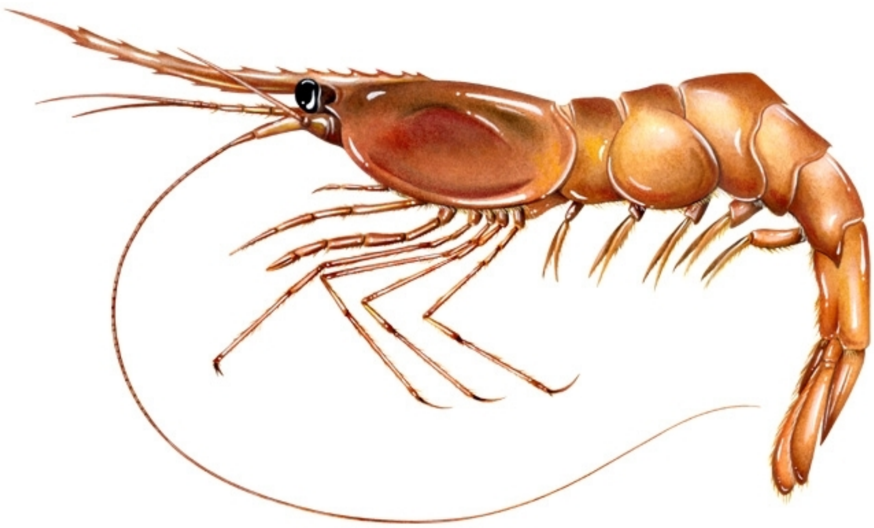
ASSESSMENT REPORT

FOR

GULF OF MAINE NORTHERN SHRIMP – 2012



Prepared

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by the

Atlantic States Marine Fisheries Commission's

Northern Shrimp Technical Committee

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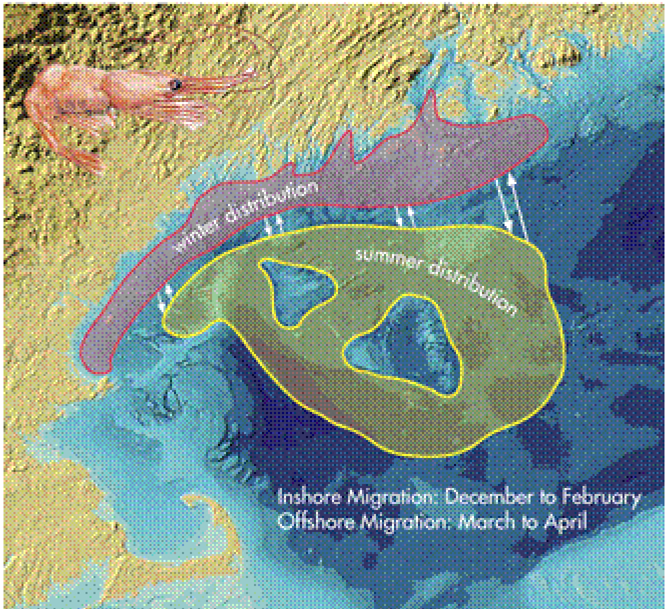
INTRODUCTION

Biological Characteristics

Northern shrimp (*Pandalus borealis* Krøyer) are hermaphroditic, maturing first as males at about 2½ years of age and then transforming to females at about 3½ years of age in the Gulf of Maine.



Distribution of adult female northern shrimp (NAMA, 2006)

Spawning takes place in offshore waters beginning in late July. By early fall, most adult females extrude their eggs onto the abdomen. Egg-bearing females move inshore in late autumn and winter, where the eggs hatch. Juveniles remain in coastal waters for a year or more before migrating to deeper offshore waters, where they mature as males. The exact extent and location of these migrations is variable and unpredictable. The males pass through a series of transitional stages before maturing as females. Some females may survive to repeat the spawning process in succeeding years. The females are the individuals targeted in the Gulf of Maine fishery. Natural mortality seems to be most pronounced immediately following hatching, and it is believed that most northern shrimp do not live past age 5 in the Gulf of Maine (reviewed by Clark et al 2000).

Fishery Management

The Gulf of Maine fishery for northern shrimp is managed through interstate agreement between the states of Maine, New Hampshire and Massachusetts. 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, FMR No. 9). Amendment 1, implemented in 2004, established biological reference points for the first time in the shrimp fishery and expanded the tools available to manage the fishery (ASMFC, FMR No. 42). Management of northern shrimp under Amendment 1 resulted in a rebuilt stock and increased fishing opportunities. However, early season closures occurred in the 2009/2010 and 2010/2011 fishing seasons because landing rates were far greater than anticipated. Furthermore, late landings reporting resulted in short notice of the season closures and an overharvest of the recommended total allowable catch (TAC) by 40% in 2010 and 60% in 2011. In response to these issues, Amendment 2, approved by the ASMFC Northern Shrimp Section (hereafter, Section) in October 2011, provides management options to slow catch rates throughout the season, including trip limits, trap limits, and days out of the fishery.

Amendment 2 completely replaces the FMP, and 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 addendum process.

Addendum I to Amendment 2, implemented in November 2012, provides flexibility and transparency in the annual specification process with the goal of maximizing benefits to the fishery while ensuring stock rebuilding. Specifically, the Addendum includes provisions to (1) set an annual hard TAC that may range between the fishing mortality target and threshold values, inclusive; (2) allocate 87% of the TAC to the trawl fishery and 13% to the trap fishery; and (3) close each fishery when a certain percentage of the TAC is projected to be reached. The exact percent, ranging between 80 and 95%, would be established by the Section during the annual specification process. The Addendum also provides flexibly to (1) transfer unused TAC between gear types; (2) set aside a portion of the TAC for research purposes; and (3) allow for the optional use of a size sorting grate system (compound grate or double Nordmore) to minimize the retention of small shrimp.

Management in the 2011/2012 Season

Within the ISFMP structure, the Northern Shrimp Technical Committee (NSTC) provides annual stock assessments and related information to the Section. Annually, the Section decides on management regimes after thorough consideration of the NSTC stock assessment, input from the Northern Shrimp Advisory Panel, and public comment.

The 2011/2012 fishing season specifications were a total allowable catch (TAC) of 2,211 metric tons (mt), with the season closing when landings were projected to reach 95% of the TAC (2,100 mt). The trawl season started January 2, 2012 with three landing days a week (Monday, Wednesday, Friday). The trap season started February 1, 2012 with a 1,000 pound landing limit per vessel per day. In addition, the Section continued to require the use of a finfish excluder device known as the "Nordmore Grate" throughout the shrimp fishing season. The Section also maintained the requirement that made it unlawful to use mechanical “shaking” devices to cull, grade, or separate catches of shrimp.

The Section took emergency action to close the northern shrimp fishery on February 17, 2012. Because harvest had averaged about 400 mt per week and the fishery was known to have considerable late reporting, landings were projected to have already exceeded the total allowable catch (TAC) of 2,211 mt at the time of closure.

Fishery Assessment

Stock assessments conducted since the 1980’s have identified strong year classes (e.g., those hatched in 1982, 1987, 1992, 2001, 2004). Each strong year class supports the shrimp fishery for about three years commencing about three years after hatching.

In its 2011 assessment, the NSTC estimated the current exploitable biomass of shrimp to be below the average for the 1984-2011 time series, and recommended the Section manage using a TAC at or below 1,834 mt, to maintain a fishing mortality rate (F) of no more than 0.32, in accordance with the FMP target.

The following report presents the results of the Technical Committee's 2012 stock assessment. Analyses and recommendations are based on: 1) research vessel survey data collected by the NSTC during the annual summer shrimp survey, by the Northeast Fisheries Science Center (NEFSC) during the fall trawl survey, by the state of Maine during 1968-1983, and by the

Maine-New Hampshire spring inshore trawl survey; 2) commercial landings data collected by the National Marine Fisheries Service (NMFS) during 1968-2000; 3) biological sampling of the commercial landings by personnel from the participating states and the NMFS; and 4) data from federal and Maine vessel trip reports (VTRs) filed by shrimp fishers since 2001. In addition to index methods of assessing the stock (e.g. trends in landings data, commercial effort and CPUE estimates, indices of abundance), population models including Collie-Sissenwine Analysis, ASPIC biomass dynamics, yield per recruit, and eggs per recruit models are used to provide guidance for management of the stock.

Status of the Stock

The current fishing mortality reference points as established by Amendment 2 and re-estimated by the NSTC in 2012 are F_{target} =0.36, $F_{threshold}$= 0.46, and F_{limit}= 0.60. The terminal year estimate of fishing mortality from the base run of the stock assessment is F_{2012}= 1.08, indicating that fishing mortality has exceeded the threshold, resulting in overfishing. The current biomass reference points as established by Amendment 2 are $B_{threshold}$ = 9,000 mt and B_{limit} = 6,000 mt. The terminal year estimate of biomass is 1,500 mt, indicating that the biomass is below the threshold, resulting in an overfished condition. Amendment 2 states that if fishing mortality exceeds the limit level, and biomass is less than the threshold level, the Section must act immediately to reduce fishing mortality.

The current reference points as stated above are estimated within the assessment model framework using an assumption that natural mortality (M) = 0.25. Based on recommendations from the last benchmark peer reviewed assessment the NSTC is currently exploring a higher M value of 0.6. The NSTC notes that under an assumption that M=0.6, the stock status would still be overfished, and the stock would be experiencing overfishing.

COMMERCIAL FISHERY TRENDS

The NSTC recently reviewed state and federal harvester reports (vessel trip reports (VTRs)) and dealer reports for the 2010 through 2012 fishing seasons, and updated the landings, trips, and boat data in Tables 1-6 and associated figures for those years.

Landings

Annual landings of Gulf of Maine northern shrimp declined from an average of 11,400 metric tons (mt) during 1969-1972 to about 400 mt in 1977, culminating in a closure of the fishery in 1978 (Table 1). The fishery reopened in 1979 and landings increased steadily to over 5,000 mt by 1987. Landings ranged from 2,300 to 4,400 mt during 1988-1994, and then rose dramatically to 9,500 mt in 1996, the highest since 1973. Landings declined to an average of 1,900 mt for 1999 to 2001, and dropped further in the 25-day 2002 season to 450 mt, 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 market-limited. The proposed 180-day season for 2010 was cut short to 156 days with 6,140 mt landed, due to the industry exceeding the committee's recommended landings cap for that year, and concerns about small shrimp.

As in 2010, the 2011 season was closed early. The season was scheduled to be 136 days, but was closed after 90 days. A preliminary total of 6,394 mt of shrimp were landed, exceeding the recommended limit (4,000 mt) by approximately 2,400 mt (Table 1 and Figure 1). The average price per pound was $0.75, an improvement over previous years, and the preliminary estimated landed value of the catch was $10.5 million (Table 1). In 2012, the season was further restricted by having trawlers begin on January 2 with 3 landings days per week (Mondays, Wednesdays, and Fridays) and trappers begin on February 1 with a 1,000 pound limit per vessel per day. The TAC was set at 2,211 mt and would close when the projected landings reached 95% of the TAC. The season was closed on February 17 and trawlers had a 21-day season and trappers had a 17-day season. Preliminary landings from dealer reports for 2012 are 2,418 mt and the average price per pound was $0.96 with an estimated landed value of $5.1 million.

Maine landed 90% (2,185 mt) of the 2012 season total, New Hampshire followed with 6% (149 mt) and Massachusetts landed 3% (84 mt) of the season total (preliminary data, Table 1). The proportional distribution of landings among the states was similar to 2003-2012, but has shifted gradually since the 1980's when Massachusetts accounted for about 30% of the catch (Table 1 and Figure 1).

The relative proportion of landings by month in 2012 (Table 2 and Figure 2a, preliminary data) remained generally similar to past years, except for no landings in December since the fishery did not open until January. The month of January (13 open days for trawlers) yielded the highest proportion of the catch (53%) with February (8 open days for trawlers, 17 for trappers) slightly lower (47%).

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 VTRs, trappers averaged 12% of Maine's landings during 2001 to 2007, 18% during 2008 to 2011 (preliminary data), and 8% (preliminary data) in 2012 (Table 3). Trapping effort has been increasing in recent years, accounting for 22% of Maine's landings in 2010, but may have been lower relative to trawling in 2011 and 2012 because the early closure of the seasons may have impacted trappers more than trawlers.

Size, Sex, and Maturity Stage Composition of Landings

Size and sex-stage composition data were collected from port samples. One-kilogram samples were collected from randomly selected catches. Data were expanded from the sample to the catch, and then from all sampled catches to landings for each gear type, state, and month. Size composition data (Figures 3-5) collected from catches since the early 1980s indicate that trends in landings have been determined primarily by recruitment of strong (dominant) year classes. Landings more than tripled with recruitment 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. 2008 landings 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, catches comprised mostly 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. Transitionals and female I's from the 2008 year class, and some males and juveniles from the assumed 2009 year class were observed, especially in the Massachusetts and New Hampshire catches and Maine's December and January trawl catches (Figures 3-5). Trawl catches in the 2012 fishery were likely 4 year olds from the moderate 2008 year class, and some 5 year olds from the moderate 2007 class, but they appeared to be small for their age, as predicted by the 2011 summer survey size distributions. Lower percentages of males and juveniles were caught in 2012 most likely because of the combination of a late start date of January 2, and an early end to the season.

Maine trappers landed fewer small shrimp, and generally were more apt to catch females after egg hatch, than trawlers, as in previous years (Figure 3). See the table below for the average counts per pound by month and gear. Average counts per pound were lower in Maine than Massachusetts and New Hampshire in January and February.

Mean counts of all shrimp species per pound of landings, from port samples:

2012 Mean Counts per Pound, all shrimp species				
	Dec	Jan	Feb	Mar
Maine Trawls	59*	50	49	56*
Maine Traps	n/a	n/a	48	n/a
Massachusetts	n/a	54	61	n/a
New Hampshire	n/a	53	53	n/a

*Research tows conducted in Maine pre- and post-season.

Spatial and temporal differences in the timing of egg-hatch can be estimated by noting the relative abundance of ovigerous females to females that have borne eggs in the past but are no longer carrying them (female stage II). According to port samples for the 2012 season, in

January, in Maine, 14% of the trawled catch was female stage II; in February this increased to 38%. These percentages are higher in 2010 through 2012 than in past seasons, suggesting that egg hatch is occurring somewhat earlier than in 2008 and 2009 (2008: 5.4% in January, 13.5% in February and 2009: 5.8% in January, 17.8% in February).

In New Hampshire trawl catches, the percentage of female stage II shrimp for the 2012 season was 60.2% in January, and 94.6% in February and in Massachusetts trawl catch samples the percentage of female stage II shrimp was 18% in January, and 50% in February (Figure 4), all higher than Maine for the same months, probably reflecting the eastern Gulf lagging the west in the timing of egg hatch.

Discards

Port samplers in Maine reported seeing manual shakers on a few trawl vessels during April 2010, but made no similar observations in 2011 or 2012. Maine trappers also manually pick or shake out small northern shrimp, and the smaller Pandalid species of veined or striped shrimp (*Pandalus montagui* and *Dichelopandalus leptocerus*) on occasion. Because of a lack of detailed information, shrimp discards from the shrimp and other fisheries are not evaluated in this assessment.

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 has also been documented in white shrimp in South Carolina (http://praise.manoa.hawaii.edu/news/eh216.html) and in the Gulf of Maine in the 1960s and 1970s (Apollonio and Dunton, 1969; Rinaldo and Yevitch, 1974). Its etiology is unknown, although fungal and ciliated protist parasites have been implicated. In samples collected in Maine during the 2004-2012 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 1970's, effort in the fishery (measured by numbers of trips in which shrimp gear is used) has increased and then declined on several occasions. In the 1980's there was a gradual increase in the total number of trawl trips (Table 4 and Figure 6a) to a peak of 12,285 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 1,034 trips in 2002, a year with only a 25-day open season. The number of trips increased during 2003-2005 as the seasons were lengthened, to 3,017 trawl trips in 2005. Trips in 2006 dropped to 1,726, likely due to poor market conditions, increased in 2007 to 3,096, and increased in 2008 to 3,995, the most since 1999. In 2009, the length of the season was increased to 180 days while the effort decreased to 2,096 trips, likely caused by limited demand from the processors and poor market conditions (Table 4). In what turned out to be a 156-day season in 2010, effort increased dramatically to 4,071 trips. The market conditions were improved from prior years 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 5,084 trips (Table 4, preliminary data). The high level of effort was again due in part to a limited supply in Canada and demand from local markets. In 2012, the number of trips decreased to 2,818 (preliminary) due to the shortened season.

The number of vessels participating in the fishery in recent years has varied from a high of 347 in 1996 to a low of 144 in 2006 (Table 6). In 2012, there were 306 vessels; 273 from Maine, 15 from Massachusetts, and 18 from New Hampshire, according to dealer reports (preliminary). Of the 273 vessels from Maine, 99 were trapping.

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 weighouts to estimate the total trips: $$Total.Trips = VTR.Trips \frac{Total.Landings}{VTR.Landings}$$

Since 2000, VTR landings have exceeded dealer weighout landings, and the above expansion is not necessary. However, VTRs for 2011 and 2012 are still being received and processed. Therefore, landings and effort estimates reported here for recent years should be considered extremely preliminary. 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.

Seasonal trends in distribution of trawl effort can be evaluated from port interview data. The relative magnitude of offshore fishing effort (deeper than 55 fathoms) has varied, reflecting seasonal movements of mature females (inshore in early winter and offshore following larval hatching), but also reflecting harvesters' choices for fishing on concentrations of shrimp. Of the 235 interviews of Maine trawl fishermen in 2012, 92% fished inshore (216 trips) and 8% fished offshore (19 trips), with 16 of the 19 offshore trips made in January.

Locations of 2012 fishing trips and landings from federal and state VTRs are plotted by 10-minute square in Figure 7 (preliminary).

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 (1991-2012) and are affected by resource abundance, availability, and changes in effective fishing effort (Table 7 and Figure 6b). 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 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.

Pounds landed per trawl trip, from VTRs, averaged 1,393 pounds during 1995-2000. In 2001, the catch per trip dropped to 752 pounds, the lowest since 1988, and remained low, at 857 pounds, in 2002. During 2003 – 2005 it averaged 1,576 lbs/trip and continued to increase to a time series high of 3,129 pounds per trip in 2007. It decreased in 2008 and again in 2009 to 2,231 pounds per trip (preliminary); still well above average. The pounds per trip increased in 2010 to 2,734, which is the second highest in the time series. There was a slight decrease in 2011 to 2,422 pounds per trip (preliminary, Figure 6b) and a further decline in 2012 to 1,685 pounds per trip, due in part to reductions in fishing day length for trawlers in Maine in 2012.

More precise 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 (less precise) catch per trip data from logbooks (see Table 7 and Figure 6b). However, in 2012, Maine trawlers maintained high landings per hour trawling, 399 lbs/hr, the fourth highest value in the 1991-2012 time series, despite a decline in landings per trip. It is likely that the schedule of days off between open fishing days, and the shorter day length in Maine, both impacted hourly CPUE positively, while reducing trip CPUE.

RESOURCE CONDITIONS

Trends in abundance of Gulf of Maine northern shrimp have been monitored since the late 1960's from data collected in Northeast Fisheries Science Center (NEFSC) spring and autumn bottom trawl surveys and in summer surveys by the State of Maine (discontinued in 1983). A Maine-New Hampshire inshore trawl survey has been conducted each spring and fall, beginning in the fall of 2000 (Sherman et al. 2005). A state-federal survey was initiated by the NSTC in 1984 to specifically assess the shrimp resource in the western Gulf of Maine. The latter 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. The NSTC has placed primary dependence on the summer shrimp survey for fishery-independent data used in stock assessments, although the other survey data are also considered (see survey locations in Figure 8a.).

Abundance and biomass indices (stratified mean catch per tow in numbers and weight) for the state-federal summer survey from 1984-2012 are given in Table 9 and Figures 8c and 11, and length-frequencies by year are provided in Figure 12. The 2012 indices were the lowest on record, with a $\log_e$ transformed mean weight per tow of 2.5 kg/tow. The series averaged 15.8 kg/tow from 1984 through 1990. Beginning in 1991, this index began to decline and averaged 10.2 kg/tow from 1991 through 1996. The survey mean weight per tow then declined further, averaging 6.5 kg/tow from 1997 through 2003, and reaching a low of 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 only 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 has dropped steadily since then, to 8.5 kg/tow in 2011 and 2.5 kg/tow in 2012, a value well below the time series average of 13.7 kg/tow (Table 9). The total mean number of shrimp per tow demonstrated the same general trends over the time series (Table 9 and Figure 11).

The stratified mean catch per tow in numbers of 1.5-year old shrimp (Table 9, Figure 11, and graphically represented as the total number in the first (left-most) size modes in Figure 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. This survey 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 (less than 100 per tow), well below the time series mean of 393 individuals per tow. From 2008 to 2010, the age 1.5 index varied around 500 individuals per tow (506, 554, and 475 individuals per tow, respectively), indicating moderate but above average assumed 2007, 2008, and 2009 year classes. The age 1.5 index dropped markedly to 44 individuals per tow in 2011, signifying a weak 2010 year class. The 2012 index for age 1.5 was even worse, with only 7 individuals per tow, signifying an extremely weak 2011 year class, the weakest in the time series.

Individuals >22 mm will be fully recruited to the upcoming winter fishery (primarily age 3 and older) and thus survey catches of shrimp in this size category provide indices of harvestable numbers and biomass for the coming season (Table 9 and Figure 11). The harvestable biomass index exhibited large peaks in 1985 and 1990, reflecting the very strong assumed 1982 and 1987 year classes respectively. This index has varied from year to year but generally trended down until 2004. The 2001 index of 1.5 kg/tow represented a time series low, and is indicative of poor assumed 1997 and 1998 year classes. In 2002 the index increased slightly to 2.9 kg/tow, reflecting recruitment of the moderate 1999 year class to the index. The index subsequently dropped to the second lowest value in the time series (1.7 kg/tow) in 2003. From 2003 to 2006, the fully recruited index increased dramatically, reaching a time series high in 2006 (29.9 kg/tow). This increase may have been related to the continued dominance of the record 2001 year class, some of which may have survived into the summer of 2006, and to an unexplained increase in the number of female stage 1 shrimp (Figure 12), probably the 2003 year class. In 2007 the index declined to 4.1 kg/tow with the passing of the 2001 year class and the diminishing of the 2003 year class. The 2008 index increased to 10.8 kg/tow, reflecting the strong 2004 and moderate 2005 year classes. The >22 mm weight index declined slightly in 2009 to 8.5 kg/tow, still above the time series mean of 6.3 kg/tow. The moderate 2005 and 2007 year classes and perhaps a remnant of the strong 2004 year class contributed to the composition of the 2009 summer survey >22 mm index. Since 2009, the index has been below the time-series mean and has declined steadily to the time-series low of 0.9 kg/tow in 2012 (Table 9 and Figures 11-12). The low value in 2012 is most likely due to the weak 2010 year class, poor survival of the moderate 2008 and 2009 year classes, and overall small size (carapace length) of female shrimp from those year classes. Male shrimp from the assumed 2010 year class were also unusually small (Figure 12).

There has generally been good agreement between the NEFSC autumn survey index and fishery trends (Table 13a, Fall kg/tow, and Figure 9). The index was close to all time highs at the beginning of the time series in the late 1960's and early 1970's when the Gulf of Maine Northern shrimp stock was at or near virgin levels. In the late 1970's the index declined precipitously as the fishery collapsed; this was followed by a substantial increase in the middle 1980's to early 1990's, with peaks in 1986, 1990 and 1994. This reflects recruitment and growth of the strong presumed 1982, 1987 and 1992 year classes and the above average 1993 year class. After declining to 0.90 kg/tow in 1996, the index rose sharply in 1999 to 2.32 kg per tow, well above the time series mean of 1.77 kg/tow. This is likely due to recruitment of the 1996 year class to the survey gear. Beginning in 2000, the fall survey index declined precipitously for two consecutive years reaching a low of 0.63 kg/tow in 2001, indicating very poor 1997 and 1998 year classes. From 2002 to 2006, the index generally increased, reaching unprecedented time series highs in 2006 and 2007 of 6.64 kg/tow and 4.13 kg/tow, respectively. From 2005 to 2008, the fall survey index was well above the time series mean of 1.77 kg/tow. From 2002 to 2011, landings generally rose each year as well, although some resource highs were not reflected in the fishery, likely due to poor market conditions for shrimp. Landings in 2012 were well below 2010 and 2011 landings, due to a lower quota and improved monitoring and reporting. Elevated fall survey indices observed since 2002 are indicative of robust assumed 2001 and 2004 year classes and moderate 2003, 2005, and 2007 year classes. Because the NEFSC fall survey changed vessels and survey protocols beginning in 2009, data collected for northern shrimp by the survey since 2009 are not currently comparable to previous surveys and were not included in this assessment.

The Maine-New Hampshire inshore trawl survey takes place annually, during spring and fall, in five regions and three depth strata (1 = 5-20 fa, 2 = 21-35 fa, 3 = 36-55 fa). A deeper stratum (4 = > 55 fa out to about 12 miles) was added in 2003 (Figure 8a). The survey consistently catches shrimp in regions 1-4 (NH to Mt. Desert) and depths 3-4 (> 35 fa), and more are caught in the spring than the fall. The $\log_e$-transformed stratified mean weights per tow for *P. borealis* for the spring and fall surveys using regions 1-4 and depths 3-4 only are presented in Tables 8 and 13a and Figure 10. The Maine-New Hampshire index rose from 4.16 kg/tow during spring 2003 to 15.42 kg/tow during spring 2008. In 2009, the spring index dipped to 9.65 kg/tow. This was followed by an increase to 15.95 kg/tow in spring 2010 and to 17.05 kg/tow in spring 2011. However, this upward trend dropped abruptly in 2012 to 7.5 kg/tow, below the time-series average.

The low values in the state-federal summer survey in the most recent years have raised concerns that the survey is no longer adequately tracking abundance. The NSTC examined some of the potential hypotheses to explain the changes. One hypothesis that has been put forward is that the bulk of the northern shrimp population has moved north, outside of the area covered by the summer survey. The NEFSC bottom trawl survey samples the entire US Gulf of Maine, and although 2012 fall survey data are not yet available, the 2009 – 2011 survey data do not suggest a significant shift in distribution of shrimp that would explain the recent decline in abundance indices in the summer survey. Patchiness in the distribution of shrimp in the summer survey appears to have increased slightly since 2008, but shrimp do not appear to be crowding into cooler temperature pockets. Indices based on randomly selected stations show the same trends in abundance as indices based on fixed stations.

From 2007 – 2011, the ME-NH inshore trawl survey has not matched the declining trend in the summer survey data. 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 2012 value in the ME-NH survey is consistent with the 2012 summer survey.

ENVIRONMENTAL CONDITIONS

Ocean temperature has an important influence on northern shrimp in the Gulf of Maine (Apollonio et al. 1986; Richards et al. 1996; Richards et al. 2012). During the warm period of the 1950s, northern shrimp catches declined to zero despite continued fishing effort (Dow 1964), suggesting a population collapse. Spring ocean temperatures during the larval period are particularly important for recruitment, with cooler temperatures favoring higher recruitment (Richards et al. 2012). Spawner abundance also influences recruitment strength, with more recruits resulting from higher spawner abundance (Richards et al 2012). Timing of the larval hatch is influenced by temperature during late spring through early winter (Richards 2012).

Sea surface temperature measured at Boothbay Harbor, Maine increased during the 20th century (Figure 19A), and is now reaching peak levels seen in the 1950s. Spring temperatures in offshore shrimp habitat areas were the highest on record during 2012 (surface temperature) and 2011-2012 (bottom temperature) (NEFSC trawl survey data, 1968-2012; Figures 19B and 19C). The start of the hatch period has become earlier as temperatures have increased, with the hatch now beginning more than a month earlier than the average before 2000 (10% line in Figure 19D). The midpoint of the hatch period has not changed as much, but has trended steadily earlier since 2008 (50% line in Figure 19D).

ANALYTICAL STOCK ASSESSMENT

Descriptive information for the Gulf of Maine shrimp fishery (total catch, port samples, trawl selectivity, survey catches, and life history) was modeled to estimate fishing mortality, stock abundance, and candidate target fishing levels. Because of a lack of detailed information about discards, there were no analyses of discarding for this assessment. The analytical stock assessment comprises three fishery models. The Collie-Sissenwine Analysis, also called Catch-Survey Analysis (CSA) (Collie and Sissenwine 1983; Collie and Kruse 1998; Cadrin et al. 1999, Cadrin 2000) is a stage-based model that tracks abundance and mortality of recruits entering the fishery each year using total catches and summer survey indices. Surplus production analysis (Prager 1994, Prager et al. 1996) models the biomass dynamics of the stock with a longer time series of total landings and four survey indices of stock biomass. A yield-per-recruit and eggs-per-recruit model (Cadrin et al. 1999) simulates the life history of shrimp (including growth rates, sex transition rates, natural mortality, and fecundity) and fishing mortality on recruited shrimp using estimates of trawl selectivity to estimate yield and egg production at various levels of fishing mortality. The models provide guidance in determining the levels of fishing that are most productive and sustainable.

Catch-Survey Analysis (CSA)

The CSA model was run under two assumptions regarding natural mortality (M) (M=0.25 and M=0.6). The assumption of M=0.25 is based on direct estimates from shrimp population and fishery data, approximated from a regression of total mortality on effort (Rinaldo 1973, Shumway et al. 1985), and from catch curve analysis of survey data for age 2+ shrimp during a fishery closure (1977-1978) (Clark 1981, 1982). However, the value of M=0.25 is low relative to that assumed for other *Pandalus* stocks, which range from 0.2 to 1.0 (ICES 1977, Abramson 1980, Frechette and Labonte 1980, Shumway et al. 1985), and is low given the short life span of the species. The most recent peer review of the shrimp assessment (NE Regional SARC 2007) recommended further investigation of appropriate values of M and suggested that a value of M=0.6 is likely more realistic.

CSA results are summarized in Tables 11a (M=0.25) and 11b (M=0.6) and Figures 13-14, and model diagnostics are given in Table 12. The effect of changing the assumption of M is primarily to scale the estimates, with higher biomass and abundance and lower F estimated under M=0.6 than under M=0.25. However, trends in population size and fishing mortality over time were similar between the two models (Figure 13-14). Exploitable biomass and abundance varied about a constant level during the mid-1980s to mid-1990s, then declined to low levels until around 2004, when they began to increase, reaching the time series high in 2007. Since then abundance and biomass have declined steadily and reached the lowest values on record in 2012. Fishing mortality varied without trend during 1985-1994, then increased rapidly to a peak in 1997. F then declined to a low in 2002, fluctuated without trend during 2002-2009, and since has increased to near the peak seen in 1997. The 2012 F estimate is slightly lower than the F estimate for 2011 (but see discussion of retrospective bias below).

Model diagnostics were explored to compare the M=0.25 and M=0.60 models (Table 12). The relative bias and precision of the model estimates of abundance and F were estimated by bootstrapping , in which survey measurement errors were randomly re-sampled with replacement 1000 times to provide simulated replications of the model. The percent bias in the abundance estimates was very low for both models, with slight underestimation in the M=0.25 model and essentially no bias in the M=0.6 model. The percent bias of F estimates was larger than the bias in abundance, and was greater in the M=0.6 model (27%) than in the M=0.25 model (15%). Precision of model estimates as indicated by the average coefficient of variation (CV) was somewhat better for the M=0.25 model than for the M=0.6 model, but neither model was highly precise. A measure of overall model fit (Akiake's Information Criterion, AIC) which compares model estimates of relative abundance with observed relative abundance indices (Figure 13a) indicated that the M=0.6 estimates of relative abundance were closer to the observed survey indices than those from the M=0.25 model.

Mohn's rho (Mohn 1999) was used to evaluate the degree of retrospective patterns in both models. Retrospective patterns provide an indication of the stability of the model, and help with interpretation of terminal year estimates, which are typically the most uncertain. Mohn's rho characterizes the relative difference between estimates for a given year from a full time series model to estimates for that year if the model ended in that year. The data for the statistic are generated by sequentially removing a year from the end of the time series and re-estimating the model. We sequentially removed 4 years from the time series to estimate Mohn's rho in recent years.

Retrospective patterns for both models have become quite pronounced, with terminal year total abundance overestimated by 95% (M=0.25) and 139% (M=0.6). Terminal year F was underestimated by both models (42% for M=0.25, 54% for M=0.60). These retrospective patterns likely stem from the extreme 2006 survey observations, exacerbated by the severe drop in recruitment in 2011 and in all stages in 2012. Prior to 2006, the retrospective patterns in the model were minimal (NE Regional SARC 2007).

In summary, trends modeled by CSA are similar regardless of the assumption of M, and both models currently have diagnostic issues, including large retrospective patterns indicating that terminal year abundance is overestimated and F is underestimated. Both models show a continued decline in abundance and biomass of exploitable northern shrimp and high fishing mortality in the past 2-3 years.

An alternative method of estimating stock size and F was compared to results from the CSA analysis. A biomass dynamics model (ASPIC) was fit to seasonal catch and survey biomass indices from 1968 to 2012 (summarized in Table 13a). Biomass dynamics models such as ASPIC are generally used to track relative trends in biomass and F rather than to derive absolute estimates of these quantities. This is particularly true for species with highly variable recruitment such as northern shrimp, because the model is not able to track the rapid changes in abundance resulting from recruitment pulses (Figure 15b). Estimates of F and biomass from the surplus production model confirmed broad trends estimated by the CSA model (Figure 15c); however, biomass estimates from the CSA model have been declining since 2007, while biomass estimates from ASPIC have only declined since 2010 (Table 13a, Figure 15).

Estimates of biomass from the base model run of ASPIC, which includes all four available fishery independent indices, were below B_{MSY} in 2012 indicating the stock is overfished, which is consistent with the CSA model results. Estimates of F from the production model were below F_{MSY} in 2012, but above it in 2010 and 2011, indicating the stock has been experiencing overfishing for two of the last three years.

All surveys were weighted equally in the ASPIC model, and overall trends and stock status determinations were similar regardless of which indices were used (Figure 15c). The run with the state-federal summer survey alone was the most pessimistic about the status of the stock, while the run that omitted the summer survey was the most optimistic about the status of the stock, and the only run where the biomass in 2012 was slightly above B_{MSY}. Runs that used the NEFSC fall bottom trawl survey were more optimistic (estimating higher biomass and lower F) than those that did not incorporate it. This is most likely because of the length of the time series and the fact that the NEFSC fall bottom trawl survey effectively ended in 2008, before the steep declines in the other current indices.

The CSA model is preferred over the surplus production model for assessing stock status because the CSA model uses empirical observations of recruitment to inform its estimates of population trends, while the surplus production model estimates a single intrinsic growth rate for the population over the whole time-series. As a result, CSA is more accurate in following trends in population size that are driven by northern shrimp's variable recruitment rates (Figure 13a). The surplus production model tends to smooth these trends out over the entire time-series and thus overestimates population size in years with weak year classes and underestimates in years influenced by strong year classes (Figure 15b). With both the CSA and surplus production models, terminal year values of fishing mortality and biomass are typically poorly estimated, possibly contributing to the divergence seen in recent years.

Yield per recruit and percent maximum spawning potential were estimated for the Gulf of Maine northern shrimp fishery (Table 14 and Figure 17, from Cadrin et al 1999). Yield per recruit was maximum at F=0.77 (F_{max}) (48% exploitation) assuming M=0.25. The increase in yield per unit F decreased to one tenth the initial increase at F=0.46 ($F_{0.1}$) (33% exploitation). Maximum spawning potential (i.e., with no F) was 2,395 eggs per recruit. Spawning potential was reduced by half at F=0.25 ($F_{50\%,}$ 20% exploitation).

As concluded by the Stock Assessment Review Committee (SARC) (NEFSC 1996), the stock was not replacing itself when spawning potential was reduced to less than 20% of maximum, and the stock collapsed when egg production was reduced further. Reproductive success for Gulf of Maine northern shrimp is related to population fecundity and spring ocean temperatures, and because temperatures have risen sharply in recent years (see discussion under Environmental Conditions above), F20% may no longer provide sufficient protection to prevent collapse under current conditions. The currently defined target F (average F from 1985 through 1994) allows ~40% of maximum egg production per recruit (Table 14, Figure 17).

SUMMARY

Landings in the Gulf of Maine northern shrimp fishery since the mid-1980s have fluctuated between 450-9,500 mt, reflecting variations in year class strength as well as regulatory measures, participation, and market conditions in the fishery. A peak of 9,500 mt was reached in 1996, after which landings declined steadily to a low in 2002 (450 mt). After 2002, landings generally increased, reaching another peak of around 6,000 mt in 2010 and 2011. Preliminary landings (not accounting for late reporting) in 2012 declined to 2,418 mt, which was 9% above the target TAC set by ASMFC for 2012 (2,211 mt). The catch comprised mostly assumed 4-year-old shrimp from the 2008 year class.

The number of fishing vessels participating in the northern shrimp fishery dropped from a high in 1996 (347 vessels) to an average below 200 vessels during 2002-2007. In 2012, an estimated 306 vessels participated (207 trawl, 99 trap), 12% fewer vessels than during the 1996 peak. Trap catches accounted for about 12% of Maine's landings during 2001 to 2007, 15% during 2008 to 2011 (preliminary data), and 8% (preliminary data) during the truncated 2012 season.

Fishing mortality rates (F) as calculated by CSA under M=0.25 and M=0.60 followed trends similar to the landings, with a peak in 1997 that was about 300% above F_{target} and a low in 2002 that was about 37% below F_{target}. F varied around a relatively low level during 2003-2009 (average 28% below F_{target}), after which F began to increase. F reached the second-highest value in the time series in 2011 (~200% above F_{target}), and in 2012 was estimated to be 92% (M=0.6 model) to 195% (M=0.25 model) above F_{target}. Terminal year estimates are the most poorly estimated, and in recent years terminal F has been underestimated. The FMP target F was re-estimated in this assessment as $F_{1985\text{-}94}$=0.36 (under M=0.25), and the FMP threshold F_{1987}=0.46 (under M=0.25).

Trends in total exploitable stock biomass as estimated from CSA under M=0.25 and M=0.60 show a stable period during 1985-1997, a decline to lower biomass during 1998-2004, then increasing biomass to a time series high in 2007. Since 2007 biomass has steadily declined and reached its lowest level in the current year (2013 fishing season). Terminal year biomass estimates have been over-estimated in recent years, suggesting that the biomass estimate for 2013 may be optimistic.

Evaluation of stock status with respect to biological reference points defined in the ASMFC Northern Shrimp Fishery Management Plan and its amendments indicates that the stock was overfished and overfishing occurred during the 2010-2012 fisheries. Stock status evaluation for 2011 and 2012 was the same (overfished, overfishing occurring) regardless of the assumption of natural mortality (M=0.25 or M=0.6).

Periods of good landings have generally followed recruitment of strong year classes as indicated by the summer survey. In 2013, the female population will be composed of the 2008 and 2009 year classes (5- and 4-year-old females, respectively). Both of these year classes were above average in abundance when they first appeared in the 2009 and 2010 summer surveys. However, in the 2012 survey these age classes had declined to very low levels, and the size of individuals was relatively small. Of additional concern for future years are the low recruitment indices for the 2010 and 2011 year classes (from the 2011 and 2012 summer surveys), which will begin entering the fishery as females in 2014. The recruitment index for the 2011 year class was the lowest on record.

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 been increasing in recent years and have reached or approached unprecedented highs in the past 3 years. This suggests an increasingly inhospitable environment for northern shrimp and indicates the critical need for protecting spawning biomass.

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 2013 fishing season are very poor given the low abundance of all stages of shrimp in the 2012 survey, the relatively small size of females in the 2011 and 2012 surveys, and the low level of exploitable biomass estimated by CSA. The summer survey index of shrimp of carapace length greater than 22 mm (0.9 kg/tow) was the lowest in the 1984-2012 survey time series (1984-2012 average = 6.2 kg/tow).

Longer-term prospects are also poor due to low abundance of age 1.5 shrimp seen in both 2011 and 2012 summer surveys, suggesting poor recruitment of the 2010 and 2011 year classes. The 2010 year class will begin to enter the fishery in 2013, and influences the very low exploitable biomass for 2013 estimated by CSA.

Current trends in environmental conditions are not favorable for northern shrimp and may be a factor in the poor recruitment of the 2010 and 2011 year-classes. This suggests a need to conserve spawners and/or to allow hatching to take place prior to the fishery to help compensate for what may continue to be an unfavorable environment.

Given the current condition of the resource (overfished and overfishing occurring) and poor prospects for the near future, the NSTC recommends that the Section implement a moratorium on fishing in 2013. If a fishery is allowed in 2013, the NSTC recommends a highly conservative approach, including fishing below F_{target} and starting the season after at least 50% of shrimp have hatched their brood. In recent years the midpoint of the hatch has been around February 15 (Figure 19D).

If the Section decides to allow a fishery, projected landings under a range of F's were estimated as:

$$\text{Yield}_{2013} = F * (R_{2013} + N_{2013})\, e^{-p*M}\, w_{2013}$$

Where F = fishing mortality rate

R = CSA-estimated abundance of recruits at time of survey

N = CSA-estimated abundance of full-recruited shrimp at time of survey

p = proportion of year between mean survey date and start of fishery

M= natural mortality

w = projected mean size of shrimp in the 2013 fishery (=10.72 g), estimated from relationship between mean size in the summer survey and mean size in the subsequent year's fishery during 2000-2012 (Figure 20B).

The resulting estimates were as follows:

F level	Estimated Catch (mt) if M=0.25	if M=0.6
25% of F_{target}	139	201
50% of F_{target}	277	402
75% of F_{target}	416	660
F_{target}	555	805
$F_{threshold}$	709	1006

Yield-per-recruit and egg-per-recruit analyses (Table 14) show that shrimp reach both their potential maximum weight yield and maximum egg production at about ages 4-5. Therefore, protecting younger shrimp is recommended for both economical and biological reasons. Protecting egg-bearing females prior to egg hatch is also recommended. During 2010-2012 the mid-point of the hatch occurred in mid-February, and the hatch was 90% complete by mid- to late March (Figure 19D).

The NSTC notes the uncertainty in the estimates of F and stock abundance associated with the terminal years of the CSA model, particularly when landings data are incomplete. There is also uncertainty in projecting the exploitable biomass from the time of the summer survey to the fishing season, and in predicting the size composition of the catch in the upcoming season. The committee urges caution in selecting management options, especially since retrospective patterns in the CSA indicate that terminal year estimates in recent years have been optimistic (over-estimating biomass and underestimating F).

The NSTC urges managers to continue to take whatever action is necessary to ensure timely reporting of landings. The committee also urges managers to ensure that the summer shrimp survey continues to be adequately funded and staffed.

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Table 1. U.S. Commercial landings (mt) of northern shrimp in the Gulf of Maine.

Year	Maine		Massachusetts		New Hampshire		Total		Price	Value
	Annual	Season	Annual	Season	Annual	Season	Annual	Season	$/Lb	$
1958	2.2		0.0		0.0		2.2		0.32	1,532
1959	5.5		2.3		0.0		7.8		0.29	5,002
1960	40.4		0.5		0.0		40.9		0.23	20,714
1961	30.5		0.3		0.0		30.8		0.20	13,754
1962	159.5		16.2		0.0		175.7		0.15	57,382
1963	244.3		10.4		0.0		254.7		0.12	66,840
1964	419.4		3.1		0.0		422.5		0.12	112,528
1965	941.3		8.0		0.0		949.3		0.12	245,469
1966	1,737.8		10.5		18.1		1,766.4		0.14	549,466
1967	3,141.2		10.0		20.0		3,171.2		0.12	871,924
1968	6,515.2		51.9		43.1		6,610.2		0.11	1,611,425
1969	10,993.1		1,773.1		58.1		12,824.3		0.12	3,478,911
1970	7,712.8		2,902.3		54.4		10,669.5		0.20	4,697,419
1971	8,354.8		2,724.0		50.8		11,129.6		0.19	4,653,203
1972	7,515.6		3,504.6		74.8		11,095.0		0.19	4,586,484
1973	5,476.6		3,868.2		59.9		9,404.7		0.27	5,657,348
1974	4,430.7		3,477.3		36.7		7,944.7		0.32	5,577,465
1975	3,177.2		2,080.0		29.4		5,286.6		0.26	3,062,721
1976	617.3		397.8		7.3		1,022.4		0.34	764,094
1977	142.1		236.9		2.2		381.2		0.55	458,198
1978	0.0		3.3		0.0		3.3		0.24	1,758
1979	32.8		405.9		0.0		438.7		0.33	320,361
1980	69.6		256.9		6.3		332.8		0.65	478,883
1981	530.0		539.4		4.5		1,073.9		0.64	1,516,521
1982	883.0		658.5		32.8		1,574.3		0.60	2,079,110
1983	1,029.2		508.2		36.5		1,573.9		0.67	2,312,073
1984	2,564.7		565.4		96.8		3,226.9		0.49	3,474,352
1985	2,957.0	2,946.4	1,030.5	968.0	207.4	216.5	4,194.9	4,130.9	0.44	3,983,599
1986	3,407.2	3,268.2	1,085.7	1,136.3	191.1	230.5	4,684.0	4,635.0	0.63	6,451,207
1987	3,534.2	3,680.2	1,338.7	1,427.9	152.5	157.9	5,025.4	5,266.0	1.10	12,740,583
1988	2,272.5	2,258.4	632.7	619.6	173.1	157.6	3,078.3	3,035.6	1.10	7,391,778
1989	2,544.8	2,384.0	751.6	699.9	314.3	231.5	3,610.7	3,315.4	0.98	7,177,660
1990	2,962.1	3,236.3	993.4	974.9	447.3	451.3	4,402.8	4,662.5	0.72	7,351,421
1991	2,431.5	2,488.6	737.7	814.6	208.3	282.1	3,377.5	3,585.3	0.91	7,208,839
1992	2,990.4	3,070.6	291.7	289.3	100.1	100.1	3,382.2	3,460.0	0.99	7,547,942
1993	1,563.1	1,492.5	300.3	292.8	441.2	357.6	2,304.6	2,142.9	1.07	5,038,053
1994	2,815.4	2,239.7	381.9	247.5	521.0	428.0	3,718.3	2,915.2	0.75	4,829,107
1995		5,013.7		670.1		772.8		6,456.6	0.90	12,828,031
1996		8,107.1		660.6		771.7		9,539.4	0.73	15,341,506
1997		6,086.9		366.4		666.2		7,119.5	0.79	12,355,873
1998		3,481.3		240.3		445.2		4,166.8	0.96	8,811,939
1999		1,573.2		75.7		217.0		1,865.9	0.91	3,762,044
2000		2,085.3		110.3		212.3		2,407.9	0.79	4,190,546
2001		1,075.2		49.4		206.4		1,331.0	0.86	2,534,095
2002		391.6		8.1		53.0		452.7	1.08	1,077,534
2003		1,203.7		27.7		113.0		1,344.4	0.87	2,590,917
2004		1,926.9		21.3		183.2		2,131.4	0.44	2,089,636
2005		2,270.2		49.6		290.3		2,610.1	0.57	3,261,648
2006		2,201.6		30.0		91.1		2,322.7	0.37	1,885,978
2007		4,469.3		27.5		382.9		4,879.7	0.38	4,087,121
2008		4,515.8		29.9		416.8		4,962.4	0.49	5,407,374
2009		2,315.7		MA & NH combined		185.6		2,501.2	0.40	2,216,411
2010		5,604.3		35.1		501.4		6,140.8	0.52	6,994,107
2011		5,565.6		196.4		631.5		6,393.5	0.75	10,579,994
2012		2,185.8		83.8		148.6		2,418.2	0.96	5,100,623

Table 2. Distribution of landings (metric tons) in the Gulf of Maine northern shrimp fishery by season, state, and month.

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

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

Table 2 continued – Landings by season, state, and month.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
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.		5.2	12.7	3.3				21.3
N.H.		27.3	94.8	61.1				183.2
Total	1.8	558.7	1,052.6	510.9	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.	5.3	9.2	7.4	7.6	0.4			30.0
N.H.	3.4	27.9	9.6	43.8	6.5			91.1
Total	152.9	728.7	914.0	402.2	124.9	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.	6.6	12.6	4.8	3.5				27.5
N.H.	52.5	222.6	81.6	14.0	12.1			382.9
Total	821.0	1,715.7	1,676.8	499.4	166.3	0.4	0.03	4,879.7
2008 Season, 152 days, Dec 1 - Apr 30								
Maine	408.6	1,053.6	2,020.4	983.8	49.3		0.1	4,515.8
Mass.	4.3	3.2	7.9	14.5				29.9
N.H.	94.2	123.7	161.6	35.7	1.7			416.8
Total	507.0	1,180.5	2,189.9	1,034.0	51.0	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	20.2	92.7	68.8	1.2	2.6			185.6
Total	154.8	688.6	1,057.0	561.3	37.5	1.8	0.2	2,501.2
2010 Season, 156 days, Dec 1 - May 5								
Maine	264.1	1,682.4	2,914.5	512.3	197.6	33.0	0.4	5,604.3
Mass.	0.4	16.5	17.7	0.3	0.2			35.1
N.H.	107.3	152.4	200.0	14.2	25.2	2.2		501.4
Total	371.9	1,851.3	3,132.2	526.8	223.0	35.2	0.4	6,140.8

* Preliminary data

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
***2011** Season, 90 days, Dec 1 - Feb 28								
Maine	722.7	2,580.1	2,262.3	0.5				5,565.6
Mass.	20.8	100.9	74.7					196.4
N.H.	93.1	304.0	234.4					631.5
Total	836.6	2,985.0	2,571.4	0.5	0.0	0.0	0.0	6,393.5
***2012** Season, Trawling Mon,Wed,Fri, Jan 2- Feb 17 (21 days); Trapping Feb 1-17 (17 days)								
Maine	0.8	1,124.4	1,060.2	0.5				2,185.8
Mass.		63.3	20.6					83.8
N.H.		95.7	52.9					148.6
Total	0.8	1,283.3	1,133.6	0.5	0.0	0.0	0.0	2,418.2

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

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total	% of total
2001 Season, 83 days, Jan 9 - Apr 30, Mar 18 - Apr 16 off, experimental offshore fishery in May									
Trawl		533.0	360.1	30.9	29.8	0.3		954.0	89%
Trap		42.9	72.6	5.7				121.2	11%
Total	0.0	575.8	432.8	36.6	29.8	0.3	0.0	1,075.2	
2002 Season, 25 days, Feb 15 - Mar 11									
Trawl			263.6	77.2				340.8	87%
Trap			43.2	7.6				50.8	13%
Total	0.0	0.0	306.8	84.8	0.0	0.0	0.0	391.6	
2003 Season, 38 days, Jan 15 - Feb 27, Fridays off									
Trawl		467.2	518.8	0.4			0.6	987.0	82%
Trap		67.5	149.2					216.7	18%
Total	0.0	534.7	668.0	0.4	0.0	0.0	0.6	1,203.7	
2004 Season, 40 days, Jan 19 - Mar 12, Saturdays and Sundays off									
Trawl	1.8	514.0	905.5	430.0	4.7	2.7	0.04	1858.7	96%
Trap		12.2	39.5	16.5				68.1	4%
Total	1.8	526.2	945.1	446.4	4.7	2.7	0.04	1926.9	
2005 Season, 70 days, Dec 19 - 30, Fri-Sat off, Jan 3 - Mar 25, Sat-Sun off									
Trawl	75.0	369.4	770.6	663.6			0.01	1878.5	83%
Trap		8.6	124.0	259.0				391.6	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	144.1	675.0	733.8	256.9	117.1			1927.0	88%
Trap	0.1	16.6	163.1	93.9	0.9			274.6	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	758.2	1,443.3	1,275.6	362.1	143.6	0.4	0.0	3,983.2	89%
Trap	3.7	37.2	314.7	119.8	10.6			486.1	11%
Total	761.9	1,480.5	1,590.4	481.9	154.2	0.4	0.0	4,469.3	
2008 Season, 152 days, Dec 1 - Apr 30									
Trawl	408.5	989.6	1,680.8	603.4	42.6		0.1	3,724.9	82%
Trap	0.1	64.0	339.6	380.4	6.7			790.8	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	134.3	579.7	780.9	405.4	33.6	1.8	0.2	1,935.9	84%
Trap	0.4	16.2	207.3	154.7	1.3			379.8	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	263.4	1,488.3	2,091.1	326.3	194.3	33.0	0.4	4,396.7	78%
Trap	0.7	194.1	823.4	186.0	3.3			1,207.6	22%
Total	264.1	1,682.4	2,914.5	512.3	197.6	33.0	0.4	5,604.3	
***2011** Season, 90 days, Dec 1 - Feb 28									
Trawl	720.8	2,202.5	1,716.7	0.5				4,640.5	83%
Trap	1.9	377.7	545.6					925.1	17%
Total	722.7	2,580.1	2,262.3	0.5	0.0	0.0	0.0	5,565.6	
***2012** Season, Trawling Mon,Wed,Fri, Jan 2- Feb 17 (21 days); Trapping Feb 1-17 (17 days)									
Trawl	0.8	1,124.4	895.8	0.5				2,021.5	92%
Trap			164.4					164.4	8%
Total	0.8	1,124.4	1,060.2	0.5	0.0	0.0	0.0	2,185.8	

* Preliminary data

Table 4. Distribution of fishing effort (number of trawl trips) in the Gulf of Maine northern shrimp fishery by season, state, and month.

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

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

Table 4 continued – Trawl trips by season, state, and month.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
2003 Season, 38 days, Jan 15 - Feb 27, Fridays off								
Maine		850	1,081	1			2	1,934
Mass.		41	50					91
N.H.		81	151					232
Total	0	972	1,282	1	0	0	2	2,257
2004 Season, 40days, Jan 19 - Mar 12, Saturdays and Sundays off								
Maine	7	566	965	382	13	14	6	1,953
Mass.		9	36	11				56
N.H.		46	147	66				259
Total	7	621	1,148	459	13	14	6	2,268
2005 Season, 70 days, Dec 19 - 30, Fri-Sat off, Jan 3 - Mar 25, Sat-Sun off								
Maine	140	647	953	778			1	2,519
Mass.	15	18	49	23				105
N.H.	24	76	216	77				393
Total	179	741	1,218	878	0	0	1	3,017
2006 Season, 140 days, Dec 12 - Apr 30								
Maine	145	490	563	273	88			1,559
Mass.	10	16	16	15	1			58
N.H.	5	23	19	52	10			109
Total	160	529	598	340	99	0	0	1,726
2007 Season, 151 days, Dec 1 - Apr 30								
Maine	425	977	921	349	119	1	3	2,795
Mass.	10	18	9	8				45
N.H.	26	115	71	17	27			256
Total	461	1,110	1,001	374	146	1	3	3,096
2008 Season, 152 days, Dec 1 - Apr 30								
Maine	414	1,062	1,393	661	51	0	9	3,590
Mass.	8	9	8	13				38
N.H.	63	141	125	33	5			367
Total	485	1,212	1,526	707	56	0	9	3,995
2009 Season, 180 days, Dec 1 - May 29								
Maine	130	705	673	381	32	5	1	1,927
Mass.& NH	12	95	59	2	1			169
Total	142	800	732	383	33	5	1	2,096
2010 Season, 156 days, Dec 1 - May 5								
Maine	238	1,230	1,512	447	157	29	1	3,614
Mass.	4	22	21	1	1			49
N.H.	54	126	151	21	52	4		408
Total	296	1,378	1,684	469	210	33	1	4,071

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
***2011** Season, 90 days, Dec 1 - Feb 28								
Maine	577	2,077	1,689	1				4,344
Mass.	28	92	73					193
N.H.	108	241	198					547
Total	713	2,410	1,960	1	0	0	0	5,084
***2012** Season, Trawling Mon,Wed,Fri, Jan 2- Feb 17 (21 days); Trapping Feb 1-17 (17 days)								
Maine	2	1,254	1,034	1				2,291
Mass.		86	51					137
N.H.		120	97					217
Total	2	1,460	1,182	1	0	0	0	2,645

* Preliminary data

Table 5. Distribution of fishing trips in the Maine northern shrimp fishery by season, gear type, and month. – Table 5 data are not available yet.

Table 6. Estimated numbers of vessels in the Gulf of Maine northern shrimp fishery by fishing season and state.

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			249	15	23	287
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	236	6	14	256
*2011	172	142	310	12	19	341
*2012	174	99	273	15	18	306

note that some boats reported both trapping and trawling

* preliminary

Table 7. Gulf of Maine northern shrimp trawl catch rates by season. Mean CPUE in lbs/hour towed is from Maine port sampling. Mean catch in lbs/trip is from NMFS weighout and logbook data for trawl catches for all states.

Season	Maine pounds per hour towing			Pounds/trip
	Inshore (<55F)	Offshore (>55F)	Combined	
1991	94	152	140	988
1992	132	93	117	974
1993	82	129	92	767
1994	139	149	141	1,073
1995	172	205	193	1,362
1996	340	203	251	1,714
1997	206	192	194	1,454
1998	158	151	154	1,317
1999	148	147	147	1,067
2000	279	224	272	1,444
2001	100	135	109	752
2002	223	91	194	857
2003	174	215	182	1,102
2004	361	310	351	2,006
2005	235	212	228	1,621
2006	572	345	499	2,616
2007	531	477	507	3,129
2008	350	327	343	2,302
2009	400	315	370	2,231
2010	424	354	401	2,734
*2011	334	435	347	2,244
*2012	407	313	399	1,685

* Pounds/trip are preliminary

Table 8. Stratified retransformed 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	**4.16**	40	3.40	5.05	**1.91**	33	1.35	2.60
2004	**3.87**	42	3.31	4.51	**1.53**	38	1.04	2.14
2005	**7.81**	40	6.60	9.21	**3.59**	25	2.46	5.10
2006	**10.99**	46	8.50	14.13	**2.06**	38	1.43	2.84
2007	**10.70**	43	7.93	14.33	**4.04**	45	3.15	5.13
2008	**15.42**	45	12.72	18.64	**3.59**	37	2.32	5.36
2009	**9.65**	45	7.67	12.09	**2.73**	41	2.27	3.27
2010	**15.95**	48	12.60	20.12	**2.11**	36	1.67	2.61
2011	**17.05**	51	14.13	20.53	**4.20**	32	3.24	5.38
***2012**	**7.50**	50	6.07	9.23				

*2012 data are preliminary.

Table 9. Stratified* retransformed mean numbers and weights per tow of northern shrimp collected during *R/V Gloria Michelle* state/federal summer surveys.

Year	N Tows	Age-1.5 Number	>22 mm** Number	>22 mm Weight (kg)	Total Number	Total Weight (kg)
		Log_e retransformed				
1984		18	316	3.4	1,152	10.5
1985	44	332	1,169	11.5	1,825	17.7
1986	40	358	860	10.0	1,695	19.6
1987	41	342	854	9.5	1,533	15.4
1988	41	828	298	3.4	1,269	12.8
1989	43	276	564	6.1	1,884	17.0
1990	43	142	1,127	12.0	1,623	18.1
1991	43	482	657	8.0	1,256	11.7
1992	45	282	397	4.8	955	9.4
1993	46	757	250	2.8	1,157	9.1
1994	43	368	243	2.7	984	8.7
1995	35	292	628	7.0	1,449	13.3
1996	32	232	358	4.0	776	8.8
1997	40	374	245	2.8	762	7.7
1998	35	134	170	1.9	583	6.3
1999	42	114	174	1.9	398	5.8
2000	35	450	283	3.2	808	6.4
2001	36	18	146	1.5	451	4.3
2002	38	1,164	261	2.9	1,445	9.2
2003	37	11	173	1.7	564	5.5
2004	35	286	519	5.3	887	10.3
2005	46	1,752	871	10.3	3,661	23.4
2006	29	374	2,773	29.9	9,998	66.0
2007	43	28	412	4.1	887	11.5
2008	38	506	995	10.8	1,737	16.8
2009	49	555	702	8.5	1,627	15.4
2010	49	475	413	4.8	1,373	13.9
2011	47	44	316	3.2	830	8.6
2012	49	7	81	0.9	138	2.5
Mean	41	379	561	6.2	1,507	13.3
Median	42	332	397	4.1	1,157	10.5
1984-93 Mean	43	382	649	7.1	1,435	14.1
Median	43	337	611	7.0	1,401	14.1

*Based on strata 1, 3, 5, 6, 7 and 8.
**Will be fully recruited to the winter fishery.

Table 10. Input data for CSA models. Data sources described in text.

Survey Year*	Abundance Indices		Mean weights (kg)		Selectivity ratio	Total Catch Millions*	Mean wt (kg) in Catch
	New Recruits	Full Recruits	New Recruits	Full Recruits			
1984	448	479	0.006	0.008	0.88	353	0.012
1985	612	914	0.008	0.009	0.89	363	0.013
1986	533	849	0.007	0.010	0.93	427	0.012
1987	483	767	0.007	0.010	1.00	228	0.013
1988	460	388	0.005	0.009	0.73	286	0.012
1989	701	818	0.007	0.009	0.92	444	0.011
1990	512	908	0.008	0.010	0.95	320	0.011
1991	374	612	0.007	0.011	1.00	262	0.013
1992	314	444	0.007	0.010	1.00	195	0.011
1993	410	321	0.005	0.008	1.00	273	0.011
1994	369	364	0.006	0.008	0.84	611	0.011
1995	486	653	0.007	0.010	1.00	798	0.012
1996	258	349	0.007	0.010	1.00	711	0.010
1997	257	267	0.005	0.009	0.92	373	0.011
1998	217	227	0.006	0.009	0.92	215	0.009
1999	137	175	0.007	0.009	0.95	209	0.012
2000	276	288	0.005	0.009	1.00	139	0.010
2001	172	196	0.007	0.008	0.92	47	0.010
2002	551	373	0.004	0.008	1.00	126	0.011
2003	223	230	0.006	0.008	0.85	217	0.010
2004	293	406	0.007	0.010	0.72	239	0.011
2005	1,295	1,232	0.005	0.009	0.63	202	0.011
2006	3,878	4,024	0.006	0.008	0.94	542	0.009
2007	323	421	0.007	0.009	0.88	491	0.010
2008	562	847	0.007	0.010	0.97	207	0.012
2009	514	723	0.006	0.011	0.91	509	0.012
2010	491	539	0.006	0.009	0.95	601	0.011
2011	318	344	0.006	0.008	0.91	258	0.009
2012	45	73	0.008	0.010	0.91		

* Survey Year data are applied to the following Fishing Year

Table 11a. Summary of results from Collie-Sissenwine Analysis assuming M=0.25.

Fishing Season	New Recruits (millions)	Fully-Recruited (millions)	F (NR+FR)	Biomass (1000 mt)	Exploitation Rate
1985	658	607	0.38	9.2	28%
1986	702	677	0.35	11.6	26%
1987	535	756	0.46	11.6	33%
1988	398	634	0.29	9.4	22%
1989	659	603	0.29	8.4	23%
1990	709	733	0.42	10.9	31%
1991	445	735	0.36	11.1	27%
1992	320	640	0.37	9.1	27%
1993	283	518	0.32	7.2	24%
1994	457	454	0.41	5.9	30%
1995	913	471	0.68	9.2	44%
1996	907	548	0.94	11.3	55%
1997	629	444	1.31	8.5	66%
1998	453	226	0.94	4.6	55%
1999	314	206	0.62	3.6	41%
2000	241	218	0.71	3.6	46%
2001	265	176	0.43	3.1	31%
2002	198	222	0.13	3.2	11%
2003	421	286	0.22	4.0	18%
2004	319	440	0.39	5.5	29%
2005	648	401	0.30	8.3	23%
2006	1,387	608	0.12	12.7	10%
2007	1,122	1,376	0.28	18.2	22%
2008	303	1,471	0.37	15.0	28%
2009	426	953	0.19	12.6	15%
2010	422	893	0.57	12.0	39%
2011	380	581	1.17	7.6	63%
2012	200	232	1.08	3.2	60%
2013	51	114		1.5	
Overall mean	509	559	0.50	8.3	33%
1985-94 mean	517	636	0.36	9.4	27%

Table 11b. Summary of results from Collie-Sissenwine Analysis assuming M=0.6.

Fishing Season	New Recruits (millions)	Fully-Recruited (millions)	F (NR+FR)	Biomass (1000 mt)	Exploitation Rate
1985	2,123	1,949	0.12	29.5	9%
1986	2,509	1,979	0.11	37.4	8%
1987	1,893	2,199	0.15	36.2	10%
1988	1,392	1,936	0.10	29.9	7%
1989	2,430	1,661	0.10	26.1	7%
1990	2,664	2,037	0.13	35.0	9%
1991	1,623	2,258	0.12	36.2	8%
1992	1,118	1,898	0.12	28.3	9%
1993	947	1,465	0.11	21.2	8%
1994	1,425	1,182	0.15	16.4	10%
1995	2,094	1,233	0.28	22.4	18%
1996	1,779	1,386	0.40	25.2	25%
1997	1,010	1,166	0.55	18.1	33%
1998	993	689	0.34	11.8	22%
1999	822	655	0.21	10.5	15%
2000	623	656	0.24	10.2	16%
2001	906	551	0.13	10.1	10%
2002	713	699	0.04	10.6	3%
2003	1,504	741	0.08	12.3	6%
2004	1,057	1,140	0.14	15.6	10%
2005	2,405	1,048	0.10	26.7	7%
2006	6,994	1,722	0.03	52.0	2%
2007	4,943	4,636	0.08	68.7	6%
2008	1,046	4,863	0.12	49.9	8%
2009	1,501	2,887	0.06	39.5	5%
2010	1,318	2,257	0.21	32.0	14%
2011	1,026	1,595	0.36	20.7	23%
2012	632	1,007	0.23	12.4	16%
2013	156	713		8.2	
Overall mean	1,712	1,662	0.17	26.0	12%
1985-94 mean	1,812	1,856	0.12	29.6	9%

Table 12. Comparison of diagnostics from CSA models assuming M=0.25 and M=0.60. Values shown are averages of time series for each metric. Percent bias reflects accuracy of estimates, CV (coefficient of variation) reflects precision of estimates, Mohn's rho characterizes severity of retrospective pattern, AIC indicates overall model fit with lower values indicating better fit.

Diagnostic	Assumed M	Abundance (millions) New Recruit	Full Recruit	Total	F
Percent Bias	0.25	-0.6	-2.5	-1.9	14.6
	0.60	0.3	0.1	-0.02	26.6
CV (%)	0.25	46.9	42.8	26.6	35.1
	0.60	65.5	67.6	57.5	46.1
Mohn's rho (%)	0.25	85.6	100.2	94.7	-42.4
	0.60	157.0	128.3	139.2	-53.6

Model AIC	0.25	-40.19
	0.60	-78.40

Table 13a. Input values and summary of results from base model of surplus production model (ASPIC) run using all survey indices.

	Base ASPIC Model Input					Base ASPIC Model Results			
Year	Fall NEFSC (kg/tow)	ME Summer (kg/tow)	Summer Shrimp (kg/tow)	ME-NH Spring (kg/tow)	Catch (MT)	Biomass (000s of MT)	F	B/Bmsy	F/Fmsy
1968	3.20	45.80			6,610	43.9	0.15	1.21	0.98
1969	2.70	31.20			12,824	42.8	0.33	1.17	2.10
1970	3.70	40.80			10,670	35.7	0.32	0.98	2.07
1971	3.00	9.40			11,130	30.6	0.40	0.84	2.58
1972	3.30	7.00			11,095	24.9	0.52	0.68	3.31
1973	1.90	7.80			9,405	18.5	0.61	0.51	3.89
1974	0.80	4.90			7,945	12.9	0.80	0.35	5.09
1975	0.90	6.70			5,287	7.6	0.95	0.21	6.10
1976	0.60	4.80			1,022	3.9	0.26	0.11	1.64
1977	0.20	1.60			381	4.1	0.08	0.11	0.54
1978	0.40	3.20			3	5.0	0.00	0.14	0.00
1979	0.50	4.40			439	6.7	0.06	0.18	0.38
1980	0.50	2.70			333	8.3	0.04	0.23	0.23
1981	1.50	3.00			1,074	10.6	0.09	0.29	0.60
1982	0.30	2.00			1,574	12.5	0.12	0.34	0.75
1983	1.00	4.20			1,574	14.4	0.10	0.39	0.65
1984	1.90		10.5		3,227	16.6	0.19	0.46	1.21
1985	1.60		17.7		4,131	17.5	0.24	0.48	1.51
1986	2.50		19.6		4,635	17.5	0.27	0.48	1.72
1987	1.70		15.4		5,266	17.0	0.32	0.47	2.07
1988	1.20		12.8		3,036	15.7	0.19	0.43	1.21
1989	1.81		17.0		3,315	16.5	0.20	0.45	1.25
1990	2.04		18.1		4,663	17.3	0.27	0.47	1.76
1991	0.44		11.7		3,585	16.7	0.21	0.46	1.35
1992	0.41		9.4		3,460	17.2	0.20	0.47	1.26
1993	1.85		9.1		2,143	17.9	0.11	0.49	0.72
1994	2.24		8.7		2,915	20.1	0.14	0.55	0.89
1995	1.22		13.3		6,457	21.9	0.31	0.60	1.97
1996	0.90		8.8		9,539	20.1	0.56	0.55	3.55
1997	1.12		7.7		7,120	14.7	0.57	0.40	3.61
1998	1.99		6.3		4,167	10.8	0.42	0.30	2.66
1999	2.32		5.8		1,866	9.3	0.19	0.26	1.23
2000	1.28		6.4		2,408	10.1	0.24	0.28	1.50
2001	0.63		4.3		1,331	10.4	0.12	0.29	0.76
2002	1.70		9.2		453	12.1	0.03	0.33	0.21
2003	1.08		5.5	4.2	1,344	15.1	0.08	0.41	0.53
2004	1.58		10.3	3.9	2,131	17.7	0.11	0.49	0.73
2005	2.77		23.4	7.8	2,610	19.9	0.13	0.55	0.80
2006	6.64		66.0	11.0	2,323	22.0	0.10	0.60	0.64
2007	4.13		11.5	10.7	4,880	24.6	0.20	0.67	1.26
2008	3.05		16.8	15.4	4,962	24.8	0.20	0.68	1.28
2009			15.4	9.7	2,501	25.0	0.10	0.69	0.61
2010			13.9	16.0	6,141	27.8	0.23	0.76	1.44
2011			8.5	17.1	6,393*	27.0	0.24	0.74	1.55
2012			2.5	7.5	2,418*	25.8	0.09	0.71	0.57
2013						28.7		0.79	
Average:	1.77	11.22	13.29	10.31	4,232	18.26	0.25		

*: Preliminary data

1971-74 Average:	21.7	0.58
1985-94 Average:	17.3	0.21
2010-2012 (3-yr) Average:	26.8	0.19

Table 13b. Results of surplus production analysis (ASPIC) sensitivity runs.
See Table 13a for details from Run 1 (using all survey indices).
The second run omits the ME/NH spring survey index.
The third run omits all indices except the summer survey.
The fourth run includes only the summer survey and MH/NH spring survey indices.
The fifth run includes all survey indices except the fall.
The sixth run includes all survey indices except the old Maine survey.

	Fishing Mortality (F)						Jan-1 Biomass (000s MT)					
Year	Base model (all indices)	No ME-NH spring survey	Only summer shrimp index	Currently running (ME-NH, Summer)	No NEFSC Fall Survey	No historic ME summer survey	Base model (all indices)	No ME-NH spring survey	Only summer shrimp index	Currently running (ME-NH, Summer)	No NEFSC Fall Survey	No historic ME summer survey
1968	0.15	0.13			0.15	0.15	43.94	54.75			46.32	44.22
1969	0.33	0.30			0.33	0.33	42.83	48.33			42.99	43.11
1970	0.32	0.31			0.34	0.32	35.66	38.10			34.58	35.91
1971	0.40	0.40			0.43	0.40	30.63	31.46			29.04	30.83
1972	0.52	0.52			0.56	0.51	24.85	24.84			23.13	24.99
1973	0.61	0.62			0.68	0.61	18.47	18.13			16.84	18.55
1974	0.80	0.83			0.94	0.80	12.86	12.47			11.38	12.88
1975	0.95	1.01			1.37	0.97	7.60	7.26			6.16	7.55
1976	0.26	0.28			0.25	0.19	3.91	3.62			2.22	3.80
1977	0.08	0.09			0.09	0.07	4.07	3.80			2.50	4.19
1978	0.00	0.00			0.00		5.01	4.80			3.29	5.22
1979	0.06	0.06			0.06	0.05	6.68	6.57			4.68	6.91
1980	0.04	0.04			0.04	0.03	8.34	8.37			6.19	8.64
1981	0.09	0.09			0.12	0.08	10.57	10.77			8.28	10.91
1982	0.12	0.11			0.14	0.11	12.53	12.90			10.12	13.00
1983	0.10	0.10			0.12	0.10	14.38	14.90			11.90	14.87
1984	0.19	0.18	0.24	0.29	0.22	0.18	16.61	17.22	13.18	10.60	14.11	17.12
1985	0.24	0.23	0.29	0.36	0.28	0.23	17.47	18.09	14.05	11.48	14.96	17.98
1986	0.27	0.26	0.34	0.41	0.32	0.26	17.49	18.10	14.08	11.56	14.99	18.00
1987	0.32	0.31	0.41	0.51	0.38	0.31	16.97	17.58	13.56	11.09	14.46	17.49
1988	0.19	0.18	0.24	0.30	0.22	0.18	15.66	16.32	12.26	9.78	13.13	16.19
1989	0.20	0.19	0.25	0.30	0.23	0.19	16.54	17.28	13.16	10.66	14.00	17.08
1990	0.27	0.26	0.34	0.42	0.32	0.27	17.29	18.06	13.92	11.45	14.73	17.84
1991	0.21	0.20	0.26	0.32	0.25	0.21	16.70	17.51	13.34	10.93	14.12	17.26
1992	0.20	0.19	0.24	0.29	0.23	0.19	17.18	18.03	13.85	11.48	14.59	17.76
1993	0.11	0.11	0.14	0.16	0.13	0.11	17.88	18.75	14.57	12.31	15.28	18.48
1994	0.14	0.13	0.17	0.19	0.16	0.14	20.13	20.91	16.80	14.75	17.52	20.73
1995	0.31	0.30	0.37	0.41	0.35	0.30	21.89	22.43	18.46	16.71	19.28	22.49
1996	0.56	0.55	0.70	0.78	0.66	0.54	20.10	20.39	16.56	15.15	17.49	20.69
1997	0.57	0.55	0.80	0.91	0.73	0.54	14.66	14.91	11.08	9.95	12.01	15.27
1998	0.42	0.39	0.69	0.83	0.60	0.39	10.79	11.19	7.04	6.05	7.95	11.47
1999	0.19	0.18	0.36	0.45	0.30	0.18	9.33	9.99	5.15	4.14	6.11	10.11
2000	0.24	0.21	0.48	0.62	0.39	0.21	10.09	11.07	5.29	4.20	6.35	11.00
2001	0.12	0.10	0.26	0.35	0.21	0.11	10.44	11.80	4.85	3.61	6.03	11.50
2002	0.03	0.03	0.07	0.08	0.06	0.03	12.08	13.85	5.52	4.07	6.86	13.31
2003	0.08	0.07	0.16	0.20	0.14	0.08	15.07	17.22	7.47	5.90	8.98	16.48
2004	0.11	0.10	0.22	0.27	0.19	0.10	17.69	20.07	9.05	7.40	10.71	19.27
2005	0.13	0.11	0.25	0.29	0.21	0.12	19.91	22.34	10.19	8.56	12.02	21.65
2006	0.10	0.09	0.20	0.22	0.17	0.09	21.97	24.24	11.10	9.55	13.10	23.86
2007	0.20	0.19	0.41	0.46	0.34	0.18	24.60	26.48	12.54	11.16	14.74	26.61
2008	0.20	0.19	0.46	0.51	0.37	0.18	24.82	26.16	11.46	10.31	13.90	26.95
2009	0.10	0.09	0.24	0.26	0.19	0.09	24.99	25.76	10.03	9.13	12.79	27.24
2010	0.23	0.23	0.65	0.68	0.48	0.21	27.75	27.81	11.02	10.42	14.17	30.10
2011	0.24	0.25	1.12	1.12	0.64	0.22	26.95	26.22	8.12	7.88	11.80	29.40
2012	0.09	0.10	0.73	0.67	0.28	0.08	25.82	24.38	3.89	3.98	8.53	28.39

Table 14. Yield and egg production per recruit of Gulf of Maine northern shrimp, for an example fishing mortality F = 0.20, natural mortality M = 0.25, and 1,000 age 0 recruits.

	Input Data						Results						
Age	Length (mm)	Transition Rate (% Fem)	Fishery Selectivity	Male wt (g)	Female wt (g)	Fecundity at length	Total N	Male N	Female N	Male Catch	Female Catch	Yield (g)	Egg Production
1	11.17	0	0.033	0.84	1.24	0	774	774	0	4	0	4	0
2	18.43	0	0.230	3.79	4.82	0	575	575	0	31	0	117	0
3	23.50	0.081	0.579	7.87	9.30	1,286	399	367	32	56	0	439	41,581
4	27.04	0.922	0.799	12.00	13.58	1,876	265	21	244	48	4	635	458,156
5	29.51	0.997	0.893	15.60	17.19	2,287	173	0	172	3	35	657	393,661
6	31.23	1.000	0.933	18.50	20.04	2,574	112	0	111	0	26	523	287,027
7	32.43	1.000	1.000	20.72	22.19	2,775	71	0	71	0	18	399	197,299
											total	2,773	1,377,725
											total/recruit	2.773	1,378
											% of max		57.52

Ref. Point	F	YPR	%EPR
F_{max}	0.77	4.25	14.77
$F_{0.1}$	0.46	3.99	29.83
$F_{example}$	0.20	2.77	57.52
$F_{50\%}$	0.25	3.14	50
$F_{40\%}$	0.34	3.62	40
$F_{30\%}$	0.45	3.97	30
$F_{20\%}$	0.63	4.21	20
$F_{10\%}$	0.95	4.21	10

Count per pound

Age	Male	Female
1	540	366
2	120	94
3	58	49
4	38	33
5	29	26
6	25	23
7	22	20

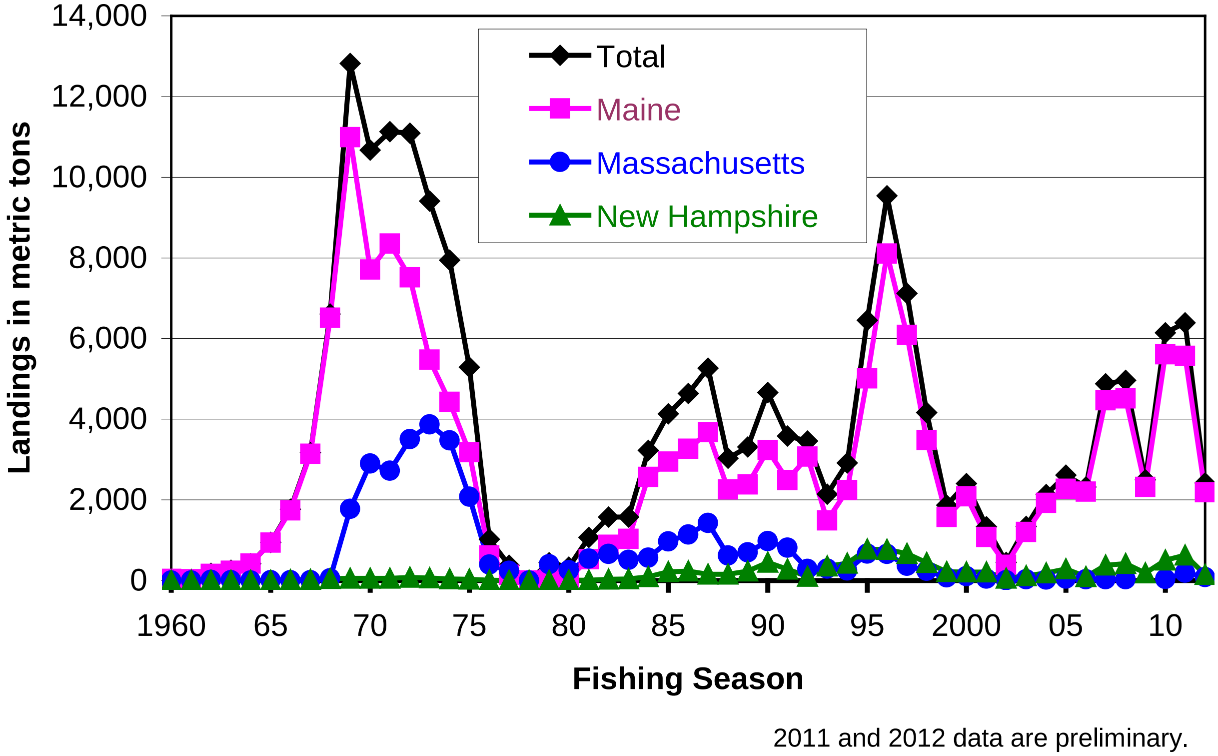


Figure 1. Gulf of Maine northern shrimp landings by season and state. MA landings are combined with NH landings in 2009 to preserve confidentiality.

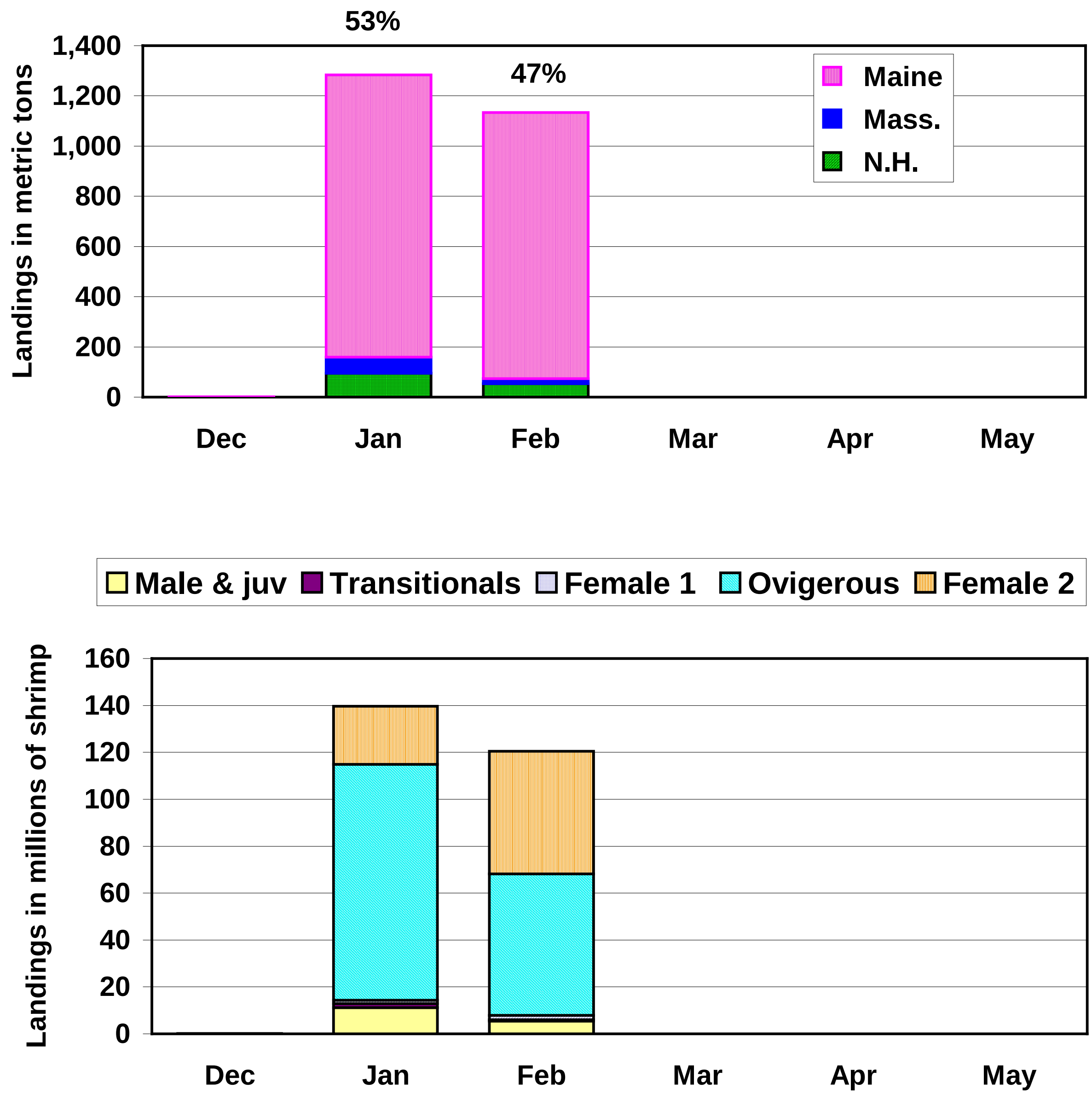


Figure 2. **Gulf of Maine northern shrimp landings by month in the 2012 season (preliminary data). Landings are in metric tons by state (above), and in millions of shrimp by development stage (below).**

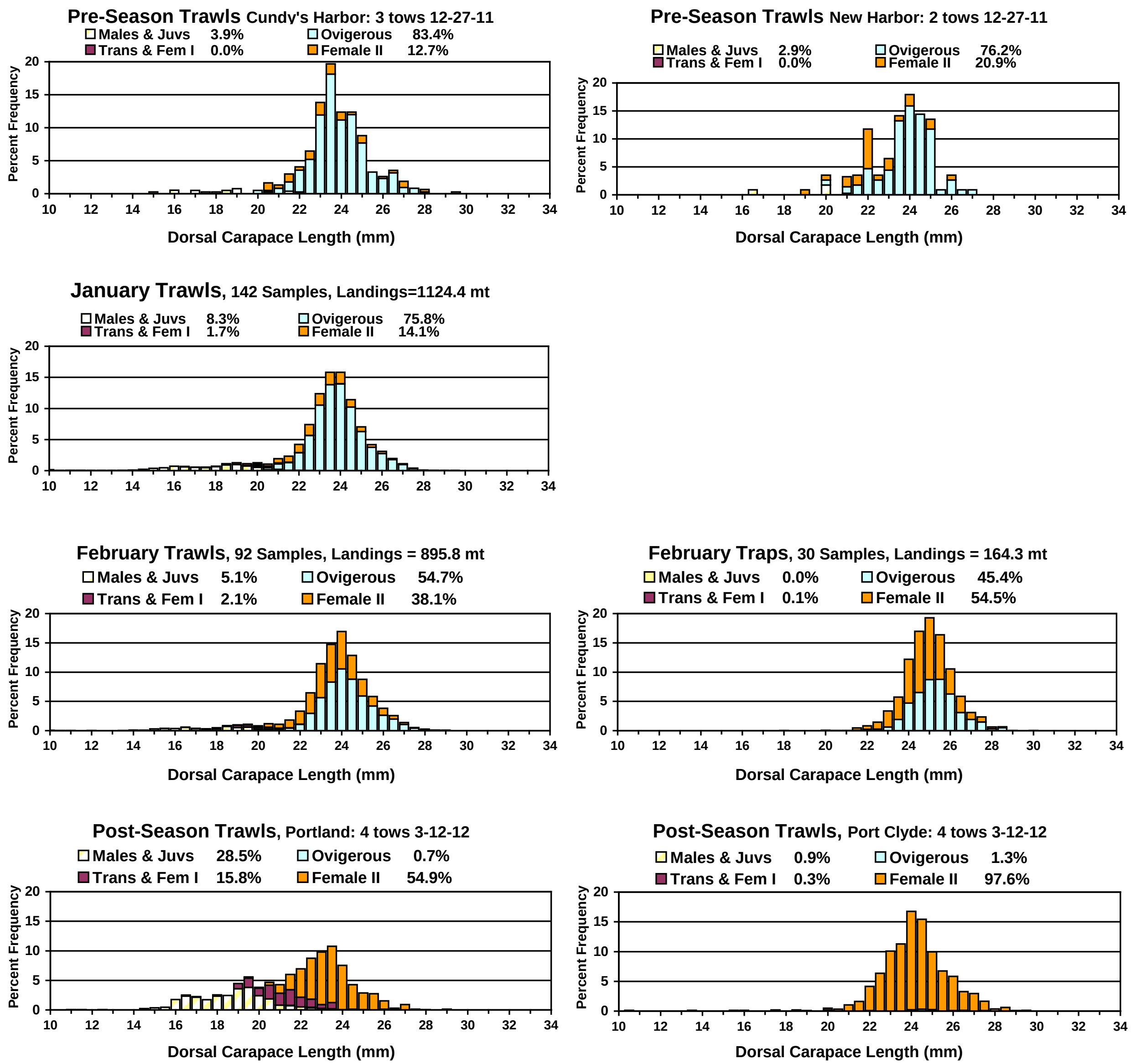


Figure 3. Relative length-frequency distributions from samples of Maine northern shrimp catches during the 2012 season by month. Landings are preliminary.

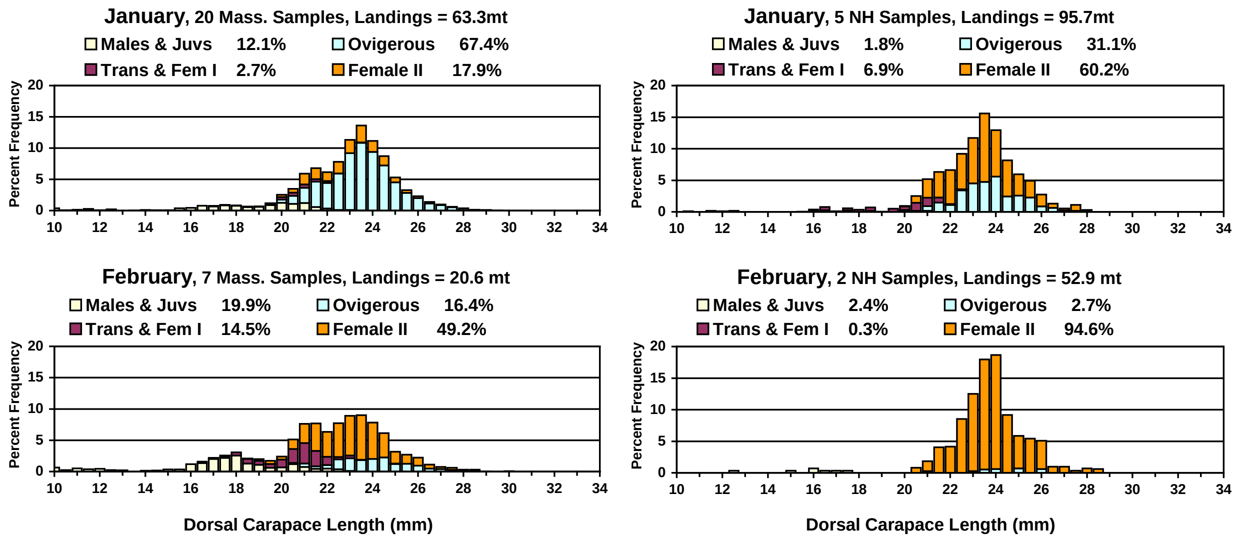


Figure 4. Relative length-frequency distributions from samples of Massachusetts (left) and New Hampshire (right) northern shrimp catches during the 2012 season by month. Landings are preliminary.

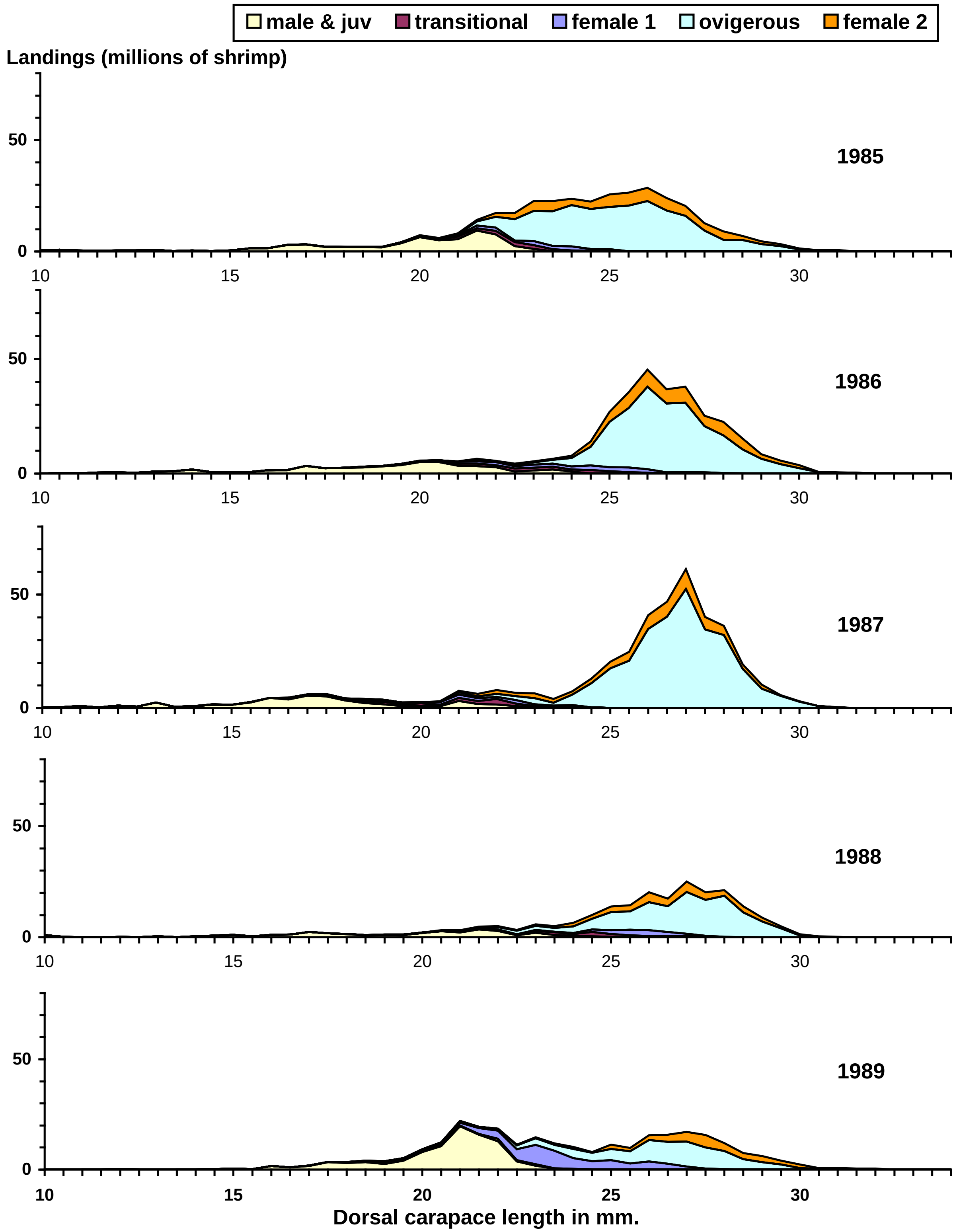


Figure 5. Gulf of Maine northern shrimp landings in estimated numbers of shrimp, by length, development stage, and fishing season. Landings are preliminary throughout.

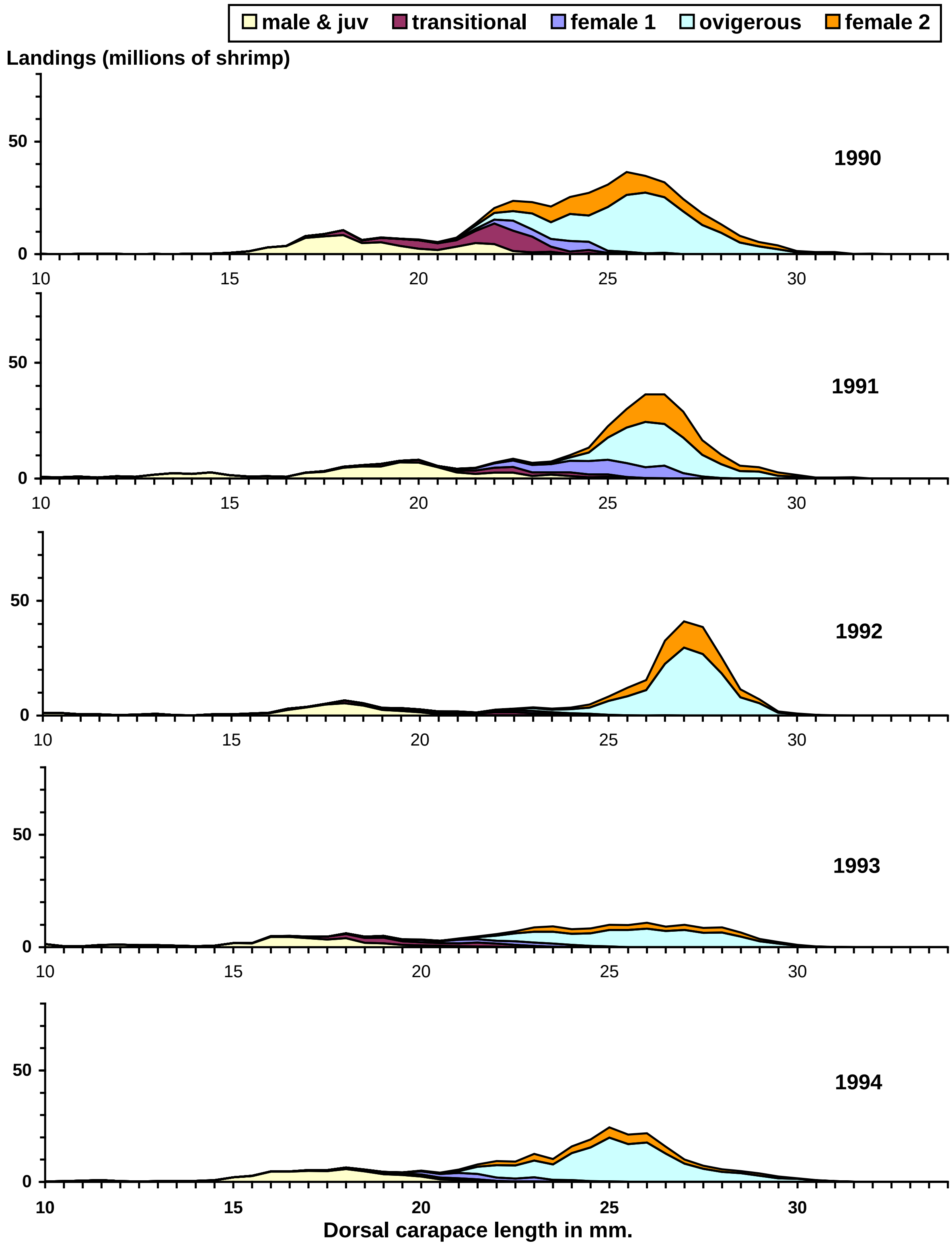


Figure 5 continued – Preliminary landings in estimated numbers of shrimp.

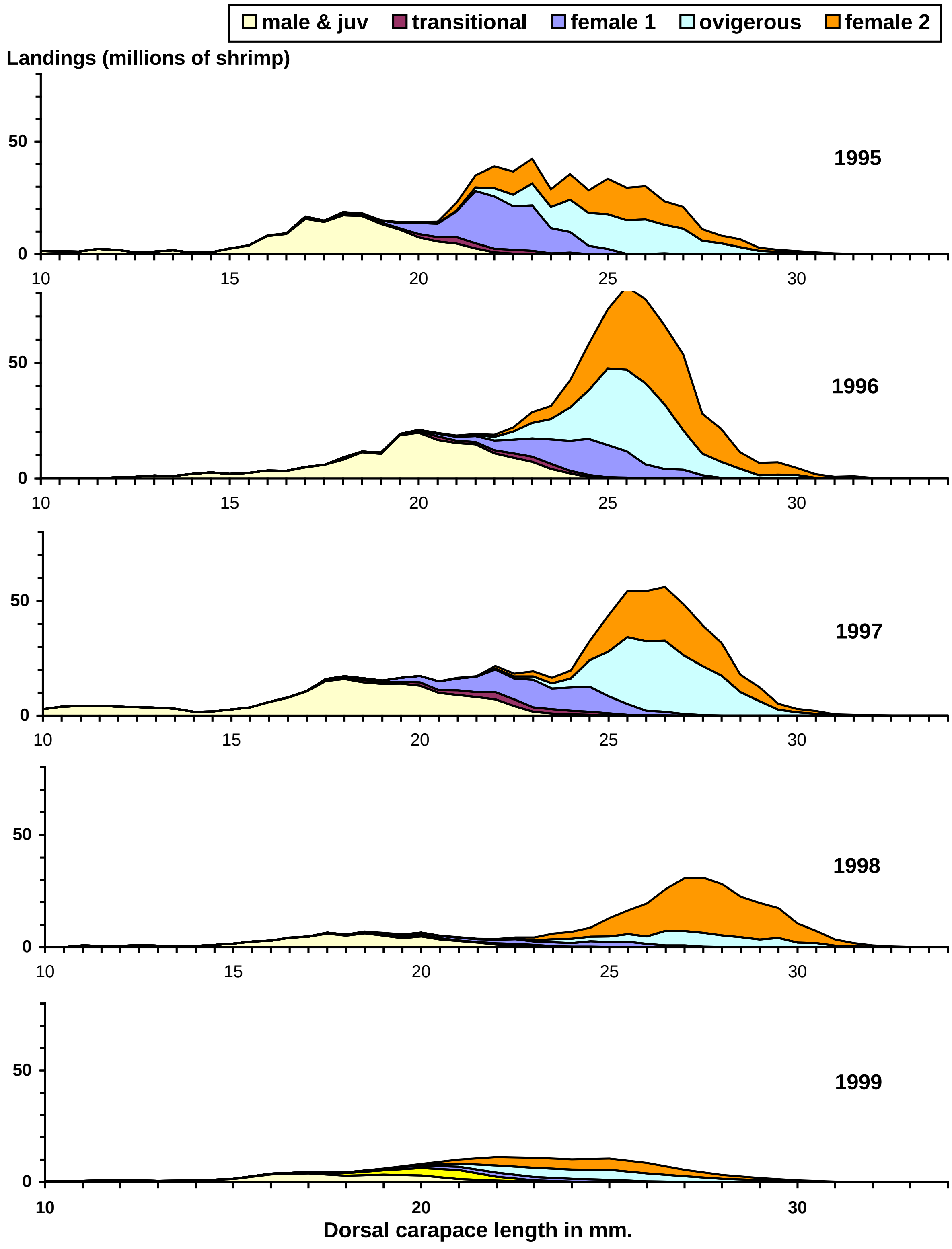


Figure 5 continued – Preliminary landings in estimated numbers of shrimp.

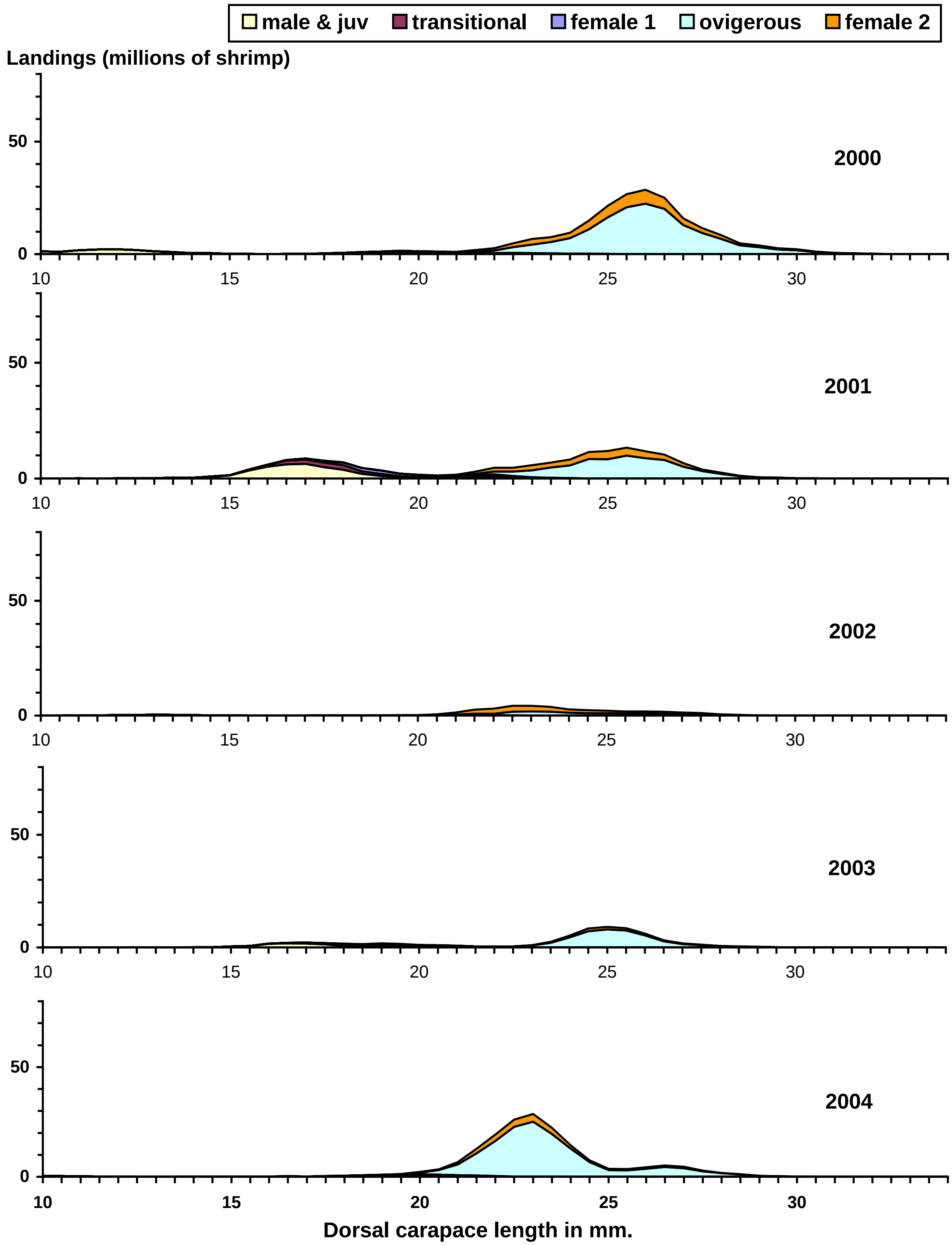


Figure 5 continued – Preliminary landings in estimated numbers of shrimp.

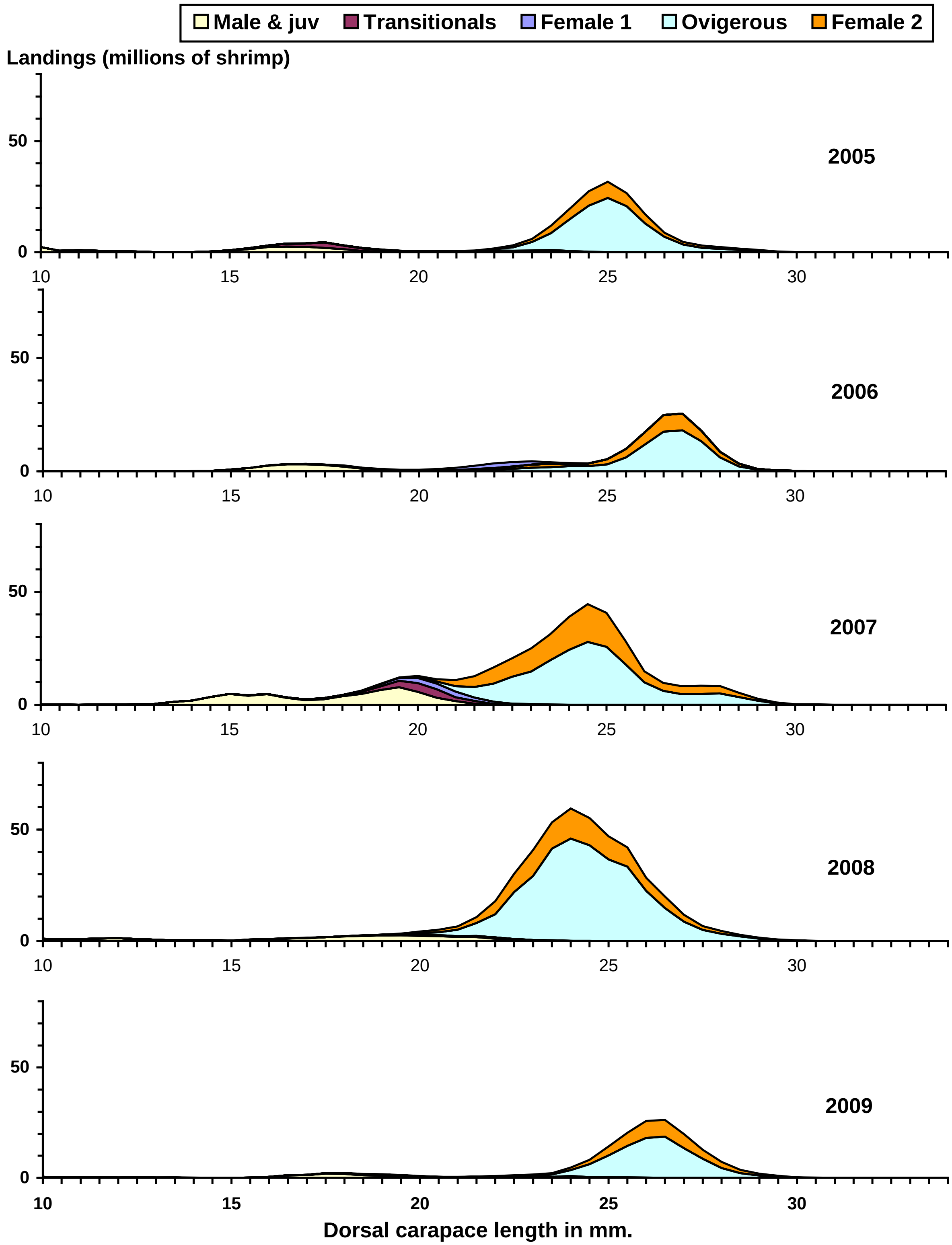


Figure 5 continued – Preliminary landings in estimated numbers of shrimp.

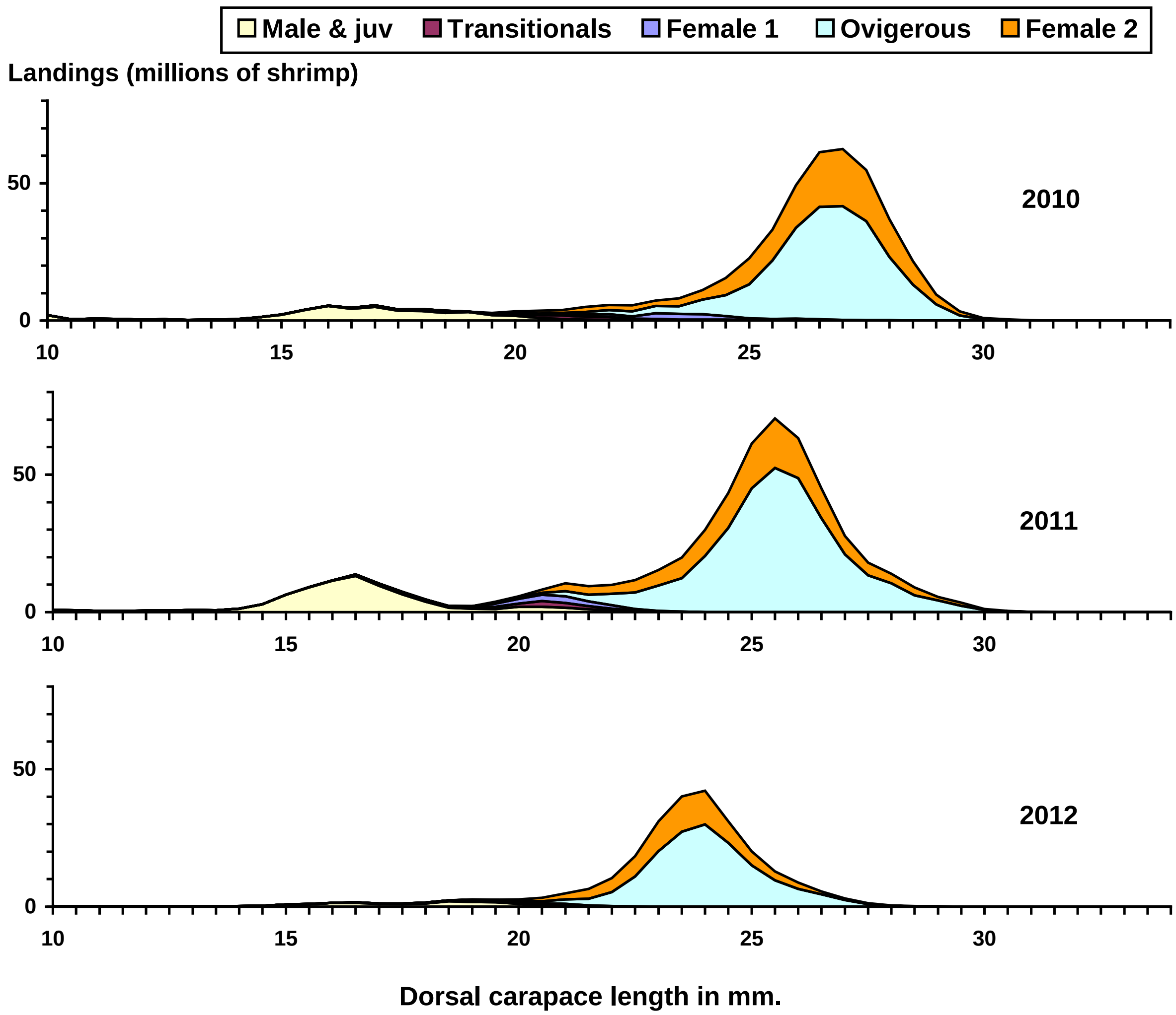


Figure 5 continued – Preliminary landings in estimated numbers of shrimp.

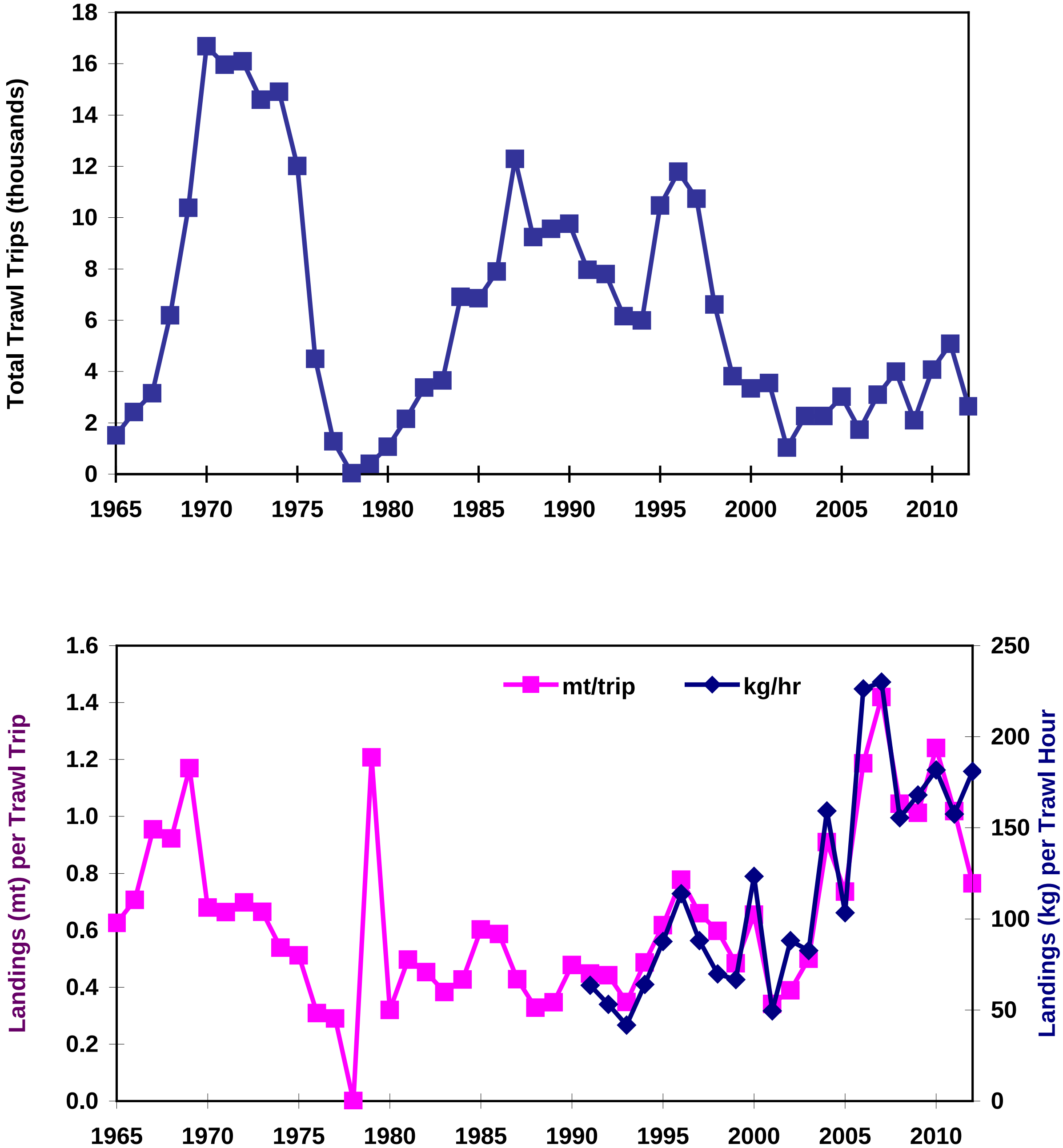
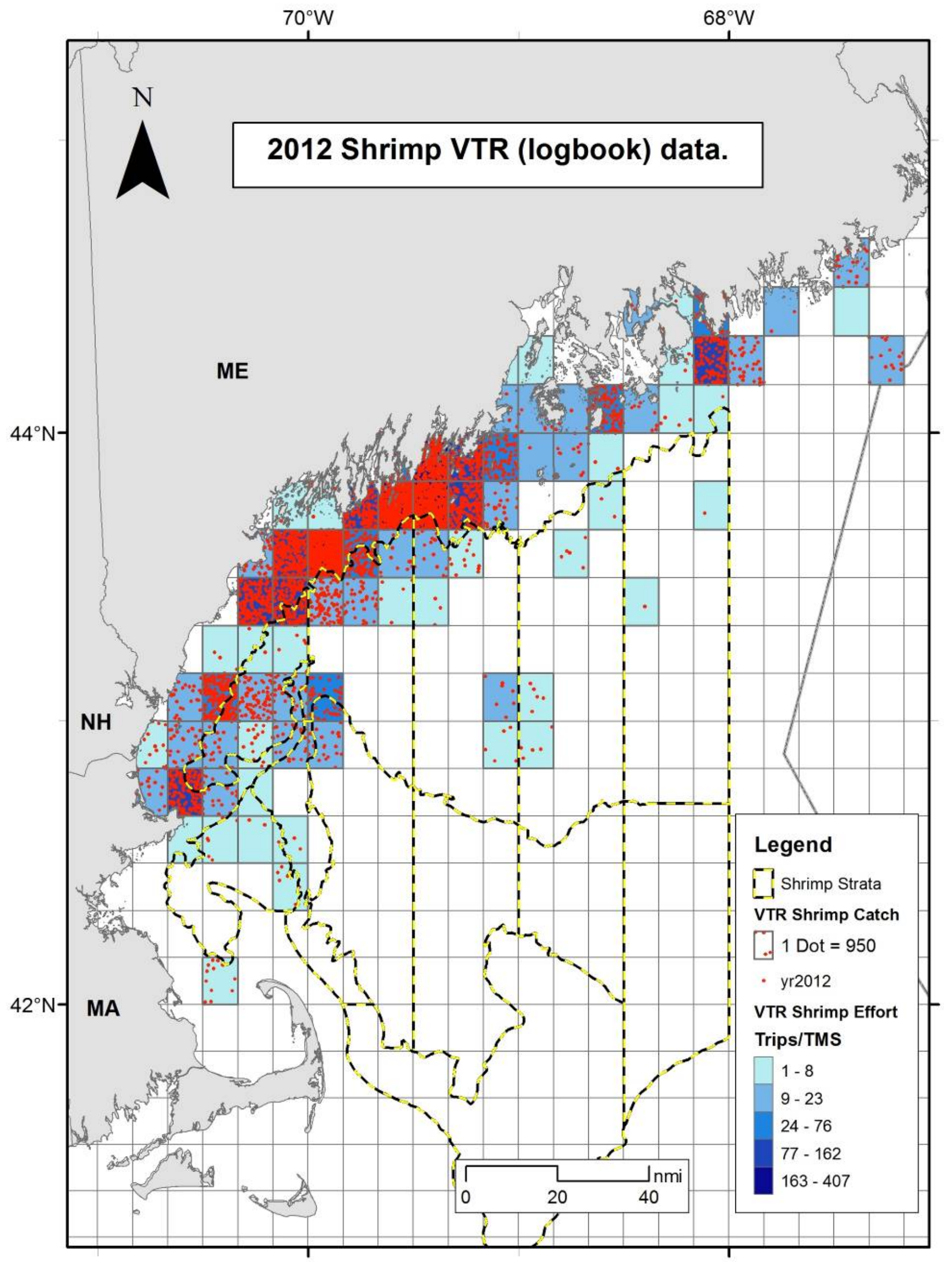


Figure 6. **Nominal fishing effort (trawl trips) (above) and catch per unit effort (below), in the Gulf of Maine northern shrimp fishery by season. 2011 and 2012 trip data are preliminary.**



Dot density symbols (red dots) were used to display pounds caught per Ten Minute Square (TMS). Each dot represents 950 lbs, the median value of pounds landed per trip across all years, therefore squares with more dots reported higher landings.

Figure 7. Pounds caught and numbers of trips during the 2012 northern shrimp fishing season by 10-minute-square. Each red dot represents 950 lbs caught; locations of dots within squares are random and do not reflect the actual location of the catch. Number of trips is indicated by the blue palette for the squares. From preliminary state and federal harvester logbook (VTR) data.

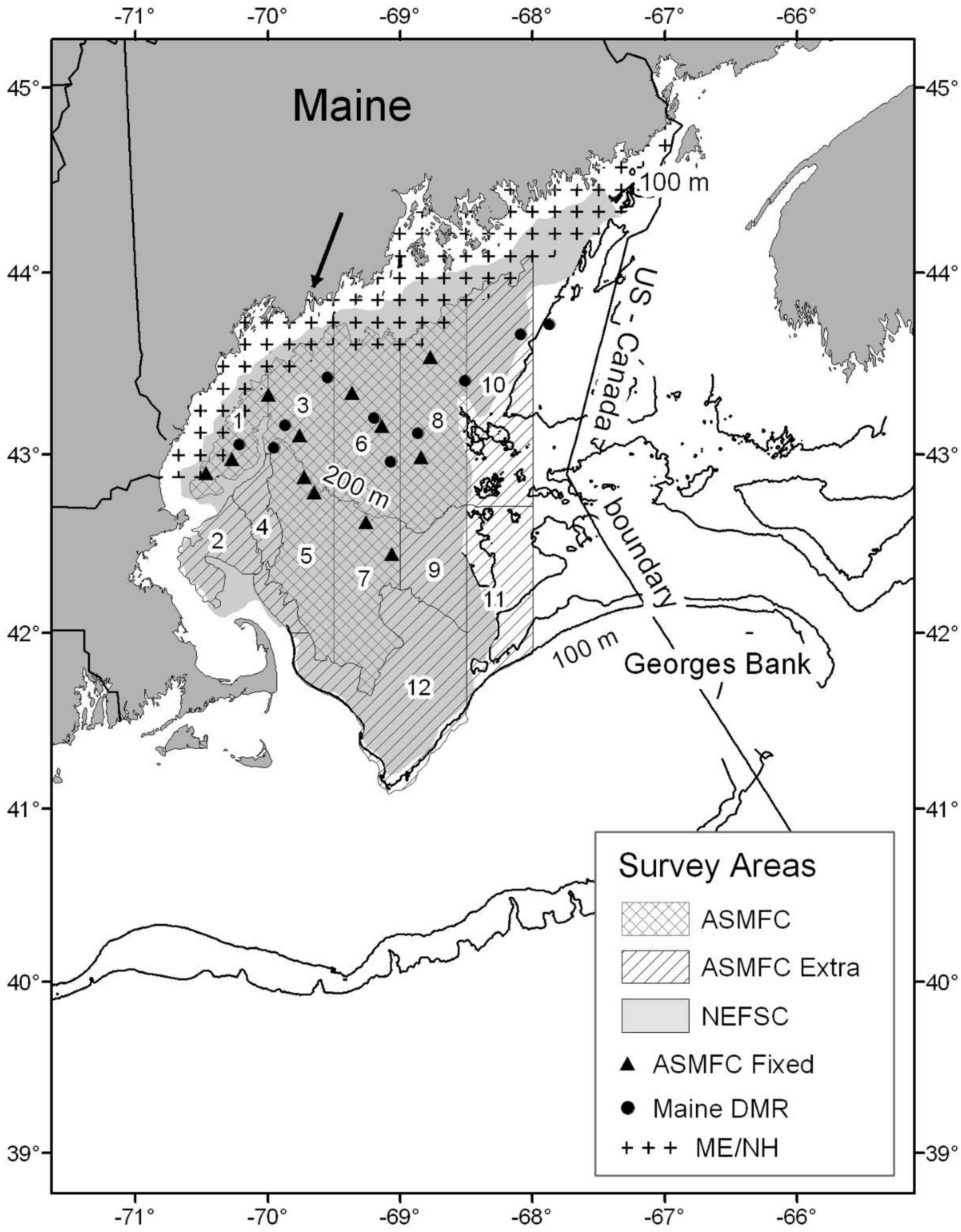
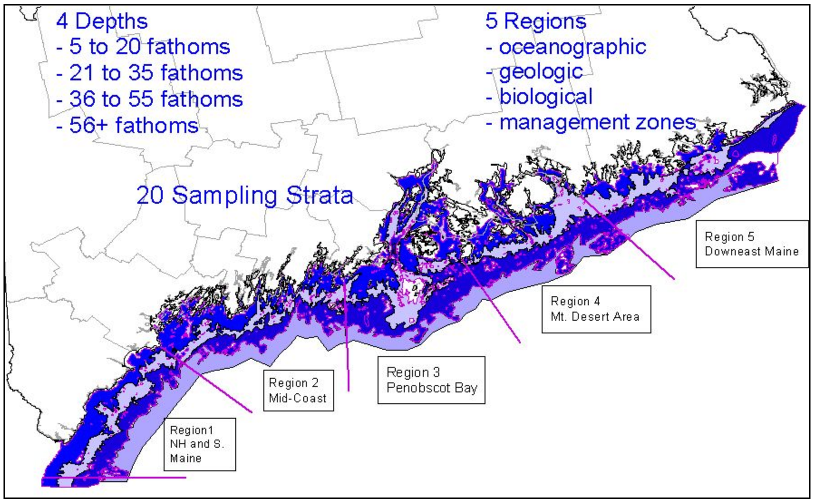
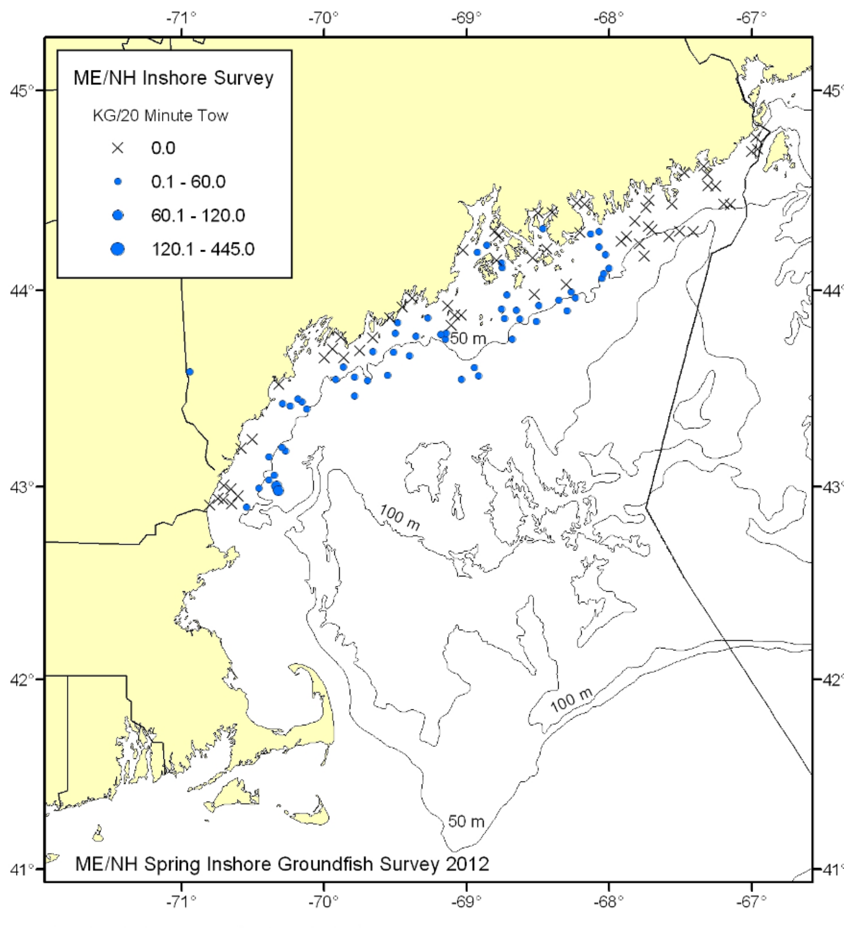


Figure 8a. Gulf of Maine survey areas and station locations.





(Region 5 data are not yet available)

Figure 8b. Maine-New Hampshire inshore trawl survey depths and regions (above) and spring 2012 results for northern shrimp below. Note that 2012 results for Region 5 sites (east of Schoodic Point) and indicated by "X"s, are not yet available.

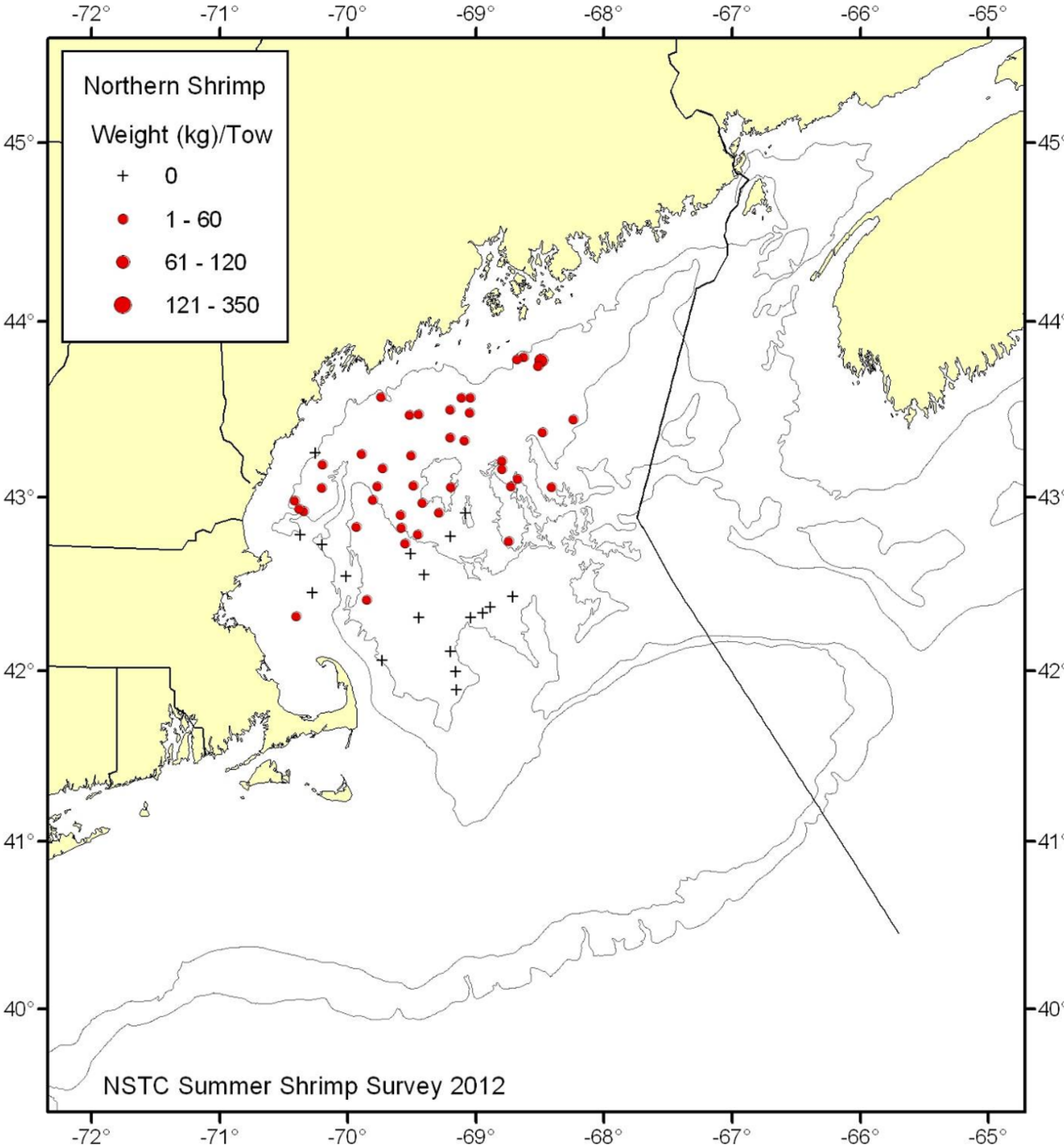


Figure 8c. State/federal summer northern shrimp survey aboard the *R/V Gloria Michelle*, July 22 – August 18, 2012, with survey sites and shrimp catches in kg/tow.

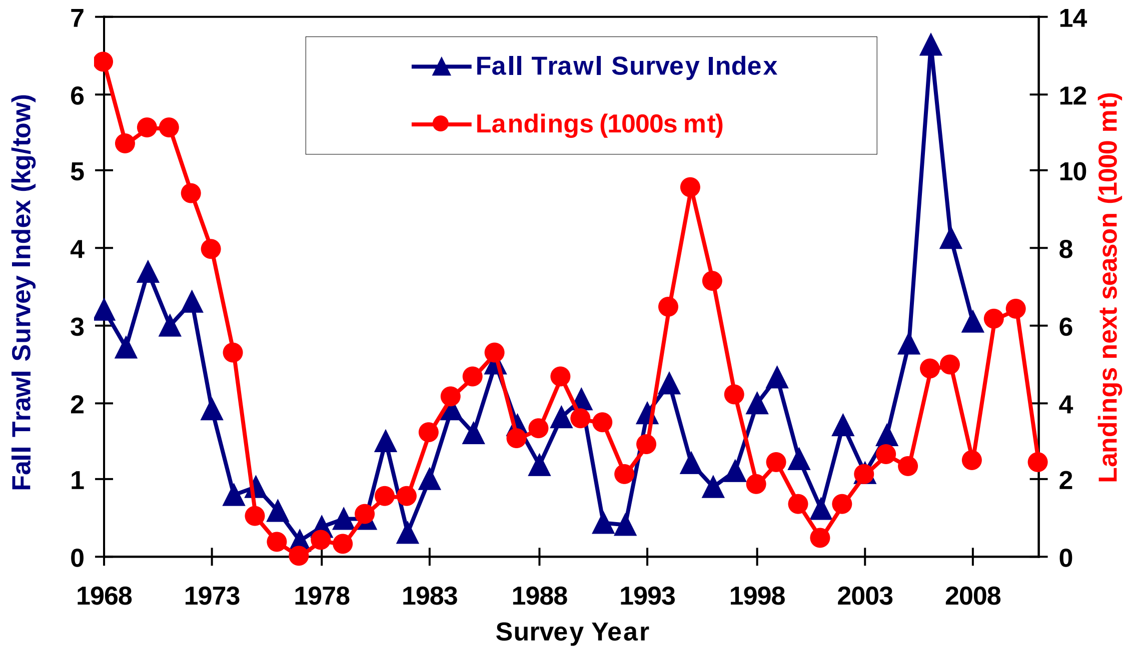
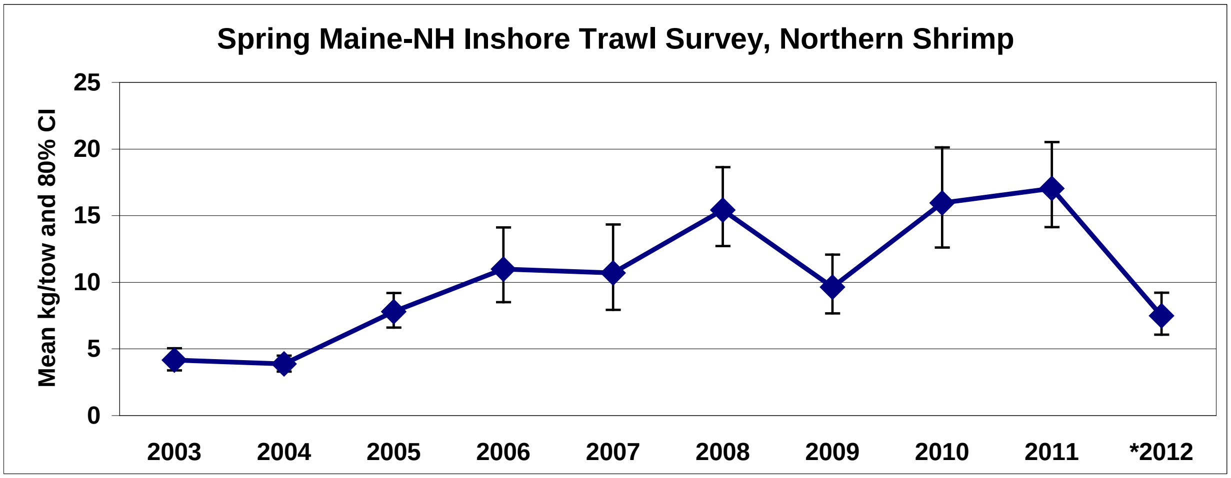


Figure 9. Fall trawl survey northern shrimp index (through 2008) and Gulf of Maine northern shrimp landings the following season.



* 2012 data are preliminary

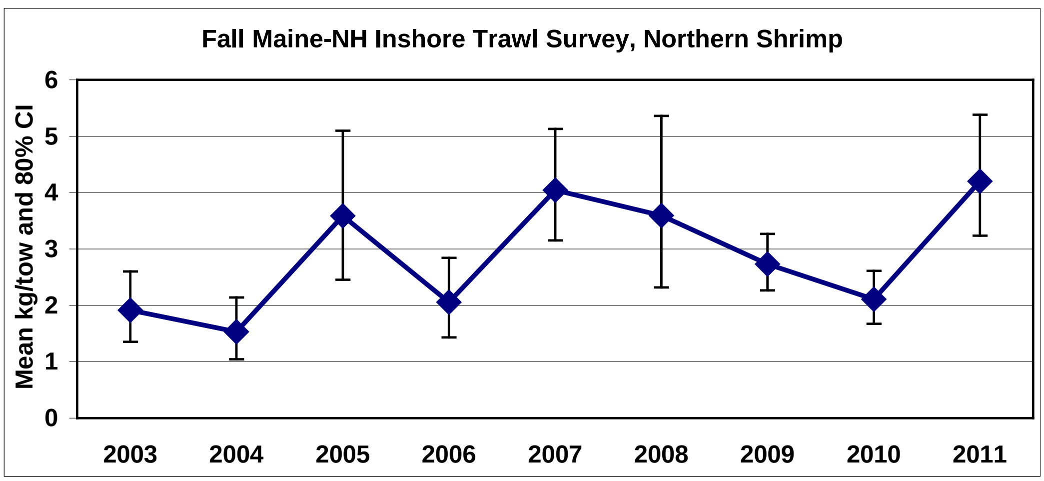


Figure 10. **Maine-New Hampshire inshore trawl survey northern shrimp biomass indices, spring above and fall below, with 80% confidence intervals. *2012 data are preliminary.**

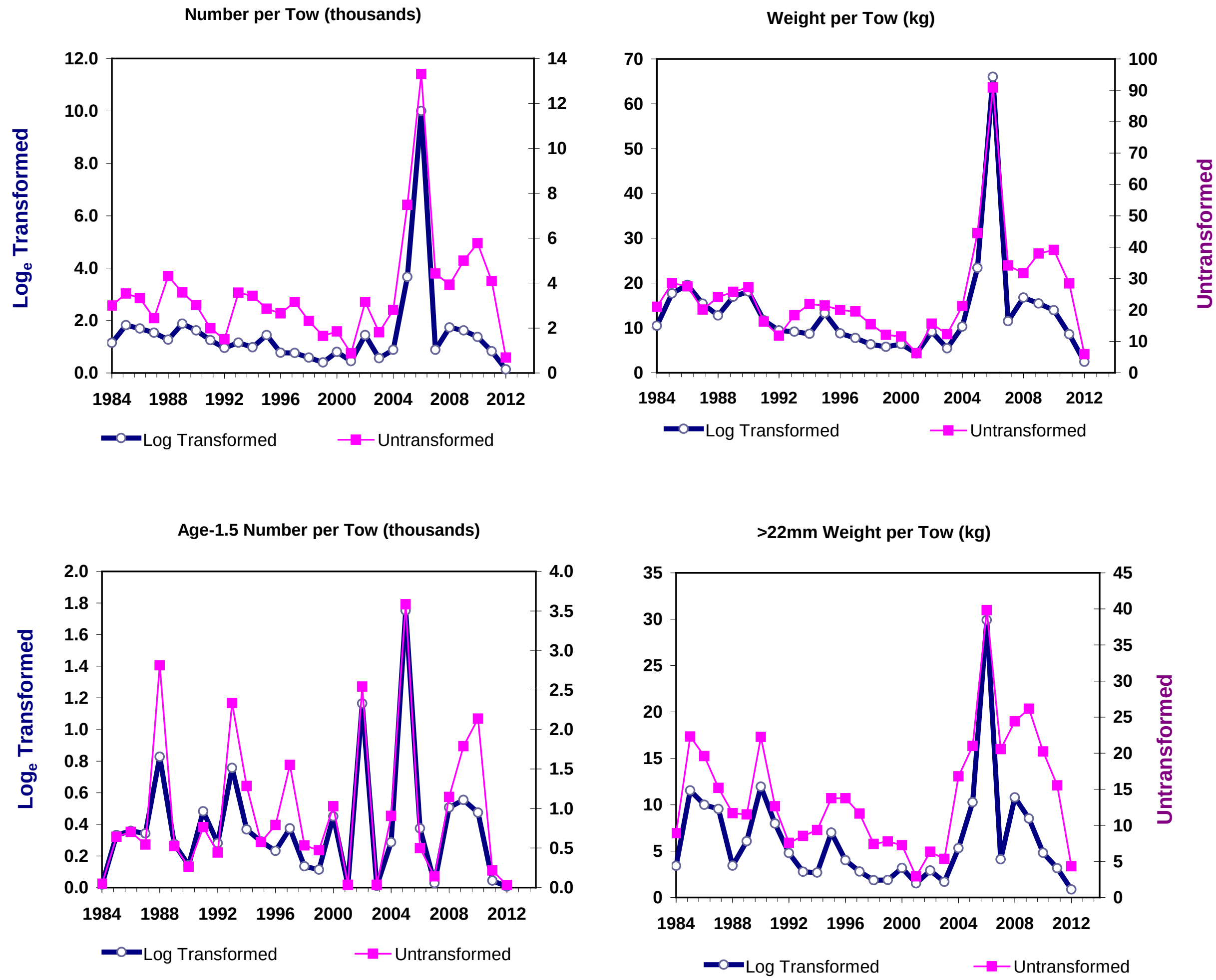


Figure 11. Gulf of Maine northern shrimp summer survey indices of abundance (left) and biomass (right), by survey year.

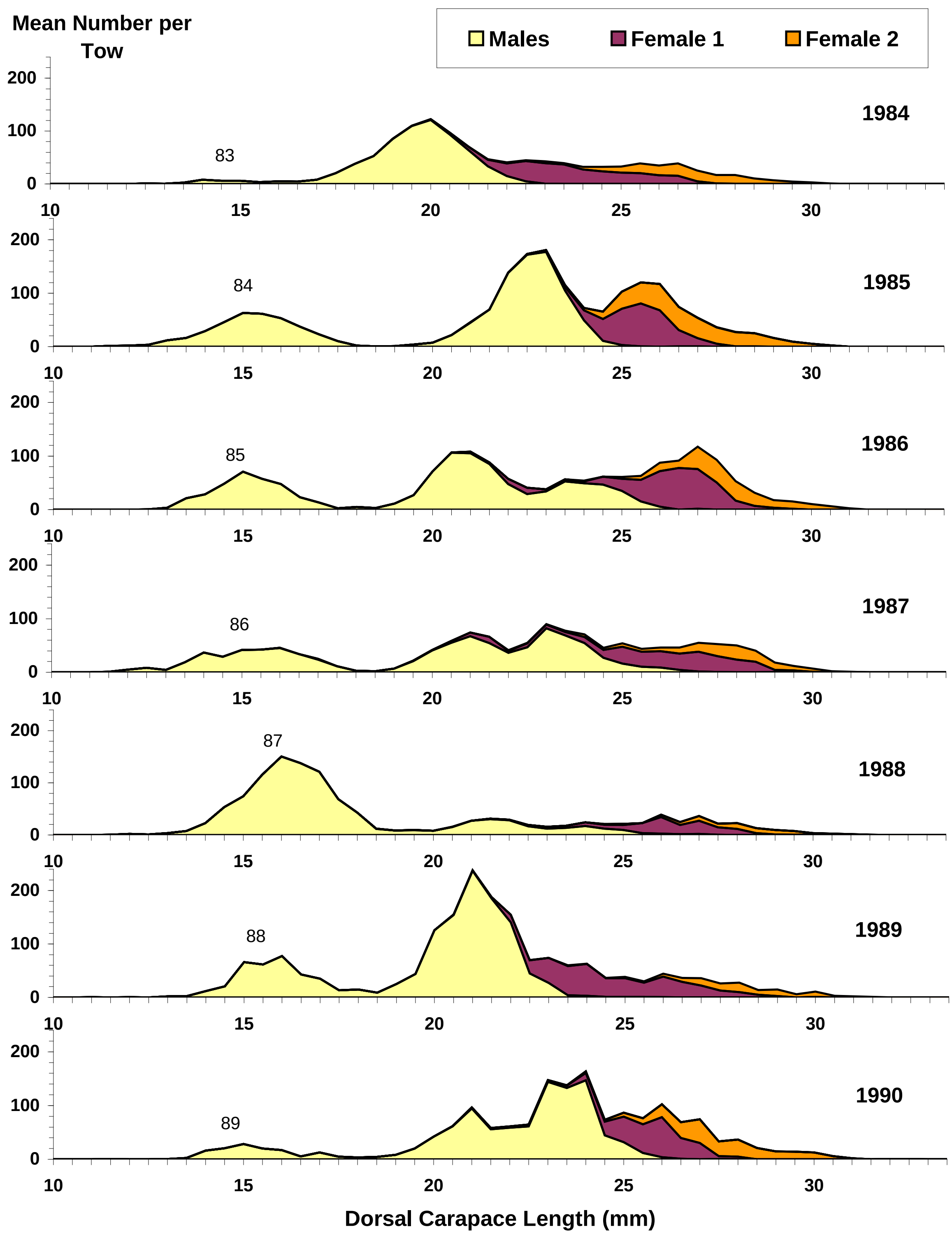


Figure 12. Gulf of Maine northern shrimp summer survey mean catch per tow by year, length, and development stage. Two-digit years are year class at assumed age 1.5.

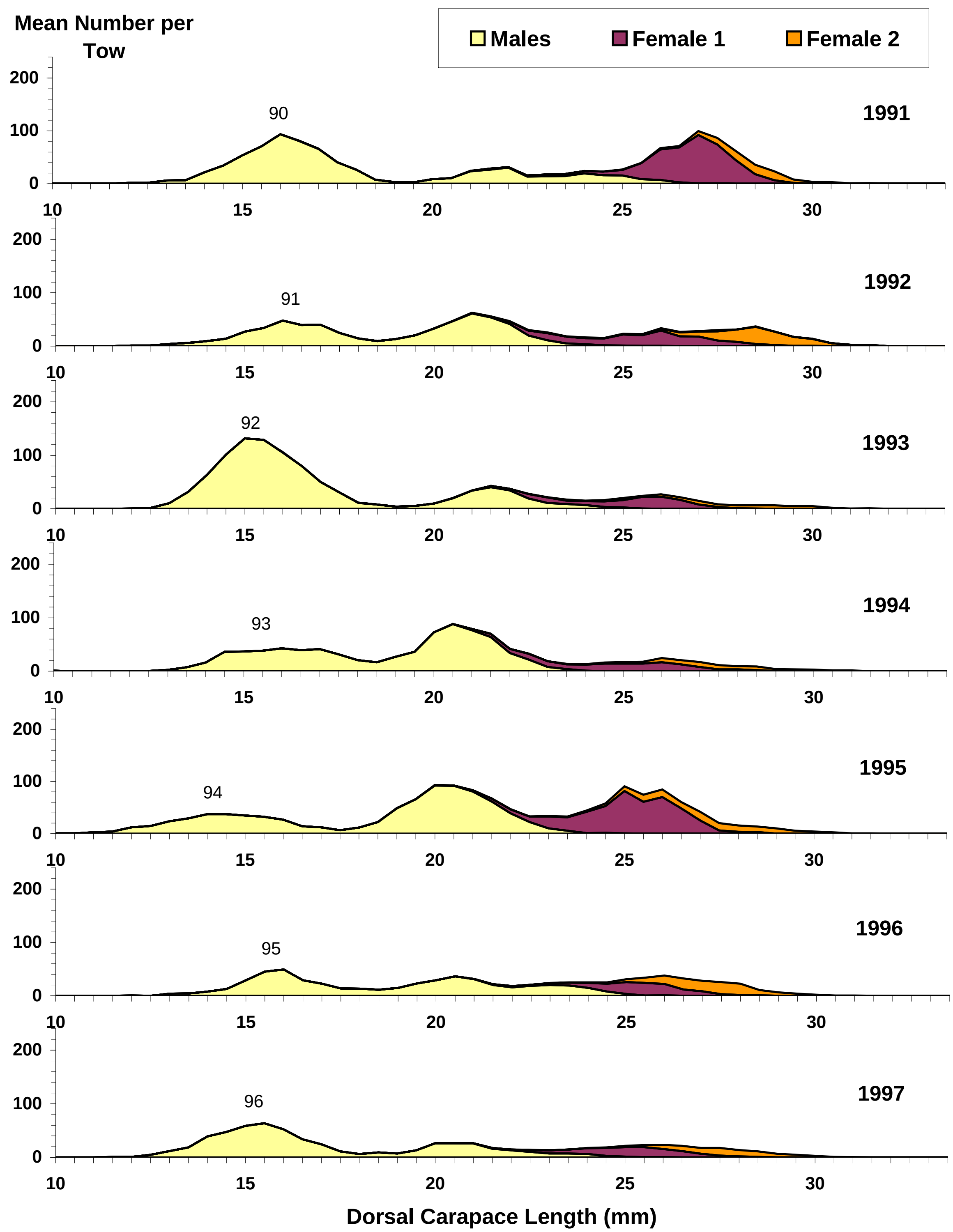


Figure 12 continued – summer survey.

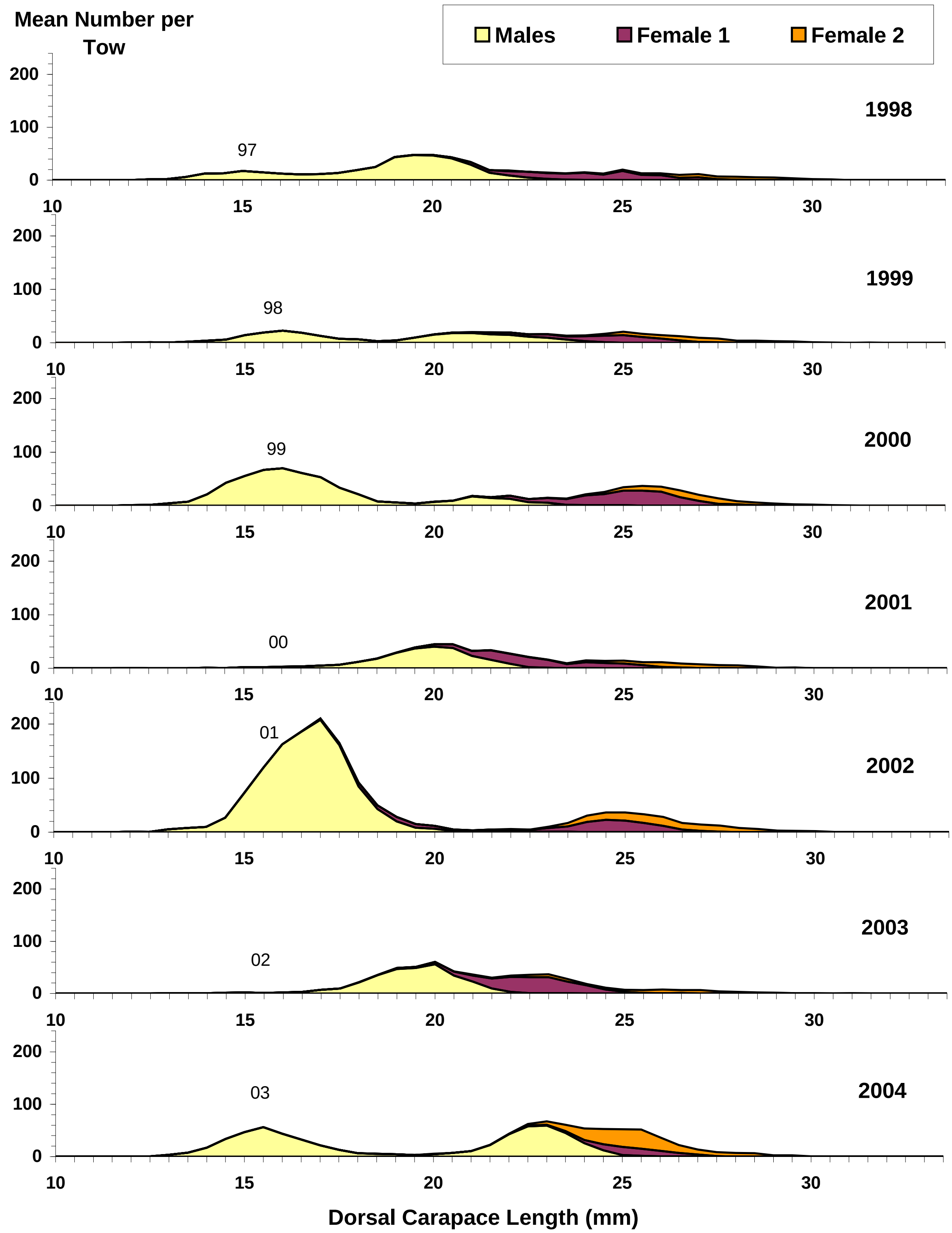


Figure 12 continued – summer survey.

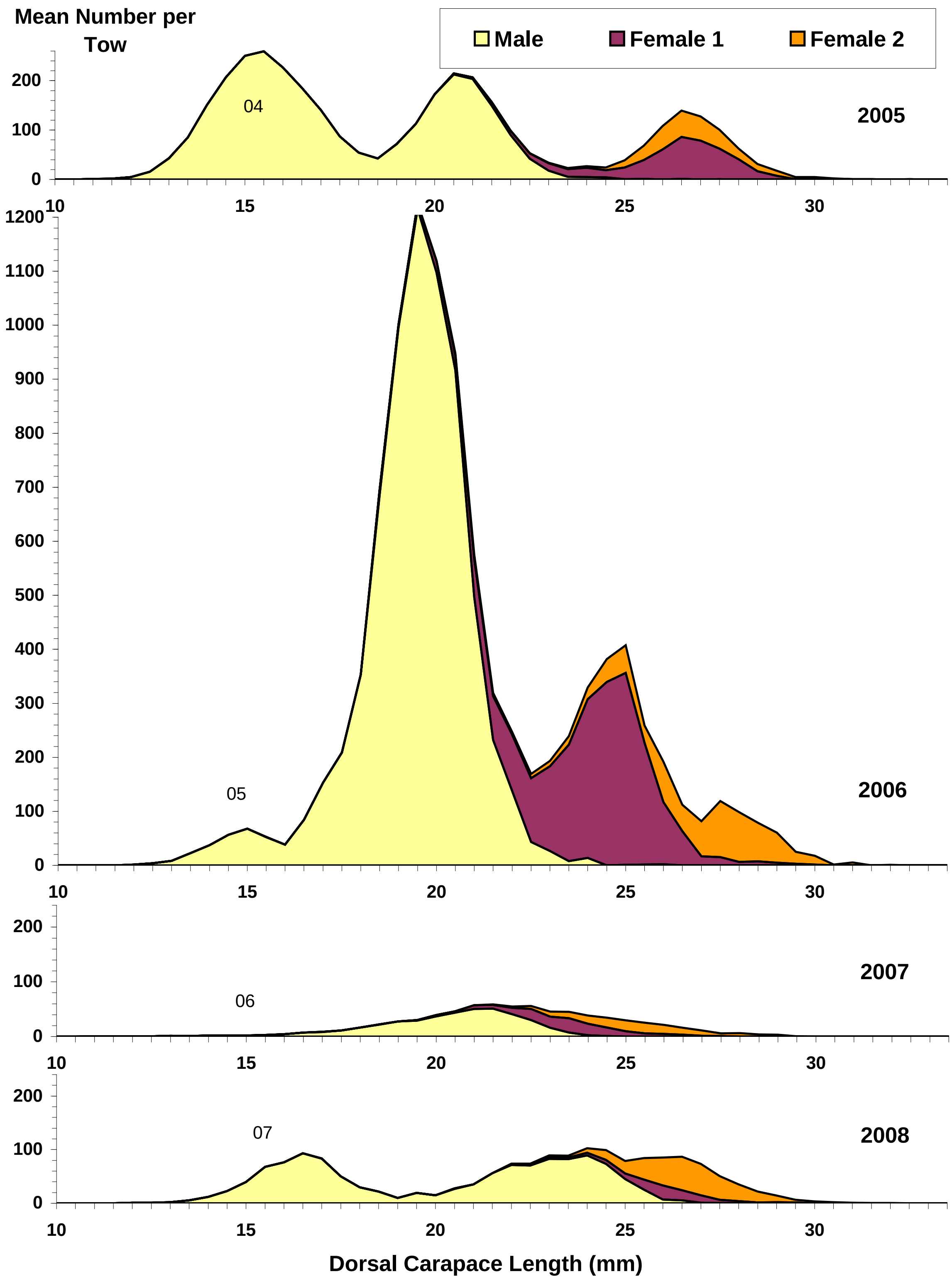


Figure 12 continued – summer survey.

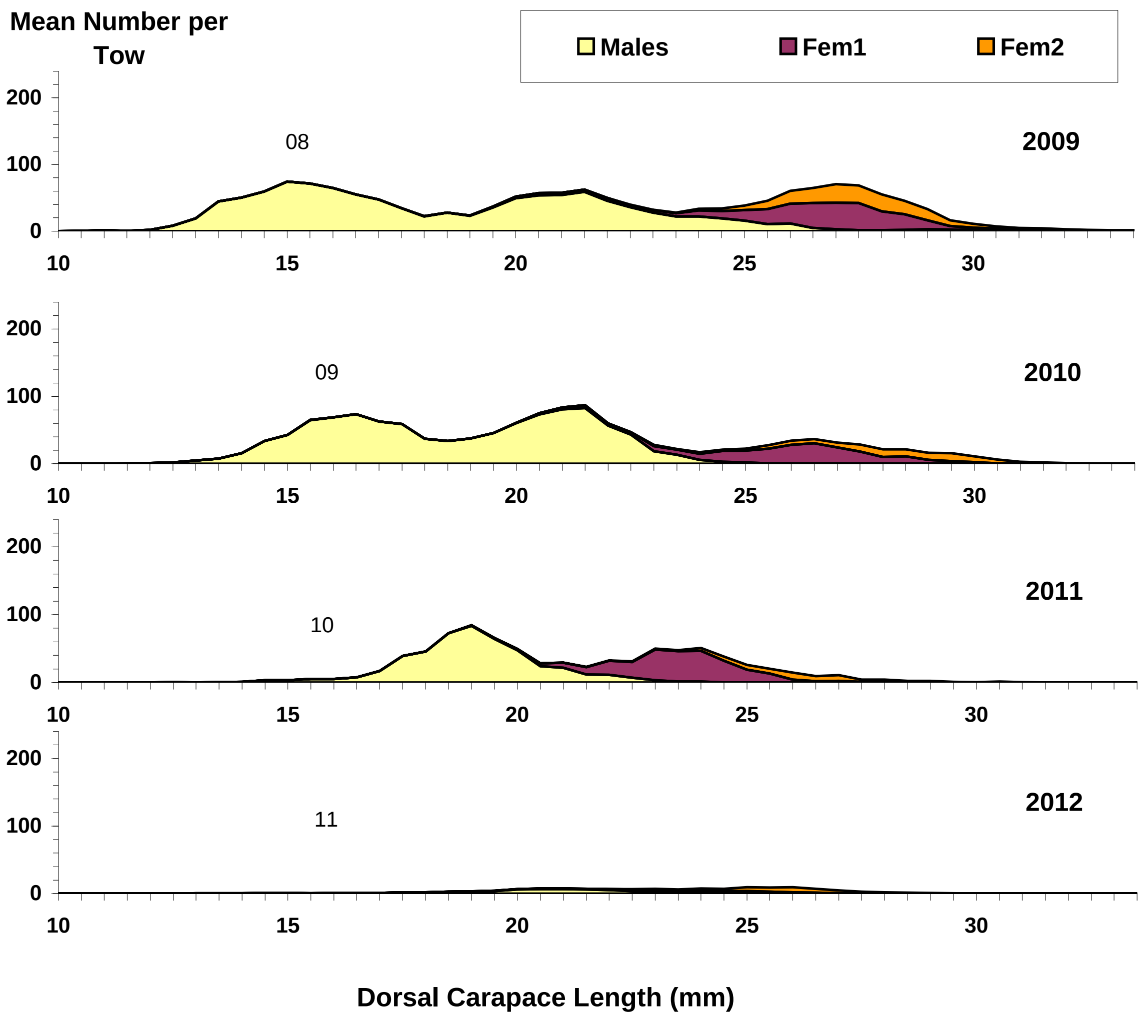


Figure 12 continued – summer survey.

(A) M=0.25 (B) M=0.60

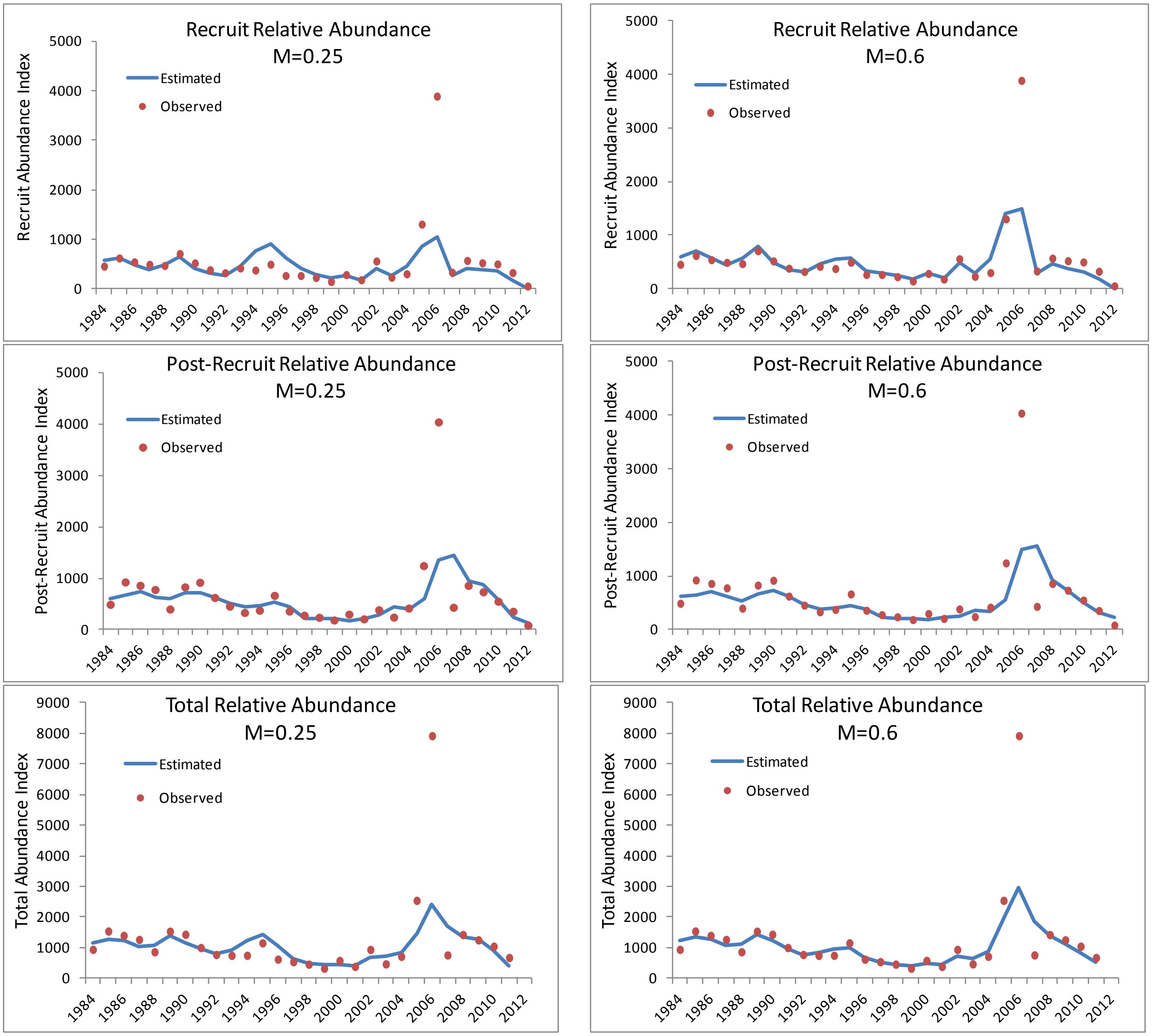


Figure 13a. Model estimates of relative abundance compared to observed abundance indices for recruits, post-recruits and total exploitable numbers of shrimp. (A) from CSA using M=0.25, (B) from CSA using M=0.6.

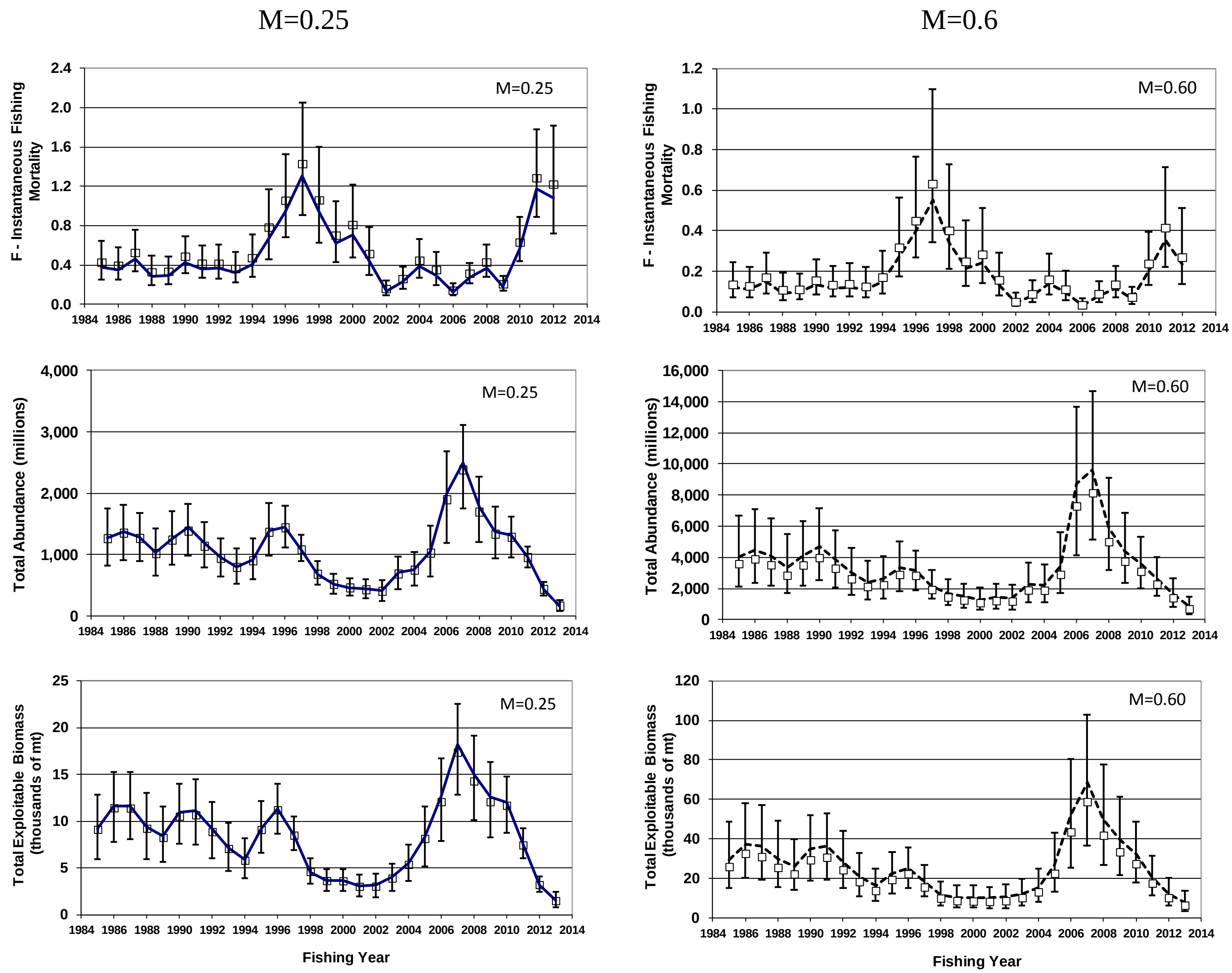


Figure 13b. Fishing mortality, exploitable abundance, and exploitable biomass of Gulf of Maine northern shrimp estimated by CSA assuming M=0.25 (left column) and M=0.60 (right column), least squares estimates (line), bootstrapped medians (squares) with 80% confidence intervals.

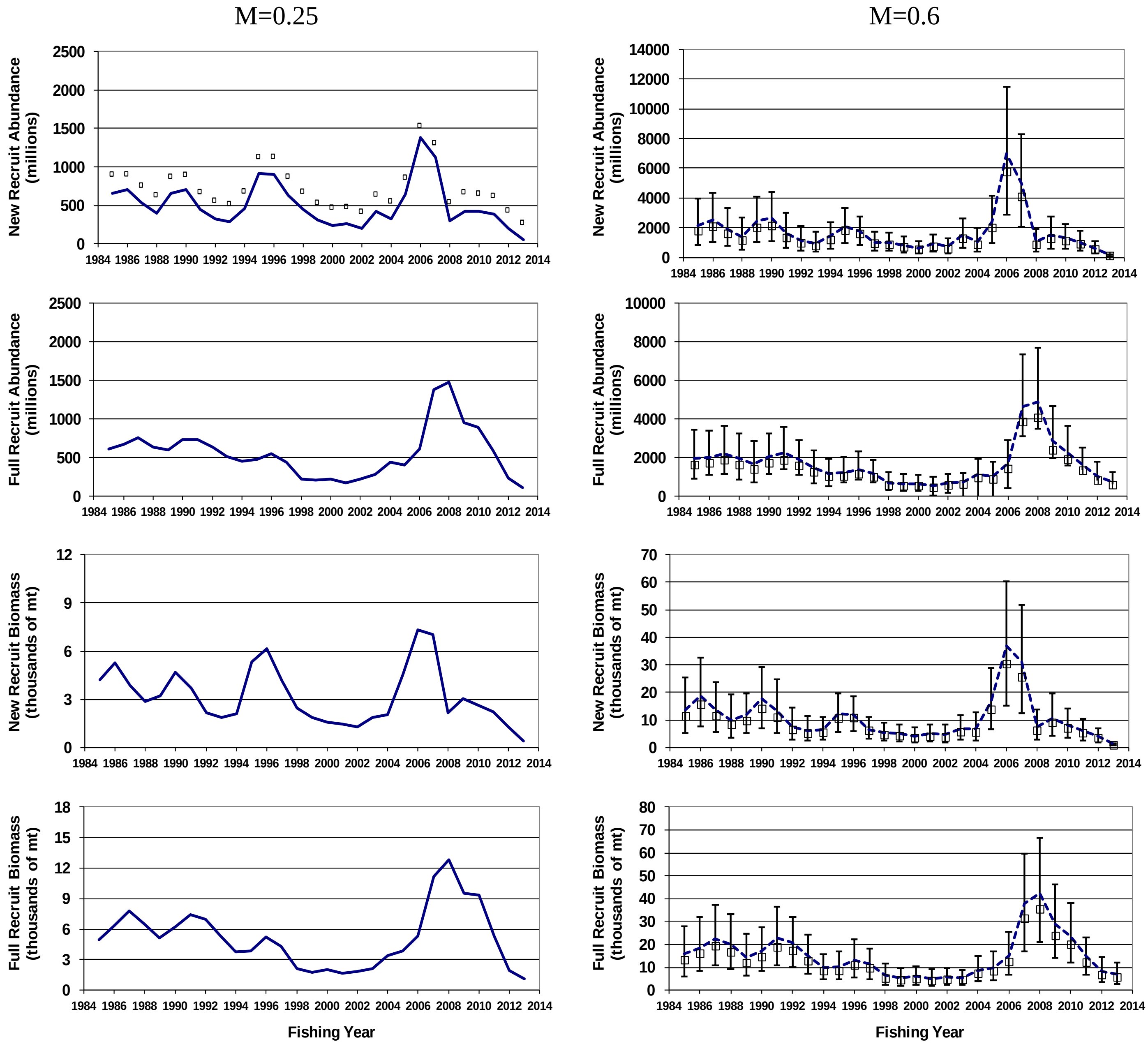


Figure 13b, continued – CSA results.

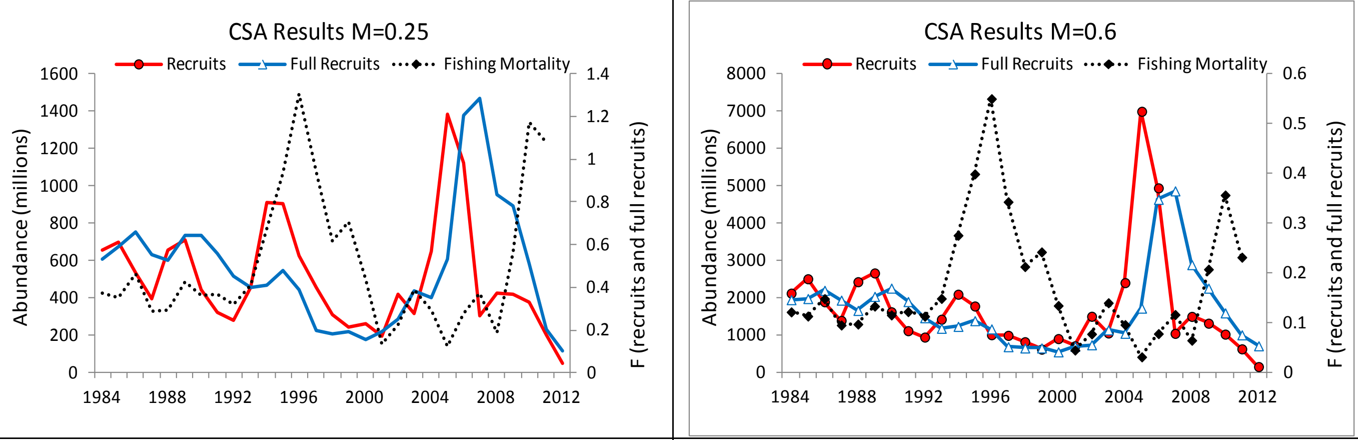


Figure 14a. CSA estimates of abundance and fishing mortality assuming M=0.25 and M=0.60.

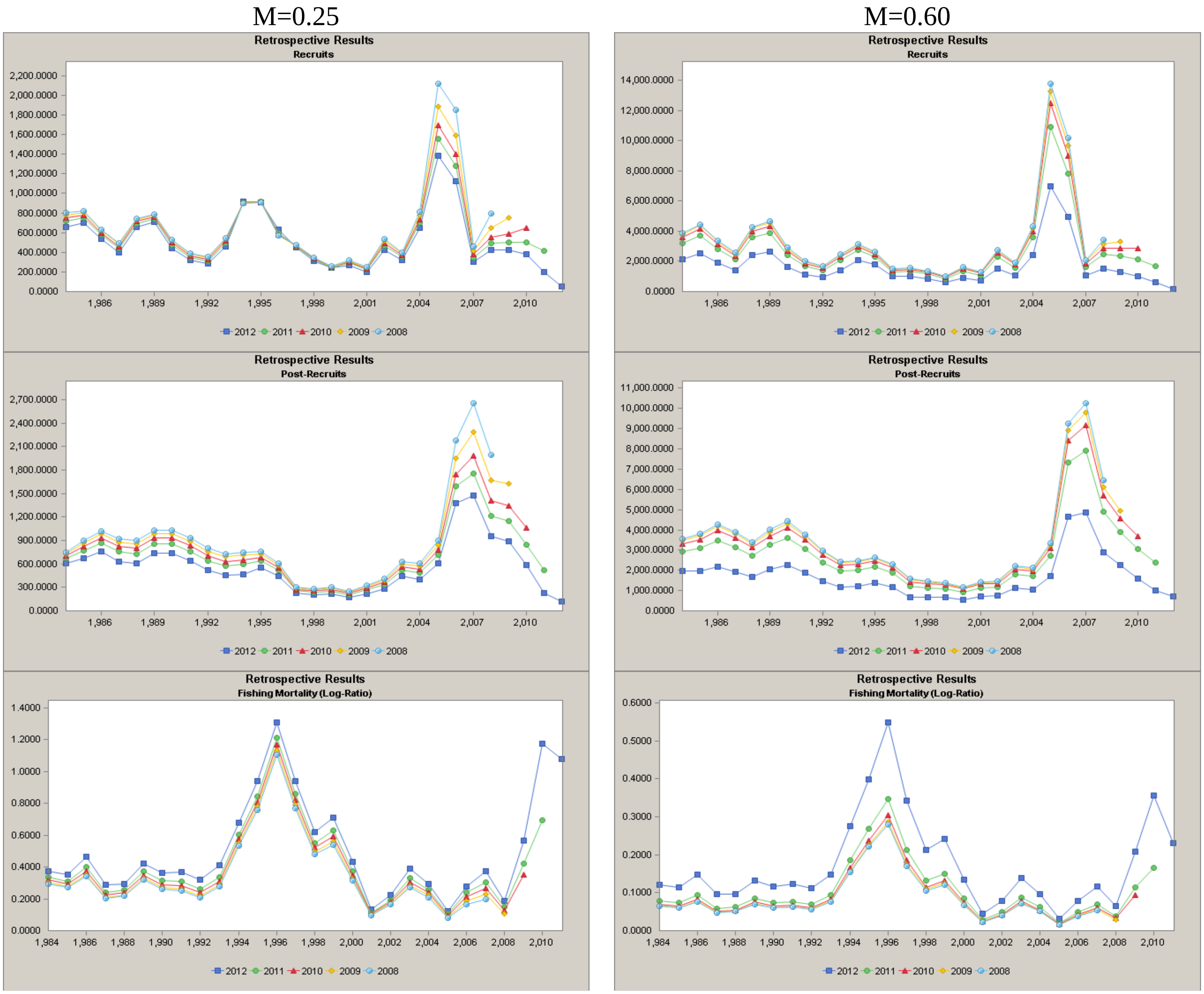
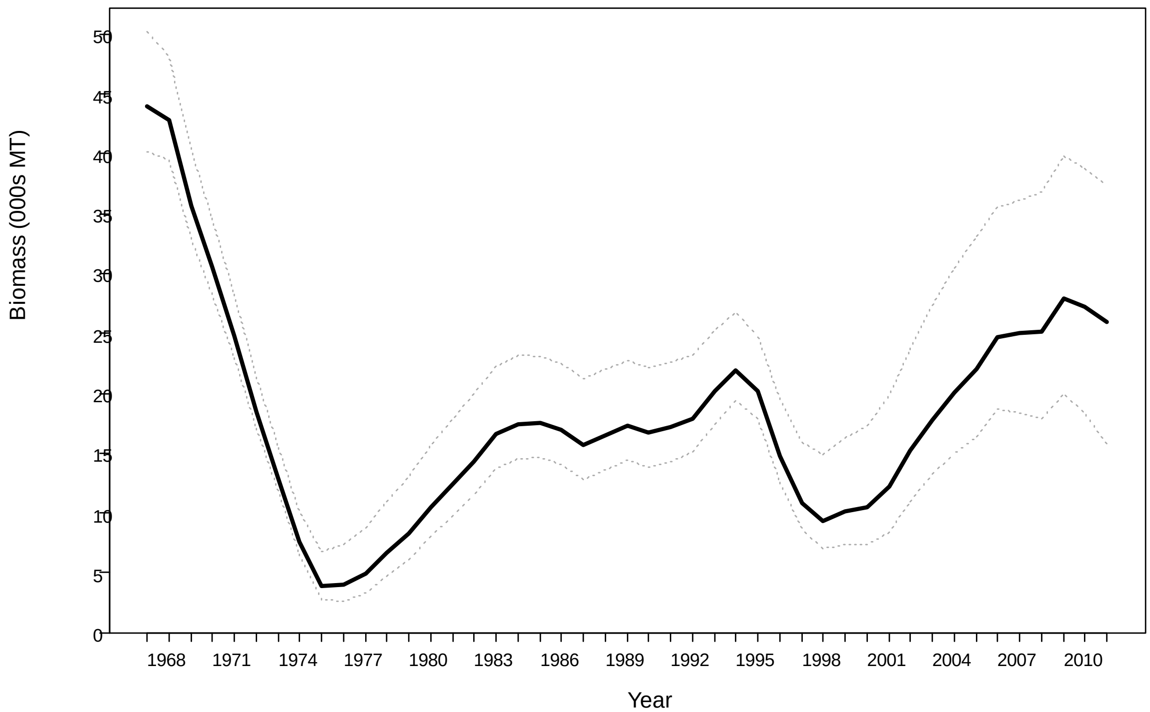


Figure 14b. Retrospective analysis of CSA results for M=0.25 and M=0.60. Models were run starting with a terminal year of 2008 and successively adding years to show how model estimates change as more information is added.



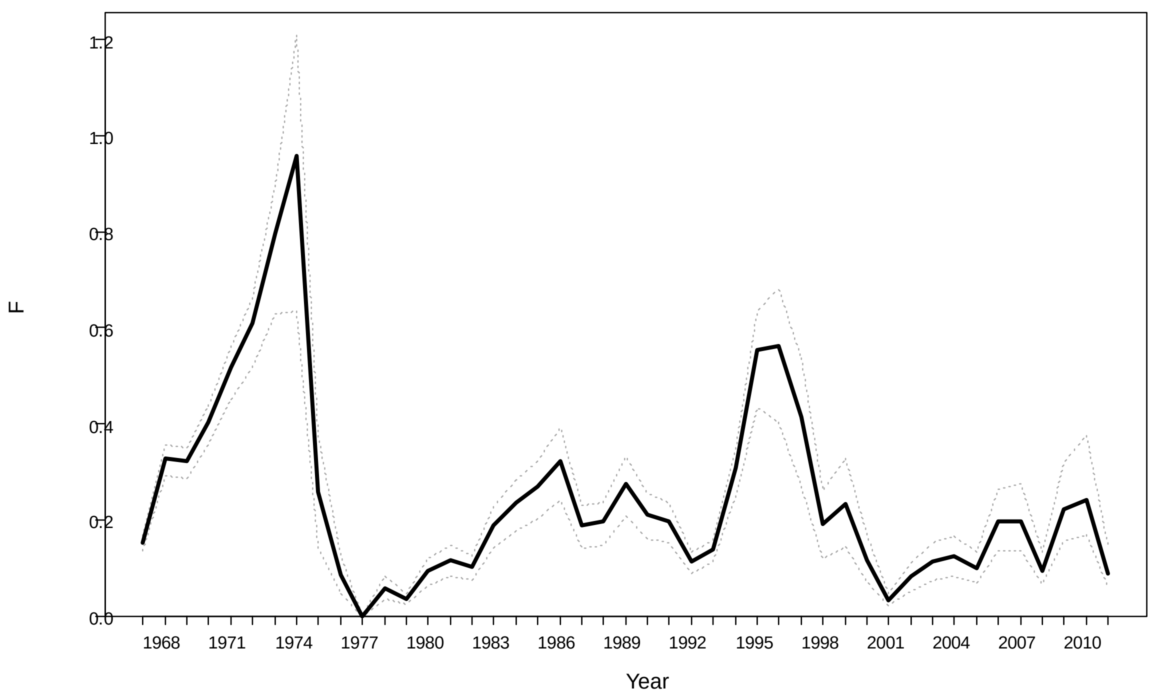


Figure 15a: Biomass (top) and fishing mortality (bottom) estimates from ASPIC base model run with all indices. Dotted lines indicate 95% bootstrapped confidence intervals.

Figure 15b: Observed and predicted index values (top) and residuals (bottom) from ASPIC base model run with all indices.

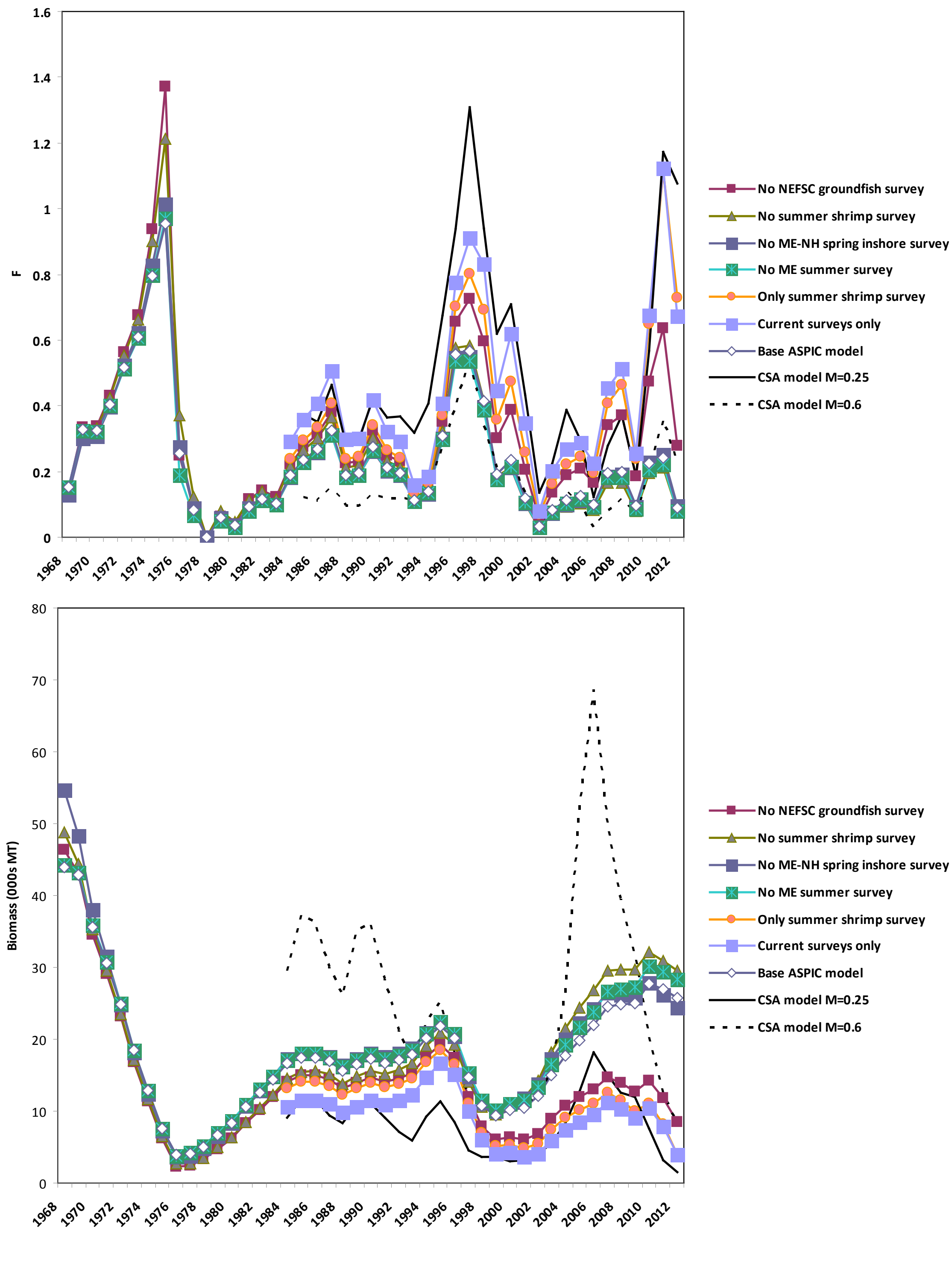
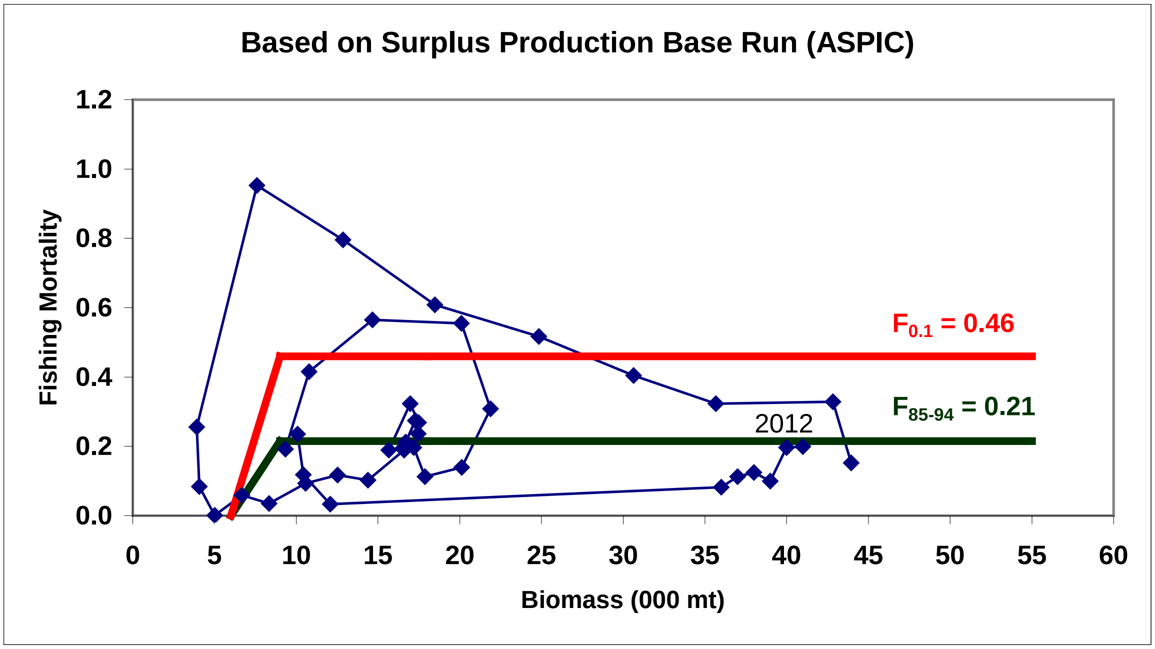


Figure 15c: Biomass (top) and fishing mortality estimates (bottom) for base and sensitivity runs of the surplus production model (ASPIC).



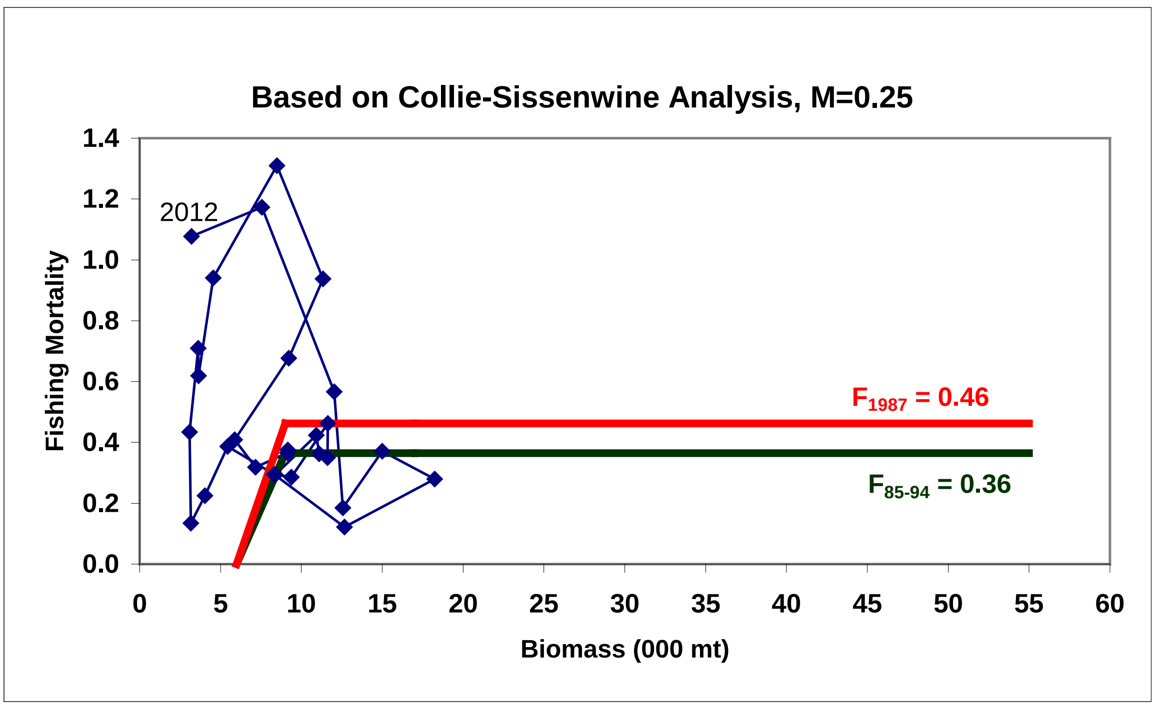


Figure 16. Biomass dynamics of the Gulf of Maine northern shrimp fishery, from surplus production (ASPIC, Base Run) (above) and Collie-Sissenwine (CSA with M=0.25) (below) analyses, with fishing mortality and biomass reference points.

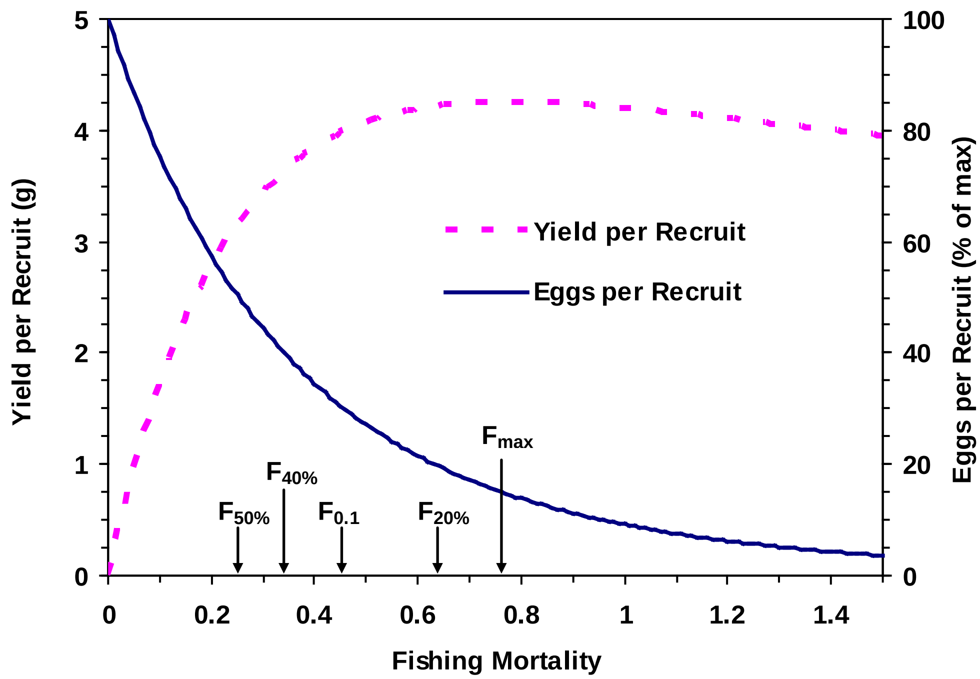


Figure 17. Yield and egg production per recruit for Gulf of Maine northern shrimp.

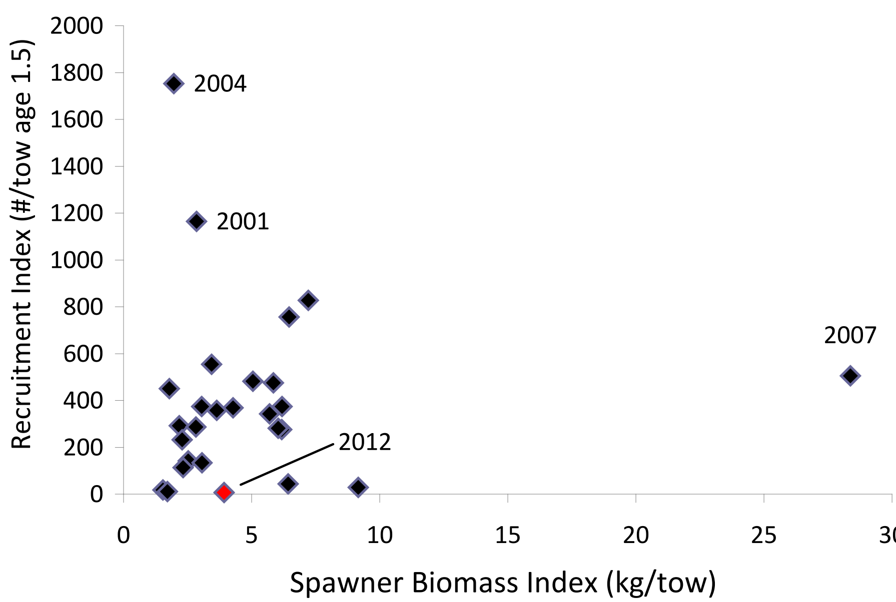


Figure 18. Relationship between summer survey index of Gulf of Maine female northern shrimp biomass the summer before spawning to age 1.5 abundance two years later. Year labels indicate the assumed age 1.5 year class.

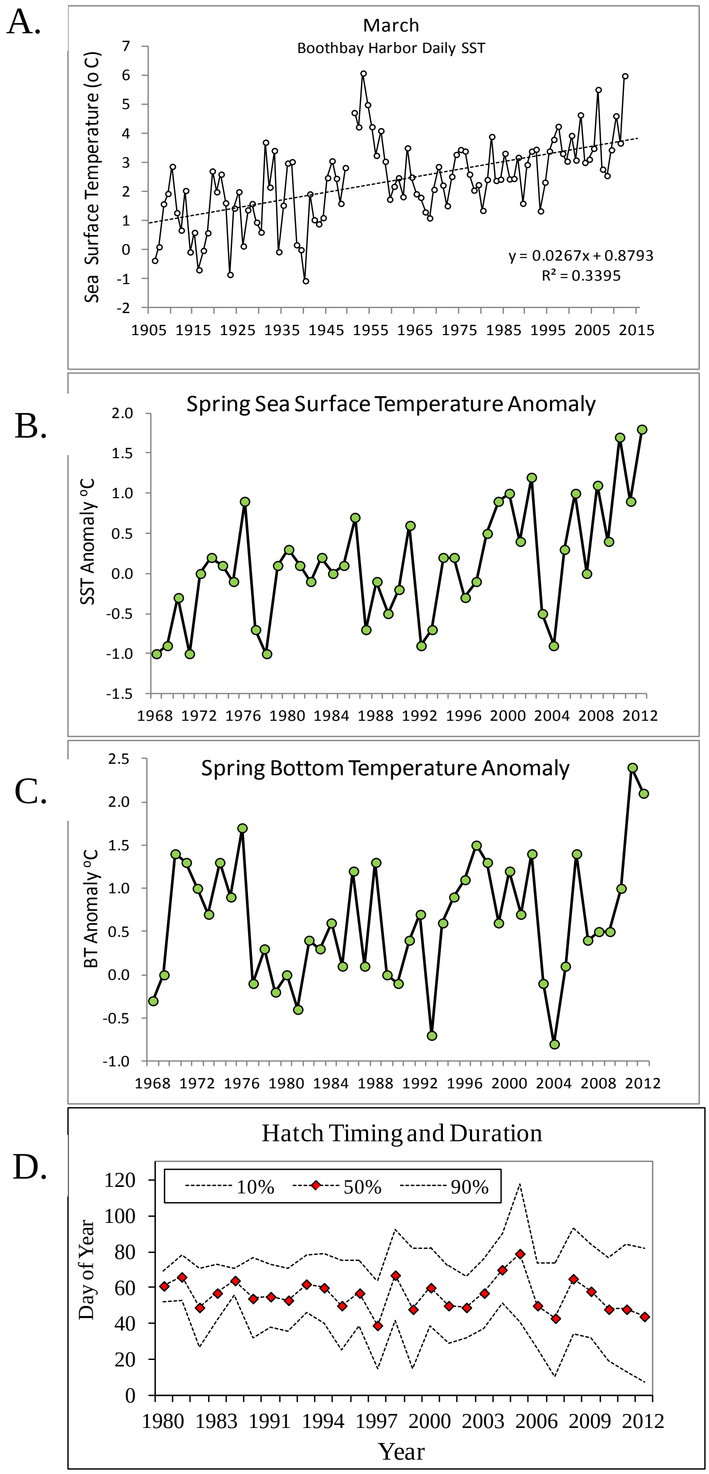
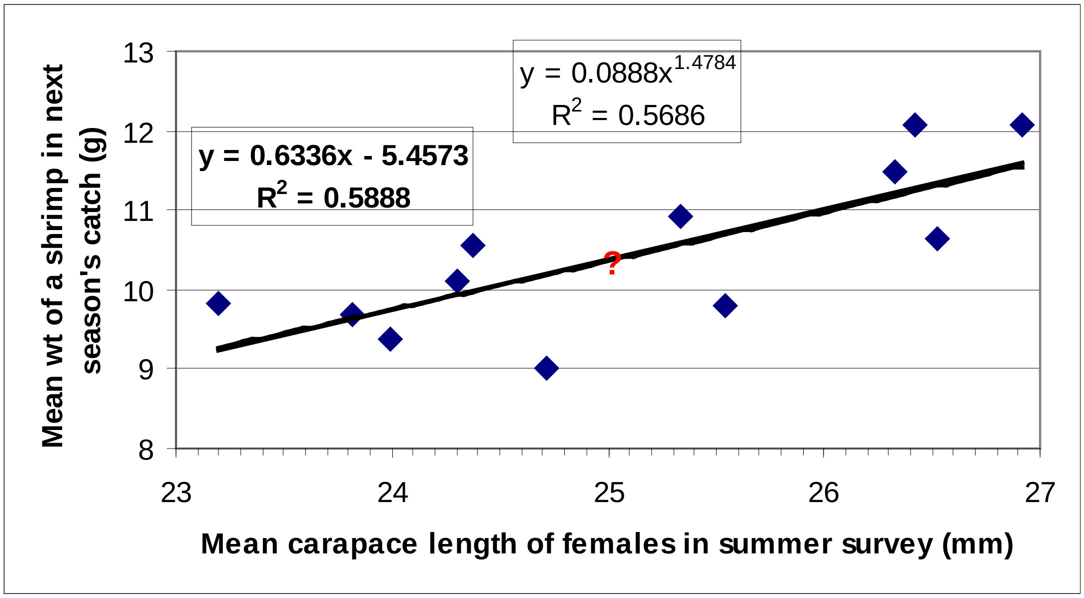


Figure 19. **(A) Average sea surface temperature at Boothbay Harbor, Maine, during March 1906-2012. (B) Spring sea surface temperature anomaly in shrimp offshore habitat areas from NEFSC trawl surveys, 1968-2012. (C) Spring bottom temperature anomaly in shrimp offshore habitat areas from NEFSC trawl surveys, 1968-2012. (D) Estimated hatch timing (10%=start, 50%=midpoint, 90%=completion) for northern shrimp in the Gulf of Maine, 1980-1983 and 1989-2012 (no data 1984-1988, 2012 preliminary).**



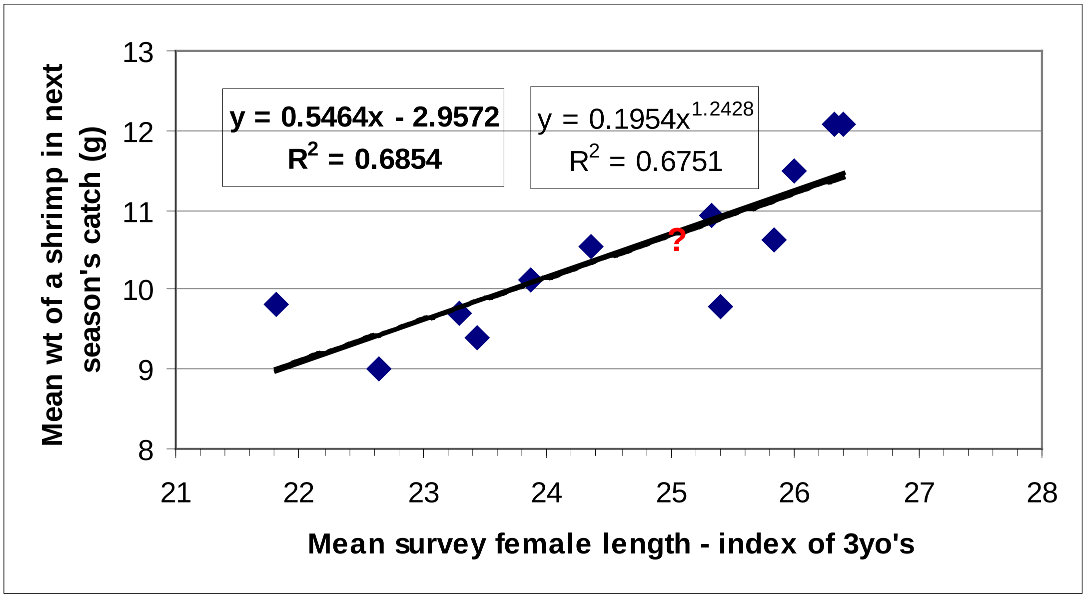


Figure 20. Relationship between the mean weight of a shrimp in the commercial catch and the mean length of female shrimp in the previous summer survey (above), and the mean length of female shrimp adjusted downward by the abundance of assumed 2.5 year-old males (below). "?" indicates survey index during 2012, and predicted size in 2013 fishery.