STOCK STATUS REPORT

FOR

GULF OF MAINE NORTHERN SHRIMP — 2016

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

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<u>TABLE OF CONTENTS</u>

List of Tables

LIST OF FIGURES

APPENDICES

SUMMARY

Landings in the Gulf of Maine northern shrimp fishery since the mid-1980s have fluctuated between 346–9,500 mt, reflecting variations in year class strength as well as regulatory measures, participation, and market conditions in the fishery. Landings in 2013 declined to 346 mt, which was 55% of the TAC set by ASMFC for 2013 (625 mt). The fishery was closed during 2014 – 2016 due to poor resource conditions. Removals in 2014, 2015 and 2016 were 0.3 mt, 6.7 mt, and 13.3 mt, respectively, as part of a cooperative winter sampling program during the moratorium. Catches from the 2016 winter sampling program were primarily of age-3 females (2013 year class).

A benchmark assessment review in 2014 revealed problems with model performance in recent years for Gulf of Maine northern shrimp. The problems were thought to be due primarily to recent extreme fluctuations in abundance. No models were accepted for use in shrimp assessment and management. The current assessment therefore uses an index-based approach to evaluate the condition of the stock. A benchmark assessment which will explore alternative modeling approaches is scheduled for peer-review in 2017.

The index-based assessment approach evaluates a suite of indicators including fishery performance, survey indices of abundance and biomass, and environmental conditions. Abundance and biomass indices for 2012–2016 are the lowest on record of the thirty-three year time series. Recruitment indices for the 2010–2015 year classes are also poor and include the three smallest year classes on record. As a result, the 2012–2016 indices of harvestable biomass are the lowest on record. The recruitment index increased in 2016 but is still well below the stable period mean (13th lowest value on record). Current harvestable biomass is almost entirely composed of the 2013 year class. Recruits from the 2015 and 2016 year classes are not expected to reach exploitable size until 2018 and 2019, respectively.

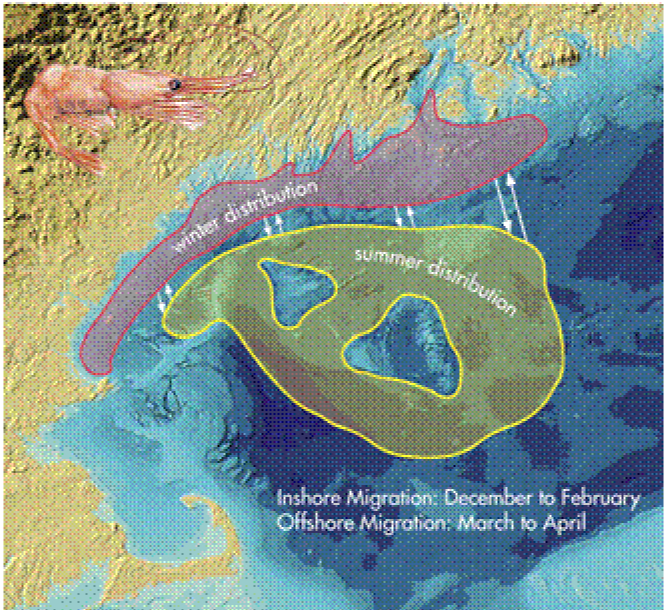
Recruitment of northern shrimp is related to both spawning biomass and ocean temperatures, with higher spawning biomass and colder temperatures producing stronger recruitment. Ocean temperatures in western Gulf of Maine shrimp habitat have increased over the past decade and reached unprecedented highs within the past several years. While 2014 and 2015 temperatures were cooler, 2016 temperatures were again high, and temperature is predicted to continue rising as a result of climate change. This suggests an increasingly inhospitable environment for northern shrimp and the need for strong conservation efforts to help restore and maintain a fishable stock.

Given the continued poor condition of the resource and poor prospects for the near future, the NSTC recommends that the Northern Shrimp Section extend the moratorium on fishing through 2017.

Introduction

Biological Characteristics

Northern shrimp (*Pandalus borealis* Krøyer) are hermaphroditic, maturing first as males at about 1½ years of age and then transforming to females at about age 3 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 have extruded 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 somewhat 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.



Distribution of adult female northern shrimp (NAMA, 2006)

Fishery Management

The Gulf of Maine Northern Shrimp fishery is managed by the 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 the Atlantic States Marine Fisheries Commission (ASMFC). The Fishery Management Plan (FMP) for Northern Shrimp was first approved under the ISFMP in October 1986 (McInnes 1986, ASMFC 1986).

In 2004, the Section implemented Amendment 1 which established biological reference points for the first time in the northern shrimp fishery and expanded the tools available to manage the fishery. Management of northern shrimp under Amendment 1 resulted in a rebuilt stock and increased fishing opportunities. However, early season closures occurred in the 2010 and 2011 fishing seasons due to landing rates being greater than anticipated, and untimely reporting, resulting in short notice of the season closures and an overharvest of the recommended total allowable catch (TAC).

In 2011, the Section implemented Amendment 2 which completely replaced the FMP. The amendment provided management options to slow catch rates throughout the season, including trip limits, trap limits, and days out of the fishery. The amendment also modifies the fishing mortality reference points to include a threshold level, includes a more timely and comprehensive reporting system, and allows for the initiation of a limited entry program to be pursued through the adaptive management process.

In November 2012, the Section implemented Addendum I to Amendment 2. The addendum, clarifies the annual specification process, and allocates the annual hard TAC with 87% for the trawl fishery and 13% for the trap fishery based on historical landings by each gear type. Addendum I also implemented a season closure provision designed to close down the northern shrimp fishery when a pre-determined percentage (between 80–95%) of the annual TAC has been projected to be caught. Lastly, the addendum instituted a Research Set Aside (RSA) program which allows the Section to "set aside" a percentage of the annual TAC to help support research on the Northern Shrimp stock and fishery. The Section may set a RSA during years of a moratorium.

Since the implementation of Amendment 2 the Gulf of Maine northern shrimp fishery and population has experienced significant changes. Also, substantial changes in other Northeast fisheries resulted in increased effort in the northern shrimp fishery in 2010 – 2012. This increased fishing pressure, coupled with failed recruitment, the lowest abundance indices on record, and unfavorable environmental conditions have resulted in a highly uncertain future for the resource. To address these uncertainties, the Section initiated development of Amendment 3 in June 2014, which considers management measures to control effort and stabilize the fishery. The Section is expected to consider Draft Amendment 3 for public comment this winter of 2017.

Biological Reference Points

Biological Reference Points Defined in Amendment 2		
Reference Point	**Value**	**Definition**
F_{target}	0.29	Average fishing mortality rate during 1985 to 1994 when biomass and landings were "stable"
$F_{threshold}$	0.37	F_{1987} = maximum annual F during the same stable period (1985–94)
F_{limit}	0.60	Value that was exceeded in the early to mid-1970s and in the mid-1990s when the stock collapsed
$B_{threshold}$	9,000 mt	Based on historical abundance estimates and response to fishing pressure. B_{limit} set at 2,000 mt higher than the lowest observed biomass at that time.
B_{limit}	6,000 mt	

Fishing mortality (F) and biomass (B) reference points described in Amendment 2 are presented in the table above. F reference points were re-estimated by the NSTC in 2013 as F_{target} = 0.38 and $F_{threshold}$= 0.48. F_{limit} was not re-estimated within the assessment framework. The F reference points were estimated under the assumption of natural mortality (M) = 0.25, as specified in Amendment 2. Higher values of M are considered more realistic (e.g. M = 0.5); however using a higher constant value for M does not generally alter conclusions about stock status because the increased M scales the entire assessment. Overfishing is occurring if the $F_{threshold}$ is exceeded.

Amendment 2 does not specify a biomass target because the Section did not want to set unlikely goals for a species whose productivity is sensitive to environmental conditions. The Section stresses that the threshold is not a substitute for a target. The Section will manage the fishery to maintain stock biomass above the threshold. Furthermore, the Section's management decisions will be affected by the year class composition of the stock.

Annual Fishery Specifications Process

The process for setting fishery specifications under Amendment 2 is as follows: The NSTC annually reviews the best available data including commercial landings, stock status and survey indices, assessment modeling, etc., and recommends an annual total allowable catch (TAC) to maintain healthy stock status relative to peer reviewed biological reference points. The Section meets annually during a public meeting in the fall to review the Advisory Panel and NSTC's recommendations, set a target TAC, and specify any combination of management measures outlined in Section 4.1 of Amendment 2 through a majority vote. Refer to Appendix 1 for NSTC recommendations and subsequent management action by year from 1986 – 2016.

2014 Benchmark Assessment Review

A set of three stock assessment models for northern shrimp were presented to the Northeast Fisheries Science Center's Stock Assessment Workshop (SAW) for review as part of the most recent benchmark assessment (NEFSC 2014). Several important conclusions came from the peer review panel. These are summarized below (the reviewers' reports can be accessed at http://www.nefsc.noaa.gov/saw/saw58/index.html.):

- Despite the high quality data available for northern shrimp, the models have difficulty fitting the data because of extreme fluctuations in recent years, including the exceptionally high 2006 shrimp survey index, and the sudden decline of all indices in 2012 followed by sustained extreme lows.
- A new statistical framework was developed for the catch-survey analysis (CSA, Collie and Sissenwine 1983; Cadrin et al. 1999). CSA has been used to guide management decisions in the shrimp fishery since 1997. The review panel considered the new statistical framework an important advance, but felt the results were overly sensitive to weightings chosen for different components of the model (e.g. catch data, survey data), and on this basis rejected the new CSA for management use. They were not able to comment on the applicability of the previously-accepted version of CSA because there was insufficient time to review the previous version.
- The review panel concluded that a new length-based model developed for northern shrimp has promise but needs further development and testing before application to management.
- The review panel agreed that the use of a surplus production model (ASPIC) as a confirmatory analysis should be discontinued. ASPIC is unable to adequately handle the large fluctuations in recruitment which are typical of northern shrimp population dynamics.

In light of the review panel's comments on the new version of CSA, the NSTC conducted exploratory work to evaluate whether the previous CSA version had similar issues (these issues could not have been detected under the previous statistical framework). The results of the exploratory analysis suggest that the previous CSA also had difficulty with the major swings in data in recent years, although the conclusions with respect to overfishing status were robust and did not differ with different weighting scenarios.

Given the results of the benchmark assessment review and exploratory CSA analysis, the NSTC is not presenting modeling results in this stock assessment. Instead, stock status is evaluated using an index-based approach.

Management in the 2014 – 2016 Fishing Seasons

Following the 2013 stock status report, the Northern Shrimp Section imposed a moratorium on the fishery for the 2014 season. The Section considered several factors prior to closing the fishery in 2014. Northern shrimp abundance in the western Gulf of Maine had declined steadily since 2006. The 2012 and 2013 survey indices of total biomass and spawning stock biomass were the lowest on record. Additionally, the stock experienced failed recruitment for three consecutive years prior to 2014 (2010–2012 year classes). The 2014 and 2015 stock status reports indicated continued poor trends in biomass, recruitment, and environmental indices which prompted the Section to extend the moratorium through 2015, and again through 2016. Winter sampling via selected commercial shrimp vessels occurred in 2014, 2015, and 2016 to continue the time series of biological samples that had been obtained from the Gulf of Maine northern shrimp fishery during the fishery moratorium.

COMMERCIAL FISHERY TRENDS

Most northern shrimp fishing in the Gulf of Maine is conducted by otter trawls, although traps are also employed off the central Maine coast. According to federal and state of Maine vessel trip reports (VTRs), trappers averaged 12% of Maine's landings during 2001 to 2007, 18% during 2008 to 2011, and 9% in 2012 (Table 4). Otter trawling effort has accounted for between 78% and 96% of Maine's landings during 2000 to 2013. Harvester reports indicate that trappers accounted for about 7% of Maine's landings in 2013, the lowest since 2004 (4%).

Landings, 1969–2013

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, Table 3 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, at the time, the lowest northern shrimp landings since the fishery was closed in 1978. 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. The proposed 180-day season for 2010 was cut short to 156 days with 6,263 mt landed, due to the industry exceeding the total allowable catch (TAC) for that year, and concerns about catching small shrimp.

As in 2010, the 2011 season was closed early due to landings in excess of the TAC. A total of 6,397 mt of shrimp were landed, exceeding the recommended TAC of 4,000 mt by approximately 2,400 mt (Table 1 and Figure 1). The average price per pound was $0.75 and the estimated 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 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%. 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 an estimated landing 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). The trawl fishery was allocated a 539.02 mt TAC and the trap fishery was allocated an 80.54 mt TAC. Trawlers fished for 54 days and trappers fished 62 days culminating in 345.5 mt landed, which is 280 mt under the TAC. The average price per pound was $1.81 and is the highest observed since 1989 (inflation-adjusted values, Table 2) with an estimated value of $1,375,788.

Cooperative Winter Sampling/Research Set Aside Program, 2014–2016

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 (Hunter 2014). No shrimp were landed during the 2014 cooperative winter sampling program, except the collected samples. In 2015, the sampling program was expanded; four trawlers and five trappers collected northern shrimp samples in the Gulf of Maine during January – March under the research set aside (RSA) program implemented through Addendum II to Amendment 2 (Whitmore et al. 2015). 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). In 2016, also under the RSA provision, four trawlers and two trappers collected northern shrimp samples in the Gulf of Maine during January – April (Hunter 2016). 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 Monhegan Island), and Eastern Maine (east of Monhegan Island). During 2015 and 2016, 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, and made no more than five trips. Also, in 2015, four trappers were selected from Midcoast and Eastern Maine and each fished ten traps, tended as often as needed. In 2016, two trappers were selected from midcoast Maine and each fished forty traps, tended as often as needed. In the 2015 RSA fishery, about 6.7 mt were landed. In the 2016 RSA fishery, about 13.3 mt were landed.

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. Data were expanded from the sample to the vessel's landings, and then from all sampled landings to total landings for each gear type, state, and month. Size composition data (Figure 2 and Figure 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 were mostly composed of 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 survey).

In the 2009 fishery, landings comprised mainly of 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 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 of 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 (Figure 2) 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) and 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.

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 2016, similar to 2015, 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 (Figure 2). The mid-point of the hatch period was estimated to have been February 23 in New Hampshire, March 7 in western Maine, March 15 in midcoast Maine, and March 11 in eastern Maine. Compared to the longer time series of hatch timing estimates (Figure 19), it appears that hatch metrics in 2014-2016 were similar to pre-2000 fisheries, when the hatch started later and the duration of the hatch period was shorter. Egg hatch trends observed in the 2016 winter sampling were consistent with historical regional trends of hatch beginning and ending earlier in the western Gulf of Maine and later in the eastern Gulf of Maine.

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 and because detailed data for estimating potential discards are lacking, shrimp discards from the shrimp and other fisheries are assumed zero in this northern shrimp stock status report. However in 2014, aside from the 2-kg samples that were provided to Maine DMR for analysis, all catches (0.3 mt) from the cooperative winter sampling program were discarded at sea.

Black Gill Syndrome

Shrimp collected during routine port-sampling in Maine in 2003 exhibited a high incidence (greater than 70%) of Black Gill Syndrome, also called Black Gill Disease or Black Spot Syndrome. Affected shrimp displayed melanized, or blackened gills, with inflammation, necrosis, and significant loss of gill filaments. Black Gill Syndrome was also documented in the Gulf of Maine in 1966 (Apollonio and Dunton, 1969; Rinaldo and Yevich, 1974). Its etiology is unknown, although fungal and ciliated protist parasites have been implicated. In samples collected in Maine during the 2004-2013 fisheries, the incidence of Black Gill Syndrome was much lower, and detected cases were much less severe, than in 2003.

Effort and Distribution of Effort

Since the 1970s, effort in the fishery (measured by numbers of trips in which shrimp gear is used) has increased and then decreased on several occasions. In the 1980s there was a gradual increase in the total number of trips (Table 5; refer to Table 6 for trips in the state of Maine only) to a peak of 12,497 during the 1987 season. Increases in season length, shrimp abundance, and record ex-vessel prices, coupled with reduced abundance of groundfish, all contributed to this increase. Effort subsequently fell to 5,990 trips in the 1994 season. Effort nearly doubled between 1994 and 1996 and then declined again from the 1996 level of 11,791 to 1,304 trips in 2002, a year with only a 25-day open season. Effort increased again during 2003–2005 as the seasons were lengthened, to 3,866 trips in 2005. Effort in 2006 dropped to 2,478, likely due to poor market conditions, increased in 2007 to 4,163, and further increased in 2008 to 5,587, the most trips since 1999.

In 2009, the length of the season was increased to 180 days while effort decreased to 3,002 trips, likely caused by limited demand from the processors and poor market conditions. In what turned out to be a 156-day season in 2010, effort increased dramatically to 5,979 trips. The market conditions were improved from prior years in part due to Canada's limited supply and an increase in local markets. In 2011, the truncated 90-day season yielded a higher effort than 2010 with 7,095 trips. The high level of effort was again due in part due to a limited supply in Canada and demand from local markets. In 2012, the number of trips decreased to 3,666 due to the shortened season. The effort further decreased in 2013 to 1,549 trips, likely due to a low quota and poor fishing conditions (Table 5).

Refer to Figure 5 for comparison of 2016 RSA program trawl and trap locations relative to 2013 fishing effort from VTR data.

The number of vessels participating in the fishery in recent years (prior to the 2014 moratorium) has varied from a high of 347 in 1996 to a low of 144 in 2006. In 2013, there were 208 vessels; 182 from Maine, 13 from Massachusetts, and 14 from New Hampshire, including one that landed in both Maine and New Hampshire (according to harvester logbook data). Of the 182 vessels from Maine, 72 were trappers (Table 7).

Prior to 1994, effort (numbers of trips by state and month) was estimated from landings data collected from dealers, and landings per trip information (LPUE) from dockside interviews of vessel captains:

$$Effort = \frac{Landings}{LPUE}$$

Beginning in the spring of 1994, a vessel trip reporting system (VTR) supplemented the collection of effort information from interviews. From 1995 to 2000, landings per trip (LPUE) from these logbooks were expanded to total landings from the dealer weigh-outs to estimate the total trips:

$$Total.Trips = VTR.Trips \frac{Total.Landings}{VTR.Landings}$$

Since 2000, VTR landings have exceeded dealer weigh-out landings, and the above expansion is not necessary. The 1996 assessment report (Schick et al. 1996) provides a comparison of 1995 shrimp catch and effort data from both the NEFSC interview and logbook systems and addresses the differences between the systems at that time. It showed a slightly larger estimate from the logbook system than from the interview system. Thus effort statistics reported through 1994 are not directly comparable to those collected after 1994. However, patterns in effort can be examined if the difference between the systems is taken into account. An additional complication of the logbook system is that one portion of the shrimp fishery may not be adequately represented by the logbook system during 1994–1999. Smaller vessels fishing exclusively in Maine coastal waters are not required to have federal groundfish permits and were not required to submit shrimp vessel trip reports until 2000. In the 1994–2000 assessments, effort from unpermitted vessels was characterized by catch per unit effort of permitted vessels.

Catch per Unit Effort

Catch per unit effort (CPUE) indices have been developed from NMFS interview data (1983–1994), logbook data (1995–2012), and Maine port interview data (1991–2013) and are utilized as measures of resource abundance and availability (Table 8 and Figure 4). They are typically measured in catch per hour (from Maine interview data) or catch per trip. A trip is a less precise measure of effort, because trips from interviews and logbooks include both trawl and trap trips, and single day trips and multiple day trips (in the spring), and the proportion of such trips can vary from season to season. Also, in some years, buyers imposed trip limits on their boats, and in 2012 and 2013, Maine DMR imposed day-length limits.

Pounds landed per trip (pounds/trip), from VTRs, averaged 1,410 pounds during 1995–2000. In 2001, the catch per trip dropped to 710 pounds, the lowest since 1994, and remained low, at 765 pounds, in 2002. During 2003–2005 pounds per trip averaged 1,407. The increasing trend continued in 2006 with 2,066 pounds per trip. In 2007, the highest pounds per trip of the time series was observed with 2,584 pounds. During 2008–2011, pounds per trip averaged 2,012, with a value of 2,264 in 2010, which is the second highest in the time series. There was a large decrease in 2012 to 1,497 pounds/trip. In 2013, the average pounds landed per trip was 492, with 619 pounds per trawl trip, both the lowest of their time series (Table 8 and Figure 4).

CPUE indices (pounds landed per hour trawling) have also been developed for both inshore (depth less than 55 fathoms) and offshore (depth more than 55 fathoms) areas using information collected by Maine's port sampling program, and agree well with the catch per trip data from logbooks (Table 8 and Figure 4). Maine’s inshore trawl CPUE for 2013 was 118 pounds/hour, offshore was 78 pounds/hour, and the season average was 110 pounds/hour, less than half the time series average of 250 pounds/hour (Table 8).

RESOURCE CONDITIONS

Trends in abundance of Gulf of Maine northern shrimp were monitored during 1963–1983 from data collected in the Northeast Fisheries Science Center’s (NEFSC) autumn bottom trawl surveys and in summer surveys by the State of Maine (discontinued in 1983). The NEFSC fall survey has continued; however, the survey vessel and gear were modernized in 2009, and this is considered the beginning of a new survey time series for shrimp. A state-federal (ASMFC) 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 R/V *Gloria Michelle* employing a stratified random sampling design and shrimp trawl gear designed for Gulf of Maine conditions. An inshore trawl survey has been conducted by Maine and New Hampshire each spring and fall, beginning in the fall of 2000 (Sherman et al. 2005). The NSTC has placed primary dependence on the ASMFC summer shrimp survey for fishery-independent data used in stock assessment, although the other survey data are also considered. See Figure 6 for a map of the areas covered by the different surveys.

Abundance and biomass indices (stratified geometric mean catch per tow in numbers and weight) for northern shrimp from the ASMFC summer survey from 1984–2016 are given in Table 9 and Figures 7–10 and 21, and length-frequencies by year are provided in Figure 11 and 12. Indices were calculated using data from successful random tows in strata (areas) 1, 3, 5, 6, 7, and 8 only (Figure 7). The series averaged 15.8 kg/tow from 1984 through 1990, then gradually declined to 4.3 kg/tow in 2001. Between 2003 and 2006 the index increased markedly, reaching a new time series high in 2006 (66.0 kg/tow). Although 2006 was a high abundance year, as corroborated by the fall survey index, the 2006 summer survey index should be viewed with caution because it was based on 29 survey tows compared with about 40 tows in most years (Table 9). The summer survey index was 16.8 kg/tow in 2008, and dropped steadily to a time series low of 1.0 kg/tow in 2013. Recent values (for 2012-2016) are well below the time series average of 11.9 kg/tow (Table 9). The 2013, 2014, and 2015 biomass indices were the lowest in the series, with a mean weight per tow of 1.0, 1.7, and 1.3 kg/tow respectively. The 2016 value of 3.8 kg/tow is higher than any of the previous four years but is the fifth lowest in the time series, well below the time series average. The total mean number of shrimp per tow demonstrated the same general trend as biomass over the time series (Table 9 and Figure 9).

The stratified mean catch per tow in numbers of assumed 1.5-year-old shrimp (Table 9, Figure 24, and graphically represented as the first (left-most) size mode in Figures 11 and 12) 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 (more than 700 per tow) assumed 1987, 1992, 2001, and 2004 year classes. The assumed 1983, 2000, 2002, and 2006 age classes were weak (fewer than 100 per tow), well below the time series mean of 344 individuals per tow. From 2008 to 2010, the recruitment index varied around 500 individuals per tow, indicating moderate but above average assumed 2007, 2008, and 2009 year classes. The index dropped markedly to 44 individuals per tow in 2011. Time series lows (fewer than 10 per tow) were observed in 2012, 2013, and 2015, indicating recruitment failure of the assumed 2011, 2012, and 2014 year classes. In 2014, the index was 116 per tow, reflecting below-average recruitment of the 2013 year class. The recruitment index for the 2016 survey (the assumed 2015 year class) was 226 individuals per tow, the highest since 2010, but still below the time series average of 344 per tow. Surveys since 2011 have shown an unprecedented six consecutive years (2010–2015 year classes) of below-average recruitment.

Mean numbers per tow at size for 2012 – 2016 are too low to be clearly visible in the figure, which uses a constant y-axis scale for the time series (Figure 11). Expanded vertical axes, for the 2012 – 2016 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 12).

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 and Figure 23). 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 time series low of 1.5 kg/tow, and is indicative of small assumed 1997 and 1998 year classes. The 2001 harvestable index of 1.5 kg/tow represented a time series low, and is indicative of small assumed 1997 and 1998 year classes. From 2003 to 2006, the index increased dramatically, reaching a time series high in 2006 (29.9 kg/tow). 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 times series low in 2014 (0.2 kg/tow), consistent with the low recruitment of the 2010, 2011 and 2012 year classes. The harvestable biomass index has been increasing since reaching a record low in 2014, but the 2016 value of 1.2 kg/tow is the fifth lowest in the time series, reflecting the failed recruitment of the 2012 and 2014 year classes, and the below average recruitment of the 2013 year class.

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 averaged about 4.9 kg/tow during 1984–1993, then declined to an average of 2.7 during 1994–2003, then rose to a time series high of 28.4 in 2006. Since 2006, the index declined to time-series lows (less than 1.0 kg/tow) in 2012–2015, and increased slightly to 1.1 kg/tow in 2016 (Table 9 and Figure 22).

A population egg production index (EPI) was estimated from summer shrimp survey data as the sum of the number of females at length times their fecundity at length:

$$EPI_t = \sum^{L} N_{tL} Fec_L$$

where *t* = year, *L* = carapace length (mm), *N* = abundance of females, Fec_L = fecundity at length. The length-fecundity relationship was derived from data in Haynes and Wigley (1969) (Richards et al. 2012):

$$Fec_L = -0.198L^2 + 128.81L - 17821 \qquad (r^2 = 0.76)$$

The EPI index for Gulf of Maine northern shrimp varied from about 0.3 million to 1.5 million until 2006 when it rose to a high of 5.6 million followed by a steep decline to time series lows in 2012–2015 (<0.2 million; Table 9 and Figure 16). The value was 0.23 million in 2016, the fifth lowest value in the time series.

An index of survival to age 1.5 was estimated for each year class as the log ratio of the number of age 1.5 recruits to the number of eggs that produced each year class, using summer shrimp survey data:

$$S_t = \exp(\ln(R_t) - \ln(EPI_{t-2}))$$

where *S* = survival index, *R* = abundance index of recruits (age 1.5), *t* = year, and *EPI* is expressed in millions. The survival index was high (greater than 1,000) for the assumed 1999, 2001, and 2004 year classes, and low (less than 20) for the 2006, 2011, 2012, and 2014 year classes (Table 9 and Figure 25). The index for the 2015 year class was 5,291, the highest in the time series. This is encouraging, but it should be noted that estimating the survival index (a ratio) is difficult when abundance is at extreme lows, as is currently the case.

The NEFSC fall survey conducted by the NOAA Ship *Albatross IV* provided an index of northern shrimp biomass from 1968 to 2008 (Table 10 and Figure 8). The index was near time series highs (above 3.0 kg/tow) at the beginning of the time series in the late 1960's and early 1970s. In the late 1970s the index declined precipitously to a time-series low (0.2 kg/tow) in 1977 as the stock collapsed; this was followed by a substantial increase in the mid to late 1980's, reflecting recruitment and growth of the strong presumed 1982 and 1987 year classes. The index continued to vary with the influences of strong and weak year classes through the 1990s and 2000s, and the survey ended in 2008 with values well above the time series mean (>1.8 kg/tow) during its last four years, including the time series high of 6.6 kg/tow in 2006. This high value corresponded with the time series high seen in the ASMFC summer survey the same year (Table 9 and Figure 8). In 2009, the NEFSC fall survey changed vessels, gear and protocols, thus indices since 2009 are not directly comparable to earlier years. The biomass index from the new NEFSC fall survey declined rapidly, from 7.8 kg/tow in 2009 to 0.7 kg/tow in 2015, parallel to trends in the summer shrimp survey and the ME-NH survey (Figure 8, Figure 10, and Figure 14). NEFSC fall survey values for 2016 are not yet available.

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 6). 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 in the spring than the fall (Table 11). The stratified geometric mean weights per tow for northern shrimp for the spring and fall surveys using regions 1–4 and depths 3–4 only are presented in Table 11 and Figures 13 and Figure 14. The Maine-New Hampshire spring index rose steadily from 4.2 kg/tow during 2003 to a time series high of 17.9 kg/tow in spring 2011. The index then dropped abruptly, to a time series low of 1.7 kg/tow in 2013 and again in 2015. The preliminary 2016 value was 2.2 kg/tow. 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 2013–2016 biomass indices and size and stage structure in the ME-NH survey (Figure 15) are consistent with the 2013–2016 ASMFC summer survey results.

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. 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 2000 (Richards et al. 2012).

Spring surface and bottom temperature anomalies (temperature changes measured relative to a standard time period) in offshore shrimp habitat areas in 2016 were relatively high and sea surface temperature (SST) approached the record reached in 2012 (Figures 17A and 17C). Spring temperature anomalies were cooler in 2014 and 2015. Fall temperature anomalies were at record highs in 2012, and have remained relatively high since then; however, the fall bottom temperature anomaly was lower in 2015 (the most recent year of data, Figure 17D).

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 2006-2016 (Figure 17E). Average winter SST during 2016 (4.1^o C) was the fourth highest on record since 1906. Late summer SST (July 15-Sept. 1) did not show a similar long term increasing trend during the 20th century, but increased sharply during the mid-1990s, reaching a record high in 2006 (20.2^o C). Late summer SST has remained relatively high since the late 1990s (Figure 17F), and was 17.8 ^{o} C in 2016.

Overall, temperature conditions for northern shrimp have been poor since around 2000. However, temperatures during periods thought to be critical for early life survival were cooler during 2014 and 2015. The 2015 year class appears to have experienced high survival to age 1.5, but not the 2014 year class (Figure 25). Survival indices for the 2016 year class are not yet available. The NSTC notes that accurately estimating survival rates is difficult when the stock is at extremely low levels.

Ocean temperatures also affect timing of the shrimp larval hatch (Richards 2012). The start of the hatch period has become earlier as temperatures have increased, with the hatch in recent years beginning more than a month earlier than it did before 2000 (10% line in Figure 19). The midpoint of the hatch period (50% line in Figure 19) has changed less than the start of the hatch. These trends were not observed during 2014 – 2016, and instead the hatch began later and reached its midpoint later in prior years (roughly 2008 – 2013).

STOCK STATUS

The NSTC utilized an index-based approach to assess stock status of Gulf of Maine northern shrimp. The Traffic Light Approach, developed by Caddy (1999*a*, 1999*b*, 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) to illustrate the state of the population, environmental conditions, and fishery. Red designates unfavorable conditions or status, yellow designates intermediate values, and green designates favorable conditions or status.

The NSTC applied the Strict Traffic Light Approach (STLA, Caddy 1999*a*, 1999*b* and 2004) to a suite of indices (Figure 20). Fishery independent indices included survey total abundance and biomass estimated from the ASMFC summer shrimp and NEFSC fall surveys, and harvestable biomass, spawning stock biomass, recruitment, and early life survival estimated from the ASMFC summer shrimp survey. The survival index represents the number of eggs that survived to become recruits at age 1.5 ($\log_e$ ratio $R/E_{lag\ 2}$, scaled by 1,000,000). Environmental indices included an index of predation pressure on Gulf of Maine northern shrimp that was developed for the benchmark assessment (NEFSC 2014; Richards and Jacobson 2016), and several sources of temperature data for the northern shrimp resource area. Fishery performance indices included commercial CPUE, price per pound, and annual landings value. Price per pound and annual landings values were standardized to 2016 US dollars (www.bls.gov).

Two qualitative stock status reference levels were developed for the traffic light approach, one based on the 'stable period' mean (SPM, 1985–1994), which was the time period used to define the reference points in Amendment 2. The second qualitative status indicator was based on the entire time series of observations. The 20th percentile of the time series (1984-2016) was considered to delineate an extremely adverse state. For fishery dependent and fishery independent indices, red denotes values at or below the 20th percentile, while green denotes values at or above the SPM. For environmental indices, red denotes values at or above the 80th percentile and green denotes values at or below the SPM.

Fishery independent indices of total biomass and spawning biomass have remained at historic lows for the past five years (2012–2016). Recruitment has been low to extremely poor for six consecutive years, and reached a time series low in 2015. The early life survival index for the 2014 year class (observed in the 2015 survey) was low despite cooler spring temperatures observed in inshore nursery areas in 2014. The survival index for the 2015 year class was very high suggesting that an unusually high proportion of the eggs produced in 2015 survived to age 1.5; however recruitment of that year class was weak. The predation pressure index has been lower in recent years (2012–2015), but has generally been high since the late 1990s. Temperatures were at or near record highs in recent years, cooler in 2014 and 2015, and high again in 2016. There were no fishery dependent indices for 2014-2016 due to a fishery moratorium.

The NSTC also examined a subset of key indicators using the Fuzzy Traffic Light Approach (FTLA; McDonough and Rickabaugh 2014). The FTLA gives a finer view of the classification of each indicator in each year. For each indicator, a line graph shows trends in the time series and the relation to the stable period mean (SPM) and 20th percentile levels. A stacked bar graph reflects the proximity of each annual value to the SPM. The greater the proportion of green or red in each stacked bar, the further that year's index is in a favorable or unfavorable direction, respectively, relative to the SPM. A bar that is 100% yellow indicates a value close to the SPM. These reference levels are not management triggers, as they are not defined in the ASMFC Northern Shrimp FMP or its Amendments. The levels are used to illustrate the current condition of the stock relative to earlier time periods.

The NSTC evaluated 10 indicators using the FTLA, including: 1) total biomass, 2) recruit abundance, 3) spawning biomass, 4) harvestable biomass, 5) commercial fishery CPUE (metric tons landed per trip; fishery closed 2014 – 2016), 6) early life survival, 7) predation pressure index (PPI), 8) spring sea surface temperature at Boothbay Harbor, ME, 9) spring bottom temperature anomaly from NEFSC surveys in shrimp resource areas, and 10) summer bottom temperature from the ASMFC summer shrimp survey (1 – 4 and 6 are also from the ASMFC summer shrimp survey).

Total biomass indices have remained below the 20^{th} percentile during 2012–2016, and are also the lowest biomass estimates on record (Table 9, Table 12, and Figure 21). Similarly, spawning biomass and harvestable biomass indices have remained below the 20^{th} percentile during 2012–2016, and are also the lowest estimates on record (Table 9, Table 12, and Figure 22 and Figure 23).

Recruitment was below the 20^{th} percentile in 2012, 2013, and 2015, with the lowest recruitment on record observed in 2015 and second lowest in 2013 (Table 9, Table 12, and Figure 24). In 2013 and 2015, abundance of recruits was less than one shrimp per tow, as compared to the SPM of 382 shrimp per tow. In 2016, recruit abundance increased to 226 shrimp per tow, but was still well below the SPM. Early life survival (to age 1.5) was at or below the 20^{th} percentile for the 2012 and 2014 year classes, with survival of the 2012 year class the lowest on record and 2011 the second lowest (Table 9, Table 12, and Figure 25). Early life survival of the 2013 and 2015 year classes was above the SPM, however recruitment of those year classes was weak. The survival index for the 2015 year class was the highest on record, possibly reflecting favorable temperatures during the larval period; however it should be noted that accurately estimating survival is difficult when the population is at low levels. The 2012–2013 year classes would be the target of a 2017 fishery.

No commercial catch occurred in 2014, 2015, or 2016 due to a harvest moratorium. In 2013, the last year prior to the moratorium, the catch rate was below the 20^{th} percentile and a record low for the time series (Table 12 and Figure 26).

Trends in the four environmental indicators suggest that conditions have not been favorable for northern shrimp in recent years (Table 13). Predation pressure has generally increased since the late 1990s. During 2009-2011, the PPI was above the 80^{th} percentile; however during 2013-2015 it has fluctuated around a lower level (Figure 27). Sea surface and bottom temperatures were colder in 2015 than in recent years, however an overall rise in temperature since the stable period is evident (Figure 28, Figure 29, and Figure 30), with spring anomalies and summer bottom temperatures in offshore shrimp habitat at or exceeding the 80^{th} percentile from 2011 to 2013 and again in 2016 (Table 13, Figure 29, and Figure 30).

Taken together, the FTLA indicators demonstrate that the Gulf of Maine northern shrimp stock status continues to be critically poor. Total biomass, spawning biomass and harvestable biomass have remained at unprecedented lows for five consecutive years. Recruitment of the 2012 and 2014 year classes were the weakest observed in the 33-year index time series, although recruitment increased marginally in 2016 (2015 year class). The higher survival of the 2013 year class may have reflected reduced fishing effort on the spawning stock. Although the stock remains in critically poor condition, the protection of the 2013 year class and the small increase in recruitment in 2016 could provide a foundation for stock recovery if these year classes survive to spawn successfully.

Accepted definitions of stock collapse include a population at 10% of un-fished biomass (Worm et al. 2009) or at 20% of B_{MSY} (Pinsky et al. 2011). Using summer survey biomass indices and the 1984–1993 “stable period” survey mean as a highly conservative proxy for un-fished biomass, the Gulf of Maine northern shrimp stock was considered collapsed during 2012 – 2015, but was slightly above this threshold in 2016. Using the stable period mean as a proxy for B_{MSY} instead (likely a more reasonable assumption), the stock remains in a collapsed state.

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 goal of protecting and maintaining the stock at levels that will support a viable fishery on a sustainable resource (Amendment 2 to the FMP, ASMFC 2011).

Short-term commercial prospects for the 2017 fishing season are very poor given the low index of harvestable biomass in 2016. Longer-term prospects have improved slightly with moderate but below-average recruitment observed in 2016.

Indices of total biomass and spawning biomass have remained at unprecedented lows for five consecutive years, including 2016. The 2016 biomass indices were slightly higher than the previous four years, but were the fifth lowest values on record.

Recruitment failure has been observed in three of the past five years (the 2011, 2012, and 2014 year classes). The 2013 year class, which was well below the long-term average recruit abundance, is responsible for the increase in spawning biomass observed in 2016. They are expected to spawn as four-year-old shrimp in 2017, and likely again in 2018. The 2016 recruitment index (the 2015 year class) was also below the long-term average, but was the highest value observed in the past six years.

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.

Given the continued poor condition of the resource, the poor prospects for a 2017 commercial season, and the value of maximizing spawning potential to rebuild the stock, the NSTC recommends that the Section extend the moratorium on fishing through 2017 to build on the conservation gains from the current moratorium.

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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 (1985–2016, right). Landings by season include the previous December. No shrimp were sold or purchased from cooperative winter sampling in 2014. Landings in 2015 and 2016 are from the RSA Program.

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	2,501.3
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	0.0	0.0	0.0	0.0
2015	6.1	0.6	0.0	6.7
2016	11.5	0.0	1.8	13.3

* Landings by Season include the previous December.

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 1985–2016. No shrimp were sold or purchased from cooperative winter sampling in 2014. 2015 and 2016 prices and value are from the RSA program.

Price $/Lb	Value $
0.32	1,532
0.29	5,002
0.23	20,714
0.20	13,754
0.15	57,382
0.12	66,840
0.12	112,528
0.12	245,469
0.14	549,466
0.12	871,924
0.11	1,611,425
0.12	3,478,910
0.20	4,697,418
0.19	4,653,202
0.19	4,586,484
0.27	5,657,347
0.32	5,577,465
0.26	3,062,721
0.34	764,094
0.55	458,198
0.24	1,758
0.33	320,361
0.65	478,883
0.64	1,516,521
0.60	2,079,109
0.67	2,312,073
0.49	3,474,351

Season	Price $/Lb	Value $	Price ($/Lb) 2016 dollars	Value ($) 2016 dollars
1985	0.44	3,984,562	0.98	8,927,095
1986	0.63	6,451,206	1.39	14,203,612
1987	1.10	12,740,581	2.33	27,050,235
1988	1.10	7,391,777	2.24	14,990,869
1989	0.98	7,177,659	1.91	13,960,583
1990	0.72	7,351,420	1.32	13,568,350
1991	0.91	7,208,838	1.61	12,725,816
1992	0.99	7,547,941	1.70	12,967,590
1993	1.07	5,038,053	1.78	8,409,229
1994	0.75	4,829,106	1.22	7,840,837
1995	0.90	12,828,030	1.42	20,212,800
1996	0.73	15,341,504	1.12	23,554,470
1997	0.79	12,355,871	1.18	18,521,057
1998	0.96	8,811,938	1.42	13,044,435
1999	0.91	3,762,043	1.32	5,429,959
2000	0.79	4,968,655	1.10	6,923,627
2001	0.86	2,534,095	1.17	3,433,191
2002	1.08	1,077,534	1.44	1,437,056
2003	0.87	2,590,916	1.14	3,378,855
2004	0.44	2,089,636	0.57	2,678,370
2005	0.57	3,261,648	0.70	4,028,047
2006	0.37	1,885,978	0.44	2,253,069
2007	0.38	4,087,120	0.44	4,733,474
2008	0.49	5,407,373	0.55	6,017,089
2009	0.40	2,216,411	0.45	2,481,435
2010	0.52	7,133,718	0.57	7,870,739
2011	0.75	10,625,533	0.81	11,424,359
2012	0.95	5,230,481	1.00	5,479,435
2013	1.81	1,375,788	1.87	1,424,395
2014		0		0
2015	3.49	51,269	3.54	52,049
2016	6.67	195,925	6.67	195,925

http://www.bls.gov/data/inflation_calculator.htm
accessed Sep. 23, 2016.

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
1985 Season, 166 days, Dec 1 - May 15								
Maine	335.7	851.8	1,095.5	525.1	116.8	21.5	0.0	2,946.4
Mass.	91.7	283.9	238.3	239.3	57.8	57.0	0.8	968.8
N.H.	67.0	86.2	50.4	11.6	1.3		0.2	216.7
Total	494.4	1,221.9	1,384.2	776.0	175.9	78.5	1.0	4,131.9
1986 Season, 196 days, Dec 1 - May 31, June 8-21								
Maine	346.9	747.8	1,405.3	415.4	104.2	149.2	99.4	3,268.2
Mass.	154.3	213.4	221.2	200.7	111.2	84.8	150.7	1,136.3
N.H.	57.7	75.9	70.8	14.2	1.3	0.0	10.6	230.5
Total	558.9	1,037.1	1,697.3	630.3	216.7	234.0	260.7	4,635.0
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

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
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
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 c								
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								
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		759.9	1,534.4	221.9				2,516.2
Mass.		25.9	86.0	12.2				124.1
N.H.		40.6	133.7	40.4				214.7
Total	0.0	826.4	1,754.0	274.6	0.0	0.0	0.0	2,855.0

Table 3 continued – Landings by season, state, and month. 2015 and 2016 data are for the RSA.

	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	0.0	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
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								
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

conf = Confidential data were combined with an adjacent month.

Table 4: Distribution of landings (metric tons) in the Maine northern shrimp fishery by season, gear type, and month. 2015 and 2016 data are for the RSA.

	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 1									
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	

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

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total	% of total
2008 Season, 152 days, Dec 1 - Apr 3									
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	
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									
2015 Season, Limited research fishery for data collection only									
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 only									
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	

Table 5: Distribution of fishing effort (number of trips) in the Gulf of Maine northern shrimp fishery by season, state, and month. 2015 and 2016 data are for the RSA.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
1985 Season, 166 days, Dec 1 - May 15								
Maine	552	1,438	1,979	1,198	260	35		5,462
Mass.	127	269	224	231	92	73		1,016
N.H.	118	135	78	26	22			379
Total	797	1,842	2,281	1,455	374	108	0	6,857
1986 Season, 183 days, Dec 1 - May 31								
Maine	590	1,309	2,798	831	224	133	68	5,953
Mass.	128	235	225	320	194	133	159	1,394
N.H.	156	163	165	51	3		17	555
Total	874	1,707	3,188	1,202	421	266	244	7,902
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	212	12,497
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.	1,000	2,509	3,146	1,546	219	179		0
Total							0	0
1989 Season,	958	2,479	2,332	936	249	84		
Maine	103	479	402	254	297	102		1,637
Mass.	120	369	312	69	16			886
N.H.	1,181	3,327	3,046	1,259	562	186		9,561
Total							0	0
1990 Season,	1,036	1,710	1,529	1,986	897	238		
Maine	147	459	273	202	175	118		1,374
Mass.	178	363	284	157	6			988
N.H.	1,361	2,532	2,086	2,345	1,078	356		9,758
Total							0	0
1991 Season,	568	1,286	2,070	1,050	438	139		
Maine	264	416	401	231	154	147		1,613
Mass.	279	285	135	82	22	1		804
N.H.	1,111	1,987	2,606	1,363	614	287		7,968
Total							0	0
1992 Season,	411	1,966	2,700	1,222	318	141		
Maine	59	337	145	101	41			683
Mass.	96	153	76	29	3			357
N.H.	566	2,456	2,921	1,352	362	141		7,798
Total							0	0

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
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	0	0	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	0	0	5,990
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	0	0	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	0	11,79
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	0	10,734
1998 Season, 152 days, Dec 1- May 31, 1 day per week 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	1,087	1,964	1,983	929	432	212	0	6,606
1999 Season, 152 days, Dec 1- May 31, 1 day per week 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	0	3,811
2000 Season, 51 days, Jan 17 - Mar 15, Sundays off								
Maine		897	2,494	647				4,038
Mass.		33	117	32	1			183
N.H.		45	201	87				333
Total	0	975	2,812	766	1	0	0	4,554

Table 5 continued – Trips by season, state, and month. 2015 and 2016 data are for the RSA.

	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 ofl								
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, 151 days, 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

	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 (21 days); 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								
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

conf = Confidential data were combined with an adjacent month.

Table 6: Distribution of fishing trips in the Maine northern shrimp fishery by season, gear type, and month. 2015 and 2016 data are for the RSA.

	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	88			1,562	68%
Trap	conf	95	384	257	13			749	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	

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

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total	%
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	
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 Season Closed									
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	

Table 7: Estimated numbers of vessels in the Gulf of Maine northern shrimp fishery by fishing season and state. 2015 and 2016 data are for the RSA.

Season	Maine			Massachusetts	New Hampshire	Total
	Trawl	Trap	Total			
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	0	0	0	0	0	0
2015	3	5	8	1	0	9
2016	3	2	5	0	1	6

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

Table 8: Gulf of Maine northern shrimp trawl catch rates by season. Mean CPUE in pounds/hour towed is from Maine trawler port sampling. Mean catch in pounds/trip is from NMFS weigh-out and logbook data for all catches for all states. Trawl pounds/trip is trawler only catch. Moratorium implemented for 2014 – 2016 seasons.

Season	Maine pounds per hour towing			Pounds/trip	Trawl lbs/trip
	Inshore (<55F)	Offshore (>55F)	Combined		
1991	94	152	140	992	
1992	132	93	117	978	
1993	82	129	92	767	
1994	139	149	141	1,073	
1995	172	205	193	1,360	
1996	340	203	251	1,784	
1997	206	192	194	1,462	
1998	158	151	154	1,391	
1999	148	147	147	1,079	
2000	279	224	272	1,382	1,475
2001	100	135	109	710	752
2002	223	91	194	765	854
2003	174	215	182	981	1,102
2004	361	310	351	1,753	2,006
2005	235	212	228	1,488	1,617
2006	572	345	499	2,066	2,613
2007	531	477	507	2,584	3,119
2008	350	327	343	1,958	2,300
2009	400	315	370	1,837	2,228
2010	424	354	401	2,301	2,704
2011	334	435	347	1,988	2,376
2012	407	313	399	1,495	1,873
2013	118	78	110	492	616

Table 9: Stratified geometric mean number (abundance) and weight (biomass, kg) per tow and derived indices of northern shrimp from summer shrimp surveys (strata 1, 3, 5, 6, 7 and 8). Recruit index is abundance of presumed age 1.5 shrimp. Other derived indices are described in text. YC=year class, EPI=egg production index.

Year	N Tows	Total Abundance	Total Biomass	Recruit Index	Spawner Biomass	EPI millions	YC Survival index	>22 mm* Number	>22 mm Weight (kg)
1984	37	1,152	10.5	18	3.6	0.72		316	3.4
1985	44	1,825	17.7	332	5.7	1.19	496	1,169	11.5
1986	40	1,695	19.6	358	7.2	1.48	287	860	10.0
1987	41	1,533	15.4	342	6.2	1.25	559	854	9.5
1988	41	1,269	12.8	828	2.5	0.52	222	298	3.4
1989	43	1,884	17.0	276	5.0	1.01	274	564	6.1
1990	43	1,623	18.1	142	6.0	1.25	476	1,127	12.0
1991	43	1,256	11.7	482	6.5	1.34	226	657	8.0
1992	45	955	9.4	282	4.3	0.85	565	397	4.8
1993	46	1,157	9.1	757	2.2	0.44	431	250	2.8
1994	43	984	8.7	368	2.3	0.46	664	243	2.7
1995	35	1,449	13.3	292	6.2	1.27	506	628	7.0
1996	32	776	8.8	232	3.1	0.63	294	358	4.0
1997	40	762	7.7	374	2.3	0.48	212	245	2.8
1998	35	583	6.3	134	1.8	0.35	239	170	1.9
1999	42	398	5.8	114	1.5	0.31	1,294	174	1.9
2000	35	808	6.4	450	2.9	0.58	57	283	3.2
2001	36	451	4.3	18	1.7	0.31	1,992	146	1.5
2002	38	1,445	9.2	1,164	2.8	0.54	35	261	2.9
2003	37	564	5.5	11	2.0	0.34	527	173	1.7
2004	35	887	10.3	286	3.1	0.63	5,155	519	5.3
2005	46	3,661	23.4	1,752	9.2	1.89	589	871	10.3
2006	29	9,998	66.0	374	28.4	5.58	15	2,773	29.9
2007	43	887	11.5	28	3.4	0.67	91	412	4.1
2008	38	1,737	16.8	506	5.9	1.22	828	995	10.8
2009	49	1,627	15.4	555	6.4	1.29	391	702	8.5
2010	49	1,373	13.9	475	3.9	0.79	34	413	4.8
2011	47	830	8.6	44	3.0	0.57	8	316	3.2
2012	49	138	2.5	7	0.7	0.15	2	81	0.9
2013	40	27	1.0	1	0.2	0.05	773	24	0.3
2014	46	139	1.7	116	0.3	0.04	17	16	0.2
2015	32	55	1.3	1	0.4	0.08	5,291	41	0.4
2016	41	332	3.8	226	1.1	0.23		103	1.2
Mean	41	1341	11.9	344	4.3	0.86	727	498	5.5
Median	41	984	9.4	286	3.1	0.63	391	316	3.4
1984-93	42	1,435	14.1	382	4.9	1.01	393	649	7.1
Median	43	1,401	14.1	337	5.4	1.10	431	611	7.0

*Would be fully recruited to a winter fishery.

Table 10: Biomass indices (stratified mean kg per tow) from NEFSC fall surveys by vessel. The survey vessel and gear changed in 2009. No conversion factors are available for northern shrimp.

	kg/tow		kg/tow	
Year	*Albatross*	Year	*Albatross*	*Bigelow*
1968	3.2	**1992**	0.4	
1969	2.7	**1993**	1.9	
1970	3.7	**1994**	2.2	
1971	3	**1995**	1.2	
1972	3.3	**1996**	0.9	
1973	1.9	**1997**	1.1	
1974	0.8	**1998**	2.0	
1975	0.9	**1999**	2.3	
1976	0.6	**2000**	1.3	
1977	0.2	**2001**	0.6	
1978	0.4	**2002**	1.7	
1979	0.5	**2003**	1.1	
1980	0.5	**2004**	1.6	
1981	1.5	**2005**	2.8	
1982	0.3	**2006**	6.6	
1983	1.0	**2007**	4.1	
1984	1.9	**2008**	3.1	
1985	1.6	**2009**		7.8
1986	2.5	**2010**		5.0
1987	1.7	**2011**		5.6
1988	1.2	**2012**		2.8
1989	1.8	**2013**		1.2
1990	2.0	**2014**		1.9
1991	0.4	**2015**		0.7

Table 11: Stratified geometric mean weights (kg) per tow of northern shrimp collected during the Maine - New Hampshire inshore trawl surveys by year, regions 1–4 (NH to Mt. Desert) and depths 3–4 (> 35 fa.) only, with number of tows (n) and 80% confidence intervals.

	Spring			Fall		
	kg/tow	n	80% CI	kg/tow	n	80% CI
2003	**4.2**	40	3.4 - 5.1	**1.9**	33	1.4 - 2.6
2004	**3.9**	42	3.3 - 4.5	**1.5**	38	1.0 - 2.1
2005	**7.8**	40	6.6 - 9.2	**3.6**	25	2.5 - 5.1
2006	**11.0**	46	8.5 - 14.1	**2.1**	38	1.4 - 2.8
2007	**10.2**	43	7.6 - 13.7	**4.0**	45	3.1 - 5.1
2008	**15.4**	45	12.7 - 18.6	**3.6**	37	2.3 - 5.4
2009	**9.7**	45	7.7 - 12.1	**2.8**	41	2.3 - 3.4
2010	**15.0**	48	12.1 - 18.5	(samples lost)		
2011	**17.9**	50	14.9 - 21.4	**4.2**	32	3.2 - 5.4
2012	**7.5**	50	6.1 - 9.2	**1.9**	42	1.5 - 2.3
2013	**1.7**	46	1.1 - 2.5	**0.6**	45	0.4 - 0.8
2014	**2.1**	47	1.7 - 2.5	**0.3**	43	0.2 - 0.3
2015	**1.7**	52	1.3 - 2.0	**0.3**	37	0.2 - 0.4
***2016**	**2.2**	48	1.8 - 2.5			

* 2016 data are preliminary.

Table 12: Recent (2013–2016) Gulf of Maine northern shrimp FTLA indicator values relative to reference levels. RED = at or below 20th percentile of time series; YELLOW = between 20th percentile and stable period (1985–1994) mean (SPM); GREEN = at or above SPM.

	Indicator values				Reference levels	
	2013	2014	2015	2016	SPM	20th percentile
Total Biomass	1.0	1.7	1.3	3.8	14.1	5.6
Spawner Biomass	0.2	0.3	0.4	1.1	4.9	1.7
Harvestable Biomass	0.3	0.2	0.4	1.2	7.1	1.7
Recruit Abundance	0.9	116	0.8	226	382	34
Early Life (YC) Survival	773	17	5291		393	57
CPUE (mt/trip)	0.23				0.45	0.40

KEY

- GREEN: ≥ SPM
- YELLOW: > 20th percentile but < SPM
- RED: ≤ 20th percentile

Table 13: Recent (2013–2016) Gulf of Maine northern shrimp FTLA environmental indicator values relative to reference levels. RED = at or above 80th percentile of time series; YELLOW = between 80th percentile and stable period (1985–1994) mean (SPM); GREEN = at or below SPM.

	Indicator values				Reference levels	
	2013	2014	2015	2016	SPM	80th percentile
Predator Predation Index	888	1005	890		546	1133
Boothbay Feb-Mar SST	3.9	2.3	1.4	4.1	2.4	3.6
Spring Bottom Temp NEFSC	1.3	0.5	0.1	1.4	0.4	1.3
Summer Survey Bottom Temp	7.1	6.2	5.8	7.2	5.4	7.0

KEY

- GREEN: ≤ SPM
- YELLOW: < 80th percentile but > SPM
- RED: ≥ 80th percentile

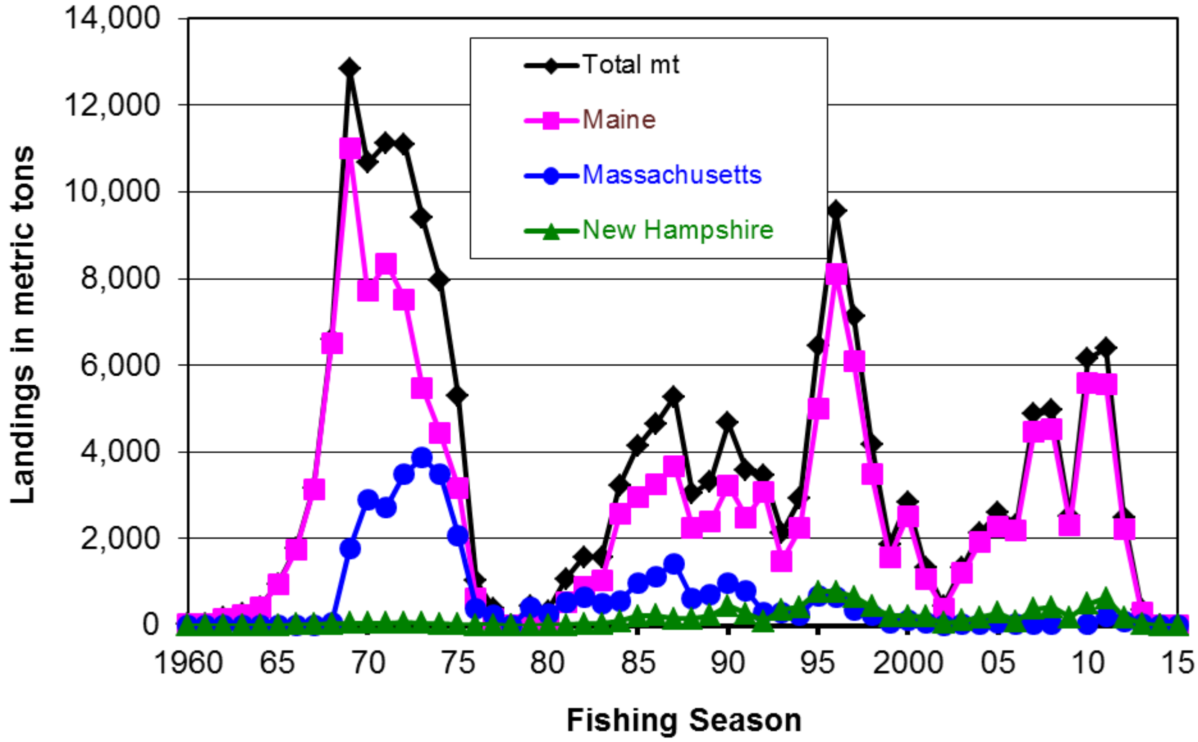


Figure 1: Gulf of Maine northern shrimp landings by season and state. Massachusetts landings are combined with New Hampshire landings in 2009 to preserve confidentiality.

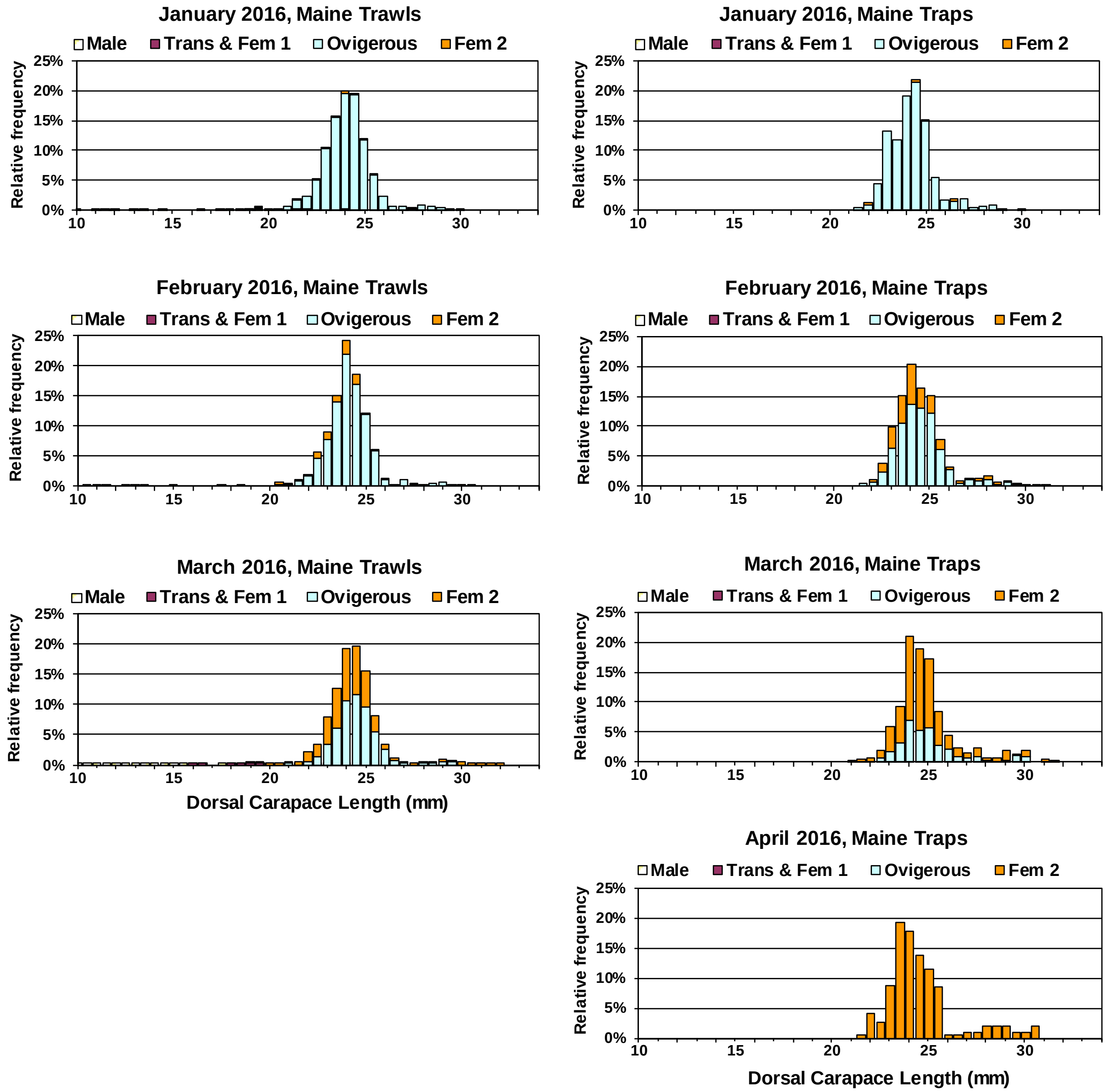
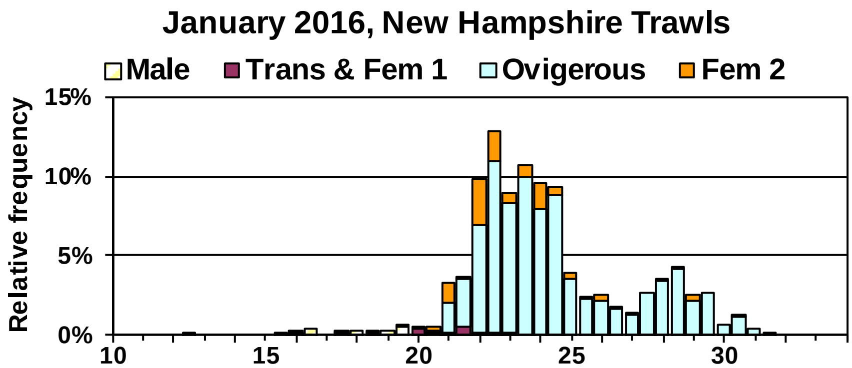
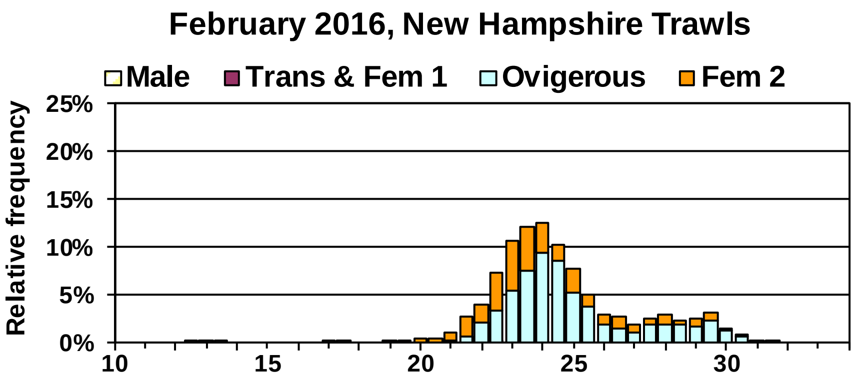


Figure 2: Gulf of Maine northern shrimp size-sex-stage frequency distributions from 2016 winter samples by month — Maine trawls (left) and traps (right). See Hunter 2016 for details.





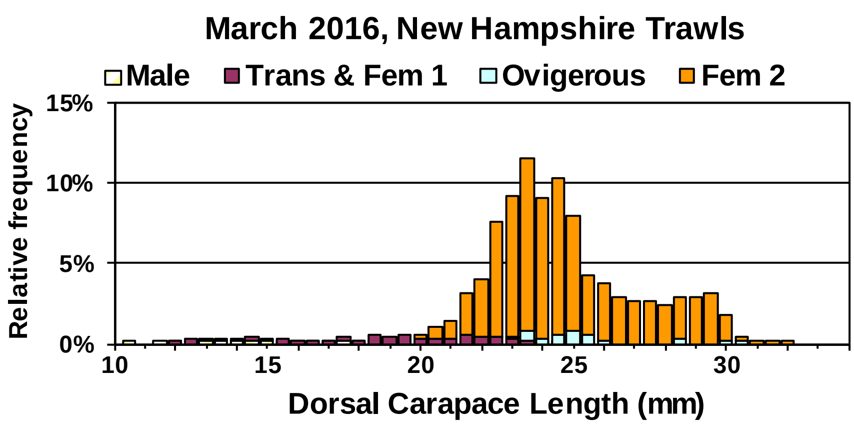


Figure 2 continued. Gulf of Maine northern shrimp size-sex-stage frequency distributions from 2015 winter samples by month — New Hampshire trawls. See Hunter 2016 for details.

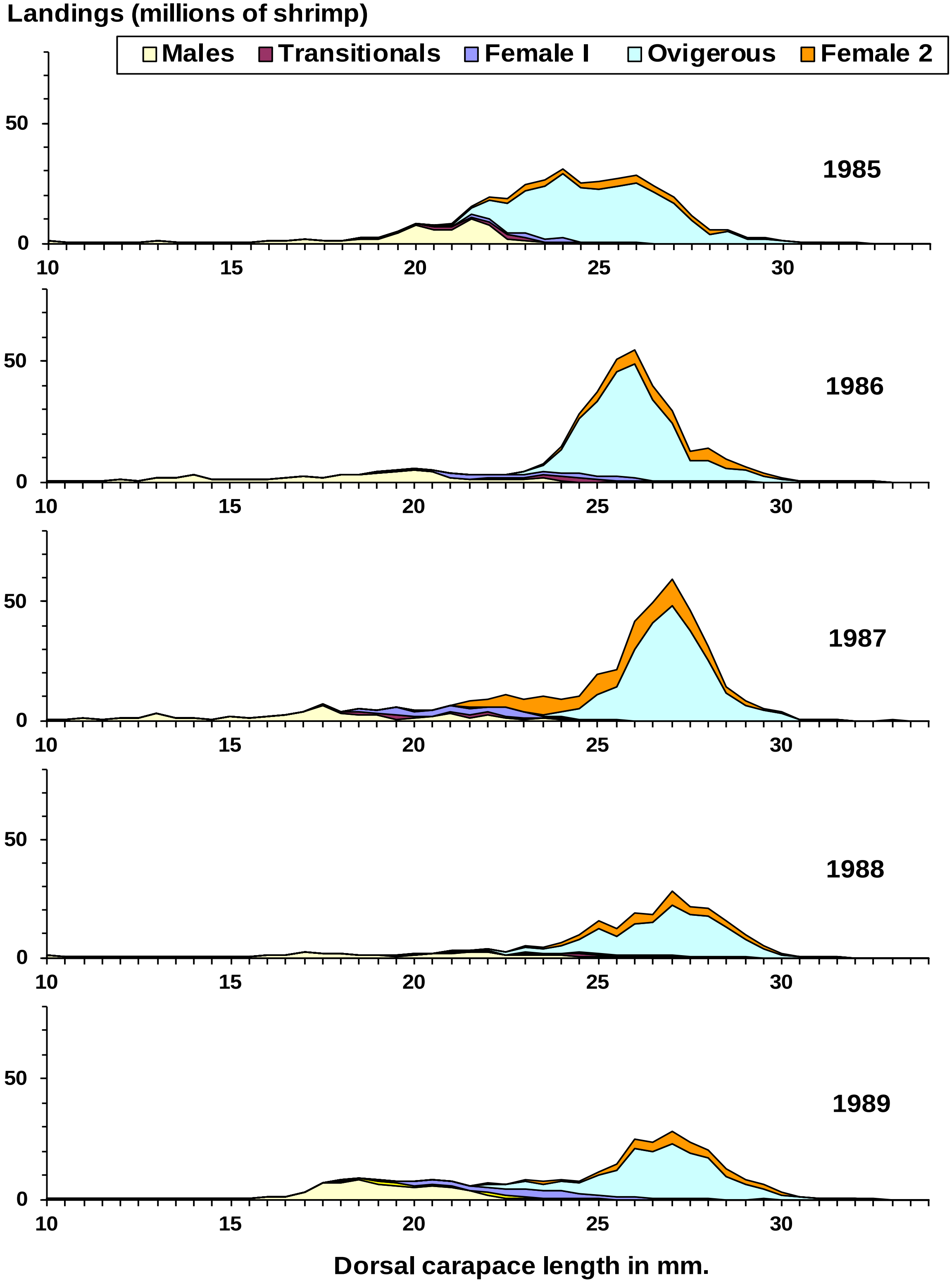


Figure 3: Gulf of Maine northern shrimp landings in estimated numbers of shrimp, by length, development stage, and fishing season.

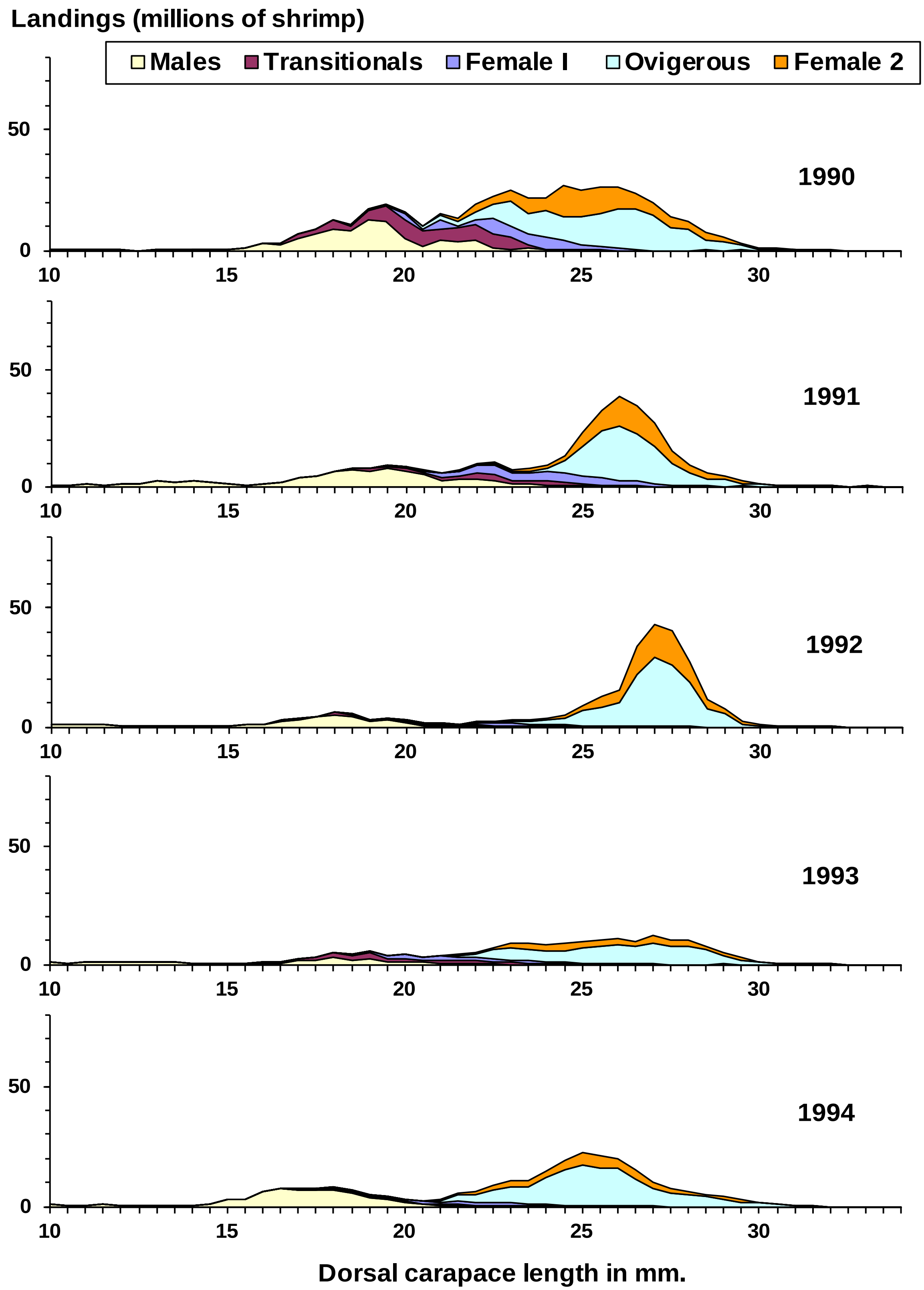


Figure 3 continued – Landings in estimated numbers of shrimp.

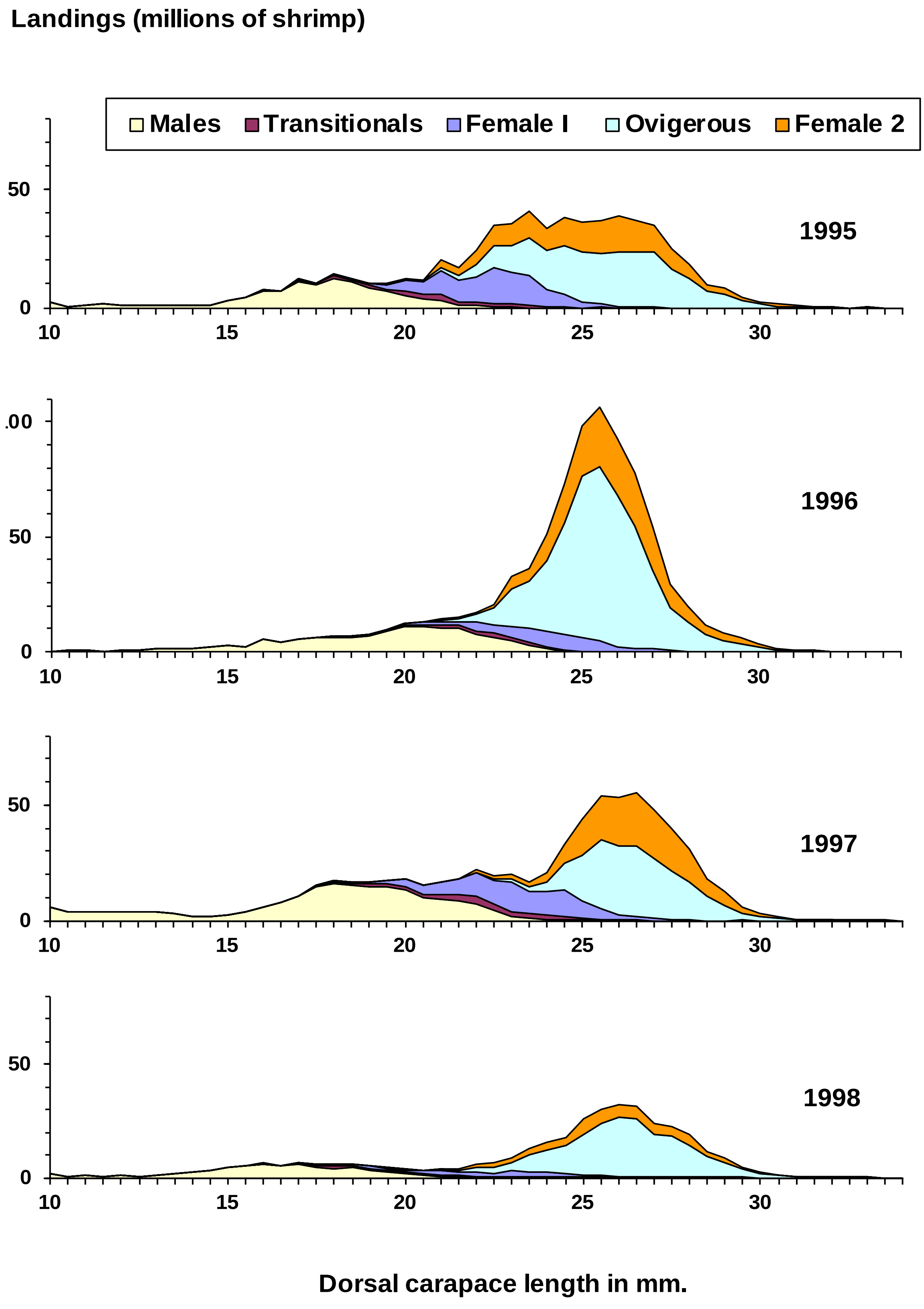


Figure 3 continued –Landings in estimated numbers of shrimp.

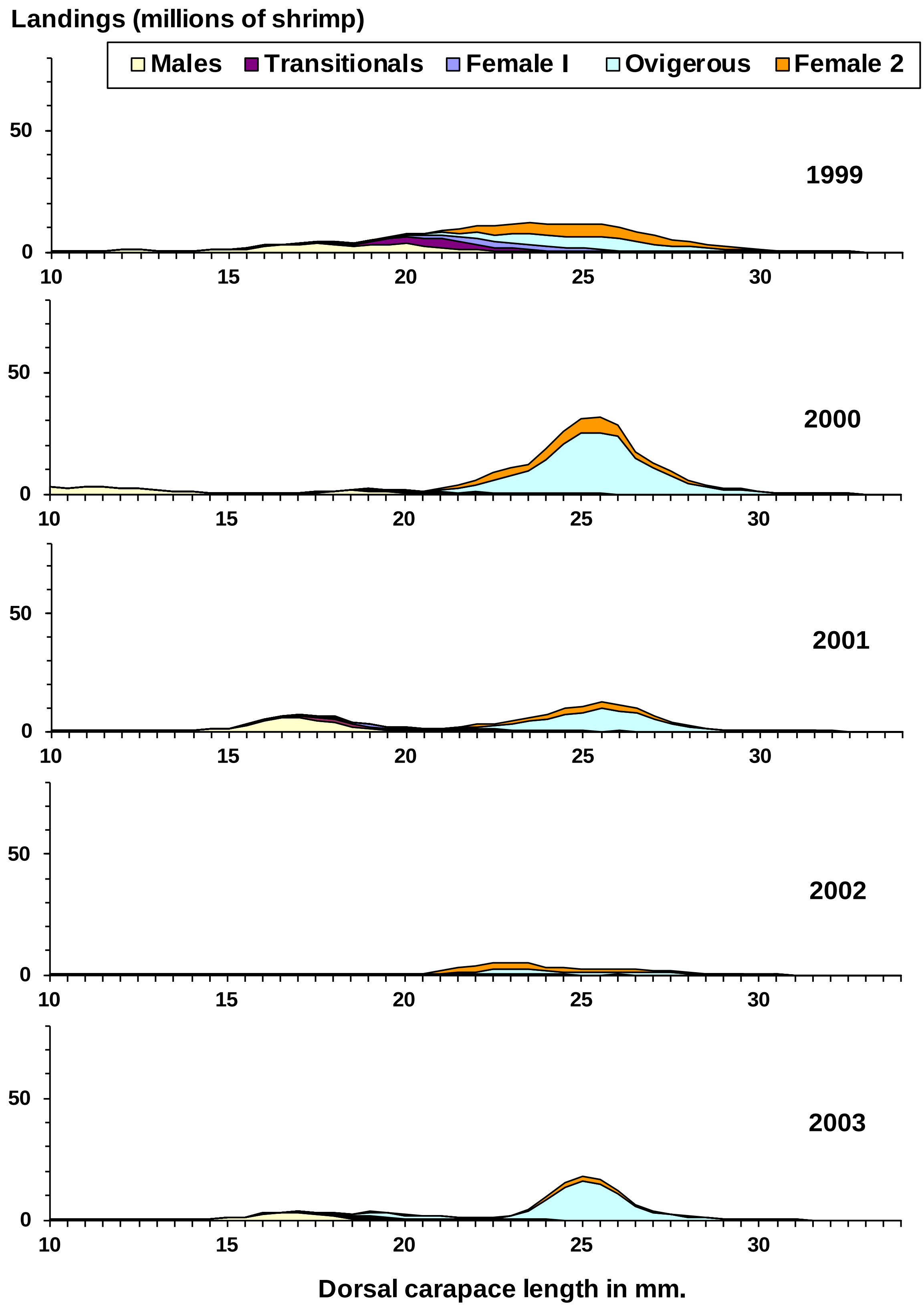


Figure 3 continued – Landings in estimated numbers of shrimp.

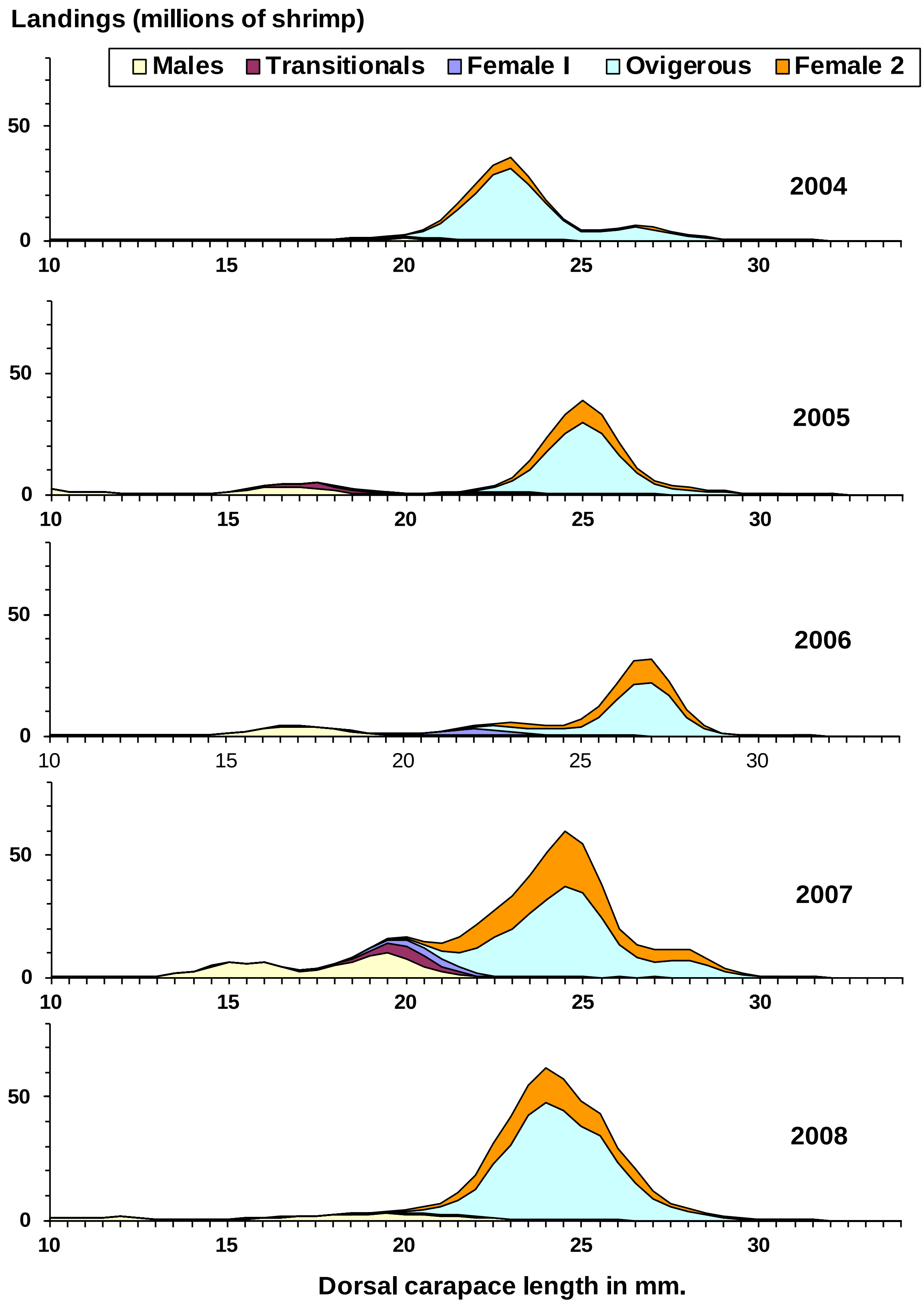


Figure 3 continued – Landings in estimated numbers of shrimp.

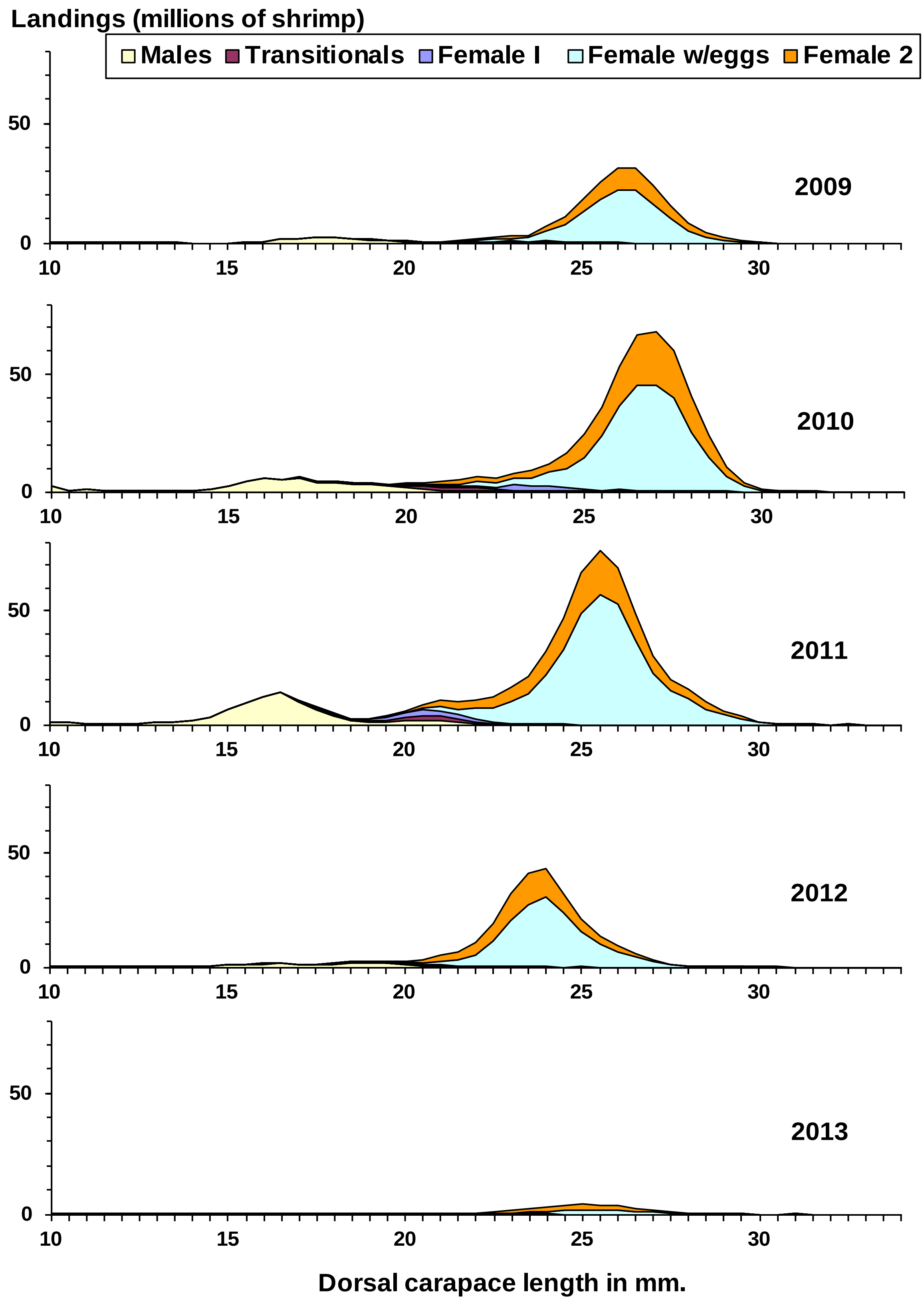


Figure 3 continued – Landings in estimated numbers of shrimp. Data for 2013 are preliminary.

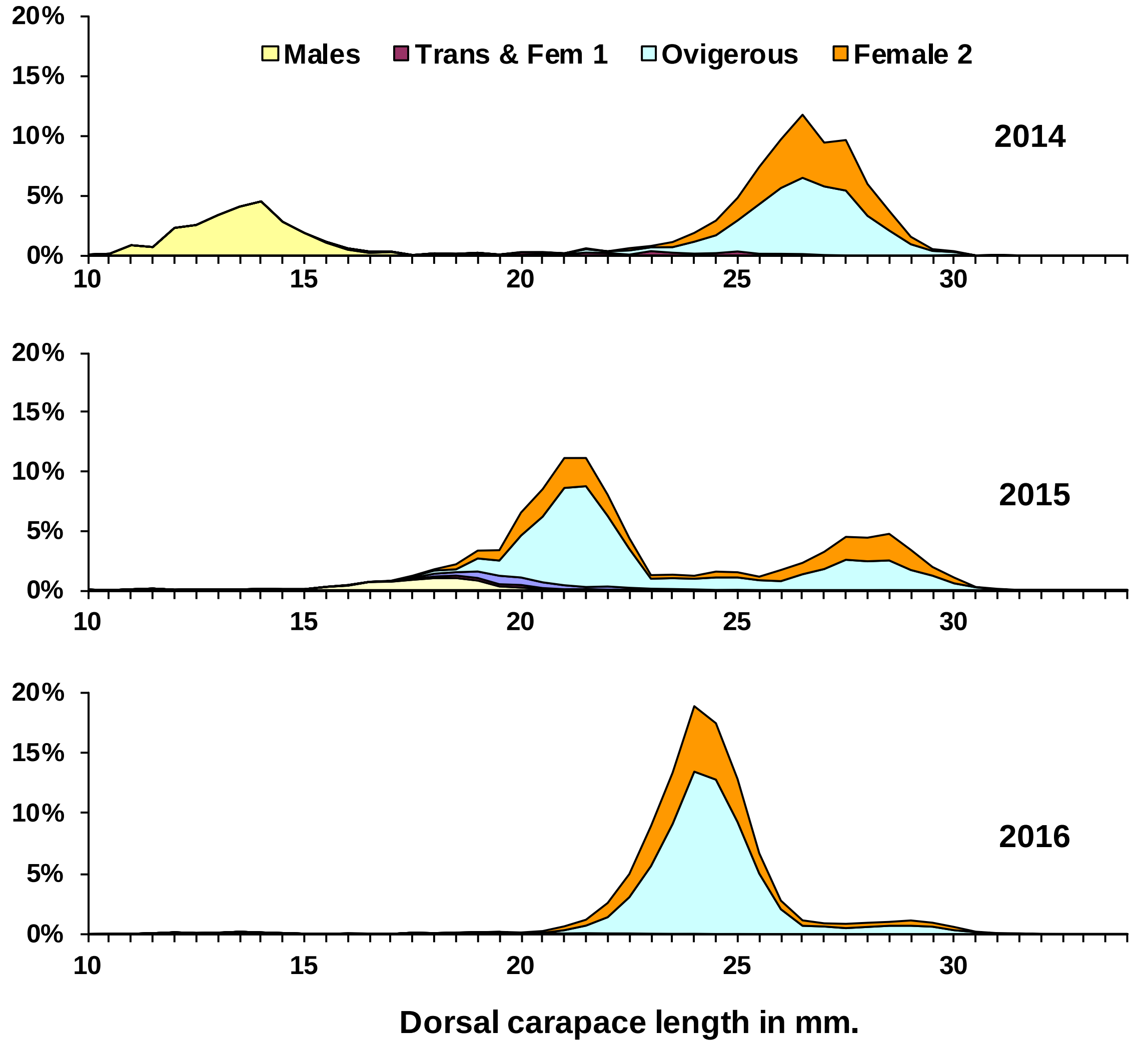
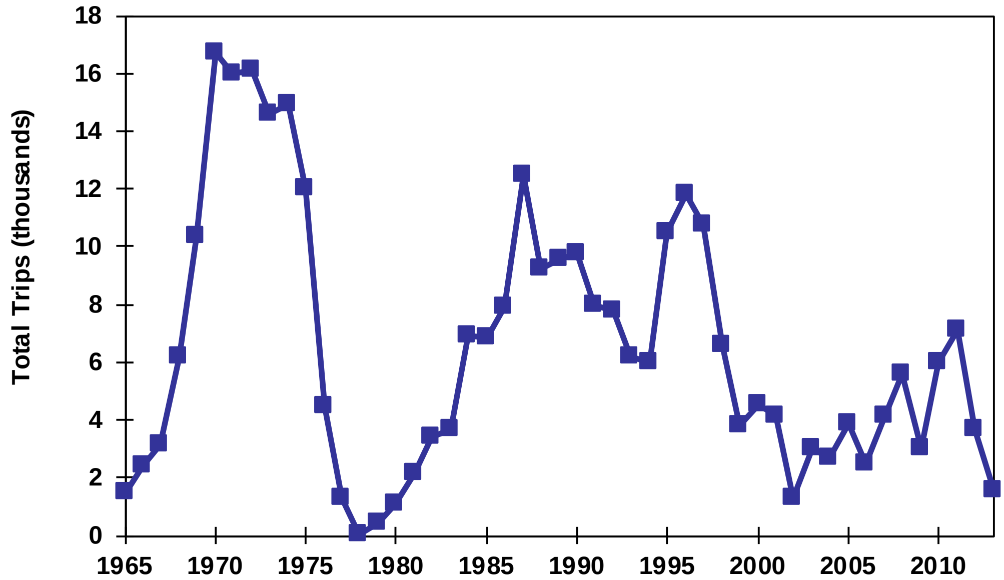


Figure 3 continued – Landings in estimated numbers of shrimp, expressed as percentages. 2014 data are from cooperative winter sampling with no landings. 2015 and 2016 data are from the Gulf of Maine RSA program. See Hunter (2014, 2016) and Whitmore et al. (2015) for details.



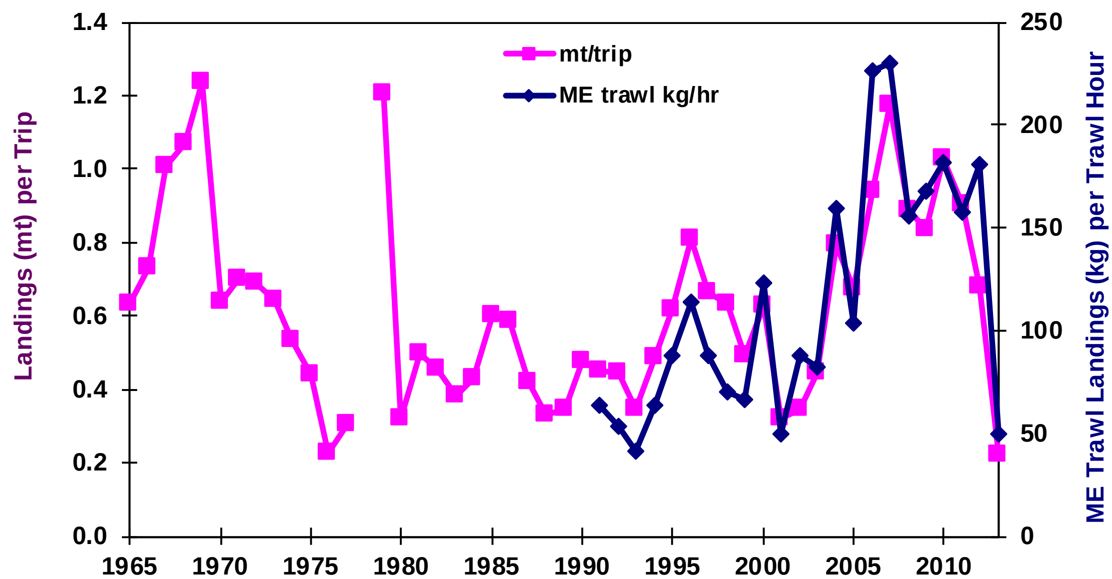


Figure 4: Nominal fishing effort (trips) (above) and catch per unit effort (below), in the Gulf of Maine northern shrimp fishery by season, 1965–2013. There was no fishery in 2014 – 2016.

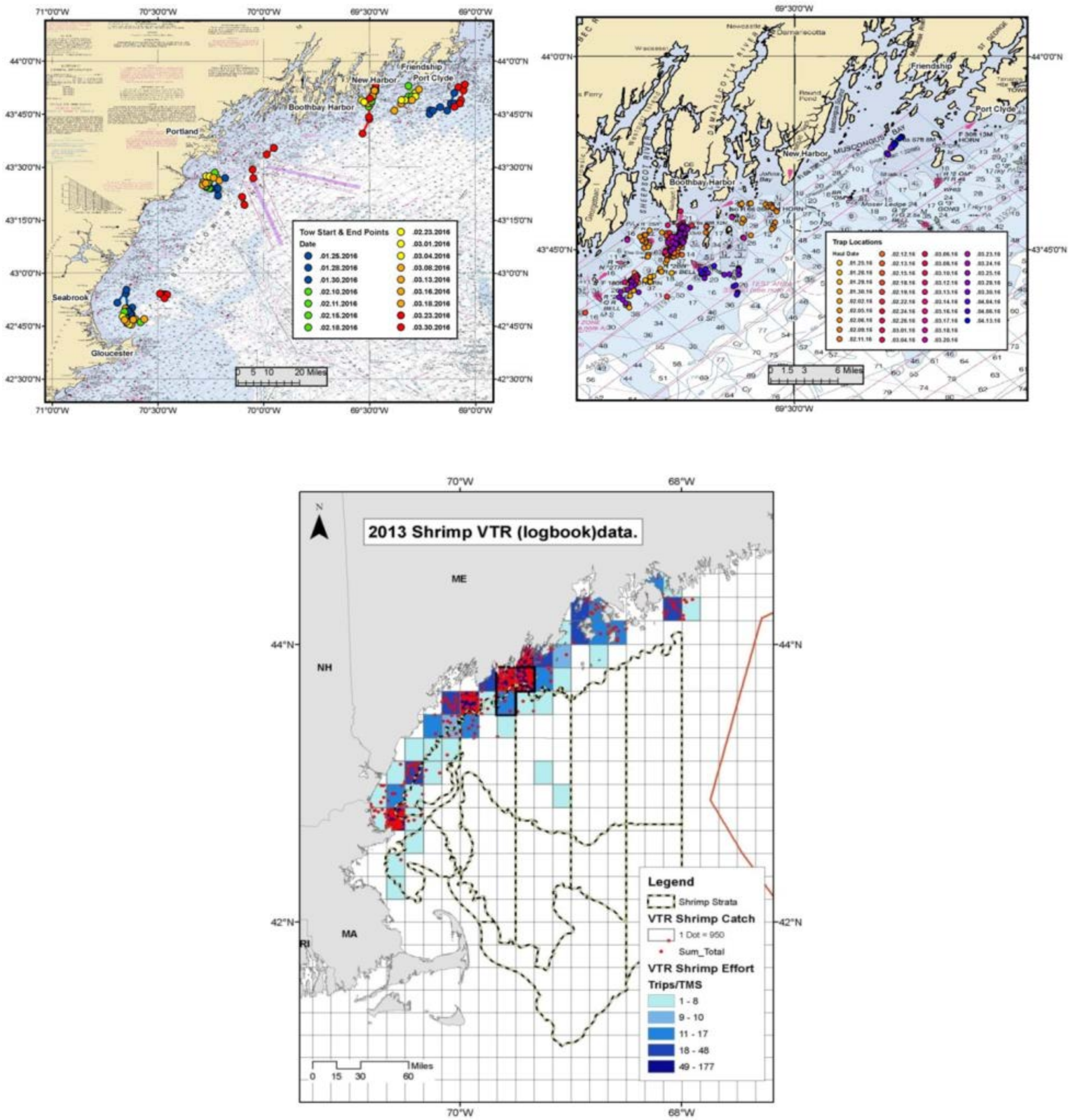


Figure 5: Locations of tows (top left) and traps (top right) for the 2016 Gulf of Maine northern shrimp RSA program relative to 2013 fishing effort from preliminary VTR data (bottom).

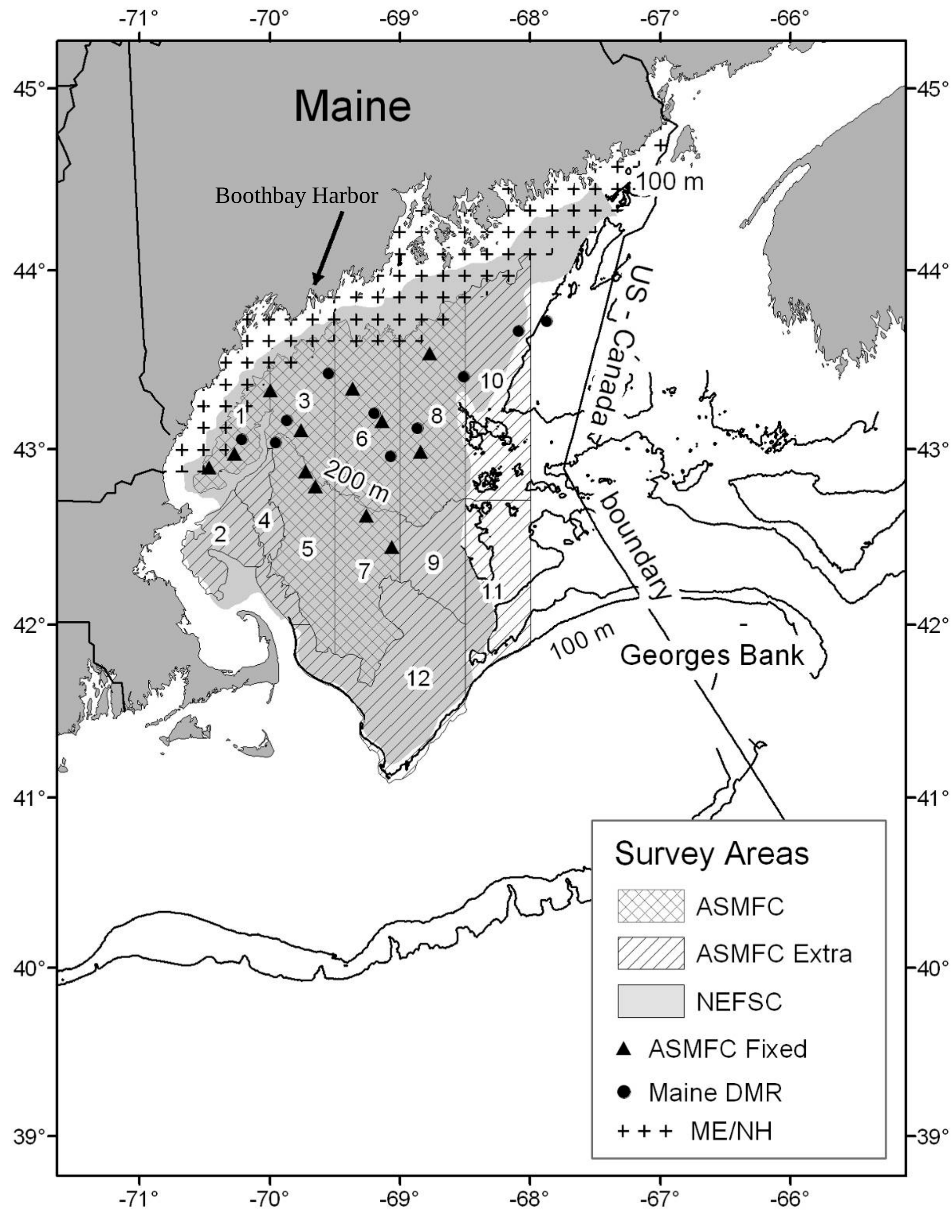


Figure 6. Gulf of Maine survey areas and station locations.

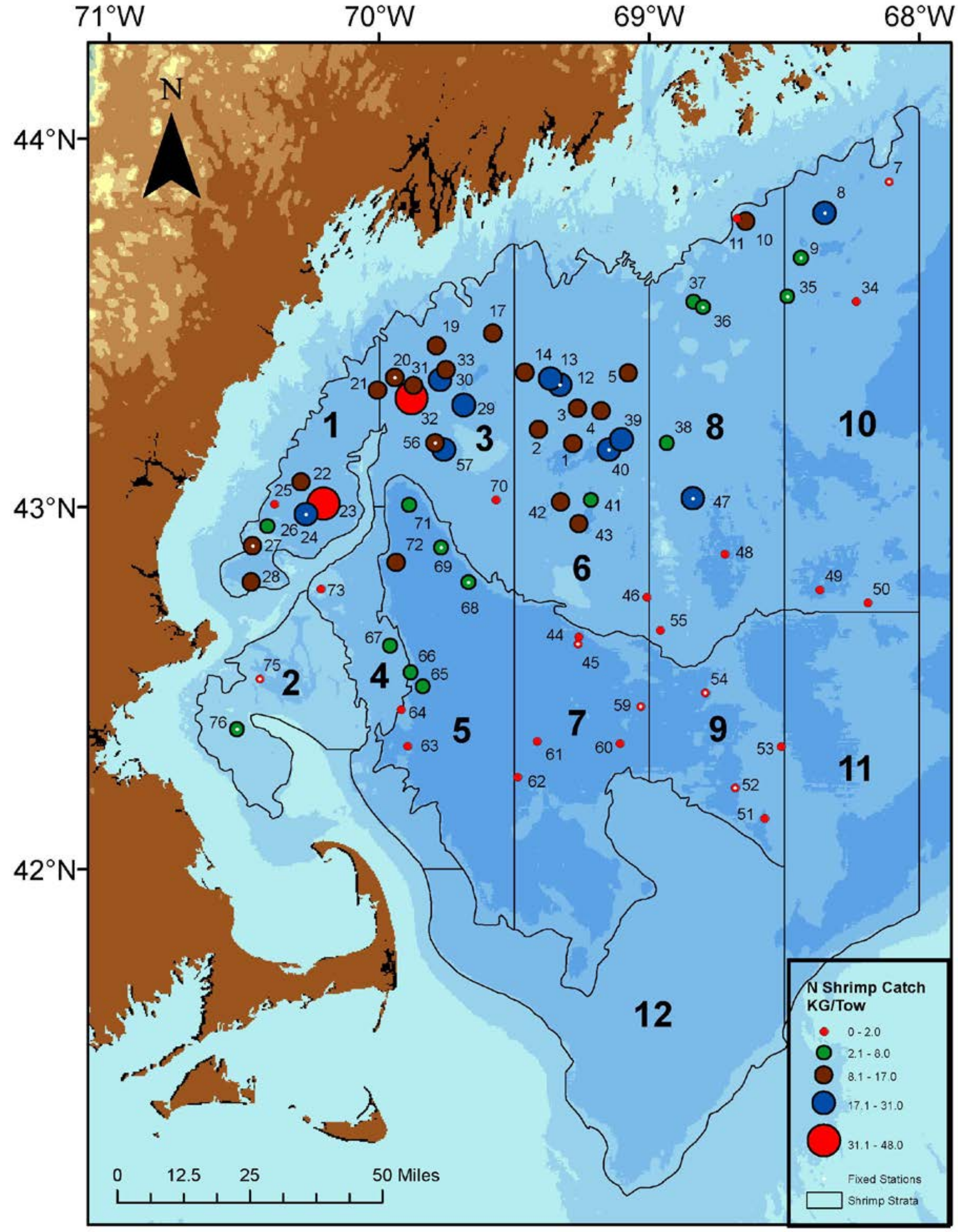


Figure 7. Shrimp catches (kg/tow) at stations surveyed during the 2016 ASMFC northern shrimp summer survey aboard the R/V *Gloria Michelle,* fixed and random survey sites.

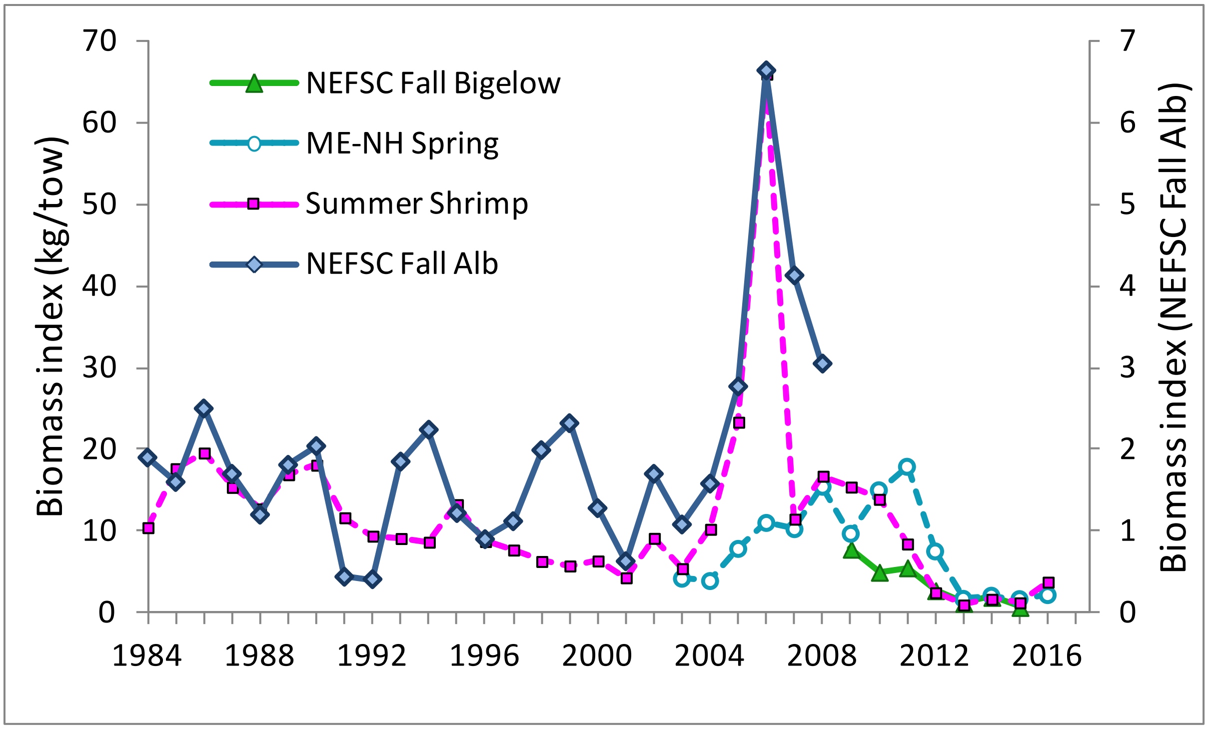


Figure 7: Biomass indices (kg/tow) from various northern shrimp surveys in the Gulf of Maine.

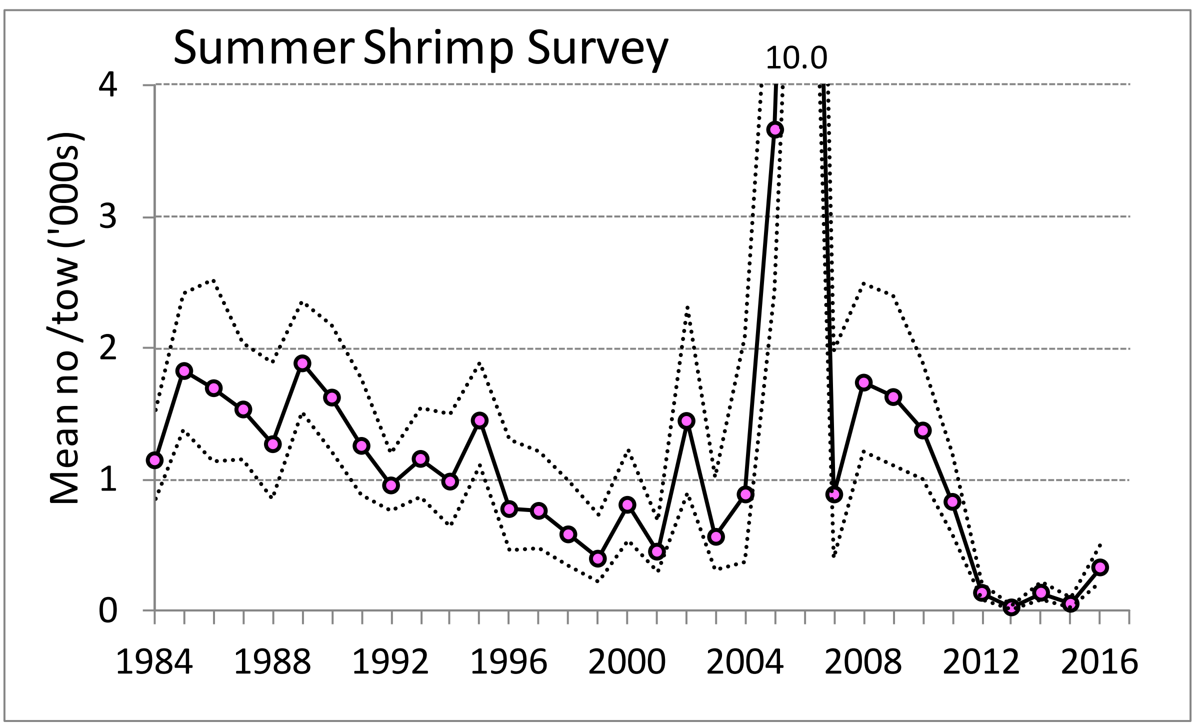


Figure 9. Abundance indices (stratified geometric mean number per tow) of northern shrimp from ASMFC summer surveys in the Gulf of Maine.

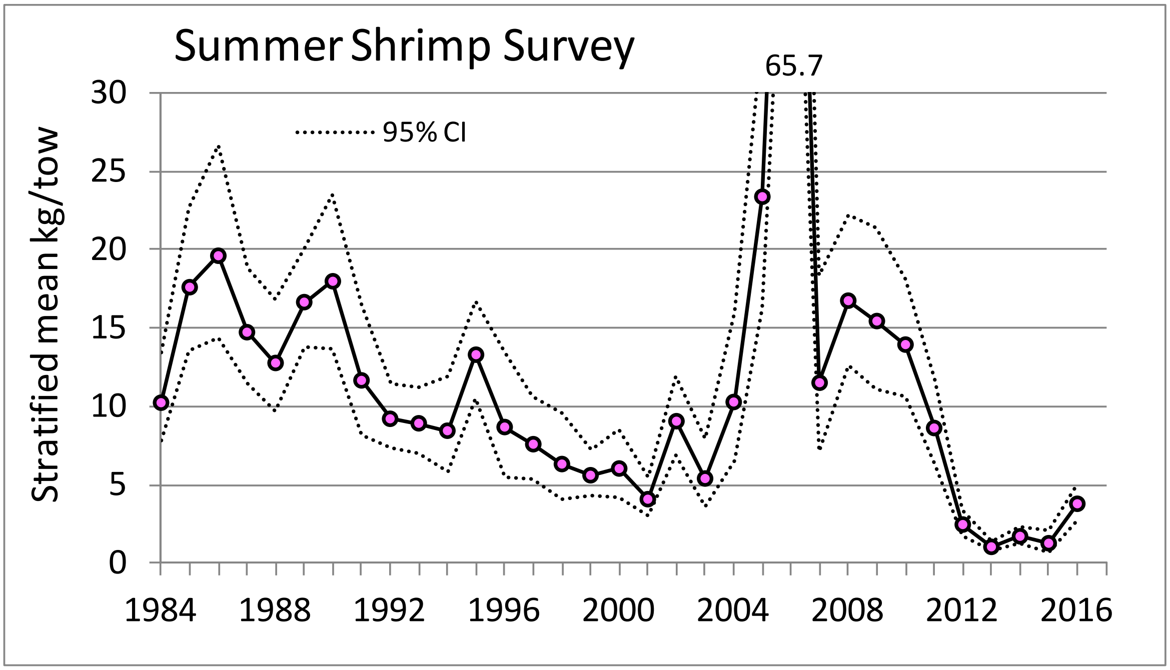


Figure 10. **Biomass indices (stratified geometric mean kg per tow) of northern shrimp from ASMFC summer surveys in the Gulf of Maine.**

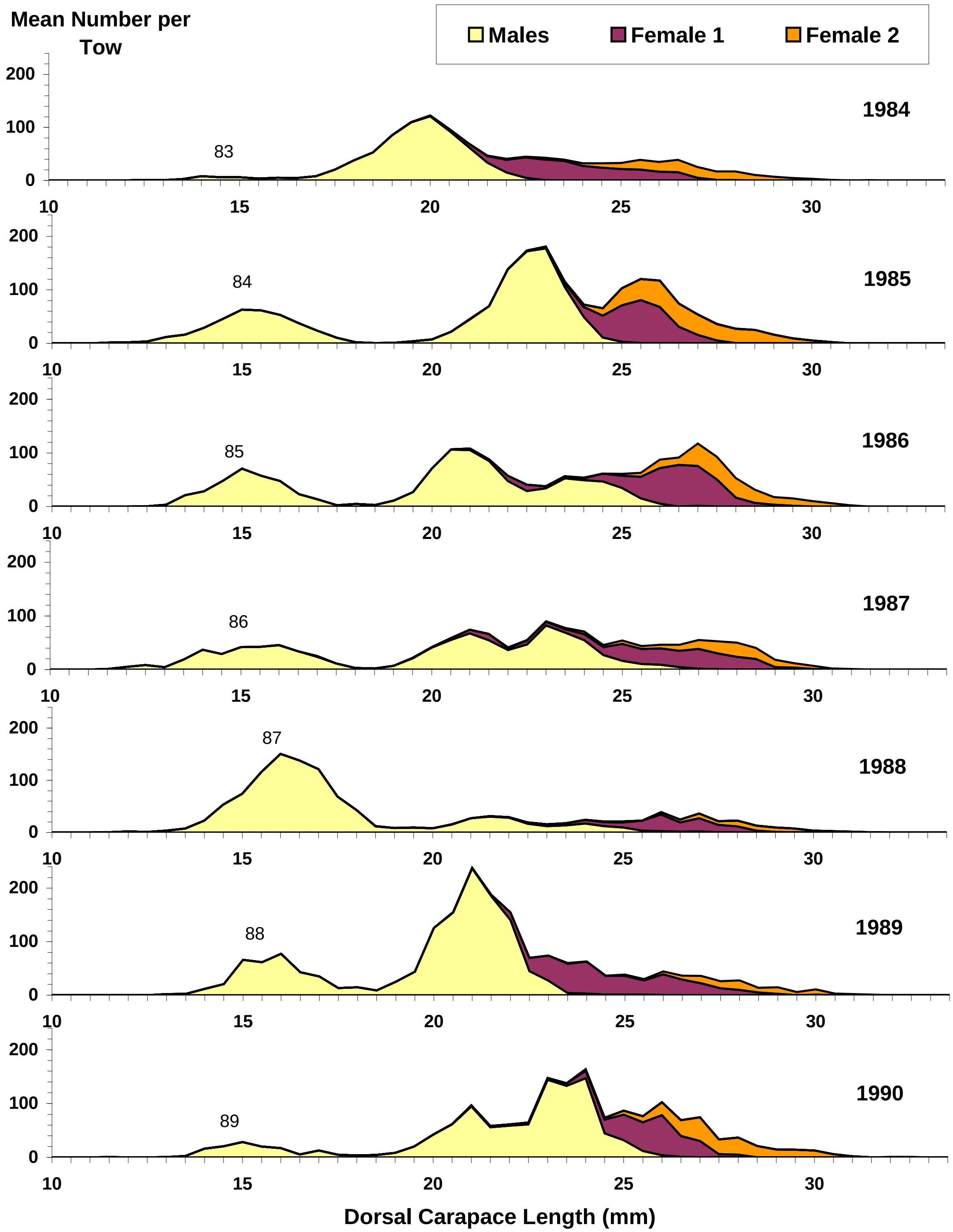


Figure 8: Gulf of Maine northern shrimp summer survey mean catch per tow by year, length, and development stage. Two-digit years are year class at assumed age 1.5.

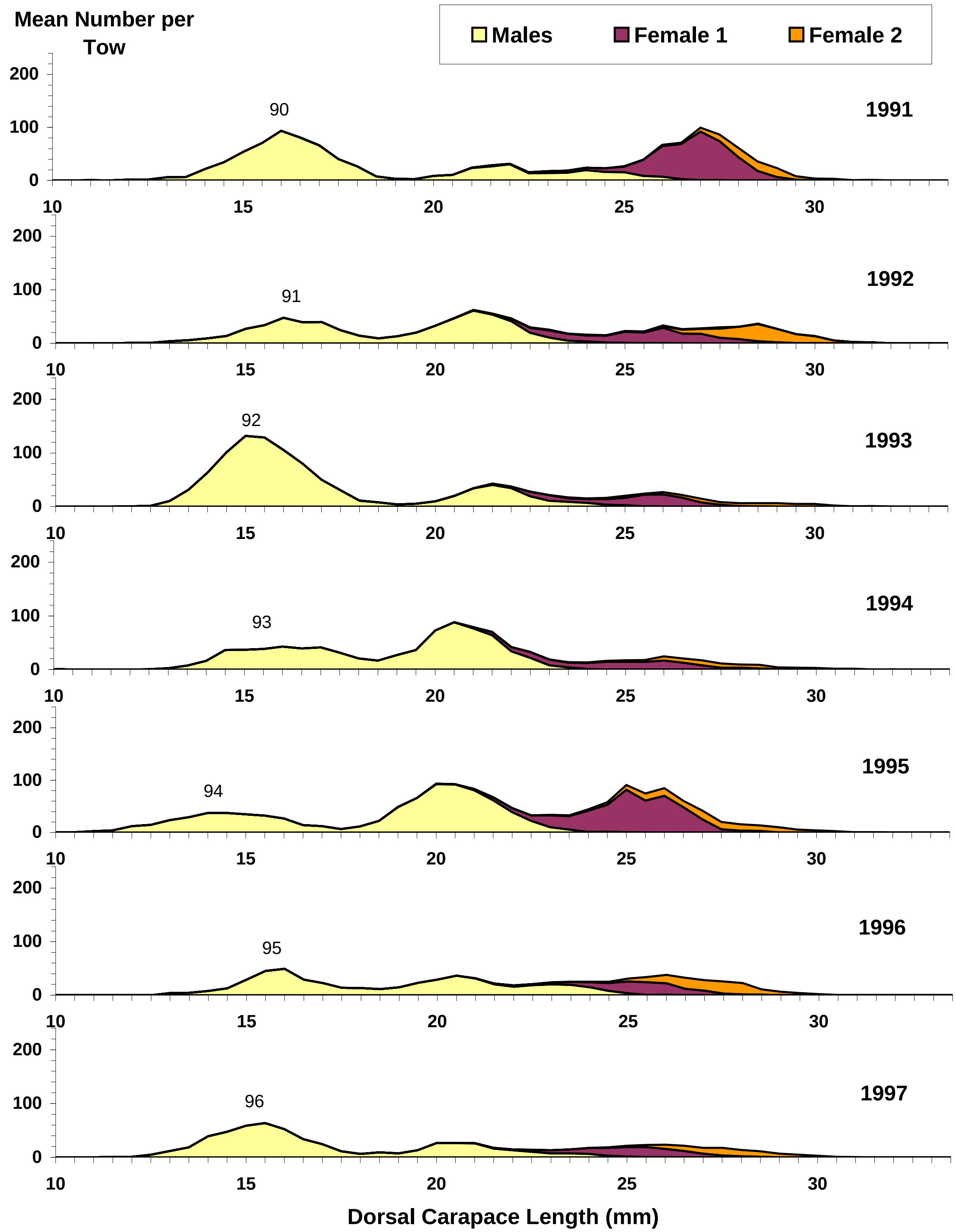


Figure 11 continued – summer survey.

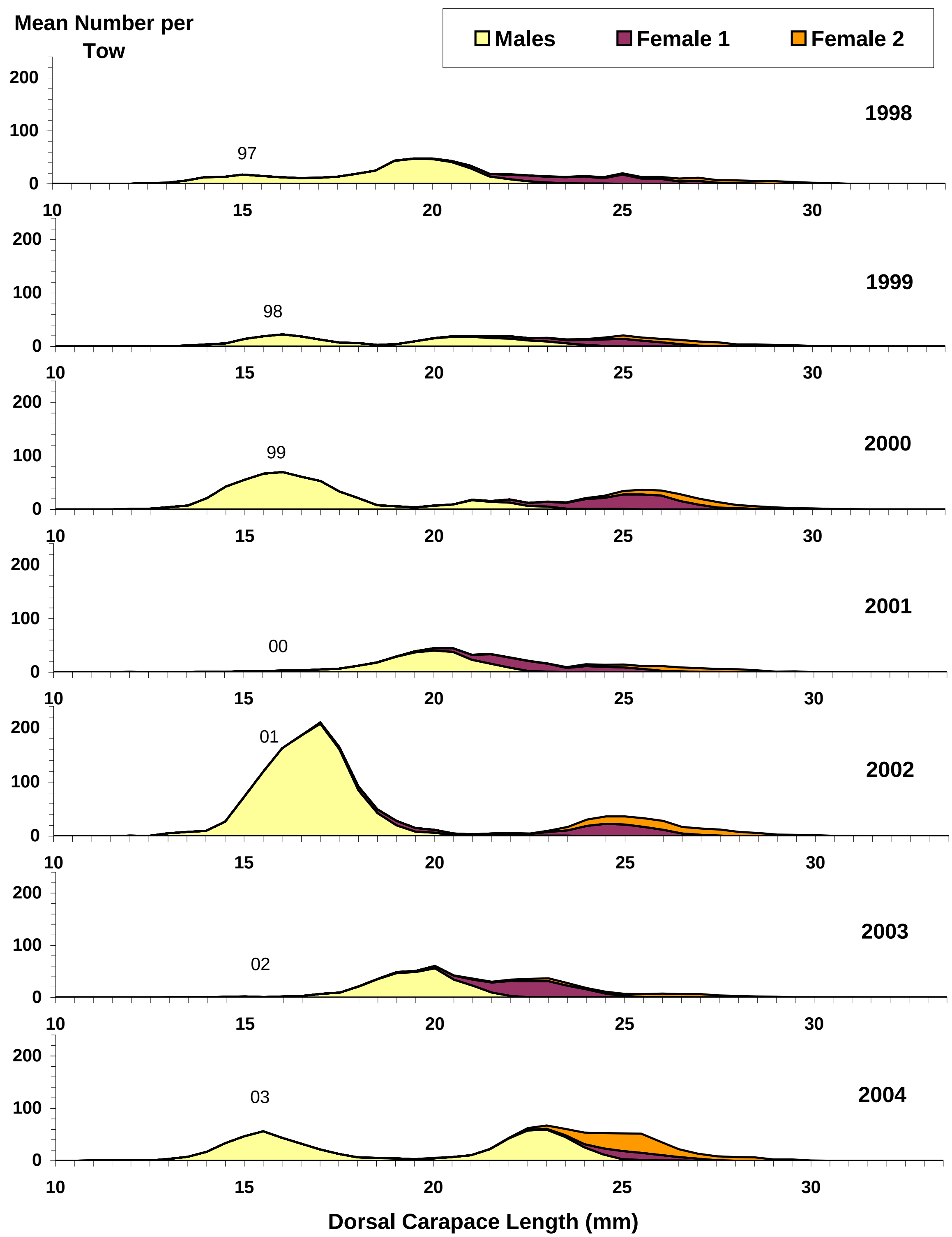


Figure 11 continued – summer survey.

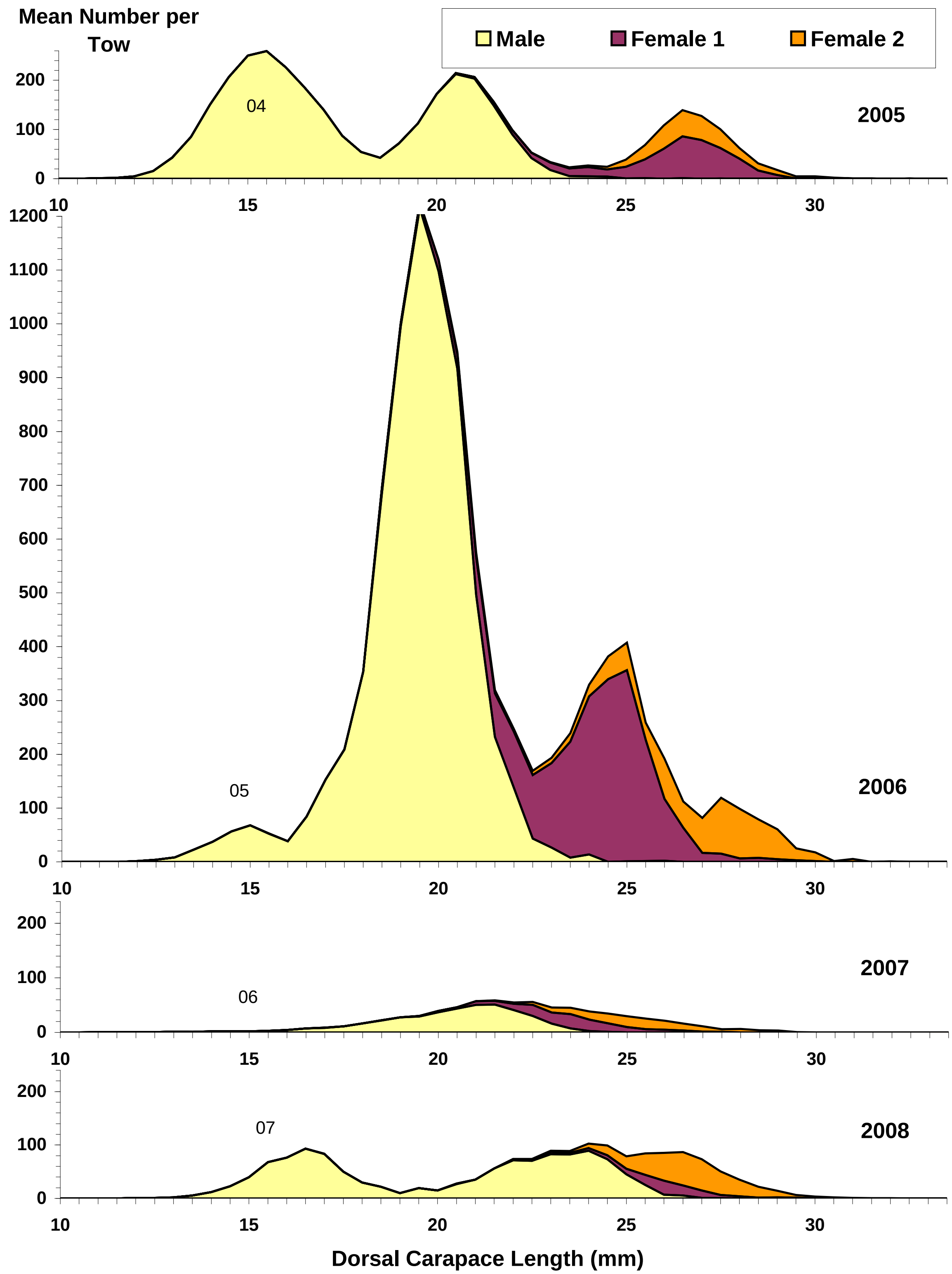


Figure 11 continued – summer survey.

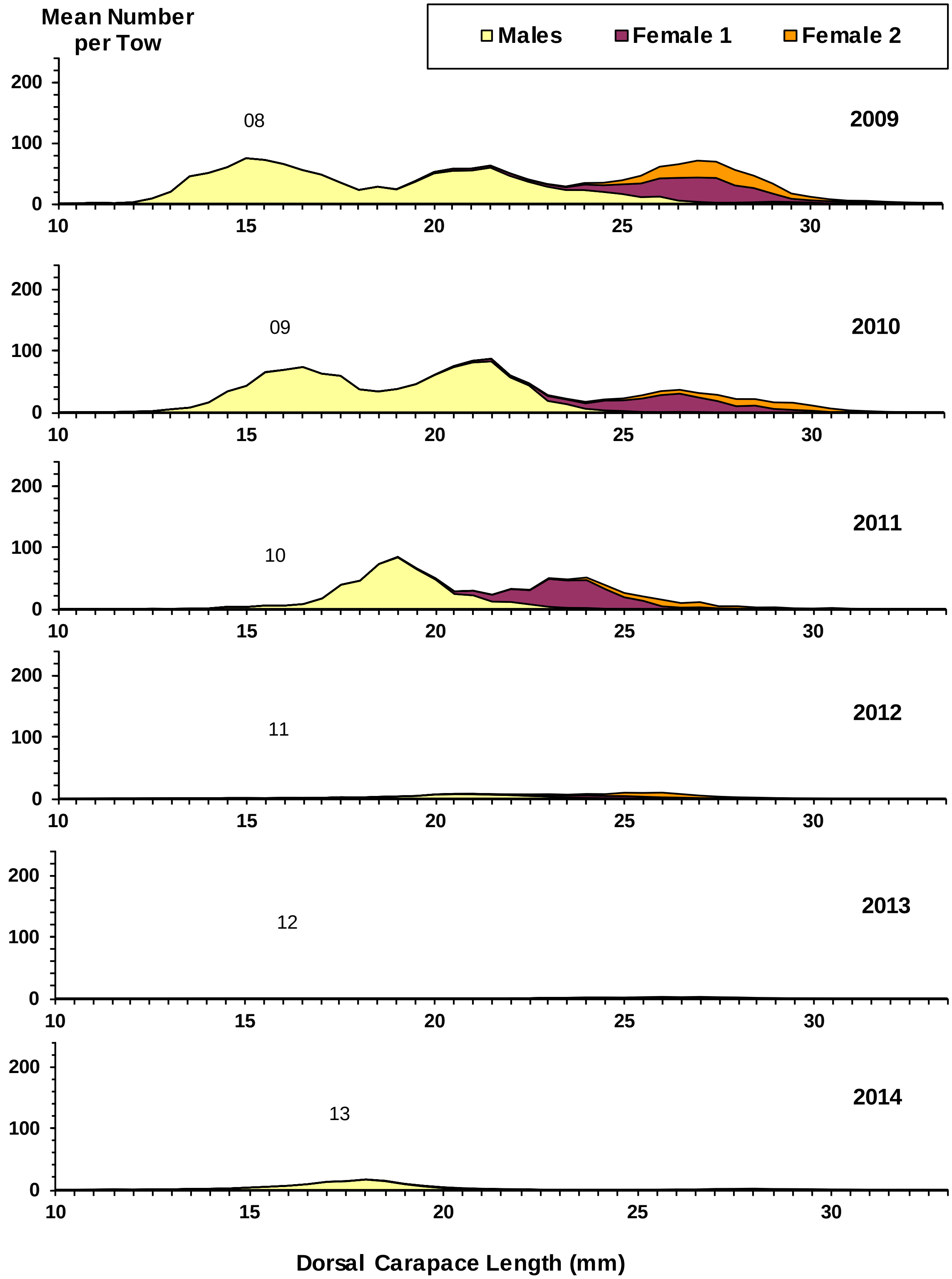


Figure 11 continued – summer survey.

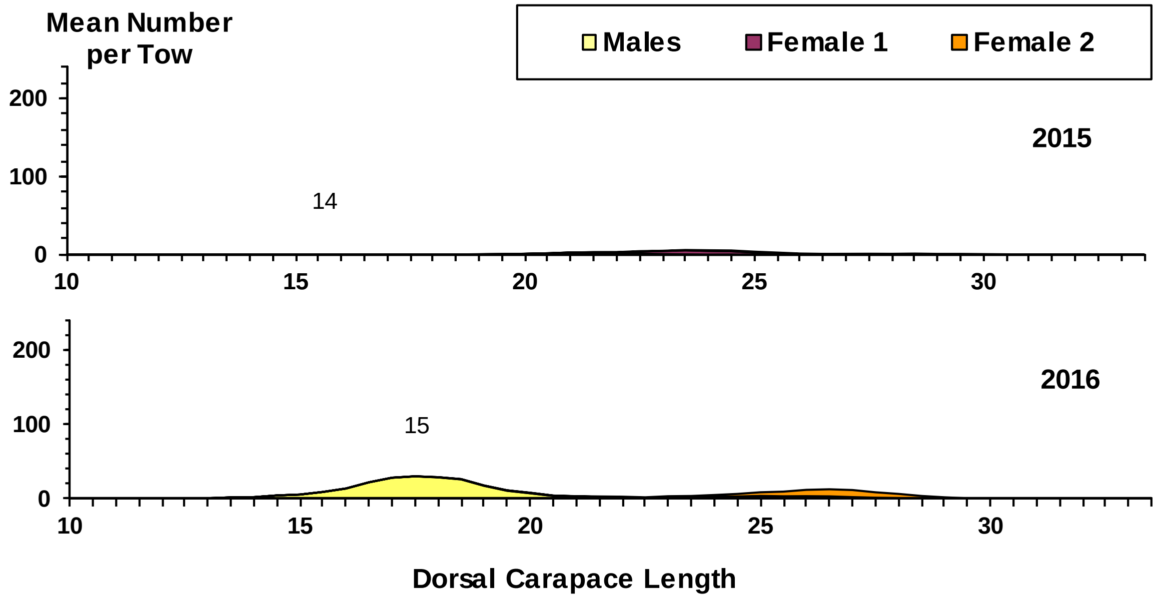


Figure 11 continued – summer survey.

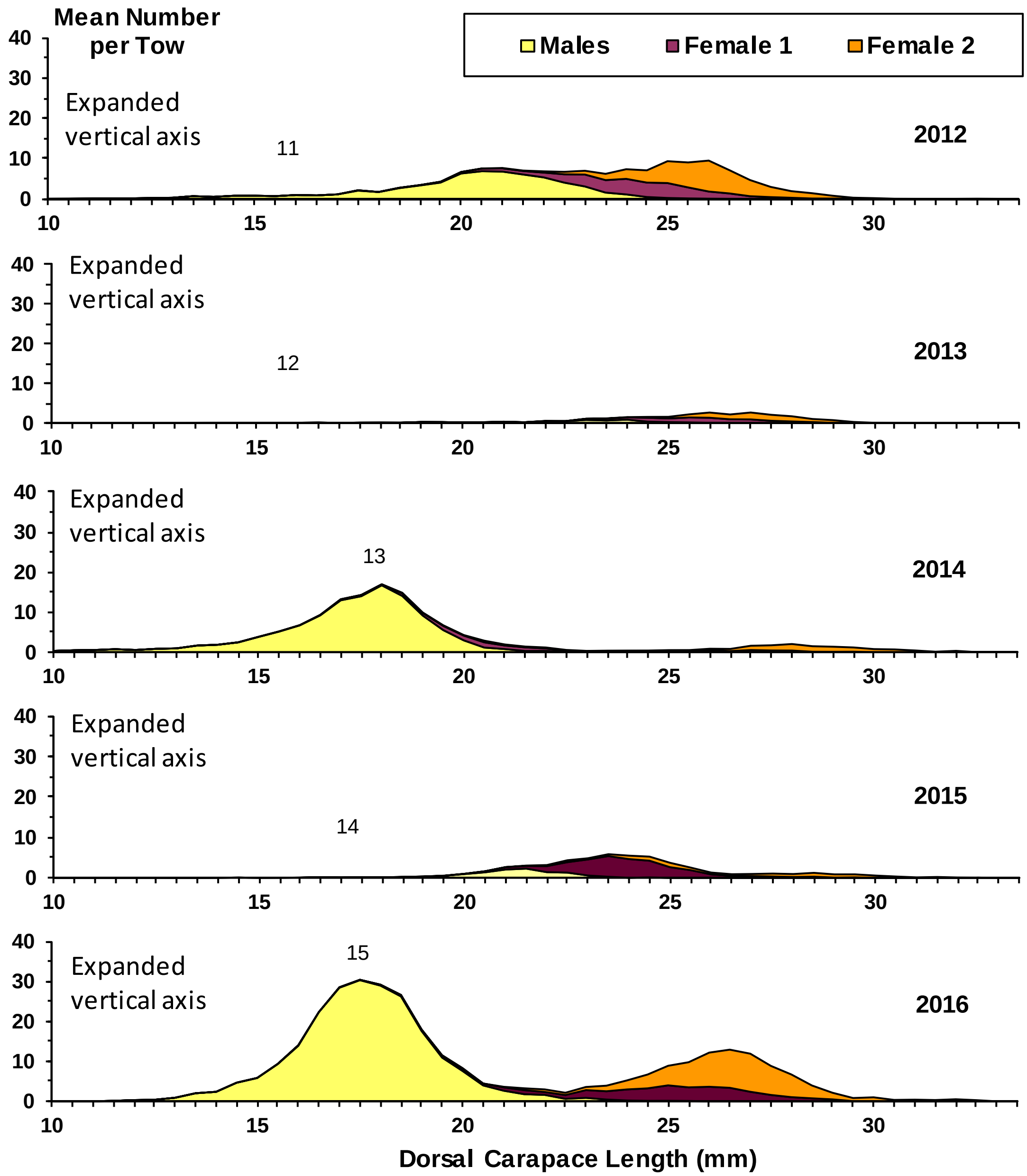


Figure 9: Gulf of Maine northern shrimp summer survey mean catch per tow by year (2012–2016 only), length, and developmental stage, with expanded vertical axes. Two-digit years indicate the year class mode at assumed age 1.5.

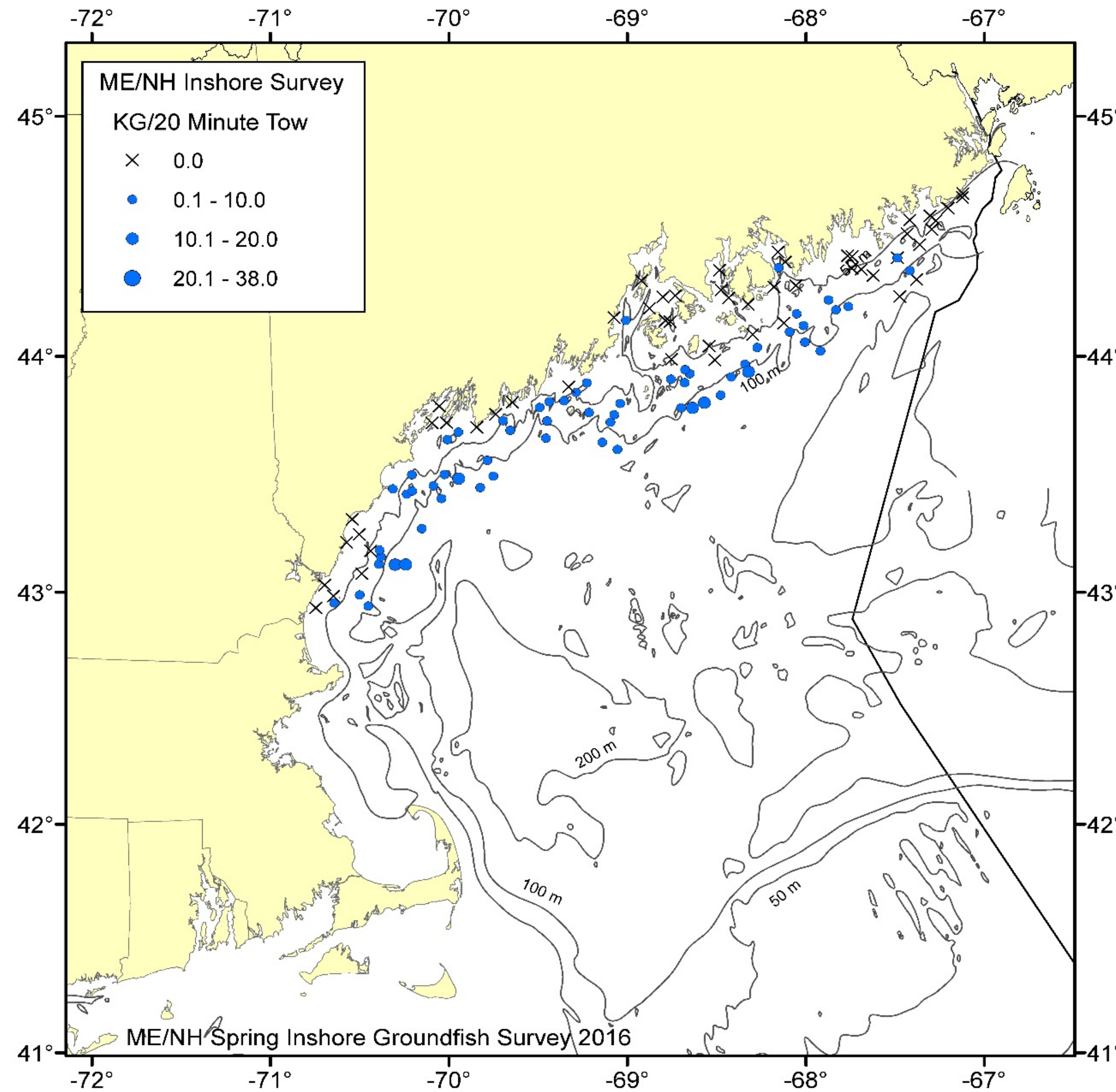
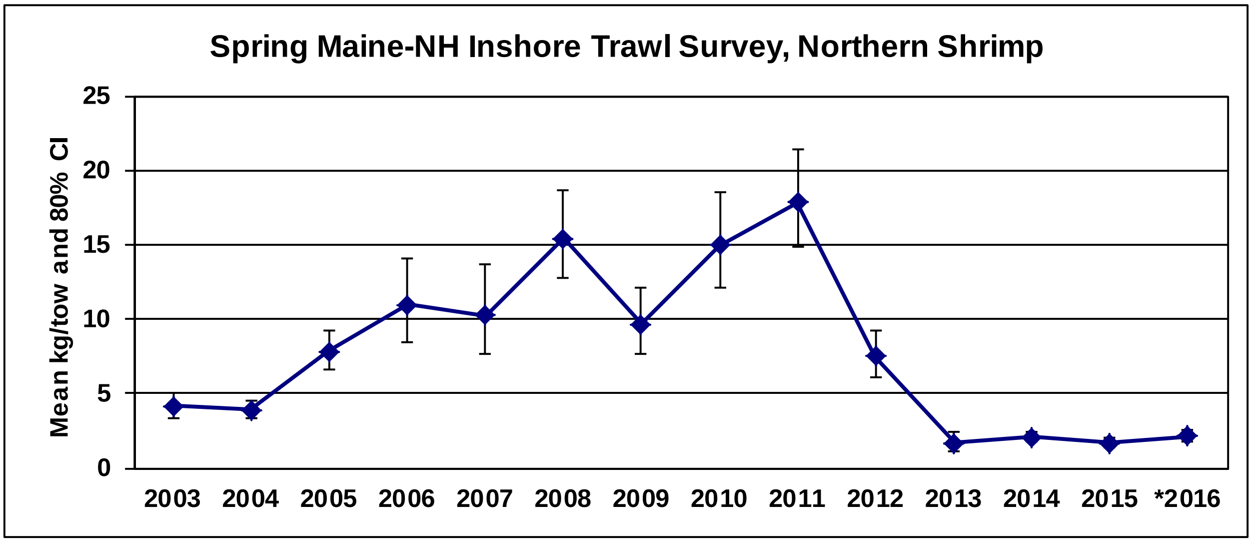


Figure 10: Distribution of northern shrimp catches (kg/tow) in the spring 2016 Maine-New Hampshire inshore trawl survey. Sites with “x” had less than 0.1 kg/tow.



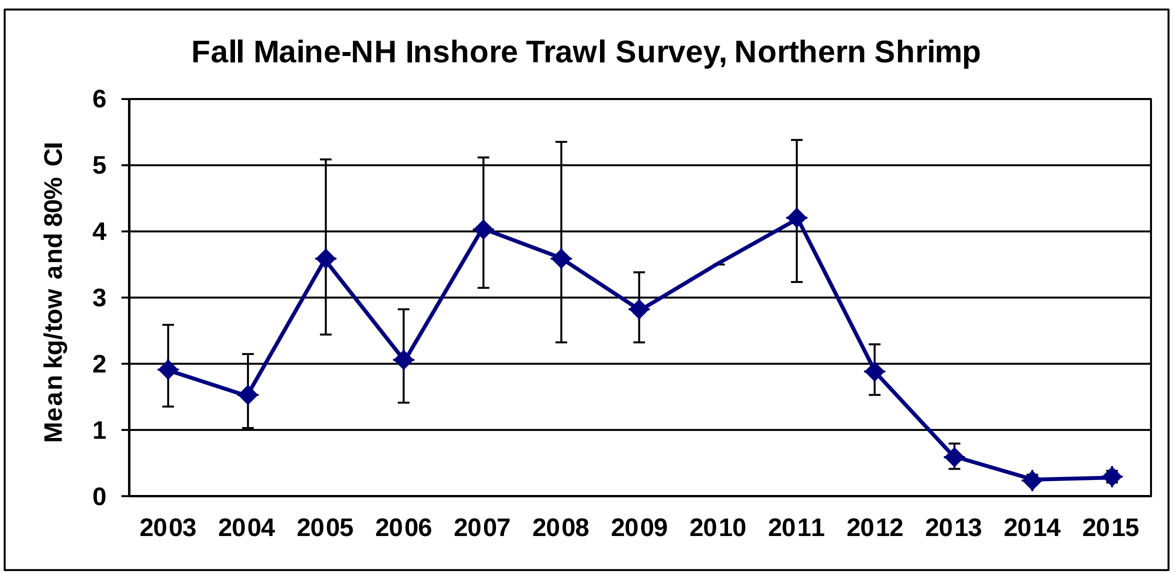


Figure 11: Maine-New Hampshire Spring (top) and Fall (bottom) inshore trawl survey biomass indices for northern shrimp with 80% confidence intervals. *2016 spring survey data are preliminary.

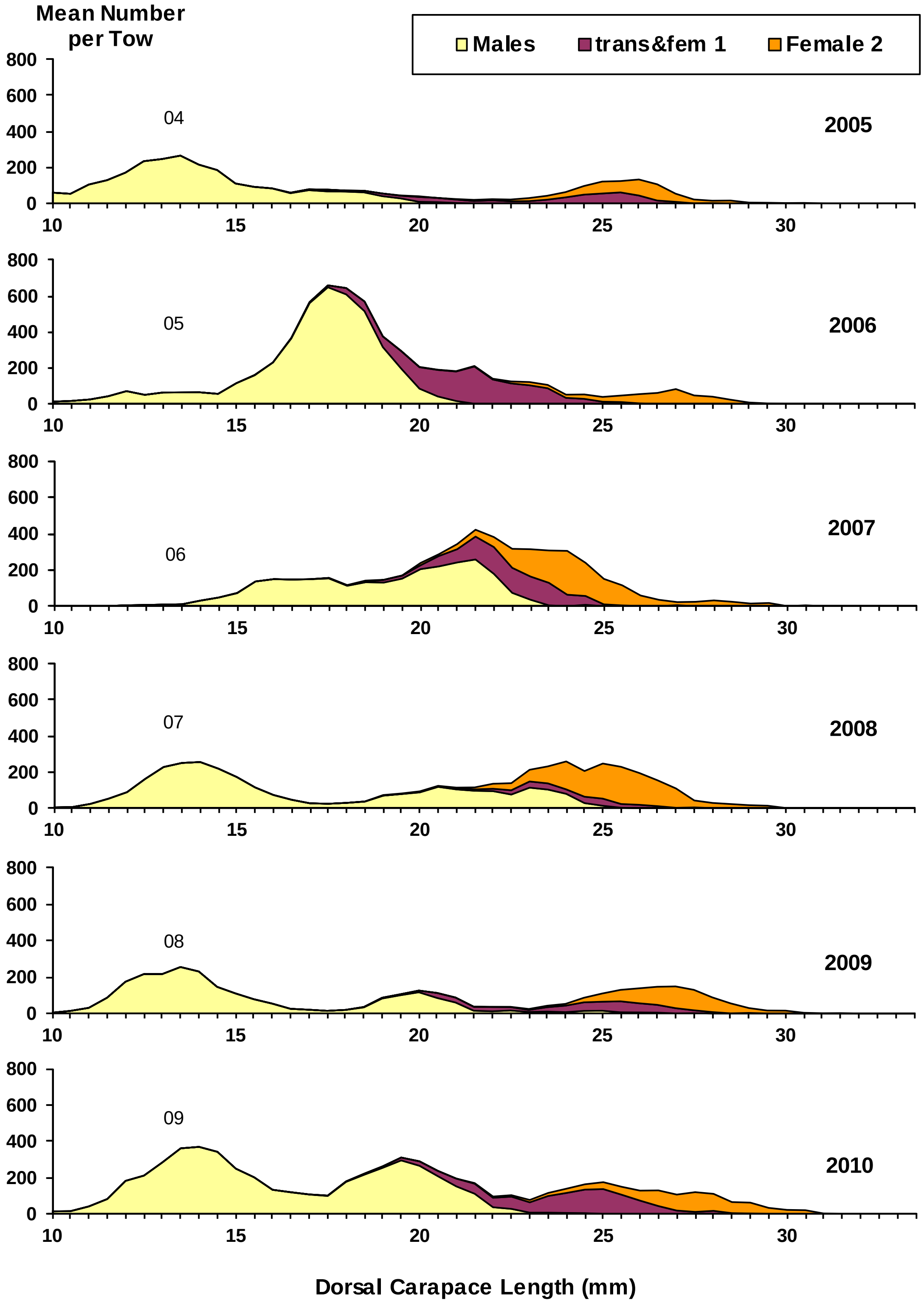


Figure 12: Maine-New Hampshire spring inshore survey mean catch per tow by year, length, and development stage. Two-digit years are the year class at assumed age 1.

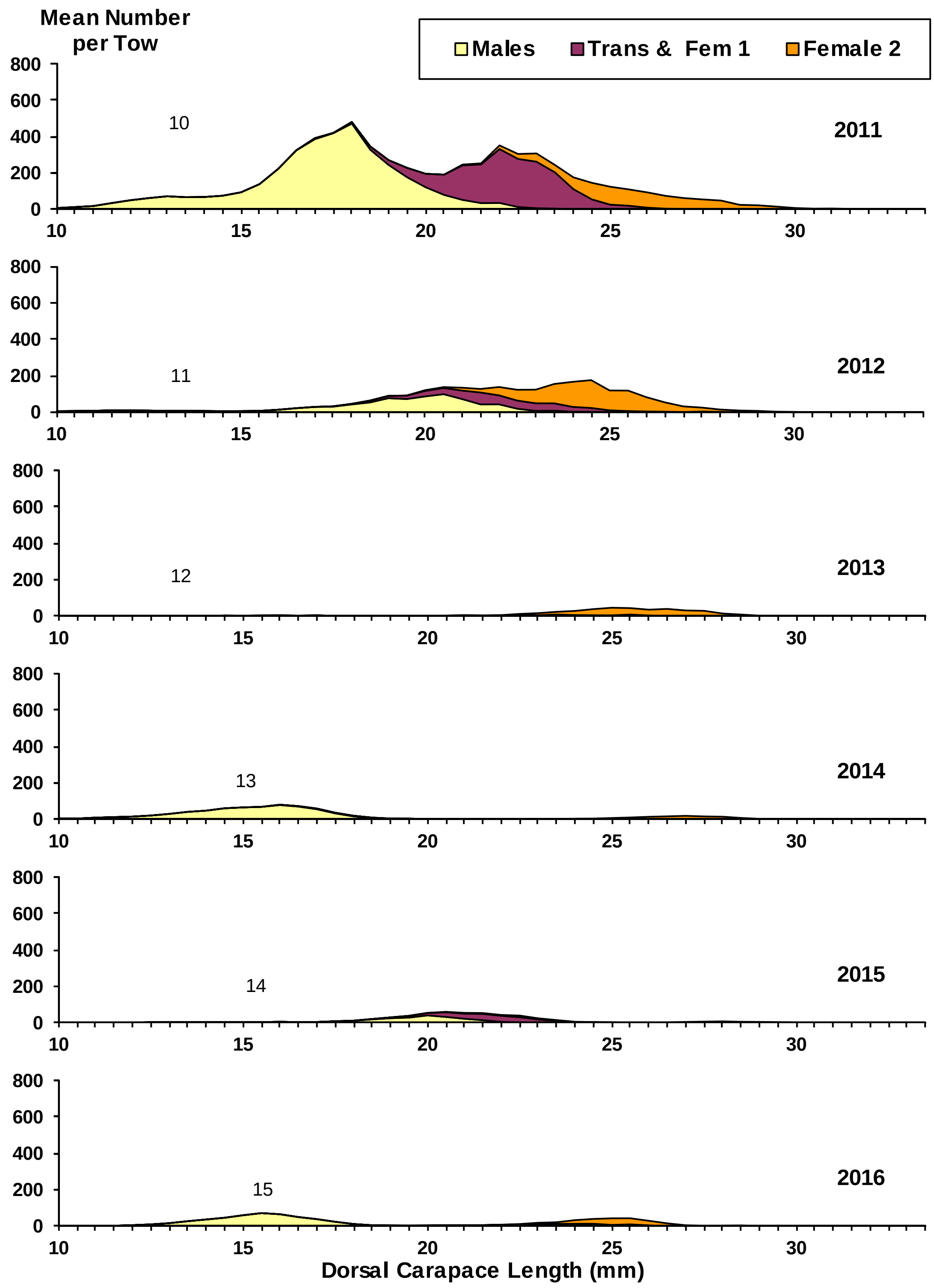


Figure 15 continued — ME/NH spring inshore survey. 2016 data are preliminary.

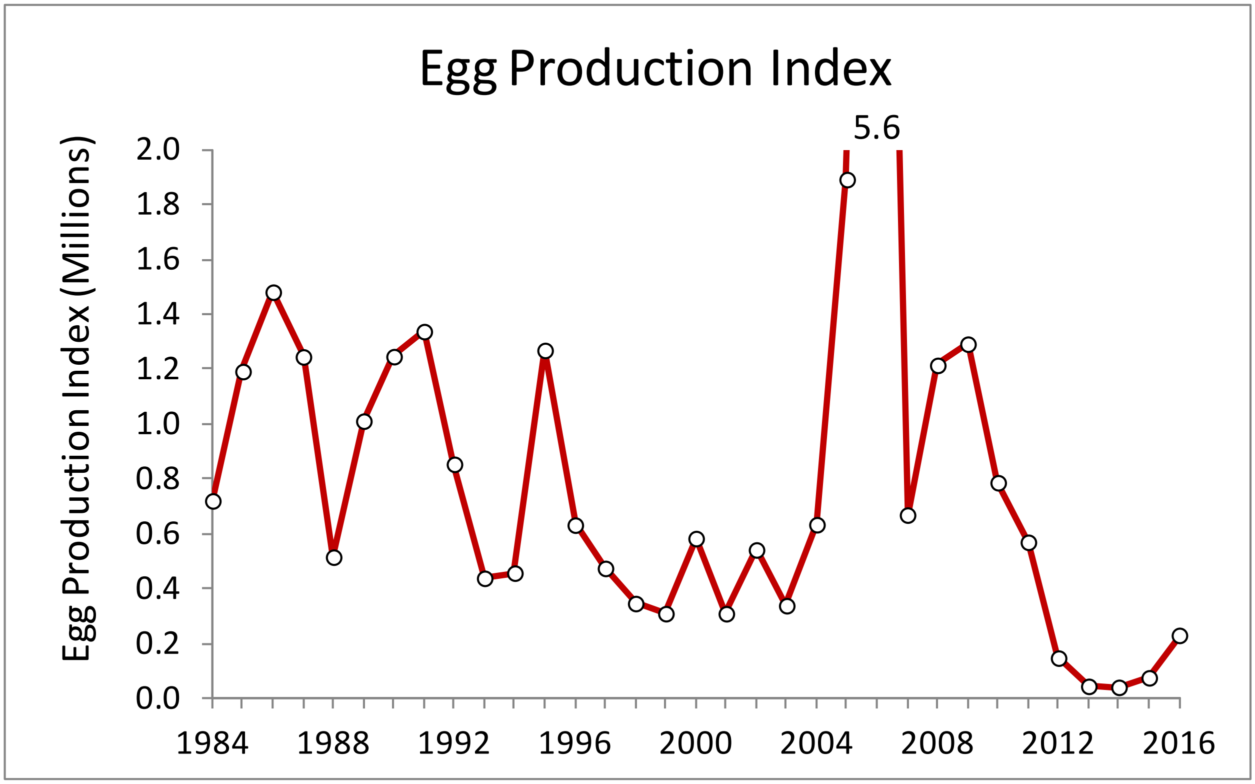


Figure 13: Egg production index for Gulf of Maine northern shrimp based on stratified mean number of females at length from the summer shrimp survey and estimated fecundity at length (Haynes and Wigley 1969). Index for 2006 (off scale) was 5.6 million.

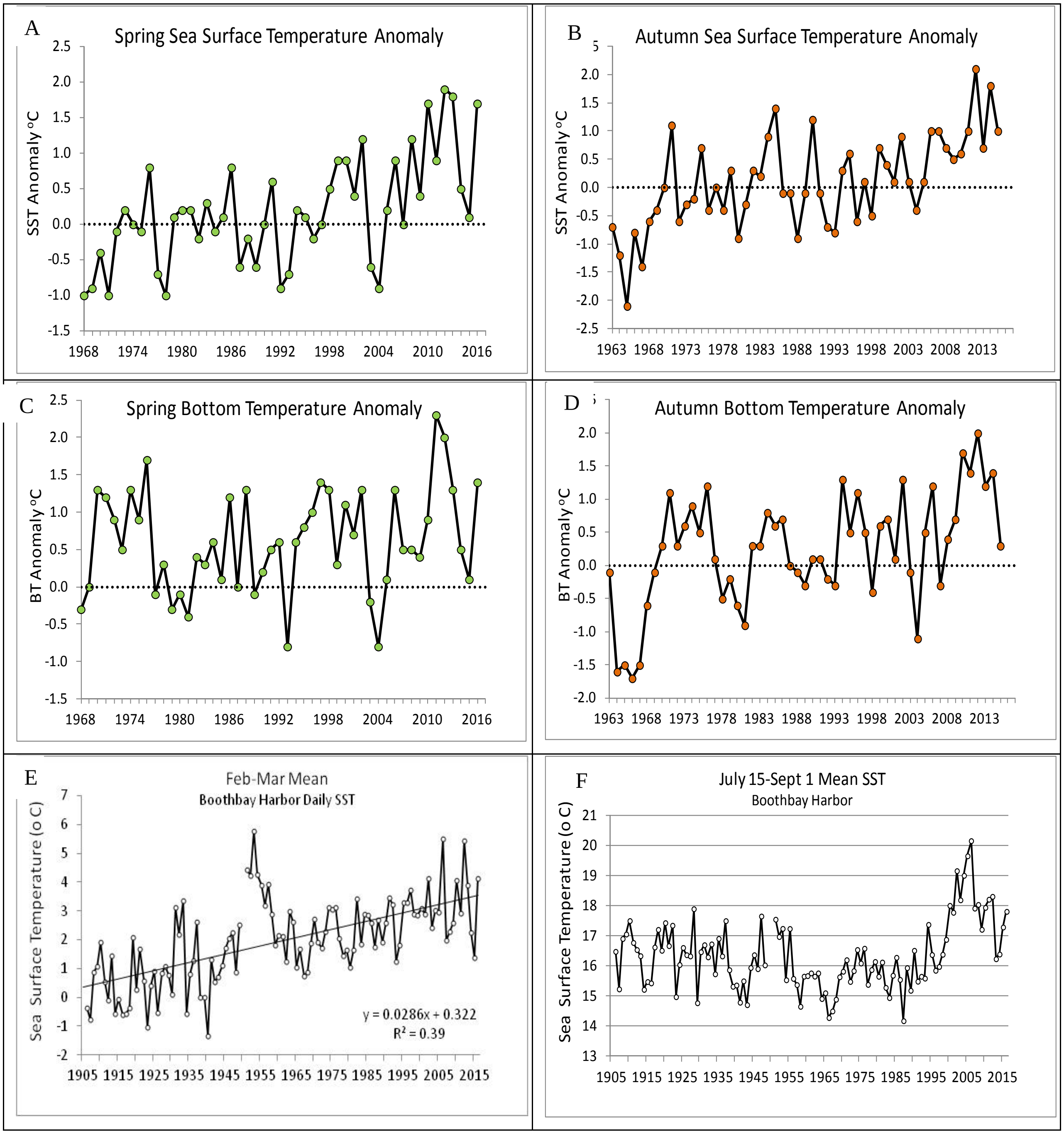


Figure 14: Ocean temperature anomalies in the Gulf of Maine. (A) spring and (B) autumn sea surface temperature anomalies in shrimp offshore habitat areas from NEFSC trawl surveys, 1968–2016 (through 2015 for autumn temperatures). (C) spring and (D) autumn bottom temperature anomalies in shrimp offshore habitat areas from NEFSC trawl survey, 1968–2016 (through 2015 for autumn temperature). (E – F) average sea surface temperature during (E) February–March and (F) July 15–September 1 at Boothbay Harbor, Maine, 1906–2016.

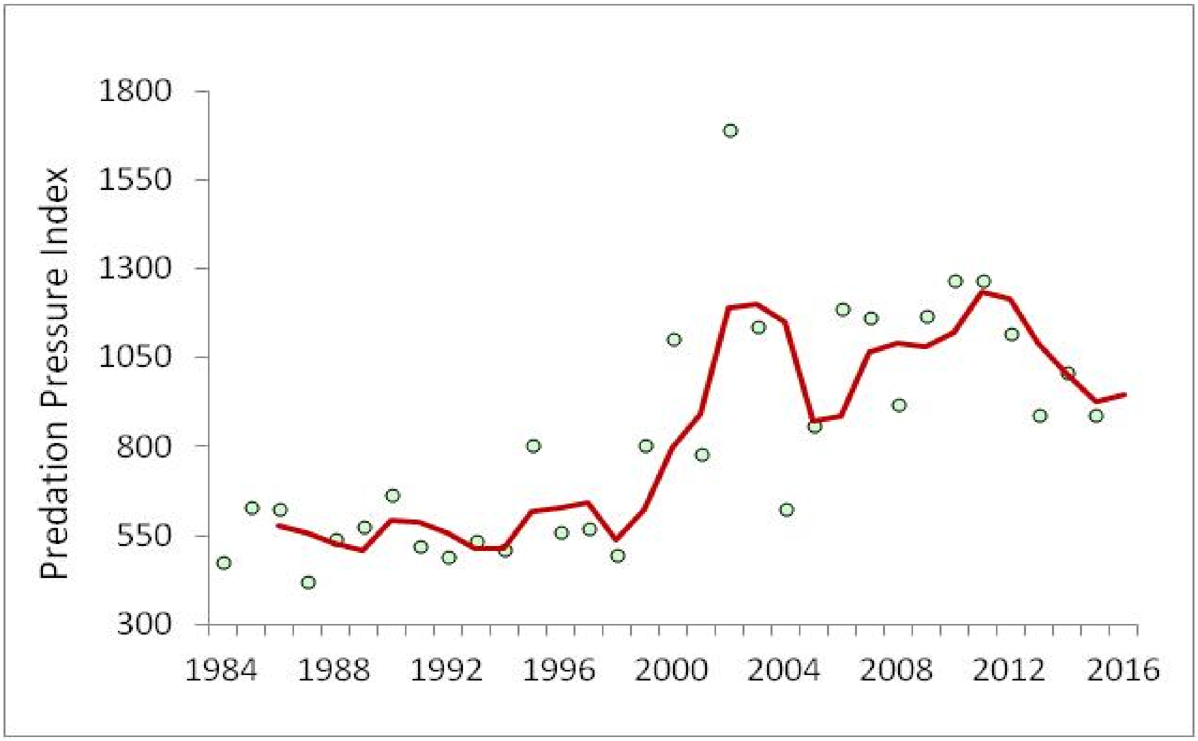


Figure 15: Predation pressure index for northern shrimp in the Gulf of Maine.

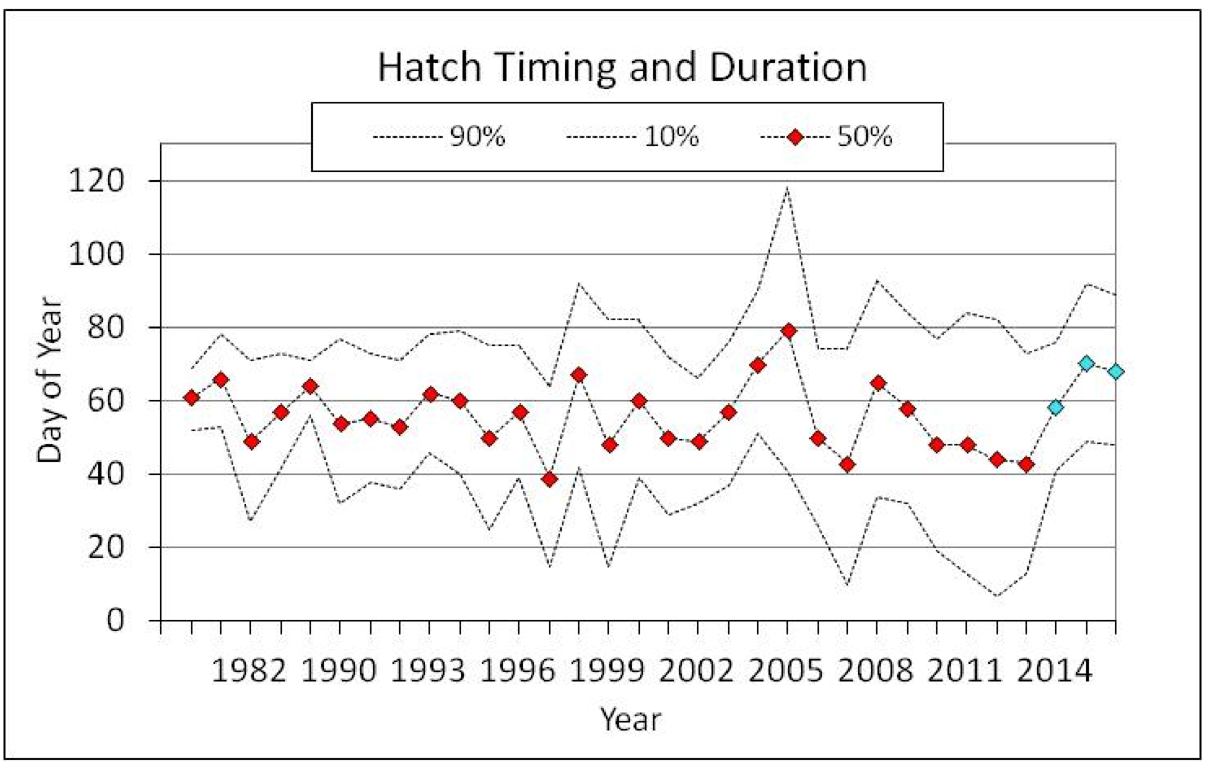


Figure 16: Timing and duration of the hatch period for northern shrimp in the Gulf of Maine. Turquoise points indicate winter sampling done by the states while the fishery was closed.

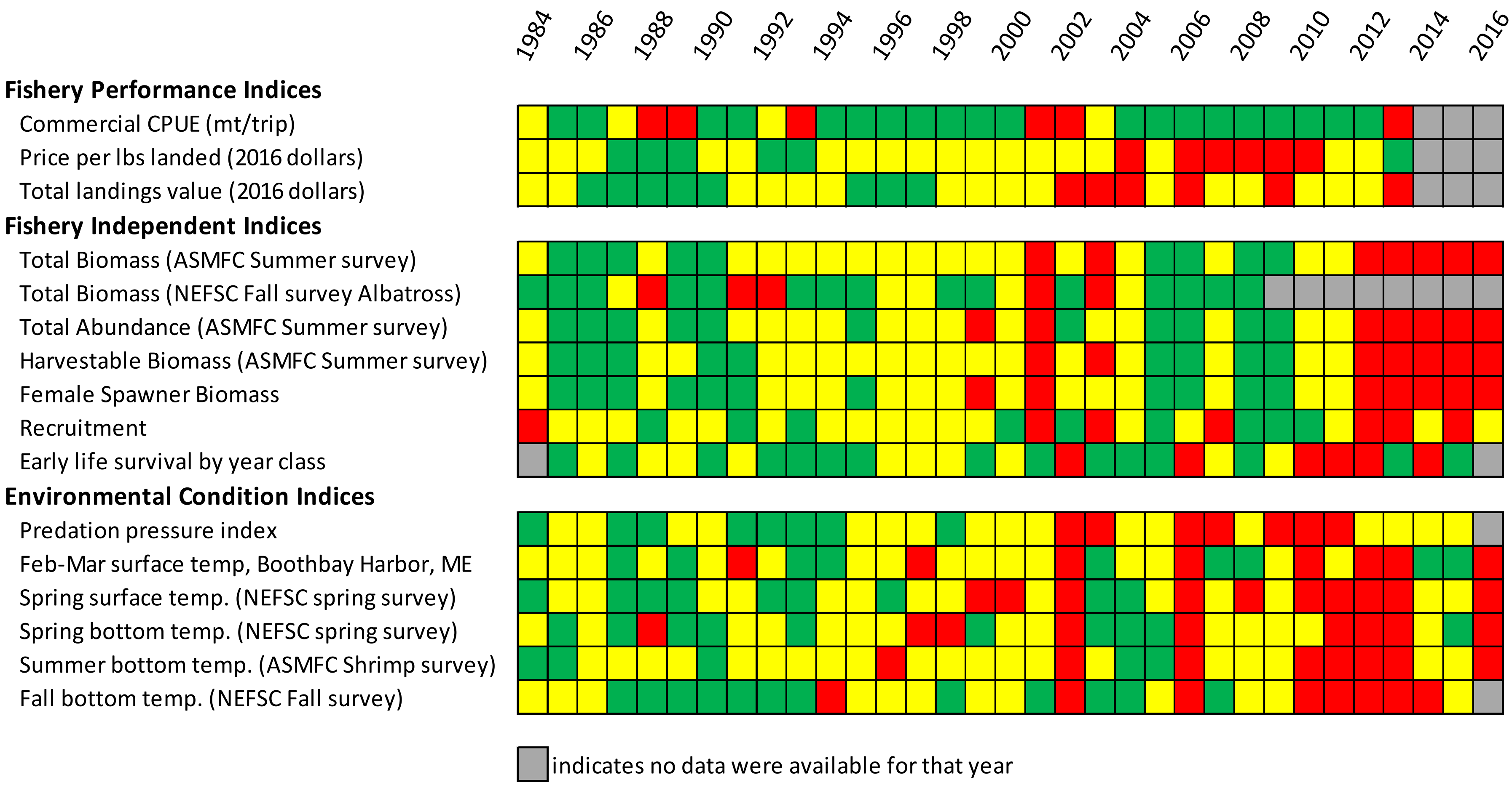
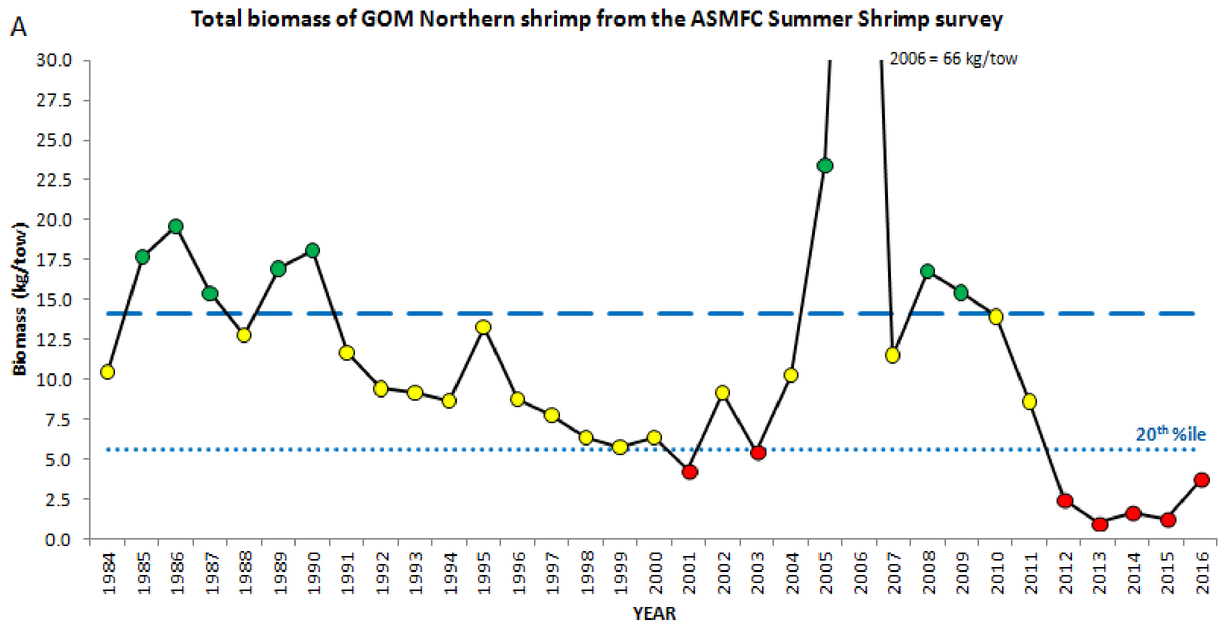


Figure 17: Strict Traffic Light Approach (STLA) results. Red indicates unfavorable conditions or status, yellow indicates intermediate values, and green indicates favorable conditions or status.



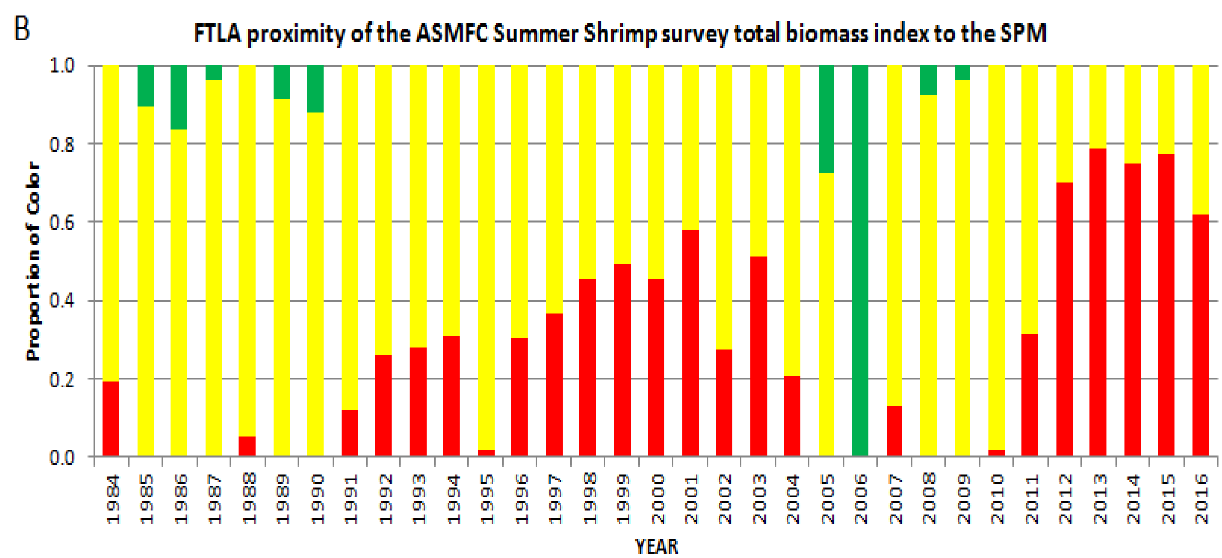


Figure 18: (A) Total biomass of Gulf of Maine northern shrimp from the ASMFC Summer Shrimp survey 1984–2016, with the 'stable period' (1985–1994) mean (SPM) (dashed) and 20th percentile of the time series from 1984–2015 (dotted) indicated. Green values ≥ SPM; red values ≤ 20th percentile; yellow values > 20th percentile and < SPM. (B) Fuzzy Traffic Light Analysis (FTLA) color proportions indicate proximity of annual indices to the SPM (red = unfavorable; green = favorable).

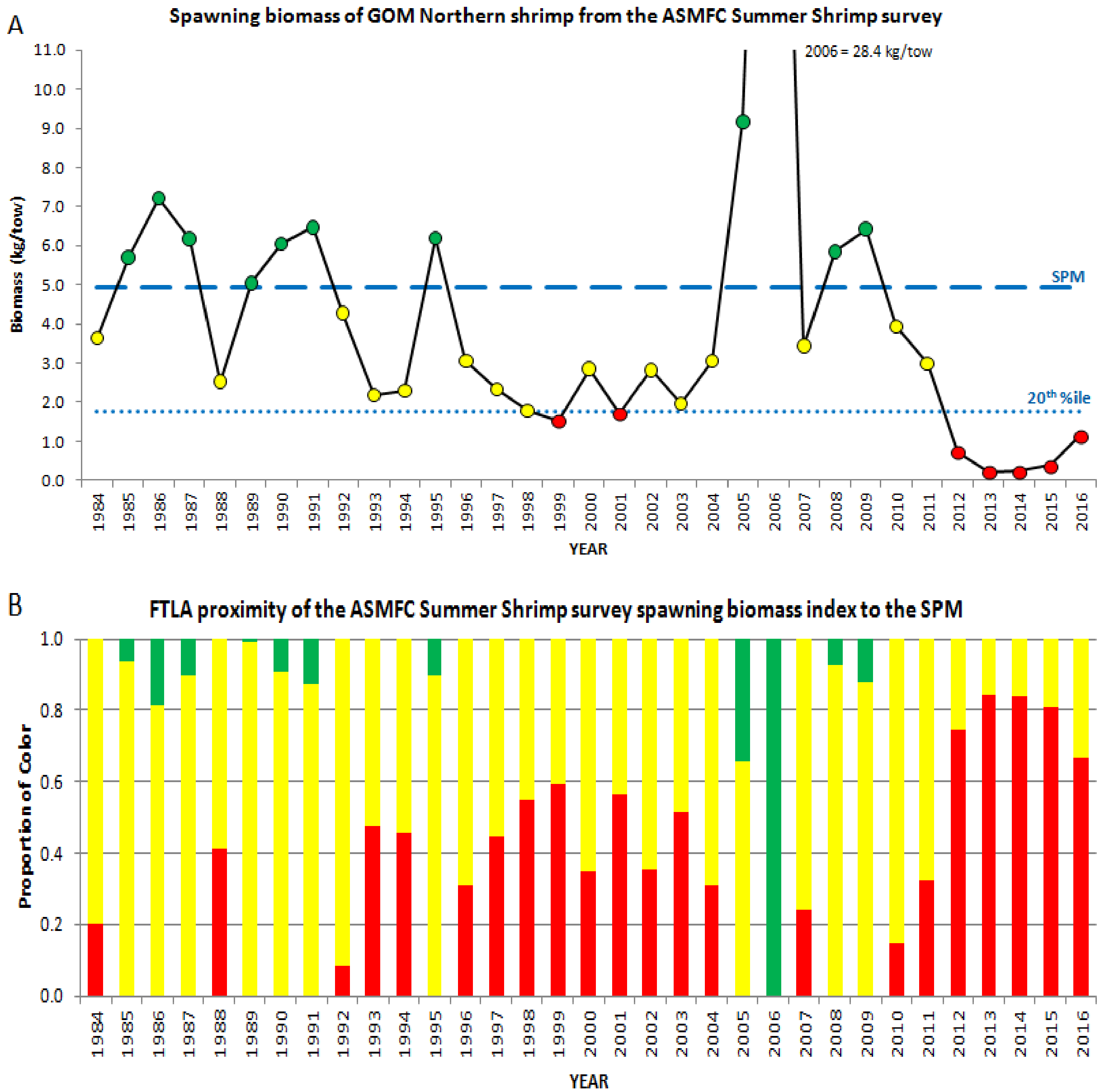


Figure 19: (A) Spawning biomass of Gulf of Maine northern shrimp from the ASMFC Summer Shrimp survey 1984–2016, with 'stable period' (1985–1994) mean (SPM) (dashed) and 20th percentile of the time series from 1984–2015 (dotted) indicated. Green values ≥ SPM; red values ≤ 20th percentile; yellow values > 20th percentile and < SPM. (B) Fuzzy Traffic Light Analysis (FTLA) color proportions indicate proximity of annual indices to the SPM (red = unfavorable; green = favorable).

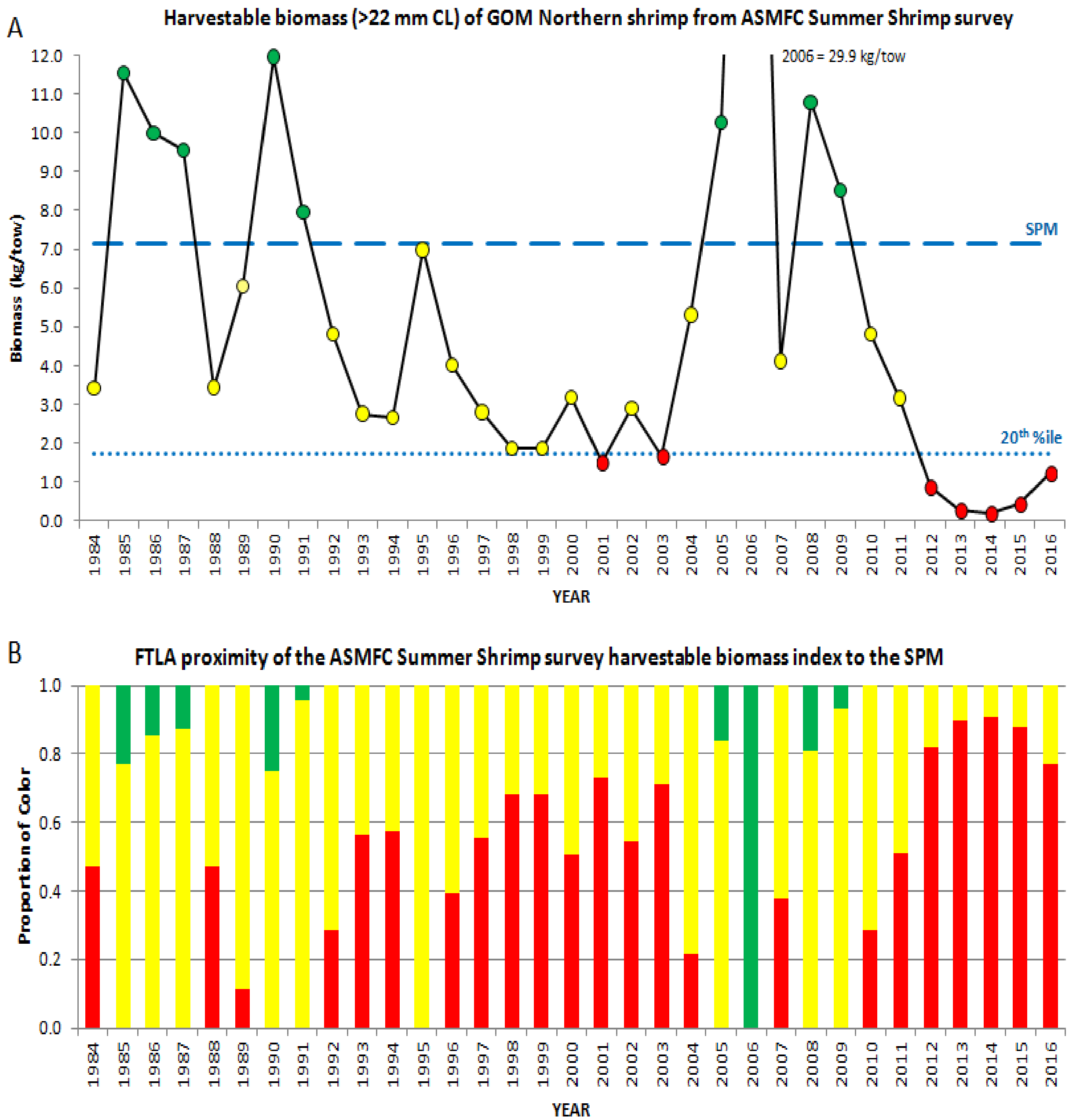
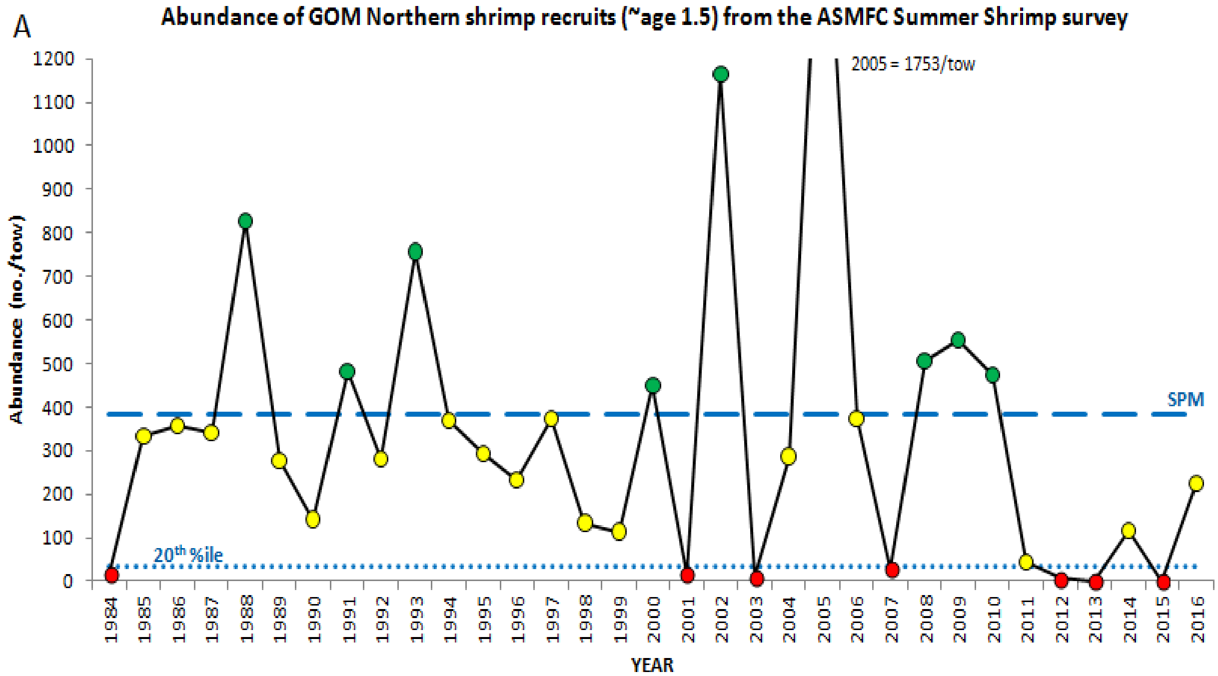


Figure 20: (A) Harvestable biomass of Gulf of Maine northern shrimp from the ASMFC Summer Shrimp survey 1984–2016, with 'stable period' (1985–1994) mean (SPM) (dashed) and 20th percentile of the time series from 1984–2015 (dotted) indicated. Green values ≥ SPM; red values ≤ 20th percentile; yellow values > 20th percentile and < SPM. (B) Fuzzy Traffic Light Analysis (FTLA) color proportions indicate proximity of annual indices to the SPM (red = unfavorable; green = favorable).



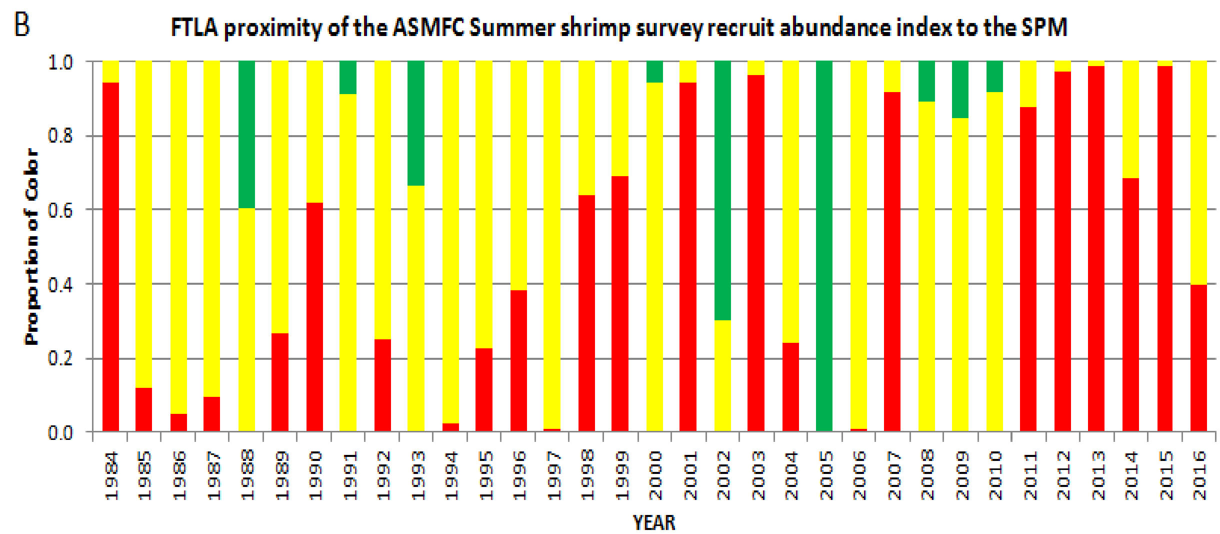


Figure 21: (A) Recruit abundance of Gulf of Maine northern shrimp from the ASMFC Summer shrimp survey 1984–2016, with 'stable period' (1985–1994) mean (SPM) (dashed) and 20th percentile of the time series from 1984–2015 (dotted) indicated. Green values ≥ SPM; red values ≤ 20th percentile; yellow values > 20th percentile and < SPM. (B) Fuzzy Traffic Light Analysis (FTLA) color proportions indicate proximity of annual indices to the SPM (red = unfavorable; green = favorable).

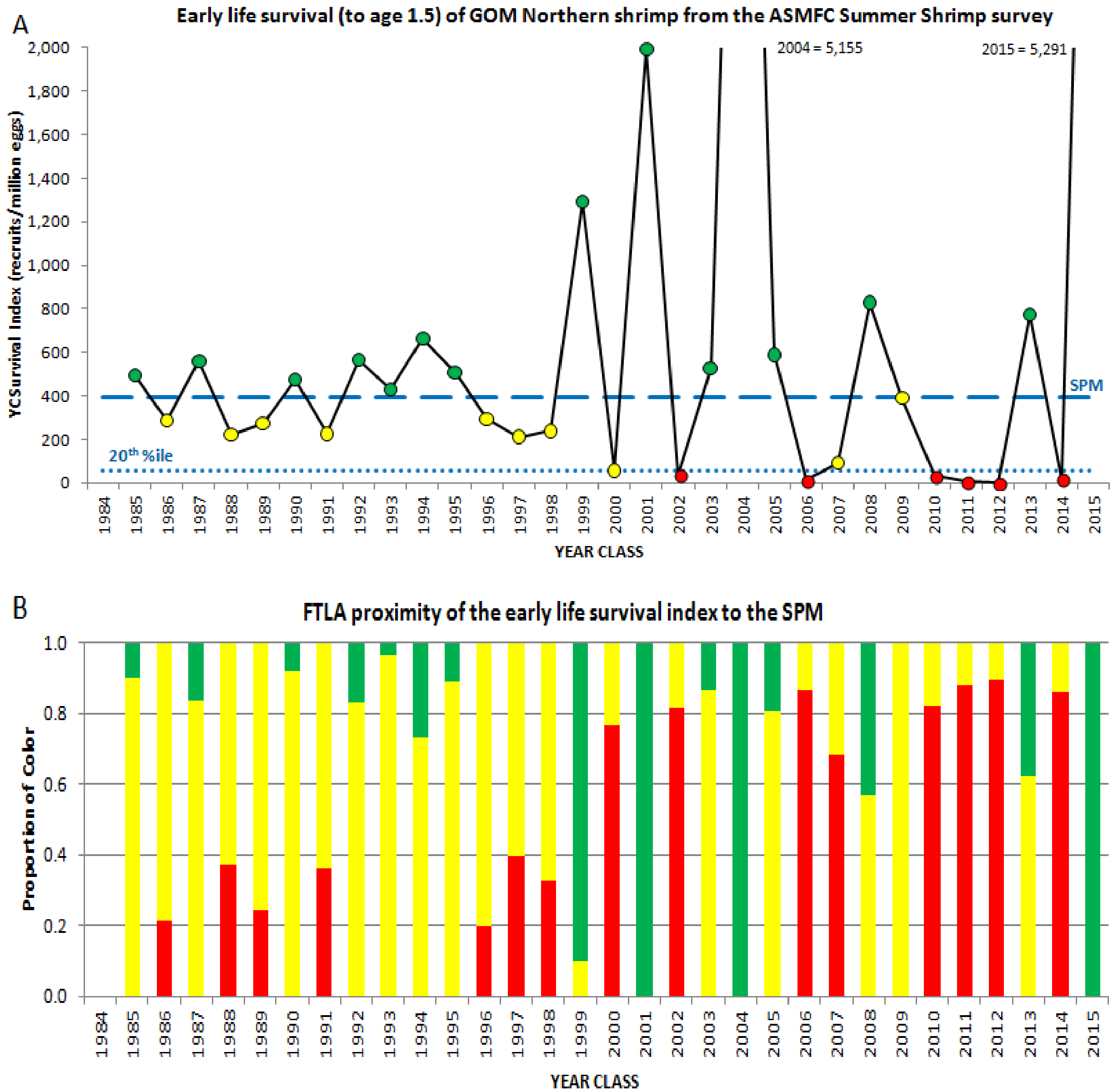
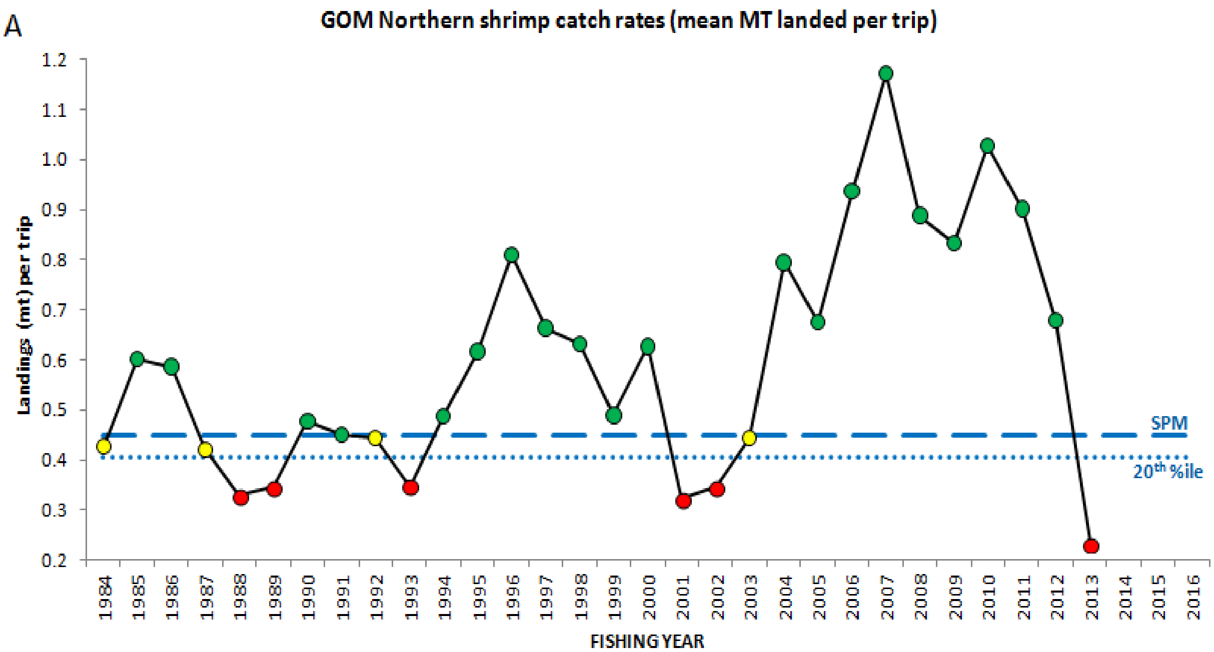


Figure 22: (A) Early life survival (to age 1.5) by year class of Gulf of Maine northern shrimp from the ASMFC Summer Shrimp survey 1984–2016, with 'stable period' (1985–1994) mean (SPM) (dashed) and 20th percentile of the time series by year class 1985–2014 (dotted) indicated. Green values ≥ SPM; red values ≤ 20th percentile; yellow values > 20th percentile and < SPM. (B) Fuzzy Traffic Light Analysis (FTLA) color proportions indicate proximity of annual indices to the SPM (red = unfavorable; green = favorable).

A



B

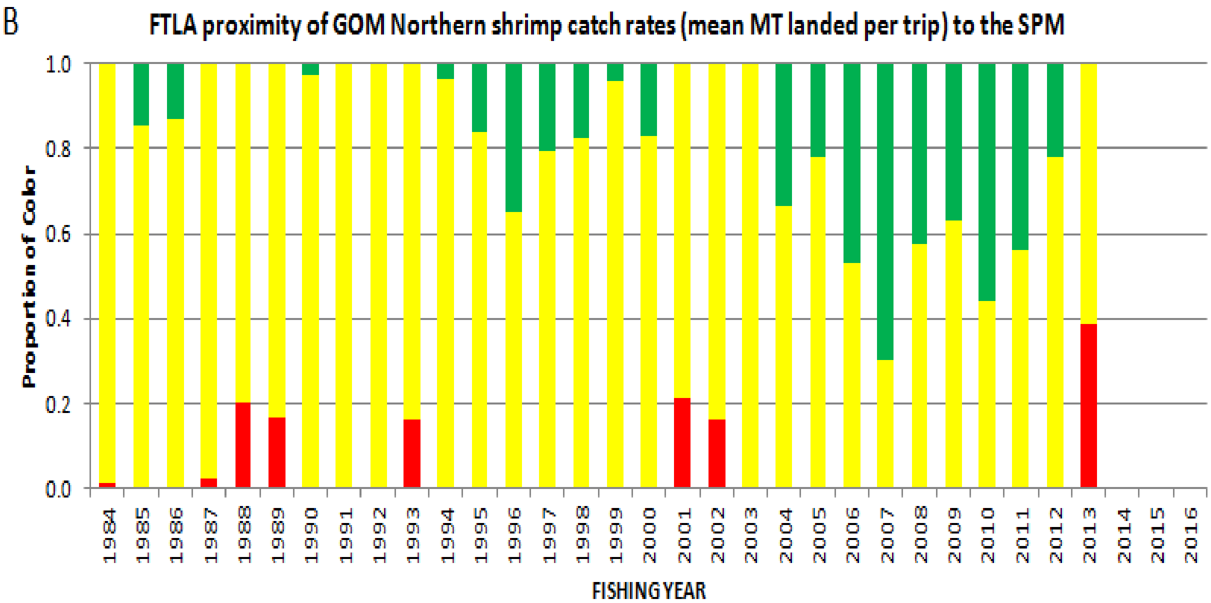
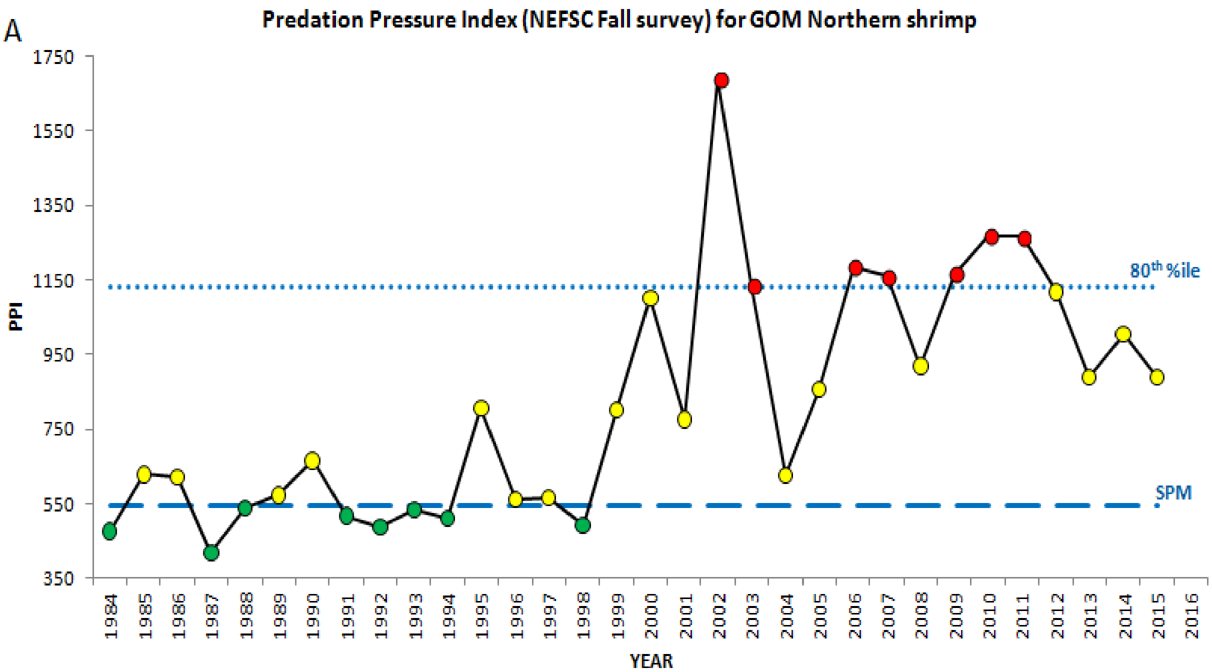


Figure 23: (A) Gulf of Maine northern shrimp fishery catch rates (mt of landings per trip) by fishing year from 1984–2013 (fishery closed 2014–2016), with 'stable period' (1985–1994) mean (SPM) (dashed) and 20th percentile of the time series from 1984–2013 (dotted) indicated. Green values ≥ SPM; red values ≤ 20th percentile; yellow values > 20th percentile and < SPM. (B) Fuzzy Traffic Light Analysis (FTLA) color proportions indicate proximity of annual indices to the SPM (red = unfavorable; green = favorable).

A



B

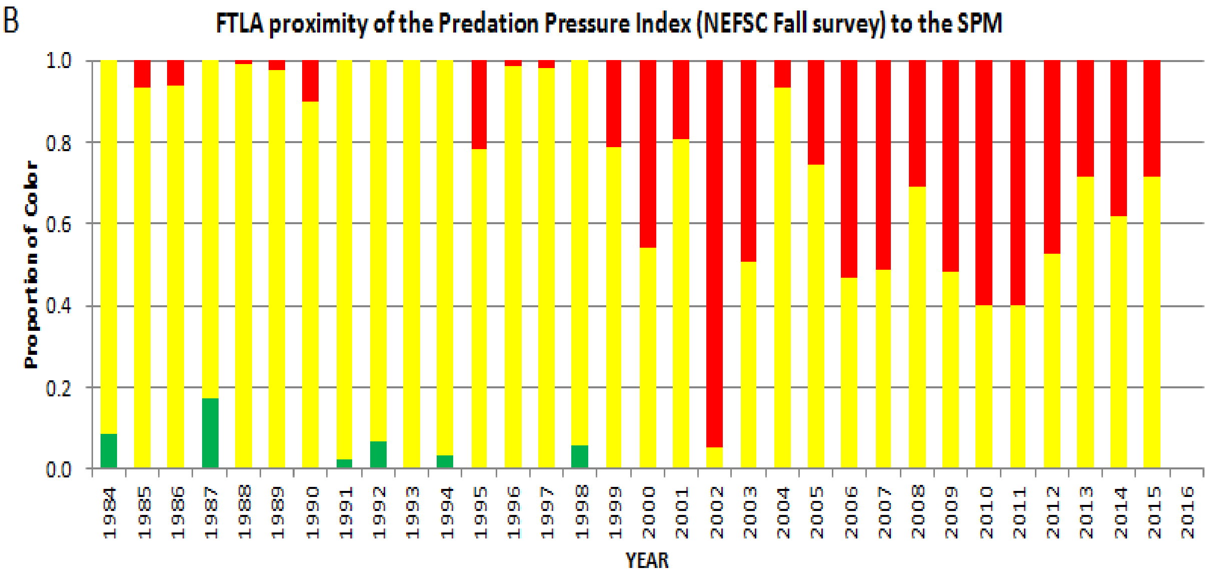


Figure 24: (A) Predation Pressure Index (PPI) for Gulf of Maine northern shrimp from 1984–2015, with 'stable period' (1985–1994) mean (SPM) (dashed) and 80th percentile of the time series from 1984–2015 (dotted) indicated. Green values ≤ SPM; red values ≥ 80th percentile; yellow values > SPM and < 80th percentile. (B) Fuzzy Traffic Light Analysis (FTLA) color proportions indicate proximity of annual indices to the SPM (red = unfavorable; green = favorable).

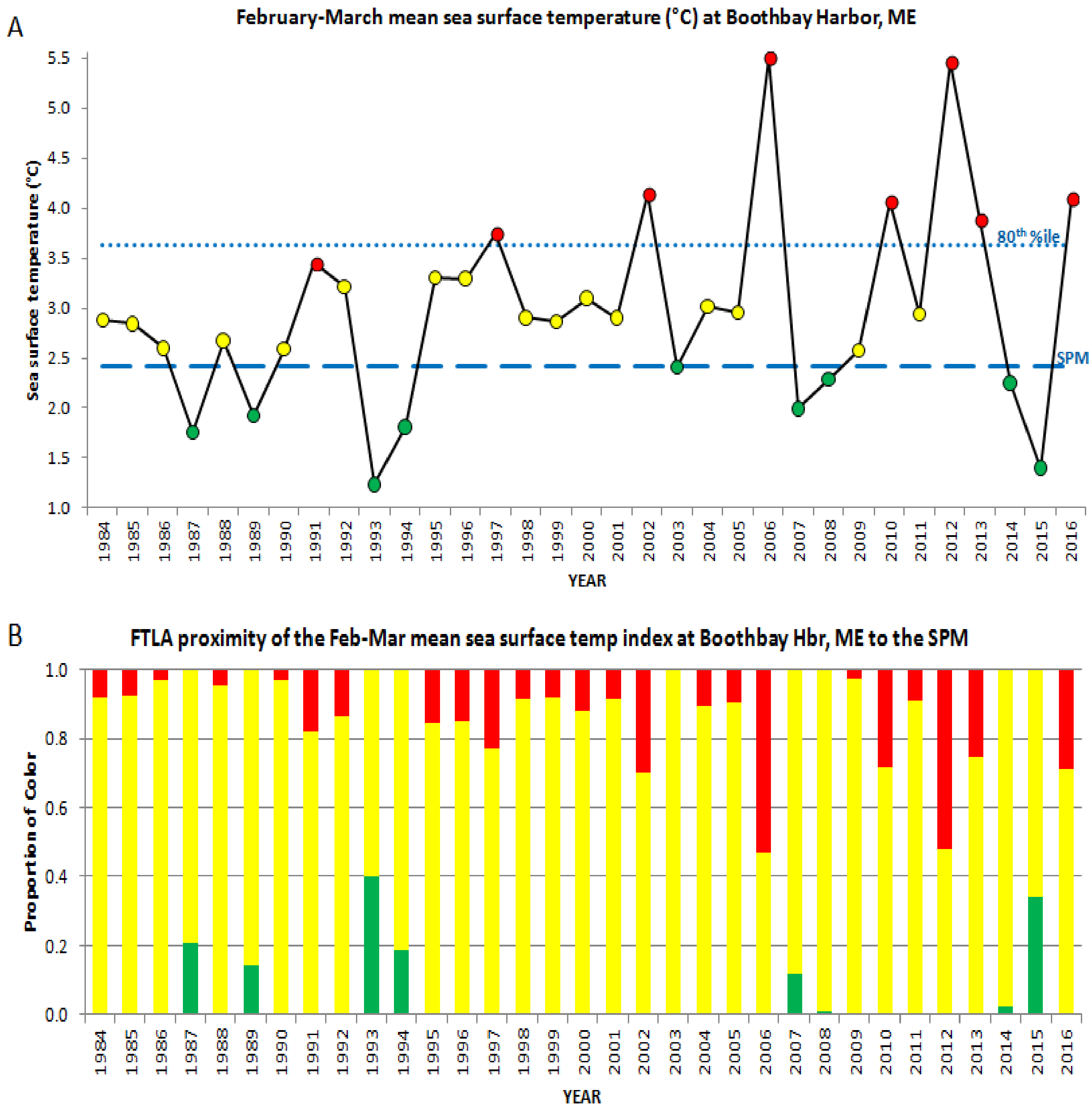


Figure 25: (A) February to March mean sea surface temperature (°C) at Boothbay Harbor, ME from 1984–2016, with 'stable period' (1985–1994) mean (SPM) (dashed) and 80th percentile of the time series from 1984–2015 (dotted) indicated. Green values ≤ SPM; red values ≥ 80th percentile; yellow values > SPM and < 80th percentile. (B) Fuzzy Traffic Light Analysis (FTLA) color proportions indicate proximity of annual indices to the SPM (red = unfavorable; green = favorable).

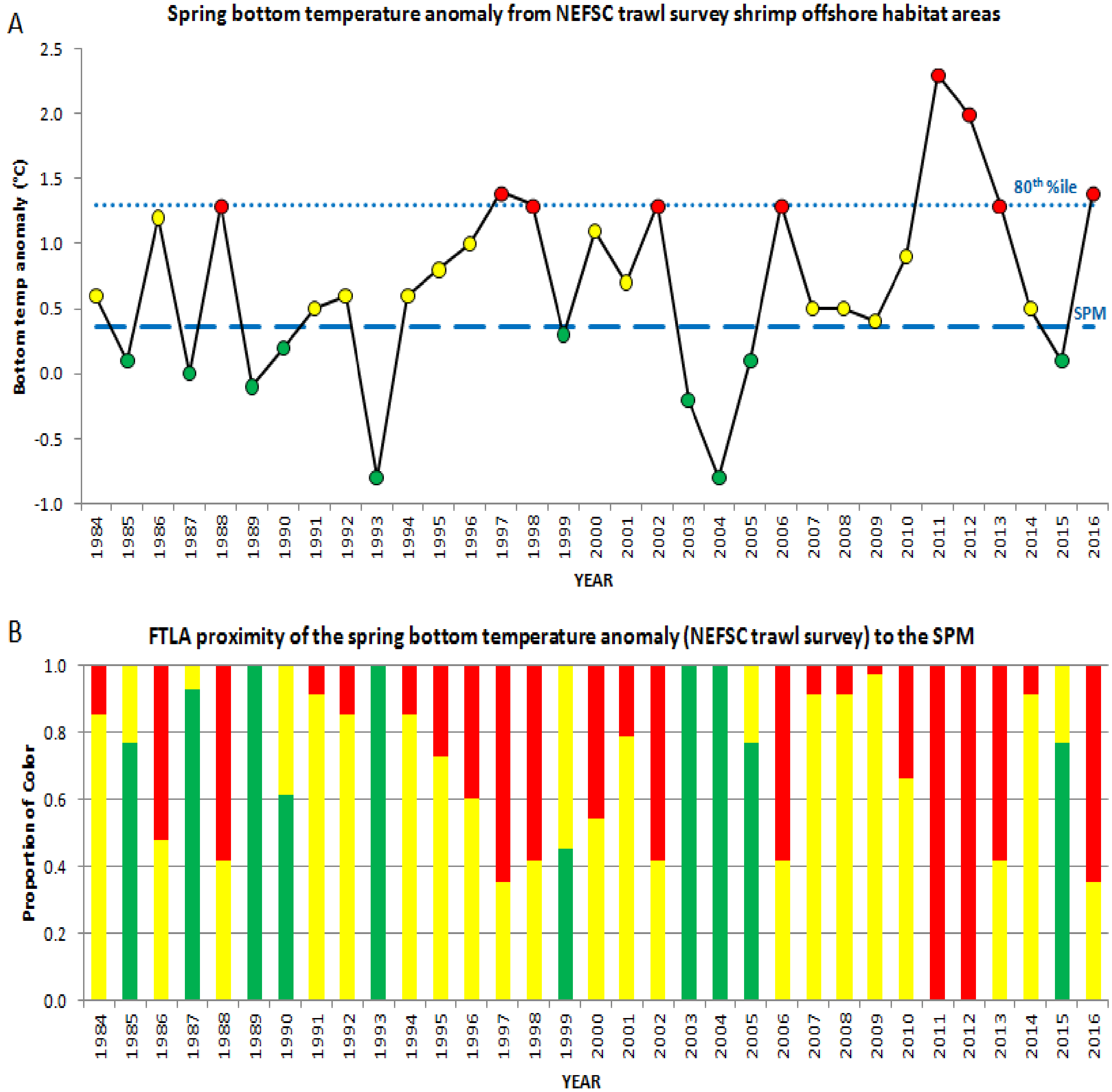


Figure 26: (A) Spring bottom temperature anomaly (°C) from the NEFSC trawl survey in shrimp offshore habitat areas from 1984–2016, with 'stable period' (1985–1994) mean (SPM) (dashed) and 80th percentile of the time series from 1984–2015 (dotted) indicated. Green values ≤ SPM; red values ≥ 80th percentile; yellow values > SPM and < 80th percentile. (B) Fuzzy Traffic Light Analysis (FTLA) color proportions indicate proximity of annual indices to the SPM (red = unfavorable; green = favorable).

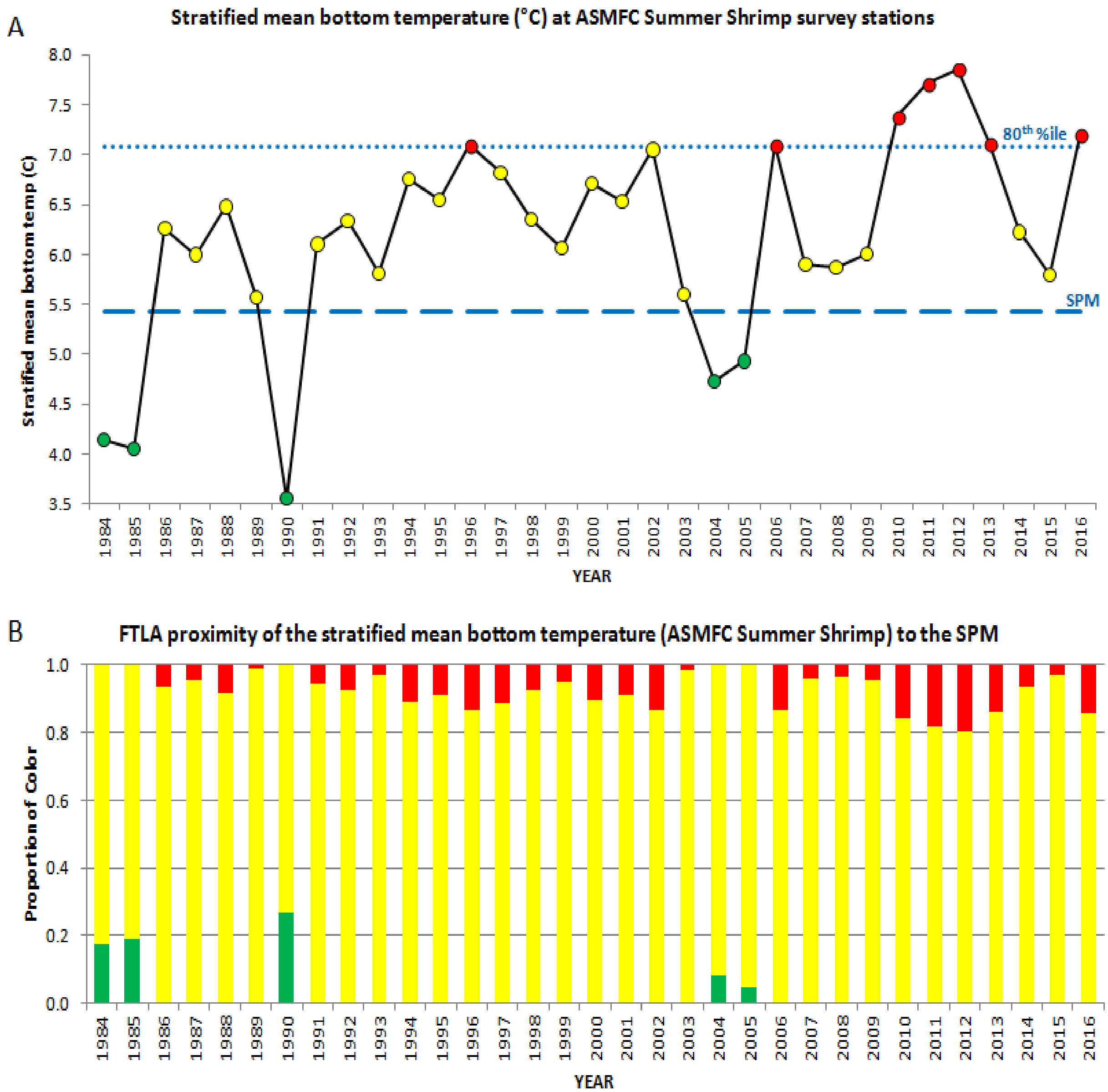


Figure 27: **(A) summer stratified mean bottom temperature (°C) at ASMFC Summer Shrimp survey stations from 1984–2016, with 'stable period' (1985–1994) mean (SPM) (dashed) and 80th percentile of the time series from 1984–2015 (dotted) indicated. Green values ≤ SPM; red values ≥ 80th percentile; yellow values > SPM and < 80th percentile. (B) Fuzzy Traffic Light Analysis (FTLA) color proportions indicate proximity of annual indices to the SPM (red = unfavorable; green = favorable).**

Appendix 1. NSTC recommendations made and actions taken by the ASMFC northern shrimp Section for management of the Gulf of Maine northern shrimp fishery, 1987– 2015 (adapted from 58th SAW Report, NEFSC 2014).

Fishing Season	Recommendations	Actions Taken
1987	• Extension of season to maximum allowed • Continuation of mesh regulations	• Open season (182 days) • Continuation of mesh regulations
1988	• Restriction of season to winter and spring • Continuation of mesh regulations	• Open season (183 days) • Continuation of mesh regulations, except 0.25 inch tolerance in codend eliminated
1989	• Extension of season to maximum allowed • Continuation of mesh regulations	• Open season (182 days) • Continuation of mesh regulations • Shrimp separator trawls required in April and May
1990	• Extension of season to maximum allowed • Continuation of mesh regulations	• Open season (182 days) • Continuation of mesh regulations • Shrimp separator trawls required in December, April, and May
1991	• Extension of season to maximum allowed • Continuation of mesh regulations	• Open season (182 days) • Continuation of mesh regulations • Shrimp separator trawls required throughout season
1992	• Restriction of season from January – March • Continuation of mesh regulations	• Open season (153 days). December 16, 1991 – May 15, 1992. • No fishing on Sundays • Continuation of mesh regulations • Shrimp separator trawls required throughout season • Finfish excluder devices required April 1 – May 15
1993	• Restriction of season from January – March • Continuation of mesh regulations	• Open season (138 days). December 14, 1992 – April 30, 1993 • No fishing on Sundays • Continuation of mesh regulations • Finfish excluder devices and separator panels required
1994	• Restriction of season from January – March • Continuation of mesh regulations	• Open season (122 days) December 15, 1993 – April 15, 1994. • Continuation of mesh regulations • Finfish excluder devices
1995	• Restriction of season from January – March • Continuation of mesh regulations	• Open season (128 days). December 1, 1994 – April 30, 1995. • No fishing Fridays or Sundays (state choice) • Continuation of mesh regulations • Finfish excluder devices required
1996	• Extension of season to maximum allowed • Continuation of mesh regulations	• Open season (152 days). December 1, 1995 – May 31, 1996 for mobile gear; no fishing one day per week. • Open season (121 days). January 1 – May 31, 1996 for fixed gear (traps) • Continuation of mesh regulations

Fishing Season	Recommendations	Actions Taken
1997	• Restriction of effort in December, April, and May • Continuation of mesh regulations	• Open season (156 days). December 1, 1996 – May 31. Two 5-day and four 4-day blocks of no fishing. Trap gear may be left untended. • Finfish excluder devices required • Continuation of mesh regulations
1998	• Restriction of effort in February – March • Continuation of mesh regulations	• Open season (105 days). December 1, 1997 – May 22, 1998 for mobile gear; no fishing weekends except March 14 – 15 and December 25–31 and March 16 – 31. • Open season (65 days). January 1 – March 15 for trap gear. No fishing on Sundays except March 15. • Continuation of mesh regulations • Finfish excluder devices required
1999	• Restriction of season to 40 days during February – March • Continuation of mesh regulations	• Open season (90 days). December 15, 1998 – May 25, 1999 for mobile gear. No fishing on weekends plus December 24–25, December 28 – January 1, January 27–29, February 24–26, March 17–31, and April 29–30. • Open season (61 days). January 10 – March 10 for trap gear. • Continuation of mesh regulations • Finfish excluder devices required
2000	• No fishing; closed season	• Open season (51 days). January 15 – March 15. No fishing on Sundays. • Continuation of mesh regulations • Finfish excluder devices required
2001	• Restriction of season to 61 days • Continuation of mesh regulations	• Open season (83 days). January 9 – April 30. March 18– April 15 no fishing. Experimental offshore fishery in May. • Continuation of mesh regulations • Finfish excluder devices required
2002	• No fishing; closed season	• Open season (25 days). February 15 – March 11. • Continuation of mesh regulations • Finfish excluder devices required
2003	• No fishing; closed season	• Open season (38 days). January 15 – February 27. No fishing on Fridays. • Continuation of mesh regulations • Finfish excluder devices required
2004	• No fishing; closed season	• Open season (40 days). January 19 – March 12. No fishing on weekends. • Continuation of mesh regulations • Finfish excluder devices required • No mechanical shaking of net on vessel

Fishing Season	Recommendations	Actions Taken
2005	• Landings should not exceed 2,500 metric tons • Continuation of mesh regulations	• Open season (70 days). December 19 – 30, no fishing on Friday and Saturday; January 3 – March 25, no fishing on weekends. • Continuation of mesh regulations • Finfish excluder devices required • No mechanical shaking of net on vessel
2006	• Landings should not exceed 5,200 metric tons • Continuation of mesh regulations	• Open season (140 days). December 12 – April 30. • 2007 fishing season tentatively set at 140 days. • Continuation of mesh regulations • No mechanical shakers allowed on vessel
2007	• No recommendation against 140-day season • Continuation of mesh regulations	• Open season (151 days). December 1 – April 30. • 2008 fishing season tentatively set at 151 days. • Continuation of mesh regulations • No mechanical shakers allowed on vessel
2008	• No recommendation against 152-day season • Maintain fishing mortality at or below the target/threshold	• Open season (152 days). December 1 – April 30. • 2009 fishing season tentatively set from December to April • Continuation of mesh regulations • No mechanical shakers allowed on vessel
2009	• Landings should not exceed 5,103 metric tons • Maintain fishing mortality at or below the target/threshold	• Open season (180 days). December 1 – May 29. • Continuation of mesh regulations • No mechanical shakers allowed on vessel
2010	• Landings should not exceed 4,400 to 4,900 metric tons • Maintain fishing mortality at or below the target/threshold	• Open season (180 days). December 1 – May 29. Closed early on May 5, 2010. • Continuation of mesh regulations • No mechanical shakers allowed on vessel
2011	• Based on favored fishing mortality rate, landings should not exceed 3,200 metrics tons (F = 0.22) or 4,000 metric tons (F = 0.29)	• Open season (136 days). December 1 – April 15. Closed early on February 28, 2011. • Continuation of mesh regulations • No mechanical shakers allowed on vessel
2012	• Maintain fishing mortality at or below the target value (F = 0.32) • Landings should not exceed 1,834 metric tons	• Total allowable catch (TAC) of 2,000 metric tons; increased to 2,211 metric tons on January 20, 2012 • Trap season start on February 1 with a 1,000 pound landing limit per vessel per day • Trawl season start on January 2, 2012 with three landing days a week
2013	• Moratorium on fishing • If fishing is allowed, start season after 50% of shrimp have hatched their brood	• TAC of 625 metric tons; divided 17% to trap fishery and 83% to trawl fishery • Trawl fishery start on January 22, 2013 with two landings days per week • Trap fishery start on February 5, 2013 with 6 landings days and an 800 lb limit • Landings days modified throughout season

Fishing Season	Recommendations	Actions Taken
2014	• Moratorium on fishing; the stock has collapsed	• Moratorium on fishing • Maine DMR contracted one shrimp trawler to collect samples during the winter
2015	• Moratorium on fishing; the stock has collapsed	• Moratorium on fishing • 25 metric ton RSA for cooperative winter sampling program; 4 trawlers with an 1,800 pounds per trip limit were allowed to sell their landings; 5 trappers had 10 trap and 100 lbs/week limits, no sale.
2016	• Moratorium on fishing; the stock has collapsed	• Moratorium on fishing • 22 metric ton RSA for cooperative winter sampling program; 4 trawlers with an 1,800 pounds per trip limit and 2 trappers with a 40 traps and 600 pounds per week limit. • Selected vessels were permitted to sell their landings