

Reports

5-2019

Annual Report - 2018 Data collection and analysis in support of single and multispecies stock assessments in Chesapeake Bay: The Chesapeake Bay Multispecies Monitoring and Assessment Program.

Christopher F. Bonzek
Virginia Institute of Marine Science

James Gartland
Virginia Institute of Marine Science

Debra J. Gauthier
Virginia Institute of Marine Science

Robert J. Latour
Virginia Institute of Marine Science

Follow this and additional works at: <https://scholarworks.wm.edu/reports>



Part of the [Aquaculture and Fisheries Commons](#)

Recommended Citation

Bonzek, C. F., Gartland, J., Gauthier, D. J., & Latour, R. J. (2019) Annual Report - 2018 Data collection and analysis in support of single and multispecies stock assessments in Chesapeake Bay: The Chesapeake Bay Multispecies Monitoring and Assessment Program.. Virginia Institute of Marine Science, William & Mary. <https://doi.org/10.25773/3v19-3f27>

This Report is brought to you for free and open access by W&M ScholarWorks. It has been accepted for inclusion in Reports by an authorized administrator of W&M ScholarWorks. For more information, please contact scholarworks@wm.edu.

ANNUAL REPORT

Data collection and analysis in support of single and multispecies stock assessments in Chesapeake Bay:

The Chesapeake Bay Multispecies Monitoring and Assessment Program

Prepared for:

Virginia Marine Resources Commission

and

U.S. Fish & Wildlife Service

For Sampling During:

Calendar Year 2018 and Previous Years

Project Number:

F-130-R-14

Submitted:

May 2019

Prepared by:

Christopher F. Bonzek

James Gartland

Debra J. Gauthier

Robert J. Latour, Ph.D

**School of Marine Science
College of William and Mary
Virginia Institute of Marine Science
Gloucester Point, VA 23062**

Table of Contents

Introduction	.....	1
Methods	.....	3
Results – Task 1	.....	9
Results – Tasks 2-4 /	.....	13
<i>Species Data Summaries</i>	.....	13
Atlantic croaker	.....	13
Black sea bass	.....	16
Bluefish	.....	17
Butterfish	.....	18
Kingfish	.....	19
Northern puffer	.....	21
Scup	.....	22
Spot	.....	23
Striped bass	.....	25
Summer flounder	.....	27
Weakfish	.....	29
White perch	.....	30
<i>Water Quality</i>	.....	32
Results – Task 5	.....	32
Results – Appendix	.....	34
Literature Cited	.....	34
Species Figures		
Atlantic croaker	.....	37
Black sea bass	.....	49
Bluefish	.....	61
Butterfish	.....	73
Kingfish	.....	77
Northern puffer	.....	89
Scup	.....	97
Spot	.....	109
Striped bass	.....	121
Summer flounder	.....	135
Weakfish	.....	147
White perch	.....	161
Water Quality Figures		
Bottom Temperature	.....	173
Bottom Salinity	.....	174
Bottom Dissolved Oxygen	.....	175
Temperature profiles	.....	176
Salinity profiles	.....	178
Diss. oxygen profiles	.....	180
Appendix – Species data summaries for blue crab (male and adult female)		
and clearnose skate	.....	182

Introduction

Historically, fisheries management has been based on the results of single-species stock assessment models that focus on the interplay between exploitation level and sustainability. There currently exists a suite of standard and accepted analytical frameworks (e.g., virtual population analysis (VPA), biomass dynamic production modeling, delay difference models, etc.) for assessing the stocks, projecting future stock size, evaluating recovery schedules and rebuilding strategies for overfished stocks, setting allowable catches, and estimating fishing mortality or exploitation rates. A variety of methods also exist to integrate the biological system and the fisheries resource system, thereby enabling the evaluation of alternative management strategies on stock status and fishery performance. These well-established approaches have specific data requirements involving biological (life history), fisheries-dependent, and fisheries-independent data (Table 1). From these, there are two classes of stock assessment or modeling approaches used in fisheries: partial assessment based solely on understanding the biology of a species, and full analytical assessment including both biological and fisheries data.

Table 1. Summary of biological, fisheries-dependent and fisheries-independent data requirements for single-species analytical stock assessment models.

Data Category	Assessment Type	Data Description
Biological / Life History	Partial	Growth (length / weight)
		Maturity schedule
		Fecundity
		Partial recruitment schedules
		Longevity
		Life history strategies (reproductive and behavioral)
Fishery-Dependent Data	Analytical	Catch, landings, and effort
		Biological characterization of the harvest (size, sex, age)
		Gear selectivity
		Discards/bycatch
Fishery-Independent Data	Analytical	Biological characterization of the population (size, sex, age)
		Mortality rates
		Estimates of annual juvenile recruitment

Although single-species assessment models are valuable and informative, a primary shortcoming is that they generally fail to consider the ecology of the species under management (e.g., habitat requirements, response to environmental change), ecological interactions (e.g., predation, competition), and technical interactions (e.g., discards, bycatch) (NMFS 1999, Link 2002a,b). Inclusion of ecological processes into fisheries management plans is now strongly recommended (NMFS 1999) and in some cases even mandated (NOAA 1996). Multispecies assessment models have been developed to move towards an ecosystem-based approach to fisheries management (Hollowed et al. 2000, Whipple et al. 2000, Link 2002a,b). Although such models are still designed to yield information about sustainability, they are structured to do so by incorporating the effects of ecological processes among interacting populations.

Over the past decade, the number and type of multispecies models designed to provide insight about fisheries questions has grown significantly (Hollowed et al. 2000, Whipple et al. 2000). While this growth has been fueled primarily by the need to better inform fisheries policy makers and managers, recent concerns about effects of fishing on the structure of ecosystems have also prompted research activities on multispecies modeling and the predator-prey relationships that are implied. From a theoretical perspective, basing fisheries stock assessments on multispecies rather than single-species models certainly appears to be more appropriate, since multispecies approaches allow a greater number of the processes that govern population abundance to be modeled. However, this increase in realism leads to an increased number of model parameters, which in turn, creates the need for additional types of data.

In the Chesapeake Bay region, there has been a growing interest in ecosystem-based fisheries management, as evidenced by the recent development of fisheries steering groups (e.g., ASMFC multispecies committee), the convening of technical workshops (Miller et al. 1996; Houde et al. 1998) development of planning processes for implementing ecosystem planning (C.B. Fisheries Ecosystem Advisory Panel, 2006) and most recently a Scientific and Technical Advisory Committee sponsored workshop titled “Assessment the Chesapeake Bay Forage Base” at which ChesMMAP data were the principal source of data for numerous species (Ihde et al., 2015).

If either single-species or ecosystem-based management plans are to be developed and maintained, they must be based on sound stock assessments. In the Chesapeake Bay region, however, the data needed to perform single and multispecies assessments are typically either partially available or nonexistent. The Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) was developed to assist in filling these data gaps, and ultimately to support bay-specific stock assessment modeling activities at both single and multispecies scales. While no single gear or monitoring program can collect all of the data necessary for both types of assessments, ChesMMAP was designed to maximize the biological and ecological information collected for several recreationally, commercially, and ecologically important species in the bay.

In general, ChesMMAP is fishery-independent monitoring survey that uses a large-mesh bottom trawl to sample late juvenile-to-adult fishes in the mainstem of Chesapeake Bay. This program currently provides data on relative abundance, length, weight, sex ratio, maturity, age, and trophic interactions for several important fish species that inhabit the bay seasonally. Among the research agencies in the Chesapeake Bay region, only VIMS has a program focused on multispecies issues involving the late juvenile and adult (i.e., harvested) components of the exploited fish species that seasonally inhabit the bay. The Multispecies Research Group (MRG) is also responsible for executing the nearshore trawl survey for the Northeast Area Monitoring and Assessment Program (NEAMAP), as well as the VIMS elasmobranch longline survey. In this report, we summarize the ChesMMAP field, laboratory, and data analysis activities through the 2016 sampling year.

A new ChesMMAP task included during recent segments was initial evaluation of a potential new sampling gear system. This system includes a one-half size (200 x 12cm fishing circle) version of the same trawl net in use for the NEFSC and NEAMAP surveys (400 x 12cm fishing circle). Scale model flume tank testing occurred during an earlier segment, initial field testing took place during 2009-2010 and the first comparative (to the existing gear) field trials took place in 2010-2011. Due to previously unanticipated upgrades and replacement plans for the *R/V Bay Eagle* it was determined that the most prudent course of action was to delay further testing during the current segment (fully explained in Methods below).

The MRG has been attempting to steadily improve its online presence and provide stakeholders, scientists, and managers with ready access to significant parts of the ChesMMAP (and other monitoring surveys conducted by the group) data bases. Three elements of particular significance have been made accessible in recent years:

- Abundance Indices – All measures of relative abundance and most other analyses presented in this report are also available online at www.vims.edu/fisheries/chesmmapiindices/index.php
- Food Habits Summaries – A variety of user-selectable summarizations of fish diet information, from either the predator or the prey point of view, are available at <http://www.vims.edu/fisheries/fishfood>.
- Station-Specific Catches – GIS style representations of tow-specific catch information for ChesMMAP (and other) data with user-selected data filters are at: www.vims.edu/fisheries/fao/index.php.

These links as well as much more information about ChesMMAP and other programs conducted by the MRG are available at <http://www.vims.edu/fisheries/mrg>.

The following Tasks are addressed in this report:

- Task 1 – Conduct research cruises
- Task 2 – Synthesize data for single species analyses
- Task 3 – Quantify trophic interactions for multispecies analyses
- Task 4 – Estimate abundance
- Task 5 – Continue evaluation of alternative sampling gear.

Methods

Task 1 – Conduct research cruises

The timing of the cruises was chosen so as to coincide with the seasonal abundances of fishes in the bay. In calendar year 2018, four bimonthly (~80 station) research cruises were planned and conducted between May to November in the mainstem of Chesapeake Bay. The March cruise was not conducted due to a funding shortfall during the previous project segment.

The *R/V Bay Eagle*, a 19.8 m aluminum hull, twin diesel vessel owned and operated by VIMS, served as the sampling platform for this survey. Fishes (and select invertebrates) were collected using a 13.7 m (headrope length), two-bridle, four-seam bottom trawl manufactured by *Reidar's Manufacturing Inc.* of New Bedford, MA. The top belly, bottom belly, and side panels of the net are constructed of 15.2 cm stretch mesh (2.6 mm diameter twine), and the cod-end is constructed of 7.6cm stretch mesh (1.6 mm diameter twine). The bridles (legs) of the net are 6.1 m and connected directly to 1.3 m x 0.8 m steel-V trawl doors weighing 71.8 kg each. The trawl net is deployed with a single-warp system using 9.5 mm (dia.) steel main cable and a 37.6 m bridle constructed of 7.9 mm stainless steel wire rope.

For each cruise, the goal was to sample 80 sites throughout the mainstem of Chesapeake Bay. Sampling sites were selected using a stratified random design. The bay was stratified by dividing the mainstem into five regions of 30 latitudinal minutes each (the upper and lower regions being slightly smaller and larger than 30 minutes, respectively). For easy reference, regions are numbered 1 through 5 from north to south. Regions 1-3 coincide with the Maryland portion of the bay and regions 4-5 correspond with

Virginia waters (note that due to the irregular state boundary it is possible that stations in the very southernmost portion of Region 3 may actually be in Virginia and likewise stations in the northernmost reaches of Region 4 may be north of the state border). Within each region, three depth strata ranging from 3.0 m-9.1 m, 9.1 m-15.2 m, and >15.2 m were defined. A grid of 1.9 km² cells was superimposed over the mainstem, where each cell represented a potential sampling location. The number of stations sampled in each region and in each stratum was proportional to the surface area of water represented. Stations were sampled without replacement and those north of Pooles Island (latitude 39° 17') have not been sampled since July 2002 due to repeated loss of gear. In the future, we plan to use sidescan sonar to identify potential sampling locations in this area.

Tows were normally conducted in the same general direction as the tidal current (pilot work conducted using the net monitoring gear in November 2001 indicated that the survey gear performed most consistently when towed with the current rather than against the current). The net was generally deployed at a 4:1 scope, which refers to the cable length: water depth ratio. For shallow stations, however, bridle wires were always fully deployed, implying that the scope ratio could be quite high in these particular situations. The target tow speed was 3.0 kts but occasionally varied depending on wind and tidal conditions. Based on data collected from the net monitoring gear, tow speed and scope were adjusted to ensure that the net maintained expected geometry. Tows were 20 minutes in duration, unless obstructions or other logistical issues forced a tow to be shortened (if the duration of a tow was at least 10 minutes, it was considered valid). Computer software was used to record data from the net monitoring gear (i.e., wingspread and headrope height) as well as a continuous GPS stream during each tow. On occasions when the monitoring gear failed or was not deployed, the trawl geometry was assumed to follow cruise averages and beginning and ending tow coordinates were recorded by hand from the vessel's GPS system.

Task 2 – Synthesize data for single species analyses

Once onboard, the catch from each tow was sorted and measured by species and size-class if distinct modal length classes within a particular species were evident. A subsample of each species/size-class was further processed for individual weight determination, stomach contents, ageing, and determination of sex and maturity stage. In addition to these biological data, water temperature, salinity, and dissolved oxygen readings were recorded at each sampling location. During 2010, acquisition of a new water quality instrument which takes near instantaneous readings of all parameters (temperature, salinity, dissolved oxygen) allowed measurement of these parameters throughout the water column rather than only at the surface and near bottom as had previously been practiced. At each location, water quality parameters were electronically recorded approximately 1m intervals until the instrument reaches the bottom.

Single-species assessment models typically require information on (among others) age-, length-, and weight-structure, sex ratio, and maturity stage. Data were synthesized to characterize annual length- and age-frequency distributions. Analytical computer programs to characterize each of the assessment-related data elements (length, weight, age, sex, maturity) were developed to allow for the summarization of these characteristics across a variety of spatial and temporal scales (e.g., by year, season, or region of the bay) for each species.

Task 3 – Quantify trophic interactions for multispecies analyses

In addition to the population-level information described under Task 2, multispecies assessment models require information on predator-prey interactions across broad seasonal and spatial scales. In general, these procedures involve examining the stomach contents of predators and identifying each prey item

to the lowest possible taxonomic level. As such, stomach samples were collected and preserved in the field and were processed at VIMS following standard diet analysis procedures (Hyslop 1980). Several diet indices were calculated to identify the main prey types for each species sampled by the ChesMMAAP Survey: percent weight, percent number, and percent frequency-of-occurrence.

Both percent weight and percent number are offered in this report. In the food habits figures presented for each species, prey types are ordered first in decreasing percentage by weight order by major taxa (e.g. fish, crustaceans, molluscs, etc.) and within each taxon by decreasing percentage for each species or subgroup. To make comparisons between percent by weight vs. by number readily accomplished, the same color scheme of major taxa is maintained in the succeeding percent by number figure though the taxa order (again by decreasing percentage), as well as species or subgroup order within each taxon are allowed to vary.

These indices can be coupled with the information generated from Task 2 and age-, length-, and sex-specific diet characterizations can be developed for each species. Characterizing spatial and temporal variability in these diets is also possible using ChesMMAAP data.

As noted above, several diet index values were calculated to identify the main prey in the diet of predators in the mainstem Chesapeake Bay. Since trawl collections essentially yield a cluster of fish at each sampling location, these indices were calculated using a cluster sampling estimator (Buckel et al. 1999).

Specifically, the contribution of each prey type to the diet by weight (% Q_k) is given by:

$$\% Q_k = \frac{\sum_{i=1}^n M_i q_{ik}}{\sum_{i=1}^n M_i},$$

where

$$q_{ik} = \frac{w_{ik}}{w_i} * 100,$$

and where n is the number of clusters (species/size-class combinations) of the predator of interest sampled, M_i is the number of individuals of this predator species represented in cluster i , w_i is the total weight of all prey items encountered in the stomachs of that predator sampled from cluster i , and w_{ik} is the total weight of prey type k in those stomachs.

Task 4 – Estimate abundance

Time-series of abundance information are standard products developed from the basic catch data of a fishery independent monitoring survey. For each species sampled by the ChesMMAAP Survey, a variety of relative abundance trends can be generated according to year, season, and location within Chesapeake Bay.

Absolute abundance estimates can be generated for each species by combining abundance data with area swept by the trawl and gear efficiency. Area swept was calculated for each tow by multiplying tow distance (provided by GPS) by average wingspread (provided by net monitoring gear). Gear efficiency

estimates, gained through hydroacoustic data collection as described in previous project reports, have been estimated for two species common in ChesMMAAP catches (Atlantic Croaker and White Perch) and results were recently published (Hoffman et al. 2009). Though calculated for previous annual reports these absolute abundance estimates are not presented for this current segment.

While minimum total or absolute abundance estimates are important for certain bioenergetics and ecosystem level analyses, fishery assessments typically depend upon relative abundance indices from surveys as important indicators of abundance. Previous ChesMMAAP progress reports have presented an evolving series of relative and absolute abundance estimates. Still another new step in the evolution of those indices was introduced in the 2011 report. Specifically, for species for which identifiable (from analysis of hard parts) age cohorts are present in ChesMMAAP samples, age-specific indices of abundance based on ChesMMAAP-developed age-length keys (ALK) were offered and those estimates are presented again this year, based on improved ALKs.

Development of ChesMMAAP-specific ALKs was required due to the multiple annual sampling events (i.e. bi-monthly cruises) and inter-cruise growth. Such specific growth information has not been previously available for most species in Chesapeake Bay and could only be accomplished now as ChesMMAAP sample sizes became large enough after several years of field sampling and laboratory ageing efforts.

To develop these ALKs the following procedure was followed for each appropriate species:

- For aged specimens, each fish was assigned into 1cm length bins.
- The proportion of aged fish belonging to each age-class within each length bin was calculated.
- Within each age-class and for each appropriate cruise (i.e. only those cruises used in calculating abundance indices for a species) these proportions were run through a loess-based smoothing algorithm. This process tended to remove spikes (positive or negative) in the raw proportions that occur due to small sample sizes of aged specimens within some length bins and to specimens with abnormally slow or fast growth. This smoothing however did mean that typically the sum of the proportions across all age classes within a length bin did not add to exactly 1.0.
- Small adjustments were made to the loess-smoothed proportions such that within each month (cruise) the sum of all proportional values at a length increment was equal to 1.0.
- For species for which there is still an insufficient sample size of aged specimens to calculate ChesMMAAP-specific ALKs, data from the most appropriate NEAMAP cruises were substituted. This includes Black Sea Bass, Bluefish, Butterfish, and Scup.

Once the ALKs were established for each index month, all measured specimens were similarly assigned to length bins, the total number of specimens captured within each length bin (within each cruise) was summed and the cruise-specific age-at-length proportions applied to those sums, thereby estimating the total number of age-x fish captured within each cruise. That number was then fed into the index calculation algorithm (below). For age-specific biomass indices, the average weight of specimens within each length bin with each age-class was calculated, then multiplied by the calculated (as above) number within the length bin to estimate total weight. Similarly, that figure was then processed through the index calculation algorithm. This method to calculate age-specific abundance differs somewhat from that employed by analysts at the Northeast Fisheries Science Center in which the proportion-at-age is applied to the overall index for each year. The methodology employed in this report has a slight disadvantage in that due primarily to the transformations and back-transformations the sum of the age-specific indices is not equal to the overall abundance index. It has the advantage however that it allows normal calculation of confidence limits on the age-specific indices.

For this report, only geometric mean abundance indices are presented. Arithmetic indices as offered in previous reports are rarely statistically valid. Delta-lognormal indices, model-based indices, and other methods of calculating relative abundance are being explored and will likely replace the geometric mean indices in future reports, on a species-by-species basis.

Abundance index calculations presented here are calculated according to:

1. Raw catch data used for each species index are restricted by month, region, and depth strata such that only those strata with maximum catch-per-unit-effort for that species are used. The methods used to determine these species-specific restrictions were described in a previous progress report (Bonzek et al. 2009). For a small number of species these limiting parameters were updated in a previous segment report.
2. Geometric Mean: Using the restricted data, annual geometric mean catch per area swept indices for each species for all ages combined, were calculated according to the formula:

$$I = \exp \left\{ \sum_{i=1}^n \left(\log \left(\frac{C}{a} + 1 \right) \right) \times w \right\} - 1$$

where: I = Index

C = number or biomass caught at a station

a = area swept at a station

i = i th stratum

n = number of strata

w = stratum weight

Task 5 – Continue evaluation of alternative sampling gear

As discussed in previous project reports, personnel associated with the ChesMMAAP Trawl Survey worked in conjunction with *Reidar's Manufacturing, Inc.* to design a survey trawl that could serve as a replacement for the sampling net currently used by this program. Specifically, a three-bridle, four-seam, 200 x 12cm (fishing circle) bottom trawl has been developed. This net is identical in design to that used to sample the near shore coastal ocean by the NEAMAP Trawl Survey, and is nearly-identical to that used by the Northeast Fisheries Science Center's (NEFSC) Bottom Trawl Survey. Because the survey vessel used by ChesMMAAP is appreciably smaller than those used by NEAMAP and by the NEFSC, however, the three-bridle, four-seam net developed for this program is half of the size of those used by the latter two (i.e., 200 x 12cm fishing circle net for ChesMMAAP vs. 400 x 12 cm fishing circle net for NEAMAP and NEFSC). Again, flume trials conducted on model trawls in December 2009 indicated that the 200 x 12cm net may be a more appropriate sampling gear than the current two-bridle four-seam, semi-balloon bottom trawl used by ChesMMAAP, as the optimal configuration and performance consistency of the alternate net appeared to be superior to that of the current gear.

In an effort to begin to document and evaluate the performance of the 200 x 12cm trawl in the field, ChesMMAAP purchased a single net, along with all associated rigging hardware, from *Reidar's* during the summer of 2010. With respect to matching a set of trawl doors to this net, several options were available. Senior project personnel worked closely with trawl door specialists at *Trawlworks Inc.* in Narragansett, Rhode Island to identify those that were most likely capable of consistently providing the optimal wingspread for the 200 x 12cm net (i.e., 6.5m, as defined by the flume trials). It was determined that the doors currently used by ChesMMAAP, a set of 1m² steel-vee doors, could not generate the

necessary spreading power. Three alternative options were therefore identified; namely, #2 Bison doors (0.86m² surface area), 44" Thyboron Type IV doors (0.88m²), and 0.6 Patriot doors (0.67m²).

Calculations showed that the Patriot doors would be able to provide sufficient spreading power. These doors, while they are the smallest, are the heaviest of the three and would therefore likely be the most difficult to handle onboard the vessel. As such, these doors were eliminated from consideration. The Thyboron doors also had more than sufficient spreading power to achieve optimal wingspread for the 200 x 12cm trawl, and these doors weigh approximately half that of the Patriots. The Bison doors were by far the lightest, although it was determined that nearly the full spreading power of these doors would be needed to achieve the optimal configuration of the trawl. In the end, project personnel decided to begin field testing of this alternate net using the #2 Bison doors as they theoretically should provide sufficient spreading power, were the lightest and therefore easiest to handle, and were already on hand (VIMS owned a set of #2 Bison doors from a previous experiment, representing a potential time and cost savings to the project) All hardware replacement and rigging necessary to match the #2 Bison doors with the 200 x 12cm trawl took place in the summer of 2010.

Following the plan outlined in the 2010 project proposal, all field-testing of this alternate survey gear package took place in the late summer and fall. This period was chosen as both the abundance and diversity of fishes typically reaches a maximum in Chesapeake Bay during this time, meaning that conducting trials during this season would most likely provide the best indication of the ability of this trawl to sample fishes. Further, normally very few days are lost to the weather during these months, so delays due to poor conditions were likely to be minimized by completing the sea trials during this time. As such, field experimentation with this 200 x 12cm trawl/#2 Bison door combination began on September 5, 2010, and tows were conducted approximately 2nm west of Kiptopeake, VA. Unfortunately, the gear was hung on the bottom partway through the second tow and suffered extensive damage in the port wing and first bottom belly. Survey personnel were able to repair the trawl and the field trials of this gear configuration resumed on November 16 & 18, 2010 in the York River and around York Spit; all tows were completed without incident.

Again, as presented in the 2010 project proposal, these gear trials began with a series of rigging and towing (e.g., vessel speed, warp length, tow direction relative to the current, etc.) adjustments in an attempt to identify protocols that would consistently yield the theoretical optimal configuration of this net. These experiments were followed by a series of 're-tows', where sampling sites occupied earlier during regular survey operations (using the two-bridle, four-seam, semi-balloon bottom trawl) were towed again with the new net/door combination using standard sampling protocols in an effort to compare catch rates and compositions. A full detailing of the rigging and towing adjustments made and their associated outcomes, along with a description of catches under standard sampling conditions, is given in the results section below.

The ChesMMAP project proposal for 2011-2012 outlined plans for further testing (two days) of the 200x12 fishing system. This testing was deferred until future segments however due to two separate vessel-related issues.

- First, as described earlier, the Bison trawl doors were determined to be barely adequate for use with the new net and that the Thyboron doors were the proper match. However, the winch and the associated hydraulic system on the *R/V Bay Eagle* are not sufficient to provide the necessary pulling power for the entire fishing system with the Thyboron doors. So, a new and larger winch was procured but still the vessel hydraulics were inadequate. Midway through 2011 however, VIMS acquired funds that were necessary to replace the vessel's well-past-life-expectancy

engines as well as the hydraulic system. These improvements were scheduled for early spring 2012 (unfortunately resulting in the loss of the vessel's availability for the March 2012 ChesMMAP cruise). ChesMMAP investigators chose not to experiment further with the new net paired with the Bison doors when we would soon have available a fishing platform which would allow us to evaluate what is anticipated to be a superior net/door pairing.

- Second, early in 2012 the Virginia General Assembly unexpectedly provided sufficient funds in the next biennial budget for VIMS to design and purchase an entirely new research vessel to replace the *R/V Bay Eagle*. That new vessel the *R/V Virginia* was delivered in October 2018. Since that time MRG and vessel crews have been testing and perfecting the fishing system for gear deployment, trawling, and trawl retrieval with the '200' trawl net. As well, we have been constructing and/or modifying other required equipment (e.g. fish workup stations, wet lab tables, NMEA data stream connections) in preparation for "ChesMMAP 2.0". The new vessel and fishing gear will be implemented for 2019, with calibration studies being conducted in parallel.

Results

Task 1 – Conduct Research Cruises

Cruise dates and the numbers of stations completed during each survey since 2002 are shown in Table 2. For years 2002-2004 the target number of stations per cruise was 90 and since 2005 that target number has been 80 (extensive analyses of data collected through 2004 revealed that the target number could be decreased by 10 stations per cruise with little effect on survey precision, but that decreases below 80 do have a significant negative effect on precision). Examination of the data presented in Table 2 reveals that as experience has been gained and survey procedures improved, the number of calendar days per cruise has decreased from an average of 11-13 days down to 9-11 (or even fewer days if we are fortunate to have a good weather window). Likewise, the number of actual work days has decreased from a range of 8-10 down to 7-8. As the survey only pays vessel costs on days actually worked, this increased efficiency has resulted in significant cost savings (note however that some of these efficiencies have likely resulted from an overall decrease in the number of fish caught, described below).

In mid-2008 we gained the ability to plot previous successful tow tracks onto electronically displayed overlays of selected sampling cells for each cruise. In difficult trawling areas, which are very common in Chesapeake Bay, by approximately retracing a successful tow track it becomes much less likely that the trawl gear will 'hang up' and/or be significantly damaged. This has resulted both in a further increase in efficiency (much less time is spent retrieving 'hung' gear so more time is spent sampling) and a decrease in the number of nets requiring major repair or replacement. Both of these elements offer further cost savings.

After reaching a maximum during the third survey year (2004), the total number of specimens sampled annually has steadily declined (Table 3). Total samples collected and processed reached a time series low in 2011 (which represented a 55% decrease in total catch compared to 2004, with comparable levels of total sampling effort) and then another low in 2012, though without a March 2012 cruise. However, even if the March cruise yielded catch rates comparable to other recent years, the total number of specimens captured in 2012 would still be a time series low value. Catch rates increased somewhat in 2013 but declined to a previously unseen low value in 2014 of only 11,000 fish.

Concerns as to whether this decrease in catch is due to actual changes in species abundance or is an artifact of unknown sampling effects were examined in the previous segment reports (Bonzek et al., 2010 and 2011). Those analyses revealed that much of the decrease in total catch can be attributed to

declines in measured abundance of a single species, Atlantic Croaker. Catch rates of other commonly abundant species, (e.g. Spot, Weakfish, Summer Flounder) have also declined when compared to the mid-2000s. There is still some uncertainty in the investigators' minds as to whether these declines represent real biological abundance in Chesapeake Bay or are a sampling artifact. Future sampling with the new three-bridle, four-seam, 200x12 net may aid in this determination.

The vast majority of ageing structures (i.e. otoliths, opercles, etc.) and stomach samples preserved have been analyzed (Table 3). Currently, most of the otolith and stomach samples that remain to be processed represent species which are either of relatively minor management interest (e.g. oyster toadfish otoliths), which involve significantly different preparation and analysis techniques (e.g. elasmobranch vertebrae), which are particularly difficult to analyze (e.g. Atlantic menhaden stomachs), or which currently have no accepted processing protocols (e.g., Butterfish sampled from inshore waters). Due in large measure to a restructuring of personnel assignments within the MRG, what had been a growing backlog of samples to be processed has been largely eliminated.

Table 2. Cruise dates and number of stations completed during ChesMMAP cruises 2002-2018.

Year	Cruise	Begin Date	End Date	Stations Completed	Calendar Days	Work Days	Year	Cruise	Begin Date	End Date	Stations Completed	Calendar Days	Work Days	
2002	March	3/29/2002	4/16/2002	50	19	8	2011	March	3/22/2011	3/30/2011	80	9	7	
	May	5/20/2002	5/28/2002	80	9	8		May	5/26/2011	6/1/2011	79	7	7	
	July	7/8/2002	7/16/2002	77	9	8		July	7/7/2011	7/13/2011	79	7	7	
	September	9/13/2002	9/22/2002	76	10	10		September	9/1/2011	9/8/2011	79	8	8	
	November	10/28/2002	11/10/2002	74	14	9	November	11/2/2011	11/10/2011	78	9	8		
2003	March	3/24/2003	4/4/2003	69	12	8	2012	March	No cruise due to vessel repowering.					
	May	5/20/2003	5/23/2003	29	4	4		May	5/26/2012	6/2/2012	80	8	8	
	July	6/30/2003	7/10/2003	87	11	8		July	7/9/2012	7/16/2012	79	8	8	
	September	9/30/2003	10/8/2003	73	9	8		September	9/3/2012	9/11/2012	80	9	8	
	November	10/28/2003	11/5/2003	76	9	9	November	11/9/2012	11/17/2012	72	9	8		
2004	March	3/20/2004	3/31/2004	90	12	8	2013	March	3/20/2013	3/28/2013	80	9	7	
	May	5/17/2004	5/26/2004	90	10	10		May	6/4/2013	6/11/2013	80	8	7	
	July	7/1/2004	7/10/2004	59	10	7		July	7/8/2013	7/15/2013	80	8	8	
	September	9/2/2004	9/15/2004	80	14	8		September	9/3/2013	9/9/2013	80	7	7	
	November	10/28/2004	11/10/2004	86	14	10	November	11/14/2013	11/22/2013	79	9	9		
2005	March	3/16/2005	3/25/2005	80	10	8	2014	March	3/20/2014	3/27/2014	79	8	7	
	May	5/2/2005	5/10/2005	80	9	8		May	5/29/2014	6/4/2014	80	7	7	
	July	7/1/2005	7/12/2005	80	12	8		July	7/16/2014	7/25/2014	80	10	10	
	September	9/8/2005	9/18/2005	76	11	8		September	9/3/2014	9/11/2014	80	9	8	
	November	10/31/2005	11/9/2005	80	10	9	November	11/8/2014	11/16/2014	80	9	9		
2006	March	3/23/2006	3/31/2006	80	9	8	2015	March	3/19/2015	3/30/2015	80	12	10	
	May	5/15/2006	5/25/2006	80	11	8		May	5/28/2015	6/5/2015	80	9	8	
	July	6/28/2006	7/13/2006	73	16	7		July	7/7/2015	7/12/2015	80	6	6	
	September	8/30/2006	9/13/2006	70	15	8		September	8/29/2015	9/4/2015	80	7	7	
	November	10/30/2006	11/7/2006	74	9	8	November	11/11/2015	11/18/2015	80	8	8		
2007	March	3/13/2007	3/23/2007	77	11	8	2016	March	3/14/2016	3/20/2016	80	7	7	
	May	5/9/2007	5/23/2007	77	15	9		May	5/25/2016	5/31/2016	80	7	7	
	July	7/2/2007	7/10/2007	78	9	9		July	7/6/2016	7/11/2016	80	6	6	
	September							September	8/29/2016	9/8/2016	80	11	7	
	November	10/30/2007	11/12/2007	77	14	8	November	11/9/2016	11/19/2016	80	11	9		
2008	March	3/17/2008	3/26/2008	80	10	8	2017	March	3/20/2017	3/28/2017	79	9	8	
	May	5/20/2008	5/27/2008	78	8	8		May	5/15/2017	5/24/2017	80	10	8	
	July	6/28/2008	7/7/2008	80	10	7		July	7/6/2017	7/12/2017	79	7	7	
	September	9/2/2008	9/11/2008	80	10	7		September	9/6/2017	9/15/2017	80	10	8	
	November	10/30/2008	11/11/2008	80	13	8	November	11/12/2017	11/29/2017	80	18	9		
2009	March	3/16/2009	3/26/2009	80	11	7	2018	March						
	May			0	0	0		May	5/22/2018	5/28/2018	80	7	7	
	July	7/14/2009	7/20/2009	80	7	7		July	7/2/2018	7/8/2018	80	7	7	
	September	9/2/2009	9/12/2009	80	11	8		September	9/4/2018	9/10/2018	57	7	5	
	November	11/3/2009	11/10/2009	78	8	7	November	11/7/2018	11/17/2018	80	11	7		
2010	March	3/22/2010	3/31/2010	79	10	7								
	May	5/22/2010	5/28/2010	79	7	7								
	July	7/6/2010	7/9/2010	45	4	4								
	September	8/31/2010	9/11/2010	80	12	8								
	November	11/2/2010	11/15/2010	79	14	8								

Table 3. Number of specimens collected, measured and processed for age determination and diet composition information from ChesMMAP, 2002 – 2018.

Year	Fish Collected	Fish Measured	Otoliths Collected	Otoliths Processed	Stomachs Collected	Stomachs Processed
2002	32,014	23,602	5,657	4,495	4,875	3,041
2003	30,914	20,819	4,246	3,055	3,767	2,423
2004	47,618	31,241	5,482	4,290	4,721	3,325
2005	45,201	36,906	6,358	5,006	5,359	3,429
2006	43,957	31,247	5,416	4,230	4,403	3,503
2007	30,893	22,127	4,282	3,276	3,671	2,868
2008	26,299	19,598	4,209	3,048	3,678	3,432
2009	22,050	15,697	3,227	2,249	2,729	2,643
2010	26,336	20,565	4,003	2,676	3,424	3,236
2011	21,185	16,397	3,429	2,011	2,742	2,525
2012	17,329	14,955	2,497	1,519	2,015	1,732
2013	21,369	14,623	2,739	1,646	1,939	1,375
2014	11,316	7,807	1,740	988	893	837
2015	22,981	13,011	2,502	1,438	1,137	1,126
2016	28,165	18,042	3,341	1,517	1,606	1,587
2017	21,246	16,516	3,169	1,625	1,887	1,863
2018	18,806	13,150	2,343	1,093	1,273	1,264
Total	467,679	336,303	64,640	44,162	50,119	40,209

Tasks 2-4 – Data Summaries

The data summaries in this report represent a subset of the biological and ecological analyses which could be calculated from the ChesMMAP data set. For those species which are well-sampled by the survey, overall abundance estimates are presented. Relative abundance index calculations were based on limiting the data used for each species to the months, regions, and depth strata of maximum abundance over all years (Table 4). Those limiting parameters have been updated for some species based on subsequent analyses conducted during 2010 and 2012 (but not presented here). For species for which age-specific indices can be calculated, those indices are shown in both graphical and tabular formats.

Length-frequency (for sexes combined and sex-specific for most species), age-frequency (for those species for which ageing has been substantially completed) and overall diet summaries are also presented. Age-frequency figures are given both in histogram format showing the ‘raw’ number at age expanded to the total catch (i.e. as if every specimen captured had been aged) and in standardized bubble plot format with the ‘raw’ figures standardized to 800 trawl minutes (the total number of minutes towed in a full ChesMMAP year if each of the 5 cruises consisted of 80 stations at 20 minutes each). The bubble plots allow a representation of the age-specific abundance for all years simultaneously and can sometimes make it easier for the reader to follow large and small year classes diagonally through the population.

Table 4. Selected months, regions, and depth strata data used for abundance indices for each species (modified in comparison to previous segment reports).

Species	Month					Region					Depth		
	3	5	7	9	11	1	2	3	4	5	1	2	3
Atlantic Croaker													
Black Sea Bass													
Bluefish													
Butterfish													
Kingfish sp.													
Northern Puffer													
Scup													
Spot													
Striped Bass (March)													
Striped Bass (November)													
Summer Flounder													
Weakfish													
White Perch (March)													
White Perch (November)													
Additional species													
blue crab - ad. female													
blue crab - male													
cleannose skate													

Some analyses (e.g. sex ratios, length-weight relationships, growth equations) presented in previous project reports are not included. It is assumed that, when needed, assessment scientists and managers will request specific analyses of these data types which could not be fully anticipated in this report. Therefore, only those general data summaries of the most universal possible use are included. The profiles that follow are organized first by species and then by type of analysis ('Task'). Each Task element (single-species stock parameter summarizations, trophic interaction summaries, and estimates of abundance) is included but is not labeled with a Task number and is not necessarily shown in Task number order (note also that not all analysis types are available for all species).

For each species, the following data summaries are presented (note that some data/analyses may not be available for all species):

- 1) A table which shows the Months, Regions, and Depth Strata used for calculating abundance indices for the species.
- 2) A series of GIS figures showing total abundance at each sampling site overlaid on the survey depth strata, for each cruise during the year (Note that in the 2009 ChesMMA report these figures were presented for all survey years. To compare results in 2010 through 2014 to prior years refer to these previous project reports – e.g. Bonzek et al. 2009, Bonzek et al. 2010).
- 3) A table which summarizes the numbers (and biomass) captured and measured during each survey year as well as the numbers of ageing structure and stomach samples preserved and processed.

- 4) Figures and tables presenting overall and age-specific (for appropriate species) area-swept-corrected abundance indices by number and biomass, calculated using geometric means.
- 5) Length-frequency data by year, for sexes combined and separately.
- 6) Age-frequency distributions by year (for those species where appreciable numbers have been captured and otoliths have been processed) in both histogram and bubble plot format, as described above.
- 7) Age-frequency distributions by month, summed over all years, in both histogram and bubble plot format, as described above. For survey years for which age assignments have not been made, age-frequencies are estimated through application of ALKs to the length data. Note that the maximum age in the ALKs is usually significantly lower than the species' maximum age.
- 8) Diet analyses by weight and number, using all data collected and analyzed 2002-2013. For this report (and for presentation elsewhere), standardized categories of prey types (Fishes, Crustaceans, Molluscs, Worms, Misc.) have been developed for all ChesMMAP species. In each figure for each predator species, these categories are presented in decreasing order of importance and within each broad category specific prey types are shown also in decreasing order. Only those specific prey types greater than or equal to 1.0% of the overall diet are shown (unless the entire category is less than 1.0%). All other specific prey are lumped into a category called 'x - other' (x = fishes, molluscs, etc.) which is distinct from unidentified prey types within the category. For the reader's convenience, the color scheme used for all species (e.g. red = crustaceans, light blue = fishes, etc.) is the same. This makes it relatively easy to compare figures across predator species or by weight/number within a species.

Species Data Summaries

Atlantic Croaker (*Micropogonias undulatus*)

Abundance: Atlantic Croaker is typically among the most abundant species in ChesMMAP survey catches, especially during the mid-year. During the years 2002 through 2007 at least 12,000 specimens totalling 2,600kg or more were captured. Between 2008 and 2012 no more than half that number were ever captured. In 2013 the number rose to about 9,000 specimens but since 2014 ChesMMAP has sampled no more than 1,723 specimens in any year. Indeed 2014 through 2018 have seen the five fewest captures in the 17-year time series (Table 5).

The majority of fish are captured in regions 4 and 5 (Virginia). In years of higher abundance specimens are regularly captured in all survey regions but in 2018 almost no Atlantic Croaker were captured north of the Maryland/Virginia border. Catches decline in November as this summer resident species leaves bay waters (Figure 1).

Relative abundance indices are calculated using data collected during May, July and September, in Regions 4 and 5 from only the mid-depth and deep strata (Table 6). As reflected in the trends of total catch, indices for all ages combined both in numbers and biomass reveal low values in 2002 and 2003 that were followed by a period of high abundance throughout 2004-2007 then very low abundances from 2008 through 2018 (Table 7, Figure 2). Anecdotal information as well as trends in commercial and recreational landings suggests that this period of low abundance in ChesMMAP samples is representative of a coast wide phenomenon and may be related to cyclical abundances that have been observed in the past, though this continued period of very low abundance is concerning. Age-specific abundances are shown for ages 0 through 4+ (all ages equal to or greater than 4 combined). Abundances along the coast as measured by the near shore North East Area Monitoring and Abundance

(NEAMAP) survey showed a steep rise in the fall of 2012 following into the spring of 2013 and those fish may be represented by the moderate rise in the Age-0 ChesMMAP index in 2013. For ages 2 and older the pattern of abundance generally follows that for overall abundance which indicates that to some extent at least, availability of this species to the ChesMMAP survey area (i.e. the proportion of the coastal stock that invades the bay during warm months) may play at least some role in determining abundance as estimated by ChesMMAP.

Length and Age: Specimens between 14mm and 499mm in total length (Figure 3) and between age 0 and 17 (Figure 4, Figure5) appear in survey data. In recent years both the length frequency distribution and the age structure appears to have become increasingly truncated towards smaller and younger fish; most individuals range between 150mm and 350mm and ages 1-5. In most year, no particular pattern of differences in sex-specific length frequencies were observed though in 2018 the samples were heavily weighted towards females.

The length distribution of this species changes considerably year-to-year as year-classes of either extremely high or extremely low abundance move through the stock. For example, a highly abundant 2002 year class was seen as a peak in the length-frequency histograms between 2003 and 2007 and as a distinctly abundant year class in the age-frequency figures even into 2008. There appears to be evidence of mildly to highly successful year class in 2006 which was still abundant in 2007 and 2008 and which was present in ChesMMAP samples until 2013, as 7-year olds. Conversely, the 2007 year class appears to have been nearly absent in Chesapeake Bay and similarly was not abundant in 2008. In 2009 these two-year-old fish were the most abundant age class but the number captured was very low compared with other years. A moderately abundant 2012 year class was still present in 2018 in very low numbers. Though the ChesMMAP sampling gear is not efficient at capturing age-0 Croaker, when substantial numbers are present it can be an indicator to expect larger numbers the following year as age-1s. In 2018 the second largest number of age-0 Croaker in the ChesMMAP time series were observed.

Croakers to age 8 are not uncommon for this survey. During 2008, program personnel attended an Atlantic Croaker ageing workshop sponsored by the Atlantic States Marine Fisheries Commission. The consensus report from that workshop set a birth date of 1 January each year, as that date is the approximate mid-point of spawning in the southern portion (i.e., south of Cape Hatteras) of the species' range. Spawning north of Hatteras, including Virginia's waters, occurs several months earlier, and is often complete by early December. As a result, all Croaker ages in the ChesMMAP data base were adjusted down one year and it is now possible to capture age-negative 1 fish in the survey. This occurs when fish spawned in late summer and autumn of a given year are collected during the September or November cruises of that year. Those fish are not considered age-0 (or young-of-the year) until that upcoming January, so to place them in the correct year-class, they are assigned an age-negative 1. This phenomenon can cause a bit of confusion in interpreting year-and-age-specific indices of abundance and we hope to influence a change in the age-assignment protocol in the future.

Compared to other survey years, a relatively large number of age-negative 1 fish were captured in the fall of 2011. These may be the same cohort that was so abundant in the NEAMAP survey in the fall of 2012 and the spring of 2013 and we could observe this moderately successful 2012 year-class still moving through the stock through 2016 though it is now nearly absent in 2017.

Histogram and bubble plots of monthly age distributions with data combined over all available survey years within each month, reveals the typical annual pattern of invasion of and retreat from Chesapeake

Bay waters by this species (Figure 6). Early in the year, abundance builds to a July peak, and then declines through September and November. Within any given month, a regular pattern of age distributions appears, with croaker being fully recruited to the survey gear by age-1 or age-2 and with each succeeding age-class declining in abundance. As the full complement of ages occurs during each month, it does not appear that there is differential migration (in or out) among age classes.

Diet: Various identifiable and non-identifiable polychaetes as well as other worm species (42.1% by weight (W) and 33.3% by number (N)) represent the largest single prey type in the diet of Atlantic Croaker. Miscellaneous prey items (primarily unidentifiable material) are the second most important prey category both by weight and number (26.6%: 27.0% respectively). This unidentified material is likely made up largely of worms and soft-bodied molluscs. Several clam and mussel prey types contribute 15.0% and 12.1% of croaker diets by weight (third largest taxonomic category) and number (fourth highest category) respectively. Small bodied crustaceans (e.g. mysid shrimp) constitute the fourth major prey category by weight totaling 14.6% by weight and 26.5% by number (third highest). Fishes constitute very minor amounts (1.8% W, 1.1% N) of Croaker diets (Figure 7).

Table 5. Atlantic Croaker sampling rates and preserved specimen analysis status by year.

Figure 1. Abundance (kg per hectare swept) of Atlantic Croaker in Chesapeake Bay, 2018.

Table 6. Months, latitudinal regions, and depth strata used for Atlantic Croaker index calculations.

Table 7. Atlantic Croaker geometric mean indices of abundance, by number and biomass, overall and by age-class.

Figure 2. Atlantic Croaker geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

Figure 3. Atlantic Croaker length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

Figure 4. Atlantic Croaker age-frequency by year, 2002-2018.

Figure 5. Atlantic Croaker age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

Figure 6. Atlantic Croaker age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

Figure 7. Diet composition, expressed as percent by weight (A) and percent by number (B) of Atlantic Croaker collected during ChesMMAP cruises in 2002-2018 combined.

Black Sea Bass (Centropristis striata)

Abundance: The ChesMMAP survey gear and sampling methodology are not considered particularly effective for a structure-oriented species such as Black Sea Bass. Indeed locations of known complex

bottom structures and other 'hangs' are purposely avoided. However, enough individuals are captured for a certain amount of information to be extracted from survey samples.

The maximum number of specimens captured during a sample year was 50 in 2002 and the minimum of only two were seen between 2012 and 2015 when between 2 and 11 fish were sampled. The total number captured in 2016 was 42 which is tied with 2003 for the second most captures and 35 were captured in 2017 which is approximately the same number captured during the period 2007 -2009. In 2018 just 8 specimens were observed (Table 8). Catches are typically highest during the July, September and November cruises and are concentrated in regions 4 and 5 but are not uncommon in Region 3 (Figure 8). Significant differences in catch rates among depth strata were not observed (Bonzek et al., 2009).

For purposes of calculating abundance indices, stations from all depth strata sampled in July, September, and November, in Regions 4 and 5 are included (Table 9). Overall relative abundance indices expressed either in numbers or biomass exhibit nearly identical inter-annual patterns, indicating that the sizes of captured specimens is relatively constant year to year. A steady decline in measured abundances between 2002 and 2006 was followed by a period of fluctuating high and low values, until 2011 when the index was in the middle range of the time series. In 2013 only two Black Sea Bass were captured and the indices found new time-series lows for both number and biomass. Between 2013 and 2016 there was a definite upward trend which greatly accelerated in 2016 with the numerical index reaching a time-series high value and the biomass index at the third highest value in the series. In 2017 the indices fell to approximately average values and in 2018 fell again to approximately the time series low (Table 10, Figure 9). Age-specific abundance indices follow a similar general downward trend, with occasional single-year upward ticks. As catch rates for this species are low and inconsistent confidence limits on the abundance estimates are comparatively broad.

Comparisons of abundance estimates between this and other surveys has not yet been accomplished but may give insight as to the reliability of data from this and other programs.

Length and Age: Specimens captured in the survey tend to be relatively small (<250mm) and young (age-0 and age-1) though individuals up to 270mm total length have been sampled (Figure 10). Due to the small sizes of most individuals captured by ChesMMAAP, the majority of specimens observed of this protogynous hermaphroditic species have been females. During 2012 the previous backlog of otolith samples was cleared and all otoliths collected through 2018 have been assigned ages. Age-frequencies reveal that in most years the survey catches are dominated by either age-0 or age-1 specimens (Figure 11, Figure 12). Monthly age-frequency plots do not exhibit any annual inward or outward age-specific migration patterns, indicating the young specimens captured by ChesMMAAP are likely using Chesapeake Bay as a nursery area which they have mostly left by age-2 and completely by age-3 (Figure 13).

Diet: Though the sample size is relatively small (299 specimens, 194 clusters) and the size range of samples is limited, the diet data is probably the most valuable ChesMMAAP contribution for this species. Crustaceans (70.9% W, 77.8% N), dominated by mud crabs (16.5% W, 9.8% N), mysids (11.8% W, 27.4% N), and amphipods (7.7% W, 17.7% N) contribute the highest portions of the diet, among identifiable prey. Fishes constitute 8.9% of the diet by weight and 5.6% by number with Bay Anchovy (2.9% W) the largest component among identifiable species. A variety of worms (6.0% W, 4.4% N) molluscs (3.4% W, 1.5% N) and other less prominent or unidentifiable taxa comprise the remainder of the diet (Figure 14).

Table 8. Black Sea Bass sampling rates and preserved specimen analysis status by year.

Figure 8. Abundance (kg per hectare swept) of Black Sea Bass in Chesapeake Bay, 2018.

Table 9. Months, latitudinal regions, and depth strata used for Black Sea Bass index calculations.

Table 10. Black Sea Bass geometric mean indices of abundance, by number and biomass, overall and by age-class.

Figure 9. Black Sea Bass geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

Figure 10. Black Sea Bass length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

Figure 11. Black Sea Bass age-frequency by year, 2002-2018.

Figure 12. Black Sea Bass age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

Figure 13. Black Sea Bass age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

Figure 14. Diet composition, expressed as percent by weight (A) and percent by number (B) of black seabass collected during ChesMMAAP cruises in 2002-2018 combined.

Bluefish (Pomatomus saltatrix)

Abundance: Due to the fast-swimming and pelagic nature of Bluefish, this species also is not considered to be well sampled by ChesMMAAP, though some useful assessment-related information can be generated from these survey data. No more than 126 (in 2010) and 125 (in 2015) Bluefish have so far been captured during a ChesMMAAP sampling year. The maximum biomass captured was about 32kg in 2003 due to a few large specimens which were captured that year. In 2016 through 2018 moderate numbers of specimens (36, 40, 85 respectively) were sampled. Except for a very small number of mishandled or mislabeled specimens all preserved stomachs and otoliths have been fully processed (Table 11).

When captured, typically between one and five specimens occur in a tow (Figure 15) though as many as 42 have been collected in a single sampling event. Bluefish are usually captured in either the shallow (10'-30') or mid-depth (30'-50') strata. Catches are typically highest late in the year, presumably as the young-of-the-year fish are moving into deeper waters in preparation for outmigration from the bay. Abundance is normally highest in regions 4 and 5 but notable exceptions occur such as a single capture of 26 specimens in Region 1 during the September 2008 cruise (Bonzek et al. 2009).

Abundance indices are calculated using data only from the September and November cruises, from all Regions and depth strata (Table 12). Abundance indices for all ages of Bluefish combined alternated between low and high values from 2002 to 2007, were consistently at time series lows between 2008 and 2011, exhibited a moderately rising pattern between 2012 and 2015, fell again in 2016 and rose slightly in both 2017 and 2018 (Table 13, Figure 16). Patterns between indices by number and weight are

very similar. As nearly all specimens captured are young-of-year fish, the age-0 index closely follows the pattern for the overall index.

Length and Age: Most individuals sampled in the survey are less than 350mm fork length and, due to the small number of specimens captured and protracted spawning season of this species, it is difficult to differentiate cohorts in length frequencies (Figure 17). No pattern of sexual differentiation by size has been observed. Nearly all ChesMMAAP Bluefish are either age-0 or age-1 and in most years the majority of specimens captured are age-0 (Figure 18, Figure 19, Figure 20).

Diet: Diet data presented here are consistent with previous studies in showing that Bluefish are highly piscivorous (Figure 21). For the 382 specimens examined, which represent 227 clusters, Bay Anchovy constitute 52.2% of the diet by weight and 50.5% by number, while Spot (11.7% W, 7.4% N) are the other major identifiable fish prey. All fish species together represent 89.6% by weight and 82.3% by number. Crustaceans, mainly mysid shrimp at 5.5% W and 5.9% N, and sand shrimp (2.3% W, 7.5% N) represent most of the remainder.

Table 11. Bluefish sampling rates and preserved specimen analysis status by year.

Figure 15. Abundance (kg per hectare swept) of Bluefish in Chesapeake Bay, 2018.

Table 12. Months, latitudinal regions, and depth strata used for Bluefish index calculations.

Table 13. Bluefish geometric mean indices of abundance, by number and biomass, overall and age-0.

Figure 16. Bluefish geometric mean indices of abundance, by number and biomass, for all ages combined and for age-0.

Figure 17. Bluefish length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

Figure 18. Bluefish age-frequency by year, 2002-2018.

Figure 19. Bluefish age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

Figure 20. Bluefish age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

Figure 21. Diet composition, expressed as percent by weight (A) and percent by number (B) of Bluefish collected during ChesMMAAP cruises in 2002-2018 combined.

Butterfish (Peprilus triacanthus)

Abundance: Butterfish are moderately abundant in ChesMMAAP survey tows with several hundred to over 1,000 specimens typically captured during any survey year (Table 14). Butterfish abundance follows a generally predictable annual pattern, building from near-zero during March, increasing (albeit low) abundance through the spring and summer, and reaching a maximum generally during the September and November cruises (Figure 22).

Abundance indices are generated from survey tows during the peak months of September and November in Regions 4 and 5. During 2017 the depth strata used to calculate abundance for this species were reexamined. Previously only the mid-depth strata were included but the reexamination indicated that all three depth strata should be used (Table 15). Abundance indices generally varied without trend between 2002 and 2009 then declined significantly in 2010 and have remained at lower levels in succeeding years, with modest upticks in 2016 and 2017 but reaching a time-series low value in 2018 (Table 16, Figure 23).

Length and Age: Yearly length frequency diagrams (Figure 24) appear to reveal at least two year classes of varying strength present in the Chesapeake Bay fish during any given year, however this will require further analysis. This program (and others) has found Butterfish collected from estuarine areas extremely difficult to age. We are still investigating methods to obtain accurate age determinations from otolith samples. Pending the results of those efforts the otoliths collected during earlier survey years have not been processed (age-specific abundance indices were calculated using age-length keys derived from NEAMAP data).

Diet: Analyses of Butterfish stomachs from early program years revealed a high percentage of generally unidentifiable gelatinous zooplankton and other unidentifiable items. It was determined that further analyses of Butterfish diets was not an efficient use of resources and the decision was made to discontinue preservation and analysis of Butterfish stomachs.

Table 14. Butterfish sampling rates and preserved specimen analysis status by year.

Figure 22. Abundance (kg per hectare swept) of Butterfish in Chesapeake Bay, 2018.

Table 15. Months, latitudinal regions, and depth strata used for Butterfish index calculations.

Table 16. Butterfish geometric mean indices of abundance, by number and biomass, overall and by age-class.

Figure 23. Butterfish geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

Figure 24. Butterfish length-frequency in Chesapeake Bay 2002-2018, overall.

Kingfish (Menticirrhus spp.)

The ranges of three closely related species, the Northern Kingfish (*Menticirrhus saxatilis*), the Southern Kingfish (*Menticirrhus americanus*), and the Gulf Kingfish (*Menticirrhus littoralis*) overlap in Chesapeake Bay. While some specimens are easily separable in the field, many are not. We have therefore adopted the practice of combining all of these specimens into a single category of Kingfish (*Menticirrhus spp.*). This practice is consistent with the manner in which these species are landed and reported in the fishery as well.

Abundance: Kingfish are moderately abundant in ChesMMAP tows with approximately 100-600 total specimens captured each year (Table 17). ChesMMAP catches for this species are almost exclusively in regions 4 and 5 (lower bay), occur throughout the warm weather months and are often high into

November (Figure 25). Abundance indices are generated from stations sampled during May through November using all depth strata in both Regions 4 and 5 (Table 18). In previous years only Stations in Region 5 were used for this species but a reevaluation of abundance patterns resulted in this change. Note as well that for the Age-0 indices only data from September and November are used as young-of-year specimens are not available to the gear in earlier months.

Until 2010 it appeared that Kingfish had been on a nearly consistent increasing abundance trend throughout the survey years. However, between 2011 and 2014 a nearly seven-fold decline was observed in the indices back to levels observed at the beginning of the time series. This was followed by a slight increase in 2015 and then a very large uptick again in 2016 to time series high values for both numbers and biomass. In 2017 overall abundance decreased significantly but was still among the five highest values in the time series and in 2018 there was a slight increase to the fourth highest value in the time series. Age-specific ChesMMAAP indices follow similar patterns with generally lower values through 2007, an increasing trend through 2010 or 2011, with a sharp decline in 2012, an uptick in 2013 and declines again 2014, with a significant rise in 2016 and nearly stable values in 2017. The increase in overall abundance in 2018 was due to a large increase in age-0 fish while abundance for other ages were on par with 2017 values (Table 19, Figure 26).

Length and Age: Due to the relatively small number of specimens captured during early survey years and to the overlapping sizes-at-age, it is difficult to interpret length frequencies, though at least two cohorts are apparent in many years (Figure 27). No differential growth patterns between male and female Kingfish have been observed.

Specimens between ages 0 and 7 have been captured with most being age-4 or less. Year-classes of high (e.g. 2002) and low (e.g. 2004) abundance do seem to track through the stock from year to year, which indicates consistent survey sampling and otolith analysis. Relatively large numbers of age-0 and age-2 specimens were captured in 2009 but the number of age-3-and-older fish was very small. It is apparent that this species does not fully recruit to the ChesMMAAP sampling gear until at least age-1 and perhaps even age-2 (Figure 28, Figure 29). As this species is not subjected to regular stock assessments the VIMS Multispecies Research Group assigns it to lower level of priority for specimen processing so there is currently a backlog of unprocessed otoliths dating to 2012. Once true ages have been assigned the patterns observed in age-specific abundance indices may change.

As stated above, age-0 Kingfish generally do not recruit to the survey gear until September and are most abundant in November cruises. Specimens from all age classes are captured during every survey month except March (Figure 30).

Diet: The largest taxa of prey items in Kingfish stomachs are crustaceans (40.8% W, 44.0% N), primarily small shrimps and crabs. Molluscs and worms constitute the next largest portions (25.9% W, 23.0%N and 15.5% W, 12.6 %N respectively) of the diet, with fishes and several other categories completing the diet (Figure 31).

Table 17. Kingfish sampling rates and preserved specimen analysis status by year.

Figure 25. Abundance (kg per hectare swept) of Kingfish in Chesapeake Bay, 2018.

Table 18. Months, latitudinal regions, and depth strata used for Kingfish index calculations.

Table 19. Kingfish geometric mean indices of abundance, by number and biomass, overall and by age-class.

Figure 26. Kingfish geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

Figure 27. Kingfish length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

Figure 28. Kingfish age-frequency by year, 2002-2018.

Figure 29. Kingfish age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

Figure 30. Kingfish age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

Figure 31. Diet composition, expressed as percent by weight (A) and percent by number (B) of Kingfish collected during ChesMMAAP cruises in 2002-2018 combined.

Northern Puffer (Sphoeroides maculatus)

Abundance: Abundance of Northern Puffer in ChesMMAAP samples varies by an order of magnitude among years, with as many as 600 being captured in 2011 and as few as 41 in 2005 (Table 20). Typical patterns of abundance for this species in the survey are minimal numbers in spring and early summer, and a peak in abundance during the September and/or November cruises, perhaps as the summer residents are migrating toward offshore wintering grounds. Catches are consistently greatest in Regions 4 and 5, though the species is common into Region 3 (Figure 32). As catches in the survey are patchy, estimates of abundance for this species are of unknown reliability.

Following the pattern described above, stations used to calculate abundance indices are limited to those conducted in September and November, in Regions 4 and 5, in all depth strata (Table 21). Prior to this reporting period, fewer strata were used but as with kingfish, a reevaluation led to changing the index strata. The peak year for the relative abundance indices from survey data have (both in numbers and biomass) was in 2007, though the total number of specimens captured that year was merely average. This lone high value likely was the result of restricted sampling that year which probably artificially inflated the index. Other years have varied without apparent trend though there was a modest increase in both 2015 and 2016, a decline in 2017 and a modest rise in 2018 (Table 22, Figure 33).

Length and Age: Specimens between approximately 50mm and 270mm total length have been captured, though most individuals measured between 100mm and 250mm. The length composition varies year to year, likely as a result of varying year-classes entering and leaving the bay stock (Figure 34). However, as this is not a high priority species and as standard ageing protocols have not been established, ageing of vertebrae has not been attempted. The largest individuals captured have generally been females but there appears to be no overall pattern of differential growth between sexes.

Diet: Molluscs (32.6% W, 27.2% N), miscellaneous taxa including unidentified material (32.0%W, 31.9%N) and crustaceans, primarily small crab species (27.8%W, 31.0%N) constitute approximately equal parts of the diets of Northern Puffer. Worms (7.2% W, 9.2% N) make up nearly all of the remainder with fish tissue contributing less than 1% by both weight and number (Figure 35).

Table 20. Northern Puffer sampling rates and preserved specimen analysis status by year.

Figure 32. Abundance (kg per hectare swept) of Northern Puffer in Chesapeake Bay, 2018.

Table 21. Months, latitudinal regions, and depth strata used for Northern Puffer index calculations.

Table 22. Northern Puffer geometric mean indices of abundance, by number and biomass, overall.

Figure 33. Northern Puffer geometric mean indices of abundance, by number and biomass, for all ages combined.

Figure 34. Northern Puffer length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

Figure 35. Diet composition, expressed as percent by weight (A) and percent by number (B) of Northern Puffer collected during ChesMMAP cruises in 2002-2018 combined.

Scup (Stenotomus chrysops)

Abundance: Total yearly captures of Scup are highly variable, probably as a result both of actual coast wide abundance and availability to the survey gear (Table 23). For example, in 2015 a time series peak of almost 1,000 scup were captured by ChesMMAP, due mainly to a small number of large catches during the September cruise but in 2016 the total number caught was only 65. In 2017 only 25 Scup were present, which was the second-lowest number in the time series but catches rebounded in 2018 with 386 total specimens captured, the fifth highest total number during the survey years. Survey catches of Scup are typically rare during spring through early summer and nearly always reach a peak in September before declining again in November as fish leave bay waters (Figure 36). The species is most abundant in regions 4 and 5 and is rarely captured north of region 4. It is important to note that 2007 data are limited due to cancellation of the September cruise. Scup are typically most abundant in shallow strata (10'-30') and mid-depth strata (30'-50') and are rarely captured in waters over 50'. Reflecting those abundance patterns, only sampling data from July through November, in Regions 4 and 5, in the shallow and mid-depth strata are included in index calculations (Table 24).

Discerning trends over the time series is problematic due to the difficulty in interpreting 2007 data when the September cruise was cancelled resulting from a budget shortfall. Geometric mean indices for both number and biomass indicate moderate abundance through 2007 then a sharp decline in 2008 followed by a two year upward trend toward a time series high in 2010. Following time-series low values between 2011 and 2014 there was a substantial increase in 2015 followed by another low value in 2016, a lower value still in 2017 but substantial increase in 2018 (Table 25, Figure 37).

As nearly all specimens captured by ChesMMAP are either age-0 or age-1, age-specific indices have been developed for only those two age classes (i.e. there is no 'age-x+' category). The annual patterns of these indices closely follow those for overall abundance.

Length and Age: Most specimens captured in the survey are less than 200mm fork length and at least two year classes are apparent in length data (Figure 38). Due to the small size and sexual immaturity of the majority of Scup sampled by ChesMMAP, sex cannot be determined in the field for large numbers of

specimens so sex-specific length frequencies do not display any discernible pattern of differences in sex ratios at size.

Nearly all specimens captured are either age-0 or age-1, so it is difficult to discern whether year-class abundance can be followed through time in age frequency figures (Figure 39, Figure 40). Monthly age frequency distributions reveal the patterns of in-migration in spring and out-migration in fall, as well as recruitment of age-0 specimens to the gear beginning in September (Figure 41).

Diet: By weight, worm species constitute a majority (48.9%) of identifiable items in Scup stomachs but represent only 28.0% of prey by number (Figure 42). Unidentifiable prey (likely largely constituted of worms and other soft-bodied prey) also make up a large portion (17.1% W, 13.5% N). At 16.5% by weight, crustaceans (primarily mysids and amphipods) are also a major prey source, and at 35.1% represent the largest single taxon in Scup diets when measured by number.

Table 23. Scup sampling rates and preserved specimen analysis status by year.

Figure 36. Abundance (kg per hectare swept) of Scup in Chesapeake Bay, 2018.

Table 24. Months, latitudinal regions, and depth strata used for Scup index calculations.

Table 25. Scup geometric mean indices of abundance, by number and biomass, overall and by age-class.

Figure 37. Scup geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

Figure 38. Scup length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

Figure 39. Scup age-frequency by year, 2002-2018.

Figure 40. Scup age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

Figure 41. Scup age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

Figure 42. Diet composition, expressed as percent by weight (A) and percent by number (B) of Scup collected during ChesMMAAP cruises in 2002-2018 combined.

Spot (Leiosomus xanthurus)

Abundance: Spot are typically among the most abundant species in the survey during all cruises except March. Prior to 2014 between 2,000 and 11,500 Spot (115kg-1000kg) were captured annually during the 12 survey years. However in 2014 only 939 specimens were sampled and in 2015 this figure fell further to only 401 individuals. While the total number captured rose to over 1,000 in 2016 this was still the third lowest total during the time series, with a moderate increase to 1,586 fish in 2017 and 1,635 in 2018 (Table 26). This species is well distributed throughout the bay, though concentrations are highest in regions 4 and 5 (Figure 43). Abundance indices are based on tows conducted in July and September, in all Regions and depth strata (Table 27).

Overall abundances for the time series were on a generally rising trend between 2002 and 2006 and have followed a downward trajectory since. Indices have been very low in each year since 2011 (Table 28, Figure 44). This pattern does not follow the trend in coastal and regional landings (both commercial and recreational) which have been erratic but generally flat during the overlapping time series and this phenomenon deserves further attention. Age-specific indices are given for ages 0 through 2+ though since relatively few specimens older than age-1 are captured; the age-2+ index is of unknown reliability. These indices largely follow the same pattern as described for all ages combined except that the age-1 index reached its peak in 2007 rather than 2006 indicating that the large 2006 year class was still abundant one year later.

Length and Age: Individuals between 100mm and 250mm are most common in the survey, with a smaller number of specimens up to 300mm occasionally captured (Figure 45). The largest individuals are most often captured in regions 2 or 3. No pattern of differential growth rates between the sexes is apparent.

Nearly all fish in the survey are either age-0 or age-1 with the oldest fish (5 total specimens) captured at age-4 (Figure 46, Figure 47). As discussed above, even though the age distribution of this species in Chesapeake Bay is not wide, the relative numbers of smaller vs. larger specimens can vary significantly year to year. This likely represents both changes in relative year class strength and the numbers and sizes of specimens invading the bay each year.

Month-specific age frequencies for all years combined reveal the same annual migration patterns described above (Figure 48).

Diet: Not surprisingly, given the bottom-feeding habit of this species, the largest single prey type is 'unidentified material' (31.6% W, 26.4% N). In total 'miscellaneous' items (those which do not fit into one of the other major taxa) constitute 46.1% by weight and 45.6% by number of Spot diets. This is followed by worms (32.8% W, 25.7% N) which for the most part were not identifiable to specific taxa. Molluscs (primarily clams) at 11.8% by weight and 9.7% by number, and crustaceans (8.0% W, 17.7% N), principally mysids and amphipods, were also major portions of the diet for Spot (Figure 49).

Table 26. Spot sampling rates and preserved specimen analysis status by year.

Figure 43. Abundance (kg per hectare swept) of Spot in Chesapeake Bay, 2018.

Table 27. Months, latitudinal regions, and depth strata used for Spot index calculations.

Table 28. Spot geometric mean indices of abundance, by number and biomass, overall and by age-class.

Figure 44. Spot geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

Figure 45. Spot length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

Figure 46. Spot age-frequency by year, 2002-2018.

Figure 47. Spot age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

Figure 48. Spot age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

Figure 49. Diet composition, expressed as percent by weight (A) and percent by number (B) of Spot collected during ChesMMAAP cruises in 2002-2018 combined.

Striped Bass (Morone saxatilis)

Abundance: Striped Bass are typically captured in relatively high numbers each survey year with as many as 2,200 (weighing almost 1,000kg) sampled (Table 29). Intra-annual patterns of abundance for Striped Bass typically follow a consistent pattern. Large numbers of spawning migrants are captured during the March cruise, followed by lower numbers in May as the spawners leave the bay. Fewer captures occur in July and September, and higher numbers are encountered again in November as fish school before leaving the bay for offshore wintering grounds. Most Striped Bass are captured in regions 1 – 3 (Maryland waters) but the species occurs regularly in samples from all bay locations. In March, catches are high in all depth strata, but in other survey months catch rates are greatest in waters less than 50' (Figure 50).

Two sets of abundance indices have been calculated for this species: one using data from the March cruise which assesses abundance of the spring spawning stock, and one using data from November which characterizes the number of summer residents as they school together in the fall. Slightly different station sets are used for these two indices: in March all stations in Regions 1-3 are included while in November only the shallow and mid-depth stations in Regions 1 and 2 contribute to the index calculations (Table 30).

March abundance for all ages combined, as measured both by number and biomass, was highest in 2004, 2008, 2013 and 2016, otherwise varying within a fairly narrow range in most years. After three low index values in 2009-2011 (no March cruise was conducted in 2012 due to vessel unavailability) a significant rise was seen in 2013 due mainly to high values for age-3 and age-4 fish. This pattern generally held for age-specific abundance as well except that for age-1 and age-2 fish 2003 was also a year of high abundance. As most of the specimens captured in March are assumed to be reproductive migrants, it follows that in years of high overall abundance that all age classes would be present (Table 31, Figure 51). In 2018 no March cruise was conducted due to a funding shortfall.

November abundance indices (summer residents) show high values in 2004 (more so in numbers than in biomass), 2006, 2014 and 2016. In 2011 through 2013 abundance turned upwards to mid-level values after a brief decline over the preceding two years then rose substantially in 2014, fell again in 2015 and rose again in 2016 and declined in both 2017 and 2018. Again the same general pattern is seen in age-specific indices though variations do exist. The uptick in 2011-2014 appears to be due mainly to a larger number of age-2, age-3, and age-4+ specimens captured. The increases in 2016 indices appear to be mainly due to larger numbers of smaller/younger specimens (Table 32, Figure 52).

New abundance indices which include data from all months and all regions, using a newly developed methodology, have been submitted to the ASMFC Striped Bass Technical Committee and ChesMMAAP indices were indeed included in the 2018 Benchmark Assessment.

Length and Age: Most specimens captured in the survey are about 600mm fork length or less (ages 1 – 7). The largest individuals approach 1000mm and are captured during spring spawning. Due to the relatively long-lived nature of this species, the varying life history scenarios for different portions of the stock and associated variable growth rates, along with variable young-of-year recruitment, it is difficult to differentiate year-classes within length-frequency histograms (Figure 53). However, age distribution figures (Figure 54, Figure 55) readily reveal year-class strength (high peaks during one year tend to follow into succeeding years, as do low abundances) which generally correspond to strong and weak year classes as measured by the Maryland and Virginia young-of-year beach seine surveys. The largest fish captured tend to be migrating females and many ‘resident’ male fish are captured up to about 50cm. The oldest specimens yet sampled by the survey, age-20, were captured in 2008, 2010, and 2015 (1988, 1990 and 1995 year classes, respectively). Age-frequencies by cruise month reveal the typical pattern of higher survey catch rates in March and November and lower, but still appreciable, catches in between. The oldest fish are typically captured during the March spawning season. Striped Bass appear to be fully recruited to the survey gear by age-1 (Figure 56).

Diet: Results of diet analyses from this study differ appreciably from previous studies using specimens from Chesapeake Bay (Figure 57). Fish comprise the largest taxonomic group in the diet (54.9% W, 47.1% N), with crustaceans the next most abundant (20.8% W vs. 33.0% N) due to consumption of a large number of small bodied mysid shrimp and amphipods. Among fish species, this survey consistently finds that Bay Anchovy contributes the highest proportion by weight (26.3%) with Atlantic menhaden second (12.2%). Mysid shrimp (10.0% W, 16.7%N) and amphipods (4.7% W, 8.3% N) combined constitute large portions of the diet, a sharp contrast to previous studies; and worms make up the only other major prey type (14.5% W, 11.5% N). These differences from previous diet studies are likely the result both of sampling methodological differences (the broad temporal and geographic scale of ChesMMAP as well as the trawl gear used compared to many studies which were limited in temporal or geographical scale or which use capture methodologies which yield a narrower size range) and analytical/mathematical differences in calculating percentages in the diet. In brief, this study calculates fish diets using cluster-sampling theory and analytical methods whereas previous studies are thought to have used the assumption of simple random sampling of fish. The cluster method moderates the effect of a relatively small number of large predator specimens with large prey in the stomachs (e.g. Atlantic menhaden) as compared to a large number of smaller specimens with a significantly different diet.

Table 29. Striped Bass sampling rates and preserved specimen analysis status by year.

Figure 50. Abundance (kg per hectare swept) of Striped Bass in Chesapeake Bay, 2018.

Table 30. Months, latitudinal regions, and depth strata used for Striped Bass index calculations.

Table 31. Striped Bass (March) geometric mean indices of abundance, by number and biomass, overall and by age-class.

Figure 51. Striped Bass (March) geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

Table 32. Striped Bass (November) geometric mean indices of abundance, by number and biomass, overall and by age-class.

Figure 52. Striped Bass (November) geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

Figure 53. Striped Bass length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

Figure 54. Striped Bass total age-frequency, 2002-2018.

Figure 55. Striped Bass age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

Figure 56. Striped Bass age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

Figure 57. Diet composition, expressed as percent by weight (A) and percent by number (B) of Striped Bass collected during ChesMMAAP cruises in 2002-2018 combined.

Summer Flounder (Paralichthys dentatus)

Abundance: Though capture numbers (and biomass) have been lower in recent years, Summer Flounder are a primary target species for the survey with several hundred being sampled in most years (up to about 1,000 specimens weighing 450kg – Table 33). The typical intra-annual pattern of numerical abundance for summer flounder shows catches increasing monthly throughout the sample year, with highest catches in September and/or November (Figure 58). Summer flounder are most abundant in regions 4 and 5 but are common in regions 2 and 3 as well. A slightly higher catch rate is exhibited for mid-depth (30' – 50') and deep (>50') stations than in shallow (10' – 30') waters. The highest catches of summer flounder often occur along the eastern portions of regions 4 and 5 but this is not an absolute. This pattern of catches informs the sampled stations which are included for abundance index calculations. That is, only data from September and November in Regions 4 and 5 (all depth strata) are included (Table 34).

Abundance indices have varied considerably over the time but exhibit a consistent downward trend since 2006, reaching time series low values in 2012 through 2018 (Table 35, Figure 59). This is in consistent with recent stock assessment updates.

Age-specific indices were calculated for ages 0 through 4+. The coastal stock assessment currently uses data for ages 0 through 7+ but as ChesMMAAP captures relatively few individuals older than age-4 or age-5, the 4+ group has been used here. Age-0 fish reached time series high values in 2006 and 2007 while most other year classes were most abundant one or two years earlier. As these abundant young of year do not seem to result in higher abundance one or two years later perhaps specific individuals of this species do not reinvade the Chesapeake Bay each year.

Length and Age: Fish which measure between approximately 20cm and 50cm total length are most prevalent in survey samples though fish as large as 760mm have been captured (Figure 60). In several years a large number of fish under 30cm (mostly age-0) can be differentiated in length-frequency graphs. This species is known to exhibit sexually dimorphic growth patterns (Dery 1981) and this is demonstrated in the sex-specific length plots. The vast majority of ChesMMAAP specimens larger than 35cm and nearly all individuals larger than 40cm are females.

Most fish in the survey are age-5 and under, and the oldest fish yet captured are three specimens at age-12. In age classes older than age-2 it appears to be more difficult, compared to other species, to follow abundance trends of particular year classes in successive years (Figure 61, Figure 62). This could be the result of differential migration patterns among different sized fish or of fishery preferences and/or regulations. As well as the declining abundance estimates described above, the Chesapeake portion of the Summer Flounder stock appear to have constricted somewhat in the age distribution in recent years. Since approximately 2007, as total captures have decreased the age composition of the Chesapeake Summer Flounder has also compressed.

Monthly age-frequency figures reveal the aforementioned pattern of age-0 summer flounder increasingly recruiting to the survey gear throughout the year, reaching peak abundance in November (Figure 63). Other age classes are generally present throughout the survey year, though as previously described, older/larger individuals tend to disappear from the survey area in November.

Diet: As measured by percent weight, fish comprise a majority (53.8%) of summer flounder diets (Figure 64) in the survey, with the primary prey being Bay Anchovy (18.6%), Weakfish (9.0%), and Spot (7.8%) and with crustaceans (42.2%) only slightly lower; as measured by number, crustaceans constitute about four-fifths of the diet (60.6%) with the main prey types being mysid shrimp (45.0%), sand shrimp (6.7%), and mantis shrimp (4.8%). The high prevalence of fish in summer flounder stomachs, especially for larger individuals, leads to the conclusion that this species should be considered a top predator in Chesapeake Bay along with Striped Bass, Bluefish, and Weakfish (Latour et al. 2008). It is noteworthy that by percent weight as measured by this survey, in Chesapeake Bay summer flounder are more highly piscivorous than are striped bass and are nearly on par with Weakfish in this characteristic.

Table 33. Summer Flounder sampling rates and preserved specimen analysis status by year.

Figure 58. Abundance (kg per hectare swept) of Summer Flounder in Chesapeake Bay, 2018.

Table 34. Months, latitudinal regions, and depth strata used for Summer Flounder index calculations.

Table 35. Summer Flounder geometric mean indices of abundance, by number and biomass, overall and by age-class.

Figure 59. Summer Flounder geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

Figure 60. Summer Flounder length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

Figure 61. Summer Flounder total age-frequency, 2002-2018.

Figure 62. Summer Flounder age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

Figure 63. Summer Flounder age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

Figure 64. Diet composition, expressed as percent by weight (A) and percent by number (B) of Summer Flounder collected during ChesMMAP cruises in 2002-2018 combined.

Weakfish (Cynoscion regalis)

Abundance: Weakfish is among the most abundant species in survey samples until 2010, with most years seeing between 1,000 and 3,500 (75kg – 550kg) total captures. In recent years numbers have dropped and only 172 Weakfish were sampled in 2014 though this rose to 688 specimens in 2015 and again reached the 1,000 mark in 2016, declined to slightly less than 1,000 in 2017 and rose again to over 1,600 in 2018 (Table 36). Catches are typically low in March but by May fish have begun to migrate into the bay and remain abundant in the survey throughout the rest of the year. Peak catches are usually in September and decline somewhat in November as fish begin their late fall migration out of the bay (Figure 65). Catches are typically higher in mid-depth (30' – 50') and deep (>50') stations than at shallow ones (10' – 30'). Abundance indices are calculated from data collected in July, September and November (previously only September and November), in Regions 4 and 5, in the mid depth and deep strata (Table 37).

Consistent with recent coast wide trends (ASMFC Weakfish Technical Committee, 2009), overall abundance for this species increased between 2002 and 2005 and then steadily declined over the next several years. However, after reaching a time series low in 2008 a slight upward tick was found in the successive two years but a sharp decline was seen again in 2011 through 2015 with a slight-to-moderate uptick in 2016, another decrease in 2017 and nearly flat values in 2018 (Table 38, Figure 66). As the vast majority of Weakfish sampled by ChesMMAP (and presumably present in the bay) in recent years have been either age-0 or age-1, the age specific abundances for these age classes tends to follow the same pattern as the overall indices.

Length and Age: Most Weakfish captured by the survey are between 100mm and 350mm total length. Minimum and maximum sizes found during the survey are 23mm and 616mm respectively (Figure 67). With only a few exceptions, most fish captured over 400mm were sampled during the first two years of the survey (2002 and 2003). Likewise, the age structure of Chesapeake Bay Weakfish has compressed over the past several years, with few individuals older than age-2 captured in recent years and almost none older than age-3 (Figure 68, Figure 69). In this survey, and others, each sampling year seems to result in (what appear to be) reasonable numbers of young fish but very few of these specimens are captured in successive years as older fish.

Few Weakfish are captured during March cruises but in other survey months each age class (in this age-compressed stock) seem to be well represented in survey tows. Age-0 Weakfish appear to recruit to the survey gear during September and November (Figure 70).

Diet: Fish (60.6%), primarily Bay Anchovy (38.0%), comprise a majority of prey types in the Weakfish diet as measured by biomass ingested (Figure 71). Notably, Weakfish account for 3.8% of prey in the diet of Weakfish, by weight. Similar to Summer Flounder, as measured by number, crustaceans dominate the diet of Weakfish in Chesapeake Bay (55.0%), dominated by mysid shrimp at 43.5%. Bay Anchovy are 25.0% of the diet by number. The relatively low percent of Atlantic menhaden seen in the survey stomach samples (2.1% W, <1.0% N), when compared to earlier studies, may be due to the truncation of the size range of Weakfish in Chesapeake Bay as well as the broad geographic and temporal scale of this survey and due to the cluster sampling analytical methodology as explained for Striped Bass above.

Table 36. Weakfish sampling rates and preserved specimen analysis status by year.

Figure 65. Abundance (kg per hectare swept) of Weakfish in Chesapeake Bay, 2018.

Table 37. Months, latitudinal regions, and depth strata used for Weakfish index calculations.

Table 38. Weakfish geometric mean indices of abundance, by number and biomass, overall and by age-class.

Figure 66. Weakfish geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

Figure 67. Weakfish length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

Figure 68. Weakfish total age-frequency, 2002-2018.

Figure 69. Weakfish age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

Figure 70. Weakfish age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

Figure 71. Diet composition, expressed as percent by weight (A) and percent by number (B) of Weakfish collected during ChesMMAAP cruises in 2002-2018 combined.

White Perch (Morone americana)

Abundance: White Perch are extremely abundant in survey samples throughout each year in regions 1 and 2 and are common into region 3 (Table 39, Figure 72). Due to this species' concentration in the shallow waters of Region 1, catches are highest in the shallowest strata (10' – 30'), followed by the mid-depth strata (30' – 50'), with this species rarely seen in samples from the deepest stations (>50'). Interpretation of abundance indices for this species must account for the fact that ChesMMAAP samples only a portion of the range of the species and catches can be significantly influenced by salinity.

As with Striped Bass, indices of abundance are presented for both the spring (March) spawning population and for the fall (November) when fish again school together. For both the March and November indices, data only from the shallow and mid-depth stations in Regions 1 and 2 are included. Interestingly, these two sets of indices show nearly opposing trends in abundance. The March indices (Table 41A, Figure 73A), measured either by number or biomass, show relatively flat abundance in all years except for peak values (about 4-5 times higher than other values) in 2007 and 2008, with a significant uptick in 2013 and downward points in 2014 and 2015 then up to record high values in 2016. Meanwhile, the November indices (Table 41B, Figure 73B) fluctuate without trend through 2006, and then reach time series lows in 2007 and 2008, followed by a steady upward trend with a distinct decline in 2012 and 2013 then upticks in 2014 and 2015 with slight declines in 2016. If it is assumed that the peaks in March abundance in 2007 and 2008 reflected a high abundance of spawners then it could well make sense that the stock increased for several of the following years.

Though ChesMMAAP captures large numbers of white perch over a broad range of ages, prior reports did not include any age-specific abundance indices. Due to the relatively small size but high longevity of this species, development of an age-length key is relatively difficult. However, further effort was placed on this task during 2017 and such a key was successfully developed. White perch in appreciable numbers

only recruit to the ChesMMAP gear at about age-4 and do not appear to be fully recruited until age-5. Based on this, age-specific indices were generated for ages-4 through 8+.

Length and Age: All White Perch of sizes greater than approximately 150mm fork length are well sampled in the survey (Figure 74). Due to the relatively small maximum size, long life, and slow growth rates it is difficult to separate year-classes of this species using length-frequency. The peak of abundance in 2007 and 2008 samples was at a smaller size than during previous years. It appears that more females are sampled by ChesMMAP than are males and that females reach a slightly larger maximum size than to males.

This species is not well sampled by the survey until approximately age-4 (Figure 75, Figure 76); however past that age the survey appears to adequately represent all age classes. Specimens as old as 19 years have been captured. The species age distribution appears to be regulated by the relative success of each year-class. Year-class specific peaks in abundance can be easily followed during successive years in survey samples (e.g., 1993, 1996, 2000, 2003, 2011 year-classes).

As would typically be expected, monthly age frequency plots for several species presented in this report show a generally declining number of specimens at each age class within any given month (e.g. Atlantic Croaker as shown in Figure 6B). Presumably due to their longevity and to highly variable year-class strength, this pattern is not present for White Perch (Figure 77). The number of specimens captured at each age class within any given cruise month generally displays no particular pattern. All age-classes are present in survey catches during each cruise month, with younger/smaller evidently recruiting to the gear as each year progresses.

Diet: Amphipods represents the largest single prey category by both weight and number (17.5% W, 26.9% N) in White Perch stomachs among identifiable prey, and crustaceans (31.2% W, 44.3% N) constitute the largest identifiable taxon, followed by a number of other small crustacean prey. Worms (26.3% W, 19.8% N), primarily *Nereis* clam worms (11.4% W, 8.3% N) and other polychaetes (13.0% W, 9.7% N), are the second most abundant prey, followed by a variety of mollusc species, (15.8% W, 13.6% N). Notably, a small number of Bay Anchovy (3.0% W, 2.2% N) are present in White Perch stomachs (Figure 78).

Table 39. White Perch sampling rates and preserved specimen analysis status by year.

Figure 72. Abundance (kg per hectare swept) of White Perch in Chesapeake Bay, 2017.

Table 40. Months, latitudinal regions, and depth strata used for White Perch index calculations for March.

Table 41. White Perch geometric mean indices of abundance for March by number and biomass, overall and by age class.

Figure 73. White Perch geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class for March.

Table 42. Months, latitudinal regions, and depth strata used for White Perch index calculations for November.

Table 43. White Perch geometric mean indices of abundance for November by number and biomass, overall and by age class.

Figure 74. White Perch geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class for November.

Figure 75. White Perch length-frequency in Chesapeake Bay 2002-2017, overall (A) and by sex (B).

Figure 76. White Perch total age-frequency, 2002-2017.

Figure 77. White Perch age-frequency by year, 2002-2017 standardized to 8,000 annual trawl minutes.

Figure 78. White Perch age-frequency by cruise month, 2002-2017 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

Figure 79. Diet composition, expressed as percent by weight (A) and percent by number (B) of White Perch collected during ChesMMAAP cruises in 2002-2016 combined.

Water Quality

Figure 80. Interpolated Chesapeake Bay bottom water temperature by cruise for 2017 (A), averaged over 2002 through 2017 (B), and 2017 deviation from average (C).

Figure 81. Interpolated Chesapeake Bay bottom salinity by cruise for 2017 (A), averaged over 2002 through 2017 (B), and 2017 deviation from average (C).

Figure 82. Interpolated Chesapeake Bay bottom dissolved oxygen by cruise for 2017 (A), averaged over 2002 through 2017 (B), and 2017 deviation from average (C).

Figure 83. Interpolated bi-monthly water temperature profiles in Chesapeake Bay, 2017.

Figure 84. Interpolated bi-monthly salinity profiles in Chesapeake Bay, 2017.

Figure 85. Interpolated bi-monthly dissolved oxygen profiles in Chesapeake Bay, 2017.

Task 5 – Evaluation of alternative sampling gear

As noted in several previous proposals and annual reports, ChesMMAAP intends to implement a change to its sampling gear to a bottom trawl that is the same design and half of the size of that used by NEAMAP. This net is often called the ‘200’ net which refers to the number of 12cm meshes around the mouth (200 x 12cm). This style of net achieves a greater headline height, more consistent geometry, and better bottom contact relative to typical survey trawls. The current ChesMMAAP net typically fishes at about 8m of wingspread and 1m of headrope height. In flume tank tests and in field trials the 200 net has a similar wingspread but more than double the headrope height. In short, it is expected to provide a much better sample of the demersal and semi-pelagic biota.

With the scheduled delivery of the new VIMS research vessel (*R/V Virginia*) during the summer of 2018, and the subsequent retirement of the *R/V Bay Eagle* implementation of several changes in sampling methods is near at hand. During this reporting period the following initial plans were made for evaluating the new sampling methods, for implementing new sampling, and for conducting calibration experiments:

New Sampling

- The *R/V Virginia* is considerably larger than the *R/V Bay Eagle* (93'LOA v. 65'LOA) and will require a vessel crew of three personnel rather than two. It is expected that the daily cost of the new vessel will be higher, though the preliminary charge figures established by VIMS are quite reasonable. Further, we have been notified by VMRC that in coming years we should expect fewer available Wallop-Breaux funds. In combination, these two facts necessitate a decrease in the number of days-at-sea available for ChesMMAP. Our current plan will be to decrease the number of cruises from five to three. Rather than conducting cruises in March, May, July, September, and November we plan three seasonal (Spring, Summer, Fall) trips each year, March/April, July/August, and October/November.
- We will continue to sample 80 sites per cruise, subject to re-evaluation based on analyses of the data collected with the new sampling gear.
- We plan to implement, at a random subset of sites, to collect an increased amount of synoptic data. Along with the newer bottom trawling gear we will also deploy a mid-water trawl to sample pelagic species which are currently under-represented in our data. As a part of a graduate student/proof of concept project three years ago we established that fishing such a net from the older vessel was possible and we gathered considerable data on how to properly design and fish such a trawl.

In addition, at this same subset of stations we plan to take bottom 'grabs' to sample the benthos as well as a plankton net with which we especially hope to sample mysid shrimp, which previous ChesMMAP food habits data have shown to be very important, but unmonitored, prey items for many other economically and ecologically valuable fish species. Over time, this synoptic data collection system will provide for development of much improved multi-species and ecosystem models of Chesapeake Bay.

Calibration:

- ChesMMAP has been sampling with its current vessel/bottom trawl combination since 2002 and will continue to do so through 2019. With the changes to sampling which will be necessitated by the new vessel, extensive calibration experiments will be required if we hope to keep a consistent time series of abundance data.
- In order to eliminate the possibility/probability that the activities of the new vessel in proximity to the older one will have an effect on survey catches, we plan to keep the regular survey cruises separate from calibration trips. While this may increase costs somewhat we believe this is the proper course of action.
- Initial sea trials of the new fishing system are planned for late fall 2018. It's likely that this will be for a limited number of days and will not involve any direct calibration work. Rather, it will be to establish a set of safe and effective protocols for deployment and retrieval of the 200 net onboard the new vessel.
- Calibration studies will occur in 2019. To the extent possible (accounting for vessel and personnel scheduling) calibration trips will be conducted according to the planned cruise schedule (Spring, Summer, Fall) to be implemented for the new vessel. The current target

number of calibration tows is at least 100 per season. This number will be adapted according to results obtained as the experiments are conducted.

- The new sampling plan will begin in 2020.

Appendix

Abundance data summaries for a selection of common species which are not considered as recreational species for funding and management purposes are provided in the Appendix. The species are blue crab – males and mature females separately, and clearnose skate.

Literature Cited

Aitchison, J. 1955. On the distribution of a positive random variable having a discrete probability mass at the origin. *Journal of the American Statistical Association* 50:901–908.

ASMFC Weakfish Technical Committee. 2009. Weakfish Stock Assessment Report. Presented to the 48th Stock Assessment Workshop Stock Assessment Review Committee. SAW/SARC 48. Woods Hole, MA. 396pp.

Bonzek, C.F., J. Gartland, and R. J. Latour. 2011. Progress Report: The Chesapeake Bay Multispecies Monitoring and Assessment Program. Project Number F-130-R-7. Virginia Institute of Marine Science, Gloucester Point, VA.

Bonzek, C.F., J. Gartland, R.A. Johnson, R.J. Latour. 2010. Progress Report: The Chesapeake Bay Multispecies Monitoring and Assessment Program. Project Number F-130-R-5. Virginia Institute of Marine Science. Gloucester Point, VA.

Bonzek, C.F., J. Gartland, R.A. Johnson, R.J. Latour. 2009. Progress Report: The Chesapeake Bay Multispecies Monitoring and Assessment Program. Project Number F-130-R-4. Virginia Institute of Marine Science. Gloucester Point, VA.

Buckel, J.A., D.O. Conover, N.D. Steinberg, and K.A. McKown. 1999. Impact of age-0 Bluefish (*Pomatomus saltatrix*) predation on age-0 fishes in Hudson River Estuary: evidence for density-dependant loss of juvenile striped bass (*Morone saxatilis*). *Canadian Journal of Fisheries and Aquatic Sciences* 56:275-287.

Dery, L.M. 1981. Post workshop age and growth study of young summer flounder. *In*: Smith, R.W., L.M. Dery, P.G. Scarlett, and A. Jearld, Jr. (eds.), Proceedings of the summer flounder (*Paralichthys dentatus*) age and growth workshop, 20-21 May 1980, Woods Hole, MA, p. 7-11. Tech. Memo. NMFS-F/NEC-1 1, Northeast Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Woods Hole, MA 02543, 30 p.

Hoffman, J.C., C.F. Bonzek, R.J. Latour. 2009. Estimation of bottom trawl efficiency For two demersal fishes, the Atlantic croaker and the white perch, in Chesapeake Bay. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 1:255-269.

Hollowed, A.B., N. Bax, R. Beamish, J. Collie, M. Fogarty, P. Livingston, J. Pope, and J.C. Rice. 2000. Are multispecies models an improvement on single-species models for measuring fishing impacts on marine ecosystems? *ICES Journal of Marine Science* 57:707-719.

- Houde, E.D., M.J. Fogarty and T.J. Miller (Convenors). 1998. STAC Workshop Report: Prospects for Multispecies Fisheries Management in Chesapeake Bay. Chesapeake Bay Program, Scientific Technical Advisory Committee.
- Hyslop, E.J. 1980. Stomach content analysis – a review of methods and their application. *Journal of Fish Biology* 17:411-429.
- Latour, R.J., J. Gartland, C.F. Bonzek, and R.A. Johnson. 2008. The trophic dynamics of summer flounder (*Paralichthys dentatus*) in Chesapeake Bay. *Fishery Bulletin* 106:47-57.
- Link, J.S. 2002a. Ecological considerations in fisheries management: when does it matter? *Fisheries* 27(4):10-17.
- Link, J.S. 2002b. What does ecosystem-based fisheries management mean? *Fisheries* 27:18-21.
- Miller, T.J., E.D. Houde, and E.J. Watkins. 1996. STAC Workshop Report: Prospectives on Chesapeake Bay fisheries: Prospects for multispecies fisheries management and sustainability. Chesapeake Bay Program, Scientific Technical Advisory Committee.
- NMFS (National Marine Fisheries Service). 1999. Ecosystem-based fishery management. A report to Congress by the Ecosystems Principles Advisory Panel. U. S. Department of Commerce, Silver Spring, Maryland.
- NOAA (National Oceanic and Atmospheric Administration). 1996. Magnuson-Stevens Fishery Management and Conservation Act amended through 11 October 1996. NOAA Technical Memorandum NMFS-F/SPO-23. U. S. Department of Commerce.
- R Development Core Team. 2010. R: a language and environment for statistical computing. R Foundation for Statistical Computing. Vienna. <http://www.R-project.org> (accessed 24 June 2011).
- Shimizu, K. 1988. Point estimation, p. 27-87. In E. L. Crow and K. Shimizu [ed.] *Lognormal distributions: theory and applications*. Marcel Dekker Inc., New York, NY.
- Whipple, S. J., J. S. Link, L. P. Garrison, and M. J. Fogarty. 2000. Models of predation and fishing mortality in aquatic ecosystems. *Fish and Fisheries* 1:22-40.

Table 5. Atlantic Croaker sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	12,689	2,835.8	64.3	7,082	1,126	1,126	1,104	93
2003	12,217	2,850.9	70.8	5,721	548	548	542	62
2004	20,394	5,330.5	62.3	8,850	717	717	702	254
2005	13,281	3,184.8	70.1	7,757	716	716	704	261
2006	14,878	3,486.6	75.7	8,904	854	854	834	750
2007	12,678	1,963.6	67.3	5,974	526	526	523	506
2008	6,260	1,031.3	59.2	3,070	480	480	460	454
2009	3,797	523.0	65.4	3,250	369	369	361	358
2010	3,243	454.3	53.8	2,355	322	322	317	310
2011	5,187	605.5	62.8	2,776	322	322	291	287
2012	2,448	152.9	46.2	1,998	312	312	280	269
2013	8,971	655.1	44.9	3,684	282	282	237	231
2014	1,449	143.3	21.8	620	111	111	73	71
2015	1,723	167.4	35.9	1,402	160	160	110	107
2016	919	90.6	26.9	551	113	113	69	69
2017	1,318	92.9	29.5	1,037	247	247	190	188
2018	1,164	51.6	16.7	455	88	88	56	56

Figure 1. Abundance (kg per hectare swept) of Atlantic Croaker in Chesapeake Bay, 2018.

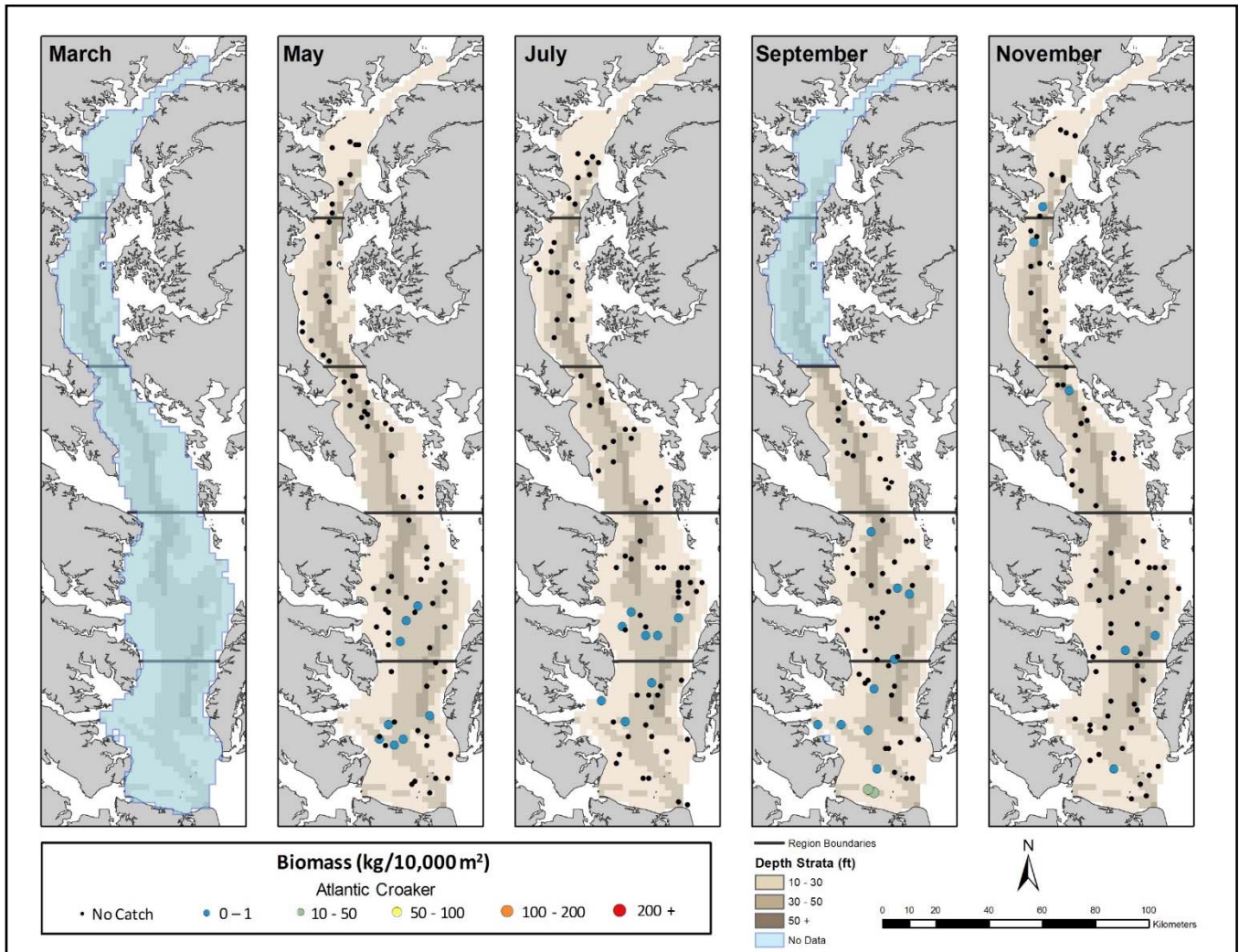


Table 6. Months, latitudinal regions, and depth strata used for Atlantic Croaker index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 7. Atlantic Croaker geometric mean indices of abundance, by number and biomass, overall and by age-class.

Year	Age	n	Numerical Index			Biomass Index			Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI
2002	All	70	91.4	242.9	643.3	35.4	79.7	178.0	2002	2	70	29.6	66.1	146.0	11.4	22.3	42.8
2003		48	191.0	511.6	1,367.4	58.7	136.9	317.8	2003		48	59.3	142.9	342.5	17.3	36.2	74.9
2004		77	1,442.2	2,689.7	5,015.8	417.2	739.0	1,308.7	2004		77	267.0	501.5	941.4	76.2	134.7	237.6
2005		77	750.1	1,486.8	2,946.2	215.8	393.7	717.5	2005		77	122.8	230.2	430.6	35.6	60.5	102.4
2006		74	520.6	1,142.0	2,503.7	150.3	295.1	578.4	2006		74	89.0	178.2	355.7	24.9	45.1	81.1
2007		52	789.8	2,075.7	5,452.8	183.8	424.5	978.8	2007		52	199.3	518.5	1,346.5	45.1	101.3	226.1
2008		76	44.6	107.8	258.7	12.8	25.1	48.3	2008		76	7.3	15.0	29.8	2.7	5.0	8.8
2009		52	230.4	557.3	1,345.9	43.0	85.7	169.9	2009		52	28.7	62.5	135.0	7.5	14.2	26.0
2010		78	47.4	104.9	230.7	11.5	21.2	38.2	2010		78	10.7	21.0	40.6	3.0	5.3	8.9
2011		78	55.0	124.4	280.1	13.1	24.7	46.1	2011		78	13.0	25.9	50.5	3.4	6.0	10.2
2012		78	14.3	34.3	80.4	3.8	7.2	13.2	2012		78	1.4	3.1	5.8	0.5	1.1	1.9
2013		78	31.1	81.7	212.2	8.7	18.3	37.1	2013		78	6.3	13.3	27.1	1.8	3.3	5.7
2014		78	3.6	8.5	18.9	1.6	3.3	6.0	2014		78	1.6	3.6	6.9	0.6	1.3	2.2
2015		78	7.1	16.1	35.3	2.7	5.3	9.7	2015		78	2.7	5.5	10.3	1.0	1.8	3.1
2016		78	3.2	7.9	17.7	1.3	2.8	5.2	2016		78	1.0	2.3	4.6	0.4	0.9	1.6
2017		78	4.1	9.8	21.7	1.5	3.0	5.5	2017		78	0.5	1.2	2.4	0.1	0.5	0.9
2018		78	1.6	3.5	7.0	0.6	1.2	2.1	2018		78	0.6	1.3	2.4	0.2	0.5	0.9
2019									2019								
2020									2020								
2002	0	70	5.4	13.2	30.3	2.0	4.2	8.0	2002	3	70	23.5	53.1	118.4	9.7	19.6	38.7
2003		48	6.4	13.8	28.5	1.9	3.6	6.3	2003		48	40.8	94.8	218.4	12.8	26.9	55.5
2004		77	5.4	11.7	23.9	2.2	4.0	6.8	2004		77	244.5	467.9	894.5	77.7	141.0	255.1
2005		77	9.3	20.6	44.6	3.1	5.9	10.6	2005		77	115.3	218.7	414.2	38.6	68.8	122.2
2006		74	13.7	29.5	62.2	3.8	7.0	12.2	2006		74	67.0	137.2	279.8	23.3	43.9	82.0
2007		52	12.8	29.0	64.1	3.3	6.4	11.8	2007		52	131.0	311.6	739.1	34.2	72.3	151.7
2008		76	9.7	22.8	51.8	2.8	5.2	9.2	2008		76	4.7	9.4	18.0	1.9	3.5	6.1
2009		52	59.4	133.3	297.2	11.2	20.0	34.9	2009		52	14.9	29.8	58.6	4.1	7.5	13.2
2010		78	9.8	19.8	39.2	2.5	4.3	7.0	2010		78	4.7	8.9	16.0	1.6	2.8	4.5
2011		78	14.6	29.1	57.2	3.5	6.0	10.0	2011		78	4.7	9.1	16.8	1.5	2.7	4.5
2012		78	8.3	19.3	43.6	2.1	4.0	6.9	2012		78	0.8	1.8	3.2	0.3	0.7	1.1
2013		78	14.2	34.4	81.2	4.2	8.2	15.2	2013		78	1.8	3.6	6.4	0.5	1.0	1.7
2014		78	1.2	2.8	5.6	0.5	1.1	1.9	2014		78	0.9	1.9	3.3	0.3	0.6	1.1
2015		78	1.9	4.3	8.7	0.7	1.5	2.7	2015		78	1.5	2.9	5.2	0.5	1.1	1.8
2016		78	1.8	4.2	8.4	0.7	1.3	2.2	2016		78	0.6	1.3	2.5	0.2	0.5	0.9
2017		78	2.7	6.3	13.3	1.0	2.0	3.5	2017		78	0.2	0.6	1.2	0.1	0.3	0.5
2018		78	0.4	1.2	2.3	0.1	0.3	0.6	2018		78	0.4	0.8	1.4	0.1	0.3	0.5
2019									2019								
2020									2020								
2002	1	70	25.6	56.4	122.9	9.3	17.4	31.7	2002	4+	70	18.6	44.2	103.0	9.1	19.4	40.2
2003		48	66.5	167.1	417.8	18.6	39.3	82.0	2003		48	27.3	67.2	163.2	10.2	23.4	52.2
2004		77	162.2	291.2	522.3	42.8	70.7	116.5	2004		77	303.8	590.8	1,148.2	117.0	218.7	408.1
2005		77	80.9	166.5	341.6	21.6	38.2	66.9	2005		77	154.0	306.9	610.9	65.2	122.8	230.3
2006		74	100.1	205.7	421.5	24.5	43.4	76.2	2006		74	62.2	139.4	311.2	28.1	58.7	121.5
2007		52	209.8	597.4	1,697.9	46.7	109.5	254.9	2007		52	89.9	216.3	518.3	33.8	71.5	150.1
2008		76	16.1	34.0	70.8	4.6	8.2	14.1	2008		76	3.0	6.2	11.9	1.4	2.8	5.0
2009		52	78.7	185.4	435.2	15.3	30.6	60.4	2009		52	4.7	10.1	20.3	1.9	3.8	7.0
2010		78	26.5	55.5	114.9	6.2	11.0	19.1	2010		78	2.1	3.9	6.6	0.9	1.5	2.4
2011		78	31.9	69.0	148.1	7.6	13.8	24.6	2011		78	1.7	3.4	6.2	0.6	1.3	2.3
2012		78	6.8	14.3	29.2	1.6	3.0	5.0	2012		78	0.5	1.1	1.8	0.2	0.4	0.6
2013		78	19.5	48.1	117.0	5.4	10.9	21.1	2013		78	0.4	0.8	1.5	0.1	0.3	0.6
2014		78	2.7	6.2	13.0	1.1	2.3	4.1	2014		78	0.2	0.6	1.0	0.1	0.2	0.4
2015		78	4.8	10.3	20.9	1.7	3.2	5.6	2015		78	0.7	1.4	2.4	0.2	0.5	0.9
2016		78	2.0	4.6	9.6	0.7	1.6	2.9	2016		78	0.2	0.6	1.2	0.0	0.2	0.5
2017		78	2.5	5.3	10.5	0.7	1.5	2.6	2017		78	0.1	0.3	0.7	0.0	0.1	0.3
2018		78	0.9	2.0	3.7	0.4	0.8	1.3	2018		78	0.1	0.3	0.6	0.0	0.1	0.2
2019									2019								
2020									2020								

Figure 2. Atlantic Croaker geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

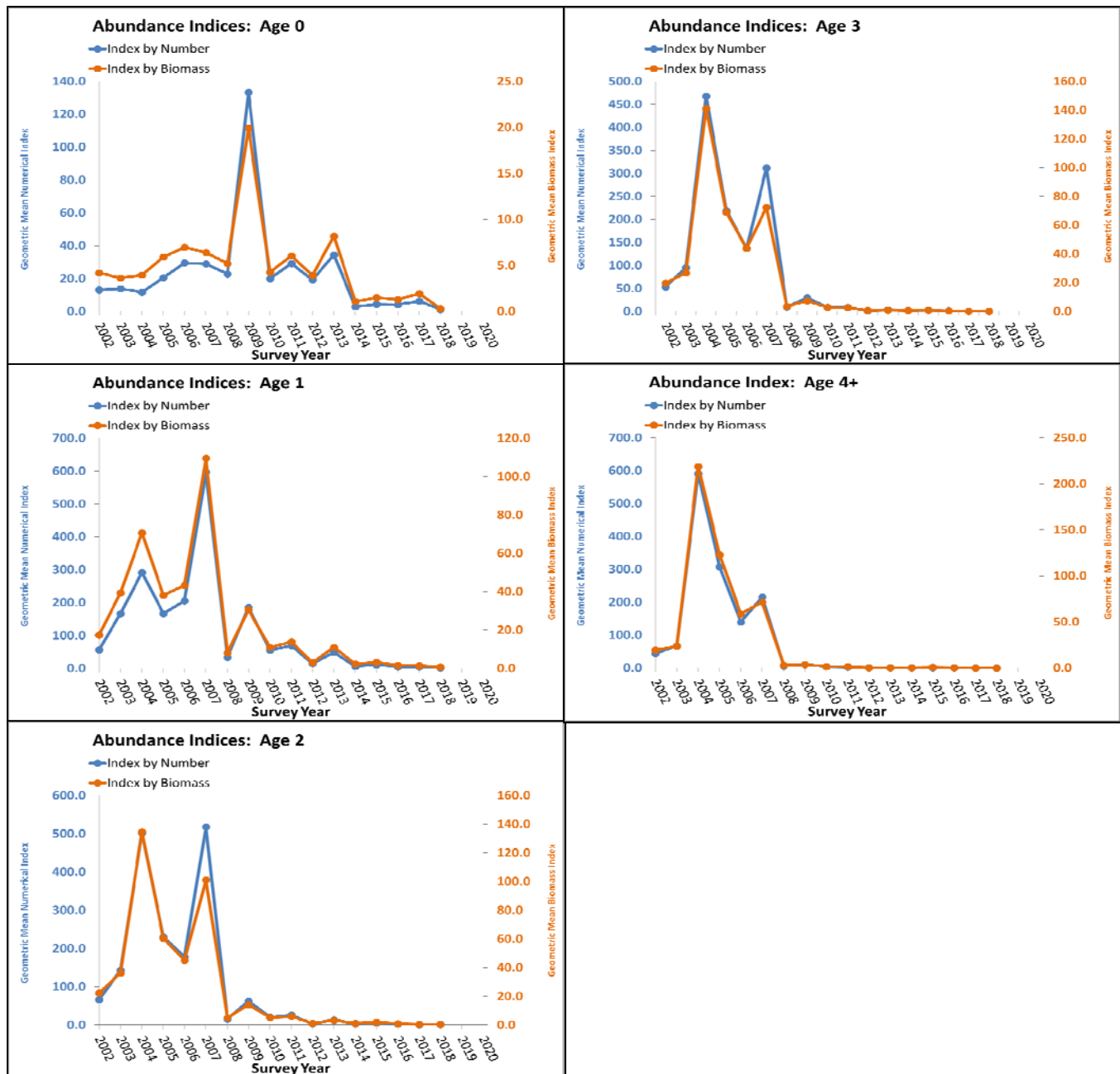
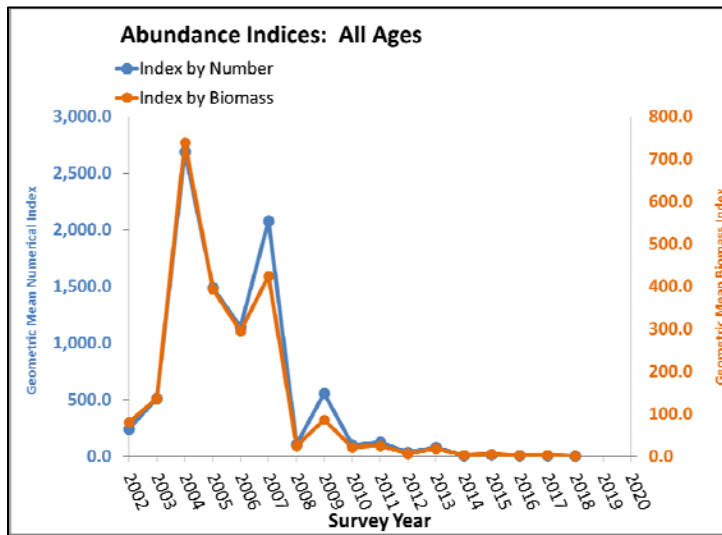


Figure 3. Atlantic Croaker length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

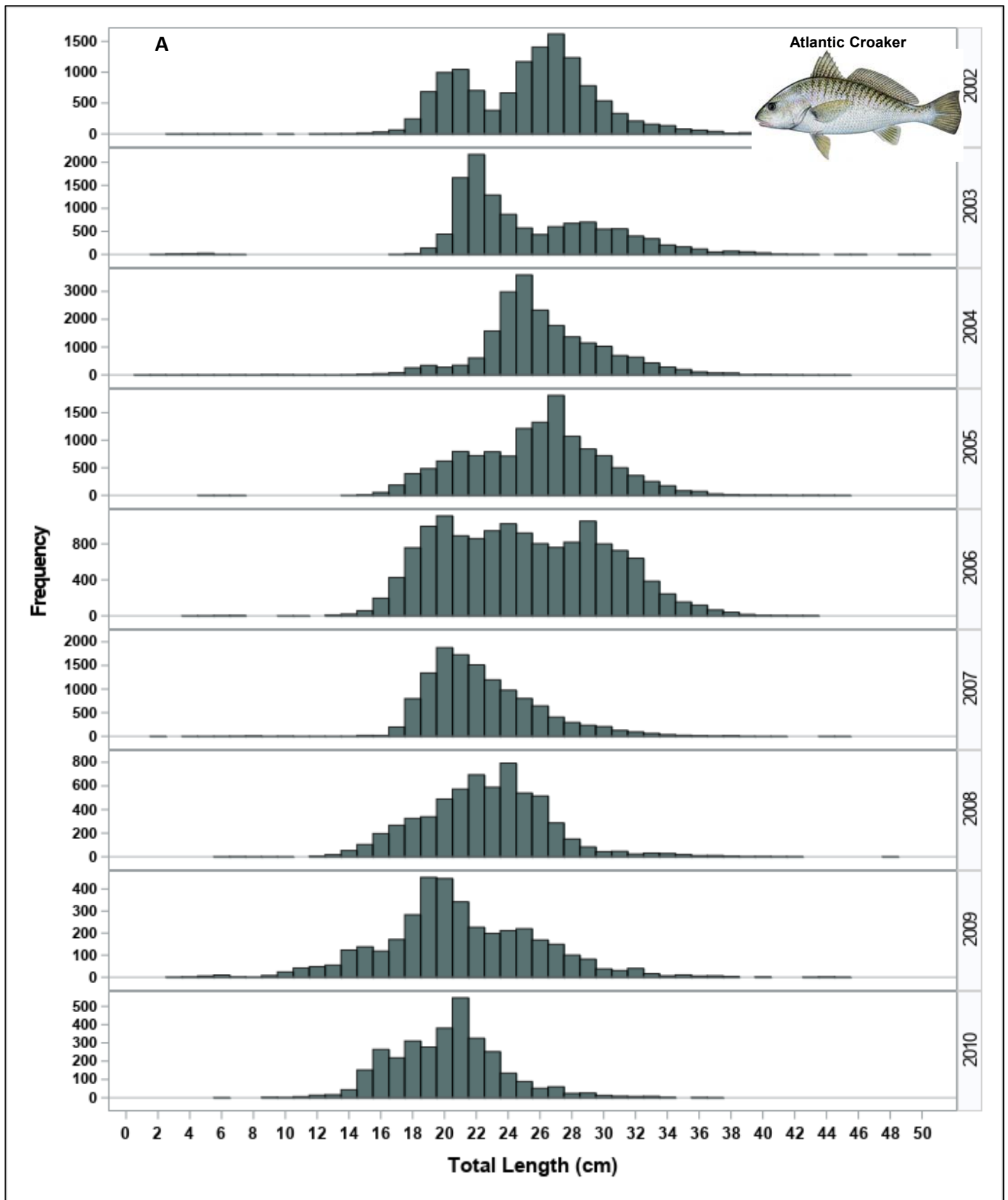


Figure 3. continued.

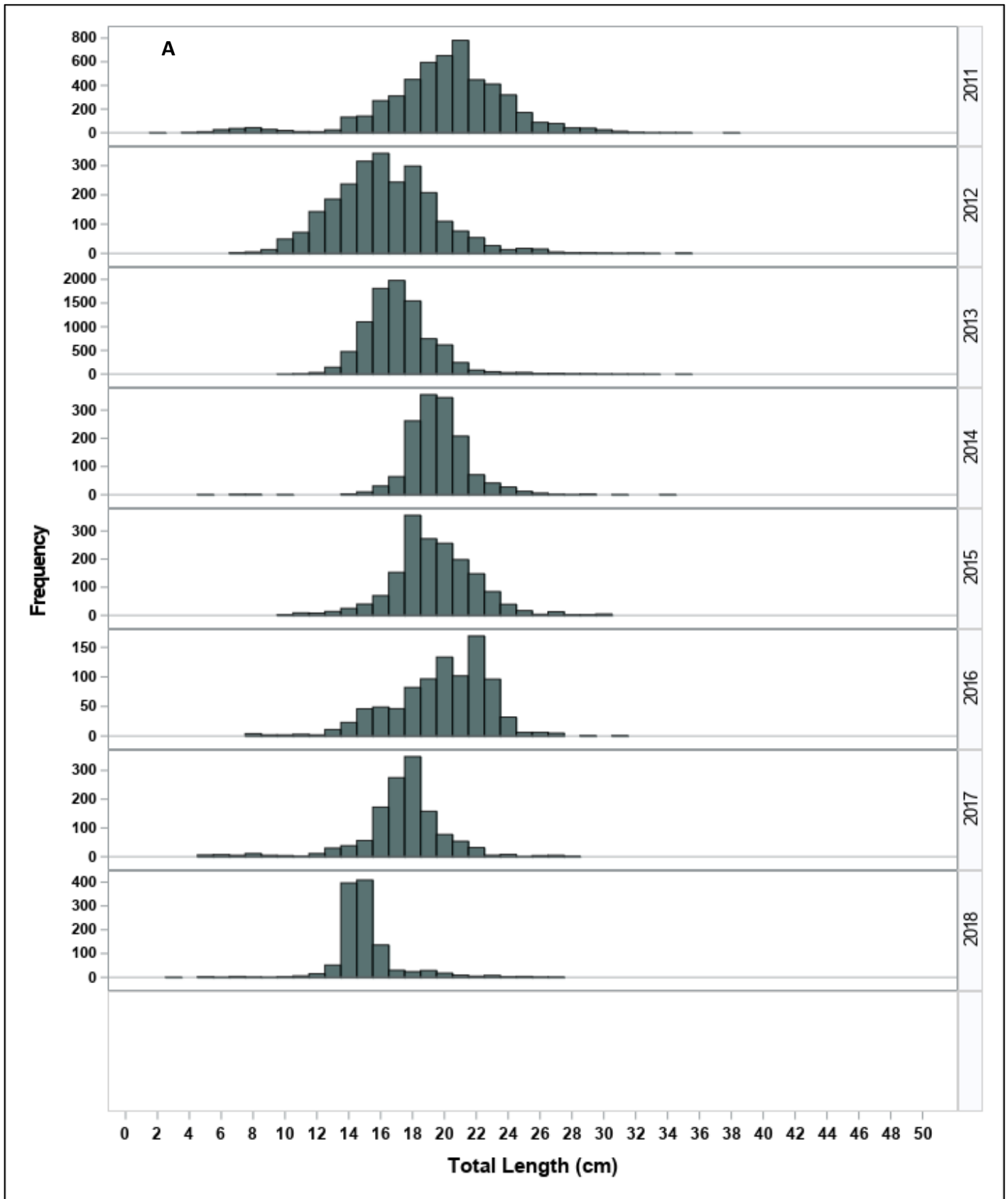


Figure 3. continued.

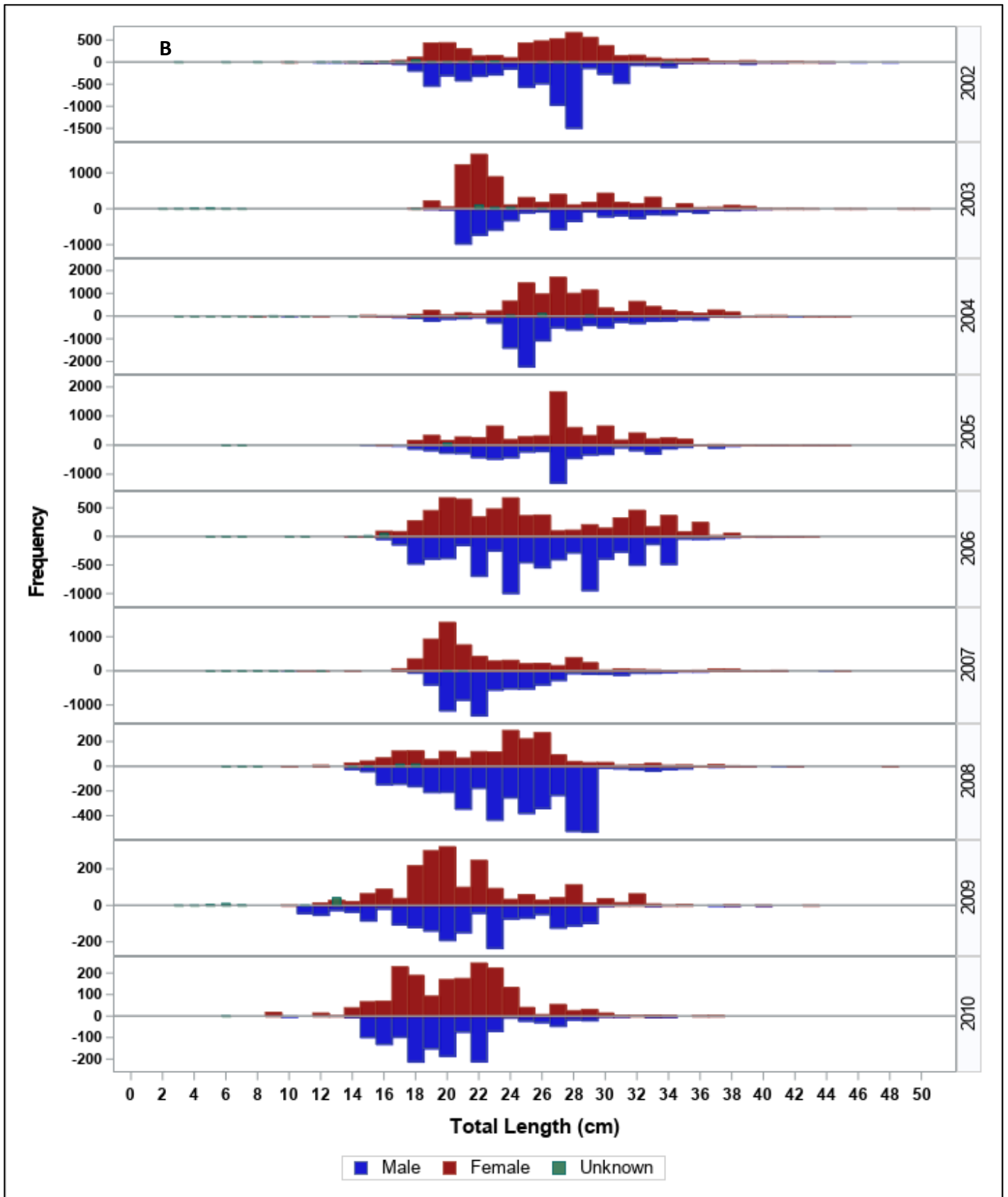


Figure 3. continued.

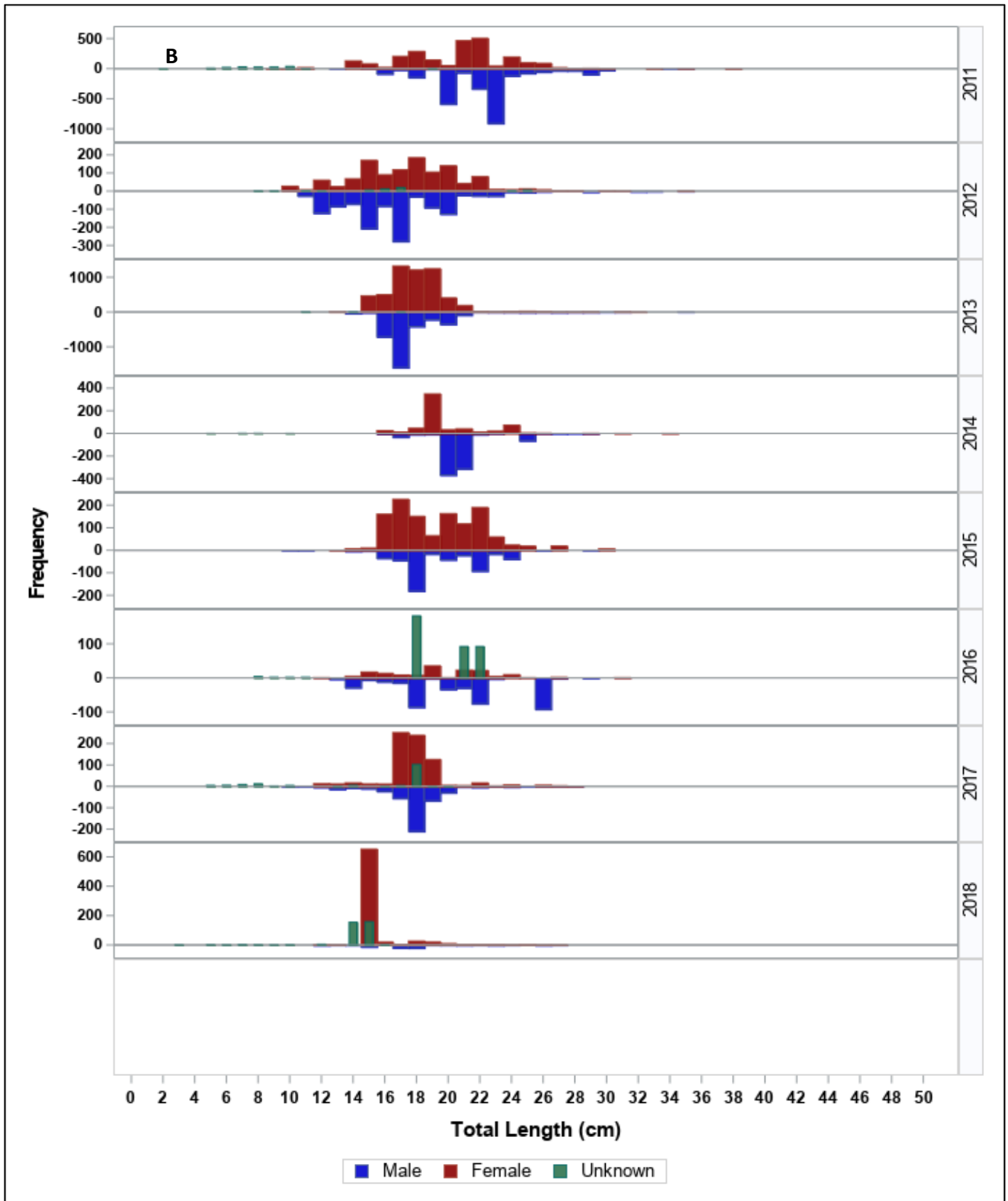


Figure 4. Atlantic Croaker age-frequency by year, 2002-2018.

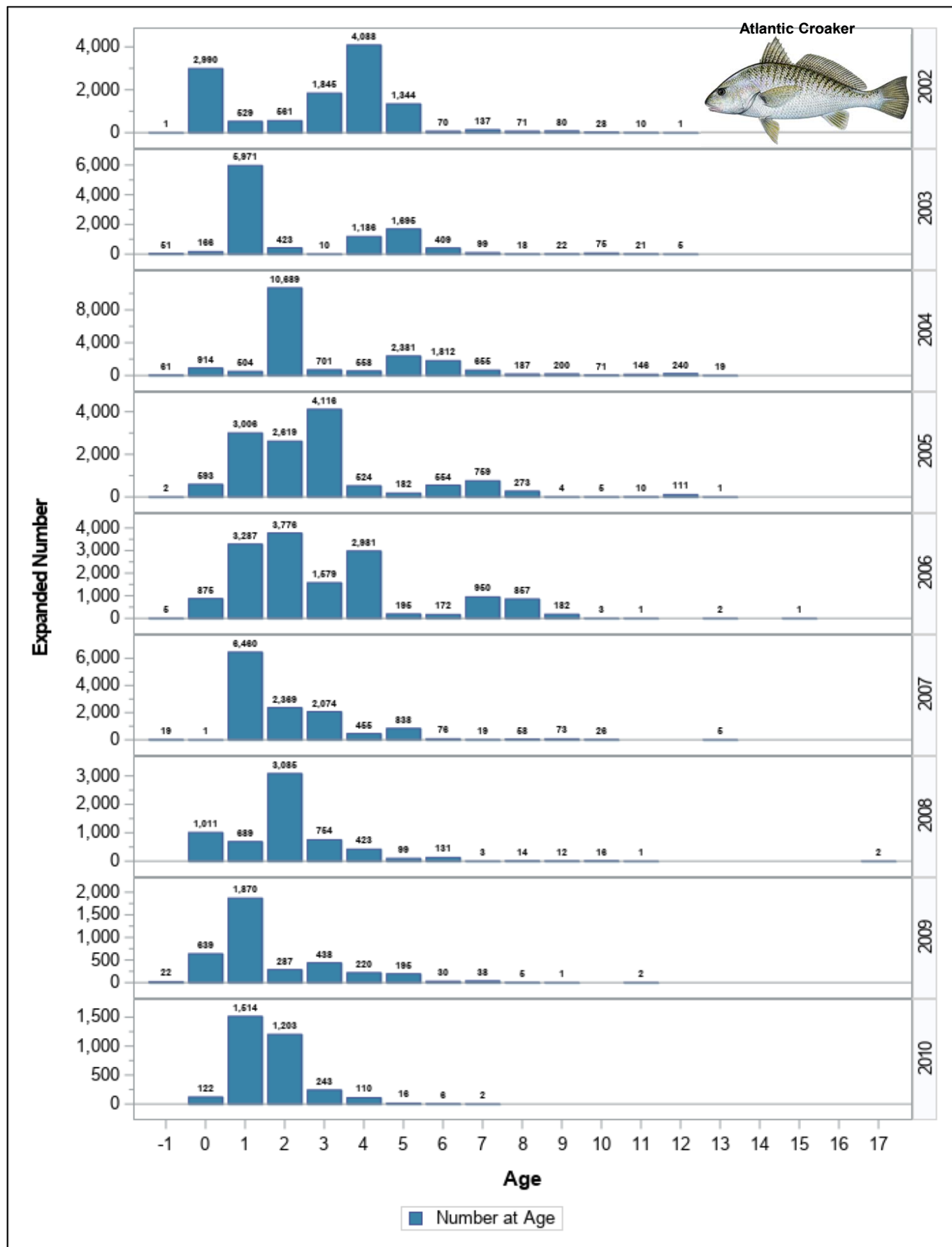


Figure 4. cont.

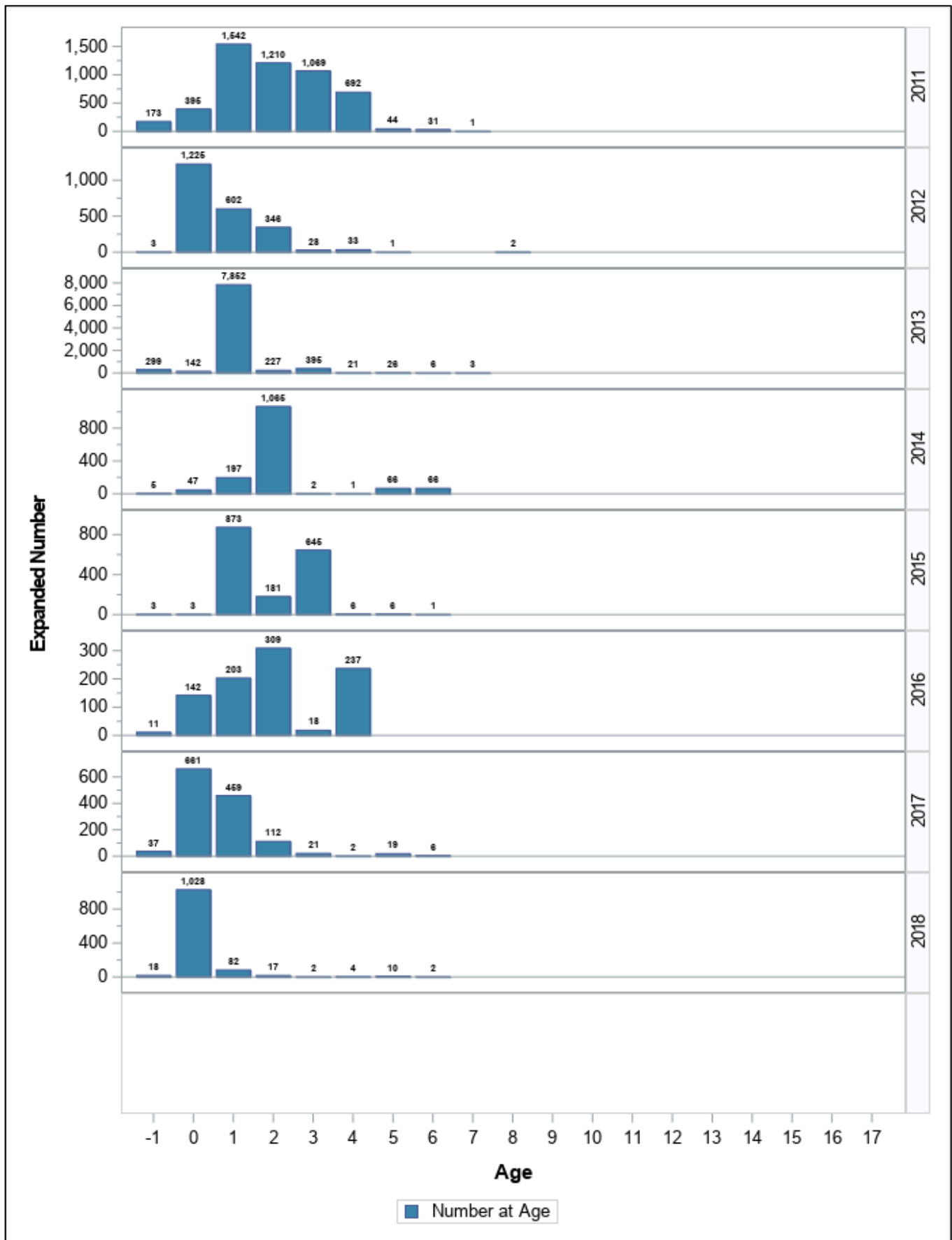


Figure 5. Atlantic Croaker age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

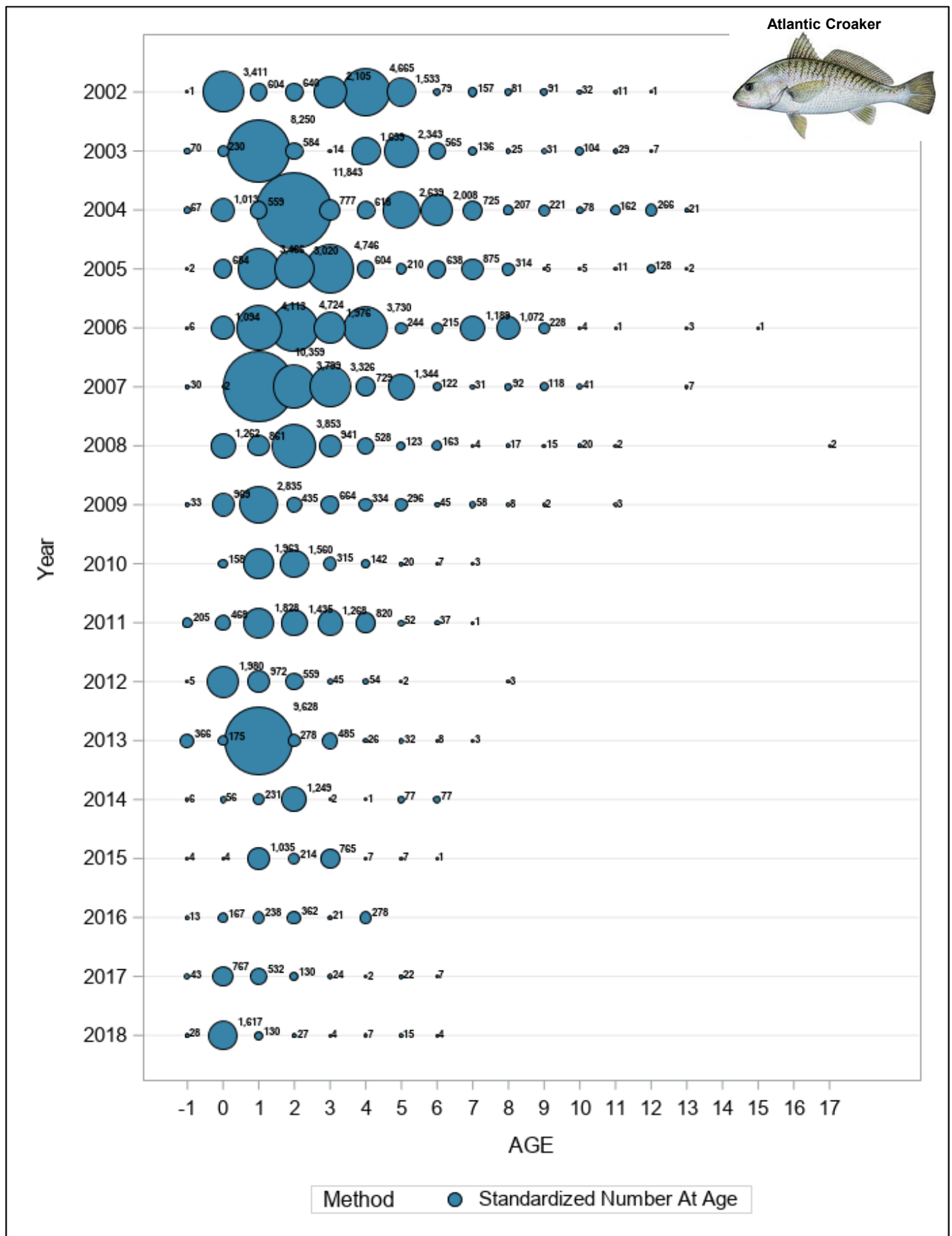


Figure 6. Atlantic Croaker age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

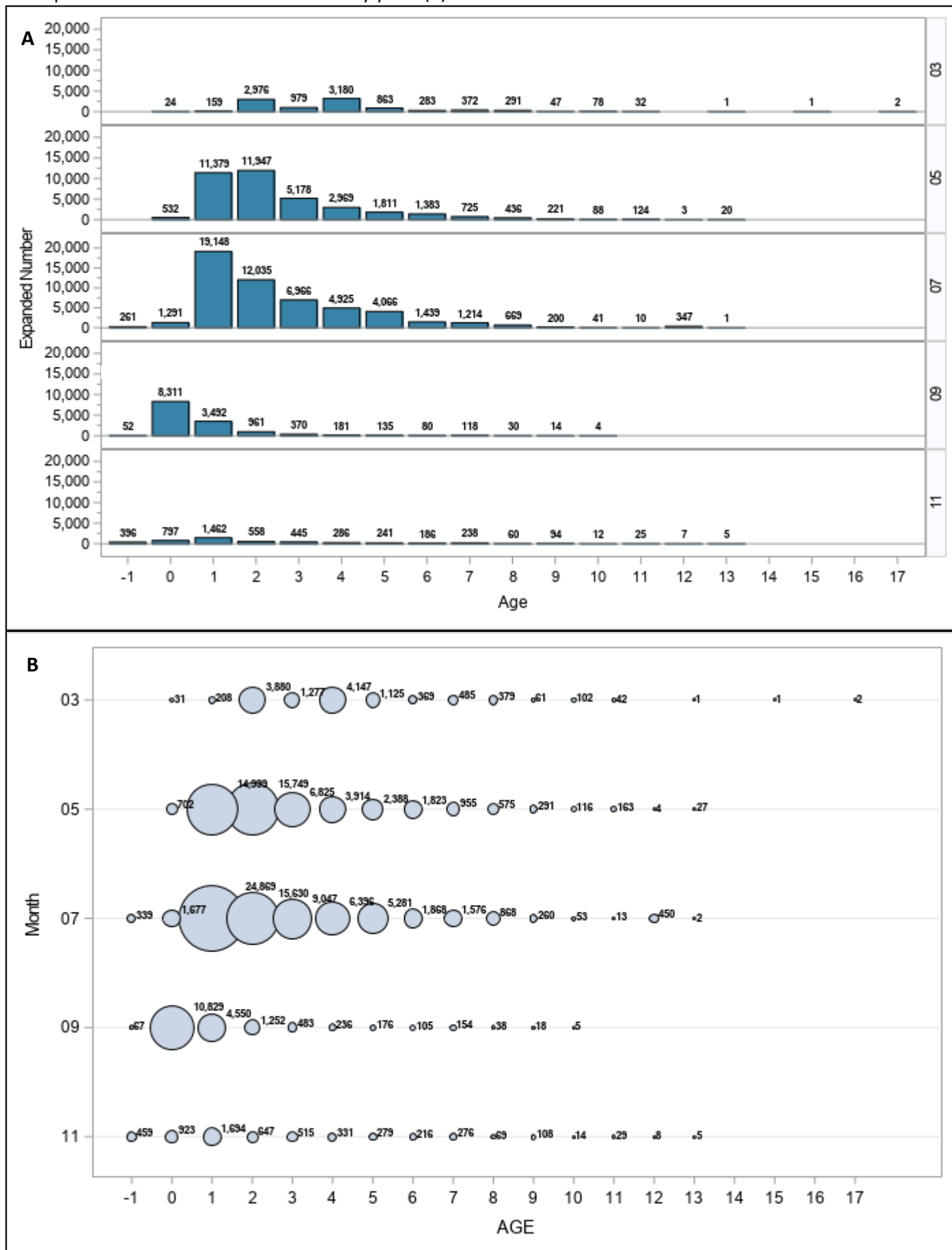


Figure 7. Diet composition, expressed as percent by weight (A) and percent by number (B) of Atlantic Croaker collected during ChesMMAAP cruises in 2002-2018 combined.

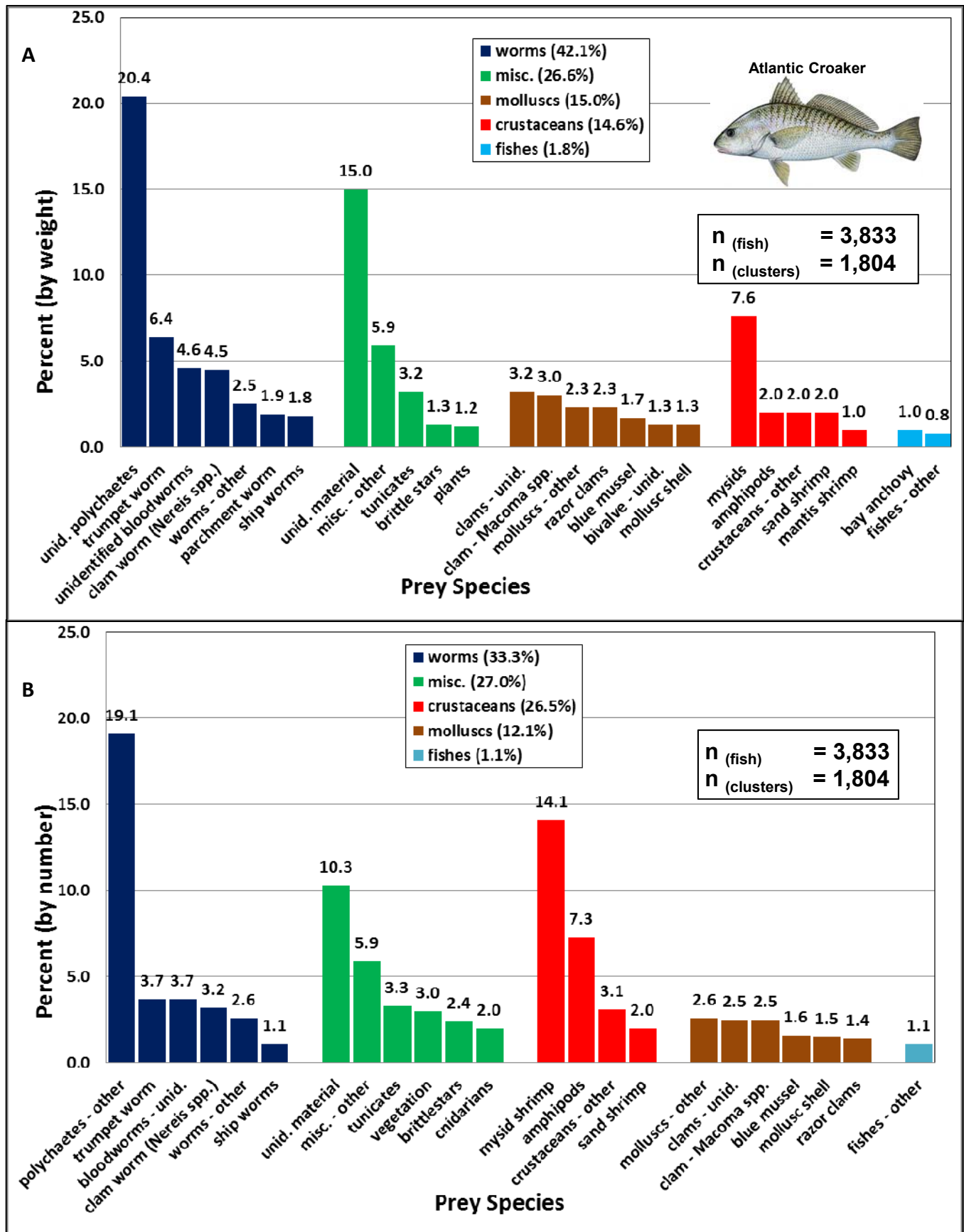


Table 8. Black Sea Bass sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	50	4.4	8.2	50	48	48	46	46
2003	42	5.0	7.3	42	32	30	31	31
2004	14	2.2	4.7	14	14	14	14	14
2005	13	1.7	4.6	13	13	13	13	12
2006	22	1.7	1.7	22	17	17	16	16
2007	30	1.8	8.0	30	30	30	29	28
2008	34	2.2	4.4	34	28	28	26	25
2009	35	2.0	7.4	35	35	35	35	34
2010	23	0.6	2.2	23	23	23	22	22
2011	23	1.4	6.7	23	23	23	21	21
2012	9	0.4	1.6	9	9	9	8	7
2013	2	0.1	1.5	2	2	2	1	1
2014	11	0.6	0.7	11	11	11	8	8
2015	11	0.5	3.0	11	11	11	9	9
2016	42	2.0	11.1	42	42	42	30	30
2017	35	1.3	3.7	35	34	34	22	22
2018	8	0.4	1.5	8	8	8	4	4

Figure 8. Abundance (kg per hectare swept) of Black Sea Bass in Chesapeake Bay, 2018.

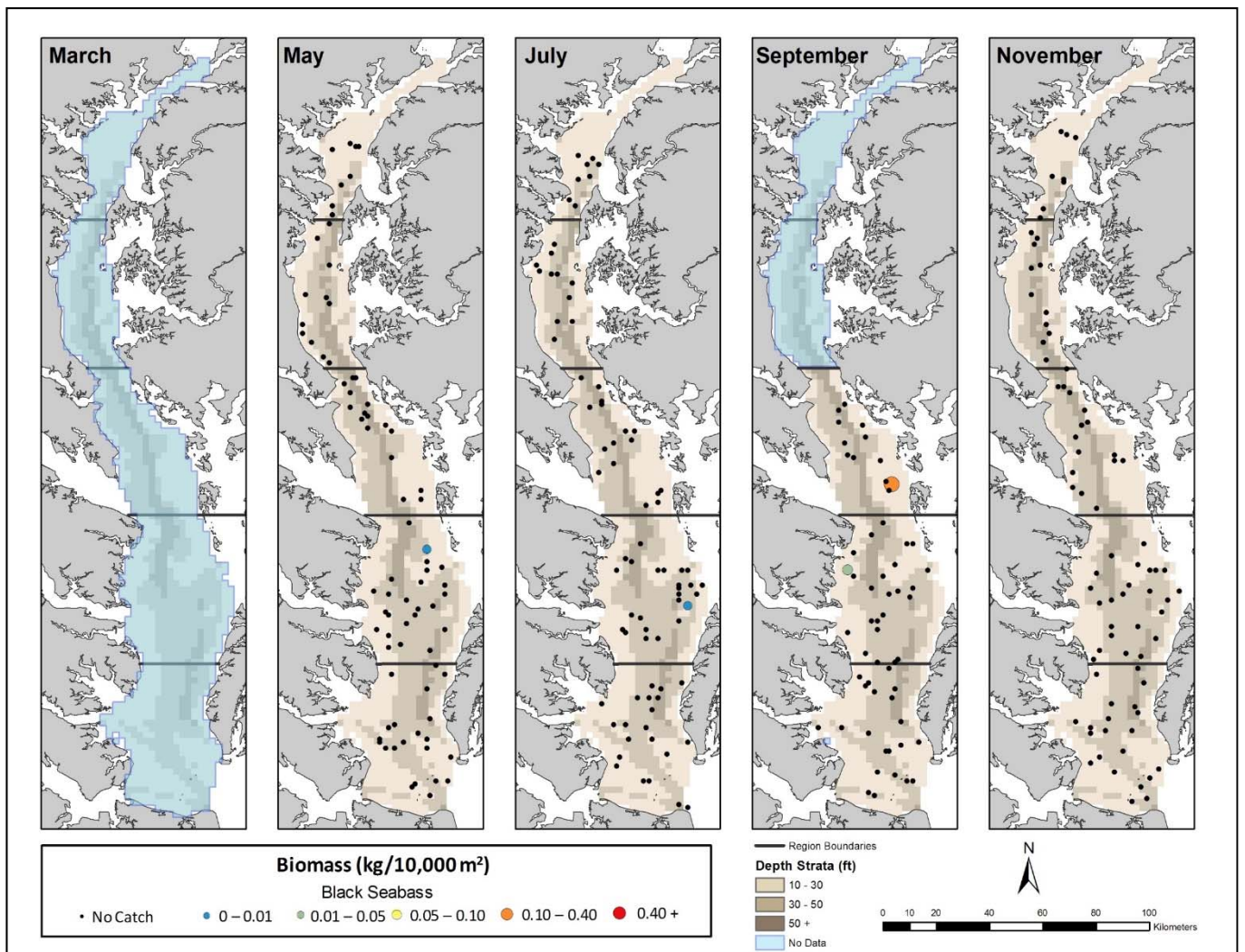


Table 9. Months, latitudinal regions, and depth strata used for Black Sea Bass index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 10. Black Sea Bass geometric mean indices of abundance, by number and biomass, overall and by age-class.

			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI	
2002	All	122	0.46	0.96	1.62	0.18	0.34	0.53		2002	1	122	0.41	0.84	1.40	0.14	0.28	0.42
2003		149	0.50	0.97	1.59	0.20	0.38	0.59		2003	1	149	0.44	0.84	1.35	0.16	0.30	0.46
2004		127	0.15	0.44	0.79	0.08	0.23	0.40		2004	1	127	0.13	0.38	0.67	0.06	0.18	0.31
2005		131	0.07	0.29	0.56	0.03	0.15	0.27		2005	1	131	0.06	0.25	0.48	0.02	0.12	0.21
2006		120	0.09	0.36	0.70	0.02	0.14	0.27		2006	1	120	0.08	0.33	0.63	0.01	0.11	0.22
2007		88	0.33	0.92	1.76	0.12	0.31	0.54		2007	1	88	0.31	0.84	1.60	0.10	0.27	0.45
2008		135	0.07	0.29	0.54	0.03	0.13	0.24		2008	1	135	0.06	0.24	0.46	0.02	0.10	0.18
2009		135	0.45	0.93	1.55	0.14	0.29	0.46		2009	1	135	0.36	0.75	1.26	0.11	0.23	0.36
2010		135	0.20	0.52	0.93	0.06	0.15	0.24		2010	1	135	0.17	0.45	0.80	0.04	0.11	0.19
2011		134	0.24	0.57	0.98	0.07	0.18	0.29		2011	1	134	0.21	0.49	0.84	0.05	0.13	0.23
2012		129	0.00	0.11	0.27	0.00	0.04	0.10		2012	1	129	0.00	0.11	0.25	0.00	0.04	0.08
2013		134	0.00	0.06	0.16	0.00	0.02	0.06		2013	1	134	0.00	0.06	0.15	0.00	0.02	0.05
2014		135	0.02	0.20	0.41	0.00	0.06	0.12		2014	1	135	0.00	0.13	0.29	0.00	0.04	0.09
2015		135	0.09	0.32	0.61	0.02	0.10	0.18		2015	1	135	0.08	0.30	0.56	0.02	0.08	0.15
2016		135	0.56	1.08	1.78	0.16	0.29	0.44		2016	1	135	0.51	0.97	1.58	0.13	0.24	0.36
2017		135	0.13	0.41	0.76	0.03	0.11	0.19		2017	1	135	0.13	0.39	0.72	0.03	0.10	0.17
2018		135	0.00	0.06	0.15	0.00	0.02	0.04		2018	1	135	0.00	0.06	0.14	0.00	0.01	0.03
2019										2019								
2020										2020								
2002	0	75	0.14	0.37	0.64	0.06	0.13	0.21		2002	2	122	0.27	0.56	0.91	0.08	0.16	0.26
2003		101	0.38	0.77	1.28	0.12	0.24	0.37		2003	2	149	0.23	0.45	0.71	0.07	0.15	0.24
2004		92	0.09	0.26	0.46	0.03	0.10	0.16		2004	2	127	0.11	0.31	0.54	0.04	0.14	0.24
2005		86	0.04	0.25	0.49	0.01	0.09	0.17		2005	2	131	0.04	0.19	0.35	0.01	0.08	0.15
2006		79	0.00	0.20	0.49	0.00	0.08	0.19		2006	2	120	0.02	0.16	0.32	0.00	0.06	0.12
2007		44	0.09	0.50	1.05	0.04	0.19	0.35		2007	2	88	0.19	0.49	0.87	0.04	0.12	0.20
2008		90	0.02	0.22	0.45	0.00	0.08	0.15		2008	2	135	0.04	0.16	0.30	0.00	0.06	0.12
2009		90	0.24	0.60	1.07	0.06	0.17	0.28		2009	2	135	0.15	0.34	0.55	0.02	0.09	0.16
2010		90	0.03	0.25	0.52	0.01	0.06	0.11		2010	2	135	0.08	0.23	0.41	0.01	0.04	0.06
2011		89	0.14	0.43	0.80	0.03	0.11	0.21		2011	2	134	0.03	0.15	0.29	0.00	0.05	0.10
2012		84	0.00	0.05	0.14	0.00	0.02	0.04		2012	2	129	0.00	0.04	0.10	0.00	0.02	0.04
2013		89	0.00	0.03	0.09	0.00	0.01	0.03		2013	2	134	0.00	0.02	0.06	0.00	0.01	0.02
2014		90	0.02	0.24	0.50	0.00	0.05	0.10		2014	2	135	0.00	0.07	0.15	0.00	0.01	0.03
2015		90	0.00	0.11	0.27	0.00	0.04	0.08		2015	2	135	0.03	0.14	0.26	0.00	0.03	0.06
2016		90	0.07	0.27	0.50	0.02	0.07	0.13		2016	2	135	0.24	0.49	0.78	0.04	0.09	0.15
2017		90	0.00	0.05	0.17	0.00	0.02	0.05		2017	2	135	0.04	0.17	0.32	0.00	0.02	0.04
2018		90	0.00	0.04	0.12	0.00	0.01	0.02		2018	2	135	0.00	0.02	0.05	0.00	0.00	0.00
2019										2019								
2020										2020								

Figure 9. Black Sea Bass geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

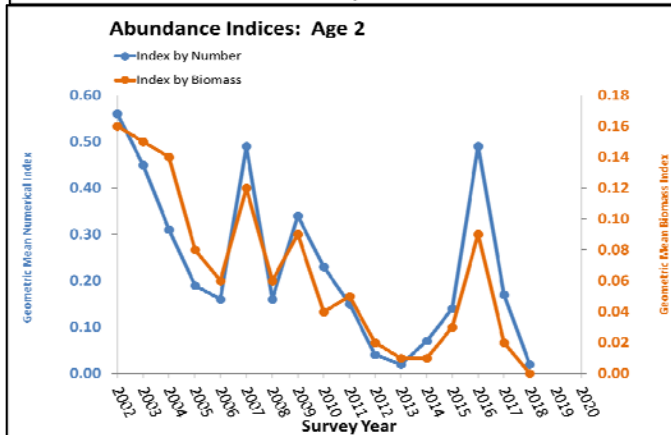
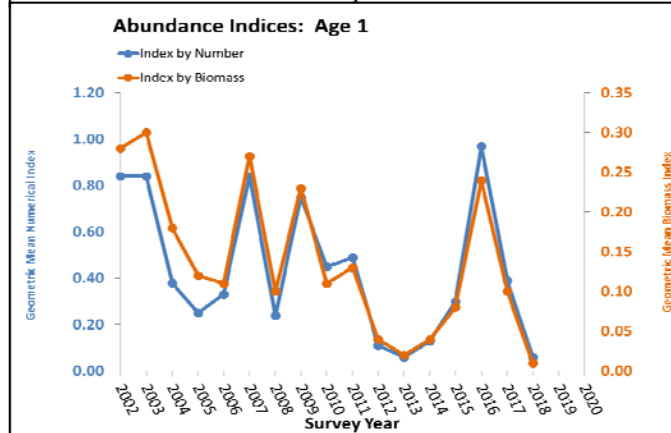
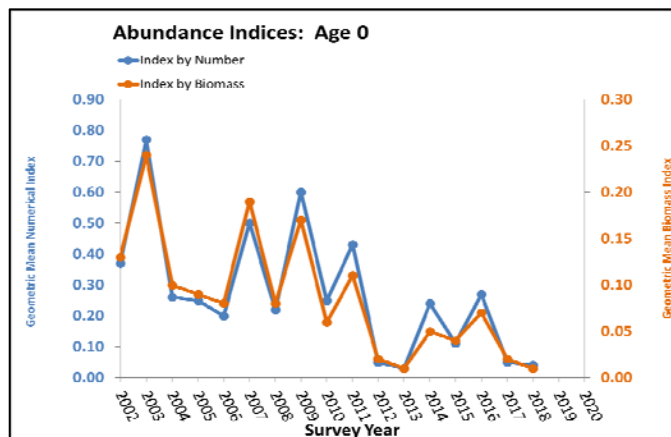
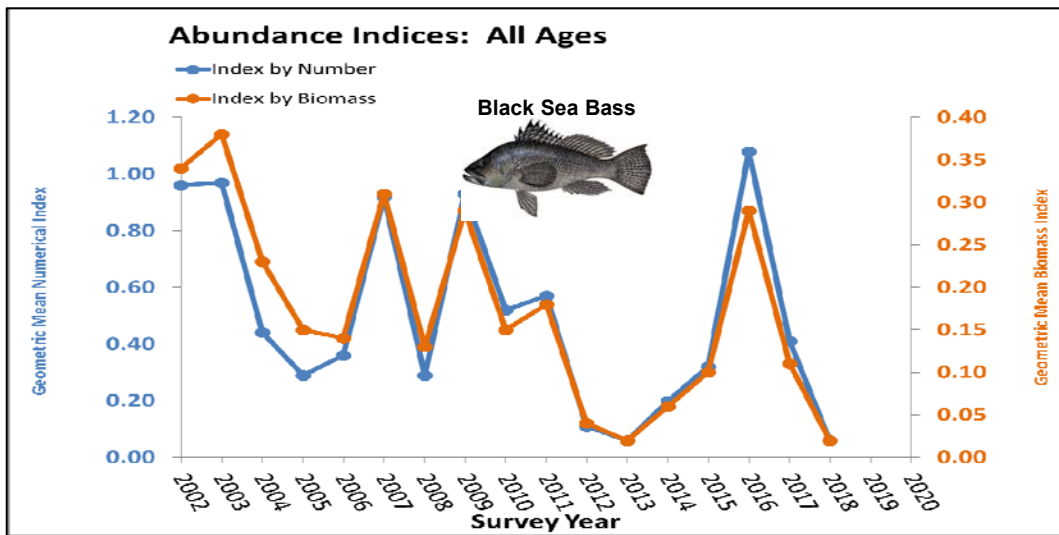


Figure 10. Black Sea Bass length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

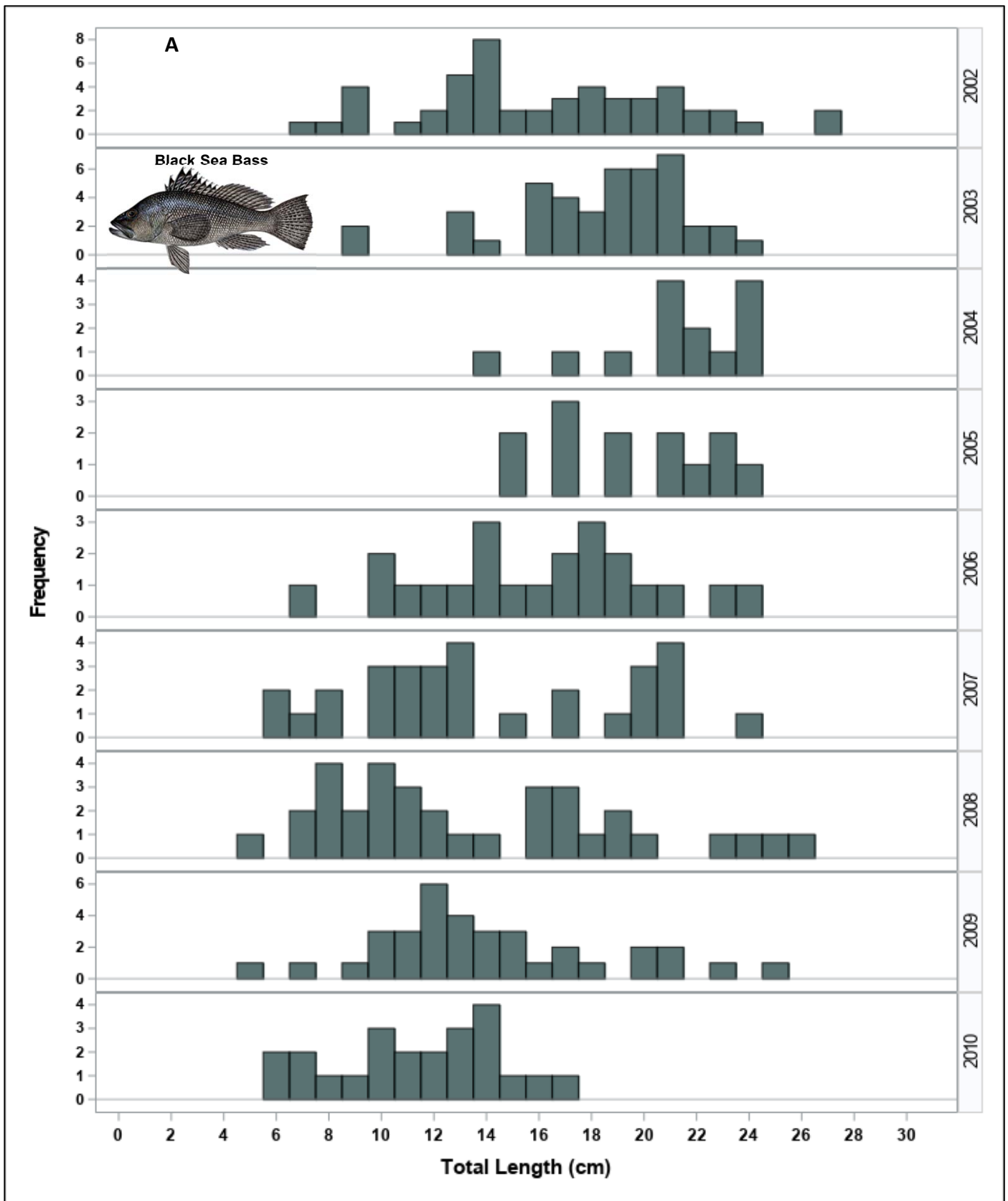


Figure 10. cont.

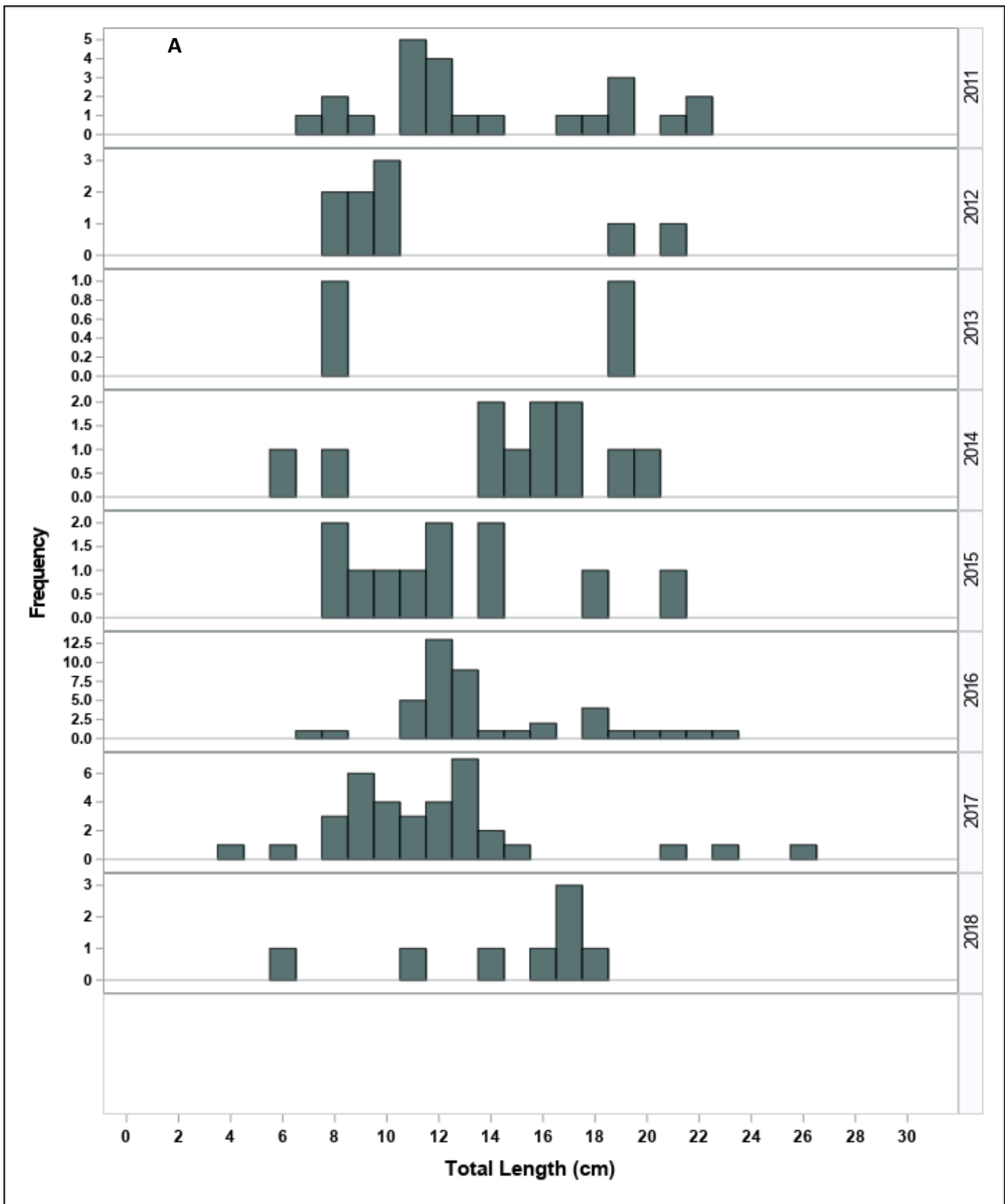


Figure 10. cont.

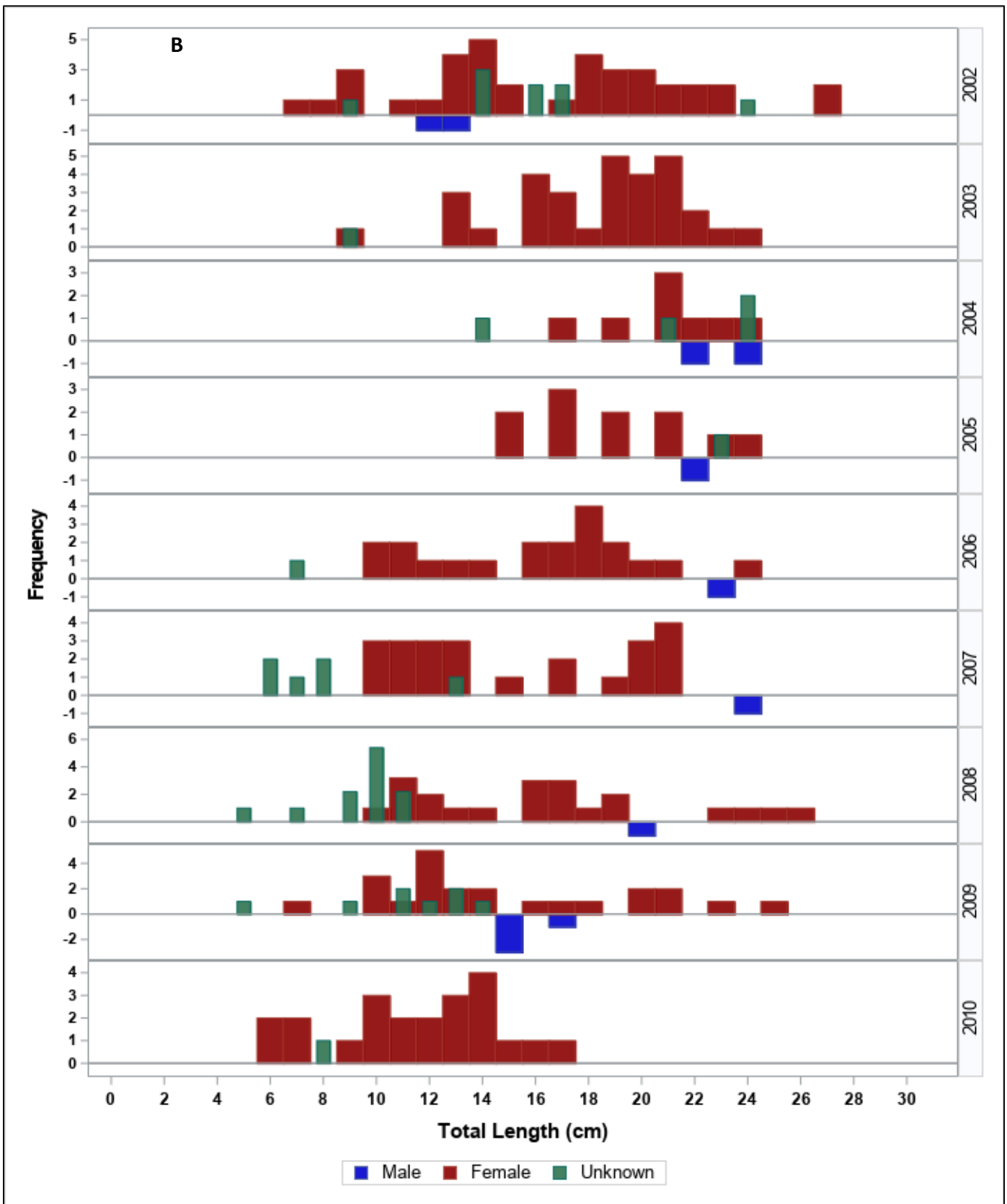


Figure 10. cont.

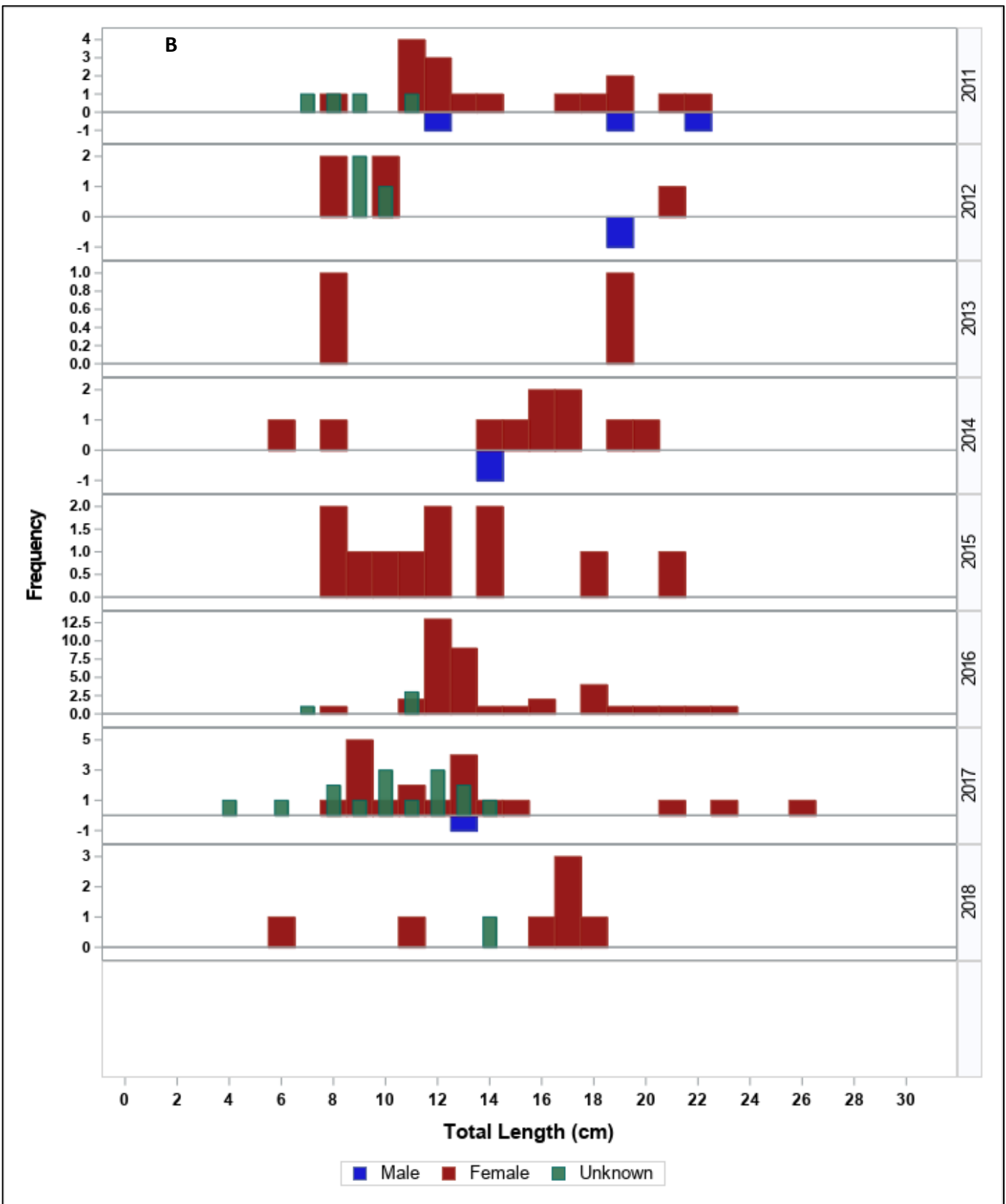


Figure 11. Black Sea Bass age-frequency by year, 2002-2018.

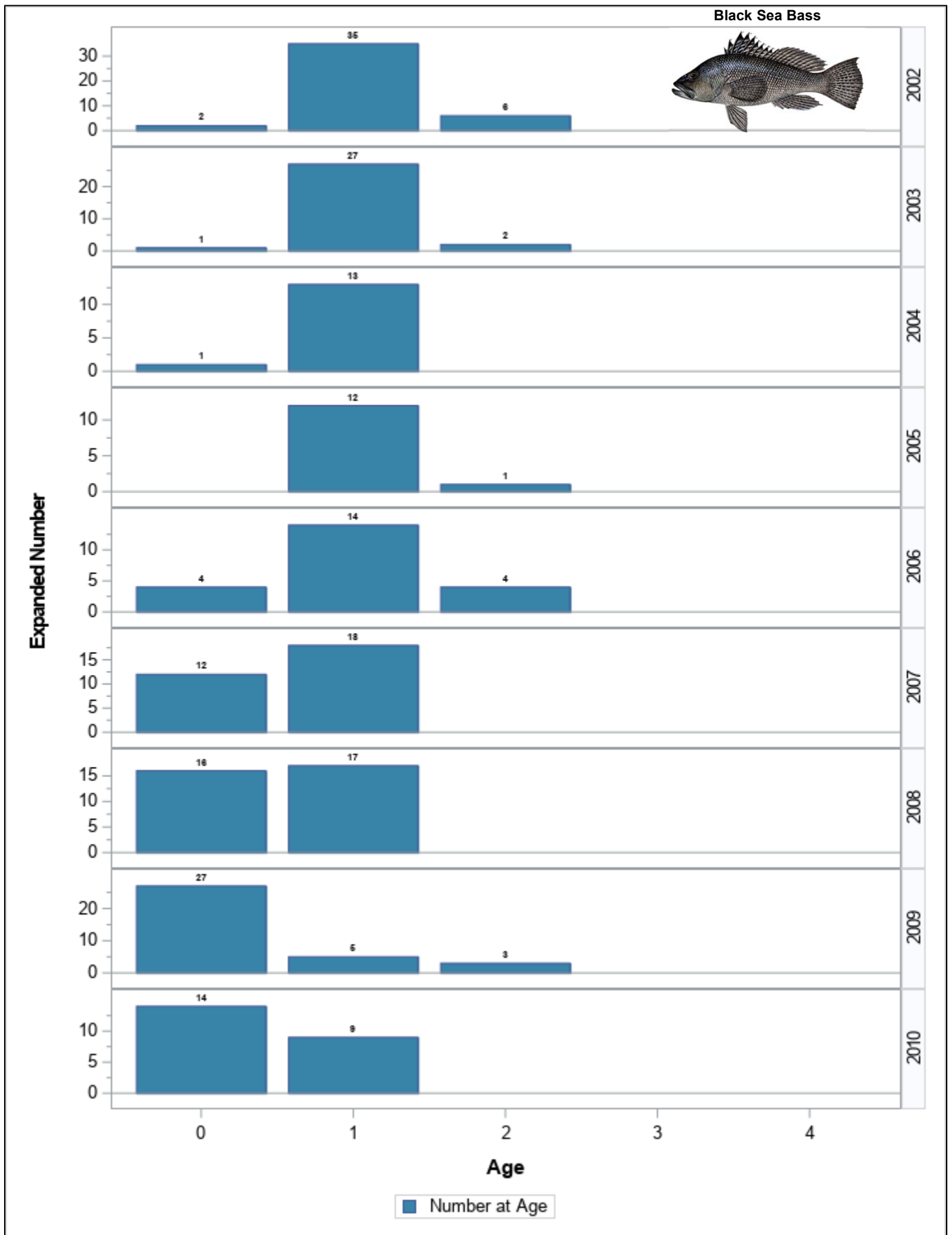


Figure 11. cont.

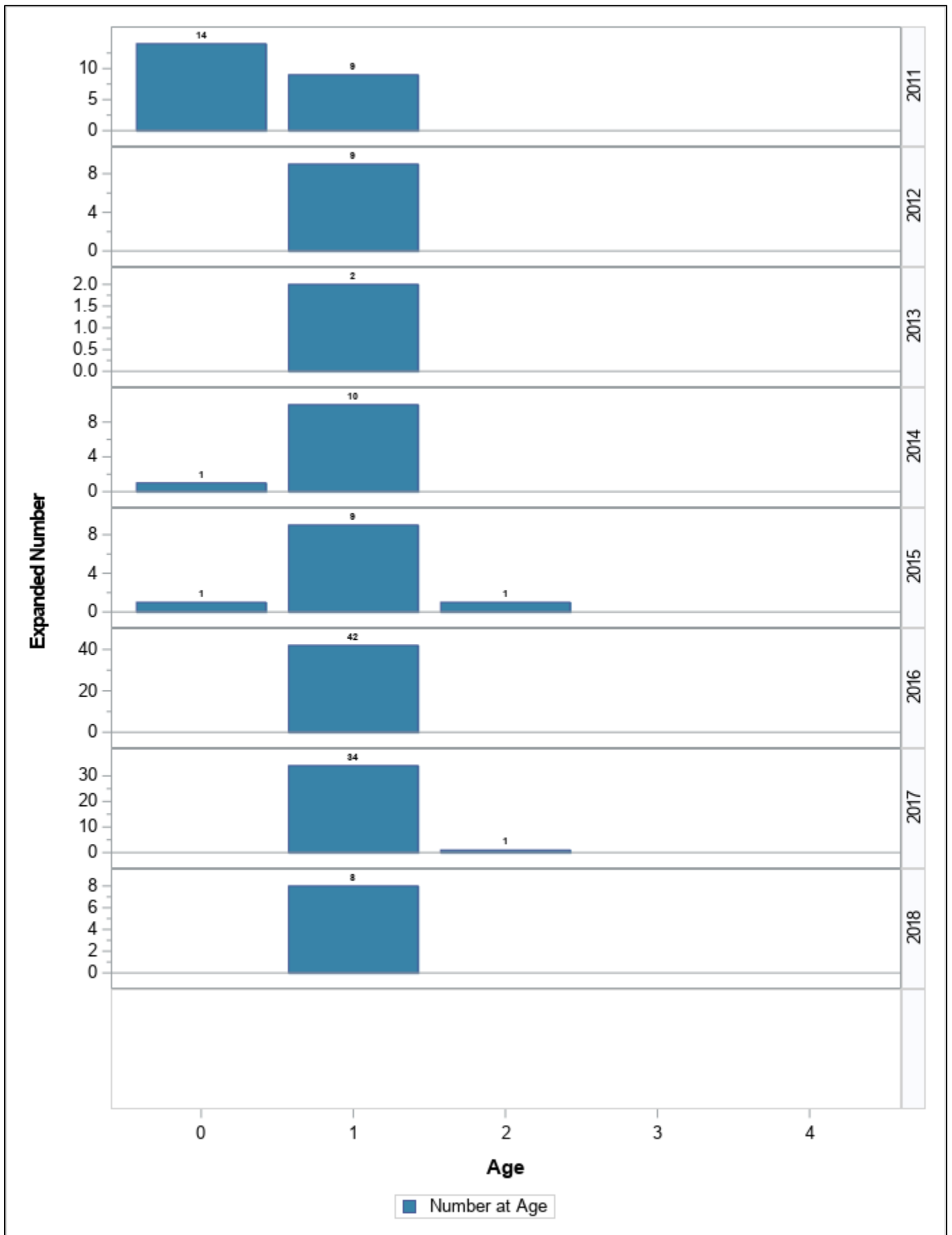


Figure 12. Black Sea Bass age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

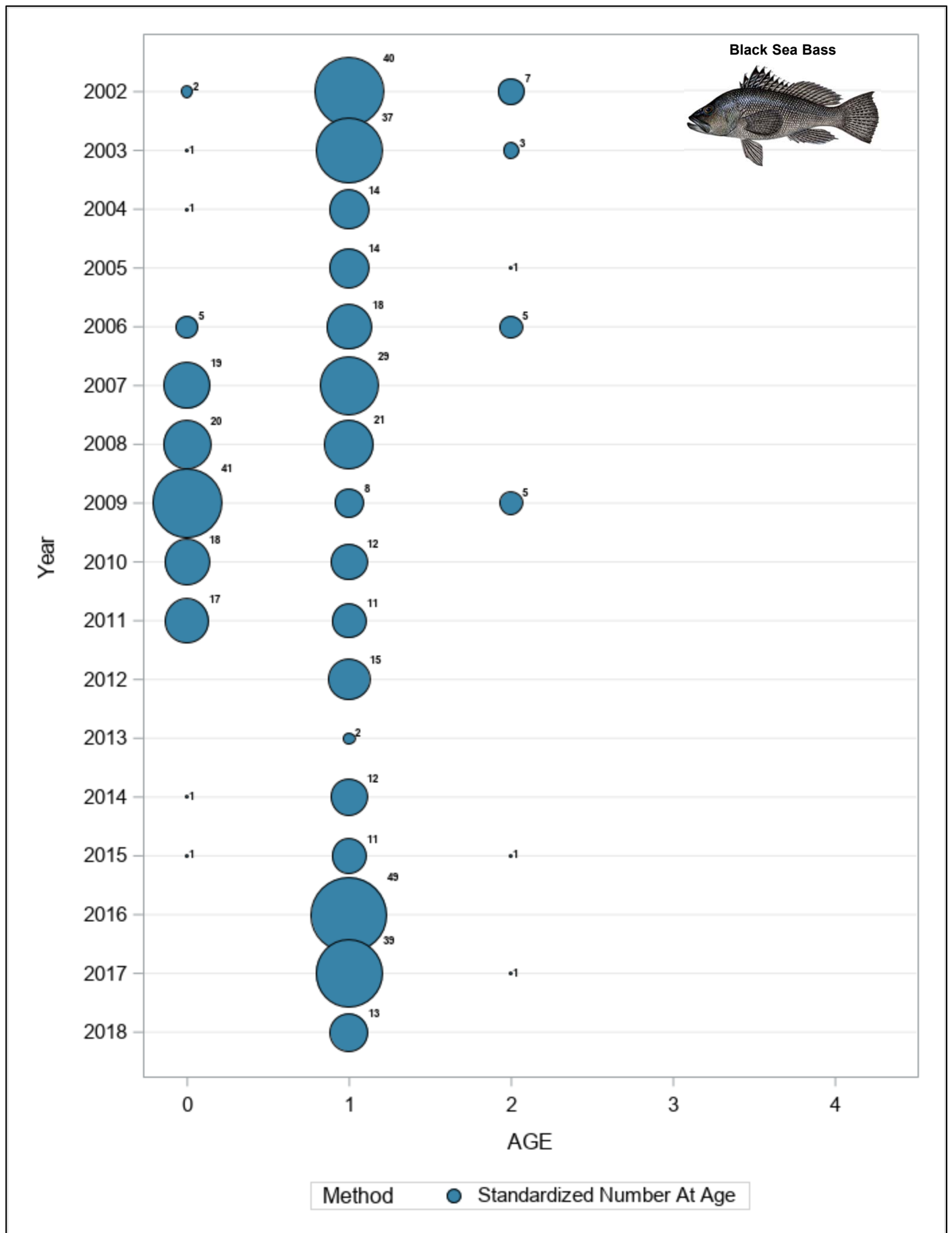


Figure 13. Black Sea Bass age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

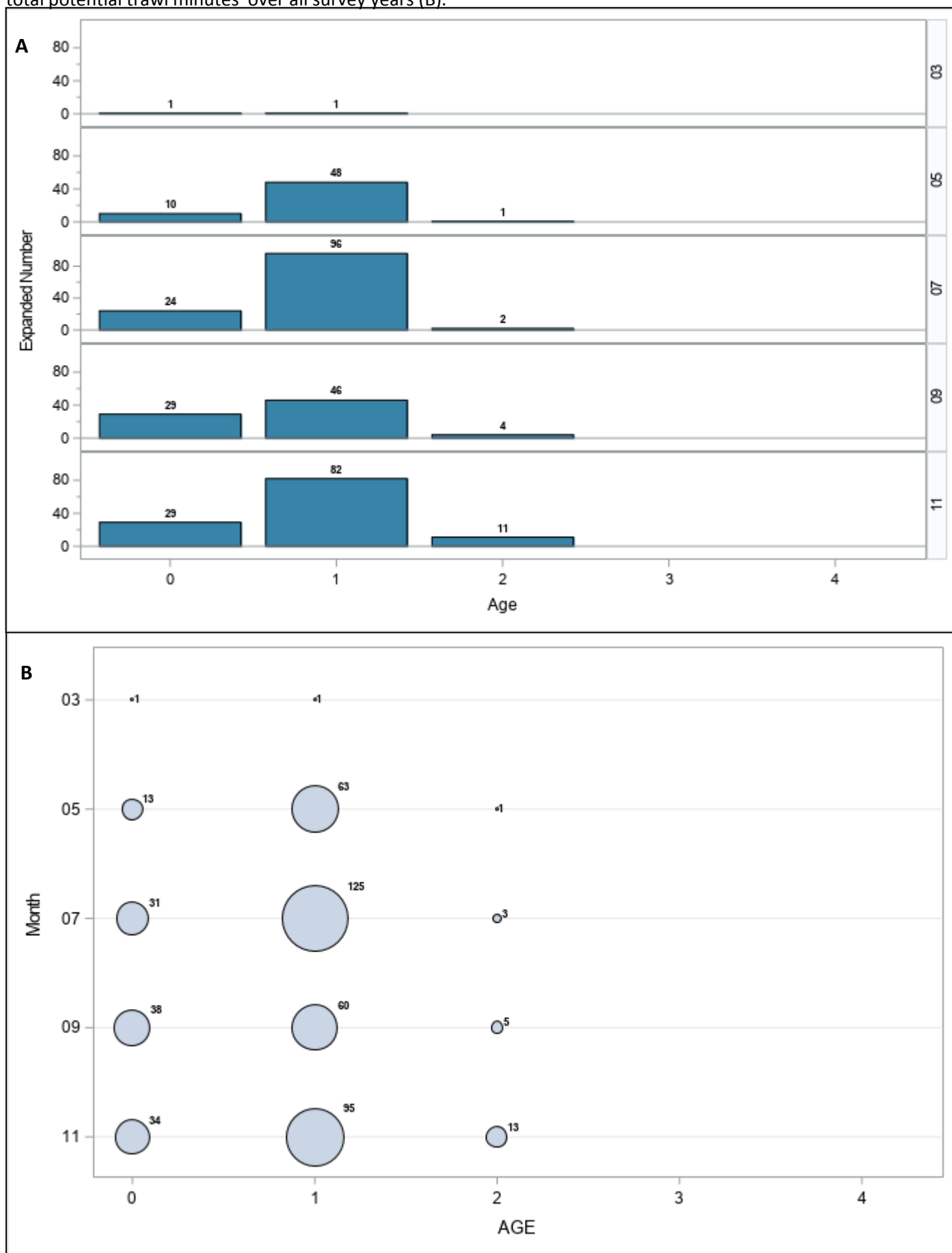


Figure 14. Diet composition, expressed as percent by weight (A) and percent by number (B) of black seabass collected during ChesMMAP cruises in 2002-2018 combined.

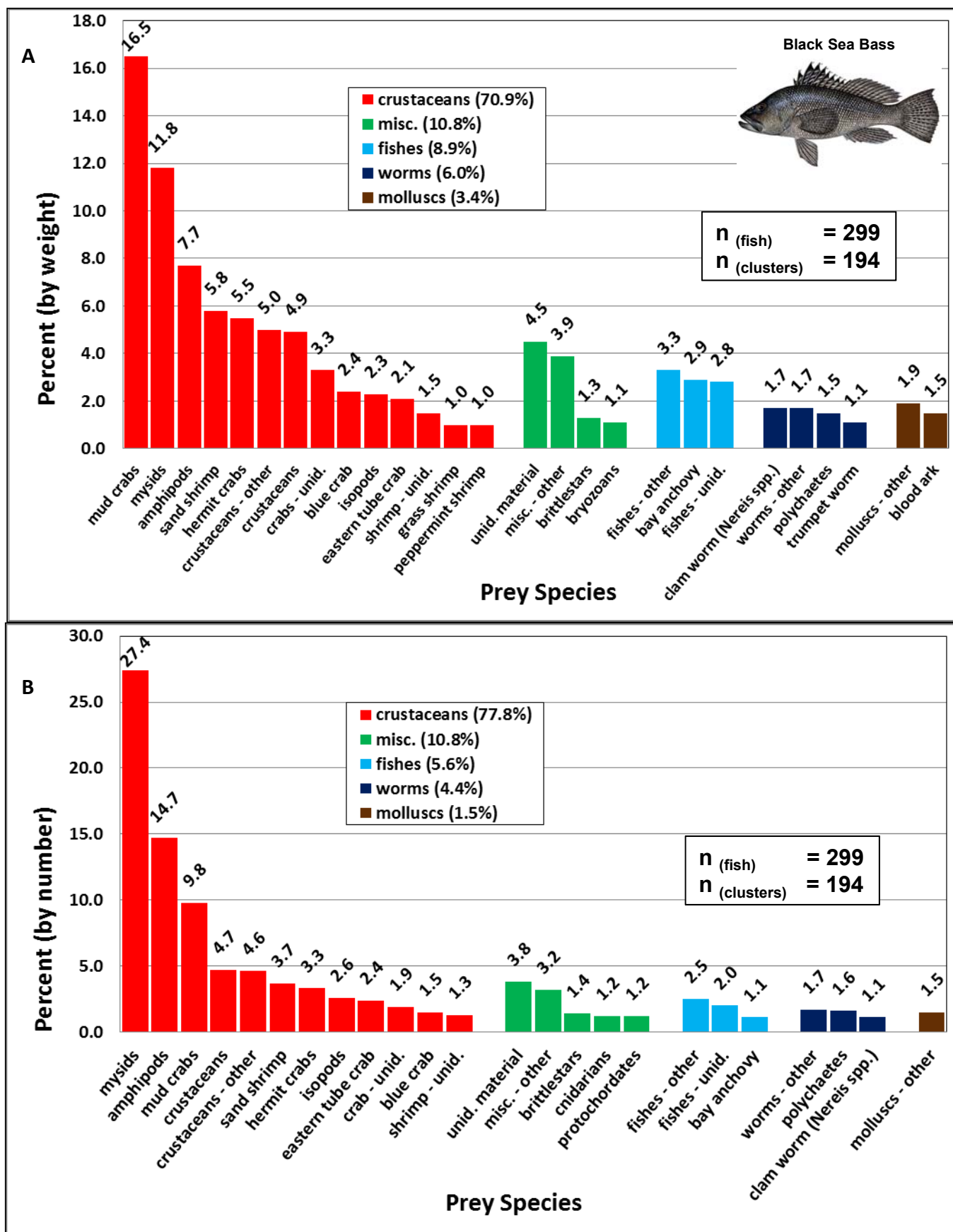


Table 11. Bluefish sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	34	10.7	0.7	34	34	34	24	22
2003	114	31.7	0.6	114	74	74	63	62
2004	28	10.0	1.2	28	27	27	22	22
2005	108	22.2	0.6	108	71	71	60	60
2006	23	5.5	0.0	23	23	23	17	17
2007	58	18.2	0.0	58	50	50	44	44
2008	52	15.8	1.3	52	27	27	14	13
2009	11	2.3	0.0	11	11	11	9	9
2010	126	20.2	0.6	82	30	30	13	12
2011	8	2.3	0.6	8	8	7	7	6
2012	17	4.0	0.7	17	17	17	12	12
2013	32	5.4	0.6	32	32	32	26	26
2014	44	5.9	0.0	44	39	39	26	25
2015	125	18.5	0.0	125	49	49	28	28
2016	36	9.8	0.6	36	36	36	19	19
2017	40	6.6	0.0	40	31	31	20	20
2018	85	8.4	0.0	85	41	41	24	24

Figure 15. Abundance (kg per hectare swept) of Bluefish in Chesapeake Bay, 2018.

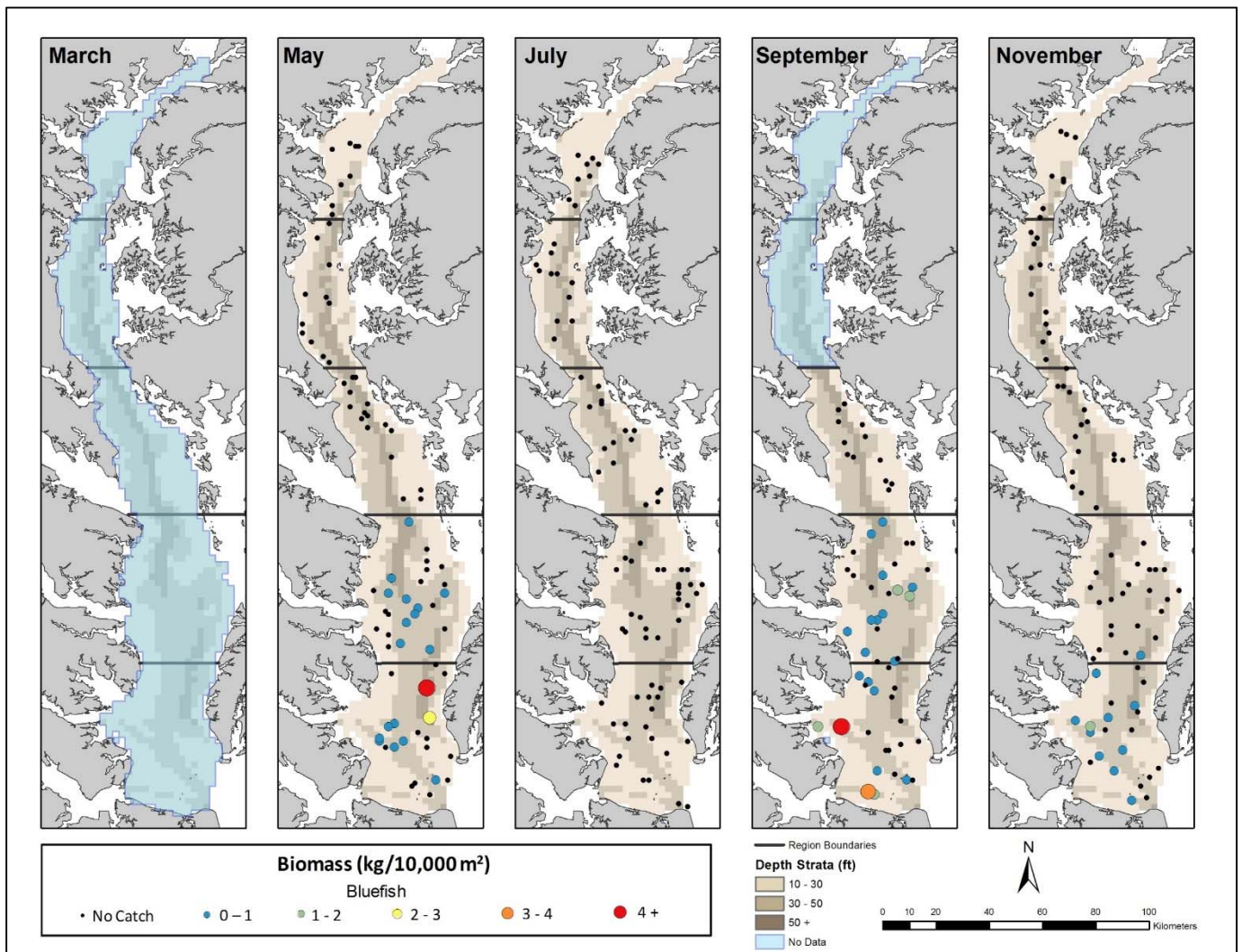


Table 12. Months, latitudinal regions, and depth strata used for Bluefish index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 13. Bluefish geometric mean indices of abundance, by number and biomass, overall and age-0.

Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI
2002	All	75	0.35	1.00	1.98	0.24	0.68	1.28
2003		101	1.59	3.10	5.48	0.68	1.24	1.99
2004		92	0.33	0.85	1.56	0.23	0.59	1.05
2005		86	1.19	2.61	4.94	0.68	1.38	2.36
2006		79	0.29	0.87	1.70	0.15	0.49	0.92
2007		44	1.27	3.55	8.09	0.76	1.88	3.70
2008		90	0.07	0.39	0.81	0.04	0.23	0.47
2009		90	0.07	0.38	0.80	0.04	0.22	0.44
2010		90	0.00	0.31	0.78	0.00	0.19	0.47
2011		89	0.03	0.29	0.61	0.02	0.20	0.42
2012		84	0.12	0.52	1.04	0.08	0.33	0.64
2013		89	0.11	0.50	1.01	0.08	0.33	0.64
2014		90	0.59	1.38	2.55	0.30	0.66	1.10
2015		90	0.57	1.33	2.46	0.25	0.54	0.90
2016		90	0.07	0.40	0.85	0.03	0.21	0.43
2017		90	0.10	0.47	0.95	0.06	0.28	0.54
2018		90	0.42	1.04	1.94	0.19	0.47	0.83
2019								
2020								

Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI
2002	0	75	0.22	0.69	1.33	0.14	0.42	0.77
2003		101	1.43	2.77	4.85	0.59	1.07	1.69
2004		92	0.20	0.54	0.98	0.12	0.33	0.58
2005		86	1.04	2.26	4.21	0.58	1.15	1.93
2006		79	0.24	0.69	1.31	0.12	0.35	0.63
2007		44	0.86	2.47	5.48	0.49	1.21	2.30
2008		90	0.07	0.36	0.73	0.04	0.21	0.41
2009		90	0.05	0.33	0.68	0.03	0.18	0.34
2010		90	0.00	0.31	0.77	0.00	0.19	0.46
2011		89	0.00	0.20	0.43	0.00	0.12	0.26
2012		84	0.10	0.42	0.85	0.06	0.26	0.48
2013		89	0.09	0.43	0.87	0.06	0.27	0.52
2014		90	0.52	1.22	2.23	0.26	0.55	0.91
2015		90	0.56	1.29	2.37	0.24	0.52	0.86
2016		90	0.06	0.38	0.79	0.03	0.19	0.38
2017		90	0.10	0.45	0.91	0.06	0.26	0.51
2018		90	0.40	1.00	1.84	0.17	0.44	0.76
2019								
2020								

Figure 16. Bluefish geometric mean indices of abundance, by number and biomass, for all ages combined and for age-0.

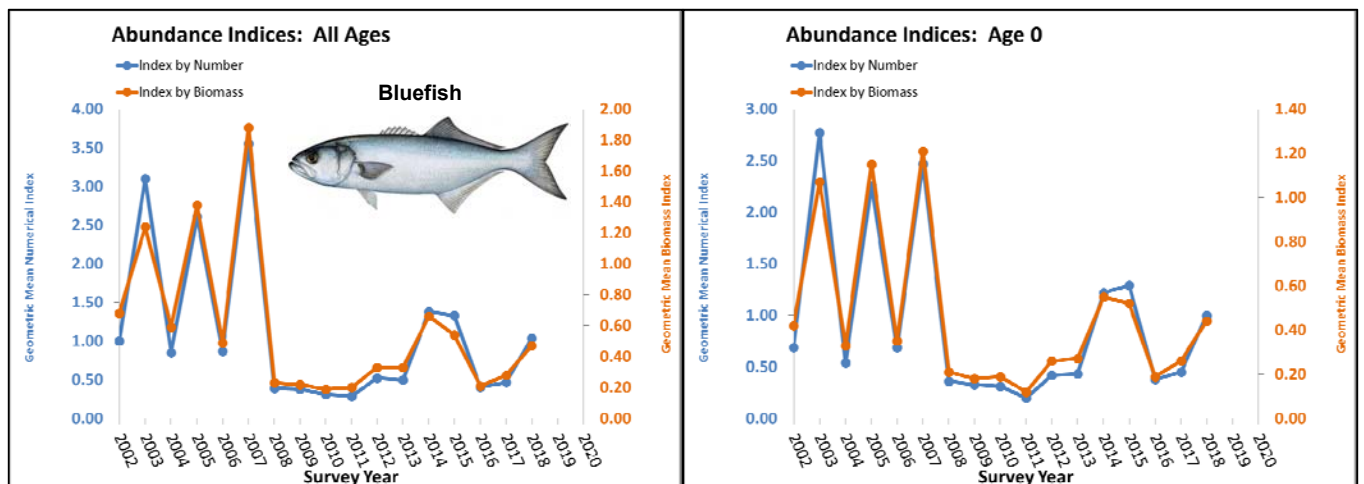


Figure 17. Bluefish length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

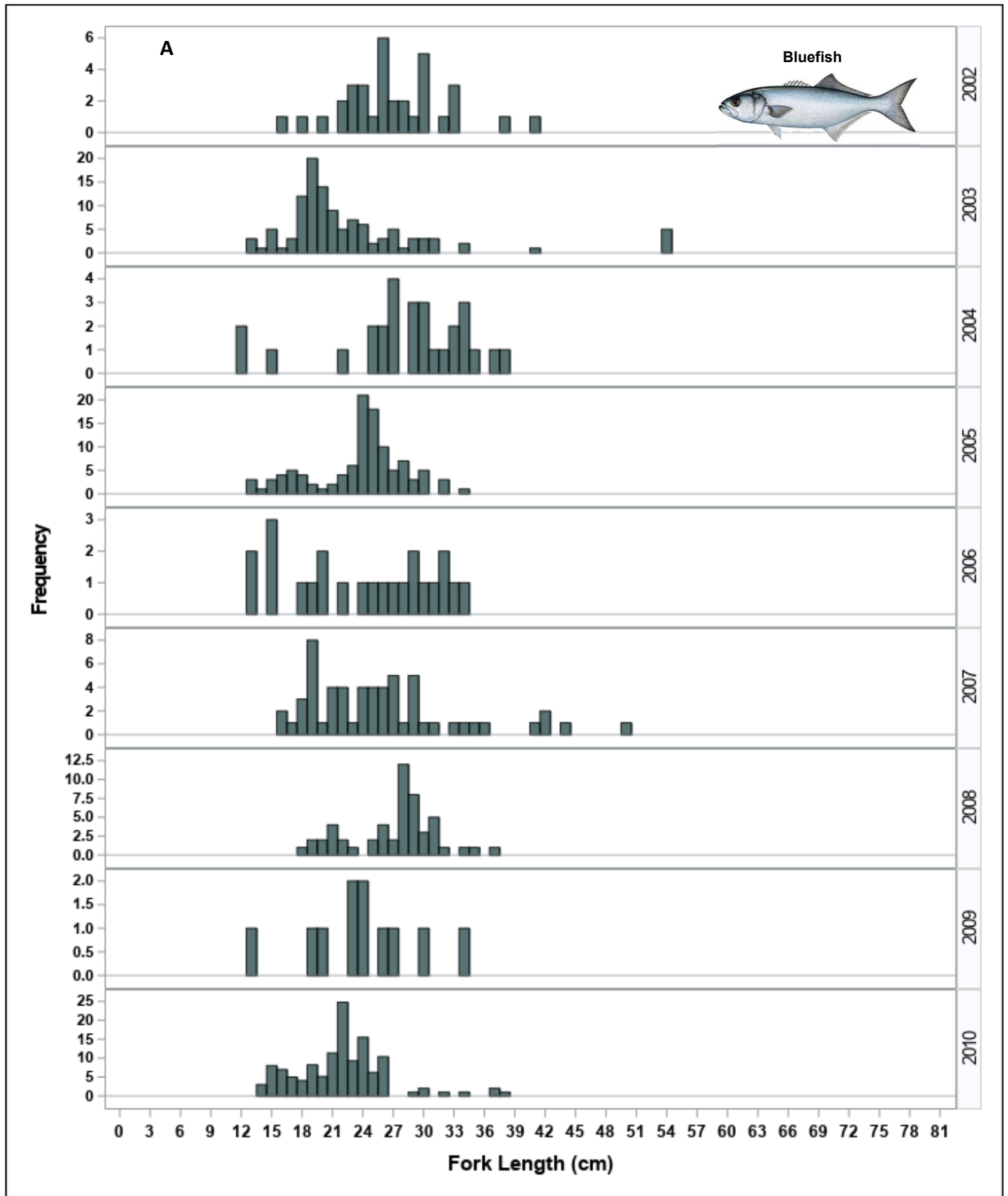


Figure 17. cont.

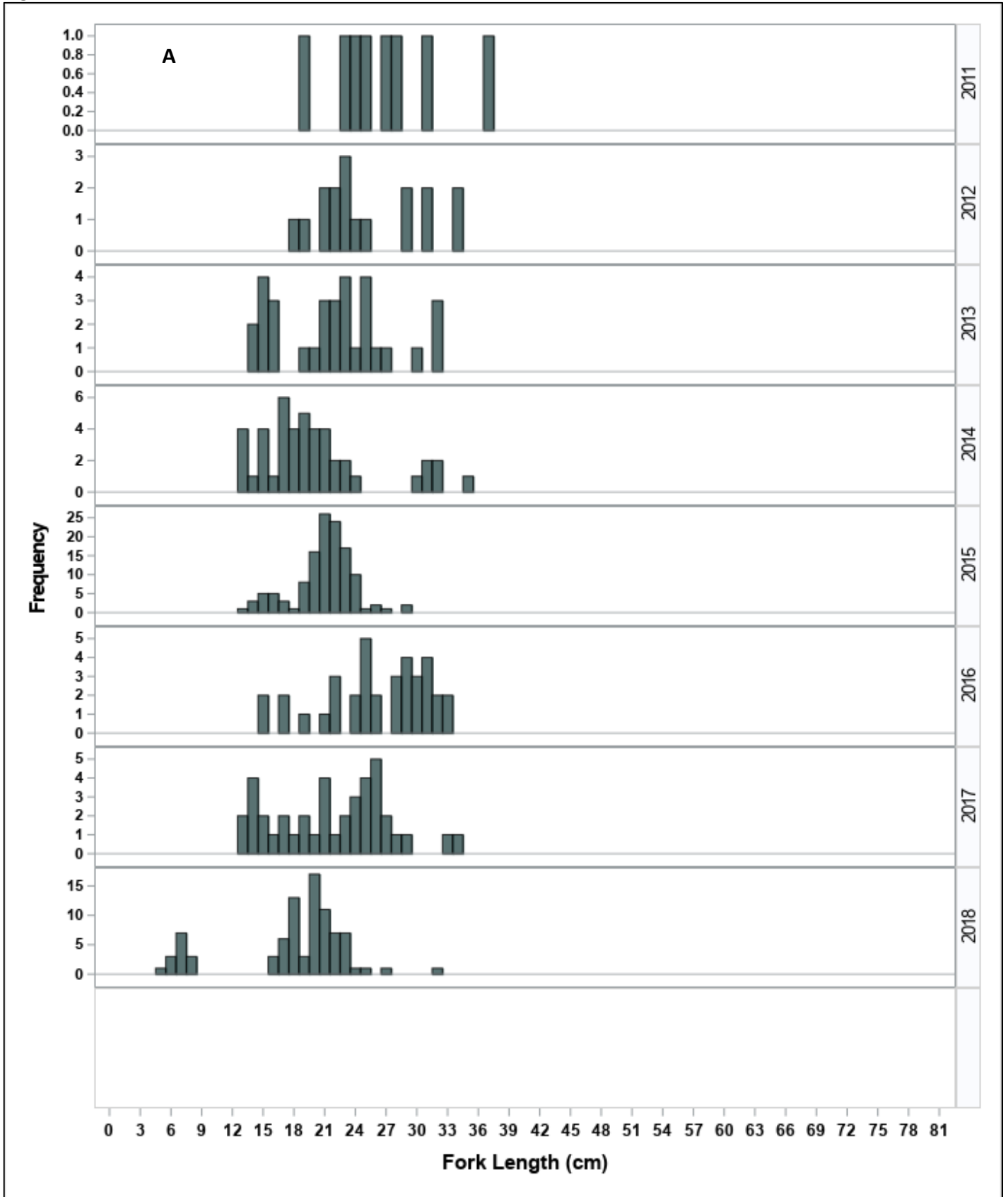


Figure 17. cont.

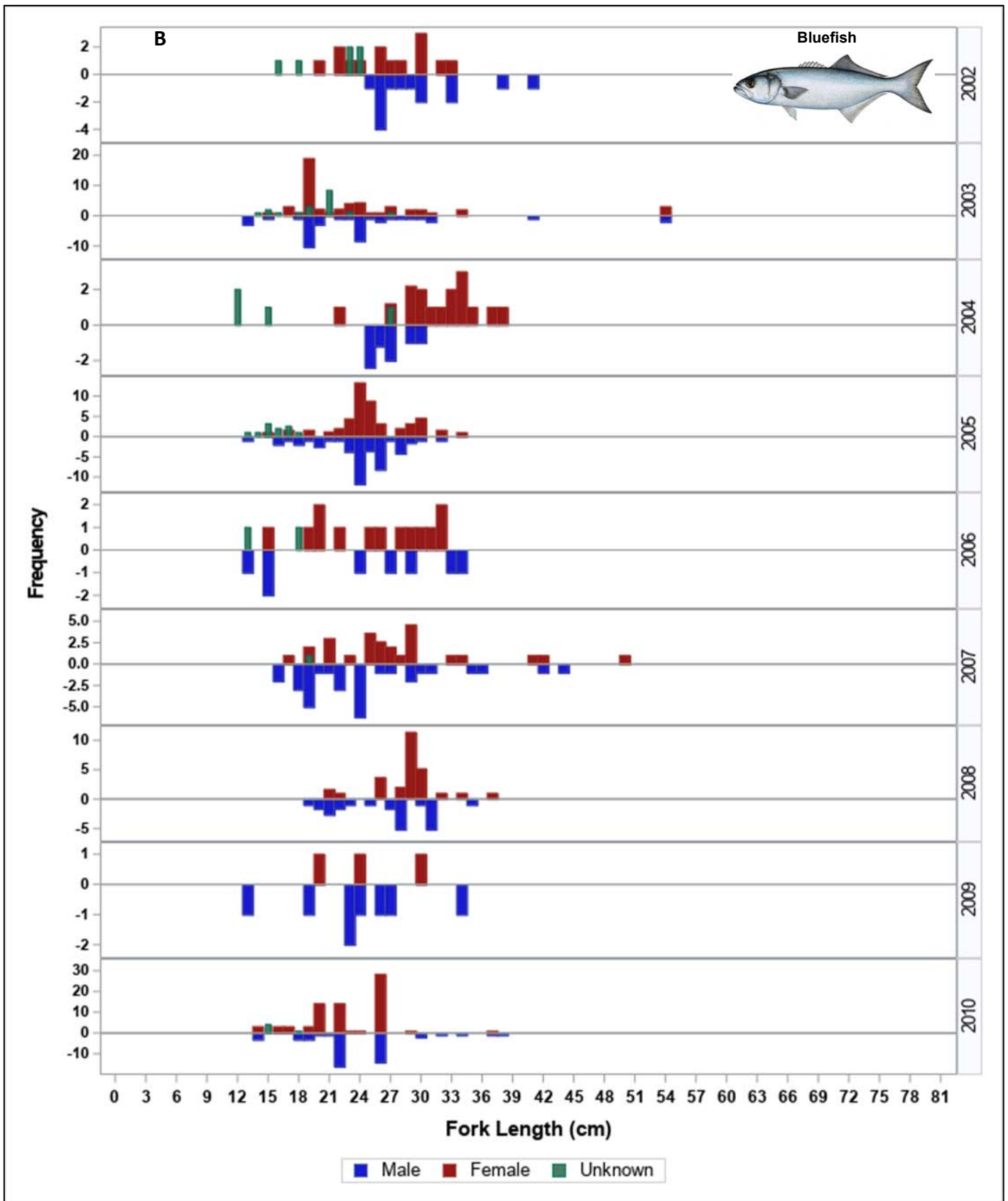


Figure 17. cont.

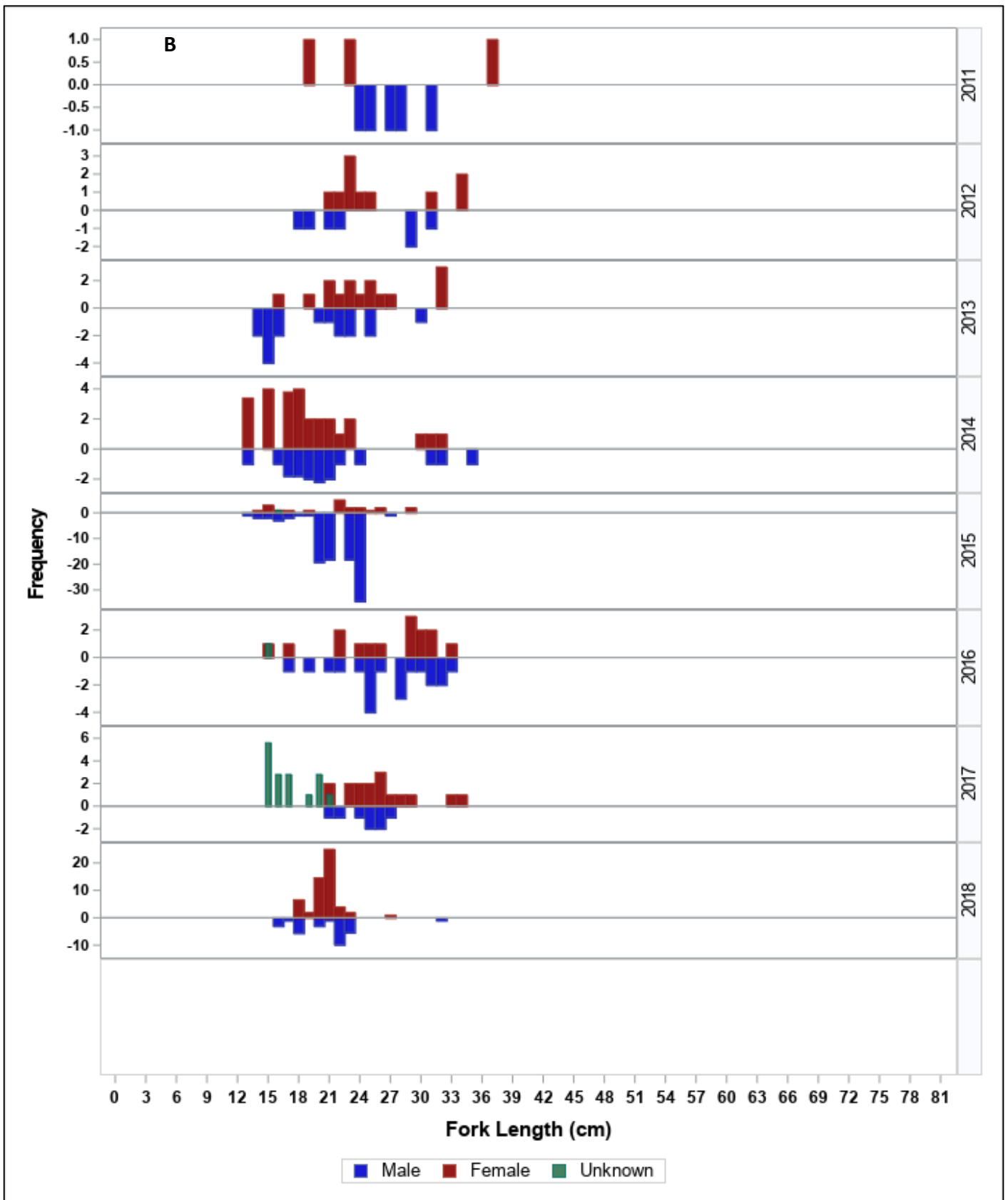


Figure 18. Bluefish age-frequency by year, 2002-2018.

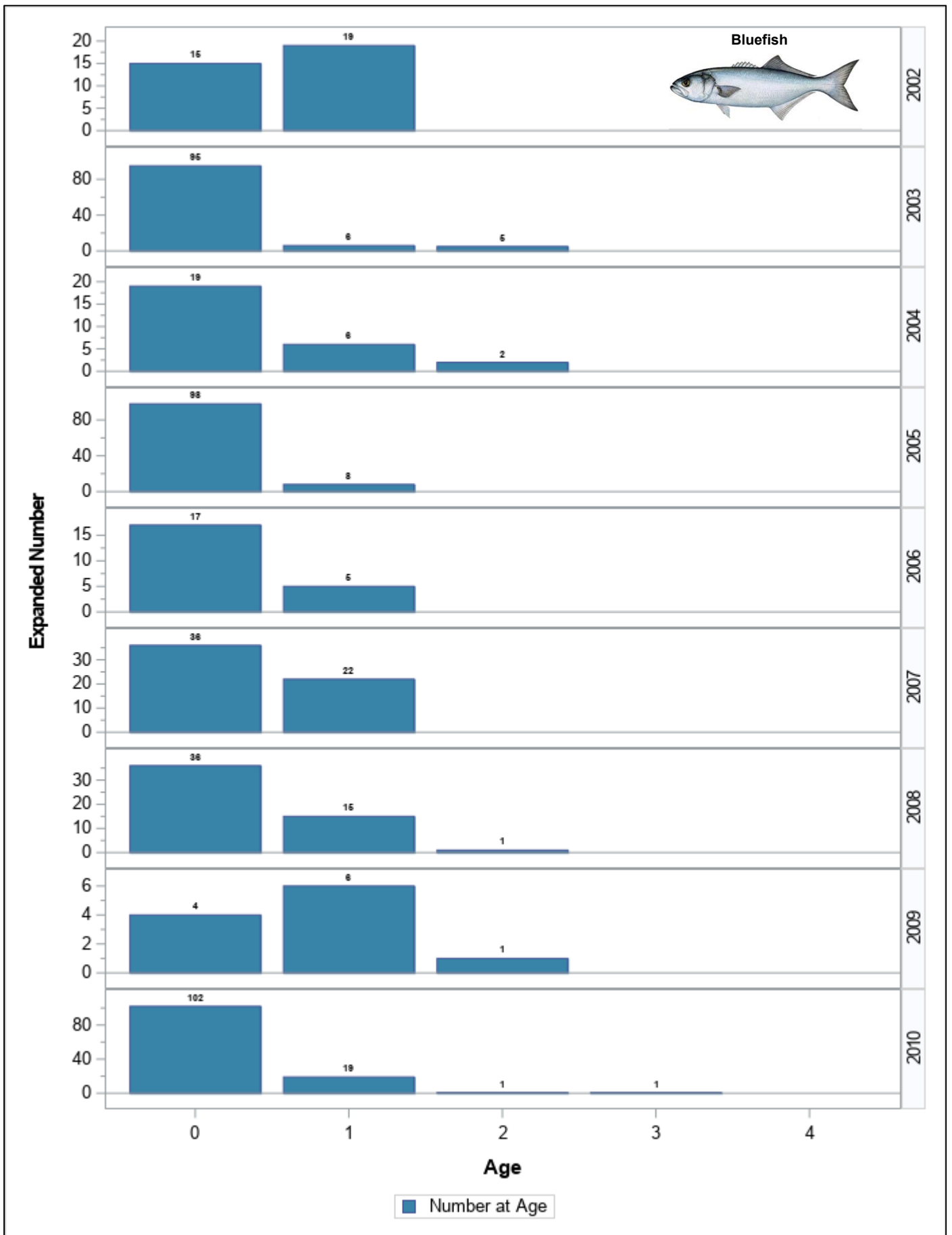


Figure 18. cont.

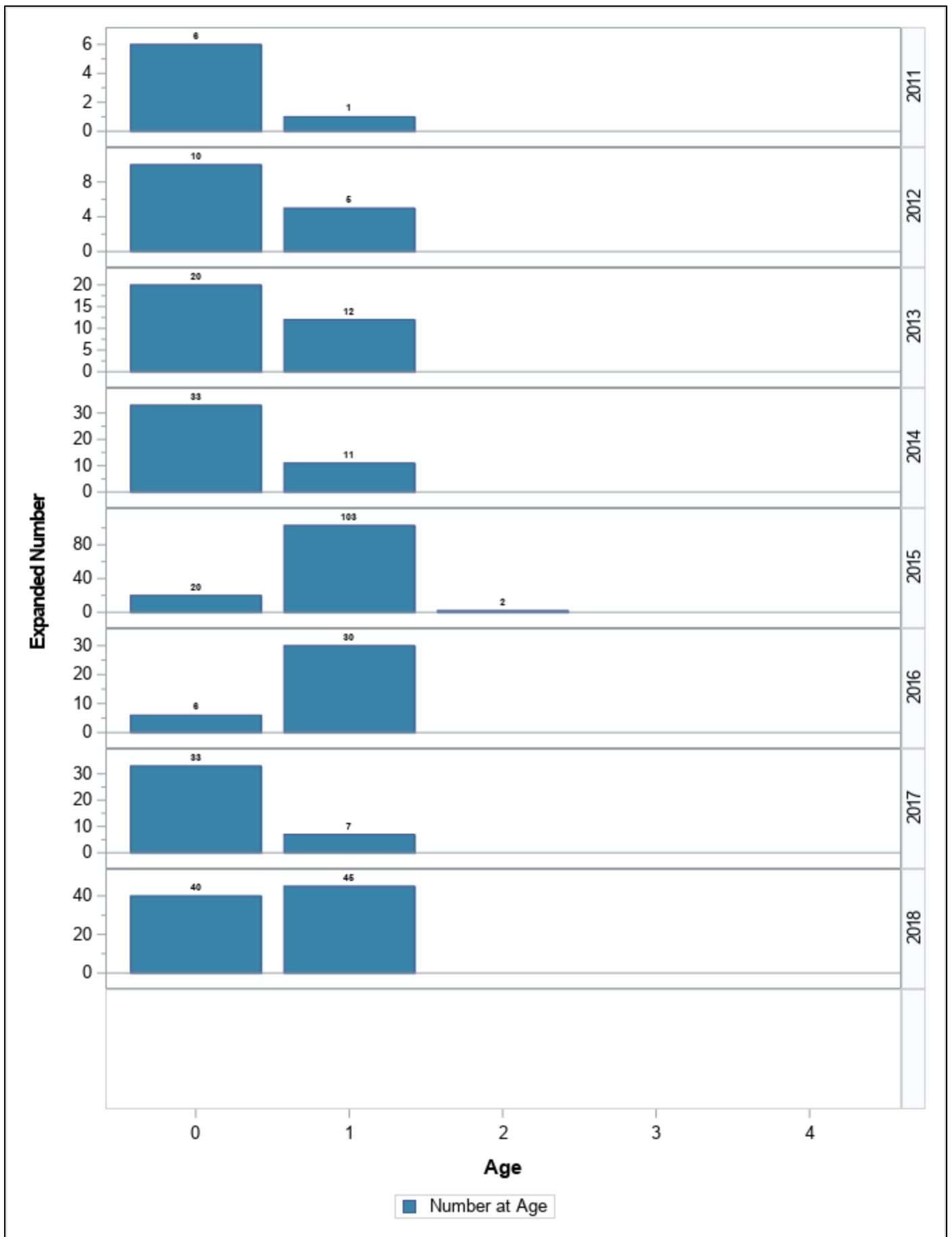


Figure 19. Bluefish age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

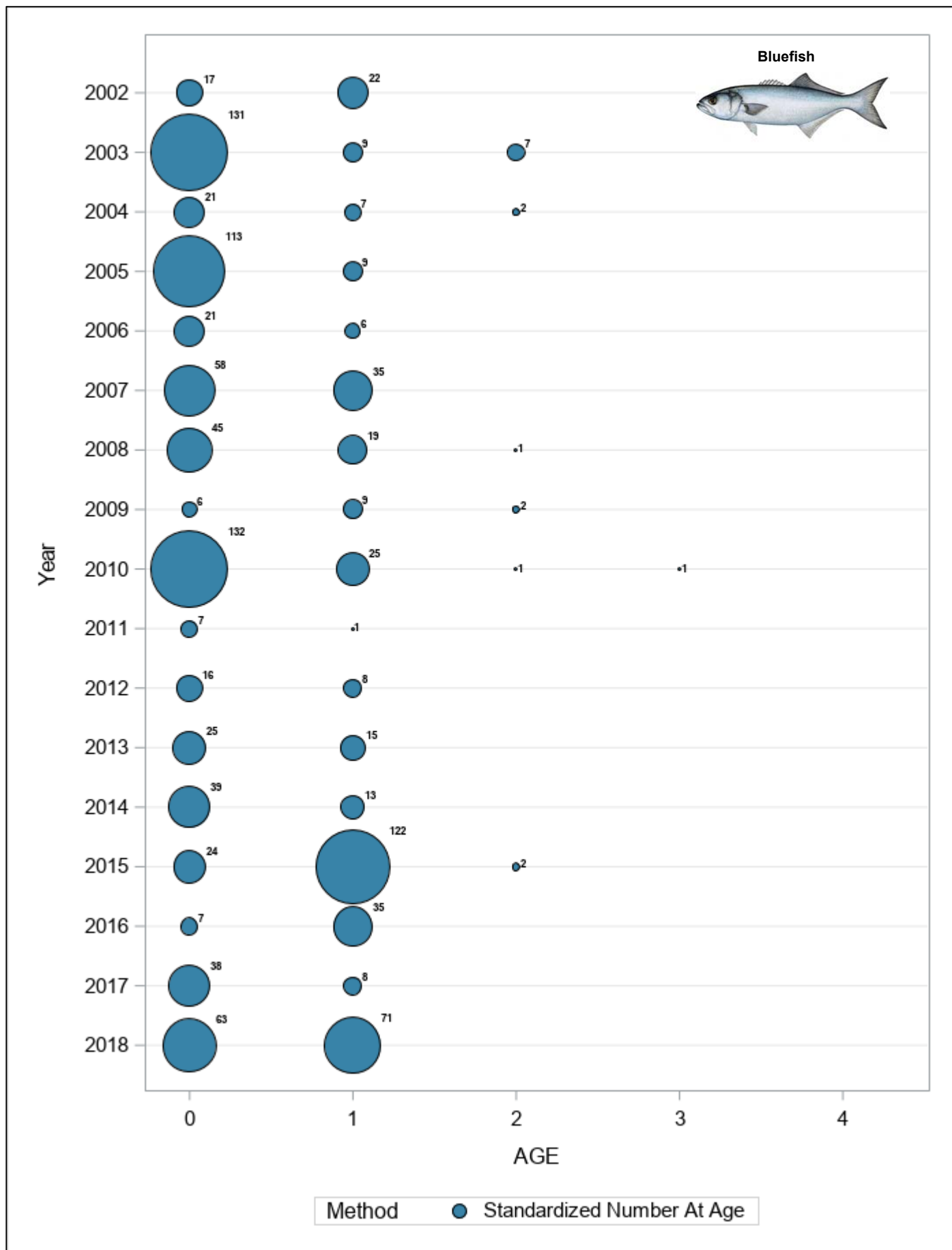


Figure 20. Bluefish age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

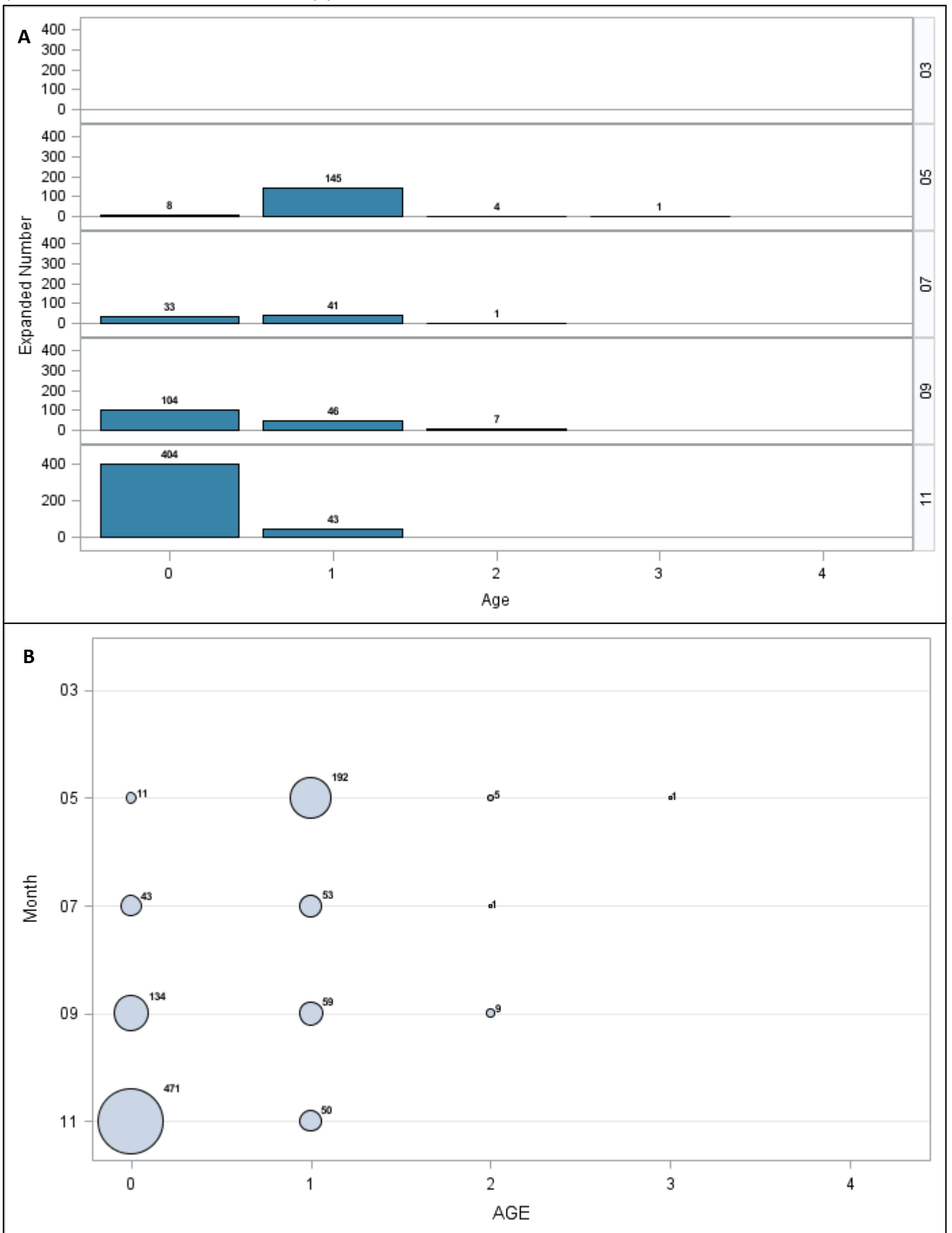


Figure 21. Diet composition, expressed as percent by weight (A) and percent by number (B) of Bluefish collected during ChesMMAP cruises in 2002-2018 combined.

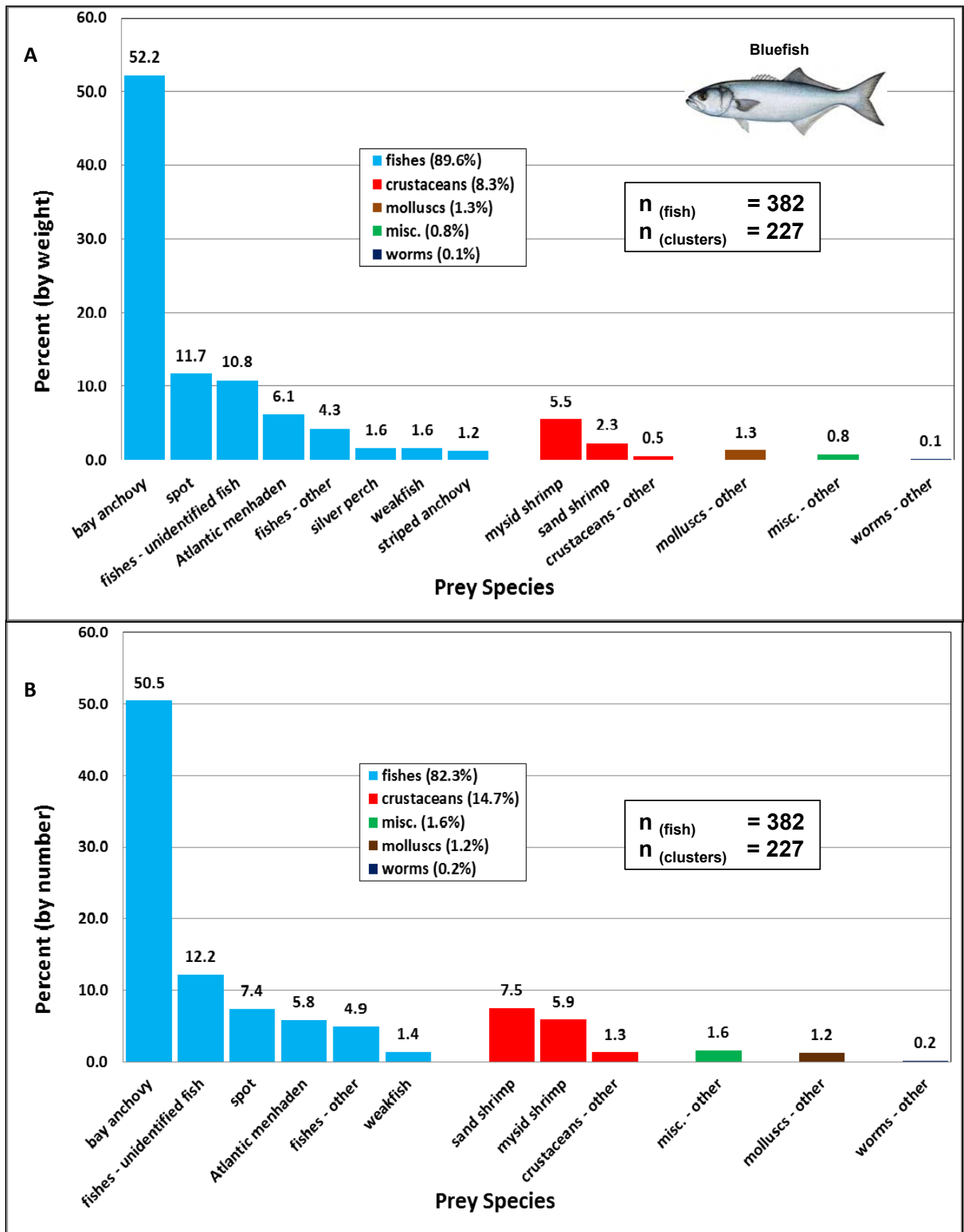


Table 14. Butterfish sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	310	18.3	61.3	310	170	0	168	158
2003	1,000	57.4	66.0	1,000	334	0	334	17
2004	1,133	113.4	54.8	1,071	316	0	316	1
2005	693	48.0	77.8	693	294	0	293	0
2006	634	43.7	61.5	634	3	0	1	0
2007	204	18.8	55.0	204	0	0	0	0
2008	318	22.0	48.7	318	2	0	0	0
2009	415	18.7	57.5	415	0	0	0	0
2010	429	21.9	37.5	429	0	0	0	0
2011	366	22.5	40.0	366	0	0	0	0
2012	991	65.3	37.8	991	0	0	0	0
2013	220	9.6	32.5	220	1	0	0	0
2014	409	20.2	40.0	409	0	0	0	0
2015	402	25.6	20.0	402	0	0	0	0
2016	300	23.3	17.5	300	0	0	0	0
2017	408	21.8	45.0	408	0	0	0	0
2018	124	6.7	17.5	124	0	0	0	0

Figure 22. Abundance (kg per hectare swept) of Butterfish in Chesapeake Bay, 2018.

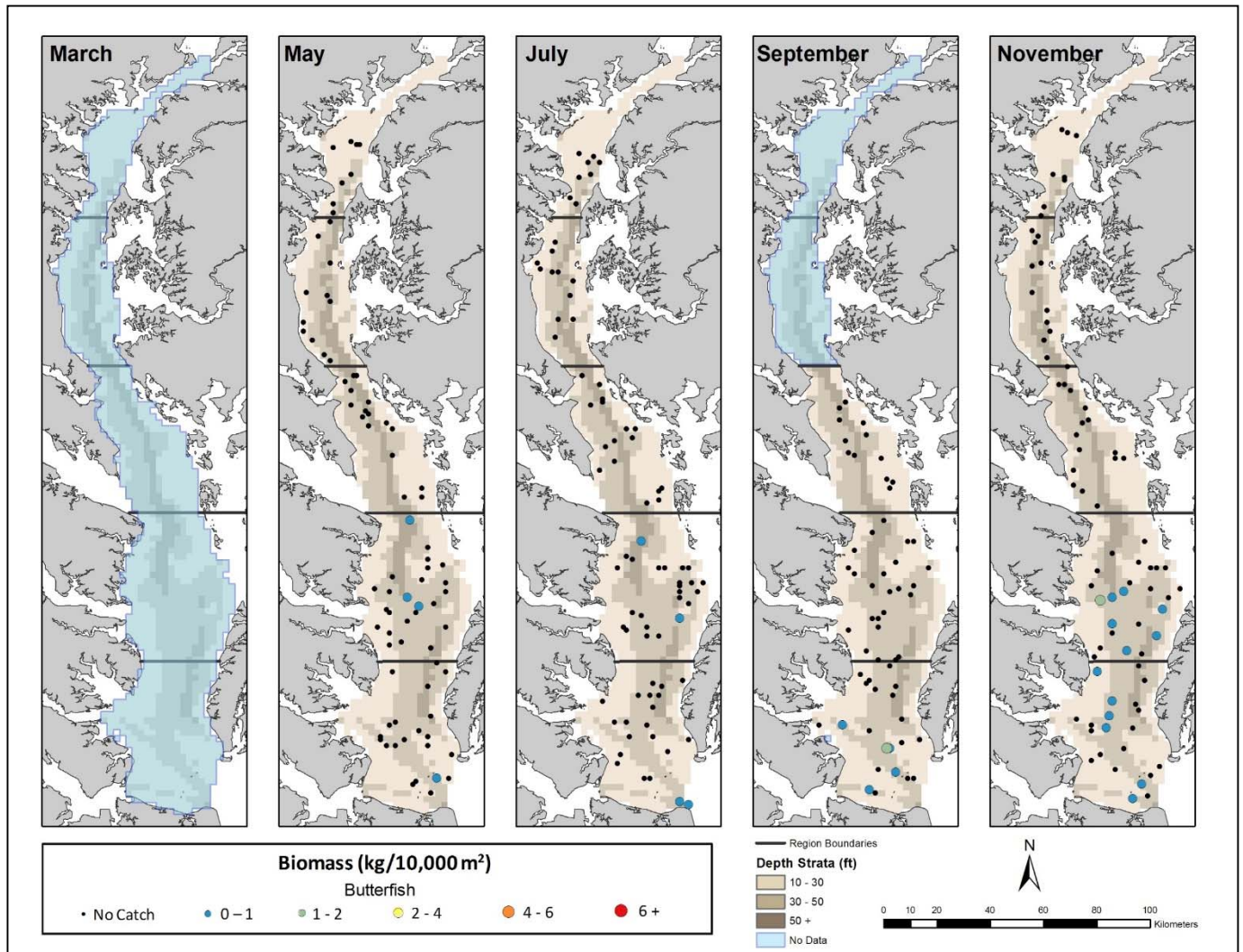


Table 15. Months, latitudinal regions, and depth strata used for Butterfish index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 16. Butterfish geometric mean indices of abundance, by number and biomass, overall and by age-class.

Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI
2002	All	75	5.54	11.85	24.25	1.39	2.45	3.98
2003		101	20.34	37.64	68.98	3.55	5.42	8.07
2004		92	15.29	29.84	57.38	4.21	7.00	11.28
2005		86	18.48	37.31	74.31	4.10	6.72	10.67
2006		79	16.12	33.66	69.17	2.88	4.98	8.21
2007		44	4.50	10.35	22.43	1.37	2.56	4.35
2008		90	5.07	9.07	15.72	1.54	2.38	3.49
2009		90	14.04	26.12	47.90	2.36	3.58	5.22
2010		90	4.18	8.69	17.13	1.26	2.21	3.58
2011		89	6.34	12.36	23.33	1.62	2.65	4.09
2012		84	3.07	6.40	12.46	1.17	2.11	3.46
2013		89	1.97	4.09	7.73	0.57	1.07	1.72
2014		90	3.59	6.88	12.54	0.97	1.62	2.50
2015		90	1.29	3.01	6.02	0.54	1.12	1.92
2016		90	2.38	4.83	9.06	0.99	1.76	2.82
2017		90	3.50	7.47	14.93	1.11	1.97	3.18
2018		90	0.85	1.83	3.32	0.25	0.53	0.88
2019								
2020								
2002	0	75	2.95	5.81	10.72	0.59	1.03	1.58
2003		101	8.52	14.97	25.80	1.33	2.00	2.86
2004		92	4.18	6.81	10.78	0.78	1.12	1.54
2005		86	6.61	12.44	22.73	1.25	1.92	2.79
2006		79	7.70	14.47	26.50	1.17	1.84	2.71
2007		44	1.64	3.56	6.87	0.39	0.75	1.20
2008		90	2.33	4.02	6.56	0.56	0.86	1.21
2009		90	8.49	14.80	25.33	1.26	1.82	2.53
2010		90	2.06	3.97	7.06	0.50	0.88	1.36
2011		89	3.29	5.85	9.92	0.71	1.11	1.61
2012		84	1.18	2.22	3.75	0.32	0.60	0.95
2013		89	1.19	2.38	4.21	0.26	0.52	0.83
2014		90	3.07	3.77	6.39	0.45	0.75	1.13
2015		90	0.80	1.77	3.24	0.26	0.53	0.86
2016		90	0.95	1.73	2.84	0.27	0.49	0.74
2017		90	2.00	4.00	7.33	0.53	0.92	1.41
2018		90	0.56	1.15	1.96	0.11	0.25	0.39
2019								
2020								
2002	1	75	3.97	8.07	15.53	0.94	1.64	2.57
2003		101	12.70	22.30	38.62	2.12	3.16	4.54
2004		92	9.16	16.59	29.45	2.38	3.78	5.77
2005		86	11.91	22.72	42.57	2.51	3.99	6.08
2006		79	10.47	20.52	39.37	1.78	3.01	4.79
2007		44	3.10	6.98	14.52	0.87	1.66	2.79
2008		90	3.74	6.42	10.62	1.04	1.59	2.27
2009		90	8.38	14.63	25.03	1.42	2.12	3.01
2010		90	3.20	6.35	11.87	0.90	1.56	2.45
2011		89	4.64	8.55	15.16	1.10	1.75	2.60
2012		84	2.48	4.96	9.21	0.88	1.56	2.47
2013		89	1.47	2.98	5.39	0.39	0.74	1.18
2014		90	2.67	4.88	8.41	0.65	1.08	1.64
2015		90	1.08	2.43	4.68	0.41	0.85	1.43
2016		90	1.96	3.82	6.86	0.76	1.31	2.04
2017		90	2.79	5.68	10.80	0.80	1.40	2.19
2018		90	0.70	1.47	2.59	0.17	0.39	0.64
2019								
2020								
2002	2+	75	2.29	4.31	7.57	0.47	0.89	1.41
2003		101	6.84	11.28	18.23	1.28	1.91	2.72
2004		92	8.44	15.69	28.49	2.59	4.24	6.66
2005		86	7.65	13.93	24.76	1.91	3.03	4.59
2006		79	5.02	9.59	17.62	1.02	1.86	3.07
2007		44	2.54	5.12	9.57	0.61	1.18	1.94
2008		90	2.50	4.14	6.54	0.67	1.08	1.60
2009		90	3.71	6.11	9.73	0.61	0.94	1.35
2010		90	2.12	4.05	7.15	0.58	1.00	1.55
2011		89	2.62	4.65	7.80	0.57	0.98	1.49
2012		84	2.04	3.94	7.03	0.68	1.20	1.88
2013		89	0.89	1.78	3.10	0.23	0.45	0.71
2014		90	1.50	2.70	4.49	0.36	0.65	1.00
2015		90	0.76	1.70	3.13	0.28	0.59	0.98
2016		90	1.67	3.17	5.52	0.60	1.03	1.58
2017		90	1.79	3.40	5.93	0.43	0.76	1.16
2018		90	0.40	0.86	1.47	0.06	0.21	0.38
2019								
2020								

Figure 23. Butterfish geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

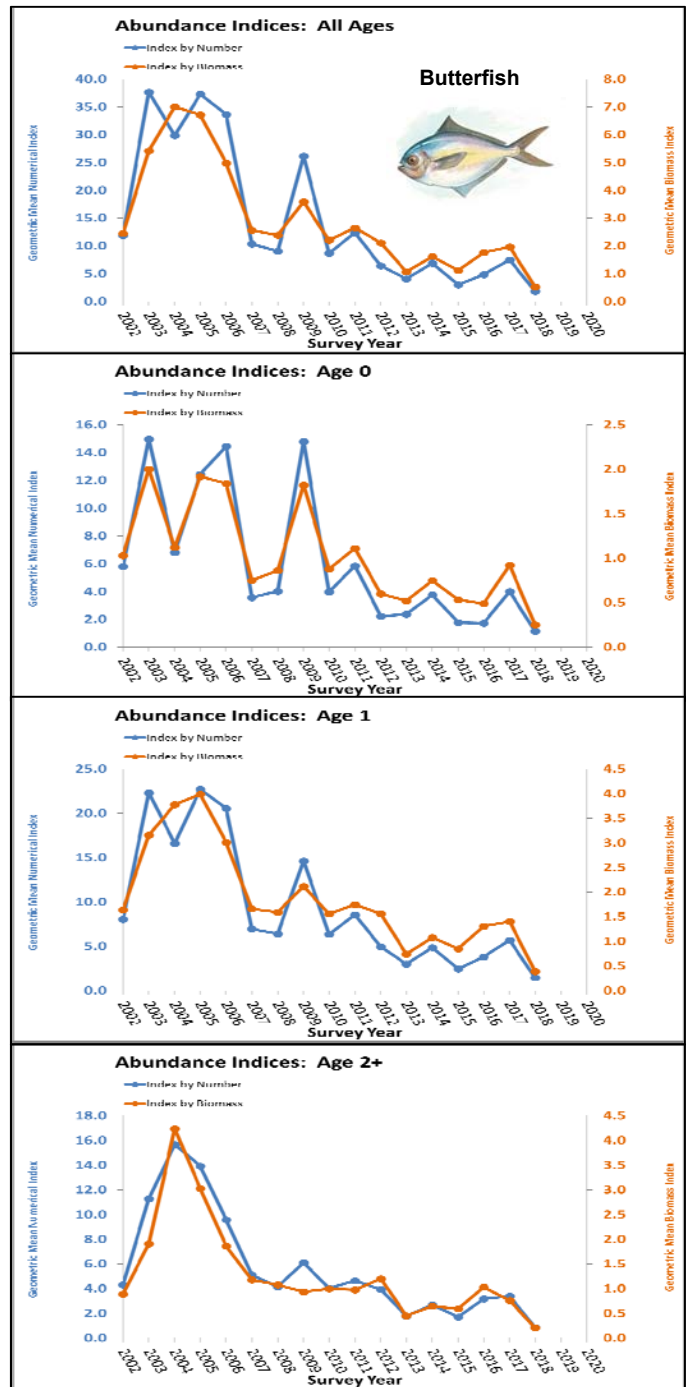


Figure 24. Butterfish length-frequency in Chesapeake Bay 2002-2018, overall.

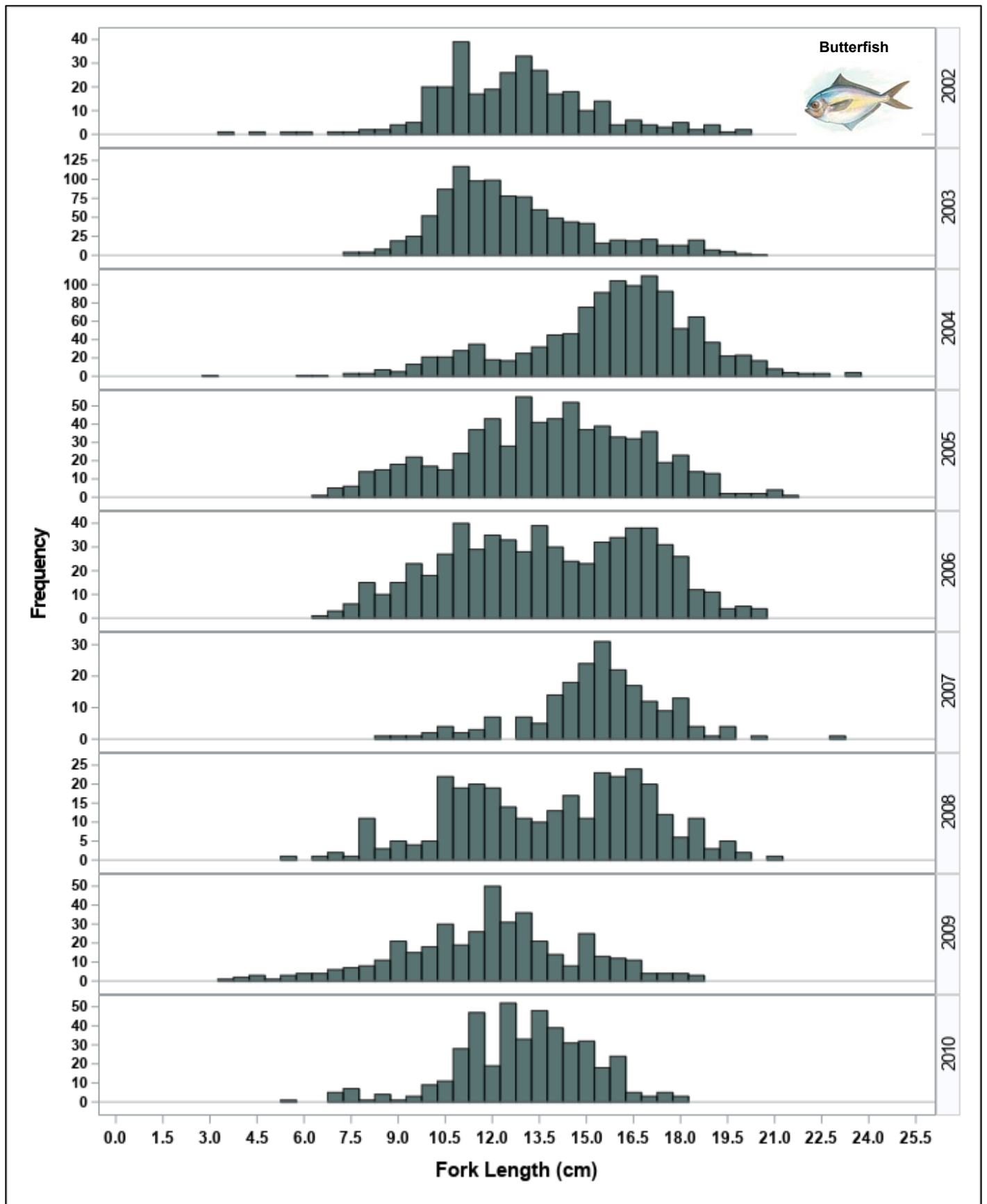


Figure 24. cont.

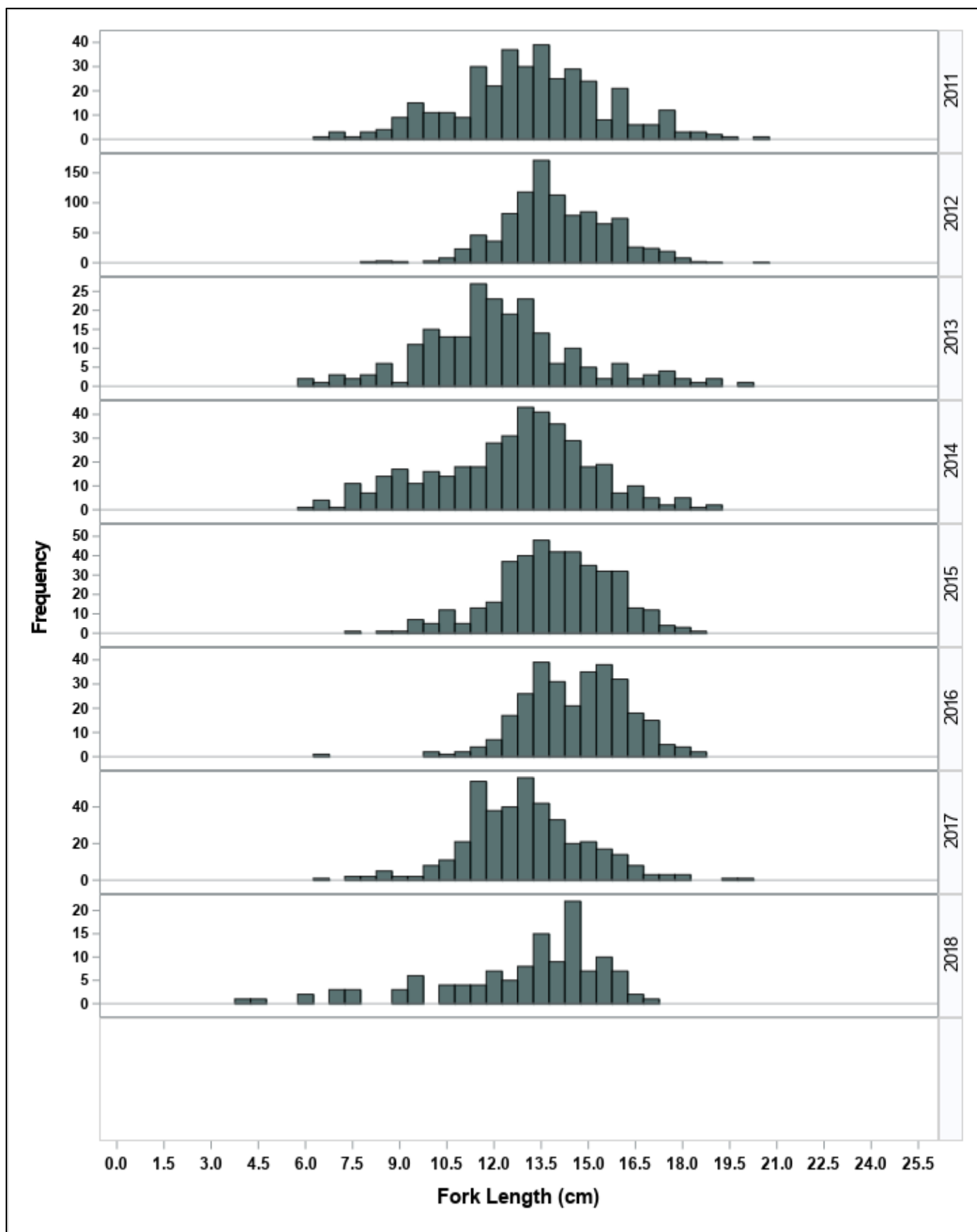


Table 17. Kingfish sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught	Percent Presence	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	143	18.5	11.5	143	91	91	87	79
2003	70	19.3	12.4	70	55	55	55	50
2004	67	16.0	11.8	67	55	55	50	48
2005	86	15.3	13.6	86	72	72	69	68
2006	120	24.1	20.6	120	94	94	84	83
2007	122	17.7	13.5	122	88	88	78	76
2008	333	62.6	20.0	300	113	113	97	97
2009	195	24.8	22.2	195	152	152	135	134
2010	447	82.5	20.1	447	231	231	206	199
2011	336	55.7	21.8	336	176	175	155	155
2012	148	24.6	12.6	148	114	0	96	92
2013	165	32.1	16.2	165	106	0	77	77
2014	76	14.2	7.8	76	57	0	39	36
2015	156	24.1	12.8	156	112	0	61	60
2016	613	80.1	20.0	613	265	0	166	163
2017	361	55.2	16.7	361	198	0	138	137
2018	239	39.0	22.2	239	167	0	104	104

Figure 25. Abundance (kg per hectare swept) of Kingfish in Chesapeake Bay, 2018.

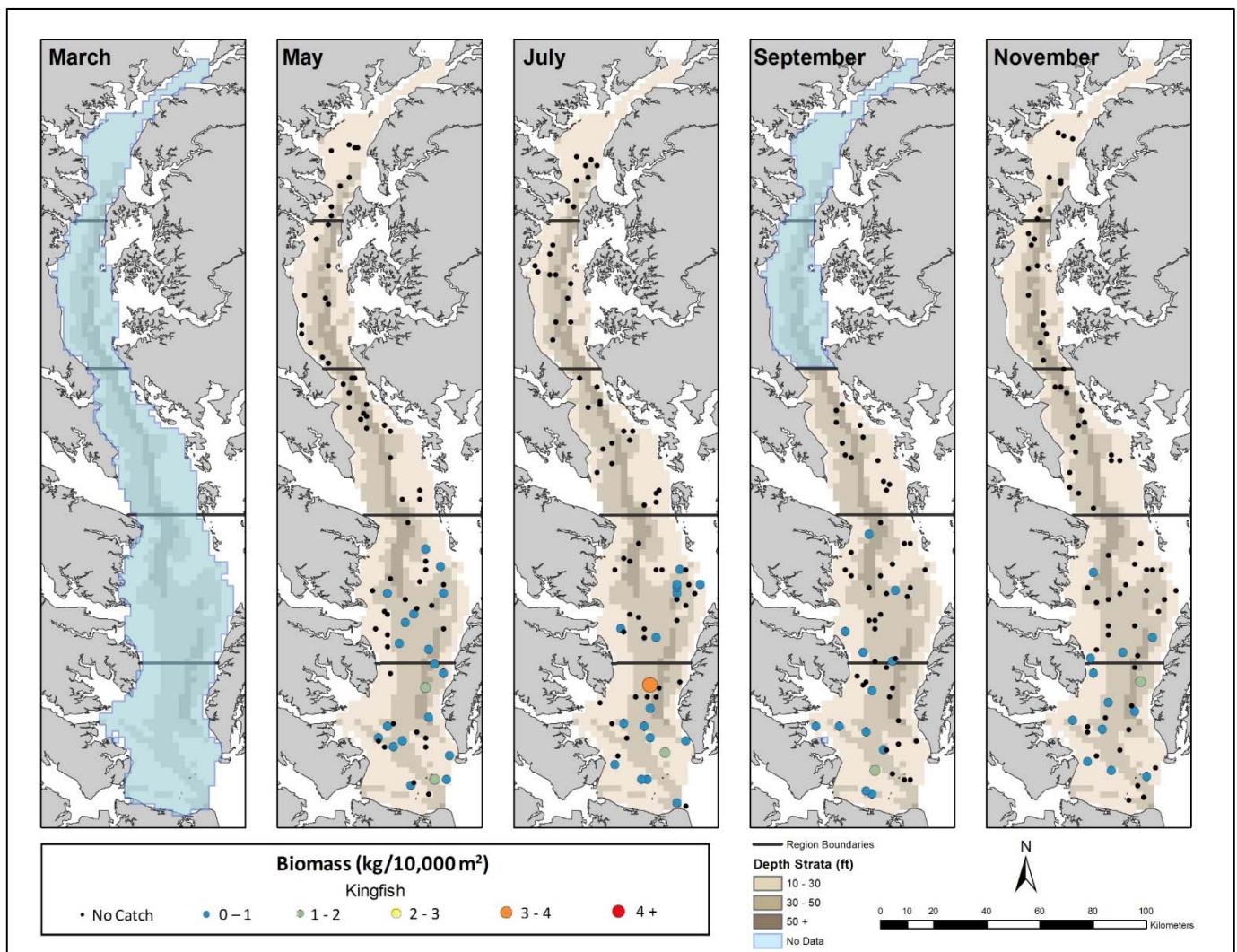


Table 18. Months, latitudinal regions, and depth strata used for Kingfish index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 19. Kingfish geometric mean indices of abundance, by number and biomass, overall and by age-class.

Year	Age	n	Numerical Index			Biomass Index			Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI
2002	All	165	1.0	1.7	2.7	0.4	0.7	1.0	2002	2	165	0.2	0.4	0.6	0.1	0.2	0.3
2003		149	0.6	1.1	1.7	0.4	0.7	1.0	2003		149	0.2	0.5	0.8	0.1	0.3	0.5
2004		177	0.4	0.8	1.3	0.2	0.4	0.7	2004		177	0.0	0.1	0.3	0.0	0.1	0.2
2005		176	1.0	1.6	2.6	0.5	0.8	1.2	2005		176	0.2	0.5	0.7	0.1	0.3	0.4
2006		165	1.7	2.8	4.3	0.9	1.4	2.0	2006		165	0.4	0.8	1.3	0.2	0.5	0.7
2007		133	1.5	2.7	4.6	0.7	1.3	1.9	2007		133	0.2	0.5	0.9	0.1	0.3	0.5
2008		180	1.5	2.5	3.9	0.8	1.3	1.9	2008		180	0.4	0.7	1.1	0.2	0.4	0.7
2009		135	3.7	6.3	10.5	1.5	2.3	3.4	2009		135	1.2	2.1	3.3	0.6	1.0	1.5
2010		179	4.2	6.8	10.8	1.9	2.9	4.2	2010		179	0.4	0.7	1.2	0.2	0.4	0.6
2011		179	3.4	5.4	8.3	1.4	2.1	3.0	2011		179	0.6	1.1	1.7	0.4	0.6	0.9
2012		174	1.7	2.8	4.3	0.9	1.4	2.0	2012		174	0.4	0.7	1.1	0.2	0.4	0.6
2013		179	1.6	2.6	4.1	0.9	1.4	2.0	2013		179	0.4	0.8	1.2	0.2	0.4	0.6
2014		180	0.5	1.0	1.6	0.3	0.5	0.9	2014		180	0.1	0.3	0.5	0.1	0.2	0.3
2015		180	1.0	1.7	2.7	0.6	0.9	1.3	2015		180	0.1	0.3	0.5	0.1	0.2	0.3
2016		180	5.9	9.5	15.0	2.4	3.6	5.1	2016		180	0.5	1.0	1.5	0.3	0.5	0.8
2017		180	2.6	4.4	7.0	1.3	2.0	3.0	2017		180	0.6	1.1	1.7	0.3	0.6	0.8
2018		180	3.8	5.9	8.9	1.5	2.1	3.0	2018		180	0.5	1.0	1.5	0.3	0.5	0.8
2019									2019								
2020									2020								
2002	0	75	0.3	0.9	1.7	0.1	0.2	0.4	2002	3+	165	0.1	0.3	0.6	0.1	0.2	0.3
2003		101	0.0	0.2	0.4	0.0	0.1	0.2	2003		149	0.2	0.5	0.8	0.1	0.3	0.5
2004		92	0.0	0.1	0.3	0.0	0.0	0.1	2004		177	0.0	0.2	0.3	0.0	0.1	0.2
2005		86	0.1	0.4	0.8	0.0	0.2	0.3	2005		176	0.2	0.5	0.7	0.1	0.3	0.5
2006		79	0.0	0.1	0.2	0.0	0.0	0.0	2006		165	0.4	0.8	1.3	0.3	0.5	0.7
2007		44	0.0	0.0	0.0	0.0	0.0	0.0	2007		133	0.2	0.5	0.9	0.1	0.3	0.5
2008		90	0.1	0.3	0.6	0.0	0.2	0.3	2008		180	0.3	0.6	1.0	0.2	0.4	0.6
2009		90	0.3	0.7	1.3	0.1	0.3	0.5	2009		135	1.0	1.6	2.6	0.5	0.8	1.2
2010		90	0.1	0.4	0.8	0.0	0.1	0.3	2010		179	0.3	0.7	1.0	0.2	0.4	0.6
2011		89	0.6	1.2	2.2	0.2	0.5	0.8	2011		179	0.6	1.0	1.6	0.3	0.6	0.9
2012		84	0.0	0.3	0.6	0.0	0.1	0.3	2012		174	0.3	0.6	0.9	0.2	0.3	0.5
2013		89	0.0	0.2	0.4	0.0	0.1	0.2	2013		179	0.3	0.6	0.9	0.2	0.3	0.5
2014		90	0.0	0.0	0.0	0.0	0.0	0.0	2014		180	0.1	0.2	0.4	0.0	0.1	0.3
2015		90	0.0	0.1	0.3	0.0	0.0	0.1	2015		180	0.1	0.3	0.5	0.1	0.2	0.3
2016		90	0.1	0.5	1.0	0.0	0.2	0.4	2016		180	0.4	0.8	1.2	0.2	0.4	0.6
2017		90	0.1	0.3	0.7	0.0	0.2	0.3	2017		180	0.5	0.8	1.3	0.2	0.4	0.6
2018		90	0.4	1.0	1.9	0.1	0.3	0.5	2018		180	0.5	0.8	1.3	0.3	0.4	0.7
2019									2019								
2020									2020								
2002	1	165	0.2	0.4	0.6	0.1	0.2	0.3									
2003		149	0.1	0.3	0.6	0.1	0.2	0.4									
2004		177	0.0	0.1	0.2	0.0	0.1	0.1									
2005		176	0.2	0.4	0.7	0.1	0.2	0.4									
2006		165	0.2	0.5	0.8	0.1	0.3	0.4									
2007		133	0.1	0.3	0.6	0.1	0.2	0.3									
2008		180	0.2	0.5	0.8	0.1	0.3	0.5									
2009		135	1.0	1.8	2.8	0.5	0.8	1.2									
2010		179	0.3	0.6	1.0	0.2	0.3	0.5									
2011		179	0.6	1.0	1.6	0.3	0.6	0.8									
2012		174	0.3	0.5	0.9	0.1	0.3	0.4									
2013		179	0.4	0.7	1.1	0.2	0.4	0.5									
2014		180	0.0	0.2	0.3	0.0	0.1	0.2									
2015		180	0.1	0.2	0.4	0.0	0.1	0.2									
2016		180	0.6	1.1	1.8	0.3	0.6	0.9									
2017		180	0.6	1.1	1.6	0.3	0.5	0.8									
2018		180	0.5	0.9	1.4	0.3	0.5	0.7									
2019																	
2020																	

Figure 26. Kingfish geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

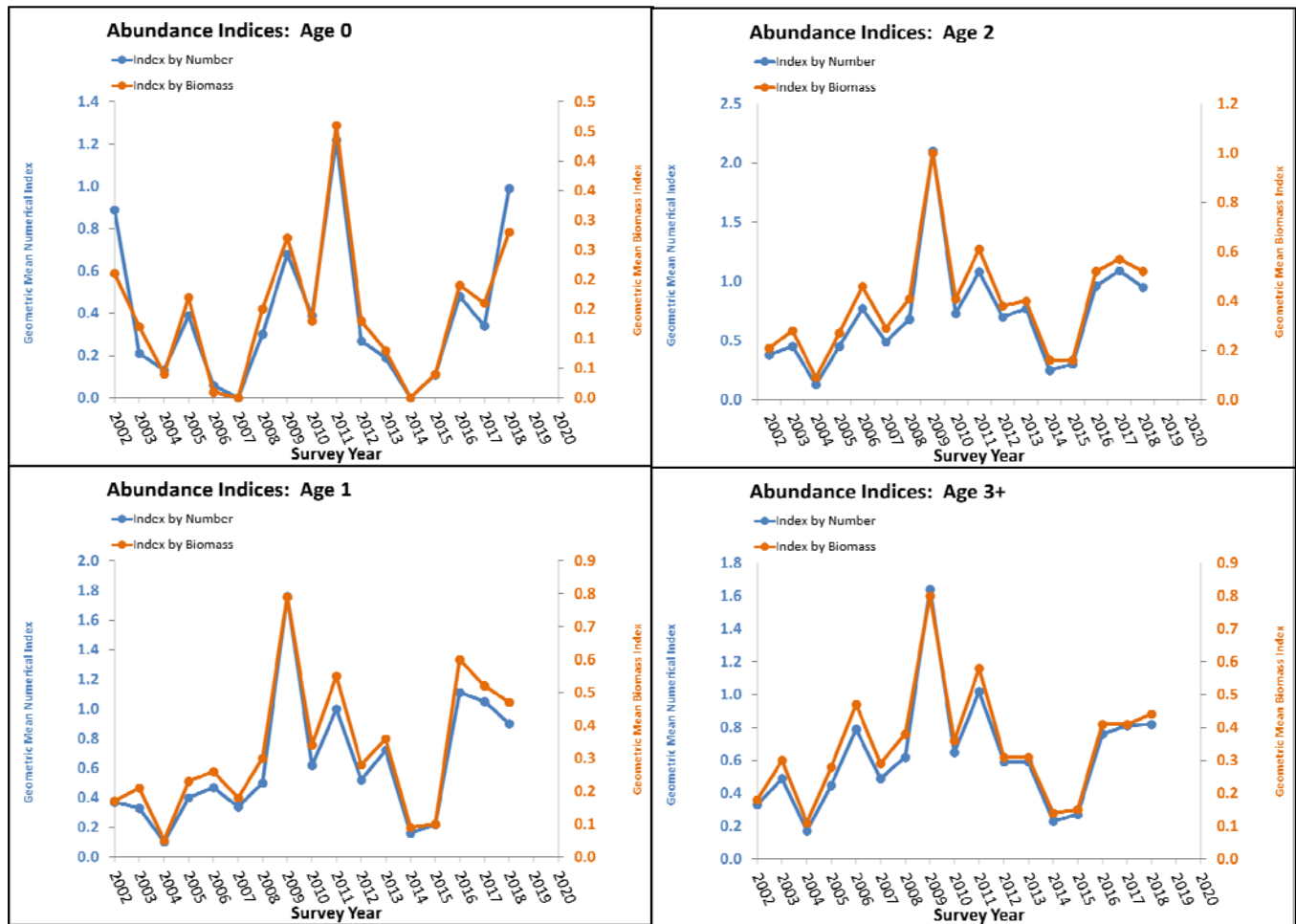
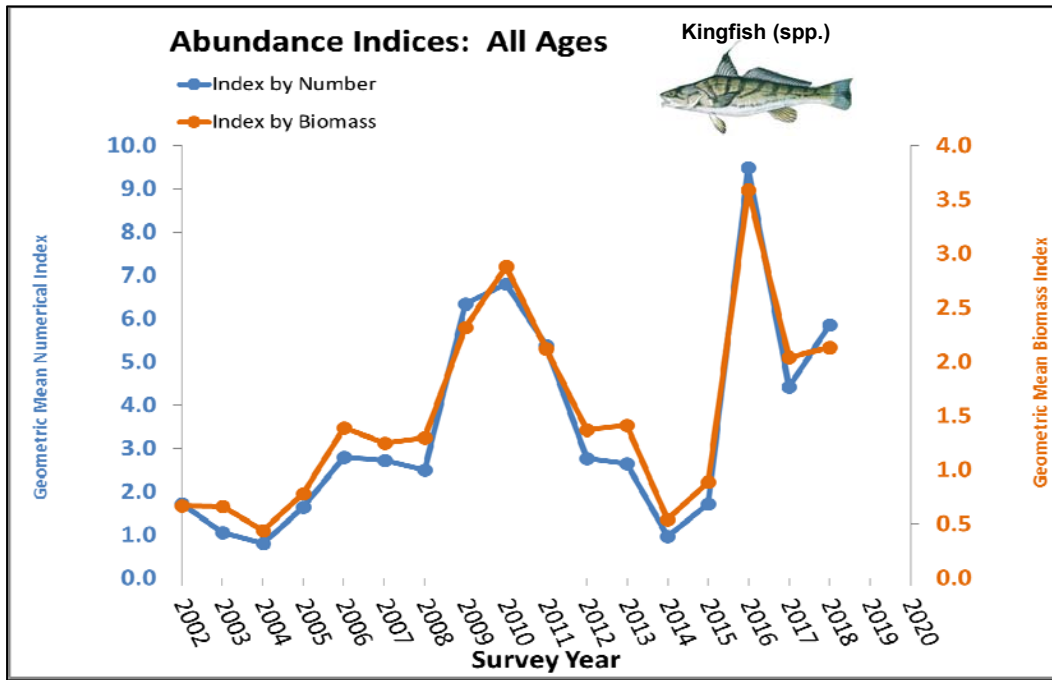


Figure 27. Kingfish length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

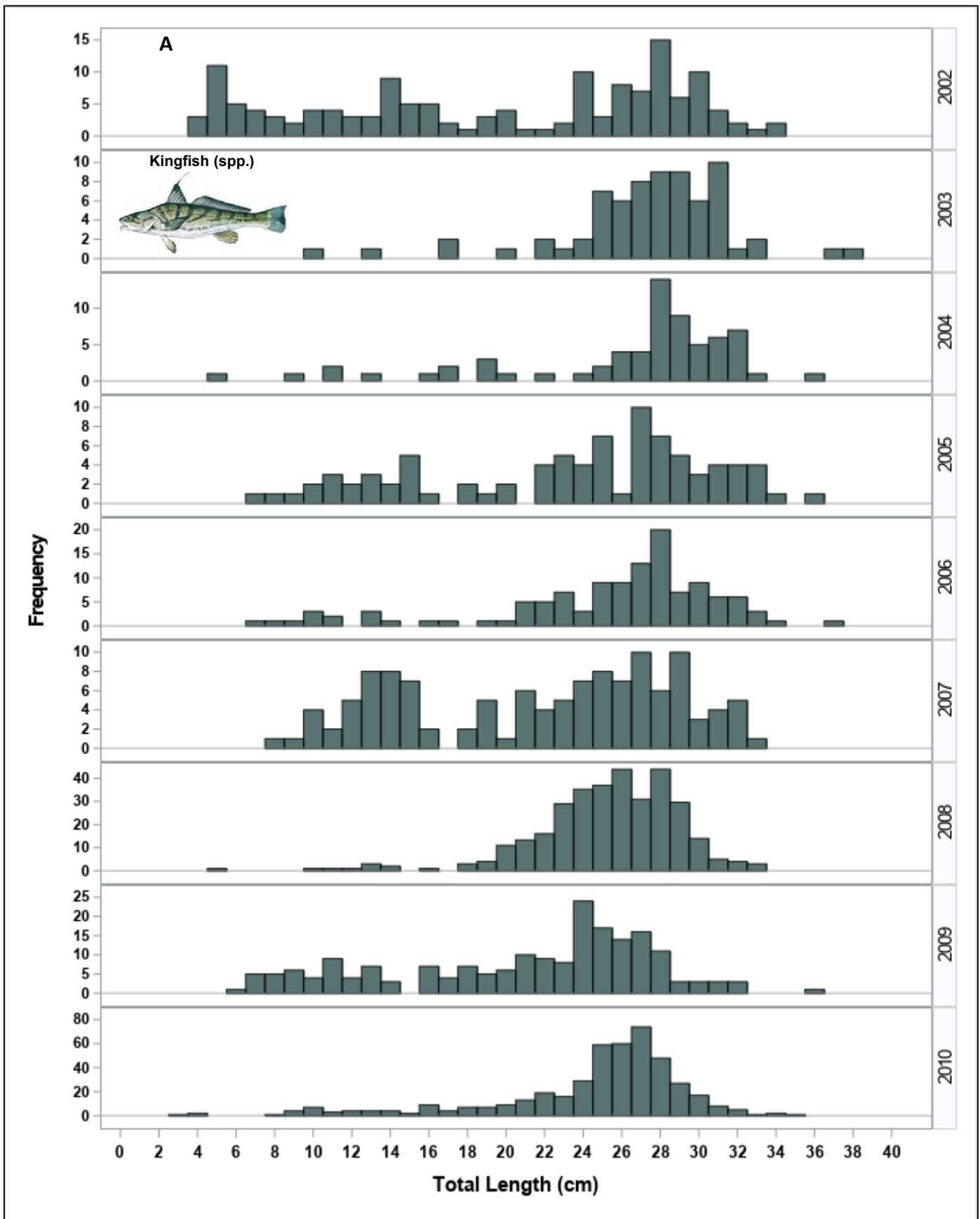


Figure 27. cont.

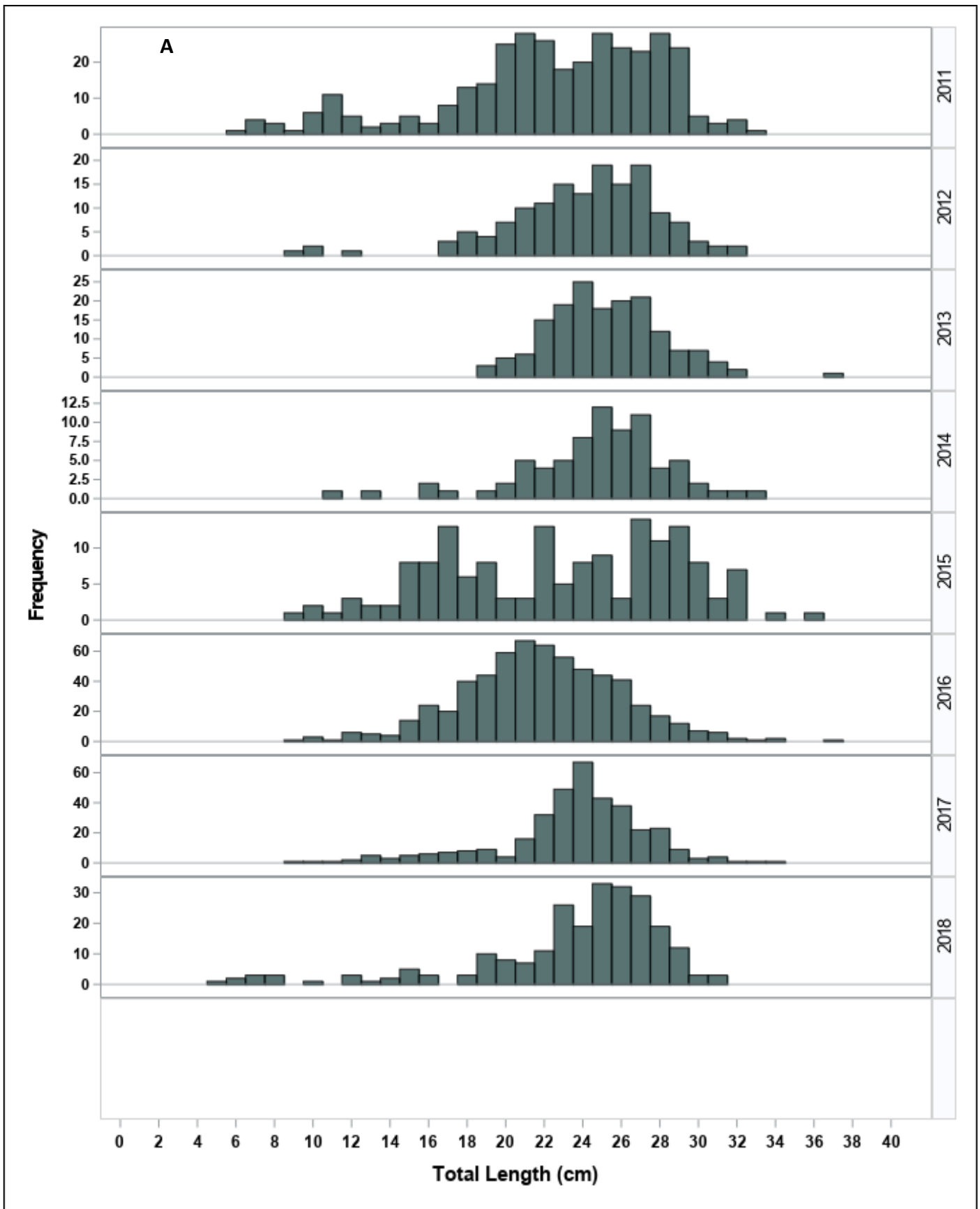


Figure 27. cont.

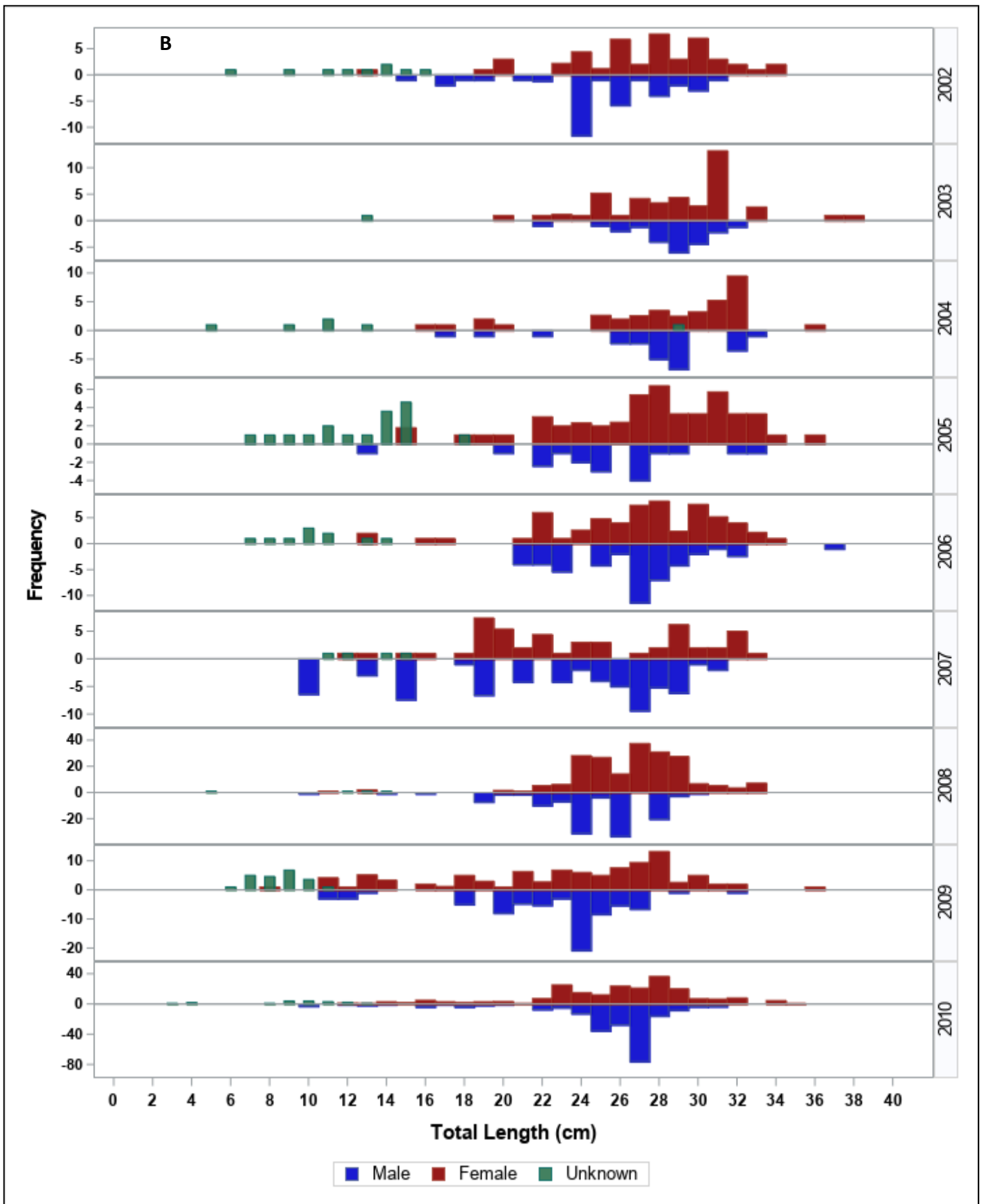


Figure 27. cont.

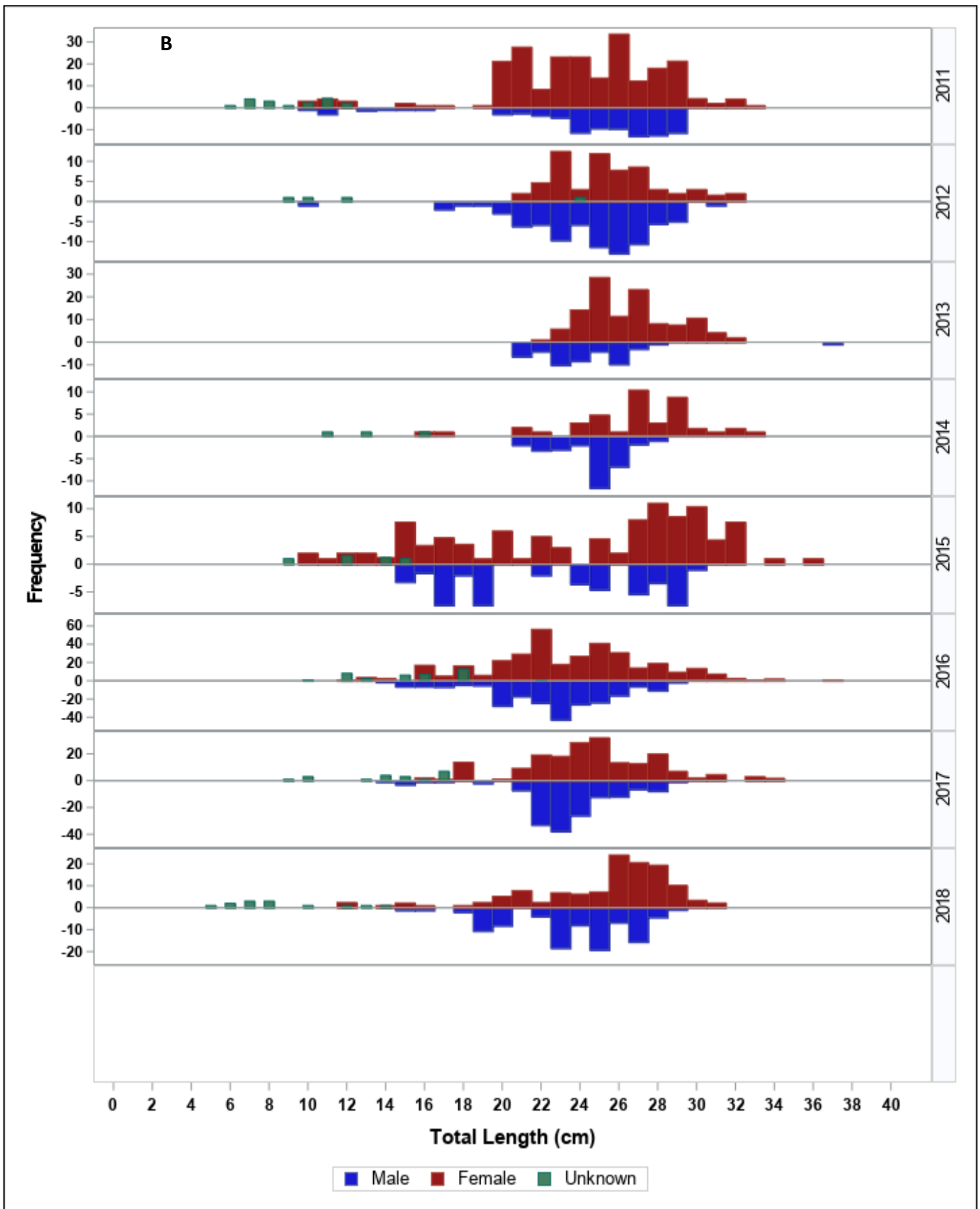


Figure 28. Kingfish age-frequency by year, 2002-2018.

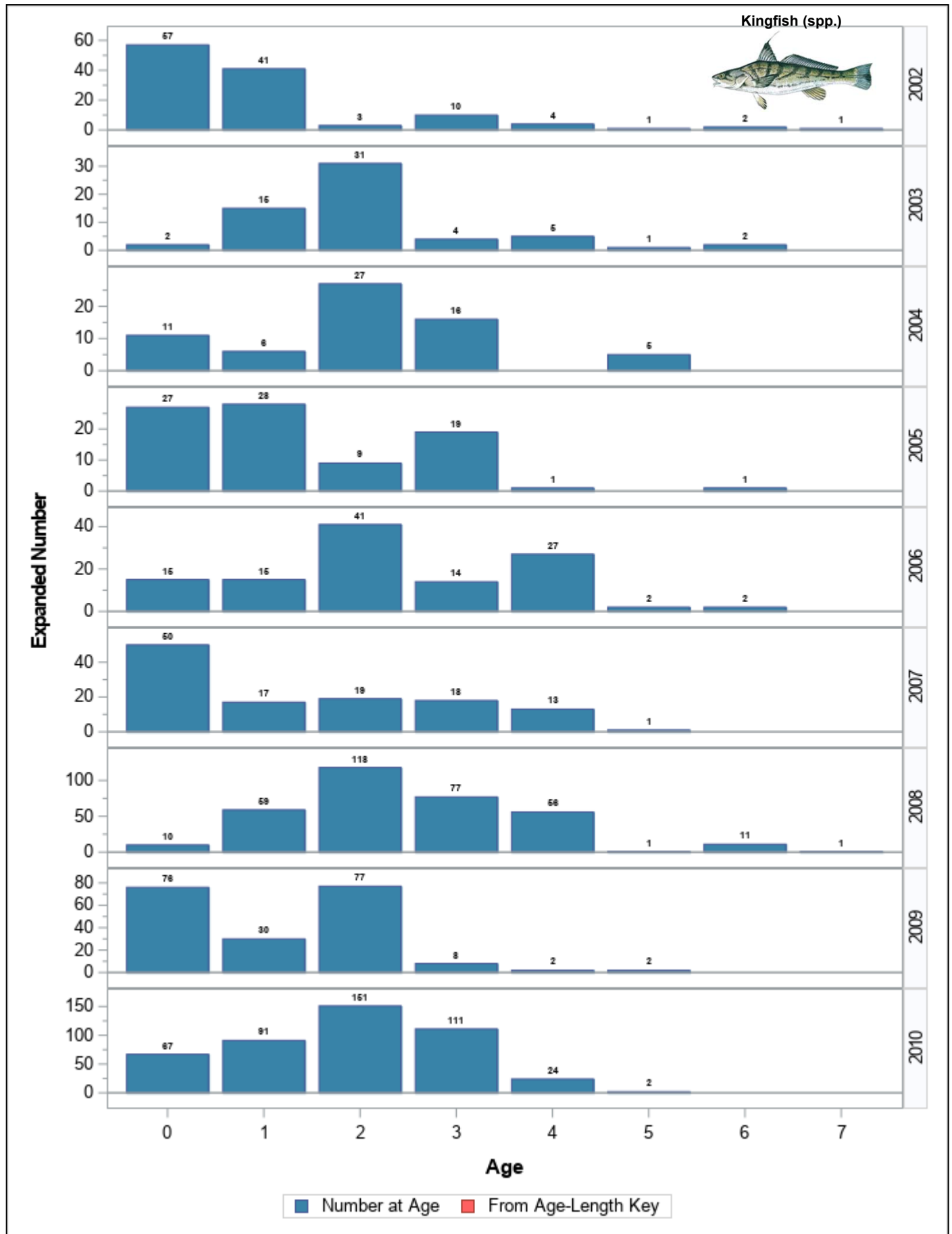


Figure 28. cont.

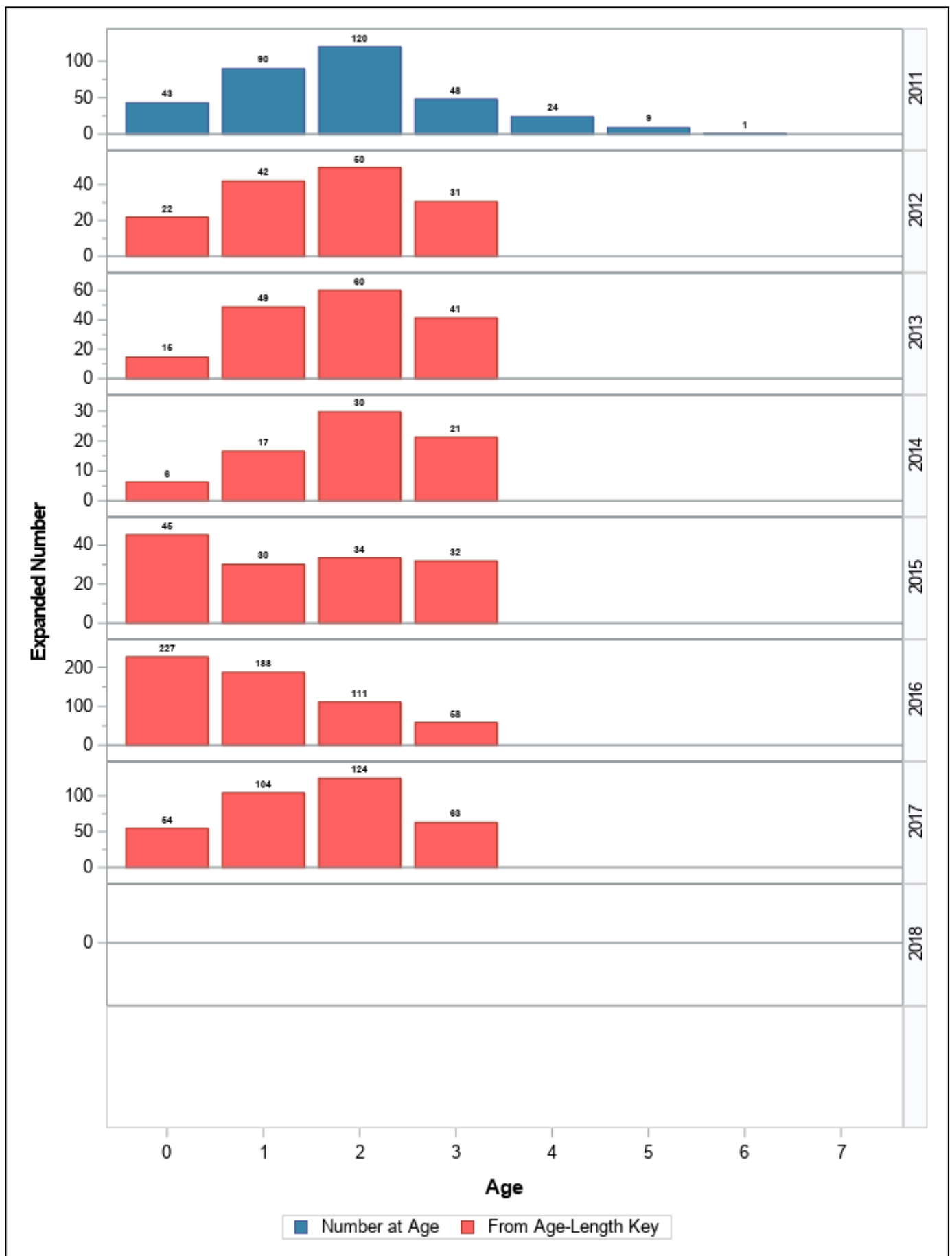


Figure 29. Kingfish age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

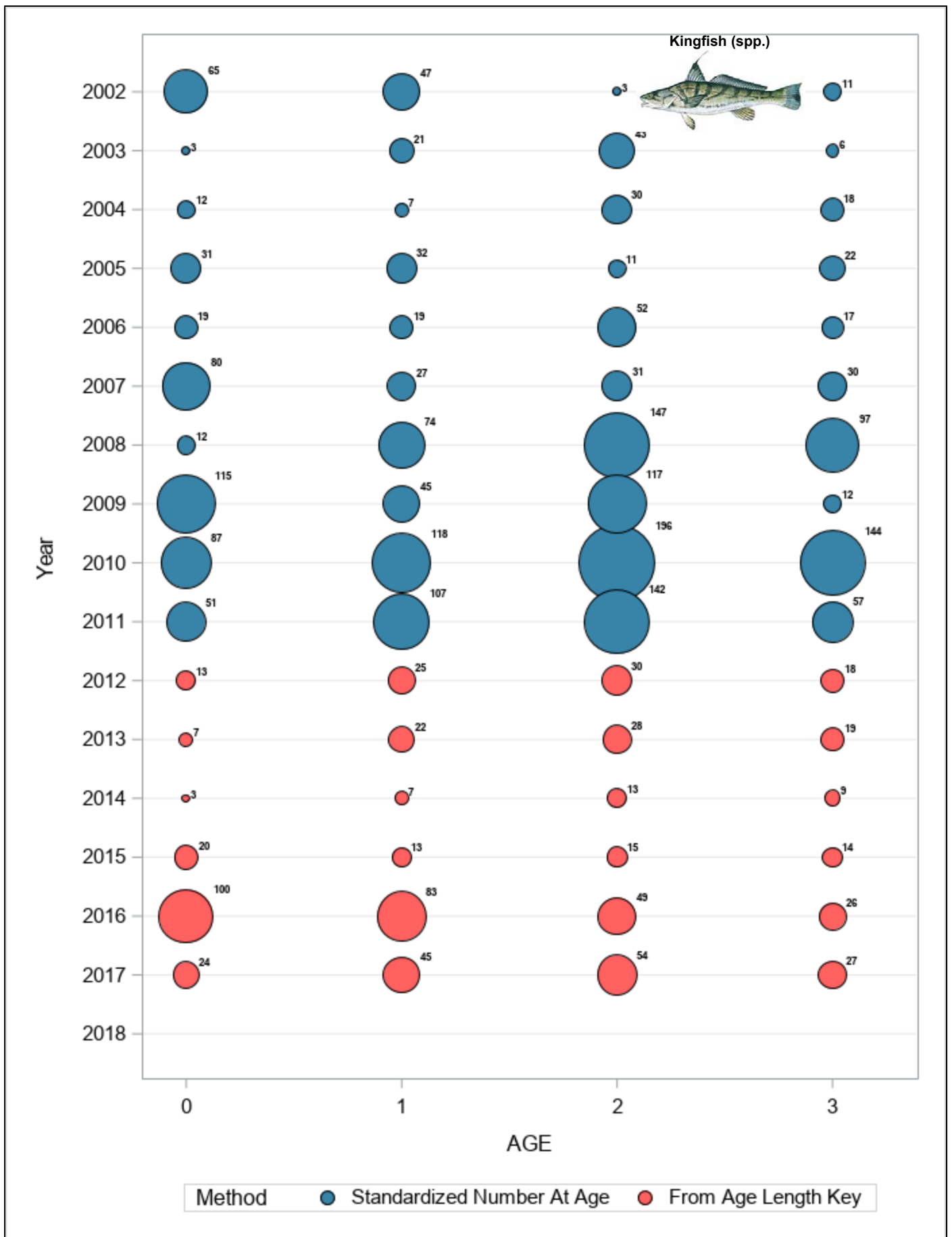


Figure 30. Kingfish age-frequency by cruise month, 2002-2011 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

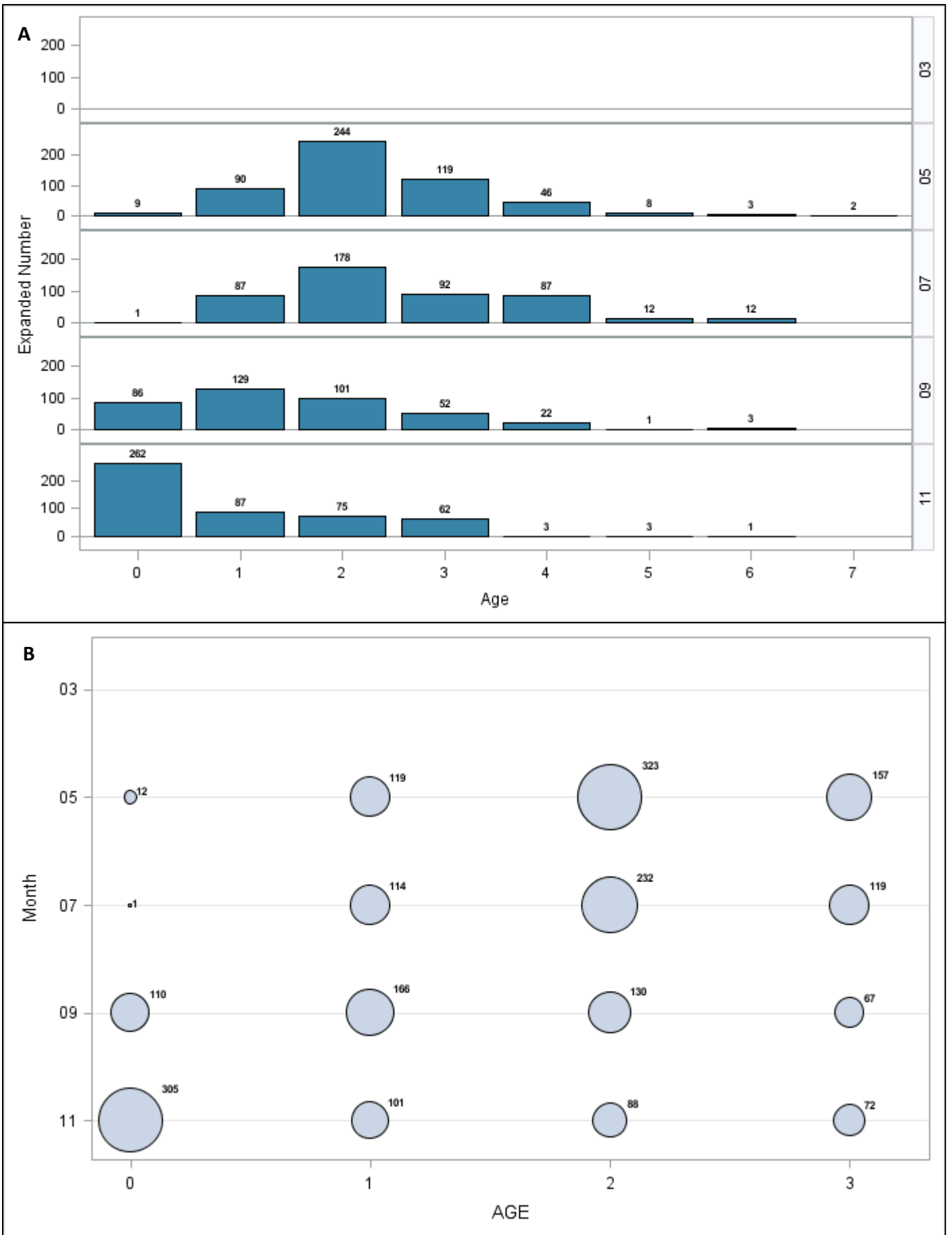


Figure 31. Diet composition, expressed as percent by weight (A) and percent by number (B) of Kingfish collected during ChesMMAP cruises in 2002-2018 combined.

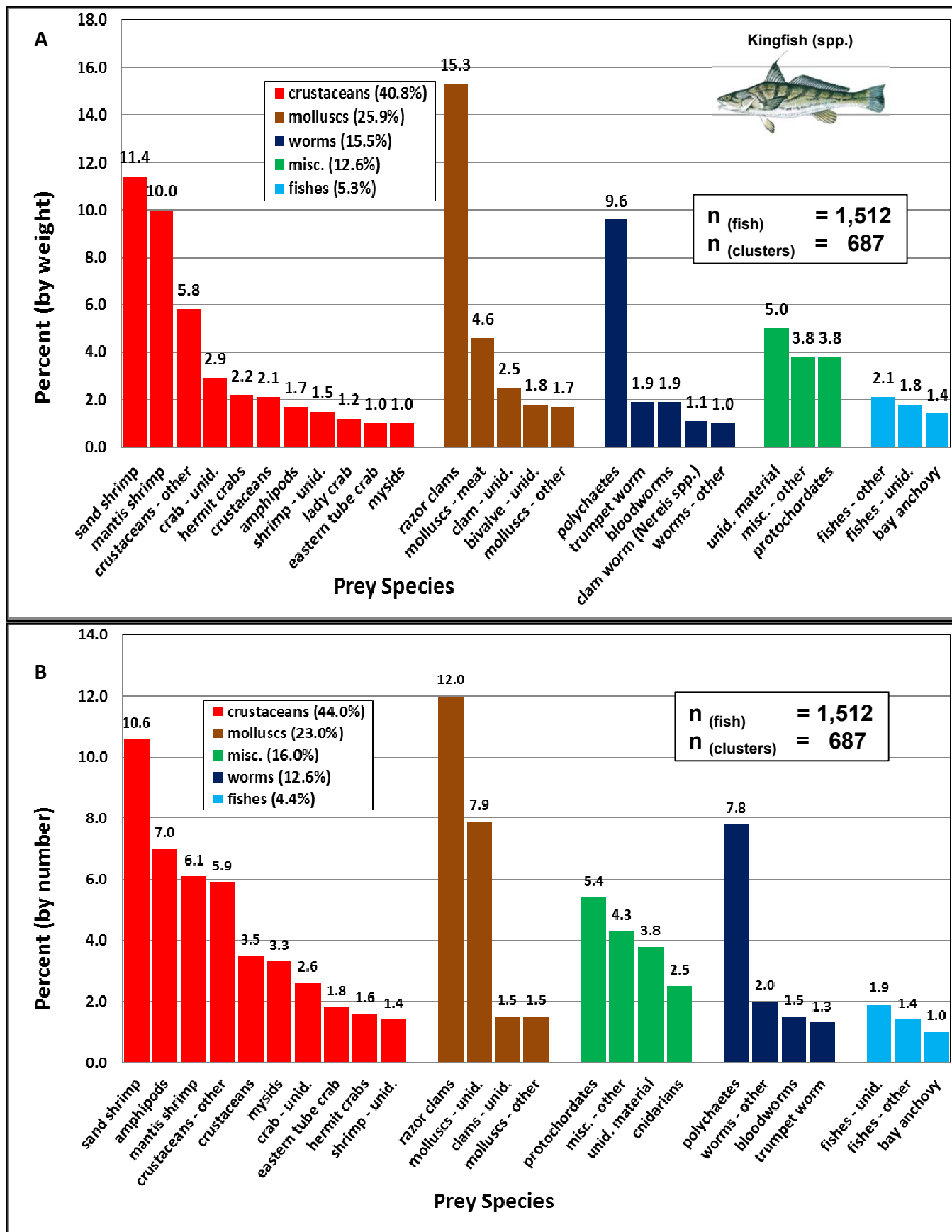


Table 20. Northern Puffer sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	231	24.2	30.7	231	177	0	171	156
2003	225	33.1	25.5	225	100	0	92	91
2004	41	6.9	7.5	41	31	0	27	26
2005	131	13.7	16.3	131	84	0	84	83
2006	52	5.5	13.9	52	51	0	48	47
2007	155	19.8	31.8	155	127	0	124	124
2008	90	6.9	14.4	90	78	0	77	77
2009	76	7.2	13.3	76	69	0	68	67
2010	326	54.7	22.2	326	176	0	157	156
2011	614	55.0	30.3	614	247	0	238	236
2012	50	5.3	8.3	50	50	0	41	40
2013	63	4.2	4.5	63	61	0	55	52
2014	49	3.7	5.6	49	39	0	16	16
2015	290	44.1	23.3	290	157	0	54	54
2016	519	65.6	20.0	519	231	0	99	97
2017	231	22.4	8.9	231	148	0	116	116
2018	246	24.5	16.7	246	128	0	87	87

Figure 32. Abundance (kg per hectare swept) of Northern Puffer in Chesapeake Bay, 2018.

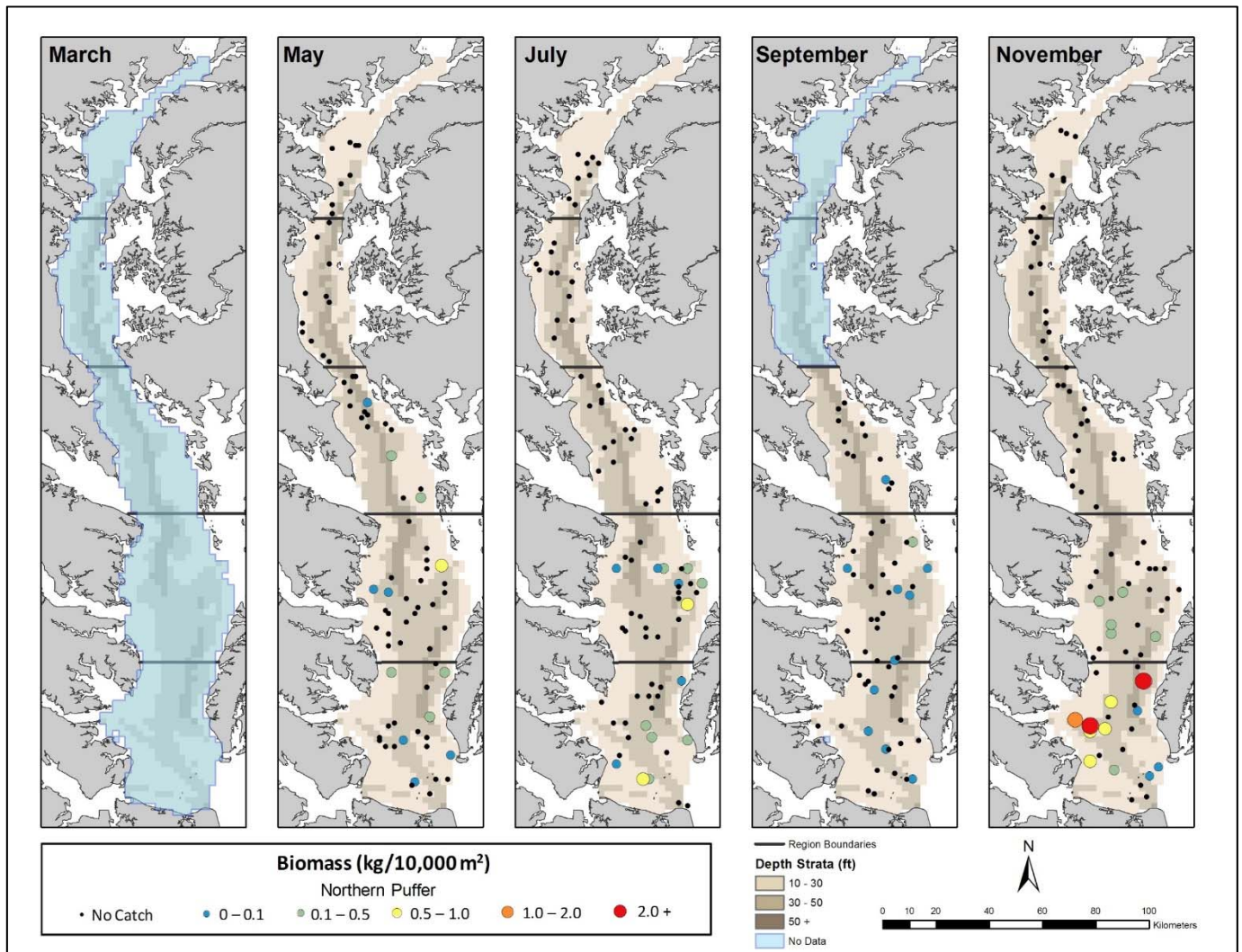


Table 21. Months, latitudinal regions, and depth strata used for Northern Puffer index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 22. Northern Puffer geometric mean indices of abundance, by number and biomass, overall.

Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI
2002	All	75	7.06	13.8	26.15	2.18	3.6	5.76
2003		101	3.28	6.0	10.44	1.38	2.3	3.53
2004		92	0.20	0.6	1.22	0.11	0.4	0.66
2005		86	1.38	3.0	5.55	0.57	1.1	1.91
2006		79	0.66	1.6	3.21	0.31	0.7	1.26
2007		44	28.89	58.3	116.54	7.12	11.9	19.35
2008		90	0.83	1.8	3.23	0.33	0.7	1.09
2009		90	1.25	2.7	5.05	0.56	1.1	1.77
2010		90	6.28	12.6	24.36	1.80	3.3	5.45
2011		89	12.08	21.8	38.91	3.61	5.6	8.35
2012		84	0.26	0.8	1.53	0.07	0.2	0.42
2013		89	0.45	1.1	2.12	0.12	0.3	0.48
2014		90	0.30	0.9	1.73	0.14	0.4	0.67
2015		90	3.36	6.7	12.55	1.28	2.4	4.00
2016		90	4.44	9.4	18.97	1.69	3.2	5.43
2017		90	1.22	2.6	4.83	0.46	0.9	1.44
2018		90	1.97	4.2	8.09	0.74	1.5	2.45
2019								
2020								

Figure 33. Northern Puffer geometric mean indices of abundance, by number and biomass, for all ages combined.

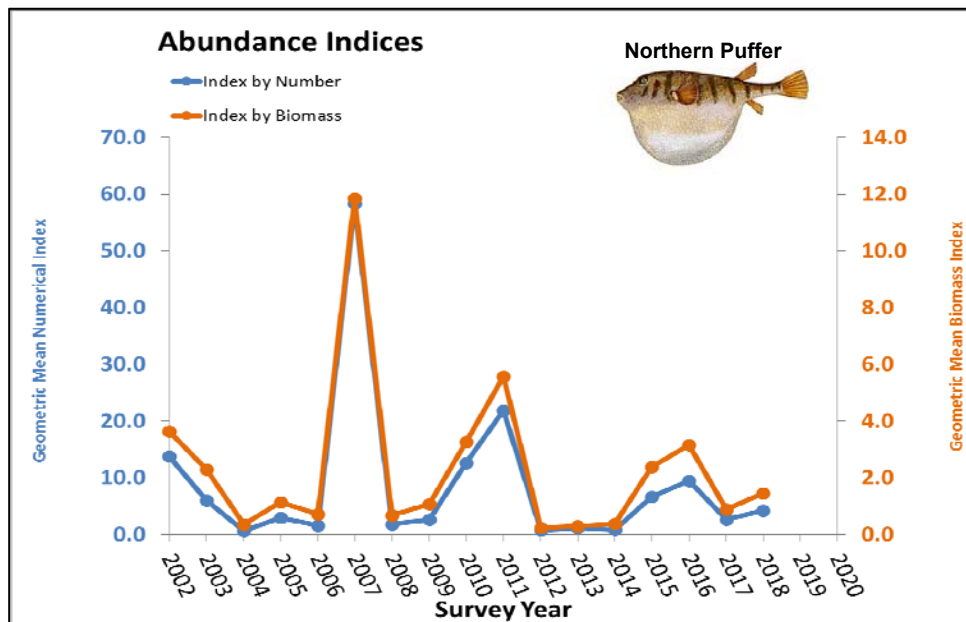


Figure 34. Northern Puffer length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

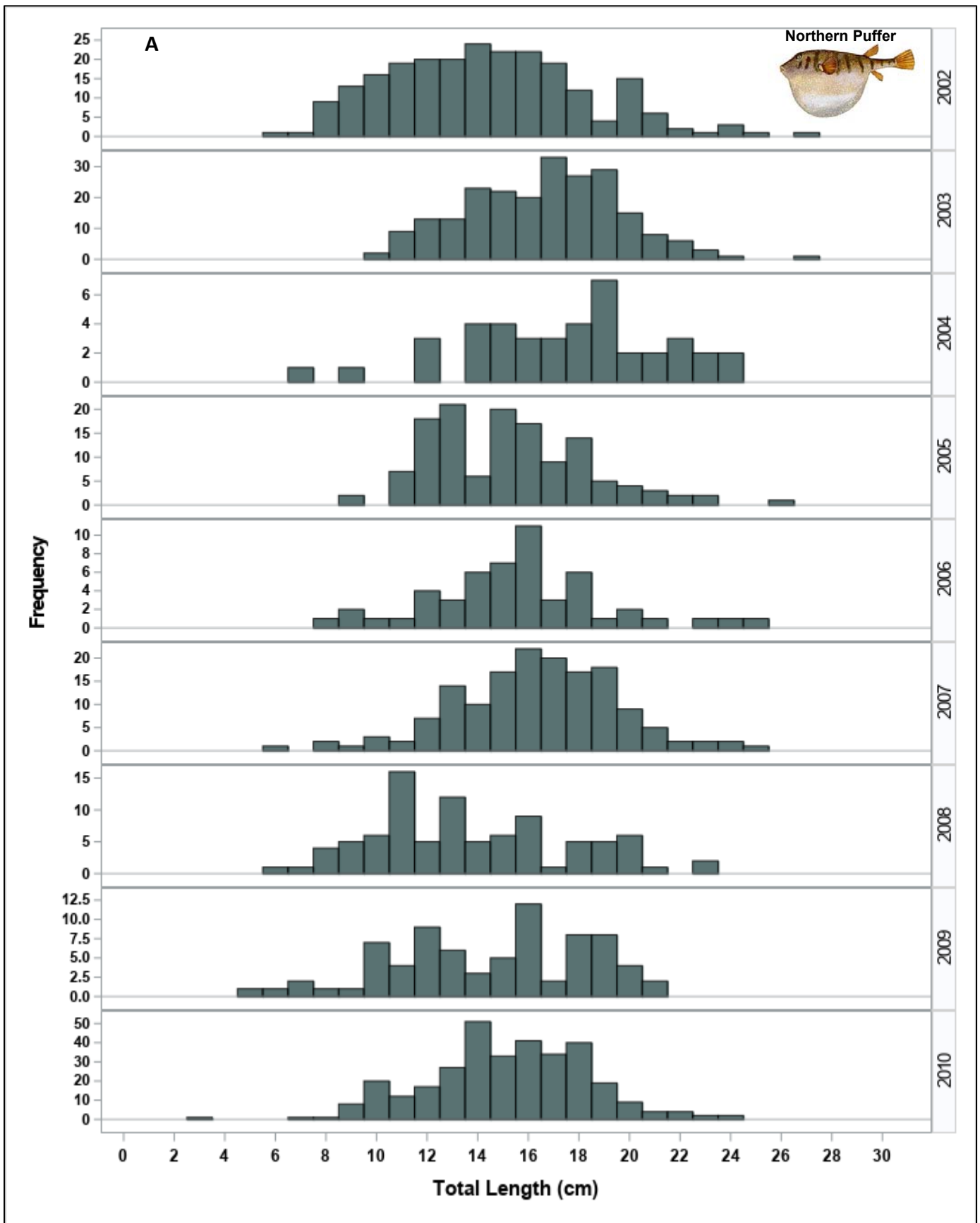


Figure 34. cont.

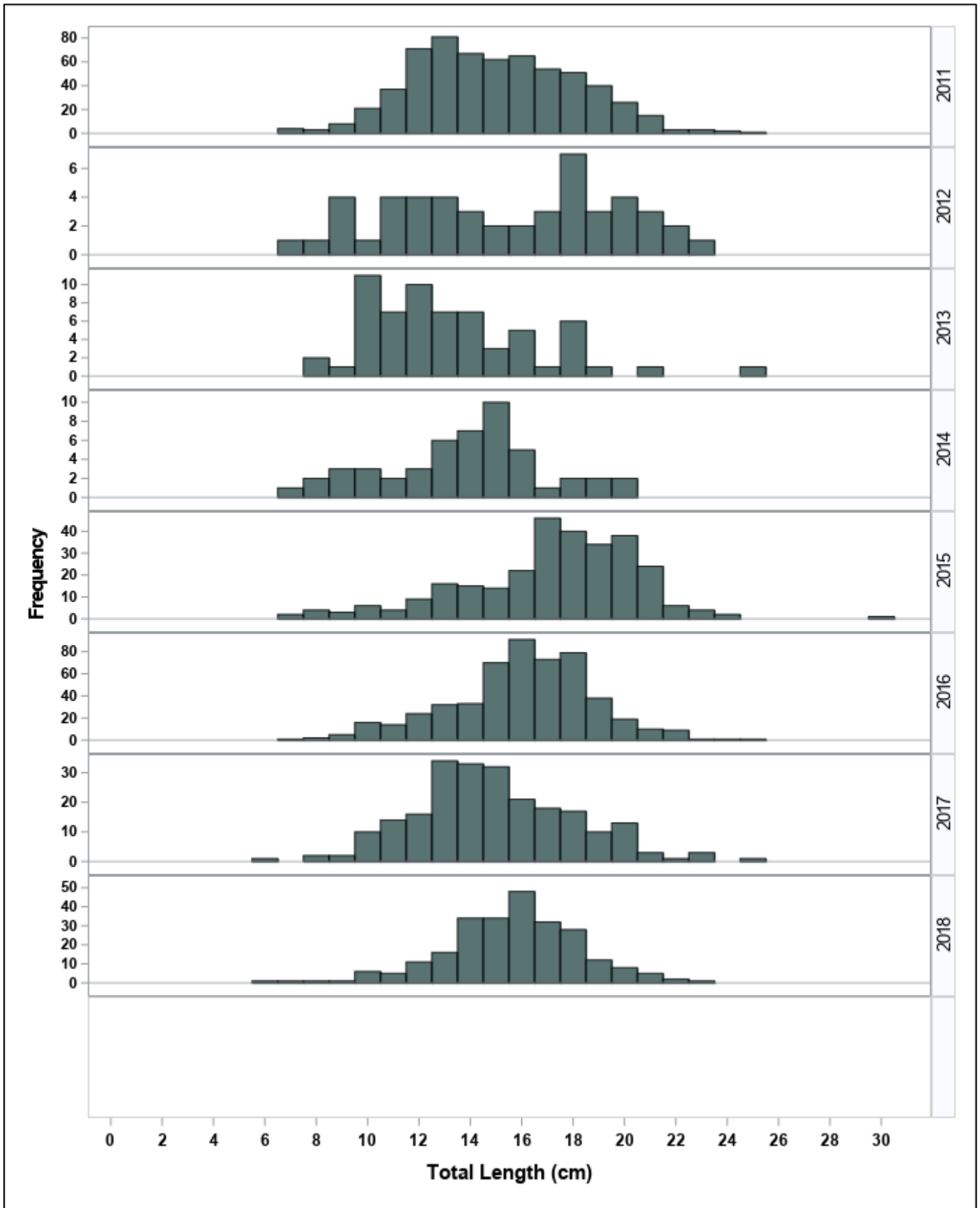


Figure 34. cont.

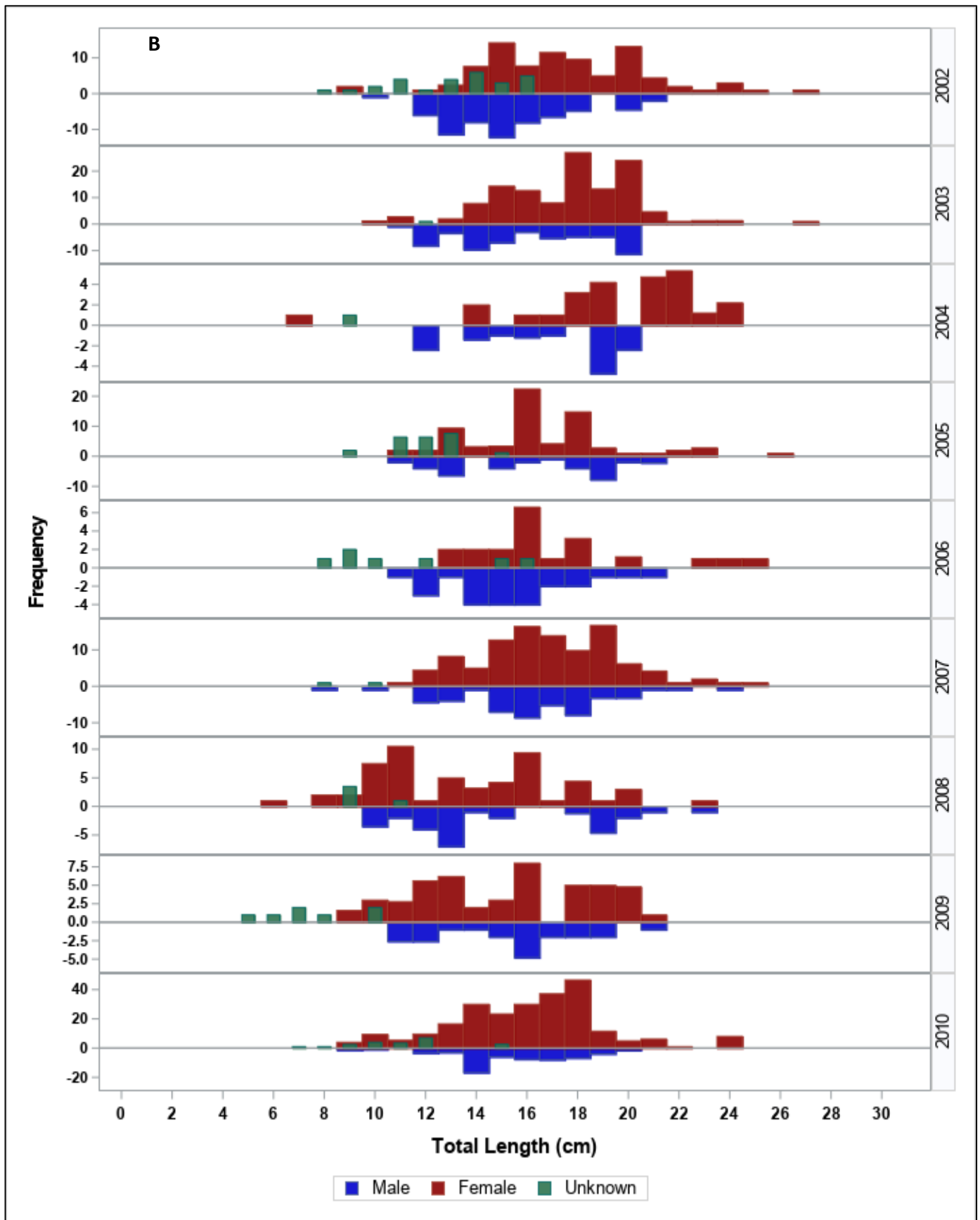


Figure 34. cont.

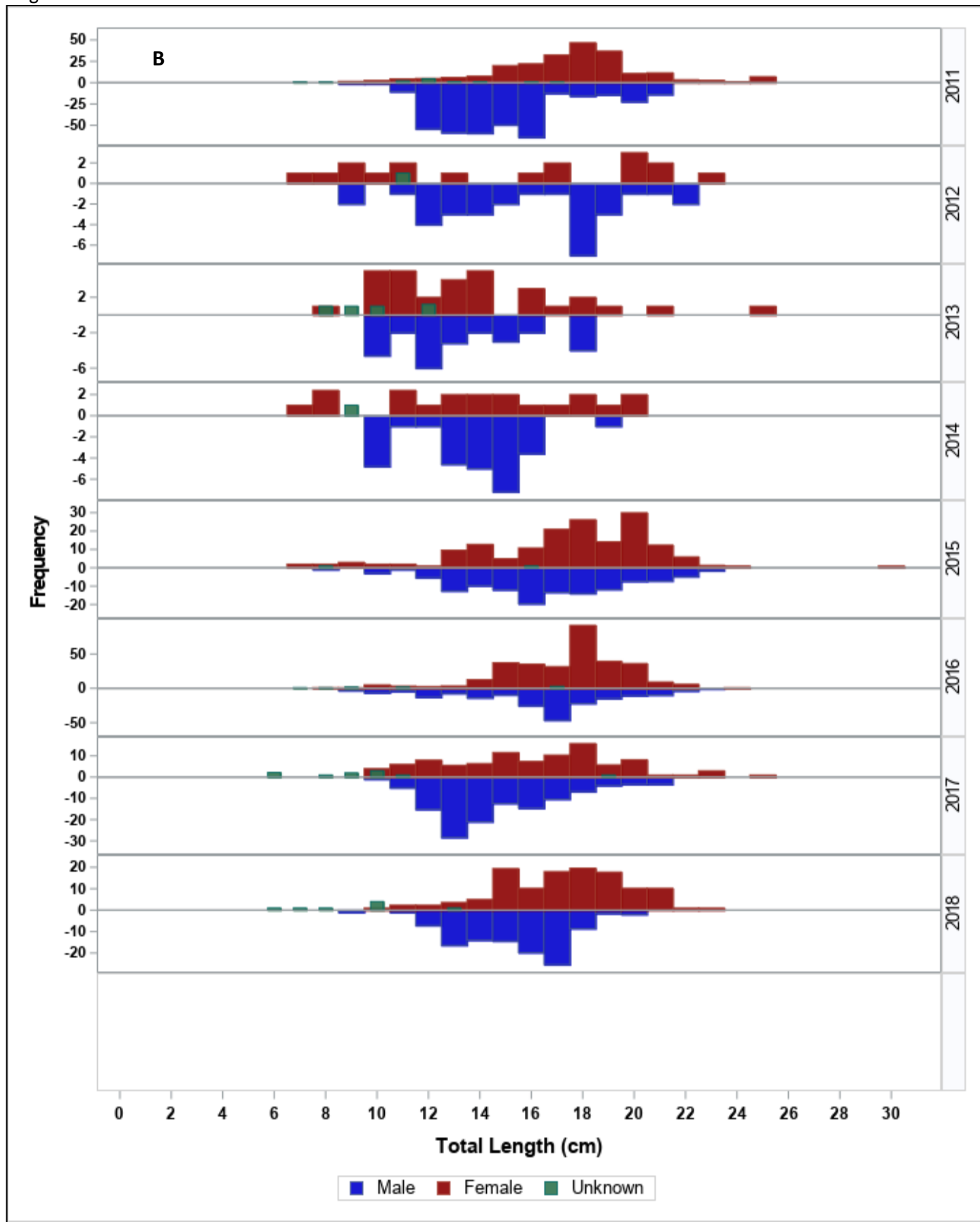


Figure 35. Diet composition, expressed as percent by weight (A) and percent by number (B) of Northern Puffer collected during ChesMMAP cruises in 2002-2018 combined.

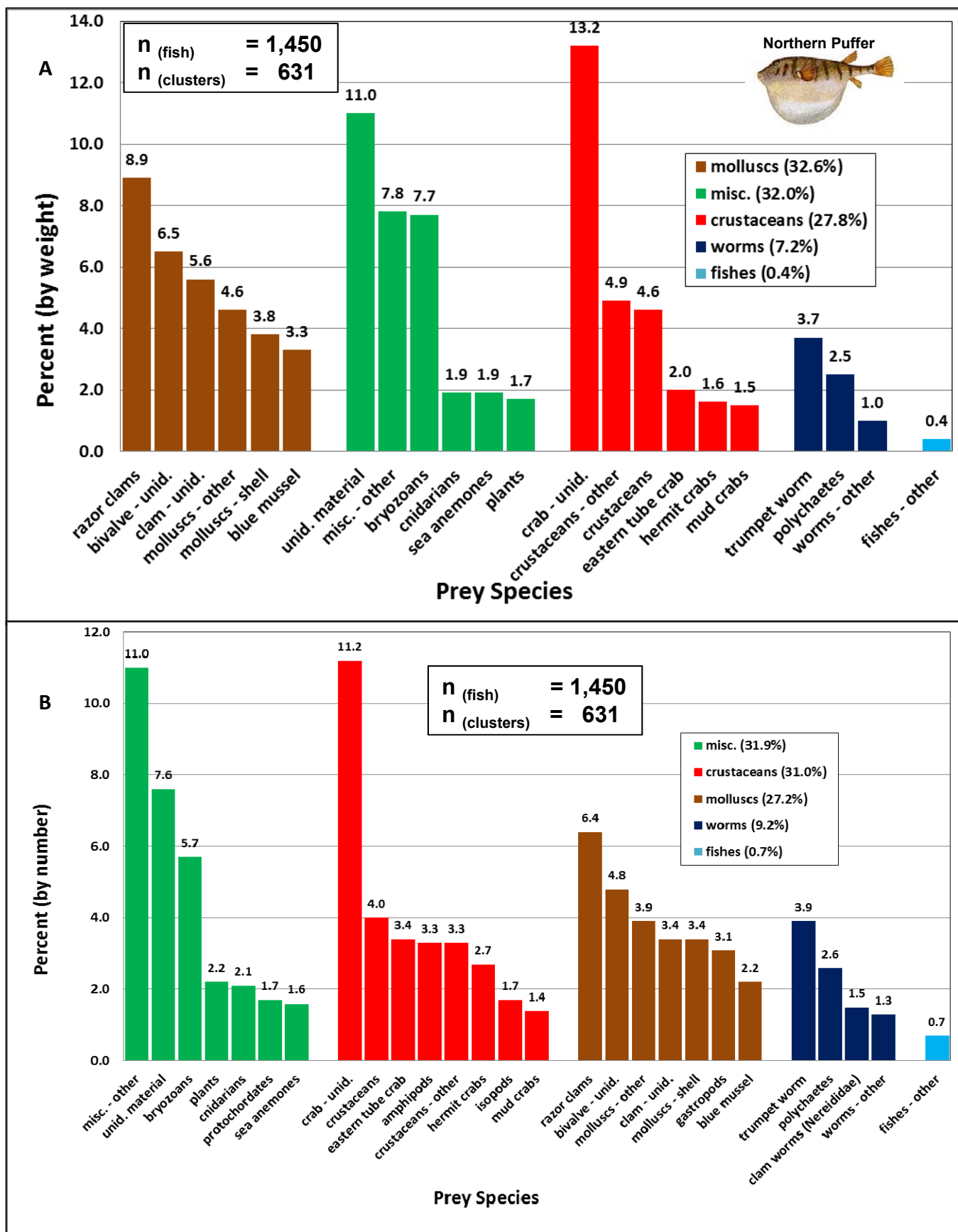


Table 23. Scup sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	107	7.8	30.0	84	40	40	39	34
2003	192	11.1	31.7	192	100	100	99	90
2004	475	26.0	50.0	475	155	155	150	142
2005	674	30.6	46.2	674	86	86	85	83
2006	317	12.7	45.7	317	115	115	112	111
2007	211	6.5	62.9	211	128	128	121	119
2008	56	4.1	16.7	56	42	0	42	42
2009	201	6.6	44.4	201	97	0	92	91
2010	853	29.2	51.9	653	126	0	125	123
2011	72	2.7	24.5	72	56	0	51	51
2012	12	0.4	7.7	12	12	0	12	12
2013	49	1.8	15.1	49	28	28	25	24
2014	63	2.6	13.0	63	26	26	19	19
2015	988	45.6	37.0	988	186	185	88	87
2016	65	2.0	14.8	65	40	40	20	20
2017	25	0.4	7.4	25	20	20	12	12
2018	386	12.2	29.6	386	94	94	58	58

Figure 36. Abundance (kg per hectare swept) of Scup in Chesapeake Bay, 2018.

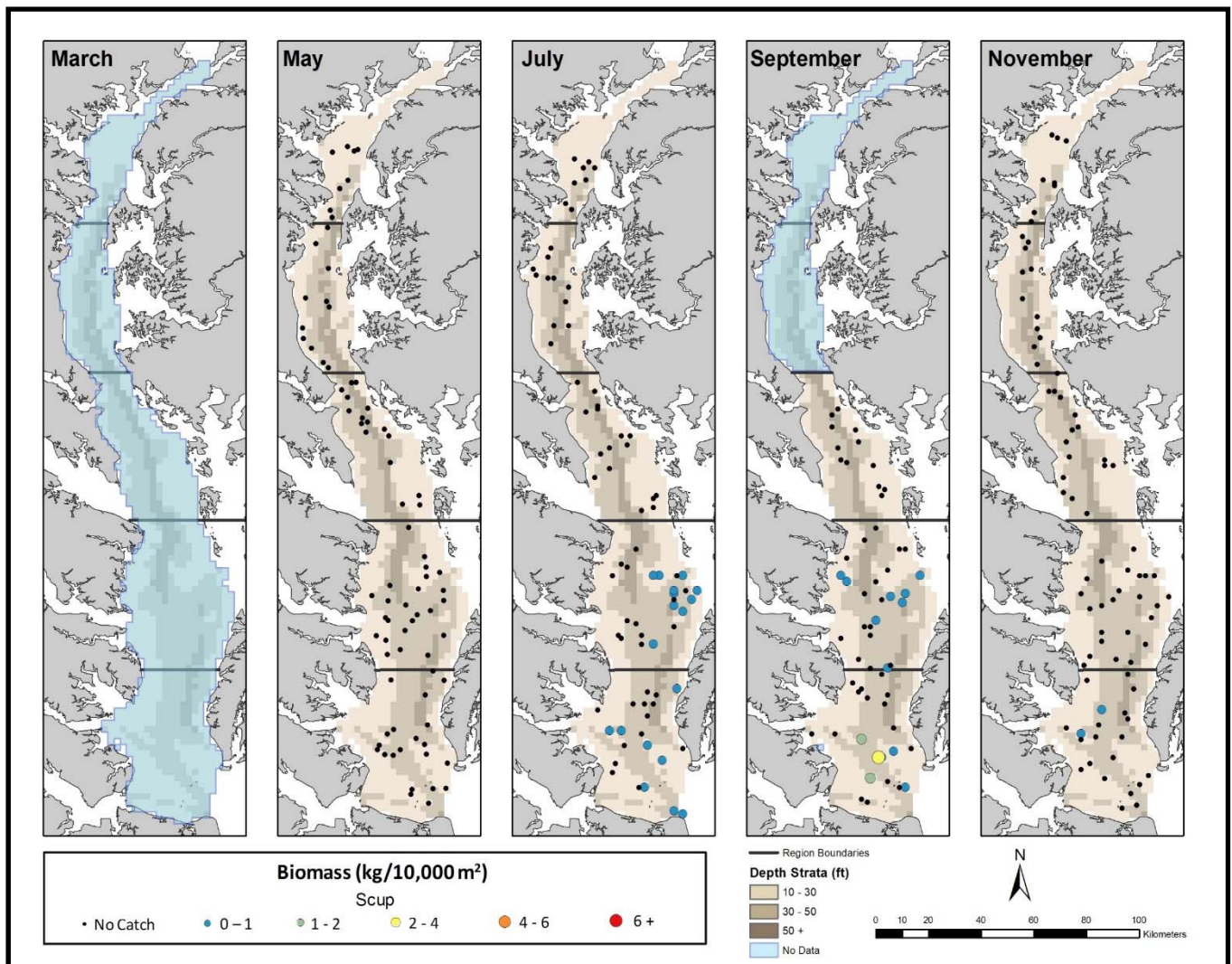


Table 24. Months, latitudinal regions, and depth strata used for Scup index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 25. Scup geometric mean indices of abundance, by number and biomass, overall and by age-class.

Year	Age	n	Numerical Index			Biomass Index			Age	n	Numerical Index			Biomass Index			Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI			LCI	Index	UCI	LCI	Index	UCI			LCI	Index	UCI	LCI	Index	UCI
2002	All	106	0.7	1.5	2.7	0.3	0.5	0.9	0	106	0.0	0.2	0.5	0.0	0.1	0.2	1	106	0.6	1.2	2.1	0.2	0.4	0.6
2003		127	1.3	2.5	4.3	0.5	0.9	1.3	0	127	0.9	1.8	2.9	0.3	0.5	0.8	1	127	1.1	2.0	3.2	0.3	0.6	0.9
2004		109	4.2	7.5	13.0	1.3	2.1	3.1	0	109	0.4	0.8	1.2	0.1	0.2	0.3	1	109	3.3	5.9	9.8	1.0	1.5	2.3
2005		112	1.9	3.7	6.8	0.6	1.2	1.9	0	112	1.0	2.1	3.9	0.4	0.7	1.3	1	112	1.5	2.8	5.0	0.4	0.8	1.3
2006		103	2.7	5.4	10.2	0.7	1.3	2.0	0	103	0.7	1.6	3.1	0.3	0.6	1.0	1	103	2.3	4.5	8.2	0.6	1.0	1.5
2007		76	5.4	11.0	21.5	0.9	1.6	2.5	0	76	0.2	0.6	1.2	0.1	0.2	0.4	1	76	4.9	9.9	19.1	0.8	1.4	2.1
2008		117	0.3	0.8	1.4	0.1	0.3	0.5	0	117	0.1	0.3	0.5	0.0	0.1	0.2	1	117	0.3	0.7	1.3	0.1	0.3	0.5
2009		117	1.7	3.2	5.5	0.5	0.8	1.2	0	117	0.3	0.7	1.4	0.1	0.3	0.4	1	117	1.4	2.6	4.5	0.4	0.6	0.9
2010		117	3.2	6.1	11.0	0.9	1.5	2.3	0	117	0.9	2.1	3.9	0.4	0.8	1.3	1	117	2.6	4.7	8.1	0.7	1.1	1.6
2011		116	1.0	2.0	3.4	0.3	0.5	0.7	0	116	0.2	0.6	1.1	0.1	0.2	0.3	1	116	0.9	1.7	2.9	0.2	0.4	0.5
2012		111	0.0	0.2	0.5	0.0	0.1	0.2	0	111	0.0	0.0	0.0	0.0	0.0	0.0	1	111	0.0	0.2	0.5	0.0	0.1	0.1
2013		116	0.2	0.6	1.2	0.1	0.2	0.4	0	116	0.1	0.4	0.9	0.0	0.2	0.3	1	116	0.2	0.5	0.9	0.0	0.1	0.2
2014		117	0.2	0.6	1.1	0.1	0.2	0.4	0	117	0.1	0.4	0.8	0.0	0.2	0.3	1	117	0.1	0.5	0.9	0.0	0.1	0.3
2015		117	4.0	7.8	14.5	1.1	1.9	2.9	0	117	1.0	2.1	3.8	0.4	0.8	1.3	1	117	3.3	6.3	11.3	0.9	1.4	2.2
2016		117	0.2	0.7	1.2	0.1	0.2	0.4	0	117	0.0	0.2	0.4	0.0	0.1	0.1	1	117	0.2	0.6	1.1	0.1	0.2	0.3
2017		117	0.0	0.3	0.6	0.0	0.1	0.2	0	117	0.0	0.0	0.1	0.0	0.0	0.0	1	117	0.0	0.3	0.6	0.0	0.1	0.1
2018		117	1.9	3.6	6.5	0.4	0.7	1.1	0	117	0.4	1.0	1.9	0.1	0.3	0.6	1	117	1.5	2.9	5.0	0.3	0.5	0.7
2019																								
2020																								

Figure 37. Scup geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

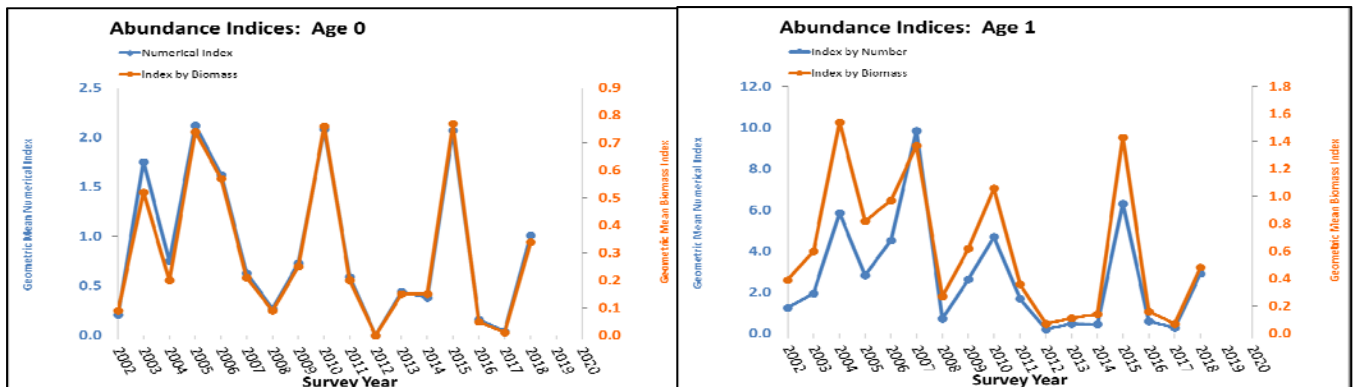
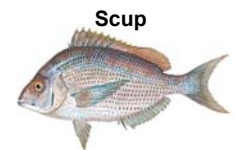
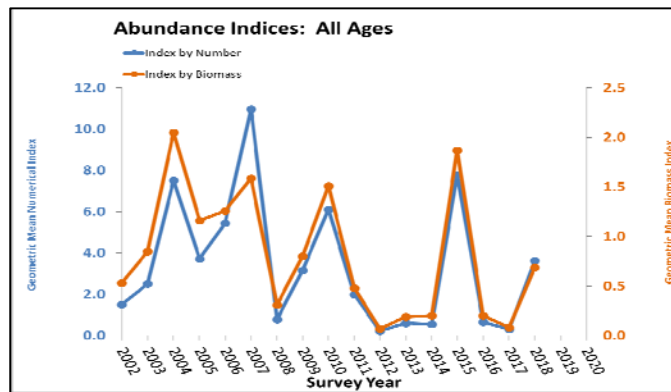


Figure 38. Scup length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

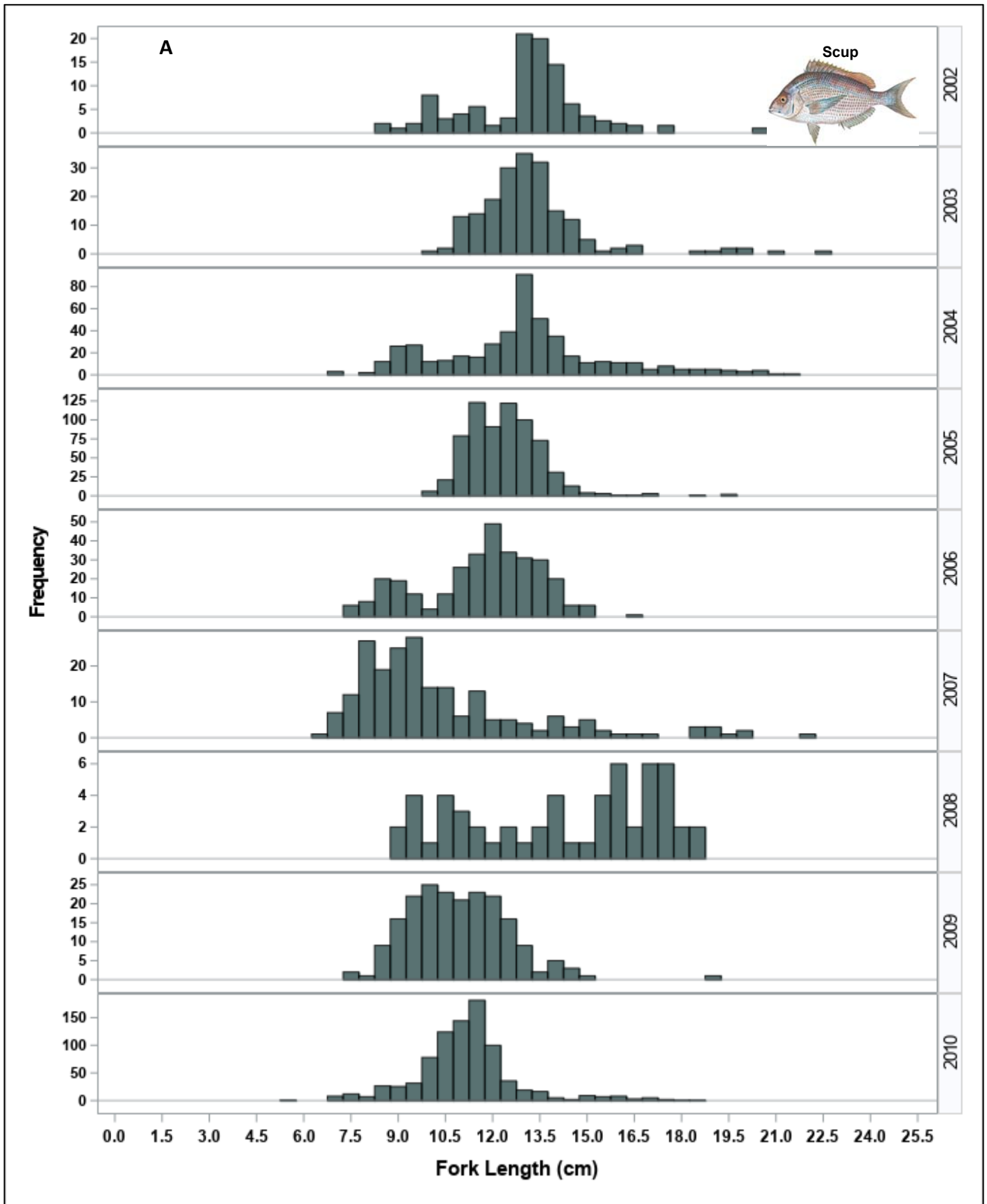


Figure 38. cont.

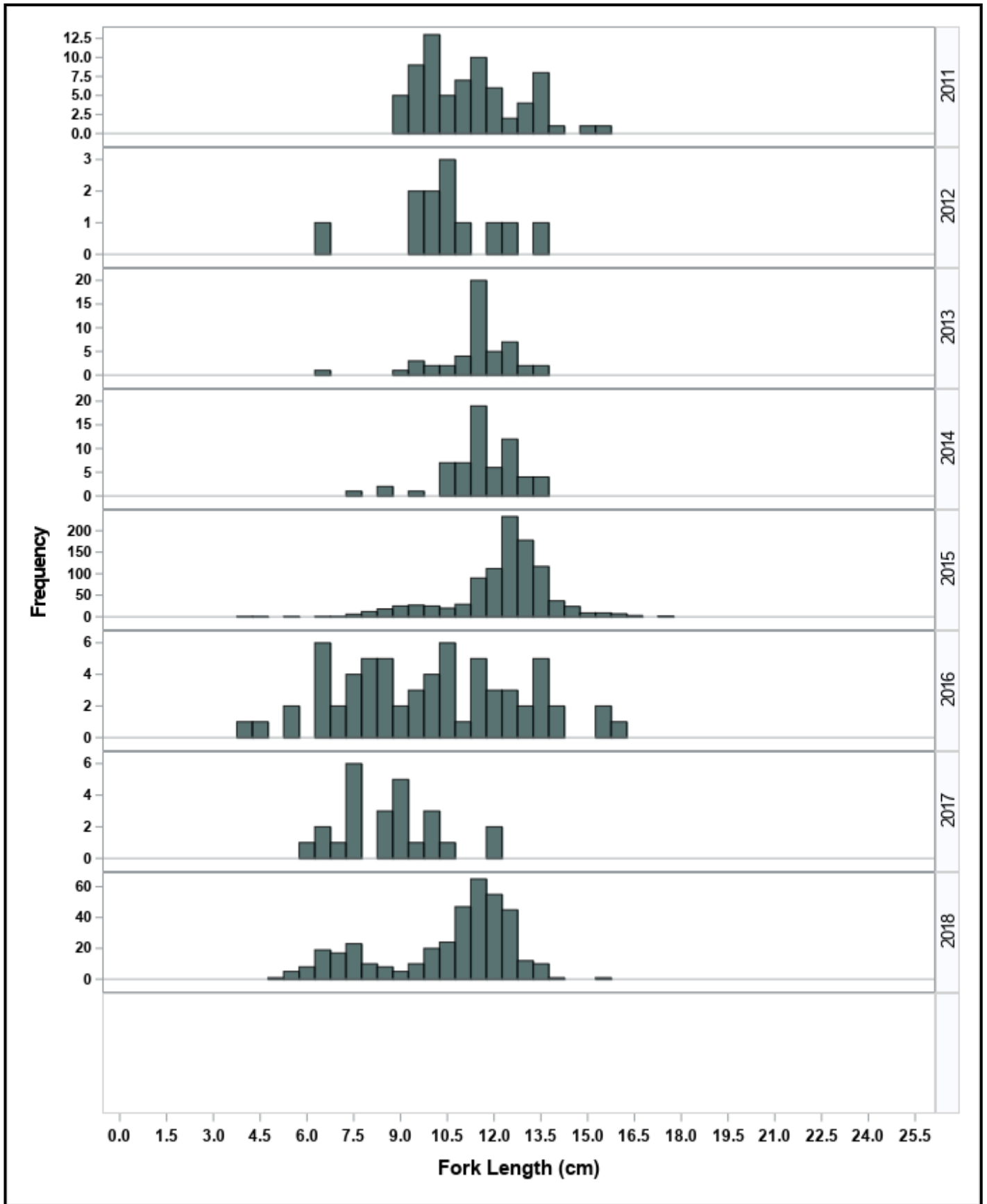


Figure 38. cont.

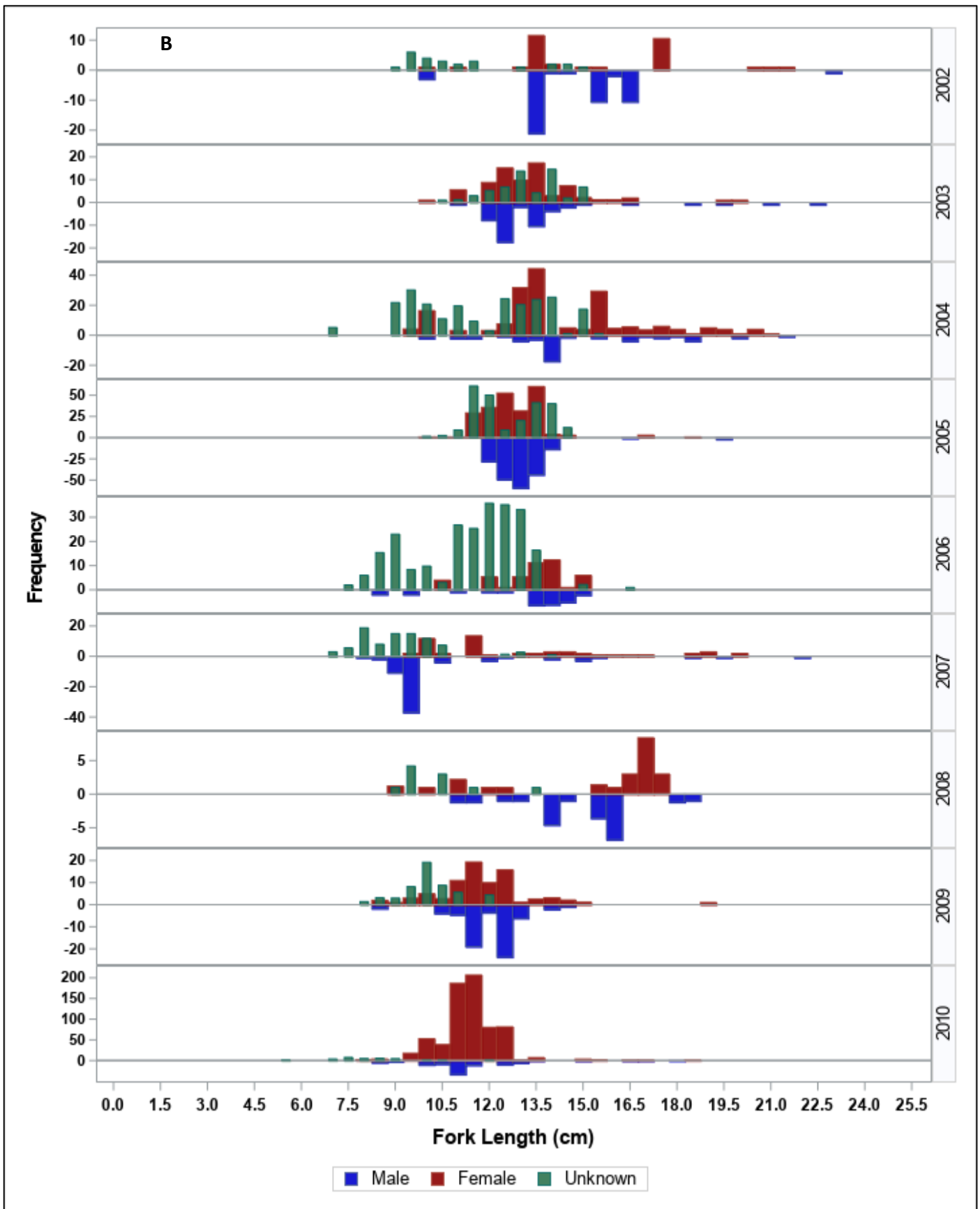


Figure 38. cont.

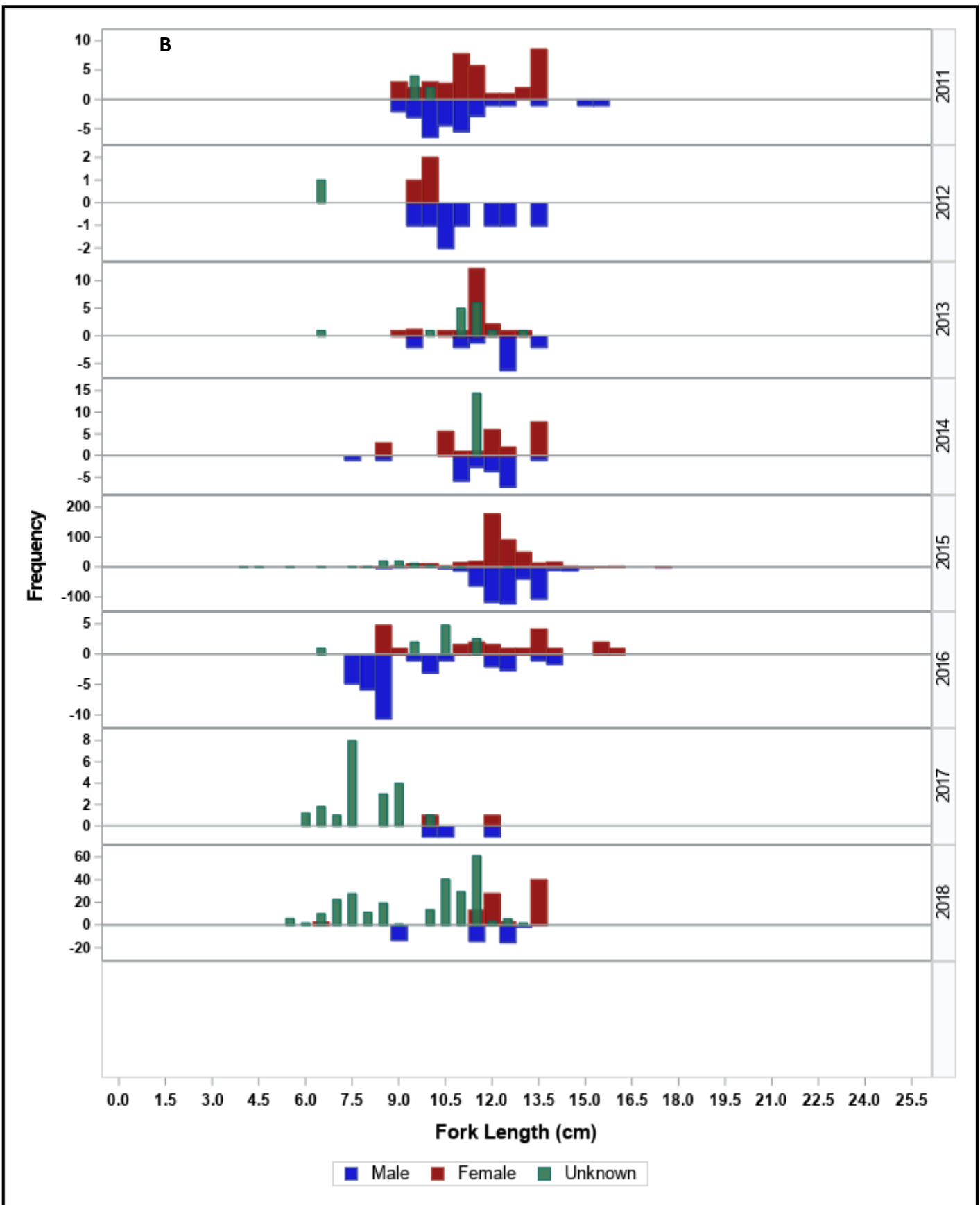


Figure 39. Scup age-frequency by year, 2002-2018.

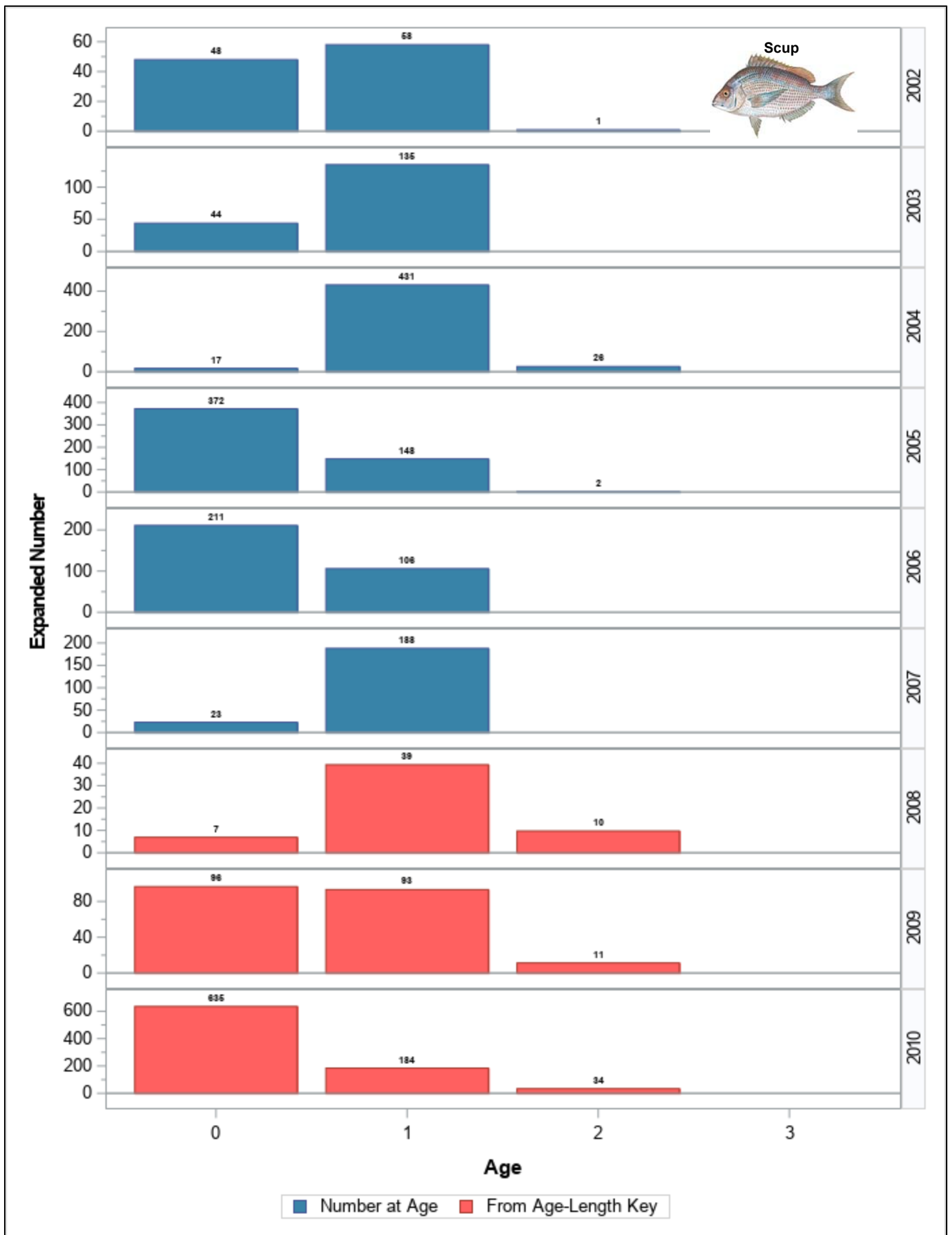


Figure 39. cont.

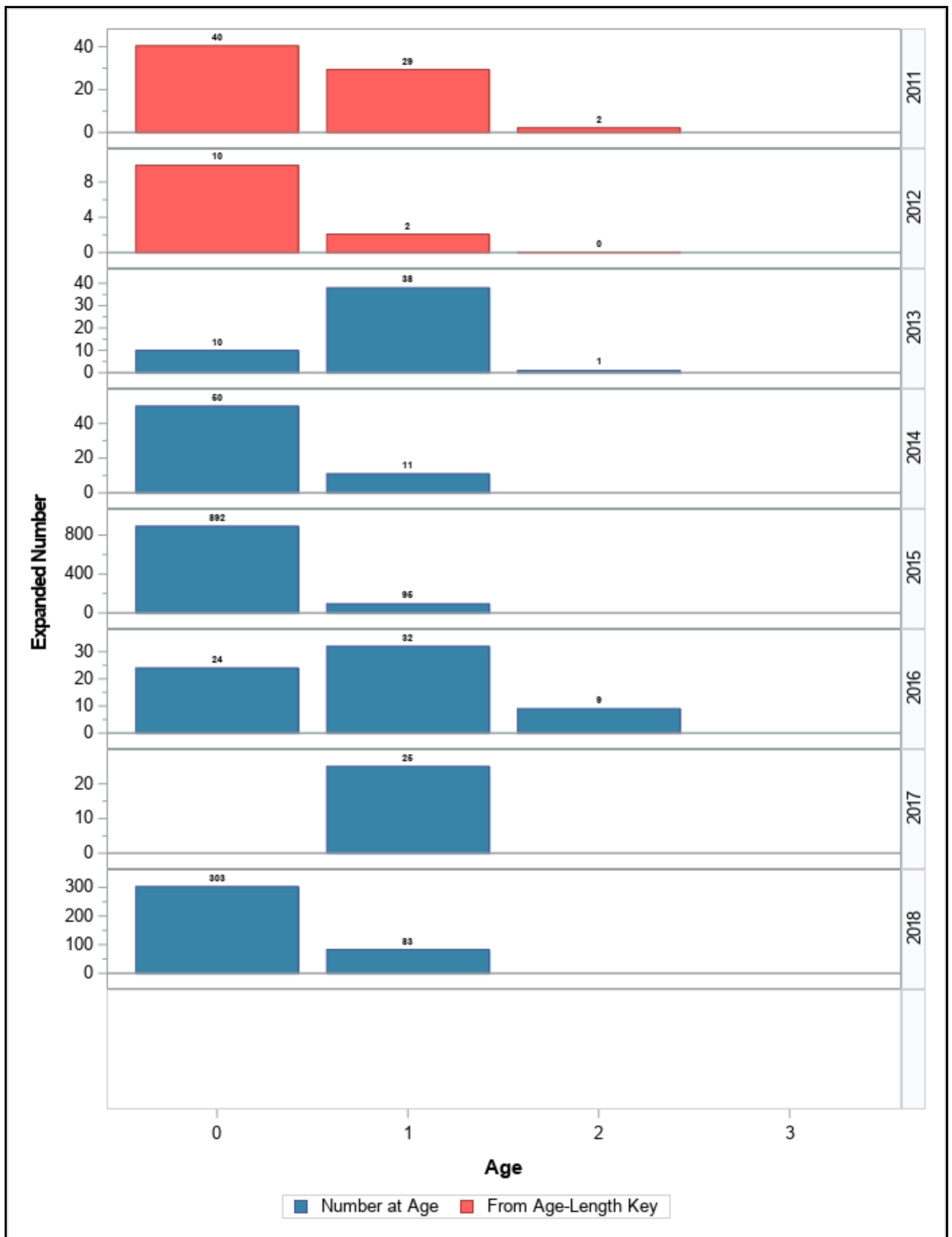


Figure 40. Scup age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

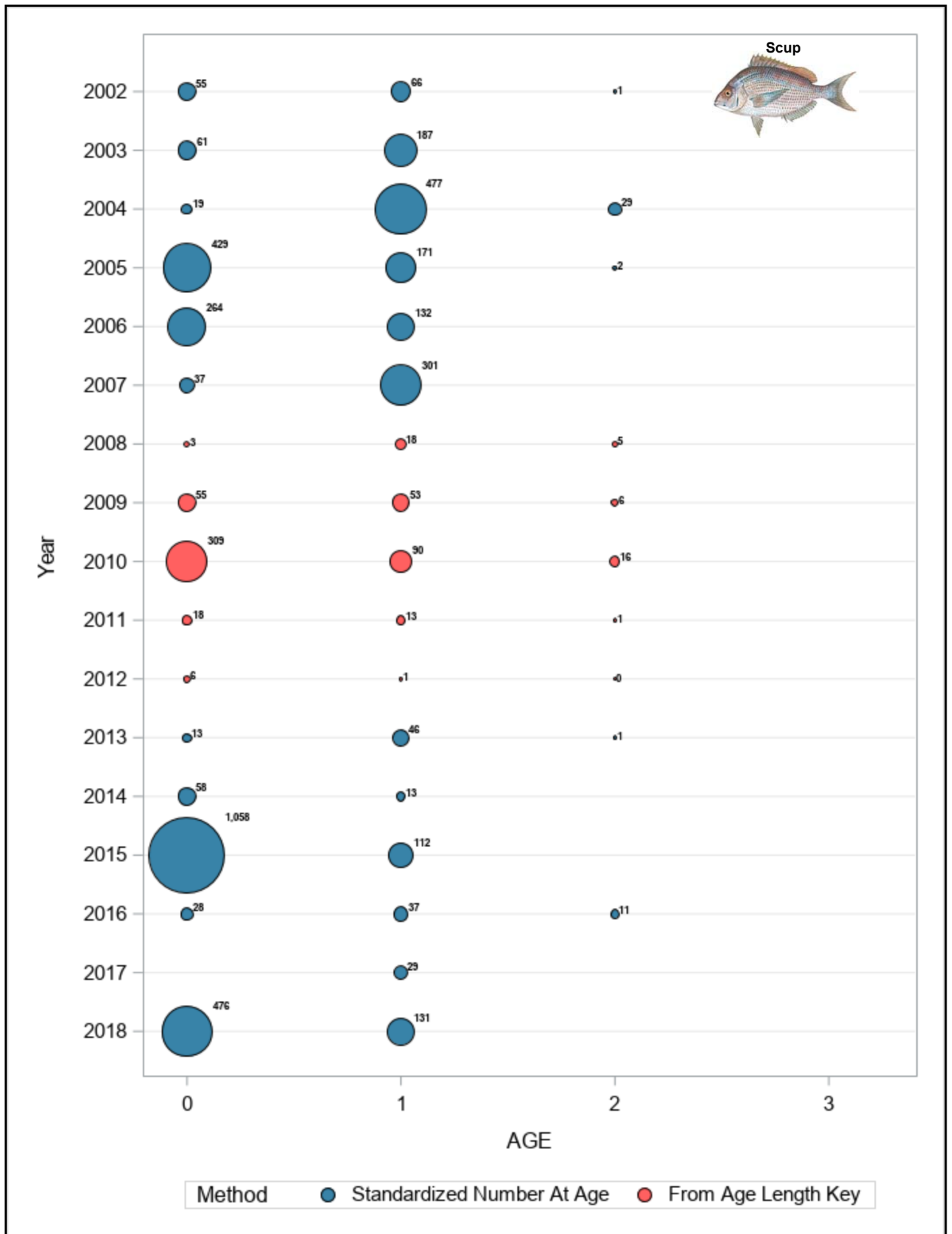


Figure 41. Scup age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

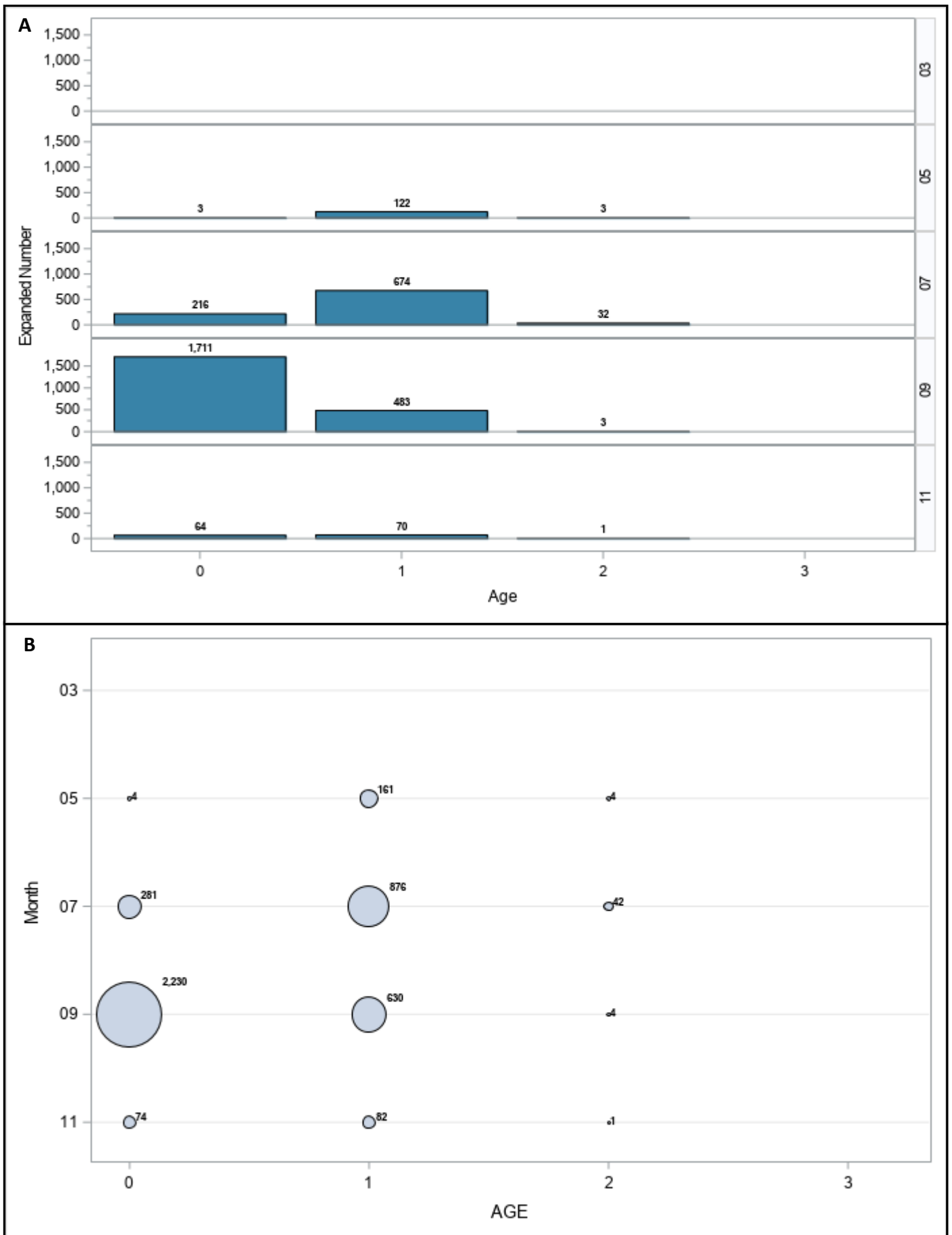


Figure 42. Diet composition, expressed as percent by weight (A) and percent by number (B) of Scup collected during ChesMMAP cruises in 2002-2018 combined.

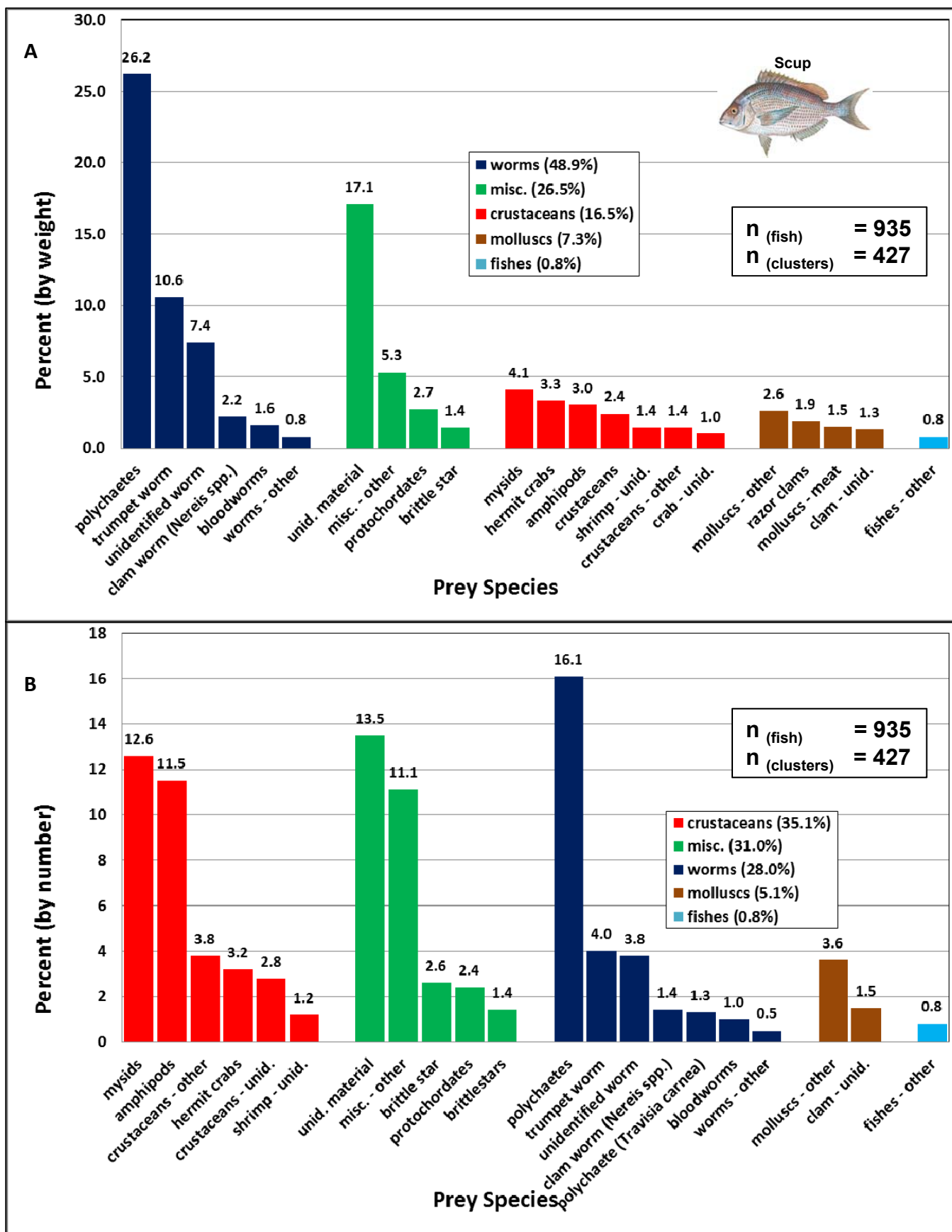


Table 26. Spot sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	3,122	443.2	9.2	3,034	672	666	647	19
2003	4,064	567.2	5.3	3,085	414	395	396	4
2004	4,131	419.6	3.6	4,089	619	619	578	18
2005	11,561	1,011.2	6.3	10,690	1,030	1,030	979	3
2006	7,080	700.4	7.7	6,439	680	656	632	7
2007	5,729	462.8	7.7	5,396	626	626	602	4
2008	6,256	417.5	6.3	5,197	785	785	742	735
2009	5,191	682.6	5.6	3,481	465	449	447	442
2010	6,744	255.3	2.4	6,336	687	687	652	623
2011	2,867	278.0	1.3	2,867	352	352	320	315
2012	2,161	114.5	6.3	1,758	345	345	259	253
2013	4,087	316.0	5.6	3,430	428	428	289	280
2014	939	117.3	5.0	939	188	188	89	88
2015	401	54.0	1.3	401	102	102	11	11
2016	1,059	67.2	1.9	835	167	167	43	40
2017	1,586	116.4	3.8	1,586	213	213	105	101
2018	1,635	77.0	0.0	1,635	204	204	101	99

Figure 43. Abundance (kg per hectare swept) of Spot in Chesapeake Bay, 2018.

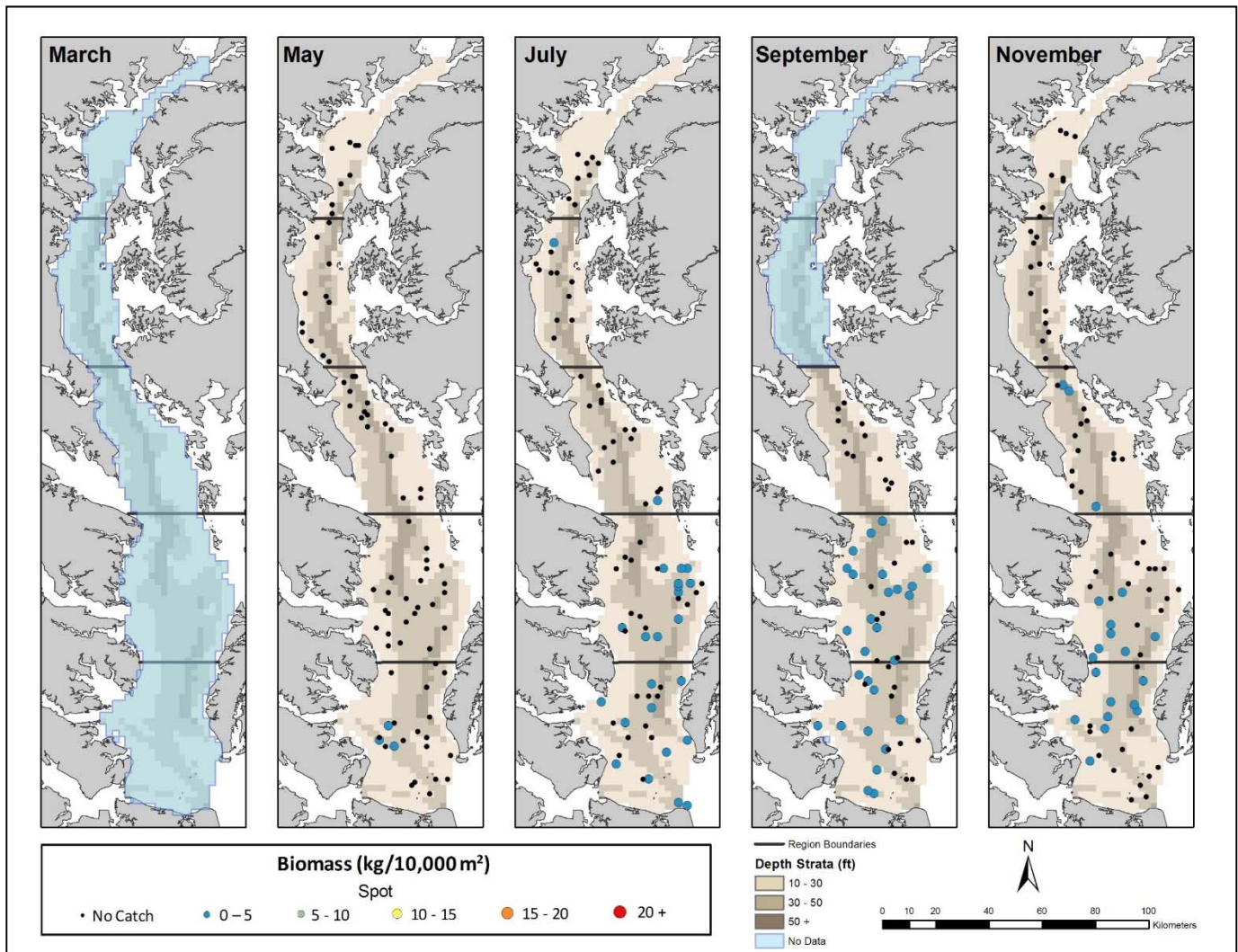


Table 27. Months, latitudinal regions, and depth strata used for Spot index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 28. Spot geometric mean indices of abundance, by number and biomass, overall and by age-class.

			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI	
2002	All	227	16.3	25.7	40.2	5.3	7.6	10.7		2002	1	227	6.0	9.3	14.3	2.3	3.4	6.5
2003		240	14.8	23.1	35.7	4.7	6.9	9.8		2003		240	4.2	6.8	10.7	2.0	3.1	7.3
2004		224	42.2	65.5	101.2	10.1	13.9	19.0		2004		224	5.9	9.2	14.2	2.4	3.5	12.2
2005		235	181.5	274.3	414.5	26.1	36.0	49.4		2005		235	11.0	17.6	27.7	4.3	6.3	29.4
2006		217	96.4	154.7	247.8	18.4	26.1	36.8		2006		217	15.8	25.5	40.7	4.9	7.1	21.2
2007		155	108.2	183.5	310.5	19.3	28.6	42.3		2007		155	7.3	13.7	25.1	3.0	5.1	32.8
2008		240	54.7	85.9	134.8	9.7	13.4	18.5		2008		240	4.9	7.8	12.1	1.8	2.7	9.7
2009		238	23.3	36.6	57.4	7.2	10.4	14.7		2009		238	9.3	14.9	23.4	3.7	5.5	10.7
2010		204	62.4	104.2	173.8	7.8	10.8	14.8		2010		204	1.6	2.6	3.8	0.6	0.9	5.7
2011		236	9.1	14.0	21.3	3.6	5.2	7.2		2011		236	6.4	9.8	14.9	2.7	3.8	5.5
2012		231	5.6	9.0	14.3	1.7	2.4	3.4		2012		231	1.0	1.6	2.4	0.3	0.5	1.5
2013		239	12.8	20.1	31.3	3.9	5.6	7.8		2013		239	4.3	6.8	10.5	1.6	2.4	5.2
2014		240	2.4	3.8	5.8	1.2	1.8	2.5		2014		240	1.7	2.7	4.2	0.9	1.4	2.2
2015		240	0.9	1.5	2.3	0.5	0.8	1.1		2015		240	0.7	1.2	1.9	0.4	0.6	0.9
2016		240	2.8	4.4	6.7	1.1	1.6	2.2		2016		240	0.9	1.5	2.2	0.3	0.5	1.2
2017		239	3.2	5.3	8.4	1.4	2.1	3.0		2017		239	1.9	3.0	4.5	0.8	1.2	1.6
2018		217	4.2	6.4	9.6	1.4	2.0	2.7		2018		217	0.9	1.4	2.0	0.3	0.4	
2019										2019								
2020										2020								
2002	0	227	9.7	14.8	22.3	3.0	4.2	5.7		2002	2+	153	11.9	19.4	31.2	3.7	5.5	8.0
2003		240	7.4	10.9	15.9	2.3	3.2	4.3		2003		150	11.1	17.9	28.4	3.7	5.5	8.1
2004		224	26.9	41.1	62.5	6.1	8.2	11.0		2004		139	15.4	25.6	42.2	4.5	6.8	10.0
2005		235	111.7	167.3	250.3	13.4	18.0	24.0		2005		156	40.5	64.8	103.5	9.7	14.5	21.4
2006		217	60.7	95.0	148.4	10.9	15.1	20.7		2006		143	68.5	106.0	163.8	11.9	17.2	24.6
2007		155	46.4	76.8	126.8	7.5	10.7	15.1		2007		78	86.8	167.5	322.6	18.7	30.5	49.4
2008		240	39.7	61.2	94.0	6.8	9.1	12.1		2008		160	10.8	18.0	29.8	3.0	4.6	7.0
2009		238	13.0	19.4	28.6	3.7	5.1	6.9		2009		160	28.0	44.2	69.6	8.1	11.8	16.8
2010		204	54.9	91.8	153.2	6.5	9.0	12.3		2010		125	4.6	7.6	12.2	1.0	1.6	2.3
2011		236	5.5	8.0	11.5	2.1	2.8	3.8		2011		158	17.8	27.0	40.7	5.4	7.5	10.2
2012		231	5.3	8.4	13.2	1.6	2.2	3.1		2012		159	1.7	3.0	4.8	0.5	0.9	1.3
2013		239	9.2	13.9	20.8	2.7	3.7	4.9		2013		160	10.2	17.0	28.0	2.9	4.5	6.7
2014		240	1.4	2.0	2.9	0.6	0.8	1.1		2014		160	3.5	5.6	8.7	1.6	2.4	3.4
2015		240	0.6	0.9	1.4	0.2	0.4	0.6		2015		160	1.2	2.1	3.4	0.5	0.9	1.4
2016		240	2.6	4.1	6.1	1.0	1.4	2.0		2016		160	1.8	2.9	4.5	0.6	0.9	1.3
2017		239	2.8	4.6	7.1	1.2	1.8	2.5		2017		159	4.2	6.8	10.8	1.4	2.1	3.0
2018		217	4.1	6.2	9.3	1.4	1.9	2.6		2018		137	2.3	3.7	5.8	0.6	1.0	1.4
2019										2019								
2020										2020								

Figure 44. Spot geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

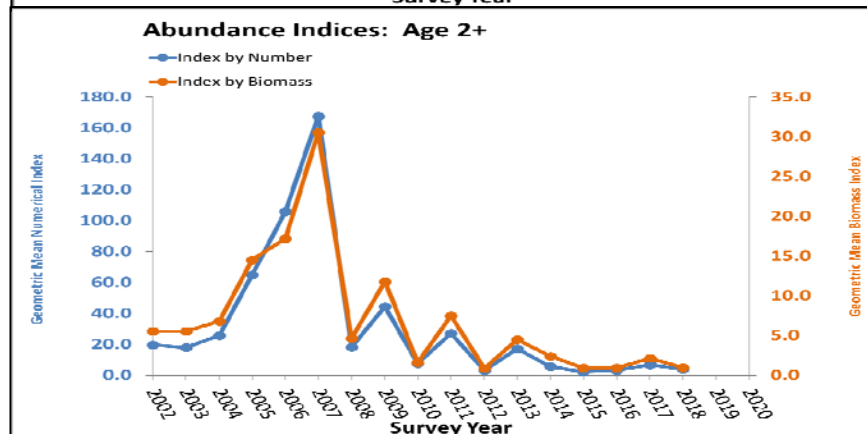
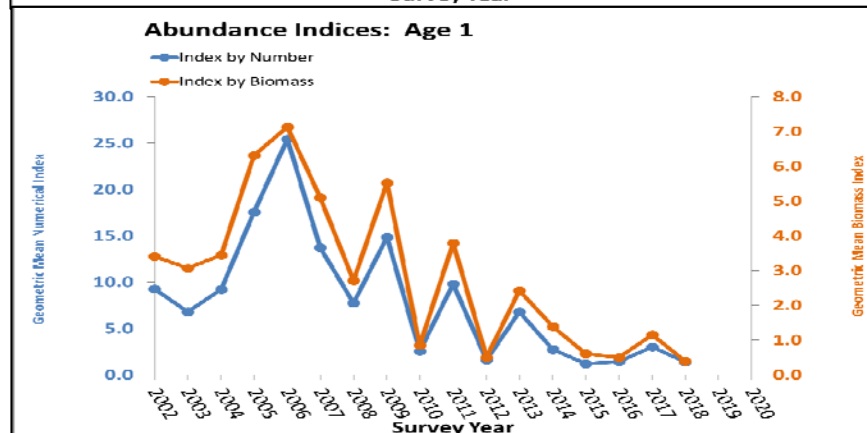
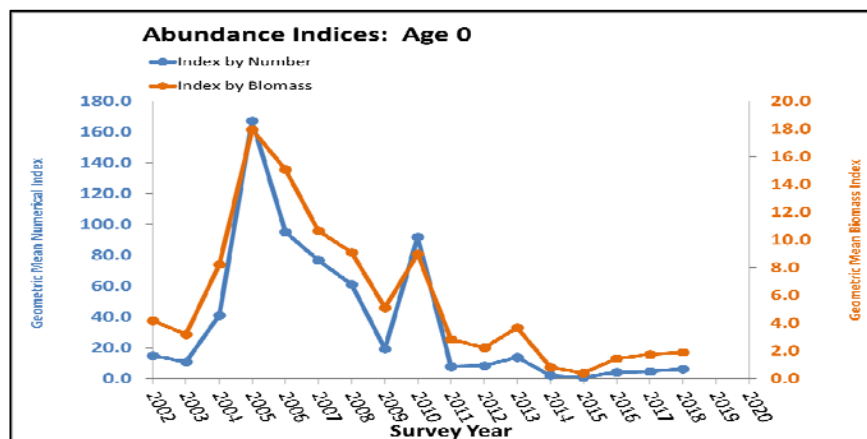
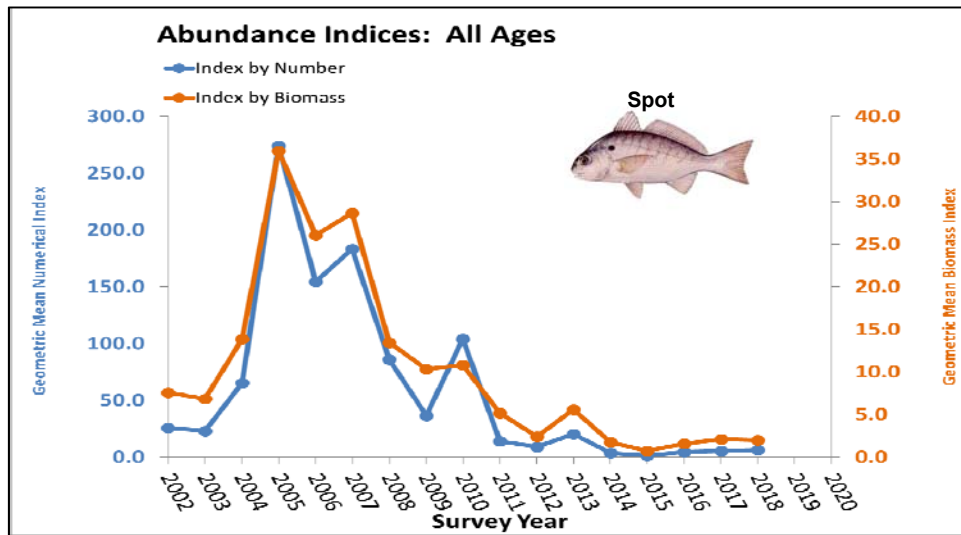


Figure 45. Spot length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

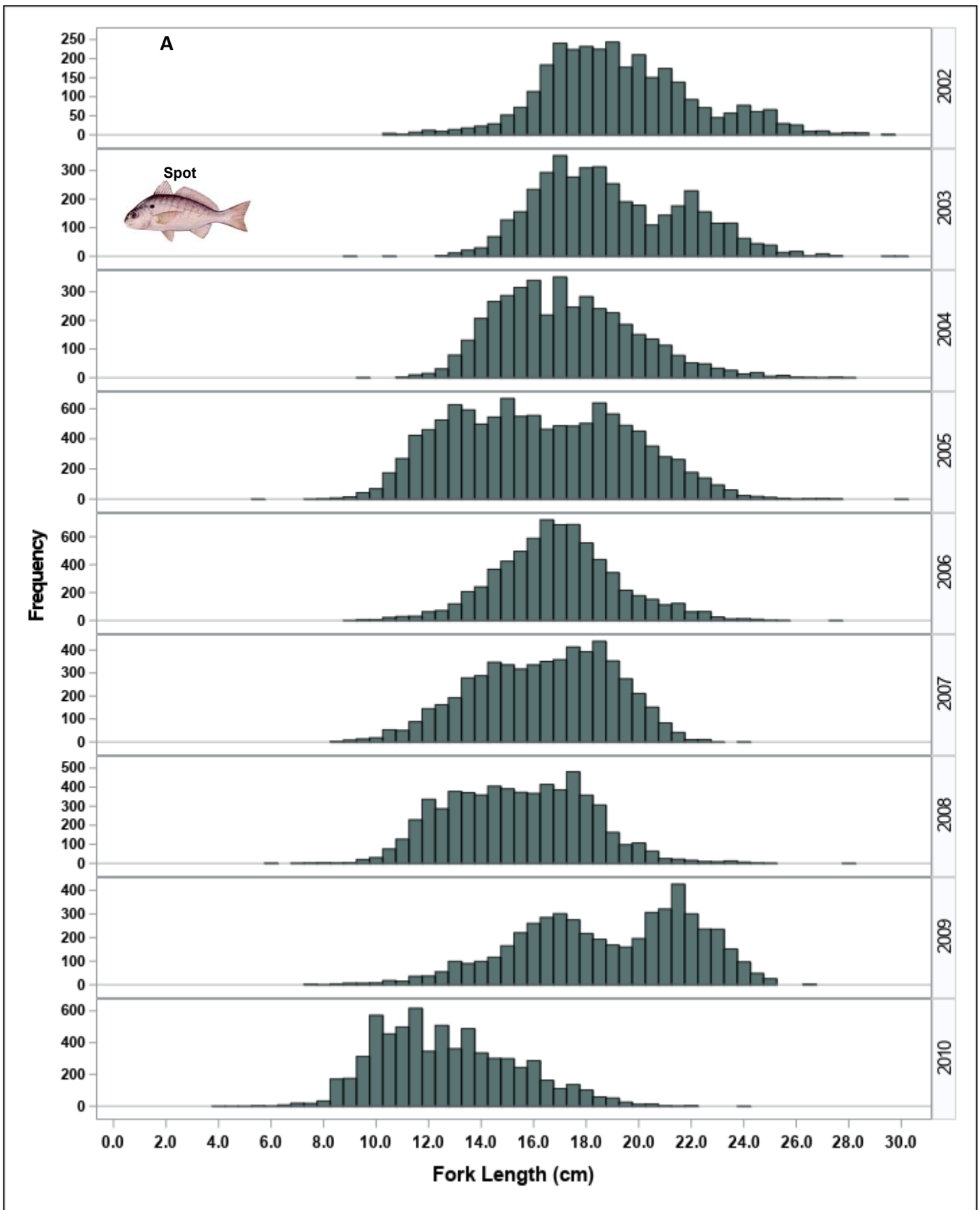


Figure 45. cont.

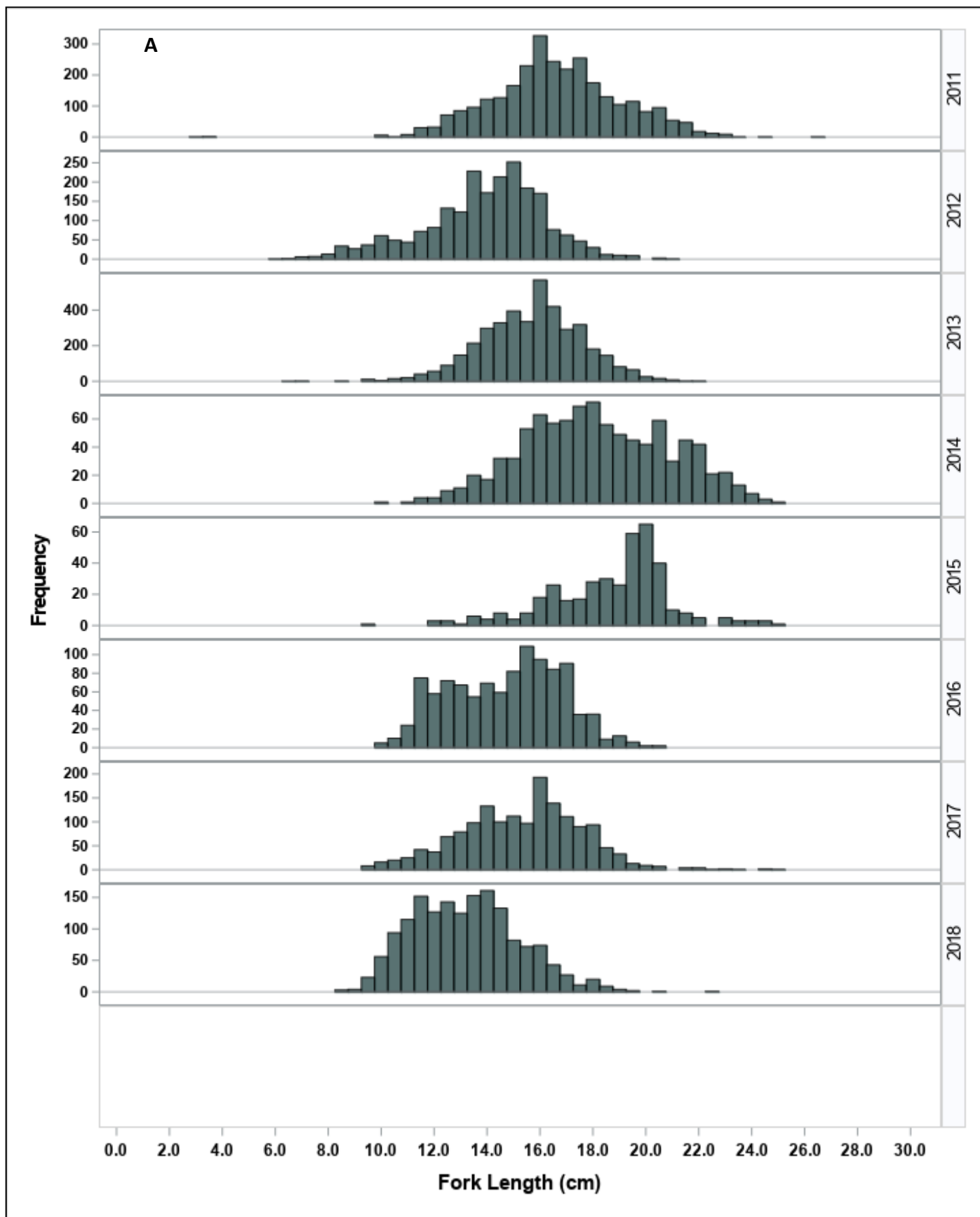


Figure 45. cont.

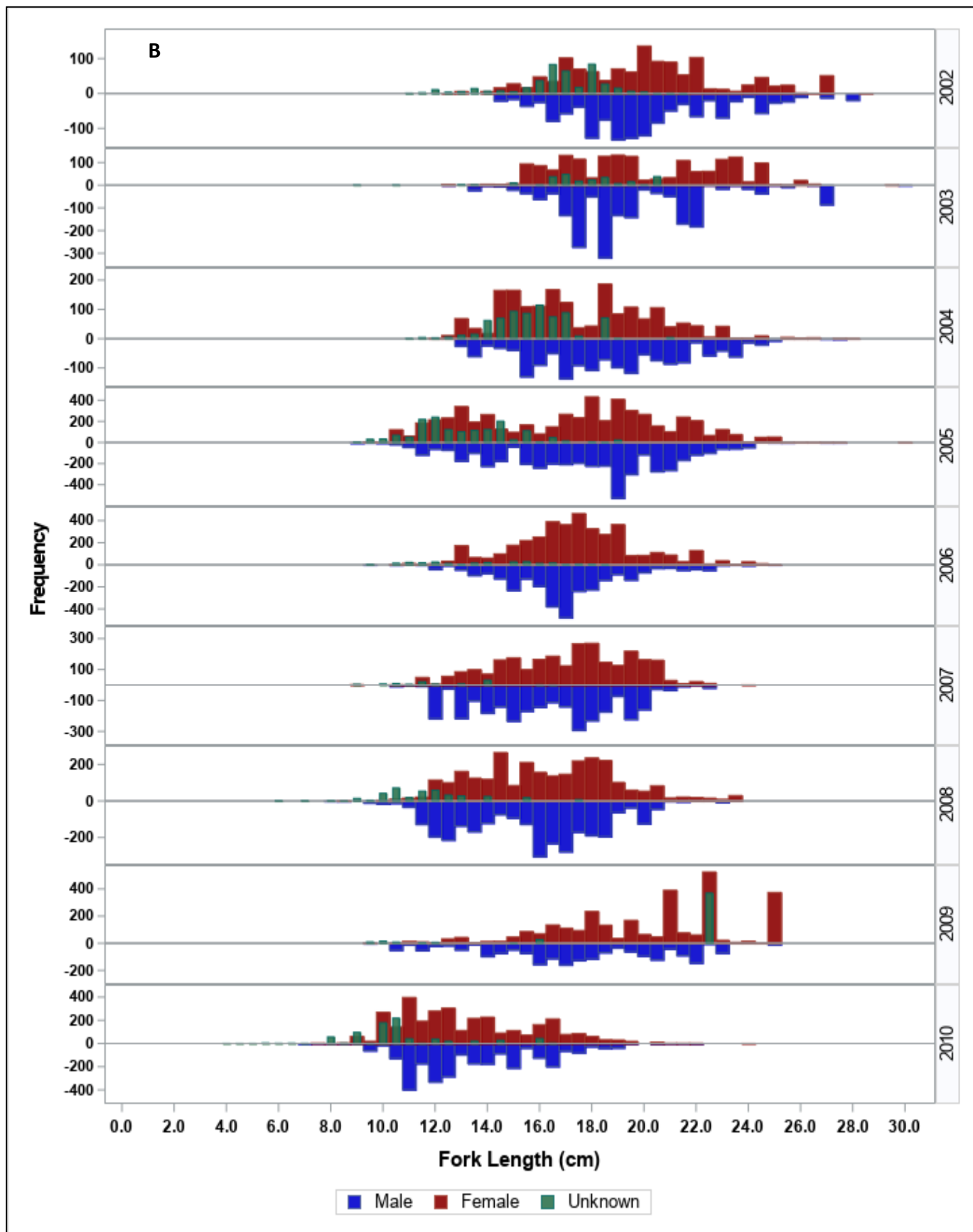


Figure 45. cont.

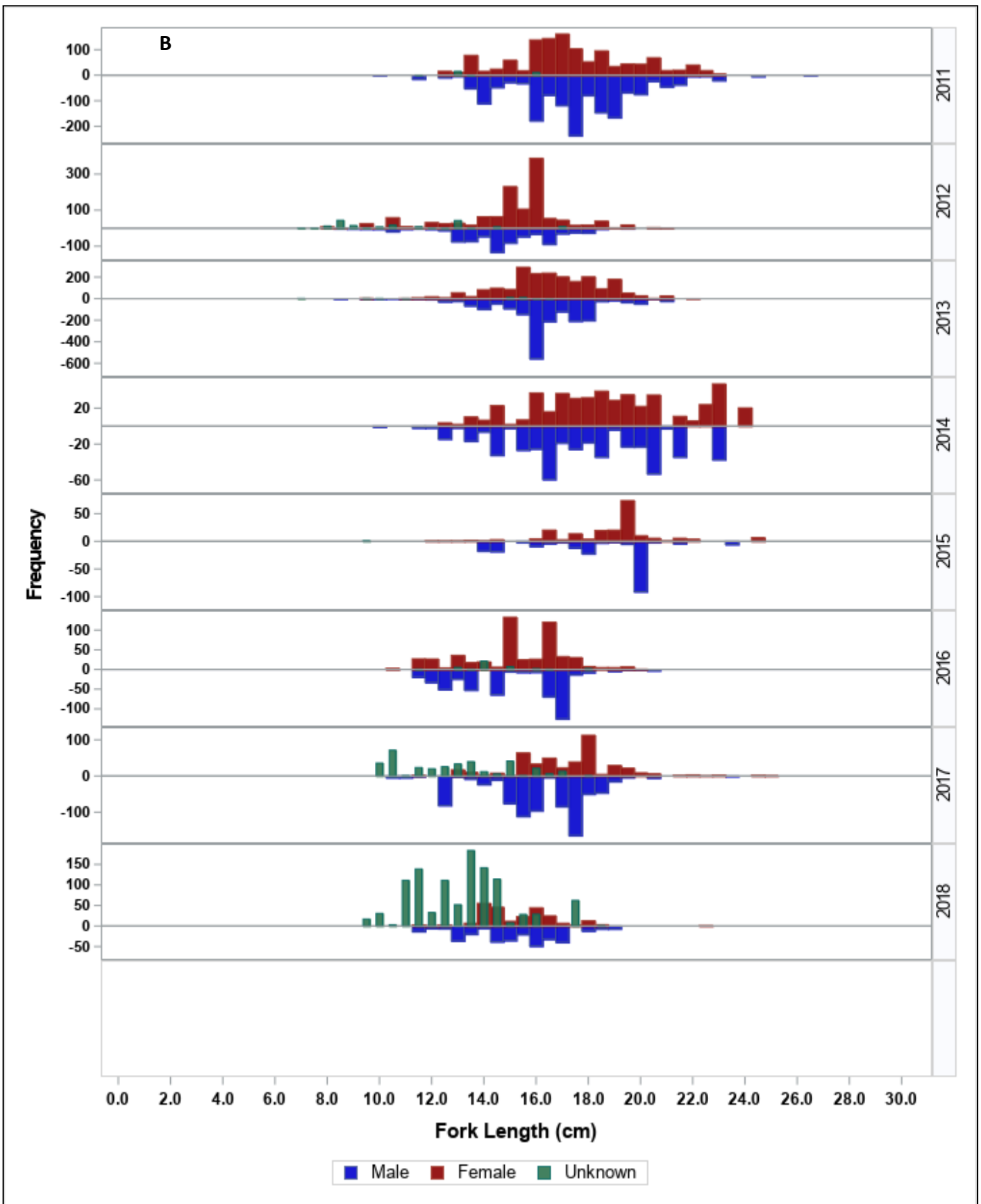


Figure 46. Spot age-frequency by year, 2002-2018.

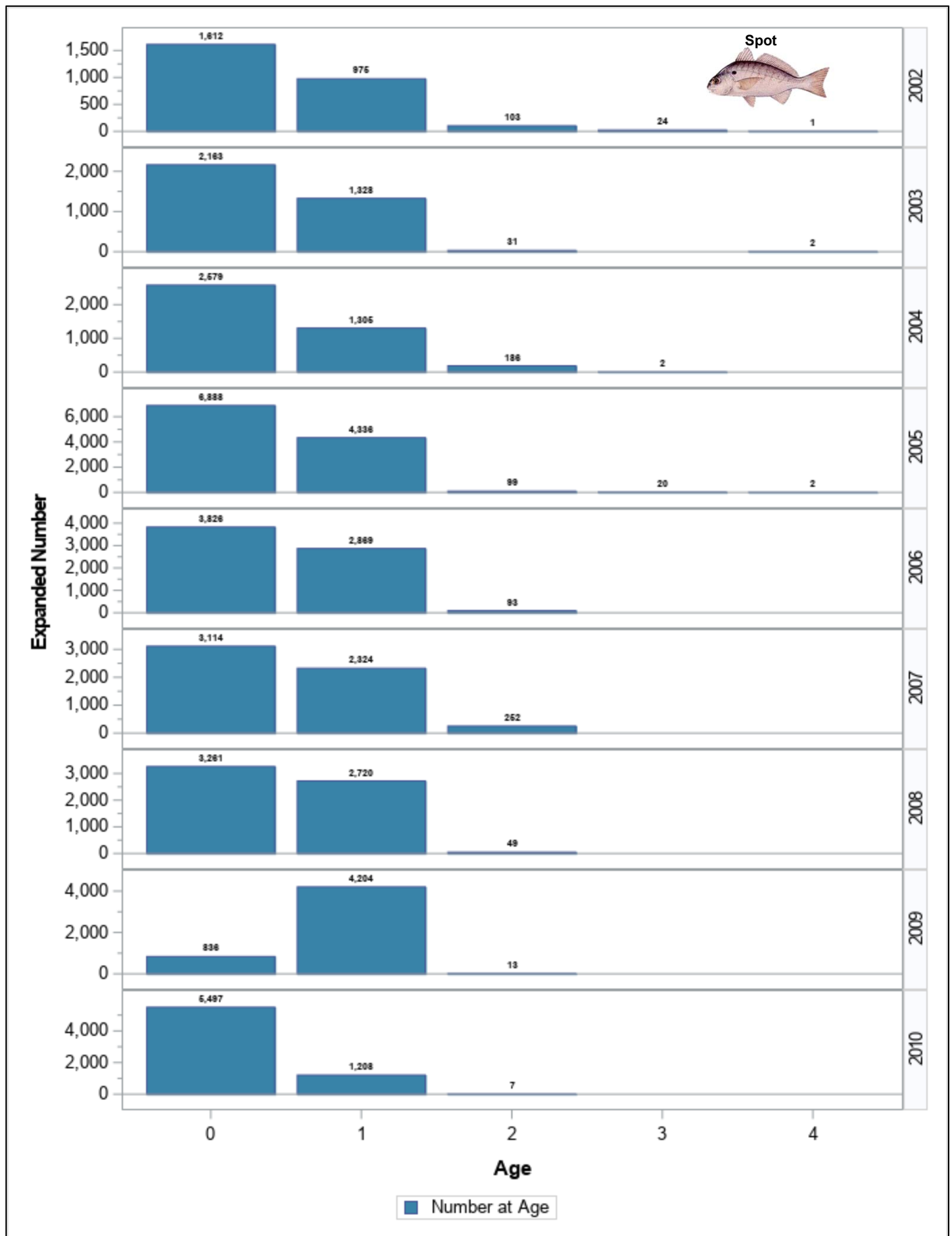


Figure 46. cont.

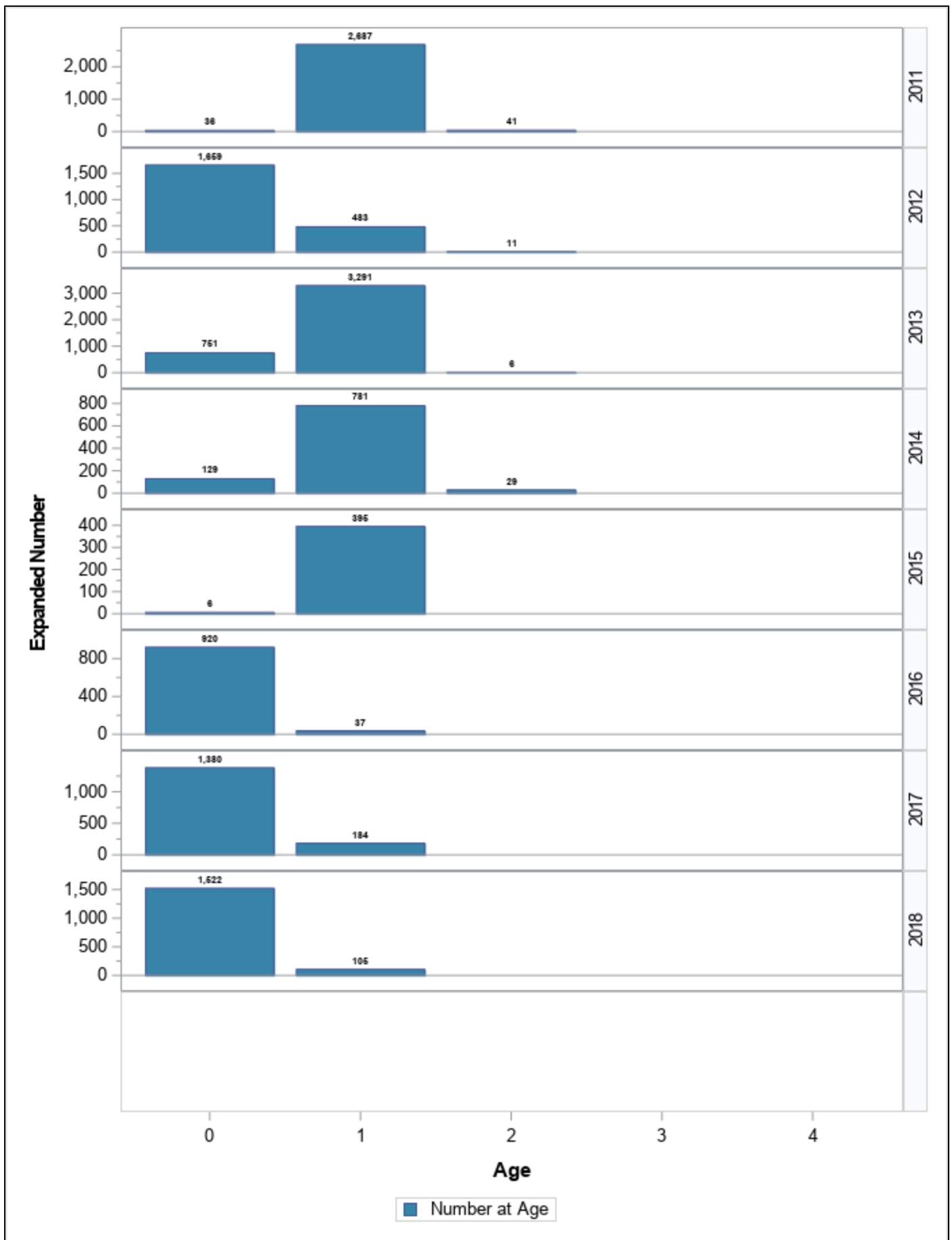


Figure 47. Spot age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

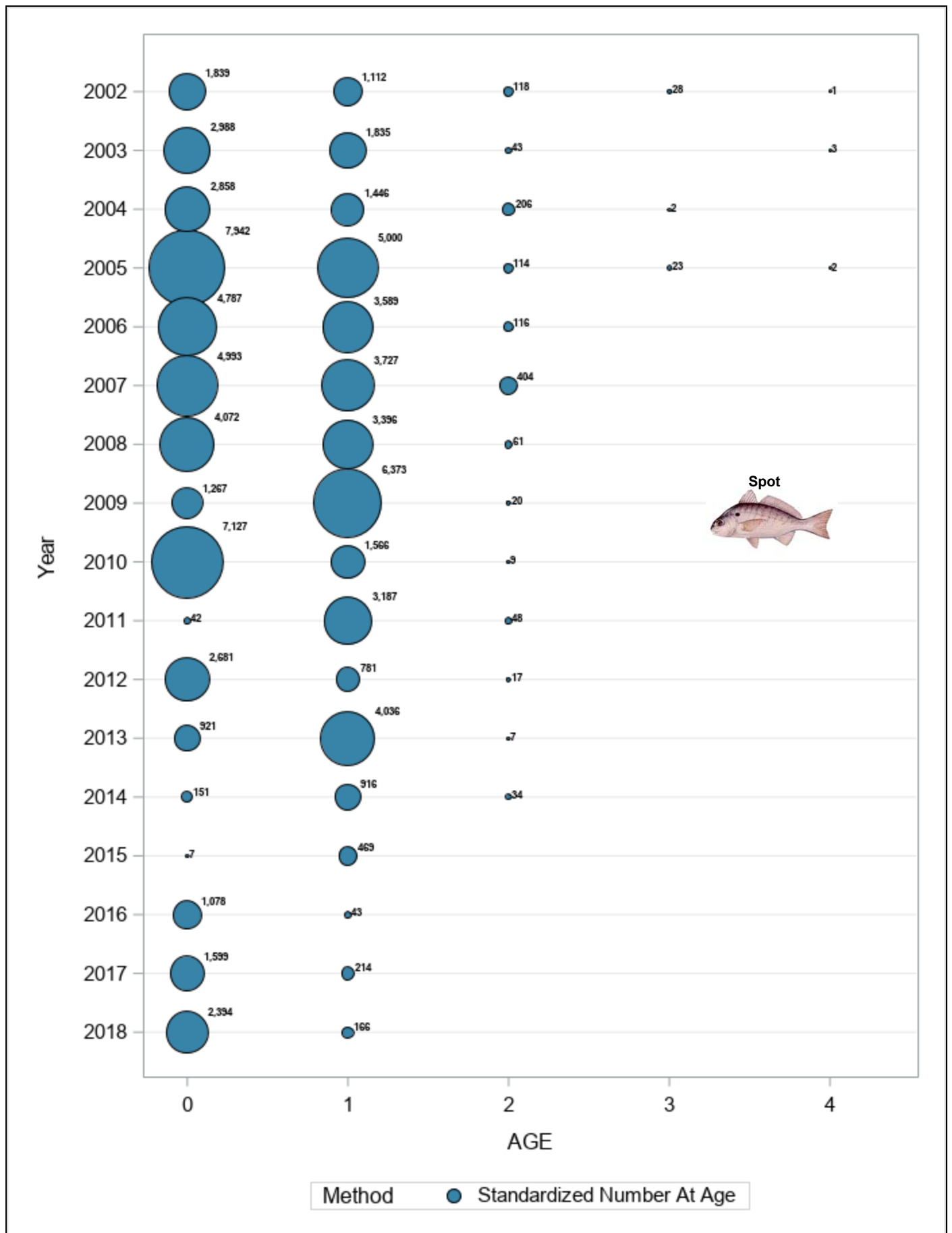


Figure 48. Spot age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

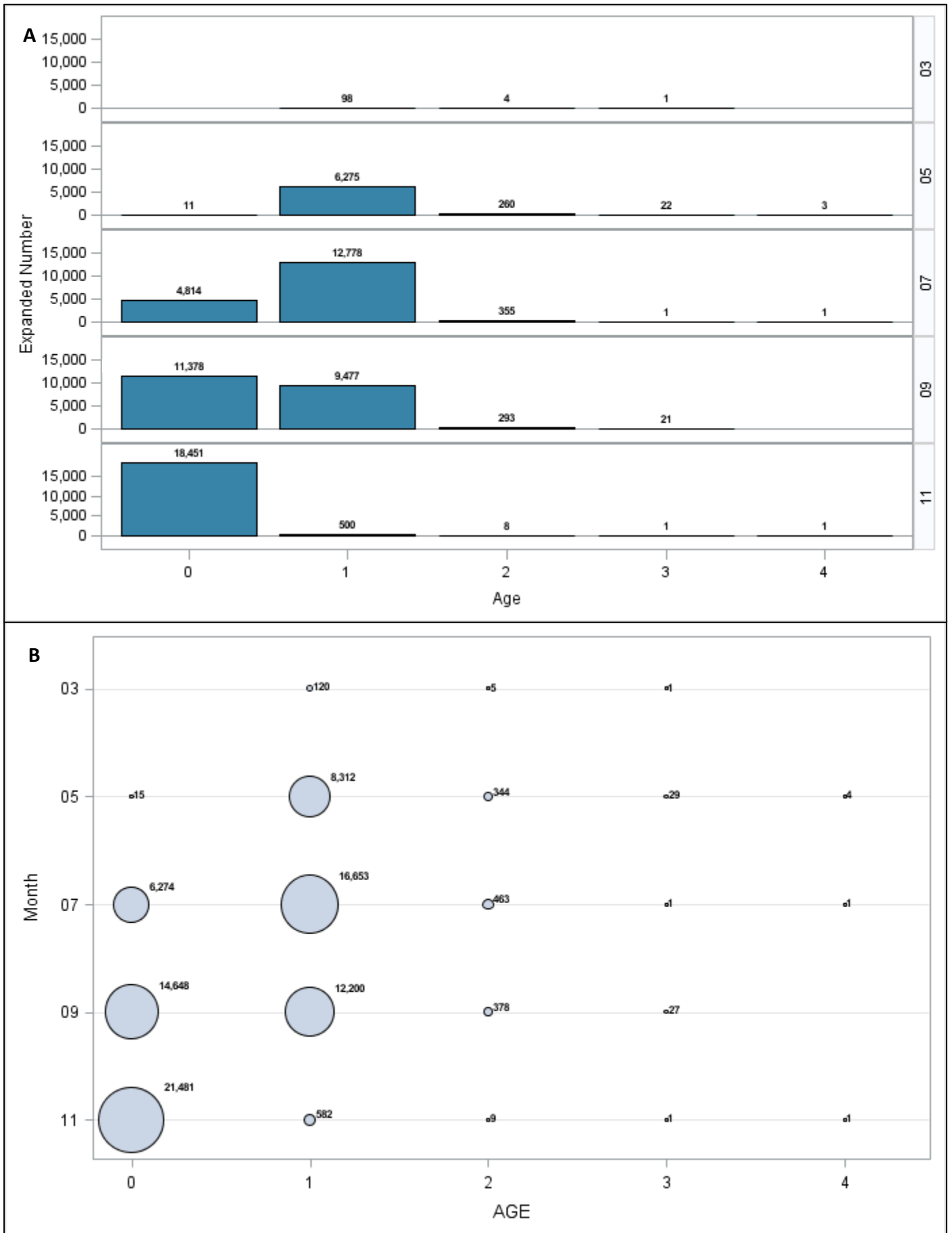


Figure 49. Diet composition, expressed as percent by weight (A) and percent by number (B) of Spot collected during ChesMMAAP cruises in 2002-2018 combined.

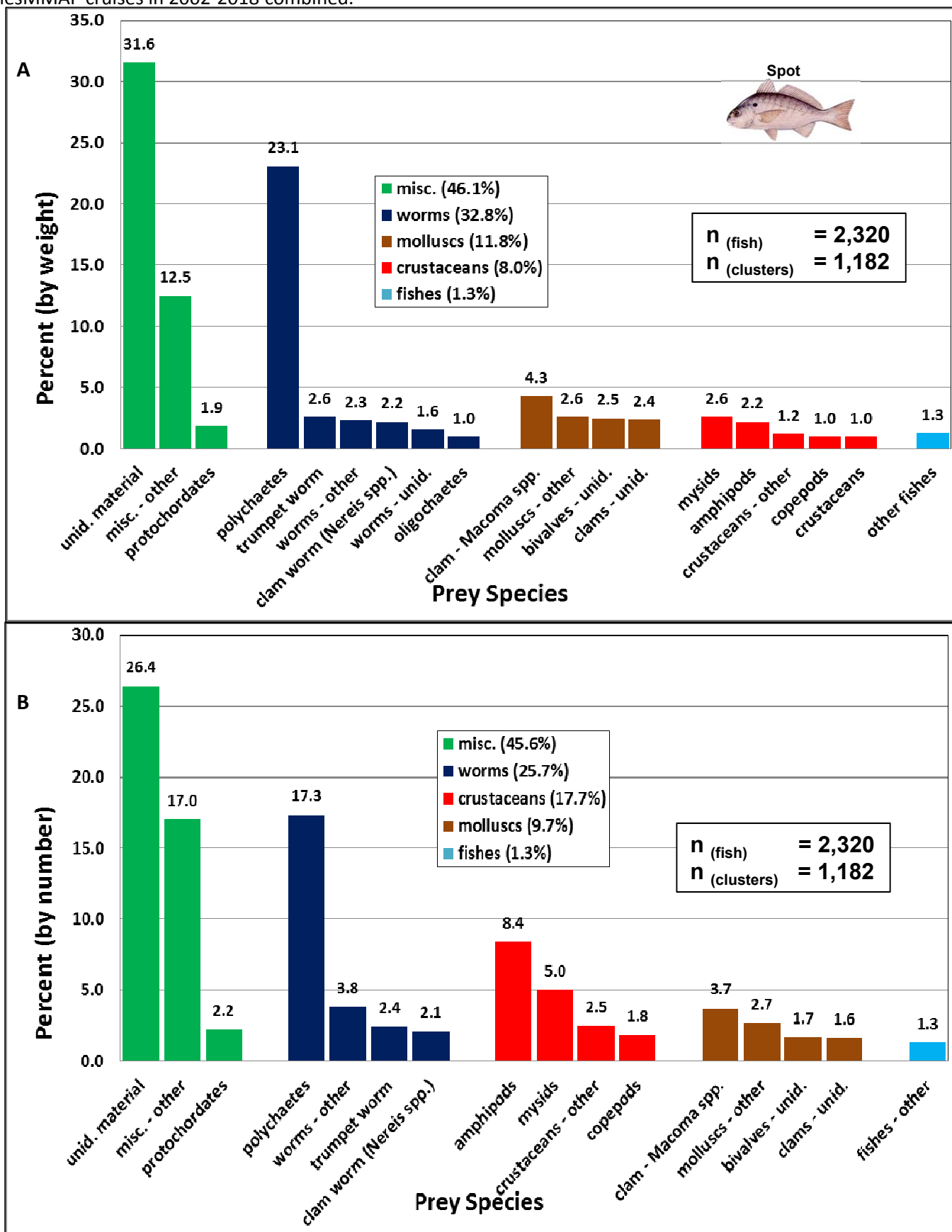


Table 29. Striped Bass sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	495	313.9	27.1	495	337	337	248	230
2003	765	710.1	22.2	765	501	501	367	354
2004	918	668.9	27.6	918	590	590	476	468
2005	2,245	982.4	16.0	1,919	724	724	528	513
2006	911	839.1	20.4	911	535	535	412	407
2007	579	423.4	18.8	579	389	389	246	241
2008	472	476.9	23.5	472	380	380	317	309
2009	315	243.1	21.6	315	198	198	152	149
2010	288	285.4	16.3	288	205	205	147	144
2011	287	231.6	24.0	284	237	237	178	178
2012	935	330.5	46.7	935	257	257	197	196
2013	695	482.3	17.6	695	373	373	259	124
2014	578	355.8	25.5	578	255	255	186	183
2015	718	398.5	21.6	718	319	319	133	131
2016	1,266	530.2	21.6	1,266	534	534	280	279
2017	1,466	829.0	16.0	1,313	426	426	270	268
2018	313	157.2	31.3	313	173	173	100	100

Figure 50. Abundance (kg per hectare swept) of Striped Bass in Chesapeake Bay, 2018.

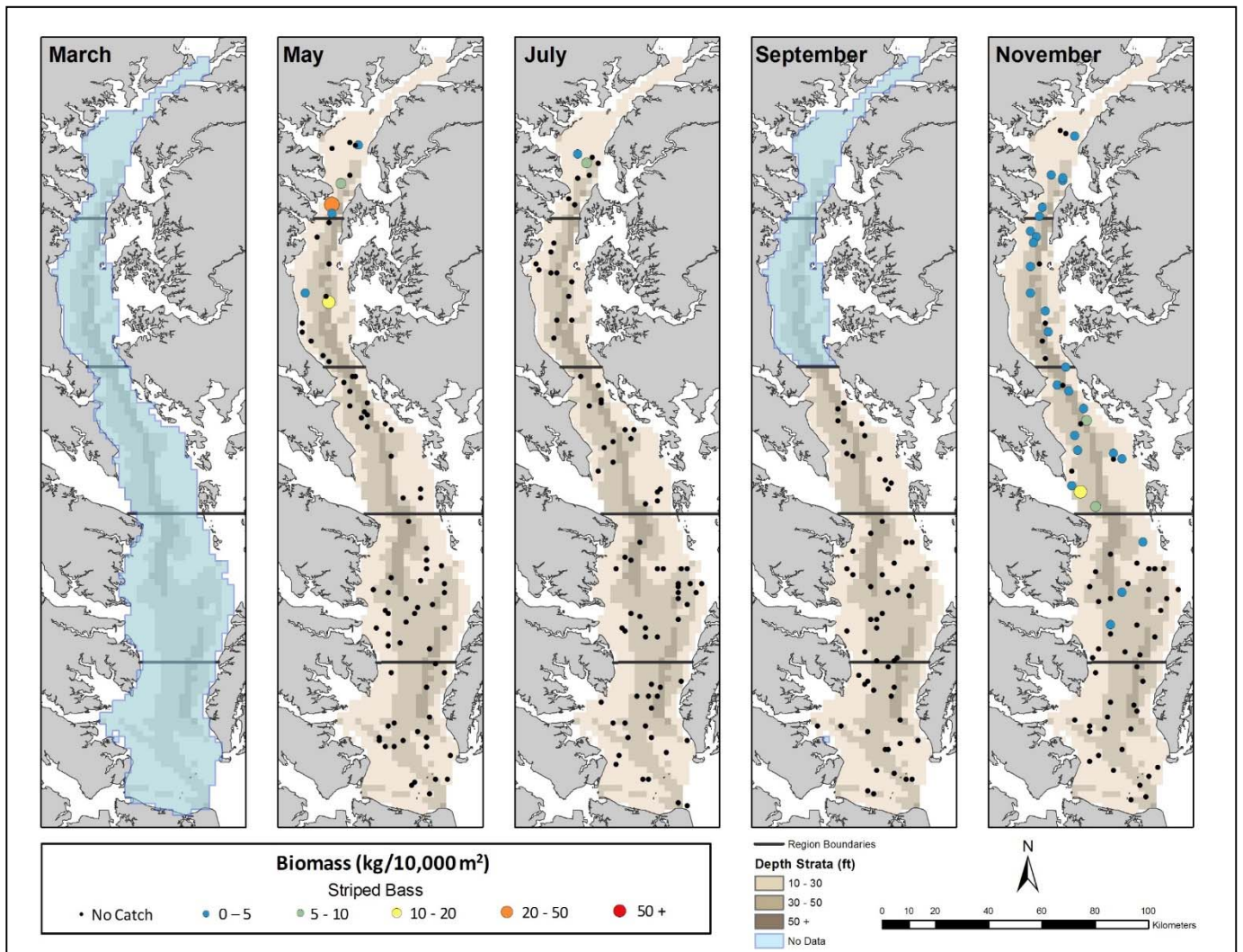


Table 30. Months, latitudinal regions, and depth strata used for Striped Bass index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 31. Striped Bass (March) geometric mean indices of abundance, by number and biomass, overall and by age-class.

Year	Age	n	Numerical Index			Biomass Index			Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI
2002	All	15	1.1	8.6	43.6	0.8	6.0	25.7	2002	3	15	0.1	1.5	5.1	0.0	1.0	3.7
2003		17	73.2	193.8	510.5	27.7	88.4	278.1	2003		17	17.6	47.4	124.9	6.1	22.3	75.7
2004		19	450.5	602.0	804.5	258.4	425.8	701.1	2004		19	73.2	139.5	265.1	59.7	111.7	208.2
2005		15	13.9	58.6	237.0	9.4	30.0	91.4	2005		15	7.4	25.6	83.8	5.1	13.6	34.0
2006		15	20.7	92.0	397.2	18.9	77.3	307.8	2006		15	6.7	30.3	126.4	5.9	21.5	72.2
2007		17	26.5	126.0	586.7	17.2	72.7	296.8	2007		17	11.7	44.2	159.7	7.7	27.1	90.0
2008		16	193.2	457.2	1,079.8	125.5	393.5	1,229.3	2008		16	46.7	121.3	312.5	35.2	85.6	206.2
2009		16	9.2	45.7	212.5	6.9	33.9	152.7	2009		16	5.7	24.2	93.8	4.3	17.5	62.9
2010		16	18.2	74.7	298.3	14.9	73.3	347.1	2010		16	5.4	17.2	50.5	4.4	13.7	39.1
2011		16	42.9	127.2	373.4	28.3	86.3	258.9	2011		16	10.5	33.0	99.0	7.3	20.3	53.4
2012		0							2012								
2013		16	110.9	247.6	551.3	130.5	324.0	801.9	2013		16	38.3	80.7	168.7	40.1	77.6	149.2
2014		16	3.4	18.3	83.9	2.6	12.1	46.6	2014		16	2.6	12.0	45.9	1.9	7.8	25.5
2015		16	1.9	12.0	56.4	1.0	4.7	15.6	2015		16	0.4	3.7	14.3	0.3	2.3	7.4
2016		16	195.3	329.3	554.9	113.7	183.1	294.3	2016		16	31.2	69.3	152.7	21.0	39.2	72.6
2017		15	18.4	135.2	957.7	12.4	58.1	259.9	2017		15	9.2	44.1	198.0	4.9	18.3	61.5
2018									2018								
2019									2019								
2020									2020								
2002	1	15	0.0	0.8	2.0	0.0	0.4	1.0	2002	4+	15	0.0	1.6	5.8	0.0	2.1	9.1
2003		17	1.3	5.9	20.0	0.6	2.6	6.9	2003		17	2.1	10.7	43.0	1.8	10.2	43.5
2004		19	0.5	1.7	4.0	0.3	0.7	1.3	2004		19	74.0	137.9	256.2	74.7	153.3	313.7
2005		15	0.6	3.2	10.3	0.3	1.5	3.9	2005		15	4.5	10.4	22.6	3.4	6.3	11.2
2006		15	0.0	1.0	3.9	0.0	0.6	2.1	2006		15	9.5	32.3	104.9	8.5	33.5	124.7
2007		17	0.5	2.2	5.7	0.2	1.0	2.2	2007		17	9.4	36.4	133.2	7.1	26.5	92.3
2008		16	0.0	0.6	2.0	0.0	0.2	0.4	2008		16	42.3	139.3	454.1	46.7	189.5	760.9
2009		16	0.4	0.5	0.6	0.2	0.3	0.3	2009		16	3.3	13.8	49.7	2.5	11.4	43.7
2010		16	0.0	0.1	0.3	0.0	0.0	0.1	2010		16	8.8	36.5	141.8	7.9	41.2	199.3
2011		16	0.1	0.8	1.8	0.1	0.4	0.7	2011		16	6.8	27.7	105.1	5.3	24.5	102.1
2012									2012								
2013		16	0.0	0.1	0.2	0.0	0.0	0.1	2013		16	71.5	142.2	281.8	84.8	215.2	544.0
2014		16	0.0	0.7	3.0	0.0	0.4	1.6	2014		16	1.5	6.5	21.4	1.1	4.6	13.9
2015		16	0.0	1.7	6.9	0.1	0.5	1.0	2015		16	0.0	0.9	2.6	0.0	0.7	1.8
2016		16	0.3	3.0	11.2	0.1	1.2	3.5	2016		16	28.5	53.1	98.2	16.9	39.6	91.2
2017		15	0.6	5.0	22.2	0.3	1.7	4.4	2017		15	3.0	7.6	17.2	2.7	7.7	19.1
2018									2018								
2019									2019								
2020									2020								
2002	2	15	0.3	4.1	19.8	0.1	2.2	8.0									
2003		17	33.1	80.0	191.6	13.2	35.3	91.7									
2004		19	40.8	92.7	208.7	23.6	56.3	132.5									
2005		15	4.4	21.8	94.9	2.8	10.6	34.7									
2006		15	4.9	22.8	95.3	3.8	14.3	47.8									
2007		17	4.9	20.9	80.5	2.9	10.9	34.9									
2008		16	20.9	53.0	132.0	10.9	24.6	54.1									
2009		16	2.8	10.3	32.8	1.9	6.7	19.3									
2010		16	2.5	6.5	15.2	1.9	4.7	10.2									
2011		16	3.0	13.7	53.1	2.1	7.5	22.3									
2012																	
2013		16	2.5	11.7	45.7	2.1	9.3	33.6									
2014		16	1.9	8.4	29.4	1.4	5.2	15.2									
2015		16	0.4	3.6	13.9	0.2	2.0	6.4									
2016		16	5.9	25.7	102.8	3.6	12.6	38.8									
2017		15	11.8	79.5	506.3	7.3	30.1	115.2									
2018																	
2019																	
2020																	

Figure 51. Striped Bass (March) geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

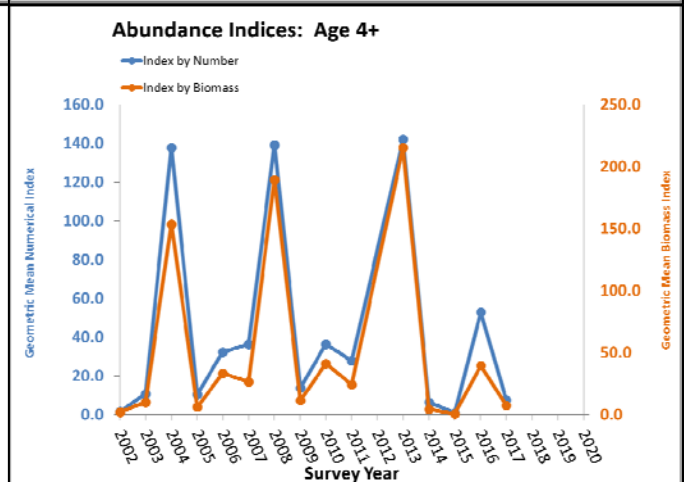
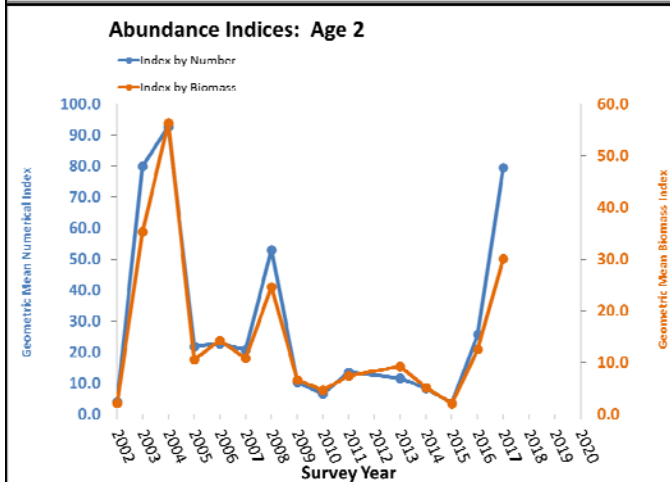
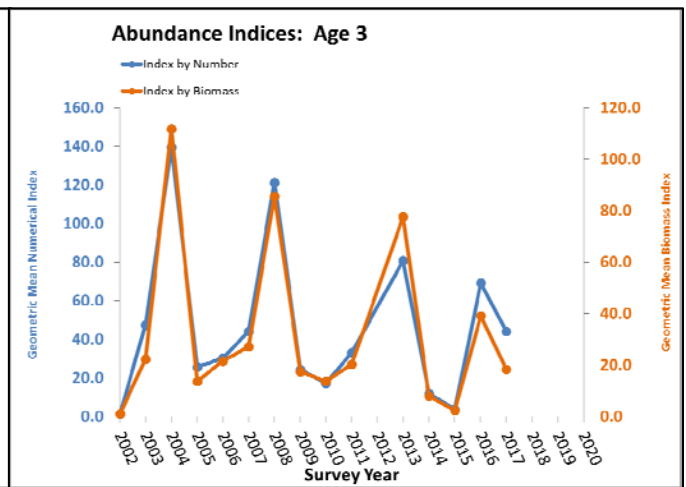
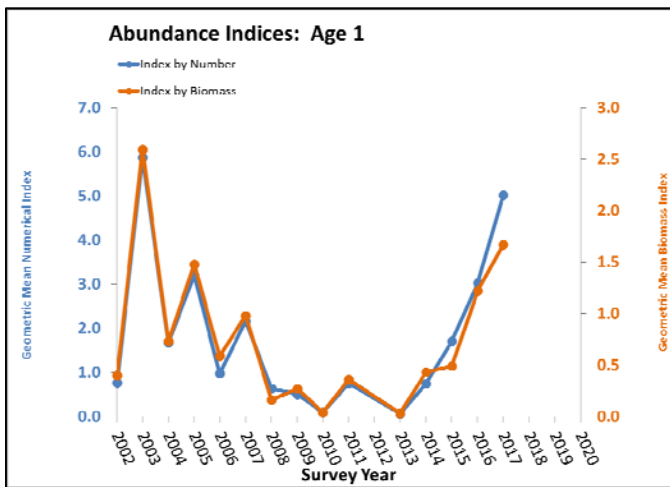
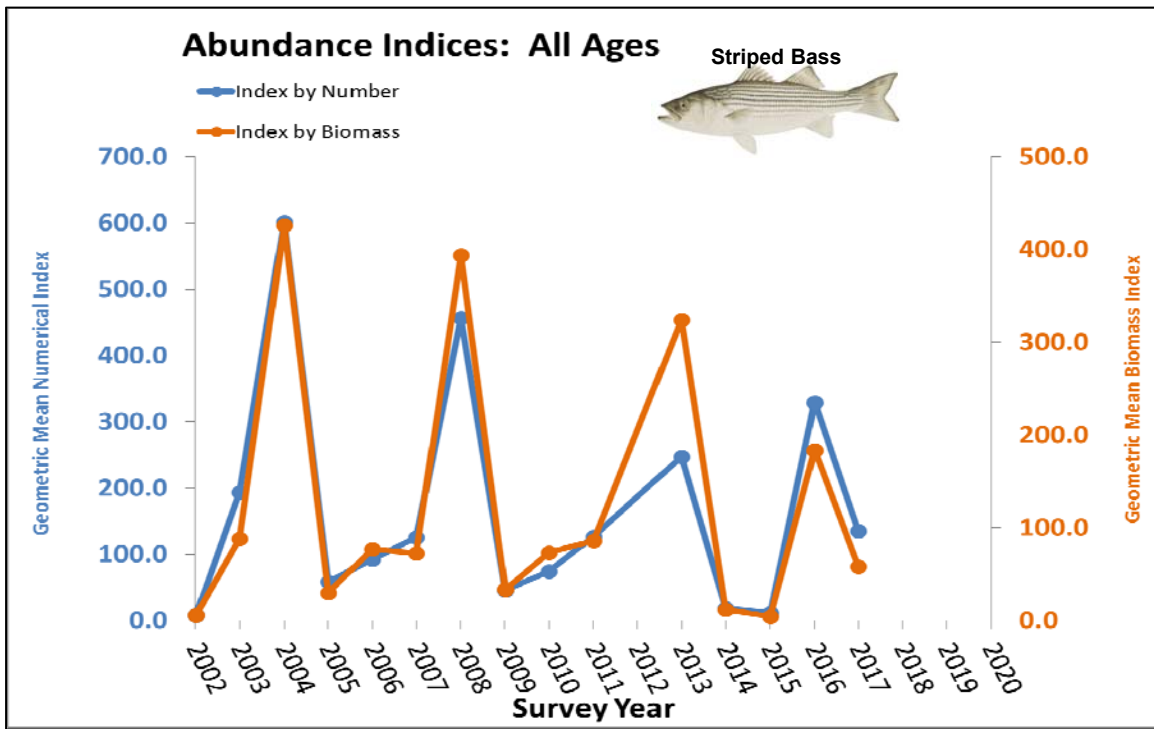


Table 32. Striped Bass (November) geometric mean indices of abundance, by number and biomass, overall and by age-class.

Year	Age	n	Numerical Index			Biomass Index			Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI
2002	All	20	41.1	111.6	300.1	24.4	55.5	124.9	2002	3	20	8.2	15.7	29.2	5.3	10.1	18.6
2003		11	2.5	19.8	124.7	2.5	6.6	15.3	2003		11	1.5	3.7	8.0	0.9	2.5	5.3
2004		18	96.4	291.1	875.4	23.0	60.0	154.0	2004		18	1.6	5.9	16.9	0.8	2.8	6.9
2005		15	14.1	89.8	546.3	8.4	43.3	206.7	2005		15	2.7	12.0	45.3	1.9	7.3	23.1
2006		14	156.6	300.2	574.9	54.8	131.7	314.5	2006		14	6.5	26.7	101.7	4.8	17.3	56.9
2007		15	3.0	28.3	213.8	3.3	27.9	195.6	2007		15	1.1	7.7	36.3	1.0	7.0	30.8
2008		16	11.4	62.3	323.4	9.3	50.7	257.3	2008		16	4.0	13.8	43.1	3.2	11.4	36.1
2009		16	3.6	32.9	246.5	2.5	20.0	125.9	2009		16	0.1	5.6	37.3	0.0	4.3	27.8
2010		15	2.2	15.8	87.8	1.2	13.9	101.4	2010		15	0.6	2.8	8.2	0.3	2.2	7.0
2011		15	28.5	142.7	698.3	13.6	59.0	244.9	2011		15	1.3	6.9	25.5	0.8	4.5	16.3
2012		15	42.2	144.3	487.2	14.4	53.0	188.7	2012		15	0.9	6.0	23.9	0.7	4.6	17.9
2013		16	10.5	69.0	424.2	8.2	45.8	236.6	2013		16	3.2	14.9	59.5	2.4	10.1	35.6
2014		16	71.8	226.3	708.3	57.3	168.8	494.0	2014		16	4.7	20.3	78.3	3.8	15.0	52.6
2015		16	15.7	85.5	448.2	4.8	20.3	77.8	2015		16	0.8	2.6	6.4	0.4	1.6	3.6
2016		16	112.3	316.6	889.2	53.7	126.4	295.9	2016		16	5.9	16.7	44.0	3.0	9.9	28.2
2017		16	30.6	181.1	1,047.5	13.9	61.1	257.9	2017		16	2.8	9.8	29.3	2.0	6.1	15.8
2018		16	4.9	31.3	174.8	2.3	13.8	64.3	2018		16	0.7	4.7	18.4	0.4	3.4	12.6
2019									2019								
2020									2020								
2002	1	20	14.9	39.3	100.8	8.2	16.3	31.6	2002	4+	20	3.4	8.4	18.7	2.5	7.0	17.5
2003		11	0.5	2.5	7.2	0.4	1.6	4.0	2003		11	0.3	1.7	4.6	0.2	1.2	3.0
2004		18	70.5	202.1	576.2	17.3	40.7	93.9	2004		18	0.3	1.8	5.0	0.1	1.3	3.8
2005		15	7.0	40.7	216.0	3.9	17.9	72.6	2005		15	1.4	8.1	33.3	1.1	6.1	22.6
2006		14	28.2	73.0	186.6	12.8	31.4	75.4	2006		14	6.7	29.3	119.0	4.7	19.2	70.2
2007		15	0.2	4.1	21.6	0.1	3.3	16.0	2007		15	1.8	11.0	51.0	1.7	11.4	55.5
2008		16	1.8	11.2	51.7	1.3	8.6	39.0	2008		16	2.1	10.6	42.2	2.0	10.6	44.2
2009		16	1.0	9.7	55.4	0.6	3.9	13.7	2009		16	0.0	4.1	26.3	0.0	4.0	26.6
2010		15	1.8	4.5	9.7	1.2	2.8	5.7	2010		15	0.0	4.2	28.8	0.0	4.7	40.9
2011		15	18.2	72.6	281.7	7.6	21.7	59.5	2011		15	0.9	6.2	25.3	0.8	6.2	28.5
2012		15	9.6	37.7	140.8	4.2	14.0	42.6	2012		15	1.2	8.7	42.3	1.1	7.5	33.9
2013		16	3.3	21.6	117.7	2.5	13.3	57.8	2013		16	2.6	10.6	36.6	2.1	9.1	31.3
2014		16	11.6	51.2	216.0	6.8	24.8	83.9	2014		16	9.0	30.4	98.3	8.6	35.9	140.1
2015		16	4.4	30.8	186.9	2.2	10.1	37.3	2015		16	0.2	1.4	4.0	0.1	1.4	4.4
2016		16	17.1	94.4	500.4	9.3	35.2	126.1	2016		16	1.3	7.5	30.3	1.0	6.3	26.3
2017		16	16.1	89.0	474.4	6.4	26.2	98.4	2017		16	1.6	5.5	14.8	1.5	5.4	15.8
2018		16	2.2	12.2	53.3	0.9	4.6	15.7	2018		16	0.2	2.8	10.7	0.1	2.3	8.5
2019									2019								
2020									2020								
2002	2	20	15.3	34.2	75.3	9.6	18.3	34.1									
2003		11	2.1	5.2	11.3	1.5	3.4	6.7									
2004		18	8.8	31.0	103.1	3.5	9.9	25.6									
2005		15	5.4	28.8	137.8	3.8	16.4	62.9									
2006		14	29.2	51.0	88.5	10.8	23.1	48.2									
2007		15	0.7	7.6	43.2	0.6	6.4	32.5									
2008		16	5.4	23.7	93.6	4.4	18.6	70.1									
2009		16	1.7	12.3	64.7	0.8	7.0	34.6									
2010		15	1.8	4.9	11.7	1.1	3.6	9.2									
2011		15	7.8	33.4	133.8	3.2	13.0	45.6									
2012		15	3.9	19.6	85.1	2.3	10.2	37.1									
2013		16	6.0	32.6	160.5	4.4	20.0	80.3									
2014		16	8.9	42.2	188.4	5.8	24.6	95.3									
2015		16	3.0	13.7	53.8	1.7	5.5	14.7									
2016		16	28.9	72.8	181.2	14.5	33.3	75.1									
2017		16	5.1	27.8	134.4	3.0	13.1	48.7									
2018		16	1.4	5.6	17.7	0.7	3.2	9.5									
2019																	
2020																	

Figure 52. Striped Bass (November) geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

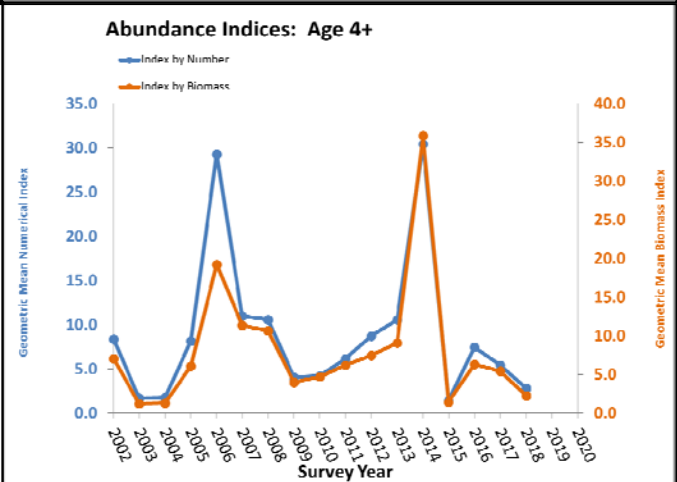
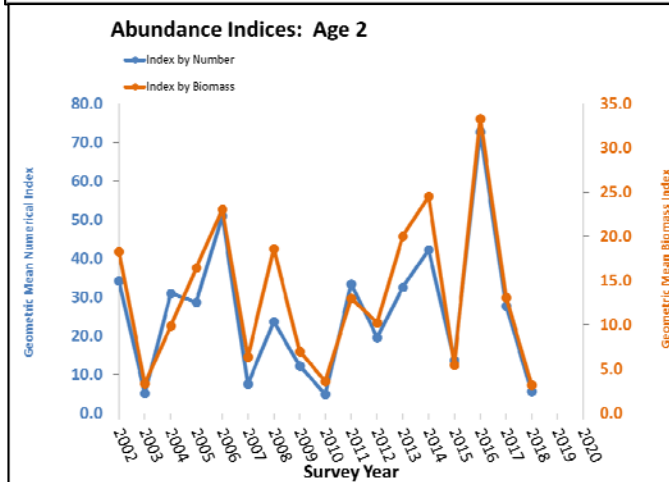
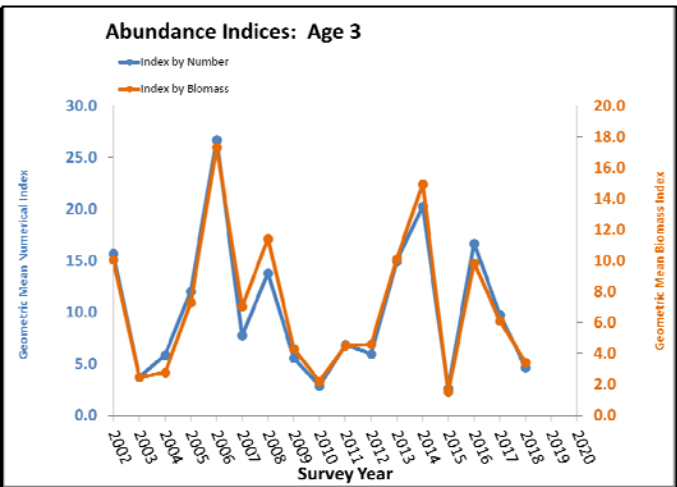
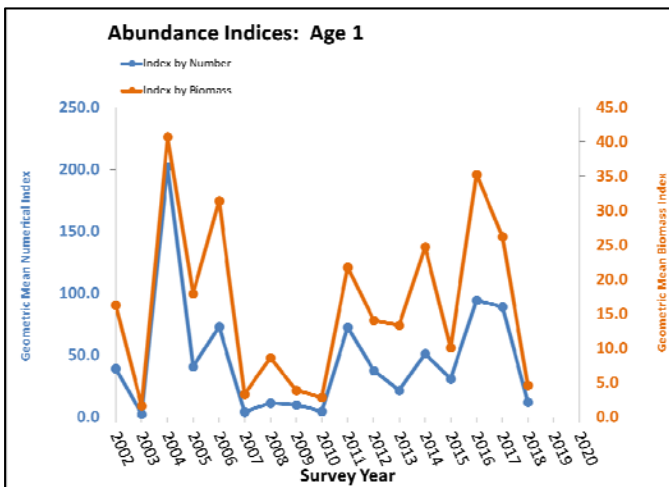
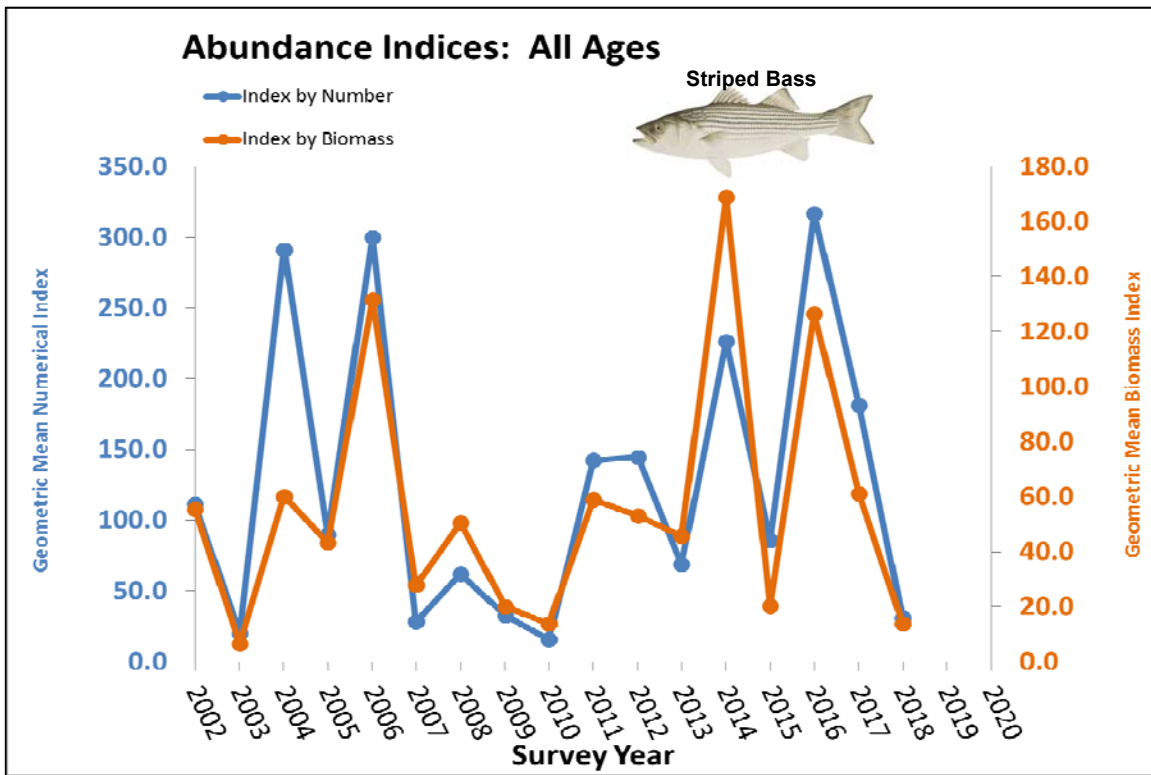


Figure 53. Striped Bass length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

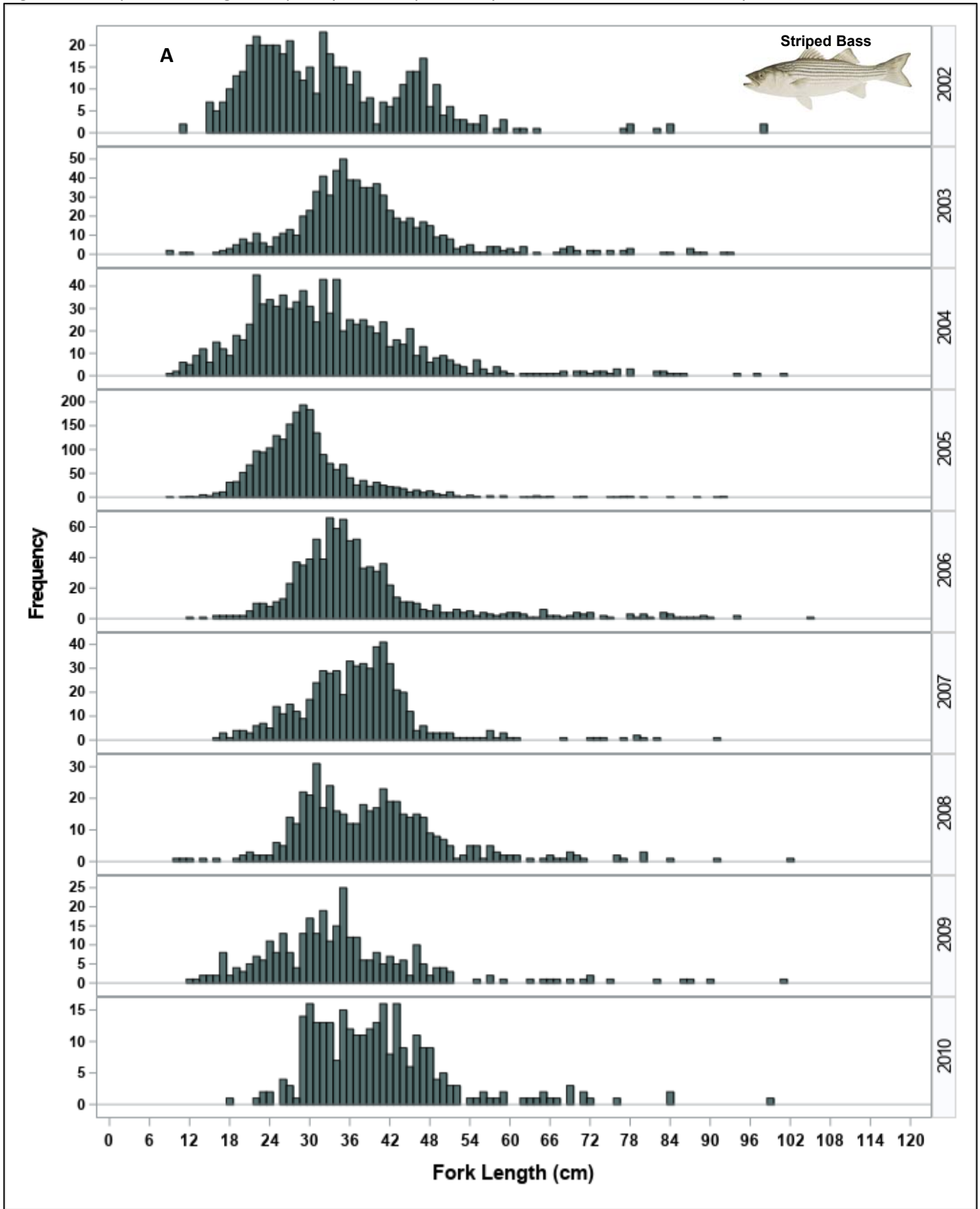


Figure 53. cont.

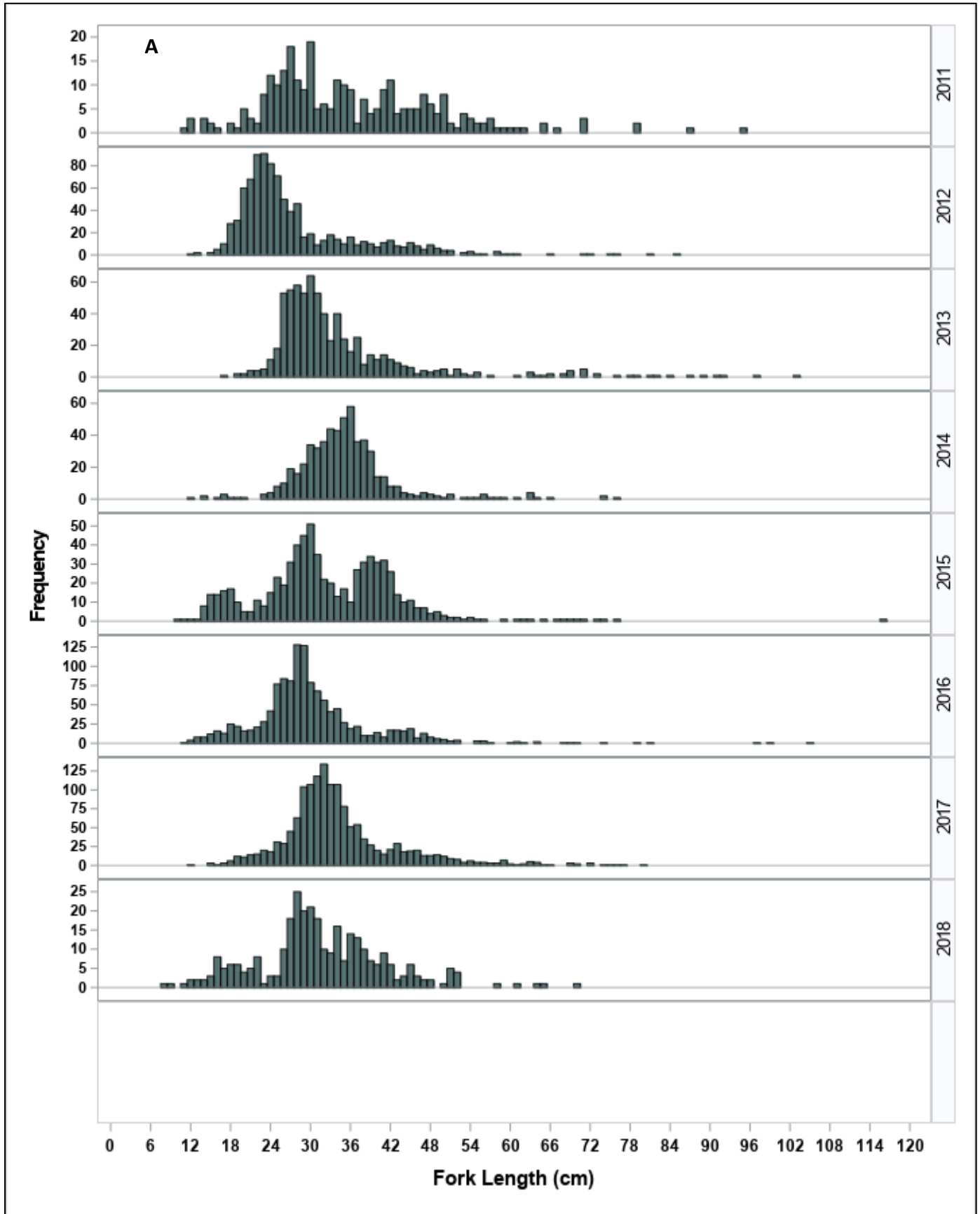


Figure 53. cont.

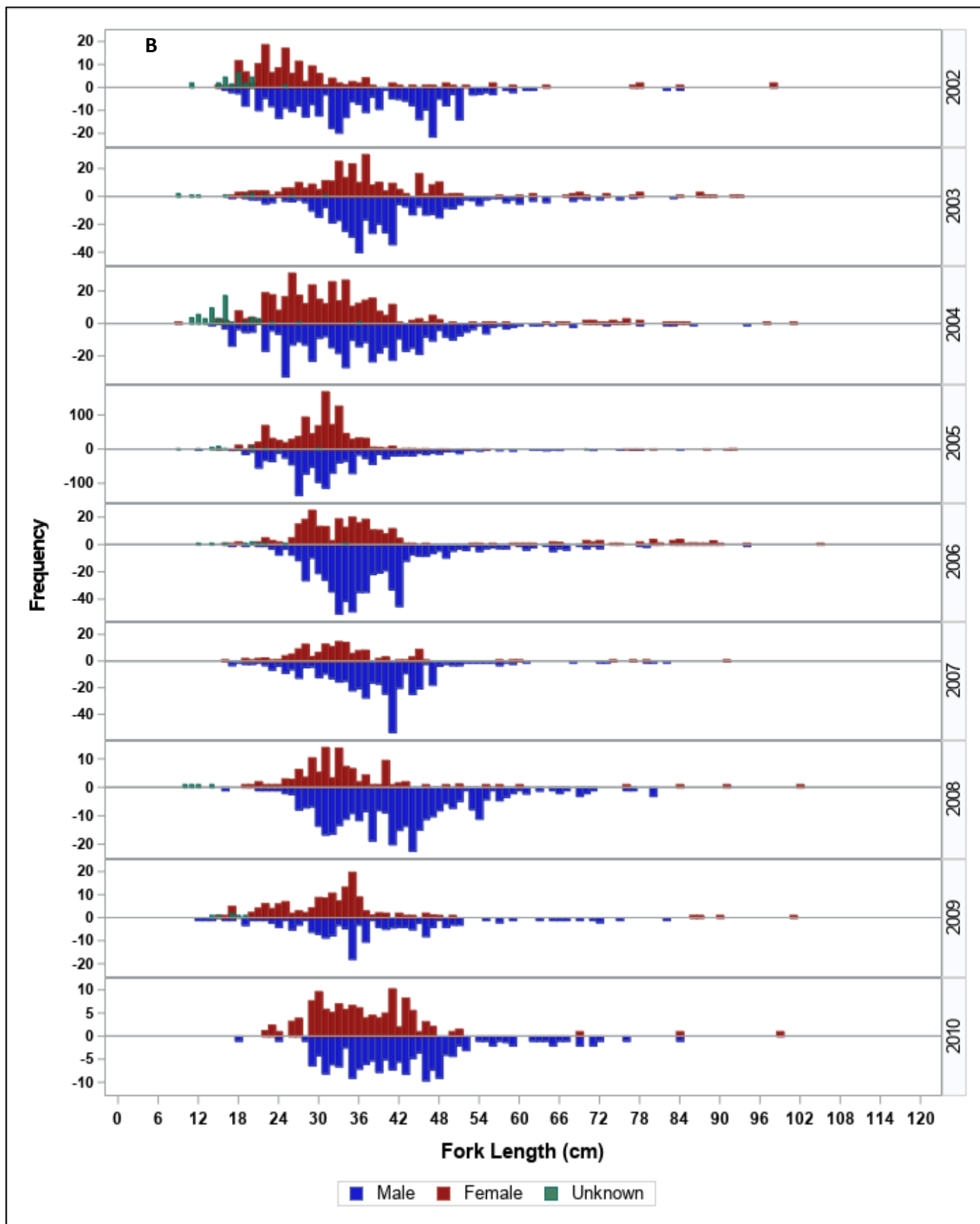


Figure 53. cont.

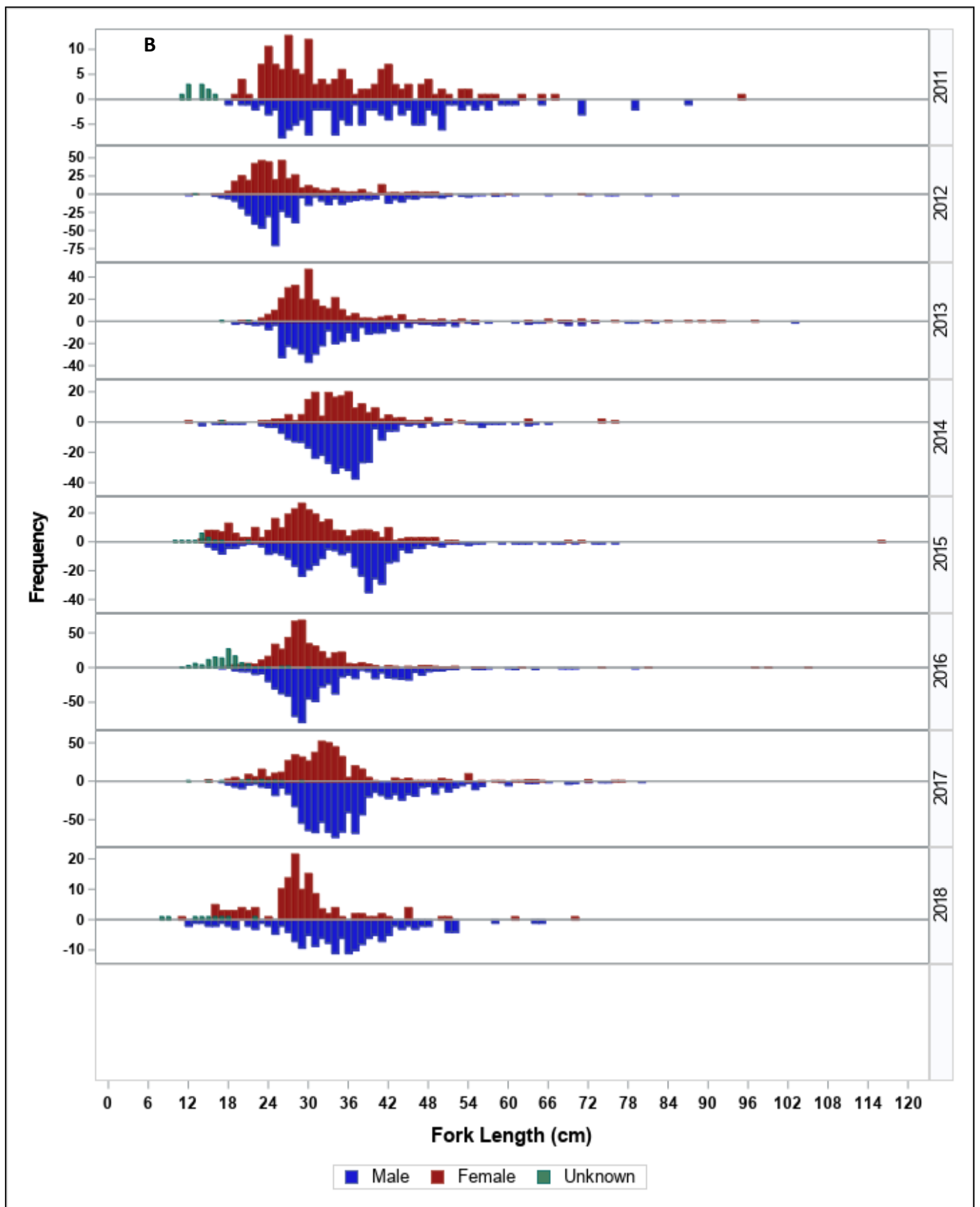


Figure 54. Striped Bass total age-frequency, 2002-2018.

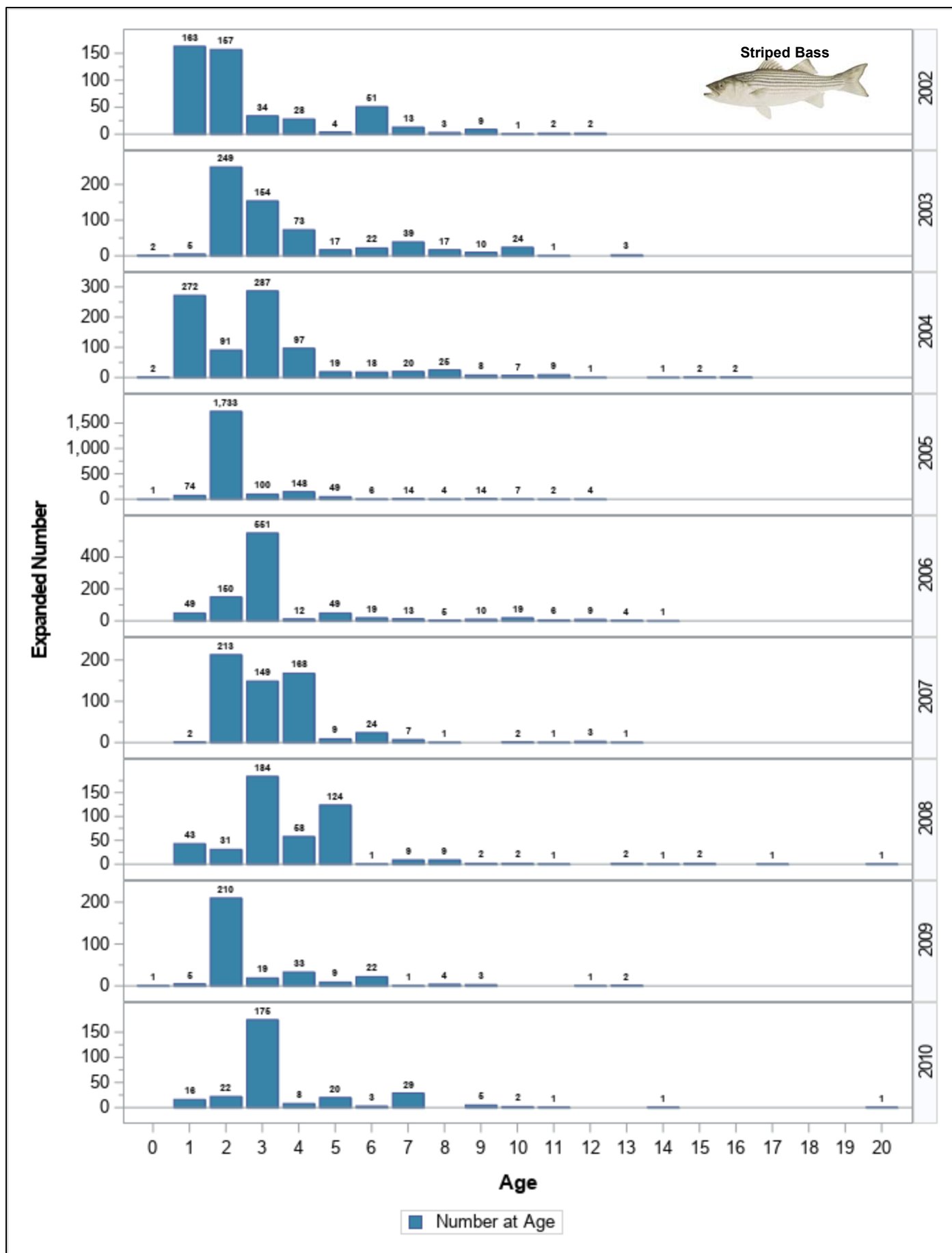


Figure 54. cont.

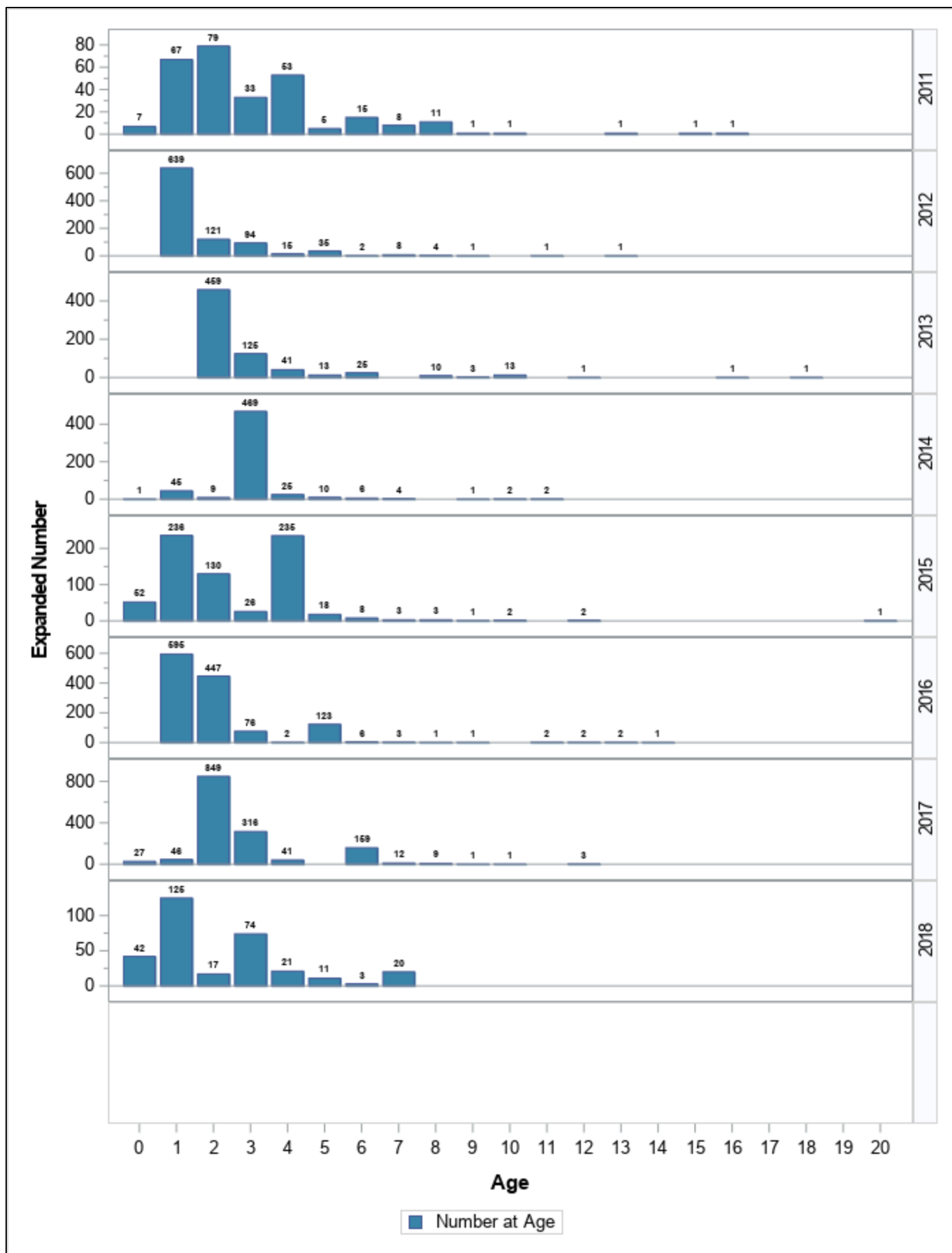


Figure 55. Striped Bass age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

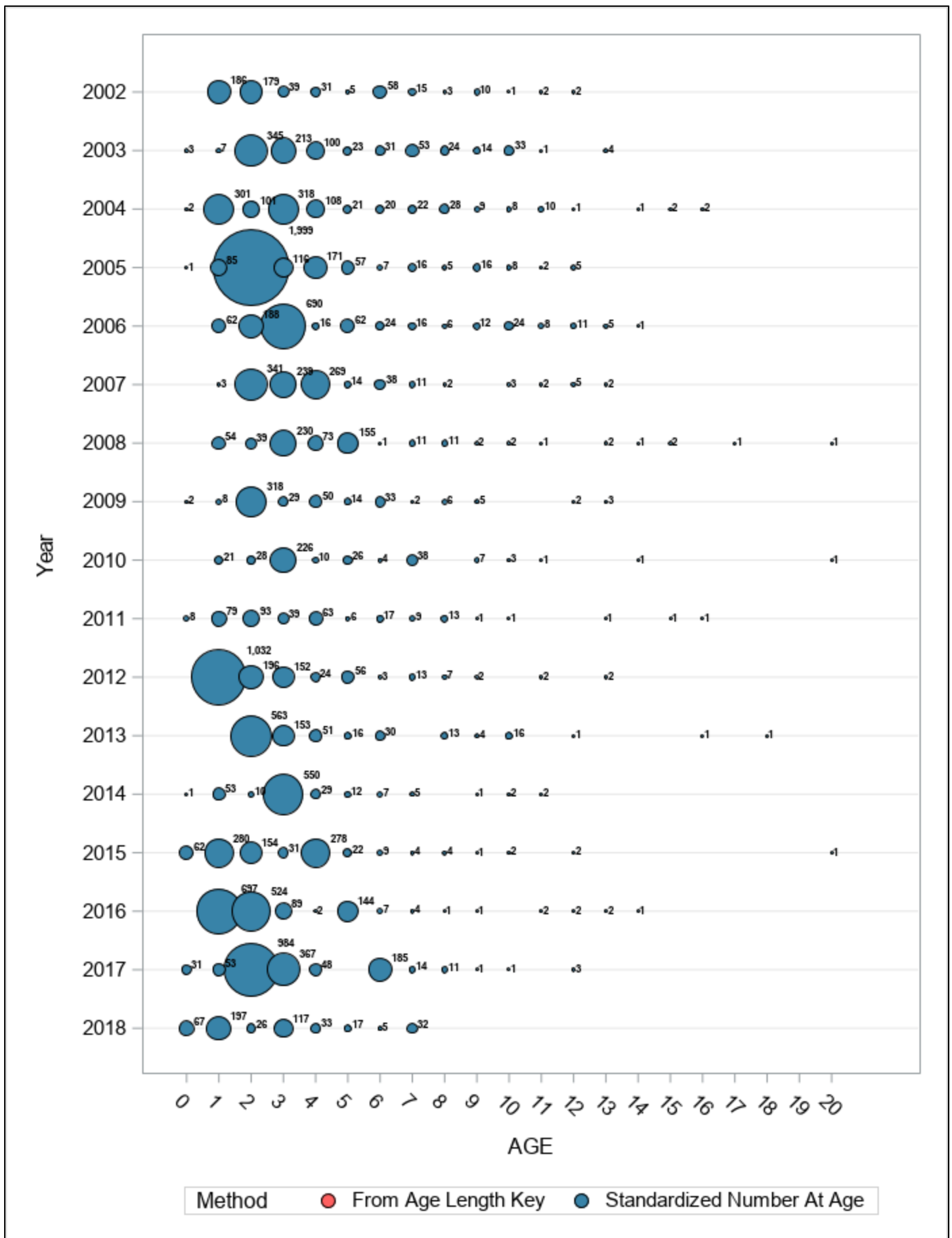


Figure 56. Striped Bass age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

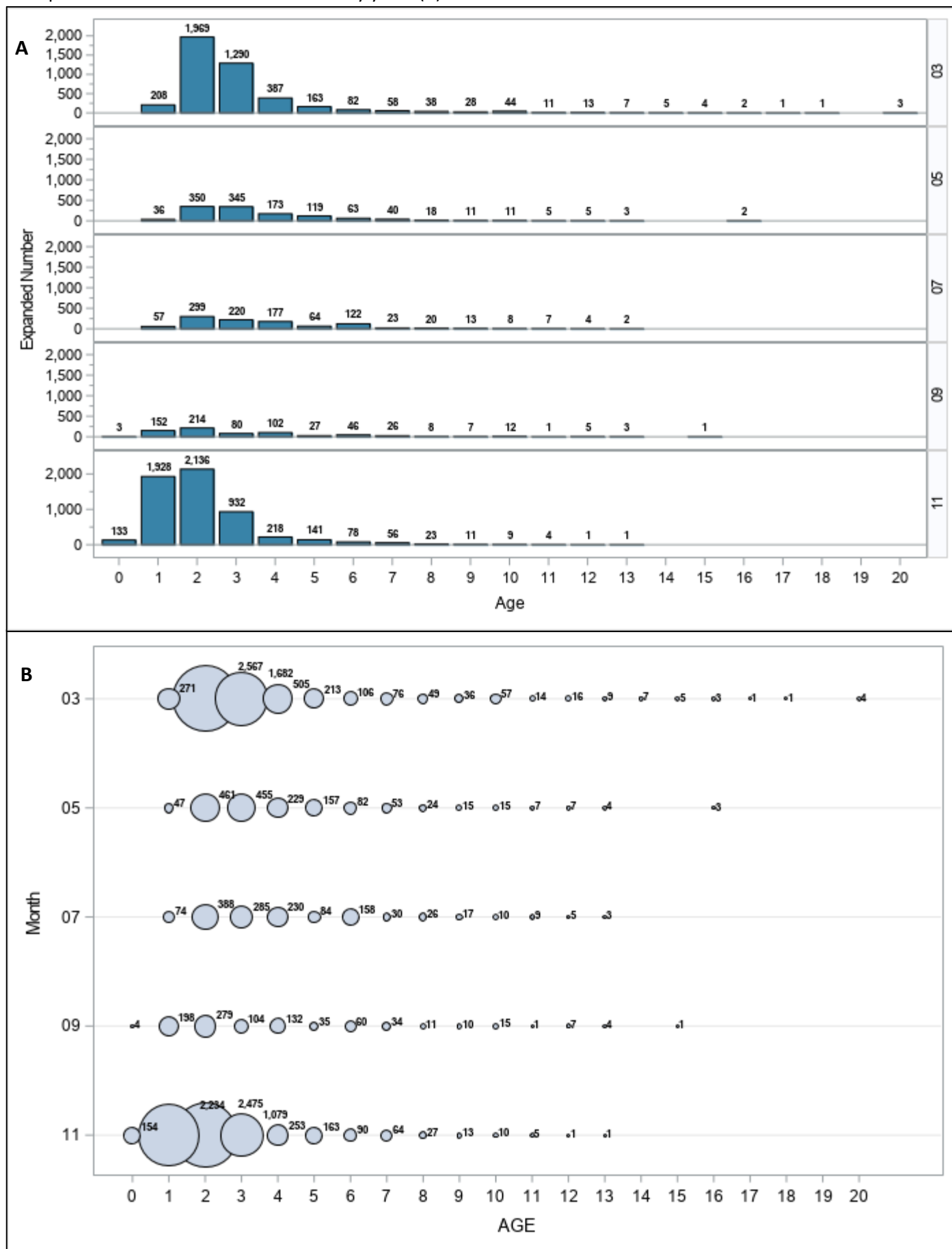


Figure 57. Diet composition, expressed as percent by weight (A) and percent by number (B) of Striped Bass collected during ChesMMAP cruises in 2002-2018 combined.

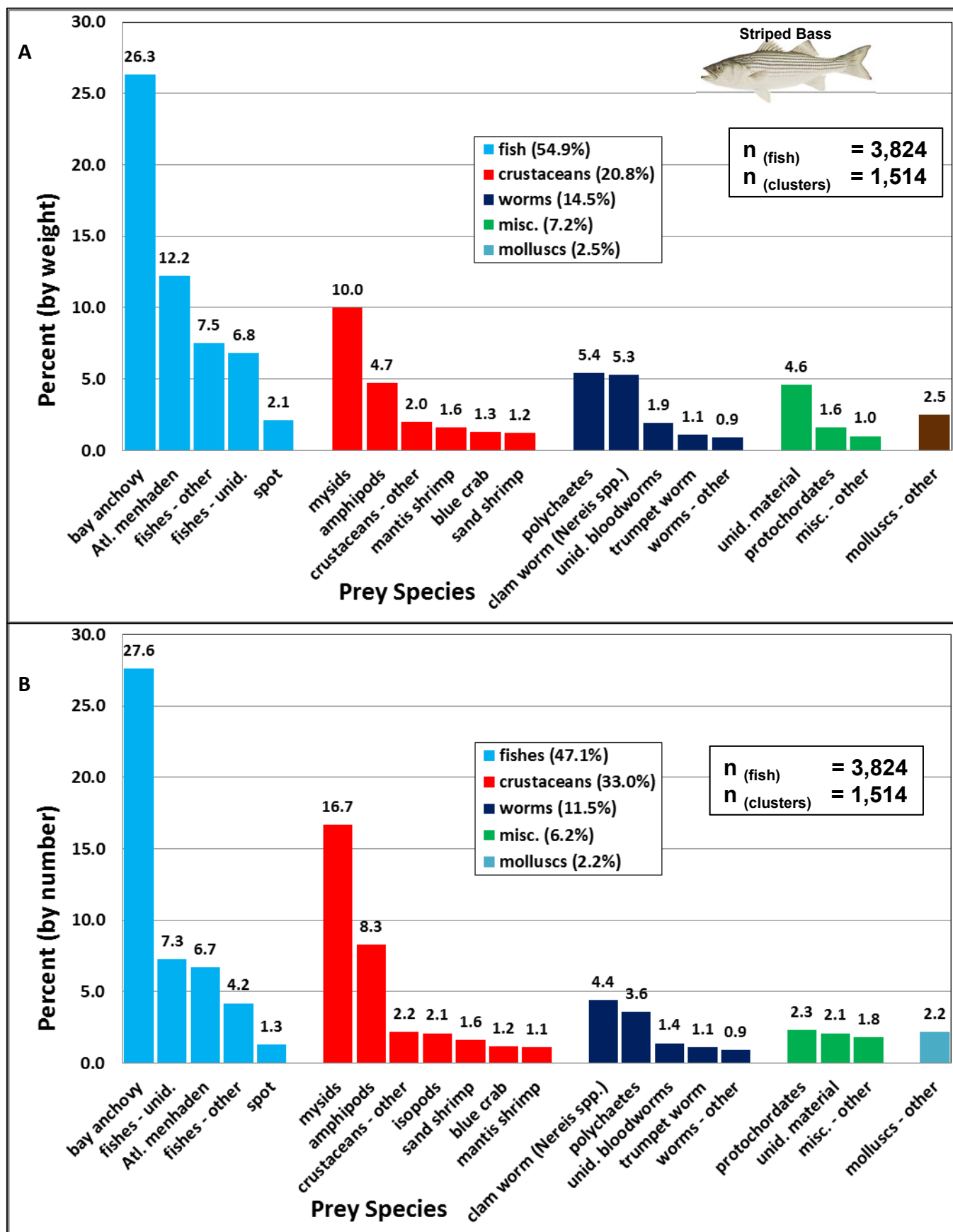


Table 33. Summer Flounder sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	770	430.5	42.7	770	649	649	425	409
2003	580	363.6	30.4	579	441	441	325	316
2004	728	309.7	30.1	728	565	565	377	372
2005	759	386.7	48.8	759	669	669	420	409
2006	940	454.2	49.4	940	755	755	444	430
2007	567	259.1	43.2	563	489	489	317	313
2008	636	280.9	42.2	638	543	543	354	346
2009	393	187.1	36.7	393	369	355	243	239
2010	385	180.0	42.2	385	354	353	215	209
2011	211	126.3	33.7	211	208	203	111	107
2012	92	33.4	17.9	92	91	91	57	53
2013	110	35.7	21.3	110	107	107	51	45
2014	63	16.7	13.3	63	63	63	40	40
2015	129	41.9	14.4	129	127	127	72	72
2016	77	21.8	14.4	77	77	77	40	39
2017	135	35.3	17.8	135	128	128	85	85
2018	105	26.5	3.3	105	96	96	44	44

Figure 58. Abundance (kg per hectare swept) of Summer Flounder in Chesapeake Bay, 2018.

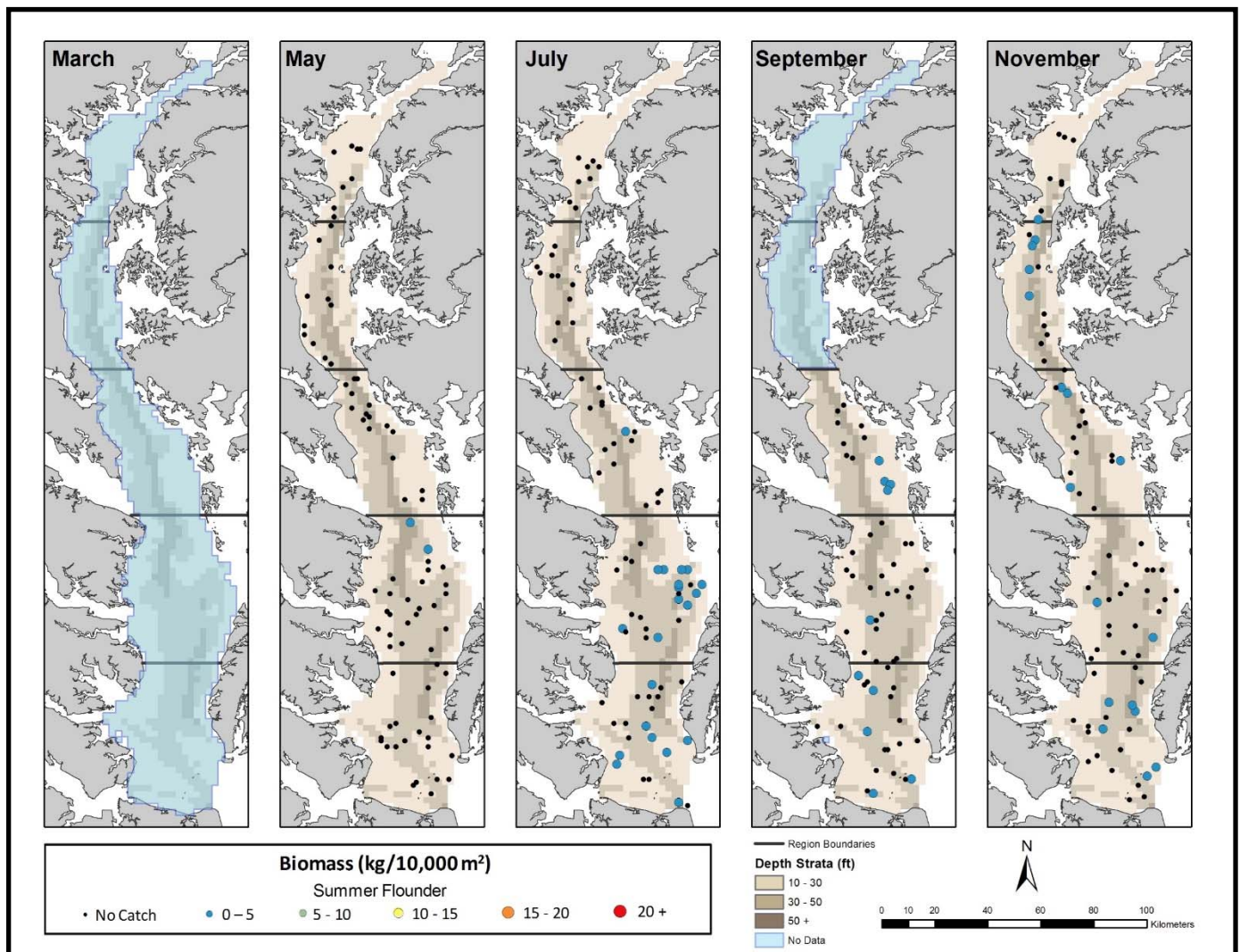


Table 34. Months, latitudinal regions, and depth strata used for Summer Flounder index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 35. Summer Flounder geometric mean indices of abundance, by number and biomass, overall and by age-class.

Year	Age	n	Numerical Index			Biomass Index			Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI
2002	All	75	71.5	120.1	201.3	34.5	55.5	88.9	2002	2	75	3.4	6.0	9.9	2.9	5.0	8.2
2003		101	19.9	35.3	62.1	12.3	20.5	34.0	2003		101	1.7	2.7	4.2	1.3	2.1	3.2
2004		92	26.9	43.7	70.6	11.9	17.9	26.7	2004		92	1.7	2.7	4.1	1.3	2.1	3.1
2005		86	99.9	150.0	225.0	39.7	57.5	83.0	2005		86	5.7	8.8	13.3	3.8	5.9	8.8
2006		79	106.9	176.4	290.6	40.1	62.0	95.7	2006		79	4.1	6.8	11.1	2.9	4.9	7.8
2007		44	61.4	116.6	220.7	22.1	38.6	67.0	2007		44	1.2	2.4	4.3	0.8	1.6	2.9
2008		90	49.2	84.9	145.9	18.5	30.2	48.9	2008		90	2.6	4.4	7.2	2.2	3.7	6.0
2009		90	19.9	35.1	61.3	9.5	15.7	25.4	2009		90	1.3	2.3	3.7	1.0	1.7	2.7
2010		90	21.0	36.6	63.2	9.8	15.6	24.4	2010		90	1.1	1.9	3.0	0.7	1.3	2.0
2011		89	13.4	23.2	39.8	8.5	14.1	23.0	2011		89	1.7	2.9	4.7	1.3	2.2	3.5
2012		84	1.6	3.1	5.6	0.8	1.6	2.6	2012		84	0.2	0.5	0.9	0.2	0.5	0.8
2013		89	2.1	4.1	7.3	1.0	1.8	2.9	2013		89	0.0	0.2	0.3	0.0	0.1	0.3
2014		90	1.6	3.2	5.7	0.9	1.6	2.5	2014		90	0.0	0.2	0.4	0.0	0.1	0.3
2015		90	2.7	5.2	9.4	1.5	2.8	4.6	2015		90	0.3	0.6	1.0	0.2	0.5	0.8
2016		90	1.5	3.0	5.3	0.9	1.7	2.8	2016		90	0.1	0.4	0.7	0.1	0.3	0.6
2017		90	1.6	3.2	5.8	0.9	1.7	2.9	2017		90	0.2	0.4	0.8	0.1	0.3	0.6
2018		90	0.4	1.1	2.0	0.3	0.7	1.2	2018		90	0.0	0.1	0.3	0.0	0.1	0.3
2019									2019								
2020									2020								
2002	0	75	34.6	59.4	101.3	13.8	21.3	32.6	2002	3	75	1.9	3.4	5.7	1.7	3.1	5.1
2003		101	10.8	18.7	32.1	5.9	9.5	15.0	2003		101	0.6	1.2	1.9	0.6	1.2	1.9
2004		92	12.8	21.8	36.7	5.0	7.5	11.1	2004		92	0.8	1.4	2.1	0.7	1.2	1.8
2005		86	34.7	55.3	87.8	13.5	19.7	28.4	2005		86	1.9	3.2	5.1	1.5	2.5	4.0
2006		79	53.3	91.0	155.1	16.3	24.4	36.1	2006		79	1.7	3.1	5.1	1.4	2.5	4.1
2007		44	50.0	93.9	175.6	17.7	29.5	48.8	2007		44	0.2	0.9	1.7	0.2	0.7	1.4
2008		90	28.0	48.4	82.9	8.7	13.3	20.1	2008		90	1.2	2.2	3.6	1.1	2.0	3.2
2009		90	9.7	17.0	29.4	4.3	6.9	10.8	2009		90	0.8	1.5	2.4	0.7	1.3	2.1
2010		90	10.4	18.2	31.3	4.7	7.4	11.2	2010		90	0.4	0.8	1.4	0.3	0.7	1.1
2011		89	3.1	5.4	9.1	1.9	3.1	4.8	2011		89	0.8	1.6	2.5	0.7	1.4	2.2
2012		84	0.9	1.9	3.4	0.4	0.8	1.3	2012		84	0.1	0.3	0.6	0.1	0.3	0.5
2013		89	1.5	3.0	5.4	0.7	1.2	1.9	2013		89	0.0	0.2	0.3	0.0	0.1	0.3
2014		90	1.3	2.5	4.5	0.7	1.2	1.9	2014		90	0.0	0.1	0.2	0.0	0.1	0.1
2015		90	2.0	3.8	6.7	1.1	2.0	3.1	2015		90	0.1	0.2	0.5	0.0	0.2	0.4
2016		90	1.0	2.0	3.5	0.6	1.0	1.7	2016		90	0.0	0.1	0.2	0.0	0.1	0.2
2017		90	1.1	2.2	3.9	0.6	1.1	1.8	2017		90	0.0	0.2	0.5	0.0	0.2	0.4
2018		90	0.2	0.7	1.4	0.1	0.4	0.7	2018		90	0.0	0.1	0.3	0.0	0.1	0.3
2019									2019								
2020									2020								
2002	1	75	11.5	18.3	29.0	5.3	8.4	12.9	2002	4+	75	2.1	3.9	6.8	1.9	3.7	6.6
2003		101	6.8	11.2	17.9	3.9	6.1	9.3	2003		101	0.6	1.2	2.0	0.6	1.2	2.1
2004		92	4.9	7.2	10.5	2.4	3.6	5.2	2004		92	0.7	1.3	2.1	0.6	1.2	1.9
2005		86	19.1	28.7	42.9	8.9	13.0	18.9	2005		86	1.4	2.5	4.0	1.2	2.1	3.4
2006		79	15.8	23.9	36.1	6.0	9.3	14.2	2006		79	1.3	2.7	4.8	1.2	2.4	4.4
2007		44	7.1	12.2	20.6	2.9	5.2	8.7	2007		44	0.3	1.0	2.0	0.2	0.9	1.9
2008		90	5.3	8.7	14.1	3.1	5.2	8.3	2008		90	0.9	1.9	3.3	0.9	1.7	3.1
2009		90	3.7	6.3	10.3	2.0	3.3	5.1	2009		90	0.5	1.1	1.8	0.5	1.0	1.7
2010		90	5.0	8.0	12.6	2.4	3.8	5.7	2010		90	0.4	0.9	1.6	0.4	0.8	1.4
2011		89	3.8	6.3	10.2	2.4	3.8	6.0	2011		89	0.8	1.5	2.4	0.7	1.3	2.2
2012		84	0.2	0.5	0.8	0.1	0.3	0.6	2012		84	0.1	0.2	0.4	0.1	0.2	0.4
2013		89	0.3	0.7	1.1	0.1	0.3	0.5	2013		89	0.0	0.2	0.5	0.0	0.2	0.5
2014		90	0.5	1.0	1.6	0.2	0.5	0.8	2014		90	0.0	0.1	0.2	0.0	0.1	0.2
2015		90	1.0	1.8	2.9	0.5	1.0	1.7	2015		90	0.0	0.2	0.4	0.0	0.2	0.3
2016		90	0.5	1.0	1.7	0.3	0.6	1.1	2016		90	0.0	0.1	0.2	0.0	0.1	0.2
2017		90	0.4	0.9	1.6	0.3	0.6	1.0	2017		90	0.0	0.2	0.4	0.0	0.2	0.3
2018		90	0.0	0.1	0.3	0.0	0.1	0.1	2018		90	0.0	0.1	0.3	0.0	0.1	0.3
2019									2019								
2020									2020								

Figure 59. Summer Flounder geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

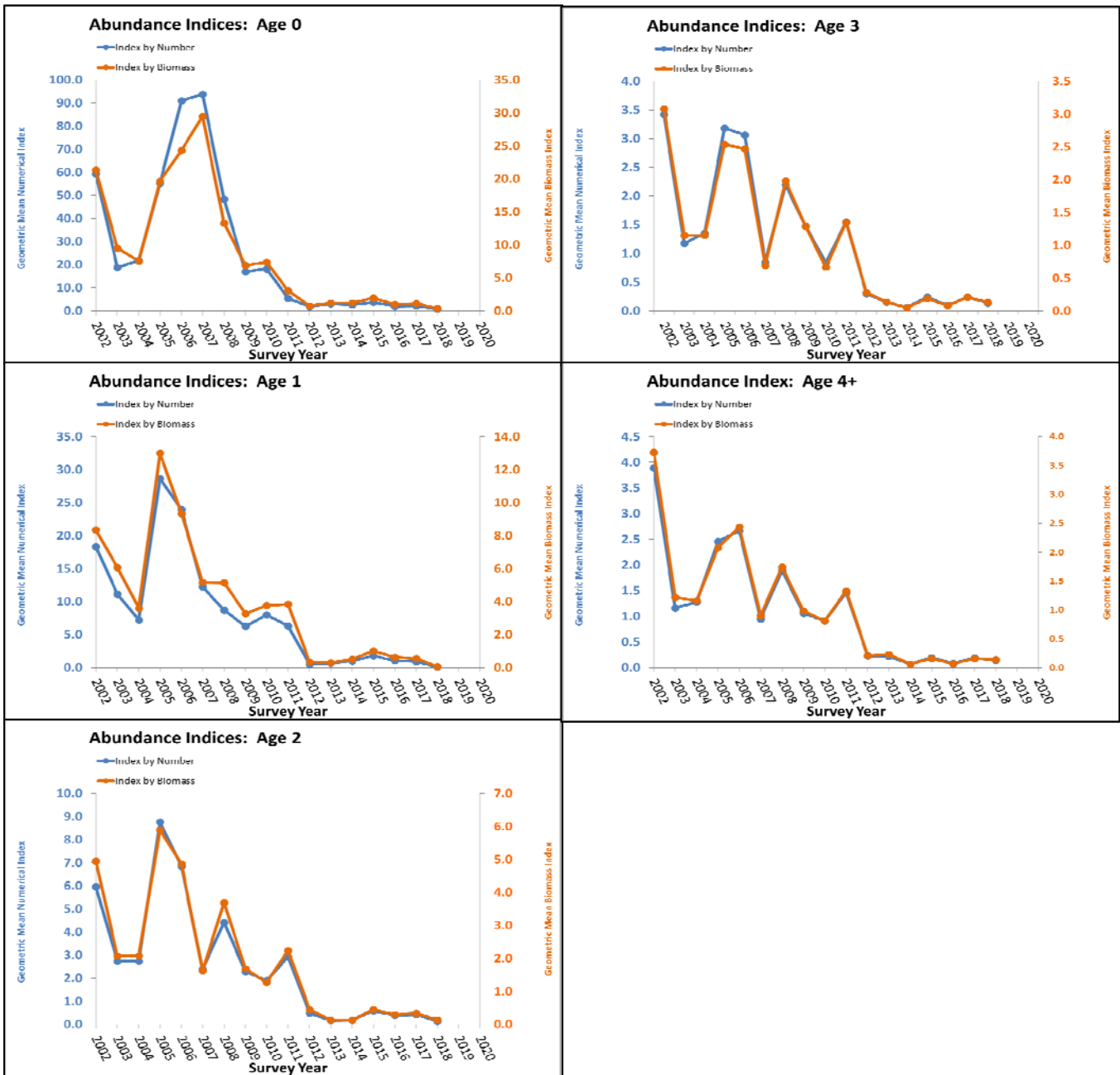
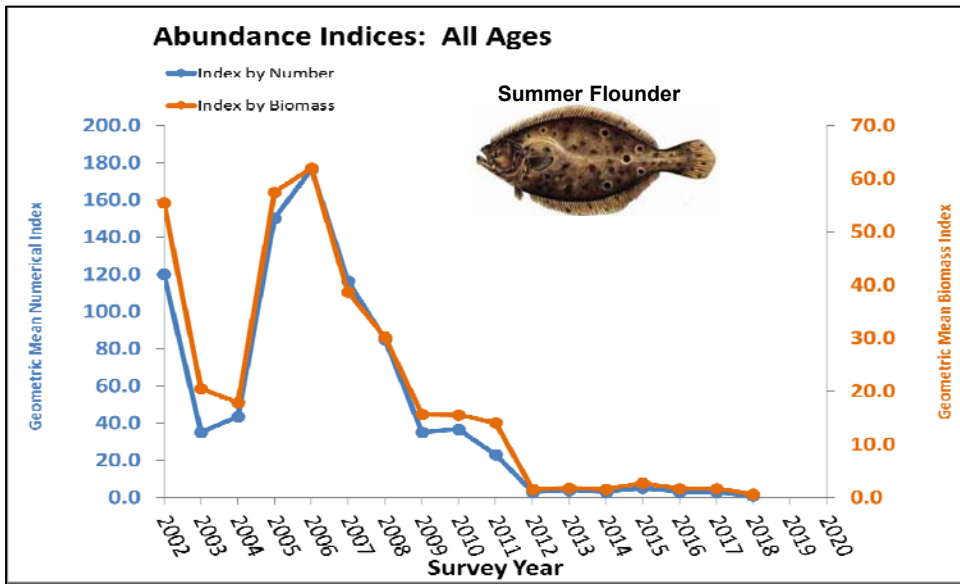


Figure 60. Summer Flounder length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

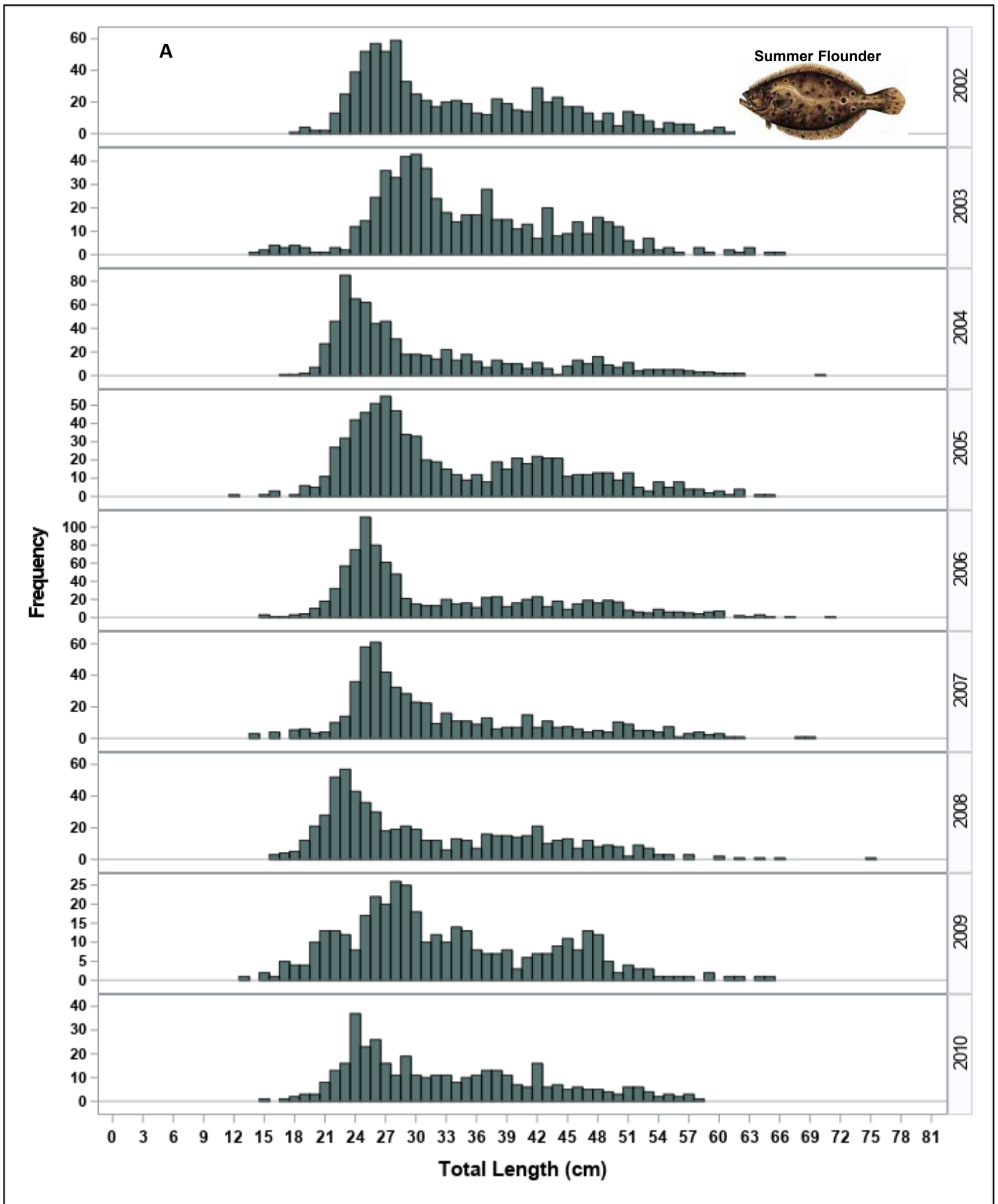


Figure 60. cont.

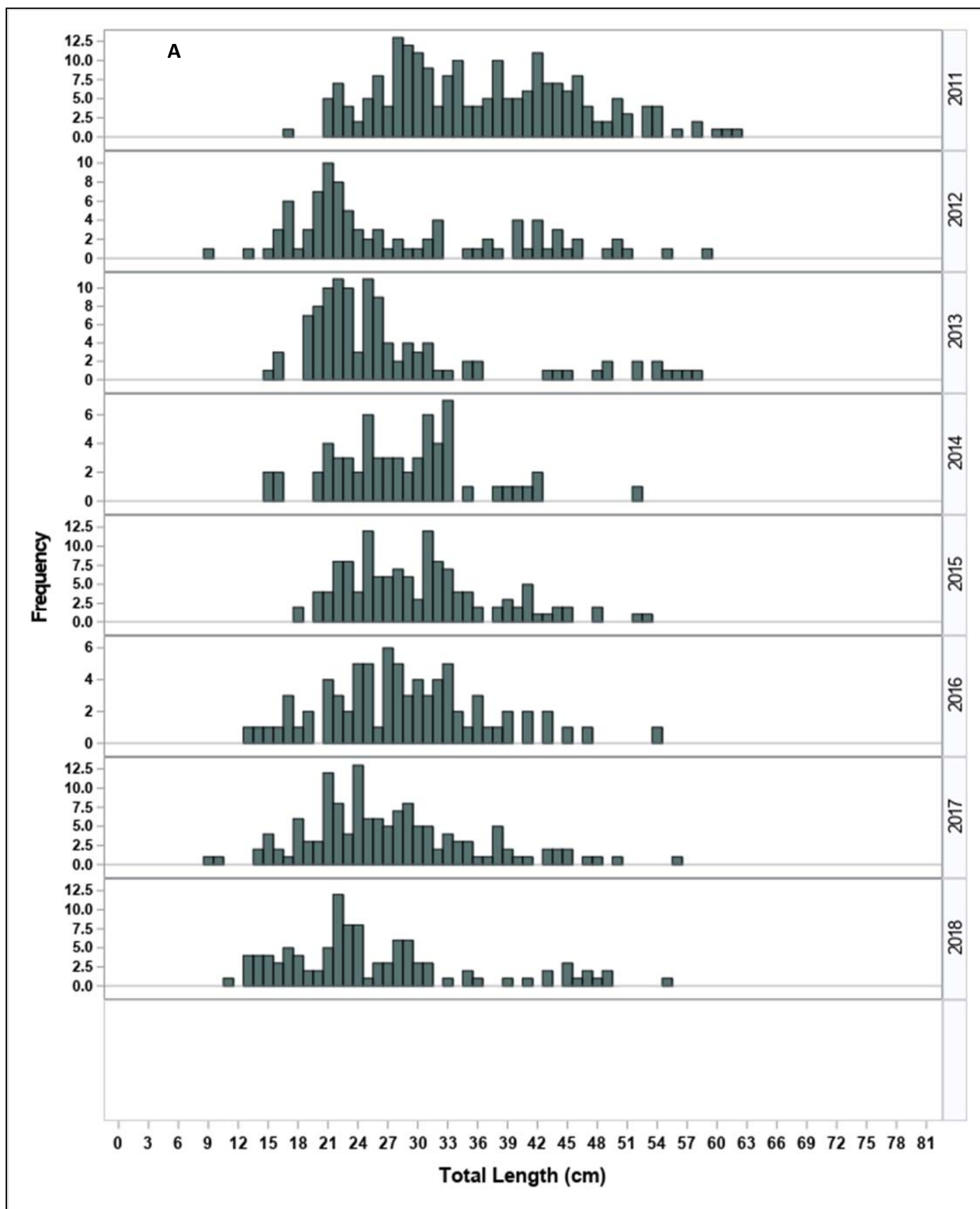


Figure 60. cont.

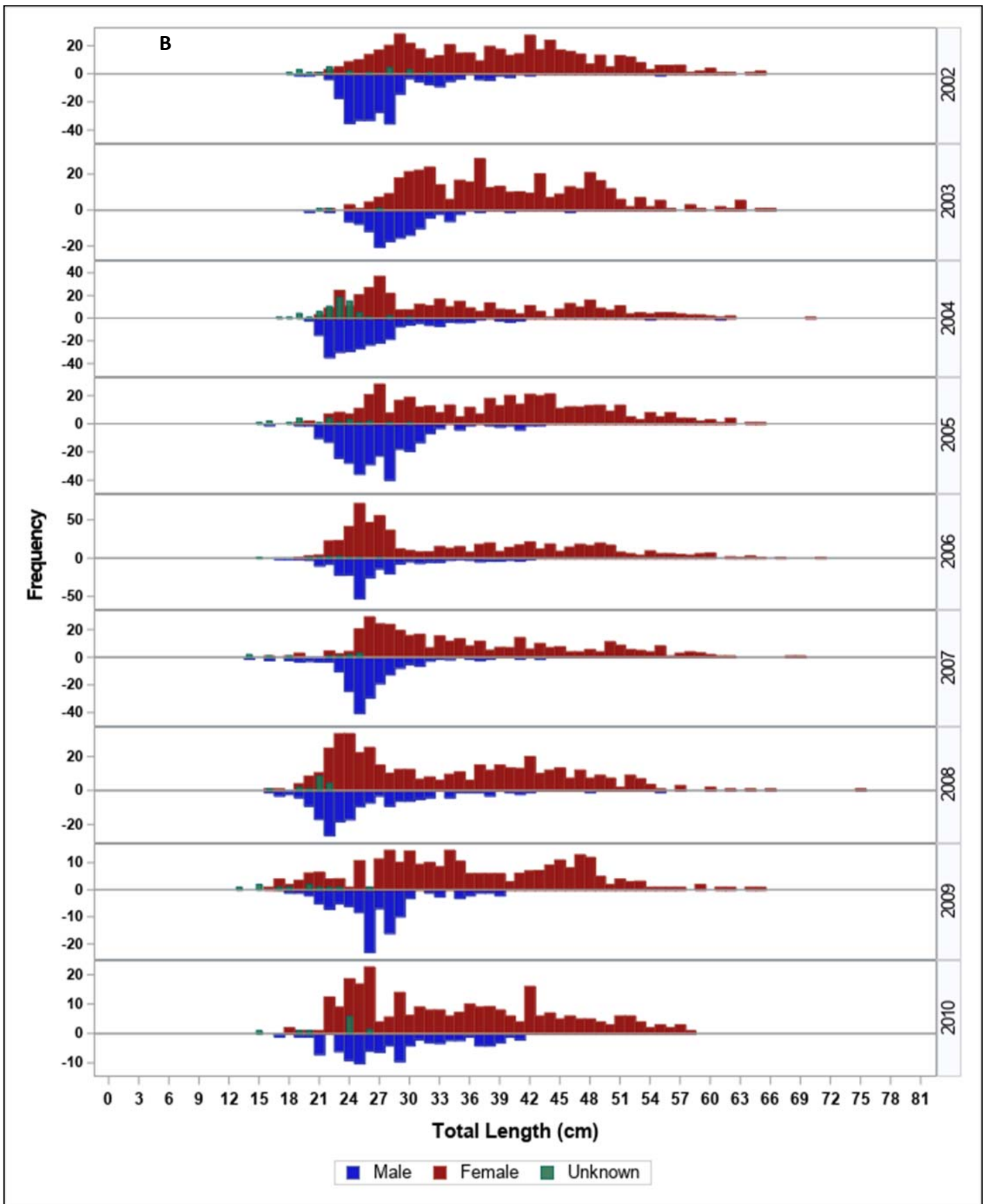


Figure 60. cont.

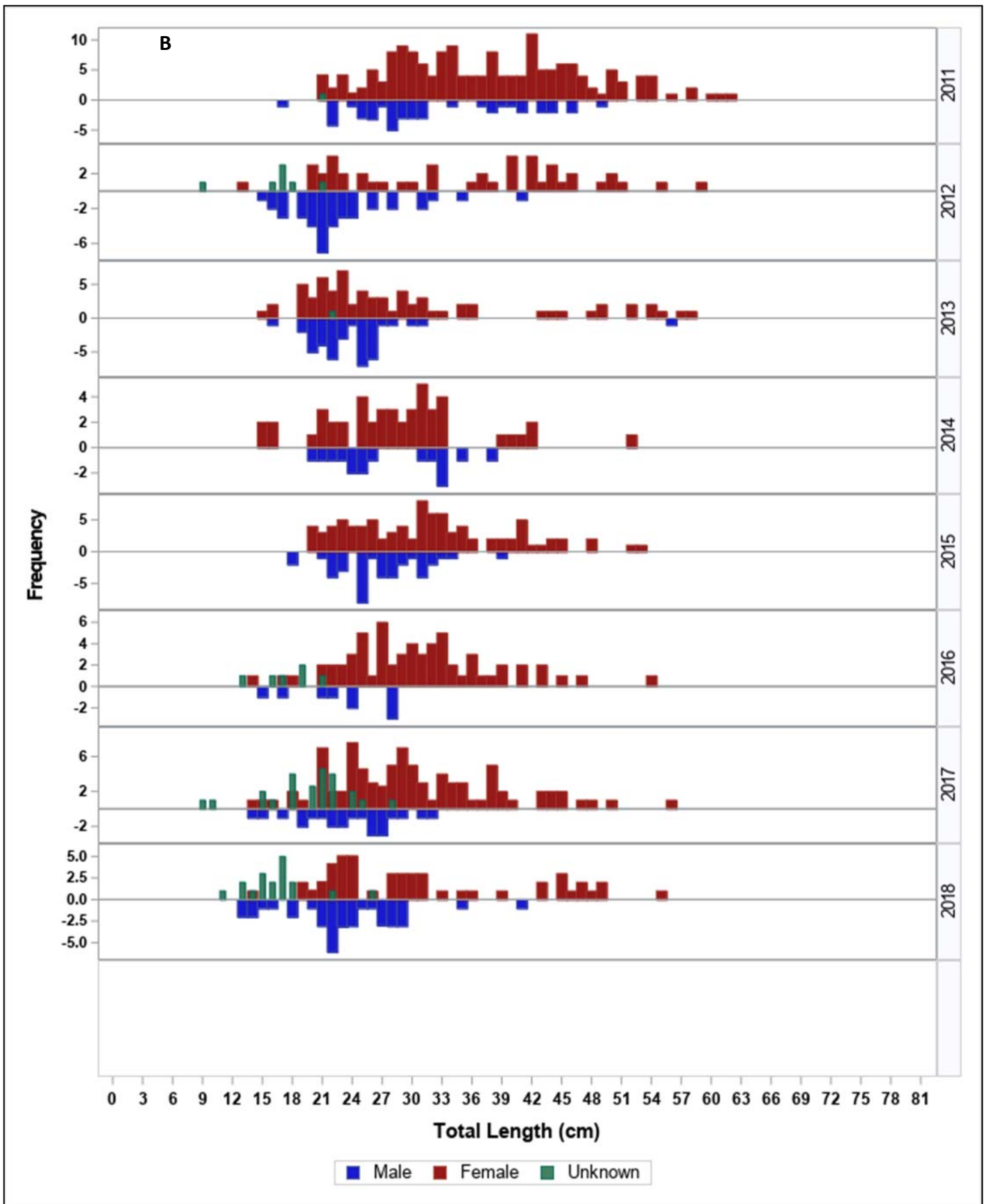


Figure 61. Summer Flounder total age-frequency, 2002-2018.

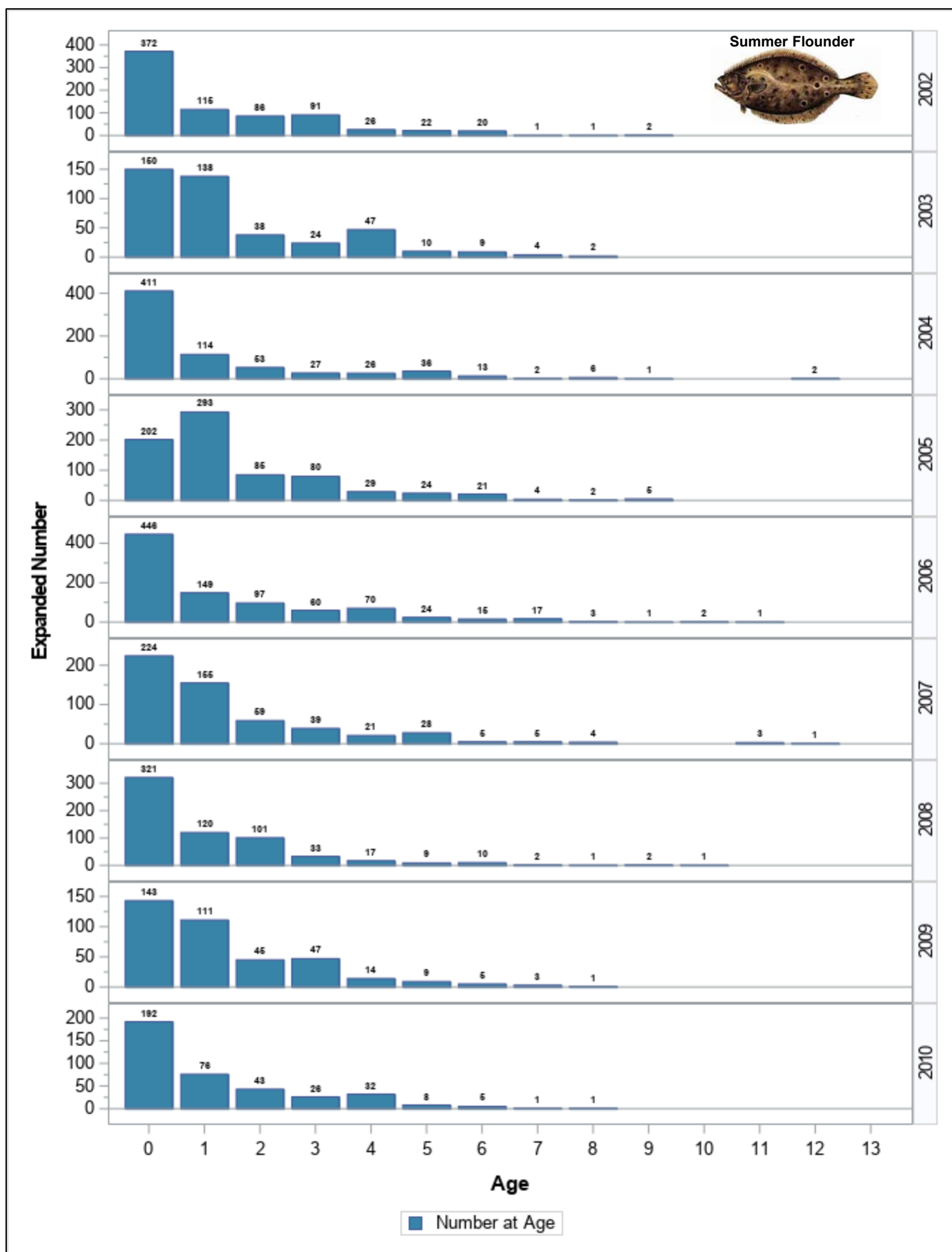


Figure 61. cont.

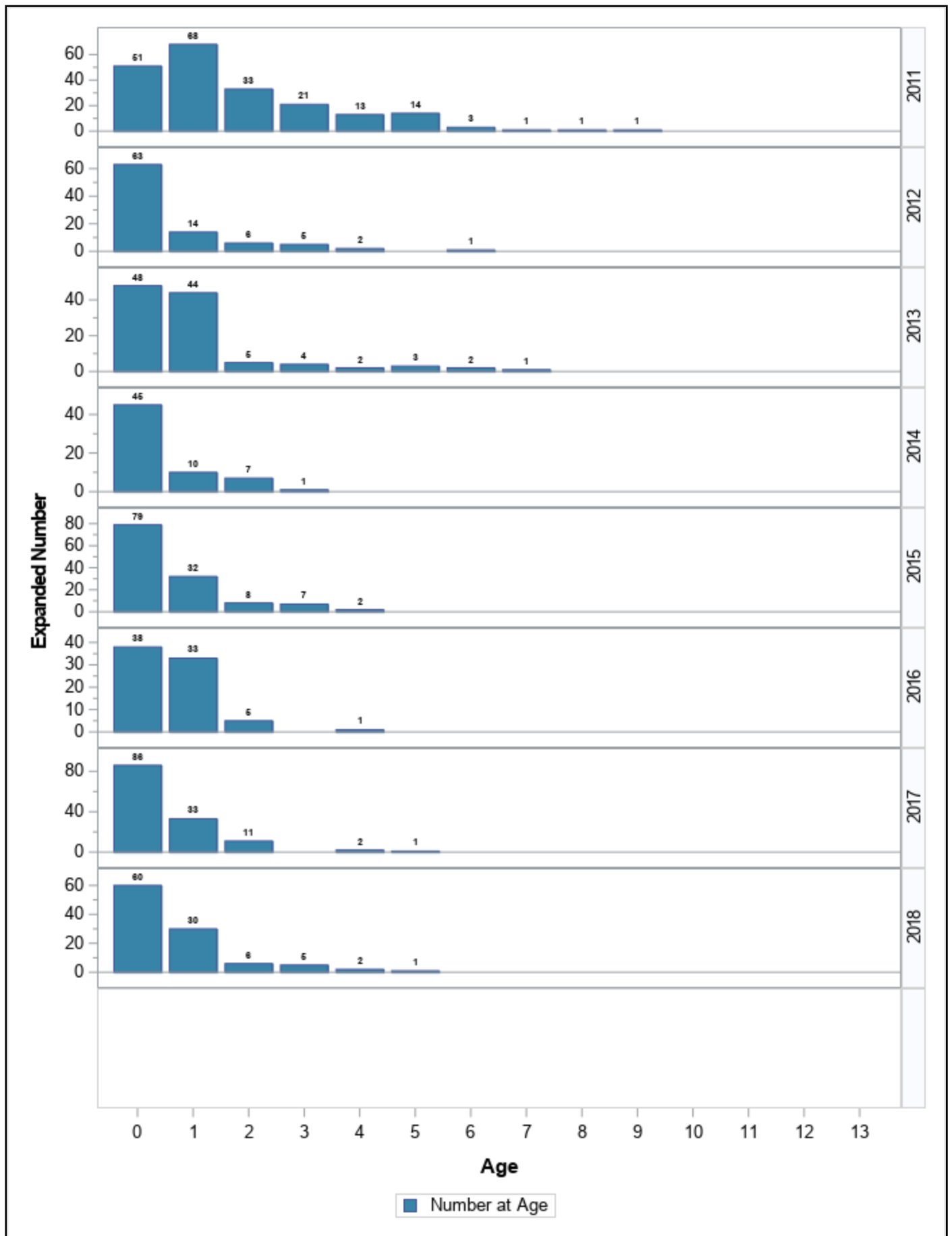


Figure 62. Summer Flounder age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

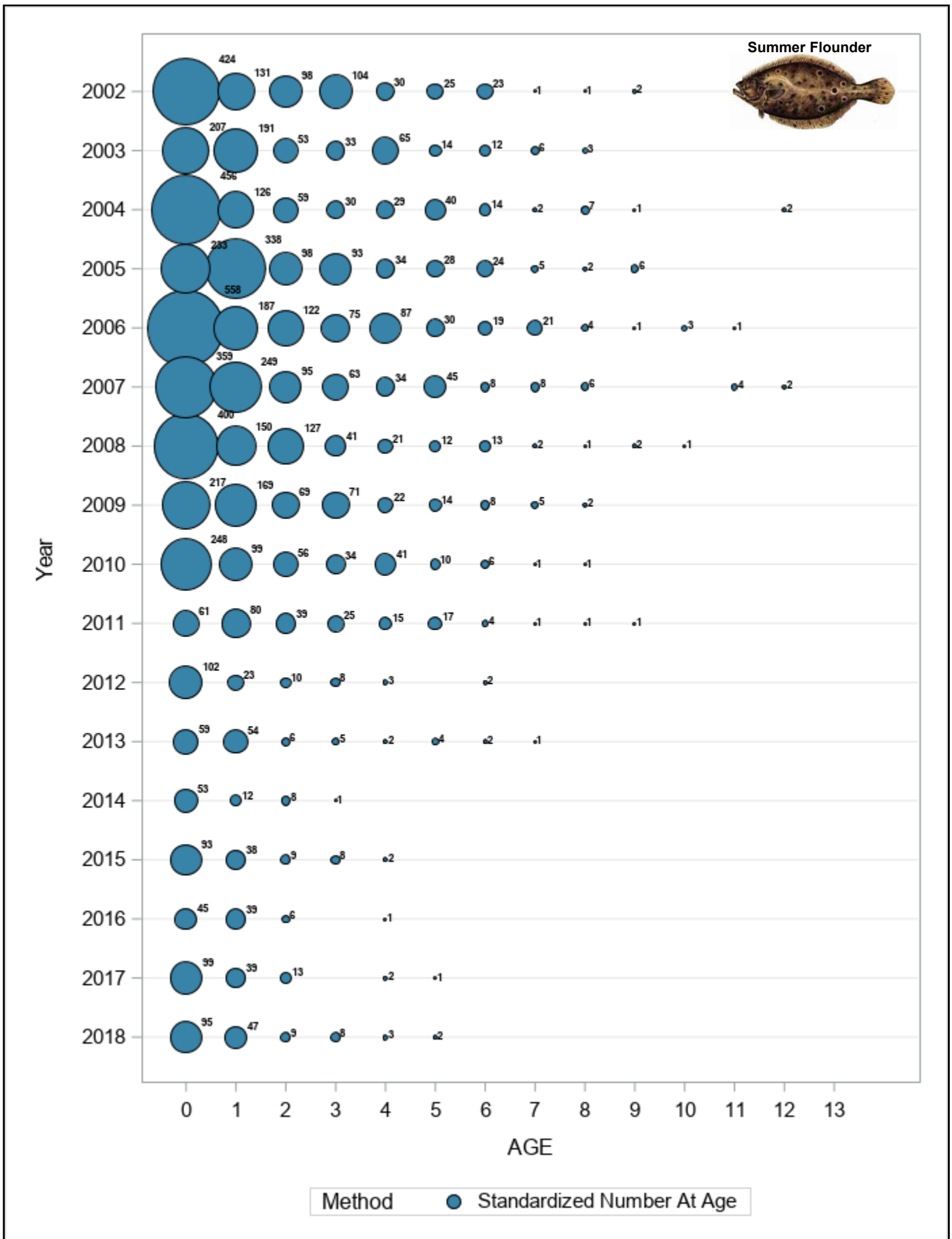


Figure 63. Summer Flounder age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

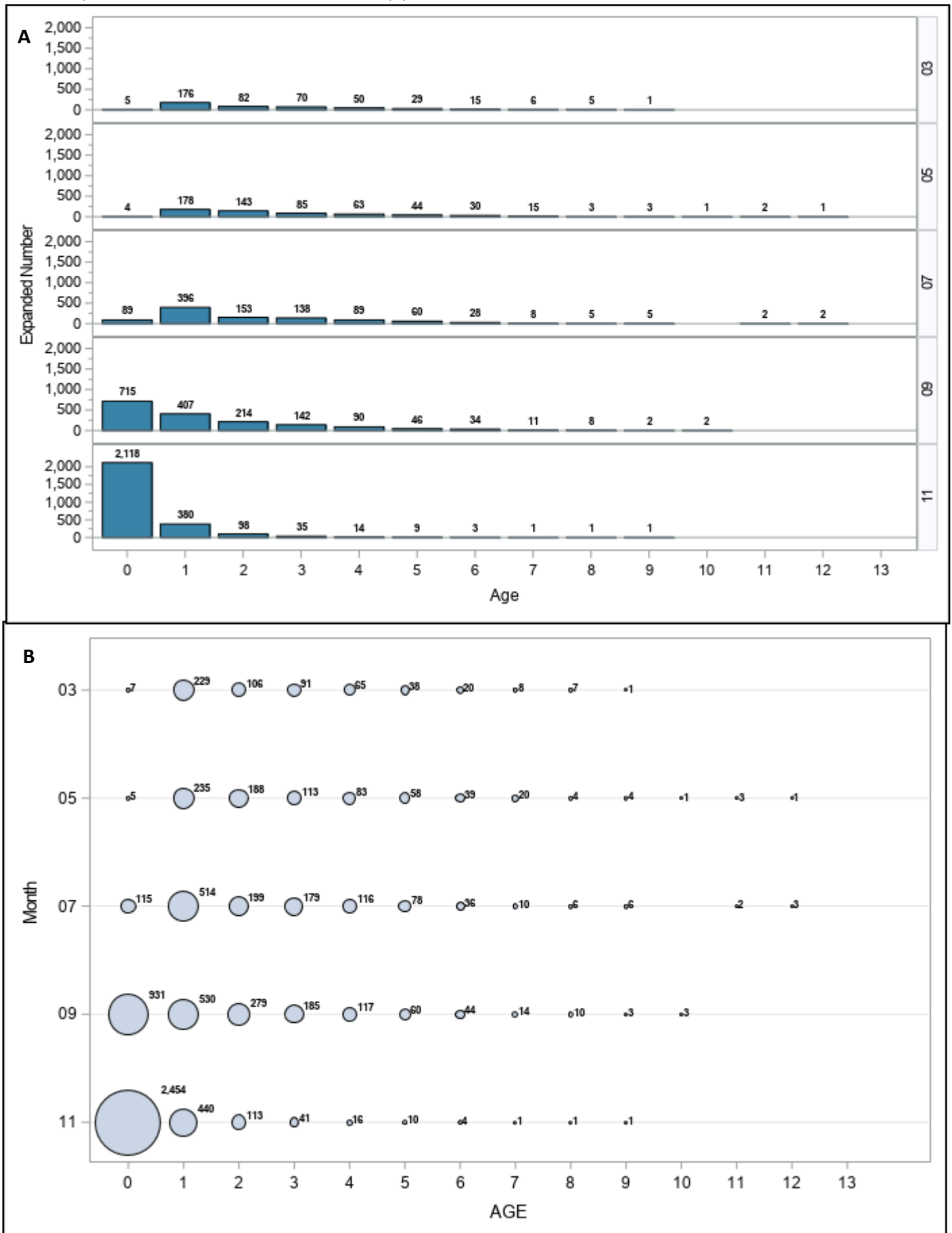


Figure 64. Diet composition, expressed as percent by weight (A) and percent by number (B) of Summer Flounder collected during ChesMMAP cruises in 2002-2018 combined.

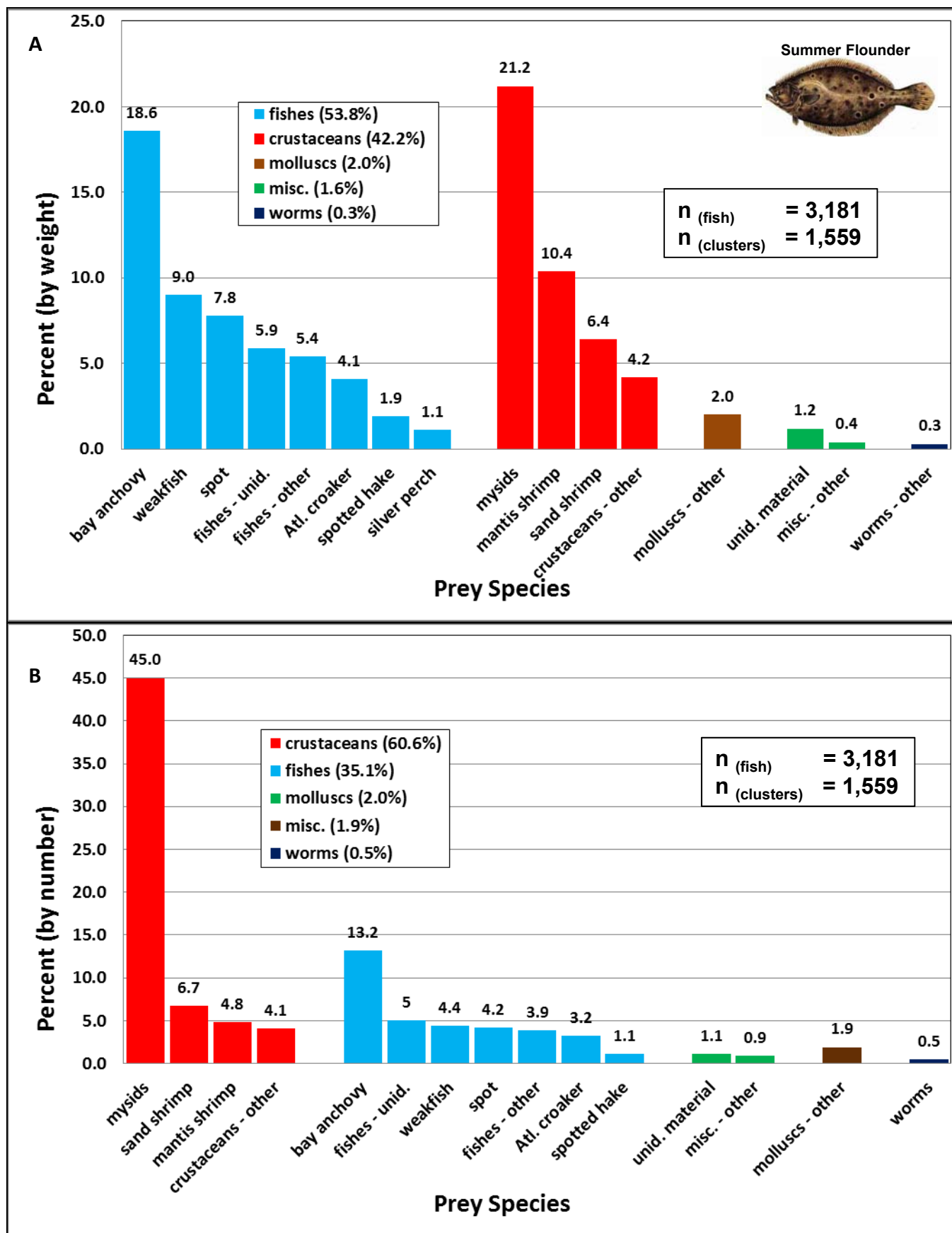


Table 36. Weakfish sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	1,734	304.7	56.1	1,692	803	803	607	583
2003	2,315	400.0	55.6	2,198	707	707	654	642
2004	3,851	561.9	51.9	3,551	1,108	1,108	901	889
2005	2,715	378.5	67.3	2,711	1,119	1,119	918	906
2006	1,476	159.5	52.0	1,462	728	728	561	554
2007	1,214	128.0	50.0	1,210	554	554	439	435
2008	812	83.8	49.0	812	368	368	330	324
2009	873	46.2	50.0	873	478	478	387	384
2010	1,207	76.8	61.5	1,207	607	607	542	531
2011	918	57.5	50.0	918	454	454	323	322
2012	886	72.2	32.7	886	328	328	260	256
2013	301	42.0	19.2	301	187	187	130	129
2014	172	8.6	15.4	172	126	126	72	72
2015	688	51.9	17.3	688	285	285	141	140
2016	1,115	91.2	36.5	1,115	281	281	143	141
2017	943	68.3	26.9	943	335	335	194	191
2018	1,621	61.5	40.4	1,621	273	273	173	171

Figure 65. Abundance (kg per hectare swept) of Weakfish in Chesapeake Bay, 2018.

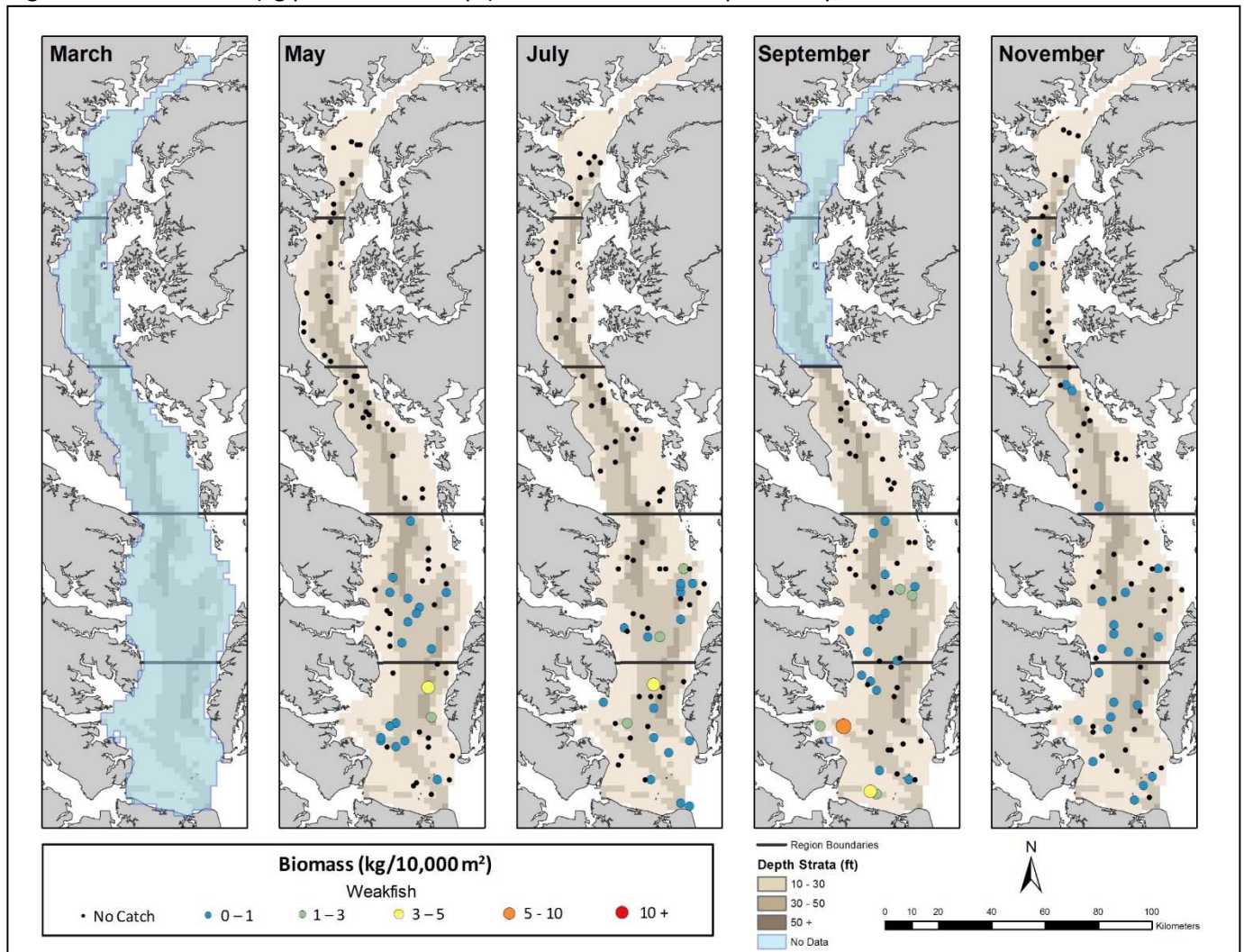


Table 37. Months, latitudinal regions, and depth strata used for Weakfish index calculations.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 38. Weakfish geometric mean indices of abundance, by number and biomass, overall and by age-class.

Year	Age	n	Numerical Index			Biomass Index			Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI
2002	All	66	23.8	50.4	105.5	6.6	12.3	22.0	2002	1	66	11.1	22.6	45.0	3.8	6.8	11.6
2003		88	48.7	101.4	210.0	12.0	21.8	39.2	2003		88	17.4	34.7	68.4	5.7	10.1	17.3
2004		76	127.1	252.2	499.5	25.3	43.9	75.5	2004		76	57.8	112.7	219.0	13.3	23.1	39.5
2005		76	127.1	267.3	561.2	26.0	47.2	84.8	2005		76	49.7	100.9	203.8	13.2	22.9	39.1
2006		74	48.5	98.5	199.1	9.8	16.8	28.1	2006		74	19.9	38.6	74.3	5.2	8.8	14.3
2007		52	76.1	175.3	402.4	12.2	22.7	41.5	2007		52	28.4	67.1	157.2	7.1	13.1	23.7
2008		77	14.0	29.3	60.2	3.6	6.2	10.3	2008		77	6.2	12.4	24.2	2.1	3.6	5.9
2009		78	38.2	77.1	154.7	4.9	7.9	12.5	2009		78	7.2	14.4	27.7	1.9	3.3	5.2
2010		79	73.5	140.1	266.0	9.6	15.0	23.0	2010		79	18.4	34.5	63.7	4.0	6.5	10.2
2011		78	37.5	75.8	152.0	5.7	9.3	14.8	2011		78	11.6	23.6	47.1	2.9	4.8	7.7
2012		75	4.1	9.4	20.4	1.5	3.0	5.2	2012		75	2.4	5.6	11.5	1.0	2.0	3.4
2013		78	2.8	6.3	13.0	1.1	2.1	3.7	2013		78	1.4	3.1	6.0	0.6	1.2	2.2
2014		78	2.1	4.8	9.6	0.6	1.1	1.8	2014		78	0.7	1.7	3.2	0.2	0.5	0.9
2015		78	3.8	8.4	17.7	1.4	2.5	4.3	2015		78	2.1	4.6	9.0	0.8	1.5	2.6
2016		78	13.6	30.2	65.7	4.0	7.2	12.5	2016		78	9.0	19.3	40.0	2.7	4.9	8.2
2017		78	6.7	15.2	33.1	2.0	3.7	6.4	2017		78	3.3	7.4	15.6	1.2	2.4	4.2
2018		78	8.7	19.6	42.7	1.8	3.3	5.5	2018		78	2.0	4.5	9.1	0.7	1.4	2.5
2019									2019								
2020									2020								
2002	0	66	3.4	7.3	14.7	0.9	1.8	3.1	2002	2+	66	9.1	18.9	38.1	3.5	6.4	11.2
2003		88	14.0	28.6	57.4	3.3	5.7	9.4	2003		88	13.3	26.1	50.3	5.2	9.2	15.8
2004		76	11.9	24.5	49.1	2.8	4.7	7.5	2004		76	34.4	64.3	119.4	9.2	15.2	24.7
2005		76	14.8	32.4	69.6	3.1	5.5	9.2	2005		76	42.5	83.4	162.6	12.6	21.5	36.4
2006		74	9.2	20.0	42.2	2.0	3.4	5.5	2006		74	12.4	23.0	41.9	3.6	5.9	9.3
2007		52	4.0	10.2	24.2	0.9	2.1	4.1	2007		52	14.2	29.3	59.3	3.5	6.1	10.2
2008		77	3.6	7.4	14.3	0.8	1.5	2.4	2008		77	3.3	6.1	10.6	1.1	1.9	2.9
2009		78	11.9	25.2	52.5	1.7	2.8	4.4	2009		78	2.0	3.6	6.2	0.6	1.0	1.5
2010		79	18.3	37.7	76.3	2.6	4.2	6.5	2010		79	5.8	10.1	17.3	1.6	2.5	3.8
2011		78	12.1	24.4	48.0	1.9	3.2	5.0	2011		78	3.0	5.2	8.8	0.7	1.1	1.6
2012		75	1.2	2.9	6.0	0.4	0.9	1.7	2012		75	1.3	2.7	4.7	0.5	0.9	1.4
2013		78	0.9	2.1	4.1	0.3	0.5	0.9	2013		78	0.9	2.0	3.9	0.4	0.9	1.7
2014		78	1.2	2.7	5.3	0.2	0.5	0.9	2014		78	0.2	0.6	1.1	0.1	0.2	0.3
2015		78	1.6	3.8	7.6	0.5	1.0	1.7	2015		78	0.9	1.8	3.1	0.3	0.6	0.9
2016		78	3.3	6.5	12.1	0.8	1.5	2.5	2016		78	2.9	5.4	9.6	0.9	1.4	2.2
2017		78	2.1	4.4	8.3	0.5	1.0	1.5	2017		78	1.4	2.8	5.2	0.5	0.9	1.5
2018		78	3.7	8.1	16.7	0.7	1.3	2.2	2018		78	0.7	1.5	2.7	0.2	0.5	0.8
2019									2019								
2020									2020								

Figure 66. Weakfish geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class.

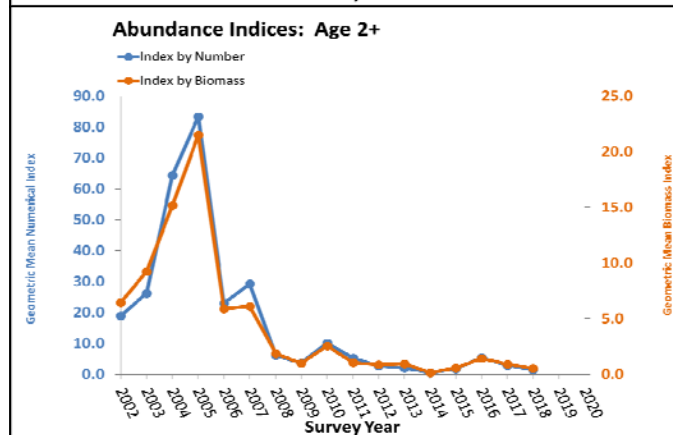
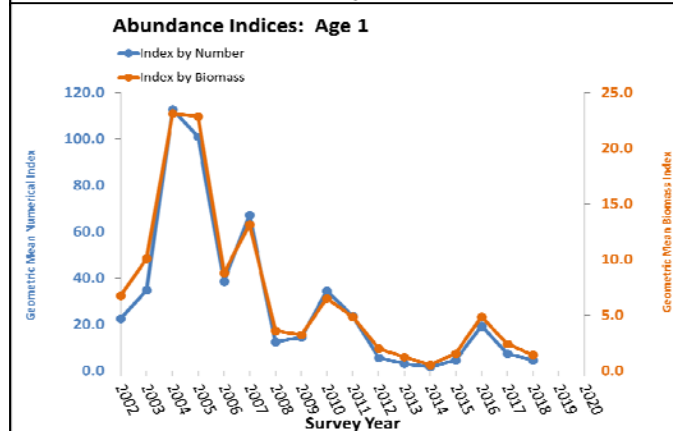
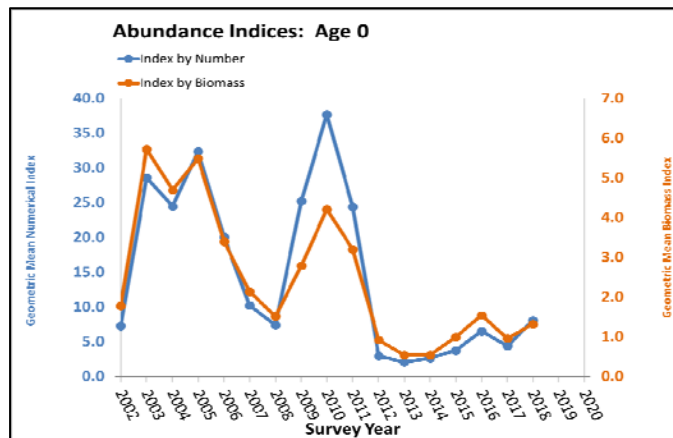
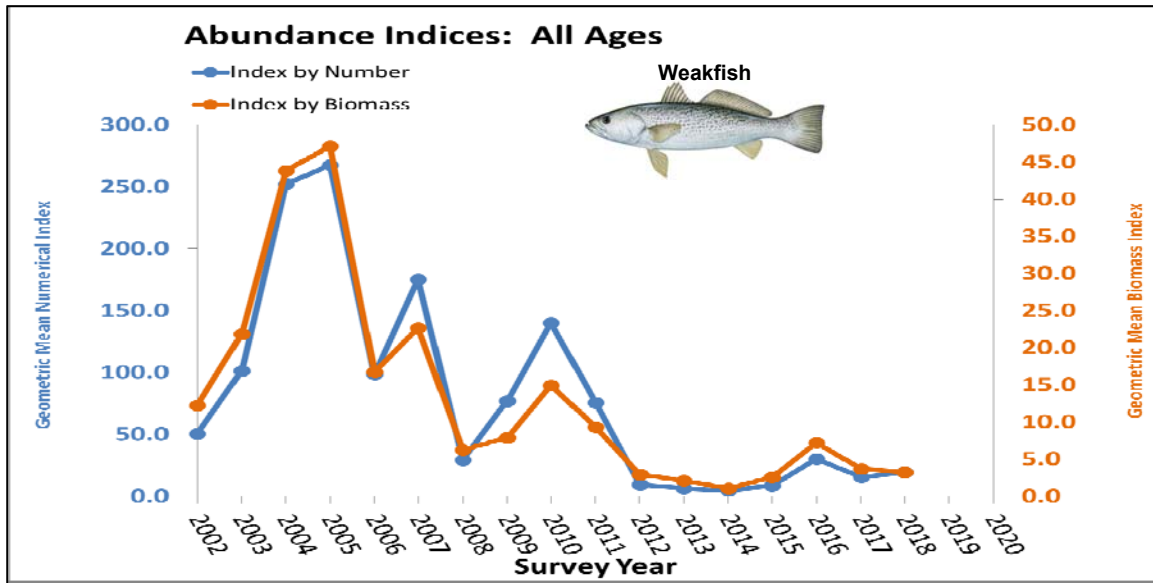


Figure 67. Weakfish length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

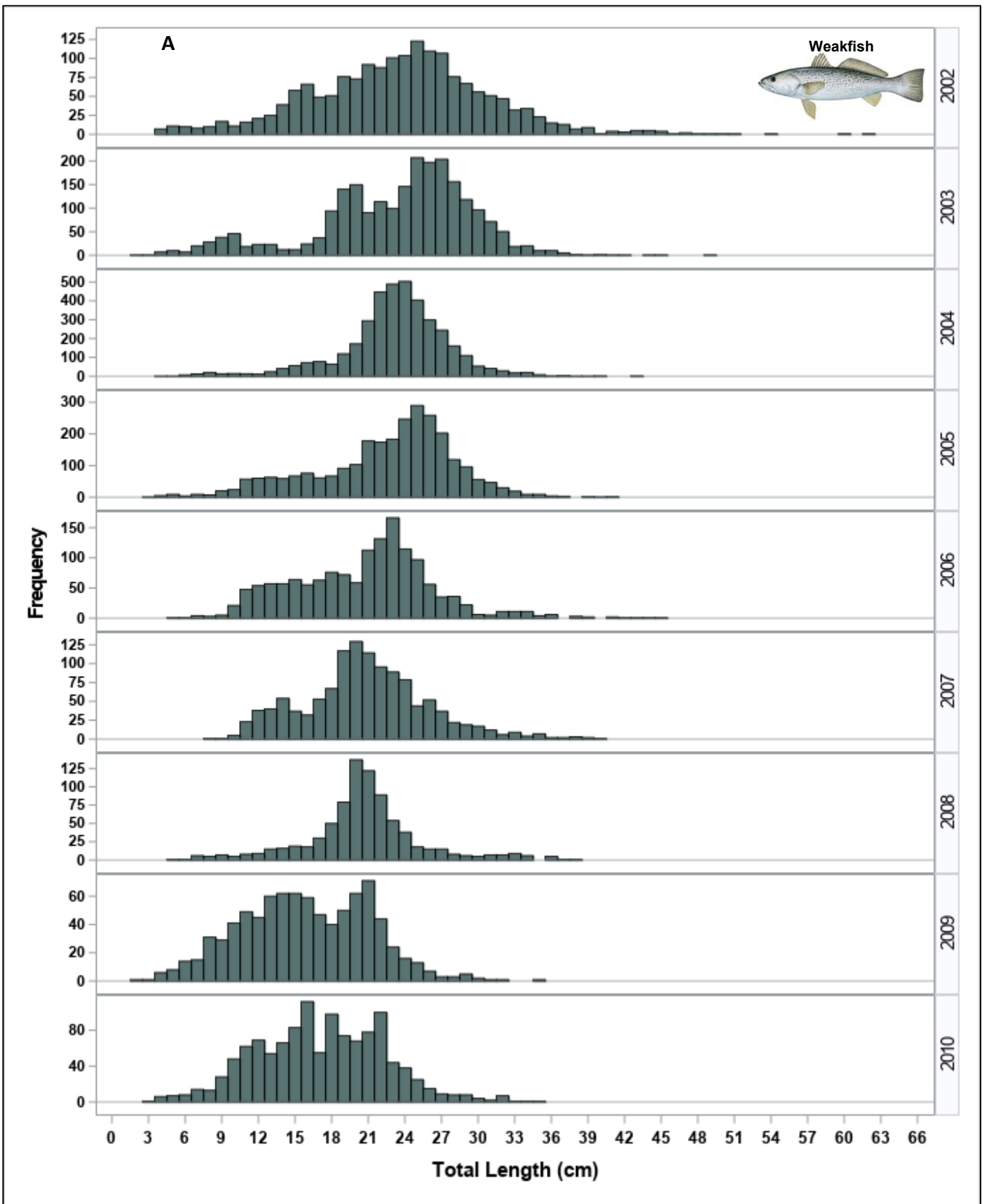


Figure 67. cont.

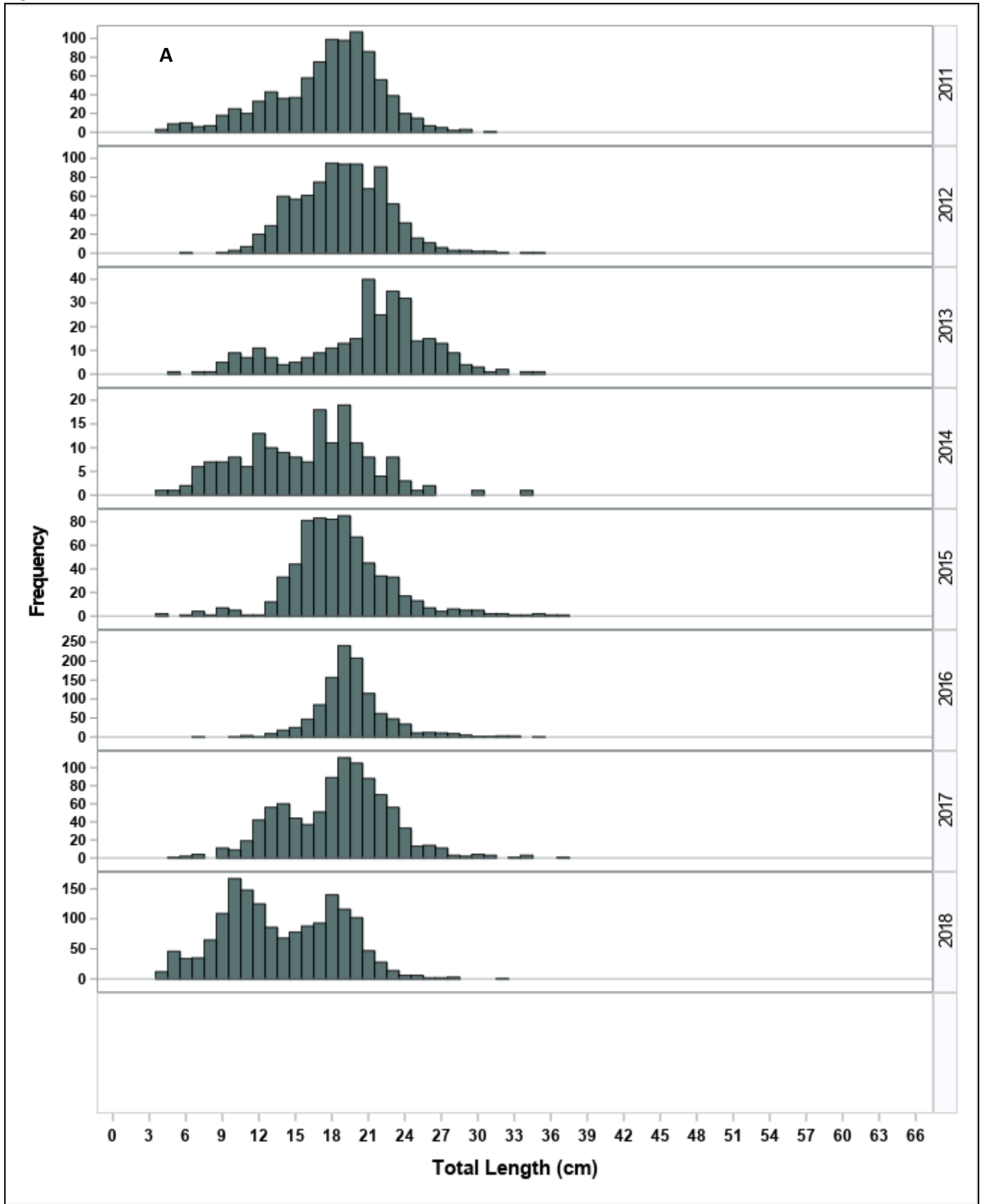


Figure 67. cont.

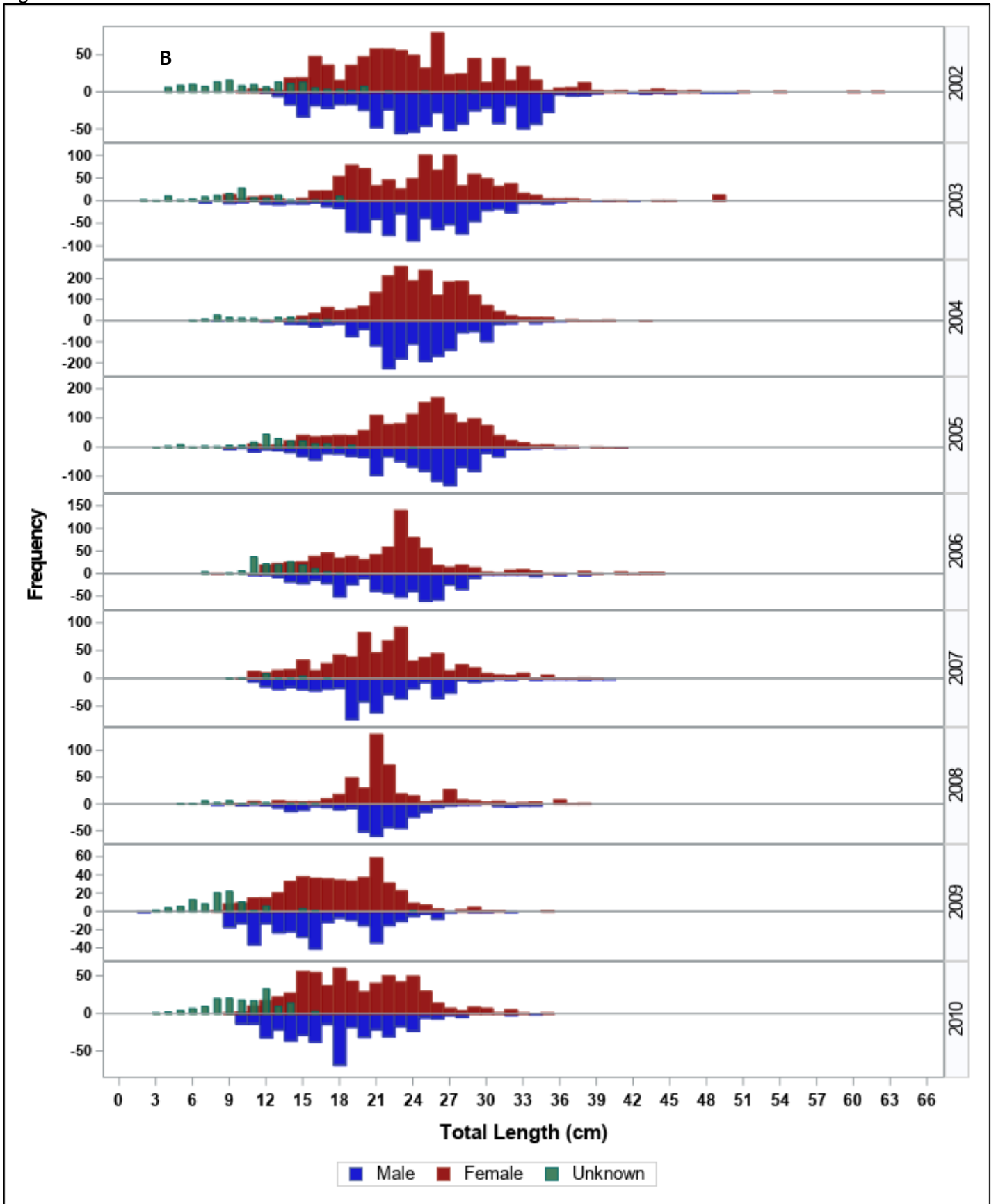


Figure 67. cont.

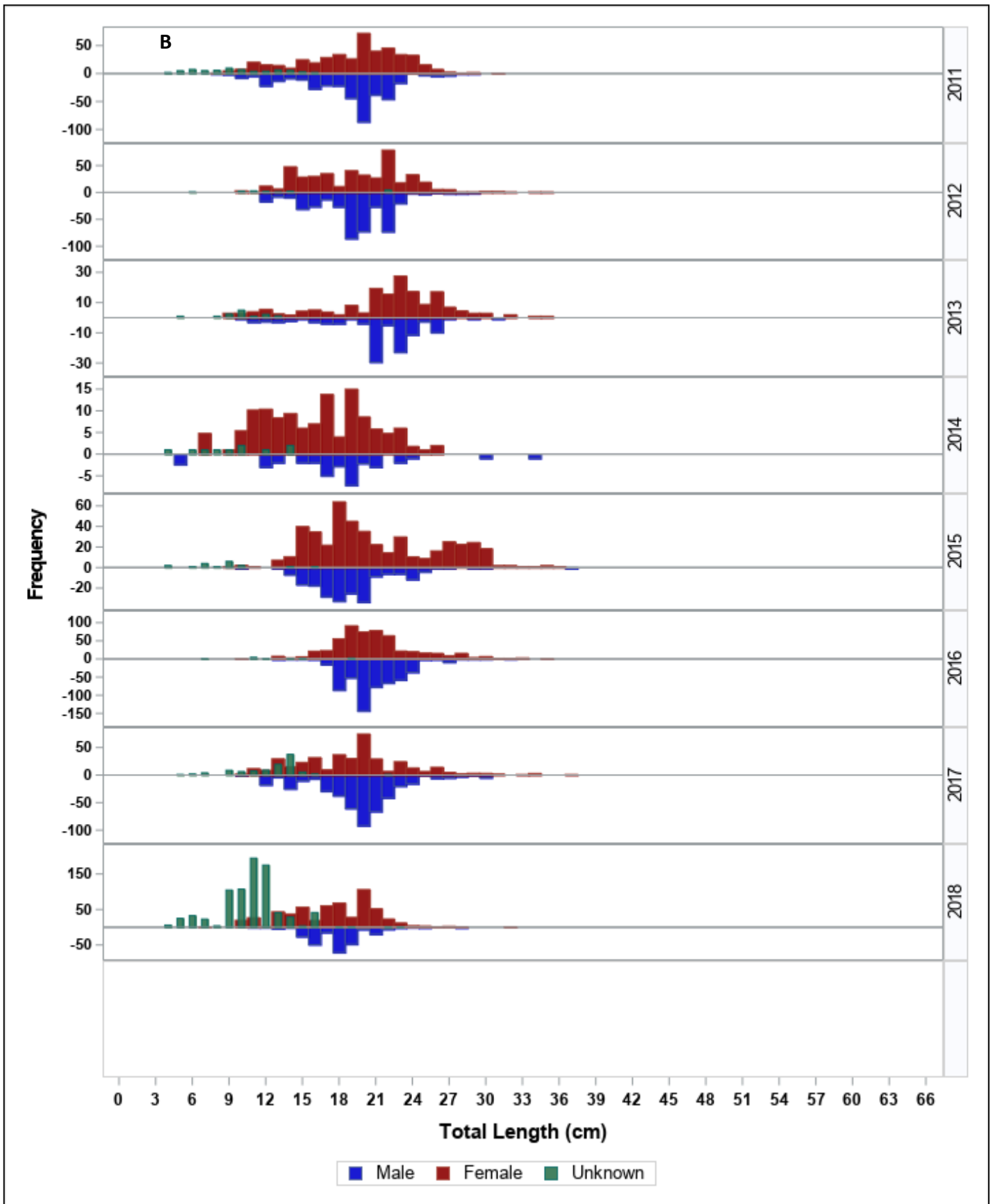


Figure 68. Weakfish total age-frequency, 2002-2018.

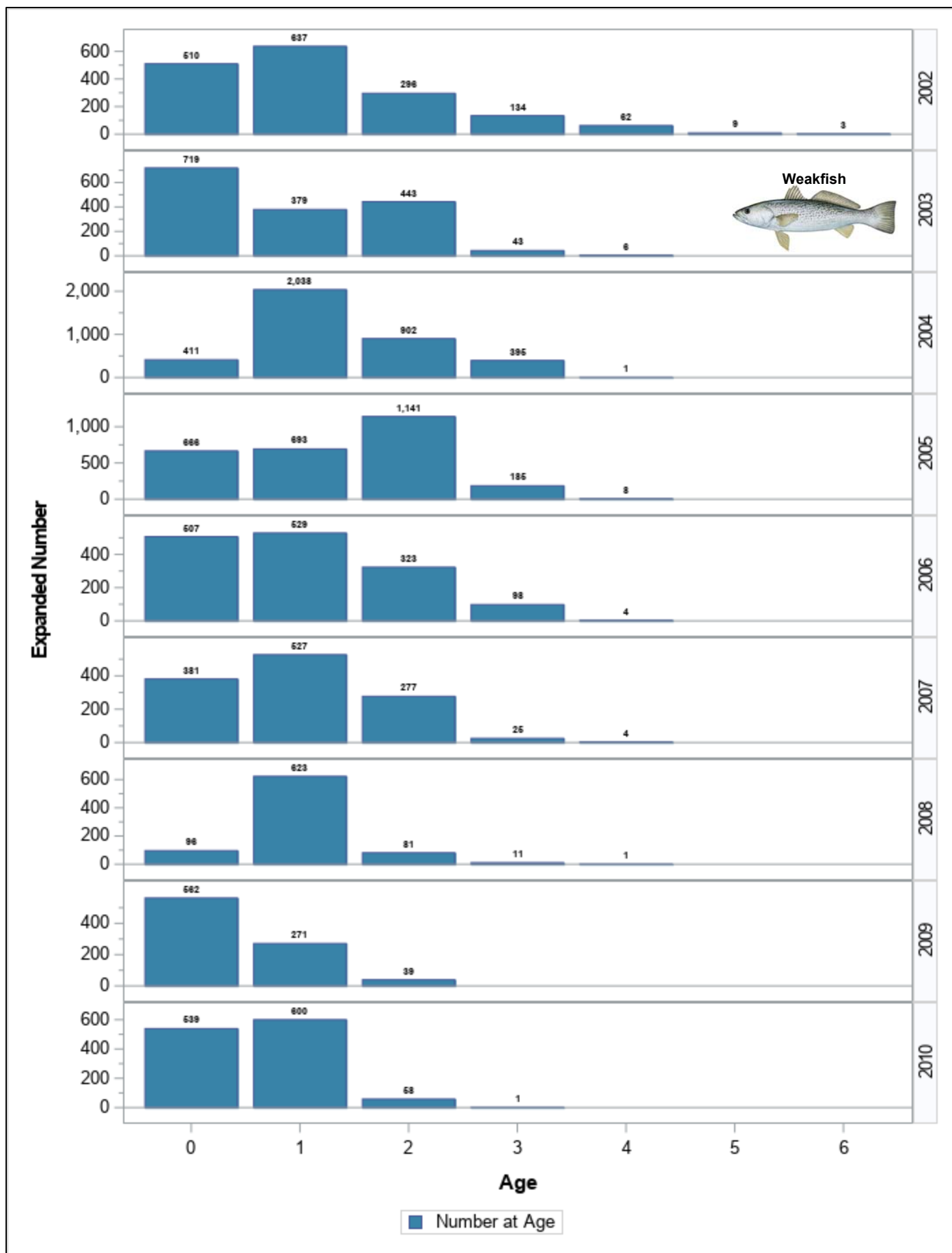


Figure 68. cont.

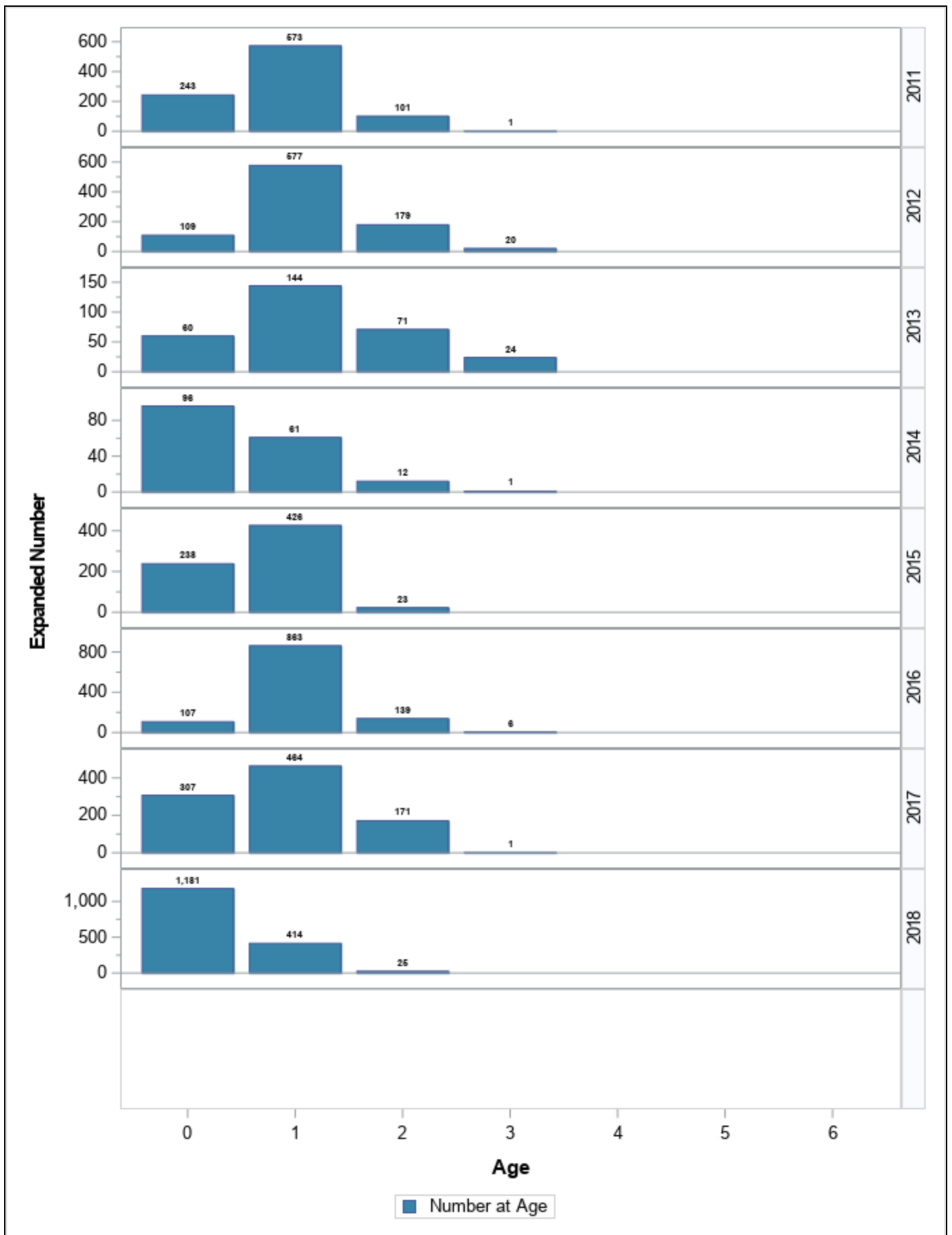


Figure 69. Weakfish age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

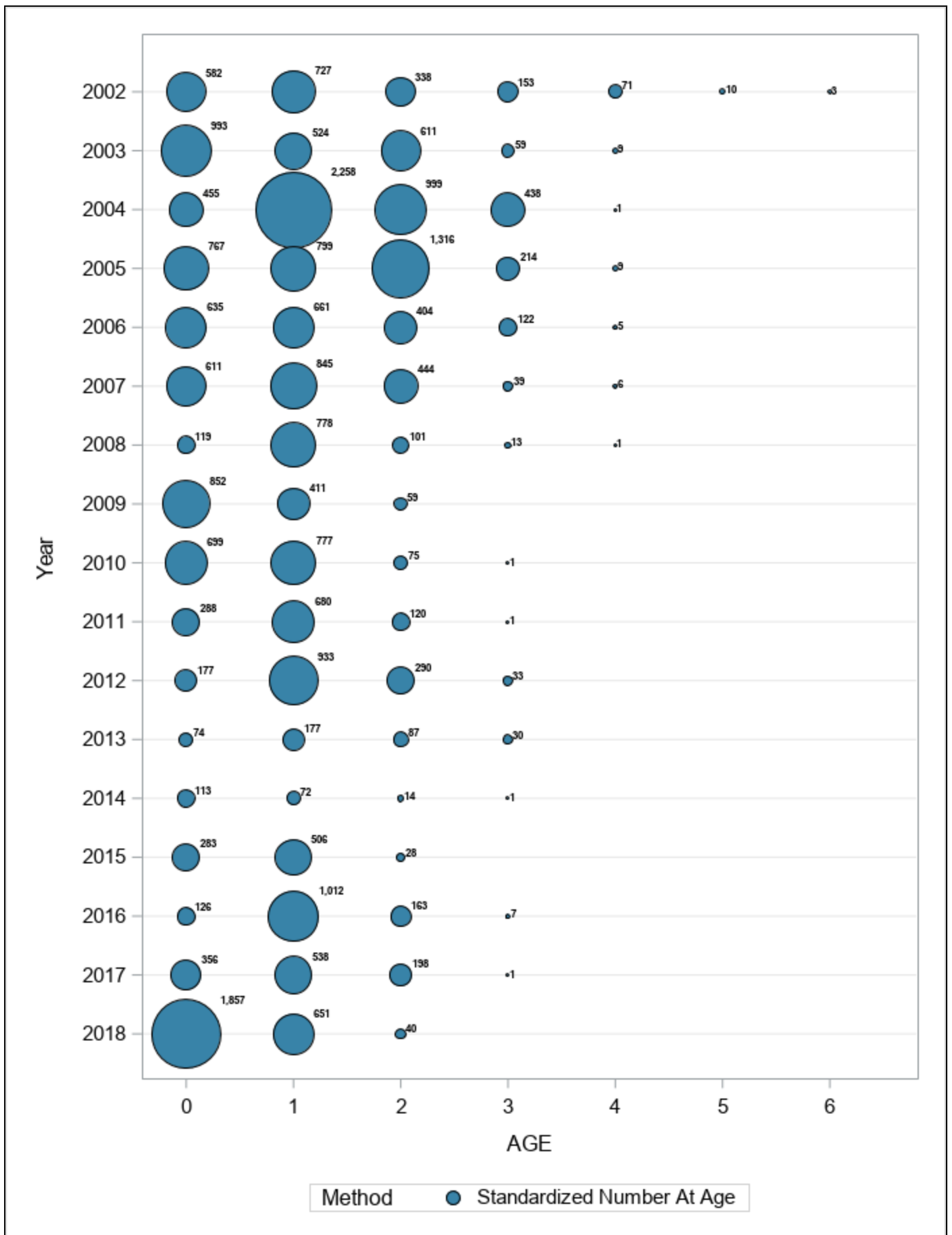


Figure 70. Weakfish age-frequency by cruise month, 2002-2017 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

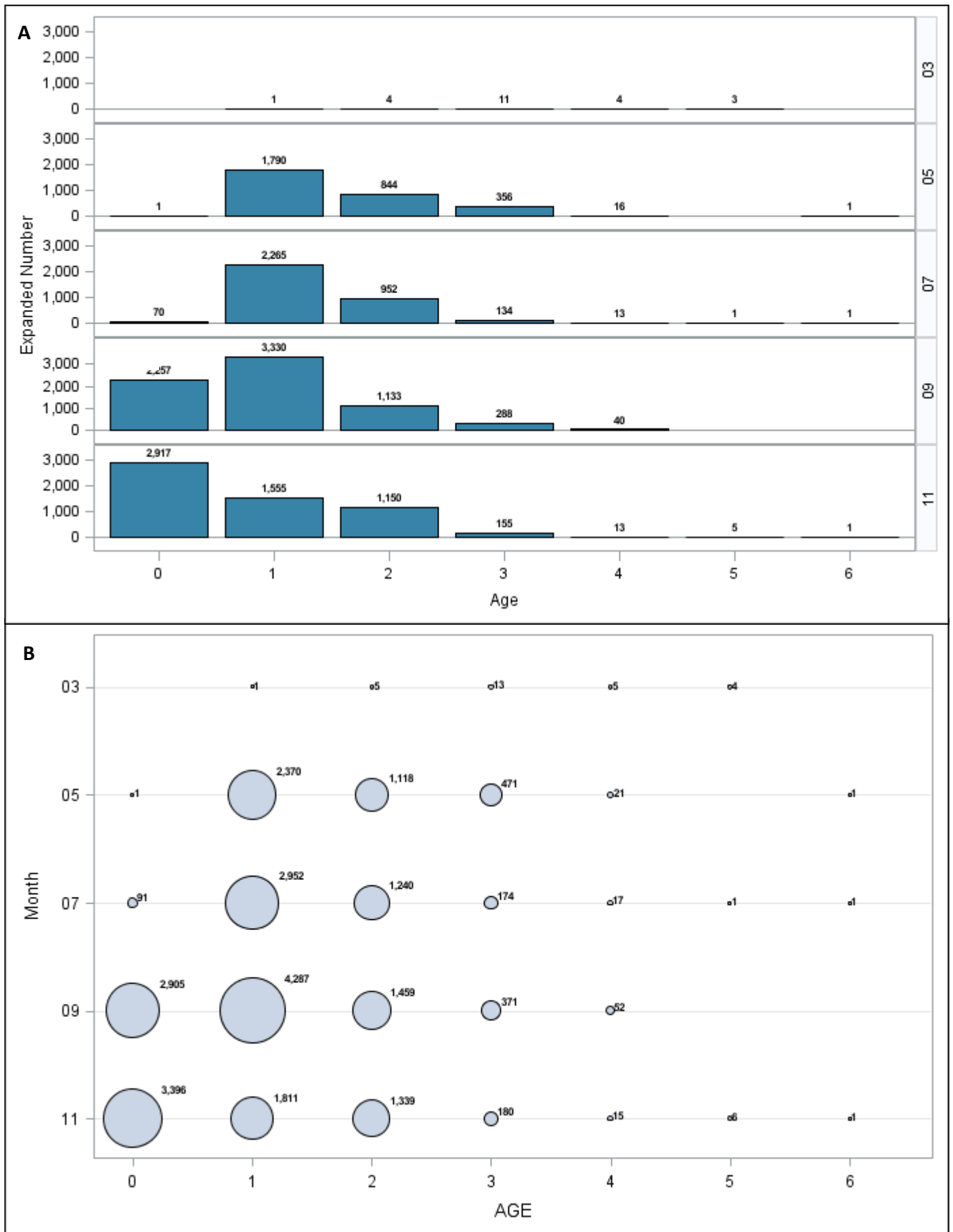


Figure 71. Diet composition, expressed as percent by weight (A) and percent by number (B) of Weakfish collected during ChesMMAP cruises in 2002-2018 combined.

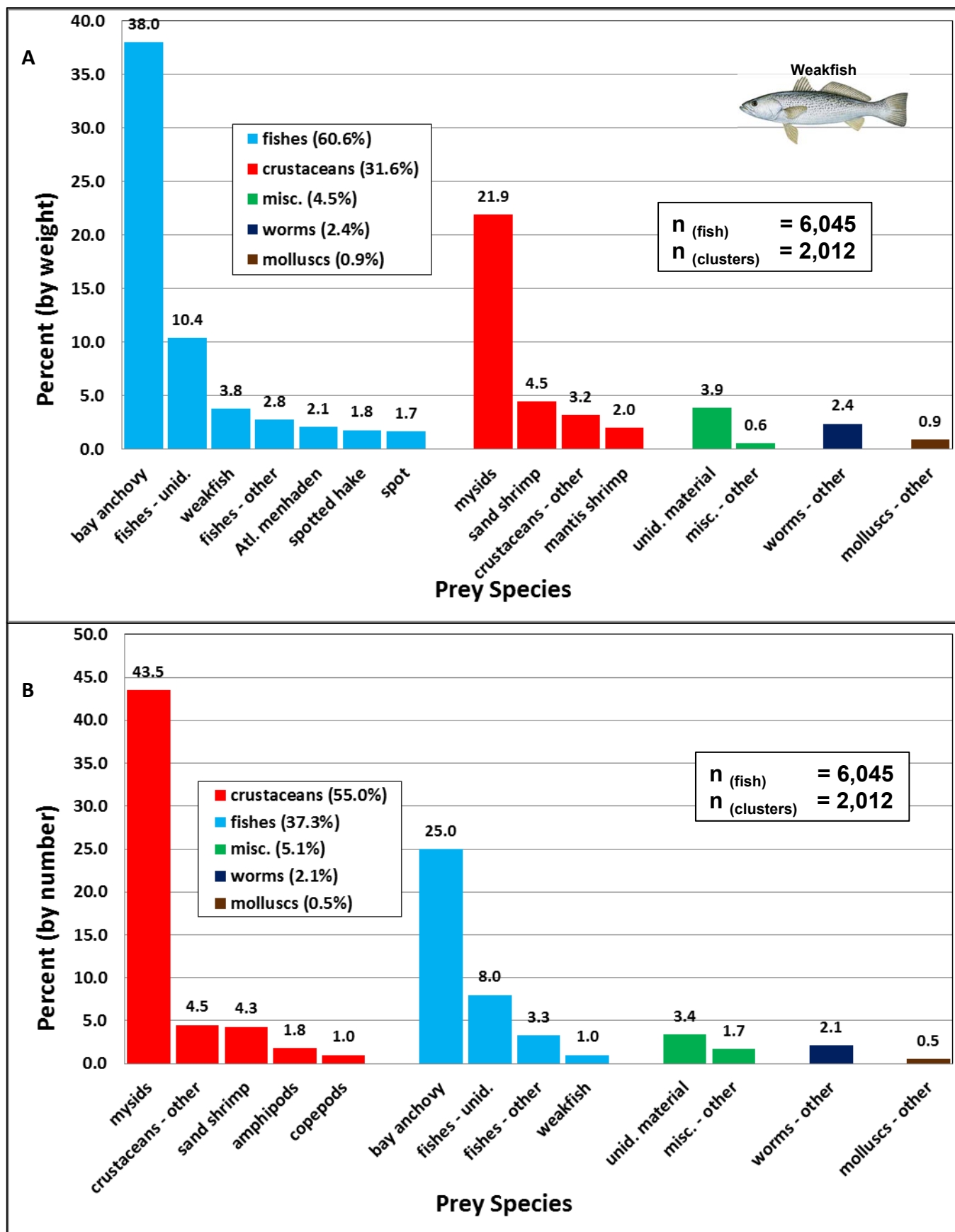


Table 39. White Perch sampling rates and preserved specimen analysis status by year.

Year	Number Caught	Biomass Caught (kg)	Presence at Index Stations (%)	Number Measured	Age Specimens	Ages Read	Stomach Specimens	Stomachs Analyzed
2002	6,625	995.3	70.8	4,020	552	551	471	401
2003	3,782	511.5	59.1	1,882	177	167	147	126
2004	11,021	1,727.4	59.3	6,677	356	356	270	267
2005	7,243	843.0	57.1	5,884	429	429	287	280
2006	11,972	1,609.9	57.1	5,891	385	385	263	254
2007	4,915	517.9	56.5	3,194	318	318	277	277
2008	2,923	339.7	60.9	2,359	259	257	227	224
2009	5,130	686.2	60.9	1,749	158	151	126	126
2010	2,999	454.1	52.2	1,627	207	207	158	156
2011	4,619	675.1	56.5	2,392	231	231	177	174
2012	3,737	459.9	100.0	2,423	151	151	111	109
2013	3,249	421.1	39.1	2,469	199	199	109	55
2014	3,208	341.6	60.9	1,844	153	153	94	92
2015	13,708	2,157.4	56.5	4,098	188	188	80	81
2016	11,406	979.5	56.5	2,935	208	208	104	103
2017	7,957	1,113.9	50.0	4,517	159	159	84	81
2018	3,777	522.7	100.0	2,131	102	102	47	46

Figure 72. Abundance (kg per hectare swept) of White Perch in Chesapeake Bay, 2018.

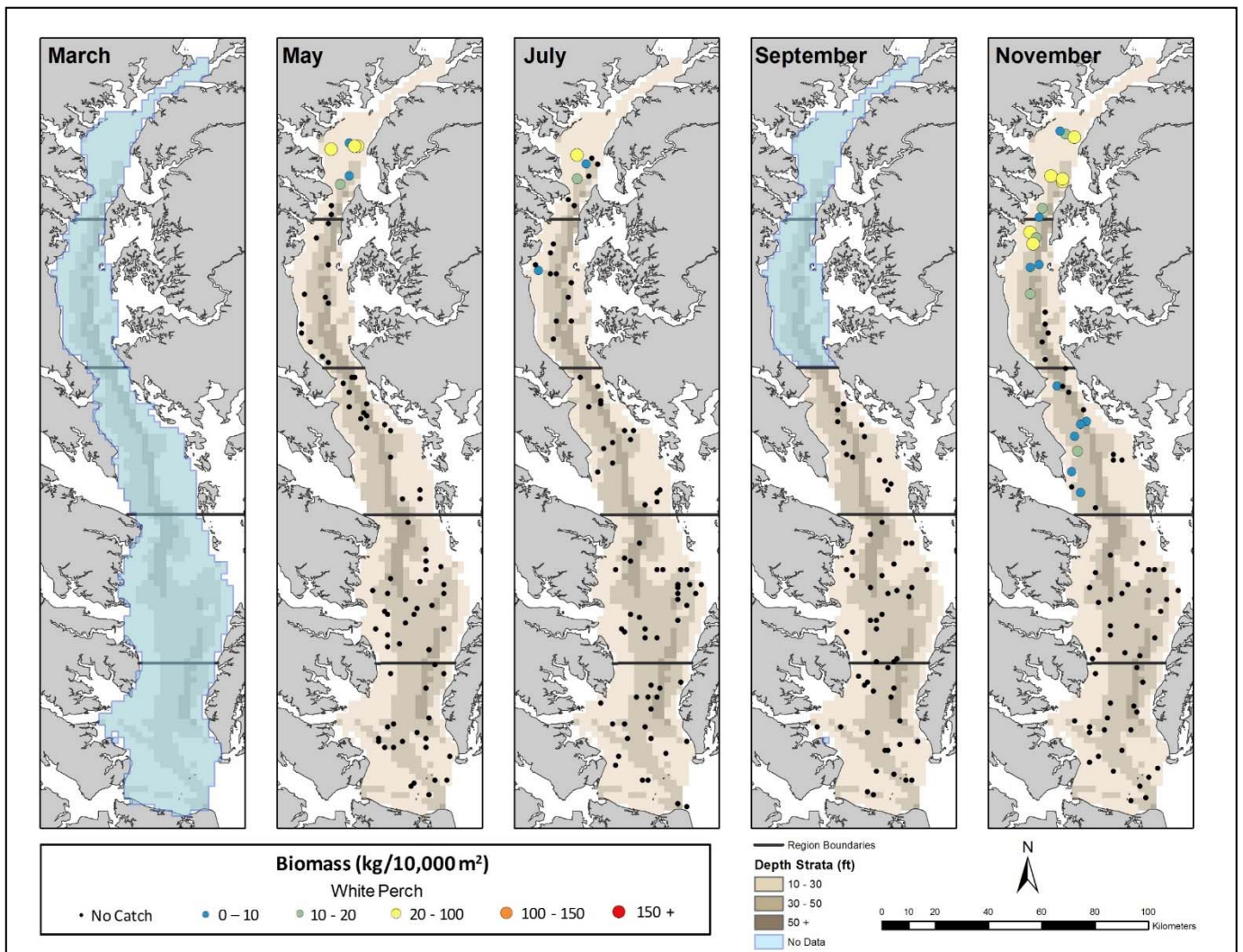


Table 40. Months, latitudinal regions, and depth strata used for White Perch index calculations for March.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 41. White Perch geometric mean indices of abundance for March by number and biomass, overall and by age class.

Year	Age	n	Numerical Index			Biomass Index			Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI
2002	All	15	19.0	37.7	73.9	8.7	16.7	31.5	2002	6	15	7.6	15.9	32.5	3.3	6.9	13.5
2003		17	25.8	152.7	880.6	11.3	49.4	205.0	2003		17	11.1	44.4	169.1	4.6	14.1	39.5
2004		19	292.3	721.2	1,777.1	81.6	179.9	394.9	2004		19	67.2	146.0	315.7	19.1	38.0	74.8
2005		15	62.1	356.4	2,024.5	17.7	85.9	403.6	2005		15	17.8	86.2	404.4	5.0	21.7	84.5
2006		15	91.4	475.2	2,453.1	24.2	102.2	421.1	2006		15	23.3	107.9	485.9	5.8	23.2	84.7
2007		17	527.3	2,240.5	9,510.0	97.2	328.1	1,101.9	2007		17	142.5	508.3	1,806.7	26.3	76.0	216.5
2008		16	796.7	2,351.1	6,934.7	127.4	309.1	747.7	2008		16	178.4	460.4	1,185.7	27.1	60.3	132.4
2009		16	90.9	141.8	220.8	20.8	33.0	52.2	2009		16	23.6	37.7	59.8	5.5	9.0	14.1
2010		16	58.3	203.6	705.1	18.9	56.0	162.1	2010		16	19.1	51.2	134.4	5.8	13.9	31.8
2011		16	33.5	130.5	500.3	12.9	38.1	109.6	2011		16	15.1	46.6	139.6	5.4	13.6	32.2
2012									2012								
2013		16	52.4	560.0	5,897.8	19.7	140.2	960.4	2013		16	19.1	141.8	1,014.7	7.2	36.8	173.5
2014		16	162.9	448.7	1,232.6	35.3	74.0	154.0	2014		16	49.2	106.3	228.3	10.3	17.9	30.6
2015		16	4.0	28.1	169.1	2.1	10.9	44.4	2015		16	2.4	12.2	49.7	1.1	4.4	12.5
2016		16	2,040.9	4,235.5	8,788.6	394.8	778.6	1,534.6	2016		16	396.2	790.0	1,574.2	76.9	145.4	274.2
2017		15	767.9	2,854.0	10,599.4	173.0	550.4	1,745.9	2017		15	195.7	635.2	2,056.7	43.3	124.0	351.9
2018									2018								
2019									2019								
2020									2020								
2002	4	15	0.0	1.3	5.5	0.0	0.8	2.9	2002	7	15	6.1	13.1	27.1	2.6	5.6	11.2
2003		17	0.0	0.0	0.0	0.0	0.0	0.0	2003		17	9.3	34.5	121.9	3.8	11.0	29.0
2004		19	0.0	0.7	2.6	0.0	0.3	0.9	2004		19	49.7	104.6	219.1	14.2	27.6	53.0
2005		15	0.0	0.0	0.0	0.0	0.0	0.0	2005		15	12.2	58.4	267.4	3.7	15.9	59.7
2006		15	0.0	0.0	0.0	0.0	0.0	0.0	2006		15	16.6	74.3	320.4	4.2	16.8	59.3
2007		17	0.0	0.0	0.0	0.0	0.0	0.0	2007		17	95.2	314.6	1,035.0	18.5	50.7	136.3
2008		16	0.0	0.5	2.2	0.0	0.4	1.9	2008		16	112.4	276.4	678.0	17.7	38.2	81.0
2009		16	0.0	0.0	0.0	0.0	0.0	0.0	2009		16	15.1	24.9	40.9	3.9	6.4	10.1
2010		16	0.0	0.0	0.0	0.0	0.0	0.0	2010		16	15.0	38.9	98.5	4.4	10.6	23.7
2011		16	0.0	0.0	0.0	0.0	0.0	0.0	2011		16	12.2	36.4	105.0	4.3	10.6	24.7
2012									2012								
2013		16	0.0	0.2	0.5	0.0	0.1	0.3	2013		16	15.4	105.8	694.5	5.8	27.9	121.4
2014		16	0.0	0.0	0.0	0.0	0.0	0.0	2014		16	31.1	63.1	126.8	6.5	10.9	17.8
2015		16	0.0	0.0	0.0	0.0	0.0	0.0	2015		16	2.1	9.8	36.2	1.0	3.5	9.2
2016		16	0.0	0.0	0.0	0.0	0.0	0.0	2016		16	270.6	537.4	1,066.4	52.9	99.8	187.6
2017		15	0.0	0.0	0.0	0.0	0.0	0.0	2017		15	141.3	446.2	1,404.5	31.3	87.9	243.2
2018									2018								
2019									2019								
2020									2020								
2002	5	15	5.7	13.0	28.3	2.4	5.5	11.5	2002	8+	15	13.3	24.9	46.1	6.0	11.1	19.8
2003		17	8.8	31.4	106.7	3.5	9.7	24.4	2003		17	16.8	87.1	435.3	7.3	29.1	107.8
2004		19	46.0	103.3	230.3	12.7	25.8	51.4	2004		19	135.9	309.1	701.1	39.8	83.9	175.6
2005		15	13.4	69.8	347.1	3.7	17.0	68.2	2005		15	26.2	128.4	615.3	8.7	37.8	153.4
2006		15	19.1	93.0	437.8	4.3	18.1	67.9	2006		15	43.2	183.2	766.1	12.7	46.8	165.6
2007		17	134.3	507.8	1,911.9	23.2	71.0	213.4	2007		17	150.4	489.5	1,587.6	31.9	86.7	233.4
2008		16	158.0	424.8	1,139.5	22.4	52.1	119.6	2008		16	231.5	575.8	1,430.2	44.0	94.9	203.0
2009		16	17.1	29.6	50.5	4.3	7.0	11.2	2009		16	30.0	53.7	95.4	8.1	14.4	24.9
2010		16	14.0	35.2	86.5	4.1	9.5	20.5	2010		16	32.8	108.9	356.5	10.4	31.2	89.9
2011		16	13.5	42.3	127.7	4.7	12.1	29.2	2011		16	17.5	57.2	182.2	6.5	17.3	43.8
2012									2012			0.0			0.0		
2013		16	14.7	104.0	702.9	5.5	26.8	118.4	2013		16	32.1	274.8	2,295.5	12.2	71.7	400.0
2014		16	50.3	109.4	236.7	10.5	18.7	32.5	2014		16	41.0	92.2	206.1	9.8	17.4	30.4
2015		16	2.3	10.4	38.8	1.1	3.6	9.4	2015		16	2.6	15.8	77.8	1.2	6.2	22.9
2016		16	287.6	589.6	1,207.9	56.2	108.1	207.3	2016		16	718.8	1,411.6	2,771.2	140.9	268.5	511.2
2017		15	160.7	516.5	1,654.7	35.8	101.7	286.0	2017		15	280.6	951.5	3,221.3	64.4	188.2	546.0
2018									2018								
2019									2019								
2020									2020								

Figure 73. White Perch geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class for March.

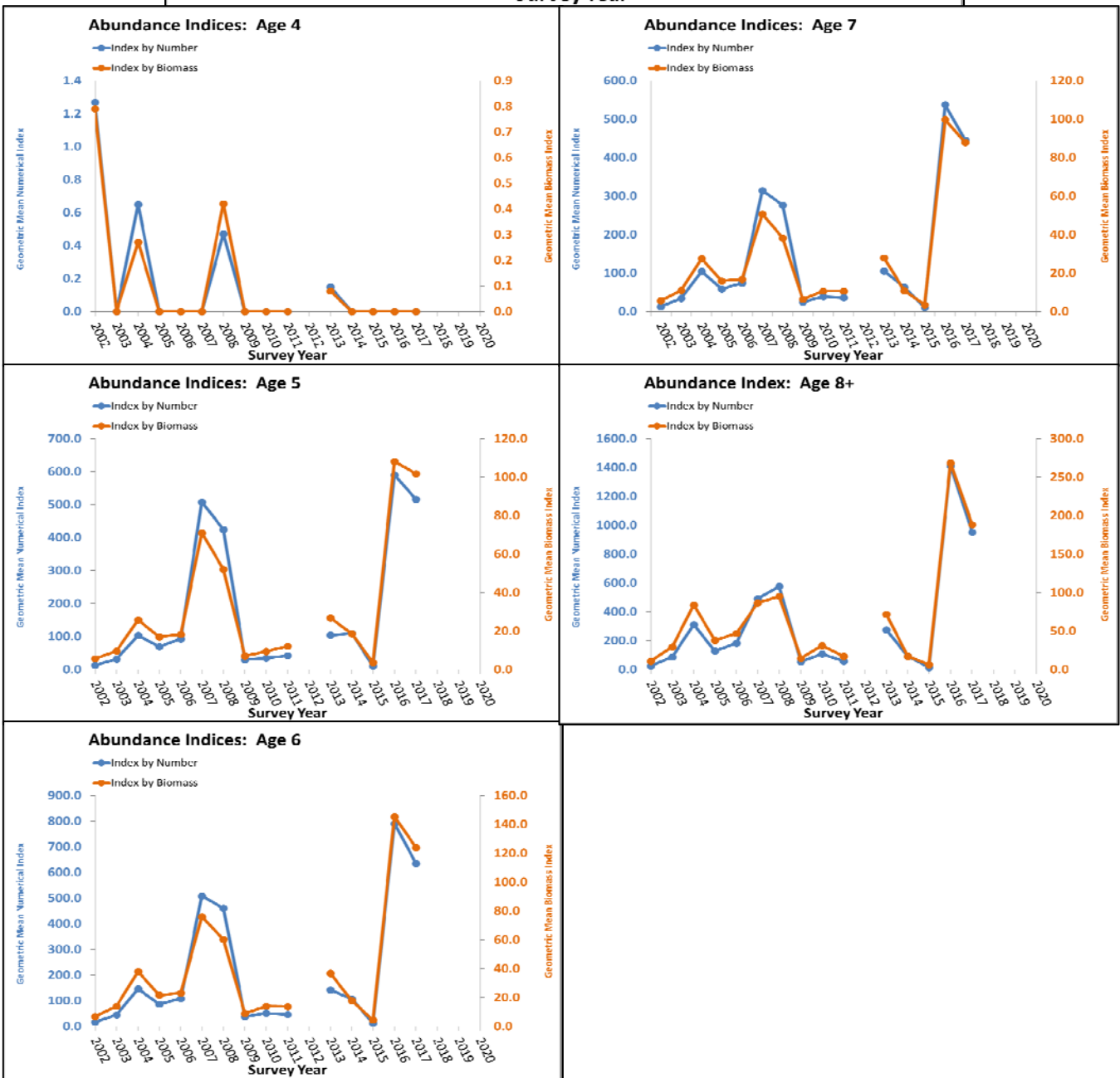
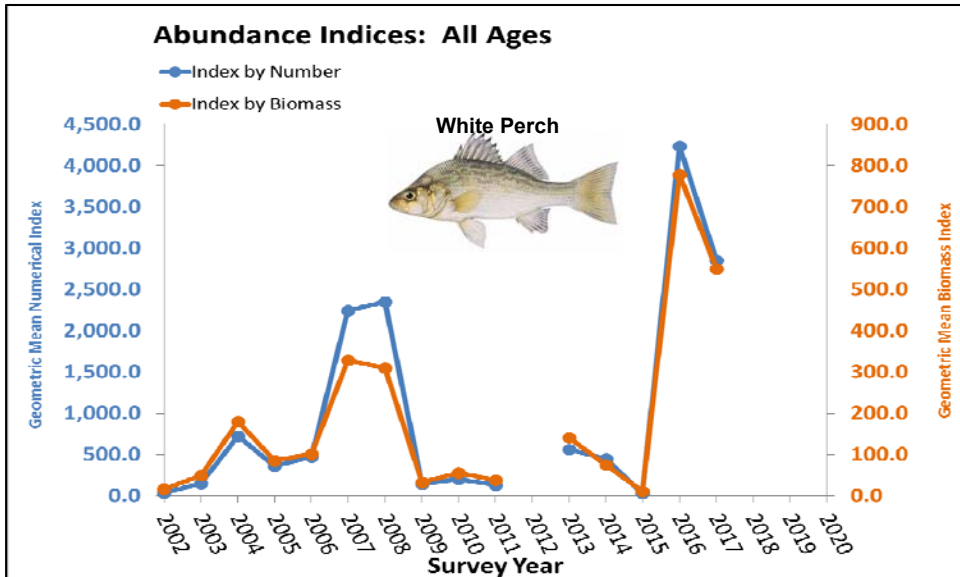


Table 42. Months, latitudinal regions, and depth strata used for White Perch index calculations for November.

Month		Region		Depth	
March		MD-North		Shallow	
May		MD-Central			
July		MD-South		Mid	
September		VA-North			
November		VA-South		Deep	

Table 43. White Perch geometric mean indices of abundance for November by number and biomass, overall and by age class.

			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI
2002	All	20	218.4	728.2	2,423.1	60.0	164.4	447.2				52.1	125.5	300.3	13.5	28.2	57.7
2003		11	162.9	376.8	869.5	37.0	81.9	179.8				24.1	64.1	167.9	5.6	14.1	33.8
2004		18	2,060.7	7,463.7	27,025.6	372.5	#####	3,285.0				318.2	1,016.0	3,239.2	62.4	163.2	424.0
2005		15	649.1	2,405.1	8,903.9	89.4	281.8	883.1				105.2	331.4	1,039.5	15.6	43.2	116.7
2006		14	4,088.8	9,464.3	21,905.5	462.8	992.6	2,127.5				468.9	1,128.9	2,715.8	53.9	124.6	286.6
2007		15	28.6	86.6	258.2	9.6	24.1	58.6				11.3	30.3	78.6	3.4	8.0	17.5
2008		16	68.8	185.4	496.9	14.8	34.7	79.6				18.1	40.1	87.2	3.3	7.6	16.1
2009		16	185.1	1,069.3	6,154.3	42.1	197.2	909.7				43.0	192.3	847.3	9.1	35.5	130.8
2010		15	1,246.0	4,207.5	14,202.0	219.1	565.6	1,457.8				111.8	447.5	1,782.5	21.3	64.4	190.9
2011		15	2,796.7	6,235.5	13,901.2	401.5	881.8	1,935.4				373.9	877.2	2,056.0	55.2	126.1	286.3
2012		15	507.7	1,974.6	7,672.5	101.8	314.7	968.7				86.3	291.8	980.5	18.0	50.4	137.6
2013		16	251.9	757.0	2,271.0	45.2	111.1	271.4				37.1	105.8	298.6	7.1	16.7	37.3
2014		16	271.5	1,374.9	6,946.7	72.9	267.7	976.3				63.2	247.3	959.3	16.6	48.0	135.6
2015		16	601.4	1,742.1	5,042.8	161.0	406.8	1,025.7				113.5	378.9	1,259.1	28.5	86.3	257.2
2016		16	1,145.6	1,518.6	2,013.0	215.2	282.9	371.7				238.0	329.3	455.3	44.7	61.3	84.0
2017		16	163.1	1,151.5	8,094.9	34.4	198.6	1,123.5				42.9	223.9	1,151.0	9.2	39.8	163.2
2018		16	201.7	1,345.3	8,939.8	56.2	282.5	1,403.8				62.8	292.5	1,349.5	17.2	63.2	225.0
2019																	
2020																	
2002	4	20	55.7	124.5	276.9	12.6	25.1	49.0				53.4	133.9	333.2	14.2	30.8	65.5
2003		11	33.9	91.0	241.6	7.8	18.5	42.2				27.0	65.1	155.1	6.3	14.7	33.2
2004		18	422.1	1,351.0	4,319.2	68.0	172.8	436.6				309.6	959.0	2,965.7	61.5	158.3	404.8
2005		15	141.0	518.7	1,901.0	17.9	55.6	168.0				98.8	304.4	933.6	15.0	40.8	108.3
2006		14	833.4	2,108.7	5,333.4	71.2	172.2	414.7				441.2	1,015.3	2,335.1	55.5	120.2	259.0
2007		15	16.1	39.1	93.2	4.7	9.8	19.7				10.1	26.8	68.7	3.1	7.3	15.6
2008		16	33.9	68.9	139.3	6.6	12.3	22.0				15.2	35.3	80.8	2.8	6.8	15.2
2009		16	53.5	205.8	783.3	12.3	37.6	110.8				39.8	184.2	840.1	8.3	34.4	133.5
2010		15	112.1	500.0	2,217.4	22.1	68.0	204.7				137.3	478.4	1,660.6	25.6	69.8	187.2
2011		15	365.9	945.5	2,440.8	44.6	116.6	302.4				381.0	837.6	1,840.1	57.0	122.4	261.5
2012		15	142.5	498.2	1,735.4	27.3	75.6	205.9				80.3	264.7	867.2	17.0	46.2	123.1
2013		16	50.4	151.9	453.8	9.3	21.2	46.7				39.2	104.2	274.6	7.5	16.8	36.5
2014		16	59.1	269.0	1,211.9	15.4	52.0	170.3				63.5	234.4	858.2	16.6	45.4	121.1
2015		16	82.0	327.4	1,299.0	21.1	74.4	256.1				118.7	366.1	1,125.1	29.9	83.6	231.0
2016		16	317.7	455.1	651.8	61.8	85.1	116.9				207.5	282.1	383.5	38.5	52.6	71.7
2017		16	43.6	245.7	1,363.3	8.8	43.1	197.4				36.7	196.3	1,032.4	8.2	35.9	146.7
2018		16	77.1	365.9	1,721.2	20.3	73.9	262.4				55.5	260.7	1,210.0	15.2	56.2	201.4
2019																	
2020																	
2002	5	20	57.3	134.6	314.6	13.7	28.2	56.9				116.7	371.3	1,176.8	34.9	92.0	240.3
2003		11	29.3	78.4	206.8	6.7	16.5	39.0				69.4	156.0	349.2	17.6	38.9	84.7
2004		18	376.0	1,205.5	3,859.6	68.0	175.8	452.0				724.2	2,394.8	7,913.2	154.3	428.6	1,187.3
2005		15	130.7	432.7	1,427.8	17.8	50.8	142.3				218.1	719.1	2,365.4	35.7	103.9	299.0
2006		14	663.1	1,608.1	3,897.9	63.4	149.6	351.6				1,262.5	2,604.6	5,372.1	187.9	362.3	697.7
2007		15	14.9	37.4	92.1	4.4	9.6	19.9				13.9	40.0	111.5	5.0	12.1	27.6
2008		16	26.7	53.8	107.5	5.0	9.8	18.3				20.1	59.5	172.7	4.3	12.6	34.2
2009		16	53.8	219.8	889.6	11.8	40.0	130.5				66.6	408.4	2,477.2	14.2	78.8	416.9
2010		15	130.8	531.8	2,153.0	24.7	73.2	213.2				617.8	1,634.9	4,323.8	110.4	251.5	571.5
2011		15	382.4	951.3	2,364.5	53.3	130.8	319.4				1,128.8	2,225.5	4,387.1	174.6	342.8	671.8
2012		15	111.5	377.8	1,273.8	22.2	62.0	170.3				160.0	586.2	2,140.1	34.9	105.4	314.1
2013		16	45.8	132.5	380.4	8.4	19.4	42.9				105.4	290.6	798.5	20.9	49.7	116.6
2014		16	67.9	286.6	1,199.9	17.8	55.5	169.0				123.0	503.7	2,054.2	32.9	100.2	301.1
2015		16	100.0	369.9	1,361.1	25.4	84.4	275.1				347.4	845.7	2,057.1	92.7	201.6	436.7
2016		16	304.4	422.3	585.5	58.4	78.8	106.2				354.0	486.8	669.3	64.0	90.7	128.5
2017		16	47.2	258.2	1,393.8	9.7	45.3	199.3				58.9	372.4	2,326.8	13.8	68.8	327.5
2018		16	73.3	342.2	1,583.4	20.2	74.0	264.0				80.3	463.7	2,654.0	22.4	100.4	437.8
2019																	
2020																	

Figure 74. White Perch geometric mean indices of abundance, by number and biomass, for all ages combined and by age-class for November.

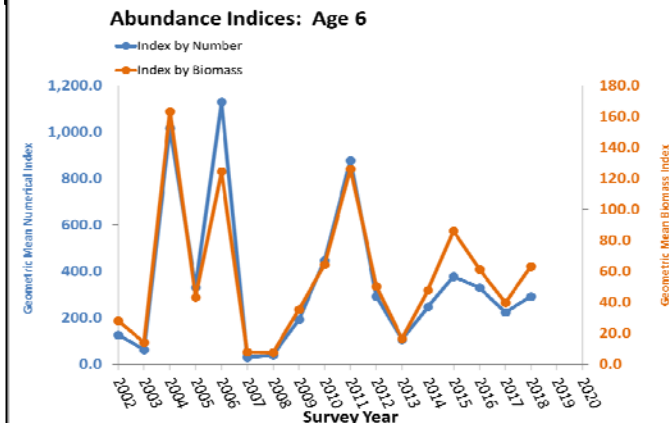
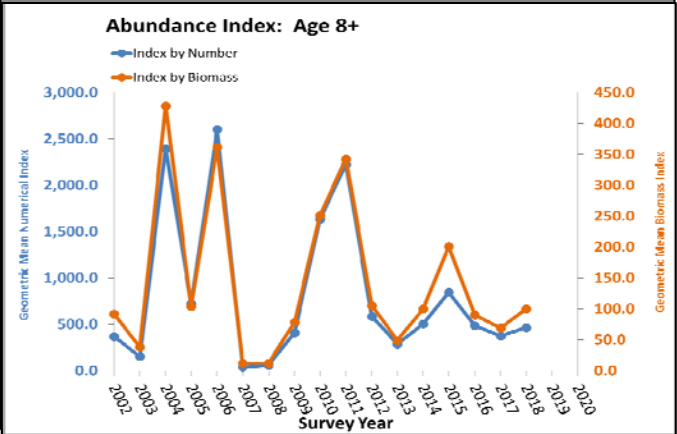
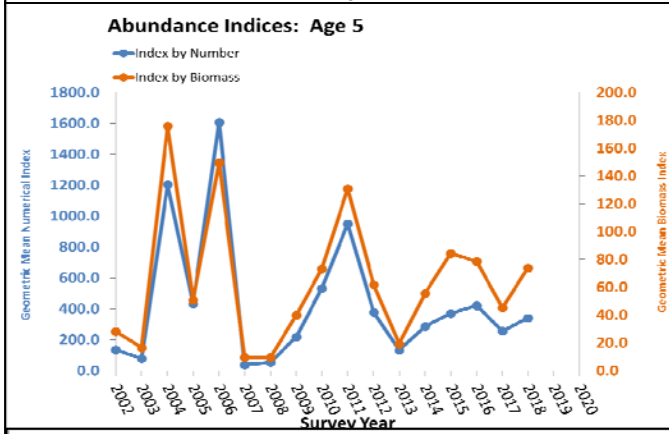
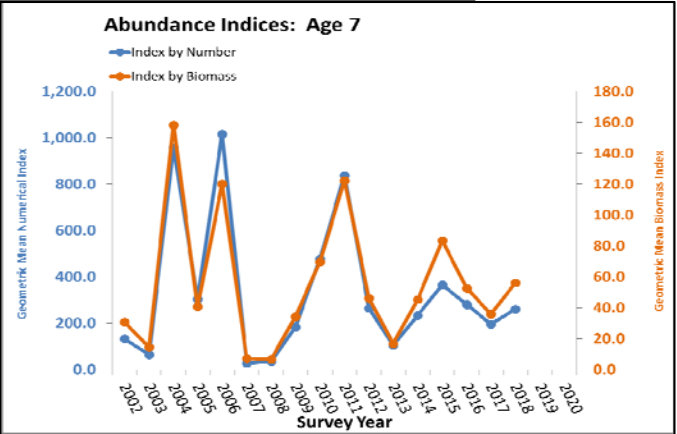
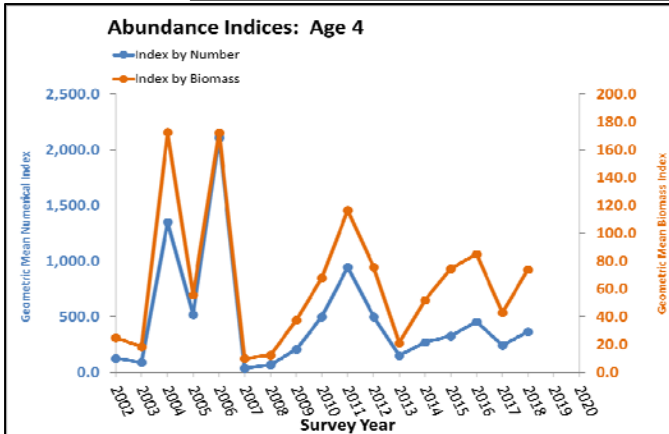
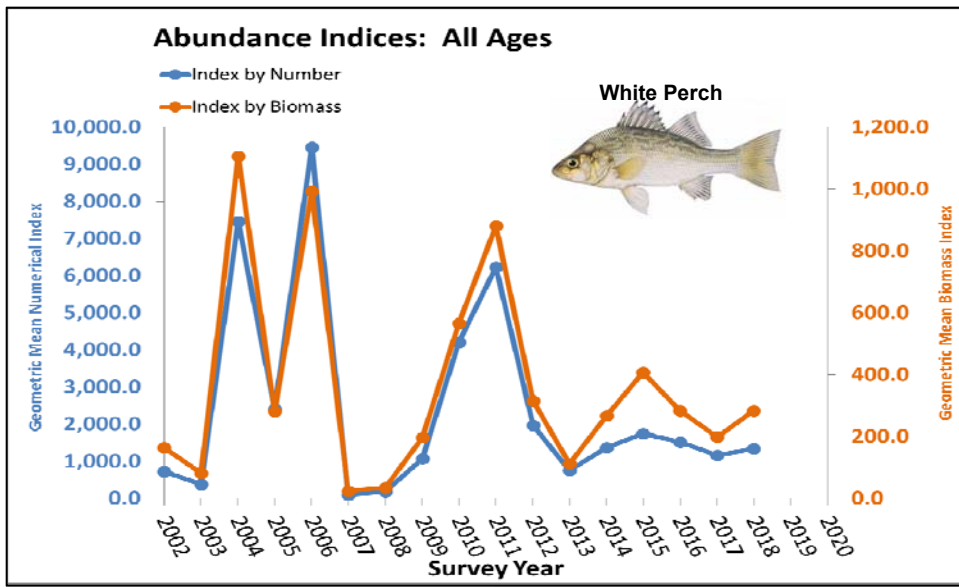


Figure 75. White Perch length-frequency in Chesapeake Bay 2002-2018, overall (A) and by sex (B).

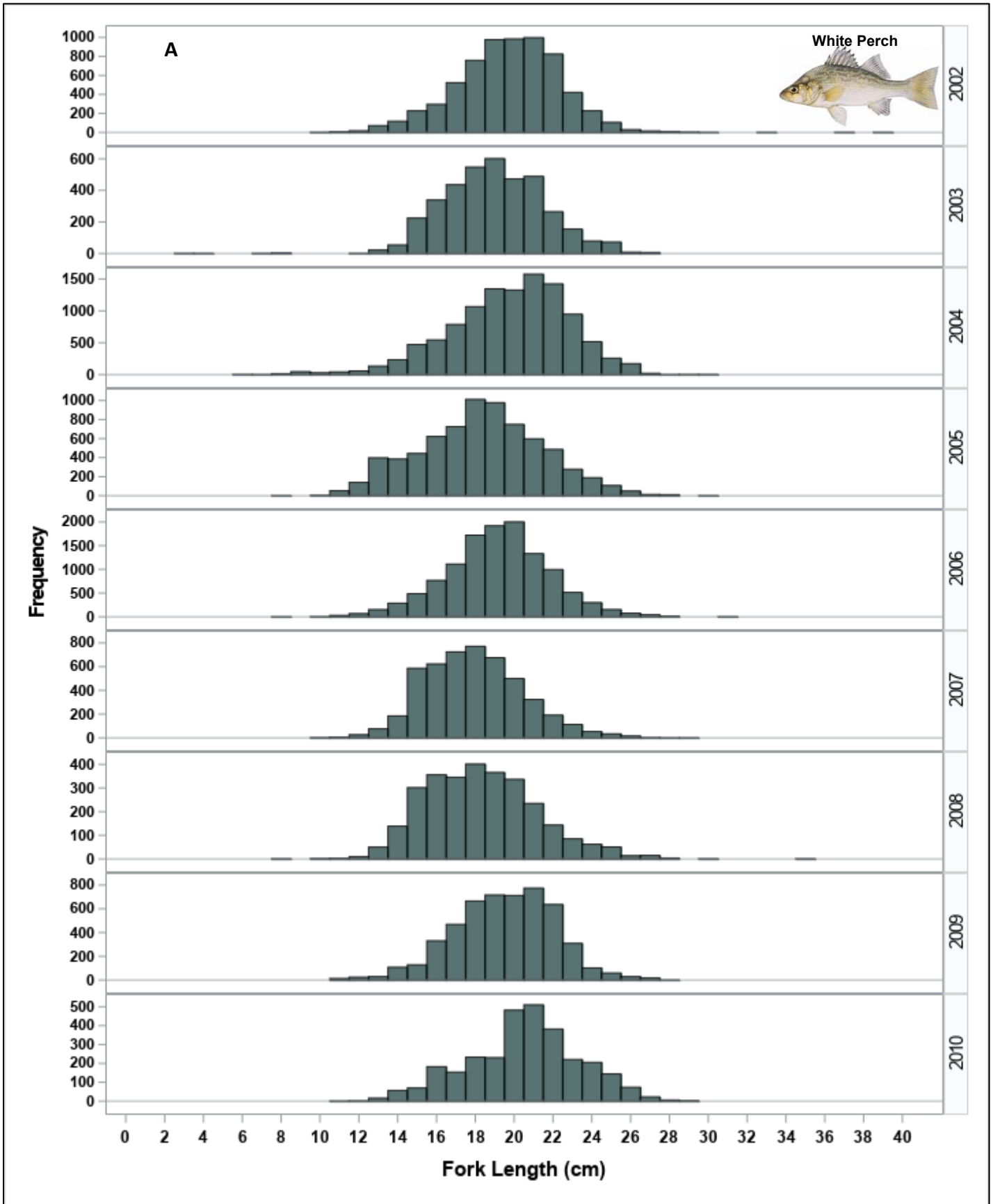


Figure 75. cont.

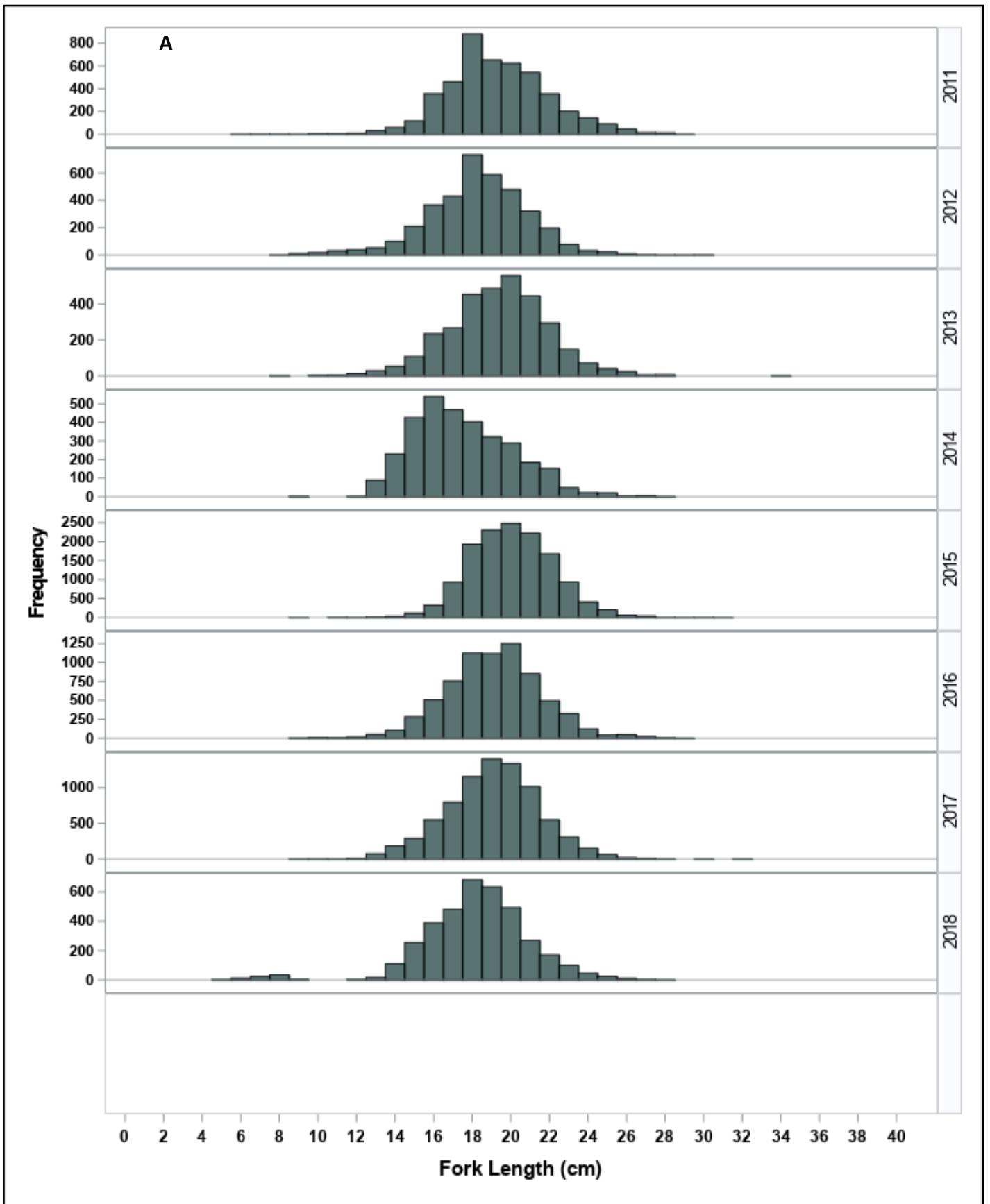


Figure 75. cont.

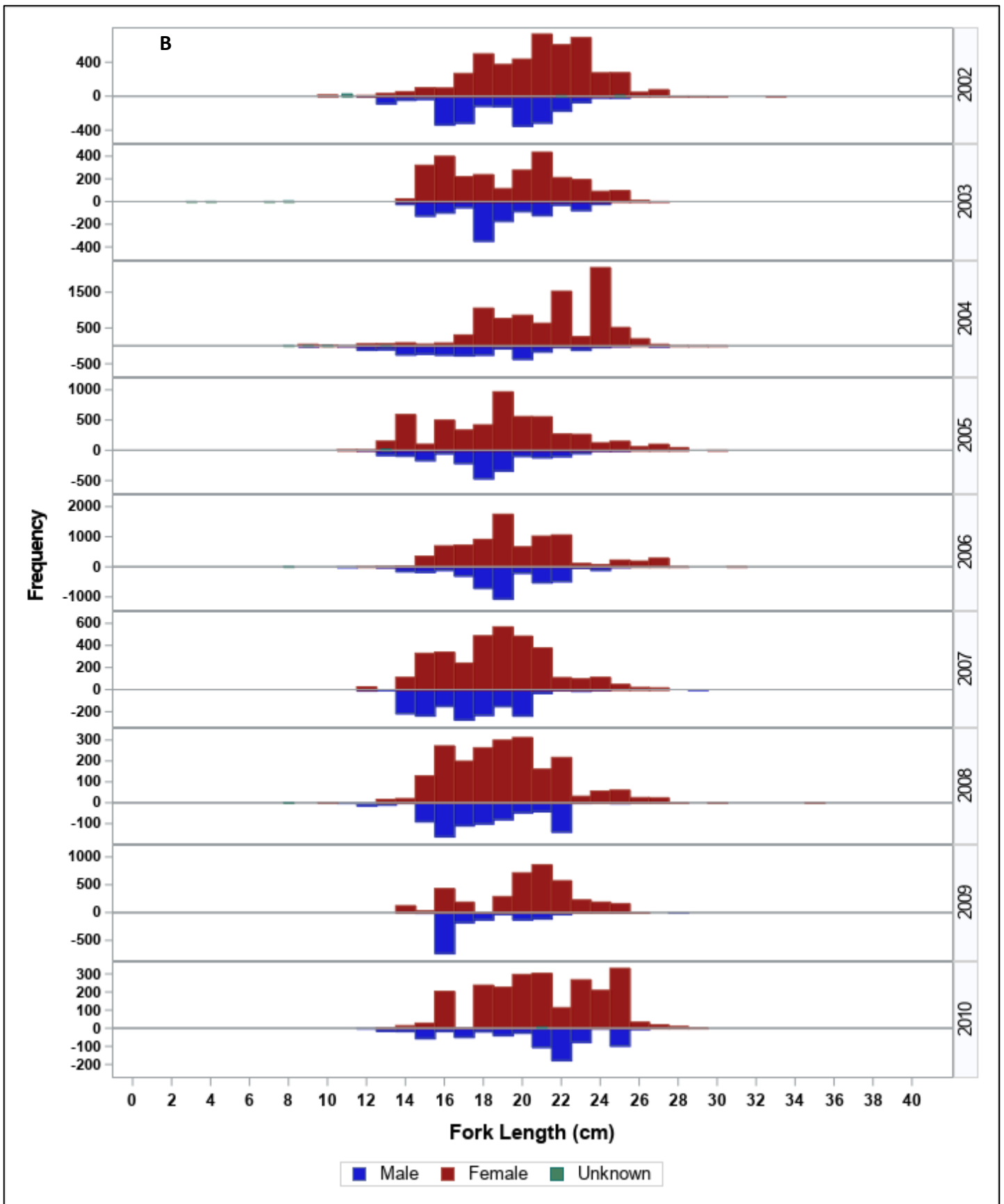


Figure 75. cont.

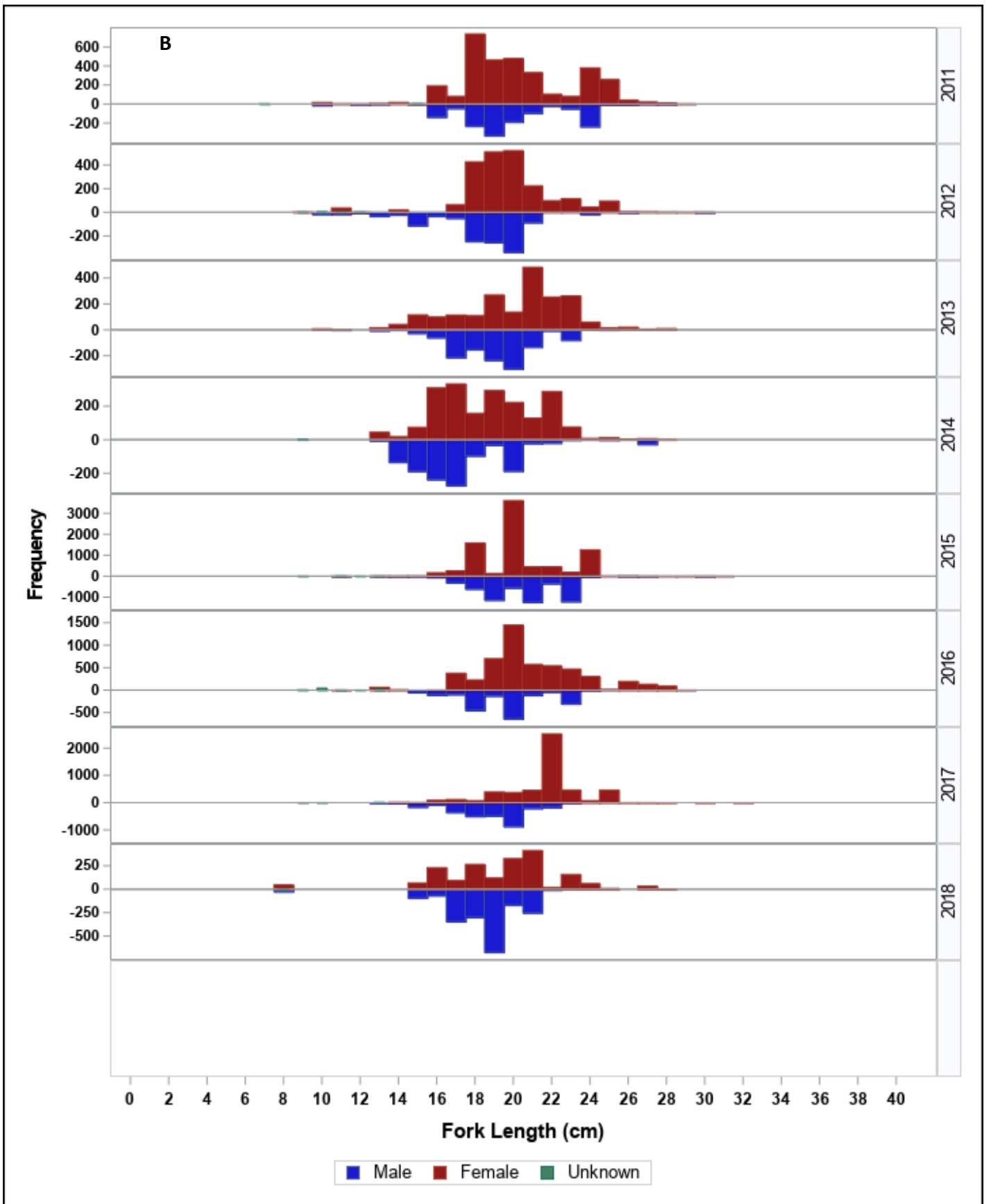


Figure 76. White Perch total age-frequency, 2002-2018.

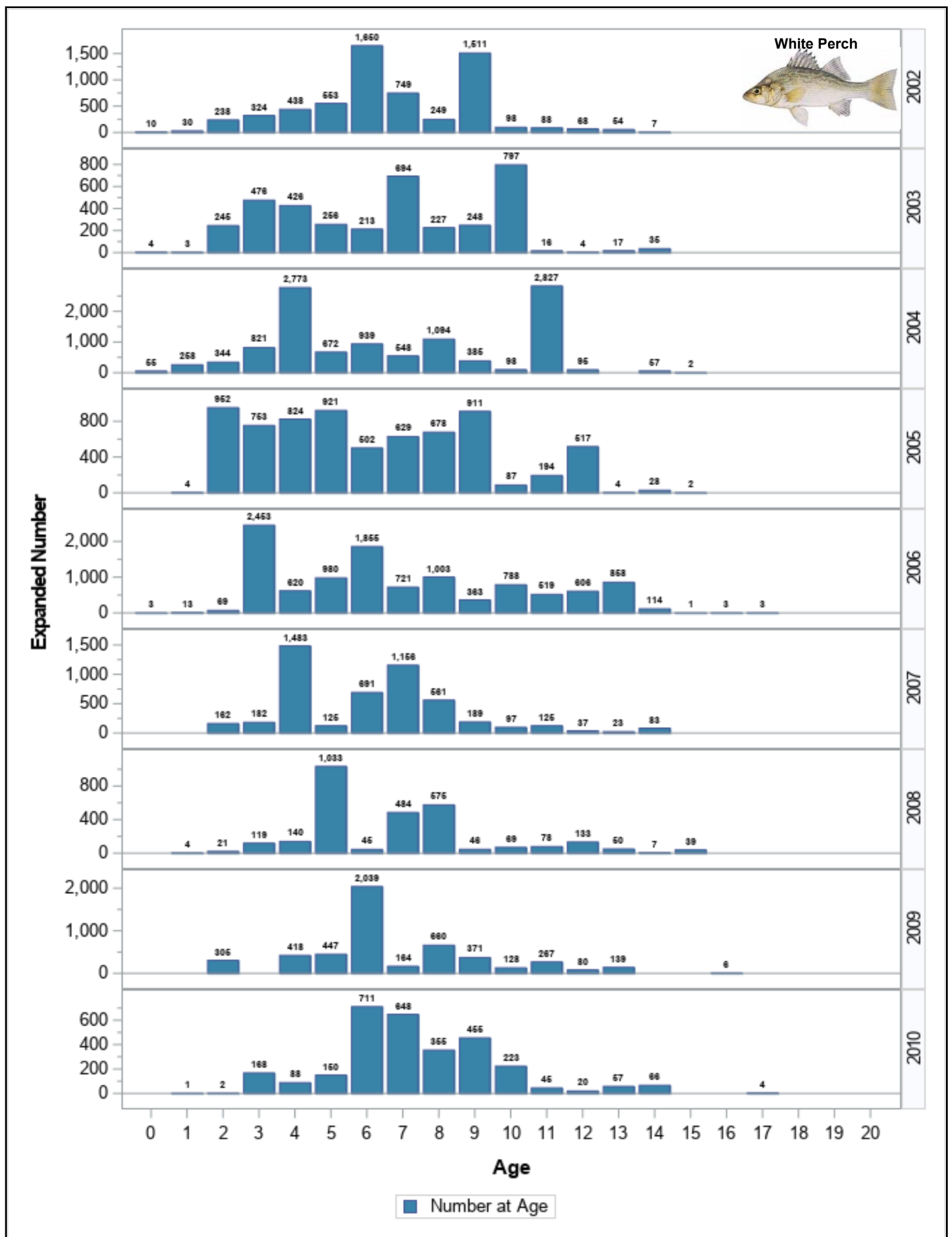


Figure 76. cont.

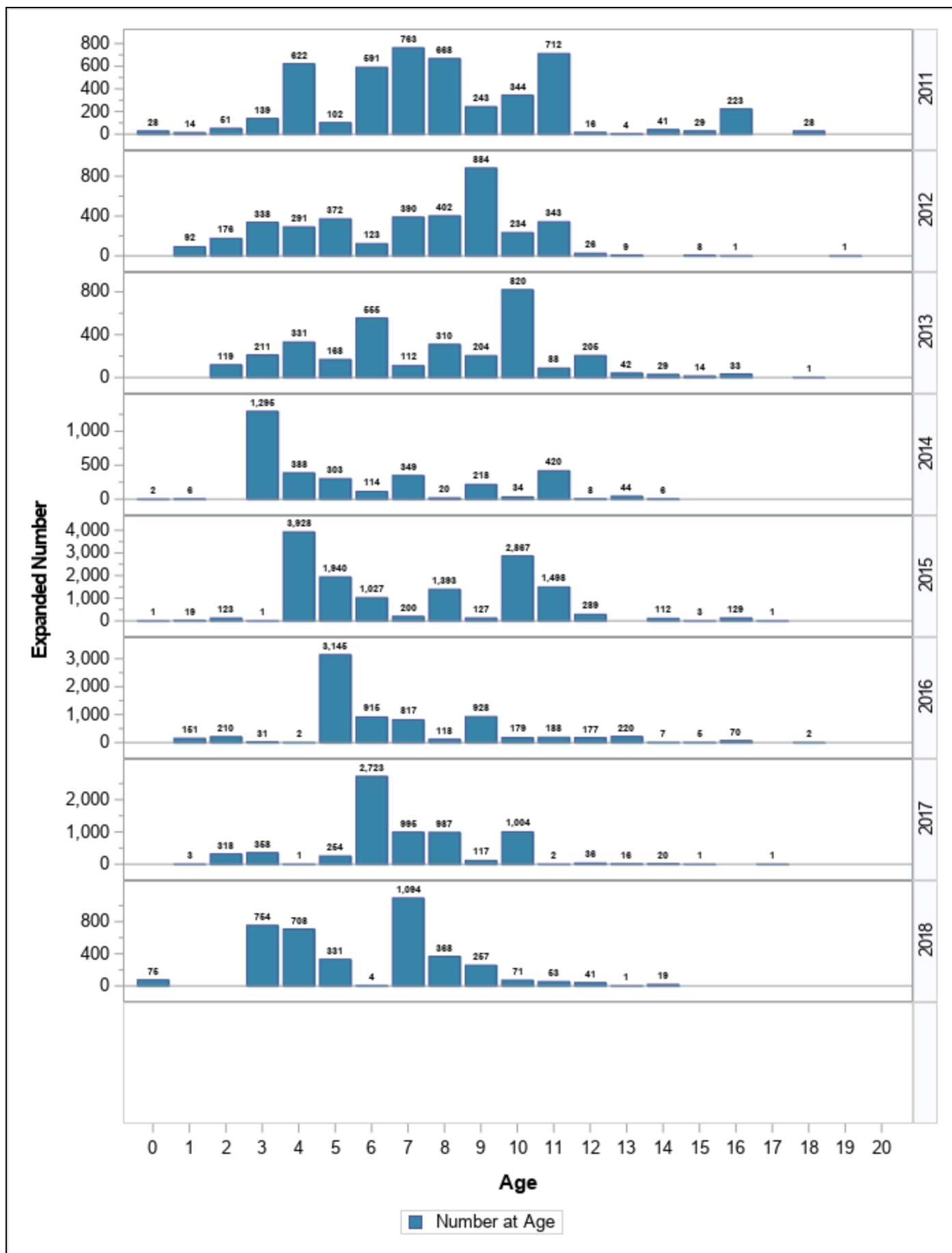


Figure 77. White Perch age-frequency by year, 2002-2018 standardized to 8,000 annual trawl minutes.

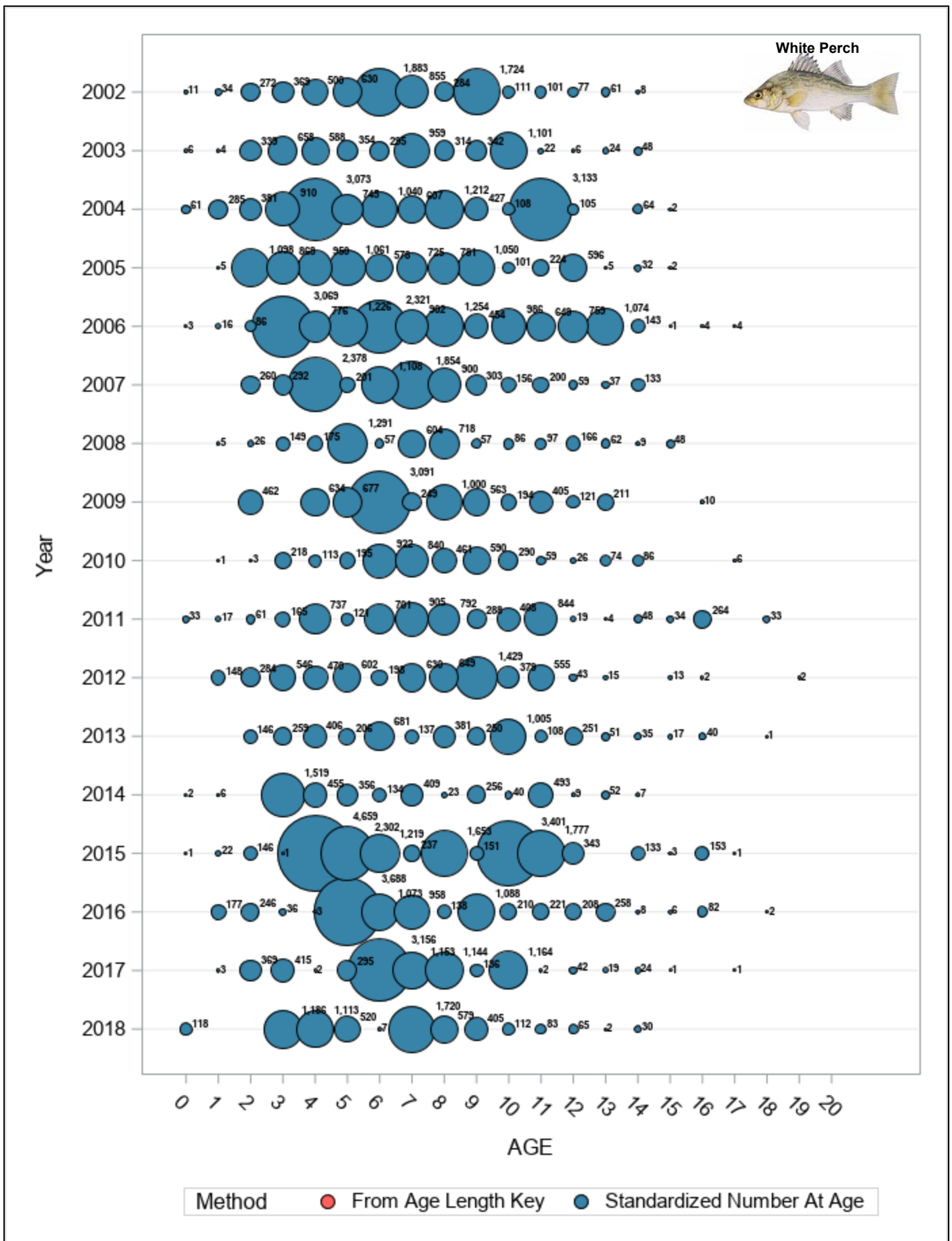


Figure 78. White Perch age-frequency by cruise month, 2002-2018 combined, actual (A) and standardized to the total potential trawl minutes over all survey years (B).

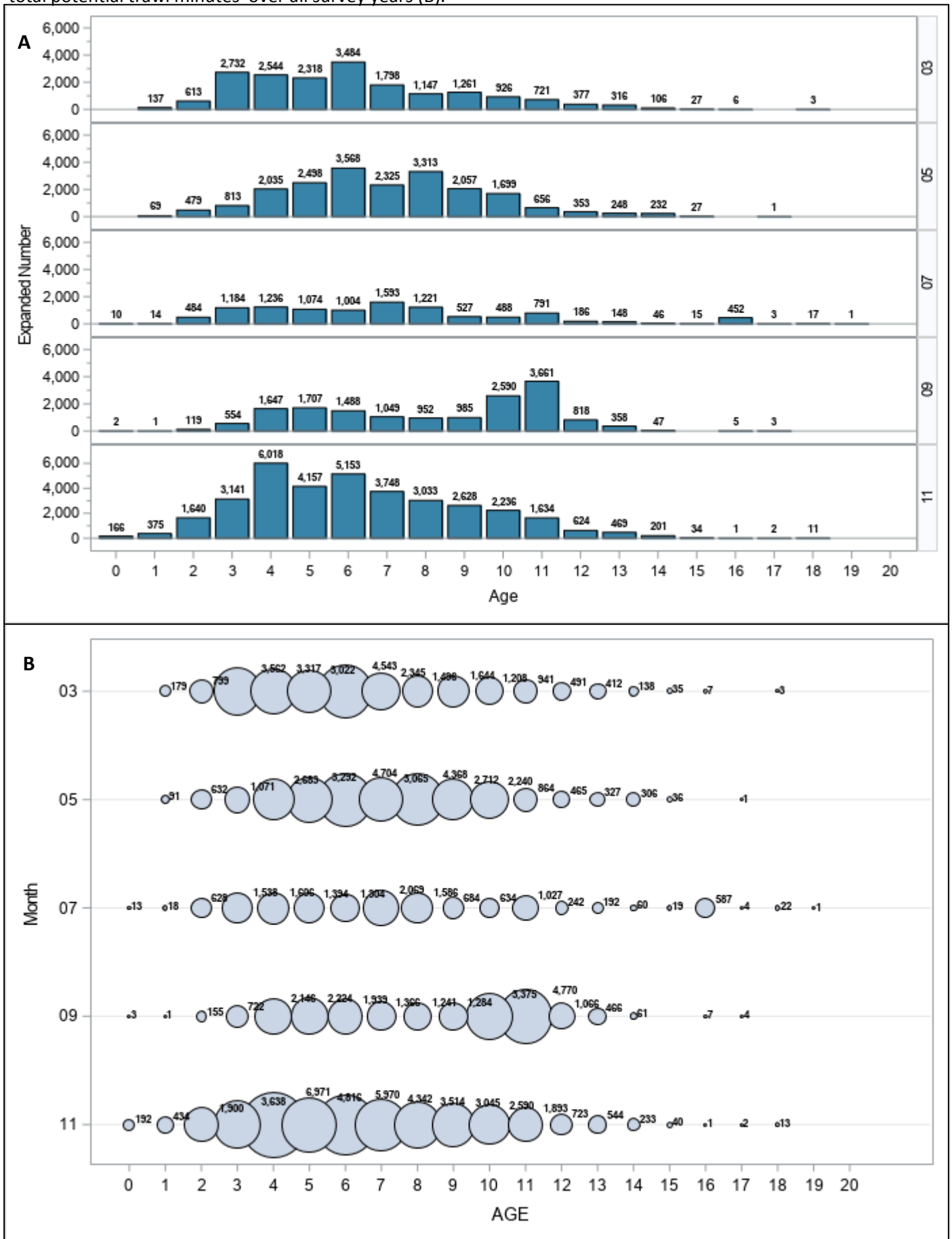


Figure 79. Diet composition, expressed as percent by weight (A) and percent by number (B) of White Perch collected during ChesMMAAP cruises in 2002-2018 combined.

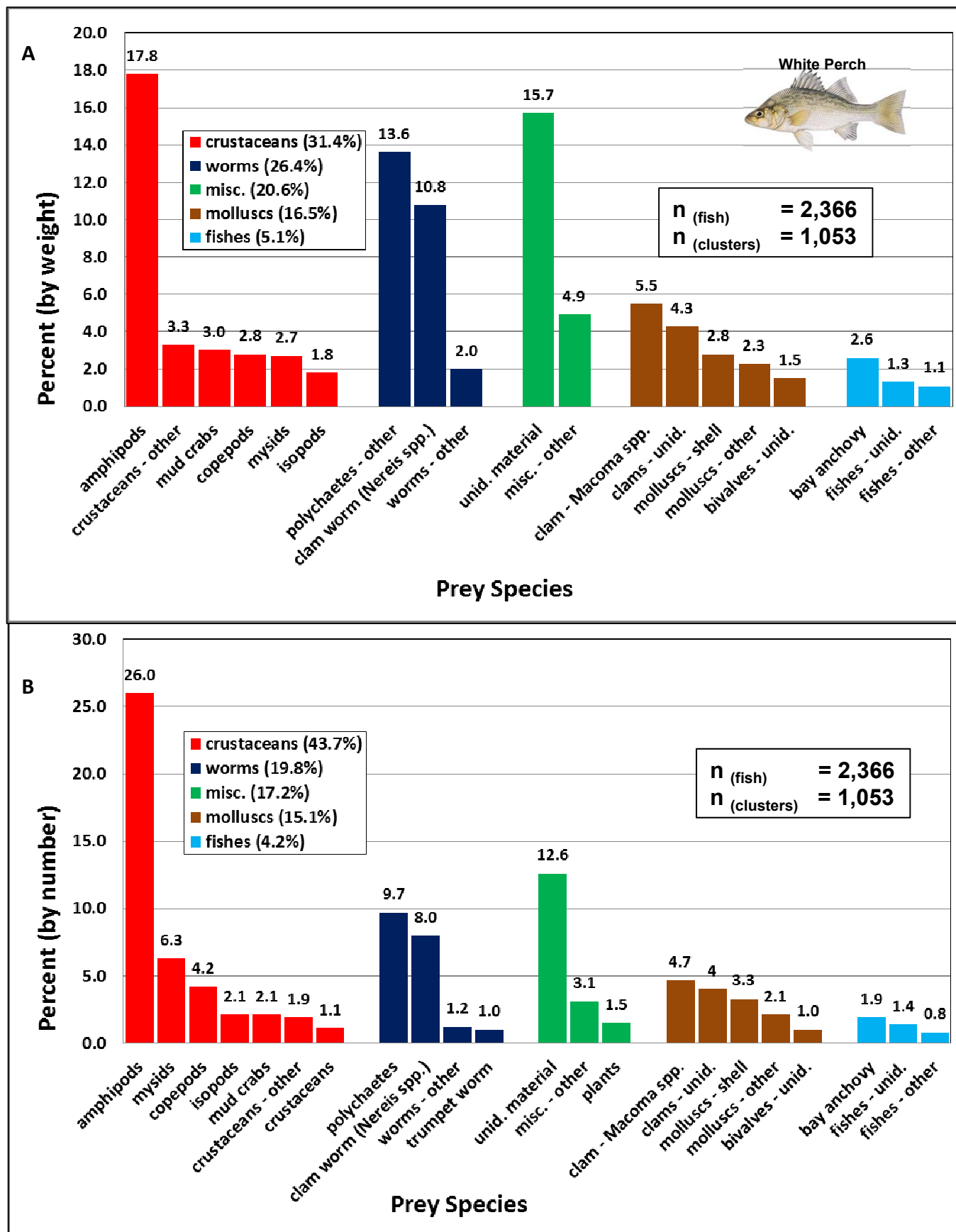


Figure 80. Interpolated Chesapeake Bay bottom water temperature by cruise for 2018 (A), averaged over 2002 through 2018 (B), and 2018 deviation from average (C).

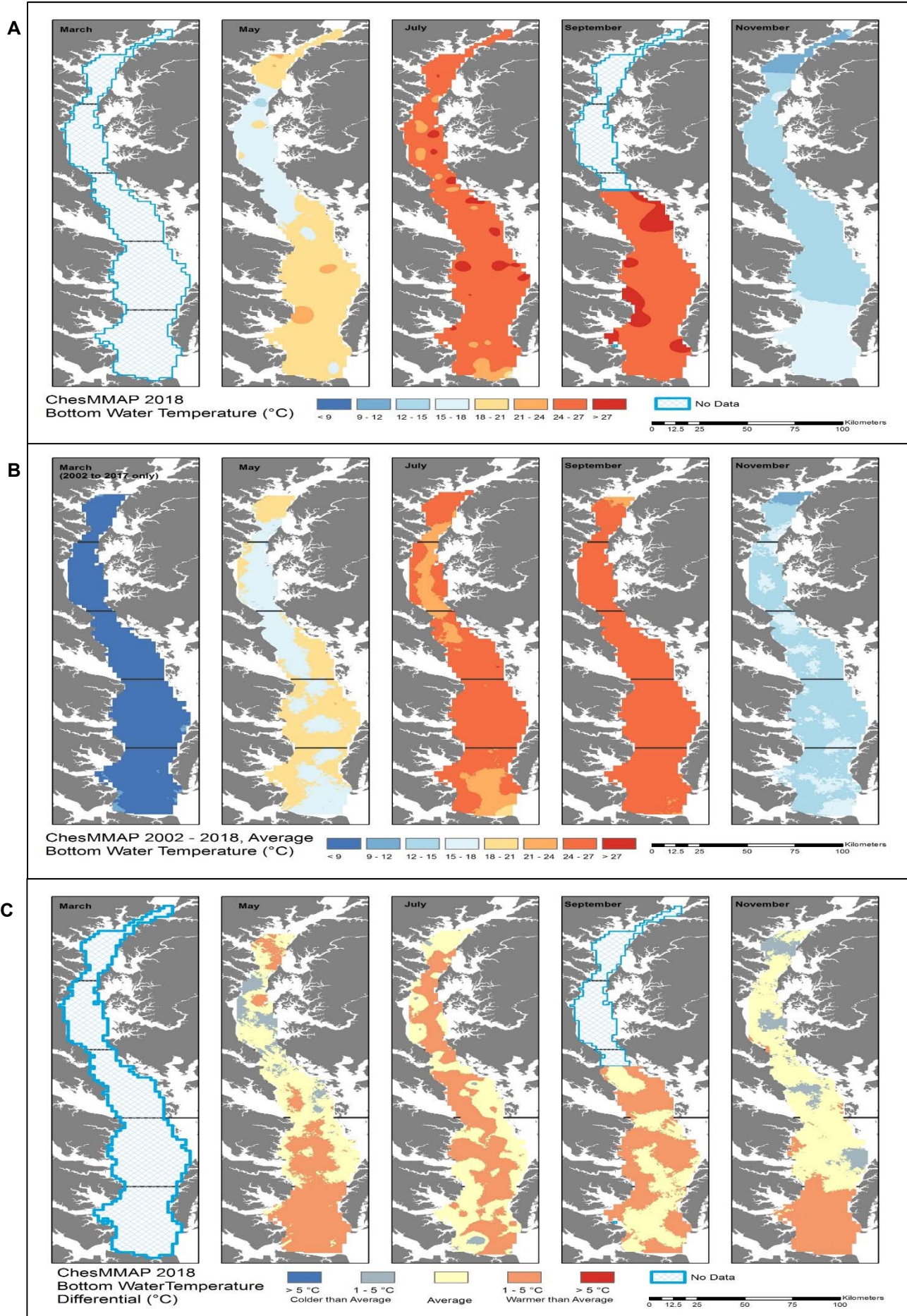


Figure 81. Interpolated Chesapeake Bay bottom salinity by cruise for 2018 (A), averaged over 2002 through 2018 (B), and 2018 deviation from average (C).

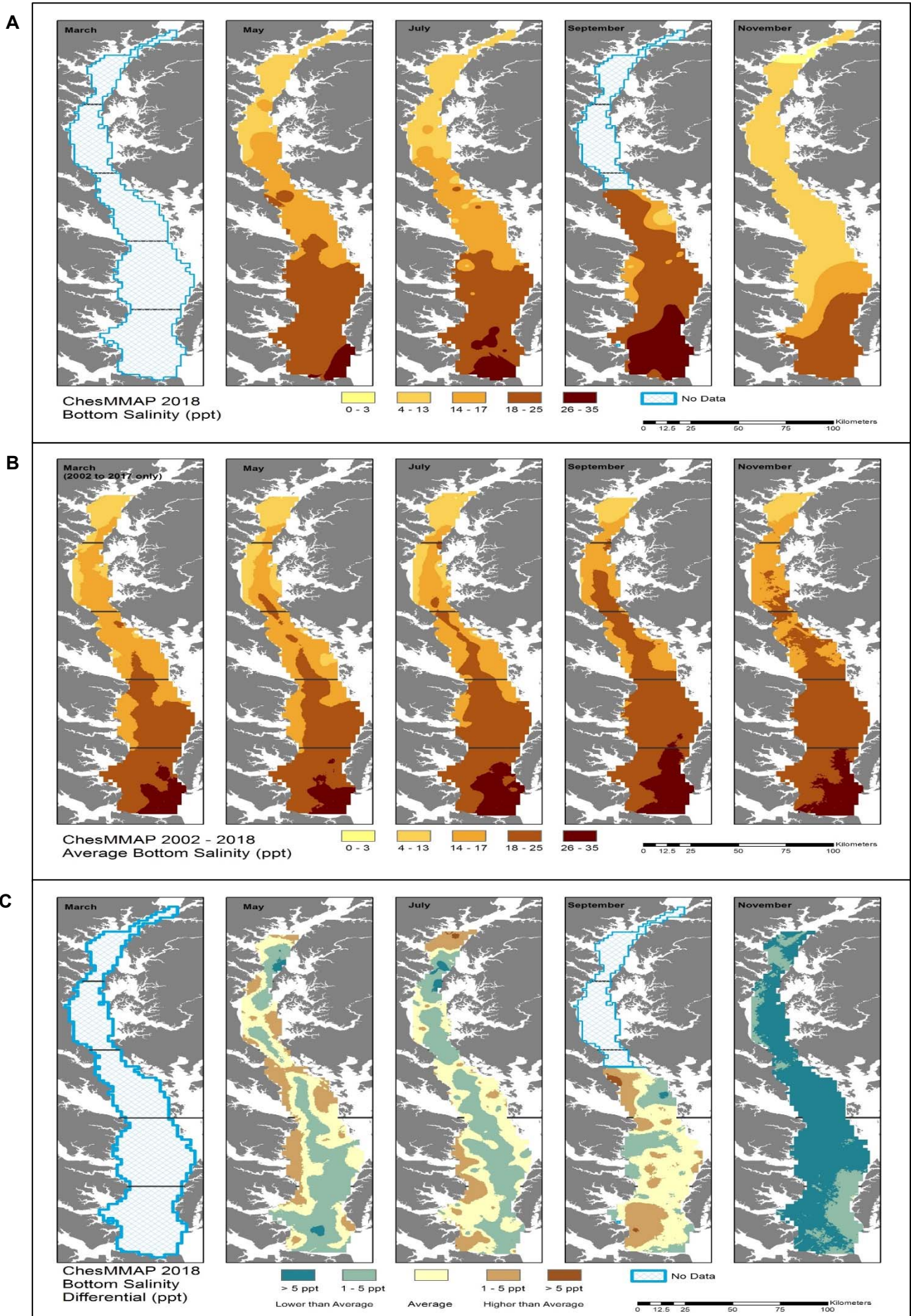


Figure 82. Interpolated Chesapeake Bay bottom dissolved oxygen by cruise for 2018 (A), averaged over 2002 through 2018 (B), and 2018 deviation from average (C).

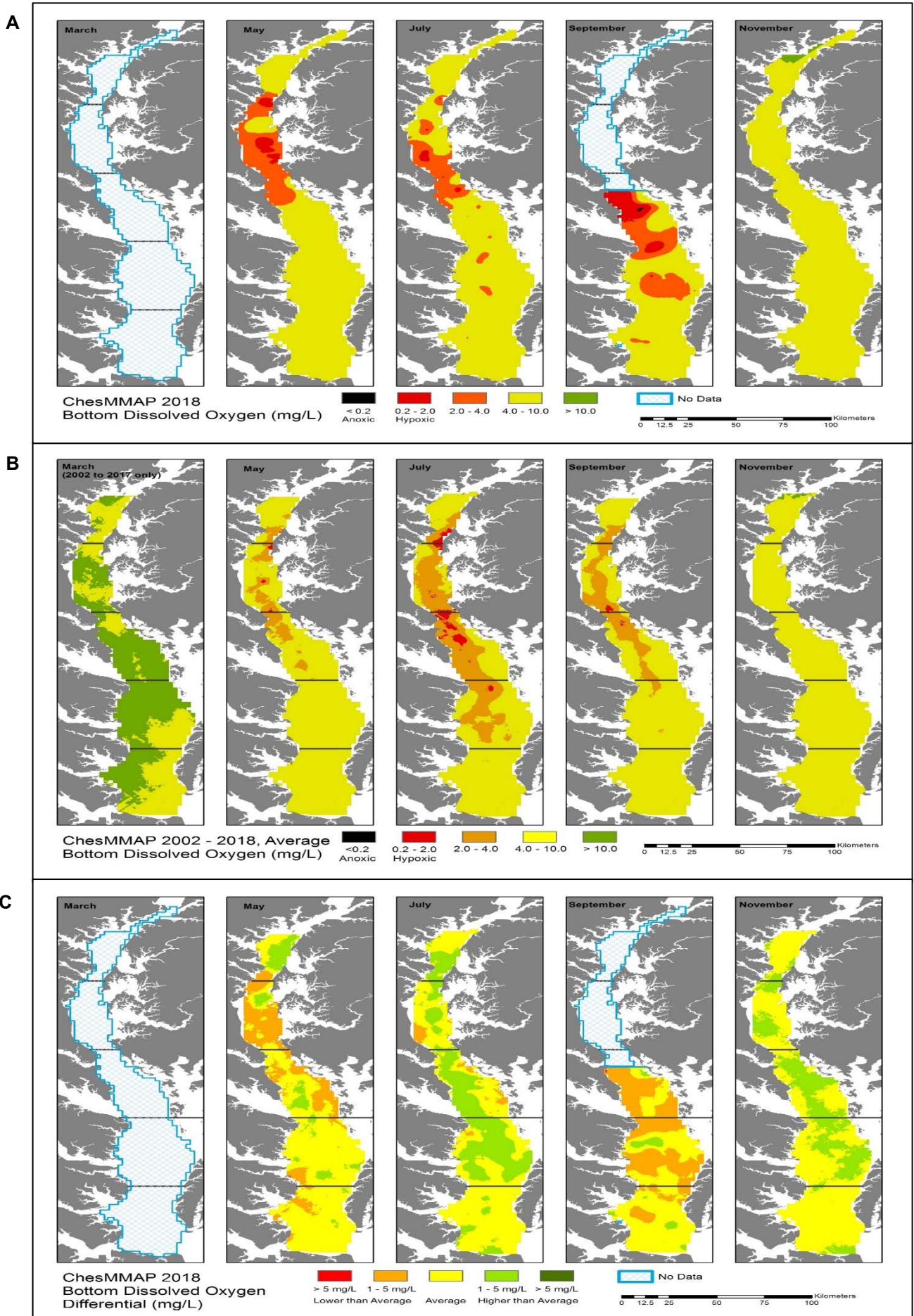


Figure 83. Interpolated bi-monthly water temperature profiles in Chesapeake Bay, 2018.

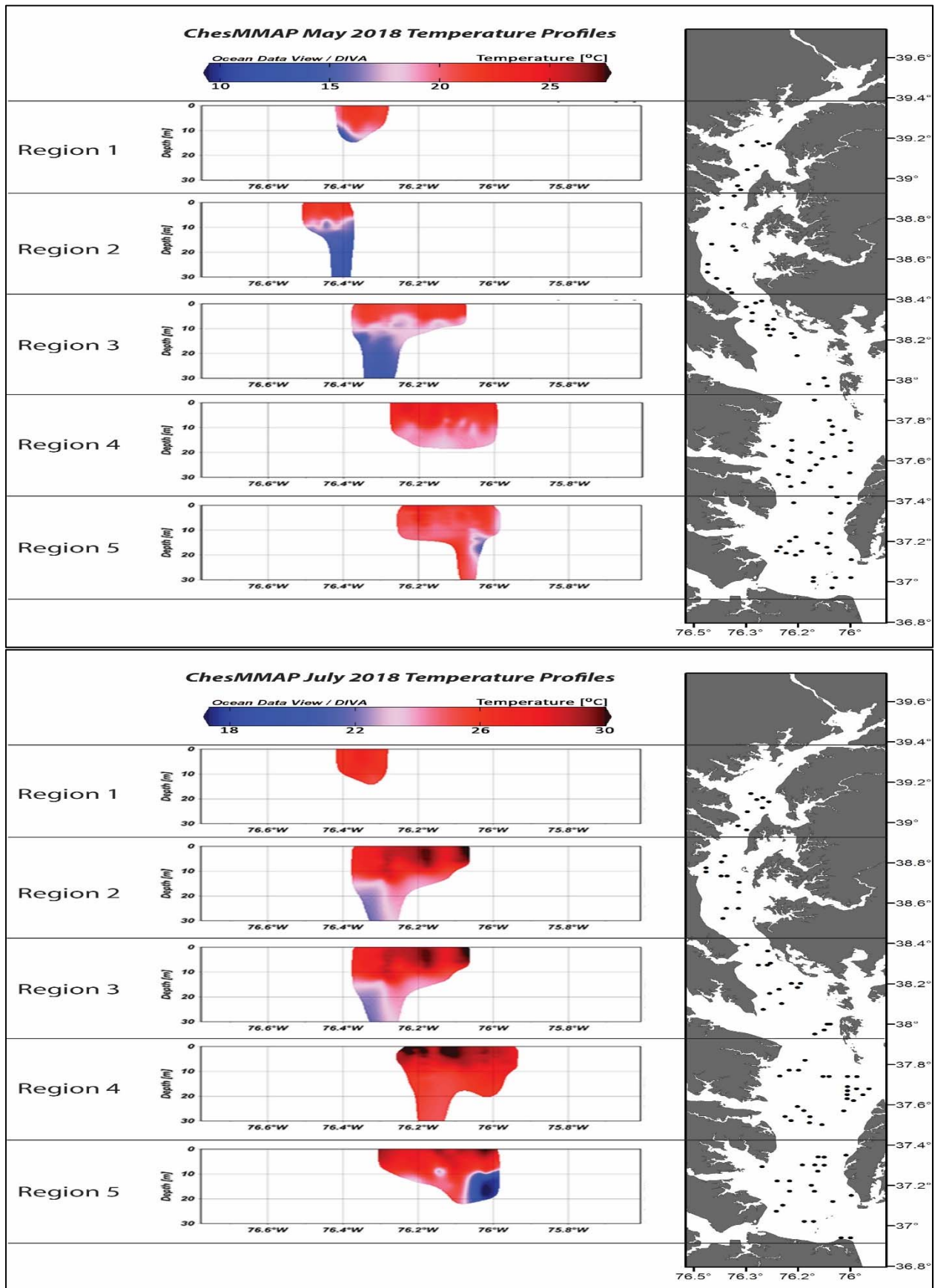


Figure 83. cont.

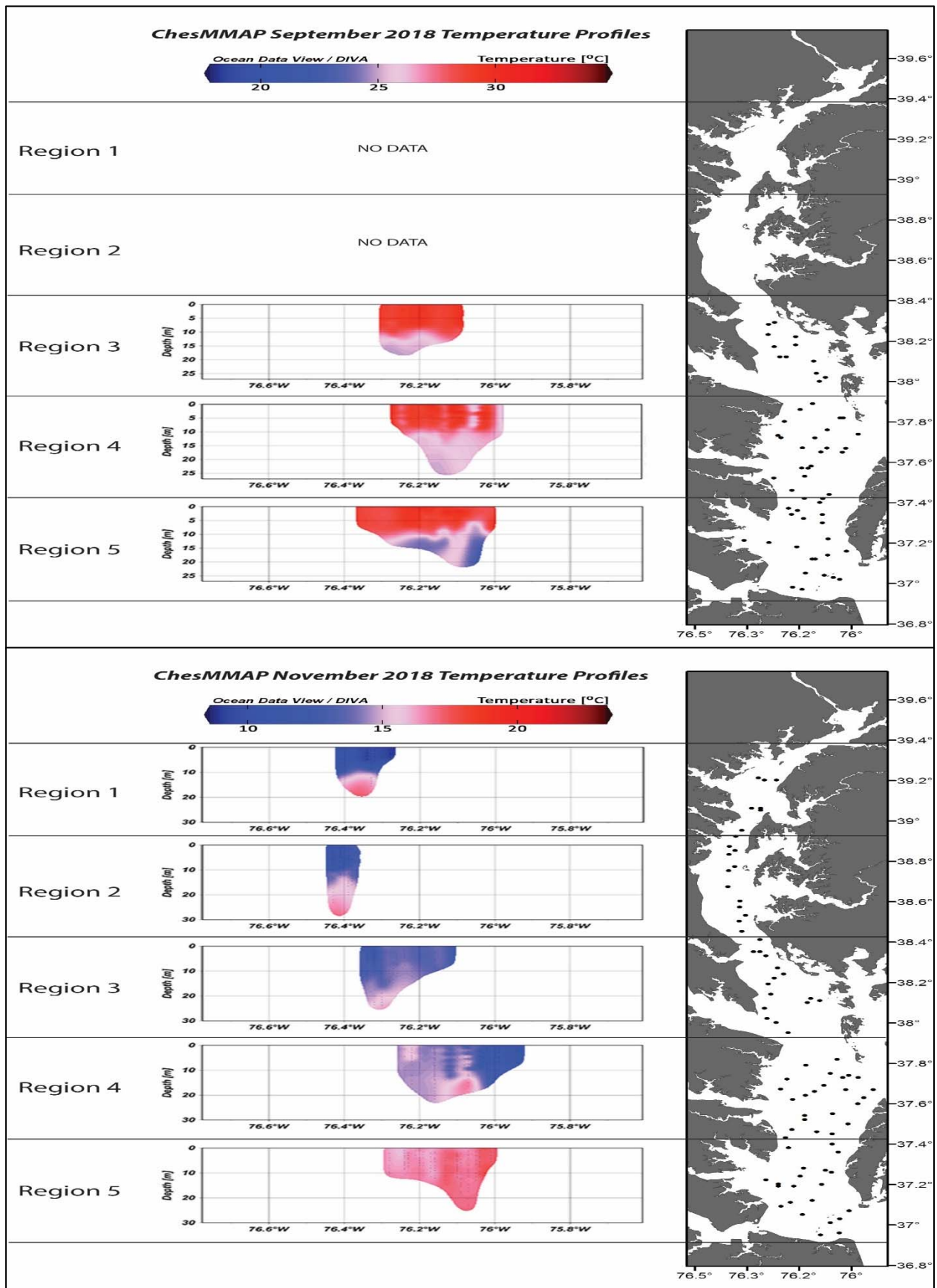


Figure 84. Interpolated bi-monthly salinity profiles in Chesapeake Bay, 2018.

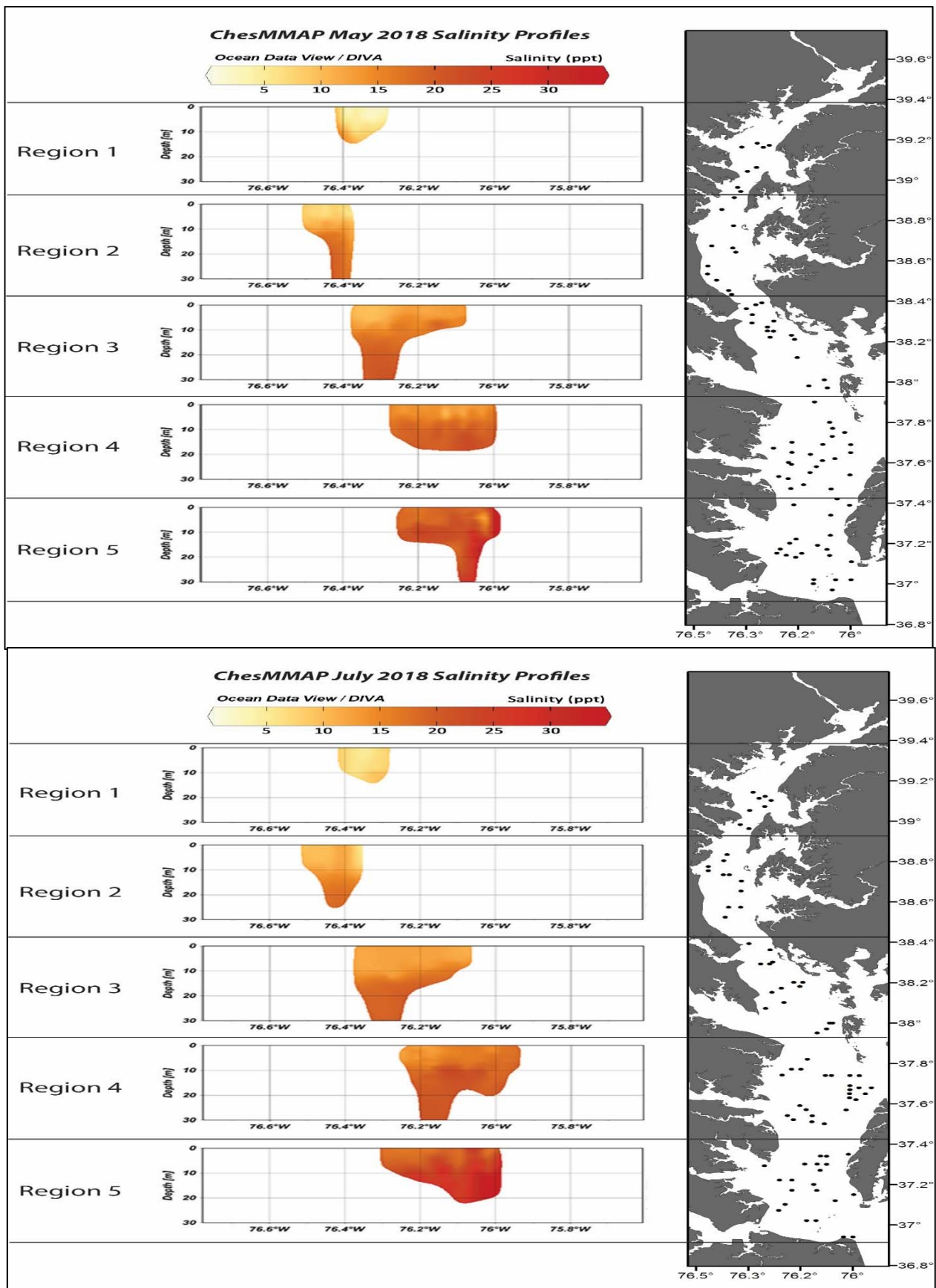


Figure 84. cont.

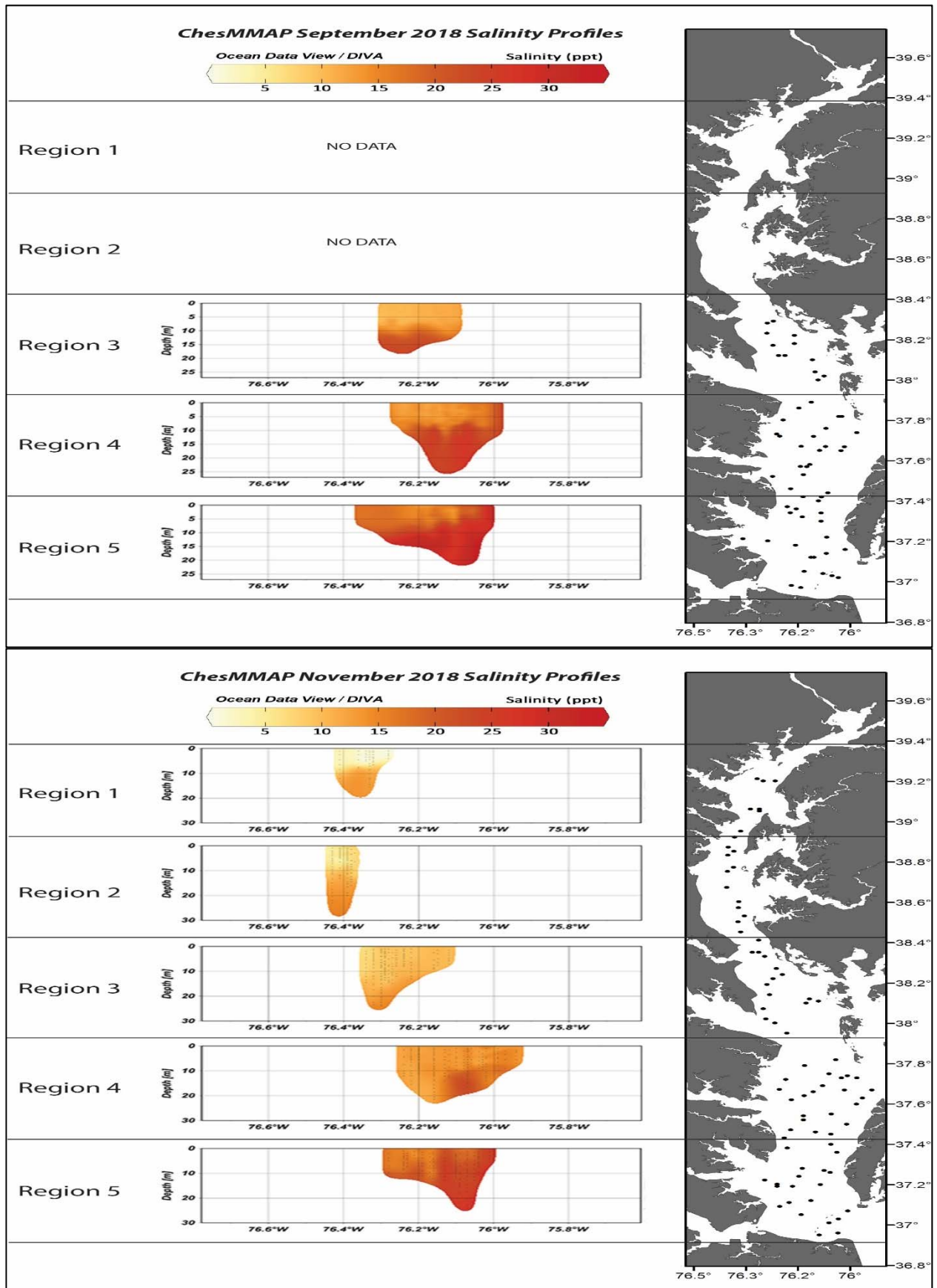


Figure 85. Interpolated bi-monthly dissolved oxygen profiles in Chesapeake Bay, 2018.

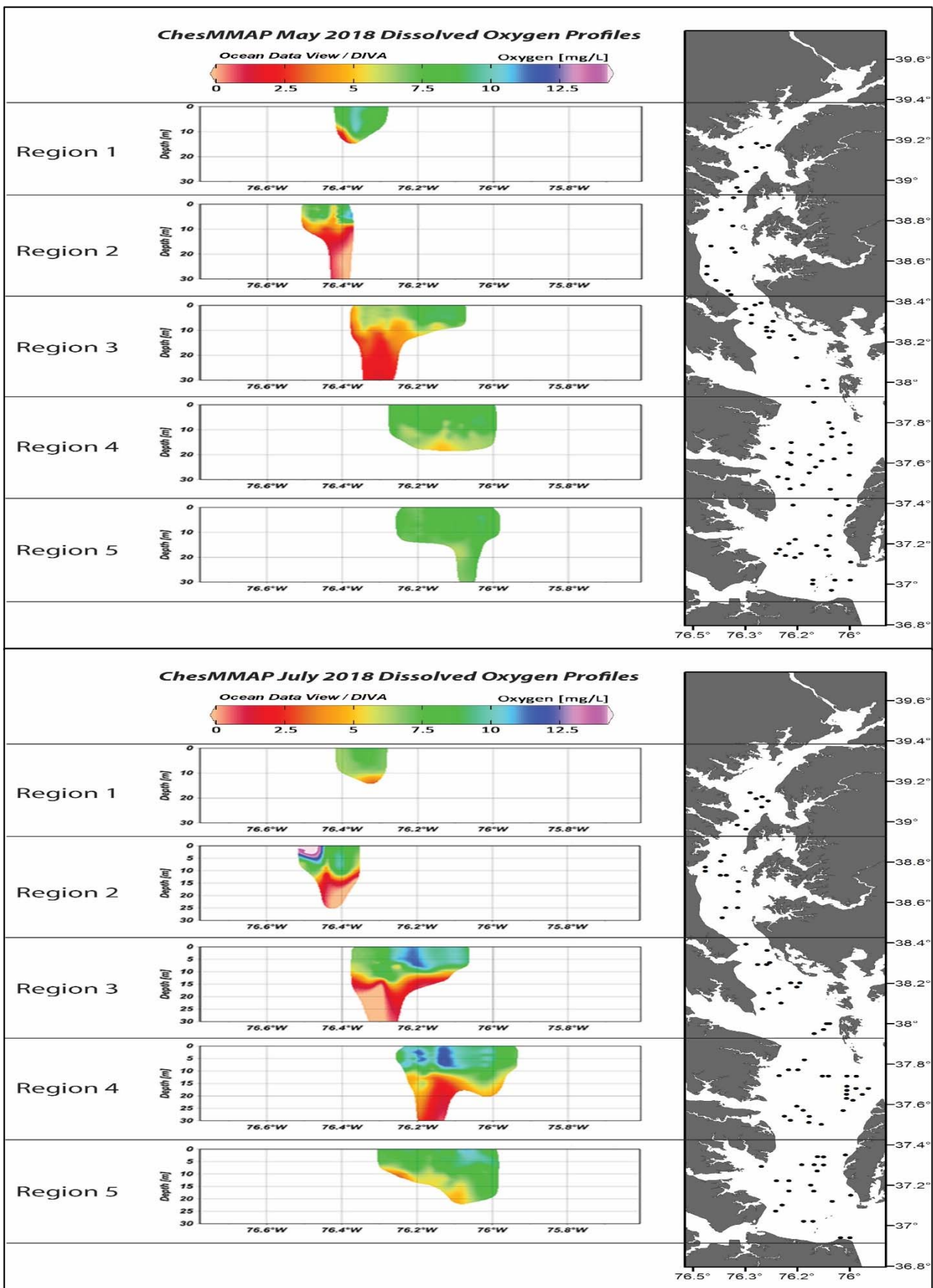
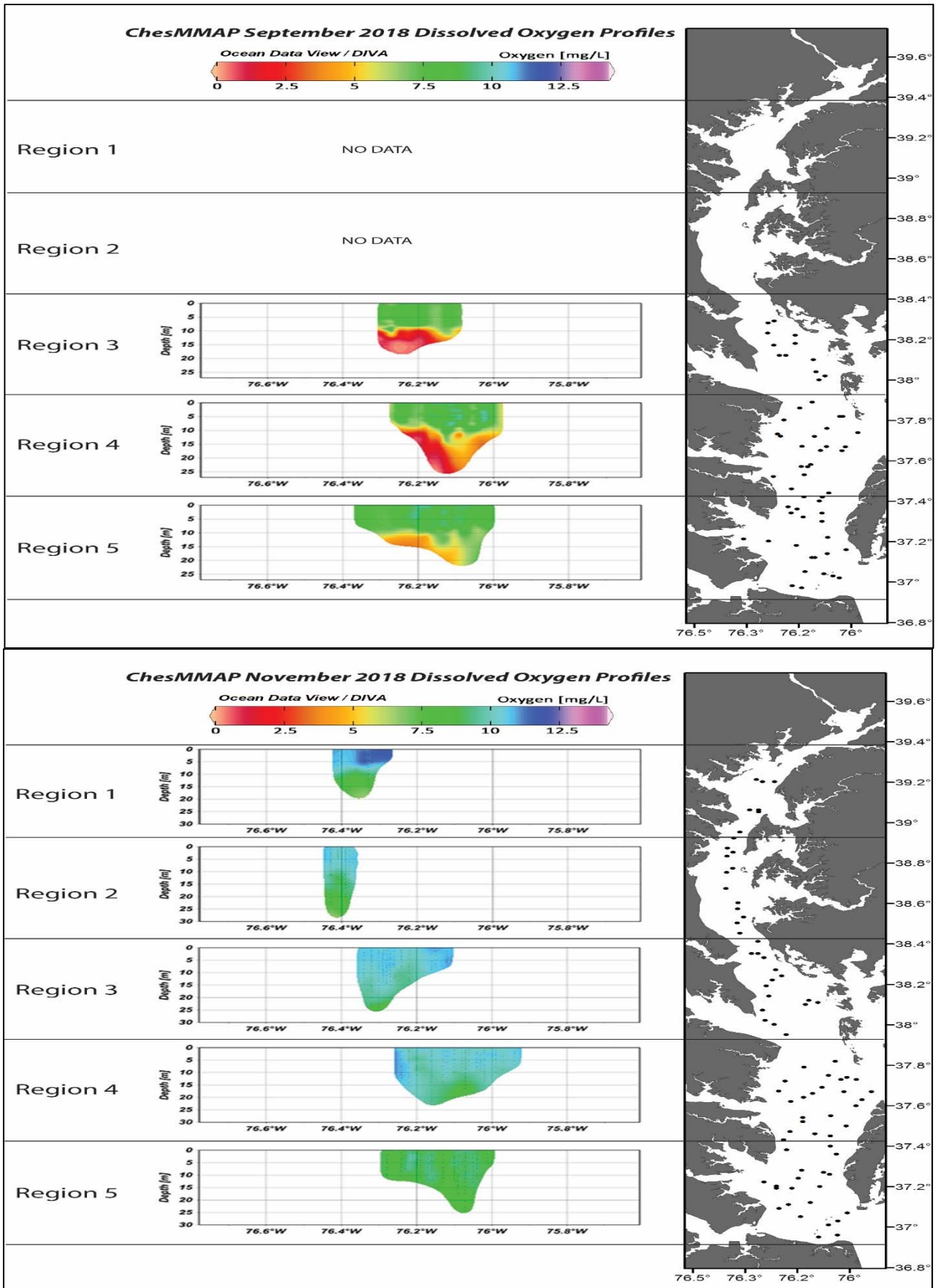


Figure 85. cont.



Appendix

Blue Crab and Clearnose Skate Abundance

Table A1. Blue Crab male (A) and mature female (B) geometric mean indices of abundance, by number and biomass, overall .

A								B									
Year	Age	n	Numerical Index			Biomass Index			Year	Age	n	Numerical Index			Biomass Index		
			LCI	Index	UCI	LCI	Index	UCI				LCI	Index	UCI	LCI	Index	UCI
2002	All	49	26.09	59.5	133.93	8.22	15.3	27.91	2002	All	20	51.29	160.6	498.34	13.34	35.4	91.24
2003		31	10.61	31.1	87.50	4.01	9.2	19.76	2003		40	174.06	318.1	580.63	30.50	50.5	83.18
2004		44	4.00	11.2	28.80	1.53	3.6	7.35	2004		28	69.07	161.2	374.61	15.40	29.8	56.80
2005		37	17.22	50.3	143.22	5.66	14.0	32.86	2005		26	381.78	741.6	1,439.78	63.20	114.3	206.20
2006		36	80.16	164.6	336.76	16.03	29.6	53.95	2006		26	353.47	522.2	771.27	45.42	68.0	101.68
2007		18	2.47	15.8	80.67	1.27	6.4	22.81	2007		26	8.65	31.7	109.86	3.51	9.7	24.54
2008		38	20.06	45.4	101.23	5.58	11.6	23.03	2008		26	742.77	1,218.4	1,998.06	102.65	173.0	291.22
2009		38	10.10	29.3	81.44	4.45	10.4	22.89	2009		26	97.72	273.9	764.32	22.86	49.9	107.51
2010		37	88.72	200.0	449.24	23.05	42.7	78.54	2010		26	335.15	769.3	1,764.15	56.04	115.7	237.68
2011		36	35.60	108.3	325.57	10.18	23.9	54.29	2011		26	24.02	77.3	244.31	7.72	18.6	43.09
2012		37	5.41	17.1	50.07	2.31	5.8	12.87	2012		23	24.23	94.6	361.43	6.87	20.2	55.85
2013		38	0.08	1.1	3.08	0.03	0.4	0.95	2013		26	7.85	33.9	136.61	3.23	10.5	30.07
2014		38	0.29	1.9	5.63	0.14	1.0	2.47	2014		26	6.93	23.1	72.03	2.59	6.4	14.43
2015		38	10.73	27.4	67.61	4.25	8.7	17.08	2015		26	61.33	187.1	566.46	15.69	38.0	90.10
2016		38	6.10	19.0	55.49	2.90	7.3	16.74	2016		26	92.37	254.5	697.99	24.15	56.0	128.29
2017		38	1.20	4.3	11.81	0.72	2.2	4.94	2017		26	6.54	27.3	105.50	2.84	8.8	23.85
2018		19	0.81	3.9	12.01	0.53	2.0	4.85	2018		26	53.57	177.6	583.68	13.97	38.1	101.26
2019									2019								
2020									2020								

Figure A1. Blue Crab male (A) and mature female (B) geometric mean indices of abundance, by number and biomass.

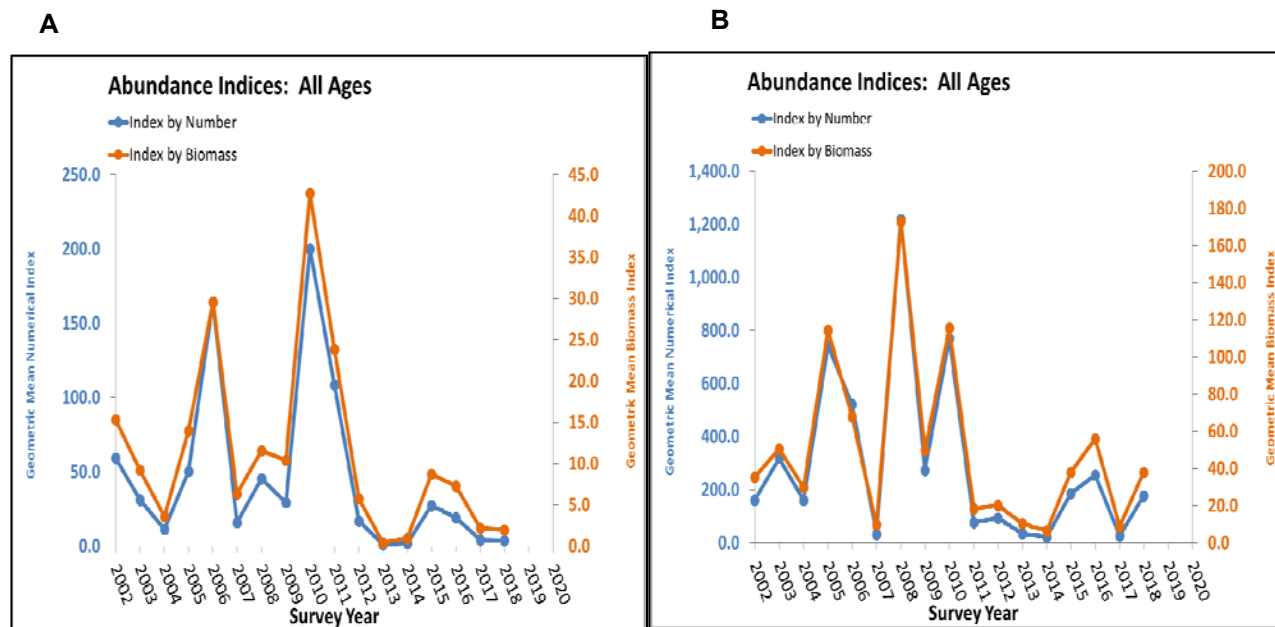


Figure A2. Abundance (kg per hectare swept) of Blue Crab males (A) and mature females (B) in Chesapeake Bay, 2018.

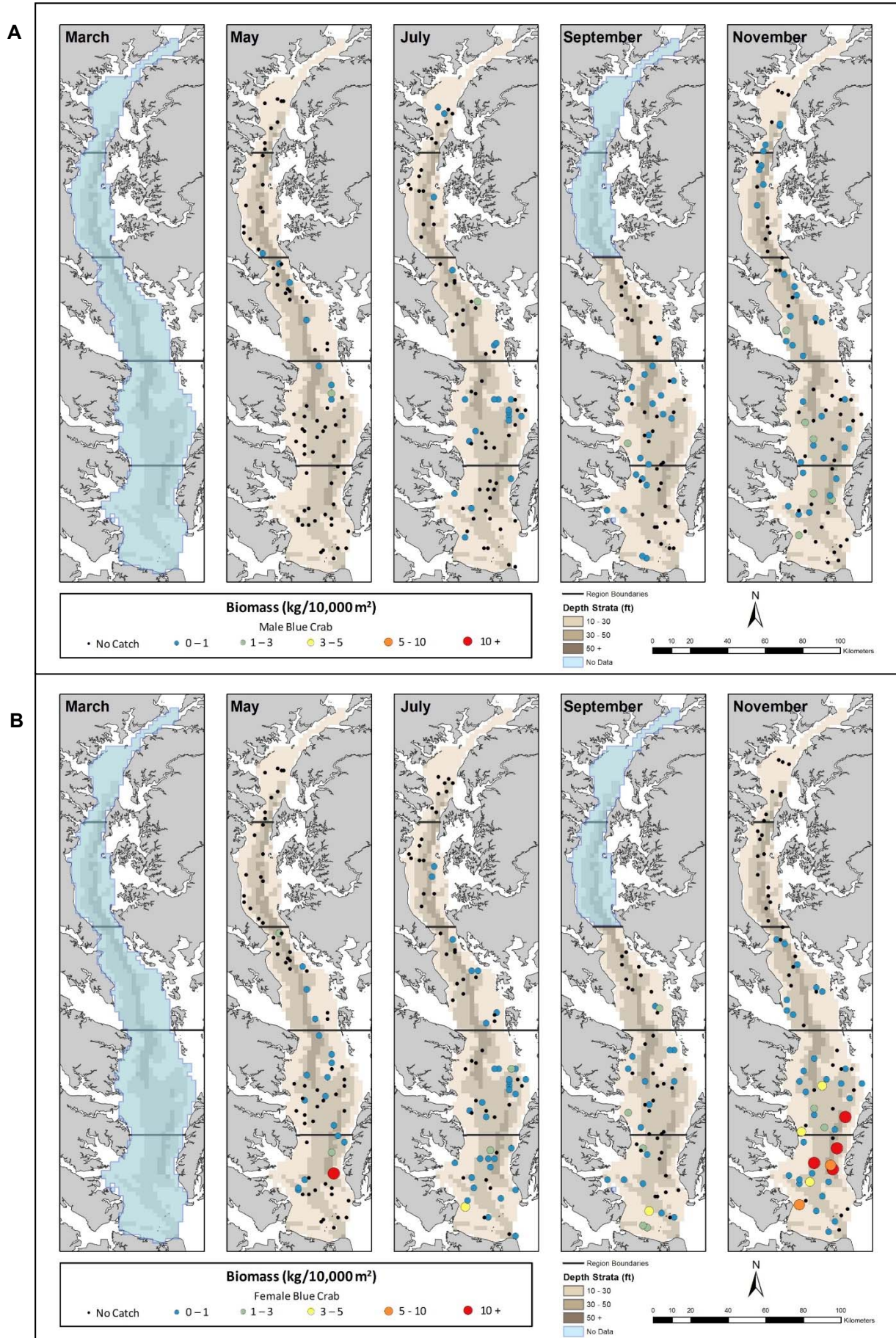


Figure A3. Clearnose Skate geometric mean indices of abundance, by number and biomass.

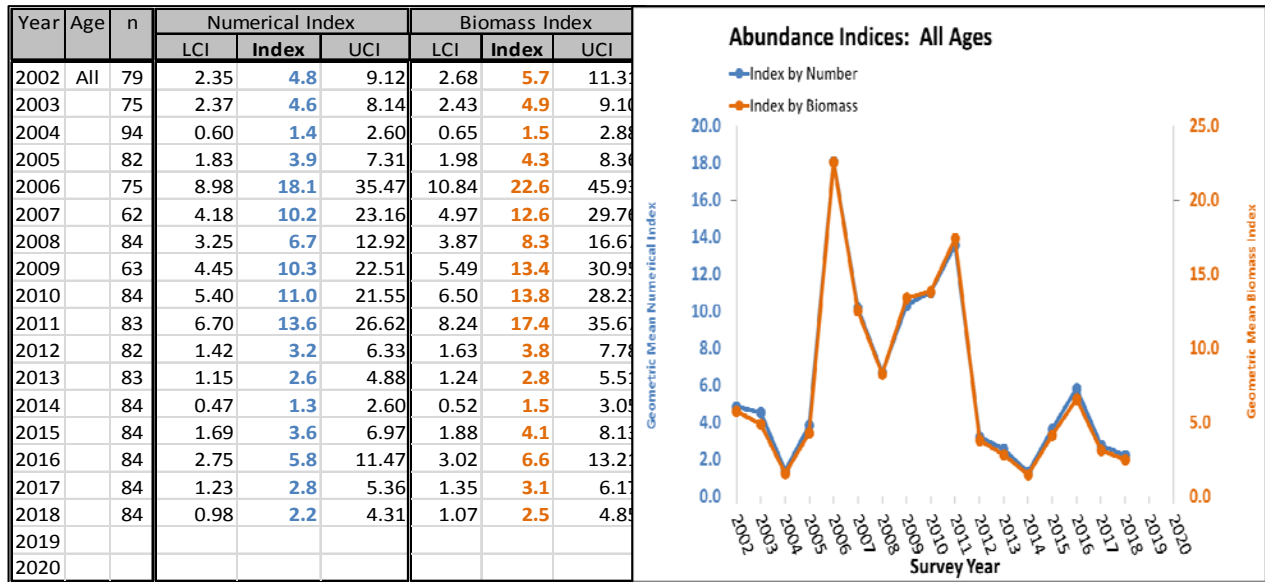


Figure A4. Abundance (kg per hectare swept) of Clearnose Skate in Chesapeake Bay, 2018.

