.675411	679.983411	666.9871226	402.6155269	240.8343007	1581.748404	5308.91
0.116177956	6.857221798	450.5973005	2107.90245	2179.080081	1597.723803	1607.427084	986.8348926	741.8635887	511.966894	1677.872498	6408.6
0.838380655	2.185406352	222.6301786	2142.092193	2302.035858	1761.230949	1497.348759	1505.286895	700.007297	376.3530914	1720.182366	6936.86
1.015753207	9.965520903	365.7008725	1556.628491	2311.318715	1957.638347	1536.373152	1254.362264	608.2823974	401.3635824	1360.868563	6339.35
1.759635083	12.41089533	68.09041265	701.3418818	1941.531422	2806.179365	1582.617308	842.2078847	415.7188211	223.9912619	760.1965004	4787.66
33.86662621	143.6551884	55.77651227	334.1625336	813.0656645	1318.505502	1602.781574	881.4412398	484.6832354	254.4499612	492.5838813	3644.02
10.78820732	94.74357502	767.8653244	288.3840725	421.1306251	688.3676776	1414.656367	1168.951673	405.5703073	268.7980538	600.6968875	3451.38
17.72595644	90.40362571	192.0820682	1180.051228	503.9660508	344.9061225	792.3855222	911.6141959	356.8653662	125.7483688	352.5751012	2424.98
```

```
4.057884043    138.8346915    367.025043     604.4629287    1158.950118    284.5470462    295.3837099    493.7878809    347.0980393    84.95913663    182.2345289    1743.82
25.19055714    245.7090434    1152.466719    1595.264994    2002.057613    1012.924893    256.2065785    260.4996796    303.3080607    323.8106356    264.1486552    2571.13
30.95943444    97.58360527    196.1549177    1524.248027    1531.489858    1271.761385    756.7777667    204.3168193    180.4165135    121.5528104    380.9215561    2751.97
57.85051286    79.55883776    73.25551783    958.6290864    1386.261087    924.0665432    600.3199594    586.4912542    218.5672894    278.0599751    389.8135989    2805.73
2921.271717    1061.518089    100.679145     738.902567     2208.750097    1371.954518    981.9579347    202.507532     548.7938629    114.693097     335.5738155    3115.31
48.45326453    683.1718811    864.7083219    881.7493384    1463.398548    1912.774219    879.9160383    284.8164719    103.3216994    282.721779     162.0040639    2717.99
104.1746542    163.1766293    390.3351983    678.5243706    1162.344534    1383.942426    1444.951529    266.5591162    218.0118546    57.73416481    114.8853537    2392.45
60.90776757    89.87894276    129.7077765    994.2676063    1189.248206    1404.641148    1114.680887    649.7475448    90.46795431    51.73249464    71.97692922    2254.24
161.4026217    152.6128551    347.4758727    865.7882732    1285.445701    1486.063998    1652.859337    387.6056722    151.8683347    16.55538629    74.45057258    2306.24
70.38551956    83.00390412    147.611678     703.9989504    1262.50931     1504.85351     1224.32768     783.7153937    260.967839     38.07073568    75.75675053    2490.21
101.8922714    78.75849953    132.6624118    497.2366386    708.8587655    1223.358007    1758.263005    1051.958297    585.7652409    100.7845164    256.6927806    2748.76
39.07799272    27.78083041    61.71019168    464.5888759    1315.672518    1198.936464    1766.265374    1471.340874    640.2307985    431.8807056    314.9804279    3406.43
16.31075742    14.56986134    37.14289183    652.7574322    1210.591501    1392.180533    2167.146504    1288.628799    649.9935861    97.09431959    206.3652549    3470.39
1.988534468    11.66328438    42.95557055    364.7793471    1300.670773    1737.055187    1944.156714    1591.59472     764.2070753    444.2615617    356.7772915    3550.97
0.760215681    16.01190584    48.58261398    448.6634368    1408.049171    1795.699657    1589.910478    1179.35169     813.0197443    335.9293917    299.9477194    3370.06
11.00124183    36.5176549     30.65752308    275.3779597    993.7544804    1996.502163    1859.312813    848.0733451    424.9728742    242.4556927    139.4294502    2916.83
6.972188858    53.35072062    126.1888042    134.4603515    344.5351545    946.97154      1624.664124    901.2781392    369.1180224    140.0685266    80.21459694    2074.69
4.752548331    29.88859912    144.4465546    179.6354318    174.4900102    310.9662426    905.6517095    607.7158517    175.4466076    99.3382131     46.48095228    1210.13
1.199930136    22.31259473    55.44322035    293.2277612    242.9158454    352.2098826    617.2928024    466.7484145    317.0190633    113.2277235    68.70899443    1135.94
0.621694892    25.12655048    40.6898391     238.691698     562.2878709    339.9770371    527.4118467    485.4242232    338.6406063    80.67286008    81.07612141    1157.43
29.16985646    370.0167012    80.70951109    110.9393807    314.6351574    543.4086136    308.3646314    407.3418629    182.7682003    234.2361632    47.80195442    912.33
46.43556927    346.5866982    245.0159323    149.012945     255.0982937    671.7348363    630.4828031    447.8921715    162.0988992    86.11875644    36.05002037    1070.97
6.487267651    57.33537102    167.7732065    270.3110203    355.4977896    480.595299     820.7949123    594.3093117    221.1890239    88.86556431    41.83632831    1257.51
3.497294934    47.99980573    43.09117501    204.8013083    227.621825     296.5701184    475.0947227    331.9083305    185.1555633    84.2083784     38.16160025    810.76
1.777519053    19.49641694    134.5170815    104.0296137    220.8298589    181.6170745    280.0243038    337.8709016    136.9684638    48.58806756    27.4666024     675.03
0.366926536    19.9456269     94.23889088    189.6269459    133.5545375    250.0763716    266.97185      290.7486523    121.7831234    36.55909766    24.11499246    584.97
# Discards
# Fleet-1 Discards Data
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0
# Release Proportion
# Fleet-1 Release Data
0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0
```

```
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
# Survey Index Data
# Aggregate Index Units
2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
# Age Proportion Index Units
2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
# Weight at Age Matrix
3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
# Index Month
4  10  4  4  10  10  4  4  10  10  8  4  10  4  10
# Index Selectivity Link to Fleet
-1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
# Index Selectivity Options 1=by age, 2=logisitic, 3=double logistic
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
# Index Start Age
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
# Index End Age
11  11  11  11  11  11  11  11  11  11  11  11  11  11  11
# Estimate Proportion (Yes=1)
1  1  0  0  0  0  0  0  0  0  1  1  1  0  0
# Use Index (Yes=1)
1  1  0  0  0  0  0  0  0  0  1  1  1  0  0
# Index-1 Selectivity Data
0.1	3	0	0.001
0.15	3	0	0.001
0.2	3	0	0.001
0.25	3	0	0.001
0.4	1	0	0.001
0.6	1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
1	-1	0	0.001
0	-1	0	0
```

```
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
# Index-2 Selectivity Data
0.1             3               0               0.001
0.15            3               0               0.001
0.2             3               0               0.001
0.25            3               0               0.001
0.4             1               0               0.001
0.6             1               0               0.001
1               -1              0               0.001
1               -1              0               0.001
1               -1              0               0.001
1               -1              0               0.001
1               -1              0               0.001
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
# Index-3 Selectivity Data
0.1             3               0               0.001
0.15            3               0               0.001
0.2             3               0               0.001
0.25            3               0               0.001
0.4             1               0               0.001
0.6             1               0               0.001
0.7             1               0               0.001
0.8             1               0               0.001
0.9             1               0               0.001
0.95            1               0               0.001
1               -1              0               0.001
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
# Index-4 Selectivity Data
0.1             3               0               0.001
0.15            3               0               0.001
0.2             3               0               0.001
0.25            3               0               0.001
0.4             1               0               0.001
0.6             1               0               0.001
0.7             1               0               0.001
0.8             1               0               0.001
0.9             1               0               0.001
0.95            1               0               0.001
1               -1              0               0.001
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
# Index-5 Selectivity Data
0.1             3               0               0.001
0.15            3               0               0.001
0.2             3               0               0.001
0.25            3               0               0.001
0.4             1               0               0.001
0.6             1               0               0.001
```

```
0.7           1             0             0.001
0.8           1             0             0.001
0.9           1             0             0.001
0.95          1             0             0.001
1             -1            0             0.001
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
# Index-6 Selectivity Data
0.1           3             0             0.001
0.15          3             0             0.001
0.2           3             0             0.001
0.25          3             0             0.001
0.4           1             0             0.001
0.6           1             0             0.001
0.7           1             0             0.001
0.8           1             0             0.001
0.9           1             0             0.001
0.95          1             0             0.001
1             -1            0             0.001
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
# Index-7 Selectivity Data
0.1           3             0             0.001
0.15          3             0             0.001
0.2           3             0             0.001
0.25          3             0             0.001
0.4           1             0             0.001
0.6           1             0             0.001
0.7           1             0             0.001
0.8           1             0             0.001
0.9           1             0             0.001
0.95          1             0             0.001
1             -1            0             0.001
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
# Index-8 Selectivity Data
0.1           3             0             0.001
0.15          3             0             0.001
0.2           3             0             0.001
0.25          3             0             0.001
0.4           1             0             0.001
0.6           1             0             0.001
0.7           1             0             0.001
0.8           1             0             0.001
0.9           1             0             0.001
0.95          1             0             0.001
1             -1            0             0.001
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
0             -1            0             0
# Index-9 Selectivity Data
```

```
0.1             3               0               0.001
0.15            3               0               0.001
0.2             3               0               0.001
0.25            3               0               0.001
0.4             1               0               0.001
0.6             1               0               0.001
0.7             1               0               0.001
0.8             1               0               0.001
0.9             1               0               0.001
0.95            1               0               0.001
1               -1              0               0.001
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
# Index-10 Selectivity Data
0.1             3               0               0.001
0.15            3               0               0.001
0.2             3               0               0.001
0.25            3               0               0.001
0.4             1               0               0.001
0.6             1               0               0.001
0.7             1               0               0.001
0.8             1               0               0.001
0.9             1               0               0.001
0.95            1               0               0.001
1               -1              0               0.001
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
# Index-11 Selectivity Data
0.6             3               0               0.001
0.6             3               0               0.001
1               -1              0               0.001
1               -1              0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
0               -1              0               0
# Index-12 Selectivity Data
1               -1              0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
1               3               0               0.001
0               -1              0               0
```

```
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
# Index-13 Selectivity Data
1              -1             0              0.001
1              3              0              0.001
1              3              0              0.001
1              3              0              0.001
1              3              0              0.001
1              3              0              0.001
1              3              0              0.001
1              3              0              0.001
1              3              0              0.001
1              3              0              0.001
1              3              0              0.001
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
# Index-14 Selectivity Data
0.1            3              0              0.001
0.15           3              0              0.001
0.2            3              0              0.001
0.25           3              0              0.001
0.4            1              0              0.001
0.6            1              0              0.001
0.7            1              0              0.001
0.8            1              0              0.001
0.9            1              0              0.001
0.95           1              0              0.001
1              -1             0              0.001
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
# Index-15 Selectivity Data
0.1            3              0              0.001
0.15           3              0              0.001
0.2            3              0              0.001
0.25           3              0              0.001
0.4            1              0              0.001
0.6            1              0              0.001
0.7            1              0              0.001
0.8            1              0              0.001
0.9            1              0              0.001
0.95           1              0              0.001
1              -1             0              0.001
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
0              -1             0              0
# Index-1 Data
1982  129606.2886     0.33           1573.004145     1487.592156     21694.64541     17217.63361     13402.56473     8423.757494     21651.93941     12886.53396     3316.83227      9228.053731
18751.49059     46
1983  227996.6303     0.405          0               2526.771365     18904.52041     44894.67714     46026.386       19253.28603     25491.92012     22506.05931     16918.69165     7619.461256
23886.88648     46
1984  106806.6256     0.24           0               3672.715561     409.2657844     10929.17586     27666.36703     14281.59646     11018.14668     7178.165976     6978.871333     4081.981346
20609.20137     46
```

```
1985  184410.536      0.285     0              0              594.3250957    16342.16071    37623.98151    42684.6419     32303.52631    14665.95041    5259.955038    5291.984534
29662.87229     46
1986  73755.03261     0.24      0              0              0              1562.327647    8551.875478    18811.99075    14655.27392    6117.633769    6911.253508    2818.595663
14349.21429     46
1987  35842.42975     0.345     0              0              0              2096.152583    4053.510682    4726.130102    9235.171397    6601.635045    338.0891263    2185.123406
6626.546875     46
1988  51019.42857     0.345     811.4139031    814.972736     2206.476403    0              2576.595026    10676.49872    13487.97672    8491.375319    4882.71875     3071.2728
4010.804688     46
1989  69222.50301     0.33      814.972736     462.6482781    1281.179847    35744.91773    3754.568718    2590.830357    2889.772321    11655.17777    2889.772321    540.942602
6612.311543     46
1990  22280.78519     0.45      288.2654656    0              1334.562341    3249.214445    11374.02997    0              1498.268654    309.618463     1793.651786    626.3545918
1822.122449     46
1991  59922.20497     0.375     1487.592156    0              27769.57318    3857.774872    3099.743463    7427.284279    1170.856027    3587.303571    2946.713648    4900.512915
3686.950893     46
1992  44844.14171     0.27      1939.563935    309.618463     6651.458705    13263.77025    3032.125638    3936.069196    5405.867188    1601.474809    5288.425702    544.5014349
2889.772321     46
1993  52284.23779     0.27      5284.866869    3993.010523    4886.277583    16808.36783    11374.02997    2053.446588    3039.243304    0              551.6191008    551.6191008
3754.568718     46
1994  111366.2023     0.345     3818.62771     24819.3007     19249.7272     22904.6486     28840.78189    5850.721301    957.3260523    1000.032047    2505.418367    295.3831314
1138.826531     46
1995  66998.94421     0.255     1441.327328    4263.481824    20683.93686    11235.23549    6366.752073    11099.99984    4135.363839    3921.833865    1494.709821    0
2366.623884     46
1996  48353.15096     0.255     597.8839286    1266.944515    8669.316964    14036.03699    12299.32653    7776.049904    2580.153858    0              0              0
1138.826531     46
1997  78953.06395     0.405     2565.918527    2359.506218    5412.984853    24648.47672    21954.44021    15569.89397    2996.537309    2943.154815    512.4719388    0              0
46
1998  152102.7391     0.255     3989.45169     38392.68941    25349.5668     13811.83052    28399.48661    25378.03747    7626.578922    5466.367347    2697.595344    0
1010.708546     46
1999  112072.2748     0.3       3765.245217    13374.09407    34655.91486    28363.89828    17171.36878    5847.162468    6491.311224    1089.00287     512.4719388    811.4139031    0
46
2000  122631.332      0.21      231.324139     8911.317602    42485.34726    24644.91789    23470.50303    8516.287149    8993.170759    4124.687341    0              1259.826849    0
46
2001  156908.587      0.24      3740.333386    3516.126913    25360.2433     52521.25606    36296.53683    14263.8023     10427.38042    5797.338807    4014.36352     1000.032047    0
46
2002  288301.7657     0.3       814.972736     2131.740912    31929.84885    93504.77583    80547.06521    29264.283      24313.94643    12480.82701    6815.165019    3654.921397
2854.183992     46
2003  185206.291      0.24      0              0              5331.131696    28751.81107    58592.625      36182.65418    30912.02264    13776.24219    7007.341996    1619.268973
3042.802136     46
2004  135215.3652     0.195     327.4126276    2138.858578    2626.418686    15231.80485    23079.03141    28790.95823    31417.37691    13107.1816     5626.514828    5719.044483
7178.165976     46
2005  119655.7918     0.3       387.912787     5694.132653    5210.131378    7811.638233    26246.3927     27054.24777    20441.93622    13637.4477     8719.140625    3078.390466
1395.0625       46
2006  109855.4777     0.21      1548.092315    16384.86671    12359.82669    4911.189413    7373.901786    24317.50526    20217.72975    14594.77376    5163.86655     2448.477041
537.3837691     46
2007  84329.74871     0.24      0              6327.604911    20310.25941    9349.05405     8587.463807    8128.374362    19438.34534    5466.367347    5637.191327    0
1089.00287      46
2008  265119.884      0.375     387.912787     13245.97608    30161.1089     100864.4423    47713.2728     22972.26642    25776.62675    19577.13983    3138.890625    1295.415179    0
46
2009  83344.30788     0.225     4800.865593    4964.571907    10309.93893    15242.48135    20445.49506    7324.078125    5523.308673    7850.785395    4284.834821    2014.299426
612.1192602     46
2010  87963.67299     0.21      4943.218909    16064.57175    9544.78986     5982.398119    14943.53938    16769.22066    5042.866231    3615.774235    6580.282047    2338.153221
2149.535077     46
2011  100383.9998     0.165     1242.032685    12996.85778    24943.85985    9526.995695    10836.64621    16708.7205     10060.82063    4185.1875      3142.449458    4092.657844
2647.771684     46
2012  64898.87691     0.18      3181.59662     6672.811703    13772.68335    11719.23677    5548.220504    8260.05118     5683.456154    5640.750159    2679.80118     1206.444356
569.4132653     46
2013  36990.50925     0.195     1266.944515    4409.393973    4950.336575    9939.820313    5138.954719    3096.18463     3879.12787     2331.035555    1110.355867    661.9429209
195.7358099     46
2014  105369.9247     0.225     20488.20105    15922.21843    24068.38696    9377.524713    15359.92283    7441.519611    4857.80692     4921.865912    2928.919483    0              0
46
2015  98629.49522     0.225     1124.591199    20705.28986    26865.62962    16399.10204    8345.46317     11388.26531    5395.190689    5377.396524    1871.94611     715.3254145
451.9717793     46
# Index-2 Data
1982  35252.87349     0.7       0              0              2046.328922    466.207111     960.8848852    2694.036511    8573.228476    4708.335938    519.5896046    975.1202168
13612.53587     35
```

1983	167921.7514	0.245	288.2654656	387.912787	18046.84168	56791.85555	26958.15928	19502.40434	15808.33578	2978.743144	4886.277583	2597.948023	19676.78715	35
1984	155613.8836	0.245	0	0	3320.391103	33584.70615	35278.71062	21527.38026	19032.63839	11021.70552	5299.1022	4469.894133	22100.35236	35
1985	98346.568	0.35	0	306.0596301	2092.59375	2694.036511	21715.99841	24342.41709	17171.36878	9601.731186	3654.921397	4348.893814	12445.23868	35
1986	56589.00207	0.2625	0	0	0	1815.004783	9484.2897	12573.35666	10978.99952	5687.014987	3985.892857	330.9714605	11448.76547	35
1987	17164.57141	0.5775	0	814.972736	0	387.912787	814.972736	1626.386639	6836.518017	2541.006696	0	306.0596301	3832.863042	35
1988	48960.64373	0.2975	231.324139	0	25790.86209	1939.563935	409.2657844	1266.944515	7644.373087	1722.475128	1647.739636	1615.71014	6690.605867	35
1989	31594.74915	0.35	647.7075893	647.7075893	2907.566486	10697.85172	323.8537946	750.9137436	590.7662628	2982.301977	2790.125	843.4433992	2238.505899	35
1990	71335.38211	0.28	3135.331792	4872.042251	13527.12388	19142.96221	6694.1647	854.119898	814.972736	814.972736	893.2670599	0	3491.215083	35
1991	74125.86299	0.49	750.9137436	6320.487245	23523.88552	11715.67793	10317.0566	5156.748884	2395.094547	2103.270249	1053.414541	1843.475446	1000.032047	35
1992	33440.75136	0.525	1042.738042	3886.245536	9199.583068	7957.550383	1907.534439	2149.535077	0	0	672.6194196	327.4126276	2861.301658	35
1993	183434.3481	0.4375	23908.23948	5487.720344	19367.16869	27655.69053	7808.079401	2060.564254	772.2667411	2896.889987	0	683.2959184	2402.212213	35
1994	78606.78951	0.28	5548.220504	10220.96811	18911.63807	5879.191964	14064.50765	1316.768176	3775.921716	0	1512.503986	323.8537946	1694.004464	35
1995	168542.0559	0.35	7213.754305	27200.15992	57788.32876	30520.55102	16804.80899	8153.286193	0	0	384.3539541	1939.563935	323.8537946	35
1996	191618.952	0.3325	3252.773278	9281.436224	27947.51483	70735.36288	49328.98294	15701.57079	2331.035555	2306.123724	1327.444675	0	1174.41486	35
1997	181668.8111	0.35	12060.88473	34837.41534	18587.78428	30993.8758	27388.77806	13633.88887	11729.91327	0	0	0	693.9724171	35
1998	131720.9471	0.35	2907.566486	18502.37229	48492.65721	16555.69069	10783.26371	5879.191964	3921.833865	1512.503986	437.7364477	0	0	35
1999	210496.0694	0.385	18552.19595	41926.61049	53870.05373	37150.65673	21342.32095	12932.79879	9801.025829	1772.298788	1316.768176	334.5302934	0	35
2000	235959.8748	0.2625	3405.803093	25577.33211	50115.48501	62137.22258	23982.97497	20965.08466	8163.962691	5398.749522	1761.62229	0	925.2965561	35
2001	282569.1976	0.28	1398.621333	7491.343272	33897.88345	112306.0901	67112.47098	28933.31154	21776.49857	5644.308992	2046.328922	1978.711097	0	35
2002	153417.0161	0.3325	0	9779.672832	15335.011	52499.90306	35485.12293	18929.43224	11769.06043	5284.866869	2530.330198	0	1804.328284	35
2003	94667.44654	0.3325	0	1363.033004	2676.242347	10914.94053	20655.4662	27388.77806	11210.32366	4576.65912	7911.285555	2946.713648	4395.158642	35
2004	135787.9814	0.56	2573.036193	512.4719388	3071.2728	16117.95424	35111.44547	29406.63632	17715.87022	12633.85682	1925.328603	3729.656888	3206.50845	35
2005	68773.02242	0.315	22598.58897	3089.066964	814.972736	4658.512277	6437.928731	9583.937022	12096.47305	1950.240434	1857.710778	416.3834503	576.5309311	35
2006	72240.03744	0.3325	3662.039063	19210.58004	11448.76547	1637.063138	3711.862723	10612.43973	10192.49745	4907.63058	2526.771365	1494.709821	512.4719388	35
2007	97526.6129	0.4025	2313.24139	5747.515147	42930.20137	16996.98597	6690.605867	7822.314732	9284.995057	2459.15354	2765.21317	0	512.4719388	35
2008	97791.39007	0.2975	754.4725765	3388.008929	15018.27487	28242.89796	9715.613839	9028.759088	8345.46317	10754.79305	484.0012755	2010.740593	288.2654656	35
2009	77611.02806	0.3325	13673.03603	6630.105708	7060.72449	13416.80006	16157.1014	5459.249681	4907.63058	4099.77551	2409.329879	153.0298151	302.5007972	35
2010	71165.98166	0.2975	14292.27296	16676.69101	6523.340721	7526.931601	5971.72162	8939.788265	1829.240115	4135.363839	2224.270568	686.8547513	847.0022321	35
2011	132068.2892	0.3675	8131.933195	30926.25797	38325.07159	14313.62596	9964.732143	15641.07063	6409.458068	2672.683514	1690.445631	2149.535077	398.5892857	35
2012	78020.29385	0.35	9295.671556	10957.64652	22926.00159	11224.55899	5007.277902	7672.84375	4793.747927	2032.093591	2085.476084	1131.708865	377.2362883	35
2013	82070.2457	0.315	6683.488202	17288.81027	6768.900191	16441.80804	8462.904656	1494.709821	3722.539222	2035.652423	918.1788903	160.1474809	0	35
2014	98359.02392	0.2975	24313.94643	11612.47178	19025.52073	8402.404496	13502.21205	5049.983897	4964.571907	4989.483737	1348.797672	270.471301	743.7960778	35
2015	112338.1196	0.2275	5341.808195	33203.91103	29513.40131	11779.73693	5708.367985	10982.55835	4647.835778	1822.122449	2131.740912	498.2366071	121.0003189	35

```
# Index-3 Data
1982  3.642         0.222         0         0         0         0         0         0         0         0         0         0         0
0
1983  6.407         0.27          0         0         0         0         0         0         0         0         0         0         0
0
1984  3.001         0.161         0         0         0         0         0         0         0         0         0         0         0
0
1985  5.182         0.193         0         0         0         0         0         0         0         0         0         0         0
0
1986  2.072         0.158         0         0         0         0         0         0         0         0         0         0         0
0
1987  1.007         0.232         0         0         0         0         0         0         0         0         0         0         0
0
1988  1.434         0.233         0         0         0         0         0         0         0         0         0         0         0
0
1989  1.945         0.217         0         0         0         0         0         0         0         0         0         0         0
0
1990  0.626         0.303         0         0         0         0         0         0         0         0         0         0         0
0
1991  1.684         0.25          0         0         0         0         0         0         0         0         0         0         0
0
1992  1.26          0.182         0         0         0         0         0         0         0         0         0         0         0
0
1993  1.469         0.177         0         0         0         0         0         0         0         0         0         0         0
0
1994  3.129         0.226         0         0         0         0         0         0         0         0         0         0         0
0
1995  0             0             0         0         0         0         0         0         0         0         0         0         0
0
1996  0             0             0         0         0         0         0         0         0         0         0         0         0
0
1997  0             0             0         0         0         0         0         0         0         0         0         0         0
0
1998  0             0             0         0         0         0         0         0         0         0         0         0         0
0
1999  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2000  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2001  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2002  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2003  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2004  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2005  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2006  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2007  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2008  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2009  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2010  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2011  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2012  0             0             0         0         0         0         0         0         0         0         0         0         0
0
2013  0             0             0         0         0         0         0         0         0         0         0         0         0
0
```

```
2014 0 0 0 0 0 0 0 0 0 0 0 0 0
0
2015 0 0 0 0 0 0 0 0 0 0 0 0 0
0
# Index-4 Data
1982 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1983 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1984 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1985 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1986 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1987 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1988 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1989 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1990 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1991 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1992 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1993 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1994 0 0 0 0 0 0 0 0 0 0 0 0 0
0
1995 1.883 0.169 0.0405 0.1198 0.5812 0.3157 0.1789 0.3119 0.1162 0.1102 0.042 0 0.0665
50
1996 1.359 0.169 0.0168 0.0356 0.2436 0.3944 0.3456 0.2185 0.0725 0 0 0 0.032
50
1997 2.219 0.267 0.0721 0.0663 0.1521 0.6926 0.6169 0.4375 0.0842 0.0827 0.0144 0 0
50
1998 4.274 0.175 0.1121 1.0788 0.7123 0.3881 0.798 0.7131 0.2143 0.1536 0.0758 0 0.0284
50
1999 3.149 0.205 0.1058 0.3758 0.9738 0.797 0.4825 0.1643 0.1824 0.0306 0.0144 0.0228 0
50
2000 3.446 0.14 0.0065 0.2504 1.1938 0.6925 0.6595 0.2393 0.2527 0.1159 0 0.0354 0
50
2001 4.409 0.163 0.1051 0.0988 0.7126 1.4758 1.0199 0.4008 0.293 0.1629 0.1128 0.0281 0
50
2002 8.101 0.203 0.0229 0.0599 0.8972 2.6274 2.2633 0.8223 0.6832 0.3507 0.1915 0.1027 0.0802
50
2003 5.204 0.161 0 0 0.1498 0.8079 1.6464 1.0167 0.8686 0.3871 0.1969 0.0455 0.0855
50
2004 3.799 0.126 0.0092 0.0601 0.0738 0.428 0.6485 0.809 0.8828 0.3683 0.1581 0.1607 0.2017
50
2005 3.362 0.203 0.0109 0.16 0.1464 0.2195 0.7375 0.7602 0.5744 0.3832 0.245 0.0865 0.0392
50
2006 3.087 0.139 0.0435 0.4604 0.3473 0.138 0.2072 0.6833 0.5681 0.4101 0.1451 0.0688 0.0151
50
2007 2.37 0.165 0 0.1778 0.5707 0.2627 0.2413 0.2284 0.5462 0.1536 0.1584 0 0.0306
50
2008 7.45 0.25 0.0109 0.3722 0.8475 2.8342 1.3407 0.6455 0.7243 0.5501 0.0882 0.0364 0
50
2009 2.342 0.147 0.1349 0.1395 0.2897 0.4283 0.5745 0.2058 0.1552 0.2206 0.1204 0.0566 0.0172
50
2010 2.472 0.138 0.1389 0.4514 0.2682 0.1681 0.4199 0.4712 0.1417 0.1016 0.1849 0.0657 0.0604
50
2011 2.821 0.114 0.0349 0.3652 0.7009 0.2677 0.3045 0.4695 0.2827 0.1176 0.0883 0.115 0.0744
50
```

2012	1.824	0.122	0.0894	0.1875	0.387	0.3293	0.1559	0.2321	0.1597	0.1585	0.0753	0.0339	0.016	50
2013	1.039	0.134	0.0356	0.1239	0.1391	0.2793	0.1444	0.087	0.109	0.0655	0.0312	0.0186	0.0055	50
2014	2.961	0.152	0.5757	0.4474	0.6763	0.2635	0.4316	0.2091	0.1365	0.1383	0.0823	0	0	50
2015	2.771	0.147	0.0316	0.5818	0.7549	0.4608	0.2345	0.32	0.1516	0.1511	0.0526	0.0201	0.0127	50

Index-5 Data

1982	0.991	0.405	0	0	0.0575	0.0131	0.027	0.0757	0.2409	0.1323	0.0146	0.0274	0.3825	50
1983	4.718	0.142	0.0081	0.0109	0.5071	1.5958	0.7575	0.548	0.4442	0.0837	0.1373	0.073	0.5529	50
1984	4.373	0.139	0	0	0.0933	0.9437	0.9913	0.6049	0.5348	0.3097	0.1489	0.1256	0.621	50
1985	2.763	0.197	0	0.0086	0.0588	0.0757	0.6102	0.684	0.4825	0.2698	0.1027	0.1222	0.3497	50
1986	1.59	0.155	0	0	0	0.051	0.2665	0.3533	0.3085	0.1598	0.112	0.0093	0.3217	50
1987	0.482	0.33	0	0.0229	0	0.0109	0.0229	0.0457	0.1921	0.0714	0	0.0086	0.1077	50
1988	1.376	0.173	0.0065	0	0.7247	0.0545	0.0115	0.0356	0.2148	0.0484	0.0463	0.0454	0.188	50
1989	0.888	0.196	0.0182	0.0182	0.0817	0.3006	0.0091	0.0211	0.0166	0.0838	0.0784	0.0237	0.0629	50
1990	2.004	0.164	0.0881	0.1369	0.3801	0.5379	0.1881	0.024	0.0229	0.0229	0.0251	0	0.0981	50
1991	2.083	0.276	0.0211	0.1776	0.661	0.3292	0.2899	0.1449	0.0673	0.0591	0.0296	0.0518	0.0281	50
1992	0.94	0.3	0.0293	0.1092	0.2585	0.2236	0.0536	0.0604	0	0	0.0189	0.0092	0.0804	50
1993	5.154	0.25	0.6718	0.1542	0.5442	0.7771	0.2194	0.0579	0.0217	0.0814	0	0.0192	0.0675	50
1994	2.209	0.164	0.1559	0.2872	0.5314	0.1652	0.3952	0.037	0.1061	0	0.0425	0.0091	0.0476	50
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Index-6 Data

1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	4.736	0.196	0.2027	0.7643	1.6238	0.8576	0.4722	0.2291	0	0	0.0108	0.0545	0.0091	50
1996	5.384	0.191	0.0914	0.2608	0.7853	1.9876	1.3861	0.4412	0.0655	0.0648	0.0373	0	0.033	50
1997	5.105	0.196	0.3389	0.9789	0.5223	0.8709	0.7696	0.3831	0.3296	0	0	0	0.0195	50
1998	3.701	0.201	0.0817	0.5199	1.3626	0.4652	0.303	0.1652	0.1102	0.0425	0.0123	0	0	50
1999	5.915	0.219	0.5213	1.1781	1.5137	1.0439	0.5997	0.3634	0.2754	0.0498	0.037	0.0094	0	50
2000	6.63	0.152	0.0957	0.7187	1.4082	1.746	0.6739	0.5891	0.2294	0.1517	0.0495	0	0.026	50
2001	7.94	0.162	0.0393	0.2105	0.9525	3.1557	1.8858	0.813	0.6119	0.1586	0.0575	0.0556	0	50
2002	4.311	0.19	0	0.2748	0.4309	1.4752	0.9971	0.5319	0.3307	0.1485	0.0711	0	0.0507	50
2003	2.66	0.19	0	0.0383	0.0752	0.3067	0.5804	0.7696	0.315	0.1286	0.2223	0.0828	0.1235	50
2004	3.816	0.318	0.0723	0.0144	0.0863	0.4529	0.9866	0.8263	0.4978	0.355	0.0541	0.1048	0.0901	50
2005	1.932	0.185	0.635	0.0868	0.0229	0.1309	0.1809	0.2693	0.3399	0.0548	0.0522	0.0117	0.0162	50
2006	2.03	0.193	0.1029	0.5398	0.3217	0.046	0.1043	0.2982	0.2864	0.1379	0.071	0.042	0.0144	50
2007	2.74	0.228	0.065	0.1615	1.2063	0.4776	0.188	0.2198	0.2609	0.0691	0.0777	0	0.0144	50

2008	2.748	0.171	0.0212	0.0952	0.422	0.7936	0.273	0.2537	0.2345	0.3022	0.0136	0.0565	0.0081	50
2009	2.181	0.19	0.3842	0.1863	0.1984	0.377	0.454	0.1534	0.1379	0.1152	0.0677	0.0043	0.0085	50
2010	2	0.169	0.4016	0.4686	0.1833	0.2115	0.1678	0.2512	0.0514	0.1162	0.0625	0.0193	0.0238	50
2011	3.711	0.206	0.2285	0.869	1.0769	0.4022	0.28	0.4395	0.1801	0.0751	0.0475	0.0604	0.0112	50
2012	2.192	0.196	0.2612	0.3079	0.6442	0.3154	0.1407	0.2156	0.1347	0.0571	0.0586	0.0318	0.0106	50
2013	2.306	0.177	0.1878	0.4858	0.1902	0.462	0.2378	0.042	0.1046	0.0572	0.0258	0.0045	0	50
2014	2.764	0.168	0.6832	0.3263	0.5346	0.2361	0.3794	0.1419	0.1395	0.1402	0.0379	0.0076	0.0209	50
2015	3.157	0.132	0.1501	0.933	0.8293	0.331	0.1604	0.3086	0.1306	0.0512	0.0599	0.014	0.0034	50

Index-7 Data

1982	3.642	0.222	0.0442	0.0418	0.6096	0.4838	0.3766	0.2367	0.6084	0.3621	0.0932	0.2593	0.5269	50
1983	6.407	0.27	0	0.071	0.5312	1.2615	1.2933	0.541	0.7163	0.6324	0.4754	0.2141	0.6712	50
1984	3.001	0.161	0	0.1032	0.0115	0.3071	0.7774	0.4013	0.3096	0.2017	0.1961	0.1147	0.5791	50
1985	5.182	0.193	0	0	0.0167	0.4592	1.0572	1.1994	0.9077	0.4121	0.1478	0.1487	0.8335	50
1986	2.072	0.158	0	0	0	0.0439	0.2403	0.5286	0.4118	0.1719	0.1942	0.0792	0.4032	50
1987	1.007	0.232	0	0	0	0.0589	0.1139	0.1328	0.2595	0.1855	0.0095	0.0614	0.1862	50
1988	1.434	0.233	0.0228	0.0229	0.062	0	0.0724	0.3	0.379	0.2386	0.1372	0.0863	0.1127	50
1989	1.945	0.217	0.0229	0.013	0.036	1.0044	0.1055	0.0728	0.0812	0.3275	0.0812	0.0152	0.1858	50
1990	0.626	0.303	0.0081	0	0.0375	0.0913	0.3196	0	0.0421	0.0087	0.0504	0.0176	0.0512	50
1991	1.684	0.25	0.0418	0	0.7803	0.1084	0.0871	0.2087	0.0329	0.1008	0.0828	0.1377	0.1036	50
1992	1.26	0.182	0.0545	0.0087	0.1869	0.3727	0.0852	0.1106	0.1519	0.045	0.1486	0.0153	0.0812	50
1993	1.469	0.177	0.1485	0.1122	0.1373	0.4723	0.3196	0.0577	0.0854	0	0.0155	0.0155	0.1055	50
1994	3.129	0.226	0.1073	0.6974	0.5409	0.6436	0.8104	0.1644	0.0269	0.0281	0.0704	0.0083	0.032	50
1995	1.883	0.169	0.0405	0.1198	0.5812	0.3157	0.1789	0.3119	0.1162	0.1102	0.042	0	0.0665	50
1996	1.359	0.169	0.0168	0.0356	0.2436	0.3944	0.3456	0.2185	0.0725	0	0	0	0.032	50
1997	2.219	0.267	0.0721	0.0663	0.1521	0.6926	0.6169	0.4375	0.0842	0.0827	0.0144	0	0	50
1998	4.274	0.175	0.1121	1.0788	0.7123	0.3881	0.798	0.7131	0.2143	0.1536	0.0758	0	0.0284	50
1999	3.149	0.205	0.1058	0.3758	0.9738	0.797	0.4825	0.1643	0.1824	0.0306	0.0144	0.0228	0	50
2000	3.446	0.14	0.0065	0.2504	1.1938	0.6925	0.6595	0.2393	0.2527	0.1159	0	0.0354	0	50
2001	4.409	0.163	0.1051	0.0988	0.7126	1.4758	1.0199	0.4008	0.293	0.1629	0.1128	0.0281	0	50
2002	8.101	0.203	0.0229	0.0599	0.8972	2.6274	2.2633	0.8223	0.6832	0.3507	0.1915	0.1027	0.0802	50
2003	5.204	0.161	0	0	0.1498	0.8079	1.6464	1.0167	0.8686	0.3871	0.1969	0.0455	0.0855	50
2004	3.799	0.126	0.0092	0.0601	0.0738	0.428	0.6485	0.809	0.8828	0.3683	0.1581	0.1607	0.2017	50
2005	3.362	0.203	0.0109	0.16	0.1464	0.2195	0.7375	0.7602	0.5744	0.3832	0.245	0.0865	0.0392	50

2006	3.087	0.139	0.0435	0.4604	0.3473	0.138	0.2072	0.6833	0.5681	0.4101	0.1451	0.0688	0.0151	50
2007	2.37	0.165	0	0.1778	0.5707	0.2627	0.2413	0.2284	0.5462	0.1536	0.1584	0	0.0306	50
2008	7.45	0.25	0.0109	0.3722	0.8475	2.8342	1.3407	0.6455	0.7243	0.5501	0.0882	0.0364	0	50
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Index-8 Data

1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0

```
2004  0        0        0        0        0        0        0        0        0        0        0        0        0
0
2005  0        0        0        0        0        0        0        0        0        0        0        0        0
0
2006  0        0        0        0        0        0        0        0        0        0        0        0        0
0
2007  0        0        0        0        0        0        0        0        0        0        0        0        0
0
2008  0        0        0        0        0        0        0        0        0        0        0        0        0
0
2009  7.628    0.147    0.439    0.454    0.944    1.395    1.871    0.67     0.506    0.719    0.392    0.184    0.056
50
2010  8.051    0.138    0.452    1.47     0.874    0.548    1.368    1.535    0.462    0.331    0.602    0.214    0.197
50
2011  9.188    0.114    0.114    1.19     2.283    0.872    0.992    1.529    0.921    0.383    0.288    0.375    0.242
50
2012  5.94     0.122    0.291    0.611    1.261    1.073    0.508    0.756    0.52     0.516    0.245    0.11     0.052
50
2013  3.386    0.134    0.116    0.404    0.453    0.91     0.47     0.283    0.355    0.213    0.102    0.061    0.018
50
2014  9.644    0.152    1.875    1.457    2.203    0.858    1.406    0.681    0.445    0.45     0.268    0        0
50
2015  9.027    0.147    0.103    1.895    2.459    1.501    0.764    1.042    0.494    0.492    0.171    0.065    0.041
50
# Index-9 Data
1982  0.99     0.4      0        0        0.058    0.013    0.027    0.076    0.241    0.132    0.015    0.027    0.383
50
1983  4.72     0.14     0.008    0.011    0.507    1.596    0.758    0.548    0.444    0.084    0.137    0.073    0.553
50
1984  4.37     0.14     0        0        0.093    0.944    0.991    0.605    0.535    0.31     0.149    0.126    0.621
50
1985  2.76     0.2      0        0.009    0.059    0.076    0.61     0.684    0.483    0.27     0.103    0.122    0.35
50
1986  1.59     0.15     0        0        0        0.051    0.267    0.353    0.309    0.16     0.112    0.009    0.322
50
1987  0.48     0.33     0        0.023    0        0.011    0.023    0.046    0.192    0.071    0        0.009    0.108
50
1988  1.38     0.17     0.007    0        0.725    0.055    0.012    0.036    0.215    0.048    0.046    0.045    0.188
50
1989  0.89     0.2      0.018    0.018    0.082    0.301    0.009    0.021    0.017    0.084    0.078    0.024    0.063
50
1990  2        0.16     0.088    0.137    0.38     0.538    0.188    0.024    0.023    0.023    0.025    0        0.098
50
1991  2.08     0.28     0.021    0.178    0.661    0.329    0.29     0.145    0.067    0.059    0.03     0.052    0.028
50
1992  0.94     0.3      0.029    0.109    0.259    0.224    0.054    0.06     0        0        0.019    0.009    0.08
50
1993  5.15     0.25     0.672    0.154    0.544    0.777    0.219    0.058    0.022    0.081    0        0.019    0.068
50
1994  2.21     0.16     0.156    0.287    0.531    0.165    0.395    0.037    0.106    0        0.043    0.009    0.048
50
1995  4.74     0.2      0.2027   0.7643   1.6238   0.8576   0.4722   0.2291   0        0        0.0108   0.0545   0.0091
50
1996  5.38     0.19     0.0914   0.2608   0.7853   1.9876   1.3861   0.4412   0.0655   0.0648   0.0373   0        0.033
50
1997  5.1      0.2      0.3389   0.9789   0.5223   0.8709   0.7696   0.3831   0.3296   0        0        0        0.0195
50
1998  3.7      0.2      0.0817   0.5199   1.3626   0.4652   0.303    0.1652   0.1102   0.0425   0.0123   0        0
50
1999  5.91     0.22     0.5213   1.1781   1.5137   1.0439   0.5997   0.3634   0.2754   0.0498   0.037    0.0094   0
50
2000  6.63     0.15     0.0957   0.7187   1.4082   1.746    0.6739   0.5891   0.2294   0.1517   0.0495   0        0.026
50
2001  7.94     0.16     0.0393   0.2105   0.9525   3.1557   1.8858   0.813    0.6119   0.1586   0.0575   0.0556   0
50
```

2002	4.31	0.19	0	0.2748	0.4309	1.4752	0.9971	0.5319	0.3307	0.1485	0.0711	0	0.0507	50
2003	2.66	0.19	0	0.0383	0.0752	0.3067	0.5804	0.7696	0.315	0.1286	0.2223	0.0828	0.1235	50
2004	3.82	0.32	0.0723	0.0144	0.0863	0.4529	0.9866	0.8263	0.4978	0.355	0.0541	0.1048	0.0901	50
2005	1.93	0.18	0.635	0.0868	0.0229	0.1309	0.1809	0.2693	0.3399	0.0548	0.0522	0.0117	0.0162	50
2006	2.03	0.19	0.1029	0.5398	0.3217	0.046	0.1043	0.2982	0.2864	0.1379	0.071	0.042	0.0144	50
2007	2.74	0.23	0.065	0.1615	1.2063	0.4776	0.188	0.2198	0.2609	0.0691	0.0777	0	0.0144	50
2008	2.75	0.17	0.0212	0.0952	0.422	0.7936	0.273	0.2537	0.2345	0.3022	0.0136	0.0565	0.0081	50
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Index-10 Data

1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	7.103251602	0.17	1.251407403	0.606812075	0.646223917	1.227955729	1.478758358	0.499650952	0.449164708	0.37522679	0.220510883	0.014005861	0.027686005	50
2010	6.513376847	0.19	1.308082283	1.526313142	0.597040544	0.688892936	0.546554301	0.818202862	0.167418898	0.378483967	0.203573563	0.062863516	0.077520813	50
2011	12.08738385	0.17	0.744264945	2.830486813	3.507653911	1.310036589	0.91200956	1.431529292	0.586617578	0.244613993	0.154715908	0.196733491	0.036480382	50
2012	7.140709137	0.21	0.850774632	1.002884798	2.098273423	1.027313626	0.458284804	0.702247361	0.438741742	0.185984807	0.190870572	0.103578229	0.034526076	50
2013	7.51137588	0.2	0.611697841	1.582336587	0.619515065	1.504815774	0.774556691	0.136801434	0.340700714	0.186310524	0.084035167	0.014657297	0	50
2014	9.002185793	0.18	2.225303326	1.062816855	1.741286824	0.76901949	1.235772954	0.462193416	0.454376192	0.456656215	0.123447008	0.024754545	0.068074999	50
2015	10.28160492	0.17	0.488902268	3.038946141	2.701176886	1.078125587	0.522451191	1.005164822	0.425387316	0.166767462	0.195104902	0.045600478	0.011074402	50

Index-11 Data

1982	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	25508.7	0.26	331.6	1097	2627.6	10229.9	5357.3	1836.8	918.4	969.4	765.4	408.1	994.9	30
1985	6755.3	0.4	161.8	0	303.4	1725.8	2015.7	1173	458.5	337.1	188.7	87.6	289.9	30
1986	2621.5	0.52	103.2	76.8	26.5	585.1	428.9	736	466	124.4	15.9	10.6	68.9	30
1987	5242.9	0.66	1957.5	460.6	308.8	654.3	246	481.5	497.3	209.3	115.1	73.3	230.3	30
1988	2621.5	0.57	171.9	192.8	1364.8	200.5	75.5	46.9	96.4	106.8	59.9	36.5	80.8	30
1989	2923.9	0.75	738.7	435.6	644.6	877.1	108.9	8.9	20.6	47.1	38.2	2.9	20.6	30
1990	6755.3	0.65	1966.5	624.2	1281.9	1671.2	885.9	87.2	13.4	20.2	33.6	26.8	53.7	30
1991	15022.9	0.78	6854.8	452	5935.8	1250.4	165.8	60.3	30.1	45.2	75.3	105.5	45.2	30
1992	24500.5	1.03	8936.7	4945.8	7614.6	2668.7	49	122.4	49	0	0	0	73.5	30
1993	21576.6	0.64	19093.1	799.1	518.3	691.2	151.2	43.2	43.2	43.2	0	0	21.6	30
1994	36599.5	0.97	14626.4	8467.9	6598.4	4179	2382.8	219.9	73.3	0	0	0	0	30
1995	18148.5	0.86	2570.3	4941.5	7511.9	2063.5	579.2	289.6	108.6	18.1	0	0	0	30
1996	15527.1	0.49	2990.6	1292.8	3613.6	4267.7	2305.2	778.8	249.2	15.5	15.5	0	31.2	30
1997	23391.4	1.02	14499.3	4911.1	327.4	1870.9	1192.7	397.6	117	46.8	0	0	0	30

1998	7360.2	0.54	1155.6	3177.8	2296.3	363	229.7	162.9	14.8	0	0	0	0	30
1999	111008.3	0.55	32739.5	24748.8	32517.5	15426.4	4106.3	887.9	332.9	221.9	0	0	0	30
2000	32667.3	0.58	3694.3	6669.5	12554.3	5492.5	2550.1	948.2	555.7	130.8	32.7	0	0	30
2001	41842.4	0.78	1465.2	4060.7	10172.7	16912.8	6028.3	1465.2	962.9	460.5	167.5	83.7	83.7	30
2002	45572.9	0.59	775.5	3969	9306.7	16788.6	8987.3	2919.8	1824.8	593.1	319.3	45.6	91.2	30
2003	24298.8	0.52	727.7	363.9	2061.7	7203.8	7397.8	3662.6	1503.8	727.7	315.3	145.5	145.5	30
2004	8771.8	0.59	370.4	635.1	441	1878.9	2090.6	1728.9	1014.4	405.7	132.3	70.6	44.1	30
2005	19963.4	0.55	10066.7	1893.7	996.7	1614.6	2312.3	1893.7	817.3	219.3	79.8	39.8	20	30
2006	30247.5	0.46	5622.9	13603.7	4625.2	1299.9	1511.6	1693	1178.9	513.9	151.1	60.5	30.2	30
2007	23290.6	0.5	1863.1	6241.7	10503.6	1886.4	1094.7	652.1	768.6	232.9	46.6	23.3	0	30
2008	15325.4	0.49	842.4	2619.1	3645.3	5682.5	980.2	566.7	428.9	321.6	153.2	30.7	15.3	30
2009	23391.4	0.57	5640.3	2433.9	2761.6	3767.9	4353	1544.6	1380.8	936.2	374.5	140.4	70.2	30
2010	18249.3	0.43	4715.5	5665.9	2467.4	1370.8	1571.9	1571.9	365.5	310.7	164.4	73.1	18.2	30
2011	18451	0.35	1235.7	6104.7	6233.8	1733.7	1014.4	1014.4	498	350.5	147.5	92.3	36.9	30
2012	18753.5	0.5	3378.4	4223.2	4992.7	2515.1	1069.9	1163.7	863.4	412.9	112.6	37.5	0	30
2013	14720.5	0.31	4193.6	4399.6	1603.8	2133.6	824	470.9	456.1	220.7	117.8	58.9	14.7	30
2014	38515.2	0.52	21339	8759.4	4630.5	1234.8	1119.1	540.2	424.5	308.7	77.1	38.6	38.6	30
2015	32566.5	0.37	1760.4	11605.8	12290.4	2216.8	1043.2	1597.5	912.8	749.8	260.8	32.6	0	30

Index-12 Data

1982	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	-999	0	0	0	0	0	0	0	0	0	0	0	0	0

1996	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	6805.3	0.6596975	3914.2	2552.8	217.8	74.9	0	6.8	0	13.6	13.6	13.6	0	20
2002	4488	0.4669	1049	201.7	1205.9	972.8	614.1	251	170.3	9	4.5	4.5	4.5	20
2003	2268.4	0.7812025	355.7	70.2	401.1	768.1	464.5	124.6	65.7	18.1	0	0	0	20
2004	1388.4	0.363355	676.9	225.6	128.1	128.1	115.6	54.3	30.6	12.5	4.2	5.6	11.1	20
2005	8184	0.39707	5129.2	1578.8	621.7	114.5	220.9	261.8	114.5	49.1	57.3	32.7	0	20
2006	5055.1	0.53571	1092	2836	687.5	207.3	50.6	60.7	45.5	40.4	20.2	0	10.1	20
2007	4272.9	0.38576	1123.8	1525.5	1222.1	115.4	81.2	17.1	76.9	34.2	42.7	0	29.9	20
2008	4155.5	0.355075	896.8	1465.6	477.5	660.2	199.3	99.6	215.9	128.7	0	0	8.3	20
2009	4057.8	0.407255	1797.9	1266.2	442.4	227.3	198.9	36.5	16.2	36.5	24.4	12.2	0	20
2010	5045.3	0.4423975	1915.1	1546.2	843.8	212.2	257.7	202.1	40.4	10.1	10.1	5.1	5.1	20
2011	5084.4	0.302	594.6	2739.2	1316.3	142.3	101.6	111.8	45.7	15.2	10.2	5.1	0	20
2012	6267.5	0.43449	833.9	2978	1699.1	495.3	87.8	81.5	37.6	31.3	12.5	6.3	0	20
2013	1515.6	0.5127875	307.7	487.1	211.1	239.8	87.5	46.8	82.9	21.1	15.1	1.5	10.6	20
2014	28013.3	0.3019525	24712	2404.1	559.1	111.8	111.8	55.9	28	28	0	0	0	20
2015	4556.4	0.2338725	883	2326	1192.6	81.9	18.2	27.3	13.7	13.7	0	0	0	20
# Index-13 Data														
1982	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-999	0	0	0	0	0	0	0	0	0	0	0	0	0

1994	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	-999	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	3803.6	0.58	920.5	2225.1	593.4	49.4	7.6	3.8	3.8	0	0	0	0	24
2001	55325.8	0.33	11120.5	25671.2	6473.1	8077.6	2213	995.9	608.6	110.7	55.3	0	0	24
2002	6148	0.59	817.7	1125.1	1155.8	2225.6	694.7	129.1	0	0	0	0	0	24
2003	7280.1	0.62	1383.2	203.8	626.1	1856.4	1594.3	982.8	269.4	123.8	167.4	43.7	43.7	24
2004	11469.2	0.66	4450.1	997.8	1319	1124	1995.6	894.6	263.8	160.6	57.3	22.9	34.4	24
2005	25613.3	0.54	22923.9	2023.5	204.9	51.2	76.8	102.5	204.9	25.6	0	0	25.6	24
2006	12544.9	0.43	5080.7	4604	2145.2	138	150.5	213.3	163.1	12.5	37.6	0	0	24
2007	14092.7	0.57	2874.9	3015.8	5608.9	1197.9	549.6	451	295.9	28.2	14.1	0	42.3	24
2008	14450.3	0.48	4840.9	3453.6	2890.1	1921.9	375.7	491.3	130.1	289	14.5	14.5	0	24
2009	10244.5	0.41	7355.6	1280.6	635.2	481.5	338.1	51.2	30.7	20.5	10.2	0	0	24
2010	15862.1	0.43	11040	3045.5	666.2	380.7	206.2	333.1	31.7	47.6	15.9	0	15.9	24
2011	9575.5	0.5	2269.4	4529.2	1896	296.8	191.5	249	57.5	19.2	9.6	9.6	9.6	24
2012	3183.9	0.49	2117.3	576.3	324.8	47.8	22.3	54.1	28.7	9.6	0	0	0	24
2013	2380.6	0.6	1180.8	742.8	166.6	164.3	50	11.9	16.7	4.8	7.1	2.4	0	24
2014	15276.1	0.43	13488.8	1542.9	198.6	15.3	15.3	0	15.3	0	0	0	0	24
2015	13640.7	0.68	3505.7	6874.9	2919.1	136.4	40.9	68.2	13.6	0	0	0	0	24

Index-14 Data

1982	0	0.39	0	0	0	0	0	0	0	0	0	0	0	0
1983	1.973	0.34	0	0	0	0	0	0	0	0	0	0	0	0
1984	1.182	0.28	0	0	0	0	0	0	0	0	0	0	0	0
1985	1.009	0.22	0	0	0	0	0	0	0	0	0	0	0	0
1986	0.698	0.18	0	0	0	0	0	0	0	0	0	0	0	0
1987	0.884	0.42	0	0	0	0	0	0	0	0	0	0	0	0
1988	0.236	0.21	0	0	0	0	0	0	0	0	0	0	0	0
1989	0.132	0.41	0	0	0	0	0	0	0	0	0	0	0	0
1990	0.207	0.64	0	0	0	0	0	0	0	0	0	0	0	0
1991	0.111	0.52	0	0	0	0	0	0	0	0	0	0	0	0

```
1992  0.2            0.52           0              0              0              0              0              0              0              0              0              0              0
0
1993  0.033          0.83           0              0              0              0              0              0              0              0              0              0              0
0
1994  0              0              0              0              0              0              0              0              0              0              0              0              0
0
1995  0.1            0.29           0              0              0              0              0              0              0              0              0              0              0
0
1996  0.025          0.73           0              0              0              0              0              0              0              0              0              0              0
0
1997  0.049          0              0              0              0              0              0              0              0              0              0              0              0
0
1998  0              0              0              0              0              0              0              0              0              0              0              0              0
0
1999  0.016          0.8            0              0              0              0              0              0              0              0              0              0              0
0
2000  1.146          0.25           0              0              0              0              0              0              0              0              0              0              0
0
2001  0.069          0.41           0              0              0              0              0              0              0              0              0              0              0
0
2002  0.109          0.42           0              0              0              0              0              0              0              0              0              0              0
0
2003  0.186          0.11           0              0              0              0              0              0              0              0              0              0              0
0
2004  0              0              0              0              0              0              0              0              0              0              0              0              0
0
2005  0.045          0.52           0              0              0              0              0              0              0              0              0              0              0
0
2006  0.161          0.39           0              0              0              0              0              0              0              0              0              0              0
0
2007  0.456          0.38           0              0              0              0              0              0              0              0              0              0              0
0
2008  0.263          0.32           0              0              0              0              0              0              0              0              0              0              0
0
2009  0.44           0.48           0              0              0              0              0              0              0              0              0              0              0
0
2010  0.152          0.29           0              0              0              0              0              0              0              0              0              0              0
0
2011  0.347          0.55           0              0              0              0              0              0              0              0              0              0              0
0
2012  0.23           0.31           0              0              0              0              0              0              0              0              0              0              0
0
2013  0.08           0.37           0              0              0              0              0              0              0              0              0              0              0
0
2014  0.042          0.56           0              0              0              0              0              0              0              0              0              0              0
0
2015  0.098          0.69           0              0              0              0              0              0              0              0              0              0              0
0
# Index-15 Data
1982  1.244          0.55           0              0              0              0              0              0              0              0              0              0              0
0
1983  2.222          0.3            0              0              0              0              0              0              0              0              0              0              0
0
1984  0.546          0.34           0              0              0              0              0              0              0              0              0              0              0
0
1985  0.764          0.45           0              0              0              0              0              0              0              0              0              0              0
0
1986  0.266          0.31           0              0              0              0              0              0              0              0              0              0              0
0
1987  0.187          0.34           0              0              0              0              0              0              0              0              0              0              0
0
1988  0.276          0.57           0              0              0              0              0              0              0              0              0              0              0
0
1989  0.129          0.49           0              0              0              0              0              0              0              0              0              0              0
0
```

```
1990  0.074    0.52    0    0    0    0    0    0    0    0    0    0    0
0
1991  0.318    0.35    0    0    0    0    0    0    0    0    0    0    0
0
1992  0.455    0.41    0    0    0    0    0    0    0    0    0    0    0
0
1993  0.297    0.4     0    0    0    0    0    0    0    0    0    0    0
0
1994  0.38     0.34    0    0    0    0    0    0    0    0    0    0    0
0
1995  2.407    0.57    0    0    0    0    0    0    0    0    0    0    0
0
1996  0.037    0.56    0    0    0    0    0    0    0    0    0    0    0
0
1997  0.515    0.6     0    0    0    0    0    0    0    0    0    0    0
0
1998  0.245    0.43    0    0    0    0    0    0    0    0    0    0    0
0
1999  0.674    0.34    0    0    0    0    0    0    0    0    0    0    0
0
2000  0.917    0.27    0    0    0    0    0    0    0    0    0    0    0
0
2001  0.432    0.21    0    0    0    0    0    0    0    0    0    0    0
0
2002  2.21     0.18    0    0    0    0    0    0    0    0    0    0    0
0
2003  1.186    0.26    0    0    0    0    0    0    0    0    0    0    0
0
2004  0.307    0.37    0    0    0    0    0    0    0    0    0    0    0
0
2005  0.514    0.28    0    0    0    0    0    0    0    0    0    0    0
0
2006  0.365    0.27    0    0    0    0    0    0    0    0    0    0    0
0
2007  0.514    0.35    0    0    0    0    0    0    0    0    0    0    0
0
2008  1.344    0.32    0    0    0    0    0    0    0    0    0    0    0
0
2009  1.275    0.25    0    0    0    0    0    0    0    0    0    0    0
0
2010  1.422    0.3     0    0    0    0    0    0    0    0    0    0    0
0
2011  3.505    0.25    0    0    0    0    0    0    0    0    0    0    0
0
2012  0.658    0.24    0    0    0    0    0    0    0    0    0    0    0
0
2013  0.545    0.31    0    0    0    0    0    0    0    0    0    0    0
0
2014  0.443    0.47    0    0    0    0    0    0    0    0    0    0    0
0
2015  1.35     0.36    0    0    0    0    0    0    0    0    0    0    0
0
# Phase Control
# Phase for F mult in 1st Year
1
# Phase for F mult Deviations
3
# Phase for Recruitment Deviations
3
# Phase for N in 1st Year
2
# Phase for Catchability in 1st Year
1
# Phase for Catchability Deviations
-5
# Phase for Stock Recruitment Relationship
```

```
1
# Phase for Steepness
-1
# Recruitment CV by Year
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
# Lambdas by Index
1  1  0  0  0  0  0  0  0  0  1  1  1  0  0
# Lambda for Total Catch in Weight by Fleet
1
# Lambda for Total Discards at Age by Fleet
0
# Catch Total CV by Year and Fleet
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
```

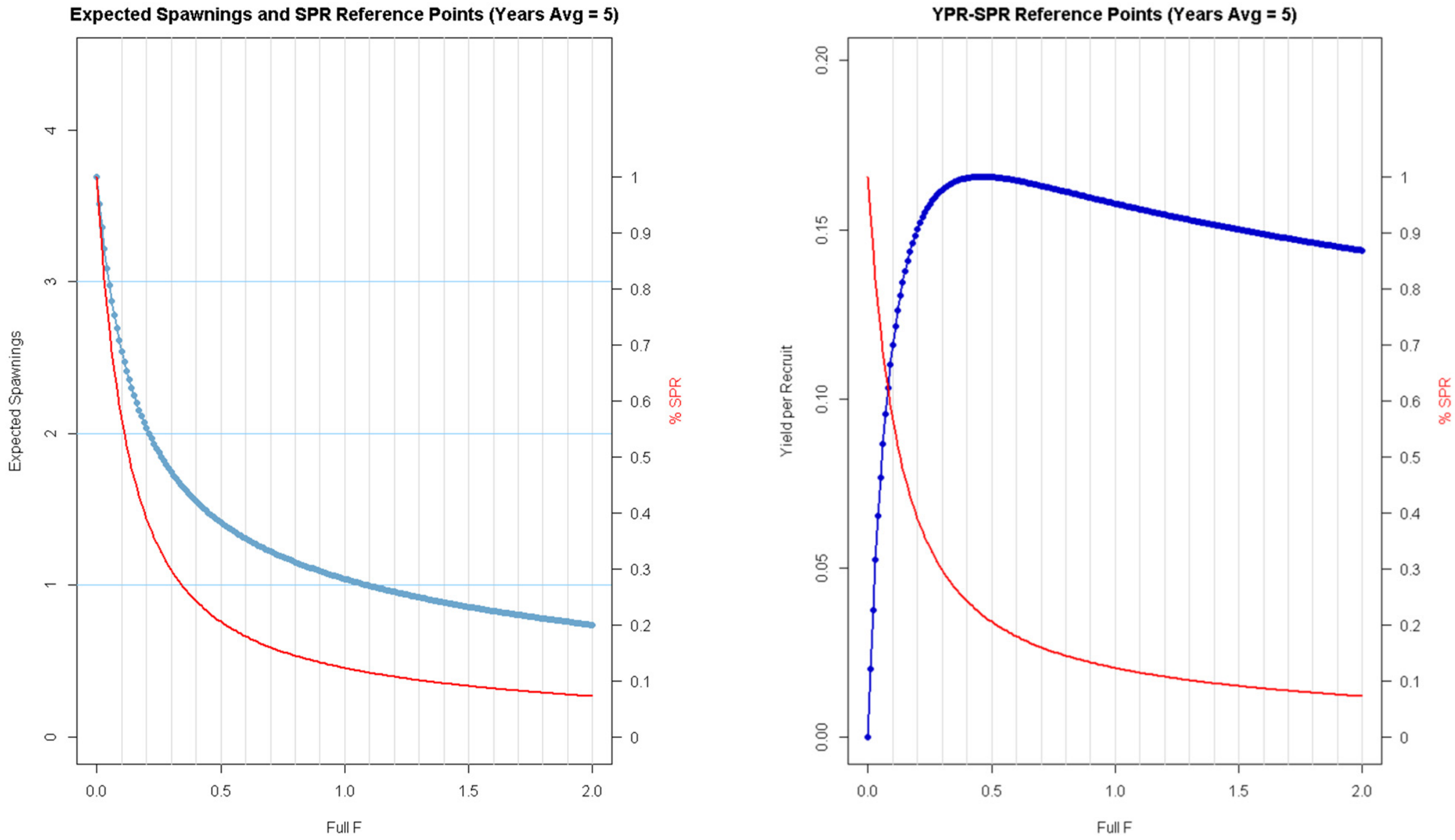
```
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
# Discard Total CV by Year and Fleet
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
0.1
# Catch Effective Sample Size by Year and Fleet
67
67
67
67
67
67
67
67
67
67
67
67
67
67
67
67
67
```

```
67
67
67
67
67
67
67
67
67
67
67
67
67
67
67
67
67
# Discard Effective Sample Size by Year and Fleet
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
# Lambda for F Mult in First year by Fleet
0
# CV for F Mult in First year by Fleet
0.1
# Lambda for F Mult Deviations by Fleet
0
# CV for F Mult Deviations by Fleet
0.1
# Lambda for N in 1st Year Deviations
0
# CV for N in 1st Year Deviations
0.1
# Lambda for Recruitment Deviations
1
```

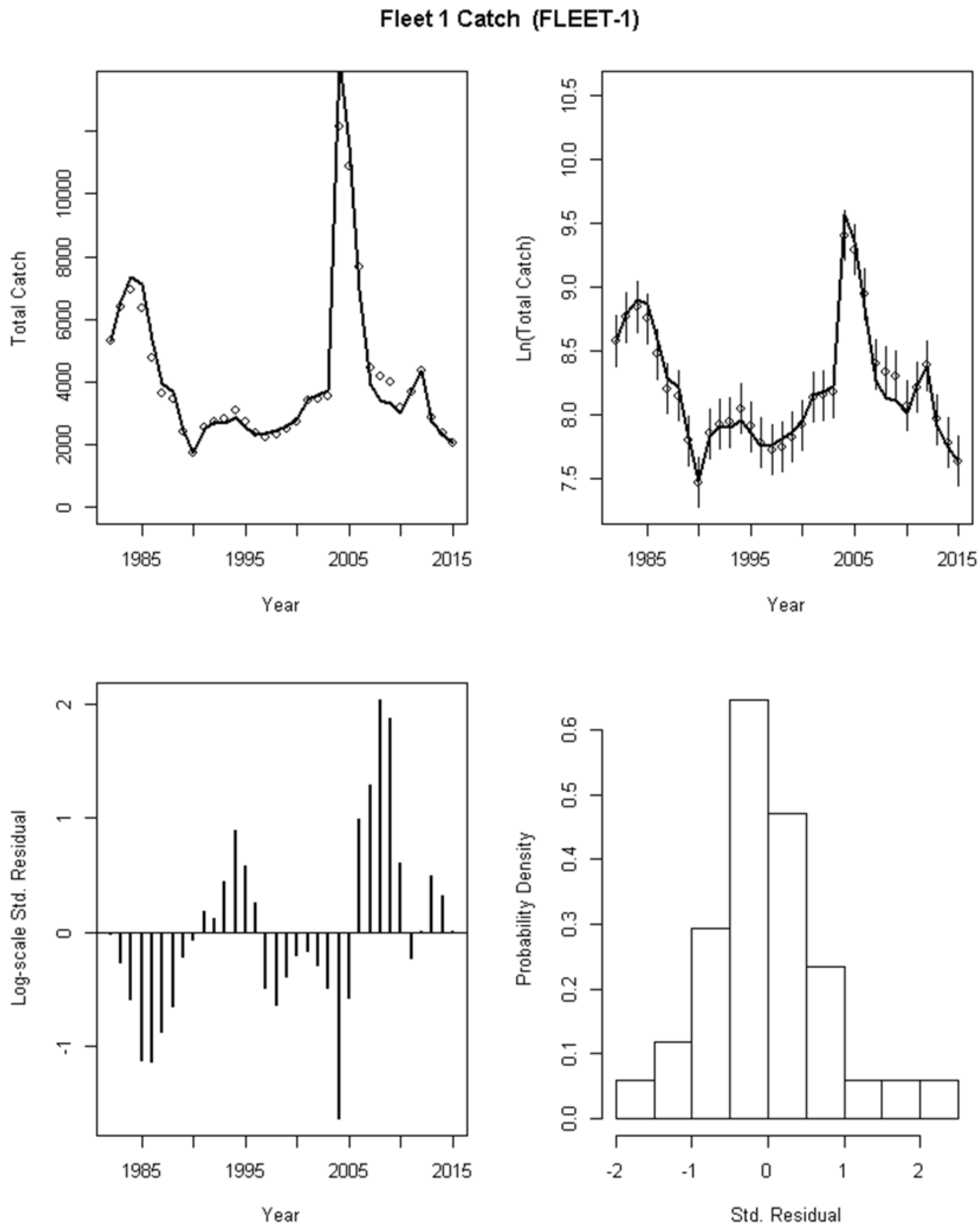
```
# Lambda for Catchability in First year by Index
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
# CV for Catchability in First year by Index
0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
# Lambda for Catchability Deviations by Index
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
# CV for Catchability Deviations by Index
0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
# Lambda for Deviation from Initial Steepness
0
# CV for Deviation from Initial Steepness
0.1
# Lambda for Deviation from Unexploited Stock Size
0
# CV for Deviation from Unexploited Stock Size
0.1
# NAA Deviations Flag
1
# Initial Numbers at Age in 1st Year
10000  10000  10000  10000  10000  10000  10000  10000  10000  10000  10000
# Initial F Mult in 1st Year by Fleet
0.2
# Initial Catchabilty by Index
0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
# Stock Recruitment Flag
1
# Initial Unexploited Stock
10000
# Initial Steepness
1
# Maximum F
5.0
# Ignore Guesses (Yes=1)
0
# Projection Control
# Do Projections (Yes=1)
0
# Fleet Directed Flag
1
# Final Year in Projection
2016
# Projection Data by Year
2016     -1         3     -99        1
# Do MCMC (Yes=1)
0
# MCMC Year Option
1
# MCMC Iterations
1000
# MCMC Thinning Factor
500
# MCMC Random Seed
12345678
# Agepro R Option
0
# Agepro R Option Start Year
2011
# Agepro R Option End Year
2015
# Export R Flag
1
# Test Value
-23456
######
###### FINIS ######
# Fleet Names
```

```
#$FLEET-1
# Survey Names
#$NEFSC_Spr_82_15
#$NEFSC_AUT_82_15
#$NEFSC_Spr_82_94
#$NEFSC_Spr_95_15
#$NEFSC_AUT_82_94
#$NEFSC_AUT_95_15
#$NEFSC_Spr_82_08
#$NEFSC_Spr_09_15
#$NEFSC_AUT_82_08
#$NEFSC_AUT_09_15
#$ASMFC_Sum_84_15
#$MENH_Spr_01_15
#$MENH_AUT_00_15
#$MADMF_SPR_82-15
#$MADMF_AUT_82-15
#
```

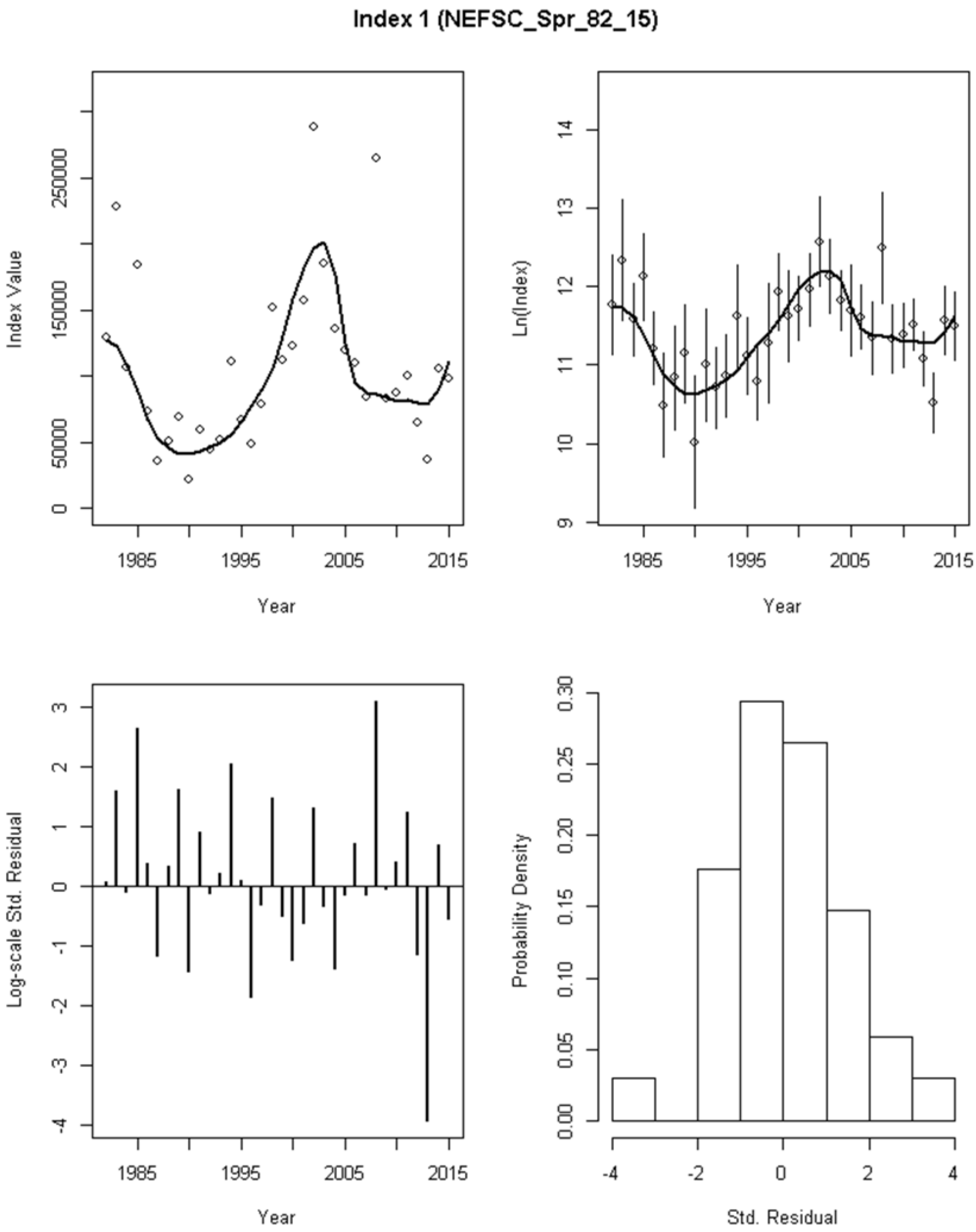
APPENDIX B6: Collection of Slides provided during the SARC discussion



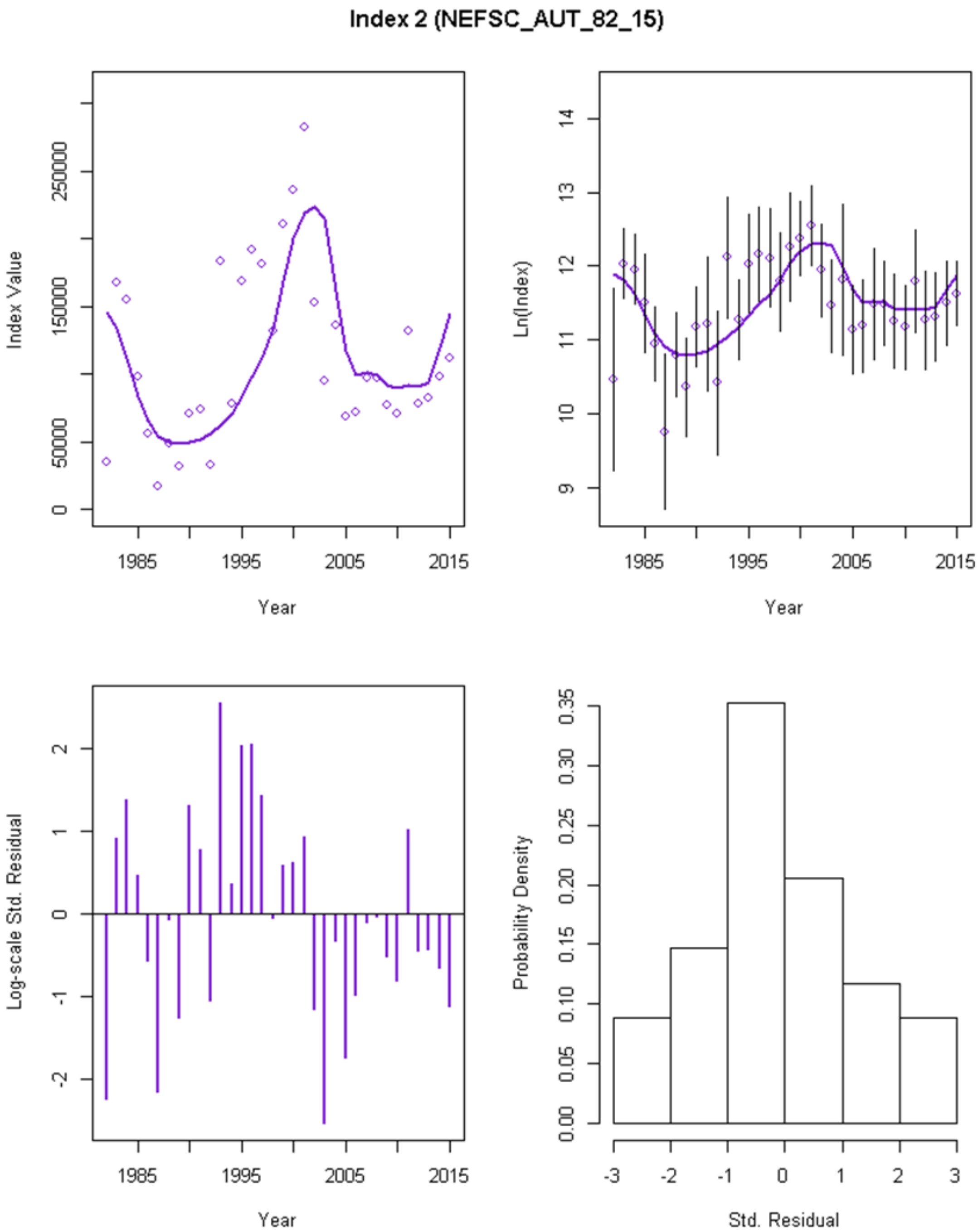
Appendix B6 Figure 1. Number of expected spawning and spawning per recruit reference points (left) and yield per recruit (right) from witch flounder; taken from ASAP Run 9_5_v2.



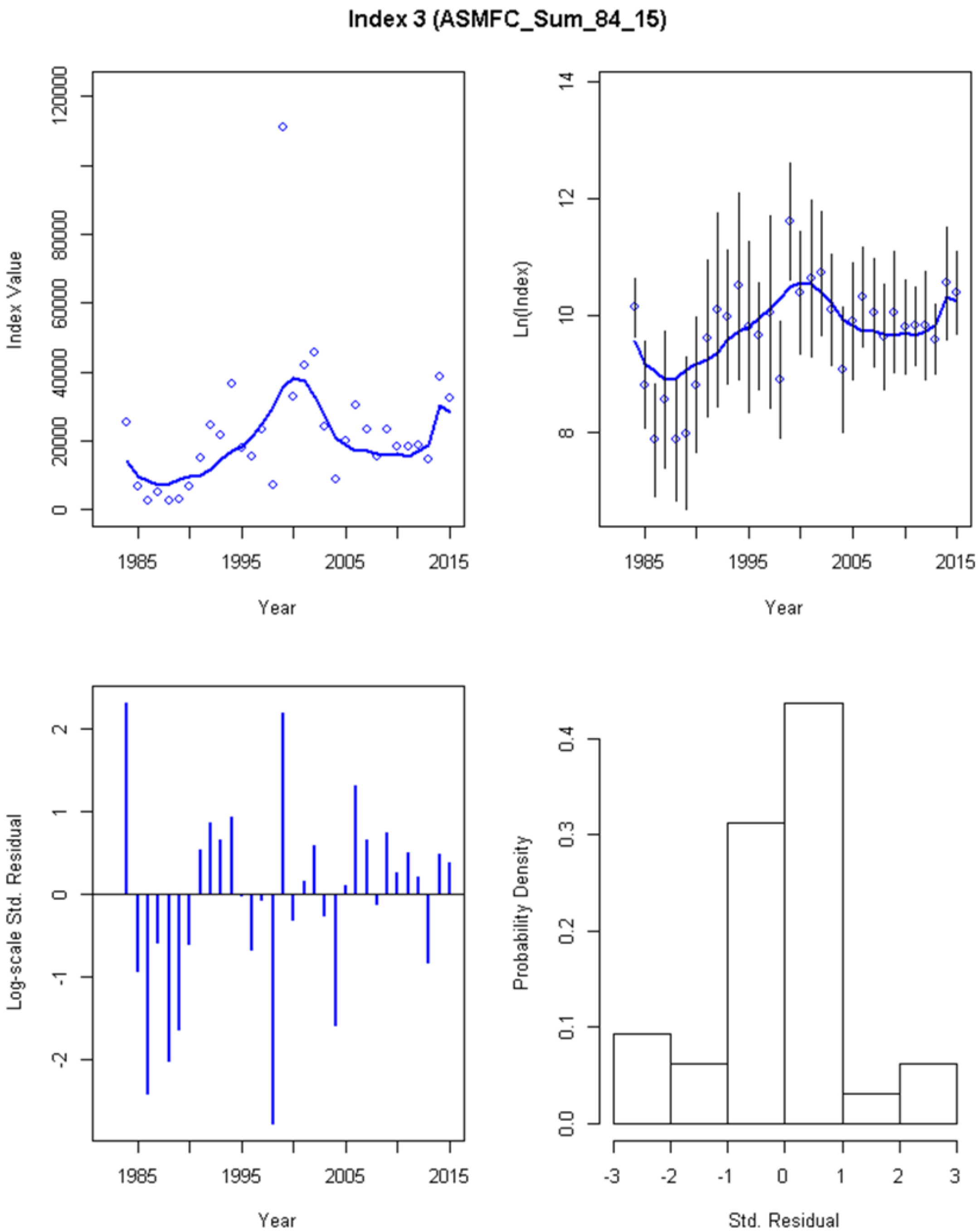
Appendix B6 Figure 2. Model fit to the total witch flounder catch (Fleet 1) from ASAP Run 15 catchx4 for 2004 onward.



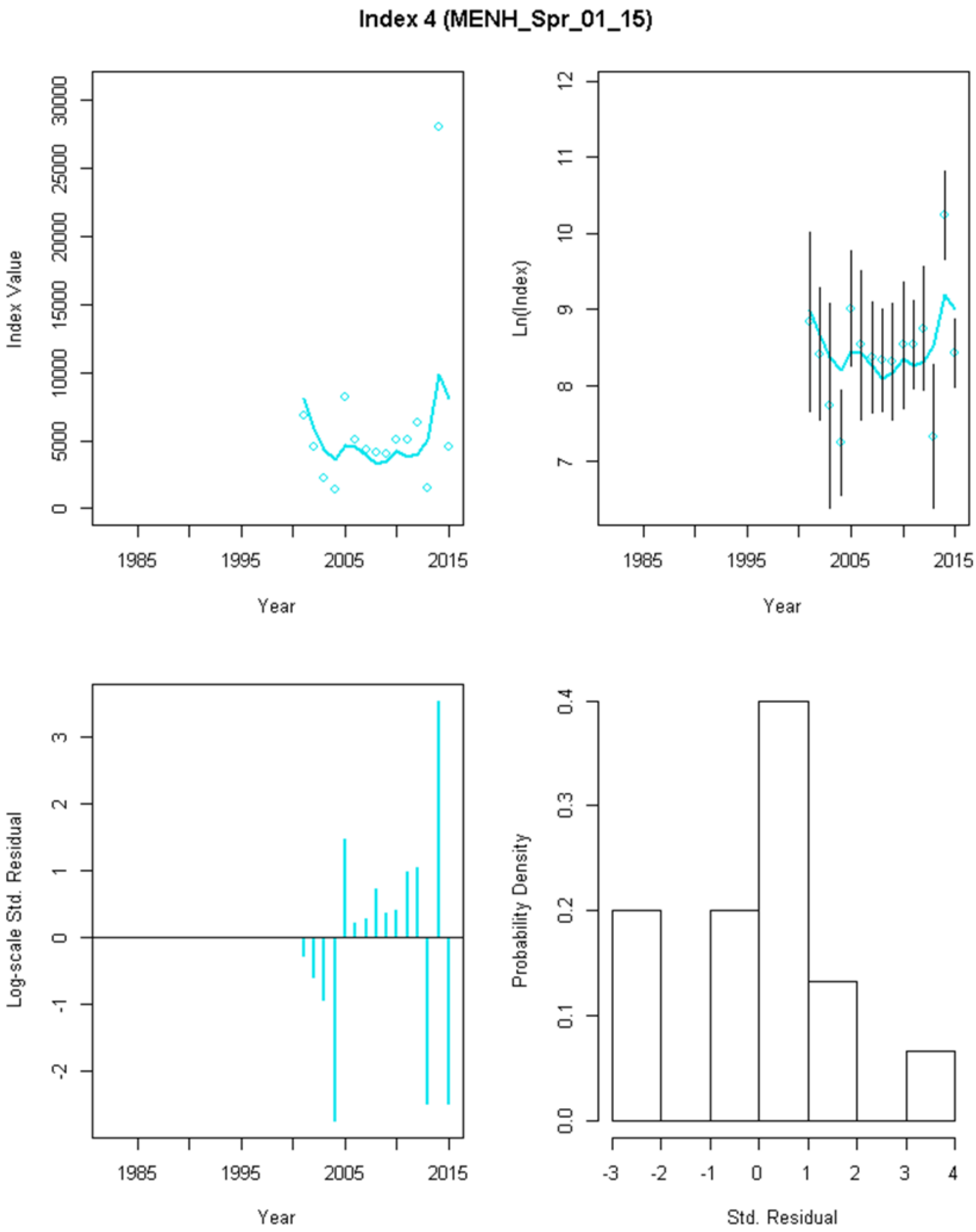
Appendix B6 Figure 3. Model fit to the Northeast Fisheries Science Center spring survey witch flounder index (Index1) from ASAP Run 15 catchx4 for 2004 onward.



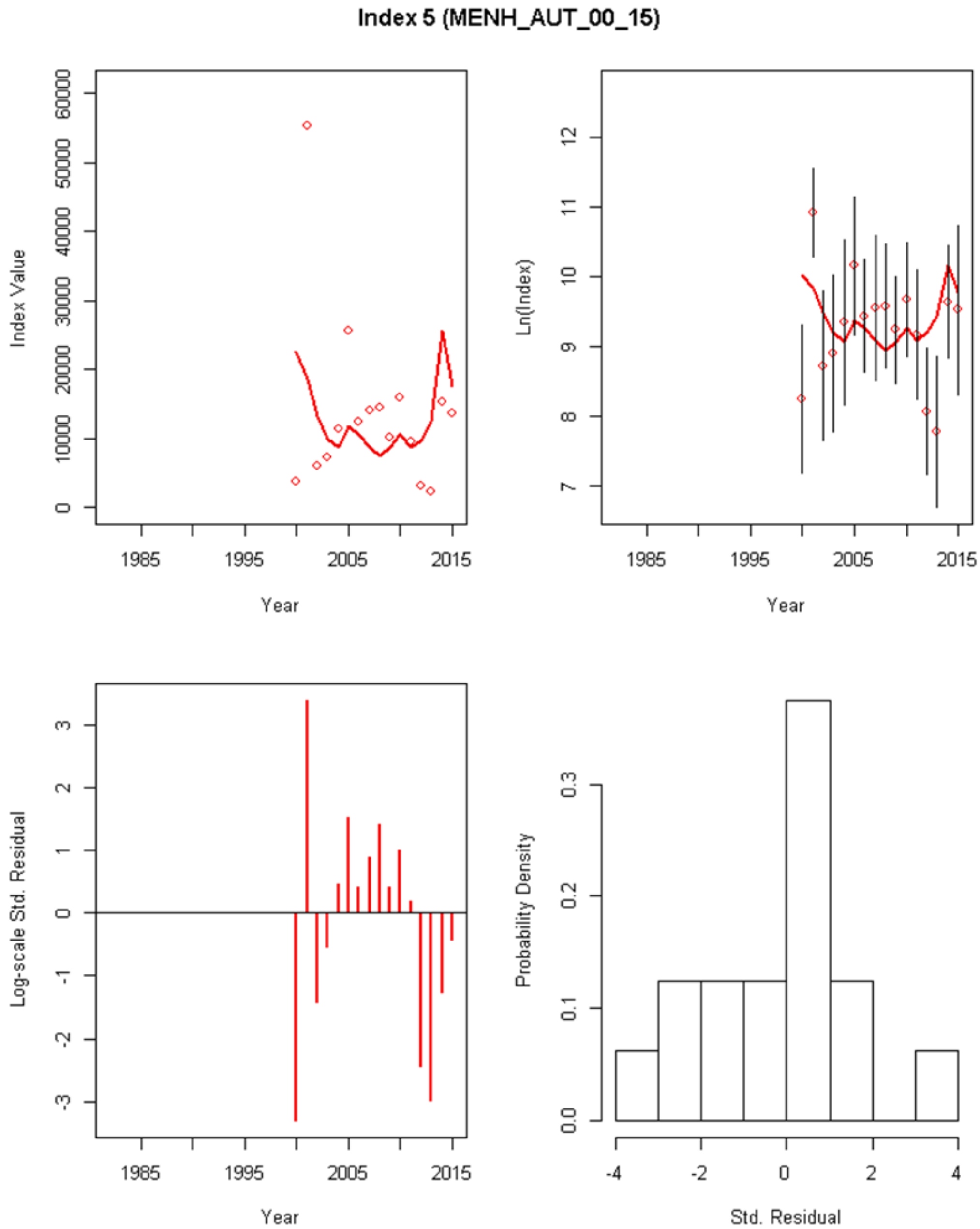
Appendix B6 Figure 4. Model fit to the Northeast Fisheries Science Center autumn survey witch flounder index (Index2) from ASAP Run 15 catchx4 for 2004 onward.



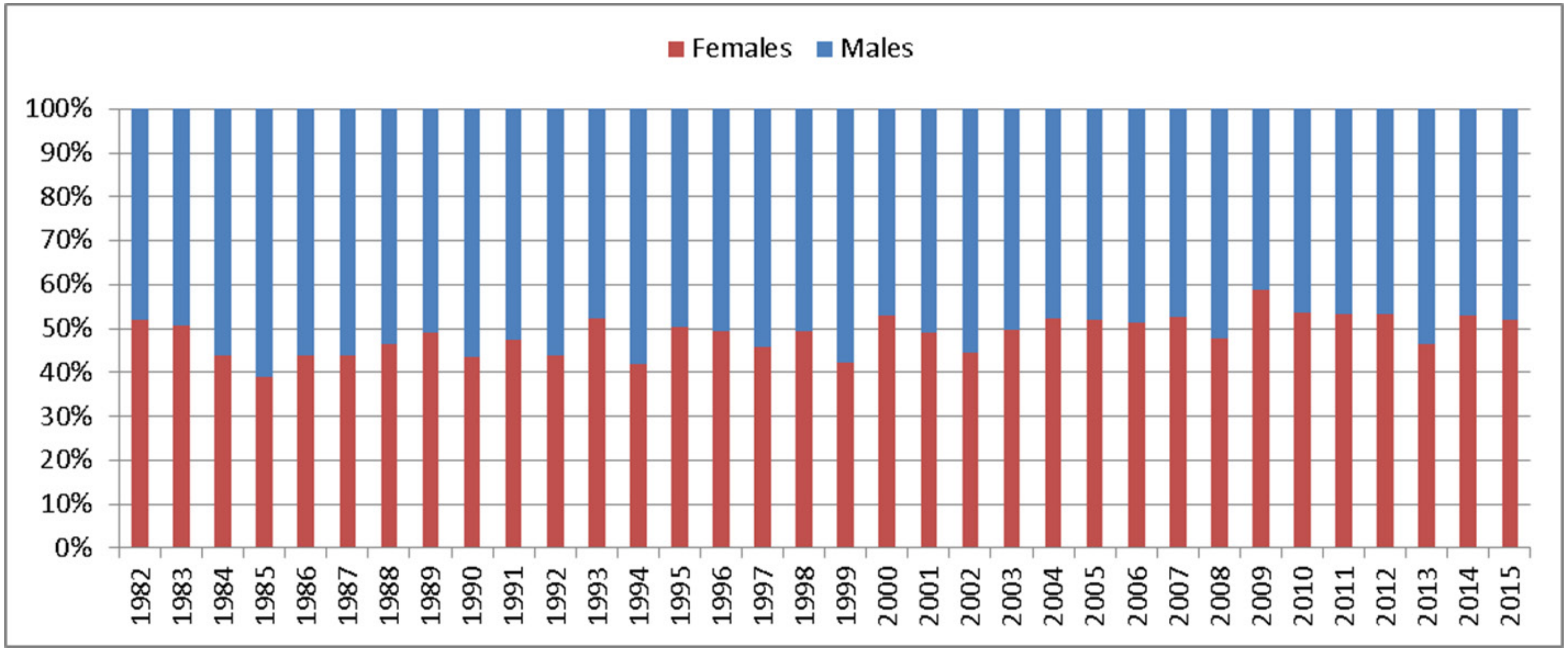
Appendix B6 Figure 5. Model fit to the Atlantic States Marine Fisheries Commission summer survey witch flounder index (Index3) from ASAP Run 15 catchx4 for 2004 onward.



Appendix B6 Figure 6. Model fit to the Maine_New Hampshire inshore spring survey witch flounder index (Index4) from ASAP Run 15 catchx4 for 2004 onward.



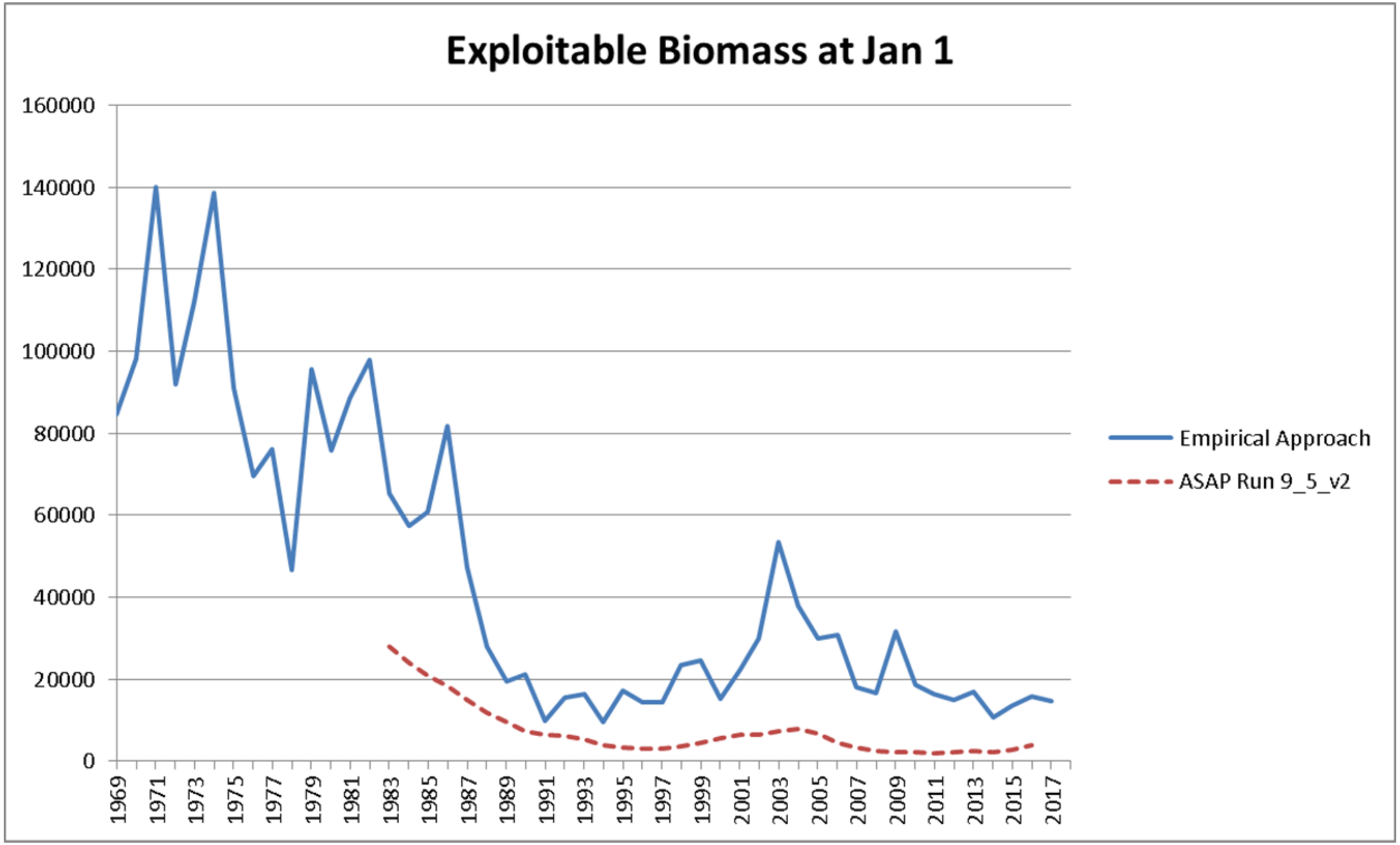
Appendix B6 Figure 7. Model fit to the Maine_New Hampshire inshore autumn survey witch flounder index (Index5) from ASAP Run 15 catchx4 for 2004 onward.



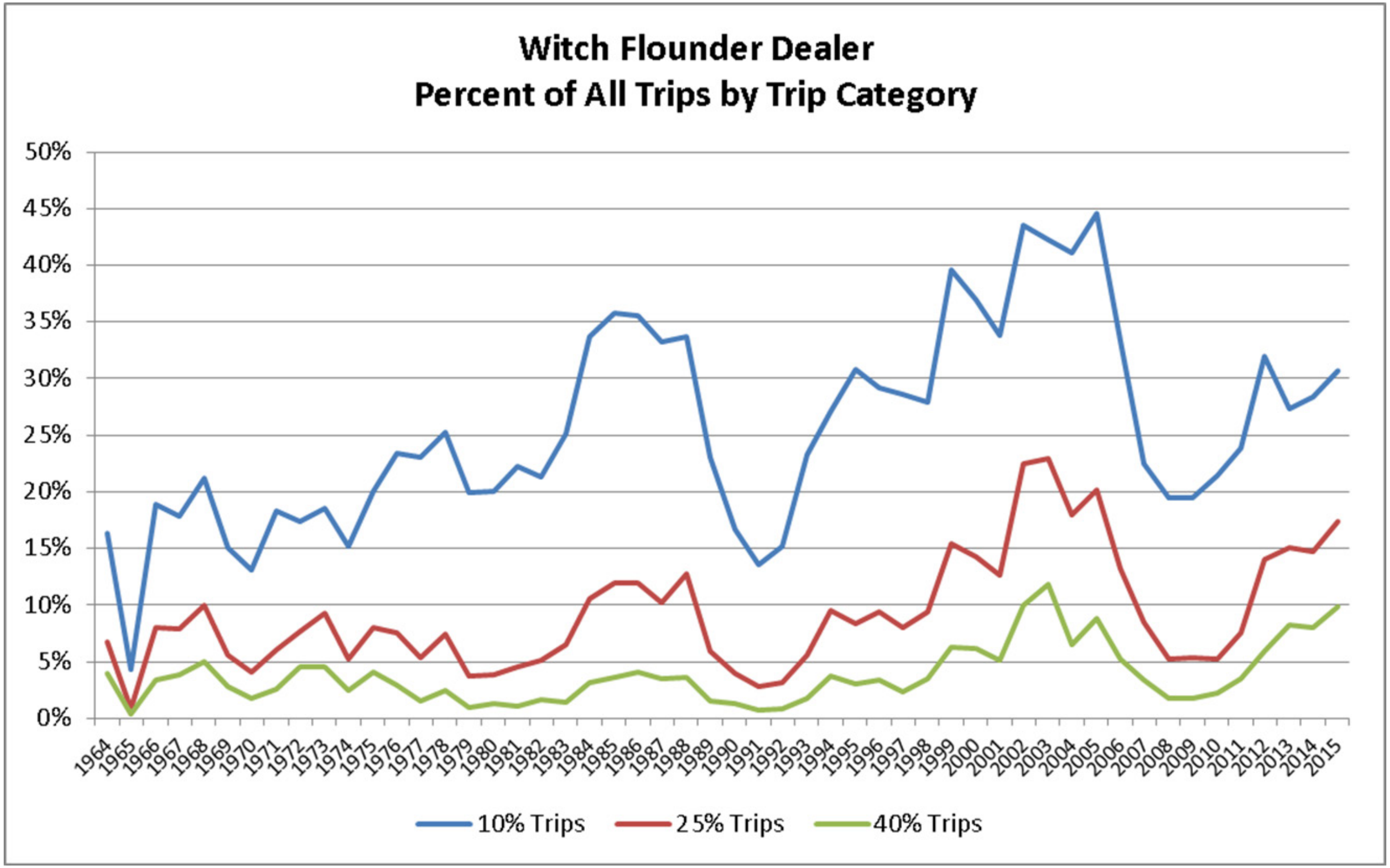
Appendix B6 Figure 8. Witch flounder sex ratio based on Northeast Fisheries Science Center spring and autumn survey data, 1982-2015.

	ASAP RhoAdjust (unadjust)	ASAP CAT4X	ASAP M3X	SWEEP	Legualt Empirical	RY4	RY1	ASAP q=1
SSB15	3335 (5,520)	9,517	5,514	11,500	N/A	N/A	N/A	24,859
EB15	2563 (4,700)			N/A	14,563	8,990	19,420	25,064
F15	0.29 (0.16)	0.4	0.21	N/A	F= ?, (mu = 0.03)	F= ?, mu= 0.2	mu= 0.06	0.025
R15		19 mil	35 mil	N/A	N/A	N/A	N/A	22 mil
NEC Qs	ALBq=~4.0	ALBq=~2.5	ALBq=~3.0	BIGq=~0.3	BIGq=~0.3	ALBq= ~4.0	ALBq= ~1.0	ALBq=~1.0
F40	0.19	0.19	0.15	N/A	mu10yravg = (mu = 0.05)	N/A	N/A	
SSB40	12,747	28,511	7,300	N/A	N/A	N/A	N/A	
MSY40	1,998	4,481 (1,120)	646	N/A	N/A	1,790	1,200	
FMSY (OFL17)	762	2,100 (525)	563	N/A	728	1,790	1,200	

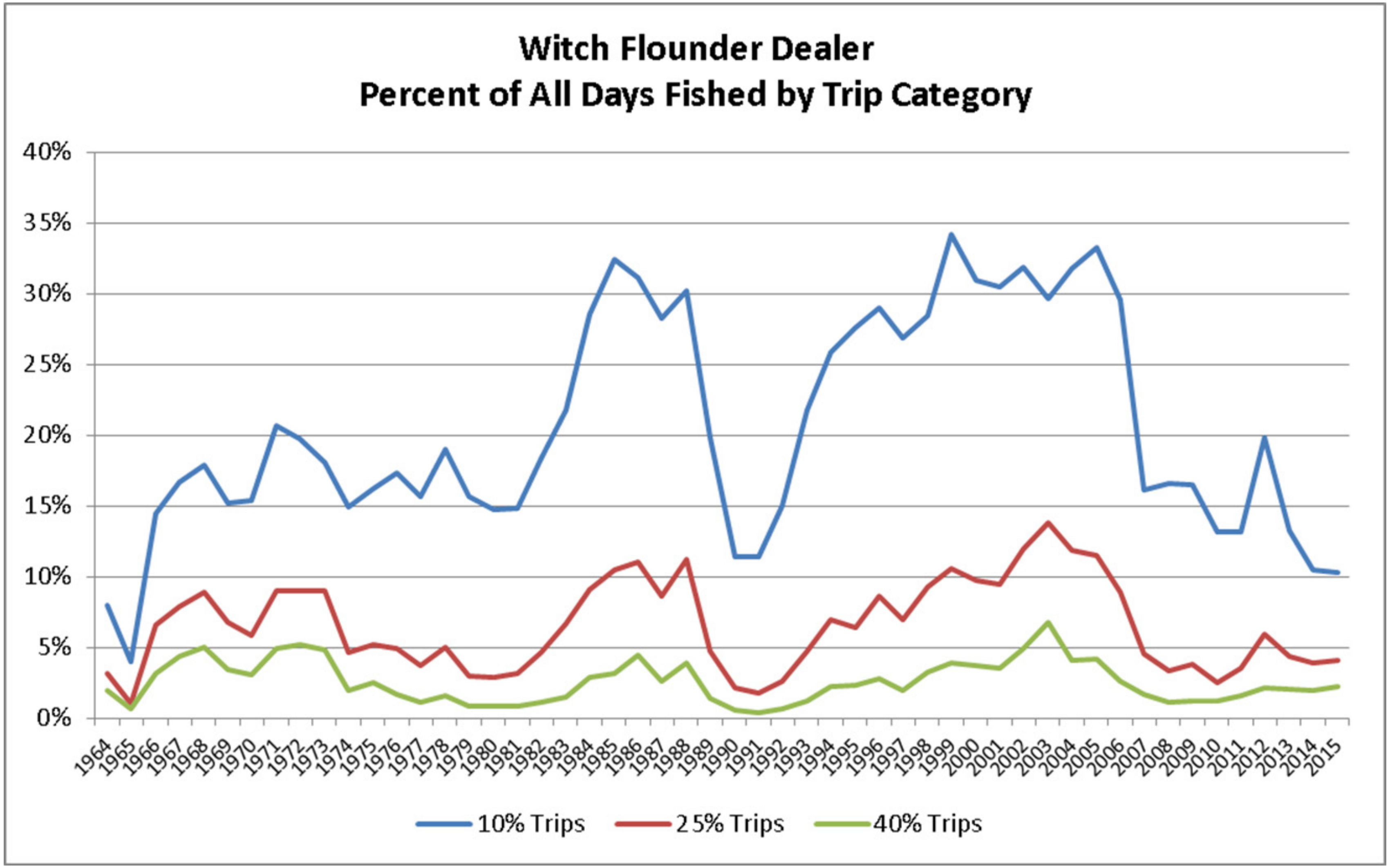
Appendix B6 Figure 9. Witch flounder model result summary compiled during the Model Meeting on the white board in the Conference Room. *Note: some values may not represent final results.*



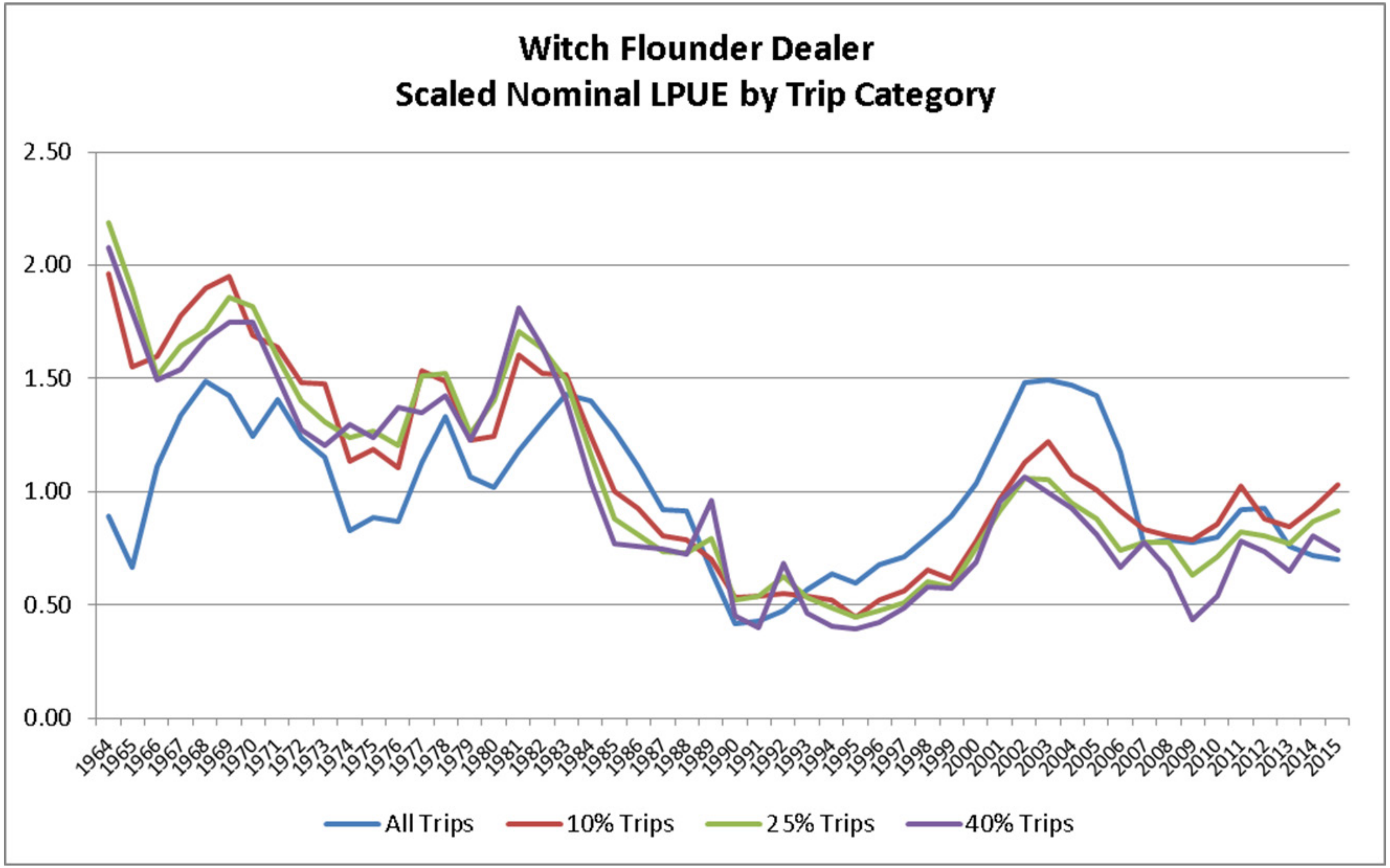
Appendix B6 Figure 10. Comparison of witch flounder January-1 exploitable biomass from Empirical Approach and ASAP Run 9_5_v2.



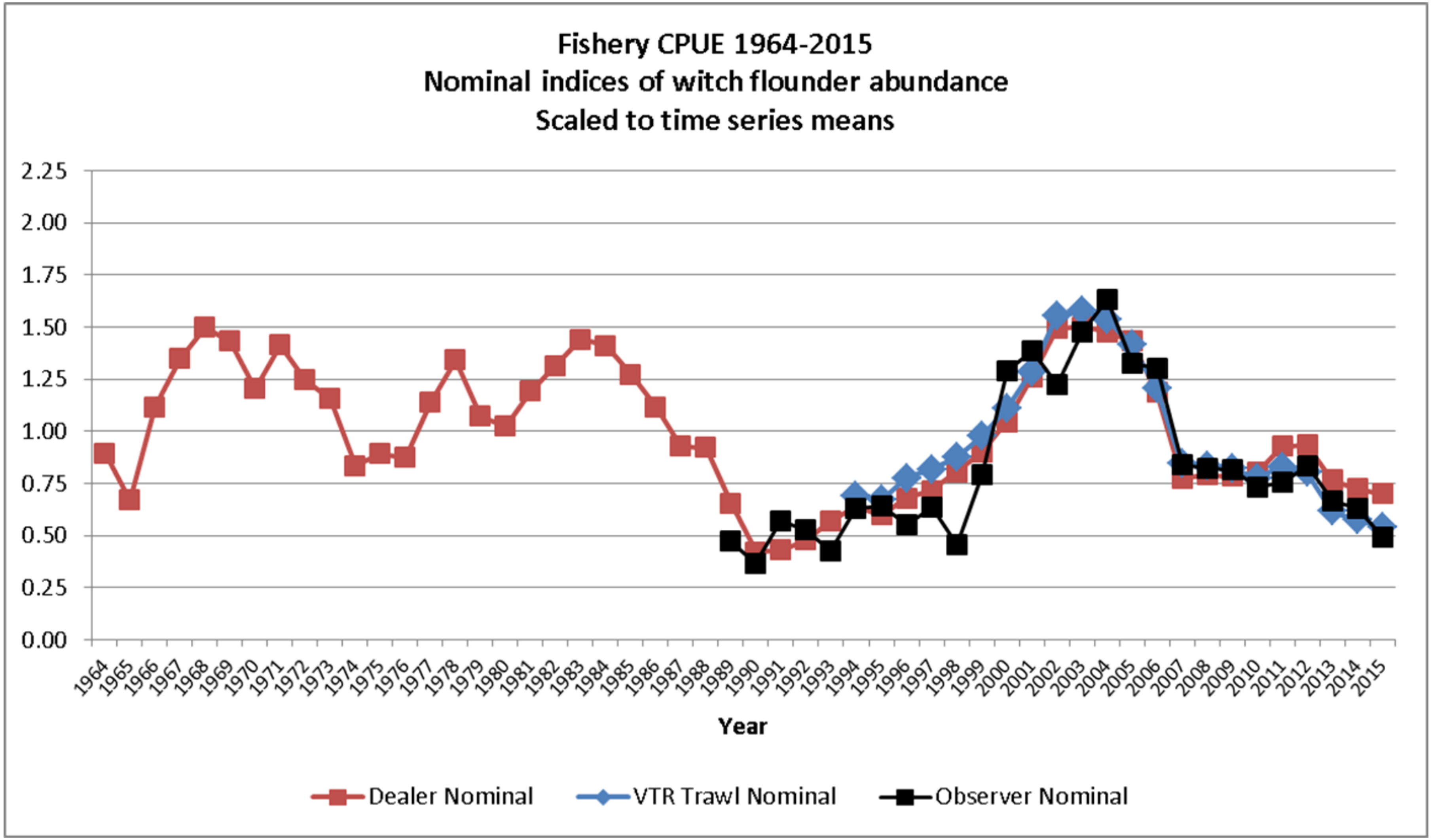
Appendix B6 Figure 11. Trends in percentage of all trips, by trip category (10%, 25% and 40% directed trips) for witch flounder.



Appendix B6 Figure 12. Trends in percentage of all days fished, by trip category (10%, 25% and 40% directed trips) for witch flounder.

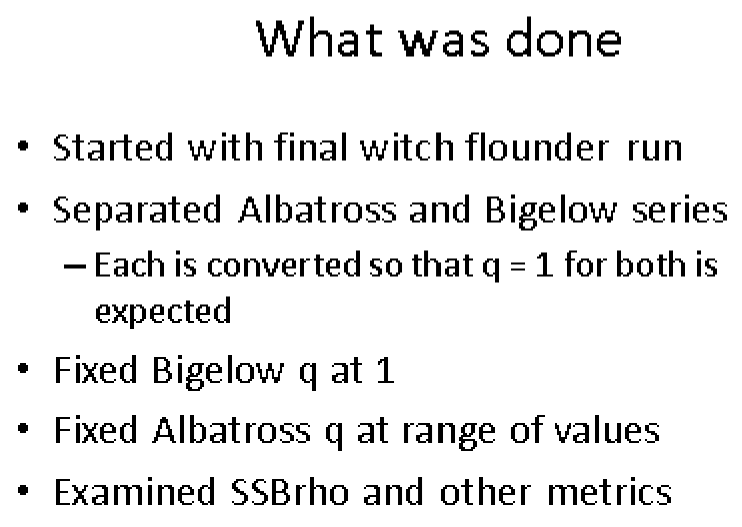


Appendix B6 Figure 13. Trends in scaled nominal landings per days fished (LPUE), by trip category (10%, 25% and 40% directed trips, and all trips) for witch flounder.

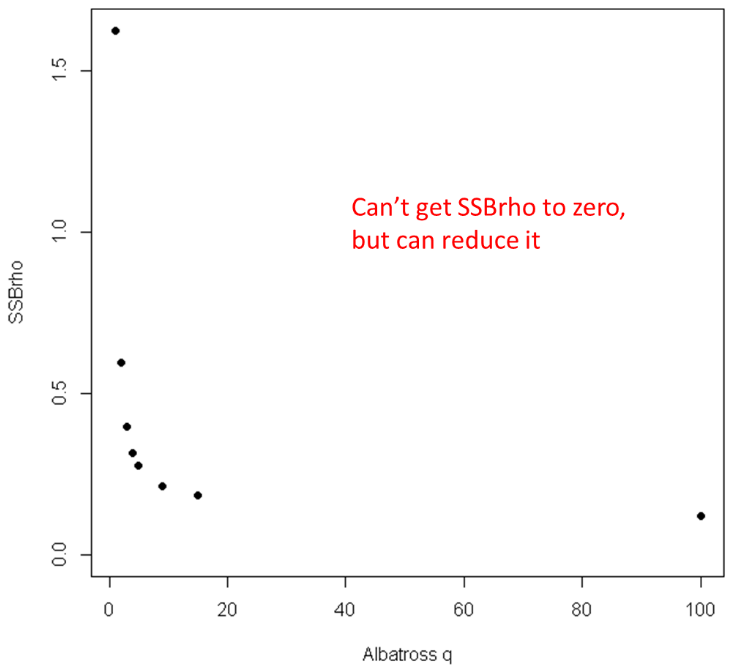


Appendix B6 Figure 14. Trends in nominal witch flounder fishery catch per day fished (CPUE) by data set (Dealer, Vessel Trip Report, and Observer).

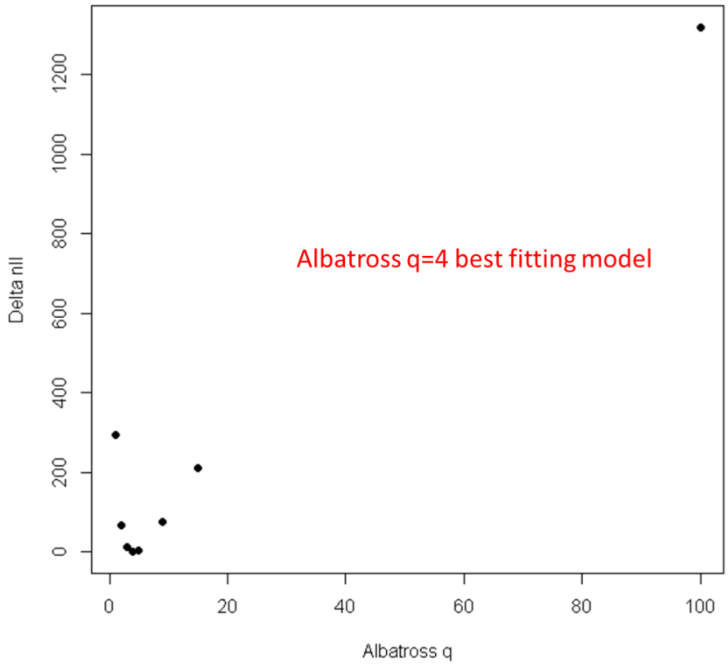
Witch Flounder Albatross-Bigelow Calibration Exploration



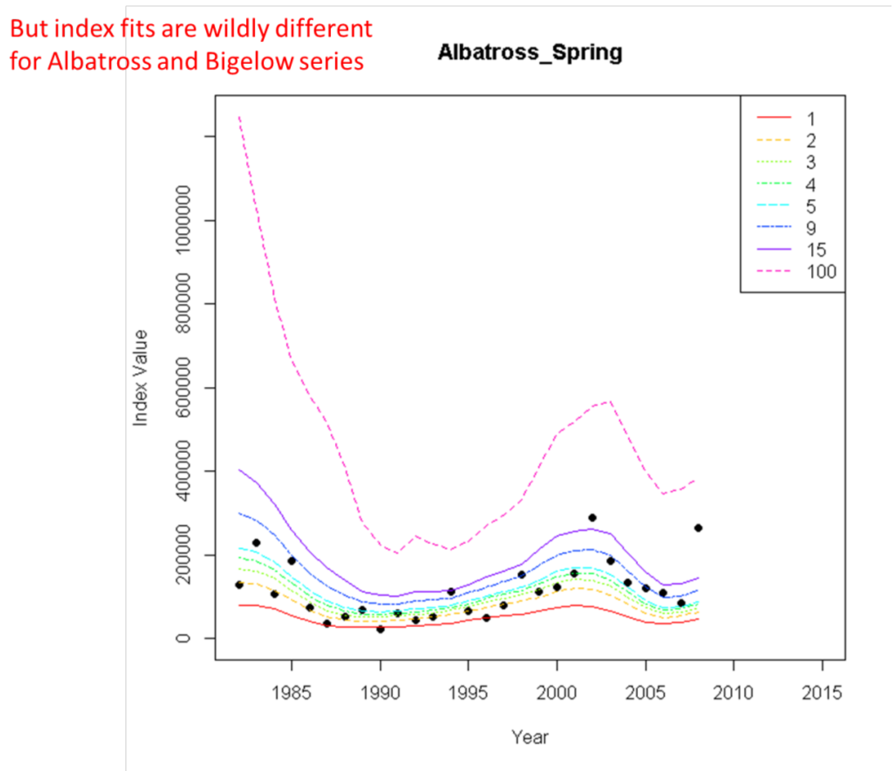
Appendix B6 Figure 15. Steps taken for the witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault).



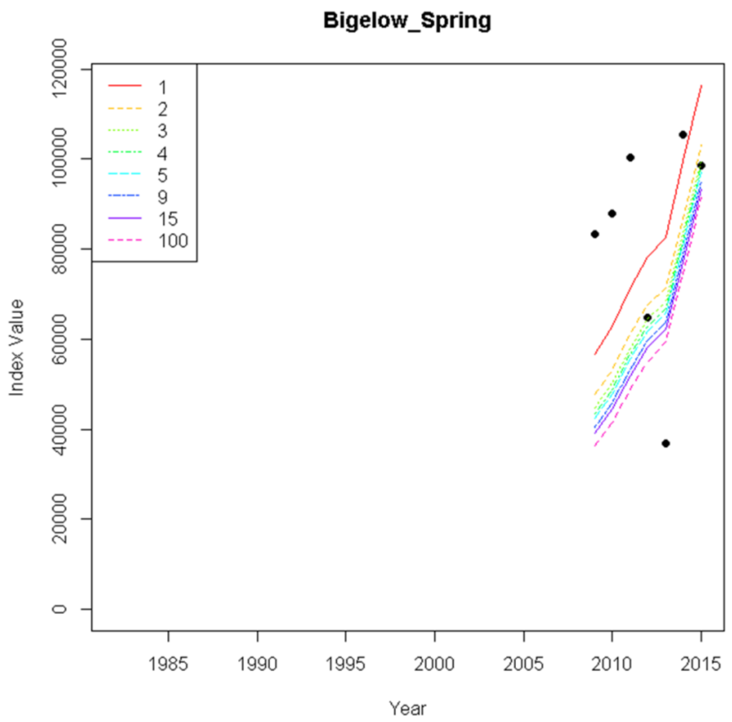
Appendix B6 Figure 16. Witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault).



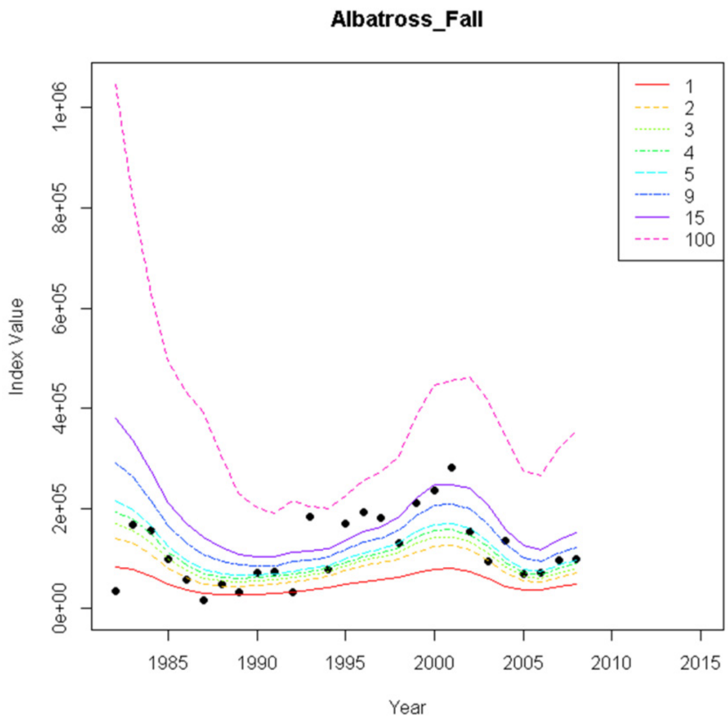
Appendix B6 Figure 17. Witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault).



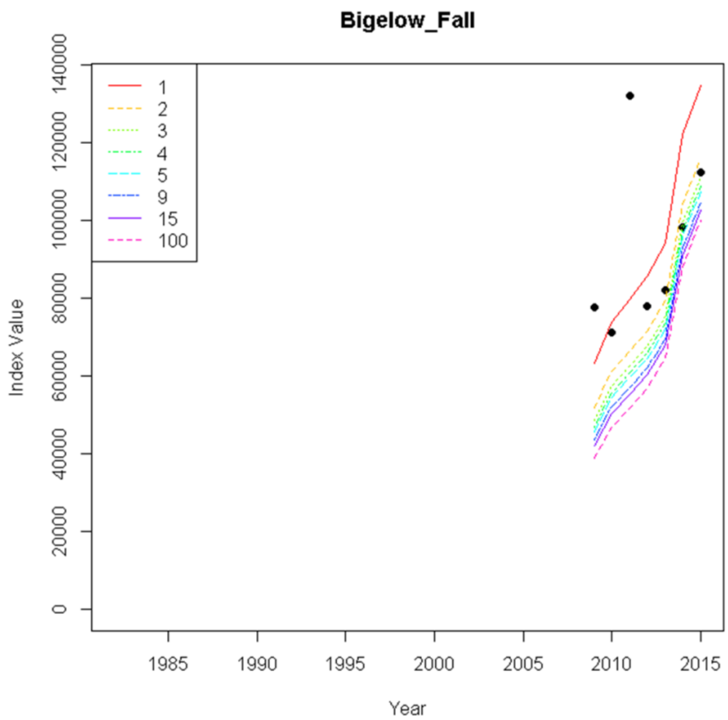
Appendix B6 Figure 18. Witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault).



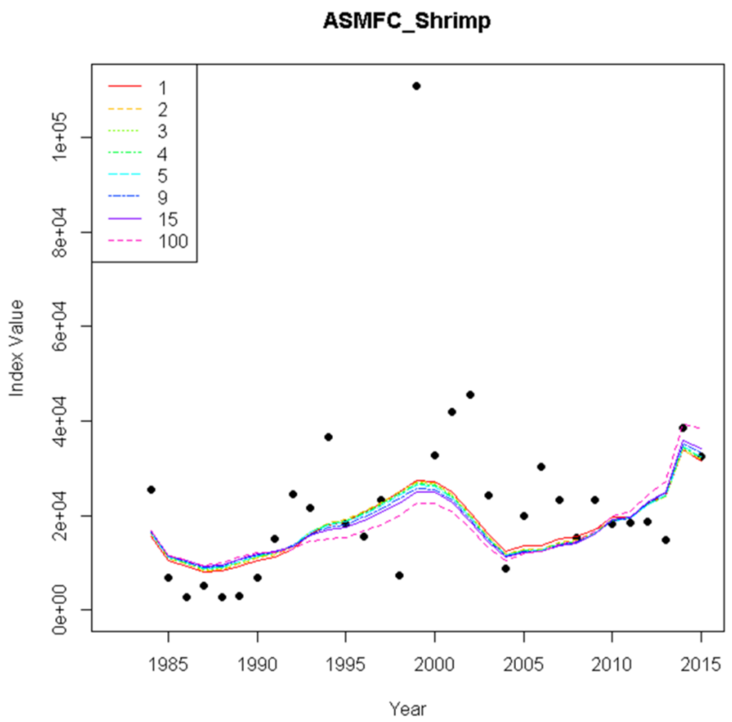
Appendix B6 Figure 19. Witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault).



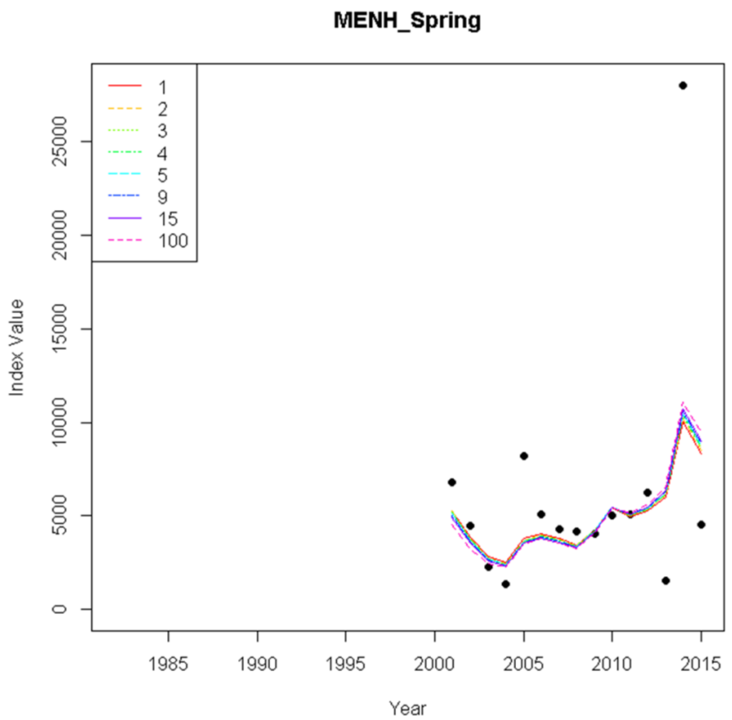
Appendix B6 Figure 20. Witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault).



Appendix B6 Figure 21. Witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault).

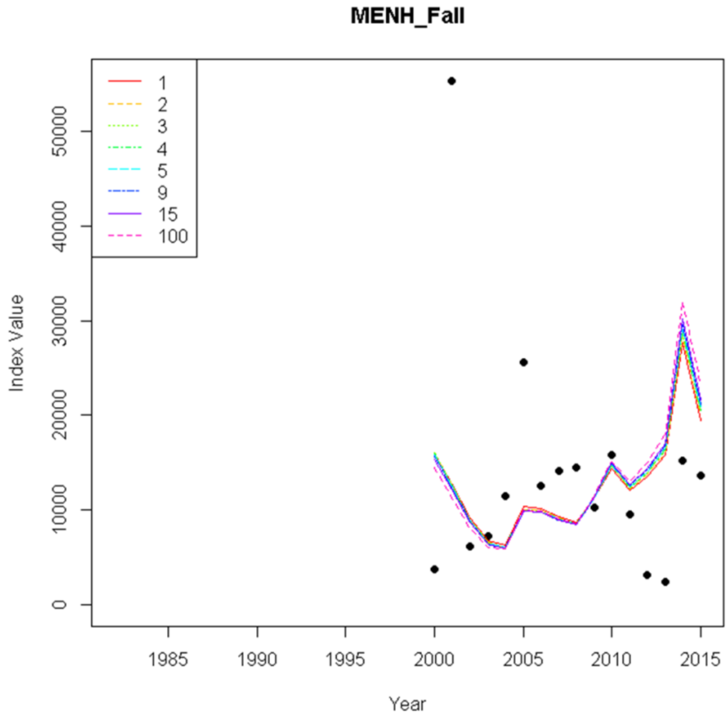


Appendix B6 Figure 22. Witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault)



Appendix B6 Figure 23. Witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault)

.



Appendix B6 Figure 24. Witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault)

Take home messages

- Changing survey q can reduce retrospective pattern
- Doing so for witch flounder at Albatross-Bigelow transition requires Albatross to have higher catchability than Bigelow (when Bigelow q fixed at 1)
  - This contradicts experimental evidence
- Could be explored more in future, but does not appear promising

Appendix B6 Figure 25. Witch flounder Albatross-Bigelow calibration Exploration (presentation by Chris Legault)