ASSESSMENT REPORT

FOR

GULF OF MAINE NORTHERN SHRIMP – 2018

Prepared
by the
Atlantic States Marine Fisheries Commission's
Northern Shrimp Technical Committee

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Preface

This document is a stock assessment update to the 2018 Benchmark Stock Assessment (ASMFC 2018). The update uses the configuration of the UME base model run and adds data from the 2018 winter sampling program, the 2018 Summer Survey, and the 2017 Northeast Fisheries Science Center (NEFSC) Fall Trawl Survey.

Acknowledgments

The Committee sincerely thanks all those who have contributed to this assessment through their time and efforts as part of the crew on the *R/V Gloria Michelle* shrimp survey, and as port samplers, sample processors, and data entry personnel. Their hard work has made this effort possible.

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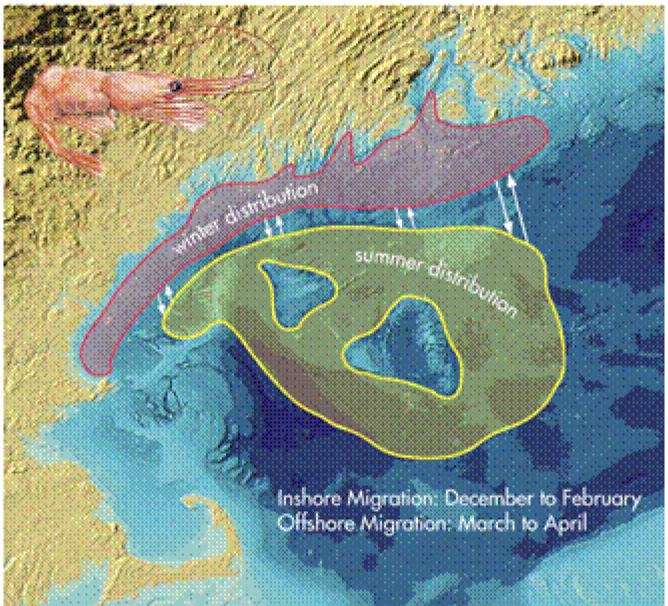
Introduction

Biological Characteristics

Northern shrimp (*Pandalus borealis* Krøyer) are hermaphroditic, maturing first as males at about 2½ years of age and then transforming to females at roughly 3½ years of age in the Gulf of Maine (Haynes and Wigley 1969). Spawning takes place in offshore waters beginning in late July. By early fall, most adult females extrude their eggs onto the abdomen. Egg-bearing females move inshore in late autumn and winter, where the eggs hatch. Juveniles remain in coastal waters for a year or more before migrating to deeper offshore waters, where they mature as males. The exact extent and location of these migrations is variable and unpredictable. The males pass through a series of transitional stages before maturing as females. Some females may survive to repeat the spawning process in succeeding years. The females are the individuals targeted in the Gulf of Maine fishery. Natural mortality seems to be most pronounced immediately following hatching, and it is believed that most northern shrimp do not live past age 5 in the Gulf of Maine (reviewed by Clark *et al*. 2000). Northern shrimp play an integral role in the food web dynamics within the Gulf of Maine both as a predator of plankton and food source to commercially important fish such as cod, redfish, and hake (Link and Idoine 2009).



Distribution of adult female northern shrimp (NAMA, 2006)

Fishery Management

The Gulf of Maine Northern shrimp fishery is managed by the Atlantic States Marine Fisheries Commission (ASMFC) Northern Shrimp Section (Section). The management framework evolved during 1972–1979 under the auspices of the State/Federal Fisheries Management Program. In 1980, this program was restructured as the Interstate Fisheries Management Program (ISFMP) of ASMFC. The Interstate Fishery Management Plan (FMP) for Northern Shrimp was first approved under the ISFMP in October 1986 (ASMFC 1986). The FMP sought to generate the greatest possible economic and social benefits from the harvest of northern shrimp and implemented measures to optimize yield. Specific regulations included a minimum mesh size, season limitations, and reporting requirements.

In 2004, the Section implemented Amendment 1 which established biological reference points for the first time in the northern shrimp fishery (ASMFC 2004). In addition, the document expanded the tools available to manage the fishery, including gear modifications. Management of northern shrimp under Amendment 1 resulted in a rebuilt stock and increased fishing opportunities. However, due to untimely reporting and higher than anticipated landings, the 2010 and 2011 fishing seasons exceeded the recommended total allowable catch (TAC) and were closed for the remainder of the season.

In 2011, the Section implemented Amendment 2. The amendment provided management options to slow catch rates throughout the season, including trip limits, trap limits, and days out of the fishery (ASMFC 2011). Subsequently, the Section implemented Addendum I to Amendment 2 in November 2012. The addendum clarified the annual specification process and allocated the annual hard TAC between gear types, with 87% allocated to the trawl fishery and 13% allocated to trap fishery (ASMFC 2012). Addendum I also implemented a season closure provision designed to close the northern shrimp fishery when a pre-determined percentage (between 80–95%) of the annual TAC had been projected to be caught. Lastly, the addendum instituted a research set aside (RSA) program which allowed the Section to "set aside" a percentage of the annual TAC to help support research on the northern shrimp stock and fishery.

In 2013, the Northern Shrimp Section imposed a moratorium on the fishery for the 2014 season. The Section considered several factors prior to closing the fishery: (1) northern shrimp abundance in the western Gulf of Maine had declined steadily since 2006; (2) the 2012 and 2013 survey indices of total biomass and spawning stock biomass (SSB) were the lowest on record; (3) the stock experienced failed recruitment for three consecutive years prior to 2014 (2010 – 2012 year classes); and (4) long term trends in environmental indices were not favorable for northern shrimp in the Gulf of Maine. The 2014 through 2017 stock status reports indicated continued poor trends in biomass, recruitment, and environmental indices which prompted the Section to extend the moratorium each year through 2018. Winter sampling via selected commercial shrimp vessels occurred in each year of the moratorium to continue the time series of biological samples that had been obtained from the Gulf of Maine commercial northern shrimp fishery.

Given the low abundance and unfavorable environmental conditions which resulted in a highly uncertain future for the resource, the Section implemented Amendment 3 in August 2017. Amendment 3 is designed to improve management of the northern shrimp resource, in the event the fishery reopens (ASMFC 2017). Specifically, the Amendment refines the FMP objectives and implements a state-specific allocation program to better manage effort in the fishery; 80% of the annual TAC is allocated to Maine, 10% to New Hampshire, and 10% to Massachusetts. The Amendment also implements mandatory use of size sorting grate systems to reduce the harvest of small shrimp, specifies a maximum fishing season length, and formalizes fishery-dependent monitoring requirements.

Amendment 3 also outlines the specification process for the northern shrimp fishery. Annually, the Section meets in-person to adjust commercial fishery management measures. Based upon the best available science as well as recommendations from the Northern Shrimp Technical Committee (NSTC) and Advisory Panel, the Section sets a hard TAC for the fishing year. In addition, the Section can specify the fishing season, the projected percentage of harvest at which the fishery will close (between 80-95%), trip limits, traps limits, days out of the fishery, and a research set aside. These management tools can be specific to a gear type and the Section can establish harvest triggers to automatically initiate or modify any option.

Overview of 2018 Benchmark Stock Assessment

The 2018 Benchmark Stock Assessment (ASMFC 2018) passed peer review in August 2018 and was approved for management by the Northern Shrimp Section in October 2018.

The assessment used both fishery-dependent and -independent data as well as information about northern shrimp biology and life history from 1984 – 2017. Fishery-dependent data came from the commercial fisheries and the cooperative winter sampling research set aside fishery. Landings data from the Gulf of Maine northern shrimp fishery included in the assessment spanned 1984-2017. In addition, size and sex-stage composition data collected from port sampling of landings was incorporated into the analysis.

Two fishery-independent surveys were used in the base model run of the assessment: the Summer Shrimp Survey and the NEFSC Fall Bottom Trawl Survey. The Summer Shrimp Survey has been conducted offshore each summer since 1984 aboard the *RV Gloria Michelle*. It employs a stratified random sampling design and gear specifically designed for Gulf of Maine conditions. The Summer Survey is considered to provide the most reliable information available on abundance, distribution, stage, and size structure because all adult life history stages are present offshore during the summer. The NEFSC Fall Survey samples waters from Maine to Cape Hatteras, NC, but only strata within the Gulf of Maine were used to develop the NEFSC Fall Survey index. The NEFSC Fall Survey has generally shown similar trends to the Summer Survey. While not incorporated into the base run of the model, information from the Maine/New Hampshire Trawl Survey was evaluated to understand size-sex-stage frequencies.

The preferred model was a statistical catch-at-length model developed in collaboration with the University of Maine (the UME model). This model divides the northern shrimp stock into size groups and tracks changes in the proportion of shrimp in each size group across seasons and years to estimate fishing mortality (F) and population size. In addition, the NSTC ran two other models, the Collie-Sissenwine Analysis (CSA) and a statistical catch-at-age model (ASAP), to compare to the preferred model. These two complementary models showed similar trends and had similar estimates of population size to the UME model, which increased the confidence in the preferred model.

Commercial Fishery Trends

The fishery formally began in 1938; during the 1940s there were a few landings in Massachusetts, but most of the landings were by Maine vessels from Portland and smaller Maine ports further east. This was a winter trawl fishery, directed toward egg-bearing females as they migrate inshore (Scattergood 1952). Landings declined from the late 1940s until the fishery stopped altogether from 1954 through 1957. Reports from fishers at the time indicate that this decline was associated with low shrimp abundance. The fishery resumed in 1958 (ASMFC 1986).

New Hampshire vessels entered the fishery in 1966, but throughout the 1960s and 1970s, New Hampshire landings were minor. New Hampshire accounted for about 9% of the total Gulf of Maine catch during 2010–2013 (Table 1).

Landings by Massachusetts vessels were insignificant until 1969, but in the early 1970s the fishery developed rapidly, with Massachusetts landings increasing from 14% of the Gulf of Maine total in 1969 to over 40% in 1974–1975. Massachusetts landings have declined to about 3% of total during 2010–2013, while Maine vessels have accounted for about 88% (Table 1 and Figure 1).

The Gulf of Maine fishery has been seasonal in nature, peaking in late winter when egg-bearing females move inshore and terminating in spring under regulatory closure (Table 3). Northern shrimp have been an accessible and valuable resource to fishermen working inshore areas in small vessels in the winter.

Most northern shrimp fishing in the Gulf of Maine has been conducted by otter trawls, although traps have also been employed, mostly off the central Maine coast, since the 1970s. According to federal and state of Maine vessel trip reports (VTRs), trappers averaged 12% of Maine's landings during 2000–2007, 18% during 2008–2011, and 7% in 2012–2013 (Table 4). Otter trawling effort accounted for 79%–96% of Maine's landings during 2000–2013.

Commercial Fishery Landings

Annual landings of Gulf of Maine northern shrimp declined from an average of 11,400 metric tons (mt) during 1969–1972 to about 400 mt in 1977, culminating in a closure of the fishery in 1978 (Table 1 and Figure 1). The fishery reopened in 1979 and landings increased steadily to over 5,000 mt by 1987. Landings ranged from 2,100 to 6,500 mt during 1988–1995, and then rose dramatically to 9,500 mt in 1996, the highest since 1973. Landings declined to an average of 2,000 mt for 1999–2001, and dropped further in the 25-day 2002 season to 450 mt, the second lowest landings in the time series at that time. Landings then increased steadily, averaging 2,100 mt during the 2003 to 2006 seasons, then jumping to 4,900 mt in 2007 and 5,000 mt in 2008. In 2009, 2,500 mt were landed during a season that was thought to be market-limited.

In 2010, the proposed 180-day season was cut short to 156 days due to landing rates being higher than expected, and concerns about catching small shrimp in the spring. Landings were 6,263 mt, while the TAC was set at 4,900 mt. In 2011, the season was similarly closed early due to landings higher than the TAC. About 6,400 mt of shrimp were landed, exceeding the recommended TAC of 4,000 mt (Table 1 and Figure 1). The average price per pound was $0.75 and the landed value of the catch was $10.6 million (Table 2). In 2012, the season was further restricted by having trawlers begin on January 2 with three landings days per week and trappers begin on February 1 with a 1,000 pound (454 kg) limit per vessel per day. The TAC was set at 2,000 mt — later increased to 2,211 mt on January 20th — and would close when the projected landings reached 95% of the TAC. The season was closed on February 17; trawlers had a 21-day season and trappers had a 17-day season. Landings for 2012 were 2,485 mt and the average price per pound was $0.95 with a value of $5.2 million. In 2013, the TAC was set at 625 mt (with 5.44 mt set aside for research tows) and would close when the projected landings reached 85% of the TAC in each fishery (trap and trawl). Trawlers fished for 54 days and trappers fished 62 days culminating in 346 mt landed, which is 279 mt below the TAC. The average price per pound was $1.81 and is the highest observed since 1989 with an estimated value of $1.4 million (inflation-adjusted values, Table 2).

Winter Sampling Programs (2014–2018)

In the absence of a commercial fishery in 2014, the State of Maine contracted with a commercial shrimp trawler to collect northern shrimp samples during January–March near Pemaquid Point, in MidCoast Maine, chosen as best representing the spatial "center" of a typical winter Maine shrimp fishery. No shrimp were landed during the 2014 cooperative winter sampling program, except the collected samples, but the total catch was estimated at 264 kg (Hunter 2014).

In 2015, the sampling program was expanded; four trawlers and five trappers collected northern shrimp during January–March under the RSA program implemented through Addendum II to Amendment 2. The traditional spatial range of the trawl fishery was divided into four regions: Massachusetts-New Hampshire, western Maine (Kittery to Phippsburg), MidCoast Maine (Phippsburg to Rockland), and eastern Maine (Vinalhaven to Lubec). One trawl captain from the qualified applicants was picked at random for each of the four sampling regions. Each trawler fished about once every two weeks, conducting at least three tows per trip, made no more than five trips, and could keep or sell up to 1,800 lbs (816 kg) per trip. Five trappers were also selected from MidCoast and eastern Maine and each fished ten traps, tended as often as needed, and could keep up to 100 lbs (45 kg) per week, for personal use only. 2015 RSA catches (including discards) were estimated at 6.7 mt (Whitmore *et al*. 2015).

In 2016, four trawlers and two trappers collected northern shrimp during January–April under the RSA program. All fishing regions were defined as in 2015, except for eastern Maine which was re-defined as the Maine coast east of Monhegan Island. Similarly, one trawl captain from the qualified applicants was picked at random for each of the four sampling regions. Each trawler fished about once every two weeks, no more than five trips total, made at least three tows per trip, and could keep or sell up to 1,800 lbs (816 kg) per trip. Two trappers were also selected from MidCoast Maine and each fished forty traps, tended as often as needed, and could keep or sell up to 100 lbs (45 kg) per week. 2016 RSA catches (including discards) were estimated at 13.3 mt (Hunter 2016).

In 2017, the RSA program continued and was expanded to ten trawlers and five trappers collecting northern shrimp during January–March: one vessel from Massachusetts, one from

New Hampshire, three from western Maine, three from MidCoast Maine, and two from eastern Maine, with a 1,200 pound (544 kg) trip limit. Four trappers were also selected from MidCoast Maine and one from eastern Maine, fishing up to 40 traps with a 500 lbs (227 kg) limit per week. 2017 RSA catches (including discards) were estimated at 32.6 mt (Hunter *et al*. 2017).

For 2018, the Section initially established an RSA of 13.3 mt; when the State of Maine declined to participate, the Section reduced the project to one trawler from Massachusetts and one from New Hampshire, each fishing one trip per week for up to 10 weeks, with an 800 pound (363 kg) landing limit per trip, for potential total RSA landings of 16,000 lbs (7.3 mt) for the RSA. Maine contracted with one trawler to make three sampling trips with no landings allowed. The three boats caught a total of 3.1 mt, including discards (Hunter *et al*. 2018).

Size, Sex, and Maturity Stage Composition of Landings

Size and sex-stage composition data have been collected from port samples of fishery landings from each of the three states. One-kilogram samples were collected from randomly selected landings. Samples were evaluated by shrimp species, and all *Pandalus borealis* were measured, sexed, and female stage was determined. Female stage I shrimp had not yet carried eggs, Female stage II shrimp had carried eggs in the past, and ovigerous females were carrying eggs. Female I and II shrimp are differentiated by presence/absence of sternal spines (McCrary 1971). Data were expanded from the sample to the vessel's landings, and then from sampled landings to total landings for each gear type, state, and month. Size composition data (Figures 2–3) indicate that trends in landings have been determined primarily by recruitment of strong (dominant) year classes.

Landings more than tripled with recruitment to the fishery of a strong assumed 1982 year class in 1985–1987 and then declined sharply in 1988. A strong 1987 year class was a major contributor to the 1990–1992 fisheries. A strong 1992 year class, supplemented by a moderate 1993 year class, partially supported large annual landings in 1995–1998. Low landings in 1999–2003 were due in part to poor 1994, 1995, 1997, 1998, and 2000 year classes with only moderate 1996 and 1999 year classes. A very strong 2001 year class supported higher landings in 2004–2006. In the 2007 fishery, landings mostly comprised assumed 4-year-old females from the moderate to strong 2003 year class, and possibly 6-year olds from the 2001 year class. Landings in 2008 mostly comprised the assumed 4-year-old females from the strong 2004 year class, and the 2003 year class (assumed 5-year-old females, which first appeared as a moderate year class in the 2004 Summer Survey).

In the 2009 fishery, landings comprised mainly assumed 5-year-old females from the strong 2004 year class. Catches in the 2010 fishery consisted of assumed 5-year-old females from the 2005 year class and possibly some 4-year-old females from the weak 2006 year class. The 2011 fishery consisted mainly of 4-year-old females from the assumed 2007 year class. Numbers of 5-year-old shrimp were limited likely due to the weak 2006 year class. Transitional stage shrimp and female stage Is (ones) from the 2008 year class, and some males and juveniles from the assumed 2009 year class were observed in 2011, especially in the Massachusetts and New

Hampshire landings and Maine's December and January trawl landings. Trawl landings in the 2012 fishery were likely 4-year olds from the moderate 2008 year class, but they were small for their age. Low percentages of males and juveniles were caught in 2012 likely due to the later start date of January 2. In the 2013 fishery, landings were limited but likely comprised 4- and 5-year olds from the moderate 2009 and 2008 year classes that were small for their assumed age. Limited numbers of males and transitionals were observed in landings.

Samples from the cooperative winter sampling program in 2014 comprised assumed 5-year old shrimp from the 2009 year class and some small males assumed to be from the fast-growing 2013 year class. Samples from the 2015 RSA program exhibited an unusually high percentage of small ovigerous females, likely early-maturing and fast-growing females from the 2013 year class. The small females were more prevalent in the Maine trawl samples than in the trap samples or the Massachusetts trawl samples. Some larger females from the assumed 2010 year class were also evident in all samples. Samples from the 2016 RSA program confirmed that members of the 2013 year class were ovigerous (at only three years old), available inshore, and represented a greater proportion of the catch than older year classes (2010-2012). Some 2016 samples, particularly those from the New Hampshire boat, contained a portion of very large females, possibly from the assumed 2010 year class. Samples from the 2017 RSA program were composed mostly of ovigerous females from the 2013 year class and males probably from the 2015 year class (Figure 3).

Past fishery samples have suggested that, in general, trappers catch fewer small shrimp than trawlers, and are more likely to catch shrimp after egg hatch than trawlers. This was confirmed by examining samples from the 2015 RSA landings, when trappers were fishing near trawlers, and each were being sampled weekly (Whitmore *et al*. 2015).

In 2018, ovigerous females made up 76% of the northern shrimp catch by count, and 18% were females caught after egg hatch. Males were 4% percent of the catch, and 2% of the catch were transitionals and female I's (which have not carried eggs yet). By state, males comprised 3.8 % of the Massachusetts catch, 2.6 % for New Hampshire, and 19.9 % for Maine. In general, the *P. borealis* size-frequency distributions (Figure 2) were bimodal, showing female modes at about 23 and 27 mm dorsal carapace length (CL), likely from the 2015 and 2013 year classes respectively. In some weeks, smaller males with CL mode at about 13 mm, probably from the 2017 year class, were also caught. In 8 of the 44 trips, shrimp species other than *Pandalus borealis* (mostly *Dichelopandalus leptocerus* and a few *Pandalus montagui*) made up more than 10% of the catch by count (in 3 out of 9 Massachusetts trips, 2 out of 6 New Hampshire trips, and all 3 of the Maine trips). Samples from the Maine trip on March 17 comprised only 58% *P. borealis* with 42% of the smaller *Dichelopandalus leptocerus*, by count (Hunter *et al*. 2018).

Spatial and temporal differences in the timing of the egg-hatch can be estimated by noting the proportion of mature females (Female II) that have hatched their brood during the season and across geographic locations. In most seasons, most of the female shrimp were still carrying eggs in late January and early February, and most had hatched off their eggs by the middle of March. Probit analysis was used to estimate the timing of hatch initiation (the day of each year on which 10% of females had hatched their brood), hatch midpoint (50% hatched), and hatch completion (90% hatched). Only Maine samples were used in the analysis (Richards 2012). The 2017 hatch midpoint was February 21, earlier than in 2014–2016, but within the historical time series range. Similarly, the hatch midpoint in 2018, based on only 3 trawl trips, was estimated to be February 23, also well within the historical time series (Figure 4).

Discards

Discard rates of northern shrimp in the northern shrimp fishery are thought to be near zero because no size limits are in effect and most fishing effort occurs in areas where only the larger females are present. Data from a study which sampled the northern shrimp trap fishery indicated overall discard/kept ratios (kg) for northern shrimp of 0.2% in 2010 and 0.1% in 2011 (Moffett *et al.* 2012). Sea sampling data from Gulf of Maine shrimp trawlers in the 1990s indicated no discarding of northern shrimp (Richards and Hendrickson 2006). On an anecdotal level, port samplers in Maine reported seeing manual shakers (used to separate the small shrimp) on a few trawl vessels during April 2010, but made no similar observations in 2011 through 2013. Discarding of northern shrimp in other Gulf of Maine fisheries is rare (on average less than 0.001% during 2000–2013; Northeast Fishery Observer Program data, NMFS). For these reasons shrimp discards from the shrimp and other fisheries are assumed zero in this assessment, with an exception for data from recent winter sampling programs. Discards from these programs were well estimated, and were usually the result of sampling program trip limits generally not in place during regular commercial shrimp fishing.

Effort, Distribution of Effort, and Catch per Unit Effort

The northern shrimp commercial fishery has been under a moratorium since the 2014 fishing year. Previous reports, e.g. Eckert *et al.* 2017, may be referenced for discussions of commercial fishery effort and CPUE. The number of fishing and winter sampling trips, by state, season, and month, are presented in Tables 5–6 and the number of vessels, by state and gear, are listed in Table 7.

Resource Conditions

Trends in abundance of Gulf of Maine northern shrimp were monitored between 1968 and 1983 from data collected in the NEFSC fall bottom trawl surveys (Despres-Panajo *et al.* 1988) and summer surveys conducted by the State of Maine DMR (discontinued in 1983). The NEFSC fall survey has continued; however, the survey vessel and gear were replaced in 2009, and this is considered the beginning of a new survey time series for shrimp (Politis *et al.* 2014). A state-federal survey (i.e. the Summer Survey) was initiated by the NSTC in 1984 to specifically assess the shrimp resource in the western Gulf of Maine. This survey is conducted each summer aboard the *RV Gloria Michelle*, employing a stratified random sampling design and shrimp trawl gear designed for Gulf of Maine conditions (Clark 1989). An inshore trawl survey has been conducted by Maine and New Hampshire aboard the *FV Robert Michael* each spring and fall, beginning in the fall of 2000 (Sherman 2005).

The NSTC has placed primary importance on the Summer Shrimp Survey (described in more detail below) for fishery-independent data used in stock assessments, although the other survey data are also considered. See Figures 5 and 6 for the areas covered by the different surveys.

In 2017, the *RV Gloria Michelle's* winches were replaced, and new Bison trawl doors replaced the old Portuguese trawl doors, which had been in use since the first year of the survey in 1984. Before the 2017 survey, eight pairs of calibration tows were made to compare the performance of the gear with the old and new doors and winches. The differences were not statistically significant (Eckert *et al.* 2017). Thirty-nine additional calibration tows were conducted in July 2018, but the results have not been analyzed yet. The data and discussion below assume that there was no significant difference in the performance of the 2017/2018 survey gear as compared with gear in prior years.

The indices of abundance from the surveys have traditionally been calculated with design-based estimators (stratified arithmetic or geometric means). For the 2018 Benchmark Assessment, a spatio-temporal standardization approach was used to develop the fishery-independent indices. This approach used a spatial delta-generalized linear mixed model (delta-GLMM) to incorporate habitat information and spatial auto-correlation in survey data to develop indices of abundance (Cao *et al.* 2017); as part of the process, the indices were then standardized to their mean, so the scale of the indices is no longer comparable to the design-based numbers or weights per tow.

Abundance and biomass indices (spatio-temporal standardized) for northern shrimp from the Summer Survey from 1984–2018 are given in Table 9 and Figures 7 and 8; length-frequencies by year are provided in Figures 9 and 10. These indices were calculated using data from all successful tows, both fixed and random, in all stratum areas surveyed. The standardized index of total biomass closely follows the trends of the total abundance index (Table 9 and Figure 7).

The total abundance index averaged 1.063 from 1984 through 1993, then gradually declined to 0.283 in 2001. The index increased markedly, reaching a time series high in 2006 (4.555). Although 2006 was a high stock year, as corroborated by the fall survey index (see below), the 2006 Summer Survey index should be viewed with caution because it was based on 41 survey tows compared with about 57 tows in most years. The Summer Survey abundance index was 1.721 in 2009, and dropped steadily to a time series low of 0.055 in 2017. The 2018 abundance index was 0.078, the fourth lowest in the time series, also based on relatively few tows (36). The 2018 biomass index was the second lowest in the time series. Seven out of eight of the lowest abundance and biomass index values in the time series have occurred since 2011.

The standardized catch of assumed 1.5-year-old shrimp (Table 9, Figure 8, and graphically represented as the first (left-most) size mode in Figures 9 and 10), represents a recruitment index. Although these shrimp are not fully recruited to the survey gear, this index appears sufficient as a preliminary estimate of year class strength. The recruitment index indicated strong (greater than 0.800) assumed 1987, 1992, 2001, and 2004 year classes. The assumed

1983, 2000, 2002, and 2006 year classes were weak (less than 0.060), well below the time series mean of 0.279. From 2008 to 2010, the recruitment index varied around 0.550, indicating above average assumed 2007, 2008, and 2009 year classes. The index dropped markedly to 0.049 in 2011. Very low values (less than 0.015) were observed in 2012, 2013, 2015, and 2017, indicating recruitment failure of the assumed 2011, 2012, 2014, and 2016 year classes. In 2014 and 2016, the indices were 0.177 and 0.169 respectively, reflecting below-average recruitment of the 2013 and 2015 year classes. The recruitment index for 2018 was 0.050, the ninth lowest in the time series. All recruitment indices have been below average since 2010, with time series lows in 2013, 2015, and 2017.

Mean numbers per tow at size for 2012-2018 are too low to be clearly visible in Figure 9, which uses a constant y-axis scale for the time series (with the exception of 2006). Expanded vertical axes for the 2012-2018 data show that the mean carapace lengths of the assumed age-1.5 shrimp in the 2014 and 2016 surveys were unusually large, suggesting a high growth rate for the 2013 and 2015 year classes (Figure 10).

Individuals larger than 22 mm carapace length (CL) in the summer are expected to be fully recruited to a fishery the following winter (as primarily age 3 and older). Thus, survey catches of shrimp in this size category provide indices of harvestable numbers and biomass for the coming winter (Table 9). The harvestable biomass index exhibited peaks in 1985, 1990, and 1995, reflecting the strong assumed 1982, 1987, and 1992 year classes respectively. The index then trended down through 2001 to a low of 0.17, and is indicative of small assumed 1997 and 1998 year classes. From 2002 to 2006, the index increased dramatically, reaching a time series high in 2006 (1.82). The index has declined steadily since 2006 despite above-average recruitment of the 2007, 2008, and 2009 year classes discussed above, and reached a new time series low in 2014, 2017, and 2018 (0.05), consistent with the below average recruitment of the 2010–2015 year classes.

An index of spawning stock biomass was estimated by applying a length-weight relationship for non-ovigerous shrimp (Haynes and Wigley 1969) to the abundance of females at each length, and summing over lengths. The spawning biomass index shows trends similar to the harvestable biomass indices, with the most recent six years having the lowest values in both time series (Table 9 and Figure 8).

The NEFSC fall survey conducted by the NOAA Ship *Albatross IV* provided an index of northern shrimp abundance from 1968 to 2008 (Table 9 and Figure 11). The spatio-temporal standardized abundance index is available beginning in 1986. The index fluctuated with the influences of strong and weak year classes through the 1980s and 1990s, and the survey ended in 2008 with values well above the time series mean during its last four years, including the time series high of 3.691 in 2006. This high value corresponded with the time series high seen in the Summer Survey the same year (Table 9 and Figure 7). In 2009, the NEFSC fall survey changed vessels, gear and protocols; thus indices since 2009 are not directly comparable to earlier years. The abundance index from the new (NOAA Ship *Bigelow*) NEFSC fall survey declined rapidly, from a high of 3.969 in 2009 to a time series low of 0.072 in 2017, parallel to trends in the Summer Shrimp Survey and the ME-NH survey (Figure 7, Figure 11, and Figure 12). The 2018 survey index is not available yet.

The Maine-New Hampshire inshore trawl survey takes place biannually, during spring and fall, in five regions and three depth strata (1 = 5–20 fa (9–37 m), 2 = 21–35 fa (38–64 m), 3 = 36–55 fa (65–101 m)). A deeper stratum (4 = > 55 fa (> 101 m) out to about 12 miles) was added in 2003 (Figure 5). The survey consistently catches shrimp in regions 1–4 (NH to Mt. Desert Is.) and depths 3–4 (> 35 fa (>64 m)), and more are caught, with less variability, in the spring than the fall. The spatio-temporal standardized abundance index for northern shrimp for the spring surveys using all regions and depths for 2003–2018 are presented in Table 9 and Figure 12. The index rose steadily from 0.441 in 2003 to a time series high of 2.473 in spring 2011. The index then dropped abruptly and reached a time series low of 0.086 in 2018 (preliminary). Trends in the spring ME/NH survey may be affected by inter-annual variation in the timing of the offshore migration of post-hatch females. However, the low 2013–2018 biomass indices and size and sex-stage structure observed in the ME-NH survey (Figure 13) are consistent with the 2013–2018 Summer Survey results (Figure 12).

Environmental Conditions

Ocean temperature has an important influence on northern shrimp in the Gulf of Maine (Dow 1964; Apollonio *et al.* 1986; Richards *et al.* 1996; Richards *et al.* 2012; Richards *et al.* 2016). Survival during the first year of life has been negatively correlated with ocean temperature during two periods: (1) during the time of the hatch and early larval period, and (2) during the late summer when ocean temperatures and water column stratification are reaching their maximum (Richards *et al.* 2016). Relatively cool temperatures during these sensitive periods are associated with higher recruitment indices in the Summer Shrimp Survey. Spawner abundance also influences recruitment, with more recruits produced with higher spawner abundance, but environmental influences have increased in importance since around 1999 (Richards *et al.* 2012).

Sea surface temperature (SST) has been measured daily since 1906 at Boothbay Harbor, Maine, near the center of the inshore nursery areas for northern shrimp. Average winter SST (Feb-Mar) at Boothbay has increased fairly steadily from an average of 0.8^o C during 1906-1948 to 3.3^o C during 2008-2017 (Figure 14). Average winter SST during 2018 was 4.5^o C.

Spring bottom temperature anomalies (temperature changes measured relative to a standard time period) in offshore shrimp habitat areas were above average in 2017 and 2018, but slightly lower than in 2016. Summer bottom temperature in shrimp habitat as measured by the Summer Survey has also shown an increasing trend over time (Figure 14). Average summer bottom temperature was 5.4^{o}C from 1984 – 1993, but averaged 6.8^{o}C from 2013 – 2018. Summer bottom temperature was 6.7^{o}C in 2018, above the long-term average, but slightly less than the time series highs seen in 2010-2013 and 2016.

Ocean temperatures also affect timing of the shrimp larval hatch (Richards 2012). The start of the hatch period became earlier in the 1990s as temperatures increased, and by the mid-2000s was beginning about a month earlier than it did before 2000 (10% line in Figure 4). The midpoint of the hatch period has changed less than the start of the hatch (50% line in Figure 4). During the past four years (2014-2017), hatch timing has been similar to hatch periods observed before 2000 (Figure 4).

Northern shrimp are an important component of the food web in the Gulf of Maine. An index of predation pressure (PPI) was developed from NEFSC survey data by weighting the predator biomass indices by the long-term average percent frequency of shrimp in each predator's diet estimated from food habits sampling (NEFSC 2014; Richards and Jacobson 2016). Predation pressure has generally increased since the late 1990s (Figure 14). During 2009-2011, the PPI was above the 80^{th} percentile; however during 2013- 2015 it fluctuated around a lower level. In 2016, predation pressure jumped to a time series high, attributable to an increased biomass index of spiny dogfish (*Squalus acanthias*) (unpub. data, NEFSC 2017), and in 2017, PPI neared the 80^{th} percentile.

Stock Assessment Update

The 2018 Stock Assessment Update for northern shrimp includes an updated run of the UME model as well as a model-free traffic light analysis.

Data Sources

The 2018 Benchmark Stock Assessment was updated with the total removals and the length composition from the 2018 Winter Sampling Program, the 2018 Summer Survey data, and the 2017 NEFSC fall survey data. The 2018 NEFSC fall survey data were not available, so a 3-year average was used for the PPI to scale natural mortality.

Traffic Light Analysis

The NSTC utilized an index-based approach to evaluate stock status of Gulf of Maine northern shrimp. The Traffic Light Approach, developed by Caddy (1999a, 1999b, 2004) and extended by McDonough and Rickabaugh (2014) was applied to the northern shrimp stock to characterize indices of abundance, fishery performance, and environmental trends from 1984 to present. The approach categorizes annual values of each index as one of three colors (red, yellow, or green). Red represents unfavorable condition or status, yellow designates intermediate values, and green represents favorable condition or status.

The NSTC applied the Strict Traffic Light Approach (STLA, Caddy 1999a, 1999b and 2004) to a suite of indicators (Tables 8-10, Figures 7, 8, 11, and 14). Fishery-independent indices included survey indices from the ASMFC summer survey, and NEFSC fall surveys, and the Maine-New Hampshire spring inshore survey. Indices of total biomass and abundance, harvestable biomass, spawner biomass, and recruitment from the Summer Survey were also evaluated. Environmental conditions included a predation pressure index (NEFSC 2014; Richards and

Jacobson 2016), and several sources of surface and bottom temperature data for the northern shrimp resource area.

Two qualitative stock status reference levels were developed for the traffic light approach. The 20th percentile of the time series from 1984-2017 (and 1984-2013 for fishery performance) delineated an adverse state, and the 80th percentile of the time series from 1984-2017 (and 1984-2013 for fishery performance) delineated a favorable state. These reference levels are not management triggers, as they are not defined in the current ASMFC Northern Shrimp FMP.

Trends in fishery performance indicated that catch rates were high but price per lb. was low in the mid to late 2000s. In 2013, the last year prior to the moratorium, the catch rate was below the 20th percentile and a record low for the time series (Table 8). No commercial catch occurred in 2014, 2015, 2016, 2017, or 2018 due to a harvest moratorium.

Fishery-independent model-based Summer Survey indices of abundance and biomass have remained at historic lows for the past seven years (2012–2018) (Table 9, Figure 7). Similarly, spawning biomass and harvestable biomass indices have remained below the 20th percentile during 2012–2018, and are also the lowest estimates on record (Table 9, Figure 8). Shrimp indices from surveys with shorter time series have exhibited a similar trend as seen in the Summer Survey. The NEFSC fall survey (*Bigelow*, 2009-2017) and ME-NH spring inshore survey (2003-2018) abundance indices were above the 80th percentile in 2009-2010, but have since declined dramatically to time series lows, well below the 20th percentiles, in 2017 (NEFSC fall) and 2018 (ME-NH spring) (Table 9).

Recruitment has been low to extremely poor for eight consecutive years. Recruitment was below the 20th percentile in 2012, 2013, 2015, and 2017, with the lowest recruitment value on record observed in 2017 (Table 9, Figure 8). Recruitment of the 2012, 2014, and 2016 year classes were the weakest observed in the 35-year time series, although recruitment of the 2013 and 2015 year classes was marginally higher (Figure 8). The 2014–2015 year classes would be the target of a 2019 fishery.

Trends in environmental indicators suggest that conditions have not been favorable for northern shrimp in recent years (Table 10, Figure 14). An overall rise in seawater temperatures since 1984 is evident across the series, with spring anomalies and summer bottom temperatures in offshore shrimp habitat at or exceeding the 80th percentile from 2011 to 2013 and again in 2016 (Table 10, Figure 14).

UME Length Structured Model

The preferred model was a statistical catch-at-length model developed in collaboration with the University of Maine (the UME model) (ASMFC 2018). This model divided the northern shrimp stock into size groups and tracked changes in the proportion of shrimp in each size group across years to estimate fishing mortality and population size. The model used a seasonal time step to better capture the growth dynamics of northern shrimp and the temporal patterns of the fishery. The UME model used length- and time-varying natural mortality estimates for northern shrimp. Length-varying natural mortality was based on the Lorenzen curve (Lorenzen 1996) scaled to a longevity based estimate of 0.5; the Lorenzen curve was scaled annually using the predation pressure index.

UME Length Structured Model Results

The model fit the total annual indices well, with more patterning in the residuals in the NEFSC fall trawl survey than in the Summer Survey (Figure 15a). The model struggled to fit the extremely high value in 2006. Overall, the model fit the total catch well, although it underestimated the peak catches in the late 1990s, prior to a steep decline into the early 2000s (Figure 15b).

The model was able to fit the length-composition data relatively well for both the indices (Figures 16 and 17) and the catch (Figures 18-20), fitting both the broader size range of the survey length composition and the narrower distribution of the catch composition. The model had more trouble fitting the size composition of the winter sampling years (2014-2018) for both the trap and trawl fleets (Figures 19 and 20), which is not surprising, given the smaller sample sizes and the higher variability in the prosecution of the fishery for those years.

An average fishing mortality (F) for the time series (e.g. numbers-weighted average F on shrimp ≥22 mm carapace length) was calculated to account for differences in selectivity patterns across years and between fleets. Average fishing mortality has been extremely low since the implementation of the moratorium in 2014 (Table 11, Figure 21). The average F peaked shortly before that in 2011 and 2012. In 2018, average F was estimated to be 0.002, lower than the both the time series mean and the mean of the winter sampling time period (2014 – 2018).

Spawning stock biomass was estimated to be at extremely low levels in 2018 and had been since 2013 (Table 11, Figure 22). SSB in 2018 was estimated at 600 mt, lower than in 2017. SSB shows three large peaks over the time series in 1995, 2007, and 2009, ranging from 7,000 – 9,000 mt. There was a decline in SSB after each peak, and after the peaks in 1995 and 2009, the decline continued for six or more years afterwards, leading to time series lows in 2004 and 2013 - 2018.

Recruitment was also low in recent years, with recruitment in 2018 estimated at 2.0 billion shrimp (Table 11, Figure 23). The median of the time series is 2.6 billion shrimp. The 2015 year class was above the median, but the 2014, 2011, 2016, and 2012 year classes were the lowest on record. Variability in recruitment has increased since 2000, with higher highs and lower lows in recruitment deviations than 1984-1999 (Figure 23). The highest year class on record is the 2001 year class at 36.2 billion recruits, an order of magnitude larger than the median value.

The retrospective pattern in the assessment was minimal, with SSB being slightly underestimated and exploitation rate being slightly overestimated over the time series, with no consistent pattern in recent years (Figure 24).

Projections

A length-based projection model in R was developed to project the population forward under various scenarios of recruitment, natural mortality (M), and F. The projection was repeated 10,000 times with stochastic draws of recruitment, M, initial abundance-at-size for non-recruits, and fishery selectivity parameters.

Recruitment was drawn from a log-normal distribution with a mean equal to recruitment from 2011-2018 (Figure 25); this distribution skews towards lower values than the distribution of the entire time series and is more representative of recent levels of recruitment. Abundance-at-size for non-recruits in the first year of the projection (2018) was calculated by the UME model by applying Season 2 (June – November) M in 2018 to the Season 2 abundance in 2018 (F is zero during Season 2). The mean and standard deviation of those estimates were used to create draws of initial abundance-at-size for non-recruits in the projections. The fishery selectivity parameters were drawn from the mean and standard deviation of the model-estimated selectivity parameters in the most recent selectivity block for the trap and trawl fisheries.

Three scenarios of length-varying M were compared and applied for the projection model (Figure 25). The time series average (1984-2018) of M represented the lowest M scenario. In contrast, the 2014-2018 average M represented the recently observed higher levels of natural mortality. To further account for uncertainty regarding M in the future, a weighted distribution of M values was also applied, where, for each year of the projections, an M was drawn from a distribution of PPI values such that values from 2014-2018 (recent high M) were as likely to be chosen as values from the whole time series (lower M). Values for M in the weighted distribution scenario were intermediate to the time series average and recent-M scenarios, and thus were more optimistic than recent environmental conditions suggest for this population in the near future.

To develop catch recommendations, the population was projected forward 5 years, and the probability that SSB would be above 2017 SSB was calculated (Table 11). The allocation of F between the trap and trawl fisheries was set using the ratio of catch for each fleet over the last 3 years of the open fishery (2011-2013); trap catch was 12% of trawl catch over that time period.

There was no probability that SSB in 2019 would be above SSB in 2017 in any M scenario, even without fishing pressure (Table 12, Figure 27). Assumptions around M and recruitment had large effects on the projection trajectories after 2019:
Scenario 1: When M was equal to the time series average (generally lower levels of M), SSB increased in the short-term. All fishing scenarios (F=0 to F=0.4, and 200mt) resulted in a 100%, or near 100%, probability of SSB being at or above 2017 levels in 2023 (Table 12, Figure 27, top).

Scenario 2: When the projections used the weighted-distribution of M, there was a lower probability of SSB being greater than SSB_{2017} than in Scenario 1, but a higher probability than

Scenario 3. The probabilities increased after 2019. Fishing at status quo ($F=F_{2018}$) for five years (the length of the projection) resulted in a TAC of 9.3 mt in 2019, and a 58% chance of being at or above SSB_{2017} by 2021. Fishing at F=0.22 for five years resulted in a TAC of 99 mt in 2019; median SSB in 2021 was estimated to be 673 mt, resulting in an approximately 50% chance of being at or above SSB_{2017}, with 95% confidence intervals of 243 – 1,811 mt. Fishing at F=0.34 for five years resulted in a TAC of 118 mt in 2019 and a 44% chance of being at or above SSB_{2017} by 2021; SSB in 2021 was estimated to be 630 mt (95% confidence intervals: 225 – 1,711 mt). As an alternative application of F in the projection model, removal of 200 mt in 2019 resulted in SSB declining from 600 mt in 2018 to 498 mt in 2019 (95% confidence intervals: 435 – 554 mt), a decline of nearly 20%. There would be less than a 50% chance of being at or above SSB_{2017} by 2023 if the stock was fished at that rate. The wide confidence intervals on the SSB estimates illustrates the uncertainty in the projections due to uncertainty about M.

Scenario 3: When M was equal to the recent, high levels of M, median SSB declined even in the absence of fishing (Figure 26), and there was a very low probability that SSB in 2023 would be greater than SSB in 2017 under any F scenario (Table 12, Figure 27, bottom). This shows the influence that M has on future conditions of the northern shrimp stock and the uncertainty that this can introduce regarding these projections.

There are several important considerations to note about the projections. The first is that, as previously mentioned, Scenario 2 draws M from the time series distribution. This begs the question whether this is a likely representation of future conditions. If future levels of M will be closer to the time series average, the probability of being above SSB_{2017} increases. In contrast, if future levels of M will be closer to recent and high levels, the stock has a much lower probability of being above SSB_{2017}. This dichotomy is demonstrated in Figure 27 where the application of the time series average of M shows very high probabilities of achieving a SSB greater than SSB_{2017}, while the application of recent levels of M shows little-to-no probability of increasing SSB over SSB_{2017}. It is also important to consider the benchmark against which these projections are measuring improvement. SSB in 2017 was 690 mt, one of the lowest levels of biomass in the time series. As a result, increases above this level do not equate to a significant change in the stock's status.

Since predation contributes significantly to natural mortality, and predation has been above its time series average in each and every one of the past ten years (Table 10), a return to historically lower levels of M is not likely in the near future, and the NSTC considers Scenario 3, in which stock levels do not increase significantly even with zero fishing, to be the most likely scenario in the short term.

Status of the Stock

Based on the results of the 2018 Stock Assessment Update, the northern shrimp stock in the Gulf of Maine remains depleted, with spawning stock biomass (SSB) at extremely low levels since 2013. SSB in 2018 was estimated at 600 mt, well below the time series average of 3,710 mt. In addition, recruitment continues to be low, with values in 2018 estimated at 2.0 billion shrimp, higher than in 2017 but still lower than the time series median of 2.6 billion shrimp.

Variability in recruitment has increased since 2000, with higher highs and lower lows in recruitment deviations than in previous years (1984-1999). Fishing mortality has been very low in recent years due to the moratorium.

Low recruitment and high natural mortality hinder stock recovery. Projections suggest the stock could recover to moderate levels under current recruitment levels, but not if natural mortality remains high. If M remains high, the likelihood of recovery to previous population levels is extremely low, even in the absence of fishing.

Recommendations

The NSTC bases its recommendations to the Section on its assessment of current stock status, the biology of the species, and the stated management objective to protect and maintain the northern shrimp stock at sustainable levels that will support a viable fishery (Amendment 3 to the FMP, ASMFC 2017).

Short-term commercial prospects for the 2019 fishing season are very poor, given the very low index of harvestable biomass in 2018. Longer-term prospects remain poor, with below-average or time series low recruitment observed in 2016–2018.

Indices of total biomass and spawning biomass have remained at unprecedented lows for six consecutive years, including 2018.

Recruitment failure has been observed in five of the past eight years (the 2010, 2011, 2012, 2014, and 2016 year classes), and recruitment of the 2013, 2015, and 2017 year classes was below average. The 2015 year class spawned in part as three-year-old shrimp in 2018, and is expected to spawn again in 2019 and 2020.

Long term trends in environmental conditions have not been favorable for northern shrimp in the Gulf of Maine. This suggests a need to conserve spawning stock biomass to help compensate for what may continue to be an unfavorable environment.

Northern shrimp provide a valuable ecosystem service to the Gulf of Maine as a trophic link to commercially important finfish. Maintaining a sustainable stock addresses the overall health of fisheries in the Gulf of Maine.

Given the continued poor condition of the resource, the extremely low likelihood of being able to fish sustainably in a 2019 commercial season, and the value of maximizing spawning potential to rebuild the stock if environmental conditions improve, the NSTC recommends that the Section extend the moratorium on fishing through 2019.

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Table 1. **U.S. Commercial landings (mt) of northern shrimp in the Gulf of Maine, by year (1958–1984, left) or by season (1985–2018, right). Landings by season include the previous December. Landings in 2014–2018 are from RSA and winter sampling programs, and include discards.**

Year	Maine	Mass.	New Hamp.	Total
1958	2.2	0.0	0.0	2.2
1959	5.5	2.3	0.0	7.8
1960	40.4	0.5	0.0	40.9
1961	30.5	0.3	0.0	30.8
1962	159.5	16.2	0.0	175.7
1963	244.3	10.4	0.0	254.7
1964	419.4	3.1	0.0	422.5
1965	941.3	8.0	0.0	949.3
1966	1,737.8	10.5	18.1	1,766.4
1967	3,141.2	10.0	20.0	3,171.2
1968	6,515.2	51.9	43.1	6,610.2
1969	10,993.1	1,773.1	58.1	12,824.3
1970	7,712.8	2,902.3	54.4	10,669.5
1971	8,354.8	2,724.0	50.8	11,129.6
1972	7,515.6	3,504.6	74.8	11,095.0
1973	5,476.6	3,868.2	59.9	9,404.7
1974	4,430.7	3,477.3	36.7	7,944.7
1975	3,177.2	2,080.0	29.4	5,286.6
1976	617.3	397.8	7.3	1,022.4
1977	142.1	236.9	2.2	381.2
1978	0.0	3.3	0.0	3.3
1979	32.8	405.9	0.0	438.7
1980	69.6	256.9	6.3	332.8
1981	530.0	539.4	4.5	1,073.9
1982	883.0	658.5	32.8	1,574.3
1983	1,029.2	508.2	36.5	1,573.9
1984	2,564.7	565.4	96.8	3,226.9

Season	Maine	Mass.	New Hamp.	Total
1985	2,946.4	968.8	216.7	4,131.9
1986	3,268.2	1,136.3	230.5	4,635.0
1987	3,680.2	1,427.9	157.9	5,266.0
1988	2,258.4	619.6	157.6	3,035.6
1989	2,384.0	699.9	231.5	3,315.4
1990	3,236.3	974.9	451.3	4,662.5
1991	2,488.6	814.6	282.1	3,585.3
1992	3,070.6	289.3	100.1	3,460.0
1993	1,492.5	292.8	357.6	2,142.9
1994	2,239.7	247.5	428.0	2,915.2
1995	5,013.7	670.1	772.8	6,456.6
1996	8,107.1	660.6	771.7	9,539.4
1997	6,086.9	366.4	666.2	7,119.5
1998	3,481.3	240.3	445.2	4,166.8
1999	1,573.2	75.7	217.0	1,865.9
2000	2,516.2	124.1	214.7	2,855.0
2001	1,075.2	49.4	206.4	1,331.0
2002	391.6	8.1	53.0	452.7
2003	1,203.7	27.7	113.0	1,344.4
2004	1,926.9	21.3	183.2	2,131.4
2005	2,270.2	49.6	290.3	2,610.1
2006	2,201.6	30.0	91.1	2,322.7
2007	4,469.3	27.5	382.9	4,879.7
2008	4,515.8	29.9	416.8	4,962.4
2009	2,315.7	MA & NH: 185.6		2,501.2
2010	5,721.4	35.1	506.8	6,263.3
2011	5,569.7	196.4	631.5	6,397.5
2012	2,219.9	77.8	187.8	2,485.4
2013	289.7	18.9	36.9	345.5
2014	0.3	0.0	0.0	0.3
2015	6.1	0.6	0.0	6.7
2016	11.5	0.0	1.8	13.3
2017	31.2	0.9	0.5	32.6
2018	0.1	1.9	1.1	3.1

Table 2. **Price per pound and value of U.S. commercial landings of northern shrimp in the Gulf of Maine, with inflation-adjusted prices and value for 1985–2018. 2014–2018 data are from RSA and winter sampling programs.**

Year	Price $/Lb	Value $
1958	$0.32	$1,532
1959	$0.29	$5,002
1960	$0.23	$20,714
1961	$0.20	$13,754
1962	$0.15	$57,382
1963	$0.12	$66,840
1964	$0.12	$112,528
1965	$0.12	$245,469
1966	$0.14	$549,466
1967	$0.12	$871,924
1968	$0.11	$1,611,425
1969	$0.12	$3,478,910
1970	$0.20	$4,697,418
1971	$0.19	$4,653,202
1972	$0.19	$4,586,484
1973	$0.27	$5,657,347
1974	$0.32	$5,577,465
1975	$0.26	$3,062,721
1976	$0.34	$764,094
1977	$0.55	$458,198
1978	$0.24	$1,758
1979	$0.33	$320,361
1980	$0.65	$478,883
1981	$0.64	$1,516,521
1982	$0.60	$2,079,109
1983	$0.67	$2,312,073
1984	$0.49	$3,474,351

Season	Price $/Lb	Value $	Price ($/Lb) *2018 dollars	Value ($) 2018 dollars
1985	$0.44	$3,984,562	$1.05	$9,564,744
1986	$0.63	$6,451,206	$1.45	$14,816,717
1987	$1.10	$12,740,581	$2.50	$29,023,857
1988	$1.10	$7,391,777	$2.40	$16,061,646
1989	$0.98	$7,177,659	$2.04	$14,910,780
1990	$0.72	$7,351,420	$1.43	$14,699,046
1991	$0.91	$7,208,838	$1.71	$13,516,239
1992	$0.99	$7,547,941	$1.81	$13,806,670
1993	$1.07	$5,038,053	$1.89	$8,928,900
1994	$0.75	$4,829,106	$1.30	$8,354,991
1995	$0.90	$12,828,030	$1.51	$21,493,893
1996	$0.73	$15,341,504	$1.19	$25,026,625
1997	$0.79	$12,355,871	$1.25	$19,619,763
1998	$0.96	$8,811,938	$1.50	$13,779,332
1999	$0.91	$3,762,043	$1.40	$5,759,047
2000	$0.79	$4,968,655	$1.18	$7,427,163
2001	$0.86	$2,534,095	$1.24	$3,638,596
2002	$1.08	$1,077,534	$1.54	$1,536,852
2003	$0.87	$2,590,916	$1.21	$3,586,328
2004	$0.44	$2,089,636	$0.60	$2,819,337
2005	$0.57	$3,261,648	$0.75	$4,315,765
2006	$0.37	$1,885,978	$0.47	$2,406,687
2007	$0.38	$4,087,120	$0.47	$5,056,211
2008	$0.49	$5,407,373	$0.59	$6,454,695
2009	$0.40	$2,216,411	$0.48	$2,646,864
2010	$0.52	$7,133,718	$0.61	$8,423,072
2011	$0.75	$10,625,533	$0.86	$12,129,566
2012	$0.95	$5,230,481	$1.06	$5,808,201
2013	$1.81	$1,375,788	$1.98	$1,508,183
2014	No sales			
2015	$3.49	$51,282	$3.77	$55,446
2016	$6.67	$195,925	$7.11	$208,767
2017	$6.30	$452,379	$6.55	$470,579
2018	Confidential			

Table 3. Distribution of landings (metric tons) in the Gulf of Maine northern shrimp fishery by season, state, and month.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
1987 Season, 182 days, Dec 1 - May 31								
Maine	485.9	906.2	1,192.7	672.9	287.6	127.9	7.0	3,680.2
Mass.	103.5	260.0	384.9	310.2	180.8	182.8	5.7	1,427.9
N.H.	18.4	53.6	62.8	15.7	7.3	0.0	0.1	157.9
Total	607.8	1,219.8	1,640.4	998.8	475.7	310.7	12.8	5,266.0
1988 Season, 183 days, Dec 1 - May 31								
Maine	339.7	793.9	788.1	243.6	24.6	67.3	1.2	2,258.4
Mass.	14.4	225.8	255.0	104.9	8.6	10.9	0.0	619.6
N.H.	13.0	72.6	53.7	14.9	0.3	0.0	3.1	157.6
Total	367.1	1,092.3	1,096.8	363.4	33.5	78.2	4.3	3,035.6
1989 Season, 182 days, Dec 1 - May 31								
Maine	353.6	770.5	700.6	246.4	218.7	94.2		2,384.0
Mass.	26.2	197.5	154.9	104.8	160.9	55.6		699.9
N.H.	28.5	106.9	77.0	15.4	3.7	0.0		231.5
Total	408.3	1,074.9	932.5	366.6	383.3	149.8	0.0	3,315.4
1990 Season, 182 days, Dec 1 - May 31								
Maine	512.4	778.4	509.8	638.7	514.1	282.8	0.1	3,236.3
Mass.	75.6	344.5	184.8	100.2	159.0	110.0	0.8	974.9
N.H.	111.3	191.7	116.2	30.7	1.4			451.3
Total	699.3	1,314.6	810.8	769.6	674.5	392.8	0.9	4,662.5
1991 Season, 182 days, Dec 1 - May 31								
Maine	238.3	509.2	884.1	455.0	251.8	148.2	2.0	2,488.6
Mass.	90.6	174.7	176.0	131.2	93.3	133.8	15.0	814.6
N.H.	107.3	104.4	33.8	27.8	7.8	1.0		282.1
Total	436.2	788.3	1,093.9	614.0	352.9	283.0	17.0	3,585.3
1992 Season, 153 days, Dec 15 - May 15								
Maine	181.2	881.0	1,295.0	462.6	163.6	87.2		3,070.6
Mass.	17.1	148.3	73.3	47.6	2.9		0.1	289.3
N.H.	33.4	47.0	11.9	6.8	1.0			100.1
Total	231.7	1,076.3	1,380.2	517.0	167.5	87.2	0.1	3,460.0
1993 Season, 138 days, Dec 14 - April 30								
Maine	101.0	369.1	597.1	297.5	127.8			1,492.5
Mass.	19.6	82.0	81.9	62.3	42.0	5.0		292.8
N.H.	33.5	85.4	101.8	77.0	59.9			357.6
Total	154.1	536.5	780.8	436.8	229.7	5.0	0.0	2,142.9
1994 Season, 122 days, Dec 15 - Apr 15								
Maine	171.5	647.8	972.1	399.6	48.7			2,239.7
Mass.	27.1	68.0	100.8	38.8	12.8			247.5
N.H.	117.2	124.3	128.7	49.6	8.2			428.0
Total	315.8	840.1	1,201.6	488.0	69.7	0.0	0.0	2,915.2

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
1995 Season, 128 days, Dec 1 - Apr 30, 1 day per week off								
Maine	747.3	1,392.9	1,336.0	912.1	625.4			5,013.7
Mass.	160.6	154.0	104.1	111.0	139.5		0.9	670.1
N.H.	210.2	186.8	118.3	158.5	99.0			772.8
Total	1,118.1	1,733.7	1,558.4	1,181.6	863.9	0.0	0.9	6,456.6
1996 Season, 152 days, Dec 1- May 31, 1 day per week off								
Maine	1,122.0	1,693.1	3,236.9	795.6	361.5	897.6	0.4	8,107.1
Mass.	167.9	106.7	190.7	67.2	66.5	60.3	1.3	660.6
N.H.	189.8	169.5	234.0	81.9	78.8	17.1	0.6	771.7
Total	1,479.7	1,969.3	3,661.6	944.7	506.8	975.0	2.3	9,539.4
1997 Season, 156 days, Dec 1- May 27, two 5-day and four 4-day blocks off								
Maine	1,178.0	1,095.8	1,749.3	758.4	766.8	538.2	0.4	6,086.9
Mass.	90.2	110.4	111.4	49.0	1.2	0.5	3.7	366.4
N.H.	185.6	104.1	140.1	108.4	85.8	42.2	0.0	666.2
Total	1,453.8	1,310.3	2,000.8	915.8	853.8	580.9	4.1	7,119.5
1998 Season, 105 days, Dec 8-May 22, weekends off except Mar 14-15, Dec 25-31 and Mar 16-31 off.								
Maine	511.1	926.8	1,211.1	401.0	228.7	202.6		3,481.3
Mass.	49.1	73.3	88.6	14.0	15.3			240.3
N.H.	89.4	106.9	143.5	54.3	49.0	2.1		445.2
Total	649.6	1,107.0	1,443.2	469.3	293.0	204.7	0.0	4,166.8
1999 Season, 90 days, Dec 15 - May 25, weekends, Dec 24 - Jan 3, Jan 27-31, Feb 24-28, Mar 16-31, and Apr 29 - May 2 off.								
Maine	79.9	192.7	599.3	247.9	205.3	248.1		1,573.2
Mass.	25.0	23.8	16.0	2.5	8.4			75.7
N.H.	46.5	63.2	52.2	10.0	36.5	8.6		217.0
Total	151.4	279.7	667.5	260.4	250.2	256.7	0.0	1,865.9
2000 Season, 51 days, Jan 17 - Mar 15, Sundays off								
Maine		609.6	1,287.2	188.5				2,085.3
Mass.		17.9	78.7	13.7				110.3
N.H.		39.6	131.1	41.6				212.3
Total	0.0	667.1	1,497.0	243.8	0.0	0.0	0.0	2,407.9
2001 Season, 83 days, Jan 9 - Apr 30, Mar 18 - Apr 16 off, experimental offshore fishery in May								
Maine		575.8	432.8	36.6	29.8	0.3		1,075.2
Mass.		38.5	9.0	1.9		0.0		49.4
N.H.		127.9	37.4	12.1	29.0			206.4
Total	0.0	742.2	479.2	50.5	58.8	0.3	0.0	1,331.0
2002 Season, 25 days, Feb 15 - Mar 11								
Maine			306.8	84.8				391.6
Mass.			5.7	2.3				8.1
N.H.			38.6	14.4				53.0
Total	0.0	0.0	351.2	101.5	0.0	0.0	0.0	452.7

Table 3 continued. Landings by season, state, and month. 2014–2018 data are from RSA and winter sampling programs.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
2001 Season, 83 days, Jan 9 - Apr 30, Mar 18 - Apr 16 off, experimental offshore fishery in May								
Maine		575.8	432.8	36.6	29.8	0.3		1,075.2
Mass.		38.5	9.0	1.9		0.002		49.4
N.H.		127.9	78.6	conf	conf			206.4
Total	0.0	742.2	520.3	38.4	29.8	0.3	0.0	1,331.0
2002 Season, 25 days, Feb 15 - Mar 11								
Maine			306.8	84.8				391.6
Mass.			8.1	conf				8.1
N.H.			38.6	14.4				53.0
Total	0.0	0.0	353.5	99.1	0.0	0.0	0.0	452.7
2003 Season, 38 days, Jan 15 - Feb 27, Fridays off								
Maine		534.7	668.0	0.4			0.6	1,203.7
Mass.		12.0	15.7					27.7
N.H.		30.9	82.1					113.0
Total	0.0	577.6	765.8	0.4	0.0	0.0	0.6	1,344.4
2004 Season, 40 days, Jan 19 - Mar 12, Saturdays and Sundays off								
Maine	1.8	526.2	945.1	446.4	4.7	2.7	0.04	1,926.9
Mass.		conf	21.3	conf				21.3
N.H.		27.3	94.8	61.1				183.2
Total	1.8	553.5	1,061.1	507.5	4.7	2.7	0.04	2,131.4
2005 Season, 70 days, Dec 19 - 30, Fri-Sat off, Jan 3 - Mar 25, Sat-Sun off								
Maine	75.0	377.9	894.7	922.6			0.01	2,270.2
Mass.	7.2	8.1	24.9	9.4				49.6
N.H.	17.3	53.5	175.4	44.1				290.3
Total	99.5	439.5	1,095.0	976.0	0.0	0.0	0.01	2,610.1
2006 Season, 140 days, Dec 12 - Apr 30								
Maine	144.2	691.6	896.9	350.8	118.0			2,201.6
Mass.	conf	conf	30.0	conf	conf			30.0
N.H.	3.4	27.9	9.6	50.3	conf			91.1
Total	147.6	719.5	936.5	401.1	118.0	0.0	0.0	2,322.7
2007 Season, 151 days, Dec 1 - Apr 30								
Maine	761.9	1,480.5	1,590.4	481.9	154.2	0.4	0.03	4,469.3
Mass.	conf	27.5	conf	conf				27.5
N.H.	52.5	222.6	81.6	26.1	conf			382.9
Total	814.4	1,730.6	1,672.0	508.1	154.2	0.4	0.03	4,879.7
2008 Season, 152 days, Dec 1 - Apr 30								
Maine	408.6	1,053.6	2,020.4	983.8	49.3		0.1	4,515.8
Mass.	conf	conf	15.4	14.5				29.9
N.H.	94.2	123.7	161.6	37.4	conf			416.8
Total	502.7	1,177.3	2,197.3	1,035.7	49.3	0.0	0.1	4,962.4

conf = Confidential data were combined with an adjacent month.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
2009 Season, 180 days, Dec 1 - May 29								
Maine	134.6	595.9	988.2	560.1	34.9	1.8	0.2	2,315.7
Mass.& NH	conf	112.9	72.6	conf	conf			185.6
Total	134.6	708.8	1,060.8	560.1	34.9	1.8	0.2	2,501.2
2010 Season, 156 days, Dec 1 - May 5								
Maine	264.1	1,689.2	2,956.0	524.3	254.4	33.0	0.4	5,721.44
Mass.	conf	16.9	18.2	conf	conf			35.1
N.H.	112.8	152.4	200.0	14.2	27.4	conf		506.8
Total	376.9	1,858.6	3,174.2	538.5	281.8	33.0	0.4	6,263.3
2011 Season, 90 days, Dec 1 - Feb 28								
Maine	722.7	2,572.2	2,274.3	0.5				5,569.7
Mass.	20.8	100.9	74.7					196.4
N.H.	93.1	304.0	234.4					631.46
Total	836.6	2,977.0	2,583.4	0.5	0.0	0.0	0.0	6,397.5
2012 Season, Trawling Mon,Wed,Fri, Jan 2 - Feb 17 (21 days); Trapping Feb 1-17 (17 days)								
Maine	0.5	1,130.6	1,088.2	0.5				2,219.9
Mass.		58.4	19.4					77.8
N.H.		119.2	68.6					187.8
Total	0.5	1,308.2	1,176.2	0.5	0.0	0.0	0.0	2,485.4
2013 Season, Trawling 3 to 7 days/wk, Jan 23 - Apr 12 (54 days); Trapping 6 or 7 days/wk, Feb 5 - Apr 12 (62 days)								
Maine		64.9	179.7	42.5	2.6			289.7
Mass.		5.3	8.9	4.7				18.9
N.H.		13.8	16.3	6.9	conf			36.9
Total	0.0	84.0	204.9	54.1	2.6	0.0	0.0	345.5
2014 Season Closed, 5 Maine trawl trips made to collect samples								
Maine		0.05	0.13	0.08				0.3
Mass.								0.0
N.H.								0.0
Total	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.3
2015 Season, Limited research fishery for data collection only								
Maine		0.2	3.7	2.3				6.1
Mass.		0.1	0.1	0.3				0.6
N.H.		0.0	0.0	0.0				0.0
Total	0.0	0.3	3.8	2.6	0.0	0.0	0.0	6.7
2016 Season, Limited research fishery for data collection only								
Maine		1.5	3.7	6.3	0.01			11.5
Mass.								0.0
N.H.		0.4	1.2	0.3				1.8
Total	0.0	1.9	4.9	6.5	0.01	0.0	0.0	13.3

2014-2018 research fishery data include some discards.

Table 3 continued. Landings by season, state, and month. 2014–2018 data are from RSA and winter sampling programs.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
2017 Season, Limited research fishery for data collection only								
Maine		4.8	19.2	7.2				31.2
Mass.		0.4	0.4	0.0				0.9
N.H.		0.2	0.3	0.0				0.5
Total	0.0	5.4	19.9	7.2	0.0	0.0	0.0	32.6
2018 Season, Limited research fishery for data collection only								
Maine		0.00	0.02	0.12				0.1
Mass.		0.68	1.14	0.09				1.9
N.H.		0.02	1.07	0.00				1.1
Total	0.0	0.7	2.2	0.2	0.0	0.0	0.0	3.1

2014-2018 research fishery data include some discards.

Table 4. **Distribution of landings (metric tons) in the Maine northern shrimp fishery by season, gear type, and month. 2014–2018 data are from RSA and winter sampling programs.**

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total	% of total
2000 Season, 51 days, Jan 17 - Mar 15, Sundays off									
Trawl		731.1	1,354.8	163.6				2,249.47	89%
Trap		28.9	179.6	58.3				266.7	11%
Total	0.0	759.9	1,534.4	221.9	0.0	0.0	0.0	2,516.2	
2001 Season, 83 days, Jan 9 - Apr 30, Mar 18 - Apr 16 off, experimental offshore fishery in May									
Trawl		533.0	360.1	30.9	29.8	0.3		954.0	89%
Trap		42.9	72.6	5.7				121.2	11%
Total	0.0	575.8	432.8	36.6	29.8	0.3	0.0	1,075.2	
2002 Season, 25 days, Feb 15 - Mar 11									
Trawl			263.6	77.2				340.8	87%
Trap			43.2	7.6				50.8	13%
Total	0.0	0.0	306.8	84.8	0.0	0.0	0.0	391.6	
2003 Season, 38 days, Jan 15 - Feb 27, Fridays off									
Trawl		467.2	518.8	0.4			0.6	987.0	82%
Trap		67.5	149.2					216.7	18%
Total	0.0	534.7	668.0	0.4	0.0	0.0	0.6	1,203.7	
2004 Season, 40 days, Jan 19 - Mar 12, Saturdays and Sundays off									
Trawl	1.8	514.0	905.5	430.0	4.7	2.7	0.04	1858.7	96%
Trap		12.2	39.5	16.5				68.1	4%
Total	1.8	526.2	945.1	446.4	4.7	2.7	0.04	1926.9	
2005 Season, 70 days, Dec 19 - 30, Fri-Sat off, Jan 3 - Mar 25, Sat-Sun off									
Trawl	75.0	377.9	770.6	663.6			0.01	1887.1	83%
Trap		conf	124.0	259.0				383.1	17%
Total	75.0	377.9	894.7	922.6	0.0	0.0	0.01	2270.2	
2006 Season, 140 days, Dec 12 - Apr 30									
Trawl	144.2	675.0	733.8	256.9	118.0			1928.0	88%
Trap	conf	16.6	163.1	93.9	conf			273.6	12%
Total	144.2	691.6	896.9	350.8	118.0	0.0	0.0	2201.6	
2007 Season, 151 days, Dec 1 - Apr 30									
Trawl	761.9	1,443.3	1,275.6	362.1	143.6	0.4	0.0	3,986.9	89%
Trap	conf	37.2	314.7	119.8	10.6			482.4	11%
Total	761.9	1,480.5	1,590.4	481.9	154.2	0.4	0.0	4,469.3	
2008 Season, 152 days, Dec 1 - Apr 30									
Trawl	408.6	989.6	1,680.8	603.4	42.6		0.1	3,725.0	82%
Trap	conf	64.0	339.6	380.4	6.7			790.7	18%
Total	408.6	1,053.6	2,020.4	983.8	49.3	0.0	0.1	4,515.8	

conf = Confidential data were combined with an adjacent month.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total	% of total
2009 Season, 180 days, Dec 1 - May 29									
Trawl	134.6	579.7	780.9	405.4	33.6	1.8	0.2	1,936.3	84%
Trap	conf	16.2	207.3	154.7	1.3			379.4	16%
Total	134.6	595.9	988.2	560.1	34.9	1.8	0.2	2,315.7	
2010 Season, 156 days, Dec 1 - May 5									
Trawl	264.1	1,495.2	2,132.6	338.3	254.4	33.0	0.4	4,517.9	79%
Trap	conf	194.1	823.4	186.0	conf			1,203.5	21%
Total	264.1	1,689.2	2,956.0	524.3	254.4	33.0	0.4	5,721.4	
2011 Season, 90 days, Dec 1 - Feb 28									
Trawl	720.8	2,194.5	1,728.5	0.5				4,644.4	83%
Trap	1.9	377.7	545.8					925.3	17%
Total	722.7	2,572.2	2,274.3	0.5	0.0	0.0	0.0	5,569.7	
2012 Season, Trawling Mon,Wed,Fri, Jan 2 - Feb 17 (21 days); Trapping Feb 1-17 (17 days)									
Trawl	0.5	1,130.6	895.2	0.5				2,026.8	91%
Trap			193.1					193.1	9%
Total	0.5	1,130.6	1,088.2	0.5	0.0	0.0	0.0	2,219.9	
2013 Season, Trawl 2-7 days/wk, Jan 23-Apr 12 (54 days); Trap 6-7 days/wk, Feb 5-Apr 12 (62 days)									
Trawl		64.9	164.5	37.5	2.6			269.5	93%
Trap			15.2	4.9	conf			20.2	7%
Total	0.0	64.9	179.7	42.5	2.6	0.0	0.0	289.7	
2014 Season Closed, 5 Maine trawl trips to collect samples									
Trawl		0.0	0.1	0.1				0.3	100%
Trap								0.0	
Total	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.3	
2015 Season, Limited research fishery for data collection									
Trawl		0.2	3.4	2.0				5.6	92%
Trap		0.0	0.3	0.2				0.5	8%
Total	0.0	0.2	3.7	2.3	0.0	0.0	0.0	6.1	
2016 Season, Limited research fishery for data collection									
Trawl		1.4	1.9	4.1				7.4	64%
Trap		0.1	1.8	2.2	0.01			4.1	36%
Total	0.0	1.5	3.7	6.3	0.01	0.0	0.0	11.5	
2017 Season, Limited research fishery for data collection									
Trawl		4.7	14.0	5.4				24.1	77%
Trap		0.1	5.2	1.8				7.1	23%
Total	0.0	4.8	19.2	7.2	0.00	0.0	0.0	31.2	
2018 Season, Limited research fishery for data collection									
Trawl only		0.00	0.02	0.12				0.1	100%
No Traps								0.0	0%

Table 5. Distribution of fishing effort (number of trips) in the Gulf of Maine northern shrimp fishery by season, state, and month.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
1987 Season, 182 days, Dec 1 - May 31								
Maine	993	2,373	3,073	2,241	617	340	16	9,653
Mass.	325	354	414	426	283	317	164	2,283
N.H.	67	164	175	95	28		32	561
Total	1,385	2,891	3,662	2,762	928	657		12,285
1988 Season, 183 days, Dec 1 - May 31								
Maine	972	2,183	2,720	1,231	193	122		7,421
Mass.	28	326	426	315	26	57		1,178
N.H.	72	231	236	99	3			641
Total	1,072	2,740	3,382	1,645	222	179		9,240
1989 Season, 182 days, Dec 1 - May 31								
Maine	958	2,479	2,332	936	249	84		7,038
Mass.	103	479	402	254	297	102		1,637
N.H.	120	369	312	69	16			886
Total	1,181	3,327	3,046	1,259	562	186		9,561
1990 Season, 182 days, Dec 1 - May 31								
Maine	1,036	1,710	1,529	1,986	897	238		7,396
Mass.	147	459	273	202	175	118		1,374
N.H.	178	363	284	157	6			988
Total	1,361	2,532	2,086	2,345	1,078	356		9,758
1991 Season, 182 days, Dec 1 - May 31								
Maine	568	1,286	2,070	1,050	438	139		5,551
Mass.	264	416	401	231	154	147		1,613
N.H.	279	285	135	82	22	1		804
Total	1,111	1,987	2,606	1,363	614	287		7,968
1992 Season, 153 days, Dec 15 - May 15								
Maine	411	1,966	2,700	1,222	318	141		6,758
Mass.	59	337	145	101	41			683
N.H.	96	153	76	29	3			357
Total	566	2,456	2,921	1,352	362	141		7,798
1993 Season, 138 days, Dec 14 - April 30								
Maine	249	1,102	1,777	1,032	227			4,387
Mass.	60	200	250	185	72			767
N.H.	76	246	275	256	151			1,004
Total	385	1,548	2,302	1,473	450			6,158
1994 Season, 122 days, Dec 15 - Apr 15								
Maine	265	1,340	1,889	1,065	122			4,681
Mass.	58	152	147	83	15			455
N.H.	169	228	266	173	18			854
Total	492	1,720	2,302	1,321	155			5,990

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
1995 Season, 128 days, Dec 1 - Apr 30, 1 day per week off								
Maine	879	2,341	2,641	1,337	694			7,892
Mass.	145	385	275	157	109			1,071
N.H.	189	331	279	359	344			1,502
Total	1,213	3,057	3,195	1,853	1,147			10,465
1996 Season, 152 days, Dec 1- May 31, 1 day per week off								
Maine	1,341	2,030	3,190	1,461	444	457		8,923
Mass.	299	248	325	269	106	126		1,373
N.H.	331	311	389	248	155	61		1,495
Total	1,971	2,589	3,904	1,978	705	644		11,791
1997 Season, 156 days, Dec 1- May 31, two 5-day and four 4-day blocks off								
Maine	1,674	1,753	2,737	1,178	793	530		8,665
Mass.	184	226	245	114	7	1		777
N.H.	277	245	301	218	189	62		1,292
Total	2,135	2,224	3,283	1,510	989	593		10,734
1998 Season, 105 days, Dec 8-May 22, weekends off except Mar 14-15, Dec 25-31 and Mar 16-31 off.								
Maine	852	1,548	1,653	725	346	189		5,313
Mass.	94	200	148	70	3	1		515
N.H.	141	216	182	134	83	22		778
Total	1,086	1,964	1,983	929	432	212		6,606
1999 Season, 90 days, Dec 15 - May 25, weekends, Dec 24 - Jan 3, Jan 27-31, Feb 24-28, Mar 16-31, and Apr 29 - May 2 off.								
Maine	190	556	1,125	553	324	172		2,920
Mass.	39	57	71	9	40			216
N.H.	82	192	213	44	123	21		675
Total	311	805	1,409	606	487	193		3,811
2000 Season, 51 days, Jan 17 - Mar 15, Sundays off								
Maine		653	1,838	401				2,892
Mass.		23	100	27				150
N.H.		36	179	78				293
Total		712	2,117	506				3,335
2001 Season, 83 days, Jan 9 - Apr 30, Mar 18 - Apr 15 off, experimental offshore fishery in May								
Maine		1,500	1,214	112	43	6		2,875
Mass.		111	48	10		1		170
N.H.		303	143	27	30			503
Total	0	1,914	1,405	149	73	7	0	3,548
2002 Season, 25 days, Feb 15 - Mar 11								
Maine			595	236				831
Mass.			19	9				28
N.H.			119	56				175
Total	0	0	733	301	0	0	0	1,034

Table 5 continued. Trips by season, state, and month. 2014–2018 data are from RSA and winter sampling programs.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
2001 Season, 83 days, Jan 9 - Apr 30, Mar 18 - Apr 15 off, experimental offshore fishery in May								
Maine		1,683	1,551	177	43	6		3,460
Mass.		111	48	10		1		170
N.H.		303	200	conf	conf			503
Total	0	2,097	1,799	187	43	7	0	4,133
2002 Season, 25 days, Feb 15 - Mar 11								
Maine			799	299				1,098
Mass.			31	conf				31
N.H.			119	56				175
Total	0	0	949	355	0	0	0	1,304
2003 Season, 38 days, Jan 15 - Feb 27, Fridays off								
Maine		1114	1,582	1			2	2,699
Mass.		41	50					91
N.H.		81	151					232
Total	0	1,236	1,783	1	0	0	2	3,022
2004 Season, 40days, Jan 19 - Mar 12, Saturdays and Sundays off								
Maine	7	647	1,197	482	13	14	6	2,366
Mass.		conf	56	conf				56
N.H.		46	147	66				259
Total	7	693	1,400	548	13	14	6	2,681
2005 Season, 70 days, Dec 19 - 30, Fri-Sat off, Jan 3 - Mar 25, Sat-Sun off								
Maine	140	667	1,305	1,255	0	0	1	3,368
Mass.	15	18	49	23				105
N.H.	24	76	216	77				393
Total	179	761	1,570	1,355	0	0	1	3,866
2006 Season, 140 days, Dec 12 - Apr 30								
Maine	148	585	947	530	101			2,311
Mass.	conf	conf	58	conf	conf			58
N.H.	5	23	19	62	conf			109
Total	153	608	1,024	592	101	0	0	2,478
2007 Season, 151days, Dec 1 - Apr 30								
Maine	437	1,102	1,514	669	136	1	3	3,862
Mass.	conf	45	conf	conf				45
N.H.	26	115	71	44	conf			256
Total	463	1,262	1,585	713	136	1	3	4,163
2008 Season, 152 days, Dec 1 - Apr 30								
Maine	418	1,291	2,076	1,286	102	0	9	5,182
Mass.	conf	conf	25	13				38
N.H.	63	141	125	38	conf			367
Total	481	1,432	2,226	1,337	102	0	9	5,587

conf = Confidential data were combined with an adjacent month.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
2009 Season, 180 days, Dec 1 - May 29								
Maine	134	785	1,122	739	47	5	1	2,833
Mass.& NH	conf	107	62	conf	conf			169
Total	134	892	1,184	739	47	5	1	3,002
2010 Season, 156 days, Dec 1 - May 5								
Maine	241	1,562	2,602	914	194	29	1	5,543
Mass.	conf	26	23	conf	conf			49
N.H.	55	127	151	21	56	conf		410
Total	296	1,715	2,776	935	250	29	1	6,002
2011 Season, 90 days, Dec 1 - Feb 28								
Maine	599	2,880	2,875	1				6,355
Mass.	28	92	73	0	0			193
N.H.	108	241	198					547
Total	735	3,213	3,146	1	0	0	0	7,095
2012 Season, Trawling Mon,Wed,Fri, Jan 2 - Feb 17 (21days); Trapping Feb 1-17 (17 days)								
Maine	1	1,305	2,014	1				3,321
Mass.		74	43					117
N.H.		129	99					228
Total	1	1,508	2,156	1	0	0	0	3,666
2013 Season, Trawl 2-7 days/wk, Jan 23-Apr 12 (54 days); Trap 6-7 days/wk, Feb 5-Apr 12 (62 days)								
Maine		202	889	260	22			1,373
Mass.		9	28	19	0			56
N.H.		20	73	27	conf			120
Total	0	231	990	306	22	0	0	1,549
2014 Season Closed, 5 Maine trawl trips made to collect samples								
Maine		1	2	2				5
Mass.								0
N.H.								0
Total	0	1	2	2	0	0	0	5
2015 Season Closed, Limited research fishery for data collection only								
Maine		1	24	20				45
Mass.		1	2	2				5
N.H.								0
Total	0	2	26	22	0	0	0	50
2016 Season Closed, Limited research fishery for data collection only								
Maine		8	21	31	3			63
Mass.								0
N.H.		1	2	2				5
Total	0	9	23	33	3	0	0	68

Table 5 continued. **Trips by season, state, and month. 2014–2018 data are from RSA and winter sampling programs.**

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
2017 Season, Limited research fishery for data collection only								
Maine		15	73	51				139
Mass.		3	3	1				7
N.H.		3	4	0				7
Total	0	21	80	52	0	0	0	153
2018 Season, Limited research fishery for data collection only								
Maine		0	1	2				3
Mass.		4	4	1				9
N.H.		2	4	0				6
Total	0	6	9	3	0	0	0	18

Table 6. Distribution of fishing trips in the Maine northern shrimp fishery by season, gear type, and month. 2014-2018 data are from RSA and winter sampling programs.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total	%
2000									
Trawl		818	2,073	462				3,353	97%
Trap		79	421	185				685	20%
Total	0	897	2,494	647	0	0	0	4,038	
2001									
Trawl		1,500	1,214	112	43	6		2,875	83%
Trap		183	337	65				585	17%
Total	0	1,683	1,551	177	43	6	0	3,460	
2002									
Trawl			595	236				831	76%
Trap			204	63				267	24%
Total	0	0	799	299	0	0	0	1,098	
2003									
Trawl		850	1,081	1			2	1,934	72%
Trap		264	501					765	28%
Total	0	1,114	1,582	1	0	0	2	2,699	
2004									
Trawl	7	566	965	382	13	14	6	1,953	83%
Trap		81	232	100				413	17%
Total	7	647	1,197	482	13	14	6	2,366	
2005									
Trawl	140	667	953	778			1	2,539	75%
Trap		conf	352	477				829	25%
Total	140	667	1,305	1,255	0	0	1	3,368	
2006									
Trawl	148	490	563	273	101			1,575	68%
Trap	conf	95	384	257	conf			736	32%
Total	148	585	947	530	101	0	0	2,311	
2007									
Trawl	437	977	921	349	119	1	3	2,807	73%
Trap	conf	125	593	320	17			1,055	27%
Total	437	1,102	1,514	669	136	1	3	3,862	
2008									
Trawl	418	1,062	1,393	661	51	0	9	3,594	69%
Trap	conf	229	683	625	51			1,588	31%
Total	418	1,291	2,076	1,286	102	0	9	5,182	

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total	%
2009									
Trawl	134	705	673	381	32	5	1	1,931	68%
Trap	conf	80	449	358	15			902	32%
Total	134	785	1,122	739	47	5	1	2,833	
2010									
Trawl	241	1,231	1,520	450	194	29	1	3,666	66%
Trap	conf	331	1,082	464	conf			1,877	34%
Total	241	1,562	2,602	914	194	29	1	5,543	
2011									
Trawl	577	2,068	1,692	1				4,338	68%
Trap	22	812	1,183					2,017	32%
Total	599	2,880	2,875	1	0	0	0	6,355	
2012									
Trawl	1	1,305	1,046	1				2,353	71%
Trap			968					968	29%
Total	1	1,305	2,014	1	0	0	0	3,321	
2013									
Trawl		202	607	158	22			989	72%
Trap		0	282	102	conf			384	28%
Total	0	202	889	260	22	0	0	1,373	
2014									
Trawl		1	2	2				5	100%
Trap								0	0%
Total	0	1	2	2	0	0	0	5	
2015									
Trawl		1	8	5				14	31%
Trap		0	16	15				31	69%
Total	0	1	24	20	0	0	0	45	
2016									
Trawl		3	3	9				15	24%
Trap		5	18	22	3			48	76%
Total	0	8	21	31	3	0	0	63	
2017									
Trawl		12	29	22				63	45%
Trap		3	44	29				76	55%
Total	0	15	73	51	0	0	0	139	
2018 Season, Limited research fishery for data collection									
Trawl only		0	1	2				3.0	100%
No Traps								0.0	0%

conf = Small amounts of confidential trap data were combined with trawl data for that month.

Table 7. **Estimated numbers of vessels in the Gulf of Maine northern shrimp fishery by fishing season and state. 2014-2018 data are from RSA and winter sampling programs.**

Season	Maine			Massachusetts	New Hampshire	Total
	Trawl	Trap	Total	Trawl	Trawl	
1980			15-20	15-20		30-40
1981			~75	~20-25		~100
1982			>75	~20-25		>100
1983			~164	~25	~5-8	~197
1984			239	43	6	288
1985			~231	~40	~17	~300
1986						~300
1987			289	39	17	345
1988			~290	~70	~30	~390
1989			~230	~50	~30	~310
1990			~220			~250
1991			~200	~30	~20	~250
1992			~259	~50	16	~325
1993			192	52	29	273
1994			178	40	29	247
1995						
1996			275	43	29	347
1997			238	32	41	311
1998			195	33	32	260
1999			181	27	30	238
2000	207	68	265	17	27	304
2001	174	60	234	19	27	275
2002	117	52	168	7	23	198
2003	142	49	191	12	22	222
2004	114	56	170	7	15	192
2005	102	64	166	9	22	197
2006	68	62	129	4	11	144
2007	97	84	179	3	15	196
2008	121	94	215	4	15	234
2009	80	78	158	12 (MA and NH combined)		170
2010	124	112	235	6	15	256
2011	172	143	311	12	19	342
2012	164	132	295	15	17	327
2013	110	72	182	13	14	208
2014	1	0	1	0	0	1
2015	3	5	8	1	0	9
2016	3	2	5	0	1	6
2017	8	5	13	1	1	15
2018	1	0	1	1	1	3

Note that some boats reported both trapping and trawling, and some landed in more than one state.

Table 8. **Fishery performance indicators for GOM northern shrimp traffic light analysis. Colors indicate status relative to reference levels, where: RED = at or below the 20th percentile; YELLOW = between the 20th and the 80th percentiles; and GREEN = at or above the 80th percentile of the commercial fishery time series from 1984-2013. Values from 2014-2018 represent RSA/winter sampling. Stipples indicate no data.**

Fishery Performance Indices

Fishing Season	Number of trips (states & gears combined)	Commercial CPUE (mt/trip)	Price per lb landed (2018 dollars)	Total landings value (2018 dollars)
1984	6,912	0.43		
1985	6,857	0.60	$1.05	$9,564,744
1986	7,902	0.59	$1.45	$14,816,717
1987	12,497	0.42	$2.50	$29,023,857
1988	9,240	0.33	$2.40	$16,061,646
1989	9,561	0.35	$2.04	$14,910,780
1990	9,758	0.48	$1.43	$14,699,046
1991	7,968	0.45	$1.71	$13,516,239
1992	7,798	0.44	$1.81	$13,806,670
1993	6,158	0.35	$1.89	$8,928,900
1994	5,990	0.49	$1.30	$8,354,991
1995	10,465	0.62	$1.51	$21,493,893
1996	11,791	0.81	$1.19	$25,026,625
1997	10,734	0.66	$1.25	$19,619,763
1998	6,606	0.63	$1.50	$13,779,332
1999	3,811	0.49	$1.40	$5,759,047
2000	4,554	0.63	$1.18	$7,427,163
2001	4,133	0.32	$1.24	$3,638,596
2002	1,304	0.35	$1.54	$1,536,852
2003	3,022	0.44	$1.21	$3,586,328
2004	2,681	0.79	$0.60	$2,819,337
2005	3,866	0.68	$0.75	$4,315,765
2006	2,478	0.94	$0.47	$2,406,687
2007	4,163	1.17	$0.47	$5,056,211
2008	5,587	0.89	$0.59	$6,454,695
2009	3,002	0.83	$0.48	$2,646,864
2010	5,979	1.03	$0.61	$8,423,072
2011	7,095	0.90	$0.86	$12,129,566
2012	3,648	0.68	$1.06	$5,808,201
2013	1,322	0.23	$1.98	$1,508,183
2014	5	-	no sales	no sales
2015	50	-	$3.77	$55,446
2016	68	-	$7.11	$208,767
2017	153	-	$6.55	$470,579
2018	18	-	confidential	confidential
1984-2013 mean	**6,229**	**0.60**	**$1.29**	**$10,245,509**
2014-2018 mean	**59**	**NA**	**$5.81**	**$244,931**
80th percentile (1984-2013)	9,304	0.81	$1.75	14,854,342
20th percentile (1984-2013)	3,523	0.41	$0.69	$3,617,689

Table 9. Fishery independent indicators for GOM northern shrimp traffic light analysis. Colors indicate status relative to reference levels, where: RED = at or below the 20th percentile; YELLOW = between the 20th and 80th percentiles; and GREEN = at or above the 80th percentile of the time series from 1984-2017. Stipples indicate no data.

Fishery Independent Indices

	Model-based Survey Indices							
Survey	ASMFC Summer	NEFSC Fall Albatross	NEFSC Fall Bigelow	ME-NH Spring	ASMFC Summer			
Indicator	Total Abundance	Total Abundance	Total Abundance	Total Abundance	Total Biomass	Harvestable Biomass (>22 mm CL)	Spawner Biomass	Recruitment (age ~1.5)
1984	0.96				1.11	0.57	0.55	0.02
1985	1.46				1.74	1.49	0.76	0.25
1986	1.16	0.68			1.48	1.15	0.86	0.25
1987	0.87	0.40			1.03	0.82	0.55	0.19
1988	1.24	0.34			1.13	0.67	0.50	0.81
1989	1.25	0.78			1.45	0.84	0.66	0.18
1990	1.13	0.59			1.56	1.34	0.76	0.10
1991	0.82	0.32			0.97	0.79	0.67	0.31
1992	0.50	0.19			0.63	0.45	0.40	0.15
1993	1.24	1.04			0.89	0.48	0.38	0.81
1994	1.01	1.09			0.90	0.44	0.37	0.38
1995	1.01	0.59			1.05	0.73	0.67	0.20
1996	0.80	0.40			0.88	0.65	0.52	0.24
1997	0.87	0.53			0.80	0.52	0.45	0.43
1998	0.56	0.97			0.56	0.30	0.29	0.13
1999	0.64	1.21			0.68	0.48	0.40	0.18
2000	0.77	0.96			0.72	0.49	0.46	0.43
2001	0.28	0.50			0.31	0.17	0.19	0.01
2002	1.08	0.69			0.80	0.35	0.38	0.87
2003	0.73	0.40		0.44	0.75	0.39	0.44	0.01
2004	1.15	0.88		0.49	1.05	0.87	0.57	0.37
2005	2.29	2.85		1.46	1.78	0.93	0.86	1.10
2006	4.56	3.69		1.51	3.87	1.82	1.86	0.17
2007	1.62	2.41		1.50	1.60	1.05	0.91	0.05
2008	1.73	1.51		1.66	1.78	1.45	0.84	0.50
2009	1.72		3.97	1.94	1.80	1.32	1.04	0.59
2010	1.63		2.01	2.82	1.63	0.94	0.78	0.56
2011	0.93		1.78	2.47	1.02	0.60	0.61	0.05
2012	0.27		0.52	0.70	0.32	0.25	0.22	0.01
2013	0.06		0.14	0.10	0.09	0.09	0.07	0.00
2014	0.21		0.30	0.29	0.16	0.05	0.07	0.18
2015	0.06		0.13	0.14	0.09	0.07	0.07	0.00
2016	0.25		0.10	0.25	0.25	0.15	0.15	0.17
2017	0.06		0.07	0.14	0.07	0.05	0.04	0.00
2018	0.08			0.09	0.08	0.05	0.05	0.05
1984-2013 mean	**1.14**	**1.00**	**1.68**	**1.37**	**1.14**	**0.75**	**0.60**	**0.31**
2014-2018 mean	**0.13**	**NA**	**0.15**	**0.18**	**0.13**	**0.08**	**0.08**	**0.08**
80th percentile (1984-2017)	**1.34**	**1.16**	**1.87**	**1.71**	**1.57**	**0.98**	**0.77**	**0.46**
20th percentile (1984-2017)	**0.41**	**0.40**	**0.11**	**0.23**	**0.46**	**0.28**	**0.26**	**0.04**

Table 10. **Environmental condition indicators for GOM northern shrimp traffic light analysis. Colors indicate status relative to reference levels, where: RED = at or above the 80th percentile; YELLOW = between the 80th and 20th percentiles; and GREEN = at or below the 20th percentile of the time series from 1984-2017. Stipples indicate no data.**

Environmental Condition Indices

Survey	NEFSC	ASMFC	NEFSC	NEFSC	Boothbay Harbor, ME	NEFSC
Indicator	Predation Pressure Index	Summer Bottom temp.	Spring Bottom temp. anomaly	Fall Bottom temp. anomaly	Feb-Mar Surface temp.	Spring Surface temp. anomaly
1984	434.3	4.14	0.6	0.8	2.9	-0.1
1985	597.8	4.05	0.1	0.6	2.8	0.1
1986	608.1	6.26	1.2	0.7	2.6	0.8
1987	387.8	6.00	0.0	0.0	1.8	-0.6
1988	503.1	6.48	1.3	-0.1	2.7	-0.2
1989	520.4	5.57	-0.1	-0.3	1.9	-0.6
1990	631.3	3.55	0.2	0.1	2.6	0.0
1991	501.8	6.10	0.5	0.1	3.4	0.6
1992	486.7	6.33	0.6	-0.2	3.2	-0.9
1993	470.1	5.81	-0.8	-0.3	1.2	-0.7
1994	351.9	6.76	0.6	1.3	1.8	0.2
1995	638.5	6.55	0.8	0.5	3.3	0.1
1996	564.8	7.10	1.0	1.1	3.3	-0.2
1997	378.1	6.82	1.4	0.5	3.7	0.0
1998	466.6	6.35	1.3	-0.4	2.9	0.5
1999	738.7	6.06	0.3	0.6	2.9	0.9
2000	813.7	6.71	1.1	0.7	3.1	0.9
2001	723.3	6.53	0.7	0.1	2.9	0.4
2002	1,305.8	7.05	1.3	1.3	4.1	1.2
2003	1,040.8	5.60	-0.2	-0.1	2.4	-0.6
2004	487.8	4.73	-0.8	-1.1	3.0	-0.9
2005	471.3	4.93	0.1	0.5	3.0	0.2
2006	663.5	7.11	1.3	1.2	5.5	0.9
2007	704.7	5.90	0.5	-0.3	2.0	0.0
2008	846.3	5.87	0.5	0.4	2.3	1.2
2009	740.6	6.01	0.4	0.7	2.6	0.4
2010	1,126.5	7.39	0.9	1.7	4.1	1.7
2011	1,150.4	7.71	2.3	1.4	2.9	0.9
2012	1,156.6	7.86	2.0	2.0	5.5	1.9
2013	769.3	7.12	1.3	1.2	3.9	1.8
2014	955.1	6.23	0.5	1.4	2.2	0.5
2015	832.2	5.80	0.1	0.3	1.4	0.1
2016	1,518.4	7.20	1.4	2.0	4.1	1.7
2017	948.2	6.90	1.0	1.3	3.8	0.9
2018		6.69	1.1		4.5	0.5
1984-2013 mean	**676.0**	**6.15**	**0.7**	**0.5**	**3.0**	**0.3**
2014-2018 mean	**1,063.5**	**6.6**	**0.8**	**1.3**	**3.2**	**0.7**
20th percentile (1984-2017)	**480.5**	**5.72**	**0.1**	**-0.1**	**2.3**	**-0.2**
80th percentile (1984-2017)	**950.9**	**7.07**	**1.3**	**1.3**	**3.8**	**0.9**

Table 11. Summary of results from the UME length-structured assessment model.

Year	Average F (N-weighted)	Recruitment (billions of shrimp)	Total Abundance (billions of shrimp)	Spawning Stock Biomass (metric tons)	Total Biomass (metric tons)
1984	0.323	2.1	6.4	4,677	18,759
1985	0.237	3.2	6.7	3,838	21,982
1986	0.319	2.3	5.1	4,717	19,314
1987	0.572	2.2	4.3	4,620	15,470
1988	0.289	5.9	8.1	3,959	17,237
1989	0.343	2.0	5.7	5,182	18,795
1990	0.381	1.7	4.4	3,080	17,829
1991	0.441	2.7	4.4	3,515	13,860
1992	0.486	2.0	4.0	4,273	12,358
1993	0.296	6.5	8.3	3,477	15,314
1994	0.293	3.0	6.9	4,657	19,216
1995	0.357	2.7	6.8	6,964	24,576
1996	0.613	1.8	4.5	5,442	18,691
1997	0.881	2.9	4.7	4,186	13,734
1998	0.672	2.0	4.4	3,583	12,743
1999	0.293	2.0	4.1	3,265	12,622
2000	0.804	7.5	8.9	3,144	14,306
2001	0.765	1.6	4.0	2,070	10,601
2002	0.088	36.2	37.6	3,617	35,504
2003	0.495	1.8	6.2	2,142	16,718
2004	0.283	3.9	5.4	1,256	12,277
2005	0.340	12.8	15.3	4,348	22,031
2006	0.212	15.5	22.7	5,791	39,483
2007	0.363	4.5	12.7	8,916	41,196
2008	0.234	9.1	13.9	4,948	36,914
2009	0.151	10.6	14.6	7,689	31,024
2010	0.574	14.5	19.3	6,184	35,350
2011	1.348	2.5	5.9	3,524	17,894
2012	0.873	0.8	1.9	1,614	7,060
2013	0.229	1.2	1.5	839	3,141
2014	0.000	2.6	3.1	1,013	4,253
2015	0.005	1.0	1.7	843	3,701
2016	0.007	4.2	4.7	1,200	6,015
2017	0.028	0.7	1.2	690	2,529
2018	0.002	2.0	2.3	600	3,198
Mean	0.388	5.1	7.8	3,710	17,591
Median	0.323	2.6	5.4	3,617	16,718

Table 12. Projection results from the UME model under different F and M scenarios.

M	Year	Trawl F	Trap F	Trawl Catch	Trap Catch	p(SSB > SSB2017)
M=Time series mean, R=Recent	2019	F = 0	F = 0	0 mt (0 lbs)	0 mt (0 lbs)	0%
	2023			0 mt (0 lbs)	0 mt (0 lbs)	100%
	2019	Status quo		2.3 mt (5,020 lbs)	0.3 mt (672 lbs)	0%
	2023			7.3 mt (16,003 lbs)	1 mt (2,183 lbs)	100%
	2019	F = 0.1	F = 0.01	38.1 mt (83,985 lbs)	5.1 mt (11,170 lbs)	0%
	2023			113 mt (249,104 lbs)	15.4 mt (33,952 lbs)	100%
	2019	F = 0.2	F = 0.02	73.8 mt (162,703 lbs)	9.8 mt (21,569 lbs)	0%
	2023			202.2 mt (445,688 lbs)	27.5 mt (60,569 lbs)	100%
	2019	F = 0.3	F = 0.04	107.1 mt (236,158 lbs)	14.2 mt (31,381 lbs)	0%
	2023			276 mt (608,492 lbs)	37.4 mt (82,381 lbs)	100%
	2019	F = 0.4	F = 0.05	138.1 mt (304,567 lbs)	18.3 mt (40,410 lbs)	0%
	2023			337.9 mt (745,051 lbs)	44.6 mt (98,334 lbs)	100%
	2019	200 mt		181.7 mt (400,666 lbs)	24 mt (52,959 lbs)	0%
	2023			420.5 mt (926,964 lbs)	55 mt (121,235 lbs)	98%
M=Weighted Mean, R=Recent	2019	F = 0	F = 0	0 mt (0 lbs)	0 mt (0 lbs)	0%
	2023			0 mt (0 lbs)	0 mt (0 lbs)	73%
	2019	Status quo		8.2 mt (18,136 lbs)	1.1 mt (2,417 lbs)	0%
	2023			14.8 mt (32,644 lbs)	2 mt (4,328 lbs)	72%
	2019	F = 0.1	F = 0.01	36.8 mt (81,232 lbs)	4.9 mt (10,820 lbs)	0%
	2023			63.1 mt (139,189 lbs)	8.3 mt (18,336 lbs)	68%
	2019	F = 0.2	F = 0.02	71.5 mt (157,565 lbs)	9.5 mt (20,947 lbs)	0%
	2023			113.7 mt (250,620 lbs)	14.8 mt (32,685 lbs)	64%
	2019	F = 0.3	F = 0.04	104 mt (229,217 lbs)	13.8 mt (30,358 lbs)	0%
	2023			155.4 mt (342,692 lbs)	20.1 mt (44,325 lbs)	59%
	2019	F = 0.4	F = 0.05	134.4 mt (296,295 lbs)	17.8 mt (39,212 lbs)	0%
	2023			191.2 mt (421,538 lbs)	24.5 mt (53,975 lbs)	55%
	2019	200 mt		176.9 mt (389,902 lbs)	23.3 mt (51,360 lbs)	0%
	2023			234.4 mt (516,872 lbs)	29.6 mt (65,153 lbs)	49%
M & R = Recent	2019	F = 0	F = 0	0 mt (0 lbs)	0 mt (0 lbs)	0%
	2023			0 mt (0 lbs)	0 mt (0 lbs)	10%
	2019	Status quo		2.1 mt (4,690 lbs)	0.3 mt (626 lbs)	0%
	2023			2 mt (4,451 lbs)	0.3 mt (568 lbs)	10%
	2019	F = 0.1	F = 0.01	35.5 mt (78,364 lbs)	4.8 mt (10,514 lbs)	0%
	2023			31 mt (68,443 lbs)	4 mt (8,716 lbs)	6%
	2019	F = 0.2	F = 0.02	68.9 mt (151,903 lbs)	9.2 mt (20,212 lbs)	0%
	2023			56.2 mt (123,964 lbs)	7.1 mt (15,643 lbs)	4%
	2019	F = 0.3	F = 0.04	100.7 mt (221,986 lbs)	13.4 mt (29,526 lbs)	0%
	2023			77.1 mt (170,034 lbs)	9.8 mt (21,520 lbs)	2%
	2019	F = 0.4	F = 0.05	130.3 mt (287,155 lbs)	17.3 mt (38,057 lbs)	0%
	2023			95.1 mt (209,716 lbs)	11.8 mt (26,068 lbs)	1%
	2019	200 mt		171.6 mt (378,335 lbs)	22.6 mt (49,903 lbs)	0%
	2023			117.2 mt (258,326 lbs)	14.3 mt (31,433 lbs)	1%

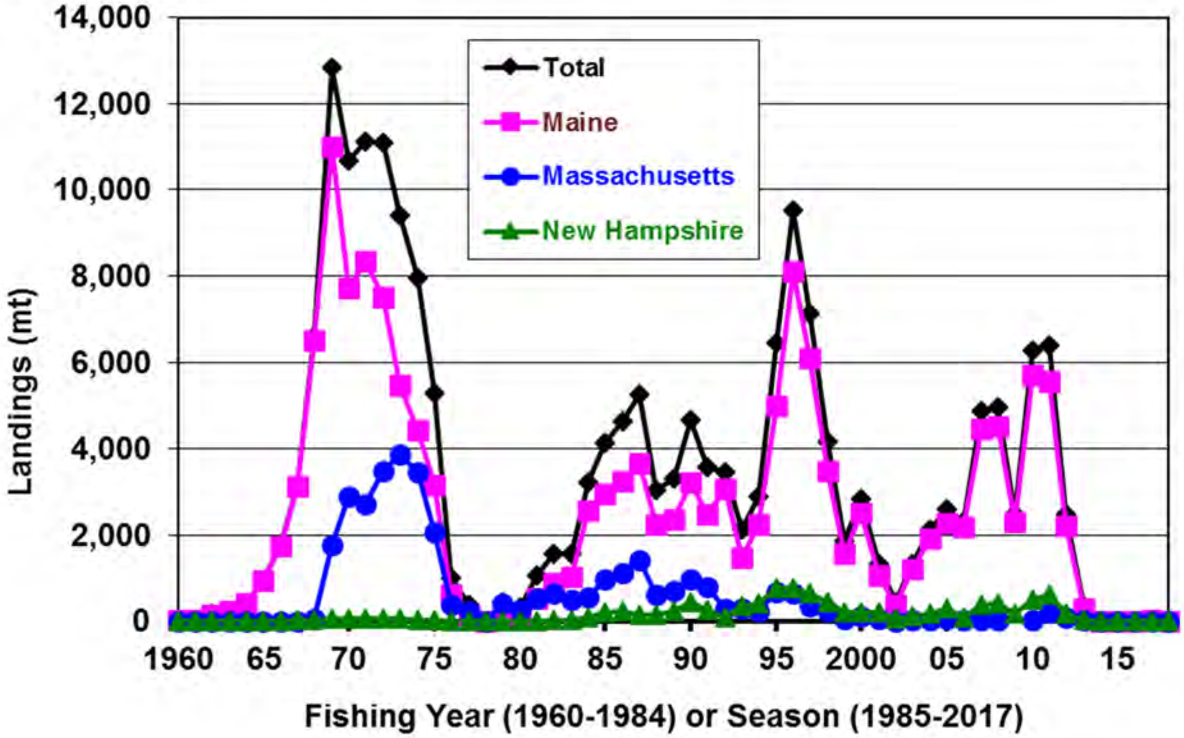


Figure 1. **Gulf of Maine northern shrimp landings by year and state. MA landings are combined with NH landings in 2009 to preserve confidentiality. Landings by season include the previous December. Landings in 2014–2018 are from RSA and winter sampling programs, and include discards.**

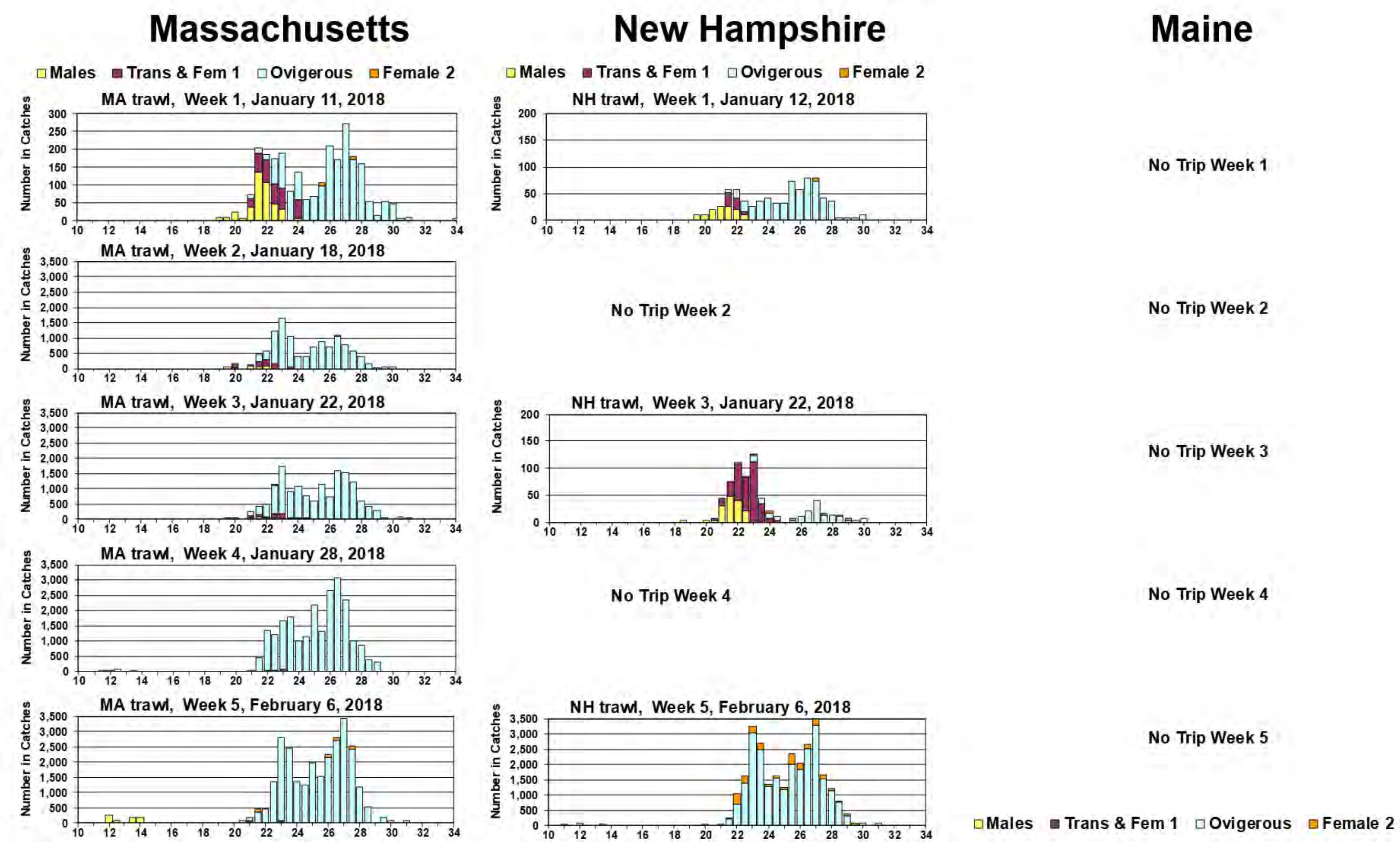


Figure 2. 2018 RSA and winter sampling — Northern shrimp size-sex-stage frequency distributions (in estimated total numbers of *P. borealis* in catches) by state (left to right; west to east) and week (top to bottom). Note that the vertical scales vary.

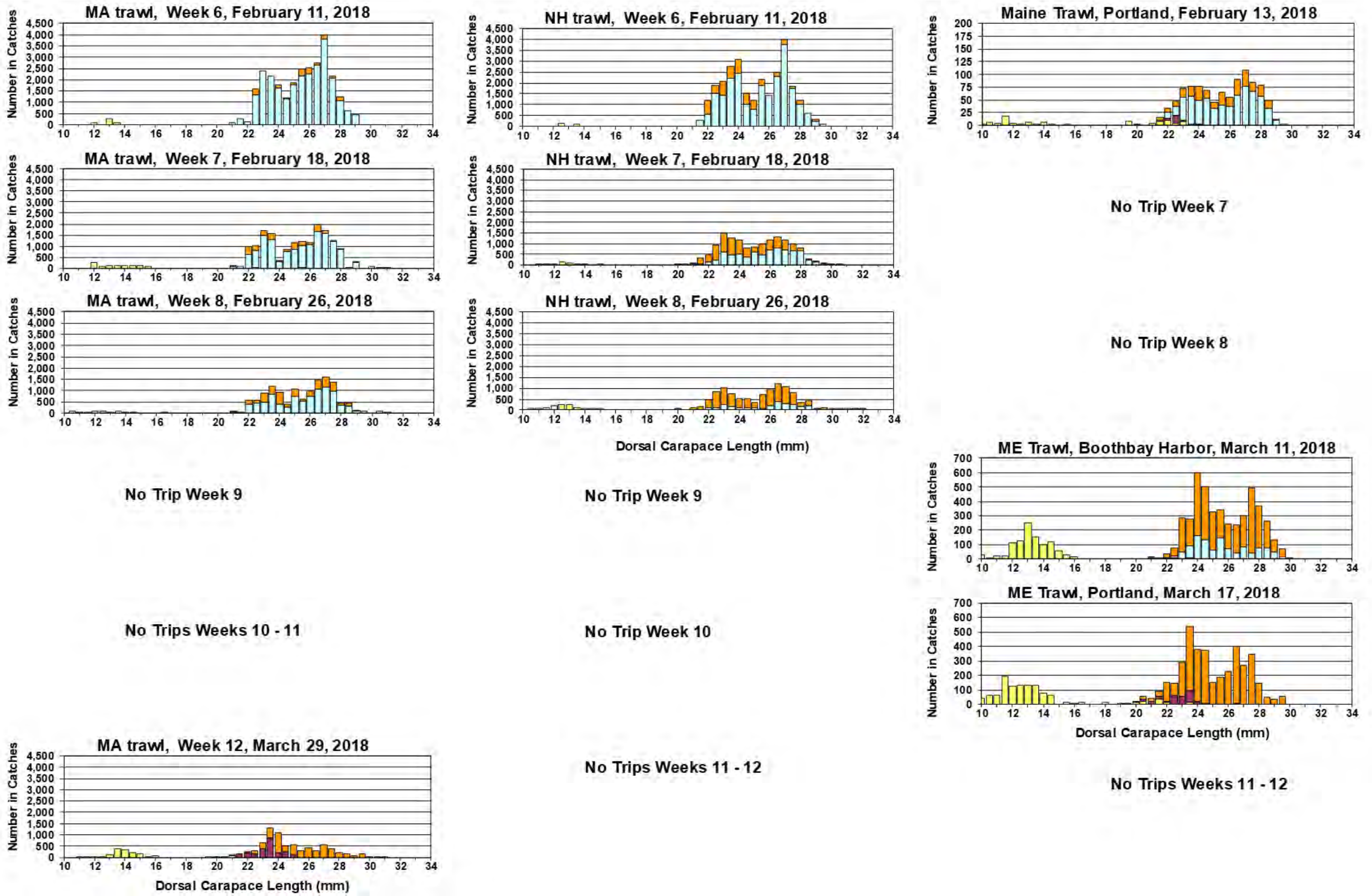


Figure 2 continued. **2018 RSA and winter sampling — Northern shrimp size-sex-stage frequency distributions (in estimated total numbers of *P. borealis* in catches) by state (left to right; west to east) and week (top to bottom). Note that the vertical scales vary.**

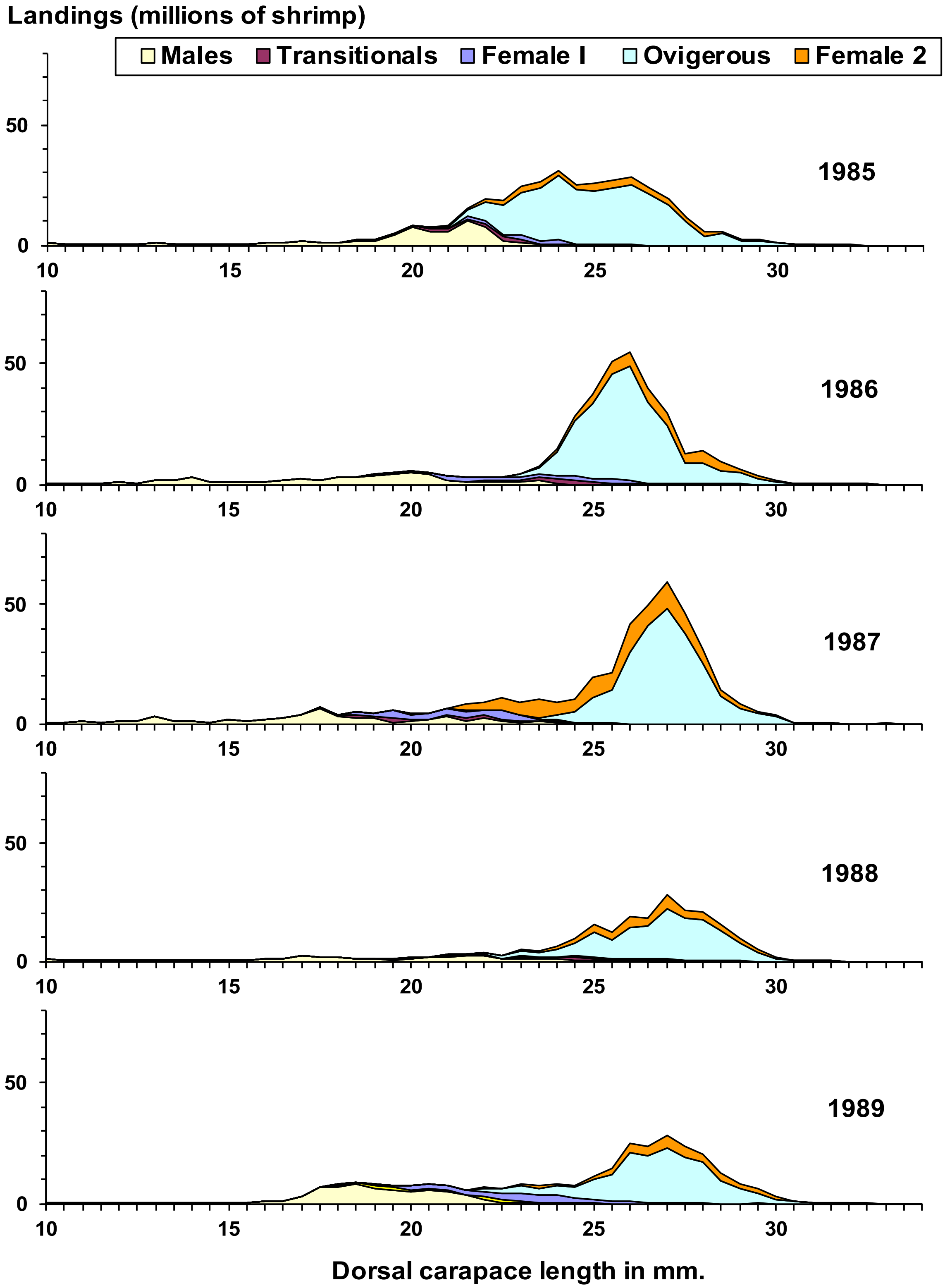


Figure 3. **Gulf of Maine northern shrimp landings in estimated numbers of shrimp, by length, development stage, and fishing season.**

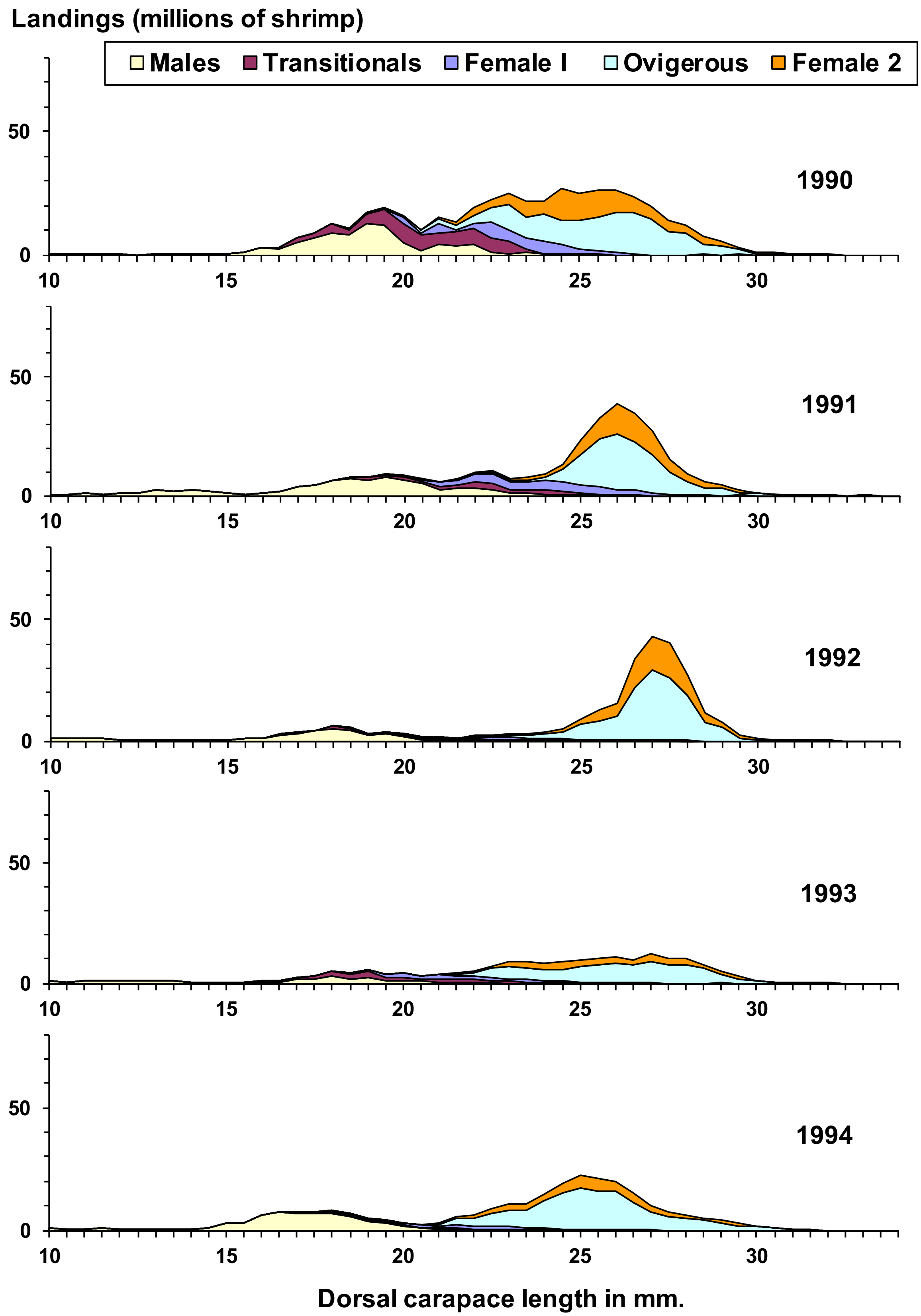


Figure 3 continued. **Landings in estimated numbers of shrimp.**

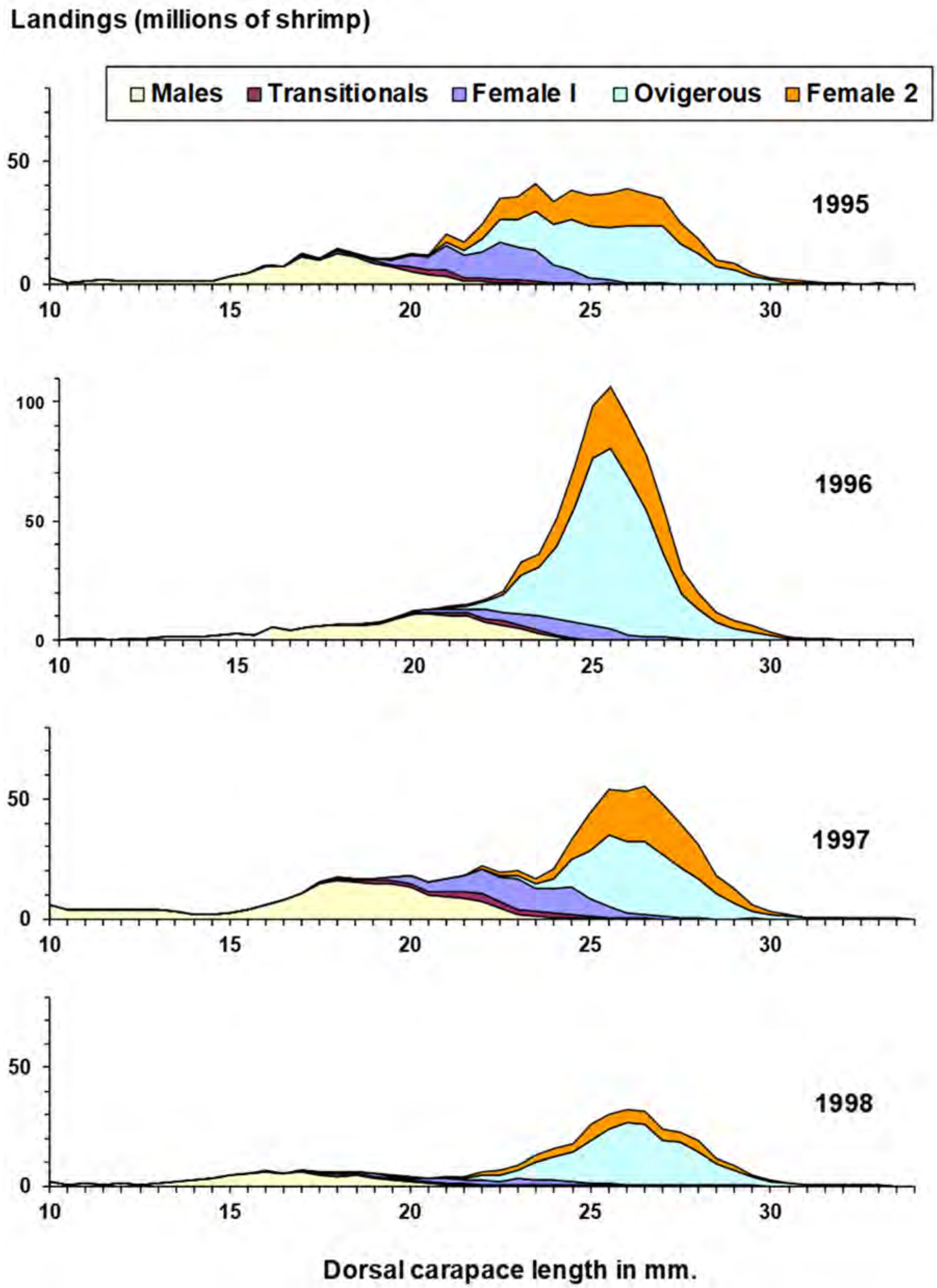


Figure 3 continued. Landings in estimated numbers of shrimp.

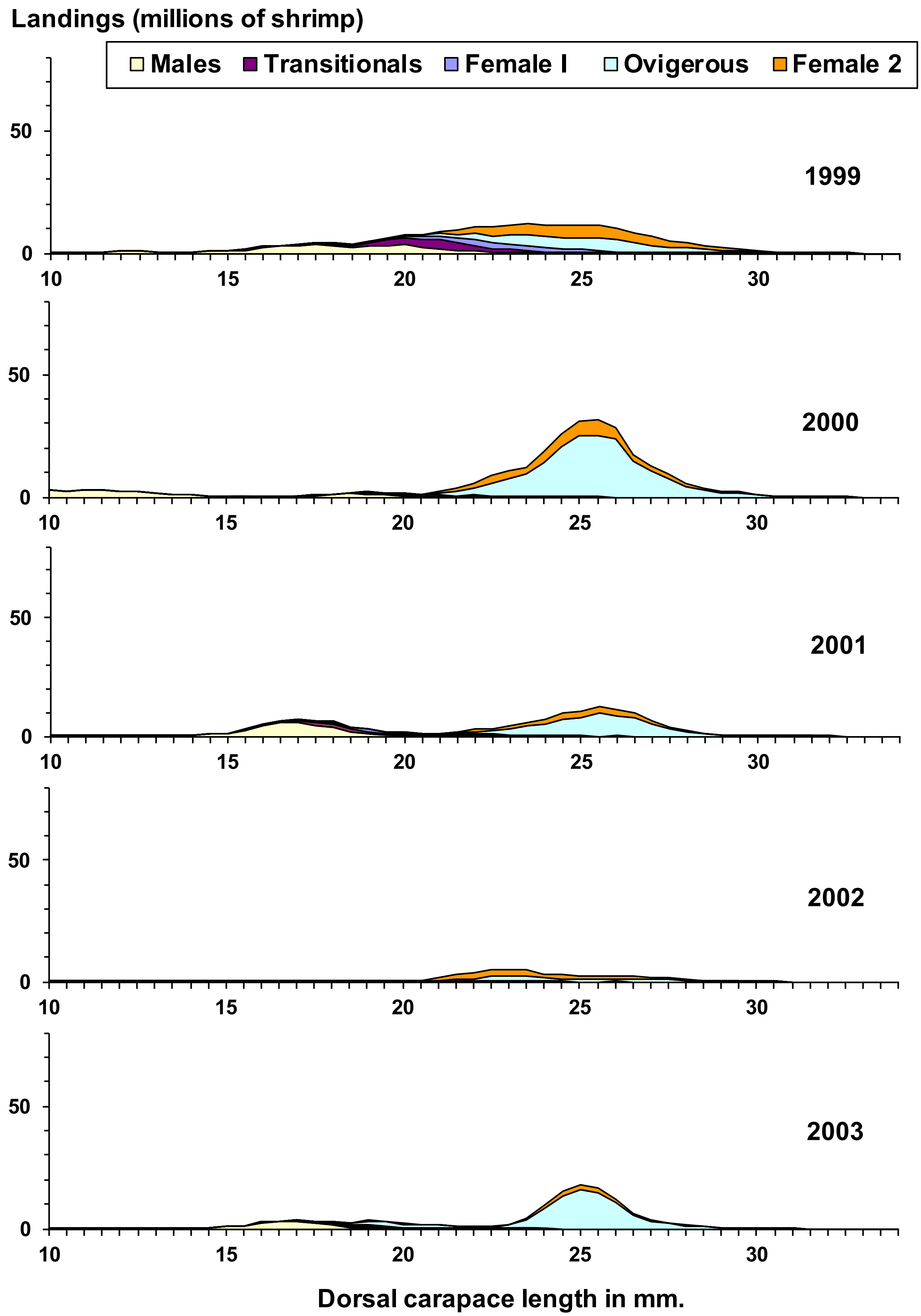


Figure 3 continued. Landings in estimated numbers of shrimp.

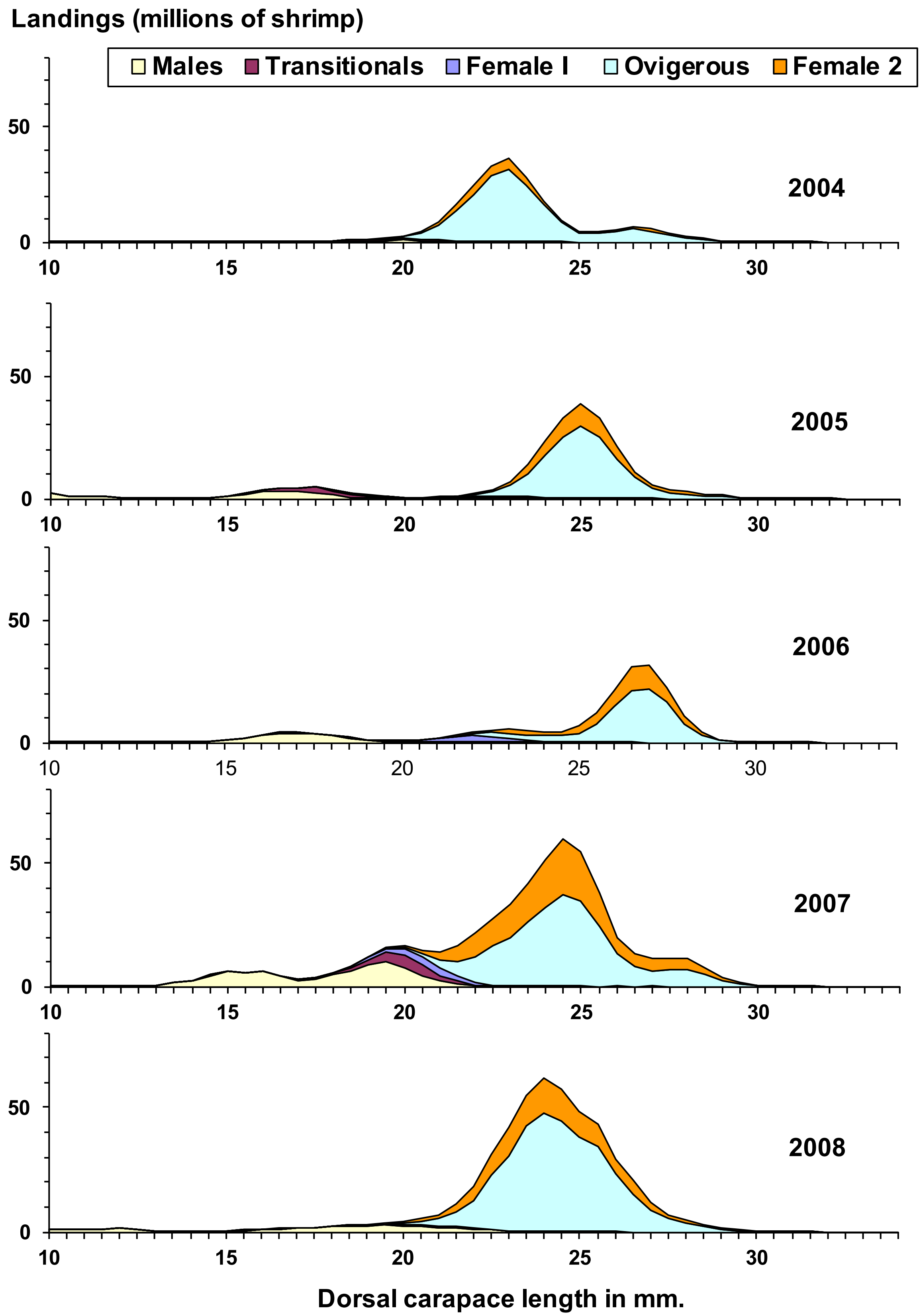


Figure 3 continued. Landings in estimated numbers of shrimp.

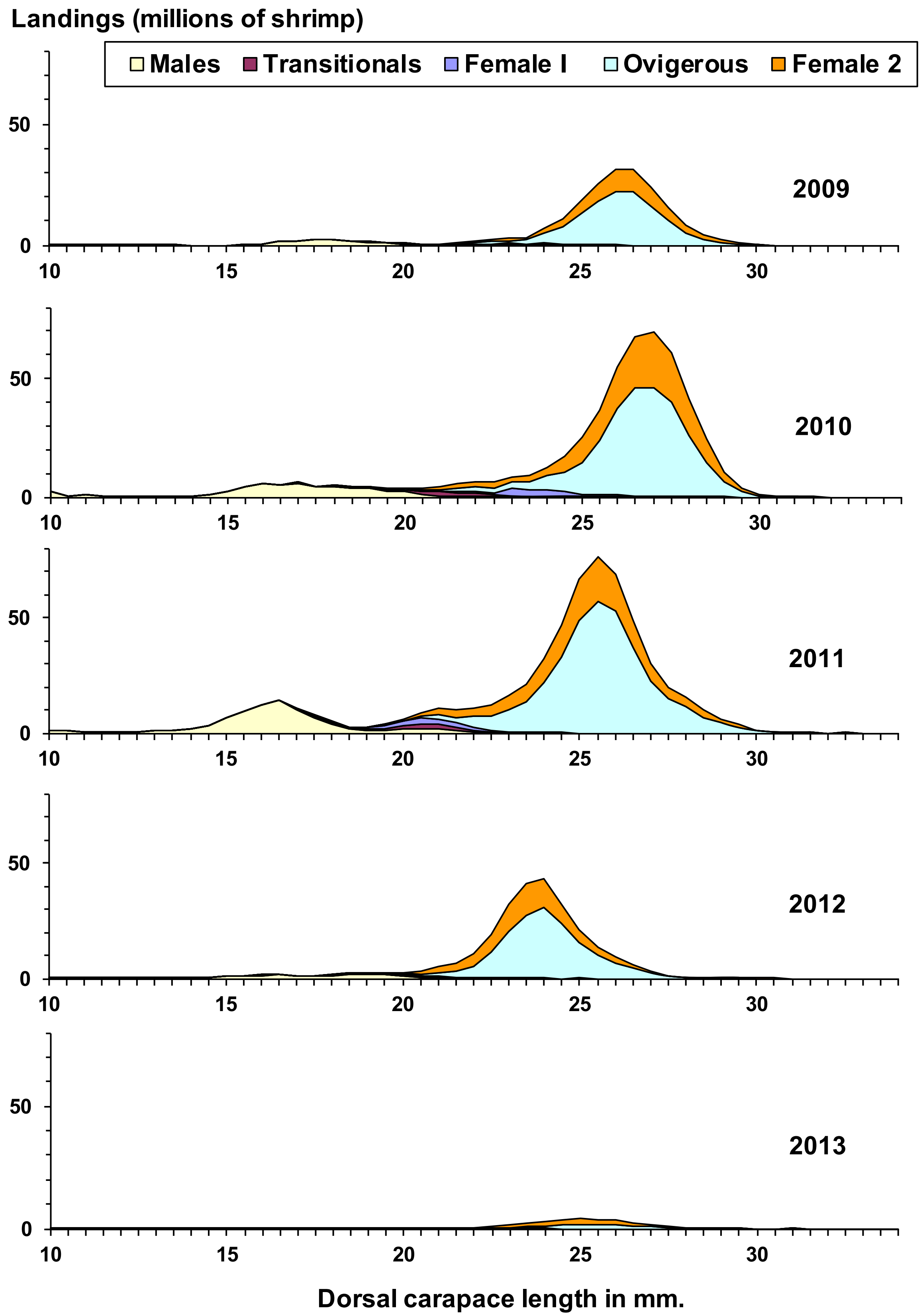


Figure 3 continue. **Landings in estimated numbers of shrimp.**

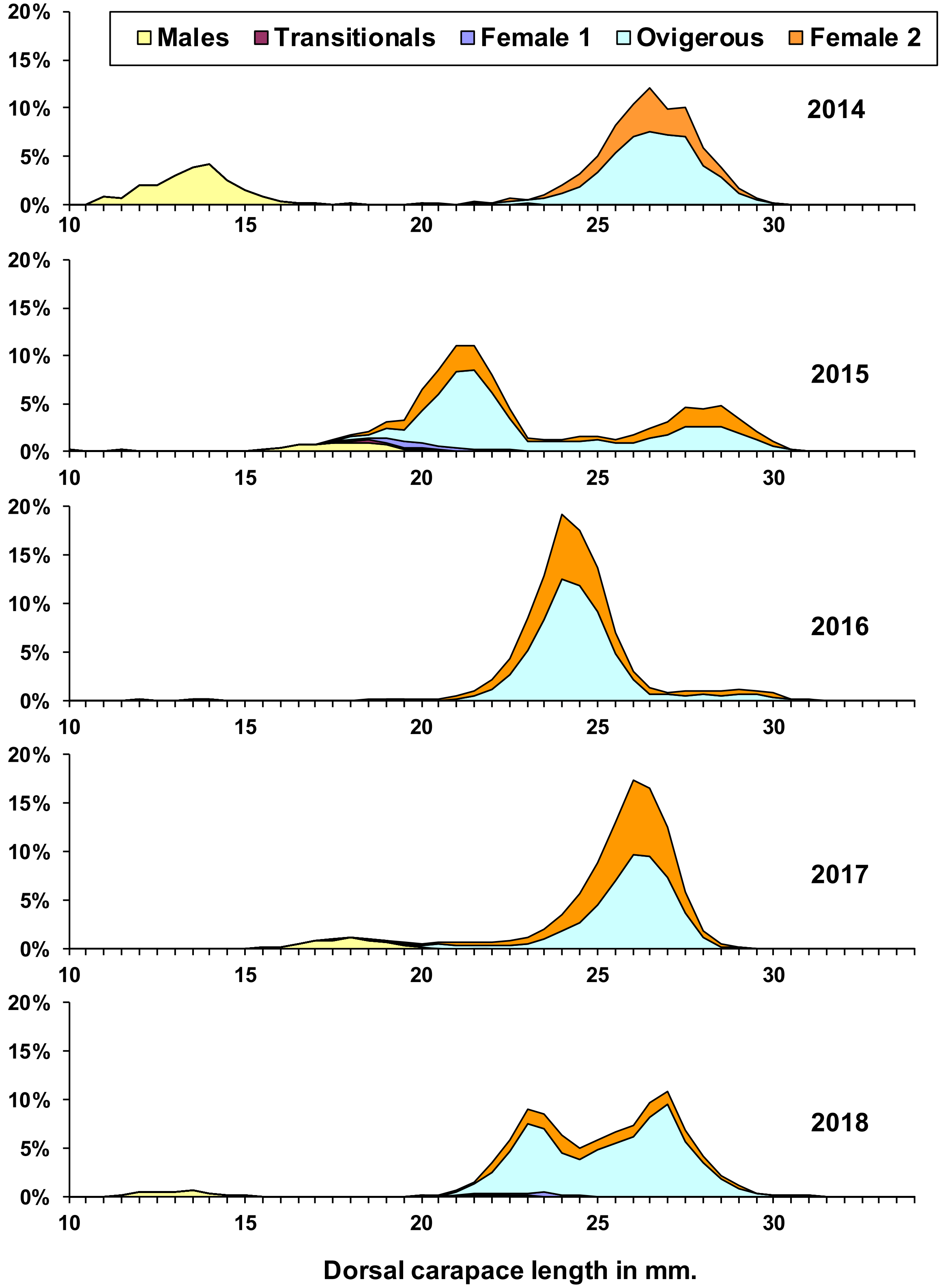


Figure 3 continued. Landings in estimated numbers of shrimp.

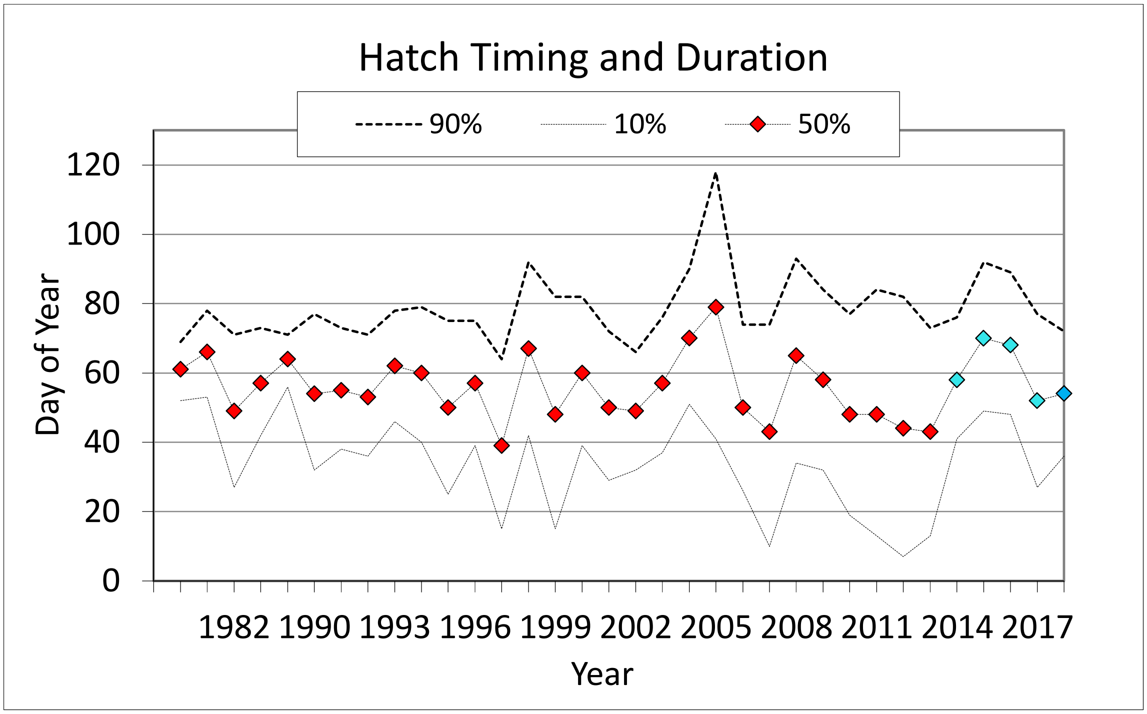


Figure 4. **Estimated hatch timing (10%=start, 50%=midpoint, 90%=completion) for northern shrimp in the Gulf of Maine, 1980-1983 and 1989-2018 (no data 1984-1988). Turquoise points (2014–2018) indicate data from RSA and winter sampling.**

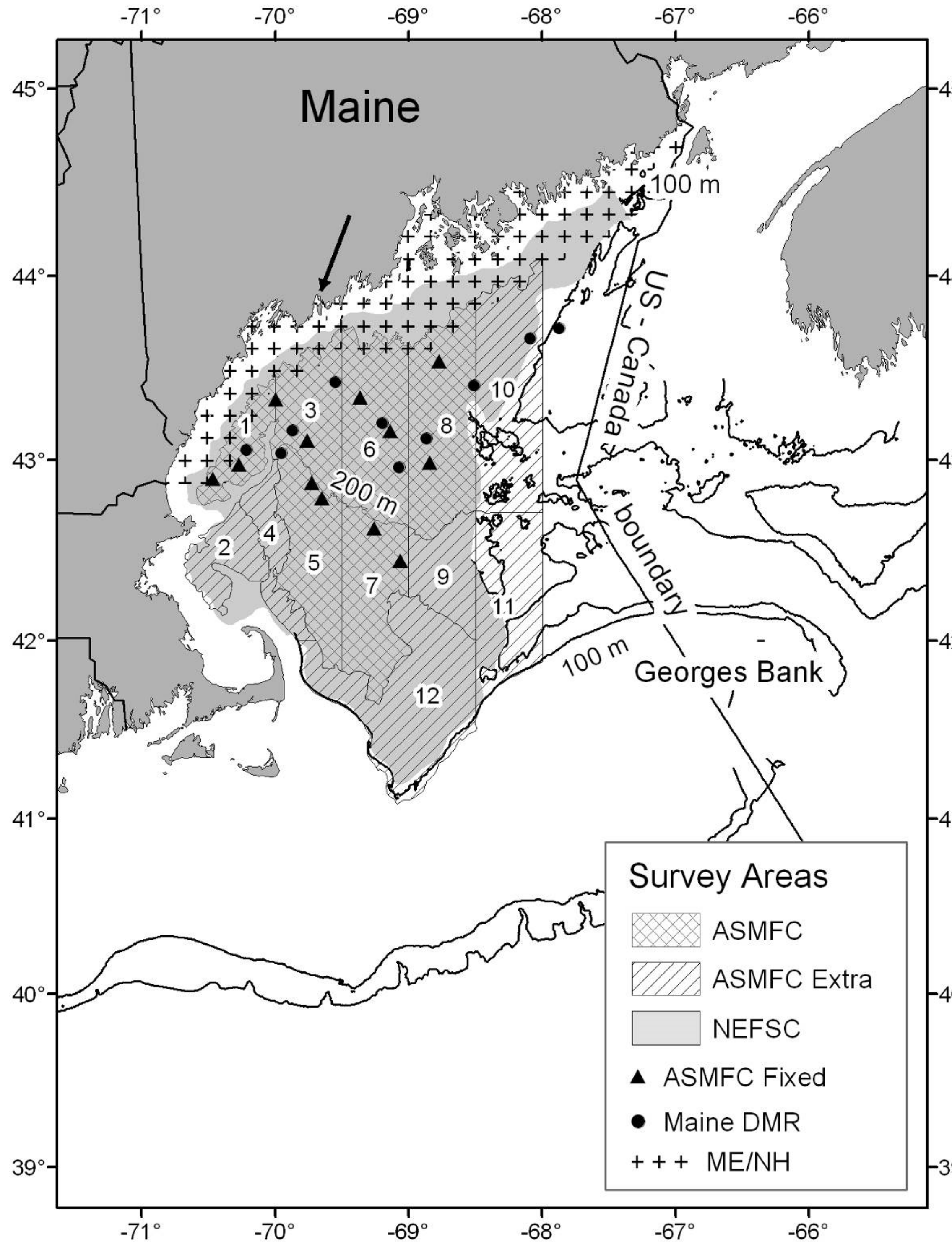


Figure 5. Gulf of Maine survey areas and station locations. The arrow on the figure points to Boothbay Harbor, ME.

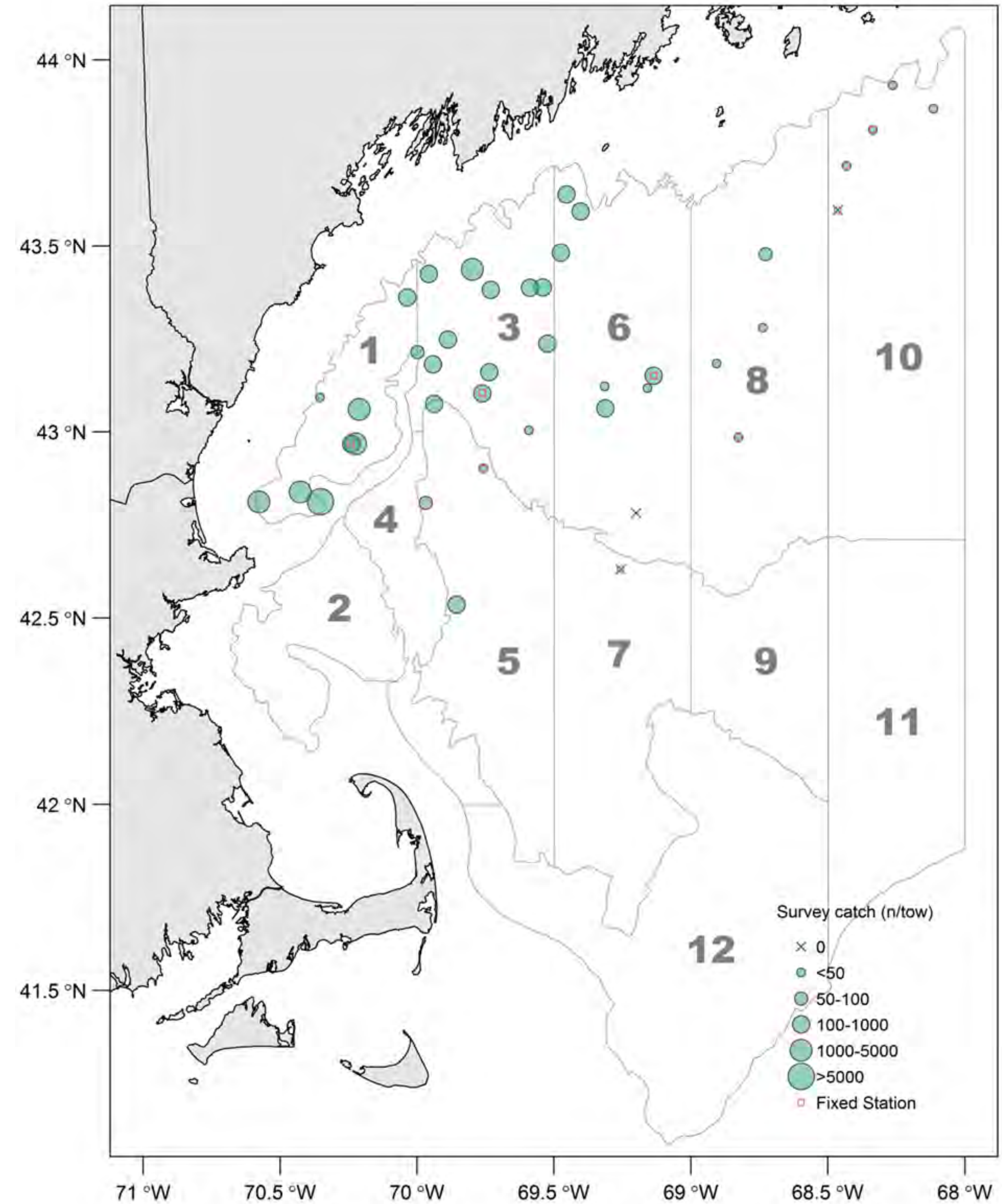
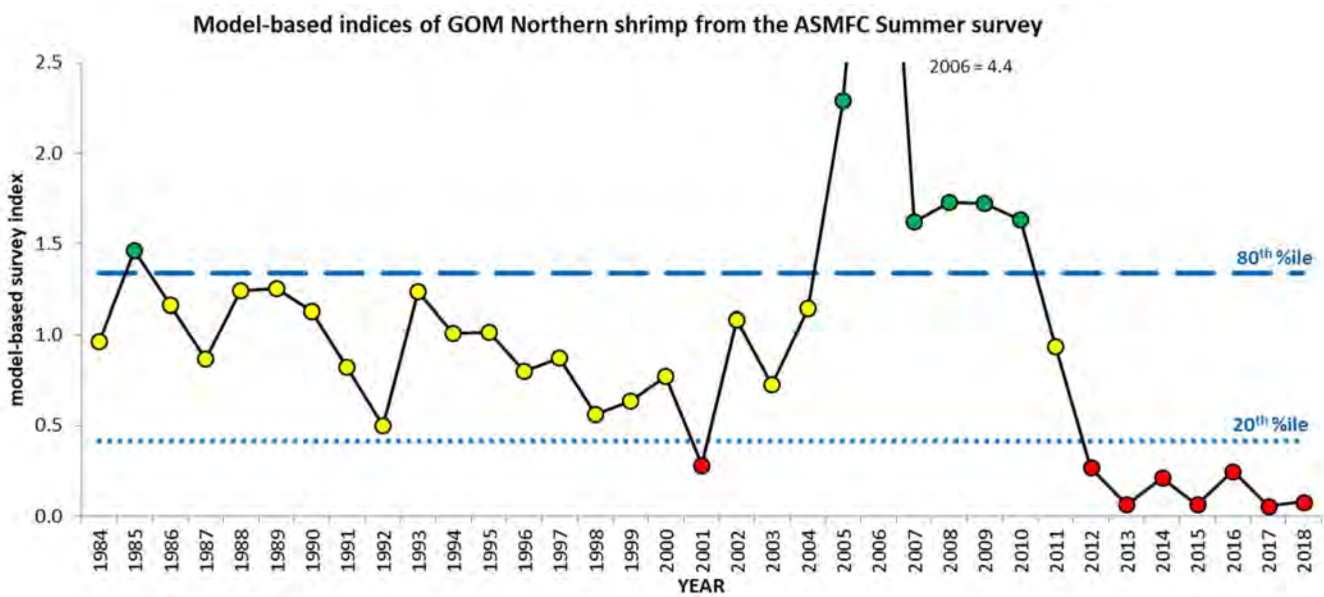


Figure 6. **2018 Summer Shrimp Survey aboard the *R/V Gloria Michelle*, with survey sites and shrimp catches in number/tow.**



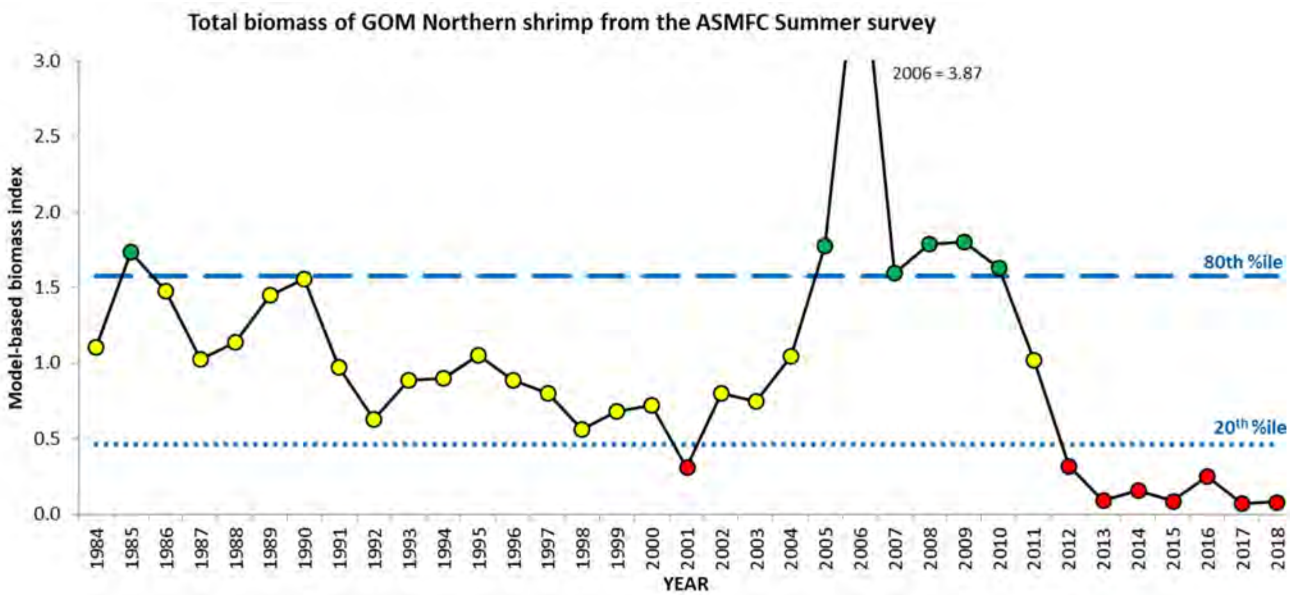
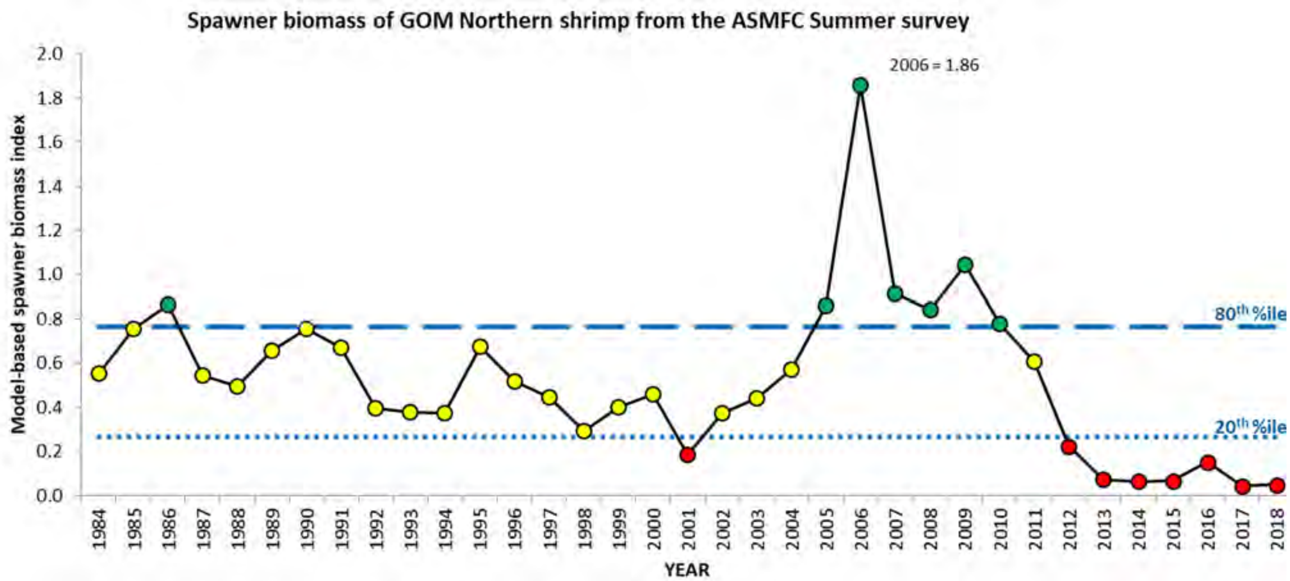


Figure 7. **Traffic light analysis for the model-based index of Gulf of Maine northern shrimp from the Summer Shrimp Survey 1984-2018 for total abundance (top) and total biomass (bottom). The 20th percentile of the time series from 1984-2017 delineated an adverse state, and the 80th percentile of the time series from 1984-2017 delineated a favorable state.**



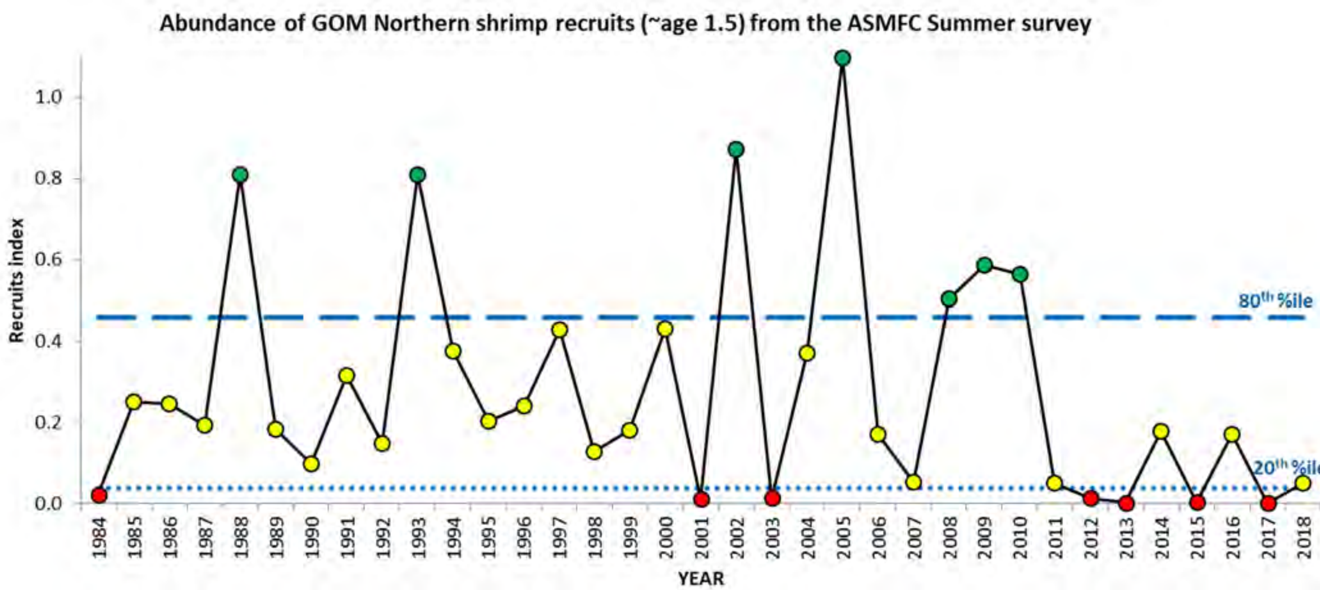


Figure 8. **Traffic light analysis of spawning biomass (top) and recruitment (bottom) of Gulf of Maine northern shrimp from the Summer Shrimp survey 1984-2018. The 20th percentile of the time series from 1984-2017 delineated an adverse state, and the 80th percentile of the time series from 1984-2017 delineated a favorable state.**

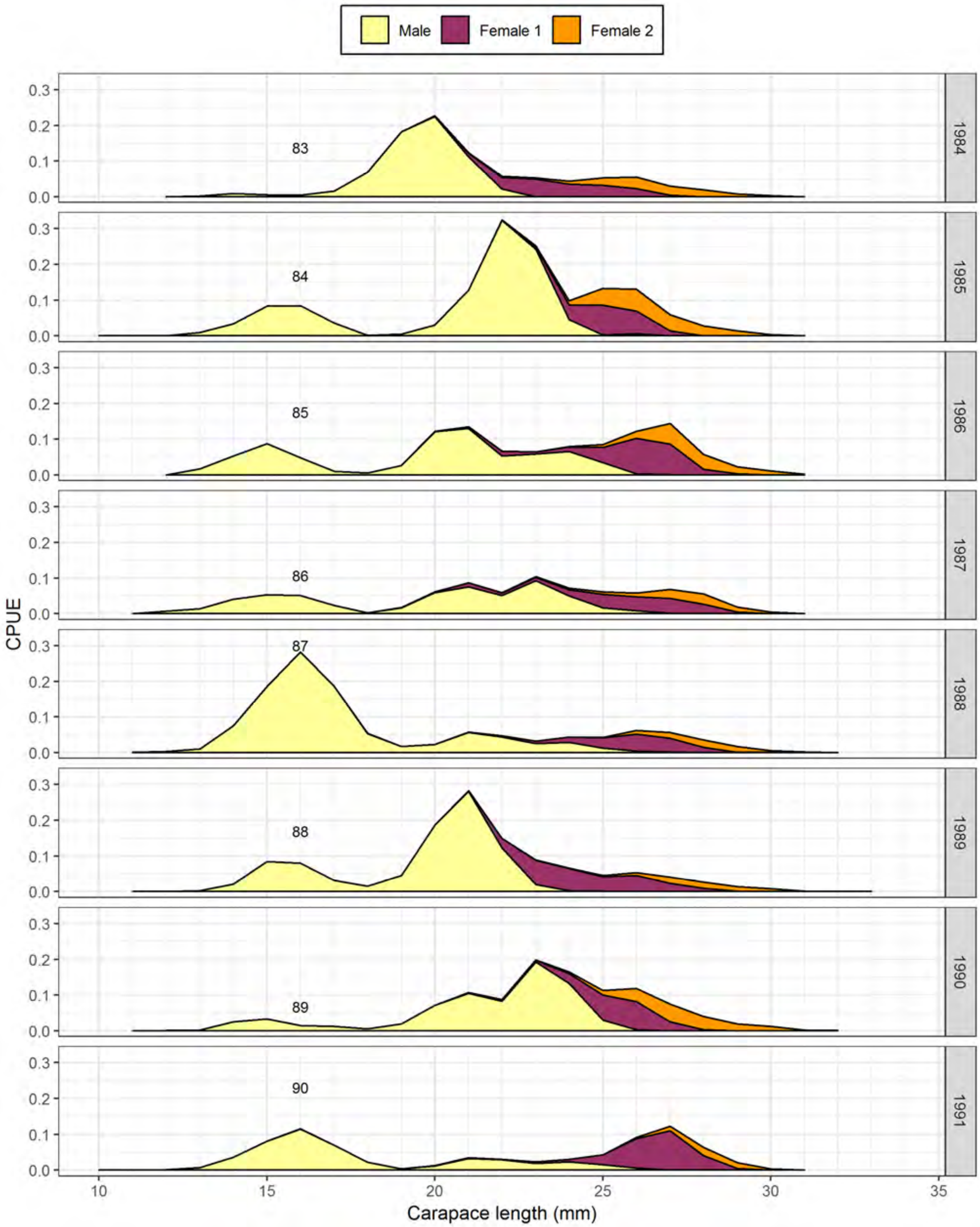


Figure 9. Gulf of Maine northern shrimp Summer Survey abundance by year, length, and development stage. Two-digit years are year class at assumed age 1.5.

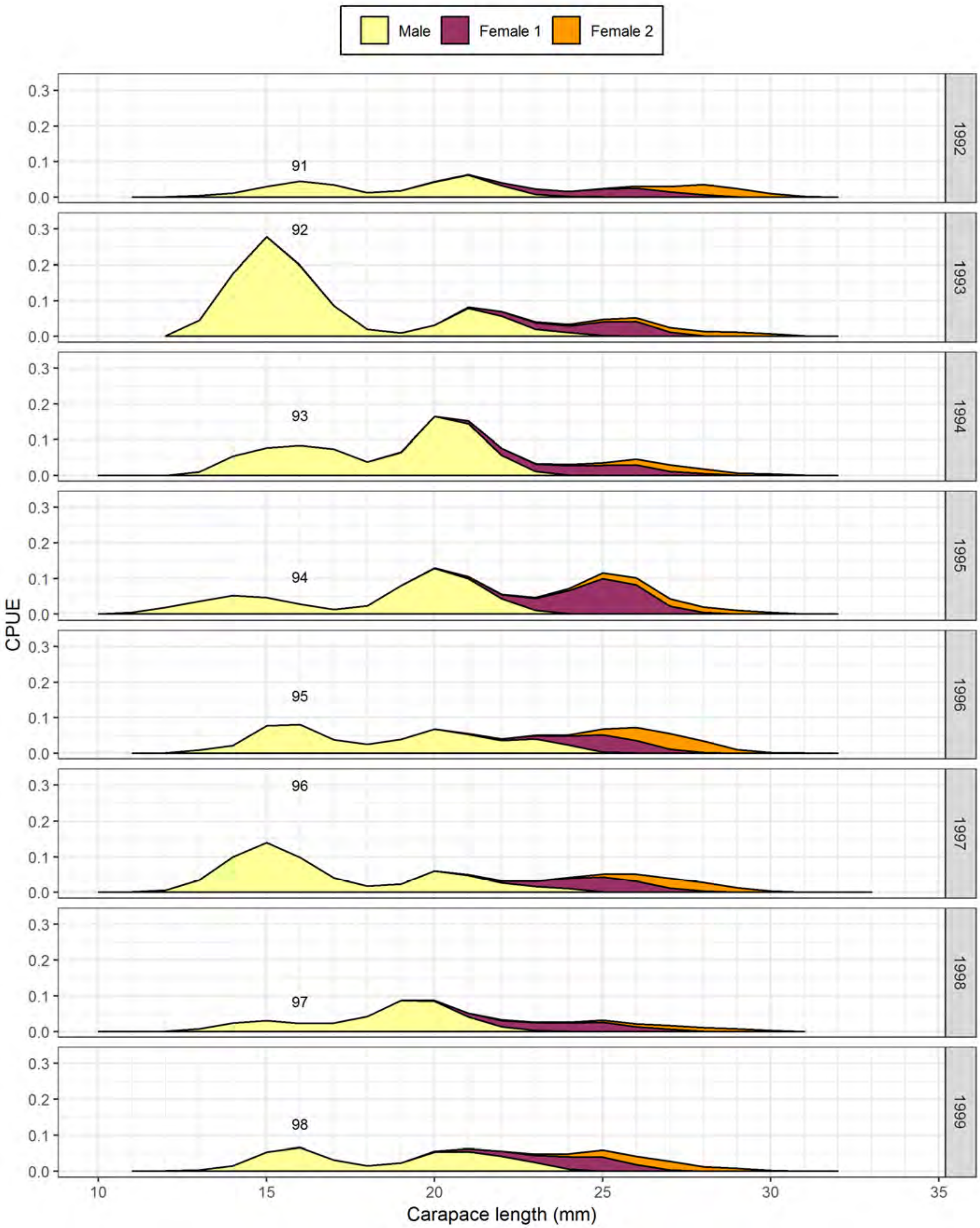
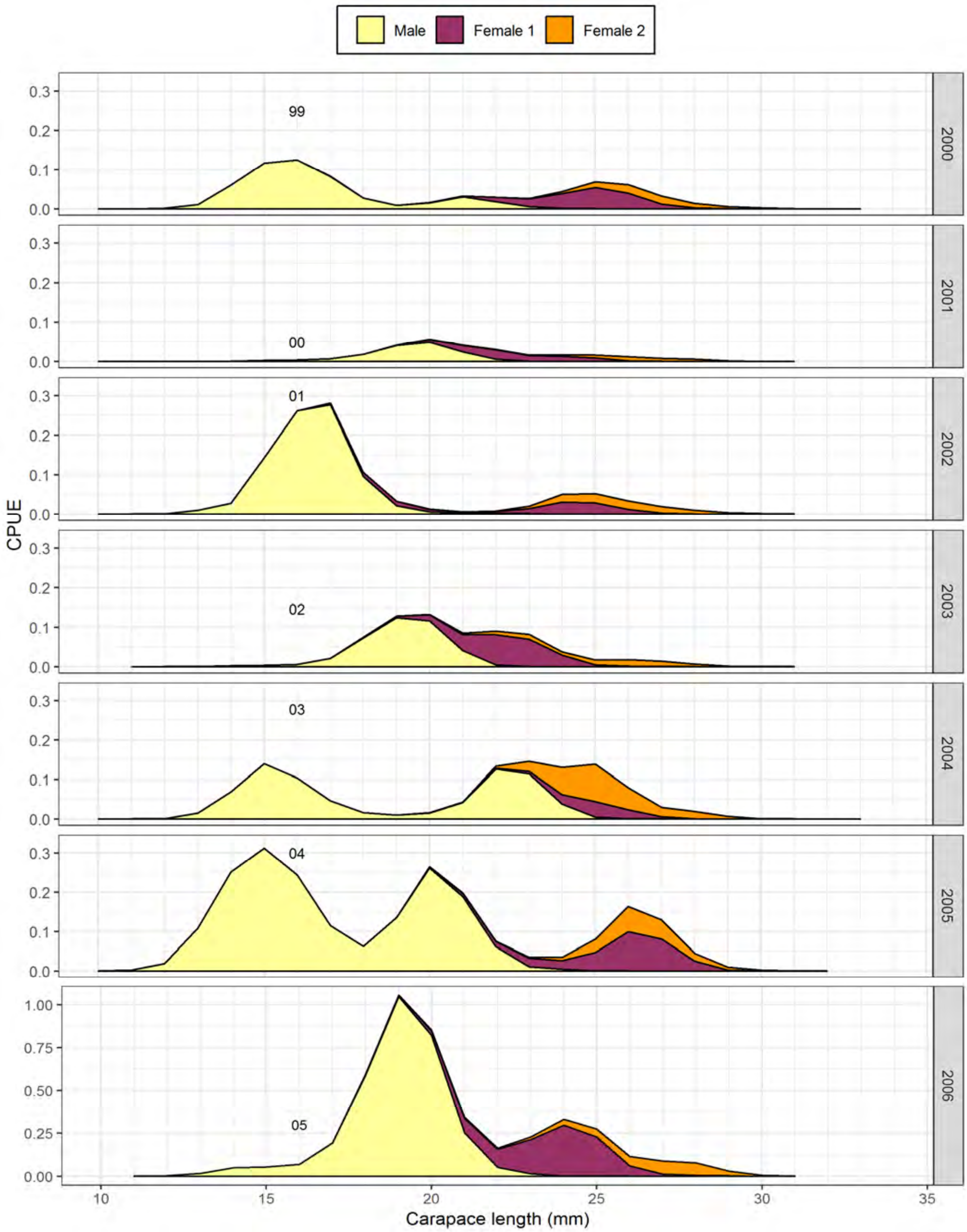


Figure 9 continued. Summer Survey.



Male
Female 1
Female 2
CPUE
Carapace length (mm)
99
00
01
02
03
04
05
2000
2001
2002
2003
2004
2005
2006

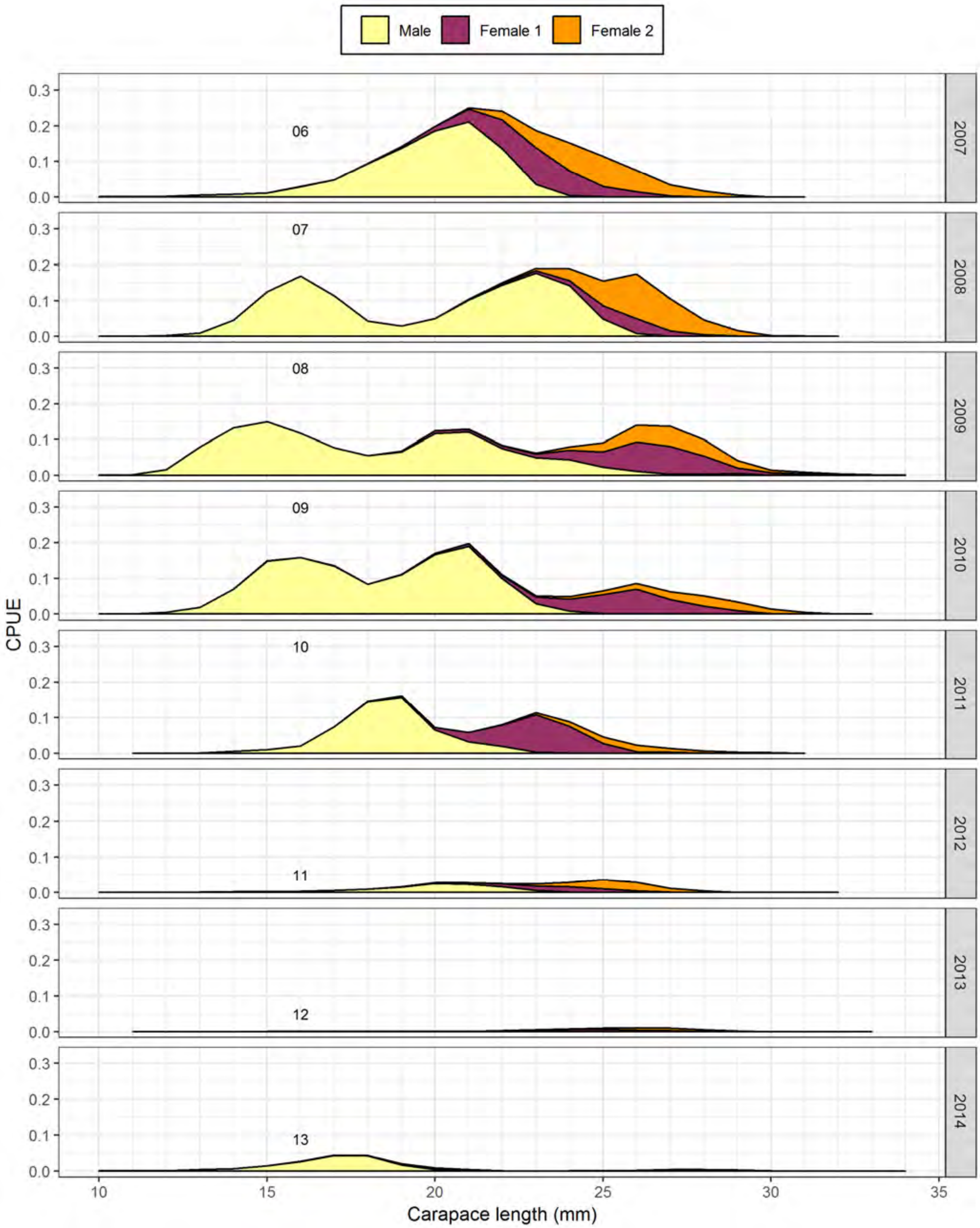


Figure 9 continued. Summer Survey.

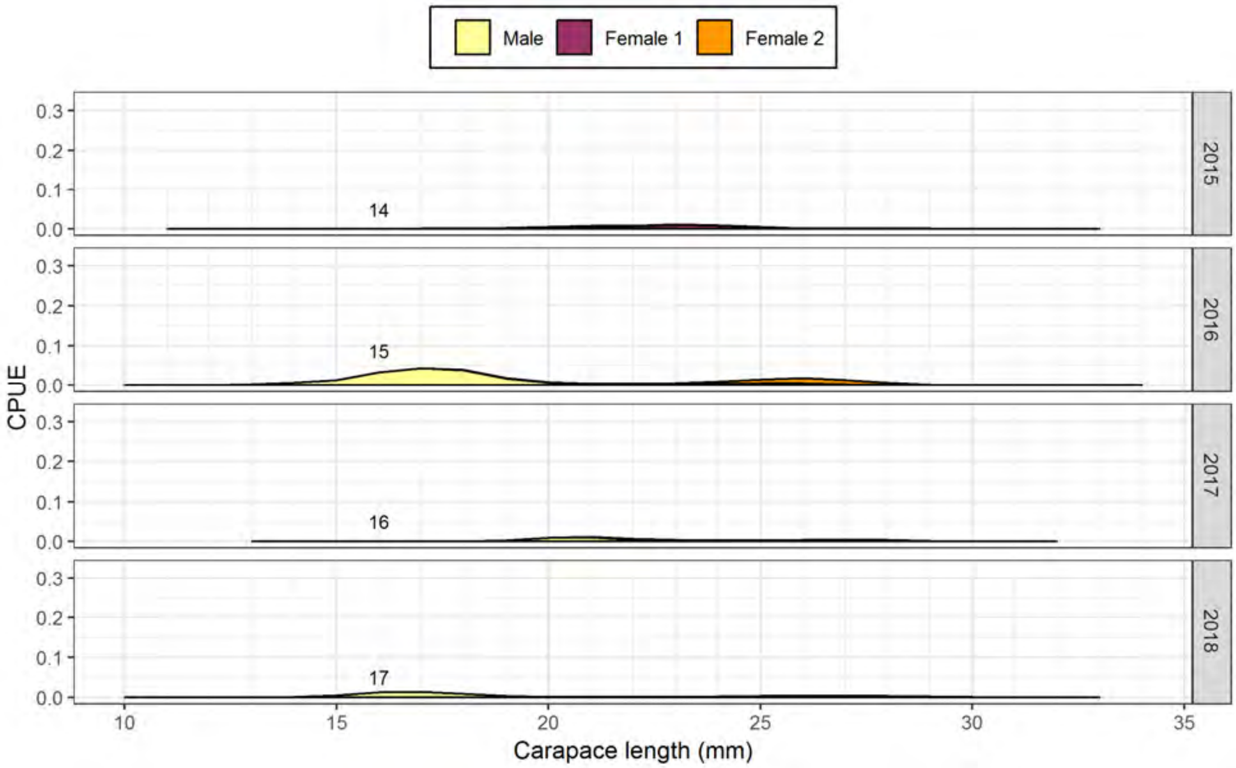


Figure 9 continued. Summer Survey.

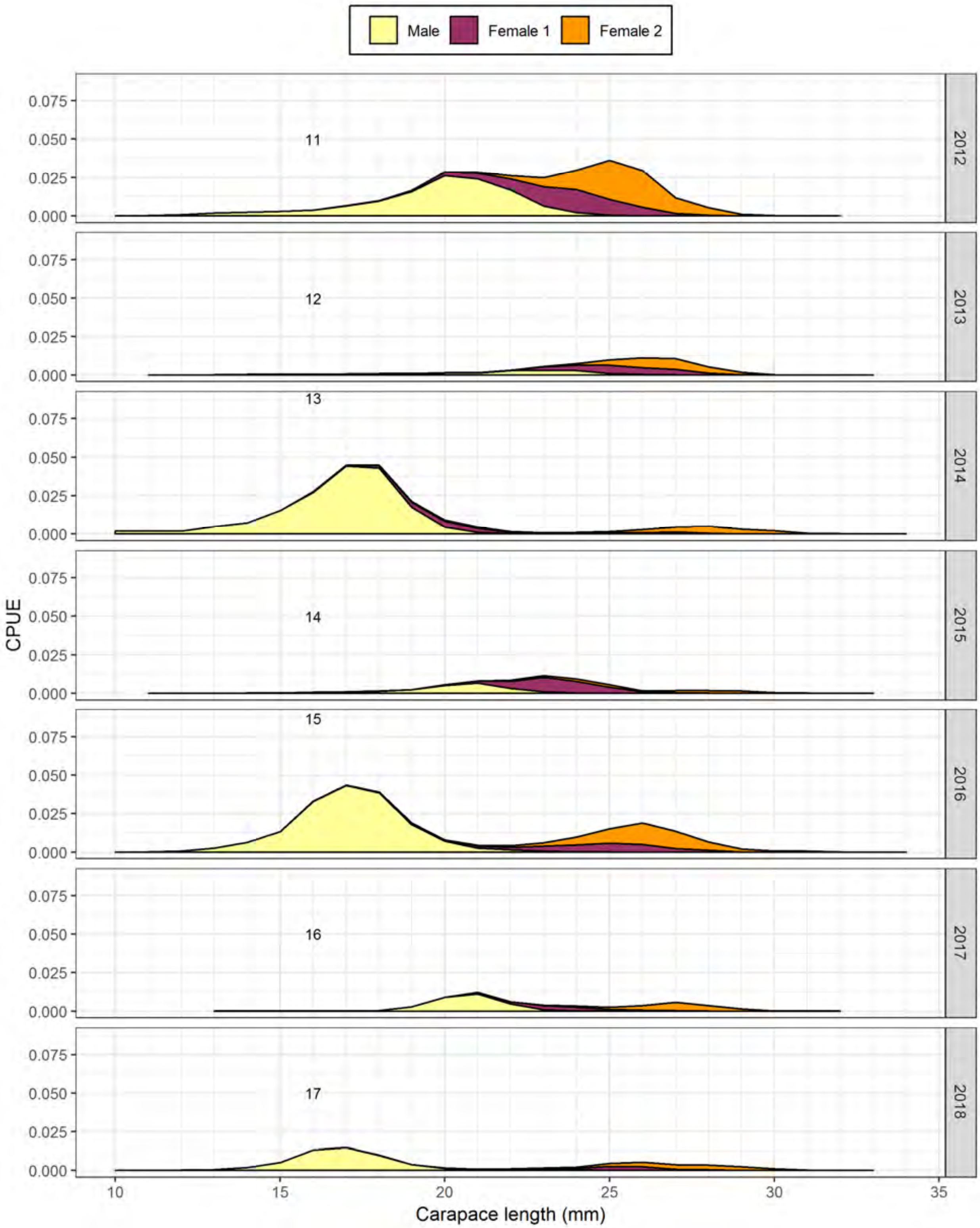
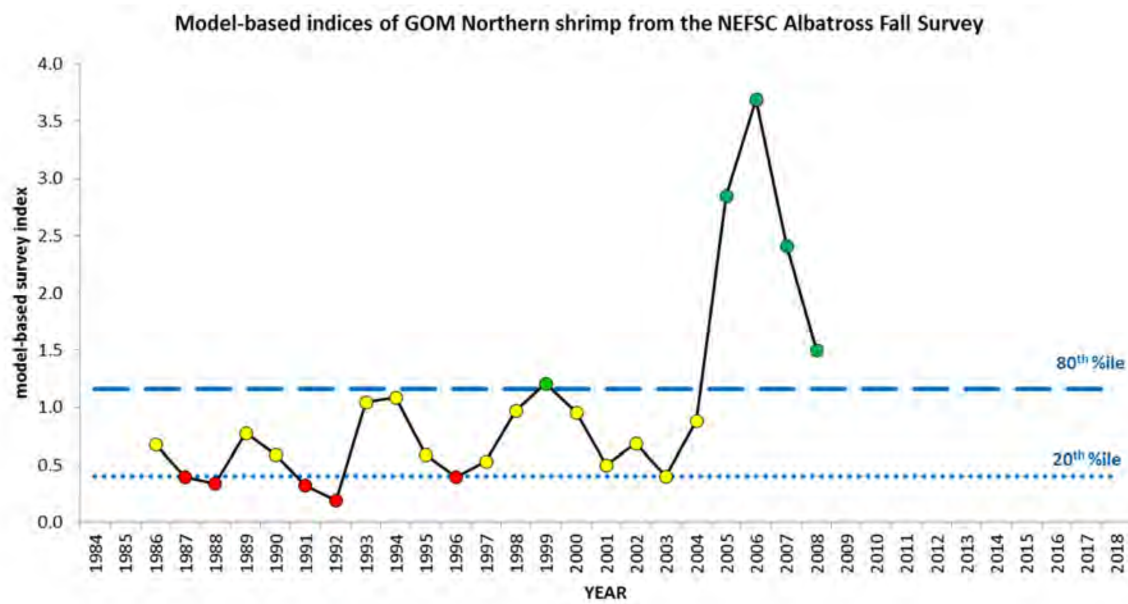


Figure 10. Gulf of Maine northern shrimp Summer Survey abundance by year, length, and development stage for 2012 – 2018 with an expanded axis to show detail. Two-digit years are year class at assumed age 1.5.



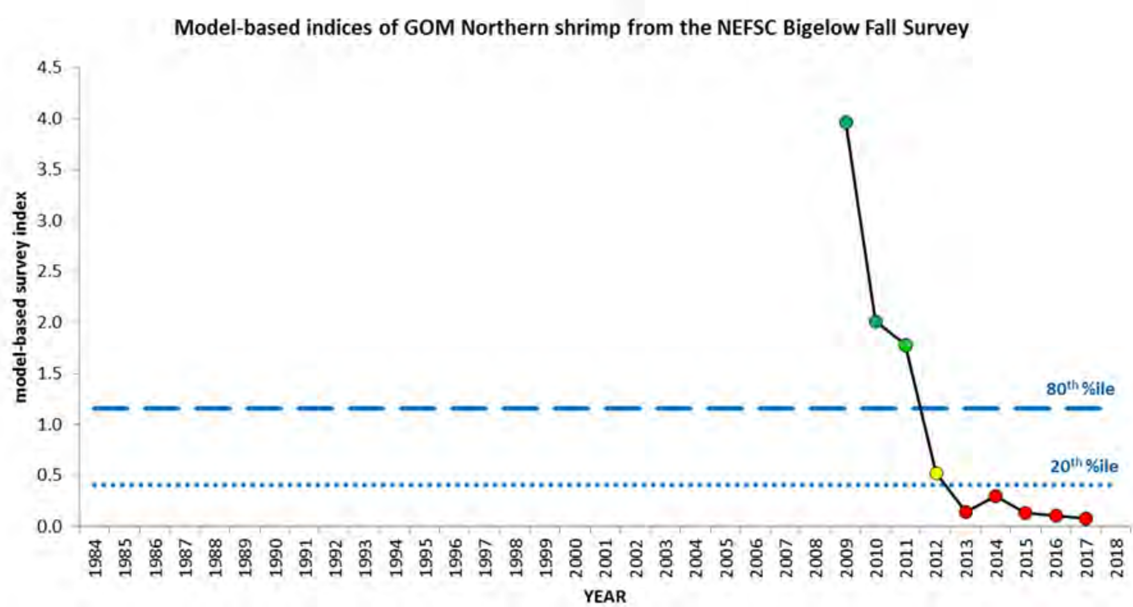


Figure 11. **Traffic light analysis of abundance of Gulf of Maine northern shrimp from the NEFSC Fall Survey for the *Albatross* (top) and *Bigelow* (bottom) years. The 20th percentile of the time series from 1984-2017 delineated an adverse state, and the 80th percentile of the time series from 1984-2017 delineated a favorable state.**

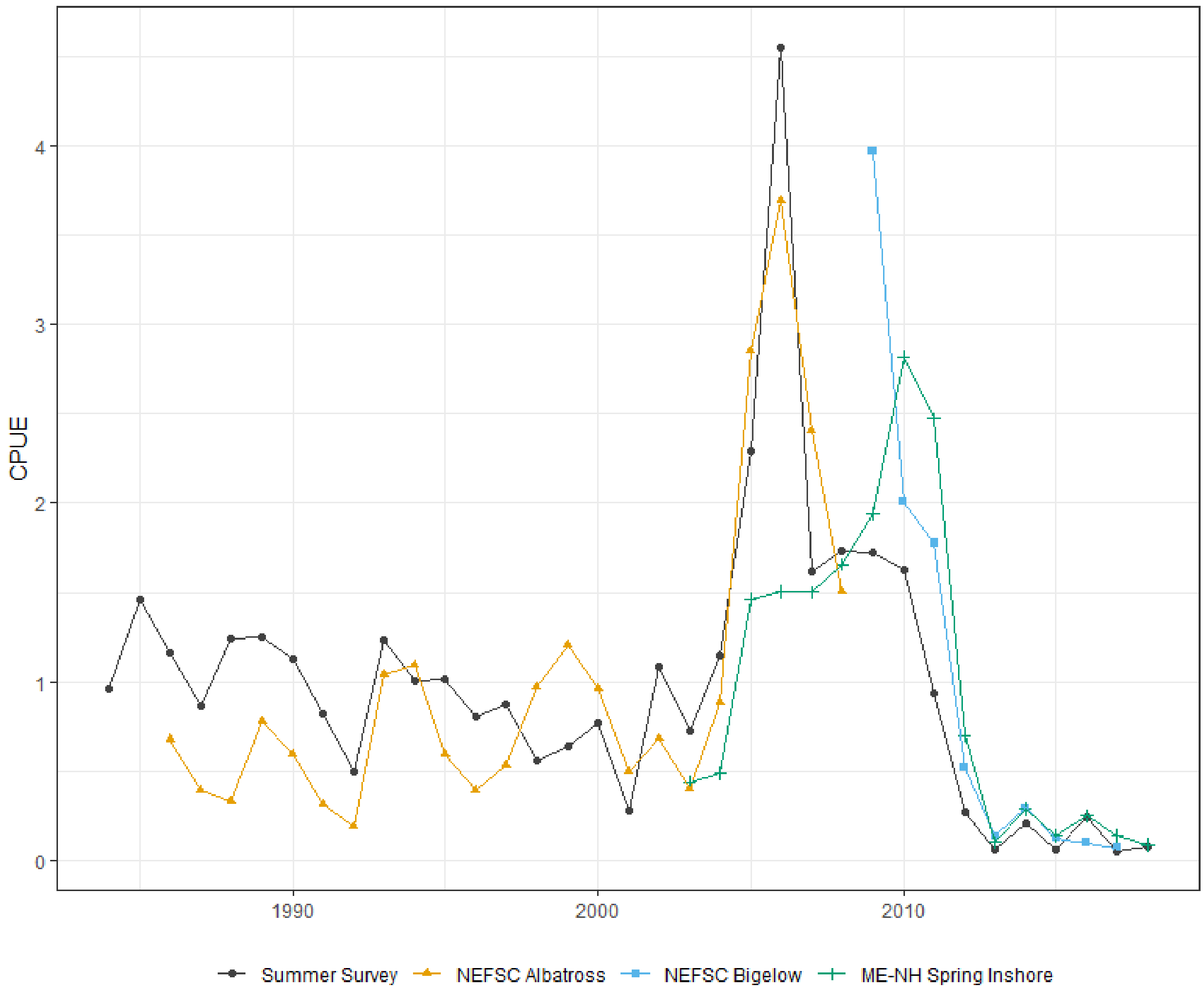


Figure 12. **Model-based indices of abundance from the Summer Survey, the NEFSC fall survey, and the ME-NH inshore spring survey plotted together.**

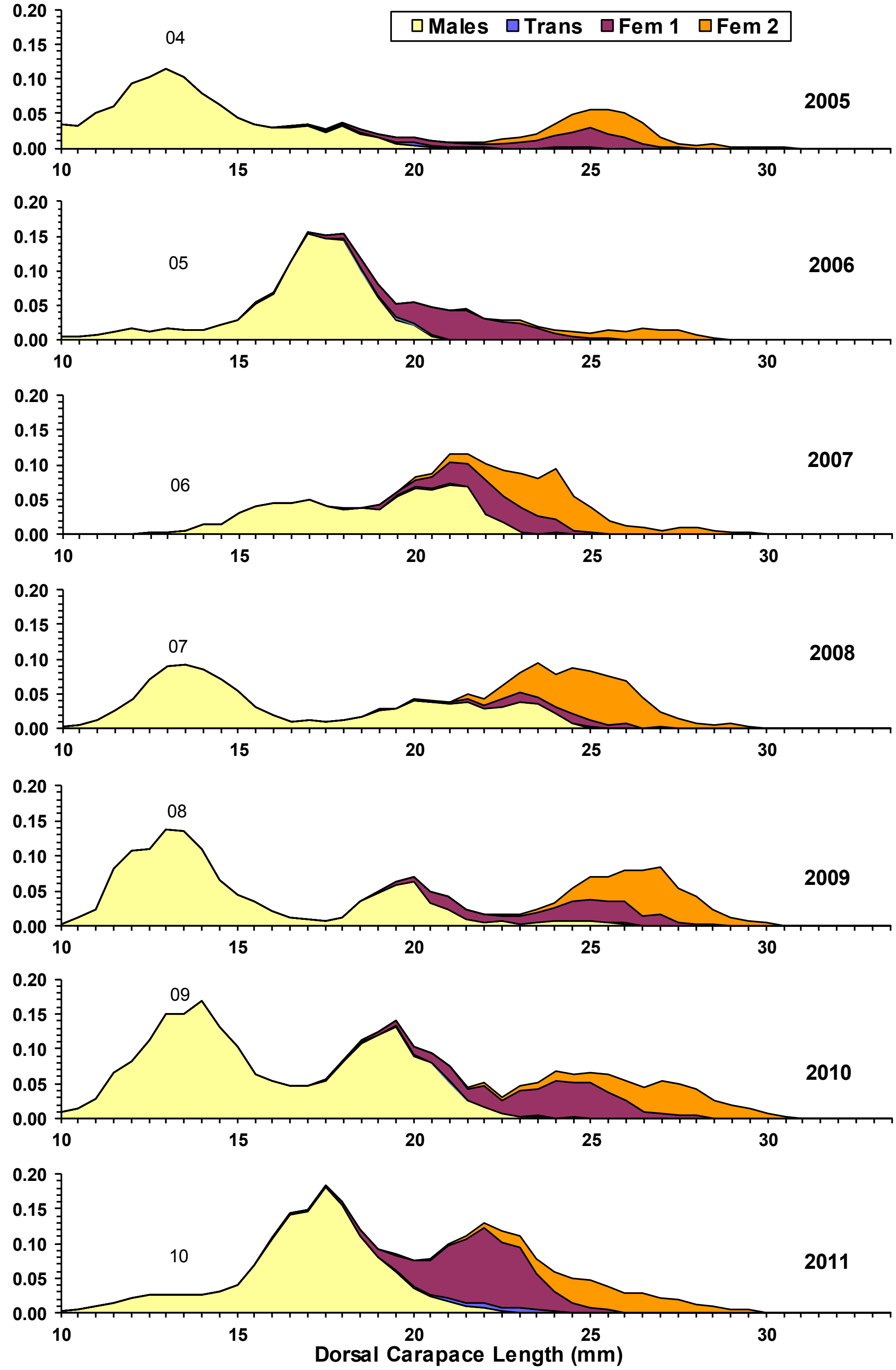


Figure 13. **Maine-New Hampshire spring inshore survey; northern shrimp standardized abundance indices by year, length, and development stage. Two-digit years are the year class at assumed age 1.**

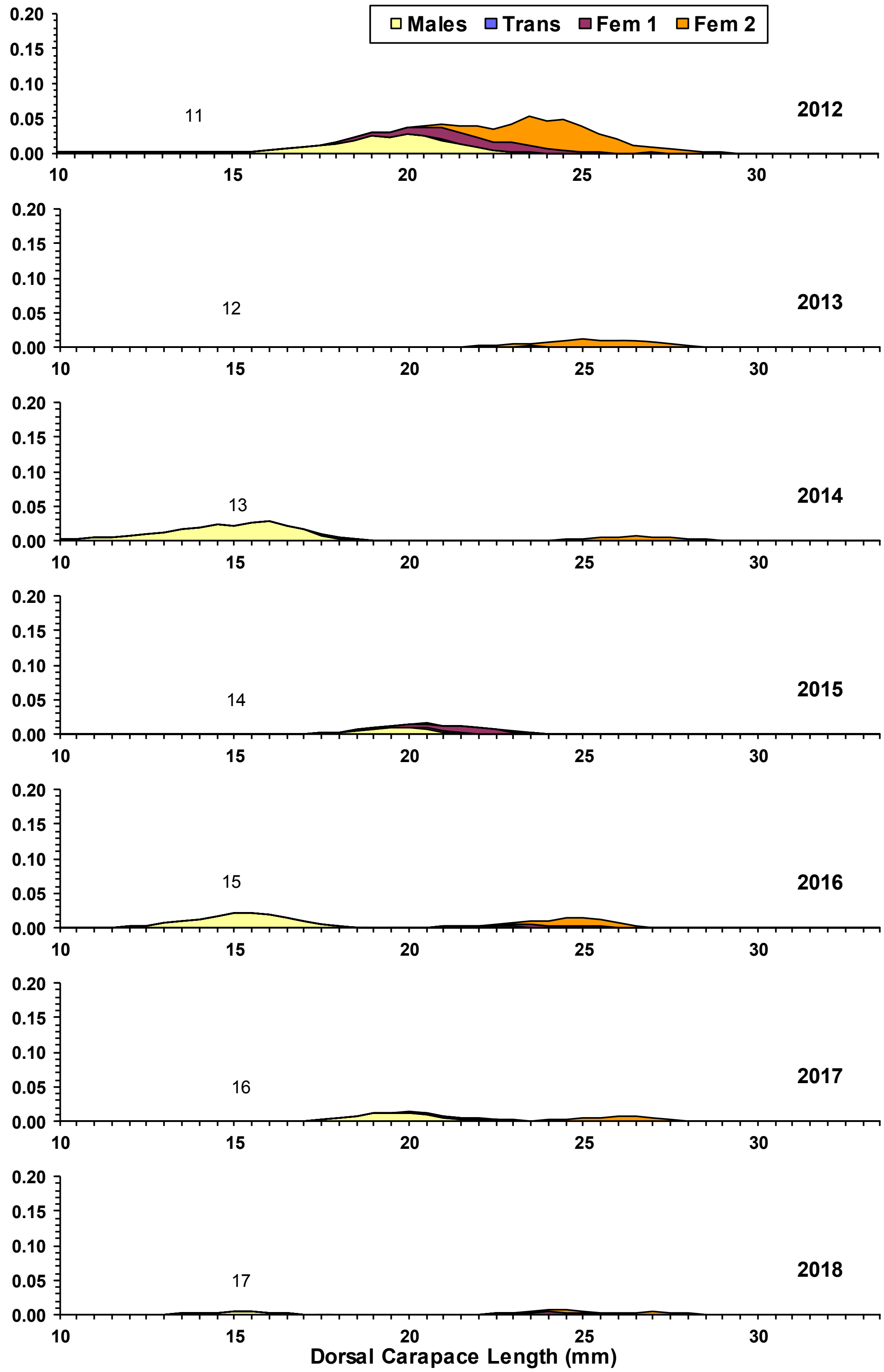


Figure 13 continued. **Maine-New Hampshire spring inshore survey.**

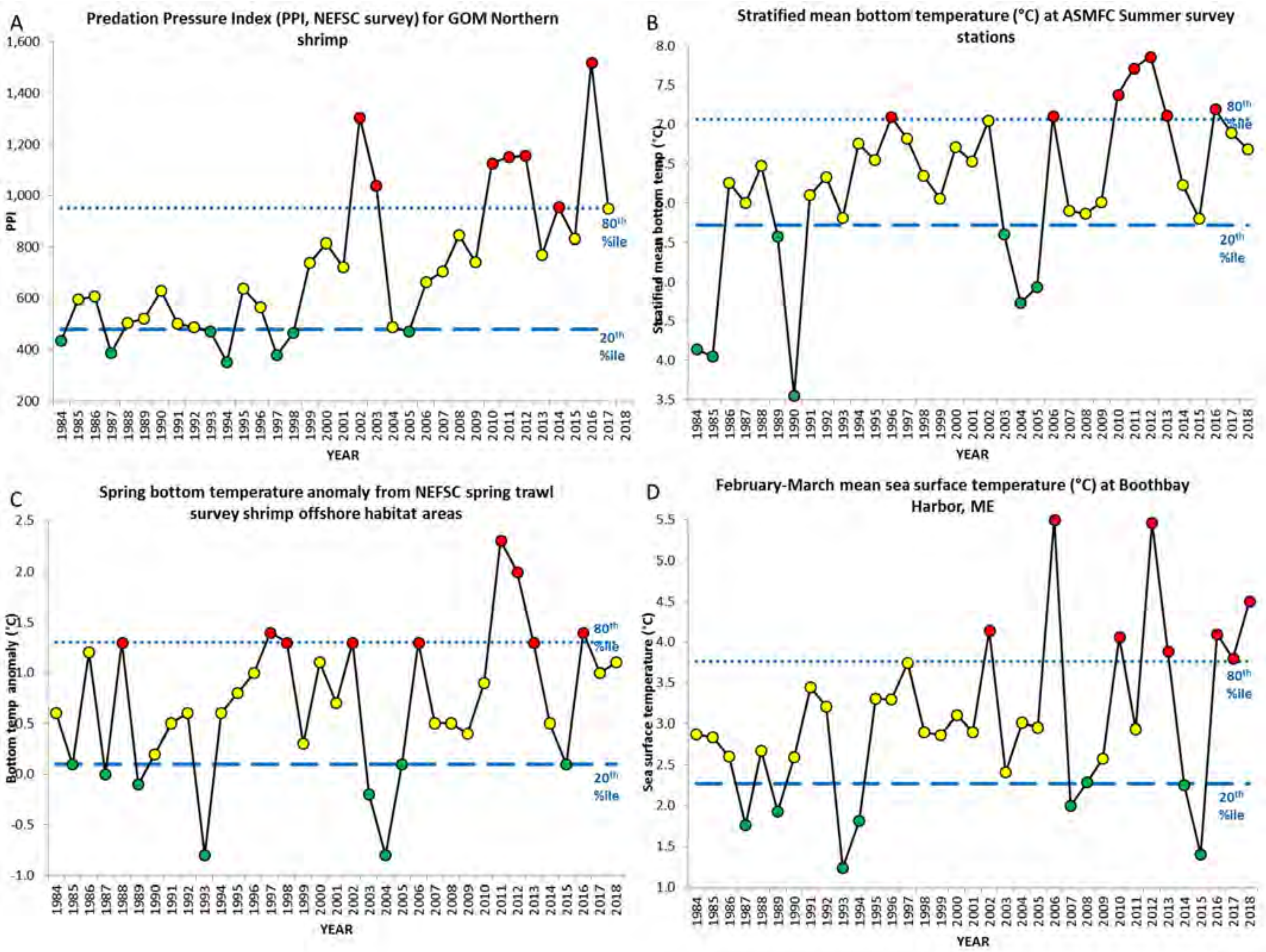


Figure 14. **Traffic light analysis of environmental conditions in the Gulf of Maine, including predation pressure (A), summer bottom temperature (B), spring bottom temperature (C), and winter sea surface temperature (D). The 20th percentile of the time series from 1984-2017 delineated a favorable state, and the 80th percentile of the time series from 1984-2017 delineated an adverse state.**

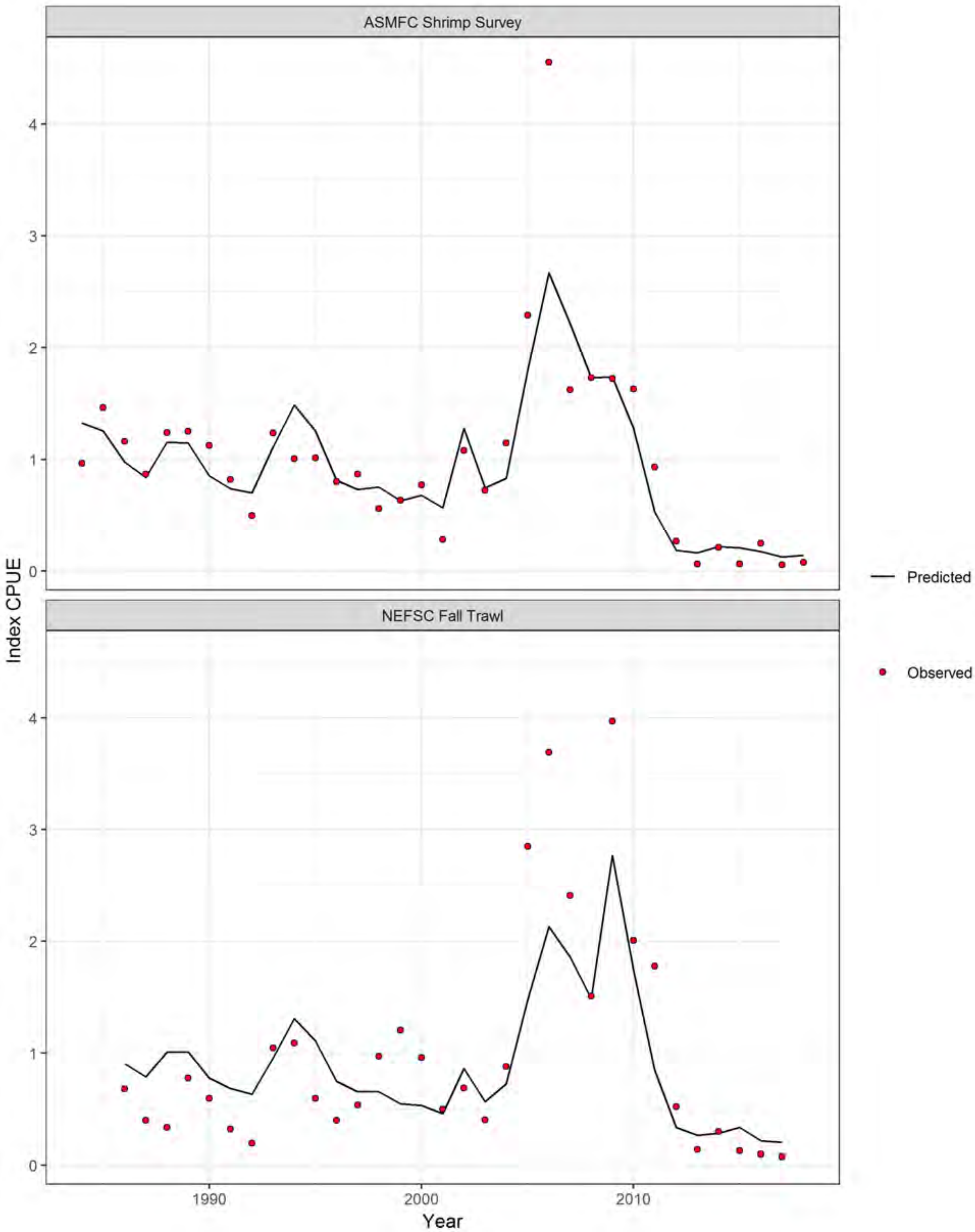


Figure 15a. Observed and predicted estimates of abundance from the UME model.

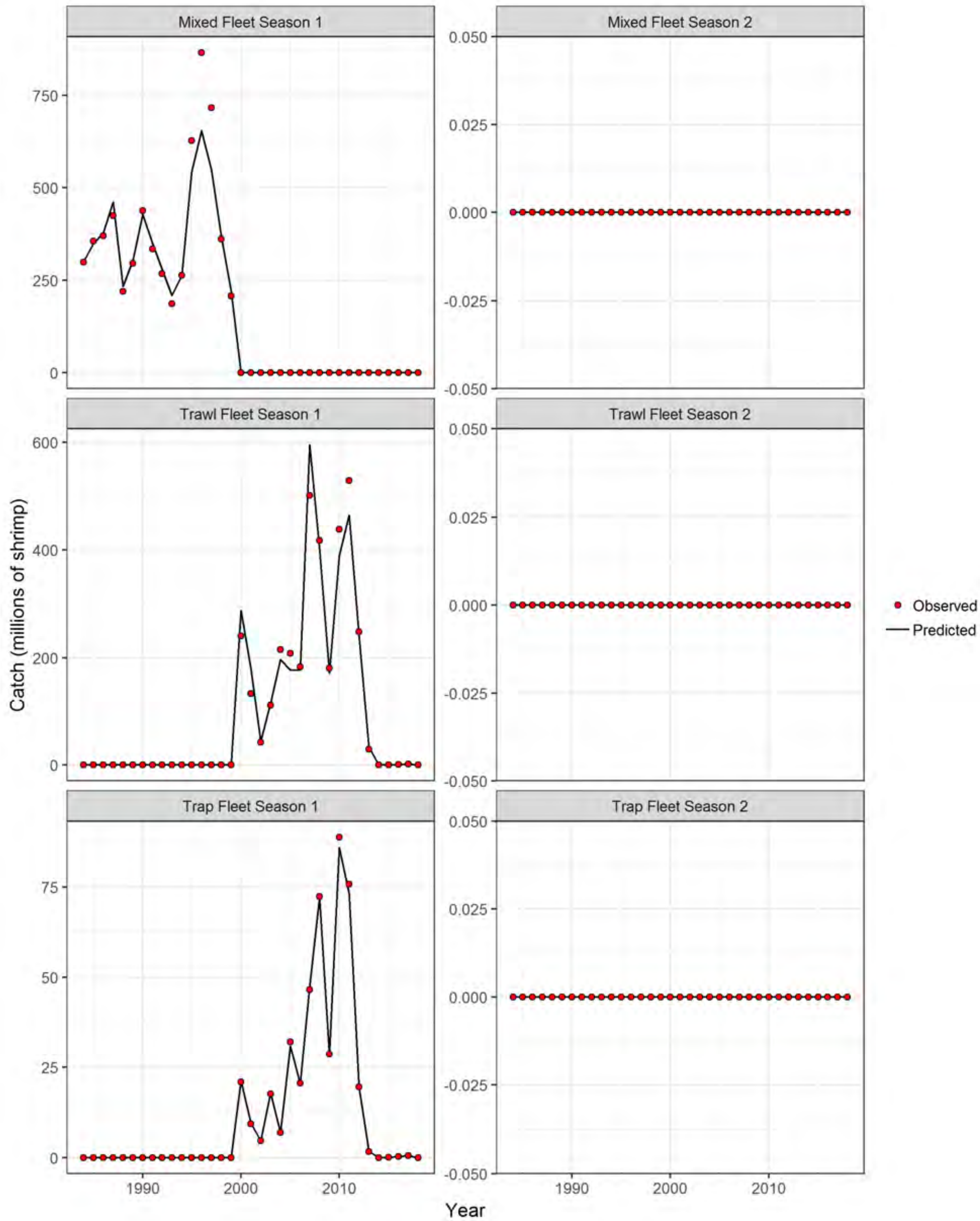


Figure 15b. **Observed and predicted estimates of catch by fleet and season from the UME model.**

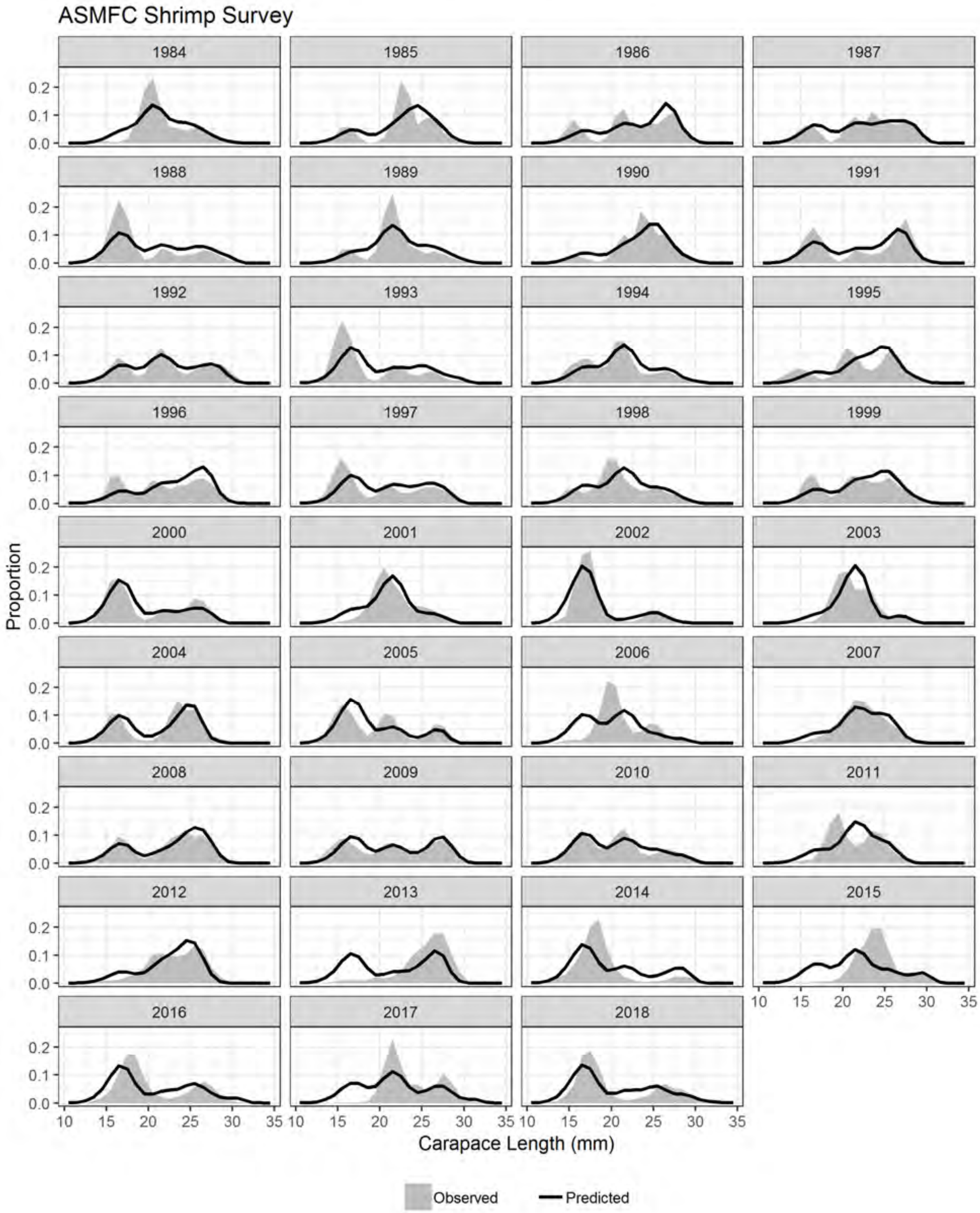


Figure 16. Observed and predicted length compositions for the Summer Survey from the UME model.

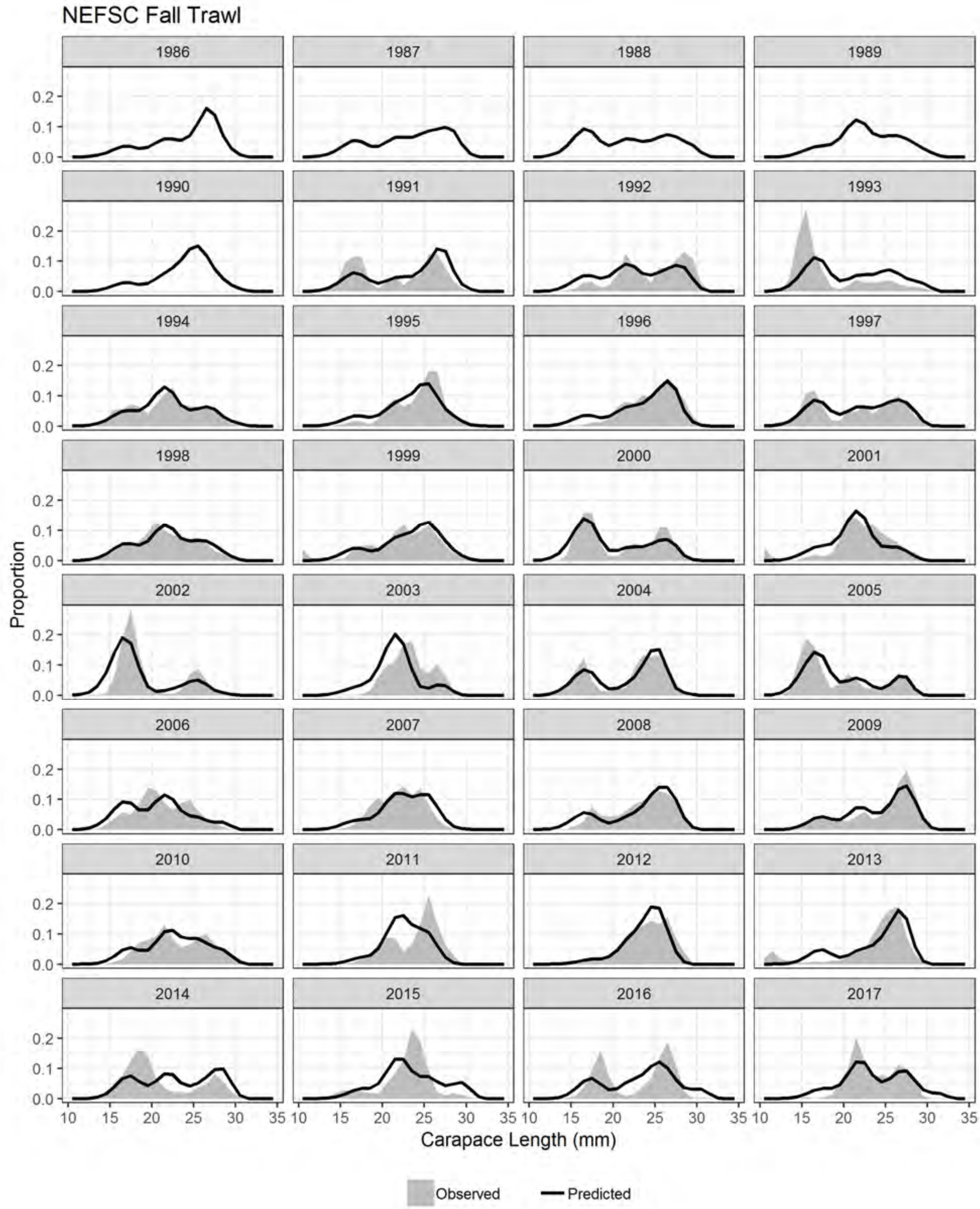


Figure 17. **Observed and predicted length compositions for the NEFSC fall survey from the UME model.**

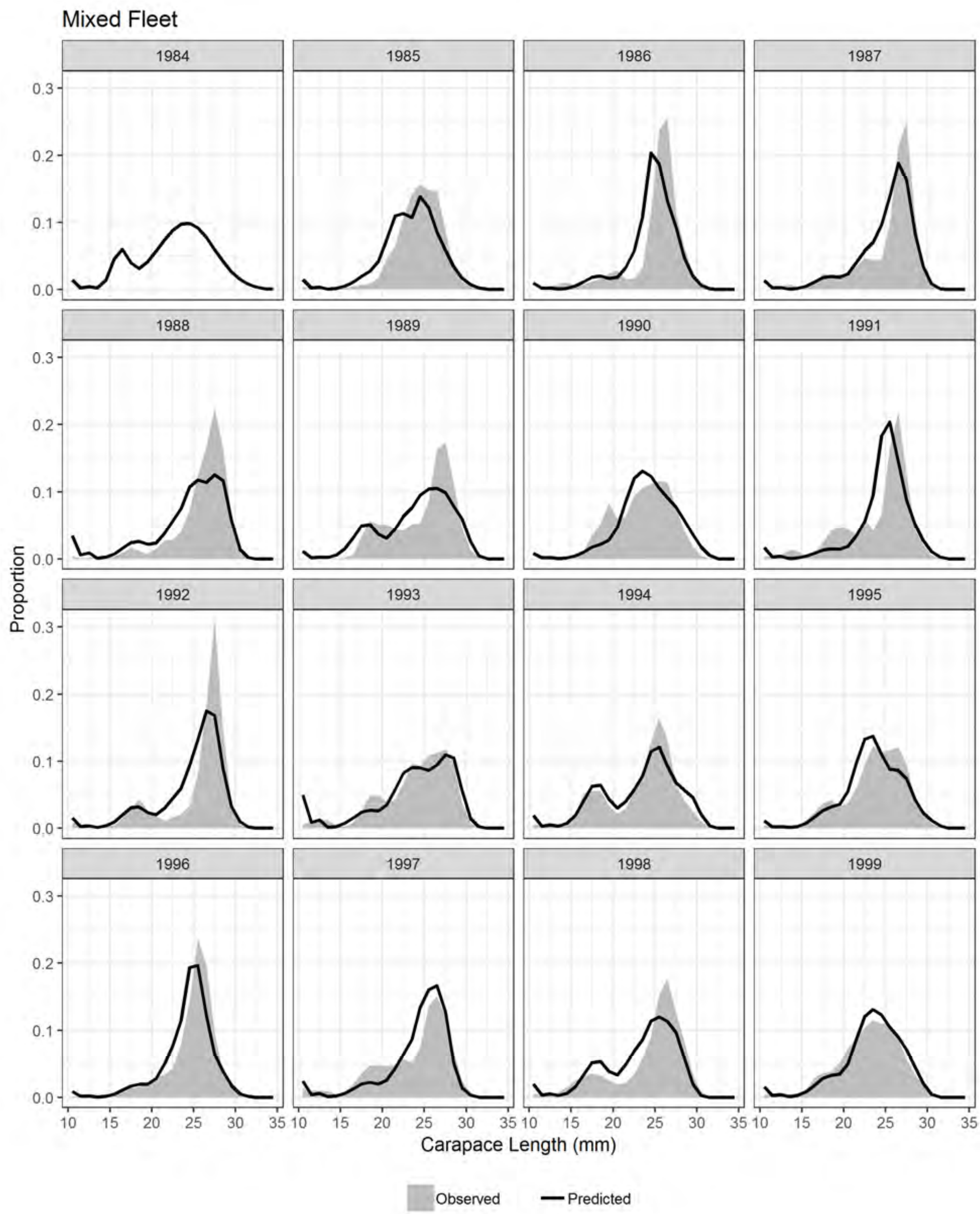


Figure 18. **Observed and predicted length compositions for the mixed gear fleet from the UME model.**

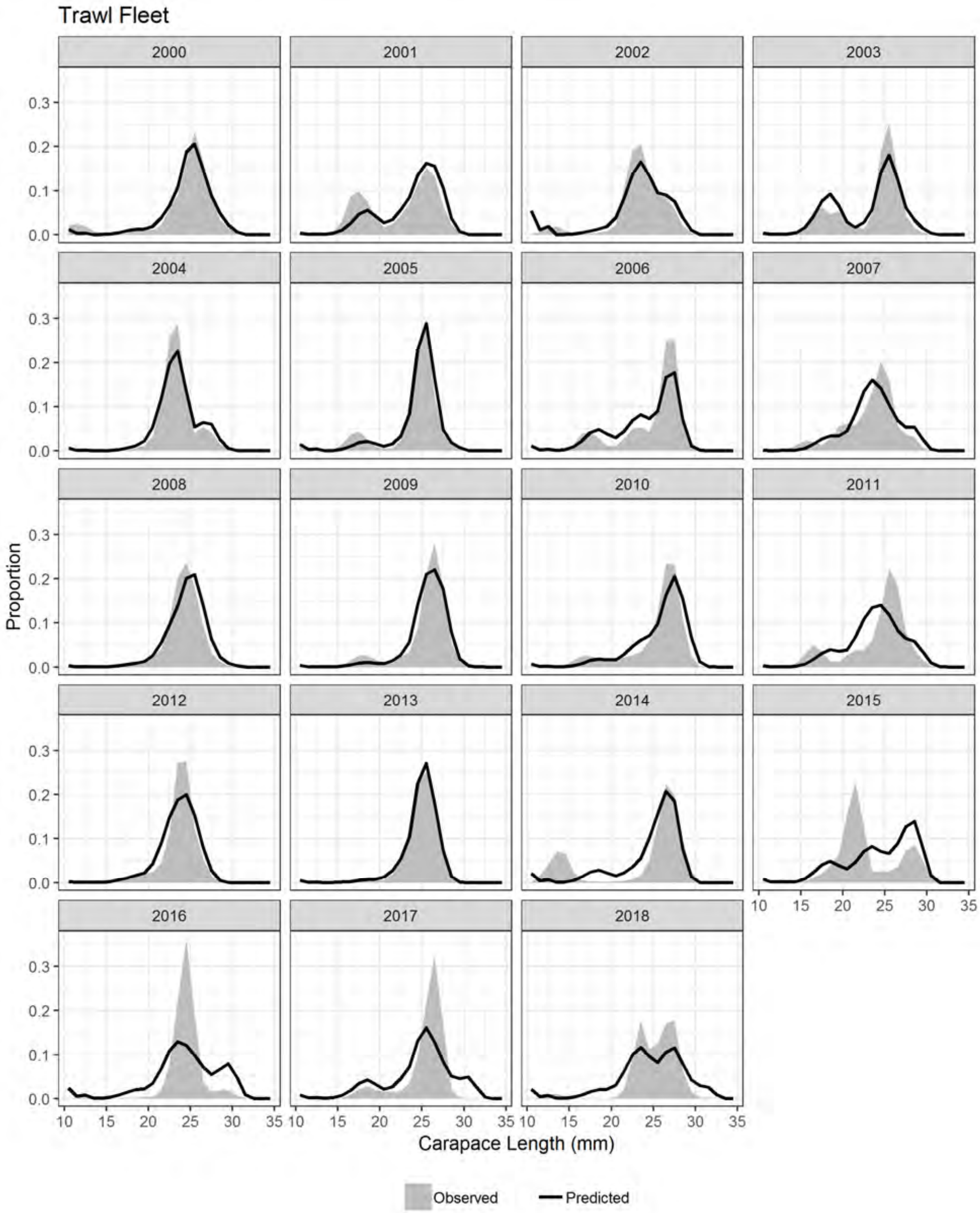


Figure 19. Observed and predicted length compositions for the trawl fleet from the UME model.

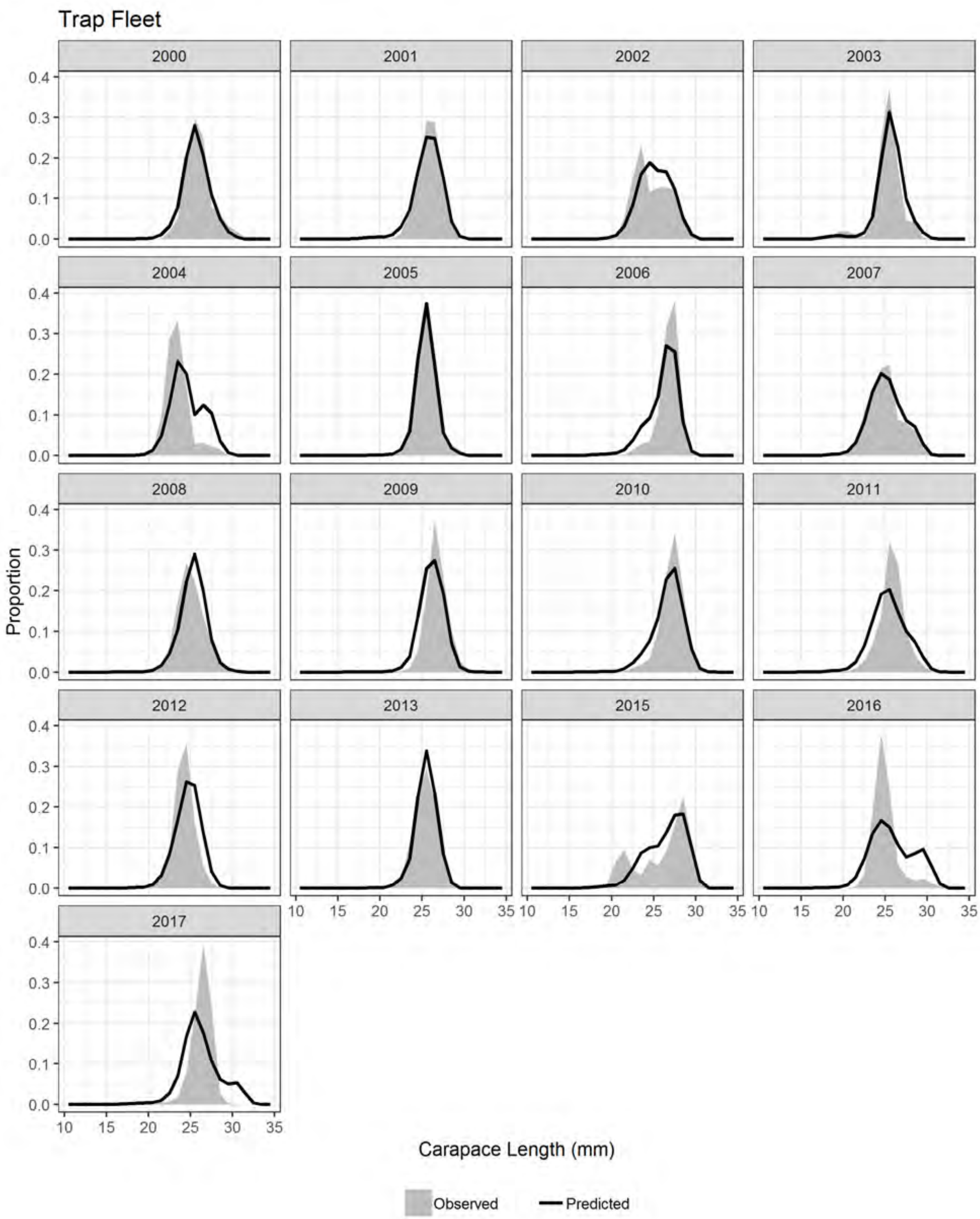


Figure 20. **Observed and predicted length compositions for the trap fleet from the UME model.**

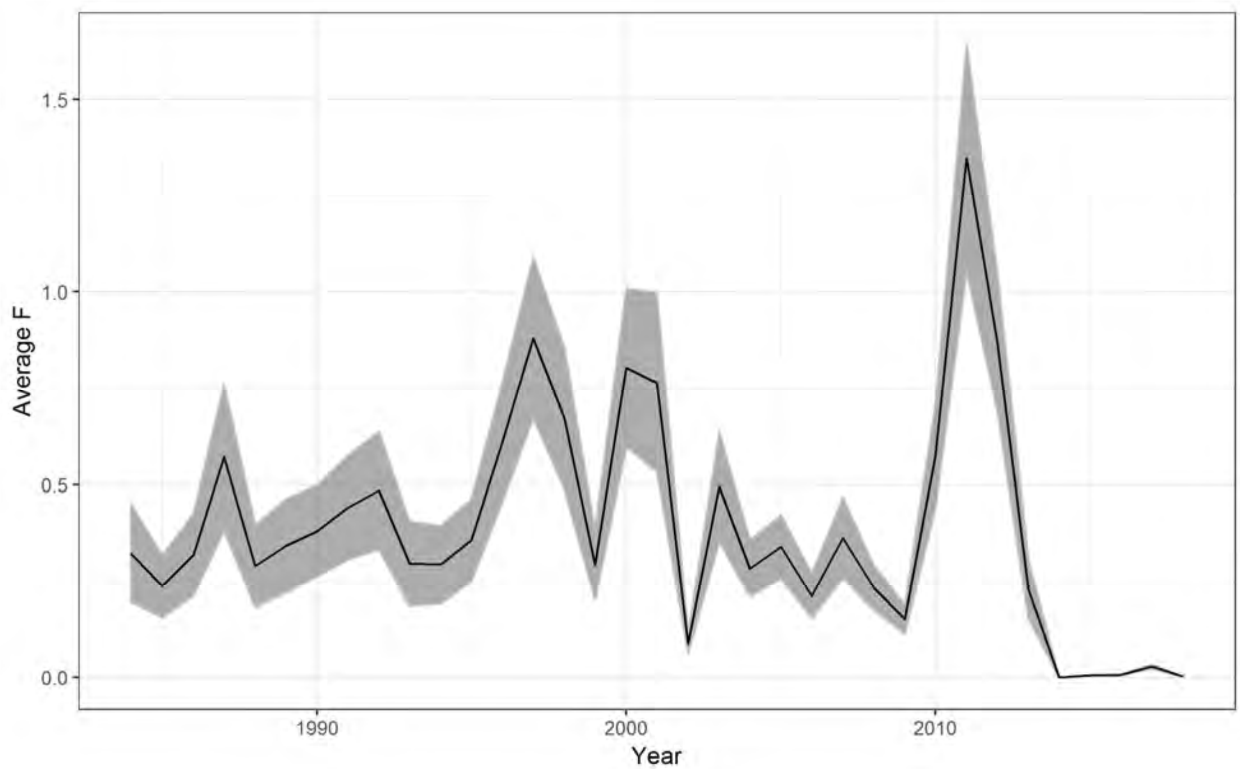


Figure 21. **Average fishing mortality on Gulf of Maine northern shrimp estimated by the UME model with 95% confidence intervals.**

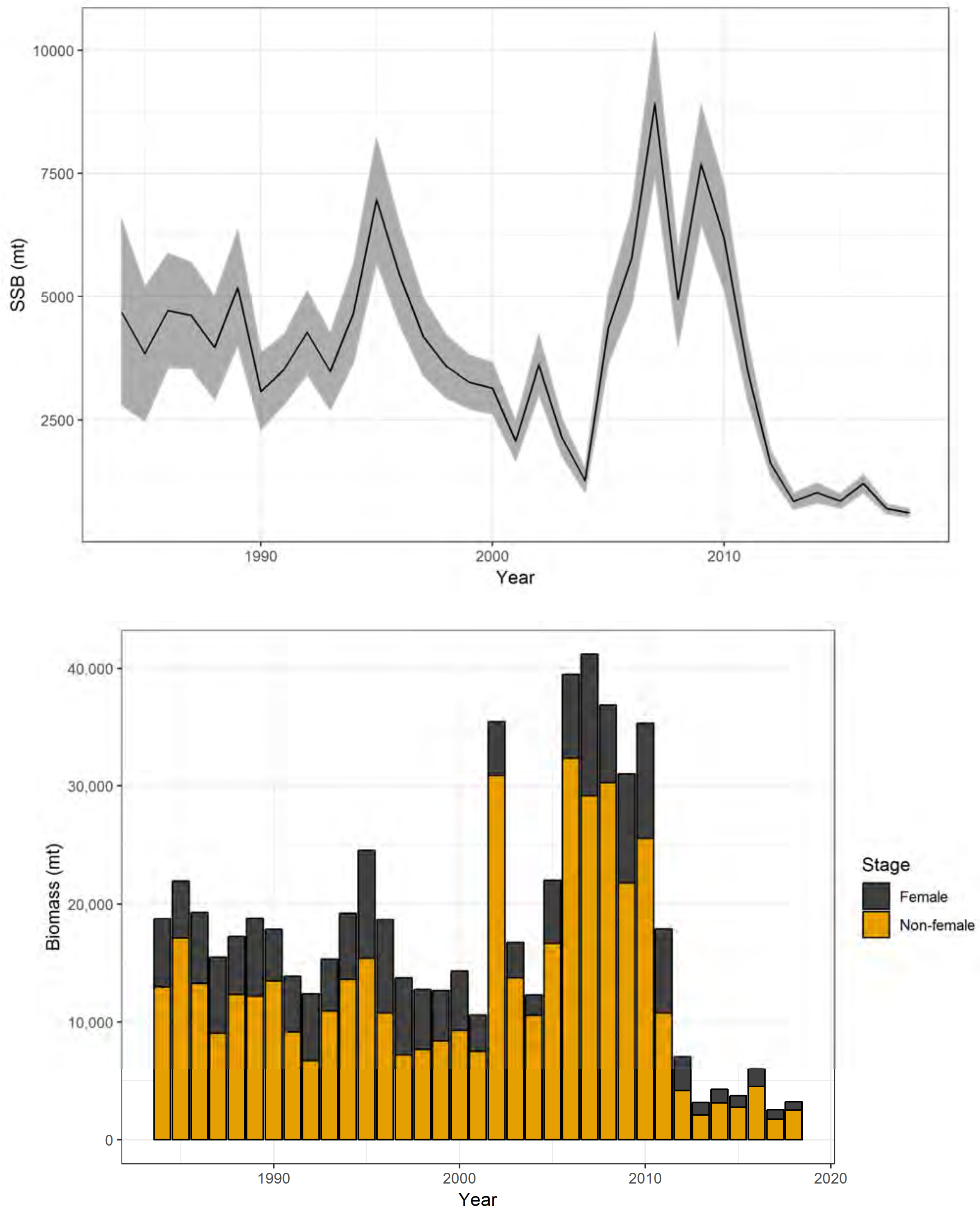


Figure 22. **Estimates of Gulf of Maine northern shrimp spawning stock biomass with 95% confidence intervals (top) and total biomass by stage (bottom) from the UME model.**

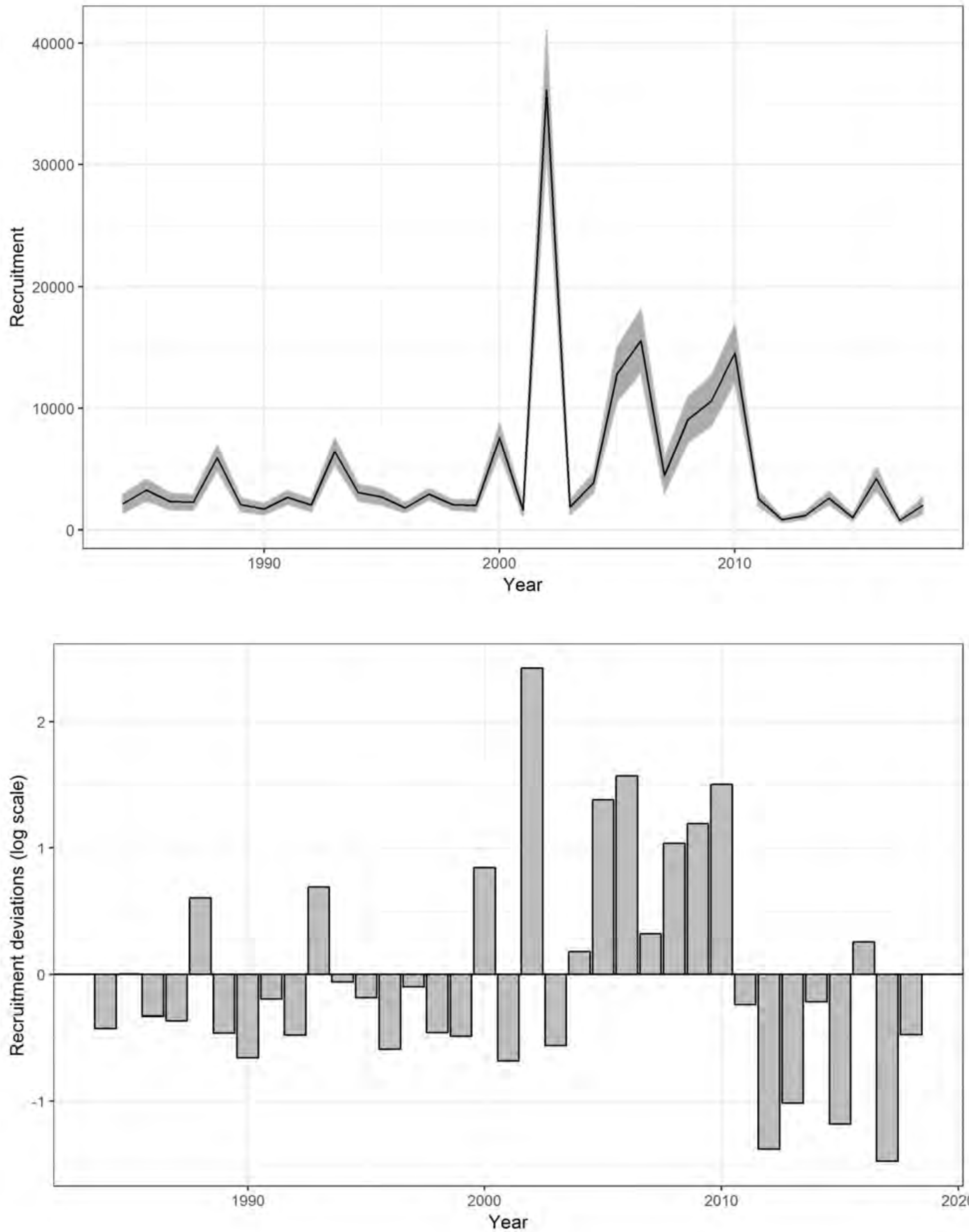


Figure 23. **Estimates of total recruitment with 95% confidence intervals (top) and annual deviations from mean recruitment (bottom) for Gulf of Maine northern shrimp from the UME model.**

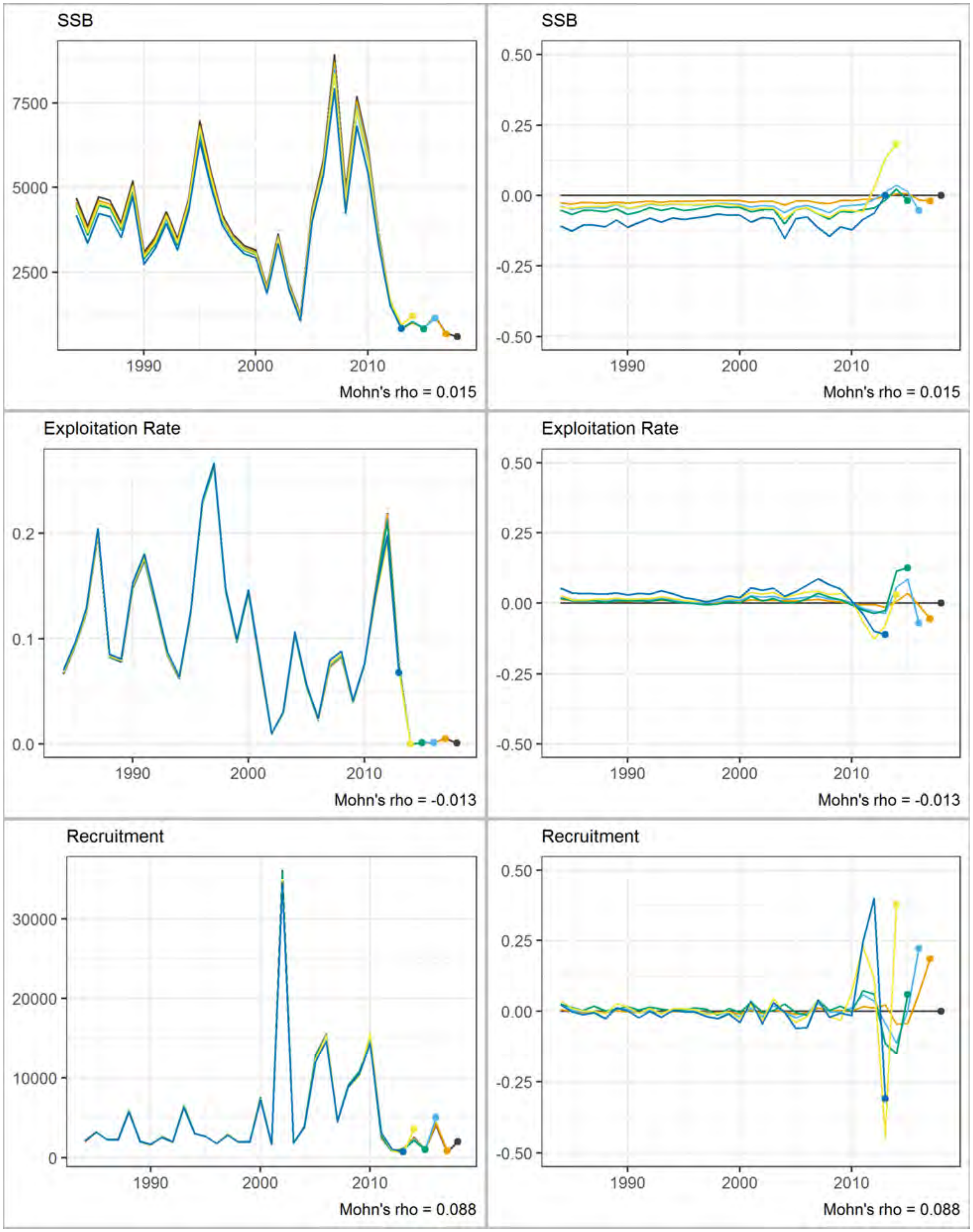


Figure 24. **Retrospective analysis of UME model results for spawning stock biomass (top), exploitation rate (middle), and recruitment (bottom).**

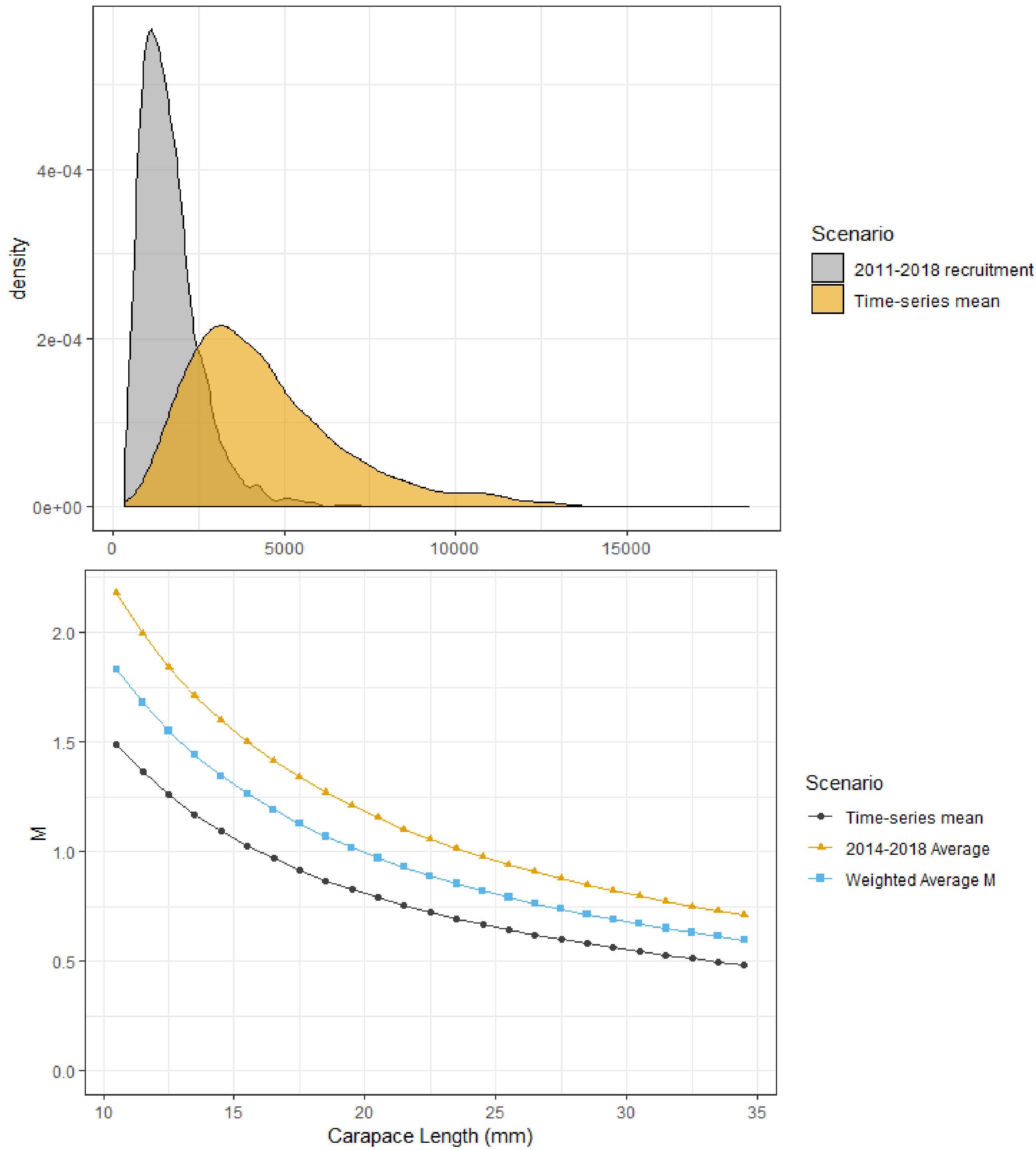


Figure 25. Distribution of recent recruitment and time series mean recruitment (top) and three scenarios of natural mortality (bottom).

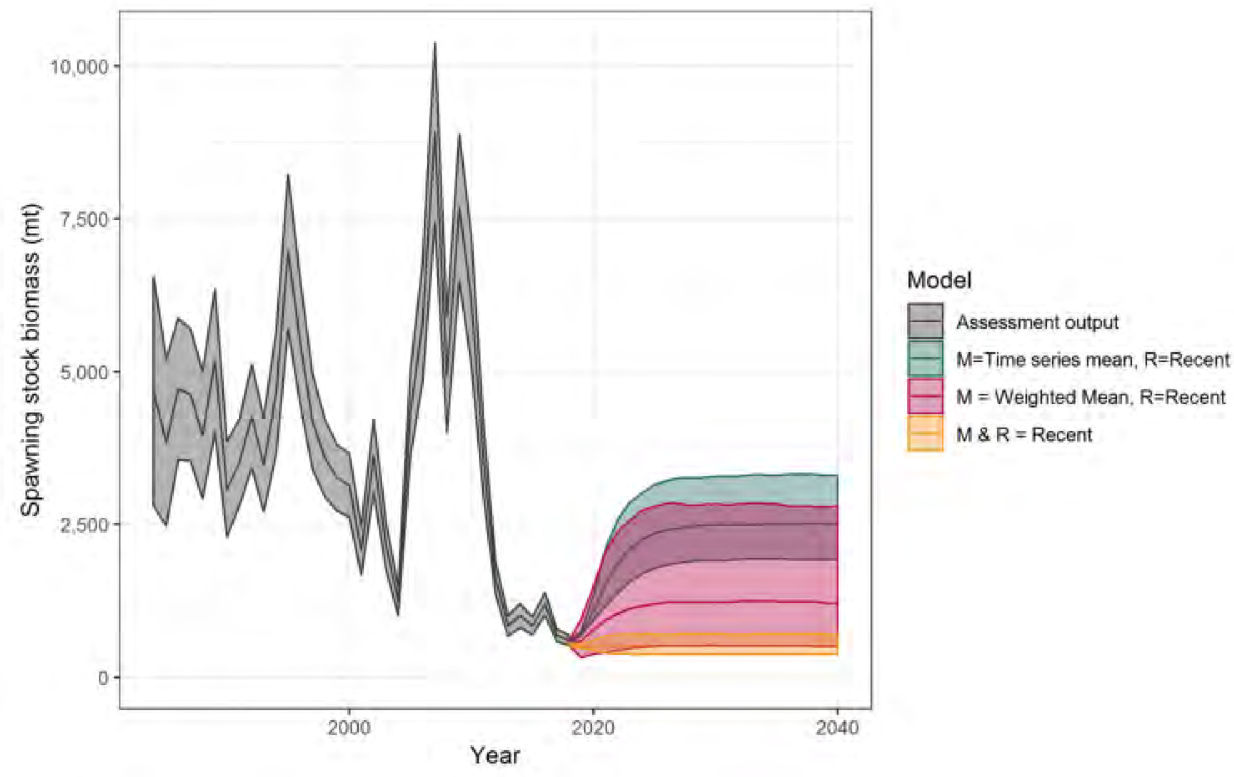


Figure 26. **Trajectory of long term median spawning stock biomass estimates for Gulf of Maine northern shrimp under different natural mortality scenarios in the absence of fishing. Shaded areas indicate 90% confidence intervals.**

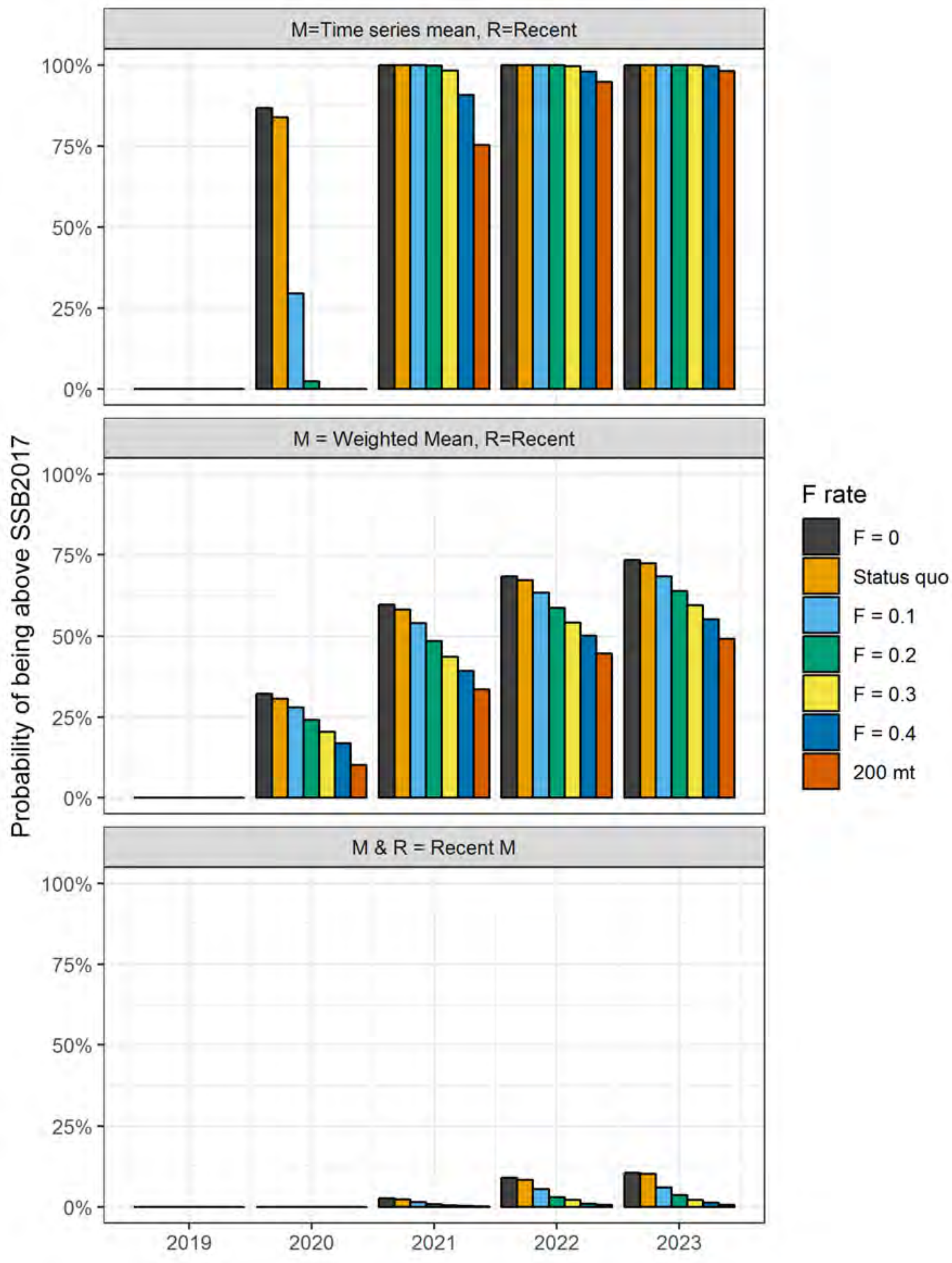


Figure 27. **Probability of SSB being above SSB_{2017} under different fishing mortality scenarios, with M equal to the time series average (top), the weighted average of long-term and recent M (middle), and the recent (2014-2018) average (bottom).**