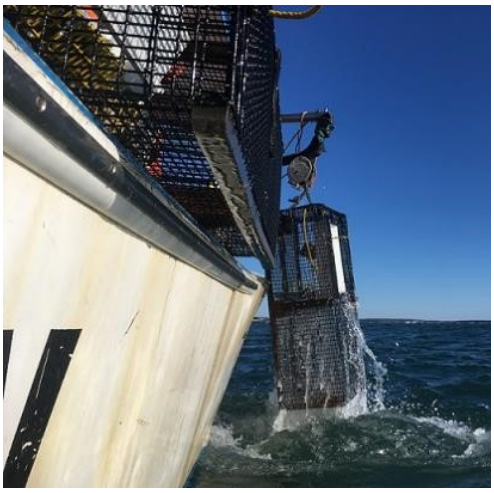
# 2017 Winter Sampling

# for Gulf of Maine Northern Shrimp



*Photos by Michael Kersula, Maine DMR, 2-28-17* F/V Ocean Spray *and 3-18-17* F/V Tradition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Northern Shrimp Technical Committee
October 20, 2017
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## SUMMARY

In the absence of a commercial fishery, ten trawlers and five trappers participated in a cooperative winter sampling program to collect northern shrimp samples in the Gulf of Maine during January – March 2017 under the ASMFC's northern shrimp FMP RSA provision. They caught a total of 32.6 mt, or 62% of the 53 mt RSA, and 164 trawl and 36 trap samples were collected and evaluated for shrimp size and sex-stage, and the timing of egg hatch was estimated. Catches comprised mostly assumed 4-year-old female shrimp from the 2013 year class. The estimated time of 50% egg hatch was about February 21, 2017, which was earlier than during the previous three years. An evaluation of the performance of compound size-sorting grates used by trawlers to reduce the catch of small shrimp is discussed in a separate report.

## INTRODUCTION

Fisheries for northern shrimp (*Pandalus borealis*) in the Gulf of Maine (GOM) have usually been conducted in the winter when egg-bearing (ovigerous) female shrimp move inshore, and sometimes in the spring while the shrimp return offshore after egg hatch. The highest landings usually occur in the months of January and February (see Table 3 in Eckert *et al.* 2016). Shrimp are caught by trawlers and trappers, with trawlers averaging about 86% of the Maine catch in 2009–2013 (Table 4 in Eckert *et al.* 2016). Shrimp samples from commercial catches have been collected by member states (Maine (ME), Massachusetts (MA), and New Hampshire (NH)) each season for over thirty years, and have informed annual stock assessment updates.

The 2016–2017 winter GOM fishery was closed by the Atlantic States Marine Fisheries Commission (ASMFC) due to low stock abundance. This was the fourth consecutive year the fishery was closed. In the absence of a fishery, the ASMFC Northern Shrimp Technical Committee (TC) recommended a limited cooperative winter sampling project be implemented, like the previous year's project. The purpose of the project was to collect samples similar to those that might have been collected from commercial shrimp catches if there had been a fishery, in order to:

- Continue the TC's time series of samples from GOM northern shrimp fishery catches, estimating the winter size (carapace length) and sex-stage composition of the shrimp stock in traditionally fished areas.
- Estimate the timing of egg hatch. Northern shrimp in the GOM extrude eggs onto their abdomens in the late summer to early fall and egg hatch has generally begun in February and ended in early April (Clark *et al.* 2000), but has started earlier and lasted longer in recent years (Richards 2012). It also tends to begin and end earlier in the western GOM

and later in the east (*e.g.* Whitmore *et al.* 2013, Figures 3–4), so the location of the sampling may influence the results.

- Evaluate the performance of compound size sorting grates used by trawlers, discussed in a separate report.

At their November 10, 2016 meeting, the ASMFC Northern Shrimp Section established a 53 mt quota under the northern shrimp fisheries management plan (FMP) research set aside (RSA) program (ASMFC 2012) to support data collection during the winter of 2016–2017. The Section stipulated that preference in selecting trawler participants be given to those willing to use a size-sorting grate, for excluding small shrimp. The Section also established the time period for the project, the number of participants by gear (trawl or trap) and region, the maximum number of trips and trip landings limits for trawlers, and trap limits and weekly landings limits for trappers.

## METHODS

### Trawl Sample Collection

The traditional coastal spatial range of the GOM northern shrimp commercial trawl fishery was divided into five regions: Massachusetts, New Hampshire, Western Maine (Kittery to Small Point, Phippsburg), Midcoast Maine (Phippsburg to Monhegan Island), and Eastern Maine (east of Monhegan Island). Experienced GOM shrimp trawlers were solicited to participate in the project by e-mail and web announcements. One trawl captain and boat from Massachusetts, one from New Hampshire, three from Western Maine (Boon Island to Small Point, Phippsburg), three from Midcoast Maine (Small Point to Monhegan Is.), and two from eastern Maine (Monhegan to the Canadian border) were picked at random from among the qualified applicants from that region. The selected vessels were from Gloucester MA, Rye NH, Portland ME (Western), South Bristol and New Harbor ME (Midcoast, Pemaquid Point area), and Port Clyde ME (Eastern), (Figure 1), and ranged in length from 38–57 feet (11.6–17.4 m). The Port Clyde captain fished one vessel for his first three trips and a different vessel for his last four trips, while all other captains each fished from a single vessel throughout. The trawlers fished once a week, for seven or eight weeks, using their standard shrimp nets with a standard Nordmore grate (finfish excluder) or a compound grate (with finfish exclusion and small shrimp exclusion panels). The grates and their comparative performance are discussed in a separate report. Each trawler observed a 1,200 pound (544 kg) trip landing limit, and all trips were single day trips. All trawlers could keep or sell their landings to offset fishing expenses. The Massachusetts, New Hampshire, and Western Maine boats made their first trips the week of January 16, 2017, and the last trip was made March 10. The Midcoast and Eastern Maine boats began the week of January 30, 2017 and the last trip was made March 25.

Observers from the MA Div. of Marine Fisheries (DMF) or NH Fish and Game (F&G) collected one to five 2-kg samples of each catch each day from the Massachusetts and New Hampshire boats. Each sample was collected randomly from a tow's shrimp catch after finfish were discarded, and samples were bagged and kept on ice. One of the Portland boats, the *F/V North Star*, fished a trouser trawl, that is, a net rigged with two codends, each with a different grate, standard Nordmore or compound, and collected a 1-kg random sample from each codend from each tow. Another Portland boat (*F/V November Gale*) had two net reels with two identical nets with different grates, standard Nordmore or compound, and alternated nets with each tow, and collected a 1-kg random sample from each tow. The other Maine trawlers collected one 1-kg random sample from each day's shrimp catch. All Maine samples were frozen for later delivery to the ME Dept. of Marine Resources (DMR). Similar 1-kg samples were also collected from all trips for further analysis by scientists at the University of Maine. Maine DMR provided temperature loggers (Onset Tidbit v2 and DST Centi by Star-Oddi) to affix to each fisherman's net, which recorded temperature every five minutes continuously throughout the project. Other information such as date, tow duration (hours), begin and end locations, minimum and maximum depths (fathoms), and estimated catch weight (pounds, of all shrimp species) was recorded for each tow, by observers or by the vessel captains. Observers from Maine DMR and U. Maine also recorded finfish bycatch for 15 trips, discussed in a separate report. Prices paid were gleaned from dealer reports.

**Trap Sample Collection**

Shrimp trappers were also invited to participate, and four were picked at random from among the qualified applicants from Midcoast Maine, and one from Eastern Maine. The Midcoast area historically lands more than 90% of GOM trapped shrimp. The trappers could fish up to forty traps, tended (hauled) as often as needed, landing no more than 500 lbs (227 kg) of shrimp per week, and were similarly allowed to keep or sell their landings to offset fishing expenses. Each trapper was asked to combine the catches of all forty traps and collect one randomly chosen 1-kg sample from his day's catch once a week, frozen for later delivery to the ME DMR. Trappers also collected samples for U. Maine, and each was provided with a temperature logger to secure to one of his traps. Other information such as date set, date hauled, haul location, depth (fathoms), and estimated catch weight (pounds, of all shrimp species) was recorded for each trap string by the vessel captains. Price data were collected from dealer reports. The trappers used their standard wire shrimp traps and bait (a mix of Atlantic herring or mackerel with menhaden, or just herring for the Eastern boat) in bait bags or wire mesh boxes. They all fished pairs (two traps per string) except the Eastern trapper fished a mix of pairs and triples (three traps per string) during March. Traps were first set out on January 30, 2017 and the last hauls were March 26.

**Sample Work-Up**

At the state labs, samples were analyzed following the usual procedures for commercial shrimp samples. Frozen Maine samples were thawed; Massachusetts and New Hampshire samples were worked up while they were still fresh. Each trawl or trap sample was weighed, and then separated by shrimp species. *P. borealis* specimens were counted, measured (dorsal carapace length (CL)), and sexed (male, transitional, or female), and female stage (I, II, or ovigerous) was determined. Female stage I shrimp have not yet carried eggs, and female stage II shrimp are not carrying eggs but have in the past, as determined by the presence/absence of sternal spines (McCrary 1971). All other shrimp species in the samples, usually *Pandalus montagui, Dichelopandalus leptocerus*, or *Crangon septemspinosa*, were counted and measured.

**Calculations for Trawl Data**

**Catch rates** — Pooled mean catch rates in pounds per tow-hour were calculated for each trip and region as the total catch weight of shrimp (of all species) divided by the total number of boat-tow-hours for the trip or region.

**Depth** — The mean depth fished for each tow was found by averaging the minimum and maximum depth for each tow; these were then averaged over all the tows for the trip to give the mean depth for the trip. The mean depths for each trip in a region were then averaged to give the mean depth fished for the region.

**Bottom temperature** — Mean bottom temperature for each trip was calculated by averaging all the 5-minute temperature readings logged during towing, which were identified as those recorded at least 5 or 10 minutes after the brake was set, until the last temperature recorded at or before haul-back began, for each tow.

**Size-sex-stage distributions** — For samples collected from a tow, the numbers of northern shrimp of each sex, stage and size (CL in 0.5 mm categories) in each sampled tow were estimated ("raised" or "expanded") by multiplying the numbers in the sample by the tow catch weight divided by the sample weight. For the Massachusetts and New Hampshire trips, where some but not all of the tows were sampled, the estimated numbers in sampled tows were further expanded to the trip's catch by multiplying by the trip's total catch weight divided by the sum of the catch weights of the sampled tows. For the *North Star* and *November Gale* trips, where almost all tows were sampled, the estimated numbers from each trip's tows were added to give the estimated numbers for the trip. For the remaining Maine trips, where one sample was collected from each trip's catch, the numbers of northern shrimp in each sex, stage and size category in each trip were estimated by multiplying the numbers in the sample by the trip catch weight divided by the sample weight.

**Count per pound** — Shrimp counts per pound (all species) for each sample were calculated by dividing the total number of shrimp of all species in the sample by the sample weight. For trips

with more than one sample, the results for each sampled tow were weighted by the catch weight for the tow to calculate a pooled trip mean. The results for each trip in a region were weighted by the trip's catch weight to calculate a pooled region mean.

**Percent of catch that was *Pandalus borealis*** — The proportion of the catch, in numbers, that was *P. borealis* was calculated for each sample as the numbers of P. borealis in the sample divided by the total number of shrimp of all species in the sample. For trips with more than one sample, the results for each sampled tow were weighted by the catch weight for the tow to calculate a pooled trip mean.

**Percent of egg hatch** — The proportion of female *P. borealis* whose eggs had hatched off was calculated for each trip from the expanded size-sex-stage distributions described above, as the numbers female IIs divided by the sum of the female IIs plus ovigerous females.

**Calculations for Trap Data**

**Bottom temperature** — The median bottom temperature for each vessel-week was calculated from all the 5-minute temperature recordings made by that vessel's temperature logger during the week. Medians were used instead of means, to avoid the influence of temperature spikes or troughs that occurred while the trap was being tended.

**Depth** — The mean depth fished for each vessel-week was found by averaging all the reported depths of each trap string hauled during the week. The mean depths for each vessel-week were then averaged to give the mean depth for the vessel.

**Size-sex-stage distributions** — The numbers of northern shrimp of each sex, stage and size (CL in 0.5 mm categories) in each vessel-week were estimated ("raised" or "expanded") by multiplying the numbers in the vessel-week's sample by the vessel-week's total catch weight divided by the sample weight.

**Count per pound** — Shrimp counts per pound (all species) for each vessel-week's sample were calculated by dividing the total number of shrimp of all species in the sample by the sample weight. The results for each vessel-week for a vessel were weighted by the vessel-week's catch weight to calculate a pooled vessel mean.

**Percent of catch that was *Pandalus borealis*** — The proportion of the catch, in numbers, that was *P. borealis* was calculated for each vessel-week's sample as the numbers of P. borealis in the sample divided by the total number of shrimp of all species in the sample

**Percent of egg hatch** — The proportion of female *P. borealis* whose eggs had hatched off was calculated for each trip from the expanded size-sex-stage distributions described above, as the number of female IIs divided by the sum of the female IIs plus ovigerous females.

### Hatch Timing

A time series of hatch timing estimates was developed using data collected by the Maine DMR from the commercial shrimp fishery beginning in 1980 (Richards 2012). Samples were not available from Massachusetts and New Hampshire until later years, so for consistency, the time series only uses data collected from Maine ports. Probit analysis was used to estimate the timing of hatch initiation (the day of each year on which 10% of females had hatched their brood), hatch midpoint (50% hatched), and hatch completion (90% hatched). Duration of the hatch period is the number of days from initiation to completion (inclusive). For 2017, trawl samples were weighted by the weight of the trip's catch from which they were collected, and trap samples were weighted by the weight of the week's catch for that vessel. Samples from both trawl and trap gear were included in all years, except hatch metrics for the 2013–2014 winter, when there also was no fishery, are from limited trawl samples collected off Pemaquid Point in Midcoast Maine (Hunter 2014).

## RESULTS

### Trawl Catches and Samples

**Catches, effort, and samples:** The ten trawlers fished from the ports of Gloucester MA (1), Rye NH (1), Portland ME (3) (Western), South Bristol and New Harbor ME (3) (Midcoast, Pemaquid Point area), and Port Clyde ME (2) (Eastern) (Figure 1). They each made seven or eight fishing trips, one trip per week, for a total of 77 trips. Summaries of their results are in Tables 1–2. A total estimated 56,176 pounds (25.5 mt) were caught in trawls, or 48% of the 53 mt total RSA, or 59% of the 43.5 mt RSA available to trawlers. One of the Port Clyde captains switched boats after the first three trips. Some shrimp catch was discarded, 200 lbs (0.09 mt) or less from each of nine trips, and about 1000 lbs (0.45 mt) from one trip. Fourteen samples were collected from the Massachusetts boat, 21 from the New Hampshire boat, and 129 from the Maine boats, for a total of 164 samples collected and analyzed (not including samples collected for U. Maine). Most of the captains mentioned having to relocate or take steps to avoid fixed lobster gear in their traditional tows. Locations fished are charted in Figures 1–3. Fishing dates are listed in Table 1. All trips were single-day trips.

**Trawl catch rates**: Mean catch rates varied tremendously, from a low of 4 lbs/hr (2 kg/hr) (Eastern Maine, March 17) to a high of 1,100 lbs/hr (499 kg/hr) (Midcoast Maine, February 19) (Table 1). The Western and Midcoast Maine boats consistently had the highest catch rates throughout the sampling season (Table 1), and caught their 1,200 lb daily limit, or within 200 lbs of it, during 32 of their 49 trips. Most boats had their lowest catch rates during their last one or two trips of the season in March. The pooled mean catch rate for all regions and dates (total estimated pounds caught divided by total trawl hours) was 162 lbs/hr (74 kg/hr) (Table 2). This

is lower than the 2016 winter sampling season (214 lbs/hr, or 97 kg/hr) (Hunter 2016) and higher than the 2015 winter sampling season (149 lbs/hr, or 67 kg/hr) (Whitmore *et al.* 2015).

**Size and sex-stage composition in trawl samples**: Ovigerous females made up 55% of the northern shrimp catch by count, and 37% were females caught after egg hatch. Males were 8% percent of the catch, and less than 1% of the catch were transitionals and Female I's (which have not carried eggs yet).

The pooled mean number of shrimp of all species per pound (Number/Lb, Table 2) was 39, and varied by trip from 32 (Midcoast ME, February 12, 19, and 28, and Eastern ME, January 30) to 105 (Eastern ME, March 17, when the catch comprised only 19% *P. borealis*) (Table 1). (The low count of 29 by the *November Gale* on January 17 is not included in this discussion because the trip's samples contained herring and whiting which reduced the shrimp count). The mean count per pound of 39 was lower than the 2016 value of 43, and probably represents the intervening growth of females in the 2013 year class, as illustrated in Figures 9-10.

In general, the *P. borealis* size-frequency distributions (Figures 6–7 and 9) show a mode at about 26 mm CL, probably from the 2013 year class (4-year-old females). Another, smaller mode comprising males is seen at about 18 mm in some of the Massachusetts, New Hampshire, and Western Maine samples. These shrimp are probably from the 2015 year class.

The assumed 2013 year class was first identified in the 2013 fall Maine-New Hampshire inshore trawl survey, and appeared again as a weak (the ninth lowest abundance index in the time series) and unusually fast-growing year class in the 2014 summer shrimp survey (Whitmore *et al.* 2014). Likewise, the assumed 2015 year class first appeared in the 2015 fall Maine-New Hampshire inshore trawl survey and again as a below-average (13th lowest in the 33-year time series) abundance of age 1.5s in the 2016 summer survey (Eckert *et al*. 2016). See Figure 10 for the progress of these two year classes from season to season as detected in recent surveys and cooperative winter sampling projects.

**Species composition in trawl samples**: In 30 of the 77 trips, shrimp species other than *Pandalus borealis* (mostly *Dichelopandalus leptocerus* and a few *Pandalus montagui*) made up more than 10% of the catch by count (in 6 out of 7 New Hampshire trips, 1 of 7 Massachusetts trips, 11 of 25 Western Maine trips, 6 of 24 Midcoast Maine trips, and 6 of 14 trips in Eastern Maine) (Table 1).

**Egg hatch in trawl samples**: Most of the female shrimp were still carrying eggs in late January, and most had hatched off their eggs by early March (Figures 6–7). Egg hatch rates from trawl samples are plotted in Figure 11, and support past observations of egg hatch progressing chronologically from west to east in the Gulf of Maine. The approximate date of 50% egg hatch was day-of-the-year (DOY) 36 (February 5) for the Massachusetts vessel, and about DOY 31 (January 31) for the New Hampshire vessel. Note that these boats sometimes fished very near each other (Figure 1). The approximate date of 50% egg hatch was about DOY 47 (February 15)

in Western Maine, about DOY 56 (February 25) in Midcoast Maine, and about DOY 58 (February 27) in Eastern Maine. Note that the Midcoast and Eastern Maine boats fished within about 10 miles (16 km) of each other during some trips (Figures 1-2), so it is not surprising that their hatch dates were similar.

**Trawl depths**: Mean trip depths varied from 28 to 59 fa (51–108 m). All of the Midcoast Maine boats fished depths from 28 to 47 fa in their first six trips, and then moved to deeper depths (51–59 fa) for their last two trips (Table 1).

**Trawl bottom temperatures**: Mean bottom temperatures during towing varied from 3.0 to 8.3°C. Highest temperatures were in January (Table 1).

## Trap Catches and Samples

**Catches, effort, and samples:** The five trappers fished from the ports of Five Islands, South Bristol, Pemaquid Harbor, New Harbor (Midcoast Maine), and Swans Island (Eastern Maine) (Figures 4-5). A total of 15,668 pounds (7.1 mt) were caught in traps, or 13% of the 53 mt total RSA, or 78% of the 9.1 mt RSA available to trappers. Thirty-six samples were collected. Data collected by vessel and week are listed in Table 3. There were 2,433 trap-hauls made during 76 trips in total. The Midcoast trappers caught their 500 lb weekly limit (or near it) in 20 out of 32 vessel-weeks, and discarded shrimp in 10 vessel-weeks.

**Trap catch rates:** The pooled mean catch rate was 6.4 lbs/trap-haul (2.9 kg/trap-haul). The mean Midcoast catch rate was 8.0 lbs/trap-haul (3.6 kg/trap-haul), while the Eastern catch rate was 0.4 lbs/trap-haul (0.2 kg/trap-haul). Catch rates were generally lowest during the last week of the project (March 20) (Table 3).

**Size and sex-stage composition in trap samples**: Only 1 out of 2,658 northern shrimp in the trapped samples was male and one was a Female I (which has not carried eggs yet). Ovigerous females made up 40% of the northern shrimp catch by count, and 60% were females caught after egg hatch.

The pooled mean number of shrimp of all species per pound (Number/Lb, Table 4) was 38, and vessel-week means varied from 29 (Midcoast, week of January 30) to 82 (Eastern, week of March 20) (Table 3). In general, the *P. borealis* size-frequency distributions (Figures 8–9) showed a mode at about 26.0–26.5 mm CL, probably from the 2013-year class (4-year-old females). There were almost no small northern shrimp (around 18 mm CL, the assumed 2015 year class) in the trapped catch samples.

**Species composition in trap samples**: In 16 of the 36 samples, species other than *Pandalus borealis* (*Dichelopandalus leptocerus* and *Pandalus montagui*) made up more than 10% of the sample by count, especially at Five Islands and Eastern Maine throughout the project period and in the other Midcoast areas in the last week or two (Table 3).

**Egg hatch in trap samples:** Most northern shrimp caught in traps were still carrying eggs when trapping began the week of January 30, except for those caught by the Five Islands vessel, whose first sample exhibited 60% egg hatch. All samples had reached 80% or more egg hatch by the week of March 13 (Table 3). The estimated date of 50% egg hatch (Figure 12) was about DOY 29 (January 29) in the Five Islands samples, compared with about DOY 46 (February ~~5~~ 15 [corrected 11-30-21 MH]) for the three Pemaquid area trappers, a surprising difference considering the two locations are less than 10 miles (16 km) apart (Figures 4-5). The estimated date of 50% egg hatch was about DOY 56 (February 25) at Swans Island, further supporting past observations of egg hatch progressing chronologically from west to east. Comparing the DOYs of 50% egg hatch for the Pemaquid area trappers (46) with that area's trawlers (56) supports past observations that trappers are more likely to catch shrimp after egg hatch than trawlers fishing at approximately the same time and place (Whitmore *et al.* 2013; Whitmore *et al.* 2015; Hunter 2016).

**Trap Depths**: Mean depths for vessel-weeks varied from 22 to 44 fa (41–80 m) (Table 3).

**Trap Bottom Temperatures**: Median weekly bottom temperatures are displayed in Table 3, and ranged from a high of 6.7 to a low of 2.8 °C. The highest temperatures were observed during the first week of the project (January 30) and the lowest were seen in the last week (March 20).

## Size and Sex-Stage Composition for Trawl and Trap Samples Combined

When all samples were expanded to catch as described above, and summed (Figure 9), the northern shrimp mean size was 25.2 mm CL. Ninety-four percent of the northern shrimp in the catch were female, mostly from the 2013 year class, and the rest were males or transitionals mostly from the 2015 year class; 55% of females were ovigerous and 45% had carried and hatched eggs.

## Hatch Timing for Trawl and Trap Samples Combined

In 2017 the estimated hatch initiation day was DOY 27 (January 27), the midpoint was DOY 52 (February 21), completion was DOY 77 (March 18), and duration of the hatch period was 51 days. The 2017 egg hatch midpoint was earlier than those of the previous three seasons. (Figure 14).

## Prices

Due to confidentiality of the dealer data, prices are reported here in an aggregated form. The Massachusetts and New Hampshire boats together were paid an average of $6.27, Maine trappers were paid an average of $6.78, and Maine trawlers were paid an average of $6.23 per pound. The overall pooled mean price for the RSA fishery was $6.30 per pound.

## DISCUSSION

The 2017 cooperative winter sampling program successfully provided winter length and sex-stage composition information and maintained the time series of egg hatch timing estimation for the Gulf of Maine northern shrimp stock, with 164 research samples analyzed from 77 trawl trips by 10 vessels, and 36 trap samples from 76 trips by 5 vessels. Although the number of participating vessels was higher than in the sampling projects of 2014–2016, it is important to recognize that the effort was still limited in comparison to data collected during a typical commercial fishing season. On average, about 207 trips were sampled annually over the last ten years (2004–2013) through the states' shrimp port sampling programs, with a much broader range of locations and larger numbers of vessels.

Differences among fishing trips made on the same day within a few miles of each other suggest that the results could be influenced by moving even very short distances. The presence of fixed gear influenced towing operations in all regions.

Egg hatch trends observed in the 2017 winter samples were consistent with historical regional trends of hatch, beginning and ending earlier in the western GOM and later in the eastern GOM. The 2017 hatch midpoint of February 21 (DOY 52) was earlier than in 2014–2016, but well within the ranges for the decade and the time series. The 2017 hatch midpoint was later than the warm year of 2012, for example, where the midpoint of hatch occurred on February 13 (DOY 44).

It is tempting to assume that the catch rates estimated here would be representative of a 2017 fishery had there been one. The Maine industry pooled mean catch rate for trawlers over the past 10 commercial fishery years is 350 lbs/hr (Eckert *et al*. 2016). But note that the purpose of this program was not to estimate catch rates. A few fishermen fishing once a week on unbroken aggregations of shrimp on their choice of day and location should do exceptionally well. On the other hand, these fishermen were asked to collect samples from areas they might normally have fished, but they were impeded by fixed gear, were lacking information from other harvesters, were lacking the opportunity to find or follow shrimp aggregations from day to day, and were told when they could begin the project and when to end. The samples were collected successfully, and data were collected to evaluate the performance of compound grates, described in a separate report.

## ACKNOWLEDGEMENTS

We would like to thank all the fishermen who participated in cooperative winter sampling this year: Joseph Jurek, Michael Anderson, Vincent Balzano, Joseph Leask, Robert Tetrault, Troy Benner, David Osier, Arthur Poland, Randy Cushman, Glen Libby, Darryl Chadwick, Chad Gamage, George Gilbert, Robert Tracy, Thomas Riedel, and their crews; also Ashley Charleson (University of Maine) and Mike Kersula (Maine DMR) for bycatch sampling and photos, Brad Schondelmeier (MA DMF) for sample collection, Elizabeth Morrissey (MA DMF), Marilyn Lash (Maine DMR) and Mike Kersula for sample analysis, and Katherine Thompson at Maine DMR for providing the temperature loggers.

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Table 1. Summary statistics for the trawl data by region (west to east), vessel, and trip: estimated total shrimp catch, number of tows, total towing time, mean depth, mean bottom temperature, pooled mean catch rate, number of samples collected for the states, type of grate used, pooled mean shrimp count per pound (all species), percent of the shrimp catch that was *Pandalus borealis* (by count), and percent of *P. borealis* females whose eggs had hatched off. "Comp" is compound grate; "Nord" is standard Nordmore grate; "Both" means both grates were used in either a trouser trawl or by alternated tows.

| Region | Vessel | Date | Catch Pounds | Tows Count | Tow Time Hours | Depth Fathoms | Bottom Temp. °C | Rate Lbs/Hr | Samples Count | Grate | Count Num/Lb | *P.borealis* % | Egg Hatch % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MA | *Mystique Lady* | 16-Jan-17 | 225 | 5 | 4.2 | 39 | | 54 | 2 | Comp | 44 | 94% | 9% |
| | | 22-Jan-17 | 425 | 3 | 4.7 | 41 | | 91 | 2 | Comp | 40 | 98% | 19% |
| | | 30-Jan-17 | 260 | 4 | 4.8 | 38 | | 55 | 2 | Comp | 41 | 90% | 30% |
| | | 11-Feb-17 | 400 | 4 | 5.3 | 42 | | 76 | 2 | Comp | 42 | 95% | 80% |
| | | 18-Feb-17 | 335 | 3 | 6.0 | 40 | | 56 | 2 | Comp | 47 | 90% | 88% |
| | | 19-Feb-17 | 210 | 3 | 6.5 | 43 | | 32 | 2 | Comp | 55 | 82% | 85% |
| | | 02-Mar-17 | 90 | 2 | 4.0 | 42 | | 23 | 2 | Comp | 47 | 90% | 82% |
| | | | | | | | | | | | | | |
| NH | *Rimrack* | 16-Jan-17 | 99 | 7 | 3.2 | 44 | | 31 | 3 | Comp | 41 | 92% | 10% |
| | | 26-Jan-17 | 190 | 7 | 7.3 | 40 | 6.4 | 26 | 5 | Both | 45 | 81% | 37% |
| | | 30-Jan-17 | 178 | 8 | 3.7 | 46 | 7.4 | 49 | 4 | Nord | 39 | 88% | 41% |
| | | 07-Feb-17 | 240 | 3 | 2.8 | 42 | 6.3 | 85 | 3 | Comp | 41 | 89% | 67% |
| | | 18-Feb-17 | 25 | 4 | 1.8 | 37 | 4.4 | 14 | 1 | Nord | 58 | 53% | 90% |
| | | 21-Feb-17 | 276 | 4 | 7.5 | 37 | 5.1 | 37 | 3 | Nord | 46 | 89% | 99% |
| | | 27-Feb-17 | 85 | 2 | 3.2 | 46 | 5.2 | 27 | 2 | Nord | 49 | 82% | 100% |
| | | | | | | | | | | | | | |
| Western | *North Star* | 21-Jan-17 | 1,295 | 4 | 2.7 | 53 | 7.8 | 474 | 8 | Both | 42 | 93% | 3% |
| ME | | 29-Jan-17 | 210 | 1 | 0.7 | 55 | 6.8 | 323 | 2 | Both | 42 | 89% | 18% |
| | | 01-Feb-17 | 980 | 4 | 3.8 | 53 | 6.6 | 255 | 8 | Both | 45 | 81% | 16% |
| | | 11-Feb-17 | 1,105 | 3 | 2.9 | 41 | 5.3 | 384 | 6 | Both | 46 | 84% | 60% |
| | | 18-Feb-17 | 1,200 | 5 | 7.0 | 37 | 5.0 | 172 | 8 | Both | 44 | 82% | 62% |
| | | 23-Feb-17 | 1,205 | 4 | 3.3 | 48 | 4.6 | 362 | 8 | Both | 43 | 89% | 62% |
| | | 28-Feb-17 | 1,210 | 3 | 3.5 | 47 | 4.6 | 346 | 6 | Both | 45 | 87% | 85% |
| | | 06-Mar-17 | 1,225 | 3 | 3.9 | 46 | 4.3 | 312 | 6 | Both | 52 | 83% | 95% |
| | | 10-Mar-17 | 895 | 3 | 4.5 | 47 | 5.3 | 198 | 6 | Both | 56 | 74% | 93% |
| | | | | | | | | | | | | | |
| | *November Gale* | 17-Jan-17 | 1,200 | 4 | 1.9 | 50 | 7.6 | 625 | 3 | Both | 29 | 95% | 3% |
| | | 29-Jan-17 | 350 | 2 | 1.1 | 50 | 6.8 | 330 | 2 | Both | 40 | 91% | 14% |
| | | 30-Jan-17 | 1,200 | 4 | 5.9 | 51 | 6.8 | 202 | 4 | Both | 44 | 88% | 25% |
| | | 11-Feb-17 | 1,200 | 1 | 1.5 | 49 | 6.0 | 816 | 1 | Both | 37 | 98% | 71% |
| | | 18-Feb-17 | 1,275 | 4 | 4.3 | 51 | 4.9 | 297 | 3 | Both | 40 | 94% | 73% |
| | | 24-Feb-17 | 1,200 | 3 | 5.8 | 52 | 4.4 | 206 | 3 | Both | 33 | 92% | 80% |
| | | 28-Feb-17 | 750 | 3 | 4.1 | 53 | 4.9 | 184 | 3 | Both | 43 | 77% | 73% |
| | | 06-Mar-17 | 1,000 | 5 | 7.5 | 53 | 5.6 | 133 | 5 | Both | 48 | 89% | 96% |
| | | | | | | | | | | | | | |
| | *Robert Michael* | 16-Jan-17 | 955 | 2 | 2.0 | 56 | 8.3 | 478 | 1 | Nord | 37 | 99% | 4.2% |
| | | 26-Jan-17 | 650 | 3 | 3.8 | 52 | 5.8 | 170 | 1 | Comp | 40 | 99% | 15.5% |
| | | 31-Jan-17 | 1,350 | 4 | 2.9 | 44 | 6.4 | 464 | 1 | Nord | 36 | 95% | 9.9% |
| | | 09-Feb-17 | 1,069 | 5 | 2.8 | 45 | 5.7 | 376 | 1 | Comp | 37 | 100% | 15.4% |
| | | 19-Feb-17 | 1,100 | 2 | 2.6 | 44 | 4.6 | 426 | 1 | Nord | 38 | 98% | 44.4% |
| | | 22-Feb-17 | 1,200 | 3 | 2.9 | 42 | 4.7 | 411 | 1 | Nord | 34 | 99% | 12.1% |
| | | 01-Mar-17 | 1,200 | 4 | 4.4 | 45 | 4.5 | 271 | 1 | Comp | 36 | 100% | 46.9% |
| | | 09-Mar-17 | 200 | 2 | 2.2 | 44 | 4.9 | 92 | 1 | Comp | 42 | 90% | 87.0% |
| | | | | | | | | | | | | | |

Table 1. continued.

| Region | Vessel | Date | Catch Pounds | Tows Count | Tow Time Hours | Depth Fathoms | Bottom Temp. °C | Rate Lbs/Hr | Samples Count | Grate | Count Num/Lb | *P.borealis* % | Egg Hatch % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Midcoast** | ***Lori Ann*** | 31-Jan-17 | 1,200 | 3 | 2.7 | 32 | 6.9 | 453 | 1 | Comp | 37 | 95% | 7.1% |
| **ME** | | 10-Feb-17 | 1,200 | 2 | 2.6 | 35 | 4.7 | 463 | 1 | Nord | 35 | 98% | 11.1% |
| | | 17-Feb-17 | 1,400 | 2 | 2.0 | 34 | 3.1 | 693 | 1 | Comp | 34 | 99% | 10.8% |
| | | 24-Feb-17 | 1,375 | 3 | 3.8 | 37 | 3.5 | 367 | 1 | Nord | 34 | 97% | 21.5% |
| | | 03-Mar-17 | 1,400 | 5 | 7.2 | 41 | 5.2 | 193 | 1 | Comp | 42 | 92% | 65.2% |
| | | 10-Mar-17 | 1,075 | 6 | 8.7 | 47 | 4.9 | 124 | 1 | Nord | 55 | 77% | 75.0% |
| | | 17-Mar-17 | 300 | 5 | 7.5 | 59 | 4.1 | 40 | 1 | Comp | 39 | 100% | 100.0% |
| | | 21-Mar-17 | 162 | 2 | 4.0 | 58 | 3.2 | 41 | 1 | Nord | 56 | 77% | 100.0% |
| | | | | | | | | | | | | | |
| | ***Miss Taylor*** | 30-Jan-17 | 1,200 | 2 | 1.3 | 33 | 6.9 | 902 | 1 | Nord | 33 | 97% | 7.8% |
| | | 12-Feb-17 | 1,175 | 2 | 2.0 | 31 | 4.1 | 588 | 1 | Comp | 32 | 99% | 12.1% |
| | | 15-Feb-17 | 1,200 | 3 | 2.3 | 34 | 3.0 | 533 | 1 | Nord | 34 | 99% | 14.4% |
| | | 20-Feb-17 | 1,325 | 2 | 2.1 | 32 | 4.4 | 637 | 2 | Comp | 33 | 100% | 15.4% |
| | | 05-Mar-17 | 450 | 2 | 2.1 | 31 | 5.5 | 212 | 1 | Nord | 37 | 99% | 73.5% |
| | | 06-Mar-17 | 925 | 3 | 5.1 | 40 | 5.9 | 182 | 1 | Comp | 40 | 99% | 89.6% |
| | | 13-Mar-17 | 540 | 3 | 4.8 | 55 | 5.1 | 112 | 1 | Nord | 42 | 91% | 100.0% |
| | | 21-Mar-17 | 140 | 2 | 4.1 | 56 | 3.2 | 34 | 1 | Comp | 50 | 85% | 100.0% |
| | | | | | | | | | | | | | |
| | ***Ocean Spray*** | 02-Feb-17 | 1,350 | 4 | 3.1 | 28 | 6.2 | 431 | 1 | Nord | 33 | 96% | 9.2% |
| | | 12-Feb-17 | 1,300 | 2 | 2.0 | 33 | 3.8 | 650 | 1 | Comp | 34 | 98% | 12.7% |
| | | 19-Feb-17 | 2,200 | 2 | 2.0 | 31 | 4.4 | 1100 | 1 | Nord | 32 | 99% | 19.8% |
| | | 22-Feb-17 | 1,010 | 6 | 5.0 | 32 | 3.5 | 203 | 1 | Comp | 34 | 92% | 22.2% |
| | | 28-Feb-17 | 1,225 | 4 | 4.1 | 33 | 4.2 | 297 | 1 | Nord | 32 | 98% | 26.8% |
| | | 06-Mar-17 | 685 | 5 | 5.5 | 32 | 5.8 | 126 | 1 | Comp | 42 | 83% | 41.9% |
| | | 18-Mar-17 | 600 | 6 | 7.9 | 51 | 4.0 | 76 | 1 | Nord | 51 | 84% | 90.5% |
| | | 25-Mar-17 | 90 | 2 | 4.8 | 55 | 4.7 | 19 | 1 | Comp | 53 | 82% | 100.0% |
| | | | | | | | | | | | | | |
| **Eastern** | ***Ella Christine*** | 30-Jan-17 | 500 | 4 | 6.1 | 39 | 6.1 | 82 | 1 | Comp | 32 | 91% | 3.4% |
| **ME** | | 11-Feb-17 | 670 | 3 | 6.0 | 34 | 4.4 | 112 | 1 | Nord | 34 | 98% | 9.4% |
| | | 18-Feb-17 | 750 | 4 | 8.3 | 30 | 3.9 | 90 | 1 | Comp | 33 | 99% | 12.4% |
| | | 24-Feb-17 | 540 | 4 | 8.3 | 33 | 3.9 | 65 | 1 | Nord | 35 | 100% | 55.6% |
| | | 03-Mar-17 | 330 | 4 | 7.3 | 38 | 4.5 | 46 | 1 | Comp | 36 | 98% | 73.9% |
| | | 10-Mar-17 | 130 | 3 | 6.8 | 33 | 4.0 | 19 | 1 | Nord | 41 | 81% | 40.0% |
| | | 17-Mar-17 | 27 | 3 | 6.3 | 32 | 3.4 | 4 | 1 | Comp | 42 | 79% | 90.7% |
| | | | | | | | | | | | | | |
| | ***Capt'n Lee*** **or** | 30-Jan-17 | 320 | 4 | 8.7 | 36 | | 37 | 1 | Nord | 42 | 75% | 4.5% |
| | | 11-Feb-17 | 360 | 3 | 5.1 | 33 | | 71 | 1 | Comp | 33 | 97% | 29.8% |
| | | 18-Feb-17 | 190 | 4 | 7.4 | 39 | | 26 | 1 | Nord | 41 | 83% | 27.1% |
| | ***Leslie & Jessica*** | 24-Feb-17 | 95 | 4 | 7.2 | 34 | | 13 | 1 | Comp | 39 | 92% | 54.3% |
| | | 03-Mar-17 | 310 | 4 | 6.9 | 30 | 4.4 | 45 | 1 | Nord | 42 | 84% | 66.7% |
| | | 10-Mar-17 | 125 | 4 | 7.0 | 40 | 4.0 | 18 | 1 | Comp | 39 | 95% | 86.3% |
| | | 17-Mar-17 | 40 | 5 | 6.8 | 46 | 3.4 | 6 | 1 | Nord | 105 | 19% | 88.0% |
| | | | | | | | | | | | | | |
| **Totals and Averages** | | **77 trips** | **56,176 lbs 25.5 mt** | **271** | **347.4** | **42** | | **162** | **164** | | **39** | | |

Table 2. Summary statistics for the trawl data by region (west to east): number of vessel captains participating, number of fishing trips, number of tows, estimated total shrimp catch, total towing time, pooled mean catch rate, mean depth, number of samples collected for the states, and pooled mean shrimp count per pound (all species).

| Region | Vessels | Trips | Tows | Est. Total Catch Pounds | Tow Time Total hours | Avg Rate Lbs/Hr | Avg Depth Fathoms | Samples | Avg Count Number/Lb |
|---|---|---|---|---|---|---|---|---|---|
| Massachusetts | 1 | 7 | 24 | 1,945 | 35 | 55 | 41 | 14 | 44 |
| New Hampshire | 1 | 7 | 35 | 1,093 | 29 | 37 | 42 | 21 | 44 |
| Western Maine | 3 | 25 | 81 | 25,224 | 88 | 286 | 48 | 90 | 41 |
| Midcoast Maine | 3 | 24 | 78 | 23,527 | 97 | 244 | 39 | 25 | 37 |
| Eastern Maine | 2 | 14 | 53 | 4,387 | 98 | 45 | 35 | 14 | 36 |
| Totals & Avgs | 10 | 77 | 271 | 56,176 lbs<br>25.5 mt | 347 | 162 | 42 | 164 | 39 |

Table 3. Summary statistics for the Maine trap data: number of trips, estimated total shrimp catch, number of traps hauled, median bottom temperature, mean depth, number of samples collected, shrimp (all species) count per pound, percent of the shrimp catch that was *Pandalus borealis* (by count), and percent of *P. borealis* females whose eggs had hatched off, by area, vessel, and week.

| Port | Vessel | Week of | Trips | Catch Pounds | Trap Hauls | Bottom Temp. °C | Depth Fathoms | Samples | Count Num/Lb | *P.borealis* % | Egg Hatch % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Five Islands** | ***Miss Maris*** | 30-Jan-17 | 4 | 369 | 84 | 6.7 | 35 | 1 | 40 | 81% | 60% |
| **(Midcoast ME)** | | 06-Feb-17 | 0 | 0 | 0 | 6.3 | | 0 | no traps hauled this week | | |
| | | 13-Feb-17 | 3 | 461 | 60 | 3.6 | 31 | 1 | 39 | 87% | 78% |
| | | 20-Feb-17 | 2 | 452 | 42 | 3.6 | 32 | 1 | 39 | 89% | 97% |
| | | 27-Feb-17 | 2 | 480 | 44 | 3.7 | 33 | 1 | 35 | 99% | 95% |
| | | 06-Mar-17 | 2 | 480 | 50 | 4.8 | 34 | 1 | 36 | 89% | 94% |
| | | 13-Mar-17 | 3 | 484 | 46 | 4.3 | 34 | 1 | 61 | 38% | 98% |
| | | 20-Mar-17 | 3 | 301 | 68 | 3.4 | 31 | 1 | 51 | 56% | 100% |
| **South Bristol** | ***Blake David*** | 30-Jan-17 | 3 | 486 | 118 | 6.4 | 30 | 1 | 37 | 86% | 34% |
| **(Midcoast ME)** | | 06-Feb-17 | 2 | 1,054 | 80 | 4.8 | 30 | 1 | 35 | 94% | 35% |
| | | 13-Feb-17 | 1 | 240 | 12 | 3.3 | 27 | 1 | 34 | 100% | 43% |
| | | 20-Feb-17 | 2 | 650 | 80 | 3.6 | 30 | 1 | 35 | 98% | 60% |
| | | 27-Feb-17 | 2 | 800 | 80 | 4.3 | 34 | 1 | 37 | 97% | 82% |
| | | 06-Mar-17 | 1 | 300 | 40 | 4.5 | 33 | 1 | 38 | 93% | 88% |
| | | 13-Mar-17 | 2 | 260 | 80 | 3.5 | 36 | 1 | 63 | 38% | 82% |
| | | 20-Mar-17 | 1 | 40 | 40 | 3.2 | 36 | 1 | 66 | 41% | 95% |
| **Pemaquid &** | ***Whistle Gear*** | 30-Jan-17 | 5 | 500 | 170 | 6.1 | 35 | 1 | 33 | 100% | 27% |
| **South Bristol** | | 06-Feb-17 | 2 | 820 | 80 | 4.7 | 35 | 1 | 35 | 100% | 69% |
| **(Midcoast ME)** | | 13-Feb-17 | 1 | 1,000 | 40 | 3.3 | 35 | 1 | 36 | 99% | 49% |
| | | 20-Feb-17 | 1 | 876 | 40 | 3.5 | 32 | 1 | 35 | 99% | 81% |
| | | 27-Feb-17 | 1 | 500 | 40 | 4.1 | 32 | 1 | 36 | 100% | 63% |
| | | 06-Mar-17 | 2 | 500 | 80 | 4.3 | 33 | 1 | 35 | 100% | 62% |
| | | 13-Mar-17 | 2 | 140 | 80 | 3.6 | 33 | 1 | 36 | 100% | 89% |
| | | 20-Mar-17 | 1 | 40 | 40 | 3.2 | 33 | 1 | 37 | 100% | 96% |
| **New Harbor** | ***Tradition*** | 30-Jan-17 | 3 | 854 | 120 | | 31 | 1 | 29 | 97% | 32% |
| **(Midcoast ME)** | | 06-Feb-17 | 2 | 707 | 68 | | 29 | 1 | 38 | 95% | 60% |
| | | 13-Feb-17 | 2 | 1,140 | 58 | | 29 | 1 | 35 | 99% | 36% |
| | | 20-Feb-17 | 2 | 793 | 58 | lost | 30 | 1 | 34 | 100% | 25% |
| | | 27-Feb-17 | 3 | 365 | 45 | temperature | 29 | 1 | 36 | 94% | 28% |
| | | 06-Mar-17 | 1 | 140 | 12 | logger | 33 | 1 | 38 | 97% | 96% |
| | | 13-Mar-17 | 1 | 129 | 40 | | 44 | 1 | 44 | 71% | 100% |
| | | 20-Mar-17 | 1 | 91 | 38 | | 44 | 0 | | | |
| **Swans Island** | ***Katelynn's Way*** | 30-Jan-17 | 2 | 8 | 80 | 4.6 | 22 | 1 | 60 | 17% | 0% |
| **(Eastern ME)** | | 06-Feb-17 | 1 | 5 | 30 | 3.9 | 38 | 0 | | | |
| | | 13-Feb-17 | 1 | 9 | 40 | 3.5 | 34 | 1 | 60 | 28% | 30% |
| | | 20-Feb-17 | 3 | 87 | 120 | 3.8 | 35 | 1 | 82 | 2% | 25% |
| | | 27-Feb-17 | 1 | 21 | 40 | 3.9 | 36 | 0 | | | |
| | | 06-Mar-17 | 2 | 30 | 80 | 3.8 | 37 | 1 | 59 | 35% | 75% |
| | | 13-Mar-17 | 1 | 25 | 40 | 3.0 | 37 | 1 | 60 | 27% | 97% |
| | | 20-Mar-17 | 2 | 32 | 70 | 2.8 | 37 | 1 | 82 | 11% | 96% |
| **Totals and Averages** | | | **76** | **15,668 lbs 7.1 mt** | **2,433** | | **33** | **36** | **38** | | |

Table 4. Summary statistics for the Maine trap data: number of trips, number of trap-hauls, estimated total shrimp catch, mean depth, number of samples collected, and pooled mean shrimp (all species) count per pound, by vessel and port, roughly west to east.

| Port | Vessel | Trips | Trap Hauls | Est. Total Catch Pounds | Avg Depth Fathoms | Samples | Avg Count Number/Lb |
|---|---|---|---|---|---|---|---|
| **Five Islands** | ***Miss Maris*** | **19** | **394** | **3,027** | **33** | **7** | **43** |
| **South Bristol** | ***Blake David*** | **14** | **530** | **3,830** | **32** | **8** | **38** |
| **Pemaquid & South Bristol** | ***Whistle Gear*** | **15** | **570** | **4,376** | **34** | **8** | **35** |
| **New Harbor** | ***Tradition*** | **15** | **439** | **4,219** | **34** | **7** | **35** |
| **Swans Island** | ***Katelynn's Way*** | **13** | **500** | **217** | **34** | **6** | **73** |
| **Totals & Avgs** | | **76** | **2,433** | **15,668 lbs**<br>**7.1 mt** | **33** | **36** | **38** |

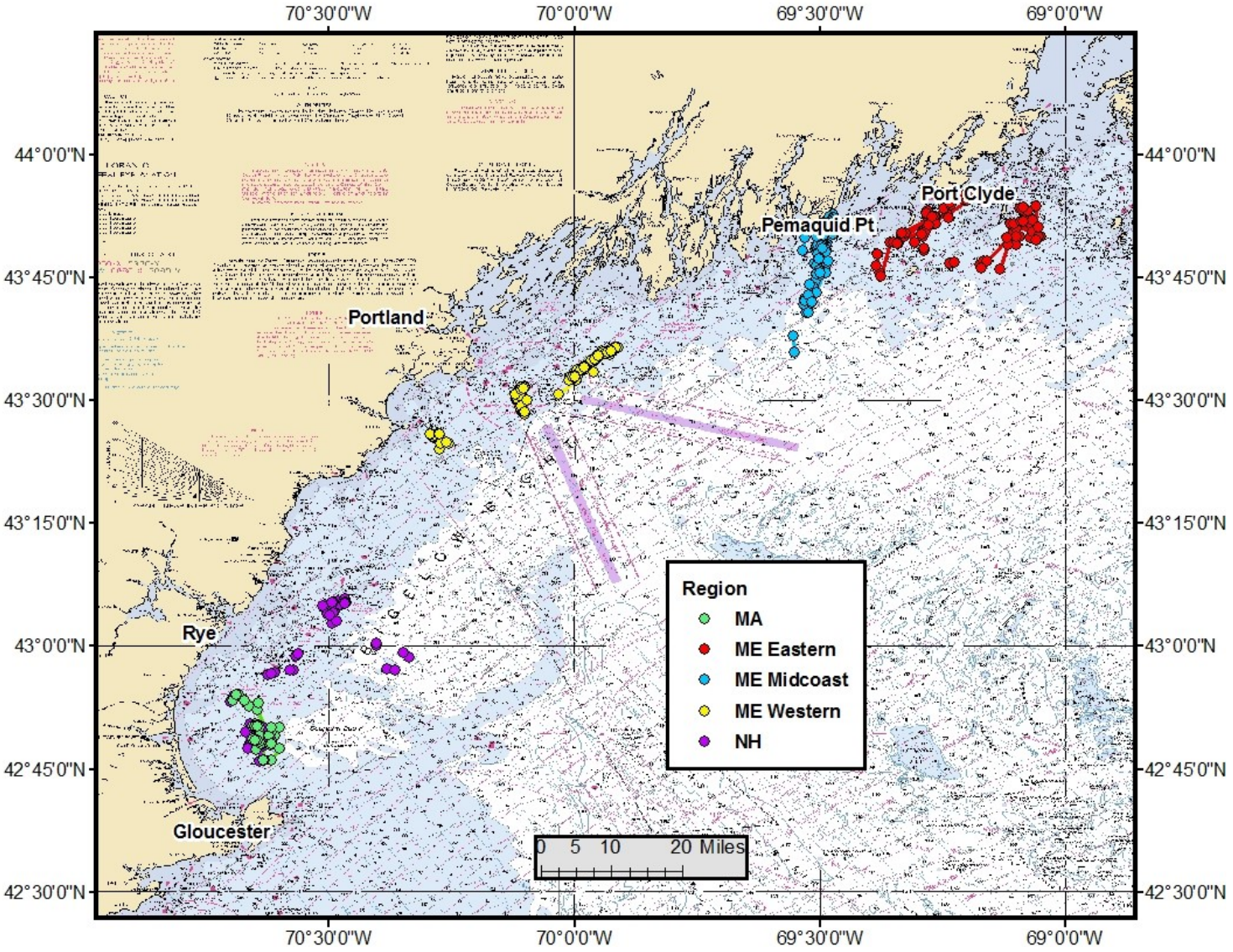


Figure 1. Locations of 2017 Gulf of Maine northern shrimp sampling tows, by region.

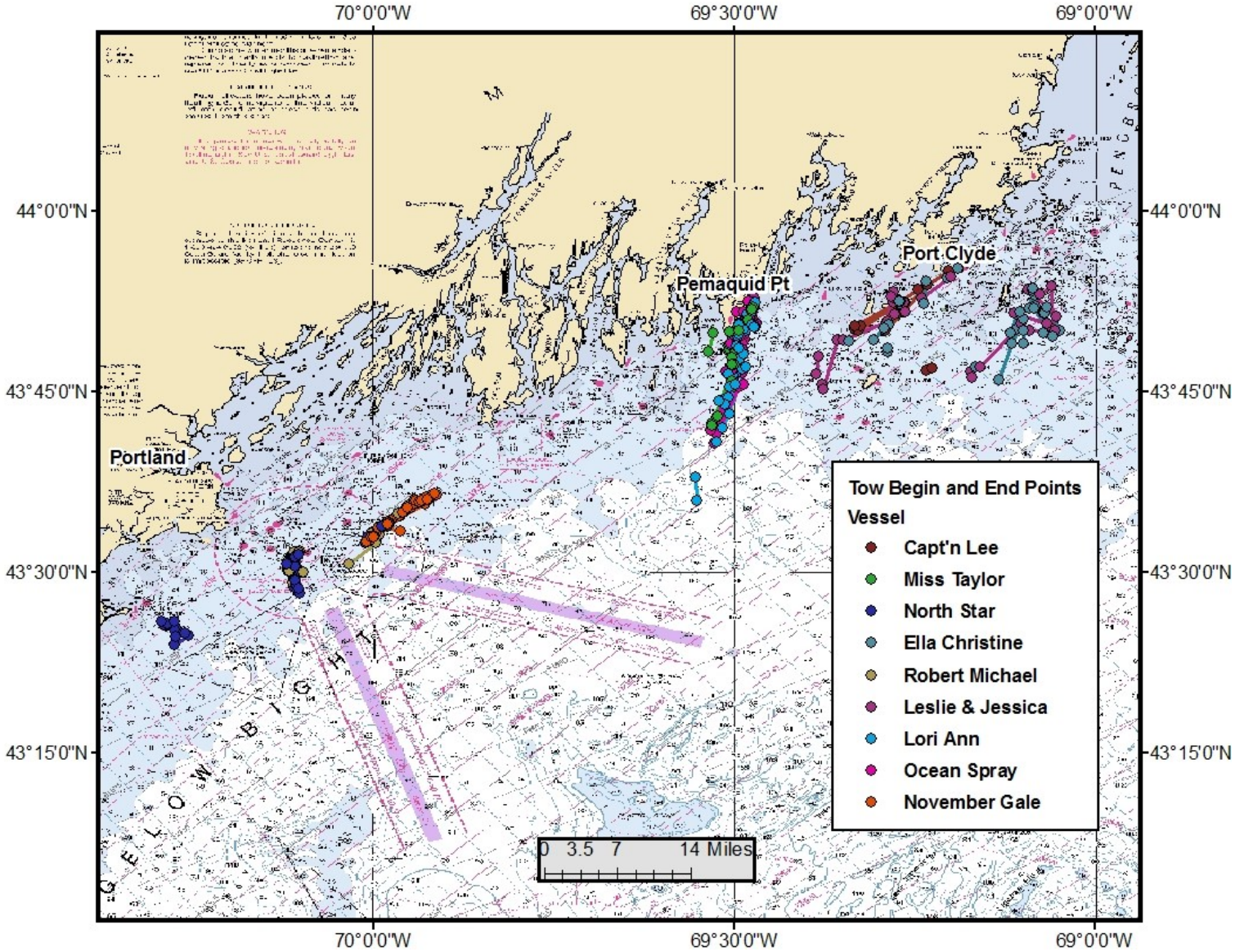


Figure 2. Locations of 2017 Maine northern shrimp sampling tow begin and end points by vessel.

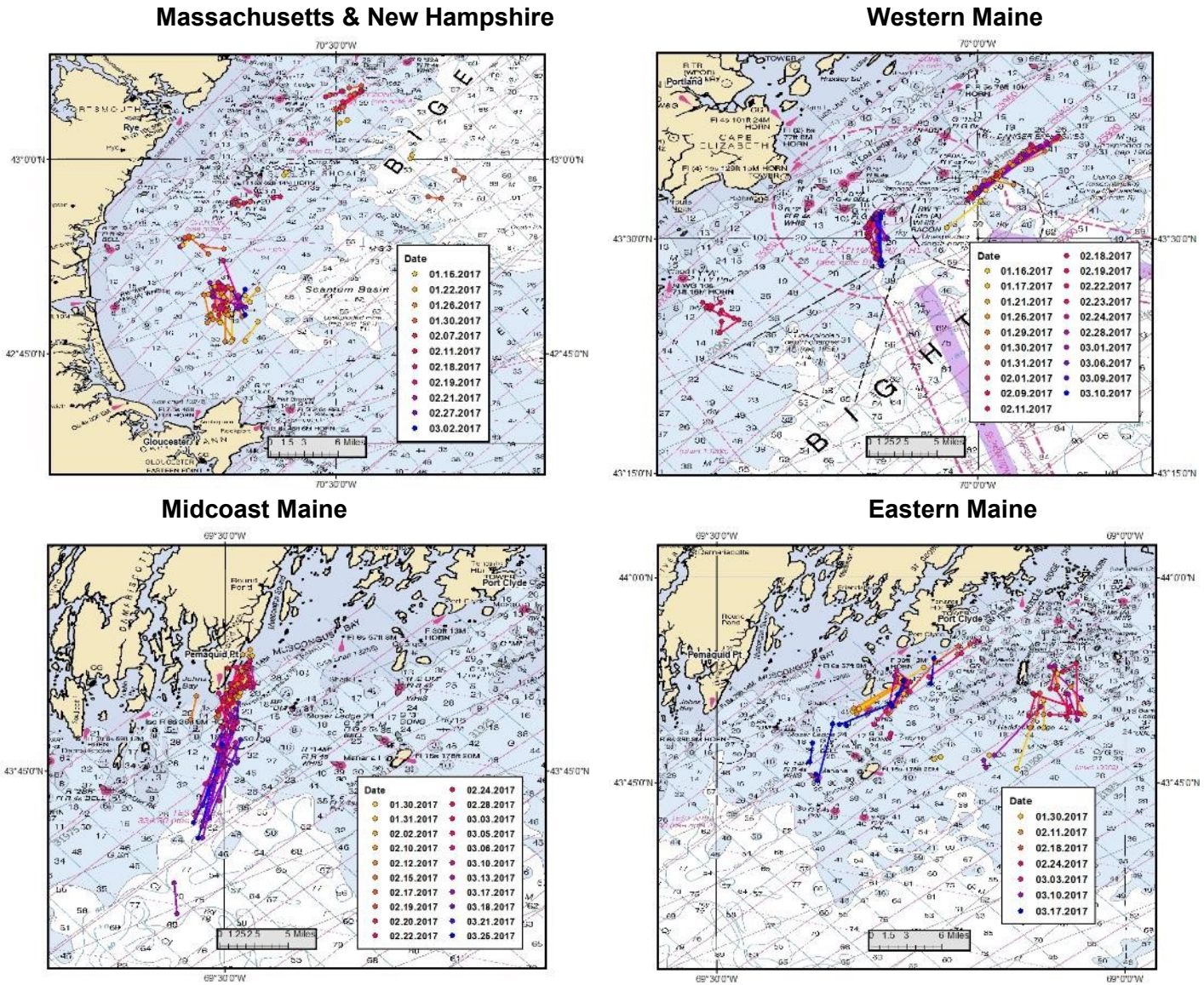


Figure 3. Locations of 2017 Gulf of Maine northern shrimp sampling tow begin and end points by region. Color palette (yellow to blue) indicates fishing date.

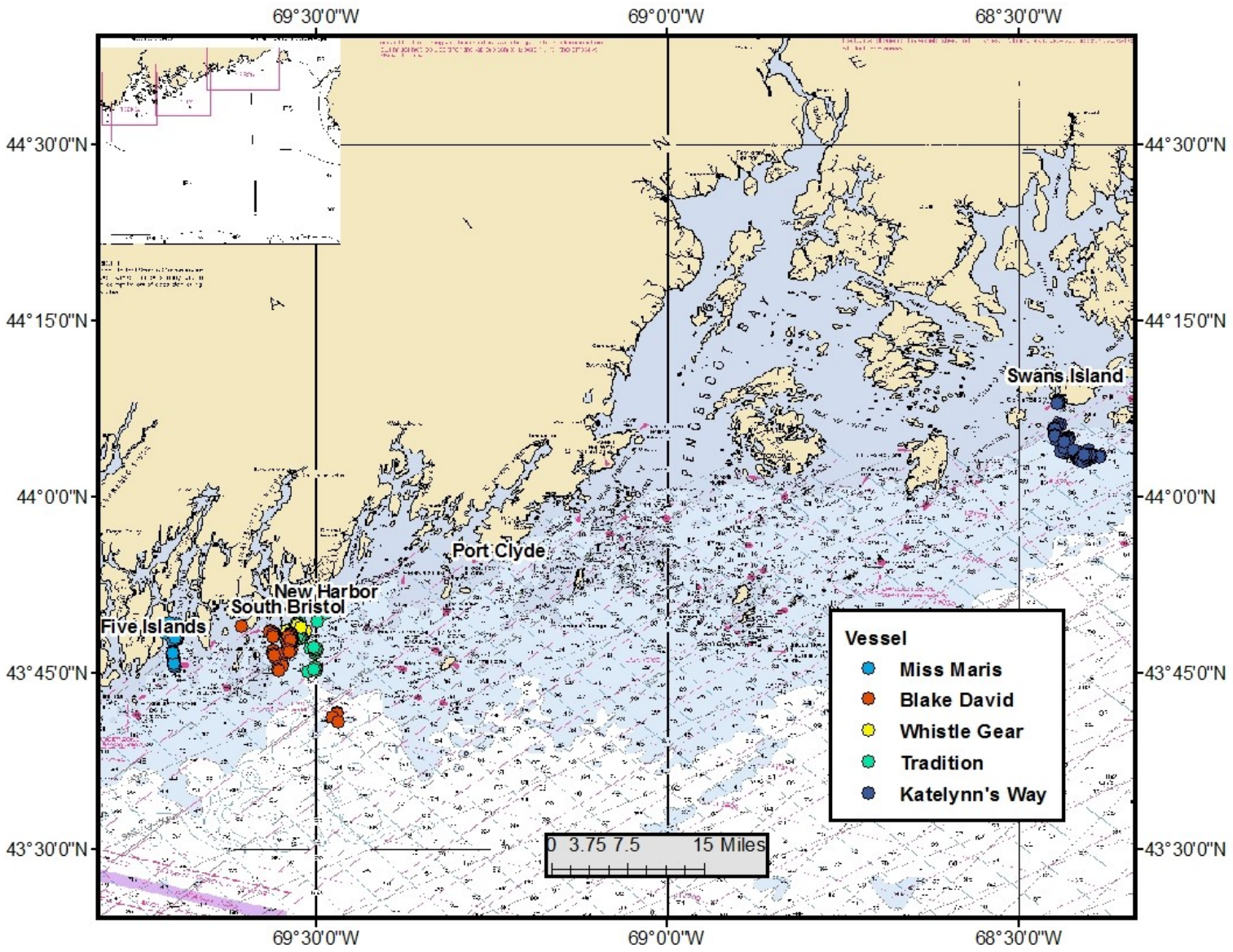


Figure 4. Locations of 2017 Gulf of Maine shrimp sampling traps by vessel.

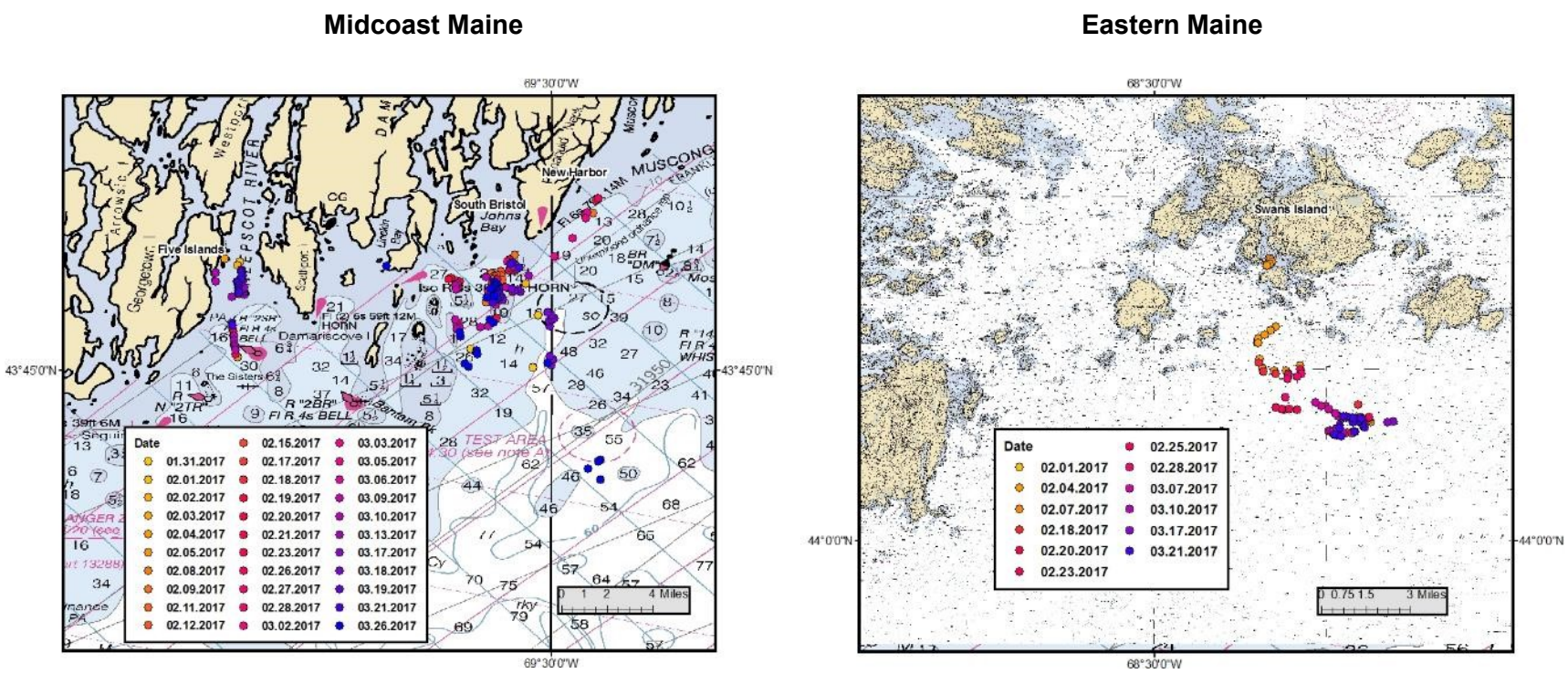


Figure 5. Locations of 2017 Gulf of Maine shrimp sampling traps by region (Midcoast Maine left; Eastern Maine right) and haul date. Color palette (yellow to blue) indicates fishing (trap haul) date.

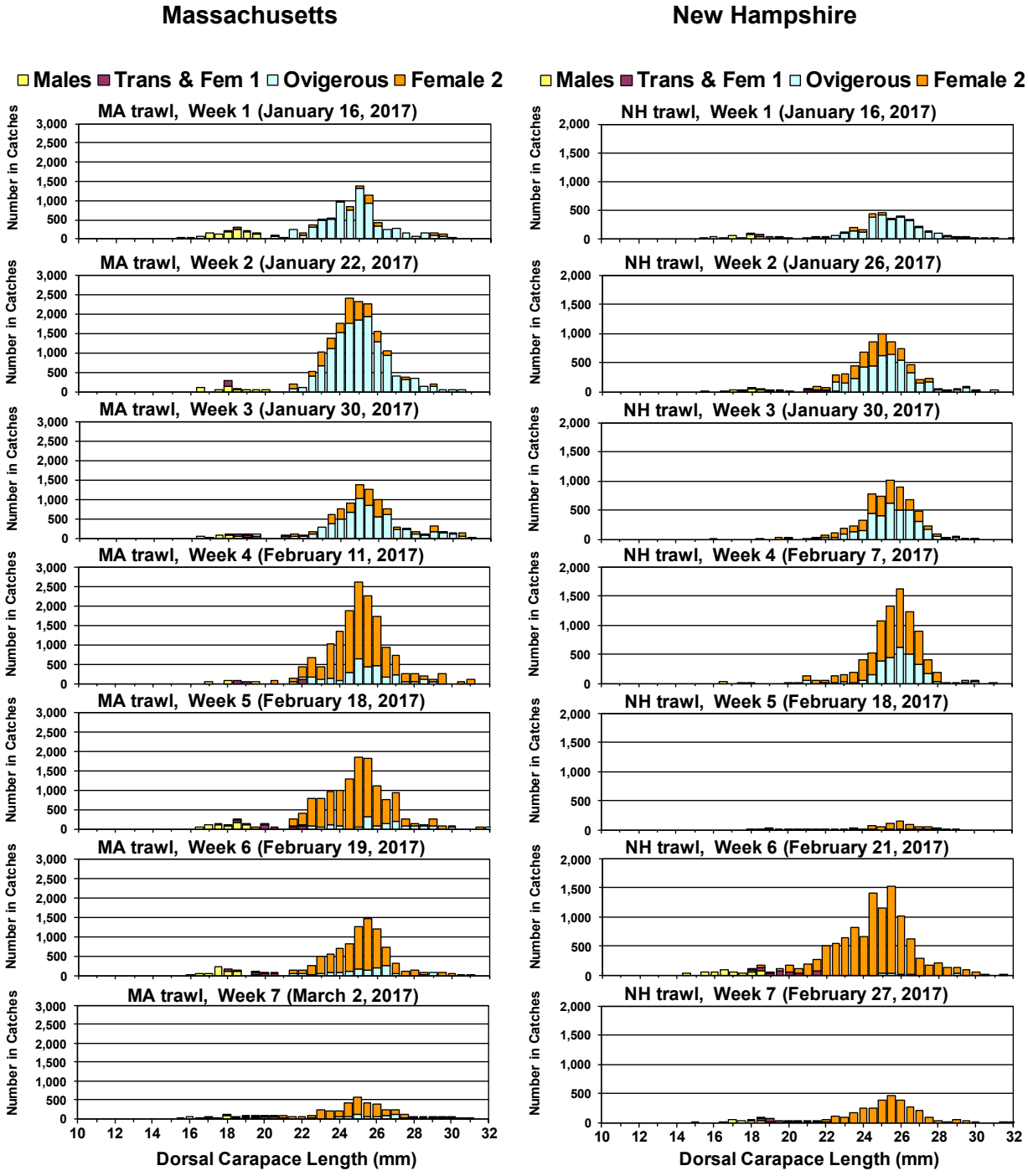


Figure 6. Northern shrimp size-sex-stage frequency distributions (in estimated total numbers of *P. borealis* in catches) from Massachusetts (left) and New Hampshire (right) trawlers, by week. Note that the vertical scales are different for the two regions.

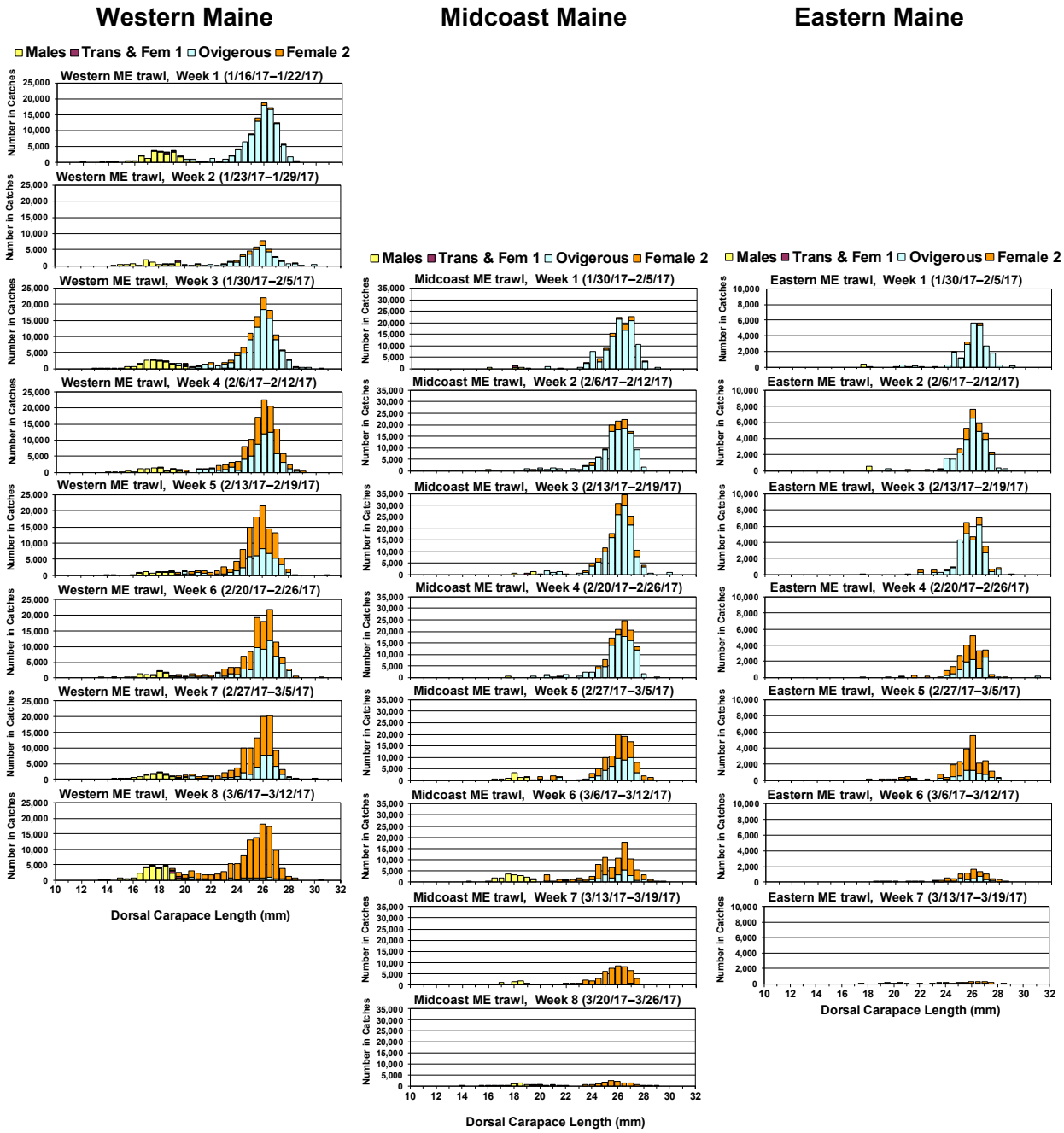


Figure 7. Northern shrimp size-sex-stage frequency distributions (in estimated total numbers of *P. borealis* in catches) from Maine trawlers, by region (left to right; west to east) and week (top to bottom). Note that the Western region started two weeks earlier than the others, and the vertical scales are different for each region.

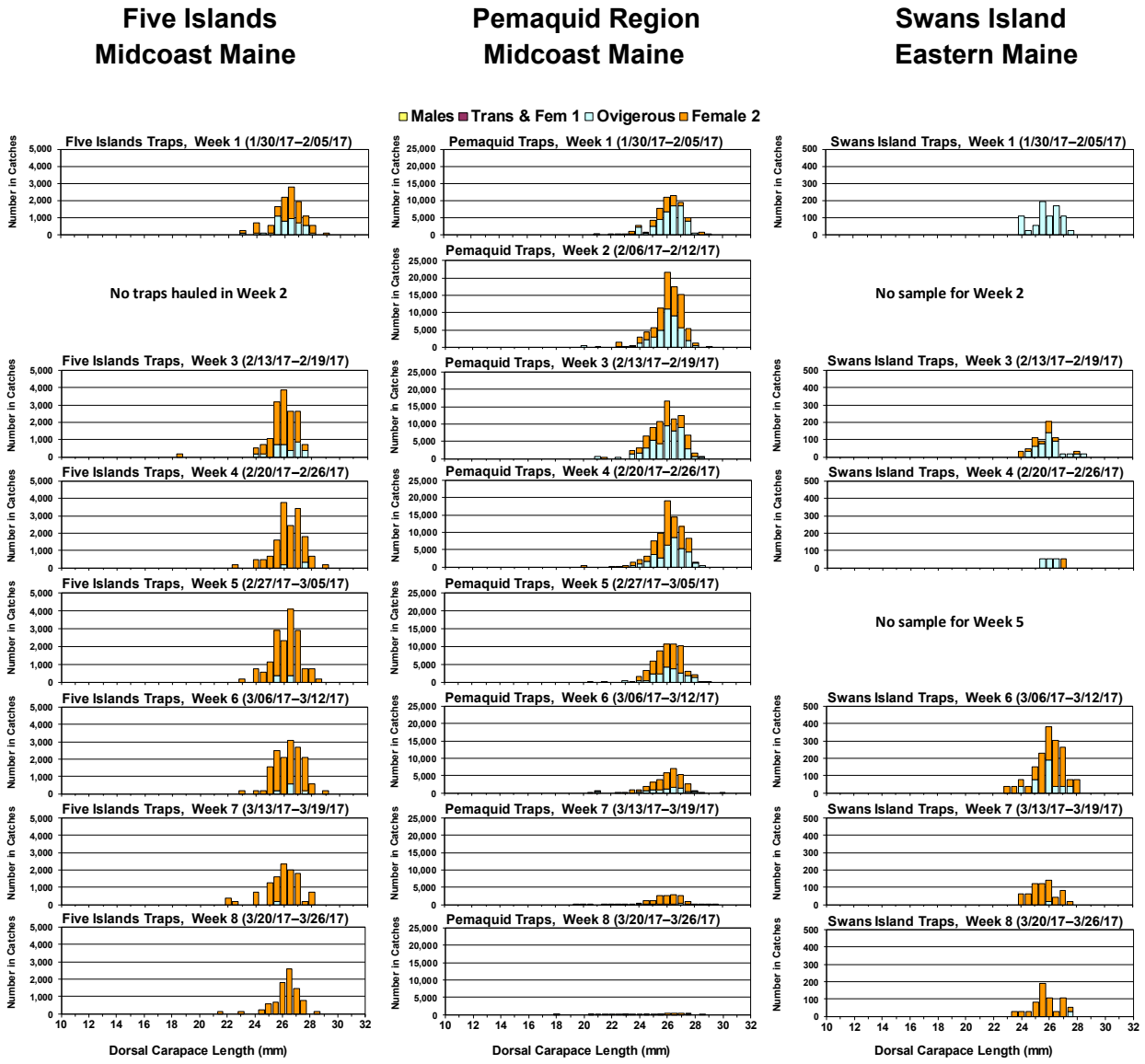


Figure 8. Northern shrimp size-sex-stage frequency distributions (in estimated total numbers of *P. borealis* in catches) from Maine trappers, by area (left to right; west to east) and week (top to bottom). "Pemaquid Region" includes the three trappers who fished from South Bristol, Pemaquid, and New Harbor. Note that the vertical scales are different for each area.

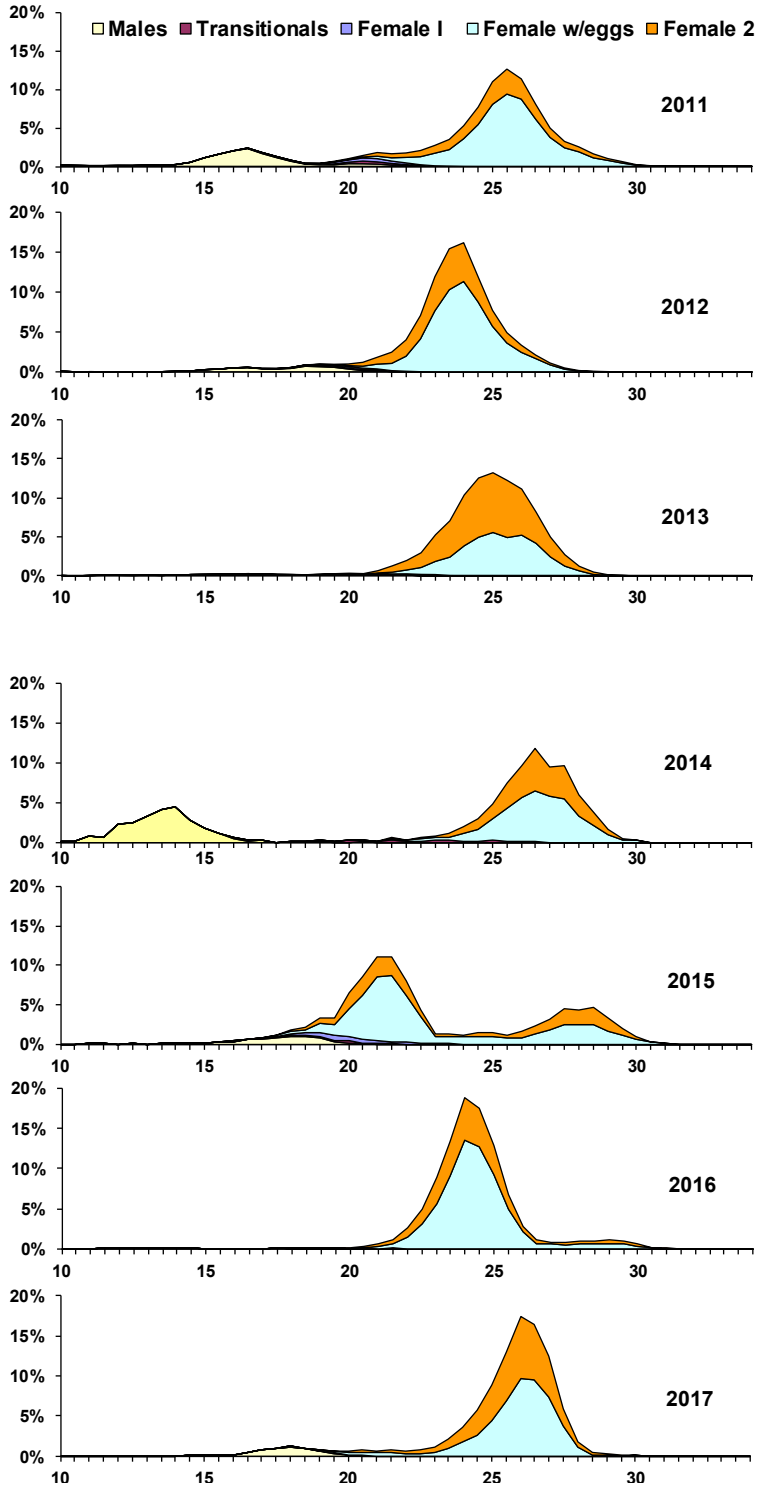


Figure 9. Northern shrimp relative size-sex-stage frequencies from winter sampling with data from 2011–2013 GOM fishery samples expanded to landings, 2014 Pemaquid Point, Maine samples, and 2015–2017 GOM RSA samples expanded to sampled catches.

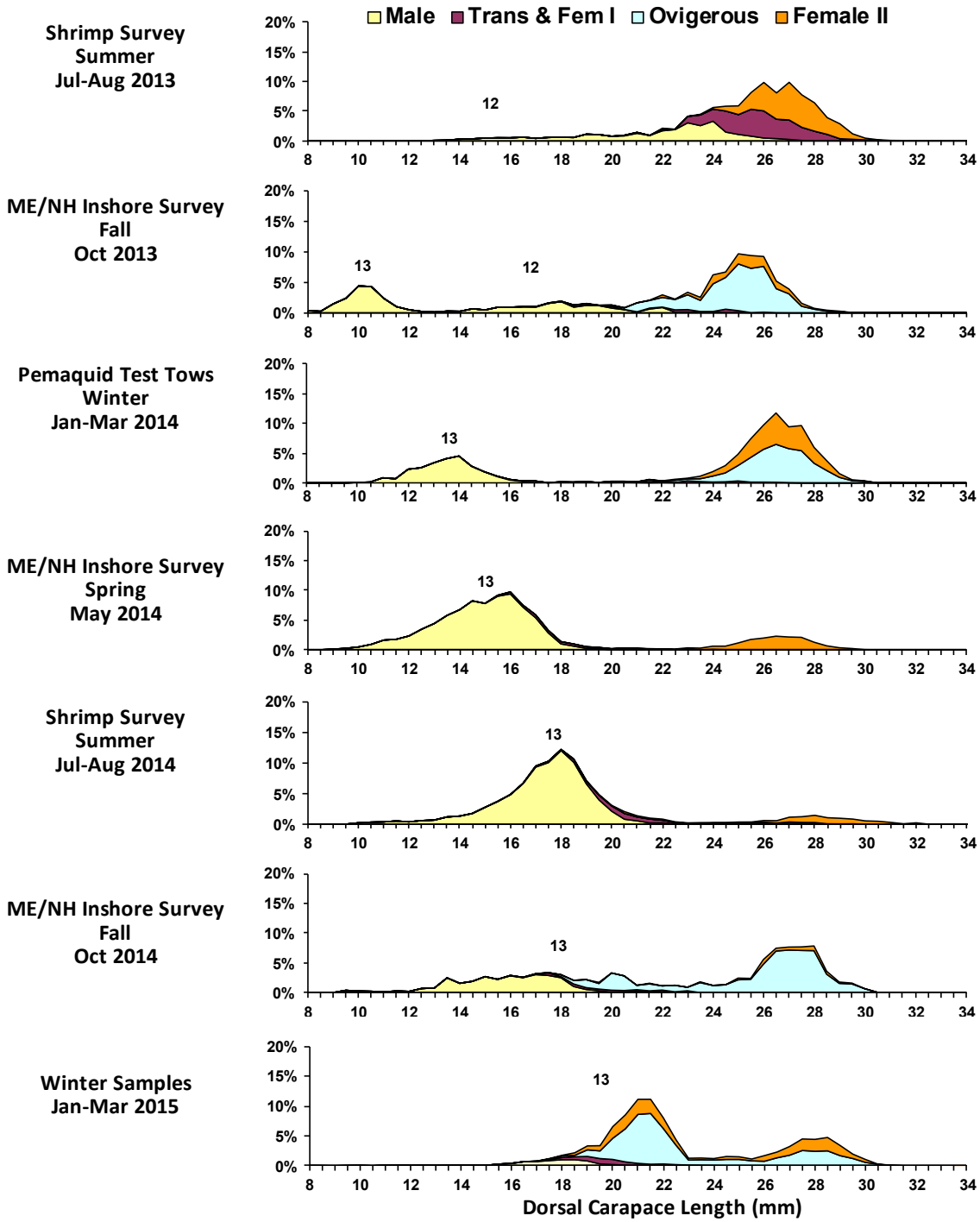


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Figure 10. Northern shrimp relative size-sex-stage frequencies from 2013–2017 GOM surveys and sampling programs. Two-digit years denote the mode of assumed 2012–2015 year classes.

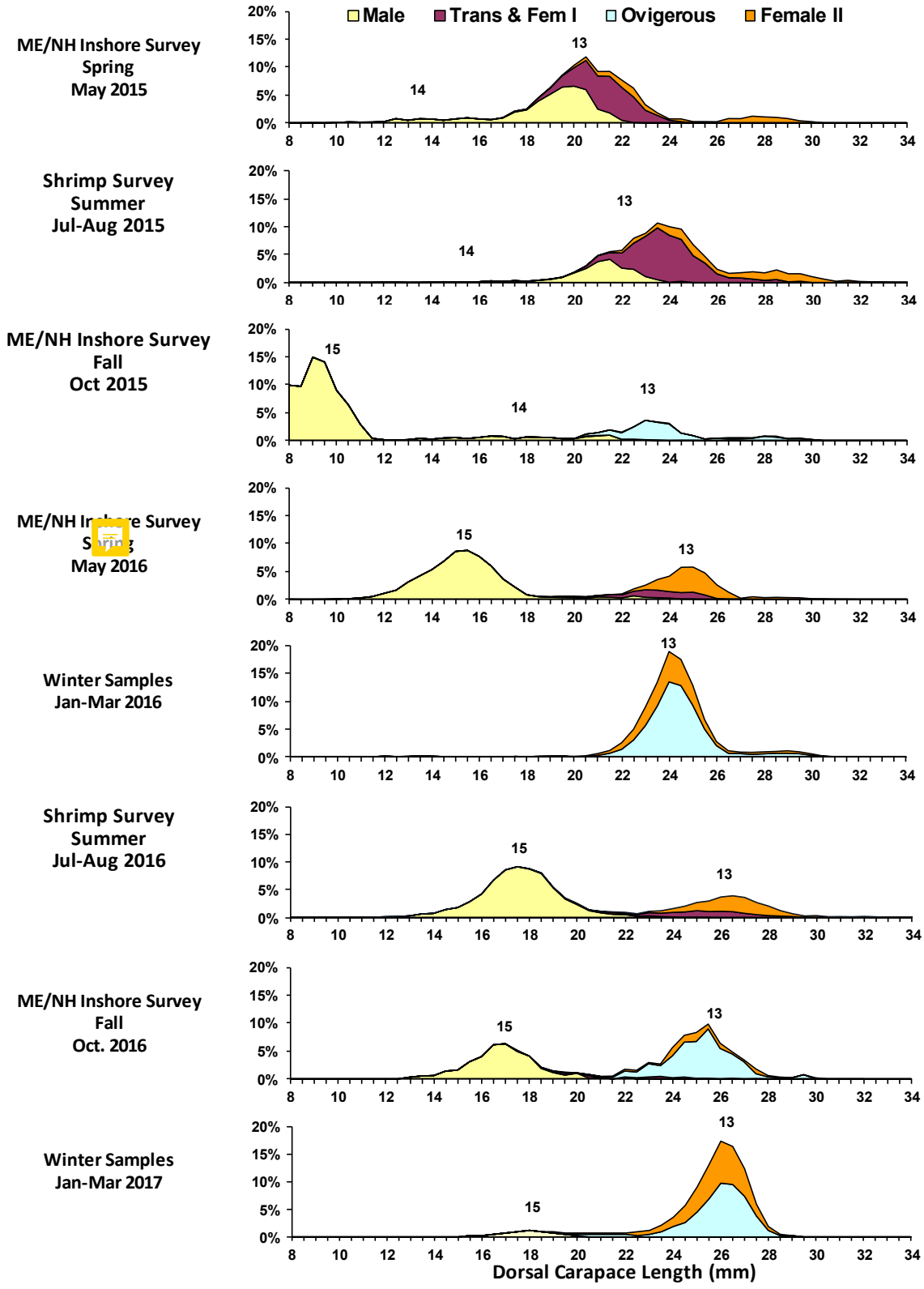



Figure 10. Continued from previous page.

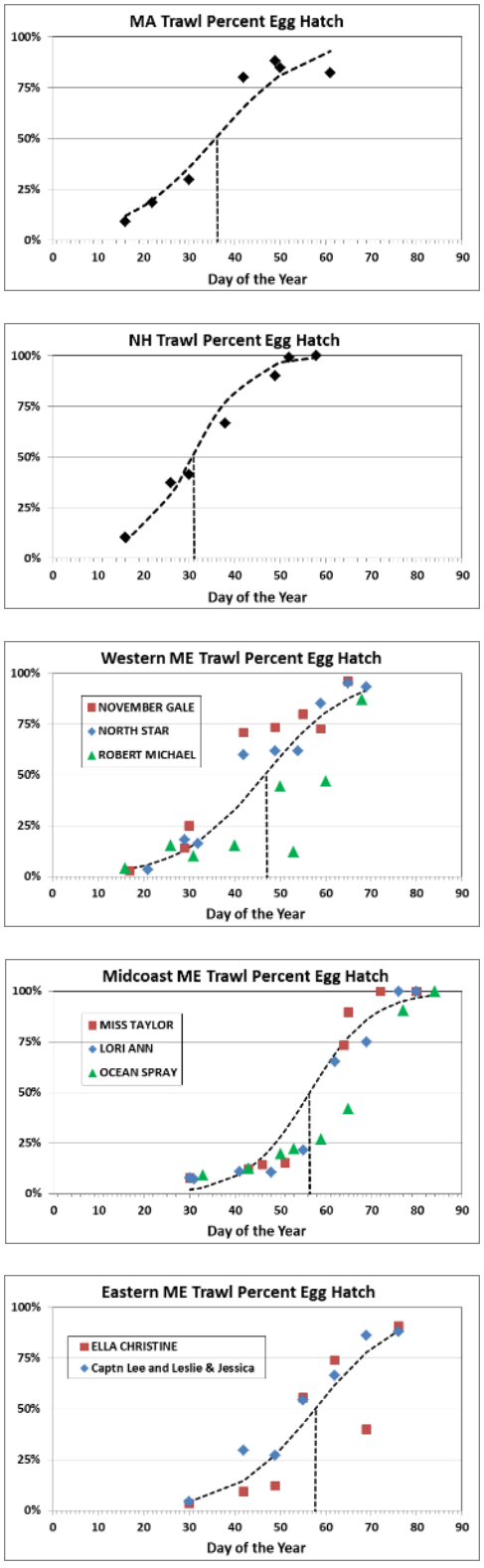
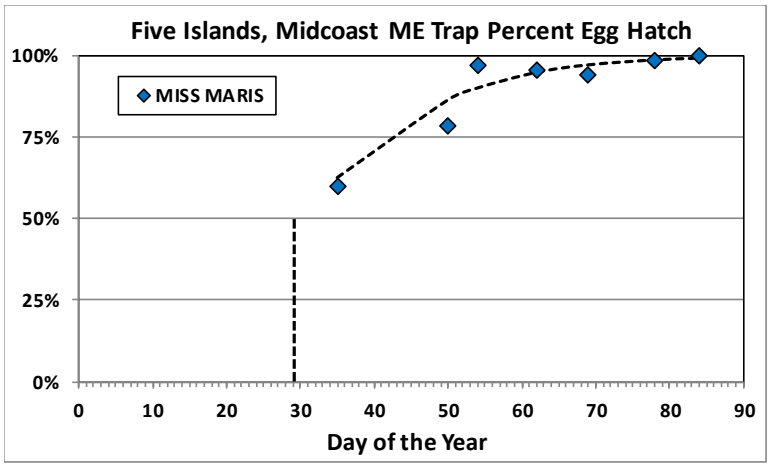
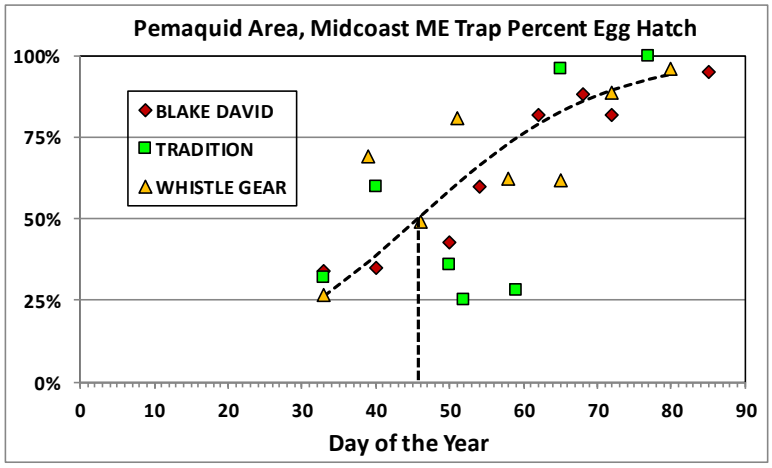



Figure 11. Mean percentage of egg hatch by day of the year (2017) for female northern shrimp, by region, for trawlers. Vertical dotted line indicates approximate day of 50% hatch.



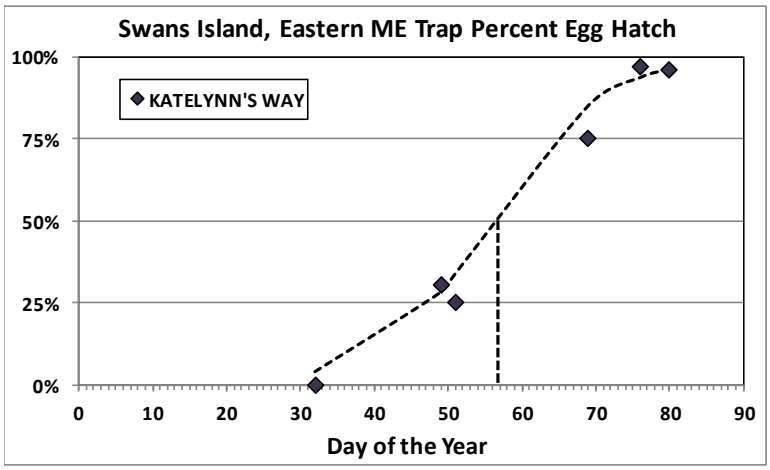




Figure 12. Mean percentage of egg hatch by day of the year (2017) for female northern shrimp, by area, for Maine trappers. Vertical dotted lines indicate approximate day of 50% hatch.

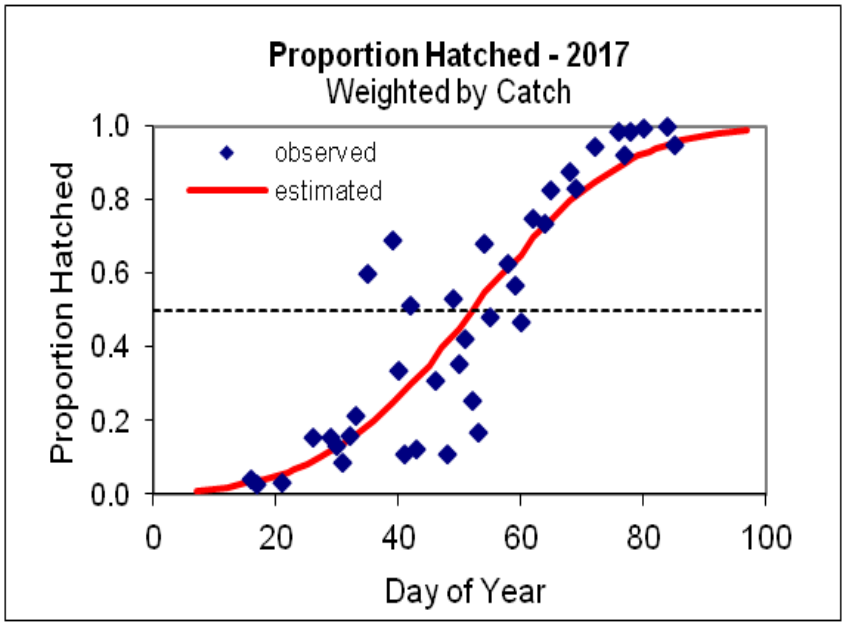



Figure 13. Proportion hatched over time in all Maine samples during 2017. Blue dots are observed proportions in samples; red line is a fitted estimate from probit analysis.

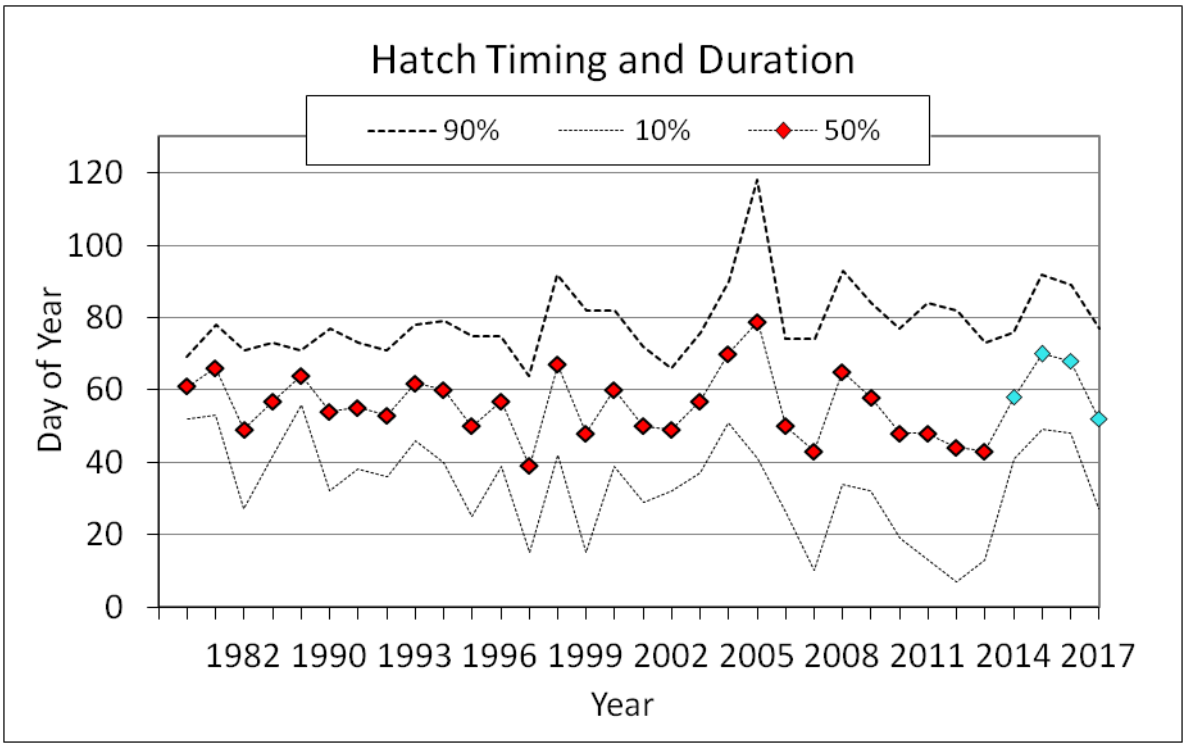



Figure 14. Time series of hatch timing estimates from sampling of the Maine commercial fishery (1980–1984, 1989–2013) (red), and NSTC winter sampling in Maine (2014–2017) (blue).