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2016 Monkfish Operational Assessment

by R Anne Richards

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Preface

This document represents the findings of an Operational Assessment of monkfish. The meeting was held June 20, 2016 at the Northeast Fisheries Science Center, National Marine Fisheries Service, Woods Hole, MA. The Review Panel comprised Wendy Gabriel (chair), Chris Legault and Jake Kritzer. All of the reviewers are members of the New England or Mid-Atlantic Fishery Management Councils' Science and Statistical Committees. Comments by the Operational Assessment Review Panel are included in their entirety in this report.

The Terms of Reference were approved on March 18, 2016 by the Assessment Oversight Panel (AOP) which included John Boreman and Jake Kritzer. One purpose of the AOP meeting was to confirm the recommendation made by the NEFSC and the concurrence of the NEFMC's Scientific and Statistical Committee to not update the monkfish assessment using the same modeling approach as used in the last assessment. This recommendation was based on new scientific evidence that the vertebral ageing method for monkfish is not valid. The AOP agreed with the recommendation to not update the previous modeling approach (SCALE) for monkfish during the update assessment. This decision is recognized as a departure from standard procedure but is based on the recognition that the inability to estimate monkfish growth makes any analysis using SCALE unusable for providing catch advice. The AOP recommended that stock status not be evaluated during this data update for monkfish because of the lack of biological reference points to allow status determination. The full AOP report is attached as an Appendix to this report.

Thanks to the assessment scientists and colleagues for their efforts to implement the operational assessment of monkfish. I also thank the review panel and especially the Chair, for their timely and insightful reviews. This document is part of an overall program to streamline the stock assessment process and provide more timely information to the New England and Mid Atlantic Fishery Management Councils. I thank the executive staff of the NEFMC for their efforts to identify, coordinate, and support the peer review panel. All meetings of the AOP and Review Panel were open to the public and we appreciate the valuable input we received.

James Weinberg
NEFSC Stock Assessment Workshop Chairman
June 30, 2016

Northeast Regional Coordinating Council (NRCC). 2011. A new process for assessment of managed fishery resources off the Northeastern United States. Unpublished white paper. 26 pages.

Comments from the Monkfish Operational Assessment Review Panel (June 20, 2016)

Report of Review Panel: 2016 Monkfish Operational Assessment

Wendy L. Gabriel, Chair
Jake Kritzer
Chris Legault

Charge to the Review Panel: Comment on whether the data update has been completed properly and documented in a written report.

The first four TOR for the Working Group addressed this topic. Overall, the Review Panel agreed the data were updated properly and appreciated the detailed report.

<u>TOR 1. Update time series of catch estimates including landings and discards, estimate size composition of catch.</u>
The Review Panel endorses the Working Group conclusion that the catch estimates were updated correctly.

<u>TOR 2. Update time series of fishery-independent indices for monkfish, including recruitment indices and length composition of survey catches.</u>
The Review Panel supports the Working Group conclusion that the fishery-independent indices were updated correctly. Due to the lateness of the 2016 NEFSC spring survey, the length frequency data from this survey were only presented in a preliminary form. If possible, these data should be shared with the PDT for inclusion in their report to the SSC as an indication of when the 2015 cohort might be expected to enter the fishery. The 2016 NEFSC spring survey stratified mean biomass and abundance data should not be used in an empirical approach until potential effects of the timing of the 2016 survey can be evaluated.

<u>TOR 3. Provide data that addresses potential biological changes such as shifts in distribution or condition of individual fish.</u>
The Review Panel agrees with the Working Group that there is no evidence of major biological changes. However, the Review Panel notes that the short time series used for the bottom temperature and depth analyses limits the power of these diagnostics. The Review Panel does not encourage backward expansion of the time series used in these analyses at this time based on lack of obvious change in distribution observed in the visual depiction of the full survey time series.

<u>TOR 4. Compare annual catches to ACLs to evaluate performance of the fishery.</u>
The Review Panel endorses the Working Group conclusion that landings have been below the ACL for both stocks due to groundfish regulations in the North and market demand, price, sturgeon bycatch, and monkfish regulations in the South. There is no indication that abundance is limiting the ability to catch the full ACL. The Review Panel notes that the comparison presented by the Working Group does not exactly match the TOR and requests the PDT provide a comparison of the annual catches and ACLs (=ABCs) as supporting information for the SSC. The Review Panel recommends the PDT expand on the reasons for the differences between realized catch and management limits.

TOR 5. Comment on the appropriateness and adequacy of the work that was carried out to support the SSC in making its ABC recommendation.

The Review Panel clarified that the approach recommended by the Working Group is a method for developing catch advice, and not an alternative method for determining updated reference points and stock status. The Review Panel agrees with the Working Group conclusion that a survey-based approach to developing catch advice is appropriate for a variety of reasons if changes to the status quo management measures are warranted. In the absence of an adequate analytical model, survey data provide a direct index of stock trends, and one that aggregates a wide range of biological, environmental and fishery factors. Survey data seem to work well for monkfish, producing consistent signals through time. Survey-based approaches were used for management of the fishery in the past, prior to adoption of an analytical model for the stock.

The Working Group based its recommendation on the recent approval of a similar method for the Georges Bank cod stock, so there is precedent for the approach. However, the Review Panel notes that the performance of the approach for management of Georges Bank cod is not yet clear, and therefore that only limited weight should be placed on that precedent. The Review Panel notes that the Working Group considered a range of survey-based approaches in addition to the one recommended, including different numbers of years in calculation of the trend and different smoothing functions. However, other approaches, such as those incorporating catch information in addition to survey data, were not considered by the Working Group.

The Review Panel notes, however, that it is not clear whether deviation from the status quo catch advice for monkfish is warranted. Although examination of the survey time series indicates current biomass is not as high as it has been in the past, the flat survey trend in the NFMA and the declining survey trend in the SFMA are potentially within the bounds of expected survey noise. Therefore, the biomass trends do not appear to be of major concern. The substantial disparity between landings and TAL in both management areas (30-50%) currently acts as an additional buffer that safeguards against potential declines. The 2015 cohort appears strong in both regions, but whether it will persist into the fishery remains to be seen. The Review Panel feels that the operational assessment report contains a rich array of data that the SSC can use to make alternative determinations.

Key sources of uncertainty

1. Without an accepted assessment model and associated reference points, the most significant uncertainty in this operational assessment is the lack of a quantitative determination of stock status and projected ABCs. In this assessment, survey indices have been used as proxies for stock abundance, and relative exploitation rates have been used as proxies for trends in fishing mortality rates. Neither of these quantities have been used as bases for proxies for biological reference points, however. Moreover, there is no direct method to map these relative quantities into absolute quantities (i.e. ABC).
2. The critical uncertainty that led to the rejection of the previous SCALE model is related to age determination, which continues to be unresolved.
3. Although the 2015 cohort has initially appeared to be relatively large, it is uncertain whether the cohort will persist in future surveys and fisheries.
4. Uncertainties in natural mortality rate also continue to be unresolved.

5. The relationship between management areas and stock areas is undefined. The extent of movement across management areas is an important consideration for stock structure. Furthermore, although the spatial distribution appears relatively stable in recent years, it is uncertain whether this stability will persist.
6. Fine-scale data on temporal and spatial patterns in discards are unavailable.

Important research needs

1. Age determination should be resolved to address model uncertainties noted above. This may include evaluation of alternative age structures and use of the 2015 cohort to validate age estimates and growth patterns (see below).
2. The 2015 cohort should be tracked through the suite of available surveys to evaluate effect on abundance, and potentially help determine growth with monthly sampling when possible. Density dependent growth has been observed in other species and should be considered when tracking this cohort.
3. Continue monitoring distribution of stock over shifting climate conditions.
4. Continue microsatellite research to determine stock structure.
5. Continue tagging studies to elucidate movement patterns.

2016 Monkfish Assessment Update

Executive Summary

Assessment data for northern and southern management units of monkfish were updated with minmal changes to methodological approaches of the previous assessment (NEFSC 2013). The current assessment does not include an update to the model used previously because the method for aging monkfish failed a validation test completed in 2016, thus invalidating the growth model.

TOR 1. Update time series of catch estimates including landings and discards, estimate size composition of catch.

Commercial fishery statistics for monkfish were updated for 2012-2015. In the north, landings and catch have fluctuated around a steady level since 2009. In the south, landings and catch have declined slightly in recent years, but have continued to be higher than in the north. There have been no evident shifts in length composition of the catch in either management area, with the exception of high discard rates of small fish in the south in 2015, reflecting the appearance of a strong yearclass.

TOR 2. Update time series of fishery-independent indices for monkfish, including recruitment indices and length composition of survey catches.

All survey index time series reported in past assessments were updated through 2015.

Within the northern management area, most surveys showed an increasing trend in biomass and abundance during 2013-2015. Exploitable biomass (43+cm) in the NEFSC fall survey has increased since 2013. Survey length composition data and associated recruitment indices suggest the appearance of a strong yearclass in 2015.

In the southern management area, survey indices have generally fluctuated without trend or declined slightly, with the exception of sharply increased abundance in summer and fall surveys in 2015. Length frequency data and recruitment indices suggest a strong 2015 yearclass in this area as well as in the north. However, exploitable biomass (43+cm) in the south estimated from NEFSC fall surveys has decreased since 2012.

TOR 3. Provide data that addresses potential biological changes such as shifts in distribution or condition of individual fish.

Distribution plots of survey catch rates do not indicate a shift in monkfish distribution. Evaluation of physical data associated with monkfish catches also does not indicate shifts in relative depth distribution or distribution with respect to bottom temperature (fall survey data). Time series of condition factors of individual fish fluctuate without trend.

TOR 4. Compare annual catches to ACLs to evaluate performance of the fishery.
In both management areas, fishing year landings have remained below the annual TAL since 2009. Landings averaged 60% of the TAL in the north and 59% in the south during 2013-2014. In 2015, 70% of the TAL was landed in the north, and 53% in the south.

TOR 5. Carry out analyses that will support the NEFMC SSC in making its ABC recommendation.

Calculations were carried out to support application of a model-free method previously used to derive Georges Bank cod catch limits. The method was based on calculating the proportional rate of change in smoothed survey indices over the most recent 3 years and using

those rates to revise catch limits. For monkfish, the estimated proportional change in exploitable biomass during 2012-2015 ranged from 1.02-1.06 in the north (2-6% increase) and 0.80-0.87 in the south (13-20% decrease), depending on which surveys were included in the calculation.

Introduction

Life History

The monkfish (*Lophius americanus*), also called goosefish, is distributed in the Northwest Atlantic from the Grand Banks and northern Gulf of St. Lawrence south to Cape Hatteras, North Carolina (Collette and Klein-Macphee 2002). Monkfish may be found from inshore areas to depths of at least 900 m (500 fathoms). Seasonal onshore-offshore migrations occur and appear to be related to spawning and possibly food availability (Collette and Klein-MacPhee 2002).

Monkfish rest partially buried on soft bottom substrates and attract prey using a modified first dorsal fin ray that resembles a fishing pole and lure. Monkfish are piscivorous and can eat prey as large as themselves. Despite the behavior of monkfish as a demersal 'sit-and-wait' predator, recent information from electronic tagging suggests seasonal off-bottom movements which may be related to migration (Rountree et al. 2006).

Growth rates of monkfish are not well understood. A recent study has shown that the method currently used to age monkfish in the U.S. (counting rings on vertebrae) does not consistently identify the correct number of presumed-annual rings at the margin of the vertebra (Bank 2016), thus calling into question the growth curves used in previous assessments. In addition, it appears that first year growth may be much faster than previously understood. Growth estimated by following size modes of a strong yearclass spawned in 2015 suggests that monkfish may grow more than 20 cm during their first year (Figure 30). Even faster growth of a presumed young-of-year monkfish has been seen in the laboratory (C. Bank, UMass Dartmouth, personal communication). Because growth rates are currently highly uncertain, the assessment model used in past monkfish assessments was not updated in this assessment.

The estimated size at 50% maturity of monkfish is 41 cm for females and 37 cm for males (Richards et al. 2008). Few males are found larger than 70 cm, but females can reach sizes greater than 130 cm. Spawning takes place from spring through early autumn, progressing from south to north, with most spawning occurring during the spring and early summer (Richards et al. 2008). Females lay a buoyant mucoid egg raft or veil which can be as large as 12 m long and 1.5 m wide and only a few mm thick. The eggs are arranged in a single layer in the veil, and the larvae hatch after about 1-3 weeks, depending on water temperature. Females likely produce more than one egg veil per year (McBride et al. in prep.). The larvae and juveniles spend several months in a pelagic phase before settling to a benthic existence at a size of about 8 cm (Collette and Klein-MacPhee 2002).

Stock Identification

The Fishery Management Plan (FMP) defines two management areas for monkfish (northern and southern), divided roughly by a line bisecting Georges Bank (Figure 1). The two assessment and management areas for monkfish were defined in the 1999 FMP based on differences in temporal patterns of recruitment (estimated from NEFSC surveys), perceived differences in growth patterns, and differences in the contribution of fishing gear types (mainly trawl, gill net, and dredge) to the landings. Since then, genetic studies using mitochondrial DNA have suggested a homogeneous population of monkfish off the U.S. east coast (Chikarmane et al.

2000; Johnson et al. in prep.); however research in progress using microsatellite DNA suggests a possible delination off Delaware Bay in the Mid-Atlantic Bight (Housbrouck et al. 2015).

Monkfish larvae are distributed over deep (< 300 m) offshore waters of the Mid-Atlantic Bight in March-April, and across the continental shelf (30 to 90 m) later in the year, but relatively few larvae have been sampled in the northern management area (Steimle et al. 1999). NEFSC surveys continue to indicate different recruitment patterns in the two management units in recent years; however a recruitment event appears to have occurred in both management regions in 2015.

The perceived differences in growth in the two management areas were based on studies about 10 years apart and under different stock conditions (Armstrong et al. 1992: Georges Bank to Mid-Atlantic Bight, 1982-1985; Hartley 1995: Gulf of Maine, 1992-1993). Age, growth, and maturity information from the NEFSC surveys and the 2001, 2004 and 2009 cooperative monkfish surveys indicated only minor differences in age, growth, and maturity between the areas (Richards et al., 2008; Johnson et al., 2008). However these growth studies used the vertebral aging method which is now called into question.

The southern deepwater extent of the range of American monkfish (*L. americanus*) overlaps with the northern extent of the range of blackfin monkfish (*L. gastrophysus*; Caruso 1983). These two species are morphologically similar, which may create a problem in identification of survey catches and landings from the southern extent of the range of monkfish. The potential for a problem however is believed to be small. The NEFSC closely examined winter and spring 2000 survey catches for the presence of blackfin monkfish and found none. The cooperative monkfish survey conducted in 2001 caught only eight blackfin monkfish of a total of 6,364 monkfish captured in the southern management area.

Current Research

Ongoing research was summarized by investigators currently funded by the monkfish Research Set-Aside (RSA) program. The following summaries were provided by the investigators.

Monkfish Age and Growth, and Tagging

Monkfish Age Validation (C. Bank, UMass Dartmouth). To validate the vertebral ageing protocol and to explore alternative ageing methods, we injected oxytetracycline or fluorexon into individual monkfish, kept them alive in the laboratory, and subjected them to a seasonal cycle of temperature, light, and feeding. Monkfish were also injected in the field with the same chemical markers as part of an on-going tagging study. The chemical left a visible mark on the growth ring that was forming at the time of injection. Vertebrae, otoliths, and illicia were analyzed from fish that lived six months or more after marking, from both the laboratory study and the field recaptures. Digital images were taken with an ultraviolet light to illuminate the mark and reflected light to show the growth rings. An experienced monkfish age reader determined age from vertebrae and each annulus after the chemical mark was identified. Results indicate that annuli counts on vertebrae cannot be used to accurately determine the age of monkfish, irregular growth of the otolith prohibits its use as a reliable age structure, and age determination using illicia is the most promising.

Monkfish Tagging (G. Sherwood (GMRI), C. Brown (GMRI), C. Bank (UMass Dartmouth), J. Grabowski (Northeastern).

Monkfish growth is currently assumed to be linear based on age results from vertebrae. New evidence from tagging and otolith data call into question linear growth and rather support a

more biologically reasonable asymptotic growth pattern. From a multi-year tagging program (6,176 releases and 282 recaptures) we were able to glean growth information from 46 individuals. Daily growth increment was found to be negatively correlated to length ($r^2 = 0.19$, $p < 0.01$) and using this information we were able to model non-linear growth curves and associated Von Bertalanffy growth function parameters. Tagging results agreed very well with another line of inquiry involving otolith microchemical signatures. Specifically, strontium/calcium ratios (Sr/Ca), which were verified to mirror the seasonal temperature cycle for monkfish (and hence annuli), also indicated a pattern of decreasing growth with age and size. While some subjectivity existed for interpreting Sr/Ca data, the real strength of this technique was in establishing the width of the first annulus which was quite large and consistent with rapid early growth in monkfish.

Tagging studies using electronic data storage tags (DSTs) have been in progress for several years. A total of 607 tags were released: 221 in the western Gulf of Maine (northern management area), 238 in southern New England (inshore and offshore), and 148 in the southern Mid-Atlantic Bight. The rate of recaptures to date is 7.6% (46 recaptures).

Very little movement across management boundaries has been observed based on release and recapture locations in either the conventional or DST tagging programs. The DST tagging data are currently being analyzed to estimate position data which will be used to construct a probabilistic path of travel for each fish.

Funding has been recently obtained to use conventional tags on small (<40 cm) monkfish caught as bycatch in small mesh gillnet fisheries (e.g. dogfish, groundfish) to obtain growth estimates for juvenile monks.

Working Group Comments - Monkfish Age and Growth, and Tagging
The Working Group made note that the current vertebral-based age estimates are not valid, and that previous estimates of length at age may be inaccurate at both small (< 40 cm) and large (~ 75 cm) sizes. Further work on the development of ilicia-based age and growth estimates is likely to occur over the summer of 2016, but sufficient information for peer review and incorporation into the assessment will not be available until 'a long time' subsequent. The NEFSC has collected paired samples of illicia and vertebrae (ie. from the same fish). If and when a method for determining ilicia-based ages is developed, investigators will attempt to understand the relationship between the two and possibly calibrate/correct the vertebral ages estimated in the past. The WG noted that incorporating new research results into the existing SCALE model (e.g. as part of an RSA project) should done in coordination with the SAW Monkfish WG, and not made public until vetted through an appropriate peer review process.

Monkfish Genetic Study using Microsatellite DNA (E. Hasbrouck (Cornell Univ), Isaac Wirgin, NYU). In 2012 Cornell University Cooperative Extension Marine Program (CCE) received an RSA grant to help determine if the monkfish population is comprised of a single or of multiple stocks over their coast wide distribution from Newfoundland to North Carolina. The project used a sensitive genetic approach known as microsatellite DNA analysis to evaluate the coast wide structure of the stock. Utilizing a collaborative approach, monkfish biological samples were collected and the genetic structure of the monkfish population was analyzed. For the first time, this project empirically evaluated the coast wide monkfish stock structure using sensitive DNA markers. In summary our genetic analysis indicates that there are 2 and perhaps 3 genetic stocks of monkfish along their coastwide distribution and this differentiation may result from a latitudinal gradient in genetic differentiation. The delineation between genetically different stocks does not coincide with the current management division between the northern and

southern management areas. Clearly, these genetic divisions do not respect the current 2 stock model by which monkfish are managed in U.S. waters today. However, the boundaries of these genetic stocks require further delineation and the temporal stability of these units between and with years requires confirmation before this new information can be effectively employed in a management context. The project will continue under a 2016 Monkfish RSA grant awarded to Cornell Cooperative Extension and New York University.

Working Group Comments - Monkfish Genetic Study using Microsatellite DNA
The WG noted that the results of the genetic research should be coordinated with the DST tagging results to help understand how movements and timing of migration could affect those results. Genetic samples collected from recaptured tagged fish should be analysed using microsatellites.

The investigators indicated that the planned 2016 work will focus sampling on areas that will help clarify whether the 2012 results are temporally and geographically stable and will include an analysis of any blackfin monkfish that are encountered.

The WG noted that while the results of the 2012 RSA project are informative, questions remain:
-What do the results indicating genetic differentiation in areas 3D and 6 really mean – are they truly indicative of stock structure in the southern end of the range? If the differences persist, are they biologically meaningful?
- Sample sizes in the southern end of the sampling area were small in the 2012 RSA project, especially in the offshore areas. The 2016 work will attempt to increase sample sizes in these areas, but it was also noted that it may be difficult to obtain large sample sizes in depths greater than 200 m.
-More information on all stages of monkfish life history from larvae to spawning adults would be helpful for developing a more targeted sampling protocol for genetic stock identification.

Fisheries Management

Commercial fisheries for monkfish occur year-round using gillnets, trawls and scallop dredges. No significant recreational fishery exists. The primary monkfish products are tails, livers and whole gutted fish. Peak fishing activity occurs during November through June, and value of the catch is highest in the fall due to the high quality of livers during this season.

U.S. fisheries for monkfish are managed in the Exclusive Economic Zone (EEZ) through a joint New England Fishery Management Council - Mid-Atlantic Fishery Management Council Monkfish Fishery Management Plan (FMP). The primary goals of the Monkfish FMP are to end and prevent overfishing and to optimize yield and economic benefits to various fishing sectors involved with the monkfish fisheries (NEFMC and MAFMC 1998; Haring and Maguire 2008). Current regulatory measures vary with type of permit but include limited access, limitations on days at sea, mesh size restrictions, trip limits, minimum size limits and annual catch limits (Tables 1 and 2).

Biological reference points for monkfish were established in the original Fishery Management Plan (FMP), but were revised after SAW 34 (NEFSC 2002), after the Data Poor Stocks Working Group (DPSWG) in 2007 (NEFSC 2007a), and after SAW 50 in 2010. The overfishing definition is F_{max}. Prior to 2007, $B_{threshold}$ was defined as one-half of the median of the 1965-1981 3-year average NEFSC fall trawl survey catch (kg) per tow). After acceptance of an analytical assessment in 2007 (NEFSC 2007a), B_{target} was redefined as the average of total biomass for the model time period (1980-2006) and $B_{threshold}$ as the lowest observed value in the

total biomass time series from which the stock had then increased (termed "B_{Loss}"). According to the earlier (survey index-based) reference points, monkfish were overfished and overfishing status could not be determined (NEFSC 2005); however, with adoption of the analytical assessment in 2007, monkfish status was changed to no longer overfished and overfishing was not occurring. Assessments in 2010 and 2013 (NEFSC 2010; 2013) also concluded that both stocks were not overfished and overfishing was not occurring, while recognizing the continuing significant uncertainty in the determination.

TOR 1. Update time series of catch estimates including landings and discards, estimate size composition of catch.

Landings

Landings of monkfish tails are converted from landed weight to live weight, because a substantial fraction of the landings occur as tails only (or other parts). The conversion of landed weight of tails to live weight of monkfish in the NEFSC weigh-out database is made by multiplying landed tail weight by a factor of 3.32. In 2012, the dealer data base for 2005-2011 was corrected because some dealers were reporting 'head-on, gutted' monkfish (conversion factor of 1.14) as 'round' (no conversion). This resulted in a 1.5% overestimate of monkfish landings (live weight) during those years (all years combined).

Early catch statistics (before ~1980) are uncertain, because much of the monkfish catch was sold outside of the dealer system or used for personal consumption until the mid-1970s. For 1964 through 1989, there are two potential sources of landings information for monkfish; the NEFSC 'weigh-out' database, which consists of fish dealer reports of landings, and the 'general canvass' database, which contains landings data collected by NMFS port agents (for ports not included in the weigh-out system) or reported by states not included in the weigh-out system (Table 3). All landings of monkfish are reported in the general canvass data as 'unclassified tails.' Consequently, some landed weight attributable to livers or whole fish in the canvass data may be inappropriately converted to live weight. This is not an issue for 1964-1981 when only tails were recorded in both databases. For 1982-1989, the weigh-out database contains market category information that allows for improved conversions from landed to live weight. The two data sources produce the same trends in landings, with general canvass landings slightly greater than weigh-out landings. It is not known which of the two measures more accurately reflects landings, but the additional data sources suggest that the general canvass is most reliable for 1964-1981 landings, whereas the availability of market category details suggests that the weigh-out database is most reliable for 1982-1989.

Beginning in 1990, most of the extra sources of landings in the general canvass database were incorporated into the NEFSC weigh-out database. However, North Carolina reported landings of monkfish to the Southeast Fisheries Science Center and until 1997 these landings were not added to the NEFSC general canvass database. Since these landings most likely come from the southern management area, they have been added to the weigh-out data for the southern management area for 1977-1997 for the landings statistics used for stock assessment.

Beginning in July 1994, the NEFSC commercial landings data collection system was redesigned to consist of vessel trip reports (VTR) and dealer weigh-out records. The VTRs include area fished for each trip which is used to apportion dealer-reported landings to statistical areas. The northern management area includes statistical areas 511-515, 521-523 and 561; and the southern management area includes areas 525-526, 562, 537-543 and 611-636 (Figure 1). Each VTR trip should have a direct match in the dealer data base, but this is not always true. VTR records with no matching dealer landings were excluded, but dealer landings with no

matching VTR were included in landings statistics, apportioning the unmatched landings to management area using proportions calculated from matched trips pooled over gear, state and quarter.

Total U.S. landings (live weight) remained at low levels until the middle 1970s, increasing less than 1,000 mt to around 6,000 mt in 1978 (Table 3, Figure 2). Annual landings remained stable at between 8,000 and 10,000 mt until the late 1980s. Landings increased from the late 1980s to over 20,000 mt per year during 1992-2004, peaking at 28,500 mt in 1997. Landings declined steadily after 2003, and stabilized around an average of 8,600 mt during 2009-2015. During recent years (2008-2015 North; 2009-2015 South), fishing year landings have reamined below the TAL (Table 2).

Monkfish landings began to increase in the northern management region in the mid-1970s and in the late 1970s in the southern area. Most of the increase in landings during the late 1980s through mid-1990s was from the southern area. Historical under-reporting of landings should be considered in the interpretation of this series.

Trawls, scallop dredges and gill nets are the primary gear types that land monkfish (Table 4, Figure 3). Trawls have been the predominant gear in the north, accounting for approximately 75% of the landings on average. In the south, trawls and dredges dominated the landings before about 2002, but were subsequently replaced by gillnets as regulations changed. Gillnets now account for about 60% of the landings from the southern management area.

Until the late 1990s, total landings were dominated by landings of monkfish tails. From 1964 to 1980 landings of tails rose from 19mt to 2,302mt, and peaked at 7,191mt in 1997 (Table 5). Landings of tails declined after 1997, but are still an important component of the landings. Landings of gutted whole fish have increased steadily since the early 1990s and are now the largest market category on a landed-weight basis. On a regional basis, more tails were landed from the northern area than the southern area prior to the late 1970s (Tables 5 and 6). From 1979 to 1989, landings of tails were about equal from both areas. In the 1990's, landings of tails from the south predominated, but since 2000, landings of tails have been greater in the north.

Beginning in 1982, several market categories were added to the system (Table 5). Tails were broken down into large (> 2.0 lbs), small (0.5 to 2.0 lbs), and unclassified categories and the liver market category was added. In 1989, unclassified round fish were added, in 1991 peewee tails (<0.5 lbs) and cheeks, in 1992 belly flaps, and in 1993 whole gutted fish were added. Landings of unclassified round (whole) or gutted whole fish jumped in 1994 to 2,045 mt and 1,454 mt, respectively; landings of gutted fish continued to increase through 2003. The tonnage of peewee tails landed increased through 1995 to 364 mt and then declined to 153 mt in 1999 and 4 mt in 2000 when the category was essentially eliminated by regulations.

Foreign Landings

Landings (live wt) from NAFO areas 5 and 6 by countries other than the US are shown in Table 3 and Figure 2. Reported landings were high but variable in the 1960s and 1970s with a peak in 1973 of 6,818 mt. Landings were low but variable in the 1980s, declined in the early 1990s, and have generally been below 300 mt in recent years. NAFO data for monkfish were not updated for this assessment update.

Discard Estimates

Catch data from the fishery observer, dealer and VTR databases were used to investigate discarding frequencies and rates using standardized bycatch reporting methodology (SBRM, Rago et al. 2005; Wigley et al. 2007). The number of trips with monkfish discards available for analysis varied widely among management areas and gear types (Tables 7, 8). As in previous

monkfish assessments (NEFSC 2007a, NEFSC 2010, NEFSC 2013), monkfish discards were estimated on a gear, half-year and management area basis using observed discard-per-kept-monkfish to expanded to total discards for otter trawls and gillnets, and observed discard-per-all-kept-catch to expanded for scallop dredges and shrimp trawls. Discards for 1980-1988 (before observer sampling) were estimated by applying average discard ratios by management area and gear type (trawl, shrimp trawl, gillnet, dredge) from 1989-1991 to landings for 1980-1988 as follows:

Area	Shrimp Trawls	Trawls	Gillnets	Dredges
North				
Years included	1989-1991	1989-1991	1989-1991	1992-1997
Number of trips	124	253	1191	54
South				
Years included	n/a	1989-1991	1991-1992	1991-1993
Number of trips		334	177	32

The proportion of discards in the northern area catch was about 13% in the 1980s, 7% during 2002-2006, became slightly higher on average (12%) during 2007-2009, and was 14% for 2010-2015 (Table 9, Figures 4, 5). The proportion of discards in the southern area catch has generally increased since the 1980s (average 16% 1980-1989), with an annual average of 29% during 2002-2006, 24% during 2007-2009, and 27% in 2010-2015 (Table 9, Figure 4, 5). Gill nets consistently have had the lowest discard ratios. Some of the trends in discarding may reflect imposition of size limits starting in 2000 and decreased trip limits in the south starting in 2002. The most frequent discard reasons were that fish were too small for regulations or the market. In 2015, a large increase in discards of small fish was observed in the southern area dredge and trawl fisheries (Figure 7), reflecting a strong recruitment event. A similar spike was not seen in the north even though there was evidence of strong recruitment; however the recruits in the north were smaller than in the south, perhaps reflecting later birth dates. The estimates of total catch for 1980-2015 are shown in Figure 5 and Table 9.

Size Composition of U.S. Catch

Tail lengths were converted to total lengths using relations developed by Almeida et al. (1995). As in previous assessments, (NEFSC 2007a and later), length composition of landings and discard were estimated from fishery observer samples by management area, year, gear-type (trawls, dredges and gillnets) and catch disposition (kept or discarded). Landings in unknown gear categories were allocated proportionately to the 3 major gear types before assigning lengths. The stratification used for assigning lengths within area and gear type is shown in Table 10.

The estimated length composition of landings and discard is shown in Figures 6-9. Age composition of the catch was not estimated.

Effort and CPUE

Evaluating trends in effort or catch rates in the monkfish fishery is difficult for several reasons. Much of the catch is taken in multi-species fisheries, and defining targeted monkfish trips is difficult. There have been programmatic changes in data collection from port interviews (1980-1993) to logbooks (1994-2009), and comparison of effort statistics among programs is

difficult. Catch rates may not reflect patterns of abundance, because they have been affected by regulatory changes (e.g., 1994 closed areas, 2000 trip limits, 2006 reductions in trip limits).

CPUE data have not been used in the assessment model for monkfish, therefore they were not examined for this assessment update.

Working Group Comments – TOR 1
The WG noted that landings in the North area have recently been stable, while landings in the South have decreased since 2011. However, the number of vessels actively fishing for and landing monkfish has likely decreased in the North since 2011. Therefore, an analysis of landings and effort would likely indicate that LPUE has increased in spite of management restrictions.

The WG noted that the reason that landings taken by the scallop dredge gear are low (and discards high) is due to regulatory and economic disincentives to land monkfish. The WG noted that mortality rate of discarded monkfish is assumed to be 100%.

TOR 2. Update time series of fishery-independent indices for monkfish, including recruitment indices and length composition of survey catches.

Resource surveys used in the 2013 assessment were updated, including NEFSC spring and fall offshore surveys, ASMFC northern shrimp surveys (NFMA only), ME/NH spring and fall inshore surveys, and scallop dredge surveys conducted by NEFSC and Viginia Institute of Marine Science (VIMS) (SFMA only). The NEFSC survey strata used to define the northern and southern management areas are:

Survey	Northern Area	Southern Area
NEFSC offshore bottom trawl	20-30, 34-40	1-19, 61-76
ASMFC Shrimp	1,3,5-8	
Shellfish		6,7,10,11,14,15,18,19,22-31,33-35,46,47,55,58-61,621,631

NEFSC spring and fall bottom trawl survey indices for 1963-2008 were standardized to adjust for statistically significant effects of trawl type (Sissenwine and Bowman 1977) on catch rates. The trawl conversion coefficients apply only to the spring survey during 1973-1981.

Previous monkfish assessments have used delta distribution estimators for the mean and variance of stratified catch per tow because of the high proportion of zero tows in the surveys conducted using the F/V Albatross (1963-2008) (Pennington 1996). Generally the delta distribution means are very similar to arithmetic estimates (Appendix, Figures 1 and 2). However, the appearance of a very strong 2015 yearclass caused problems with the delta distribution biomass estimates because of very high within stratum variances in catch weights. The high within-stratum variance in monkfish catch weight was due to catches of very small individuals (which weighed very little) being caught in many tows. Similar problems with the delta distribution estimators have been previously documented (Syrjala 2000). Therefore estimates of arithmetic means with bootstrapped confidence intervals are provided in this assessment, along with the delta distribution estimators.

NEFSC indices derived from surveys on the FSV Henry Bigelow (starting spring 2009) were adjusted using calibration coefficients estimated during experimental work (Miller et al. 2009). The FSV *Henry B. Bigelow*, which became the main platform for NEFSC research surveys in spring 2009, has significantly different size, towing power, and fishing gear

characteristics than the previous survey platform (*Albatross IV)*, resulting in different fishing power and catchability for most species. Calibration experiments to estimate these differences were conducted during 2008 (Brown 2009, NEFSC 2007b), and were peer reviewed by a Panel of three non-NMFS scientists during the summer of 2009 (Anonymous 2009). The objective was to develop specific protocols for guidance in the selection and use of appropriate estimators based on the amount of data available and the relative performance of two candidate estimators. The Panel developed general guidance on which estimator to use given sample sizes for each species. Following these guidelines, monkfish catches were converted using a simple ratio estimator without a seasonal (spring vs. fall) or length-specific correction. The low catch rates of monkfish in the Albatross series made development of more detailed coefficients infeasible. The overall coefficients for monkfish were 7.1295 for numbers and 8.0618 for biomass (kg) (Anonymous 2009; Miller et al. 2009).

Coefficients of variation and confidence intervals for survey indces are given in the tables for each survey and region discussed below.

Northern Area

Biomass indices from NEFSC fall and spring research trawl surveys fluctuated without trend between 1963 and 1975, increased briefly in the late 1970's, but declined thereafter to near historic lows during the 1990's (Tables 11-14, Figures 10, 11, 13). From 2000 to 2003, indices increased, reflecting recruitment of a relatively strong 1999 yearclass. Subsequently, biomass indices declined and have remained relatively low since. In the Bigelow time series (2009-2015, Figure 11), biomass and abundance indices in the north have generally increased since 2009. Trends in the ME/NH trawl survey suggest a general decline since 2000, but a strong increase in 2015 (Figure 12).

NEFSC survey length distributions have become increasingly truncated over time (Figures 14-15). By 1990, fish greater than 60 cm long were uncommon. The minimum, median and maximum lengths in the trawl surveys declined during the 1980s and have fluctuated around smaller sizes since around 1990 (Figure 16). Despite relatively low landings and discards in recent years, there is little evidence of increased abundance of large individuals in the survey catches. Several modes potentially representing strong yearclasses have appeared in survey length distributions (Figure 14-15), most recently in 2015 (fall). Length composition of catches in the summer shrimp survey and the ME/NH surveys are shown in Figures 17 and 18.

Recruitment indices (abundance) were estimated for monkfish of lengths corresponding to presumed young-of-year (YOY, age 0) (Figure 19). The size ranges used were based on length frequencies observed for the strong 2015 yearclass, and differ from those used previously, as detailed below.

	2013		2016	
North	Putative age	cm range	Putative age	cm range
Fall NEFSC	1	11-19	0	6-18
Fall ME-NH	1	11-19	0	8-18
South				
Spring/summer scallop	1	11-19	0	7-18
Fall NEFSC	1	11-17	0	12-28

Based on the recruitment indices, the frequency of recruitment events in the northern area has increased since the late 1980s, with strong yearclasses produced in 1993, 1999 and 2015.

Additional surveys that catch monkfish in portions of the northern area include the ASMFC shrimp survey, the Massachusetts Division of Marine Fisheries fall and spring surveys, and ME/NH inshore surveys (Table 17, Figures 10, 14, 15). The shrimp survey samples the western Gulf of Maine during summer and caught more monkfish than the spring or fall surveys prior to 2009 (when the FSV Bigelow survey series began) (Table 16, Figure 10). Patterns of abundance and biomass have been relatively consistent among the NEFSC spring and fall, ME-NH, and shrimp surveys (Figure 10). The Massachusetts surveys catch few monkfish and were not considered to reflect patterns of abundance for the entire management area (NEFSC 2007a); therefore have not been used in recent assessments.

Southern Area

Inconsistent geographic coverage should be considered in the interpretation of southern survey indices. For example the fall survey did not sample south of Hudson Canyon until 1967. The winter survey (Tables 22-23) sampled Georges Bank inconsistently and did not sample deep strata before 1998. The NEFSC scallop survey has been limited to the southern flank of Georges Bank since 2014, and sampling intensity over the entire mid-Atlantic Bight declined starting in 2011 (Appendix Figure 3). In addition, the timing of the scallop dredge survey shifted in 2009 from mid-summer to late spring. VIMS is now conducting the scallop dredge survey in the areas south of Georges Bank (see Appendix Figure 4). NEAMAP inshore surveys in the Mid-Atlantic (http://www.vims.edu/research/departments/fisheries/programs/multispecies_fisheries_research/abundance_indices/NEAMAP/index.php) catch relatively few monkfish, so are not included here.

Biomass and abundance indices from NEFSC spring and fall research surveys were high during the mid-1960s, fluctuated around an intermediate level during the 1970s-mid 1980s, and have been relatively low since the late 1980s (Tables 18-21, Figures 20, 22). A sharp increase in abudance was observed in the 2015 scallop and fall surveys (Tables 18, 19, 25) reflecting an apparent recruitment event. In the Bigelow time series (2009-2015, Figure 21), biomass and abundance indices in the south have declined or remained steady with the exception of the abundance index in the fall of 2015, which was more than 3 times greater than the previous high in the 7-year time Bigelow series.

Length distributions from the southern area show truncation over time but somewhat less dramatically than in the north (Figure 23). As in the northern area, fish greater than 60 cm have been rare since the 1980s, especially when compared to the 1960s. Recruitment indices (presumed YOY) (Figure 28) indicate two exceptional recruitment events in the south, occurring in 1972 and 2015. Distribution plots suggest that the 2015 recruits were broadly distributed north of about 38o (off northern Mayland) in the fall (Figure 29). This strong yearclass may help elucidate growth rates of young monkfish through progression of length modes in successive seasonal surveys (Figure 30).

Working Group Comments – TOR 2

Delta distribution means have been used in previous monkfish assessments as the statistic of central tendency. However, some unusual patterns in the 2015 surveys (tows with many small fish that weigh very little in aggregate) resulted in large variance estimates that translated to inflated delta means.

The WG explored the use of arithmetic means for monkfish (which is also the usual practice in most current NEFSC assessments). The delta and arithmetic means are very similar for nearly all of the time series.

The WG noted that for the Bigelow surveys in 2009 and later, the proportion of zero monkfish catch tows is relatively low (~10-20%), and so the delta means may not be appropriate. The WG recommended use of the arithmetic means for the entire time series (Albatross and Bigelow survey vessels), and as the basis for the calculations in TOR 5.

TOR 3. Provide data that address potential biological changes such as shifts in distribution or condition of individual fish.

Distribution shifts are a potential response to climatic changes on the northeast continental shelf, and have been seen in a number of species (e.g. Kleisner et al. 2016). Evaluation of physical data associated with monkfish catches in NEFSC fall surveys does not indicate systematic shifts in relative depth distribution or distribution with respect to bottom temperature (Figure 31, Appendix Figures 5-6). Similarly, distribution animations do not suggest a change over time in monkfish geographic range (http://www.nefsc.noaa.gov/ecosys/spatial-analyses/demersal/monkfish.html).

Time series of condition factors of individual monkfish appear to fluctuate without trend (Figure 32).

Working Group Comments – TOR 3
The WG noted that there is no evidence of large scale distributional shifts in monkfish abundance in the NEFSC surveys in response to temperature. There is no evidence of any change in condition factor of the monkfish sampled in NEFSC surveys.

TOR 4. Compare annual catches to ACLs to evaluate performance of the fishery.
In both management areas, fishing year landings have remained below the annual TAC/TAL since 2009 (Table 2). Landings averaged 60% of the TAL in the north and 59% in the south during 2013-2014. In 2015, 70% of the TAL was landed in the north, and 53% in the south.

Working Group Comments – TOR 4
The WG noted that the fishery has only attained 50-70% of annual TALs in recent years. In the North, this is likely due to the impacts of groundfish management restrictions. In the South, market demand, price, sturgeon bycatch in gillnets, and monkfish-specific regulations have impacted the magnitude of the landings.

TOR 5. Carry out analyses that will support the NEFMC SSC in making its ABC recommendation.

Exploitable biomass indices are shown in Figure 33. Relative exploitation indices calculated from landings or catch and survey indices are shown in Tables 26-28 and Figures 34-35.

A model-free method used to derive Georges Bank cod catch limits in 2015 (NEFSC 2015) was applied to monkfish in the northern and southern management areas. The method calculated the rate and direction of change in survey indices for the past 3 years using the slope of a log-linear regression during the three years. The proportional change in the indices (re-

transformed slope) was applied to average cod catch in the three previous years to derive new cod catch limits.

The monkfish analysis used NEFSC fall survey exploitable biomass indices (43+ cm in both areas). The time series of exploitable biomass in each area (1980-2015) was Loess-smoothed (smoothing parameter=0.25) before being entered into a log-linear regression to estimate the proportional change during 2013-2015. The estimated proportional change for monkfish was 1.06 in the north (6% increase) and 0.80 in the south (20% decrease) (Table 29 and Figure 36).

The Working Group requested that the analysis also be carried out using the average of NEFSC fall and spring surveys rather than just the fall survey. The estimated proportional change using the combined surveys was 1.02 in the north (2% increase) and 0.87 in the south (13% decrease) (Table 29 and Figure 37). The WG noted that the spring survey may be affected more strongly than the fall survey by availability of monkfish to the gear due to timing of seasonal migrations.

Working Group Comments – TOR 5
The WG noted that relative exploitation indices based on landings, catch, and survey indices have recently decreased slightly in the North, but have been increasing in the South.

The lead analyst initially prepared calculations (derived from the 2016 Georges Bank cod catch advice procedure) to inform future catch advice for the monkfish areas based on the NEFSC fall survey, feeling that series provided the best index of monkfish biomass. Those calculations indicated the recent slope of the biomass trend in the North was 1.06 (6% increase) and in the South was 0.80 (20% decrease).

The WG discussed all available surveys for possible use in the catch advice calculations. The WG recommended:

-omission of the NEFSC winter survey for the South because it ended in 2007
-omission of the ME-NH survey for the North because of limited spatial coverage
-omission of the ASMFC shrimp survey for the North because of limited spatial coverage
-omission of the scallop surveys in the South because of the limited size range of monkfish captured and the lack of biomass indices from that survey

The WG recommended examination of survey trends in averaged NEFSC spring and fall exploitable biomass indices (43 cm and larger fish) in the catch advice calculations.
The revised calculations based on averaged spring and fall surveys indicated the recent slope of the biomass trend in the North was 1.02 (2% increase) and in the South was 0.87 (13% decrease).

The WG recommended use of the averaged NEFSC spring and fall exploitable biomass indices as the basis for advice for possible near-term adjustments to monkfish catch targets.

The WG notes that surveys indicate that recruitment in 2015 was strong in both management areas, which may lead both to increased discards in 2016 and an opportunity for increased landings as those fish recruit above the minimum size in 2017.

Given the current uncertainty about the potential size and longer term impact of the 2015 recruitment, it may be advisable to repeat the TOR 5 catch projection exercise for the 2018 and later ABCs.

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Tables

Table 1. Timeline of fishery management actions for monkfish.
(http://www.greateratlantic.fisheries.noaa.gov/sustainable/species/monkfish/)

Year	Action
1999	Monkfish FMP was implemented which included a limited access permit program, a DAS management system, trip limits, and minimum size limits.
1999	Amendment 1 (FR Notice) approved to ensure compliance with essential fish habitat requirements of the Magnuson-Stevens Act.
2002	Framework Adjustment 1 (FR Notice) was disapproved by NMFS. NMFS instead published an emergency rule that implemented measures based upon the best available science to temporarily suspend the restrictive Year 4 default management measures that would have become effective May 1, 2002.
2003	Framework Adjustment 2 (FR Notice) modified the overfishing definition and implemented annual adjustments to the management measures.
2003	Final rule implemented a series of seasonal closures that prohibited the use of large mesh gillnets in Federal waters off the coast of Virginia and North Carolina to reduce the impact of the monkfish fishery on endangered and threatened species of sea turtles.
2005	Amendment 2 (FR Notice) addressed essential fish habitat, bycatch concerns, and issues raised by public comments.
2006	Framework Adjustment 3 (FR Notice) implemented to prohibit targeting monkfish on Multispecies B-regular DAS.
2007	Interim management measures Framework 4 (FR Notice) adopted in May to address overfishing while NMFS conducted a stock assessment. Framework 4 was implemented in October to establish 3-year target total allowable catches (TACs), a target TAC backstop provision, and adjustments to DAS allocations and trip limits.
2007	Amendment 3 (FR Notice) was implemented as an Omnibus Amendment to standardize bycatch reporting methodology for monkfish and other fisheries.
2008	NMFS implemented Framework 5 (FR Notice) to ensure the Monkfish FMP succeeds in keeping landings within the target total allowable catch levels. Measures include reduction in carryover DAS, reduction in bycatch or incidental catch limits, and revision in the biological reference points used to determine if the stock is overfished.
2008	Framework 6 (FR Notice) eliminated the backstop provision adopted in Framework Adjustment 4 to the FMP, October 2007.
2011	Amendment 5 (FR Notice) implemented a suite of measures including annual catch limits and accountability measures, measures to promote efficiency and reduce waste, and bring the biological reference points into compliance.
2011	Framework Adjustment 7 (FR Notice) implemented measures that were disapproved in Amendment 5 due to newly available science. Specifically, DAS allocations, trip limits, and an annual catch target for the Northern Area.
2012	Amendment 6 is still being developed in considering a catch shares management system for the fishery. Information on Amendment 6 is located here.
2013	NMFS implements an emergency action (FR Notice) to suspend the monkfish possession limits in the Northern Fishery Management Area for monkfish permit categories C and D under a monkfish DAS.
2014	Framework Adjustment 8 (FR Notice) implemented measures to incorporate results of latest stock assessment, increase monkfish day-at-sea allocations and landing limits to better achieve optimum yield, and increase operational flexibility by allowing all limited access monkfish vessels to use an allocated monkfish-only day-at-sea at any time throughout the fishing year and Category H vessels to fish throughout the Southern Fishery Management Area.
2016	Framework 9 submitted. Would modify rules for at-sea DAS declarations and possession limits to reduce discarding and provide flexibility to vessels fishing in both the monkfish and NE multispecies fisheries.

Table 2. Management measures for monkfish, fishing years 2000-2015 (note that regulations pertain to fishing years (May 1- April 30), and do not correspond to calendar year landings in Table 3.

Northern Fishery Management Area

		Trip Limits*	Trip Limits*			
Fishing Year	Target TAC/TAL	Cat. A & C	Cat. B & D	DAS Restrict	FY Landings (mt)	Percent of TAC
2000	5,673	n/a	n/a	40	11,859	209%
2001	5,673	n/a	n/a	40	14,853	262%
2002	11,674	n/a	n/a	40	14,491	124%
2003	17,708	n/a	n/a	40	14,155	80%
2004	16,968	n/a	n/a	40	11,750	69%
2005	13,160	n/a	n/a	40	9,533	72%
2006	7,737	n/a	n/a	40	6,677	86%
2007	5,000	1,250	470	31	5,050	101%
2008	5,000	1,250	470	31	3,528	71%
2009	5,000	1,250	470	31	3,344	67%
2010	5,000	1,250	470	31	2,834	57%
2011	5,854	1,250	600	40	3,699	63%
2012	5,854	1,250	600	40	3,920	67%
2013	5,854	1,250	600	40	3,596	61%
2014	5,854	1,250	600	45	3,403	58%
2015	5,854	1,250	600	45	4,105	70%

* Trip limits in pounds tail weight per DAS

** Excluding up to 10 DAS carryover, became 4 DAS carryover in FY2007

In 2011, the target TAC became a target TAL

Southern Fishery Management Area

		Trip Limits*	Trip Limits*			
Fishing Year	Target TAC/TAL	Cat. A,C,G	Cat. B, D, H	DAS Restrict	FY Landings (mt)	Percent of TAC
2000	6,024	1,500	1,000	40	7,960	132%
2001	6,024	1,500	1,000	40	11,069	184%
2002	7,921	550	450	40	7,478	94%
2003	10,211	1,250	1,000	40	12,198	119%
2004	6,772	550	450	28	6,223	92%
2005	9,673	700	600	39.3	9,656	100%
2006	3,667	550	450	12	5,909	161%
2007	5,100	550	450	23	7,180	141%
2008	5,100	550	450	23	6,751	132%
2009	5,100	550	450	23	4,800	94%
2010	5,100	550	450	23	4,484	88%
2011	8,925	550	450	28	5,801	65%
2012	8,925	550	450	28	5,184	58%
2013	8,925	550	450	28	5,088	57%
2014	8,925	610	500	32	5,415	61%
2015	8,925	610	500	32	4,703	53%

* Trip limits in pounds tail weight per DAS

** Excluding up to 10 DAS carryover, became 4 DAS carryover in FY2007

In 2011, the target TAC became a target TAL

Table 3. Landings (calculated live weight, mt) of monkfish as reported in NEFSC weighout data base (1964-1993) and vessel trip reports (1994-2014) (North = SA 511-523, 561; South = SA 524-639 excluding 551-561 plus landings from North Carolina for years 1977-1995); General canvass database (1964-1989, North = ME, NH, northern weigh out proportion of MA; South = Southern weigh out proportion of MA, RI-VA); Foreign landings from NAFO database areas 5 and 6. Shaded cells denote suggested source for landings which are used in the total column at the far right (see text for details).

	Weigh Out Plus NC			General Canvas				
Year	US North	US South	US Total	US North	US South	US Total	Foreign	Total
1964	45	19	64	45	61	106	0	106
1965	37	17	54	37	79	115	0	115
1966	299	13	312	299	69	368	2,397	2765
1967	539	8	547	540	59	598	11	609
1968	451	2	453	449	36	485	2,231	2716
1969	258	4	262	240	43	283	2,249	2532
1970	199	12	211	199	53	251	477	728
1971	213	10	223	213	53	266	3,659	3925
1972	437	24	461	437	65	502	4,102	4604
1973	710	139	848	708	240	948	6,818	7766
1974	1,197	101	1,297	1,200	183	1,383	727	2110
1975	1,853	282	2,134	1,877	417	2,294	2,548	4842
1976	2,236	428	2,663	2,256	608	2,865	341	3206
1977	3,137	830	3,967	3,167	1,314	4,481	275	4756
1978	3,889	1,384	5,273	3,976	2,073	6,049	38	6087
1979	4,014	3,534	7,548	4,068	4,697	8,765	70	8835
1980	3,695	4,232	7,927	3,623	6,035	9,658	132	9790
1981	3,217	2,380	5,597	3,171	4,142	7,313	381	7694
1982	3,860	3,722	7,582	3,757	4,492	8,249	310	7,892
1983	3,849	4,115	7,964	3,918	4,707	8,624	80	8,044
1984	4,202	3,699	7,901	4,220	4,171	8,391	395	8,296
1985	4,616	4,262	8,878	4,452	4,806	9,258	1,333	10,211
1986	4,327	4,037	8,364	4,322	4,264	8,586	341	8,705
1987	4,960	3,762	8,722	4,995	3,933	8,926	748	9,470
1988	5,066	4,595	9,661	5,033	4,775	9,809	909	10,570
1989	6,391	8,353	14,744	6,263	8,678	14,910	1,178	15,922
1990	5,802	7,204	13,006				1,557	14,563
1991	5,693	9,865	15,558				1,020	16,578
1992	6,923	13,942	20,865				473	21,338
1993	10,645	15,098	25,743				354	26,097
1994	10,950	12,126	23,076				543	23,619
1995	11,970	14,361	26,331				418	26,749
1996	10,791	15,715	26,507				184	26,691
1997	9,709	18,462	28,172				189	28,361
1998	7,281	19,337	26,618				190	26,808
1999	9,128	16,085	25,213				151	25,364
2000	10,729	10,147	20,876				176	21,052
2001	13,341	9,959	23,301				142	23,443
2002	14,011	8,884	22,896				294	23,190
2003	14,991	11,095	26,086				309	26,395
2004	13,209	7,978	21,186				166	21,352
2005	10,140	9,177	19,317				206	19,523
2006	6,974	7,980	14,955				279	15,234
2007	4,953	7,388	12,341					12,341
2008	3,942	7,250	11,192					11,192
2009	3,210	5,532	8,742					8,742
2010	2,424	4,996	7,420					7,420
2011	3,227	5,371	8,599					8,599
2012	4,033	5,724	9,757					9,757
2013	3,332	5,253	8,586					8,586
2014	3,402	5,135	8,537					8,537
2015	4,027	4,609	8,636					8,636

Table 4. US landings of monkfish (calculated live weight, mt) by gear type.

	North					South					Regions Combined				
Year	Trawl	Gill Net	Scallop Dredge	Other	Total	Trawl	Gill Net	Scallop Dredge	Other	Total	Trawl	Gill Net	Scallop Dredge	Other	Total
1964	45	0			45	19				19	64	0			64
1965	36	0			37	17				17	53	0			53
1966	299	0		0	299	13			0	13	311	0		0	312
1967	532		8		539	8				8	540		8		547
1968	447		4		451	2				2	449		4		453
1969	253	1	4		258	4				4	257	1	4		262
1970	198	0		0	199	12				12	210	0		0	211
1971	213		0		213	10				10	223		0		223
1972	426	8	1	2	437	24				24	451	8	1	2	461
1973	661	29	12	8	710	132		5	1	137	794	29	17	9	848
1974	1,060	105	7	25	1,197	98			0	98	1,160	105	7	25	1,297
1975	1,712	123	10	9	1,853	265	0	2	2	269	1,990	123	12	10	2,135
1976	2,031	143	47	15	2,236	333		7	0	340	2,459	143	54	15	2,670
1977	2,737	230	142	28	3,137	508		57	26	591	3,487	230	202	53	3,973
1978	3,255	368	212	54	3,889	605	0	507	26	1,138	4,016	368	774	80	5,238
1979	2,967	393	584	71	4,014	944	6	1,015	16	1,981	3,989	399	2,070	87	6,545
1980	2,526	518	596	56	3,696	1,139	10	1,274	7	2,429	3,723	528	2,276	62	6,589
1981	2,266	461	443	47	3,217	1,100	16	782	105	2,003	3,483	477	1,399	152	5,512
1982	3,040	421	367	32	3,860	1,806	12	1,507	27	3,352	4,998	433	2,061	60	7,551
1983	3,233	314	266	37	3,849	1,819	11	2,119	17	3,966	5,166	325	2,431	56	7,977
1984	3,648	315	196	43	4,202	1,714	15	1,704	18	3,452	5,513	330	1,968	61	7,871
1985	3,982	315	264	55	4,616	1,739	17	2,347	3	4,106	5,757	332	2,611	58	8,758
1986	3,412	326	553	36	4,327	1,841	32	2,068	12	3,954	5,318	358	2,621	48	8,345
1987	3,853	374	695	38	4,960	1,680	26	1,997	3	3,707	5,561	400	2,692	41	8,694
1988	3,554	304	1,172	36	5,066	1,828	58	2,594	3	4,483	5,399	363	3,765	39	9,567
1989	3,429	349	2,584	30	6,391	3,240	17	5,036	3	8,297	6,679	366	7,620	33	14,698
1990	3,298	338	2,141	25	5,802	2,361	32	4,744	5	7,142	5,697	372	6,885	30	12,984
1991	3,299	338	2,033	24	5,694	5,515	363	3,907	16	9,800	8,847	700	5,941	39	15,528
1992	4,330	359	2,211	24	6,923	6,528	977	6,409	11	13,925	10,860	1,336	8,619	35	20,850
1993	5,890	695	4,034	26	10,645	5,987	1,722	7,158	192	15,059	11,879	2,417	11,192	218	25,707
1994	7,574	1,571	1,808	86	11,039	5,233	2,342	3,995	556	12,126	12,707	3,884	5,759	638	22,988
1995	9,119	1,531	1,266	54	11,970	5,785	3,800	4,030	746	14,361	14,905	5,331	5,296	800	26,331
1996	8,445	1,389	913	45	10,791	7,141	4,211	4,330	33	15,715	15,586	5,599	5,243	78	26,507
1997	7,363	988	1,318	40	9,709	8,161	5,203	4,890	208	18,462	15,524	6,192	6,208	249	28,172
1998	5,421	885	948	27	7,281	7,815	6,198	5,190	134	19,337	13,236	7,083	6,138	161	26,618
1999	7,037	1,470	598	24	9,128	6,364	6,187	3,481	54	16,085	13,401	7,656	4,079	78	25,213
2000	8,234	2,102	316	76	10,729	4,018	4,005	1,975	150	10,147	12,252	6,107	2,291	226	20,876
2001	9,990	2,959	381	11	13,341	3,091	5,119	1,719	30	9,959	13,081	8,078	2,100	41	23,301
2002	10,839	2,978	181	13	14,011	1,584	5,410	1,847	43	8,884	12,423	8,389	2,028	56	22,896
2003	12,028	2,488	222	254	14,991	2,034	7,262	1,717	83	11,095	14,062	9,750	1,939	336	26,086
2004	9,918	2,866	14	411	13,209	1,228	4,605	671	1,474	7,978	11,145	7,471	685	1,885	21,186
2005	6,876	2,567	99	598	10,140	1,706	4,673	1,581	1,216	9,177	8,582	7,241	1,680	1,814	19,317
2006	5,054	1,573	185	162	6,974	1,457	3,970	1,532	1,022	7,980	6,511	5,542	1,717	1,184	14,955
2007	3,482	1,172	243	56	4,953	1,084	3,782	1,594	928	7,388	4,566	4,954	1,837	984	12,341
2008	3,055	802	52	34	3,942	1,041	4,098	1,370	741	7,250	4,095	4,900	1,422	775	11,192
2009	2,491	651	21	47	3,210	721	3,117	826	868	5,532	3,212	3,768	847	915	8,742
2010	1,947	460	12	6	2,424	590	2,738	579	1,089	4,996	2,537	3,198	590	1,094	7,420
2011	2,696	482	45	5	3,227	1,178	3,480	565	149	5,371	3,874	3,962	609	153	8,599
2012	3,551	347	134	1	4,033	1,144	3,688	739	153	5,724	4,695	4,035	873	154	9,757
2013	2,799	421	112	0	3,332	1,112	3,366	599	176	5,253	3,911	3,787	711	176	8,586
2014	2,950	418	33	0	3,402	1,028	3,142	879	86	5,135	3,978	3,560	912	87	8,537
2015	3,256	635	100	36	4,027	681	3,308	537	84	4,610	3,937	3,942	638	120	8,637

Table 5. Landed weight (mt) of monkfish by market category for 1964-2015 for the northern management area.

Year	Belly Flaps	Cheeks	Livers	Head on, Gutted	Round	Dressed	Heads	Tails Unc.	Tails Large	Tails Small	Tails Peewee	All Tails
1964	0	0	0	0	0	0	0	14	0	0	0	14
1965	0	0	0	0	0	0	0	11	0	0	0	11
1966	0	0	0	0	0	0	0	90	0	0	0	90
1967	0	0	0	0	0	0	0	163	0	0	0	163
1968	0	0	0	0	0	0	0	136	0	0	0	136
1969	0	0	0	0	0	0	0	78	0	0	0	78
1970	0	0	0	0	0	0	0	60	0	0	0	60
1971	0	0	0	0	0	0	0	64	0	0	0	64
1972	0	0	0	0	0	0	0	132	0	0	0	132
1973	0	0	0	0	0	0	0	214	0	0	0	214
1974	0	0	0	0	0	0	0	360	0	0	0	360
1975	0	0	0	0	0	0	0	558	0	0	0	558
1976	0	0	0	0	0	0	0	673	0	0	0	673
1977	0	0	0	0	0	0	0	945	0	0	0	945
1978	0	0	0	0	0	0	0	1,171	0	0	0	1,171
1979	0	0	0	0	0	0	0	1,209	0	0	0	1,209
1980	0	0	0	0	0	0	0	1,113	0	0	0	1,113
1981	0	0	0	0	0	0	0	969	0	0	0	969
1982	0	0	10	0	0	0	0	1,146	15	2	0	1,163
1983	0	0	9	0	0	0	0	1,152	5	2	0	1,159
1984	0	0	15	0	0	0	0	1,262	4	0	0	1,266
1985	0	0	11	0	0	0	0	1,386	2	3	0	1,390
1986	0	0	14	0	0	0	0	1,303	0	0	0	1,303
1987	0	0	24	0	0	0	0	1,492	2	1	0	1,494
1988	0	0	47	0	0	0	0	1,517	6	3	0	1,526
1989	0	0	59	0	11	0	0	1,465	327	130	0	1,922
1990	0	0	78	0	30	0	0	1,174	411	154	0	1,738
1991	0	3	70	0	0	0	0	1,014	539	153	9	1,715
1992	0	1	83	0	0	0	0	911	590	505	79	2,085
1993	0	1	208	98	351	0	0	1,034	868	1,062	103	3,067
1994	0	1	208	533	981	0	0	403	1,206	1,075	136	2,820
1995	0	1	46	1,224	1,113	0	0	362	1,180	1,003	304	2,850
1996	0	0	65	1,116	745	0	0	90	930	1,399	224	2,643
1997	0	0	51	634	244	0	0	26	1,126	1,361	119	2,633
1998	0	0	24	551	144	0	0	16	1,055	810	79	1,960
1999	0	0	40	1,701	511	0	0	28	996	848	139	2,012
2000	0	0	94	3,213	912	0	0	17	783	1,050	3	1,853
2001	0	0	93	3,084	231	0	0	128	1,115	1,647	0	2,890
2002	0	0	75	3,789	24	0	0	80	1,055	1,777	0	2,912
2003	0	0	61	2,364	14	0	0	95	1,573	2,032	0	3,699
2004	0	0	56	647	960	0	0	3	1,883	1,580	1	3,467
2005	0	0	42	1,706	22	0	0	3	1,440	1,017	2	2,462
2006	0	0	22	1,622	20	0	0	9	899	627	3	1,538
2007	0	0	13	682	0	0	1	9	870	378	1	1,258
2008	0	0	5	391	0	4	0	1	739	311	0	1,051
2009	0	0	2	290	0	11	0	2	560	299	0	861
2010	0	0	1	208	0	0	0	2	396	261	0	658
2011	0	17	72	187	44	0	8	1	527	367	1	896
2012	0	24	89	142	0	0	3	1	609	556	2	1,168
2013	0	0	76	137	0	0	4	1	549	407	3	960
2014	0	0	71	117	0	0	25	2	560	423	4	988
2015	0	0	73	179	0	0	31	2	594	556	0	1,151

Table 6. Landed weight (mt) of monkfish by market category for 1964-2014 for the southern management area.

Year	Belly Flaps	Cheeks	Livers	Head on, Gutted	Round	Dressed	Heads	Tails Unc.	Tails Large	Tails Small	Tails Peewee	All Tails
1964	0	0	0	0	0	0	0	6	0	0	0	6
1965	0	0	0	0	0	0	0	5	0	0	0	5
1966	0	0	0	0	0	0	0	4	0	0	0	4
1967	0	0	0	0	0	0	0	2	0	0	0	2
1968	0	0	0	0	0	0	0	1	0	0	0	1
1969	0	0	0	0	0	0	0	1	0	0	0	1
1970	0	0	0	0	0	0	0	4	0	0	0	4
1971	0	0	0	0	0	0	0	3	0	0	0	3
1972	0	0	0	0	0	0	0	7	0	0	0	7
1973	0	0	0	0	0	0	0	42	0	0	0	42
1974	0	0	0	0	0	0	0	30	0	0	0	30
1975	0	0	0	0	0	0	0	85	0	0	0	85
1976	0	0	0	0	0	0	0	129	0	0	0	129
1977	0	0	0	0	0	0	0	250	0	0	0	250
1978	0	0	0	0	0	0	0	403	0	0	0	403
1979	0	0	0	0	0	0	0	1,016	0	0	0	1,016
1980	0	0	0	0	0	0	0	1,189	0	0	0	1,189
1981	0	0	0	0	0	0	0	685	0	0	0	685
1982	0	0	0	0	0	0	0	912	138	51	0	1,102
1983	0	0	2	0	0	0	0	858	237	136	0	1,231
1984	0	0	10	0	0	0	0	860	183	45	0	1,087
1985	0	0	17	0	0	0	0	1,081	85	71	0	1,237
1986	0	0	23	0	0	0	0	1,063	76	52	0	1,191
1987	0	0	330	0	0	0	0	972	138	6	0	1,116
1988	0	0	65	0	0	0	0	1,129	190	32	0	1,350
1989	0	0	88	0	5	0	0	2,037	230	230	0	2,498
1990	0	0	102	0	187	0	0	1,428	443	223	0	2,095
1991	0	5	200	0	415	0	0	1,215	1,123	461	28	2,827
1992	0	3	239	0	386	0	0	1,868	1,318	788	104	4,078
1993	0	1	252	0	178	0	0	2,469	1,065	789	159	4,483
1994	0	4	251	921	1,064	0	0	854	1,025	989	122	2,989
1995	2	0	451	1,529	1,539	0	0	518	1,341	1,419	59	3,337
1996	0	0	504	2,352	318	0	0	996	1,160	1,629	46	3,830
1997	0	0	577	2,559	551	0	0	647	1,924	1,913	32	4,516
1998	0	0	582	3,036	438	0	0	842	1,952	1,840	16	4,650
1999	0	0	558	4,047	621	0	0	509	1,393	1,352	14	3,268
2000	0	4	530	3,701	179	0	0	276	797	657	2	1,732
2001	0	0	466	3,944	300	0	0	217	844	494	0	1,555
2002	0	0	433	4,013	551	0	0	167	629	336	0	1,132
2003	0	1	426	4,959	667	0	0	242	790	405	1	1,438
2004	0	2	355	2,758	1,066	8	0	186	671	274	0	1,130
2005	0	55	330	3,695	187	18	0	105	771	550	2	1,428
2006	0	108	293	3,351	27	20	5	69	658	506	1	1,233
2007	0	44	258	3,030	107	12	0	88	727	329	1	1,145
2008	0	5	253	3,008	44	13	1	61	768	300	0	1,130
2009	1	0	199	2,540	4	9	11	47	505	235	0	788
2010	0	0	188	2,117	9	4	27	61	476	235	0	772
2011	0	0	154	2,195	491	6	31	47	422	243	0	713
2012	0	0	110	2,921	0	4	40	44	405	269	1	720
2013	1	0	130	2,247	5	4	106	58	462	286	2	809
2014	0	0	111	2,049	2	14	116	45	540	250	3	837
2015	0	0	99	2,339	2	18	96	43	358	174	0	574

Table 7. Estimated monkfish discards (live weight) in the northern management region. Dredge and shrimp trawl discards are based on SBRM monkfish discards relative to kept of all species; trawl and gillnet are based on monkfish discards relative to monkfish kept.

North		Trawl					Gillnet					Scallop Dredge					Shrimp Trawl				
Year	Half	No. trips	D/K ratio	CV	Dlr monk (mt)	Discard (mt)	No. trips	D/K ratio	CV	Dlr monk (mt)	Discard (mt)	No. trips	D/K ratio	CV	Dlr all spp (mt)	Discard (mt)	No. trips	D/K ratio	CV	Dlr all spp (mt)	Discard (mt)
1989	1	30	0.037	0.58	1,550	58	1	0.036		84	3		0.001		18,213	17	31	0.002	0.33	3,412	5.5
	2	63	0.141	0.44	1,830	257	103	0.027	0.32	265	7		0.008		24,053	185	9	0.001	0.62	931	1.2
1990	1	16	0.082	0.60	1,562	128	73	0.036	0.41	121	4		0.001		9,864	9	27	0.002	0.34	4,494	8.1
	2	36	0.039	0.45	1,690	66	65	0.029	0.37	219	6		0.008		19,293	149	4	0.058	1.01	620	35.8
1991	1	27	0.042	0.45	1,233	52	191	0.030	0.47	120	4		0.001		16,608	16	46	0.004	0.19	3,536	12.8
	2	81	0.167	0.25	1,999	334	758	0.036	0.10	213	8	1	0.002		21,312	40	7	0.046	0.40	340	15.7
1992	1	51	0.122	0.30	1,674	203	403	0.065	0.16	105	7	3	0.000	0.98	14,179	1	76	0.003	0.23	3,285	9.6
	2	35	0.224	0.43	2,624	587	618	0.040	0.24	248	10	6	0.001	0.41	20,033	26	6	0.003	0.28	161	0.4
1993	1	19	0.067	0.30	2,821	189	271	0.086	0.21	119	10	7	0.002	0.26	13,702	25	78	0.001	0.26	1,890	2.5
	2	19	0.084	0.26	3,032	254	338	0.032	0.24	560	18	4	0.018	0.45	12,674	230	4	0.001	0.70	316	0.3
1994	1	18	0.035	0.29	3,273	115	65	0.065	0.29	270	18	2	0.001	1.21	5,486	5	71	0.002	0.38	2,443	5.9
	2	6	0.024	0.59	4,385	107	44	0.055	0.19	779	43	5	0.010	0.38	6,230	59	6	0.001	0.44	906	0.7
1995	1	30	0.164	0.36	4,643	762	38	0.141	0.30	469	66	1	0.014		2,318	32	64	0.000	0.23	4,452	1.8
	2	48	0.090	0.31	4,478	403	69	0.088	0.23	1,023	90	5	0.018	0.50	6,544	119	9	0.001	0.43	1,377	0.7
1996	1	21	0.190	0.23	4,294	814	28	0.137	0.43	340	47	8	0.003	0.94	5,338	14	30	0.000	0.34	7,580	0.8
	2	49	0.132	0.57	4,057	534	34	0.132	0.19	934	123	5	0.022	0.40	11,375	246	5	0.000	0.79	1,418	0.4
1997	1	13	0.100	0.49	3,795	378	19	0.036	0.32	329	12	4	0.004	0.48	10,567	42	17	0.000	0.61	5,416	0.9
	2	7	0.076	0.23	3,225	244	26	0.194	0.84	742	144	4	0.020	0.76	9,148	180		0.001		649	0.4
1998	1	7	0.124	0.37	3,150	392	39	0.028	0.41	238	7	2	0.004	0.32	7,482	28		0.001		3,095	2.7
	2	3	0.093	0.10	2,398	223	72	0.043	0.28	606	26	7	0.014	0.16	6,400	90		0.001		168	0.1
1999	1	3	0.098	0.04	3,947	388	36	0.067	0.65	282	19	2	0.004	0.65	8,347	29		0.001		1,407	1.2
	2	42	0.069	0.21	3,011	207	66	0.036	0.51	1,051	38	6	0.004	0.44	6,797	30		0.001		33	0.0
2000	1	80	0.069	0.32	3,916	271	58	0.041	0.30	501	21		0.004		6,993	31		0.001		2,068	1.8
	2	61	0.088	0.31	3,798	333	65	0.077	0.24	2,033	157	95	0.004	0.13	13,019	56		0.001		35	0.0
2001	1	61	0.102	0.20	5,088	518	41	0.061	0.69	880	53	17	0.003	0.42	14,926	41	3	0.000	0.14	813	0.1
	2	113	0.066	0.10	4,588	303	33	0.108	0.93	2,208	238		0.005		11,525	60		0.001			0.0
2002	1	47	0.076	0.25	5,634	428	33	0.045	0.39	760	34		0.005		8,712	45		0.001		308	0.3
	2	274	0.100	0.10	4,532	455	67	0.053	0.27	2,230	118	10	0.008	0.97	11,533	88		0.001			0.0
2003	1	206	0.101	0.14	6,642	671	112	0.037	0.24	628	23	5	0.001	0.89	16,053	9	15	0.000	1.01	855	0.0
	2	218	0.055	0.12	4,721	261	273	0.058	0.13	1,570	91	8	0.015	0.41	10,361	157		0.001			0.0
2004	1	163	0.042	0.12	5,307	225	212	0.021	0.22	739	16	3	0.000	0.69	5,633	0	12	0.000	0.25	1,069	0.1
	2	377	0.036	0.10	4,039	147	728	0.059	0.09	1,788	105	19	0.096	0.48	3,705	355		0.001		44	0.0
2005	1	500	0.047	0.07	3,971	187	153	0.098	0.26	516	51	20	0.001	0.57	5,745	6	17	0.000	0.52	836	0.1
	2	601	0.057	0.10	3,038	174	660	0.074	0.12	1,450	108	39	0.008	0.21	23,131	184		0.001		40	0.0
2006	1	292	0.055	0.08	2,852	158	93	0.063	0.41	262	17	5	0.001	0.42	20,833	14	17	0.000	0.56	847	0.0
	2	201	0.071	0.11	2,285	162	80	0.080	0.17	1,025	82	39	0.021	0.32	14,291	305	3	0.000	0.10	449	0.2
2007	1	221	0.050	0.10	2,075	104	42	0.061	0.32	228	14	28	0.002	0.22	11,600	26	14	0.001	0.72	1,899	1.0
	2	303	0.072	0.10	1,448	104	190	0.062	0.16	693	43	68	0.021	0.18	23,644	487		0.001		333	0.2
2008	1	277	0.088	0.10	1,821	160	61	0.076	0.28	141	11	25	0.001	0.22	7,065	11	16	0.000	0.77	1,834	0.9
	2	383	0.082	0.10	1,045	86	156	0.051	0.22	541	28	22	0.011	0.34	3,696	42	3	0.001	0.90	167	0.1
2009	1	351	0.166	0.13	1,666	276	129	0.209	0.46	149	31	7	0.001	0.47	1,960	3	7	0.001	0.61	998	0.8
	2	408	0.079	0.11	832	66	195	0.119	0.27	467	55	22	0.003	0.26	11,642	34	5	0.000	0.92	347	0.0
2010	1	339	0.097	0.08	1,537	149	305	0.056	0.15	112	6	16	0.001	0.80	3,350	4	11	0.000	1.00	2,911	0.1
	2	671	0.090	0.07	857	77	1364	0.102	0.07	303	31	25	0.003	0.31	15,930	50	4	0.000	0.91	780	0.0
2011	1	671	0.120	0.07	1,461	175	554	0.050	0.10	120	6	23	0.002	0.80	6,660	16	1	0.000		3,745	0.0
	2	743	0.058	0.08	1,174	69	1244	0.080	0.10	361	29	81	0.004	0.13	35,600	158		0.001		78	0.0
2012	1	739	0.057	0.06	1901	108	548	0.047	0.17	93	4	54	0.003	0.31	21,717	67	19	0.000	0.49	1,761	0.2
	2	664	0.078	0.05	1446	112	900	0.060	0.07	184	11	90	0.010	0.24	28,609	300				132	0.0
2013	1	471	0.125	0.07	1669	208	172	0.044	0.14	98	4	131	0.003	0.22	43,664	118	24	0.001	0.79	195	0.1
	2	440	0.097	0.10	1073	104	567	0.083	0.11	323	27	67	0.010	0.35	12,980	128				81	0.0
2014	1	405	0.143	0.07	1908	272	278	0.090	0.30	82	7	66	0.000	0.33	10,688	4				1	0.0
	2	528	0.100	0.09	927	93	830	0.062	0.11	336	21	61	0.029	0.21	5,406	155				21	0.0
2015	1	298	0.155	0.10	1891	294	87	0.056	0.21	120	7	77	0.002	0.49	12,517	28					0.0
	2	381	0.117	0.11	1223	143	475	0.063	0.12	514	32	50	0.020	0.16	4,916	97					0.0

Table 8. Estimated monkfish discards (live weight) in the southern management region. Dredge discards are based on SBRM monkfish discards relative to kept of all species; trawl and gillnet are based on monkfish discards relative to monkfish kept.

South		Trawl					Gillnet					Scallop Dredge				
Year	Half	No. trips	D/K ratio	CV	Dlr monk (mt)	Discard (mt)	No. trips	D/K ratio	CV	Dlr monk (mt)	Discard (mt)	No. trips	D/K ratio	CV	Dlr all spp (mt)	Discard (mt)
1989	1	46	0.709	0.50	2,195	1,556		0.031		12	0		0.010	0.010	59,696	577
	2	53	0.169	0.59	733	124	3	0.054		5	0		0.015	0.015	35,498	528
1990	1	50	0.064	0.26	1,567	100	1	0.031		14	0		0.010		64,314	622
	2	35	0.118	0.32	759	90	13	0.054		18	0		0.015		53,040	789
1991	1	73	0.258	0.30	1,257	324	3	0.031		209	2		0.010		67,829	656
	2	77	0.020	0.39	3,831	78	8	0.000		154	0	2	0.001	0.07	36,015	19
1992	1	62	0.061	0.38	3,947	239	94	0.011	0.31	786	8	7	0.001	0.69	48,686	29
	2	41	0.028	0.83	2,135	60	72	0.020	0.20	176	3	7	0.012	0.50	39,126	460
1993	1	40	0.092	0.68	2,598	238	78	0.034	0.70	1,306	44	12	0.008	0.30	23,971	197
	2	34	0.028	0.49	1,301	36	87	0.061	0.20	341	21	4	0.032	0.53	18,379	587
1994	1	43	0.095	0.29	2,925	277	124	0.079	0.33	1,565	124	10	0.020	0.26	26,657	538
	2	30	0.323	0.56	2,027	655	173	0.056	0.18	967	55	10	0.015	0.29	24,222	370
1995	1	61	0.175	0.55	2,789	488	260	0.044	0.20	2,758	121	14	0.030	0.17	34,108	1,011
	2	103	0.115	0.57	2,946	340	170	0.050	0.34	1,172	59	9	0.050	0.45	18,456	917
1996	1	56	0.164	0.36	3,187	523	226	0.077	0.27	2,615	202	19	0.020	0.23	27,505	547
	2	85	0.095	0.18	4,021	380	134	0.052	0.28	1,434	75	15	0.029	0.26	19,621	562
1997	1	60	0.025	0.47	4,130	102	238	0.067	0.34	3,089	206	16	0.028	0.18	19,067	543
	2	29	0.089	0.15	4,215	374	106	0.015	0.34	1,313	20	8	0.041	0.39	14,997	612
1998	1	31	0.108	0.33	3,991	431	228	0.070	0.20	3,606	252	8	0.008	0.24	17,094	136
	2	28	0.027	0.52	3,946	108	64	0.062	0.44	2,053	128	15	0.012	0.57	15,300	177
1999	1	39	0.045	0.30	4,370	195	52	0.052	0.34	4,207	220	13	0.010	0.26	30,059	291
	2	34	0.214	0.57	2,306	494	35	0.046	0.57	1,917	88	56	0.004	0.16	34,102	150
2000	1	67	0.786	0.32	2,255	1,773	60	0.063	0.30	2,683	170	38	0.014	0.16	47,847	666
	2	47	0.107	0.62	1,709	182	44	0.051	0.81	1,157	59	133	0.009	0.16	43,879	382
2001	1	61	0.946	0.47	1,703	1,611	57	0.030	0.42	2,248	67	42	0.015	0.11	64,029	972
	2	96	0.404	0.73	1,348	545	35	0.033	0.38	2,788	92	48	0.014	0.15	70,044	973
2002	1	50	0.338	0.38	1,123	379	34	0.017	0.80	3,590	61	34	0.019	0.09	83,888	1,571
	2	94	0.327	0.39	566	185	40	0.063	0.44	1,967	124	61	0.018	0.10	81,620	1,475
2003	1	120	0.331	0.36	1,172	388	50	0.016	0.35	4,452	69	46	0.014	0.15	82,660	1,192
	2	99	0.406	0.45	1,177	478	56	0.070	0.31	2,849	199	71	0.017	0.12	91,638	1,542
2004	1	237	0.240	0.44	1,012	243	78	0.073	0.22	3,441	252	82	0.014	0.08	107,728	1,543
	2	436	0.300	0.31	733	220	74	0.089	0.22	1,043	93	193	0.015	0.10	95,117	1,432
2005	1	534	0.175	0.14	945	165	100	0.104	0.22	3,217	334	108	0.014	0.18	99,628	1,419
	2	654	0.064	0.11	1,588	102	82	0.081	0.20	1,372	111	174	0.019	0.19	67,548	1,290
2006	1	327	0.180	0.19	1,008	181	43	0.054	0.19	2,865	155	43	0.009	0.31	87,842	767
	2	277	0.055	0.15	1,010	56	35	0.082	0.32	967	79	166	0.022	0.14	99,456	2,210
2007	1	335	0.125	0.25	741	93	59	0.220	0.37	2,139	471	138	0.010	0.14	103,992	1,083
	2	420	0.159	0.40	657	104	45	0.054	0.33	1,569	84	156	0.013	0.15	68,914	920
2008	1	343	0.098	0.19	744	73	54	0.108	0.25	2,882	311	374	0.006	0.11	106,134	686
	2	316	0.017	0.31	594	10	39	0.104	0.29	993	104	245	0.010	0.13	74,506	717
2009	1	414	0.080	0.30	646	52	62	0.052	0.19	2,438	128	370	0.006	0.08	122,576	725
	2	529	0.088	0.31	280	25	32	0.074	0.24	610	45	103	0.009	0.15	73,175	652
2010	1	569	0.248	0.24	474	118	114	0.060	0.21	2,034	122	132	0.010	0.11	108,617	1,098
	2	545	0.190	0.51	369	70	95	0.077	0.18	695	54	174	0.008	0.12	81,139	648
2011	1	573	0.123	0.13	634	78	178	0.078	0.12	2,357	185	156	0.010	0.13	107,870	1,132
	2	601	0.088	0.11	598	53	84	0.122	0.19	1,066	130	150	0.010	0.12	62,873	623
2012	1	476	0.147	0.13	812	119	203	0.051	0.13	3,015	153	205	0.016	0.08	98,241	1,545
	2	337	0.180	0.18	366	66	32	0.058	0.18	576	33	130	0.017	0.15	46,675	797
2013	1	594	0.117	0.24	720	84	60	0.058	0.15	2,142	124	154	0.017	0.17	49,832	864
	2	500	0.053	0.28	447	24	34	0.101	0.37	1,168	118	177	0.016	0.13	45,168	709
2014	1	633	0.171	0.22	616	105	126	0.056	0.16	2,249	127	174	0.014	0.09	62,720	892
	2	700	0.107	0.15	518	56	131	0.030	0.28	861	26	188	0.012	0.14	44,960	518
2015	1	563	0.179	0.15	487	87	225	0.022	0.16	2,403	52	227	0.008	0.12	56,569	464
	2	527	0.521	0.12	326	170	273	0.027	0.20	823	22	202	0.008	0.14	58,571	443

Table 9. Estimated annual catch (landings plus discards) of monkfish by management region and combined.

	North			South			Areas Combined				
Year	Landings	Discard	Total (mt)	Landings	Discard	Total (mt)	Landings	Discard	Total (mt)	Foreign	Total (mt)
1980	3,623	635	4,258	6,035	563	6,598	9,658	1,197	10,855	132	10,987
1981	3,171	754	3,925	4,142	451	4,593	7,313	1,204	8,517	381	8,898
1982	3,860	699	4,559	3,722	586	4,308	7,582	1,285	8,867	310	9,177
1983	3,849	664	4,513	4,115	659	4,774	7,964	1,323	9,287	80	9,367
1984	4,202	616	4,818	3,699	684	4,383	7,901	1,301	9,202	395	9,597
1985	4,616	640	5,256	4,262	636	4,898	8,878	1,276	10,154	1,333	11,487
1986	4,327	548	4,875	4,037	618	4,655	8,364	1,166	9,530	341	9,871
1987	4,960	766	5,726	3,762	1,039	4,801	8,722	1,805	10,527	748	11,275
1988	5,066	784	5,850	4,595	1,030	5,625	9,661	1,814	11,475	909	12,384
1989	6,391	534	6,925	8,353	2,786	11,139	14,744	3,320	18,064	1,178	19,242
1990	5,802	406	6,208	7,204	1,602	8,806	13,006	2,008	15,014	1,557	16,571
1991	5,693	481	6,174	9,865	1,080	10,945	15,558	1,561	17,119	1,020	18,139
1992	6,923	844	7,767	13,942	801	14,743	20,865	1,644	22,509	473	22,982
1993	10,645	730	11,375	15,098	1,123	16,221	25,743	1,853	27,596	354	27,950
1994	10,950	353	11,303	12,126	2,019	14,145	23,076	2,372	25,448	543	25,991
1995	11,970	1,475	13,445	14,361	2,935	17,297	26,331	4,410	30,741	418	31,159
1996	10,791	1,780	12,572	15,715	2,289	18,004	26,507	4,069	30,576	184	30,760
1997	9,709	1,002	10,712	18,462	1,856	20,318	28,172	2,858	31,030	189	31,219
1998	7,281	769	8,050	19,337	1,231	20,568	26,618	2,000	28,618	190	28,808
1999	9,128	713	9,841	16,085	1,438	17,523	25,213	2,151	27,364	151	27,515
2000	10,729	871	11,599	10,147	3,232	13,379	20,876	4,103	24,979	176	25,155
2001	13,341	1,213	14,554	9,959	4,260	14,219	23,301	5,473	28,773	142	28,915
2002	14,011	1,169	15,180	8,884	3,796	12,680	22,896	4,964	27,860	294	28,154
2003	14,991	1,212	16,203	11,095	3,869	14,964	26,086	5,080	31,167	309	31,476
2004	13,209	847	14,056	7,978	3,782	11,760	21,186	4,629	25,816	166	25,982
2005	10,140	711	10,851	9,177	3,421	12,597	19,317	4,132	23,449	206	23,655
2006	6,974	738	7,712	7,980	3,448	11,428	14,955	4,186	19,140	279	19,419
2007	4,953	778	5,732	7,388	2,755	10,143	12,341	3,533	15,875	8	15,883
2008	3,942	338	4,280	7,250	1,901	9,151	11,192	2,240	13,432	2	13,434
2009	3,210	465	3,675	5,532	1,626	7,158	8,742	2,092	10,833		10,833
2010	2,424	317	2,741	4,996	2,109	7,105	7,420	2,426	9,846		9,846
2011	2,362	452	2,814	6,344	2,200	8,545	8,707	2,652	11,359		11,359
2012	4,033	602	4,635	5,724	2,714	8,438	9,757	3,316	13,073		13,073
2013	3,332	589	3,922	5,253	1,922	7,176	8,586	2,512	11,097		11,097
2014	3,402	552	3,954	5,135	1,724	6,859	8,537	2,276	10,813		10,813
2015	4,027	601	4,628	4,609	1,239	5,848	8,636	1,840	10,476		10,476

Table 10. Temporal stratification used in expanding landings and discards to length composition of the monkfish catch. Unless otherwise indicated, sampling was expanded within gear type and area.

	Trawl		Gillnet		Dredge	
North	**Kept**	**Discarded**	**Kept**	**Discarded**	**Kept**	**Discarded**
1994	annual	annual	1994-1999	1994-1999	1994-1999	1994-1999
1995	annual	annual	1994-1999	1994-1999	1994-1999	1994-1999
1996	annual	annual	1994-1999	1994-1999	1994-1999	1994-1999
1997	annual	annual	1994-1999	1994-1999	1994-1999	1994-1999
1998	annual	annual	1994-1999	1994-1999	1994-1999	1994-1999
1999	annual	annual	1994-1999	1994-1999	1994-1999	1994-1999
2000	annual	annual	annual	2000-2002 N+S	annual N+S	annual N+S
2001	annual	annual	annual	2000-2002 N+S	annual N+S	annual N+S
2002	annual	annual	annual	2000-2002 N+S	annual N+S	annual N+S
2003	half-year	half-year	annual	annual N+S	annual N+S	annual N+S
2004	half-year	half-year	annual	annual N+S	annual N+S	annual N+S
2005	half-year	half-year	annual	annual N+S	annual N+S	annual N+S
2006	half-year	half-year	annual	2006-2008 N+S	annual N+S	annual N+S
2007	half-year	half-year	annual	2006-2008 N+S	annual N+S	annual N+S
2008	half-year	half-year	annual	2006-2008 N+S	annual N+S	annual N+S
2009	half-year	half-year	annual	2009-2011 N+S	annual N+S	annual N+S
2010	half-year	half-year	annual	2009-2011 N+S	annual N+S	annual N+S
2011	half-year	half-year	annual	2009-2011 N+S	annual N+S	annual N+S
2012	half-year	half-year	annual	2012-2014 N+S	annual N+S	annual N+S
2013	half-year	half-year	annual	2012-2014 N+S	annual N+S	annual N+S
2014	half-year	half-year	annual	2012-2014 N+S	annual N+S	annual N+S
2015	annual	half-year	annual	2015 N+S	annual N+S	annual N+S

	Trawl		Gillnet		Dredge	
South	**Kept**	**Discarded**	**Kept**	**Discarded**	**Kept**	**Discarded**
1994	annual		annual	annual	annual	annual
1995	annual		annual	annual	annual	annual
1996	annual		annual	annual	annual	annual
1997	annual		annual	annual	annual	annual
1998	annual		annual	annual	annual	annual
1999	annual		annual	annual	annual	annual
2000	annual N+S	annual N+S	annual	2000-2002 N+S	annual	annual
2001	annual N+S	annual N+S	annual	2000-2002 N+S	2000-2002	2000-2002
2002	annual N+S	annual N+S	annual	2000-2002 N+S	2000-2002	2000-2002
2003	annual	half-year	annual	annual N+S	annual	annual
2004	annual	half-year	annual	annual N+S	annual	annual
2005	annual	half-year	annual	annual N+S	annual	annual
2006	annual	half-year	annual	2006-2008 N+S	annual	annual
2007	annual	half-year	annual	2006-2008 N+S	annual	annual
2008	annual	half-year	annual	2006-2008 N+S	annual	annual
2009	annual	half-year	annual	2009-2011 N+S	annual	annual
2010	annual	half-year	annual	2009-2011 N+S	annual	annual
2011	annual	half-year	annual	2009-2011 N+S	annual	annual
2012	annual	half-year	annual	2012-2014 N+S	annual	annual
2013	annual	half-year	annual	2012-2014 N+S	annual	annual
2014	annual	half-year	annual	2012-2014 N+S	annual	annual
2015	annual	half-year	annual	2015 N+S	annual	annual

Table 11. Survey results from NEFSC offshore fall bottom trawl surveys in the northern management region (strata 20-30, 34-40). Indices are delta distribution stratified means.

	Biomass Index				Abundance Index				Mean	Length						of	Number	Non-zero	Proportion
	Mean	CV	L95%	U95%	Mean	CV	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max	Fish	of Tows	Tows	Non-zero
1963	3.82	27.3	2.3	5.3	0.80	18.4	0.5	1.1	4.7	11	14	59	58.3	103	111	86	90	39	0.43
1964	1.89	23.2	1.0	2.8	0.39	22.5	0.2	0.6	4.8	21	21	58	59.4	92	102	32	87	23	0.26
1965	2.54	22.7	1.4	3.7	0.35	17.1	0.2	0.5	7.3	28	36	70	71.6	96	110	40	88	30	0.34
1966	3.38	18.4	2.2	4.6	0.51	16.7	0.3	0.7	6.5	37	48	73	73.1	90	96	55	86	33	0.38
1967	1.23	34.2	0.4	2.0	0.19	26.7	0.1	0.3	6.5	48	48	69	70.3	91	92	18	86	14	0.16
1968	2.05	37.8	0.5	3.6	0.29	30.5	0.1	0.5	7.2	11	26	72	71.4	105	106	32	86	16	0.19
1969	3.76	26.3	1.8	5.7	0.42	17.2	0.3	0.6	8.8	13	41	78	78.8	101	110	39	88	30	0.34
1970	2.28	29.1	1.0	3.6	0.40	22.4	0.2	0.6	5.8	22	36	67	67.2	90	98	41	92	21	0.23
1971	2.93	25.9	1.5	4.4	0.49	18.6	0.3	0.7	5.9	15	22	69	67.0	97	101	44	94	27	0.29
1972	1.42	27.3	0.7	2.2	0.32	19.8	0.2	0.4	4.4	21	21	61	56.9	97	99	29	94	22	0.23
1973	3.18	26.7	1.8	4.6	0.51	19.3	0.3	0.7	6.0	16	16	58	65.2	109	112	63	92	29	0.32
1974	2.06	23.5	1.1	3.0	0.31	20.1	0.2	0.4	6.4	13	13	69	64.9	109	111	37	97	23	0.24
1975	1.73	21.1	1.0	2.4	0.30	20.5	0.2	0.4	5.7	11	11	60	62.9	97	102	40	106	27	0.25
1976	3.39	27.6	1.6	5.2	0.42	21.6	0.2	0.6	7.6	29	30	71	72.1	106	121	32	87	24	0.28
1977	5.57	19.0	3.5	7.6	0.63	13.7	0.5	0.8	7.2	21	35	73	71.1	107	119	112	126	56	0.44
1978	5.11	16.1	3.5	6.7	0.58	13.2	0.4	0.7	6.7	10	24	70	67.6	104	116	146	201	78	0.39
1979	5.12	16.9	3.6	6.7	0.47	12.0	0.4	0.6	8.9	15	19	77	73.5	103	115	125	211	78	0.37
1980	4.46	25.5	2.2	6.7	0.53	16.0	0.4	0.7	6.3	6	16	66	63.9	101	111	65	97	39	0.40
1981	2.00	27.8	0.3	1.5	0.41	15.4	0.1	0.2	4.4	9	13	55	57.5	93	101	46	93	30	0.32
1982	0.94	30.3	0.4	1.5	0.14	25.7	0.1	0.2	6.6	29	29	71	68.9	97	100	17	95	14	0.15
1983	1.62	21.8	0.9	2.3	0.47	20.2	0.3	0.7	3.4	13	17	54	53.0	88	96	38	82	27	0.33
1984	3.01	27.1	1.4	4.6	0.48	13.7	0.4	0.6	5.8	11	26	63	62.7	102	106	36	88	29	0.33
1985	1.44	36.2	0.4	2.5	0.37	24.6	0.2	0.5	4.0	12	15	55	53.1	101	102	32	88	23	0.26
1986	2.35	27.2	1.1	3.6	0.60	18.9	0.4	0.8	3.7	19	23	52	53.8	82	100	46	90	26	0.29
1987	0.87	36.1	0.3	1.5	0.26	28.6	0.1	0.4	3.3	15	15	53	52.2	92	96	22	87	15	0.17
1988	1.52	34.8	0.5	2.6	0.31	29.7	0.1	0.5	4.9	11	11	53	57.1	92	93	26	89	17	0.19
1989	1.40	40.2	0.5	2.3	0.43	19.3	0.3	0.6	2.6	9	9	39	40.8	93	96	39	87	25	0.29
1990	1.06	28.7	0.5	1.6	0.59	18.1	0.4	0.8	1.4	9	10	25	32.3	72	89	55	89	35	0.39
1991	1.25	29.4	0.6	1.9	0.58	17.1	0.4	0.8	1.7	9	10	31	38.3	83	95	62	88	33	0.38
1992	1.12	28.6	0.6	1.7	0.94	18.3	0.6	1.3	1.2	9	9	26	33.0	79	86	78	86	37	0.43
1993	1.13	44.1	0.5	1.8	0.99	15.4	0.7	1.3	0.9	6	9	20	27.1	71	94	103	86	45	0.52
1994	1.05	31.3	0.4	1.6	1.35	14.4	1.0	1.7	0.7	9	9	19	24.9	55	98	110	87	51	0.59
1995	1.71	31.2	0.7	2.8	0.92	12.9	0.7	1.2	1.7	10	12	34	39.6	84	91	87	93	40	0.43
1996	1.09	27.3	0.5	1.7	0.63	18.1	0.4	0.9	1.7	8	11	38	40.3	63	95	51	88	30	0.34
1997	0.75	26.6	0.4	1.1	0.50	19.9	0.3	0.7	1.3	8	9	35	35.4	70	86	39	90	27	0.30
1998	1.02	23.7	0.6	1.5	0.61	17.7	0.4	0.8	1.5	10	10	30	35.5	68	77	56	104	38	0.37
1999	0.90	32.2	0.4	1.4	1.08	16.3	0.7	1.4	0.7	8	8	22	25.7	58	81	111	106	44	0.42
2000	2.53	25.1	1.3	3.7	2.40	17.7	1.6	3.2	1.0	9	11	25	30.3	70	88	165	87	43	0.49
2001	2.07	23.0	1.1	3.0	1.62	12.8	1.2	2.0	1.1	8	12	31	34.7	65	93	145	90	50	0.56
2002	2.32	27.1	1.1	3.6	1.28	14.4	0.9	1.6	1.4	9	9	34	35.1	65	93	114	86	45	0.52
2003	2.72	31.3	1.1	4.4	1.07	13.8	0.8	1.4	1.7	8	8	40	37.8	73	88	90	88	39	0.44
2004	0.63	29.6	0.3	1.0	0.52	20.1	0.3	0.7	1.2	8	8	21	29.8	68	89	36	85	24	0.28
2005	1.62	46.2	0.2	3.1	0.59	20.2	0.4	0.8	1.7	8	8	24	34.3	79	88	46	87	29	0.33
2006	1.04	25.2	0.5	1.6	0.76	16.4	0.5	1.0	1.3	6	7	33	33.2	69	86	56	94	37	0.39
2007	1.20	32.7	0.4	2.0	0.64	16.5	0.4	0.8	1.7	9	17	31	37.5	77	81	63	90	32	0.36
2008	0.99	31.8	0.4	1.6	0.78	22.7	0.4	1.1	1.2	9	9	27	31.6	68	85	60	90	27	0.30
2009	0.44	20.0	0.3	0.6	0.40	14.5	0.3	0.5	1.3	9	9	31	35	68	93	205	70	48	0.69
2010	0.84	31.1	0.3	1.4	0.51	10.8	0.4	0.6	1.4	7	8	35	36	64	95	249	66	49	0.74
2011	0.90	16.8	0.6	1.2	0.68	9.0	0.6	0.8	1.5	8	8	35	34	70	91	213	46	42	0.91
2012	0.85	15.4	0.6	1.1	0.70	8.9	0.6	0.8	1.3	6	8	31	34	65	97	314	62	57	0.92
2013	0.83	28.1	0.4	1.3	0.74	7.9	0.6	0.9	1.0	7	8	29	30	61	90	385	63	58	0.92
2014	0.76	10.1	0.6	0.9	0.95	10.8	0.8	1.2	0.9	7	8	27	30	60	87	264	36	30	0.83
2015	2.64	37.5	0.7	4.6	1.26	12.4	1.0	1.6	1.1	5	9	28	31	64	95	634	83	70	0.84

Bigelow, no calibration coefficient applied:

2009	3.6	20.0	2.2	5.0	2.82	14.5	2.0	3.6
2010	6.8	31.1	2.7	11.0	3.66	10.8	2.9	4.4
2011	7.3	16.8	4.9	9.7	4.83	9.0	4.0	5.7
2012	6.9	15.4	4.8	9.0	4.97	8.9	4.1	5.8
2013	6.7	28.1	3.0	10.3	5.27	7.9	4.5	6.1
2014	6.1	10.1	4.9	7.3	6.81	10.8	5.4	8.3
2015	21.2	37.5	5.6	36.9	8.99	12.4	6.8	11.2

Table 12. Survey results from NEFSC offshore fall bottom trawl surveys in the northern management region (strata 20-30, 34-40). Indices are arithmetic stratified means with bootstrapped variance estimates.

	Biomass Index				Abundance Index			
	Mean	CV	L95%	U95%	Mean	CV	L95%	U95%
1963	3.79	16.3	2.64	4.99	0.81	15.7	0.57	1.05
1964	1.89	19.9	1.15	2.65	0.39	19.6	0.25	0.54
1965	2.52	19.5	1.67	3.57	0.35	15.3	0.24	0.45
1966	3.33	16.0	2.32	4.37	0.51	14.0	0.38	0.66
1967	1.24	32.8	0.53	2.08	0.19	25.3	0.10	0.28
1968	2.05	35.0	0.83	3.56	0.29	26.9	0.15	0.45
1969	3.69	22.9	2.17	5.42	0.42	15.3	0.29	0.54
1970	2.32	26.1	1.22	3.63	0.40	19.6	0.25	0.55
1971	2.90	21.7	1.79	4.25	0.49	17.2	0.33	0.66
1972	1.39	24.5	0.80	2.13	0.32	18.5	0.20	0.43
1973	3.19	21.0	1.94	4.53	0.53	19.9	0.34	0.75
1974	2.02	21.0	1.24	2.90	0.32	19.5	0.20	0.43
1975	1.71	19.0	1.09	2.42	0.30	18.8	0.20	0.42
1976	3.22	21.0	1.96	4.67	0.42	20.0	0.28	0.59
1977	5.43	17.5	3.72	7.39	0.76	12.6	0.58	0.96
1978	4.73	12.7	3.62	5.85	0.70	12.4	0.53	0.87
1979	4.91	14.4	3.58	6.21	0.55	11.6	0.42	0.68
1980	4.04	18.8	2.53	5.61	0.64	14.6	0.46	0.83
1981	1.98	17.8	1.34	2.71	0.45	14.1	0.33	0.58
1982	0.94	26.6	0.49	1.45	0.14	23.2	0.08	0.21
1983	1.61	19.0	1.04	2.18	0.47	17.9	0.31	0.63
1984	2.82	20.5	1.77	3.95	0.49	12.8	0.37	0.61
1985	1.48	33.2	0.61	2.52	0.37	22.4	0.22	0.54
1986	2.23	21.5	1.35	3.10	0.61	16.8	0.41	0.81
1987	0.88	30.9	0.37	1.45	0.26	25.0	0.14	0.40
1988	1.53	32.4	0.64	2.60	0.31	25.5	0.17	0.49
1989	1.32	28.5	0.68	2.12	0.51	16.9	0.36	0.70
1990	1.01	26.8	0.53	1.55	0.71	15.3	0.50	0.92
1991	1.20	23.5	0.70	1.78	0.70	17.2	0.47	0.93
1992	1.12	23.6	0.65	1.67	0.94	16.6	0.65	1.25
1993	1.10	33.9	0.53	1.92	1.23	15.3	0.89	1.61
1994	0.90	22.8	0.56	1.34	1.34	12.7	1.03	1.68
1995	1.60	23.1	0.94	2.34	0.93	12.0	0.72	1.16
1996	1.07	25.3	0.60	1.66	0.63	16.8	0.44	0.85
1997	0.67	21.9	0.40	0.96	0.50	17.4	0.33	0.67
1998	0.96	20.5	0.62	1.35	0.62	18.3	0.42	0.86
1999	0.78	22.3	0.46	1.14	1.08	15.1	0.76	1.42
2000	2.41	20.3	1.57	3.41	2.34	13.3	1.78	2.96
2001	1.84	15.7	1.31	2.40	1.61	11.4	1.24	1.97
2002	1.83	16.8	1.27	2.51	1.28	12.7	0.96	1.62
2003	1.81	18.0	1.19	2.46	1.07	12.3	0.81	1.33
2004	0.64	28.2	0.30	1.01	0.52	18.5	0.35	0.72
2005	1.01	21.8	0.61	1.43	0.60	18.8	0.39	0.82
2006	1.04	24.0	0.58	1.56	0.77	15.6	0.55	1.01
2007	1.08	28.1	0.54	1.73	0.64	14.6	0.46	0.83
2008	0.99	28.8	0.48	1.57	0.79	22.5	0.47	1.17
2009	0.44	17.7	0.30	0.60	0.39	9.8	0.31	0.46
2010	0.6	14.9	0.46	0.82	0.51	8.7	0.43	0.60
2011	0.9	15.2	0.65	1.16	0.67	6.5	0.59	0.75
2012	0.8	11.0	0.65	1.00	0.68	6.7	0.60	0.78
2013	0.6	11.3	0.49	0.75	0.73	6.7	0.64	0.83
2014	0.8	8.8	0.63	0.89	0.95	8.7	0.80	1.13
2015	1.1	11.4	0.87	1.39	1.22	9.1	1.02	1.44
Bigelow, no calibration coefficient applied:								
2009	3.55	17.7	2.38	4.83	2.78	9.8	2.22	3.27
2010	5.13	14.9	3.69	6.60	3.65	8.7	3.07	4.30
2011	7.09	15.2	5.21	9.34	4.77	6.5	4.18	5.38
2012	6.50	11.0	5.22	8.02	4.88	6.7	4.26	5.53
2013	4.97	11.3	3.92	6.06	5.21	6.7	4.55	5.94
2014	6.11	8.8	5.09	7.19	6.79	8.7	5.71	8.08
2015	9.20	11.4	7.05	11.18	8.71	9.1	7.24	10.26

Table 13. Survey results from NEFSC offshore spring bottom trawl surveys in the northern management region (strata 20-30, 34-40). Indices are delta distribution stratified means.

	Biomass Index				Abundance Index					Length						Number of	Number	Number of Nonzero	Proportion
	Mean	CV	L95%	U95%	Mean	CV	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max	Fish	of Tows	Tows	Non-zero
1968	1.01	35.9	0.30	1.72	0.17	31.3	0.07	0.27	6.0	50	51	68	70.4	89	90	13	86	11	0.13
1969	1.34	44.9	0.16	2.52	0.18	38.3	0.05	0.32	7.5	33	33	71	71.5	99	100	15	87	10	0.11
1970	2.02	30.9	0.80	3.25	0.34	19.0	0.22	0.47	5.9	30	30	62	65.4	98	99	32	90	22	0.24
1971	1.04	29.4	0.44	1.64	0.16	27.9	0.07	0.24	6.5	45	53	69	72.6	99	100	20	96	15	0.16
1972	4.74	18.1	3.06	6.42	0.64	15.0	0.45	0.83	7.1	13	39	74	72.7	100	105	59	96	38	0.40
1973	6.39	25.5	3.20	9.58	1.07	29.5	0.45	1.68	4.3	17	26	68	65.7	99	106	91	87	36	0.41
1974	4.95	21.2	2.89	7.00	1.07	14.4	0.77	1.37	3.4	20	23	58	58.3	97	111	86	83	41	0.49
1975	3.16	18.6	2.01	4.31	0.83	16.7	0.56	1.10	2.8	16	19	53	54.0	87	109	73	87	36	0.41
1976	9.47	20.5	5.66	13.27	1.65	15.5	1.15	2.15	3.8	14	20	60	61.5	95	106	158	99	52	0.53
1977	3.39	22.7	1.89	4.90	0.64	19.7	0.39	0.88	3.6	10	31	66	63.4	93	106	61	107	37	0.35
1978	2.10	23.3	1.14	3.06	0.34	16.4	0.23	0.45	4.0	15	19	73	65.5	89	92	37	113	30	0.27
1979	3.48	36.8	0.97	5.98	0.37	14.5	0.26	0.47	4.7	12	14	67	62.5	100	118	48	139	40	0.29
1980	5.43	26.3	2.64	8.23	1.10	14.9	0.78	1.41	3.7	17	22	43	53.3	98	107	84	85	38	0.45
1981	5.84	24.3	3.06	8.63	1.11	12.8	0.83	1.39	4.4	11	21	52	57.7	95	120	95	87	42	0.48
1982	3.02	29.5	1.27	4.76	0.42	28.1	0.19	0.65	8.6	25	36	61	68.8	105	108	33	92	22	0.24
1983	1.59	34.0	0.53	2.64	0.42	27.7	0.19	0.64	3.7	12	13	49	49.9	96	112	34	90	22	0.24
1984	1.70	33.1	0.60	2.80	0.33	22.9	0.18	0.47	4.7	17	19	62	60.8	93	100	26	86	19	0.22
1985	2.11	24.6	1.09	3.13	0.35	21.6	0.20	0.49	6.1	13	13	68	66.9	104	108	25	81	21	0.26
1986	2.33	29.5	0.98	3.67	0.34	21.1	0.20	0.48	6.2	11	14	63	65.4	109	121	30	90	22	0.24
1987	1.73	29.6	0.73	2.73	0.28	22.1	0.16	0.40	7.1	16	16	66	64.2	99	100	21	83	16	0.19
1988	2.11	29.1	0.91	3.31	0.61	17.8	0.40	0.82	3.3	10	20	49	49.8	89	110	43	90	26	0.29
1989	1.64	32.0	0.61	2.66	0.75	24.8	0.39	1.12	2.6	10	11	40	43.2	80	94	48	85	24	0.28
1990	1.00	32.4	0.37	1.64	0.28	22.6	0.16	0.41	3.6	15	18	47	49.1	106	107	25	90	17	0.19
1991	1.83	37.7	0.48	3.18	0.59	18.8	0.37	0.81	2.7	12	15	35	42.3	78	100	48	86	28	0.33
1992	0.91	63.3	-0.19	2.01	0.49	34.6	0.16	0.83	1.8	16	17	35	40.6	82	101	36	83	20	0.24
1993	1.20	22.7	0.74	1.67	0.68	15.6	0.48	0.89	1.7	10	11	44	41.0	71	90	59	87	27	0.31
1994	0.95	34.1	0.40	1.50	0.45	20.0	0.28	0.63	2.2	10	13	40	41.0	83	89	45	88	24	0.27
1995	1.75	37.7	0.81	2.70	0.98	16.7	0.66	1.31	1.8	15	16	33	39.9	73	97	83	88	39	0.44
1996	1.01	28.2	0.45	1.56	0.67	24.7	0.34	0.99	1.5	15	17	41	43.0	60	70	49	82	20	0.24
1997	0.56	37.0	0.17	0.95	0.34	27.2	0.16	0.52	1.6	9	9	36	39.4	75	89	34	89	19	0.21
1998	0.49	29.3	0.23	0.74	0.41	15.5	0.29	0.54	1.1	11	11	19	31.3	67	78	46	115	33	0.29
1999	1.22	24.5	0.65	1.80	0.82	17.2	0.55	1.10	1.4	9	14	31	35.5	71	97	62	87	33	0.38
2000	1.44	21.1	0.85	2.03	1.13	12.9	0.84	1.41	1.2	15	17	29	34.5	75	87	99	89	42	0.47
2001	1.97	33.1	0.69	3.25	1.69	14.1	1.22	2.15	1.1	9	11	24	31.4	75	86	151	89	50	0.56
2002	2.00	16.8	1.34	2.66	1.76	12.3	1.33	2.18	1.1	12	15	34	36.6	60	73	155	91	50	0.55
2003	2.38	33.5	0.82	3.95	0.81	20.9	0.48	1.14	2.3	10	13	42	44.2	69	95	79	86	30	0.35
2004	2.29	30.7	0.91	3.66	0.91	18.7	0.58	1.24	2.5	9	11	48	46.7	81	85	69	88	36	0.41
2005	2.06	38.5	0.51	3.61	0.71	15.9	0.49	0.93	2.1	11	13	48	45.1	68	75	52	87	31	0.36
2006	0.93	40.9	0.18	1.67	0.37	28.7	0.16	0.57	2.5	15	13	43	44.8	72	105	33	95	23	0.24
2007	1.65	70.1	-0.61	3.91	0.56	28.3	0.25	0.86	1.9	11	10	32	36.8	78	85	43	86	19	0.22
2008	1.78	45.8	0.18	3.38	0.68	21.7	0.39	0.97	1.9	8	16	35	40.8	73	85	61	86	24	0.28
2009	0.51	19.5	0.31	0.71	0.34	13.3	0.43	0.51	1.6	11	13	36	38.4	70	93	220	94	55	0.59
2010	0.65	18.5	0.42	0.89	0.38	13.4	0.47	0.65	1.9	10	15	41	42.5	71	115	207	87	50	0.57
2011	0.89	18.1	0.57	1.20	0.46	15.9	0.61	0.89	2.2	10	14	44	46.1	78	91	185	54	40	0.74
2012	0.66	23.1	0.36	0.96	0.54	15.7	0.71	0.66	1.3	10	13	35	36.8	63	97	274	72	53	0.74
2013	0.67	20.8	0.40	0.95	0.55	8.4	0.65	0.67	1.2	8	9	29	32.2	71	87	228	65	50	0.77
2014	0.70	25.4	0.35	1.04	0.63	15.7	0.82	0.70	1.2	9	12	37	36.4	58	77	241	56	47	0.84
2015	0.85	22.7	0.47	1.23	0.54	11.1	0.65	0.85	1.5	9	13	38	39.3	66	94	336	103	70	0.68

Bigelow, no calibration coefficient applied:

2009	4.11	19.5	2.5	5.7	2.4	13.3	1.8	3.0
2010	5.27	18.5	3.4	7.2	2.7	13.4	2.0	3.4
2011	7.17	18.1	4.6	9.7	3.3	15.9	2.3	4.3
2012	5.34	23.1	2.9	7.8	3.9	15.7	2.7	5.1
2013	5.42	20.8	3.2	7.6	4.0	8.4	3.3	4.6
2014	5.62	25.4	2.8	8.4	4.5	15.7	3.1	5.8
2015	6.87	22.7	3.8	9.9	3.8	11.1	3.0	4.7

Table 14. Survey results from NEFSC offshore spring bottom trawl surveys in the northern management region (strata 20-30, 34-40). Indices are arithmetic stratified means with bootstrapped variance estimates.

	Biomass Index				Abundance Index			
	Mean	CV	L95%	U95%	Mean	CV	L95%	U95%
1968	1.01	32.4	0.44	1.69	0.17	28.9	0.08	0.27
1969	1.34	41.2	0.36	2.46	0.18	34.8	0.07	0.31
1970	2.02	26.5	0.99	3.10	0.34	16.9	0.23	0.45
1971	1.05	28.8	0.51	1.68	0.16	28.0	0.08	0.25
1972	4.63	15.3	3.31	5.98	0.65	15.0	0.45	0.84
1973	6.32	20.9	3.80	9.06	1.07	22.2	0.63	1.54
1974	5.00	19.6	3.22	6.97	1.08	13.5	0.80	1.37
1975	3.15	16.2	2.21	4.15	0.84	15.2	0.59	1.08
1976	8.40	14.2	6.02	10.77	1.63	13.4	1.24	2.09
1977	3.12	16.7	2.14	4.12	0.64	18.3	0.42	0.87
1978	1.89	18.9	1.24	2.63	0.34	15.4	0.24	0.45
1979	2.25	21.0	1.40	3.20	0.37	13.5	0.27	0.47
1980	4.80	17.8	3.10	6.55	1.11	14.0	0.81	1.42
1981	5.59	20.2	3.56	7.85	1.11	11.3	0.87	1.36
1982	2.97	24.6	1.63	4.40	0.42	25.1	0.23	0.62
1983	1.53	30.7	0.76	2.52	0.42	24.1	0.24	0.63
1984	1.57	25.3	0.80	2.32	0.33	21.6	0.21	0.48
1985	2.12	21.2	1.33	3.03	0.35	19.4	0.22	0.48
1986	2.13	26.9	1.08	3.37	0.34	19.3	0.22	0.48
1987	1.73	27.6	0.80	2.70	0.28	20.2	0.18	0.40
1988	2.03	23.7	1.13	3.00	0.61	15.9	0.42	0.80
1989	1.60	31.5	0.74	2.70	0.75	21.6	0.46	1.09
1990	1.01	30.5	0.50	1.68	0.34	20.1	0.21	0.49
1991	1.61	24.1	0.89	2.40	0.71	16.7	0.47	0.95
1992	0.89	56.9	0.22	2.03	0.49	30.4	0.26	0.82
1993	1.16	18.4	0.75	1.57	0.68	13.3	0.50	0.86
1994	0.98	30.9	0.44	1.63	0.55	17.4	0.36	0.72
1995	1.84	29.0	0.91	2.96	1.01	17.0	0.72	1.37
1996	0.98	23.0	0.57	1.44	0.67	22.2	0.39	0.97
1997	0.55	37.6	0.21	0.98	0.34	26.1	0.19	0.53
1998	0.44	27.3	0.22	0.69	0.42	14.6	0.30	0.54
1999	1.15	19.5	0.73	1.59	0.83	15.5	0.58	1.07
2000	1.40	18.4	0.91	1.90	1.13	11.8	0.89	1.41
2001	1.85	28.1	0.95	2.97	1.67	11.8	1.29	2.05
2002	1.93	13.0	1.45	2.43	1.74	10.6	1.38	2.10
2003	1.87	21.0	1.13	2.69	0.98	19.9	0.63	1.40
2004	2.26	26.0	1.20	3.47	0.91	16.4	0.61	1.21
2005	1.47	21.1	0.85	2.08	0.72	15.3	0.52	0.95
2006	0.93	37.3	0.34	1.68	0.37	26.7	0.19	0.57
2007	1.05	43.3	0.28	2.03	0.55	23.7	0.31	0.83
2008	1.29	28.3	0.65	2.06	0.67	16.9	0.46	0.91
2009	0.47	14.3	0.3	0.6	0.33	10.0	0.3	0.4
2010	0.63	14.2	0.5	0.8	0.38	13.1	0.29	0.49
2011	0.89	15.3	0.63	1.17	0.46	13.3	0.35	0.60
2012	0.61	13.7	0.44	0.76	0.54	13.4	0.40	0.68
2013	0.58	10.8	0.46	0.71	0.55	6.8	0.48	0.63
2014	0.63	15.5	0.45	0.82	0.61	11.3	0.47	0.75
2015	0.73	15.3	0.53	0.97	0.54	9.5	0.44	0.63
Bigelow, no calibration coefficient applied:								
2009	3.80	14.3	2.79	4.85	2.36	10.3	1.92	2.84
2010	5.08	14.2	3.68	6.54	2.72	13.4	2.05	3.51
2011	7.20	15.9	5.05	9.54	3.31	13.9	2.42	4.17
2012	4.90	13.7	3.64	6.22	3.83	13.2	2.93	4.90
2013	4.70	11.3	3.72	5.76	3.93	7.0	3.40	4.50
2014	5.07	15.6	3.58	6.55	4.38	11.9	3.34	5.42
2015	5.90	16.2	4.24	7.84	3.83	9.3	3.15	4.55

Table 15. Survey results from ASMFC summer shrimp surveys in the northern management region (strata 1, 3, 5, 6-8). Indices are delta distribution stratified means.

	Biomass Index				Abundance Index								Length			of	Number	Nonzero	Nonzero
Year	Mean	CV	L95%	U95%	Mean	CV	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max	Fish	of Tows	Tows	Tows
1991	1.96	20.6	1.17	2.75	2.90	11.2	2.27	3.54	0.65	11	15	24	27.5	59	96	125	43	39	0.91
1992	2.92	26.5	1.40	4.43	2.91	11.2	2.27	3.54	0.93	11	13	28	31.5	56	78	135	45	40	0.89
1993	3.34	31.7	1.39	5.30	3.76	14.4	2.70	4.81	0.83	7	9	23	27.6	59	102	170	46	42	0.91
1994	1.64	25.5	0.84	2.45	3.48	15.3	2.43	4.52	0.48	5	10	19	24.1	48	95	166	43	37	0.86
1995	1.64	28.3	0.73	2.54	2.09	21.3	1.22	2.96	0.75	11	19	26	31.2	67	76	83	35	24	0.69
1996	3.43	31.2	1.33	5.53	2.97	14.8	2.11	3.83	1.12	13	14	34	34.4	63	90	107	32	30	0.94
1997	2.08	25.5	1.04	3.12	1.58	16.5	1.07	2.09	1.32	11	16	32	37.7	62	73	72	40	31	0.78
1998	2.30	35.2	0.71	3.89	2.12	14.9	1.50	2.74	1.07	12	16	23	31.3	61	77	84	35	31	0.89
1999	6.35	19.8	4.77	7.93	7.02	12.4	5.31	8.73	0.93	8	9	28	30.9	65	82	301	42	39	0.93
2000	4.12	25.1	2.09	6.15	5.76	14.7	4.10	7.41	0.67	11	15	28	30.2	51	82	215	35	30	0.86
2001	8.55	24.5	4.44	12.66	11.12	12.2	8.46	13.79	0.67	11	13	26	29.5	51	85	442	36	36	1.00
2002	12.86	14.6	9.18	16.54	11.79	10.4	9.38	14.20	1.07	11	17	32	35.3	59	94	493	38	38	1.00
2003	8.24	30.2	4.47	12.02	5.86	14.6	4.17	7.54	1.27	3	13	38	37.4	63	87	236	37	36	0.97
2004	4.60	12.6	3.46	5.74	3.39	10.9	2.66	4.11	1.32	11	11	34	35.7	66	75	142	35	33	0.94
2005	7.60	16.6	5.13	10.06	5.25	10.4	4.19	6.32	1.38	9	14	34	37.4	66	89	271	46	44	0.96
2006	7.36	22.2	3.81	10.91	4.34	8.8	3.09	5.60	1.52	7	11	30	37.2	70	89	143	29	29	1.00
2007	5.13	32.7	1.84	8.42	4.39	13.0	3.26	5.51	0.92	9	11	19	28.2	64	79	218	43	36	0.84
2008	3.90	23.3	2.12	5.67	2.85	13.8	2.08	3.62	1.35	10	14	32	36.1	67	82	116	37	31	0.84
2009	4.23	32.7	1.5	6.9	3.10	12.1	2.4	3.8	1.03	11	11	28	32.7	58	80	159	49	45	0.92
2010	3.11	24.8	1.6	4.6	2.57	15.9	1.8	3.4	1.09	9	16	33	35.1	58	90	132	49	43	0.88
2011	2.71	18.5	1.7	3.7	2.25	10.3	1.8	2.7	1.18	13	13	37	36.2	59	77	124	47	38	0.81
2012	3.71	23.4	2.0	5.4	3.65	14.5	2.6	4.7	0.9	4	10	26	30.8	56	92	192	49	41	0.84
2013	5.18	32.4	1.9	8.5	4.19	16.0	2.9	5.5	1.0	11	12	24	30.5	60	90	207	46	42	0.91
2014	3.27	14.9	2.3	4.2	4.98	10.1	4.0	6.0	0.7	12	14	25	29.0	51	89	251	47	42	0.89
2015	1.50	32.2	0.6	2.4	2.70	26.9	1.3	4.1	0.5	7	10	21	25.4	47	62	93	30	26	0.87

Table 16. Survey results from ASMFC summer shrimp surveys in the northern management region (strata 1, 3, 5, 6-8). Indices are arithmetic stratified means with bootstrapped variance estimates.

	Biomass Index				Abundance Index								Length			of	Number	Nonzero	Nonzero
Year	Mean	CV	L95%	U95%	Mean	CV	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max	Fish	of Tows	Tows	Tows
1991	1.88	16.1	1.34	2.49	2.88	9.5	2.33	3.41	0.65	11	15	24	27.5	59	96	125	43	39	0.91
1992	2.69	16.0	1.85	3.51	2.90	9.9	2.38	3.47	0.93	11	13	28	31.5	56	78	135	45	40	0.89
1993	3.07	25.5	1.61	4.72	3.70	12.7	2.81	4.70	0.83	7	9	23	27.6	59	102	170	46	42	0.91
1994	1.66	22.0	0.99	2.39	3.42	12.9	2.55	4.31	0.48	5	10	19	24.1	48	95	166	43	37	0.86
1995	1.55	23.1	0.83	2.21	2.08	18.2	1.34	2.82	0.75	11	19	26	31.2	67	76	83	35	24	0.69
1996	3.36	31.3	1.69	5.53	2.99	13.7	2.25	3.85	1.12	13	14	34	34.4	63	90	107	32	30	0.94
1997	2.08	21.5	1.29	3.00	1.57	14.1	1.14	2.00	1.32	11	16	32	37.7	62	73	72	40	31	0.78
1998	2.27	29.6	1.10	3.75	2.12	13.1	1.59	2.69	1.07	12	16	23	31.3	61	77	84	35	31	0.89
1999	6.26	10.4	4.95	7.46	6.75	9.0	5.53	7.96	0.93	8	9	28	30.9	65	82	301	42	39	0.93
2000	3.84	15.2	2.66	4.99	5.72	12.9	4.28	7.17	0.67	11	15	28	30.2	51	82	215	35	30	0.86
2001	7.27	11.0	5.71	8.87	10.89	9.3	8.94	12.84	0.67	11	13	26	29.5	51	85	442	36	36	1.00
2002	12.44	10.6	9.91	14.97	11.65	8.1	9.89	13.52	1.07	11	17	32	35.3	59	94	493	38	38	1.00
2003	7.36	16.4	5.19	10.02	5.80	12.5	4.38	7.23	1.27	3	13	38	37.4	63	87	236	37	36	0.97
2004	4.45	10.2	3.69	5.43	3.38	9.9	2.75	4.07	1.32	11	11	34	35.7	66	75	142	35	33	0.94
2005	7.25	13.7	5.35	9.25	5.25	9.7	4.31	6.24	1.38	9	14	34	37.4	66	89	271	46	44	0.96
2006	6.54	11.3	5.12	8.08	4.31	7.1	3.71	4.92	1.52	7	11	30	37.2	70	89	143	29	29	1.00
2007	4.10	21.1	2.55	5.89	4.46	13.2	3.41	5.73	0.92	9	11	19	28.2	64	79	218	43	36	0.84
2008	3.79	19.8	2.40	5.40	2.82	11.1	2.21	3.42	1.35	10	14	32	36.1	67	82	116	37	31	0.84
2009	3.21	19.3	2.04	4.49	3.12	11.0	2.46	3.78	1.03	11	11	28	32.7	58	80	159	49	45	0.92
2010	2.76	20.5	1.70	3.95	2.54	14.1	1.88	3.30	1.09	9	16	33	35.1	58	90	132	49	43	0.88
2011	2.66	15.2	1.92	3.49	2.25	9.7	1.81	2.68	1.18	13	13	37	36.2	59	77	124	47	38	0.81
2012	3.14	14.8	2.26	4.09	3.55	12.2	2.75	4.50	0.9	4	10	26	30.8	56	92	192	49	41	0.84
2013	4.07	16.0	2.89	5.41	4.13	13.3	3.08	5.21	1.0	11	12	24	30.5	60	90	207	46	42	0.91
2014	3.31	14.1	2.45	4.20	4.94	8.8	4.07	5.83	0.7	12	14	25	29.0	51	89	251	47	42	0.89
2015	1.45	24.2	0.78	2.11	2.76	20.7	1.59	3.84	0.5	7	10	21	25.4	47	62	93	30	26	0.87

Table 17. Monkfish indices from Maine-New Hampshire inshore surveys, strata 1-4, regions 1-5.

Fall

Year	Mean Weight	CV	L95%	U95%	Mean Number	CV	L95%	U95%
2000	1.6	39.2	1.1	2.2	4.8	28.8	3.6	6.0
2001	4.8	19.8	3.9	5.6	10.8	20.8	8.5	13.0
2002	3.5	65.9	1.2	5.7	4.1	55.6	1.8	6.3
2003	3.6	38.0	2.0	5.2	3.7	30.6	2.4	5.0
2004	3.6	40.5	2.0	5.3	3.0	31.0	1.9	4.0
2005	2.0	34.5	1.1	3.0	1.8	21.8	1.3	2.3
2006	1.8	22.6	1.4	2.2	2.9	22.4	2.3	3.6
2007	2.1	32.2	1.4	2.8	3.1	26.4	2.3	4.0
2008	3.0	27.3	2.1	3.8	4.1	33.2	2.7	5.5
2009	1.9	59.3	0.9	3.0	2.0	44.7	1.2	2.8
2010	0.7	35.3	0.5	1.0	1.1	32.1	0.7	1.4
2011	1.1	38.3	0.7	1.5	1.0	36.6	0.6	1.3
2012	0.5	51.1	0.2	0.8	0.8	34.7	0.5	1.1
2013	0.6	59.2	0.3	1.0	0.8	39.2	0.5	1.1
2014	0.3	42.7	0.2	0.4	1.1	31.9	0.8	1.4
2015	1.6	30.0	1.2	2.1	7.1	32.9	5.0	9.3

Spring

Year	Mean Weight	CV	L95%	U95%	Mean Number	CV	L95%	U95%
2000								
2001	1.0	34.7	0.7	1.3	6.0	34.6	4.2	7.8
2002	1.1	36.8	0.8	1.5	2.4	30.6	1.7	3.0
2003	0.6	52.0	0.3	1.0	1.0	25.7	0.7	1.2
2004	0.4	59.8	0.2	0.6	1.4	23.3	1.1	1.8
2005	0.8	35.5	0.5	1.1	1.1	22.0	0.8	1.5
2006	0.1	44.6	0.1	0.2	0.3	42.1	0.2	0.4
2007	0.4	49.5	0.2	0.6	1.1	30.3	0.8	1.5
2008	0.5	30.3	0.3	0.7	1.4	25.8	1.0	1.7
2009	0.2	44.0	0.1	0.3	0.8	30.9	0.6	1.0
2010	0.2	48.7	0.1	0.3	0.6	40.9	0.4	0.8
2011	0.2	69.6	0.1	0.3	0.3	35.1	0.2	0.4
2012	0.3	95.0	0.0	0.5	0.4	36.1	0.2	0.5
2013	0.2	100.9	0.0	0.3	0.4	44.5	0.2	0.5
2014	0.2	93.1	0.1	0.4	0.9	36.6	0.6	1.2
2015	0.2	32.7	0.1	0.2	1.1	28.5	0.8	1.3

Table 18. Survey results from NEFSC offshore fall bottom trawl surveys in the southern management region (strata 1-19, 61-76). Indices are delta distribution stratified means.

	Biomass Index				Abundance Index					Length						Number of	Number of	Number of Nonzero	Proportion Nonzero
	Mean	CV	L95%	U95%	Mean	CV	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max	Fish	Tows	Tows	Tows
1963	3.83	26.5	1.8	5.5	1.20	19.6	0.7	1.7	3.0	7	17	53	50.4	91	97	102	73	36	0.49
1964	9.98	57.2	2.7	9.6	1.64	22.7	0.9	2.4	3.5	14	21	53	52.0	86	101	132	83	34	0.41
1965	5.25	22.8	2.9	7.3	1.15	16.4	0.8	1.5	4.2	10	15	59	56.3	91	104	83	85	39	0.46
1966	7.14	14.5	5.1	9.1	1.93	14.9	1.4	2.5	3.6	7	7	51	49.6	87	98	101	87	56	0.64
1967	1.25	26.3	0.6	1.7	0.52	19.2	0.3	0.7	2.2	14	19	31	40.6	83	100	98	163	42	0.26
1968	0.90	25.7	0.5	1.3	0.40	24.2	0.2	0.6	2.2	12	17	45	46.3	75	86	77	164	39	0.24
1969	1.44	32.3	0.5	2.2	0.54	21.8	0.3	0.8	2.5	10	14	41	45.4	88	96	101	163	43	0.26
1970	1.34	27.2	0.6	2.0	0.35	16.8	0.2	0.5	3.6	4	13	55	53.3	84	104	58	161	35	0.22
1971	0.73	32.8	0.3	1.1	0.28	23.8	0.2	0.4	2.8	5	8	39	42.3	95	98	55	168	28	0.17
1972	5.27	18.6	3.4	6.7	4.11	35.1	1.3	6.9	1.3	12	16	23	31.8	74	99	604	161	85	0.53
1973	2.04	25.5	1.0	3.0	1.18	13.8	0.9	1.5	1.6	13	14	32	37.7	77	93	280	154	70	0.45
1974	0.71	27.8	0.3	1.1	0.22	23.8	0.1	0.3	3.3	14	16	54	52.9	81	101	56	153	26	0.17
1975	2.05	17.9	1.3	2.8	0.65	17.2	0.4	0.9	2.7	8	17	45	46.3	87	105	127	158	51	0.32
1976	1.08	25.7	0.5	1.6	0.31	20.2	0.2	0.4	3.2	11	11	51	50.7	77	95	60	165	34	0.21
1977	1.87	18.5	1.2	2.6	0.37	14.6	0.3	0.5	4.2	5	16	55	53.1	95	106	94	172	50	0.29
1978	1.39	18.7	0.9	1.9	0.26	16.0	0.2	0.3	4.5	13	17	61	56.5	87	101	68	219	39	0.18
1979	2.28	22.4	1.3	3.3	0.69	15.5	0.5	0.9	2.3	7	16	34	40.5	84	109	182	205	70	0.34
1980	1.87	19.2	1.2	2.6	0.73	21.0	0.4	1.0	2.2	3	16	34	41.6	85	104	113	159	42	0.26
1981	2.93	34.5	0.9	4.8	0.97	20.4	0.6	1.4	2.0	6	17	38	40.7	71	99	176	146	59	0.40
1982	0.65	23.3	0.4	1.0	0.61	19.8	0.4	0.8	1.1	13	15	26	32.5	66	73	98	143	42	0.29
1983	2.15	34.6	0.7	3.6	0.78	20.1	0.5	1.1	2.3	7	16	45	44.4	72	100	109	146	49	0.34
1984	0.74	40.8	0.2	1.3	0.31	32.4	0.1	0.5	2.4	5	13	47	45.7	68	93	42	146	25	0.17
1985	1.32	21.9	0.8	1.9	0.52	16.5	0.4	0.7	2.1	17	17	40	42.0	72	96	100	145	46	0.32
1986	0.55	29.1	0.2	0.9	0.33	23.6	0.2	0.5	1.5	7	14	34	37.6	68	78	60	146	33	0.23
1987	0.27	29.3	0.1	0.4	0.48	18.5	0.3	0.7	0.6	12	13	20	25.0	56	61	67	132	27	0.20
1988	0.55	31.7	0.2	0.9	0.23	29.4	0.1	0.4	2.4	19	27	36	45.1	87	91	27	129	19	0.15
1989	0.90	42.0	0.3	1.0	0.38	26.7	0.2	0.6	1.4	7	7	42	38.0	57	77	57	129	23	0.18
1990	0.43	47.5	0.0	0.8	0.29	31.0	0.1	0.5	1.1	9	13	24	33.1	61	81	47	136	22	0.16
1991	0.79	35.9	0.2	1.3	0.69	32.7	0.2	1.1	0.9	14	15	23	30.8	57	81	106	131	27	0.21
1992	0.36	34.5	0.2	0.4	0.34	17.7	0.2	0.5	0.9	8	11	30	32.2	54	74	46	129	21	0.16
1993	0.29	41.2	0.1	0.5	0.29	27.0	0.1	0.4	0.8	10	13	32	30.4	52	68	46	130	24	0.18
1994	0.61	35.9	0.2	1.1	0.60	20.9	0.4	0.8	0.9	8	12	25	29.2	59	83	85	135	31	0.23
1995	0.39	29.7	0.2	0.6	0.49	24.2	0.3	0.7	0.8	11	13	25	29.4	54	66	72	129	29	0.22
1996	0.39	22.4	0.2	0.6	0.23	22.4	0.1	0.3	1.6	18	19	42	42.3	62	68	31	131	21	0.16
1997	0.59	20.5	0.4	0.8	0.31	18.2	0.2	0.4	1.9	9	9	49	44.6	70	71	43	131	24	0.18
1998	0.50	26.1	0.2	0.8	0.33	28.0	0.1	0.5	1.5	11	11	36	37.0	68	87	45	131	20	0.15
1999	0.30	18.2	0.2	0.4	0.45	14.9	0.3	0.6	0.7	12	14	27	29.2	52	55	109	106	44	0.42
2000	1.02	62.2	0.3	0.7	0.42	18.4	0.3	0.6	1.1	5	15	33	34.3	63	70	64	132	30	0.23
2001	0.71	24.3	0.4	1.1	0.38	18.8	0.2	0.5	1.7	4	11	39	41.7	70	80	51	130	30	0.23
2002	1.32	20.6	0.8	1.8	0.83	16.2	0.6	1.1	1.5	6	14	41	39.1	61	81	110	130	47	0.36
2003	0.83	17.6	0.5	1.1	0.95	17.4	0.6	1.3	0.9	6	7	18	28.3	59	70	128	130	41	0.32
2004	0.97	33.5	0.3	1.6	0.47	24.5	0.2	0.7	1.6	7	15	45	40.4	64	78	67	133	32	0.24
2005	0.80	25.0	0.4	1.2	0.58	20.9	0.3	0.8	1.3	7	13	42	38.5	57	67	76	123	34	0.28
2006	0.83	27.8	0.4	1.3	0.45	19.5	0.3	0.6	1.7	6	12	44	40.6	65	77	83	151	36	0.24
2007	0.51	26.1	0.2	0.8	0.20	23.2	0.1	0.3	2.6	25	25	51	50.1	68	69	27	142	19	0.13
2008	0.41	37.2	0.1	0.7	0.20	26.4	0.1	0.3	2.1	4	4	45	38.6	69	88	39	142	20	0.14
2009	0.25	14.9	0.18	0.32	0.22	15.4	0.32	0.29	1.2	6	7	28	34	63	77	289	144	73	0.51
2010	0.37	20.2	0.22	0.52	0.40	19.2	0.52	0.55	1.0	5	9	22	31	64	78	386	145	70	0.48
2011	0.32	18.1	0.21	0.44	0.62	15.6	0.44	0.81	0.6	6	8	19	25	52	76	482	99	66	0.67
2012	0.45	18.1	0.29	0.61	0.28	17.3	0.61	0.38	1.8	4	24	40	44	67	82	306	135	69	0.51
2013	0.45	40.5	0.09	0.80	0.29	19.1	0.80	0.39	1.1	5	7	23	32	57	81	285	124	71	0.57
2014	0.16	22.9	0.09	0.23	0.16	16.3	0.23	0.21	1.1	7	9	29	34	60	71	213	127	54	0.43
2015	0.36	20.9	0.21	0.51	1.87	28.5	0.51	2.92	0.2	5	13	19	21	26	69	1857	166	98	0.59
Bigelow, no calibration coefficient applied:																			
2009	2.01	14.9	1.43	2.60	1.57	15.4	1.10	2.04											
2010	3.00	20.2	1.81	4.20	2.83	19.2	1.77	3.90											
2011	2.61	18.1	1.69	3.54	4.41	15.6	3.06	5.76											
2012	3.64	18.1	2.35	4.93	2.01	17.3	1.33	2.69											
2013	3.59	40.5	0.74	6.45	2.03	19.1	1.27	2.79											
2014	1.26	22.9	0.70	1.83	1.15	16.3	0.79	1.52											
2015	2.93	20.9	1.73	4.13	13.36	28.5	5.91	20.82											

Table 19. Survey results from NEFSC offshore fall bottom trawl surveys in the southern management region (strata 20-30, 34-40). Indices are arithmetic stratified means with bootstrapped variance estimates.

	Biomass Index				Abundance Index			
	Mean	CV	L95%	U95%	Mean	CV	L95%	U95%
1963	3.60	23.2	2.09	5.42	1.20	19.3	0.80	1.72
1964	5.50	17.3	3.75	7.34	1.64	15.8	1.09	2.07
1965	4.90	16.8	3.33	6.61	1.15	14.4	0.85	1.48
1966	7.01	12.9	5.27	8.81	1.93	14.5	1.44	2.53
1967	1.14	21.3	0.71	1.65	0.52	17.1	0.35	0.69
1968	0.89	23.5	0.52	1.31	0.40	21.7	0.25	0.58
1969	1.33	29.9	0.69	2.22	0.54	19.8	0.35	0.75
1970	1.29	22.2	0.76	1.85	0.35	15.9	0.25	0.47
1971	0.79	35.3	0.33	1.42	0.28	20.6	0.18	0.40
1972	4.89	14.4	3.52	6.27	4.11	23.1	2.30	5.58
1973	1.83	16.0	1.29	2.43	1.18	11.4	0.91	1.42
1974	0.72	26.8	0.39	1.13	0.22	22.2	0.13	0.32
1975	2.00	16.8	1.35	2.64	0.75	16.3	0.53	1.01
1976	1.00	17.2	0.66	1.33	0.31	19.3	0.22	0.44
1977	1.88	16.8	1.30	2.52	0.45	13.4	0.33	0.57
1978	1.40	17.0	0.96	1.87	0.31	15.9	0.22	0.42
1979	1.93	15.9	1.33	2.51	0.84	13.2	0.63	1.07
1980	1.85	16.9	1.32	2.51	0.87	15.1	0.59	1.08
1981	2.26	17.3	1.51	3.09	1.16	15.1	0.81	1.51
1982	0.65	21.3	0.39	0.94	0.61	17.3	0.41	0.83
1983	1.76	20.2	1.09	2.46	0.78	16.5	0.53	1.02
1984	0.77	41.0	0.26	1.42	0.31	32.2	0.14	0.53
1985	1.29	18.9	0.85	1.80	0.62	15.4	0.45	0.83
1986	0.55	27.6	0.28	0.89	0.36	21.5	0.22	0.52
1987	0.28	29.3	0.13	0.46	0.48	18.5	0.32	0.68
1988	0.55	29.7	0.25	0.91	0.23	26.5	0.13	0.37
1989	0.62	25.4	0.33	0.99	0.46	23.2	0.26	0.67
1990	0.37	32.0	0.17	0.63	0.35	27.6	0.17	0.55
1991	0.77	29.1	0.38	1.25	0.83	29.5	0.39	1.39
1992	0.32	20.9	0.21	0.46	0.34	16.3	0.24	0.45
1993	0.27	31.6	0.12	0.45	0.35	23.7	0.20	0.51
1994	0.55	23.1	0.31	0.82	0.60	19.4	0.38	0.85
1995	0.39	28.9	0.19	0.62	0.49	21.6	0.31	0.73
1996	0.39	20.2	0.24	0.55	0.23	20.9	0.15	0.34
1997	0.59	19.4	0.38	0.83	0.31	16.4	0.22	0.41
1998	0.50	23.7	0.28	0.75	0.33	23.0	0.19	0.48
1999	0.30	15.0	0.22	0.39	0.45	12.7	0.35	0.56
2000	0.47	19.6	0.29	0.65	0.42	16.2	0.29	0.56
2001	0.65	17.9	0.44	0.88	0.38	16.6	0.26	0.51
2002	1.25	18.7	0.84	1.74	0.83	14.9	0.59	1.07
2003	0.82	15.1	0.58	1.07	0.95	15.9	0.68	1.26
2004	0.74	18.1	0.50	1.02	0.47	19.8	0.30	0.66
2005	0.77	23.7	0.44	1.14	0.58	21.2	0.37	0.85
2006	0.76	23.4	0.45	1.13	0.45	19.0	0.30	0.64
2007	0.50	23.1	0.28	0.74	0.20	21.3	0.12	0.28
2008	0.41	34.0	0.17	0.72	0.20	24.8	0.11	0.30
2009	0.24	13.5	0.19	0.30	0.22	11.7	0.16	0.28
2010	0.36	19.2	0.26	0.50	0.40	16.6	0.27	0.58
2011	0.30	13.2	0.24	0.37	0.62	11.6	0.47	0.78
2012	0.43	13.8	0.33	0.55	0.28	13.3	0.21	0.35
2013	0.27	17.7	0.20	0.35	0.29	14.5	0.19	0.39
2014	0.15	12.3	0.10	0.20	0.16	18.2	0.12	0.20
2015	0.37	28.7	0.24	0.54	1.87	21.8	1.09	3.21
Bigelow, no calibration coefficient applied:								
2009	1.92	12.9	1.42	2.43	1.56	14.7	1.07	2.04
2010	2.92	18.2	1.77	4.07	2.87	20.8	1.55	4.19
2011	2.42	13.3	1.74	3.10	4.36	15.1	2.88	5.84
2012	3.50	18.0	1.69	5.31	1.96	15.8	1.22	2.71
2013	2.19	17.1	1.39	2.99	2.07	18.5	1.27	2.86
2014	1.20	22.7	0.43	1.98	1.14	15.0	0.74	1.54
2015	2.96	23.4	1.37	4.55	13.96	30.9	3.72	24.20

Table 20. Survey results from NEFSC offshore spring bottom trawl surveys in the southern management region (strata 1-19, 61-76). Indices are delta distribution stratified means.

	Biomass Index				Abundance Index								Length			of	Number	Nonzero	Nonzero
	Mean	CV	L95%	U95%	Mean	CV	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max	Fish	of Tows	Tows	Tows
1968	1.16	26.0	0.57	1.75	0.21	20.6	0.13	0.30	5.4	21	23	63	62.5	94	95	65	150	31	0.21
1969	0.96	27.6	0.44	1.47	0.22	19.2	0.14	0.30	4.1	7	25	47	54.3	91	111	41	155	31	0.20
1970	1.01	27.6	0.46	1.55	0.18	20.9	0.10	0.25	5.6	22	22	65	63.9	102	108	40	166	31	0.19
1971	0.77	30.0	0.32	1.22	0.20	24.8	0.10	0.30	3.7	13	16	50	53.3	101	115	42	160	24	0.15
1972	1.89	19.5	1.17	2.61	0.36	13.7	0.27	0.46	5.2	14	22	59	59.1	103	123	79	165	48	0.29
1973	1.90	13.8	1.54	2.25	1.05	9.3	0.85	1.25	2.2	11	19	32	41.1	80	110	589	187	128	0.68
1974	1.16	18.1	0.77	1.56	0.49	12.3	0.37	0.60	3.2	14	21	44	49.1	93	117	201	132	70	0.53
1975	0.95	20.4	0.57	1.32	0.45	13.8	0.33	0.57	2.8	10	22	44	47.6	87	107	169	134	61	0.46
1976	1.21	15.9	0.83	1.59	0.40	12.0	0.31	0.50	3.3	13	22	48	51.5	91	110	259	162	78	0.48
1977	1.21	18.2	0.77	1.64	0.30	11.3	0.23	0.37	4.6	16	21	51	56.8	95	116	173	160	75	0.47
1978	0.75	16.9	0.52	0.97	0.33	10.7	0.26	0.40	3.0	11	17	39	45.9	90	104	196	161	66	0.41
1979	0.76	26.2	0.46	1.05	0.28	21.2	0.16	0.40	2.9	10	14	37	44.4	98	124	125	194	50	0.26
1980	0.80	19.5	0.49	1.10	0.45	10.8	0.35	0.55	1.9	18	21	34	40.8	83	106	346	204	99	0.49
1981	1.82	18.5	1.16	2.47	0.78	15.8	0.54	1.03	2.6	12	22	40	44.6	89	113	345	141	74	0.52
1982	2.81	22.2	1.59	4.03	0.94	15.4	0.66	1.23	2.3	11	14	38	42.4	89	104	251	150	68	0.45
1983	0.95	28.5	0.42	1.49	0.27	17.8	0.18	0.36	3.5	24	24	47	51.8	97	112	55	147	36	0.24
1984	0.75	35.8	0.22	1.27	0.18	25.9	0.09	0.27	4.1	21	21	47	50.9	96	97	35	149	22	0.15
1985	0.33	36.9	0.09	0.57	0.16	28.0	0.07	0.25	2.1	22	22	39	42.3	85	90	31	147	21	0.14
1986	0.83	29.7	0.35	1.31	0.28	28.5	0.12	0.44	2.9	15	24	43	48.7	90	102	65	149	36	0.24
1987	0.50	52.4	-0.01	1.01	0.11	25.6	0.05	0.16	4.6	15	15	59	52.7	102	103	30	150	21	0.14
1988	0.43	15.0	0.30	0.55	0.44	17.9	0.29	0.60	1.0	17	18	30	34.0	61	82	67	132	33	0.25
1989	0.36	17.9	0.24	0.49	0.20	25.3	0.10	0.30	1.5	15	24	41	41.4	69	79	36	129	18	0.14
1990	1.00	22.3	0.57	1.44	0.21	13.2	0.15	0.26	4.0	16	21	53	56.5	86	93	39	128	23	0.18
1991	0.59	29.2	0.32	0.86	0.32	28.0	0.14	0.49	1.5	15	23	33	37.6	69	101	61	132	31	0.23
1992	0.21	34.1	0.07	0.35	0.18	25.5	0.09	0.27	1.2	14	19	28	35.0	69	85	28	128	17	0.13
1993	0.26	32.1	0.10	0.43	0.20	25.1	0.10	0.29	1.3	17	19	38	38.6	56	72	29	128	18	0.14
1994	0.32	29.1	0.14	0.50	0.11	24.9	0.06	0.17	2.4	13	13	41	44	91	93	24	131	18	0.14
1995	0.53	47.9	0.03	1.02	0.20	22.6	0.11	0.28	2.6	18	19	38	46	80	81	32	129	20	0.16
1996	0.29	25.1	0.15	0.43	0.14	22.9	0.07	0.20	2.1	9	9	44	44	80	81	27	143	20	0.14
1997	0.13	23.6	0.07	0.19	0.12	22.1	0.07	0.18	1.1	18	18	37	36	58	75	38	130	14	0.11
1998	0.28	16.7	0.19	0.37	0.25	15.9	0.17	0.33	1.1	12	16	35	36	64	77	40	131	30	0.23
1999	0.63	20.6	0.37	0.88	0.33	16.1	0.23	0.44	1.9	16	19	41	43	74	94	63	131	32	0.24
2000	0.29	19.8	0.18	0.41	0.24	18.3	0.15	0.33	1.2	14	14	38	38	61	78	32	131	25	0.19
2001	0.24	31.3	0.09	0.39	0.23	21.4	0.14	0.33	1.1	11	15	34	36	57	68	44	89	50	0.56
2002	0.37	32.8	0.13	0.62	0.32	35.6	0.10	0.54	1.2	22	23	37	39	53	62	50	91	50	0.55
2003	1.42	19.0	0.89	1.95	0.31	17.8	0.20	0.42	3.7	15	29	57	57	80	87	65	86	30	0.35
2004	0.19	34.9	0.06	0.32	0.12	27.1	0.05	0.18	1.6	22	21	37	40	61	62	24	88	36	0.41
2005	0.37	18.7	0.23	0.50	0.26	29.1	0.11	0.41	1.4	20	20	36	39	61	68	41	131	26	0.20
2006	0.54	30.6	0.22	0.86	0.17	22.3	0.10	0.25	3.1	24	15	37	53	80	80	28	132	20	0.15
2007	0.56	24.1	0.29	0.82	0.26	17.0	0.17	0.34	2.1	20	23	48	46	69	75	77	158	30	0.19
2008	0.39	32.9	0.14	0.64	0.19	31.3	0.07	0.30	2.1	17	17	41	46	64	84	32	140	19	0.14
2009	0.31	16.6	0.21	0.41	0.16	15.7	0.11	0.20	1.9	14	24	47	47.6	67	91	268	149	51	0.34
2010	0.23	26.4	0.11	0.35	0.16	26.1	0.08	0.25	1.3	15	17	38	40.0	70	85	207	151	56	0.37
2011	0.44	14.8	0.31	0.57	0.28	17.1	0.19	0.38	1.5	16	26	44	44.9	65	87	481	122	62	0.51
2012	0.36	13.0	0.27	0.45	0.30	11.0	0.24	0.37	1.2	10	24	39	40.8	61	88	517	142	84	0.59
2013	0.34	15.2	0.24	0.44	0.19	15.1	0.14	0.25	1.7	8	36	46	48.0	66	76	291	130	66	0.51
2014	0.25	24.6	0.13	0.37	0.15	16.9	0.10	0.19	1.7	28	27	39	45.1	73	77	134	53	32	0.60
2015	0.22	28.8	0.10	0.35	0.11	20.3	0.07	0.16	1.8	23	26	39	45.9	77	93	223	165	66	0.40

Bigelow, no calibration coefficient applied:

2009	2.47	16.6	1.7	3.3	1.11	15.7	0.8	1.5
2010	1.84	26.4	0.9	2.8	1.16	26.1	0.6	1.8
2011	3.55	14.8	2.5	4.6	2.03	17.1	1.3	2.7
2012	2.90	13.0	2.2	3.6	2.17	11.0	1.7	2.6
2013	2.72	15.2	1.9	3.5	1.37	15.1	1.0	1.8
2014	2.02	24.6	1.0	3.0	1.04	16.9	0.7	1.4
2015	1.79	28.8	0.8	2.8	0.79	20.3	0.5	1.1

Table 21. Survey results from NEFSC offshore spring bottom trawl surveys in the southern management region (strata 20-30, 34-40). Indices are arithmetic stratified means with bootstrapped variance estimates.

	Biomass Index				Abundance Index			
	Mean	CV	L95%	U95%	Mean	CV	L95%	U95%
1968	1.16	22.9	0.64	1.67	0.21	18.3	0.14	0.30
1969	0.92	23.5	0.53	1.39	0.23	20.5	0.15	0.32
1970	1.00	24.5	0.53	1.49	0.18	18.9	0.11	0.24
1971	0.76	26.9	0.40	1.18	0.21	24.1	0.12	0.31
1972	1.88	18.1	1.24	2.61	0.36	12.7	0.27	0.45
1973	1.82	7.8	1.55	2.10	1.14	8.0	0.96	1.32
1974	1.16	17.0	0.81	1.58	0.49	11.2	0.38	0.60
1975	0.91	14.9	0.65	1.19	0.44	12.5	0.34	0.56
1976	1.13	11.8	0.89	1.41	0.46	11.5	0.36	0.56
1977	1.16	14.5	0.86	1.52	0.34	10.3	0.28	0.42
1978	0.73	12.7	0.56	0.93	0.34	9.3	0.27	0.40
1979	0.70	16.3	0.48	0.94	0.33	15.7	0.23	0.42
1980	0.74	14.7	0.53	0.95	0.52	10.2	0.43	0.64
1981	1.74	15.1	1.23	2.24	0.93	12.1	0.72	1.15
1982	2.60	16.8	1.74	3.49	1.12	12.4	0.85	1.39
1983	0.95	26.7	0.52	1.46	0.27	15.7	0.19	0.36
1984	0.74	30.8	0.35	1.19	0.18	22.8	0.11	0.26
1985	0.33	31.4	0.15	0.57	0.16	25.9	0.08	0.25
1986	0.83	26.4	0.45	1.28	0.28	26.6	0.16	0.45
1987	0.50	48.7	0.15	1.03	0.11	23.0	0.06	0.16
1988	0.43	12.8	0.33	0.54	0.44	16.1	0.31	0.58
1989	0.36	15.5	0.26	0.48	0.24	21.5	0.15	0.35
1990	1.00	19.3	0.66	1.40	0.25	11.6	0.19	0.30
1991	0.58	24.3	0.32	0.89	0.39	24.5	0.23	0.59
1992	0.22	33.4	0.10	0.38	0.18	23.8	0.10	0.27
1993	0.26	27.2	0.13	0.41	0.20	24.2	0.11	0.29
1994	0.33	29.8	0.16	0.53	0.14	22.4	0.08	0.20
1995	0.52	39.7	0.17	0.93	0.20	20.5	0.12	0.27
1996	0.28	19.3	0.18	0.39	0.14	19.3	0.09	0.19
1997	0.13	20.5	0.08	0.19	0.12	20.4	0.08	0.18
1998	0.28	14.8	0.20	0.37	0.25	14.6	0.19	0.34
1999	0.64	19.9	0.41	0.89	0.34	14.2	0.25	0.43
2000	0.30	18.7	0.19	0.41	0.24	16.5	0.17	0.32
2001	0.26	31.9	0.12	0.44	0.24	20.1	0.14	0.33
2002	0.38	31.2	0.18	0.62	0.32	33.6	0.15	0.54
2003	1.38	15.0	0.99	1.79	0.37	15.5	0.26	0.49
2004	0.18	26.4	0.10	0.28	0.12	24.2	0.06	0.17
2005	0.37	16.6	0.26	0.50	0.26	26.6	0.15	0.41
2006	0.54	27.4	0.29	0.87	0.17	19.6	0.11	0.24
2007	0.55	22.0	0.35	0.82	0.26	15.0	0.19	0.33
2008	0.39	31.8	0.19	0.66	0.19	31.3	0.10	0.32
2009	0.30	15.3	0.21	0.40	0.16	13.9	0.11	0.20
2010	0.22	19.5	0.14	0.29	0.16	21.5	0.10	0.23
2011	0.42	11.4	0.34	0.52	0.28	13.6	0.21	0.36
2012	0.35	10.6	0.28	0.43	0.30	8.5	0.25	0.35
2013	0.34	14.4	0.25	0.44	0.20	16.5	0.14	0.27
2014	0.25	18.3	0.16	0.34	0.14	12.7	0.11	0.18
2015	0.20	18.6	0.13	0.27	0.11	15.2	0.08	0.14
Bigelow, no calibration coefficient applied:								
2009	2.45	15.9	1.77	3.30	1.11	14.5	0.80	1.44
2010	1.73	19.0	1.12	2.41	1.15	22.1	0.67	1.68
2011	3.41	10.7	2.73	4.16	1.99	13.8	1.49	2.53
2012	2.86	10.6	2.26	3.48	2.14	8.7	1.77	2.51
2013	2.76	14.5	2.05	3.59	1.43	16.8	1.00	1.93
2014	2.03	18.6	1.32	2.75	1.03	13.3	0.76	1.28
2015	1.58	17.1	1.11	2.22	0.77	15.4	0.55	1.01

Table 22. Survey results from NEFSC offshore winter bottom trawl surveys in the southern management region (strata 1-19, 61-76). Indices are delta distribution stratified means. The winter survey was discontinued after 2007.

	Biomass			Abundance														
	Raw Index			Raw Index				Length						Number		Number of	Proportion
	Mean	L95%	U95%	Mean	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max	of Fish	Number of Tows	Nonzero Tows	Nonzero Tows
1992	5.395	3.57	7.22	5.176	3.78	6.57	0.99	11	22	33	35.9	52	95	583	110	66	0.60
1993	7.954	4.01	11.90	5.002	3.95	6.05	1.19	9	21	36	37.7	53	98	585	109	77	0.71
1994	3.080	1.93	4.23	2.534	1.91	3.16	1.08	8	16	31	35.2	61	78	278	82	56	0.68
1995	3.398	2.32	4.48	2.738	1.88	3.59	1.24	19	21	36	37.8	57	101	390	123	76	0.62
1996	5.708	4.69	6.73	3.779	3.04	4.52	1.50	10	24	39	41.1	61	100	554	123	87	0.71
1997	5.472	4.15	6.79	3.172	2.57	3.78	1.67	10	20	43	42.0	62	91	455	119	89	0.75
1998	2.851	2.08	3.62	1.416	1.11	1.72	1.98	10	20	42	44.9	69	103	240	134	77	0.57
1999	3.792	2.92	4.67	2.803	2.22	3.38	1.34	10	18	35	38.3	61	87	459	138	83	0.60
2000	5.786	4.15	7.43	4.516	3.27	5.76	1.26	11	22	37	39.1	57	96	664	123	93	0.76
2001	8.227	4.48	11.97	4.346	3.13	5.56	1.45	8	19	37	40.0	60	84	1042	167	115	0.69
2002	7.430	5.74	9.12	3.978	3.19	4.77	1.82	15	28	43	45.2	65	86	737	153	113	0.74
2003	7.108	5.14	9.08	3.458	2.64	4.27	2.05	12	23	47	46.4	67	85	698	99	72	0.73
2004	8.074	5.27	10.87	4.673	3.16	6.18	1.67	13	22	40	42.5	66	88	896	135	103	0.76
2005	5.224	3.36	7.09	3.308	2.38	4.23	1.55	13	21	38	40.7	67	90	504	99	67	0.68
2006	7.143	5.39	8.90	4.046	3.27	4.82	1.74	20	27	42	44.2	64	92	1032	127	91	0.72
2007	5.291	4.38	6.20	2.287	1.96	2.62	2.28	12	24	50	49.1	65	91	587	132	97	0.73

Table 23. Arithmetic indices for winter survey.

	Biomass			Abundance		
	Raw Index			Raw Index		
	Mean	L95%	U95%	Mean	L95%	U95%
1992	4.87	3.99	5.72	4.94	4.11	5.73
1993	5.82	4.84	6.85	4.90	4.13	5.72
1994	2.69	2.04	3.33	2.50	2.01	3.00
1995	3.58	2.46	5.03	2.88	2.04	3.90
1996	5.76	4.78	6.98	3.85	3.13	4.69
1997	5.26	4.21	6.24	3.15	2.73	3.61
1998	2.82	2.13	3.56	1.42	1.13	1.68
1999	3.80	3.00	4.65	2.83	2.26	3.45
2000	5.49	4.45	6.74	4.35	3.56	5.25
2001	6.18	4.92	7.44	4.26	3.32	5.33
2002	7.33	6.03	8.71	4.02	3.28	4.78
2003	7.14	5.57	8.93	3.48	2.82	4.13
2004	7.61	5.77	9.51	4.55	3.58	5.78
2005	5.41	3.65	7.80	3.49	2.49	4.86
2006	7.28	5.61	9.09	4.19	3.34	5.30
2007	5.24	4.41	6.08	2.30	2.03	2.60

Table 24. Survey results from NEFSC offshore scallop dredge surveys in the southern management region (shellfish strata 6, 7, 10, 11, 14, 15, 18, 19, 22-31, 33-35, 46, 47, 55, 58-61, 621, 631). Indices are delta distribution stratified means. Biomass indices are not calculated for the dredge surveys.

	Abundance Index				Length						Number of	Number	Number of Nonzero	Proportion Nonzero
	Mean	CV	L95%	U95%	Min	5%	50%	Mean	95%	Max	Fish	of Tows	Tows	Tows
1984	1.29	7.0	1.11	1.46	6	11	28	29.5	54	82	410	254	165	0.65
1985	1.52	8.9	1.26	1.79	7	9	25	28.7	53	84	493	282	183	0.65
1986	1.25	8.2	1.05	1.45	8	10	15	22.9	54	95	431	296	183	0.62
1987	3.15	6.2	2.77	3.54	8	9	13	18.6	51	90	1253	315	255	0.81
1988	1.67	8.6	1.39	1.95	7	12	28	29.8	49	97	572	316	187	0.59
1989	1.00	8.3	0.83	1.16	6	10	31	31.9	53	101	303	304	147	0.48
1990	1.53	6.5	1.34	1.73	6	10	18	24.4	54	94	563	303	205	0.68
1991	2.28	6.5	1.99	2.57	7	9	14	21.0	45	94	808	315	241	0.77
1992	1.94	7.3	1.66	2.22	5	9	25	27.3	52	97	644	316	235	0.74
1993	2.85	5.0	2.57	3.12	8	10	15	21.8	48	73	995	301	258	0.86
1994	3.40	5.9	3.01	3.80	8	10	15	22.2	51	87	1145	314	265	0.84
1995	2.26	6.6	1.97	2.56	7	9	27	29.6	57	92	764	314	243	0.77
1996	2.01	6.6	1.75	2.27	7	9	23	29.9	59	81	638	298	226	0.76
1997	1.11	7.2	0.95	1.27	7	13	33	36.7	65	76	388	313	196	0.63
1998	1.01	7.0	0.88	1.15	6	11	20	30.2	61	79	371	319	183	0.57
1999	2.59	8.5	2.16	3.02	6	10	16	23.5	55	84	856	306	248	0.81
2000	2.24	6.1	1.97	2.51	8	9	18	27.3	54	87	832	315	240	0.76
2001	1.71	6.7	1.48	1.94	7	8	35	36.0	64	77	549	334	233	0.70
2002	1.71	6.6	1.49	1.93	7	11	35	34.2	60	86	598	310	203	0.65
2003	2.78	7.1	2.39	3.17	6	9	15	24.4	58	87	819	294	211	0.72
2004	2.88	6.5	2.51	3.24	9	11	26	29.8	61	83	860	348	290	0.83
2005	2.01	6.6	1.75	2.27	8	10	28	31.3	56	83	859	344	265	0.77
2006	1.45	6.1	1.27	1.62	7	7	29	31.1	61	83	571	327	230	0.70
2007	0.83	8.2	0.69	0.96	7	12	39	40.2	69	84	366	336	183	0.54
2008	1.00	8.9	0.83	1.18	7	7	26	31.3	68	75	350	285	162	0.57
2009	0.79	9.8	0.63	0.94	6	10	25	30.9	65	80	248	269	133	0.49
2010	0.74	9.9	0.59	0.88	7	8	35	35.9	59	77	212	275	135	0.49
2011	0.93	12.5	0.70	1.16	8	10	29	32.6	57	75	204	203	112	0.55
2012	1.32	8.4	1.10	1.54	6	8	32	33.0	55	70	170	132	84	0.64
2013	1.10	12.3	0.84	1.37	7	7	32	30.0	61	68	125	113	68	0.60
2014	0.90	14.7	0.64	1.16	11	10	33	34.1	62	65	43	51	27	0.53
2015	2.44	20.5	1.46	3.42	1	7	11	19.9	54	60	224	84	54	0.64

Table 25. Survey results from NEFSC offshore scallop dredge surveys in the southern management region (shellfish strata 6, 7, 10, 11, 14, 15, 18, 19, 22-31, 33-35, 46, 47, 55, 58-61, 621, 631). Indices are arithmetic stratified means with bootstrapped variance estimates.

	Abundance Index			
	Mean	CV	L95%	U95%
1984	1.34	7.4	1.16	1.53
1985	1.57	8.4	1.34	1.86
1986	1.29	8.0	1.08	1.50
1987	3.17	5.4	2.81	3.51
1988	1.69	6.8	1.47	1.93
1989	1.00	7.7	0.85	1.16
1990	1.53	5.7	1.37	1.71
1991	2.26	5.8	2.01	2.52
1992	1.95	6.7	1.70	2.21
1993	2.83	4.5	2.59	3.09
1994	3.33	4.8	3.01	3.64
1995	2.26	6.3	2.00	2.55
1996	2.01	6.4	1.78	2.28
1997	1.12	6.9	0.98	1.28
1998	1.03	7.1	0.89	1.17
1999	2.57	7.3	2.23	2.94
2000	2.27	7.2	1.98	2.61
2001	1.72	6.4	1.50	1.93
2002	1.69	5.8	1.49	1.88
2003	2.75	6.0	2.44	3.09
2004	2.89	6.5	2.53	3.27
2005	2.02	6.6	1.78	2.27
2006	1.44	6.1	1.29	1.61
2007	0.83	8.2	0.70	0.95
2008	1.01	8.9	0.84	1.17
2009	0.78	9.8	0.65	0.92
2010	0.74	9.9	0.61	0.87
2011	0.94	12.5	0.73	1.12
2012	1.33	8.4	1.14	1.52
2013	1.10	12.3	0.88	1.34
2014	0.90	14.7	0.68	1.11
2015	2.53	20.5	1.51	3.99

Table 26. Area-swept estimates of minimum biomass and abundance for monkfish based on NEFSC fall surveys. Estimates assume that 100% of monkfish encountered by the trawl are captured. (A) total population, (B) exploitable biomass.

A. Total population

	North		South	
	Numbers (thousands)	Weight (mt)	Numbers (thousands)	Weight (mt)
2009	7,490	9,565	6,402	7,908
2010	9,841	13,838	11,823	12,006
2011	12,085	17,958	17,499	9,721
2012	12,960	17,289	8,085	14,407
2013	13,860	13,221	8,470	8,992
2014	17,059	15,346	4,663	4,927
2015	23,512	24,814	57,471	12,197

B. Exploitable population (≥ 43 cm)

	North		South	
	Numbers (thousands)	Weight (mt)	Numbers (thousands)	Weight (mt)
2009	2,803	8,326	2,121	6,613
2010	3,450	10,774	3,278	9,542
2011	5,114	16,238	2,855	6,682
2012	4,750	15,274	3,700	10,821
2013	3,108	10,041	3,147	8,185
2014	3,576	11,202	1,309	3,480
2015	5,960	20,020	1,211	3,194

Table 27. Relative exploitation indices based on numbers landed and area-swept estimates of minimum abundance of exploitable monkfish from NEFSC fall surveys. Estimates assume that 100% of monkfish encountered by the trawl are captured.

	North	Landings (millions of fish)	Relative exploitation
Bigelow	2009	1.066363	0.38
	2010	0.819147	0.24
	2011	0.970042	0.19
	2012	1.390334	0.29
	2013	1.108966	0.36
	2014	1.139312	0.32
	2015	1.455929	0.24

	South	Landings (millions of fish)	Relative exploitation
Bigelow	2009	1.282379	0.51
	2010	1.094880	0.30
	2011	1.235961	0.39
	2012	1.438548	0.30
	2013	1.398071	0.43
	2014	1.243386	0.72
	2015	1.057866	0.63

Table 28. Relative exploitation indices (catch in numbers/abundance index) for monkfish based on fall, spring, shrimp, and scallop surveys.

	North	Catch (millions of fish)	Fall Survey Relative F	Spring Survey Relative F	Shrimp Survey Relative F
Albatross	1994	5.602087	4.2	10.3	1.64
	1995	5.700661	6.1	5.6	2.74
	1996	7.032969	11.1	10.6	2.35
	1997	4.764853	9.6	13.9	3.03
	1998	3.792122	6.1	9.1	1.79
	1999	4.847727	4.5	5.9	0.72
	2000	3.950481	1.7	3.5	0.69
	2001	4.588402	2.9	2.7	0.42
	2002	5.207431	4.1	3.0	0.45
	2003	5.850707	5.5	6.0	1.01
	2004	4.649597	8.9	5.1	1.38
	2005	3.508406	5.9	4.9	0.67
	2006	2.572532	3.3	7.0	0.60
	2007	1.891003	2.9	3.4	0.42
	2008	1.500083	1.9	2.2	0.53
Bigelow	2009	1.559159	4.0	4.7	0.50
	2010	1.168746	2.3	3.1	0.46
	2011	1.445272	2.2	3.1	0.64
	2012	1.995398	2.9	3.7	0.56
	2013	1.724258	2.4	3.1	0.42
	2014	1.865081	2.0	3.0	0.38
	2015	0.79759	0.7	1.5	0.29

	South	Catch (millions of fish)	Fall Survey Relative F	Spring Survey Relative F	Scallop Survey Relative F
Albatross	1994	8.171882	13.7	59.6	2.5
	1995	8.400046	17.0	42.8	3.7
	1996	7.117875	30.3	52.6	3.5
	1997	8.227080	26.7	66.5	7.4
	1998	7.051910	21.2	27.7	6.9
	1999	5.807313	12.9	17.3	2.3
	2000	5.645715	13.4	23.3	2.5
	2001	6.432756	17.0	27.3	3.7
	2002	5.312109	6.4	16.7	3.2
	2003	5.170862	5.4	13.9	1.9
	2004	4.252442	9.0	36.5	1.5
	2005	4.548955	7.9	17.6	2.3
	2006	3.667069	8.1	21.3	2.5
	2007	3.091468	15.8	12.0	3.7
	2008	2.627670	13.3	13.8	2.6
Bigelow	2009	2.142482	9.7	13.7	2.7
	2010	2.636741	6.6	16.4	3.6
	2011	2.659532	4.3	9.5	2.8
	2012	3.346252	11.8	11.1	2.5
	2013	2.456238	8.6	12.3	2.2
	2014	2.489241	15.4	17.3	2.8
	2015	2.304526	1.2	21.3	0.9

Table 29. Application of method used to set catch limits for Georges Bank cod applied to monkfish (described in text). (A.) based on trends in the NEFSC fall survey only, (B.) based on trends in the NEFSC fall and spring surveys averaged.

A. NEFSC fall survey indices

Year	North ln(index)	South ln(index)
2013	-0.28	-1.53
2014	-0.22	-1.72
2015	-0.17	-1.98
% change	106%	80%

B. NEFSC spring and fall surveys averaged

Year	North ln(index)	South ln(index)
2013	-0.36	-1.40
2014	-0.35	-1.52
2015	-0.33	-1.68
% change	102%	87%

Figures

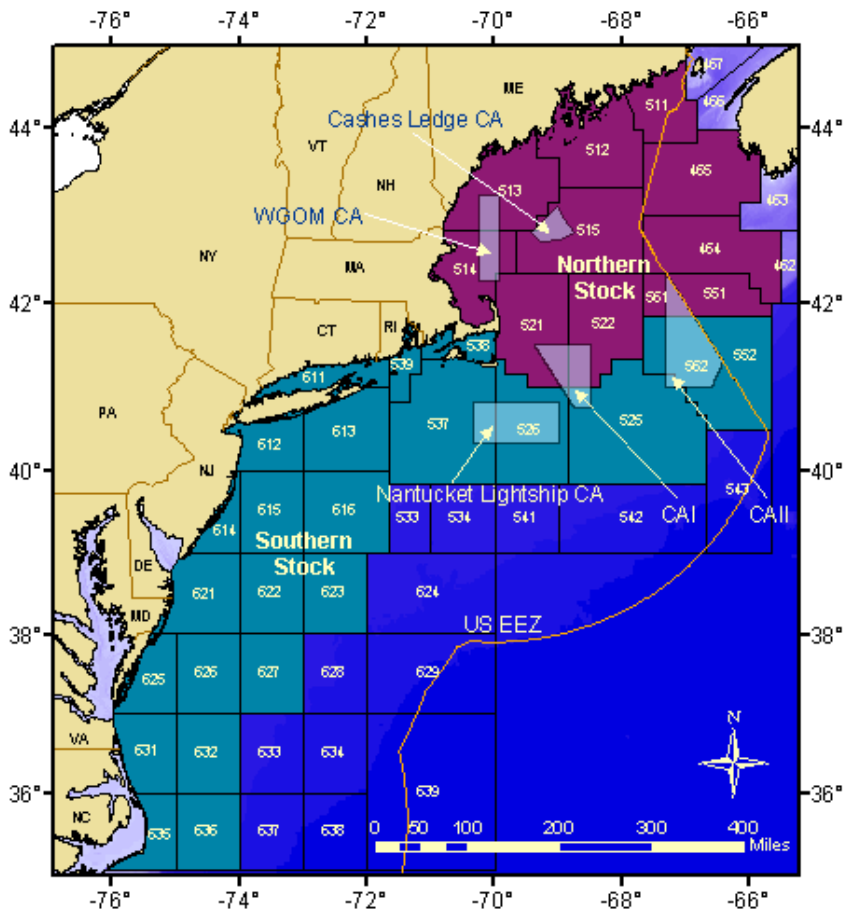


Figure 1. Fishery statistical areas used to define northern and southern monkfish management areas.

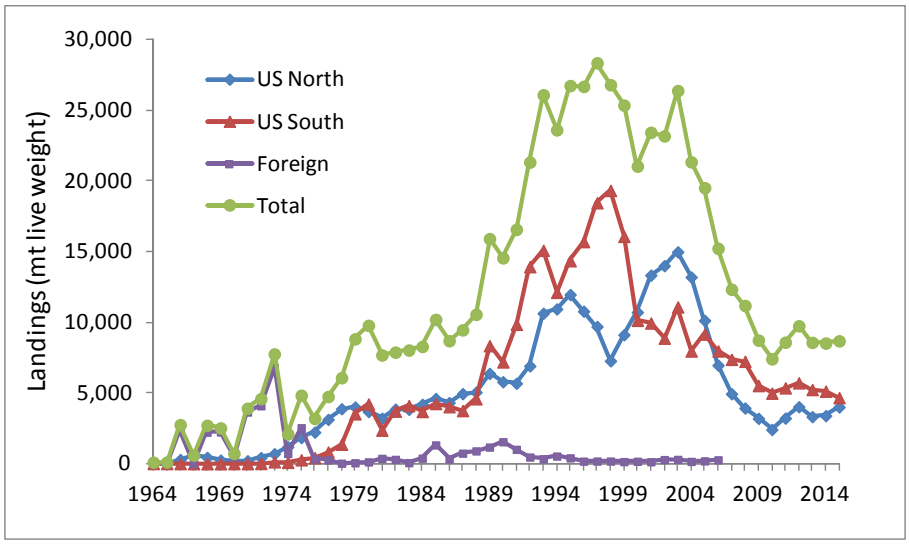


Figure 2. Monkfish landings by management area and combined areas, 1964-2015.

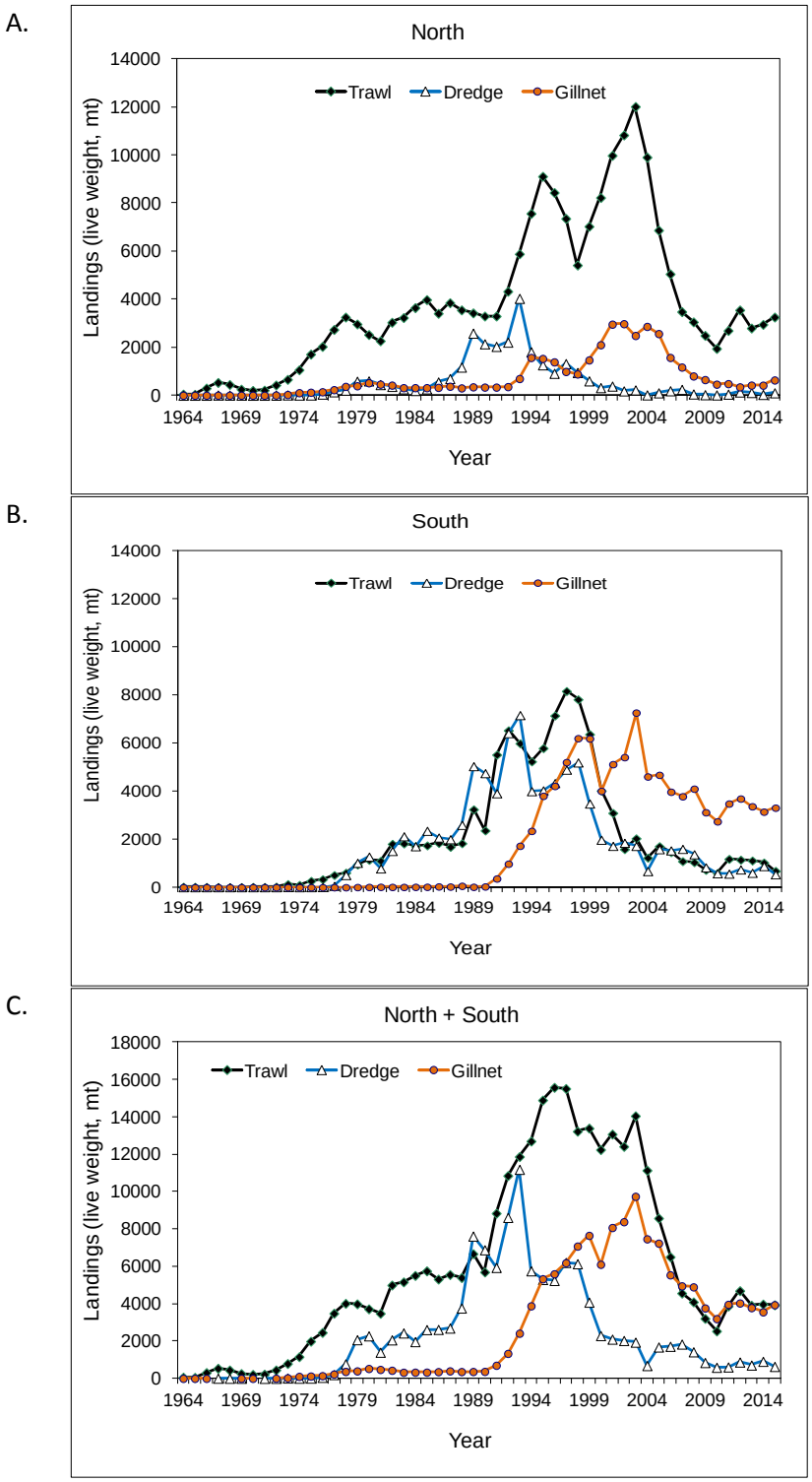


Figure 3. Commercial landings of monkfish by gear type and management area, 1964-2015. A. northern management area, B. southern management area, C. management areas combined.

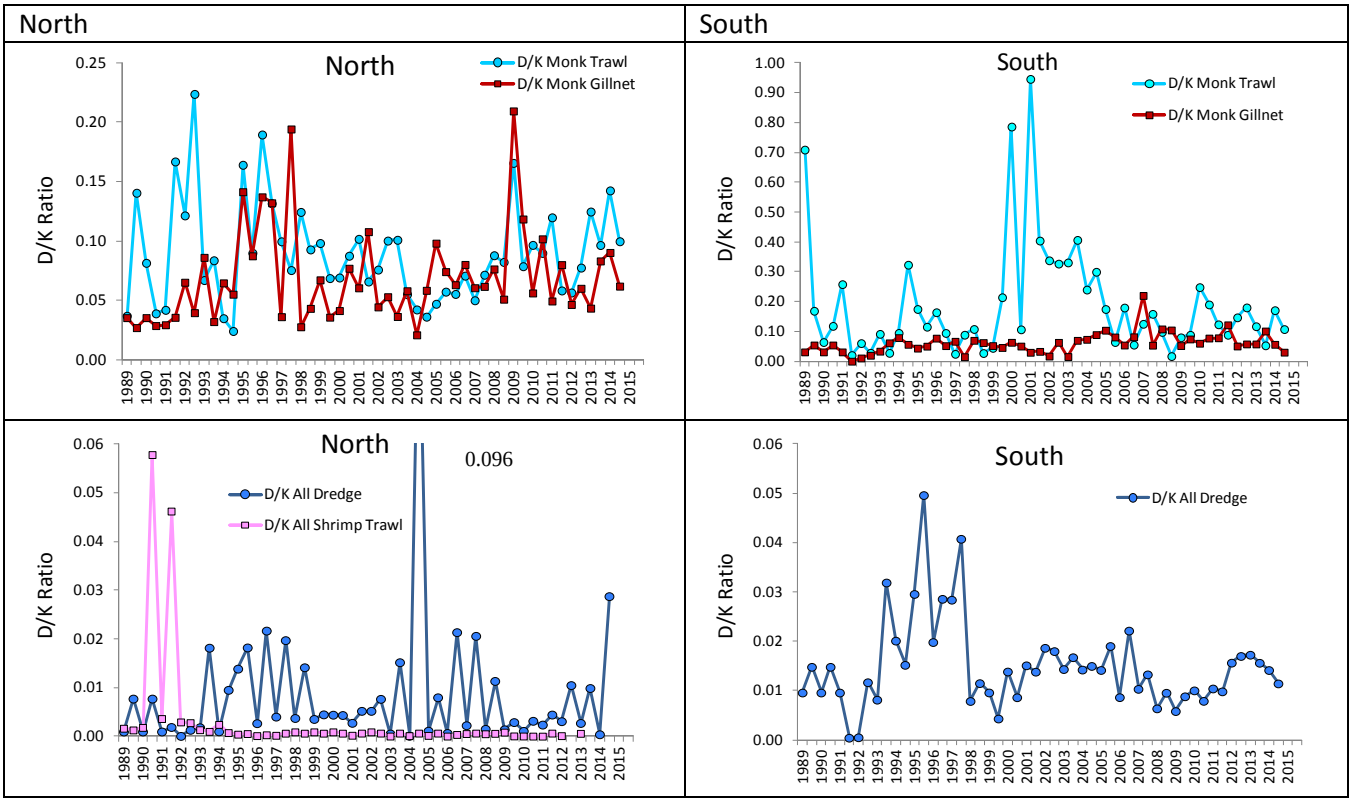


Figure 4. Discard ratios by half year for trawls and gillnets (top panels) and dredges and shrimp trawls (bottom panels) for North (left column) and South (right column). Trawls and gillnets ratios were based on kept monkfish; dredge and shrimp trawl were based on kept of all species.

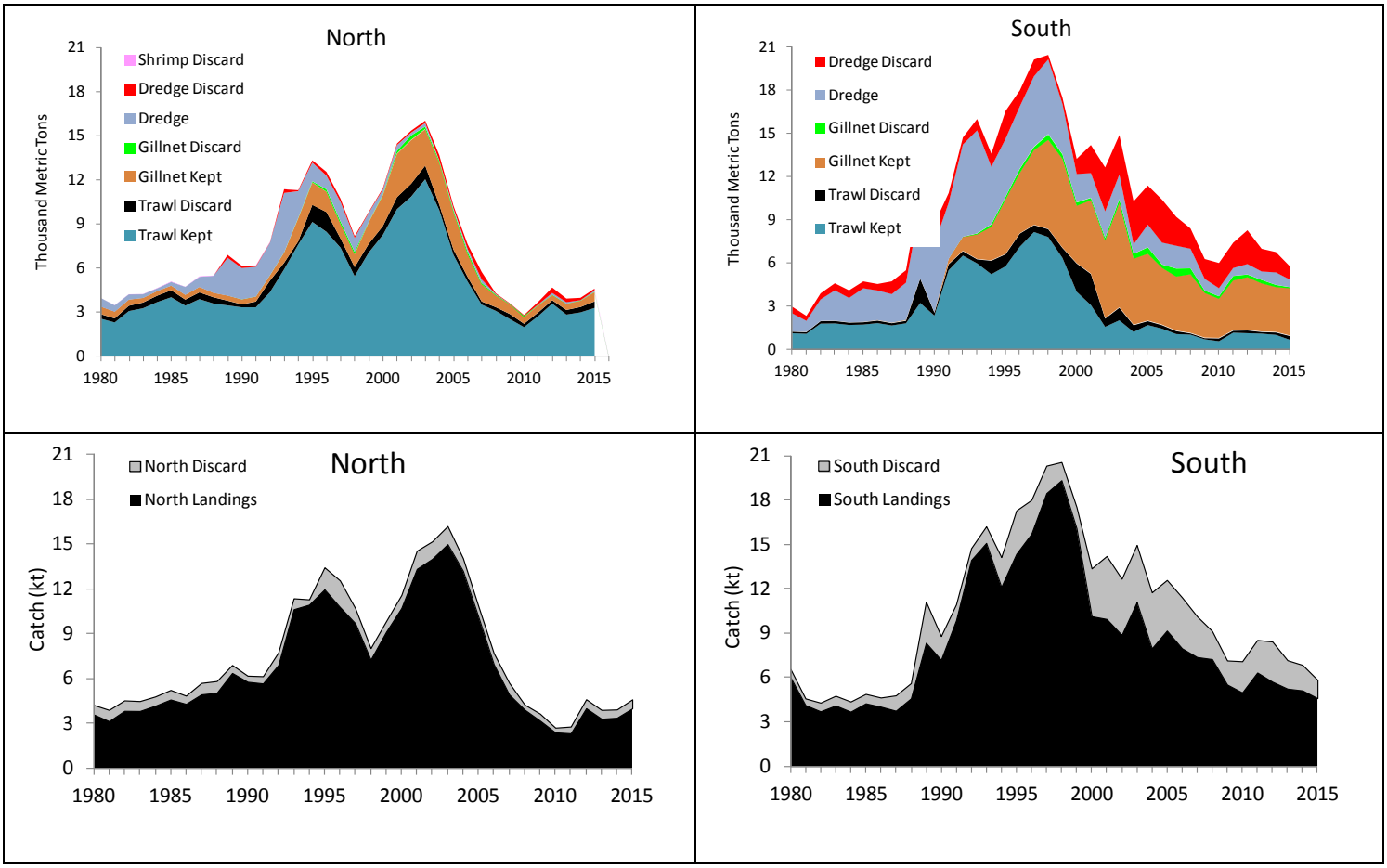


Figure 5. Monkfish landings and discard by gear type (top panels) and total (bottom panels) for North (left) and South (right).

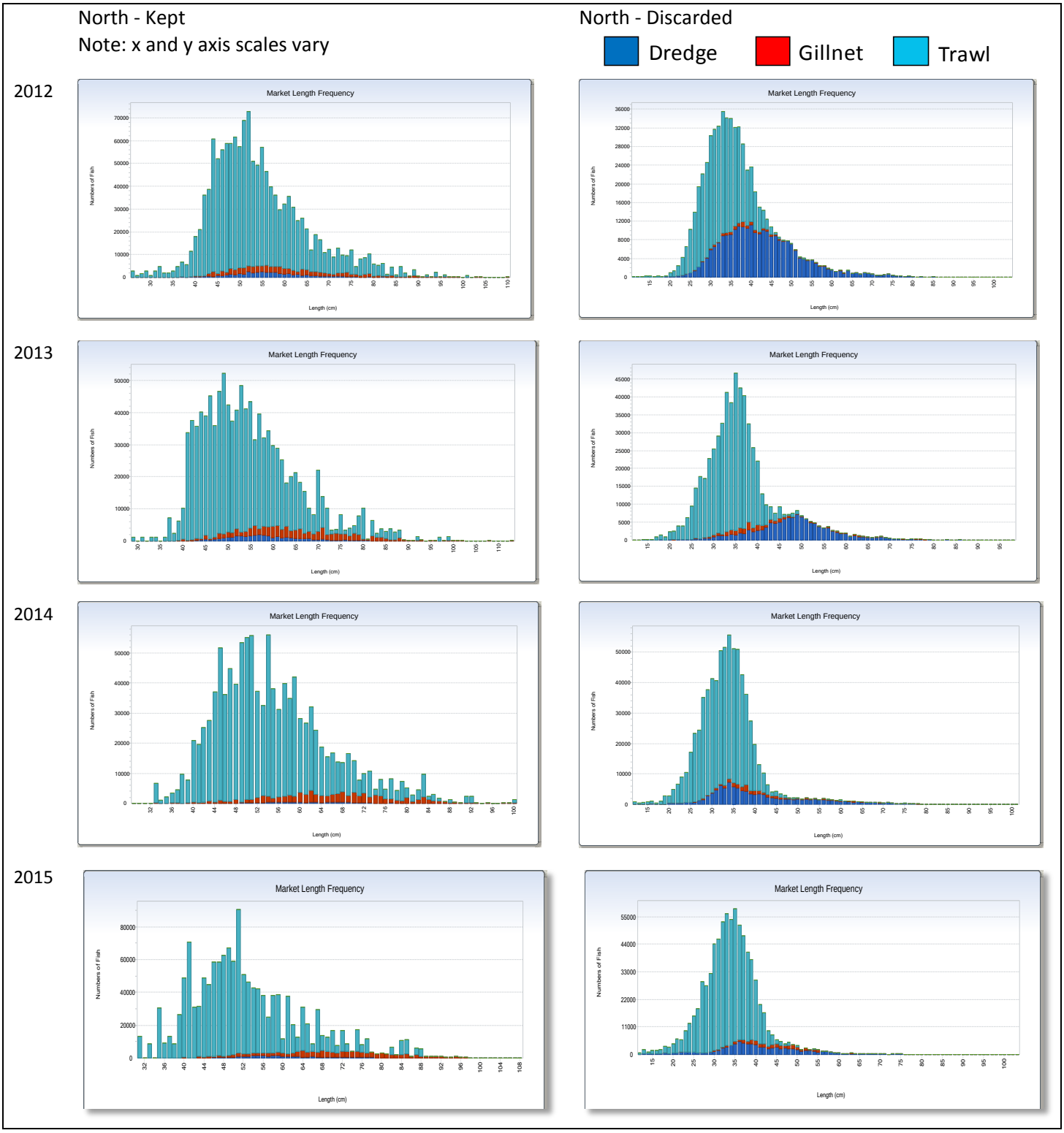


Figure 6. Estimated length composition of kept and discarded monkfish by gear type in the northern management area.

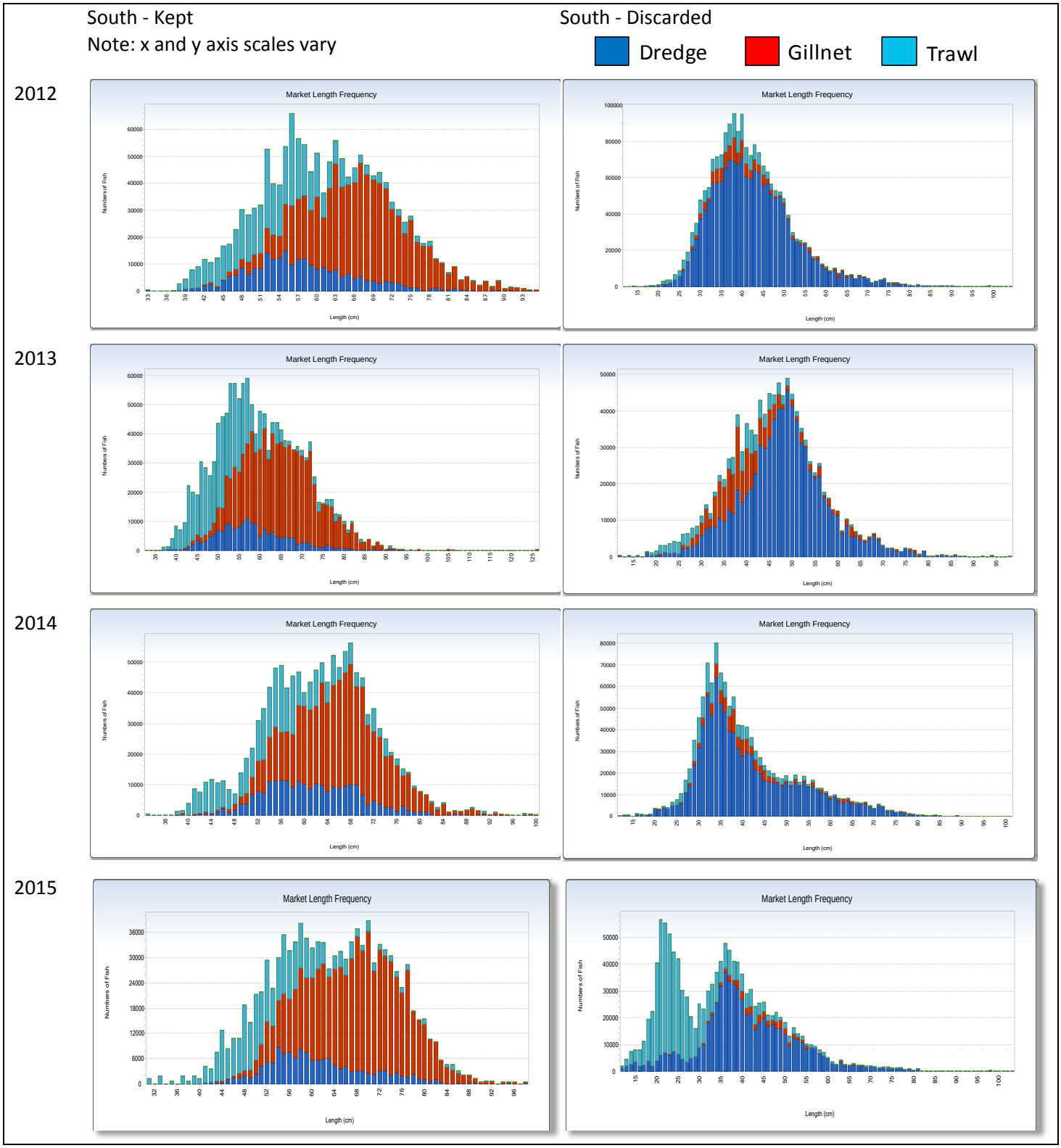


Figure 7. Estimated length composition of kept and discarded monkfish by gear type in the southern management area.

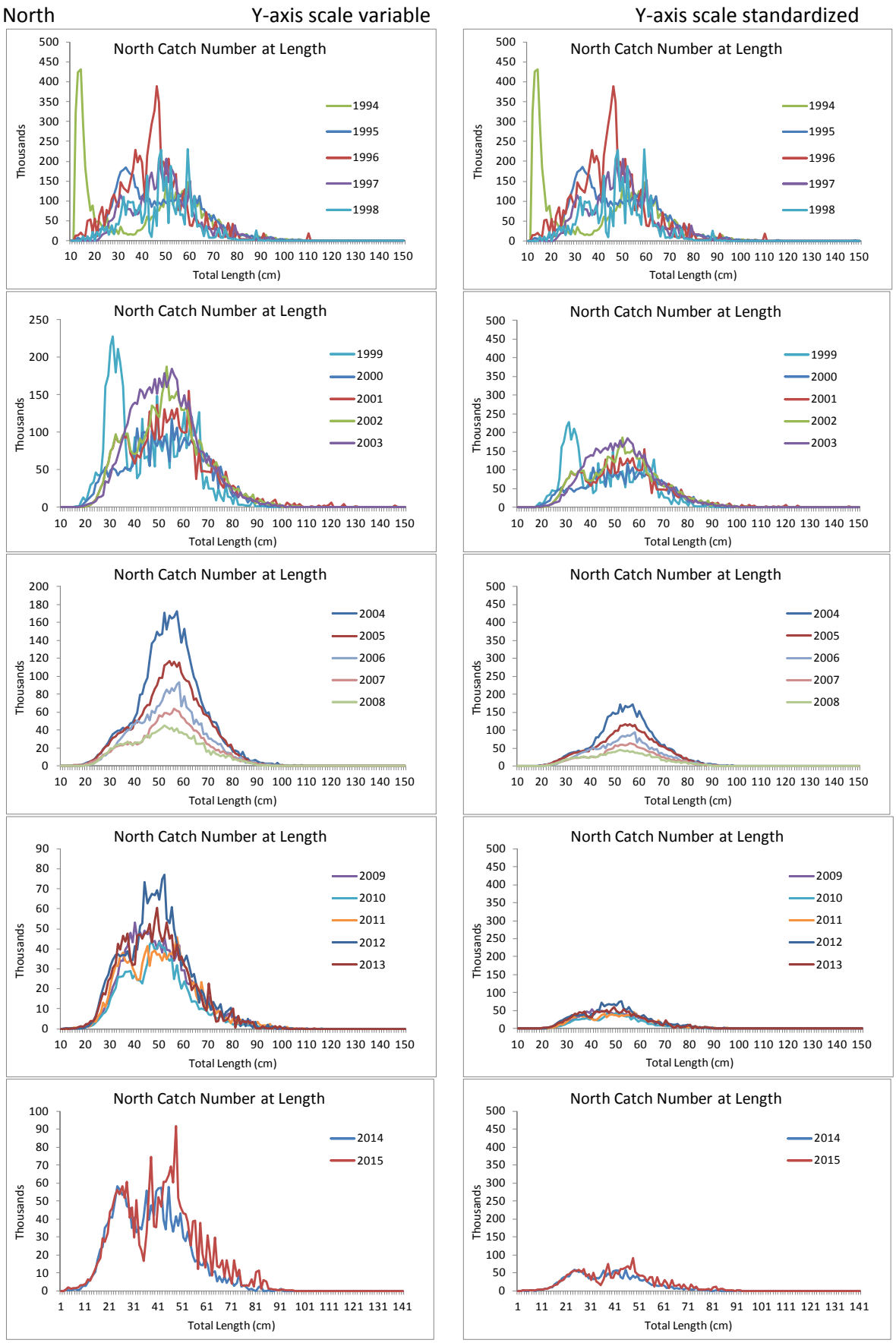


Figure 8. Estimated length composition of commercial monkfish catch, northern management area.

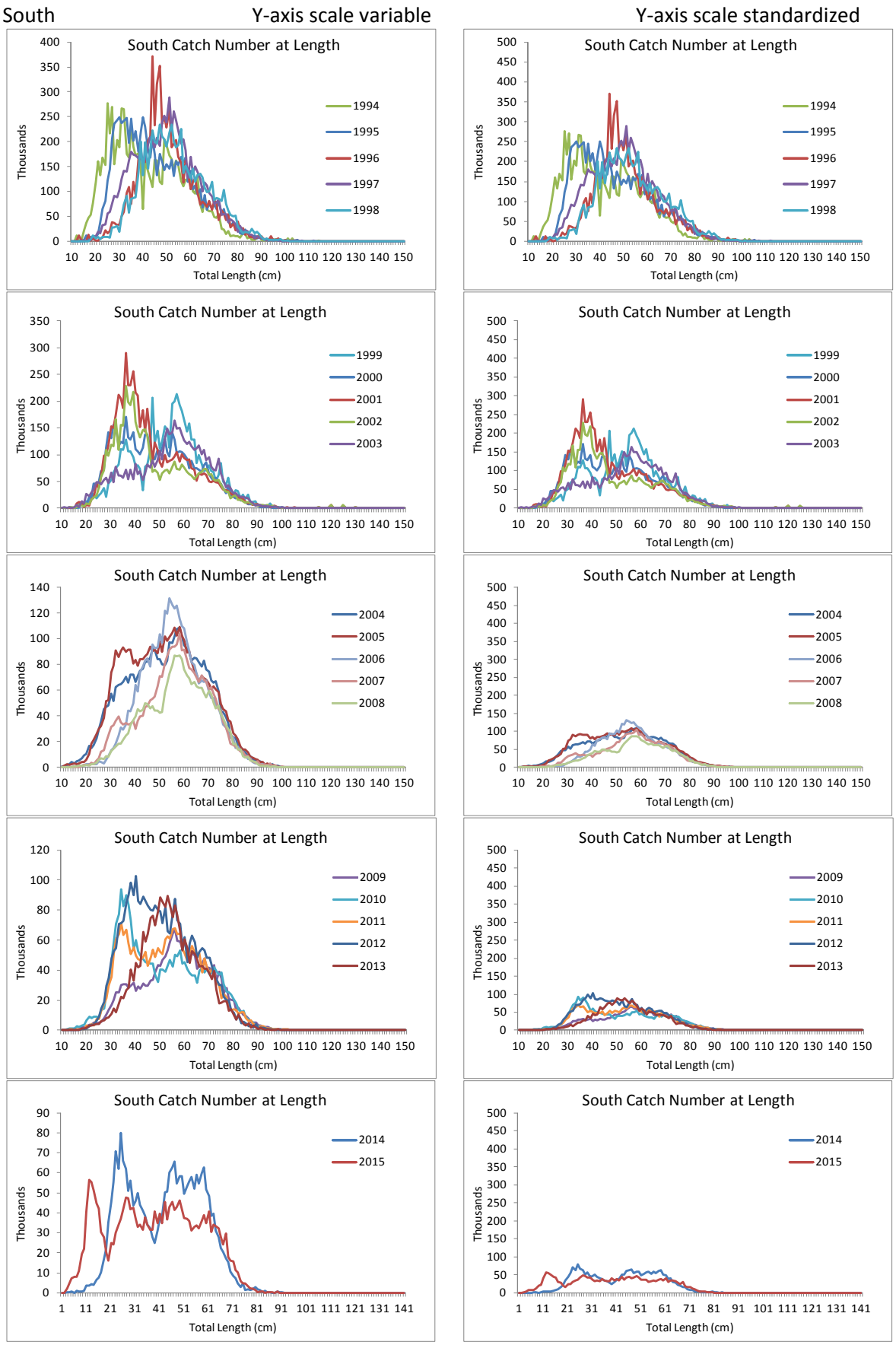


Figure 9. Length composition of monkfish commercial catch estimated using length frequency data collected by fishery observers in the southern management area.

North

Biomass Abundance

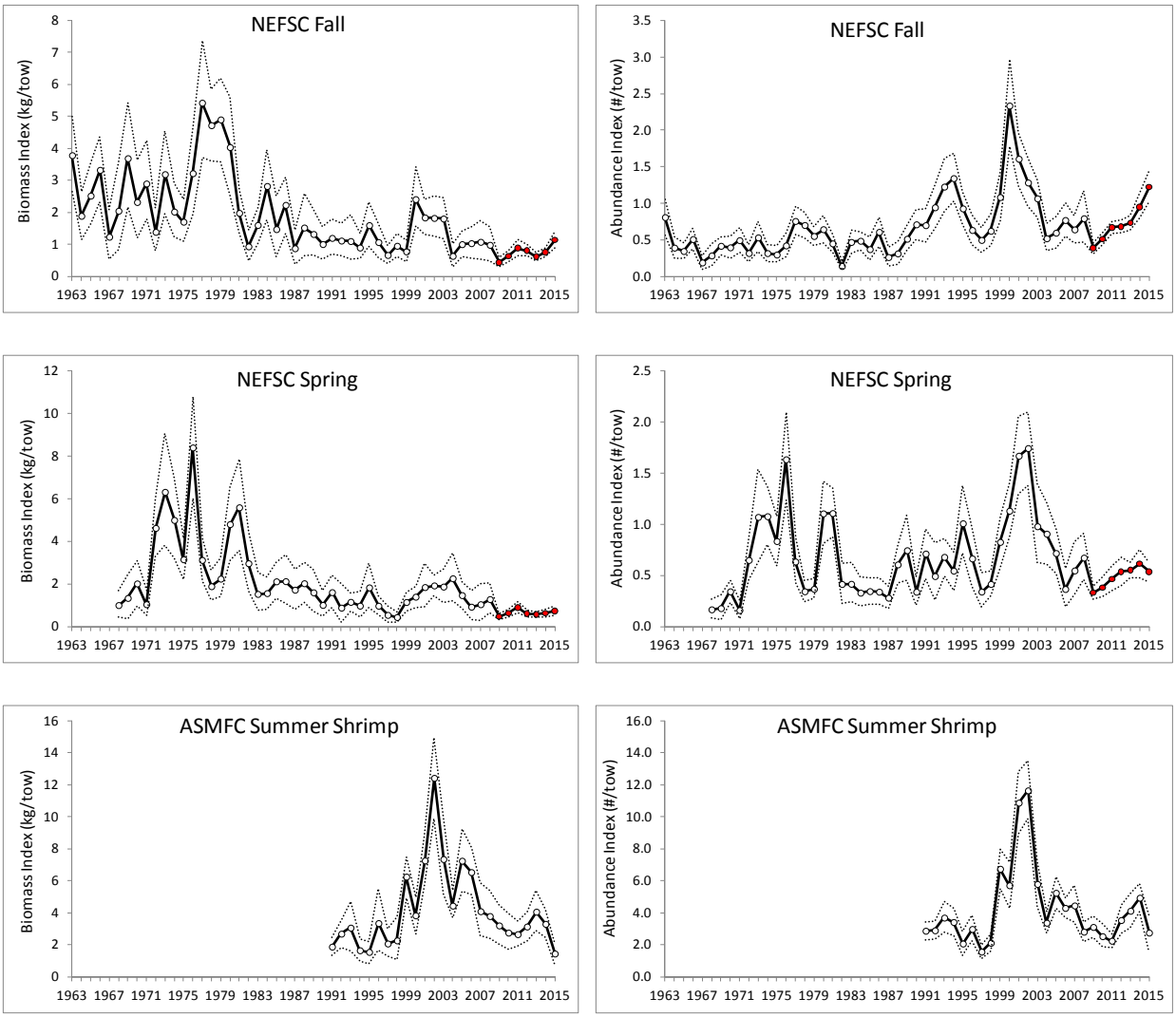


Figure 10. Survey indices for monkfish in the northern management area. Red-filled points are NEFSC surveys conducted on the FSV Bigelow (after 2008), converted to Albatross units as described in the text.

North

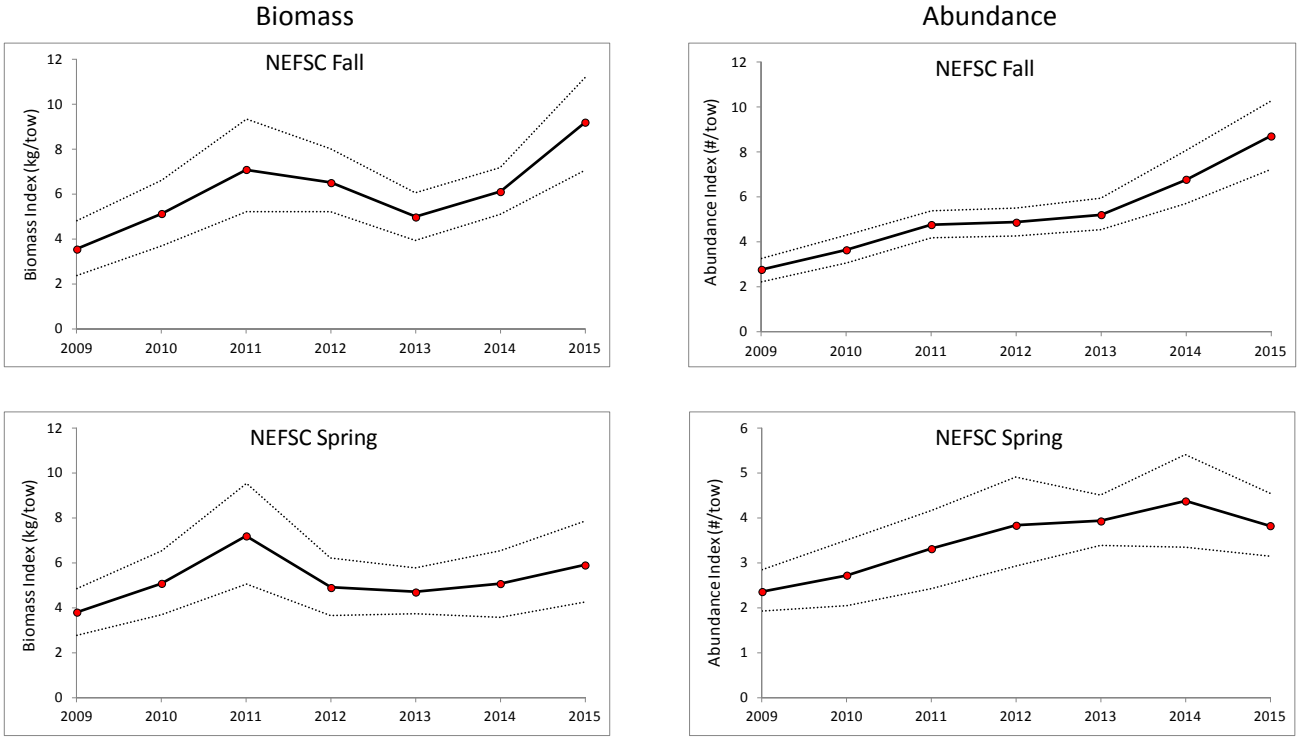


Figure 11. Survey indices from surveys conducted on the FRSV Bigelow in the northern management area, not converted to Albatross units. Note: y-axis scale varies.

North

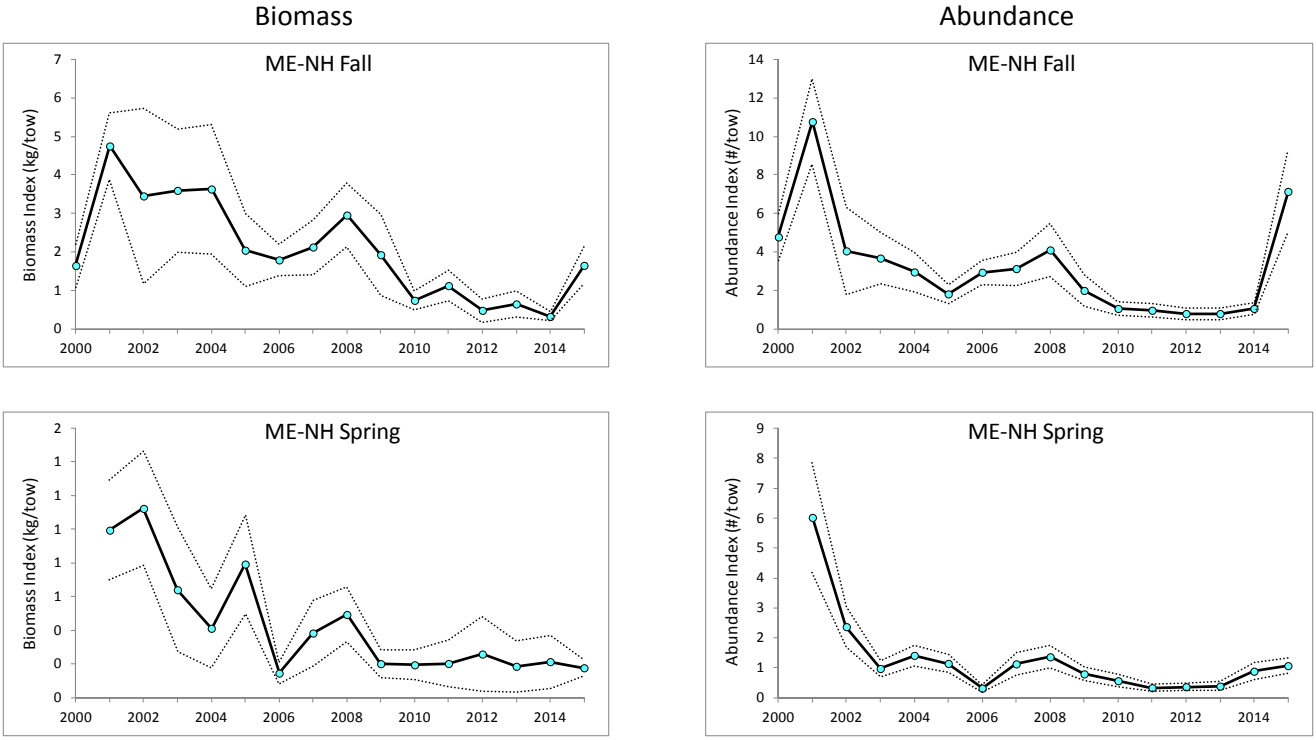


Figure 12. Survey indices for monkfish from Maine-New Hampshire inshore surveys. Data courtesy of Maine Department of Marine Resources.

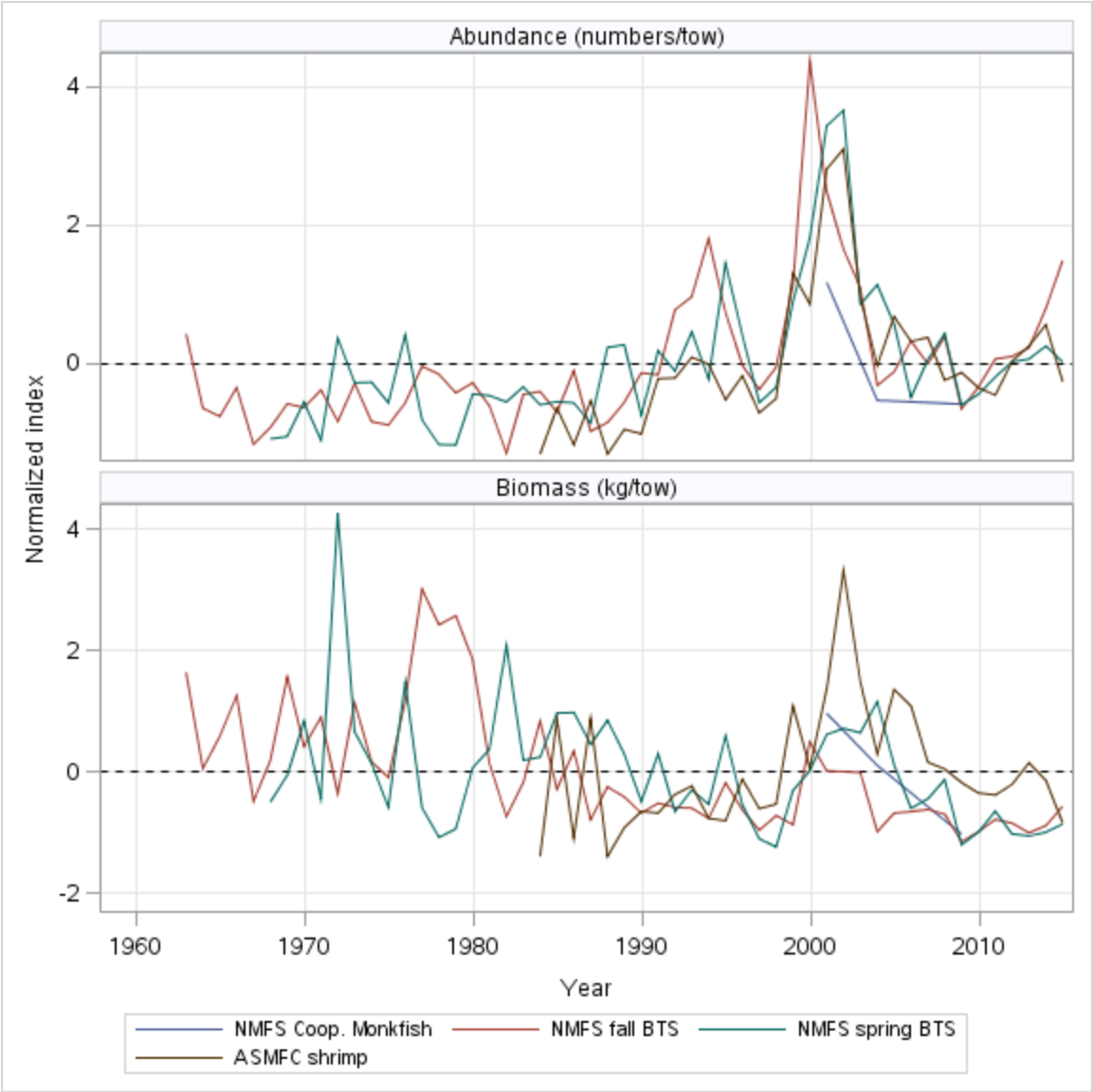


Figure 13. Normalized survey indices for monkfish in the northern management area.

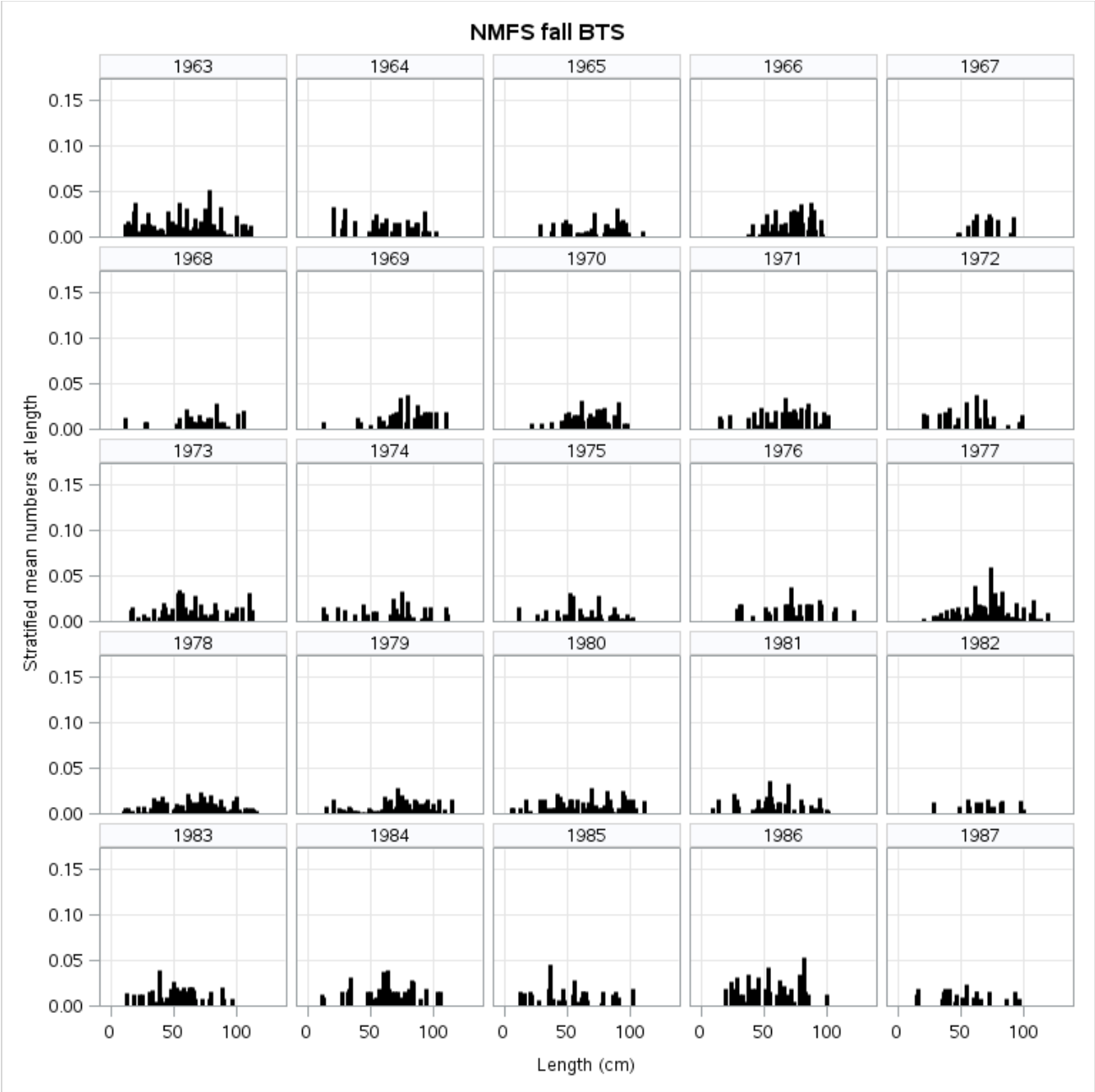


Figure 14. Abundance at length from NEFSC fall surveys in the northern management area.

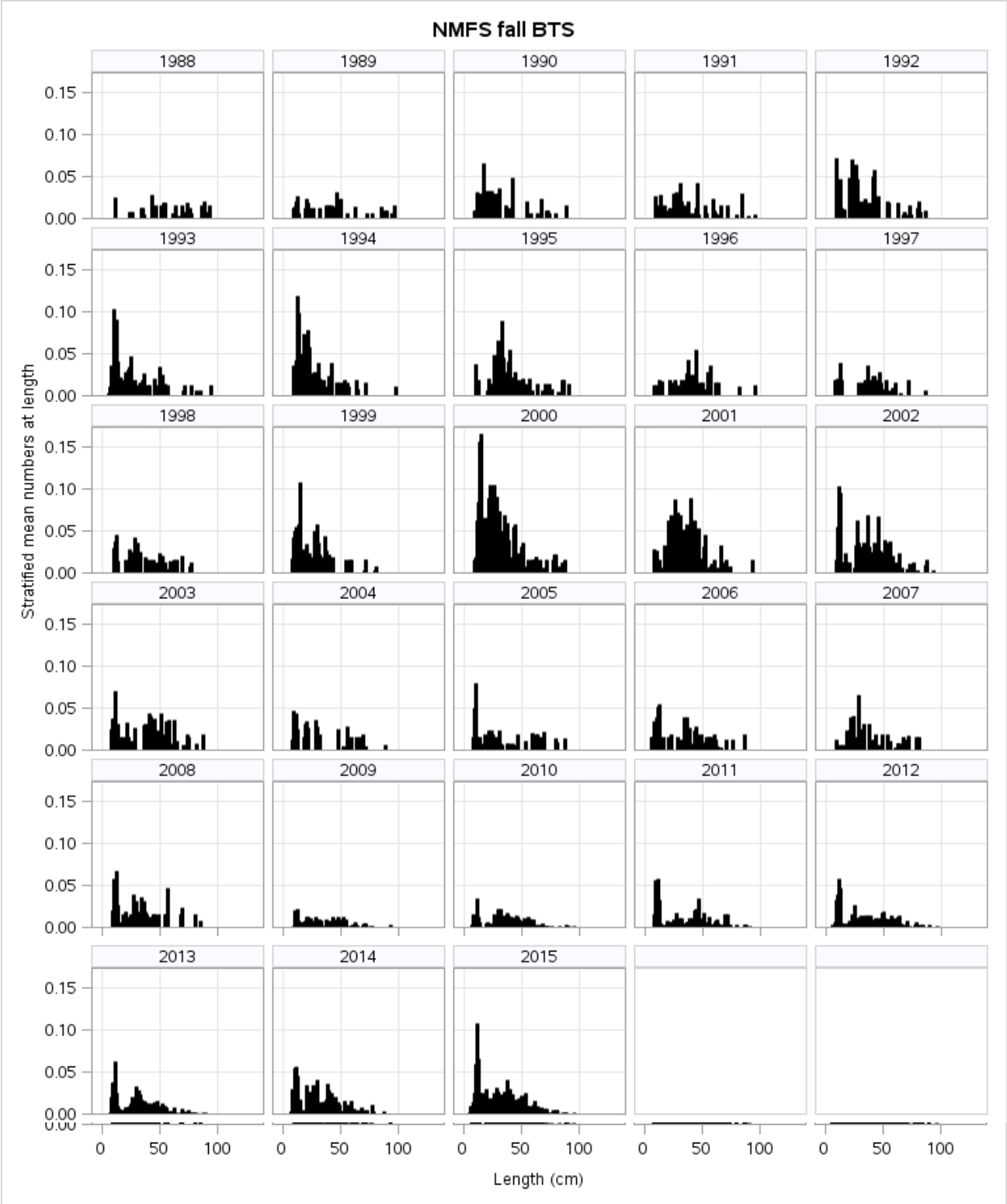


Figure 14, cont'd. (fall surveys, north)

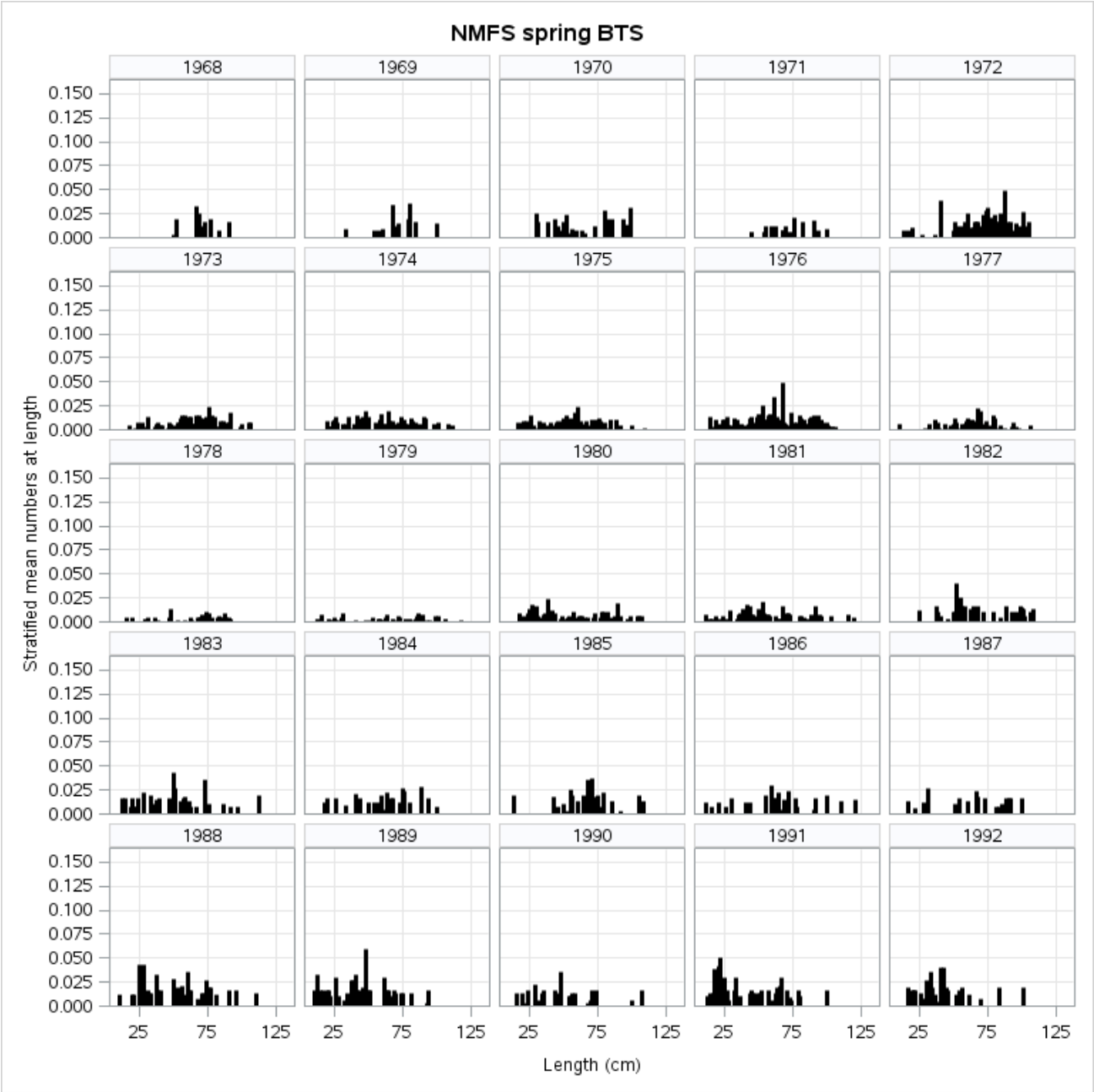


Figure 15. Abundance at length from NEFSC spring surveys in the northern management area.

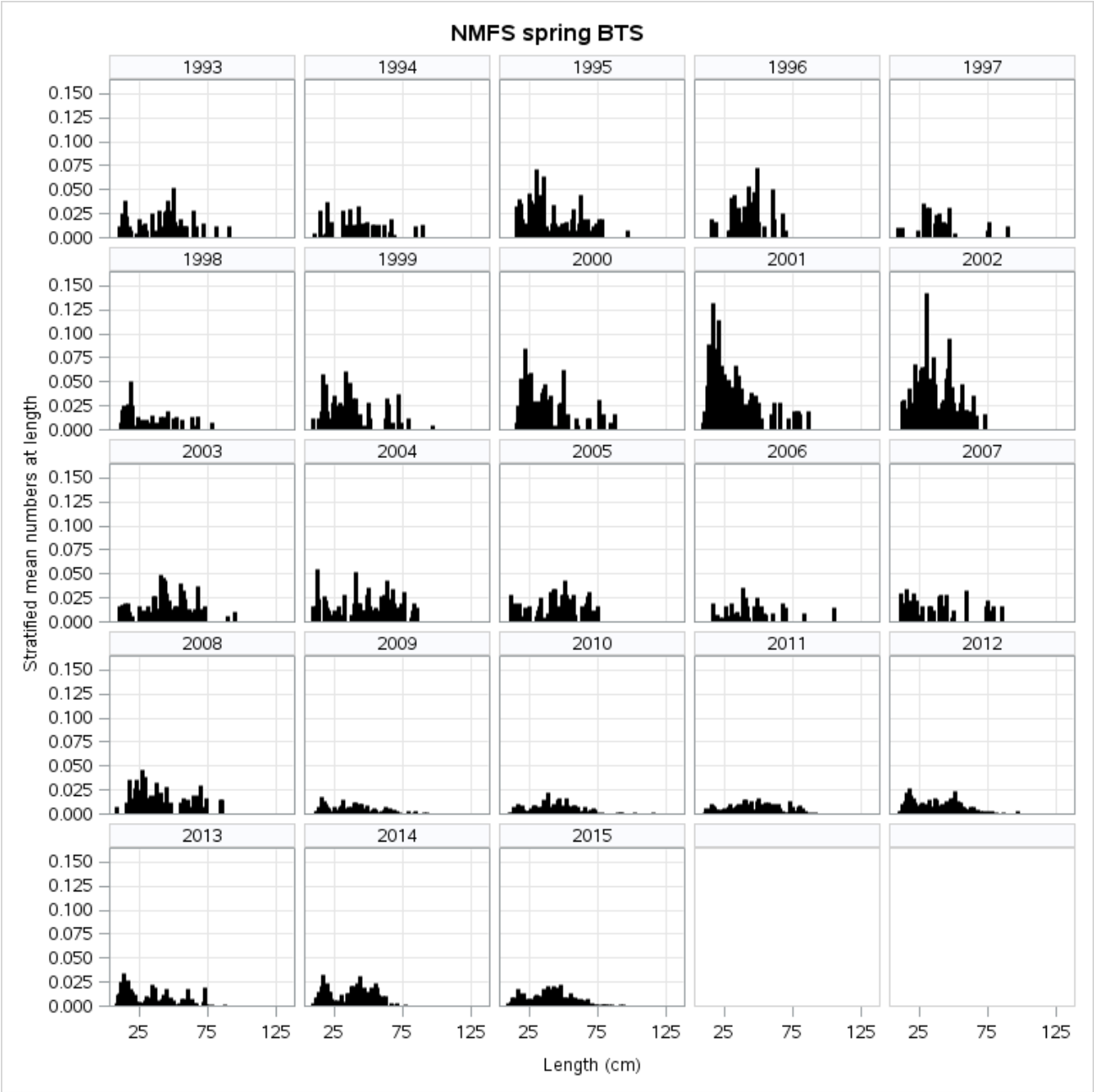
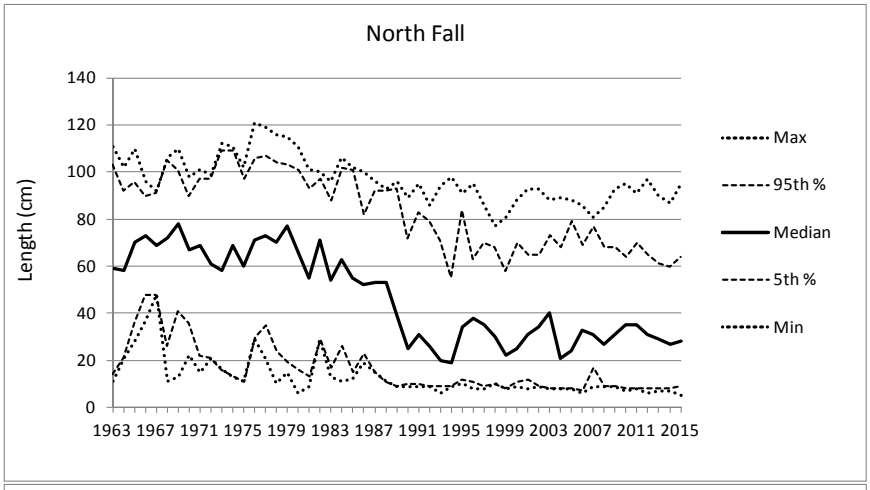


Figure 15, cont'd. (spring surveys, north)

North
NEFSC Fall



NEFSC Spring

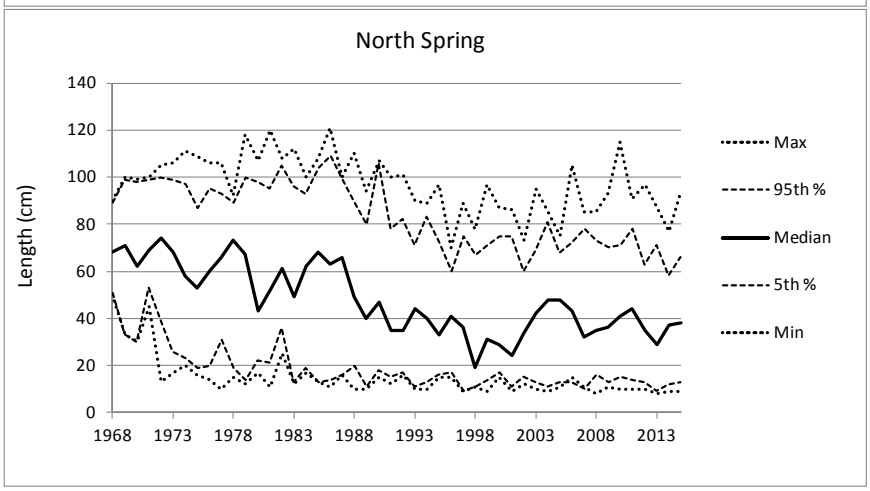


Figure 16. Length quantiles for monkfish over time from NEFSC surveys in the northern management area.

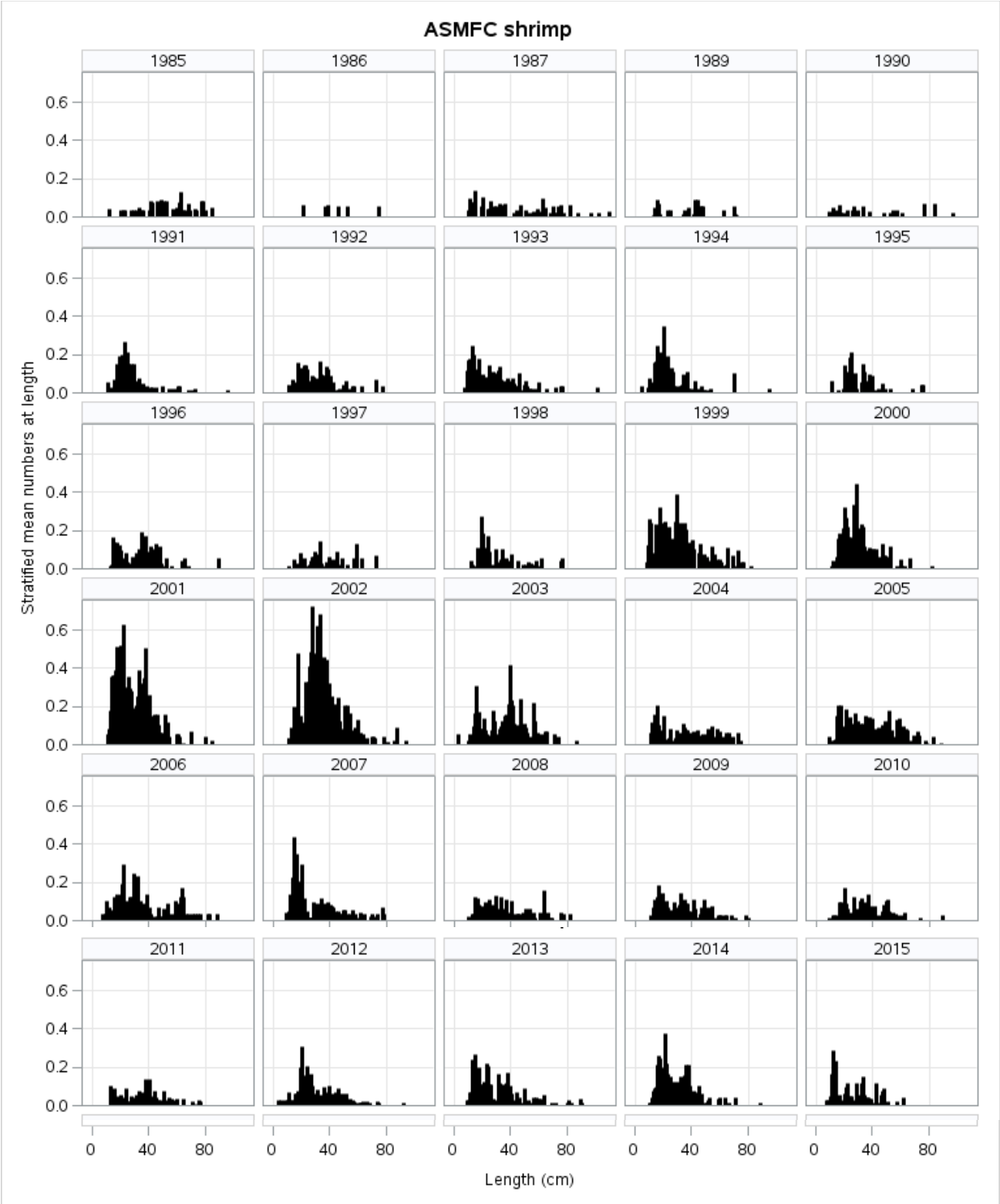
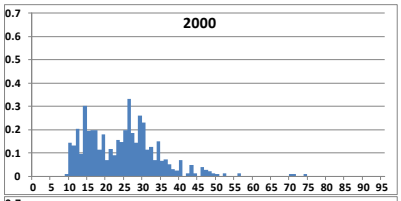


Figure 17. Abundance at length from ASMFC summer shrimp surveys in the northern management area.

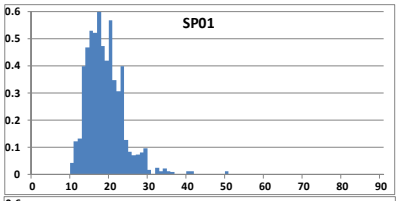
ME-NH Surveys

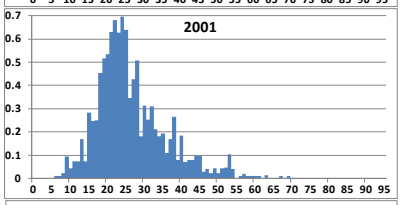
Spring | Fall

2000

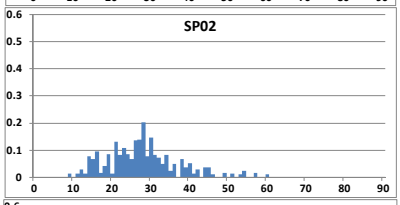


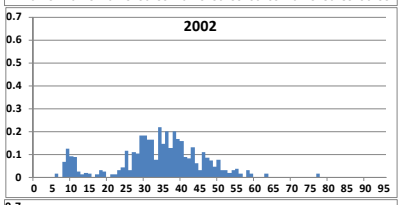
2001



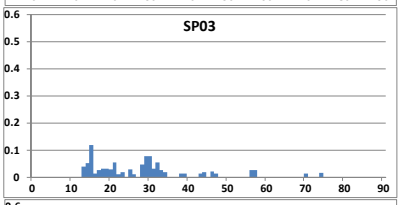


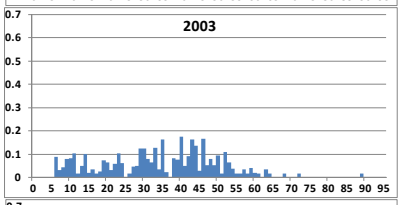
2002



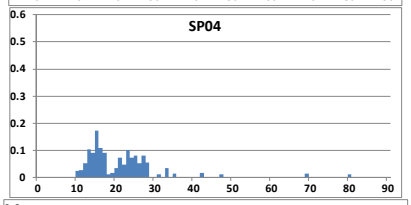


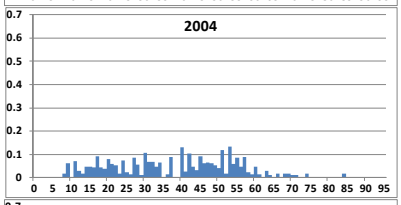
2003



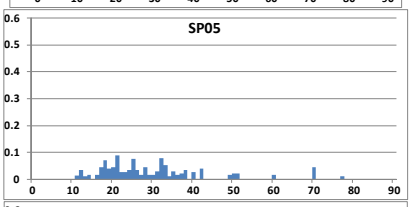


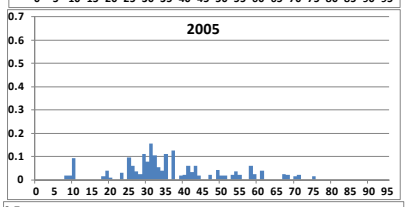
2004



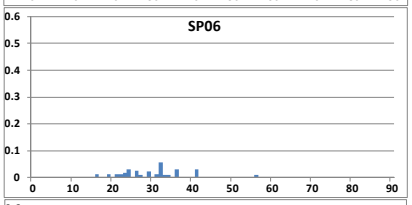


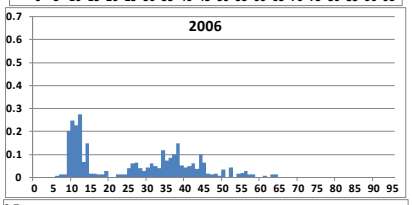
2005



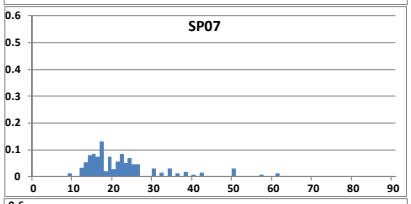


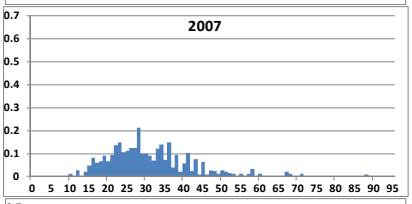
2006



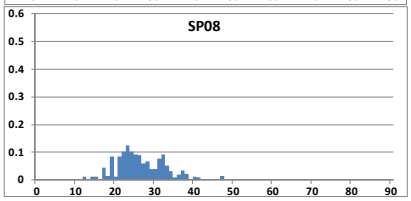


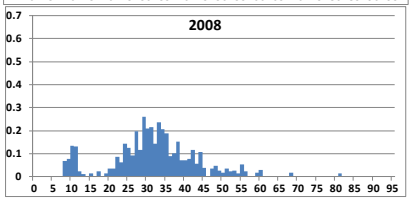
2007





2008





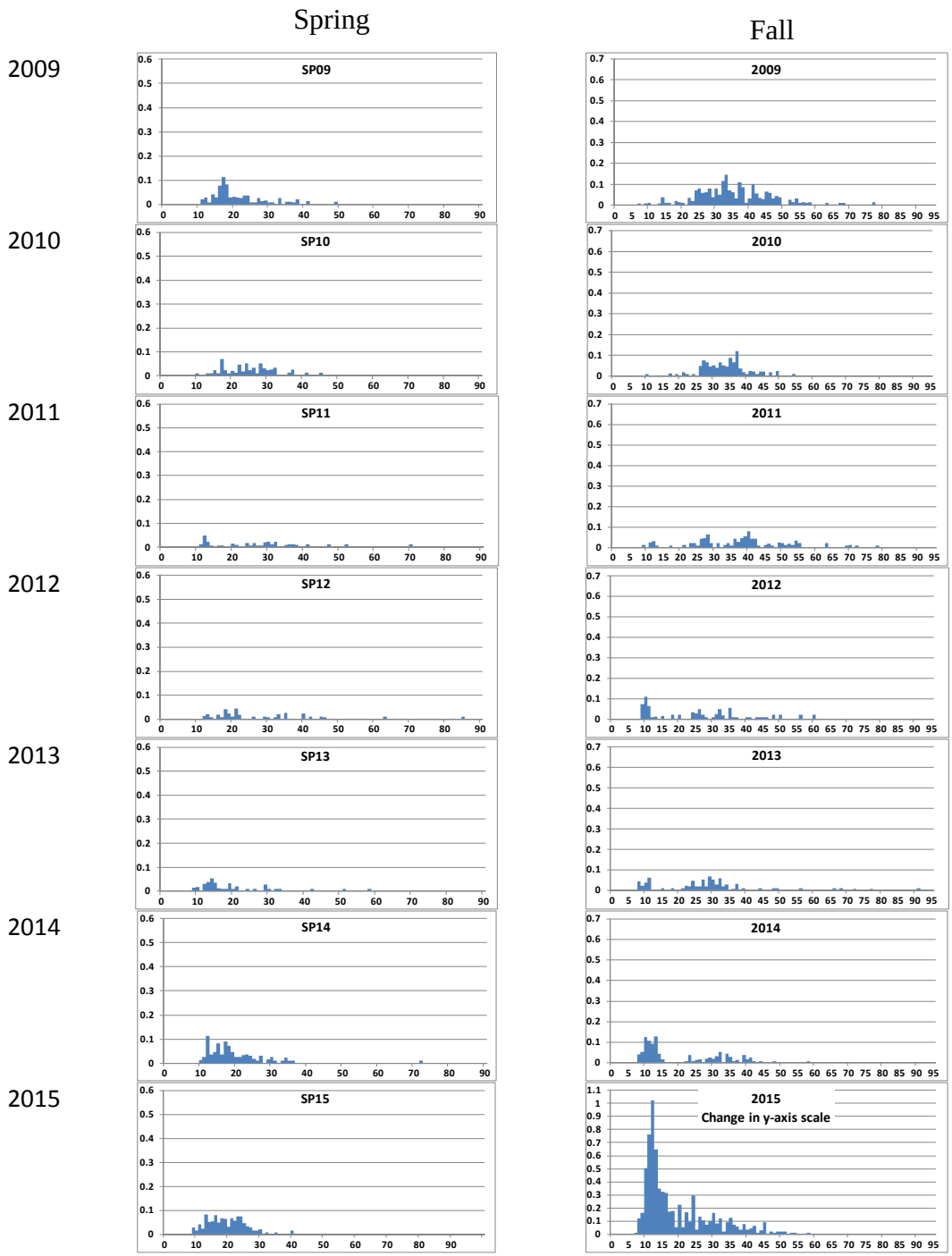


Figure 18. Abundance at length from ME/NH inshore trawl surveys in the northern management area.

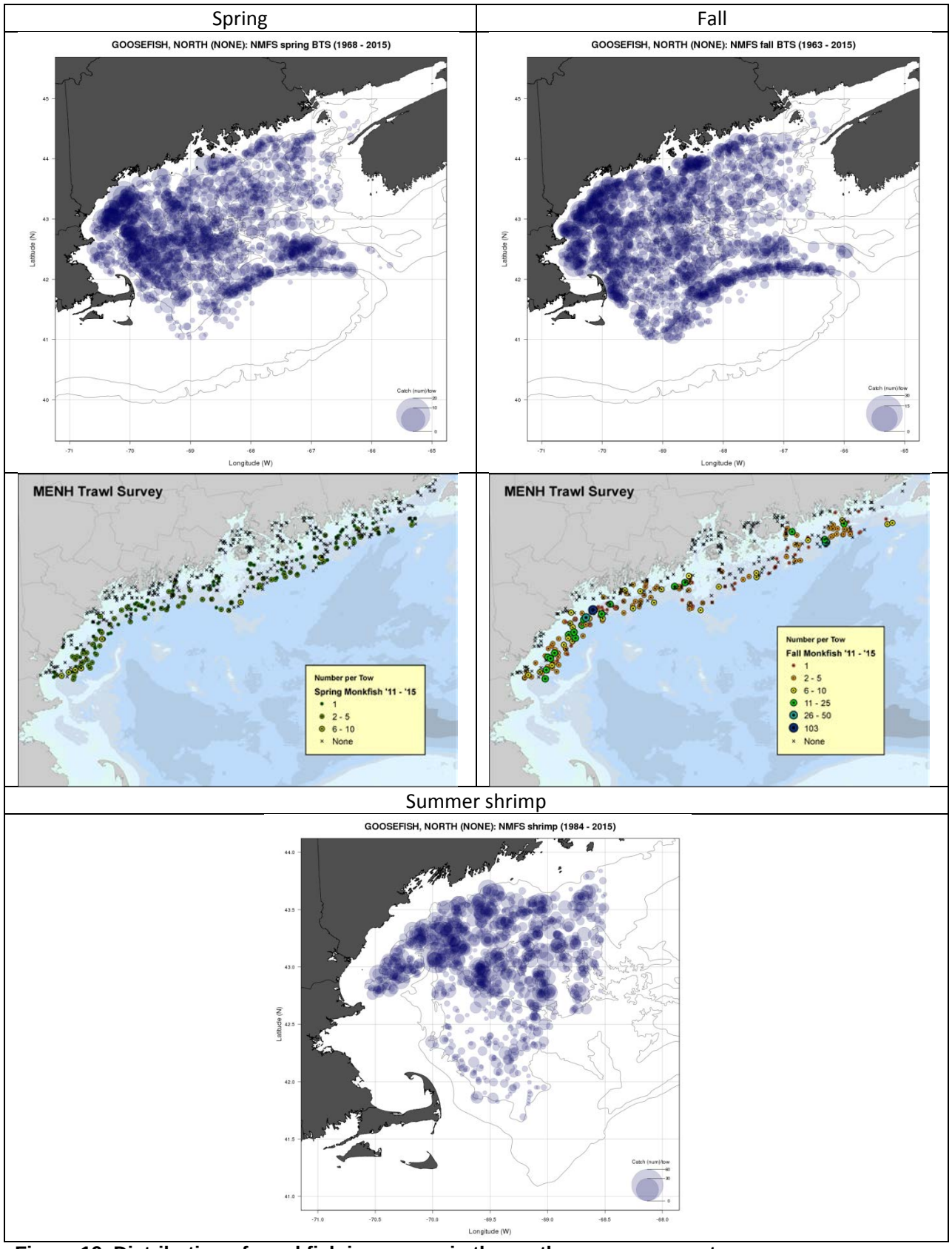


Figure 19. Distribution of monkfish in surveys in the northern management area.

South

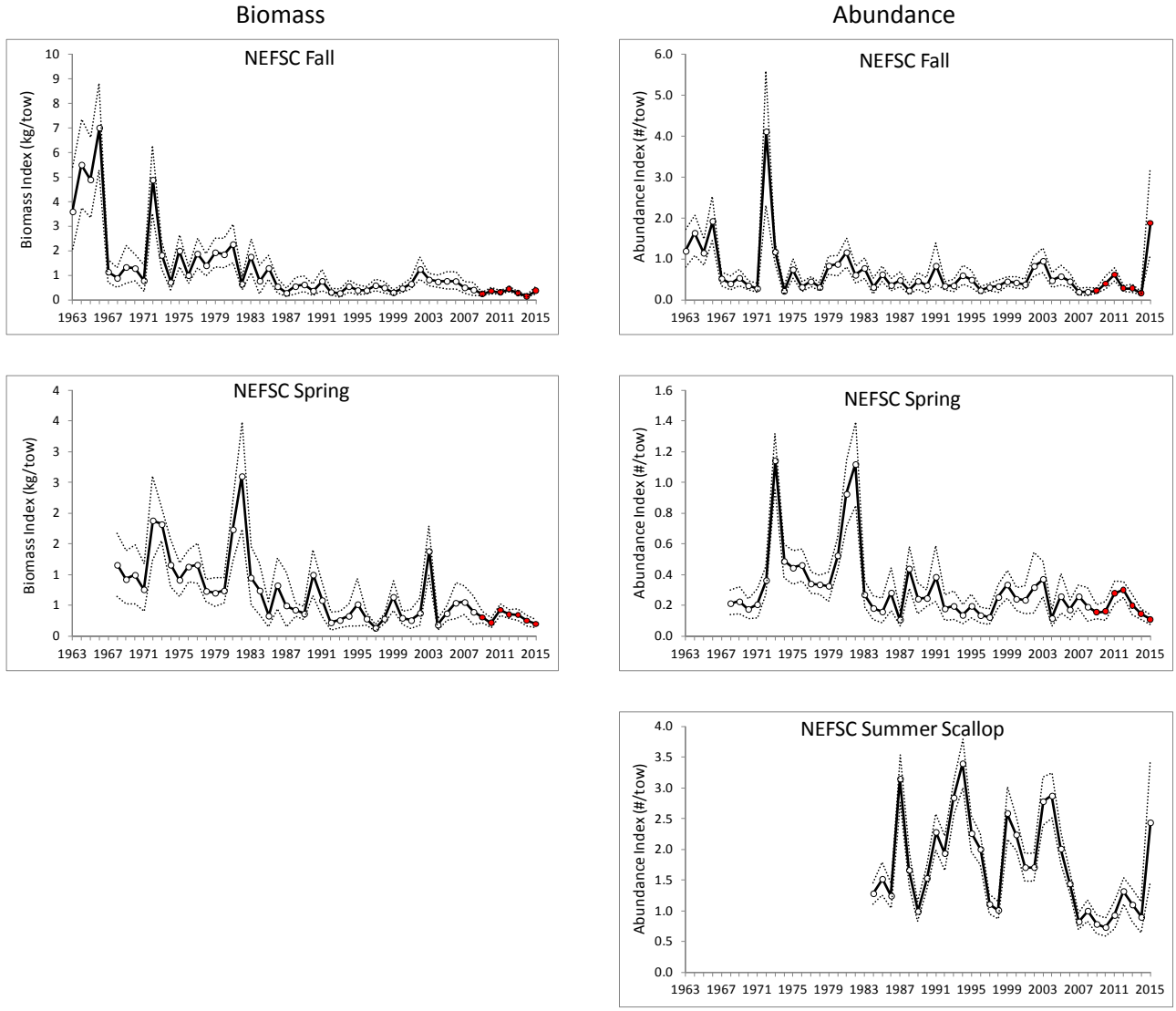


Figure 20. Survey indices for monkfish in the southern management area. Red-filled points are NEFSC surveys conducted on the FSV Bigelow (after 2008), converted to Albatross units as described in the text.

South

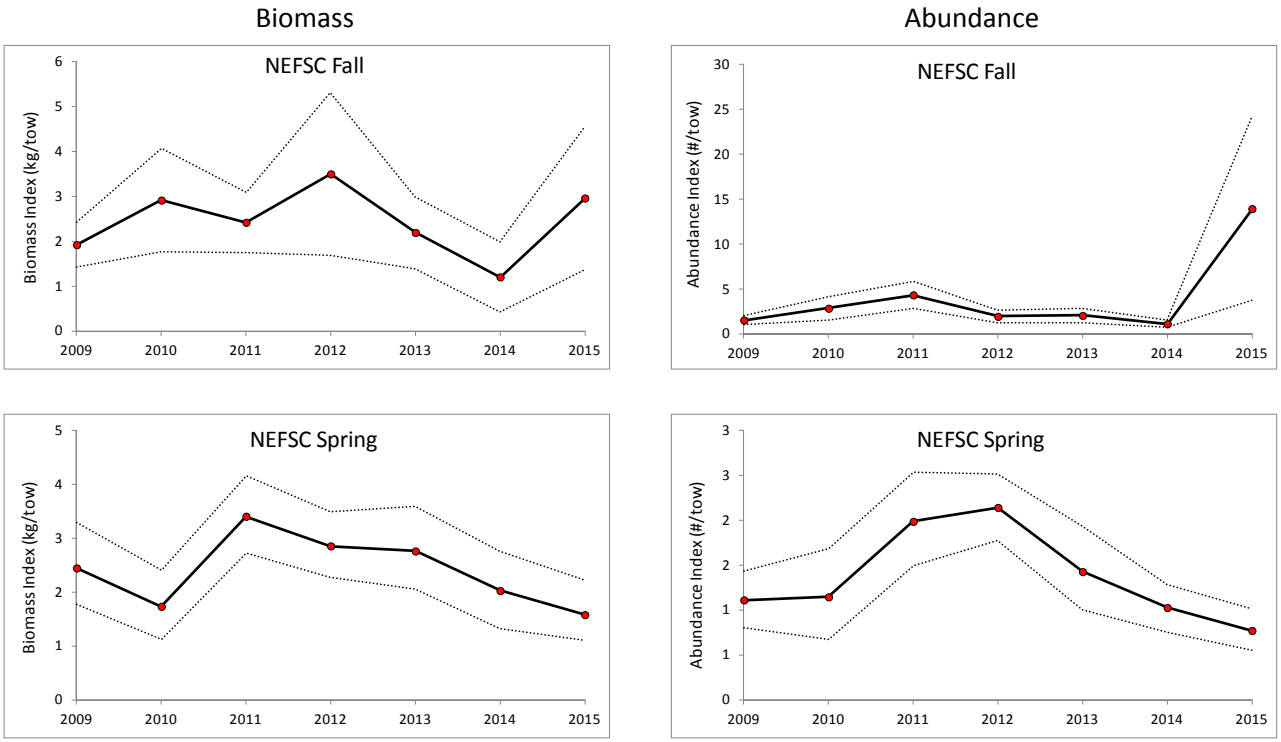


Figure 21. Survey indices from surveys conducted on the FRSV Bigelow in the southern management area, not converted to Albatross units.

South

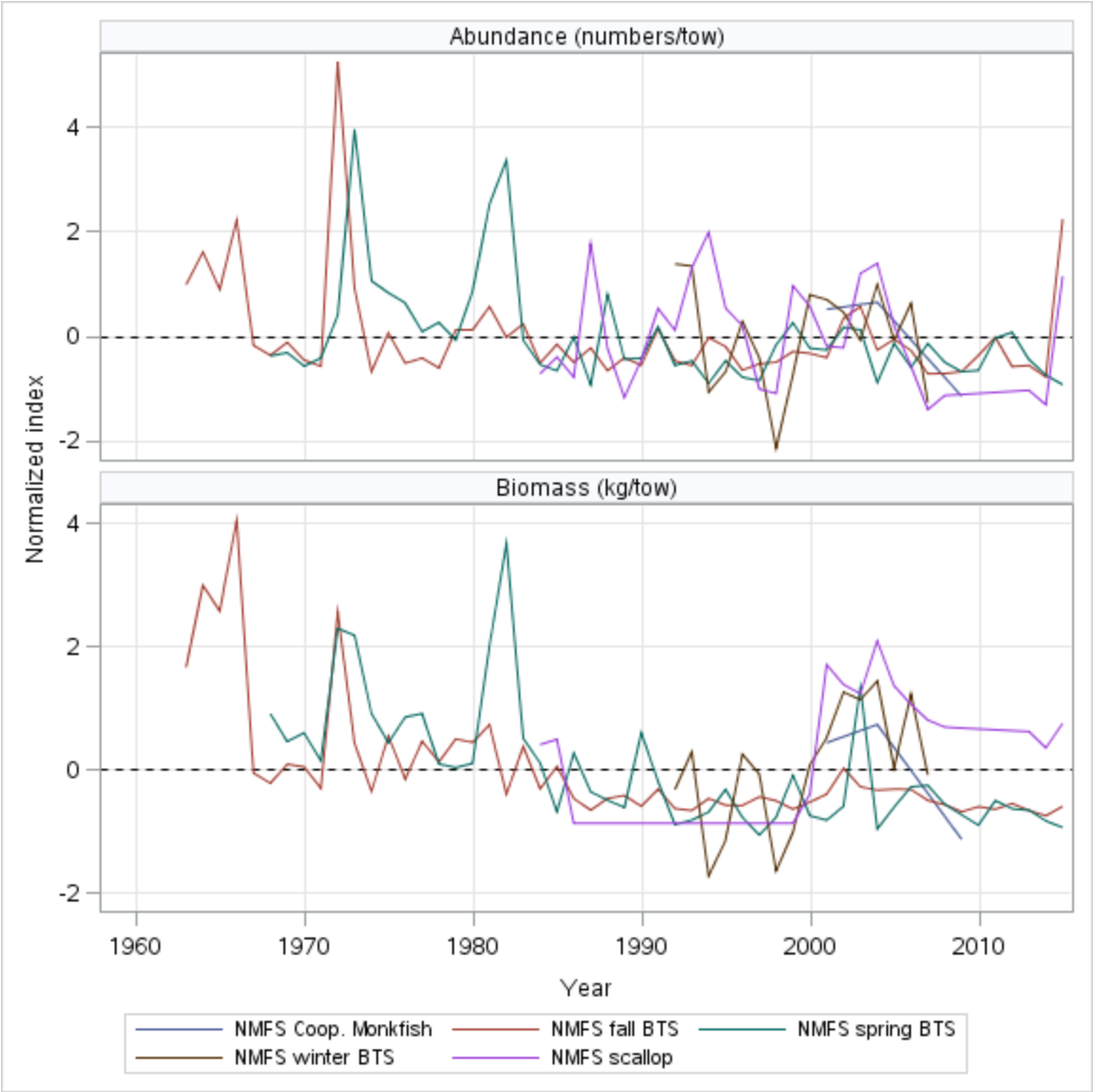


Figure 22. Normalized survey indices for monkfish in the southern management area.

South

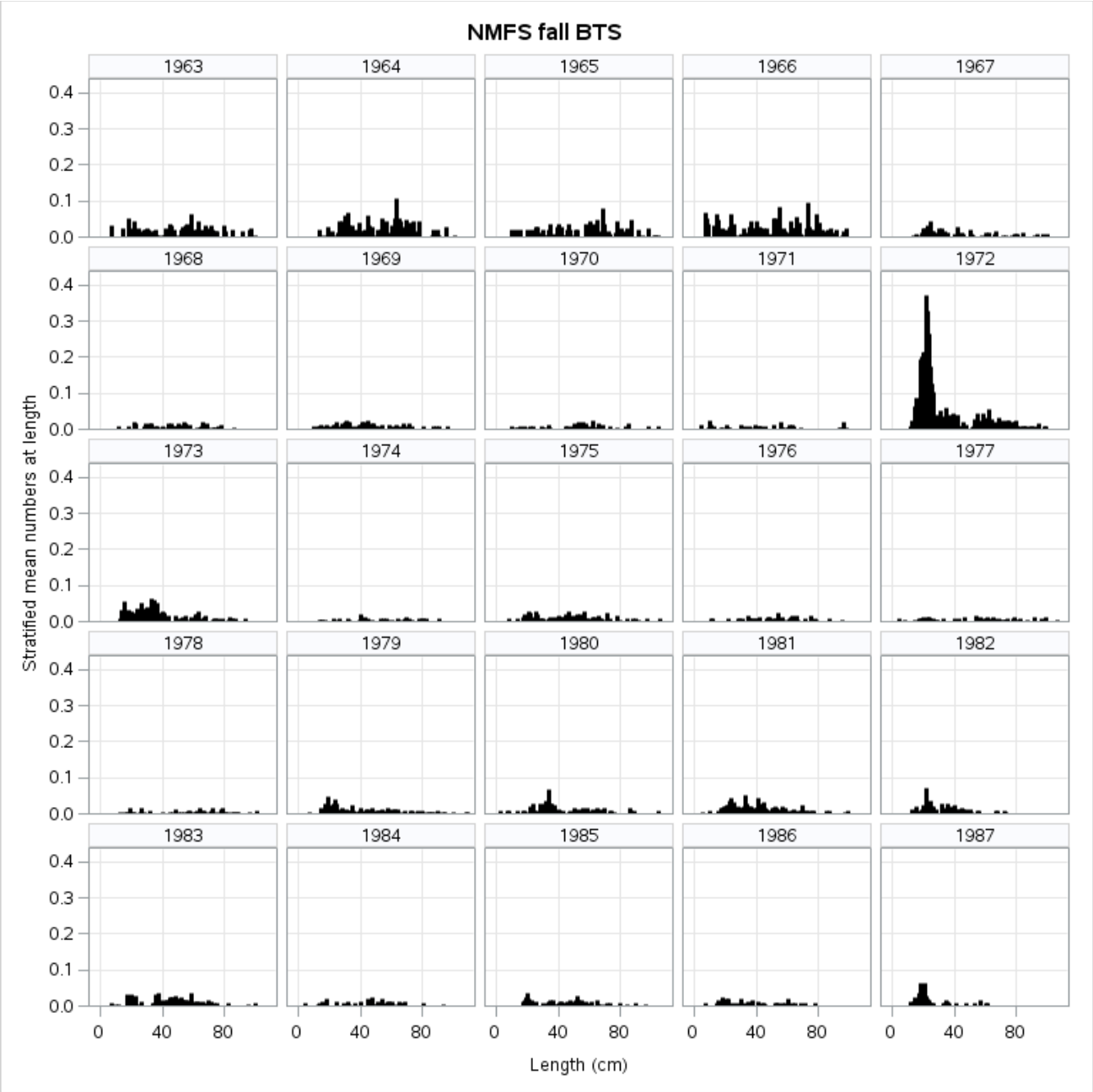


Figure 23. NEFSC fall survey indices of abundance at length, southern management area.

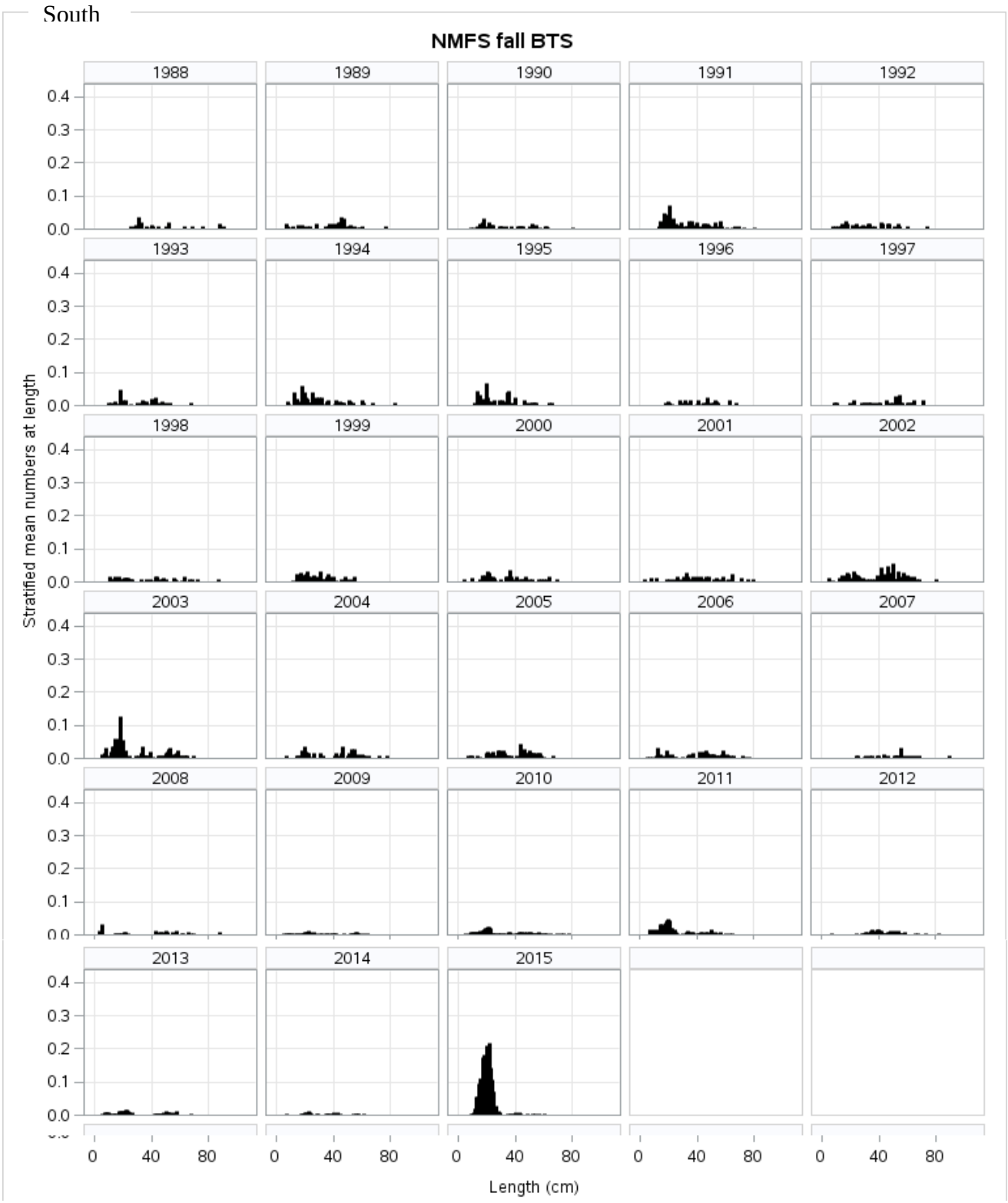


Figure 23, cont'd. (fall survey, south)

South

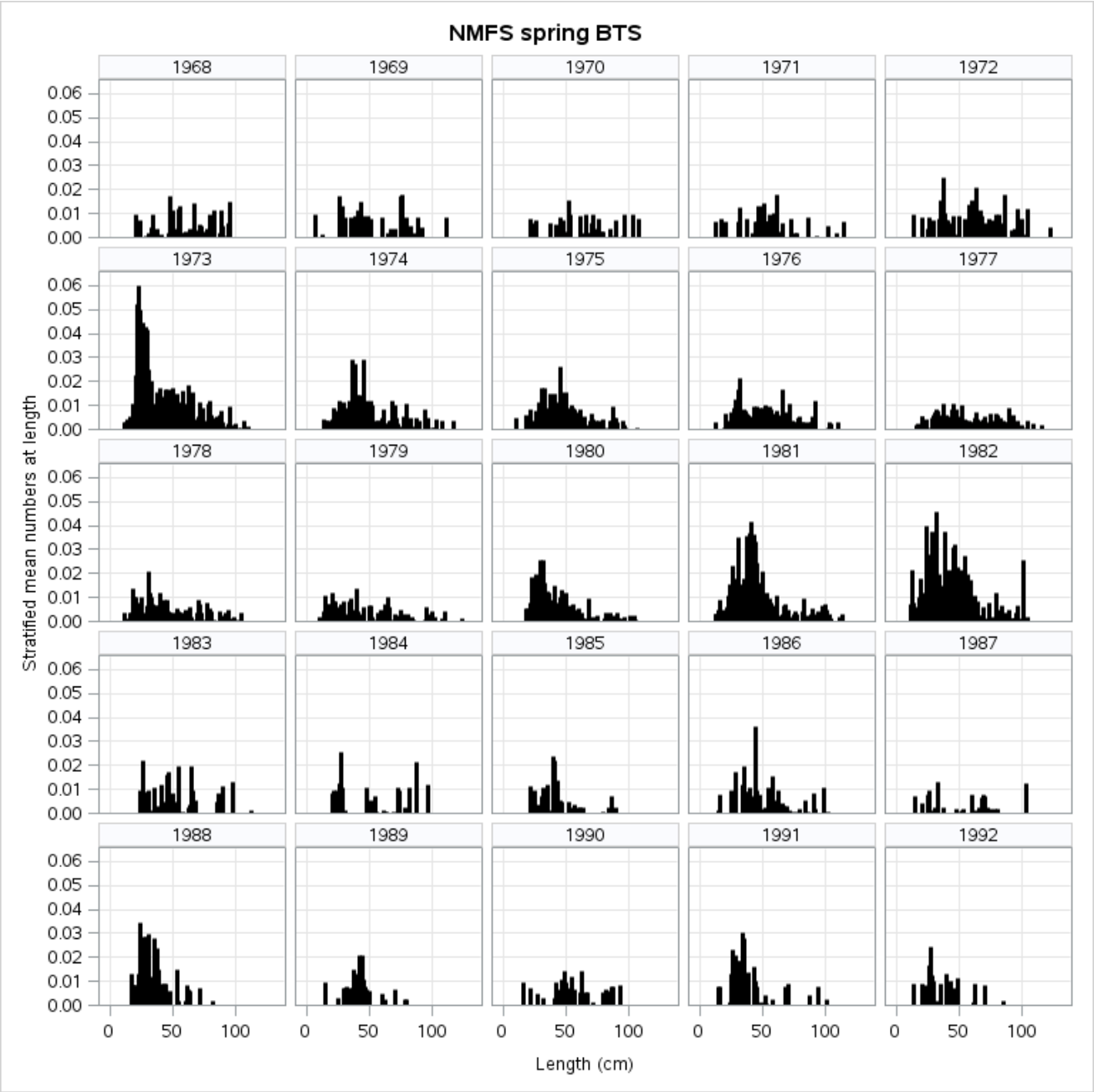


Figure 24. NEFSC spring survey indices of abundance at length, southern management area.

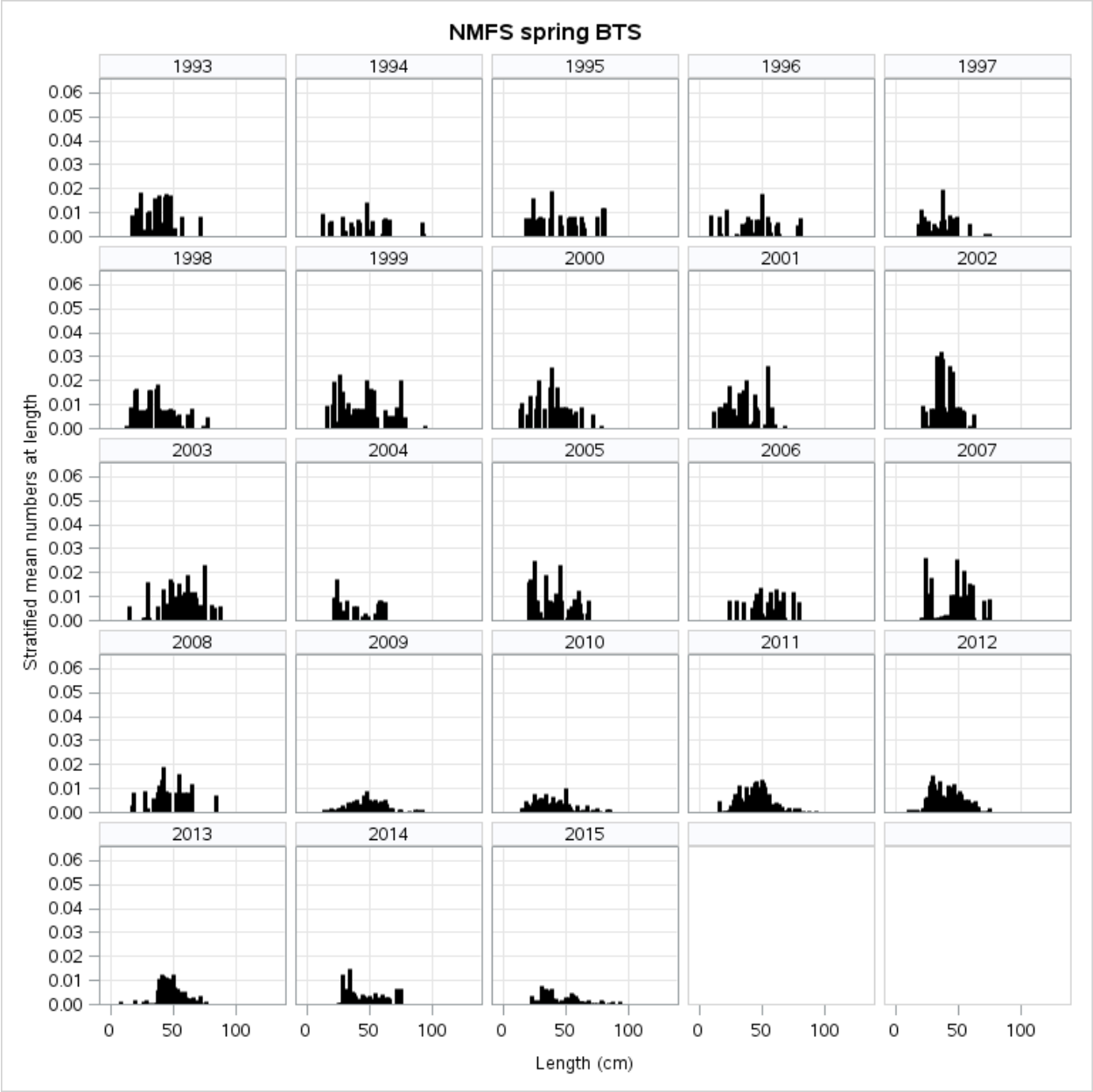


Figure 24, cont'd. (spring survey, south)

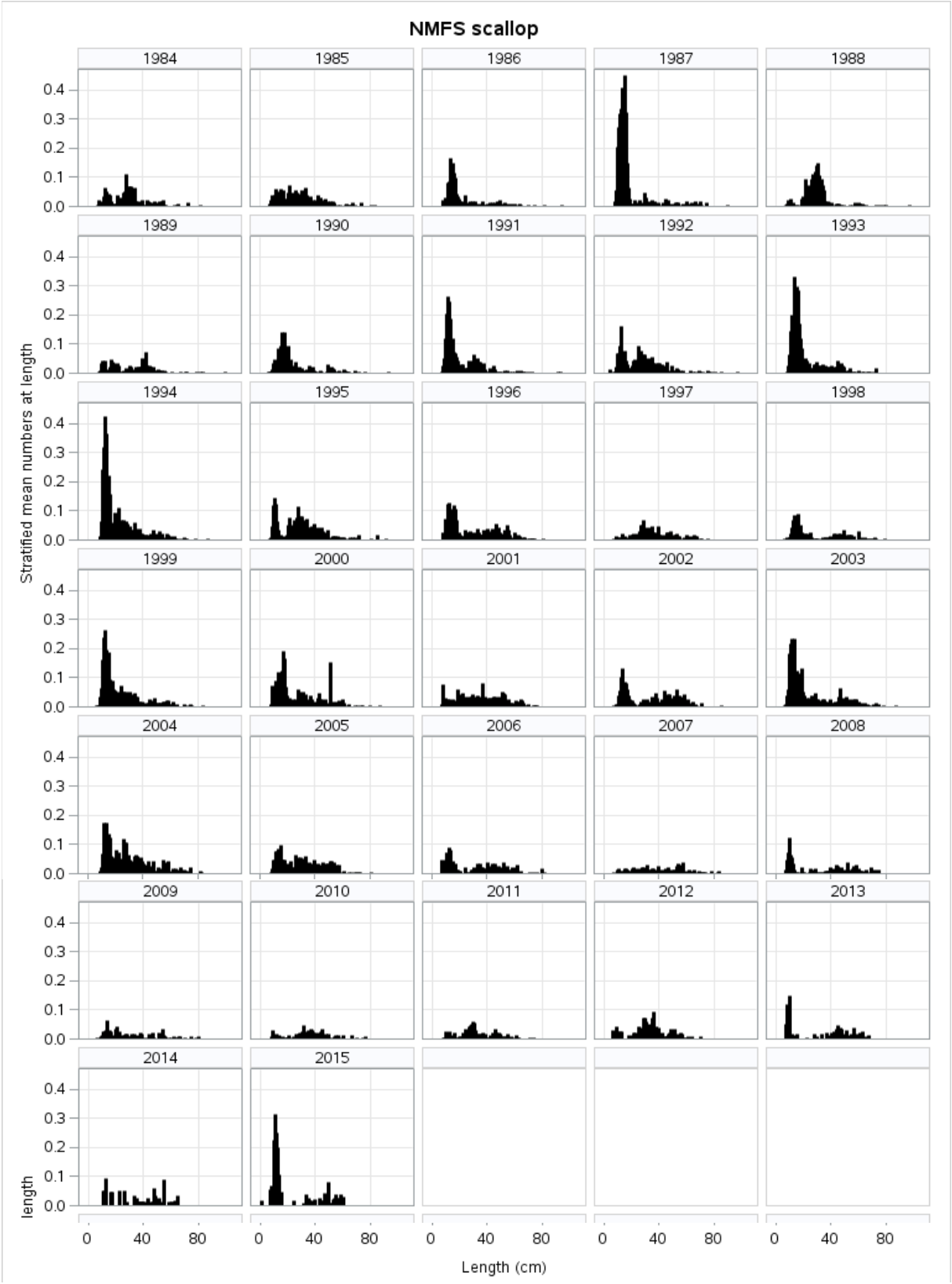


Figure 25. NEFSC spring/summer scallop surveys. Survey timing shifted from summer to spring in 2009. Data for 2014 and 2015 include only the northern portion of the survey area.

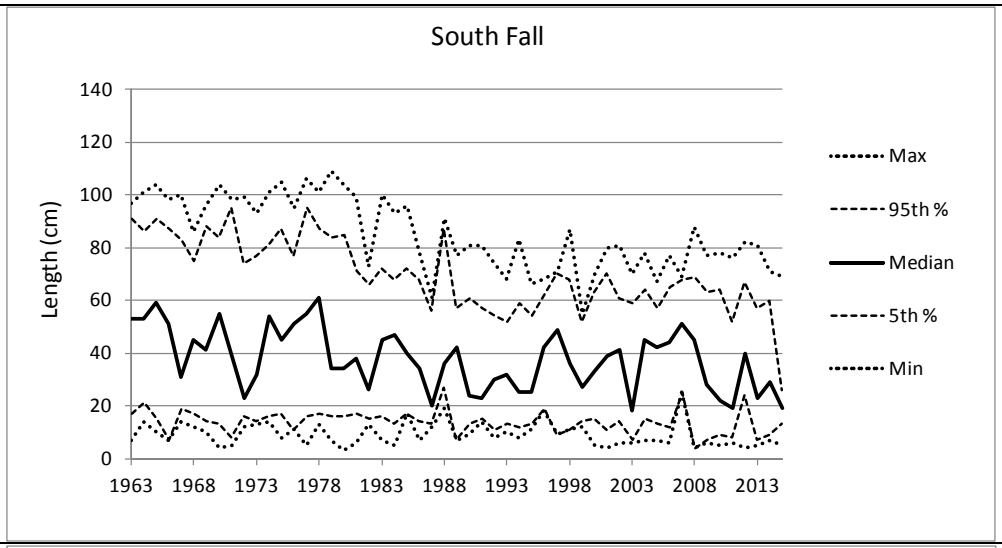
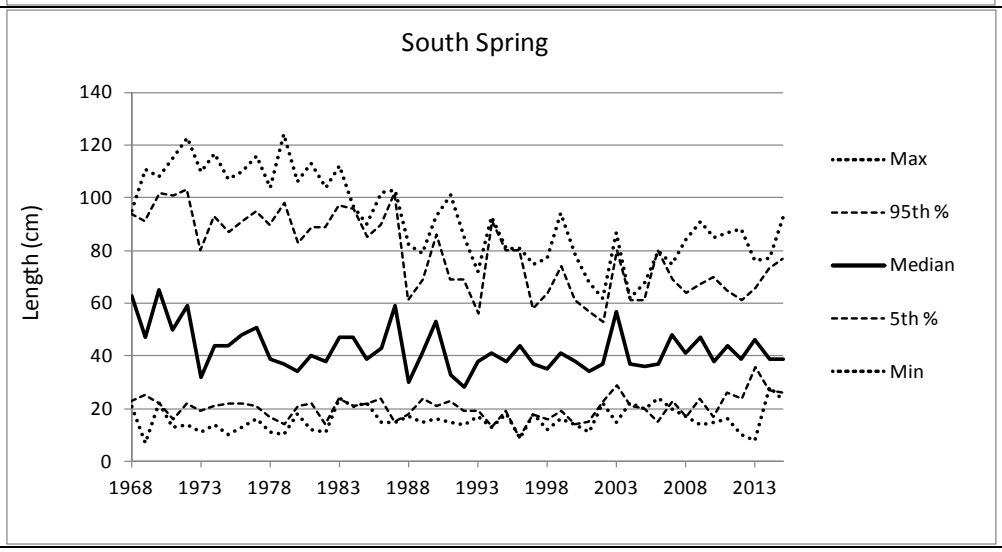
South	
NEFSC Fall	
NEFSC Spring	

Figure 26. Length quantiles for monkfish over time from NEFSC surveys in the southern management area.

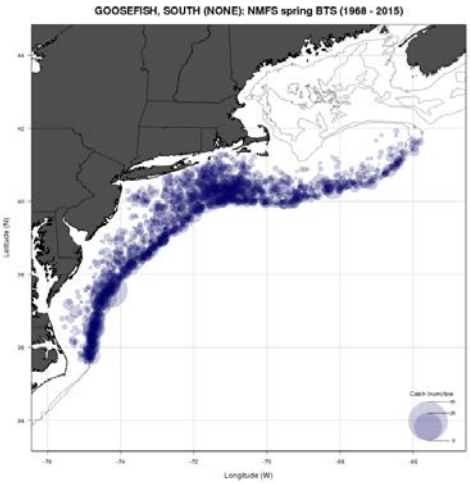
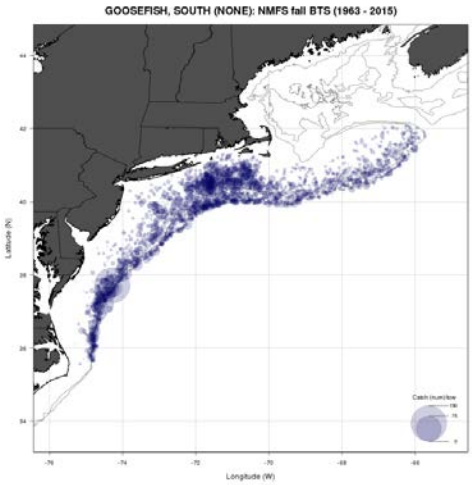
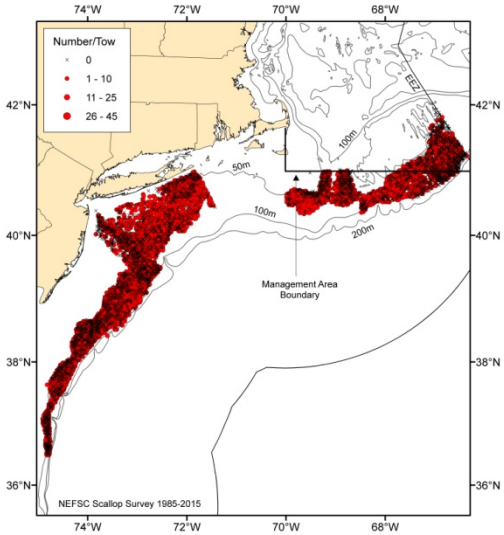
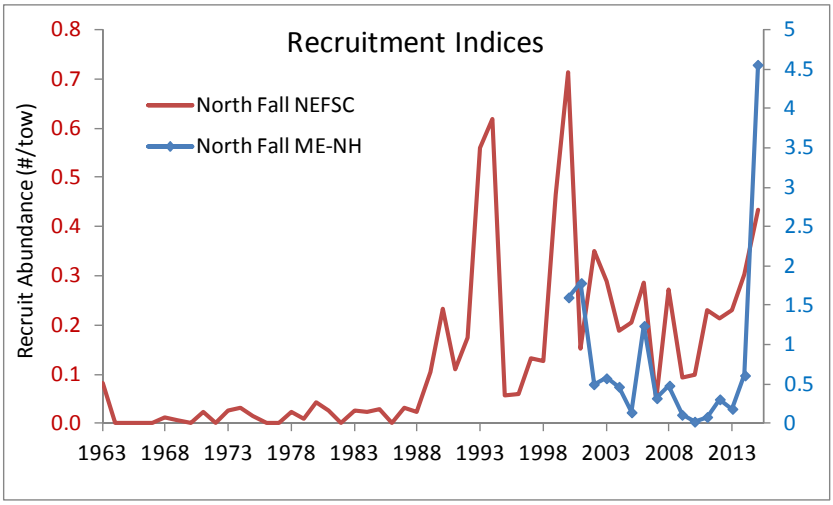
	Spring	Fall
NEFSC bottom trawl surveys		
Spring/Summer Scallop Survey		
		

Figure 27. Distribution of monkfish in the southern management area from NEFSC spring (1968-2015) and fall (1963-2015) bottom trawl surveys and NEFSC spring/summer scallop dredge surveys (1984-2015).

North



South

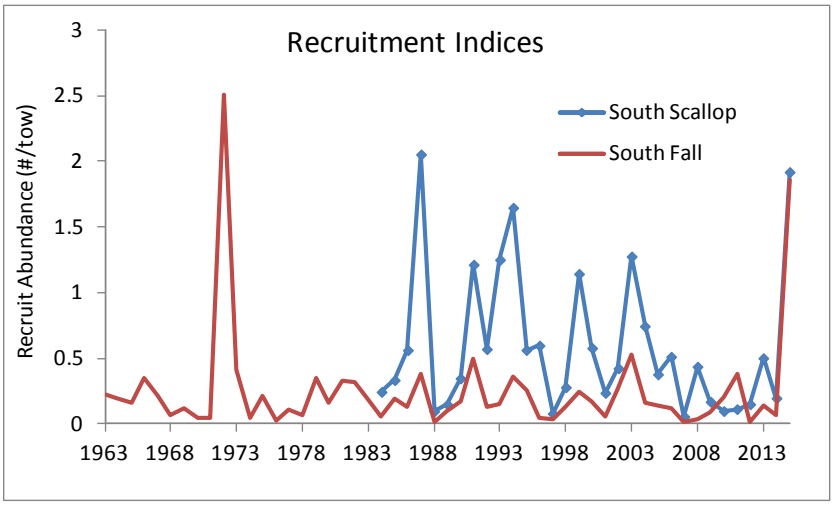


Figure 28. Recruitment indices for monkfish in the northern and southern management areas. Indices include monkfish in size ranges currently thought to represent young-of-year (age 0) in each area and season. Note: 2014 and 2015 scallop survey data include only the northern portion of the Mid-Atlantic Bight.

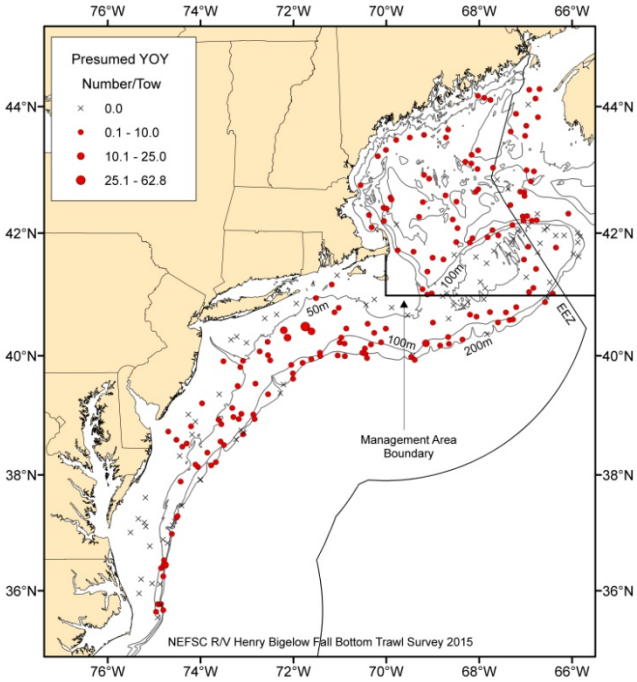
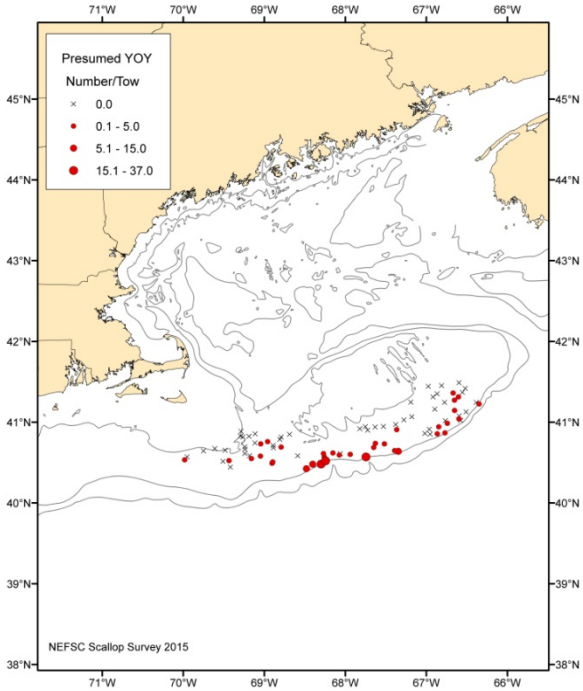
2015 Fall Survey	2015 Scallop Survey
	

Figure 29. Distribution of presumed young-of-year monkfish in 2015 NEFSC surveys (fall trawl survey, summer scallop dredge survey). Only the northern portion of the Mid-Atlantic Bight was sampled by NEFSC in 2015.

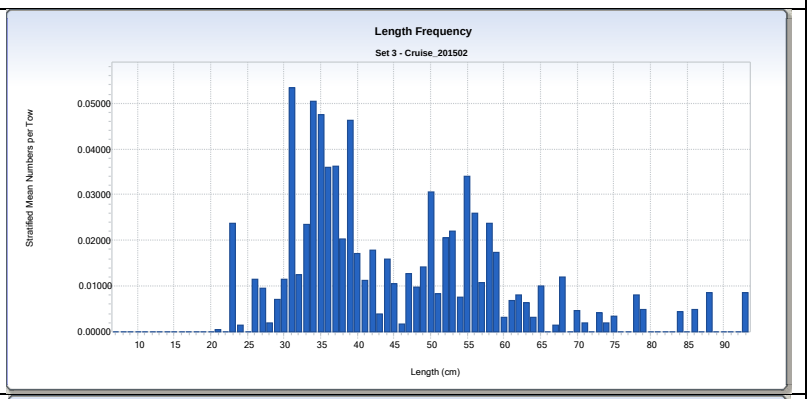
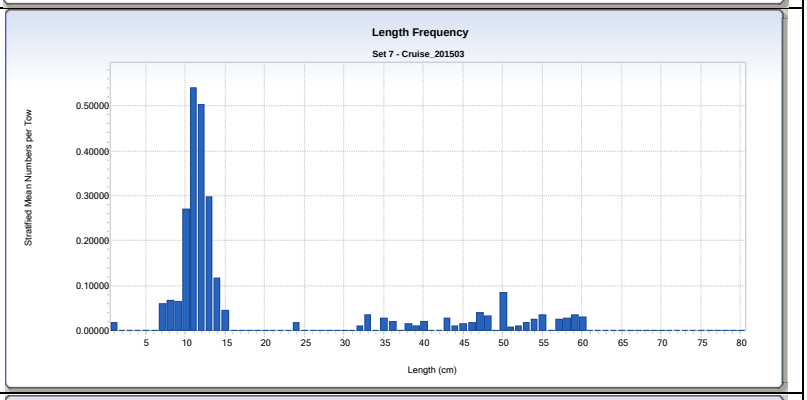
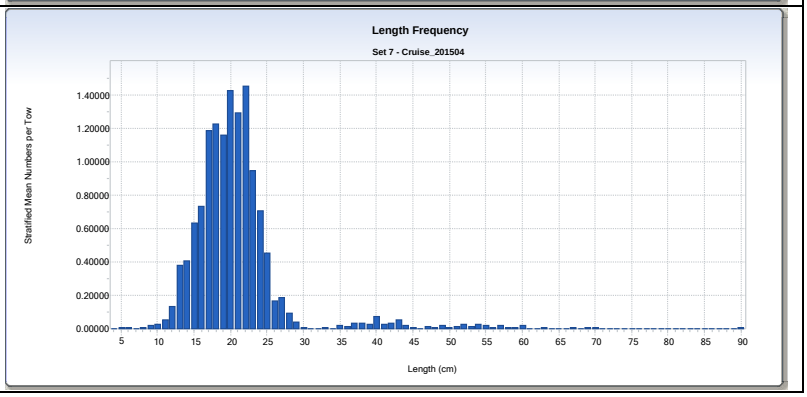
South	
Spring 2015 average DOY= 92	
Scallop 2015 average DOY = 161	
Fall 2015 average DOY= 263	

Figure 30. Length frequency distributions of monkfish from spring, summer and fall surveys in 2015 illustrating growth rates of presumed YOY monkfish. Monkfish settle to the benthos at about 8 cm.

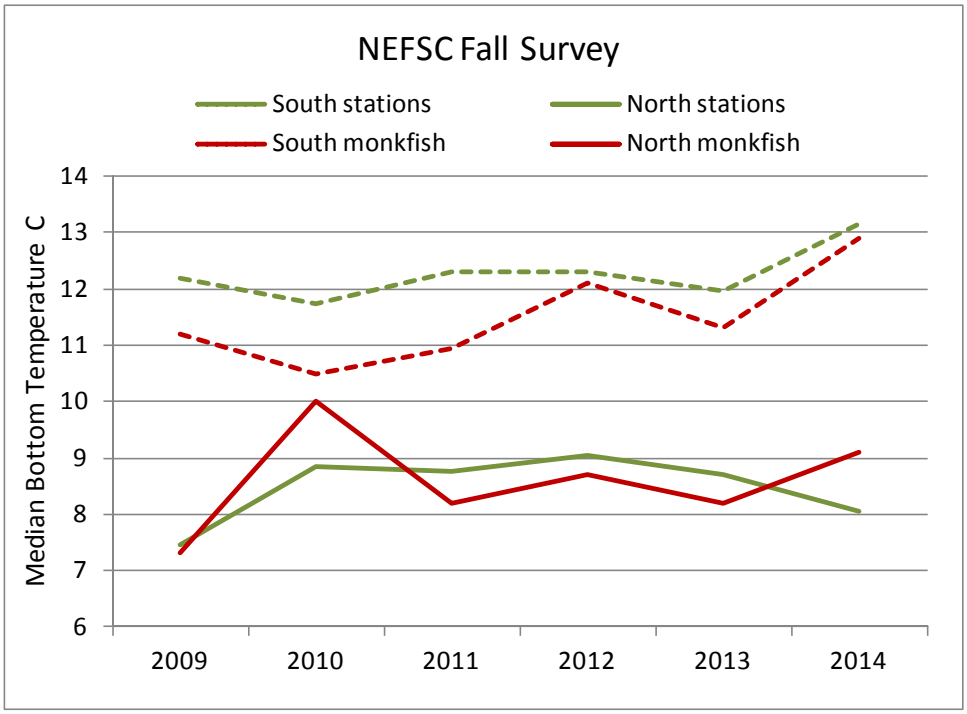
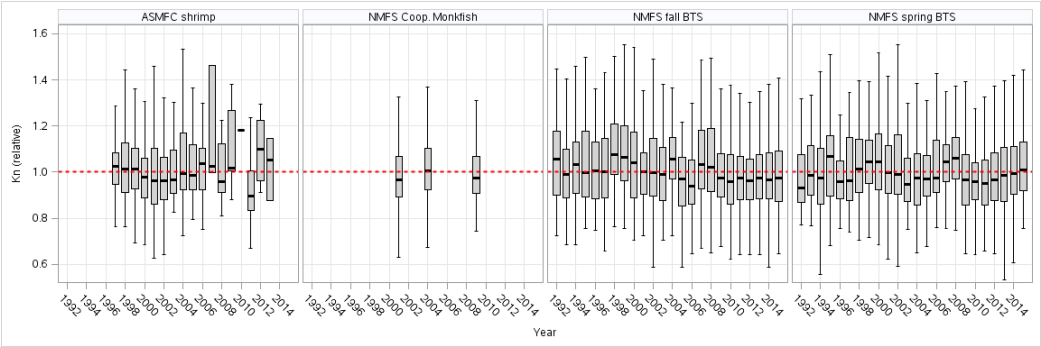


Figure 31. Median bottom temperature at all stations visited vs. bottom temperature weighted by number of monkfish at each station during NEFSC fall surveys, 2009-2014.

North



South

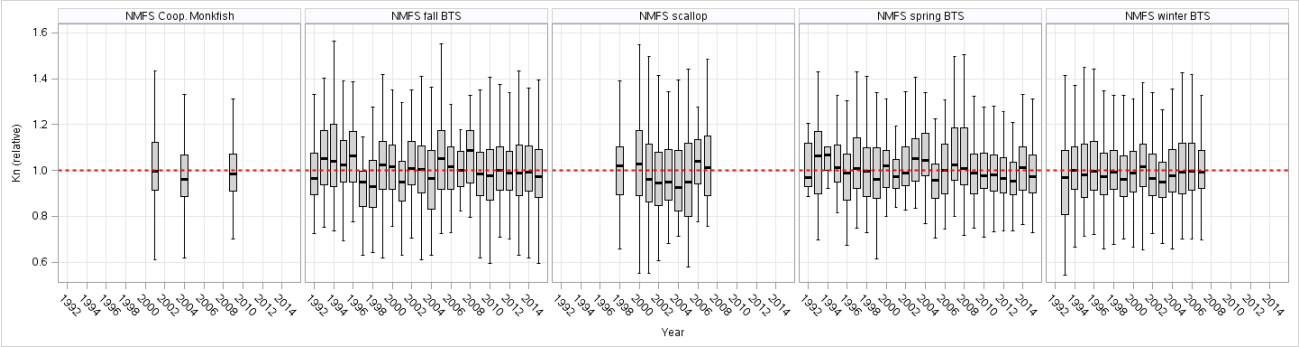


Figure 32. Condition factors (ratio of observed weight to predicted weight) for northern and southern management areas.

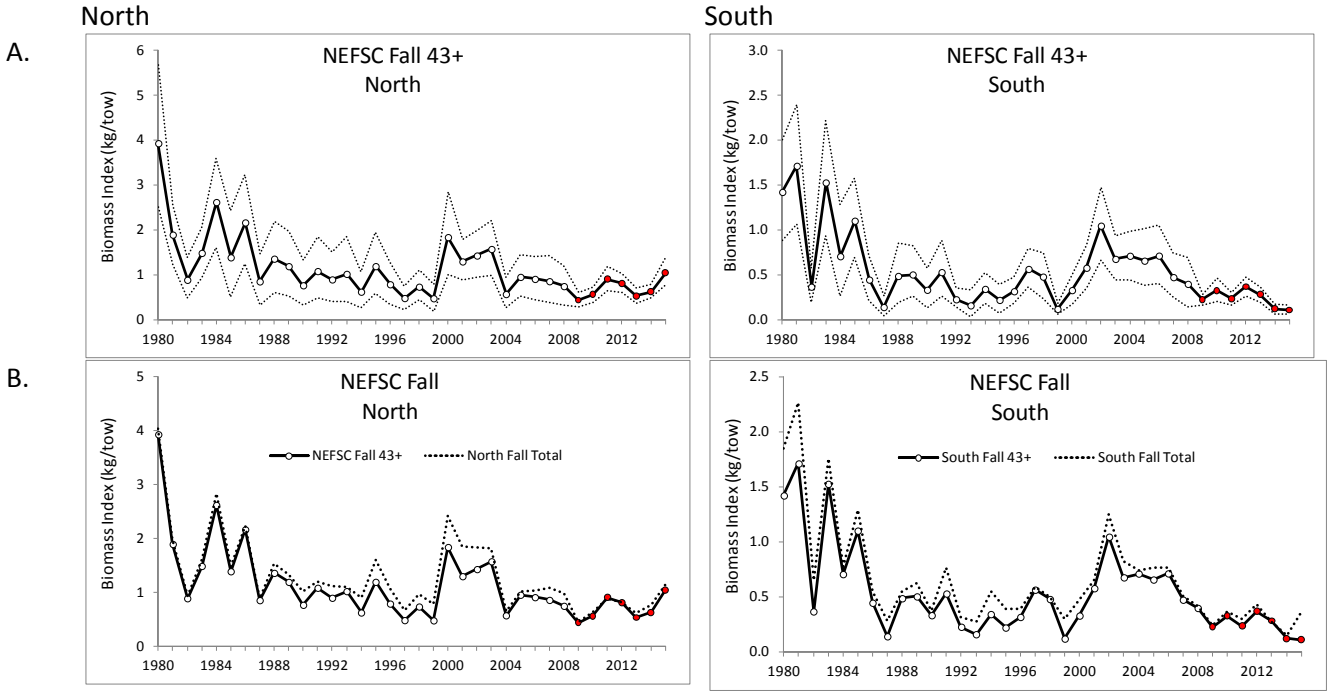
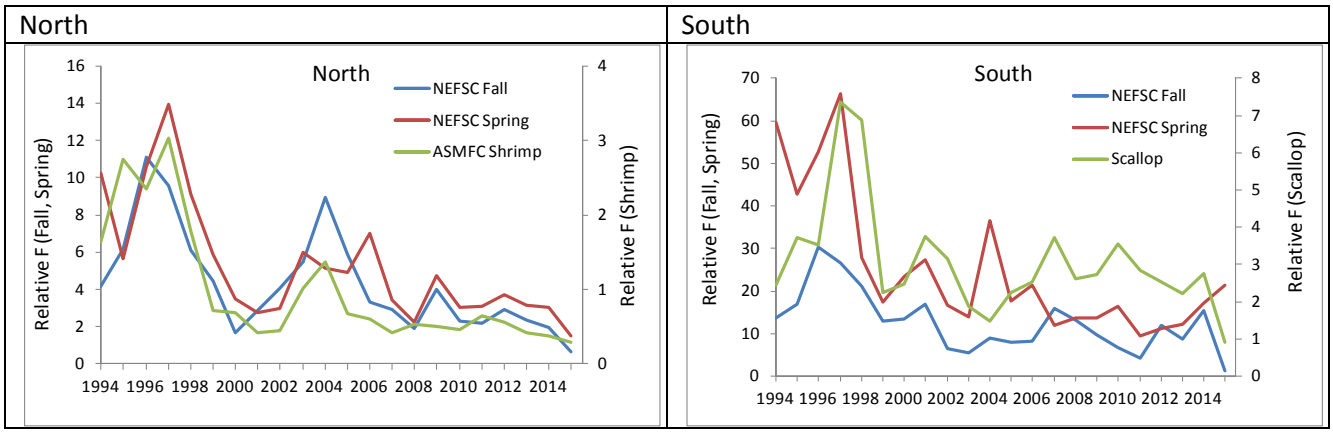


Figure 33. Exploitable biomass (> 43 cm total length) indices for monkfish in the northern and southern management areas. A. Exploitable biomass indices with 95% confidence intervals. B. Total biomass vs. exploitable biomass indices. Red points indicate years in which conversion coefficients have been applied to adjust for survey modernization (2009-2015).



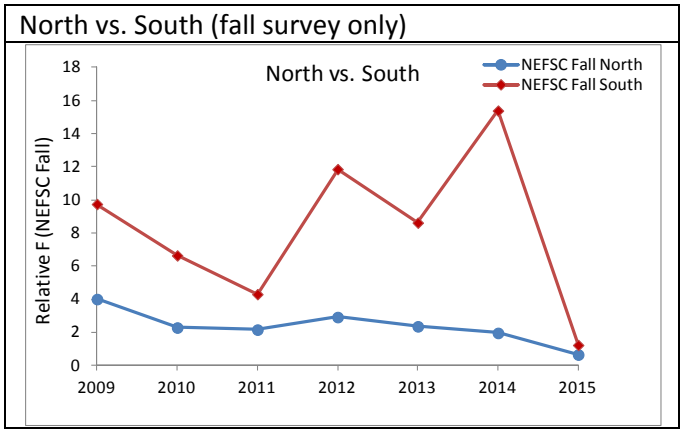
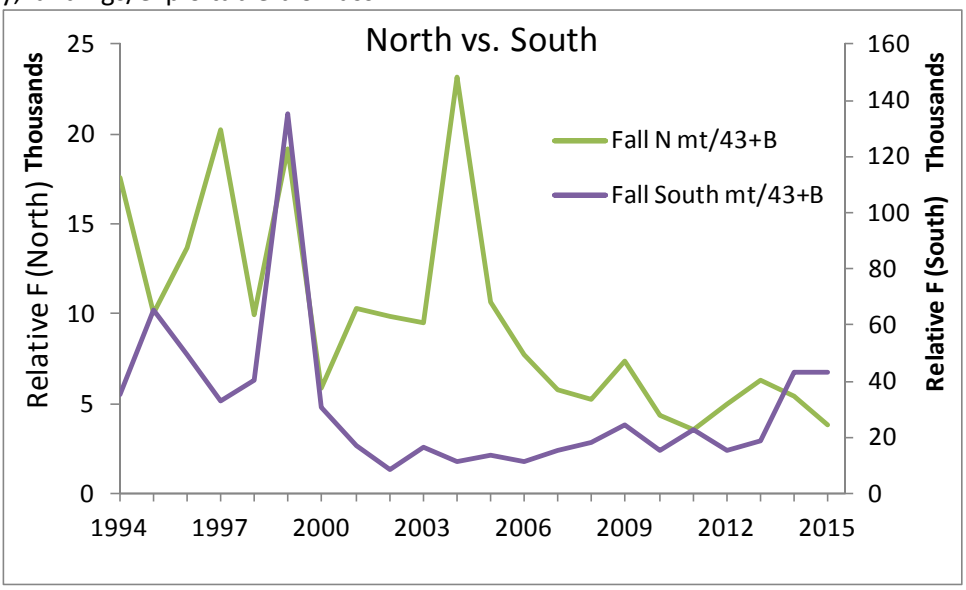


Figure 34. Relative exploitation rates (total catch in numbers/ total abundance index) of monkfish in the northern and southern management areas.

A. Fall survey, landings/exploitable biomass



B. Fall survey, landings (millions of fish) / exploitable abundance index (fall survey)

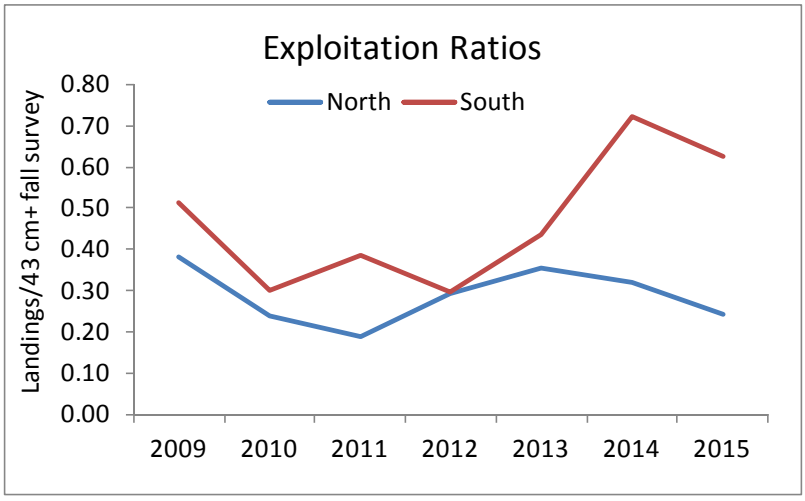


Figure 35. Relative exploitation rates based on (A.) landings (mt) / exploitable biomass index and (B.) landings (millions of fish) / area-swept minimum abundance of exploitable monkfish in the northern and southern management areas, based on NEFSC fall surveys.

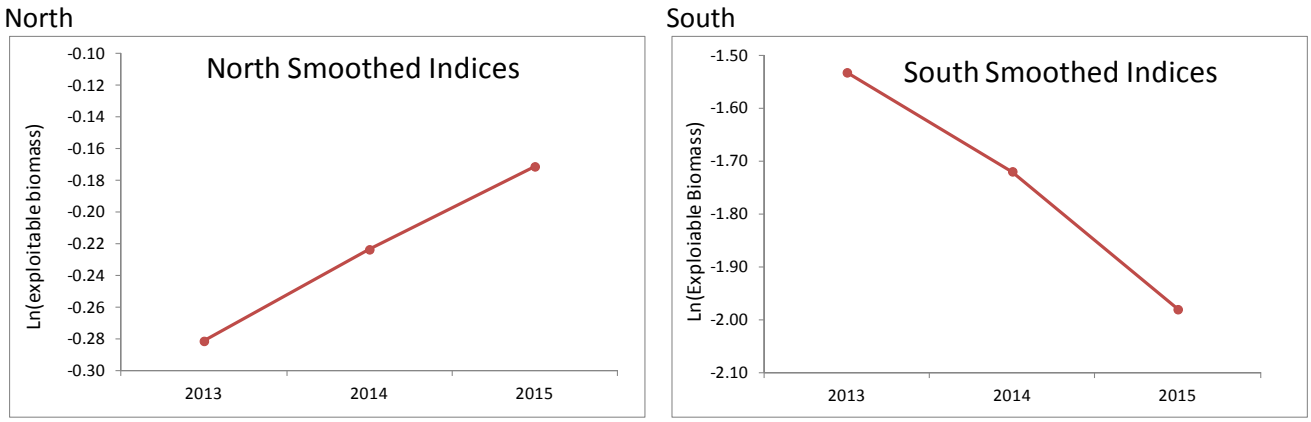
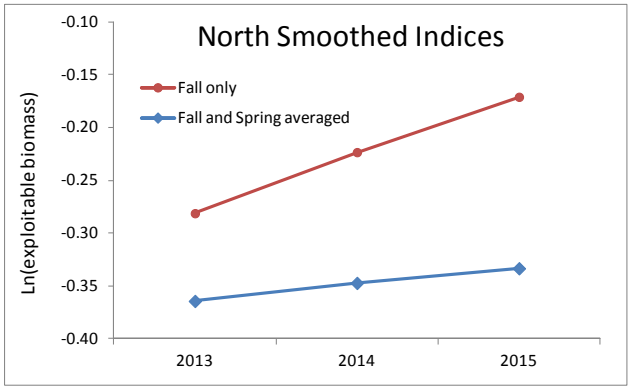


Figure 36. Trends in exploitable biomass (in scale) indices in the northern and southern management areas based on NEFSC fall surveys only.

North



South

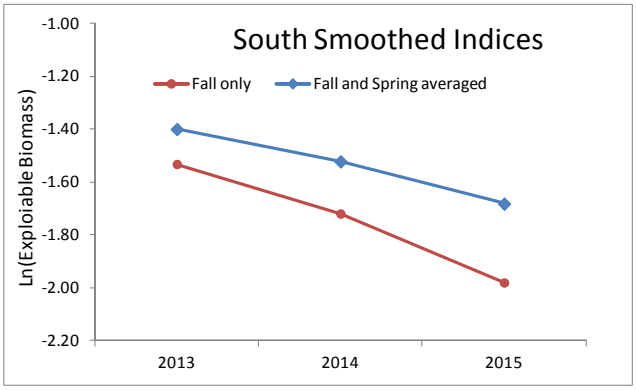


Figure 37. Trends in exploitable biomass (ln scale) indices in the northern and southern management areas based on NEFSC fall survey only (red circles) and spring and fall surveys averaged (blue diamonds).

Appendix 1. Additional Information

Figures 1 and 2 provide a comparison of survey indices calculated using the delta distribution vs. arithmetic estimators with bootstrapped confidence intervals.

Figure 3 shows the distribution of monkfish in scallop dredge surveys conducted by NEFSC during 2009-2105. Figure 4 shows the location of sampling during the 2015 scallop dredge survey conducted by VIMS.

Figures 5 and 6 relate to habitat selection of monkfish. These figures show cumulative distribution curves for temperatures or depth at all stations vs. stations where monkfish were captured (temperature or depth at each station was weighted by the number of monkfish caught there) in NEFSC fall surveys. In the northern management area, monkfish distribution does not appear to be influenced by temperature or depth, as the curves generally overlie each other. In the south, monkfish occur at relatively cooler stations; however, there does not seem to be a trend over time (and similar results were found in Richards et al. 2008). In the south, monkfish are distributed in relatively deep water, which is consistent with distribution patterns seen previously for monkfish in the Mid-Atlantic Bight (Richards et al. 2008). No trend is evident in depth distribution in the south.

Figures 7-10 provide other indicators of distribution of monkfish. Figures 5 and 6 show the annual fraction of mean catch of monkfish in each stratum in fall surveys, and the mean catch per tow by stratum over time. Figures 7 and 8 show time series of Gini Indices calculated from several surveys over time. The Gini Index ranges between 0 and 1, with 0 indicating a perfectly even distribution, and 1 indicating a highly clumped distribution.

Figures 11 and 12 compare monkfish catch rates in day and night survey tows, along with the number of stations sampled during night and day over time. Particularly in the south, catch rates tend to be higher at night; however, in both areas, the number of day and night tows over time is roughly equal.

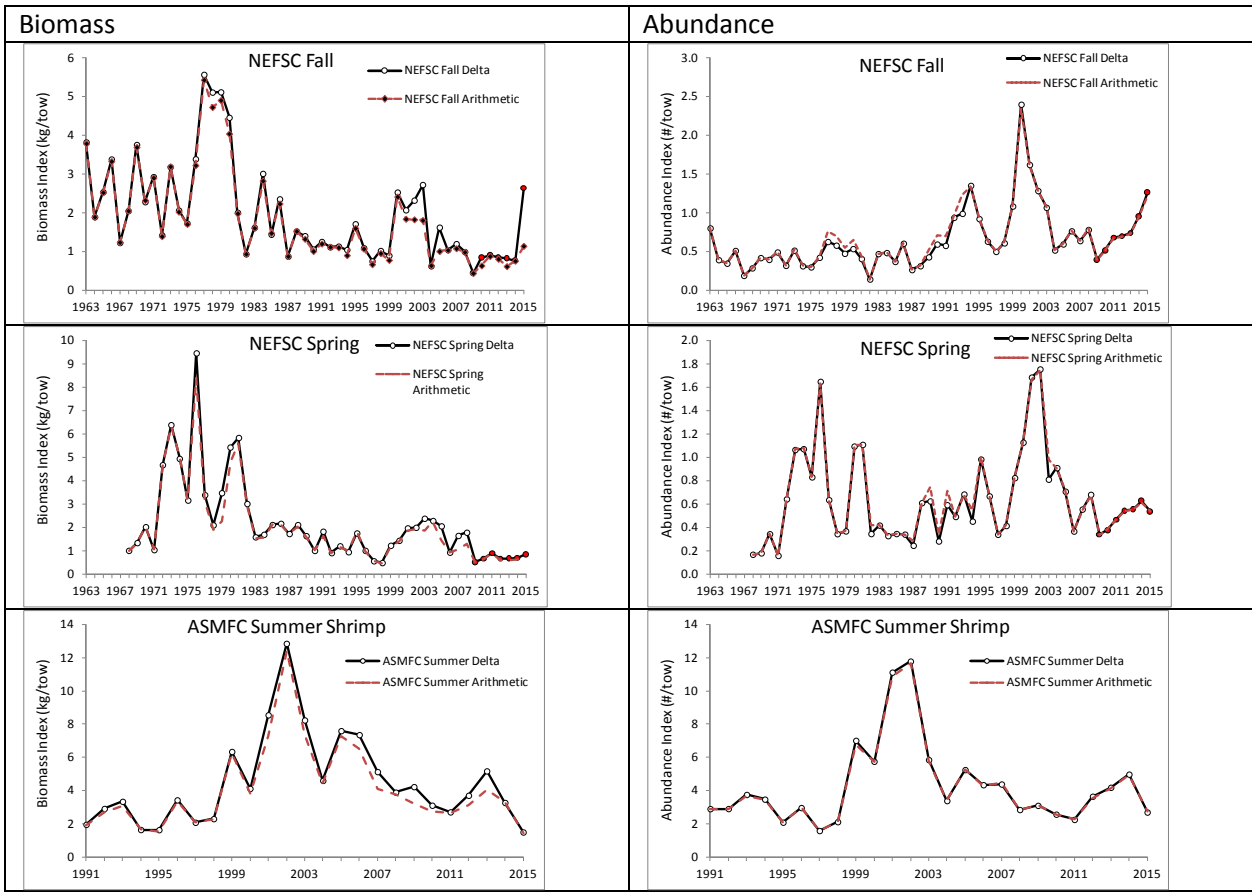


Figure A1. Comparison of delta distribution with arithmetic estimators of survey indices of abundance and biomass, northern management area. Confidence intervals for arithmetic estimators are from bootstrapping.

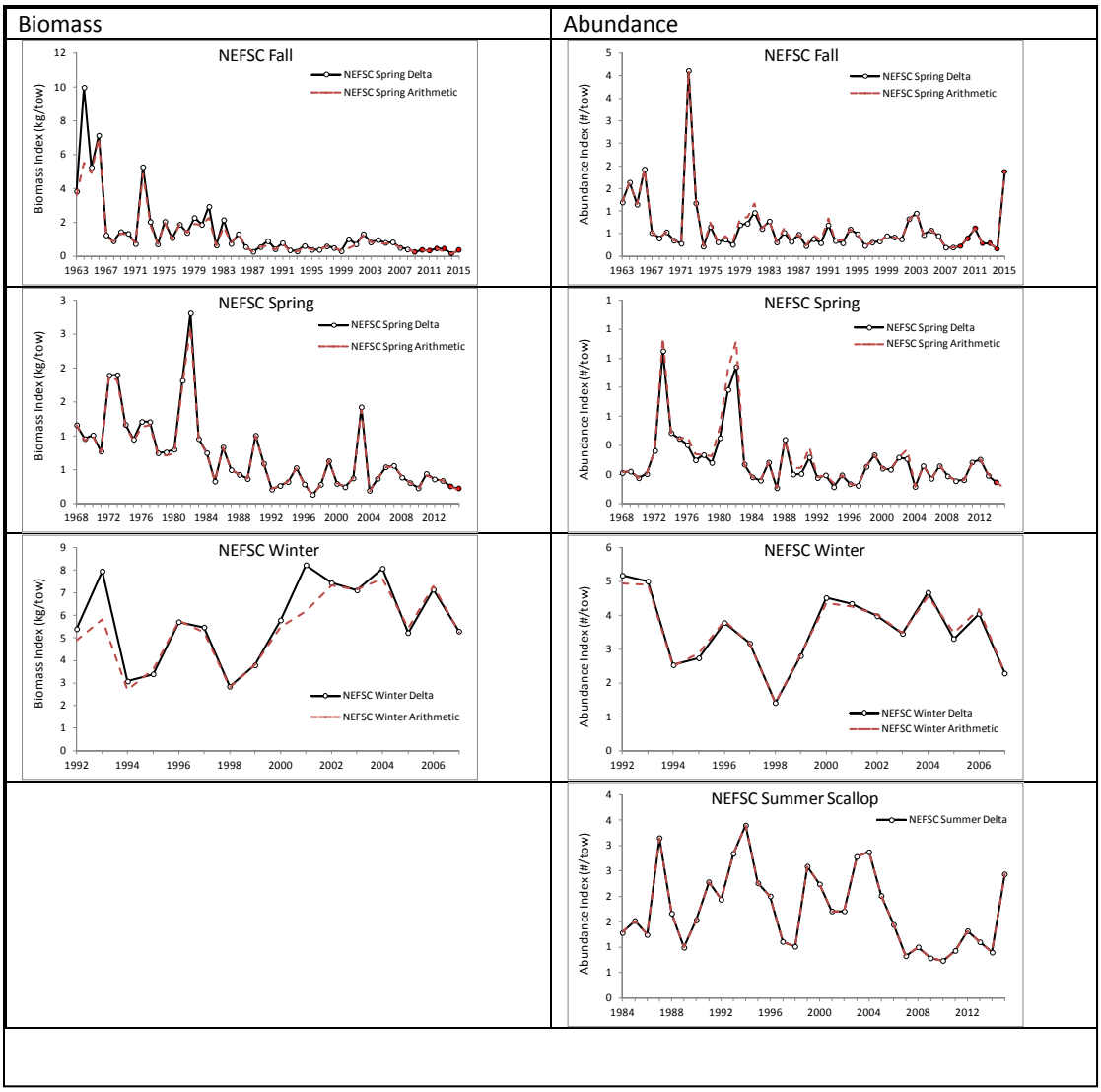
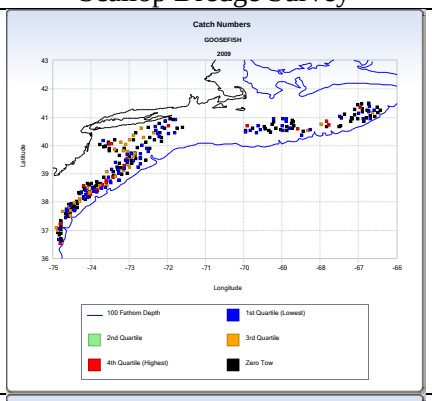
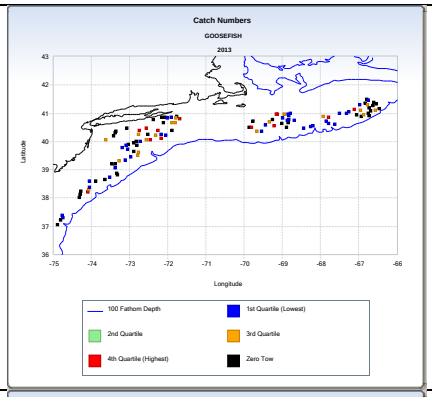
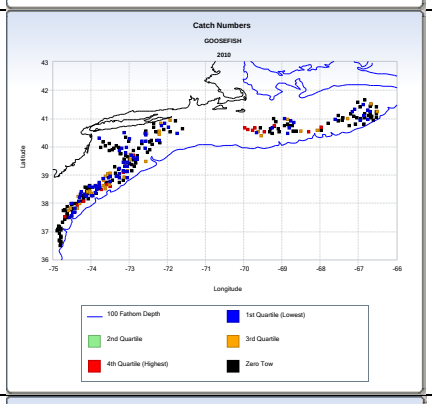


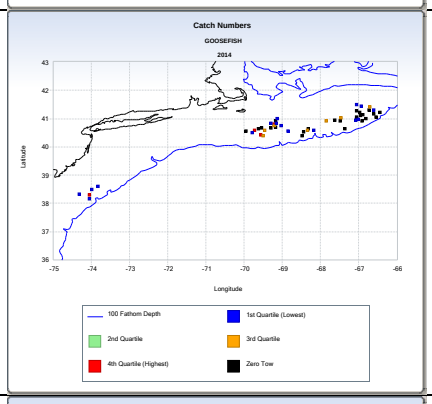
Figure A2. Comparison of delta distribution with arithmetic estimators of survey indices of abundance and biomass, southern management area. Confidence intervals for arithmetic estimators are from bootstrapping.

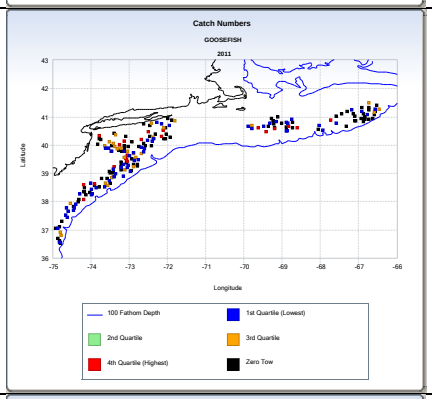
Scallop Dredge Survey

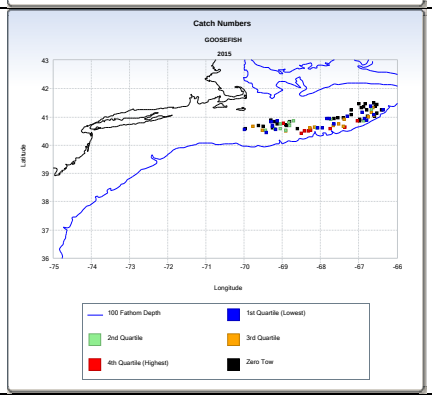












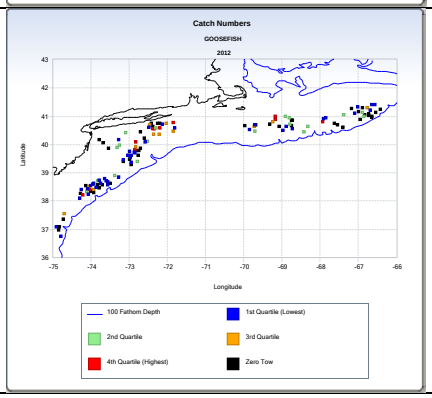


Figure A3. Distribution of monkfish in NEFSC scallop dredge surveys, 2009-2015. Survey coverage by NEFSC decreased starting in 2011 and was limited to the northern portion of the survey area in 2014 and 2015.

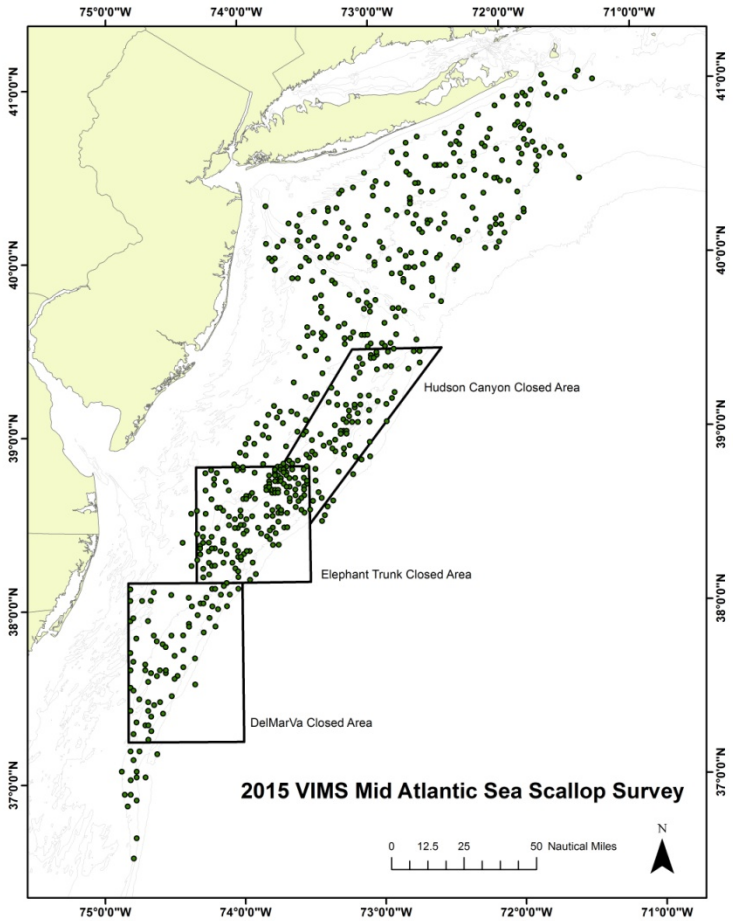


Figure A4. Sampling locations for spring scallop dredge survey conducted by VIMS in 2015.

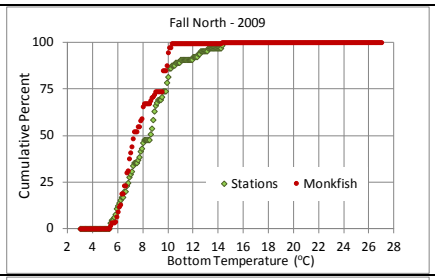
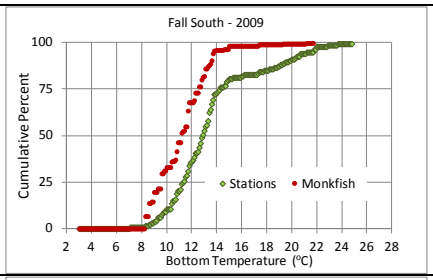
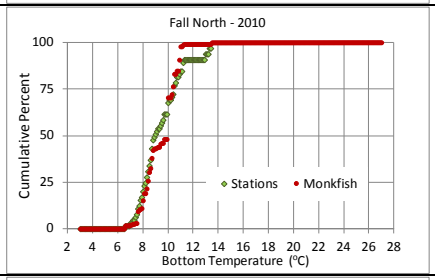
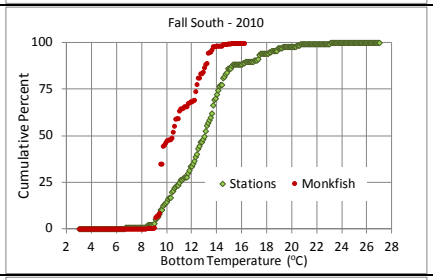
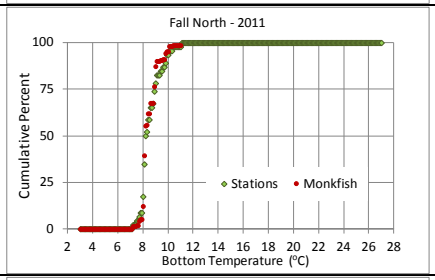
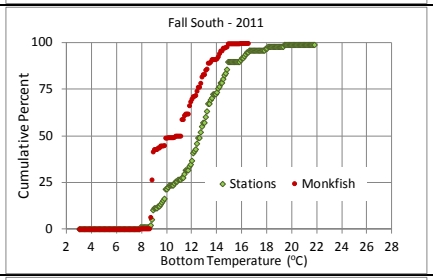
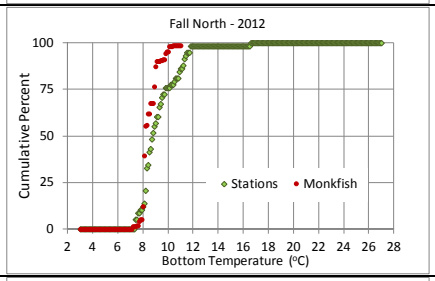
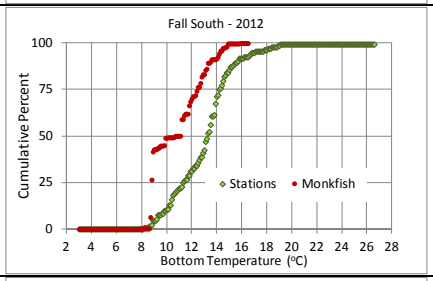
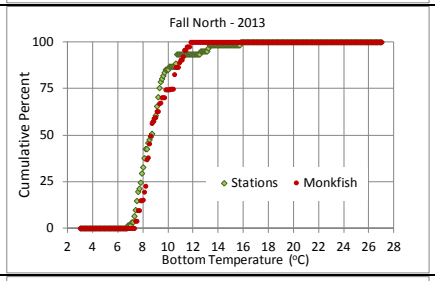
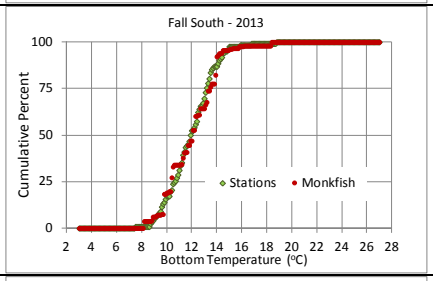
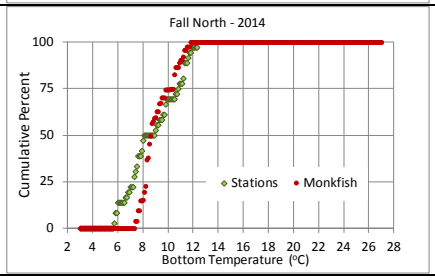
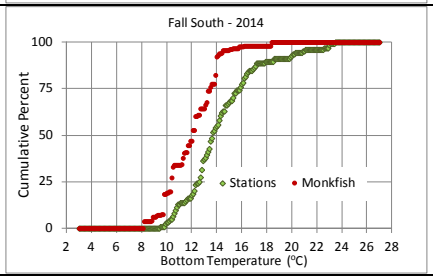
	North	South
2009		
2010		
2011		
2012		
2013		
2014		

Figure A5. Temperature selection curves for monkfish in northern and southern management regions using NEFSC fall survey data. Green shading indicates bottom temperatures at all stations visited (cumulative percent), red shading indicates temperature weighted by number of monkfish caught at each station.

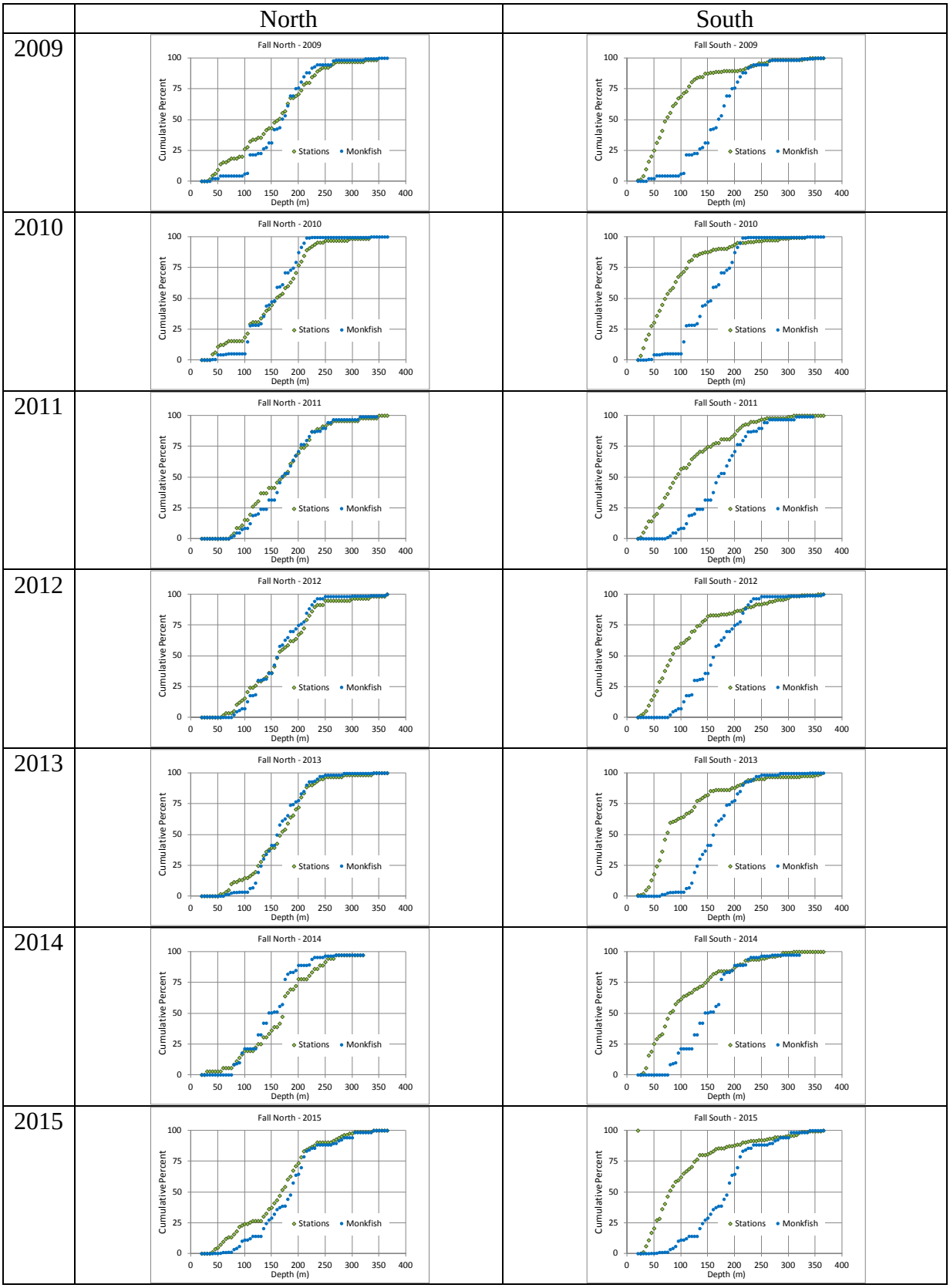


Figure A6. Depth selection curves for monkfish in northern and southern management regions using NEFSC fall survey data. Green shading indicates bottom depth at all stations visited (cumulative percent), blue shading indicates depth weighted by number of monkfish caught at each station.

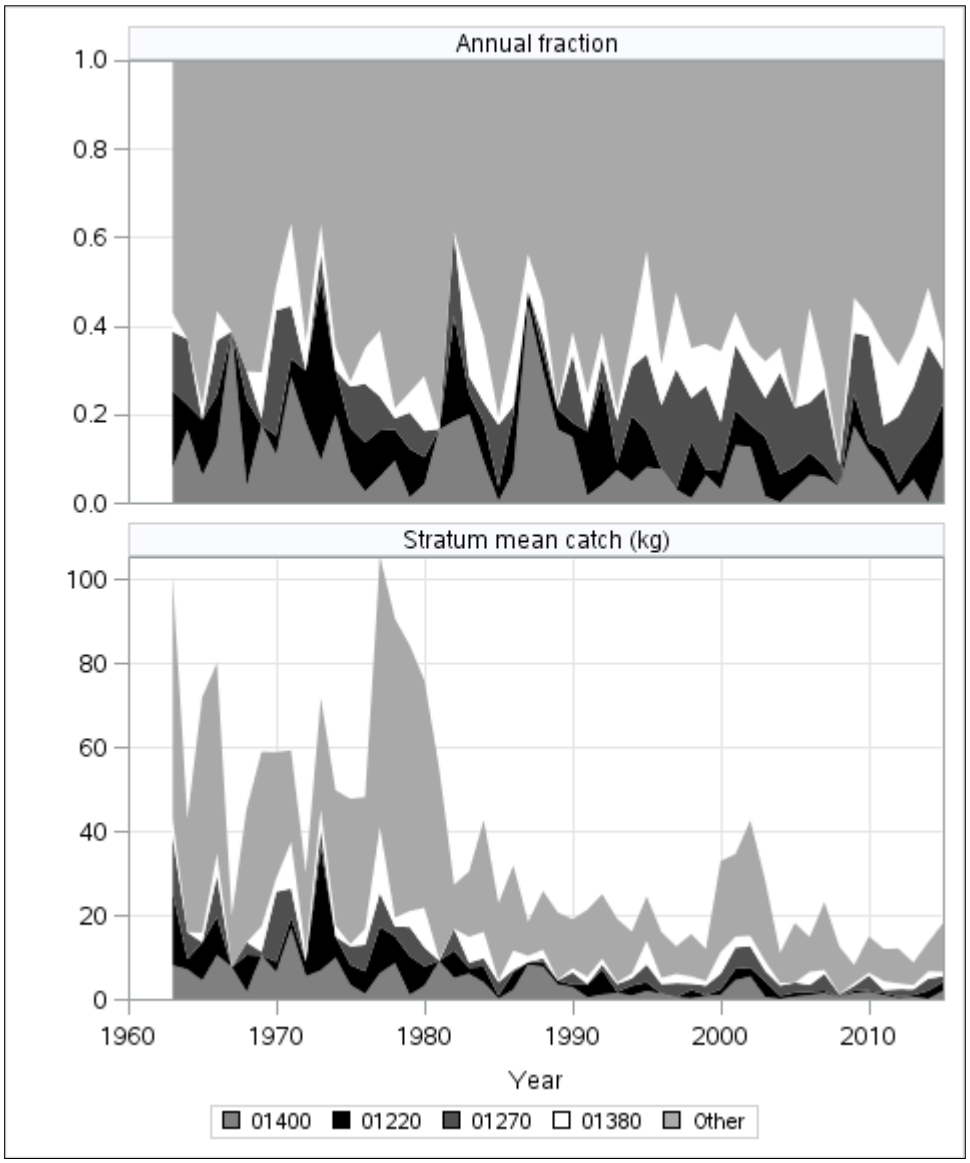


Figure A7. Top panel: Annual fraction of the mean catch in each stratum in fall surveys in the northern management area. Bottom panel: Mean catch per tow by stratum over time.

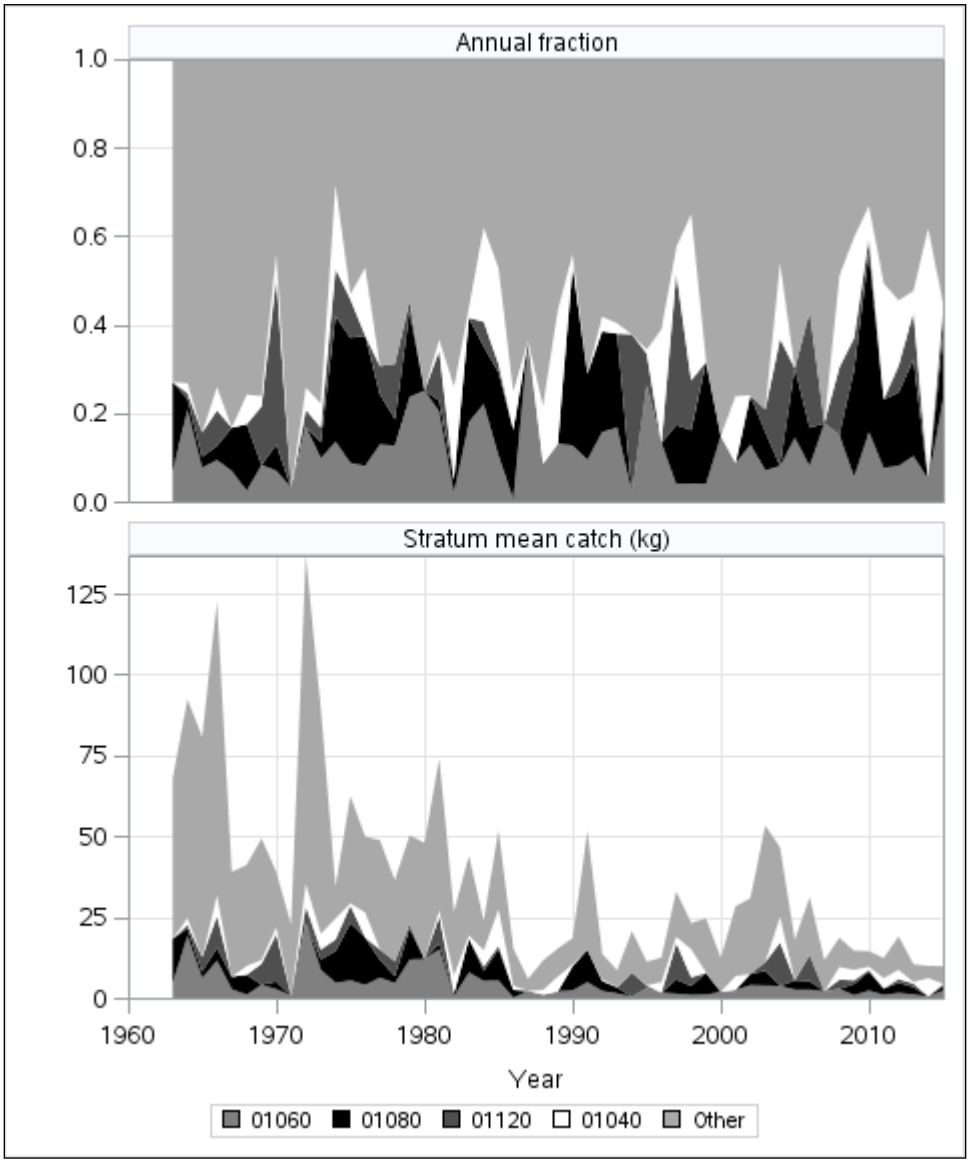


Figure A8. Top panel: Annual fraction of the mean catch in each stratum in fall surveys in the southern management area. Bottom panel: Mean catch per tow by stratum over time.

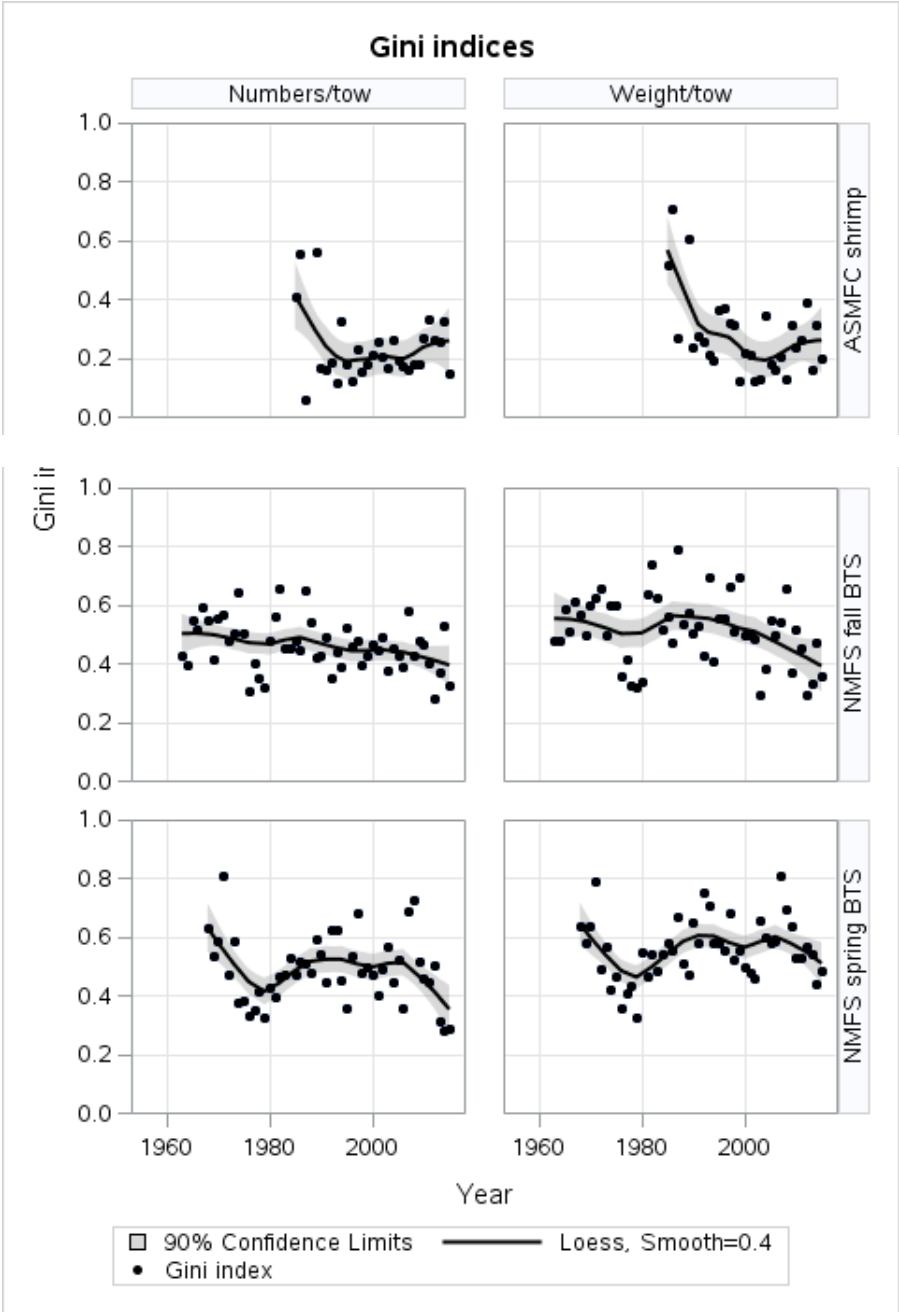


Figure A9. Gini Indices for surveys in the northern management area. The Gini Index ranges between 0 and 1, with 0 indicating a perfectly even distribution, and 1 indicating a highly clumped distribution.

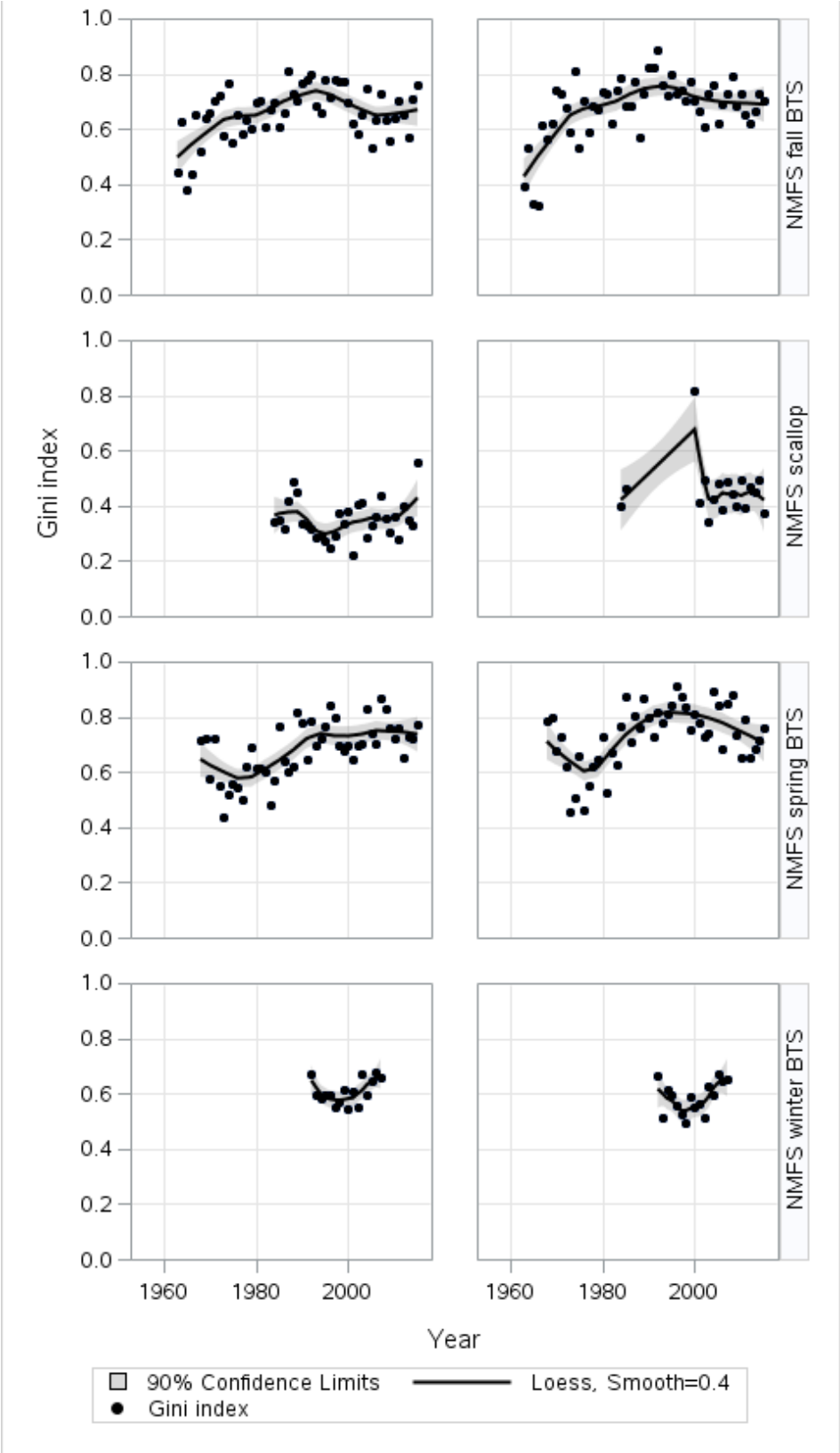


Figure A10. Gini Indices for surveys in the southern management area. The Gini Index ranges between 0 and 1, with 0 indicating a perfectly even distribution, and 1 indicating a highly clumped distribution. Left column, numbers, right column, weight.

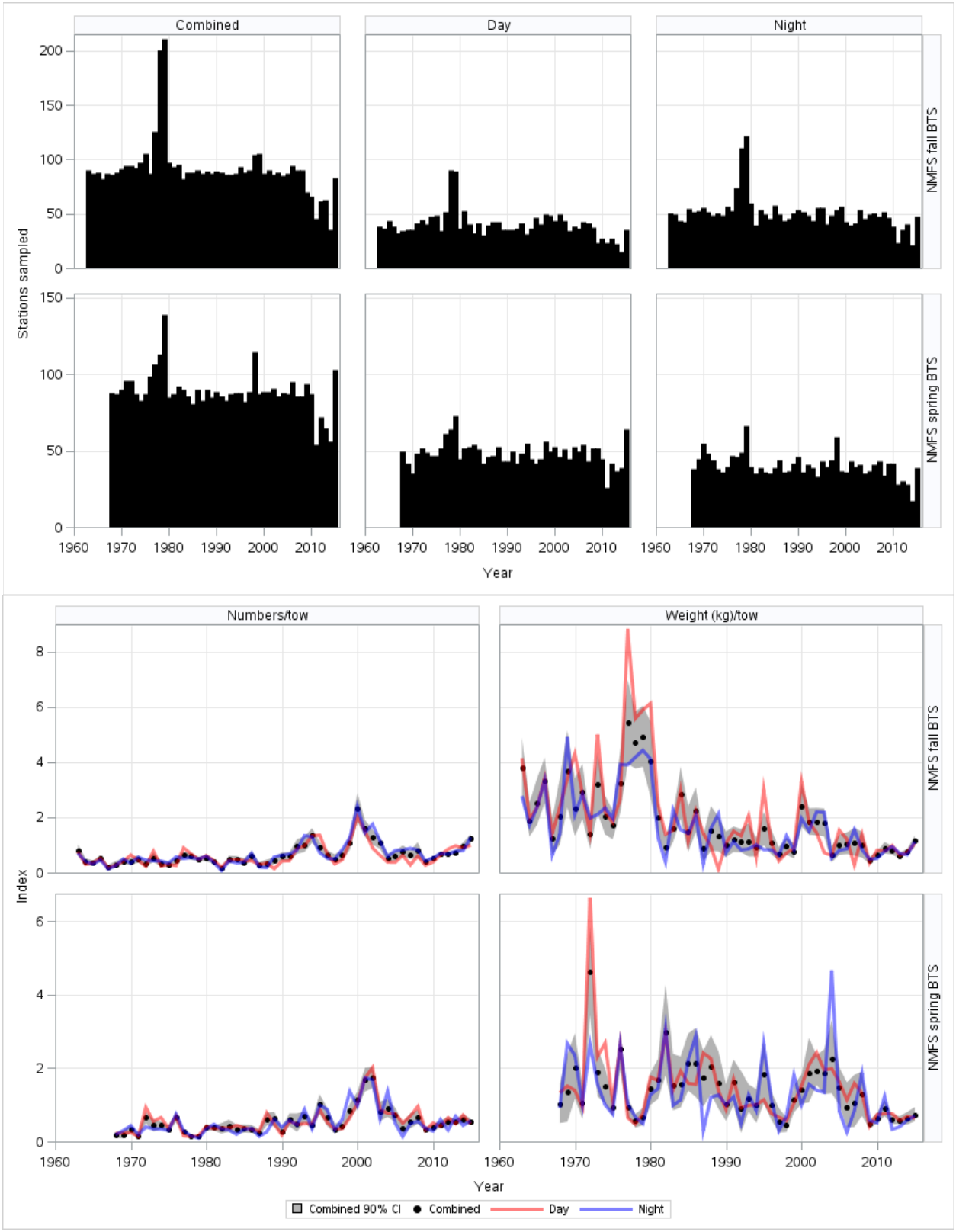
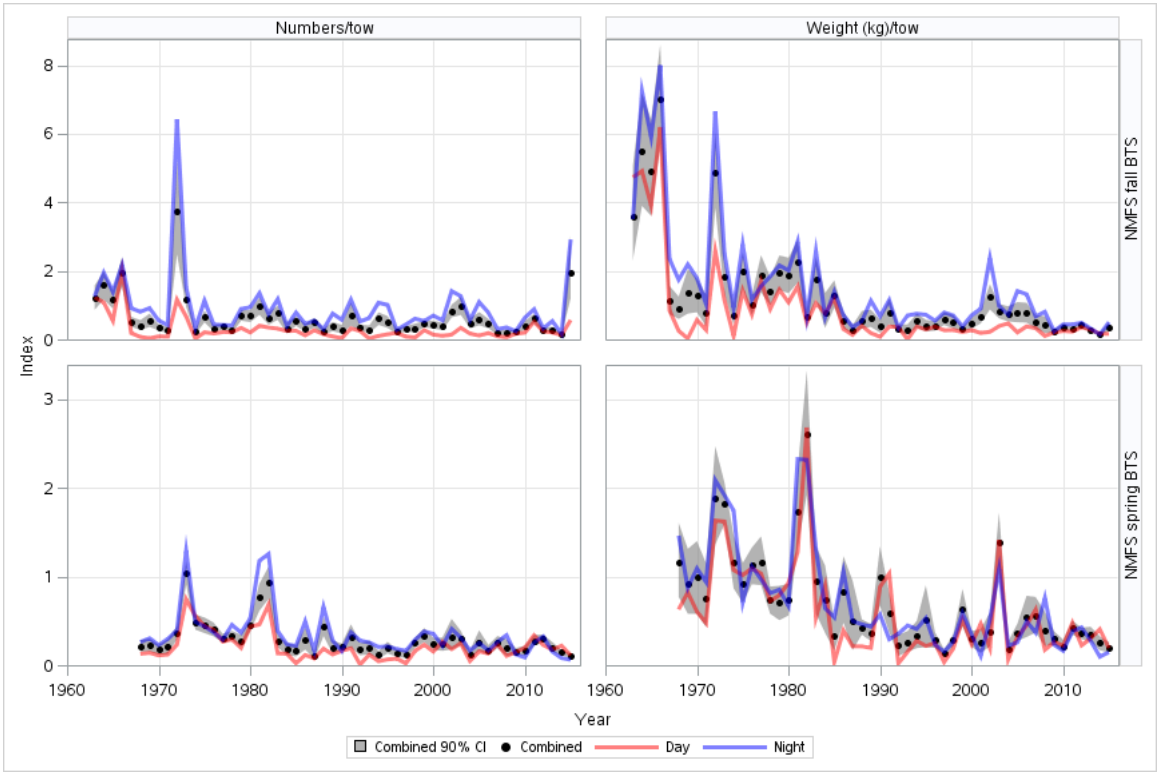


Figure A11. Northern management area. A. Comparison of monkfish catch rates in day and night survey tows. B. Number of stations sampled annually during night, day and both periods combined.



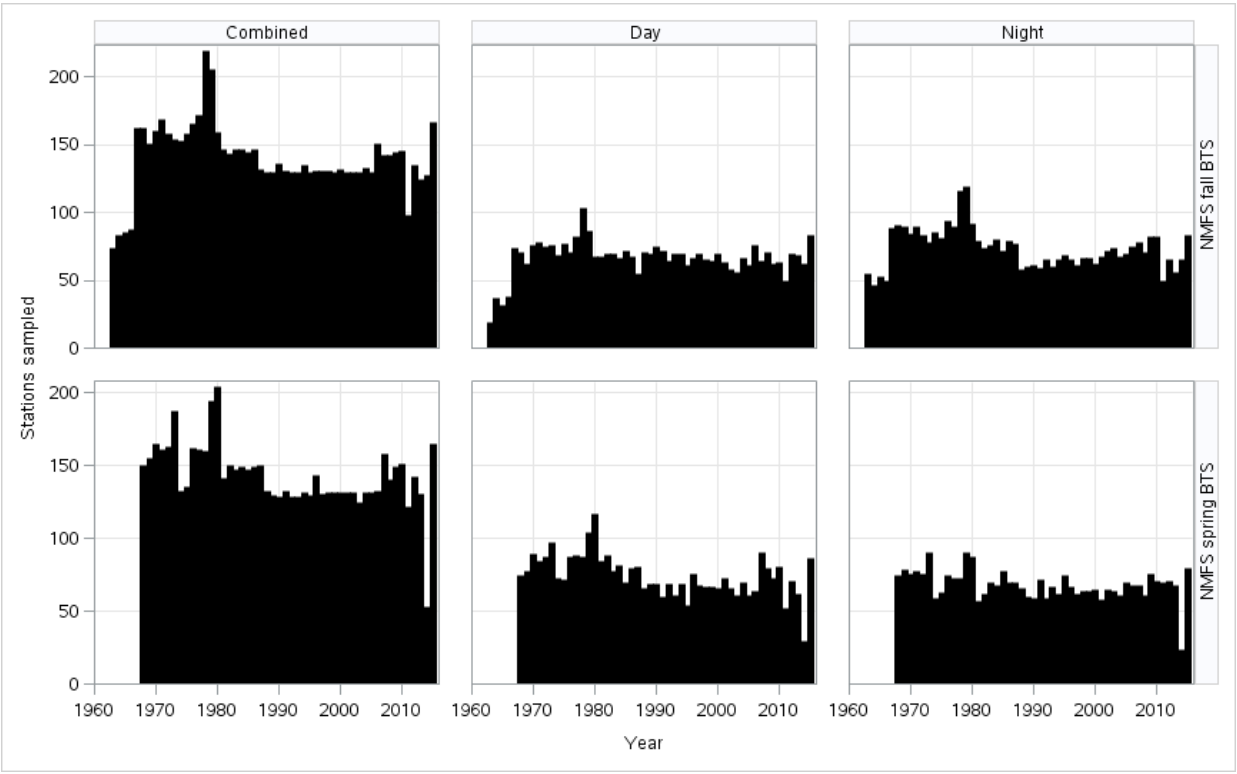


Figure A12. Southern management area. A. Comparison of monkfish catch rates in day and night survey tows. B. Number of stations sampled annually during night, day and both periods combined.

Appendix 2. Monkfish Operational Assessment Attendee List

Jim Weinberg	NEFSC	james.weinberg@noaa.gov
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Rich McBride	NEFSC	richard.mcbride@noaa.gov

Appendix 3. Monkfish Meeting Agenda

Monkfish Operational Assessment Meeting

Northeast Fisheries Science Center
National Marine Fisheries Service
S. H. Clark Conference Room
Aquarium Building
Woods Hole MA, 02543

Meeting Agenda (v. 5-19-2016)

June 20, 2016 9:00 AM-5:00 PM

9:00-12	Introductions and logistics Review of Data Update results Break Review of work done to support the SSC in making an ABC recommendation
12-1:15pm	Lunch
1:15-2:45 pm	Panel Discussion
2:45-3:15 pm	Public Comment Break
3:30-5:00 pm	Writing: Panel Conclusions and Comments The Panel is responsible for addressing 4 topics: • Comment on whether the data update has been completed properly and documented in a written report • Comment on the appropriateness and adequacy of the work that was carried out to support the SSC in making its ABC recommendation • Identify key sources of uncertainty • Identify important research needs

Appendix 4. Report of the Monkfish Assessment Oversight Panel Meeting (March 18, 2016)

The Assessment Oversight Panel (AOP) met on March 18, 2016 to discuss the monkfish update assessment. The meeting was conducted by conference call with a webinar. In addition to the AOP, lead scientist, and working group chair, four people participated in the call (see Participants List below). The meeting lasted one hour. Discussions followed the monkfish assessment analysis and peer review plan available on the SAW webpage (http://www.nefsc.noaa.gov/nefsc/saw/monkfish2016/index.html).

One purpose of the AOP meeting was to confirm the recommendation made by the NEFSC and the concurrence of the NEFMC's Scientific and Statistical Committee to not update the monkfish assessment using the same modeling approach as used in the last assessment. This recommendation was based on new scientific evidence that the vertebral ageing method for monkfish is not valid. There is not an accepted method to age monkfish and estimate a growth curve at this time. Since the previous monkfish assessment uses the SCALE model and this model relies on a growth curve to relate observed length distributions to estimated ages, the lack of a growth curve prevents its use. The AOP agrees with the recommendation to not update the previous modeling approach (SCALE) for monkfish during the update assessment. This decision is recognized as a departure from standard procedure but is based on the recognition that the inability to estimate monkfish growth makes any analysis using SCALE unusable for providing catch advice. The AOP agrees that running the SCALE model just for the sake of process, when there is no chance the results would be acceptable for management purposes, is not a good use of time.

The AOP discussed the work to be done for the monkfish update, labelled "Plan B" in the plan document. The approach will be a data update with simple analyses to support the SSC in setting the ABC for monkfish. Standard data will be updated including landings and discards, fishery independent surveys, examination of length-weight relationships, spatial distribution of the stock, and performance of the fishery relative to previously set quotas. The AOP recommends that NEFMC SSC members participate in the working group and subsequent integrated peer review to ensure that the analyses conducted by the working group contribute to the SSC catch advice deliberations. The desire is for the working group to provide the information needed by the SSC without spending time on analyses that are found to be not useful by the SSC. The AOP recommends that stock status not be evaluated during this data update for monkfish because of the lack of biological reference points to allow status determination. The next monkfish benchmark will provide biological reference points that can be used to determine stock status. It is expected that the OFL for monkfish will be unknown after this data update. The next benchmark should also consider defining a "Plan B" in case the recommended assessment approach fails in subsequent updates.

The next steps in the monkfish update will start with a public outreach meeting on April 19. Details about this meeting will be provided on the SAW webpage. The monkfish working group is scheduled to meet in Woods Hole May 24-27, but may not require the entire four days. The working group meeting will be available by web conference with details provided on the SAW webpage. The report of the working group will be reviewed during a one day integrated peer review in late June (exact time to be determined). This meeting will also be available by web conference with details provided on the SAW webpage. The AOP suggests the scheduling of meeting for update assessments be considered from a broader perspective to ensure that the appropriate balance between transparency and efficiency are met.

AOP Recommendations

- The AOP agrees with the recommendation to not update the previous modeling approach (SCALE) for monkfish during the update assessment.
- The AOP recommends that NEFMC SSC members participate in the working group and subsequent integrated peer review to ensure that the analyses conducted by the working group contribute to the SSC catch advice deliberations.
- The AOP recommends that stock status not be evaluated during this data update for monkfish because of the lack of biological reference points to allow status determination.

Participants List

John Boreman (AOP, MAFMC SSC chair)
Jake Kritzer (AOP, NEFMC SSC chair)
Chris Legault (AOP chair)
Anne Richards (lead scientist)
Mark Terceiro (working group chair)
Fiona Hogan (NEFMC)
Jean-Jacques Maguire (NEFMC SSC)
Jason Didden (MAFMC)
Sheena Steiner (NEFSC)

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