Winter 2014 Test Tows for Gulf of Maine Northern Shrimp

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Introduction

Fisheries for northern shrimp (*Pandalus borealis*) in the Gulf of Maine (GOM) during the past 30 years have been conducted from December through May, during the winter when egg-bearing (ovigerous) female shrimp move inshore, and sometimes during the spring as the shrimp return offshore after egg hatch. The highest landings usually occur in the months of January and February (Table 2 in Whitmore *et al,* 2013). Shrimp are caught by trawlers and trappers, with trawlers averaging about 86% of the Maine catch in the past five years (Table 3 in Whitmore *et al,* 2013).

The 2013–2014 fishery was closed by the Atlantic States Marine Fisheries Commission (ASMFC) due to low stock abundance. However, the Maine Department of Marine Resources (DMR) contracted with a commercial shrimp trawler operating under a special DMR research license, to collect northern shrimp samples during January–March 2014. The purpose of the project was to

- Continue DMR's time series of samples from Maine northern shrimp fishery catches, estimating the winter size and sex-stage composition of the shrimp stock in traditionally fished areas, and
- Determine 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), so the location of the sampling may influence the results.

Methods

The Boothbay area was chosen for this project as best representing the spatial "center" of a typical winter Maine shrimp fishery, which normally extends roughly from the Maine-New Hampshire border in the west to the Winter Harbor area in the east (Figure 1).

A commercial shrimp fisherman and his vessel were selected from among several applicants, based on his understanding of the project, his shrimp fishing experience, and cost. A trawler was selected, rather than a trapper, since the majority of past samples were from trawlers. The fisherman was asked to fish where he would normally fish throughout the winter, with the purpose being the collection of shrimp samples in the Maine midcoast area, using commercial shrimp gear, moving short distances between tows. The captain has shrimped for 35+ years and used his own gear for the project, fishing out of Boothbay Harbor. His vessel was a 42-foot trawler with a 70-foot, 4-seam net and standard grate.

The plan was to begin fishing when the shrimp had moved inshore and were still carrying eggs (December or January), and then stagger the rest of the trips so that the last trip would be taken when most of the eggs had hatched off, usually sometime in late March. Each trip was scheduled, weather allowing, on a mutually agreed upon date, after discussion between the captain and the project leader.

Five trips were conducted, because there was adequate funding for five. The first fishing day was January 30, 2014, the first good weather day after funds for the project became available. There were two fishing days in February and two in March, with trips approximately two weeks apart.

Each day (trip), the fisherman conducted three tows of about 15 minutes each, at about 42 fa (76m) depth. On the last day, he fished further offshore at about 85 fa (155 m). He conducted his first tow at a favorite spot near the Cuckolds (off Southport Island, Figure 1) but was unable to stay in that area because of lobster gear, so he went about ten miles (16 km) further east, near Pemaquid Point (Figure 1) for the rest of Day 1 and for Days 2–4. On Day 5 (March 25) he fished about 15–20 miles (24–32 km) south of Boothbay Harbor. He recorded the start and end locations and depths, and the duration of each tow, and an estimate of the total weight of the catch. From each catch, a random 2 kg (approximate) sample was collected, bagged, and returned to the DMR laboratory in Boothbay Harbor. The rest of the catch was immediately discarded overboard.

At the lab, samples were frozen and later thawed and analyzed, following the usual procedures for shrimp catch samples. Each sample was weighed, and then separated by shrimp species. *P. borealis* specimens were counted, measured (dorsal carapace length (CL)), sexed (male, transitional, or female), and female stage (I, II, or ovigerous) was determined. Female stage I shrimp have not yet carried eggs; female stage II shrimp are not carrying eggs but have in the past, as determined by the presence/absence of sternal spines (McCrary 1971). The proportion of females that had carried and hatched off their eggs was calculated for each sample as the number of female II shrimp divided by the sum of female II shrimp plus ovigerous females. Size-sex-stage frequency distributions for each day were calculated by standardizing *P. borealis* counts in each sample to a 1 kg sample (so that all samples were weighted equally), and then summing by size (CL in 0.5 mm categories), sex, and stage.

Hatch initiation, defined as the day of the year on which 10% of females had hatched their brood, hatch midpoint (50% hatched), hatch completion (90% hatched), and duration of the hatch period (number of days from initiation to completion inclusive) were estimated using probit analysis as described in Richards, 2012. Hatch metrics were also calculated for Pemaquid Point area commercial samples (defined as samples from catches made within the three 10-minute squares highlighted in Figure 3, according to harvester interviews), and all Maine commercial samples, for the 2010, 2011, and 2013 seasons for comparisons. 2012 was omitted because no Pemaquid Point area samples were collected after February 15, when the mean percentage of females that had hatched their eggs was only 35%.

Results

Fifteen tows were successfully conducted and fifteen samples were collected, three on each of the five days. About 583 lbs (264 kg) of shrimp were caught in total, and 2,838 *P. borealis* were collected in the samples. Information for each tow and sample is presented in Table 1 with daily summaries in Table 2. The general locations of tows are shown in Figure 1. Size and sex-stage composition from the samples are shown in Figures 2–4. Egg hatch metrics are displayed in Table 3 and Figures 5–7.

Size and sex-stage composition: The mean number of *P. borealis* per pound (Count/lb., Tables 1–2) was about 41, a slightly lower number than in the 2013 fishery, when the means for those months for Maine

trawlers were 42–45 (Whitmore *et al* 2013), indicating somewhat larger shrimp in 2014 than in 2013. Most of the female shrimp were probably five years old, from the 2009 year class. There were also some small (10–16 mm CL) male shrimp in the samples (left-most mode in Figure 2). There were proportionally more small male shrimp (composing about 26% of the *P. borealis* in the samples) than are usually seen in fishery samples in these months (Figure 4). It is likely that the males were from the 2013 year class (1-year-old) because they were about the same size as the small males in 2002 fishery samples, when the strong 2001 year class first appeared as 1-year-olds (Figure 3). Few transitional and female I shrimp appeared in samples until Day 5, March 25, which was further offshore and deeper (85 fa or 155 m) than all the earlier tows (Table 1, Figure 1).

The average weight of a northern shrimp in the samples was 11.30 grams, slightly less than the prediction of 11.68 g by Whitmore *et al* in 2013, probably because of the high proportion of small males.

Egg hatch: On January 30, most of the female shrimp were still carrying eggs, with only about 5–6% of females being post-hatch (female stage II). On the next sampling day, February 9, post-hatch females were still only about 6%, but on February 23 they were up to about 32 %, on March 8 they were about 70%, and by March 25 they were 100% post-hatch (Table 1).

Probit analysis suggests that hatch initiation (10%) was about February 10 (day 41), hatch midpoint was about February 27 (day 58), hatch completion (90%) was about March 18 (day 76), and the duration of hatch was about 36 days (Table 3, Figure 5). When comparing 2014 samples with Pemaquid area samples from recent years, hatch initiation and midpoint were later than in 2010–2013, but completion was earlier than 2010 and 2011 (Table 3). When comparing the 2014 samples with a longer time series (Figure 7), it appears that hatch metrics in 2014 were similar to pre-2000 fisheries, when hatch duration was shorter and initiated later than post-2000 fisheries (but see Discussion) (Richards 2012).

Catch rates: Catch rates ranged from an estimated 43 lbs/hr (March 25, tow 1) to about 462 lbs/hr (February 9, tow 3) and averaged 162 lbs/hr (74 kg/hr) overall (Table 1).

How does the Pemaquid Point area compare with the entire GOM fishery region?

Size-sex-stage data from samples from the Pemaquid area were compared with all samples collected from the Gulf of Maine northern shrimp fishery for 2010, 2011, 2012, and 2013, and are displayed in Figure 4. A visual perusal of the size-sex-stage frequency distributions suggests that the Pemaquid samples alone very closely approximate the size distributions from the entire fishery. However, the overall proportion of females that are carrying eggs appears to be generally higher in the Pemaquid area, suggesting that this area is fished (or sampled) more heavily before egg hatch, and less heavily after egg hatch, than the rest of the fishery region.

The egg hatch metrics for the Pemaquid region samples compared with all Maine samples for 2010, 2011, and 2013 are shown in Table 3 and Figure 6, and do not show any obvious trends. In 2010 and 2011, hatch initiation was earlier and midpoint and completion were later at Pemaquid. In 2013, initiation was later, the midpoint was about the same, and completion was earlier, at Pemaquid. It might be instructive to evaluate data from more years.

Discussion

It is important to remember the limited scope of this project. Although the Pemaquid Point area has always been heavily fished, and is roughly in the geographic middle of the Maine fishery, it would be unwise to suggest that it fully represents the entire shrimp fishing grounds of the coast of Maine. Differences among tows made on the same day (Table 1) within a couple of miles of each other suggest that the results could be influenced by moving even very short distances.

Egg hatch is known to begin earlier in the western GOM and end later in the east, so the period of egg hatch demonstrated in this project is likely to be constricted, compared with the entire range of the fishery.

It is too early to tell whether the number of small male shrimp observed in these samples is a good indicator of the strength of the 2013 year class.

It is tempting to assume that the catch rates estimated here would be representative of a 2014 fishery had there been one. The Maine industry average catch rate for trawlers over the past 10 years is 350 lbs/hr (Whitmore *et al* 2013, Table 7). But note that the purpose of this project was not to estimate catch rates. One trawler fishing alone once every couple of weeks on unbroken aggregations of shrimp on his choice of day and place should do exceptionally well. On the other hand, this trawler's purpose was only to collect samples from an area he might normally have fished, without much moving or opportunity to hunt. The samples were collected successfully.

Acknowledgements

We wish to thank Bill Sherman for his fishing expertise and flexibility, Marilyn Lash (DMR) for working up the samples, and Dr. Anne Richards (NEFSC) for the analyses of hatch metrics. We thank them all for being both highly capable and affable.

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Table 1. Data for each 2014 tow. All shrimp counts and poundage are *Pandalus borealis*.

Day	Date	Tow	Duration (minutes)	Depth (fathoms)	Estimated Pounds of Shrimp	Estimated Catch Rate (lbs/hr)	Sample wt (g)	No. of Shrimp in sample	Count per Lb	No. of Males in sample	No. of Trans & Fem I	No. of Ovigerous	No. of Fem II (non-ovig)	% Egg Hatch
	30-Jan-14	1	20	34	35	105	2,152	185	39	52	2	125	6	5%
1	30-Jan-14	2	15	48	50	200	2,192	187	39	50	0	129	8	6%
	30-Jan-14	3	15	43	25	100	2,088	212	46	85	2	117	8	6%
	09-Feb-14	1	14	41	27.5	118	2,190	211	44	73	0	127	11	8%
2	09-Feb-14	2	15	47	60	240	2,137	193	41	65	0	119	9	7%
	09-Feb-14	3	13	38	100	462	2,250	162	33	15	0	141	6	4%
	23-Feb-14	1	12	46	25	125	2,286	224	44	70	3	96	55	36%
3	23-Feb-14	2	15	44.5	30	120	2,407	247	47	98	2	88	59	40%
	23-Feb-14	3	12	37.5	45	225	1,842	147	36	18	0	104	25	19%
	8-Mar-14	1	15	37.5	60	240	1,998	168	38	23	0	46	99	68%
4	8-Mar-14	2	15	40	60	240	2,028	159	36	12	0	57	90	61%
	8-Mar-14	3	15	42.5	25	100	1,911	210	50	80	0	26	104	80%
	25-Mar-14	1	14	85	10	43	2,296	182	36	19	27	0	136	100%
5	25-Mar-14	2	15	80	15	60	2,041	180	40	37	30	0	113	100%
	25-Mar-14	3	15	90	15	60	1,841	171	42	39	25	0	107	100%
	Averages		15	50	39	162	2,111	189	41	49	6	78	56	43%

Table 2. Summary data for each 2014 sampling day. All shrimp counts and poundage are *Pandalus borealis*.

			Daily Averages											
Day	**Date**	**No. of Tows**	**Duration (minutes)**	**Depth (fathoms)**	**Estimated Pounds of Shrimp**	**Estimated Catch Rate (lbs/hr)**	**Sample wt (g)**	**No. of Shrimp in sample**	**Count per Lb**	**No. of Males in sample**	**No. of Trans & Fem I**	**No. of Ovigerous**	**No. of Fem II (non-ovig)**	**% Egg Hatch**
1	30-Jan-14	3	17	42	37	135	2,144	195	41	62	1	124	7	5.6%
2	09-Feb-14	3	14	42	63	273	2,192	189	39	51	0	129	9	6.4%
3	23-Feb-14	3	13	43	33	157	2,179	206	42	62	2	96	46	32%
4	8-Mar-14	3	15	40	48	193	1,979	179	41	38	0	43	98	70%
5	25-Mar-14	3	15	85	13	54	2,059	178	39	32	27	0	119	100%
	Averages	3	15	50	39	162	2,111	189	41	49	6	78	56	43%

Table 3. Day of the year that the hatch percentile was reached, estimated using all samples from Maine compared with samples from just the Pemaquid area, for 2010 – 2014. 2012 data are not shown because Pemaquid samples were not collected after February 15 (day 46).

	10% (Hatch initiation)		50% (Median hatch)		90% (Hatch completion)		Number of sampled trips		
Season	All Maine	Pemaquid	All Maine	Pemaquid	All Maine	Pemaquid	All Maine	Pemaquid	% Pemaquid
2010	19	14	48	57	77	99	219	36	16%
2011	13	5	48	57	84	109	242	56	23%
2013	13	22	43	44	73	67	99	45	45%
2014	-	41	-	58	-	76	-	5	100%

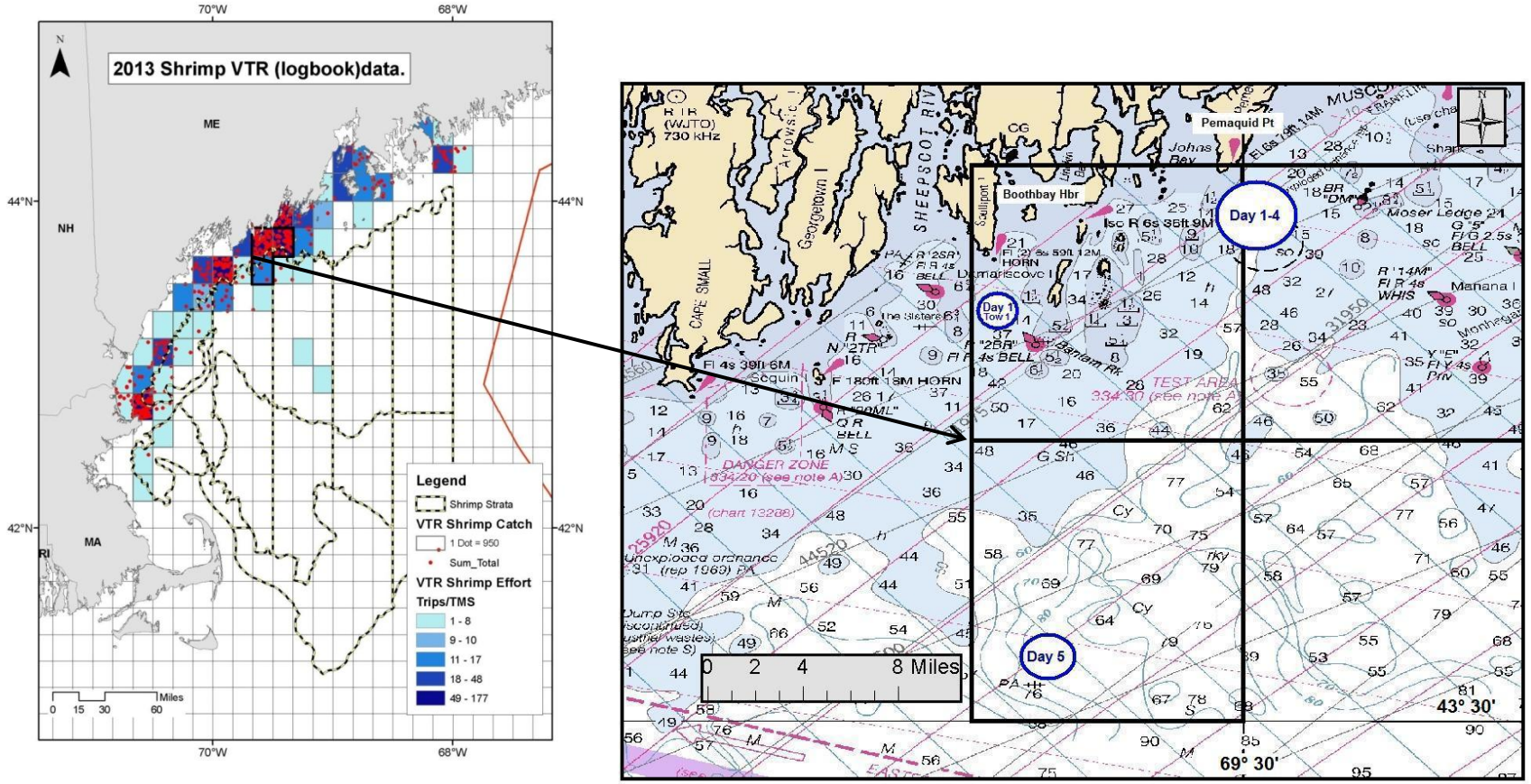


Figure 1. **Left:** Pounds caught and numbers of trips during the 2013 Gulf of Maine northern shrimp fishing season by 10-minute-square. Each red dot represents 950 lbs caught; locations of dots within squares are random and do not reflect the actual location of the catch. Number of trips is indicated by the blue palette for the squares. From preliminary state and federal harvester logbook (VTR) data, as displayed in Figure 7 in Whitmore *et al*, 2013. The three 10-minute squares that are bordered in heavy black indicate the Pemaquid Point region that was sampled in 2014.

Right: Locations of tows for the 2014 northern shrimp sample collection, by day.

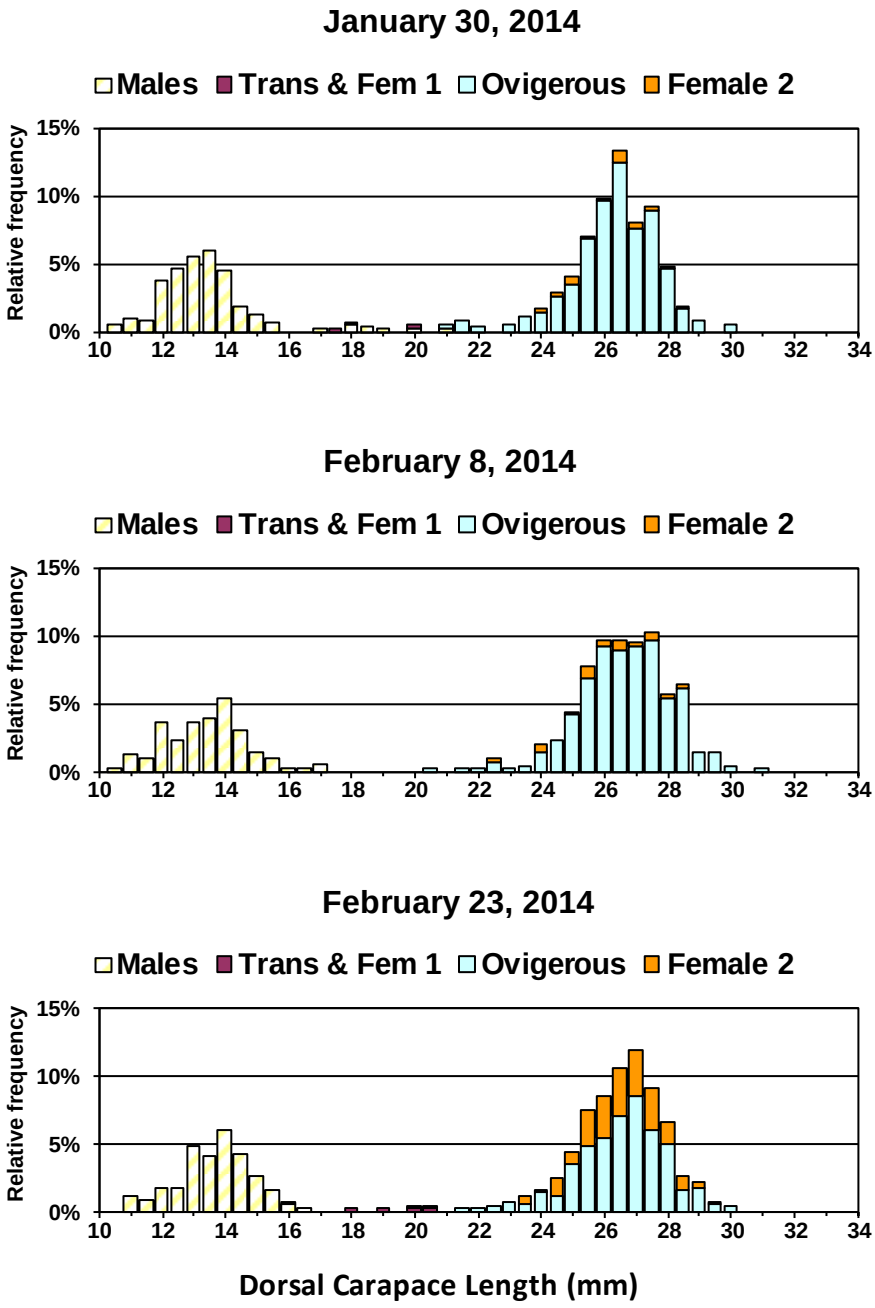


Figure 2. Northern shrimp size-sex-stage frequency distributions from 2014 samples.

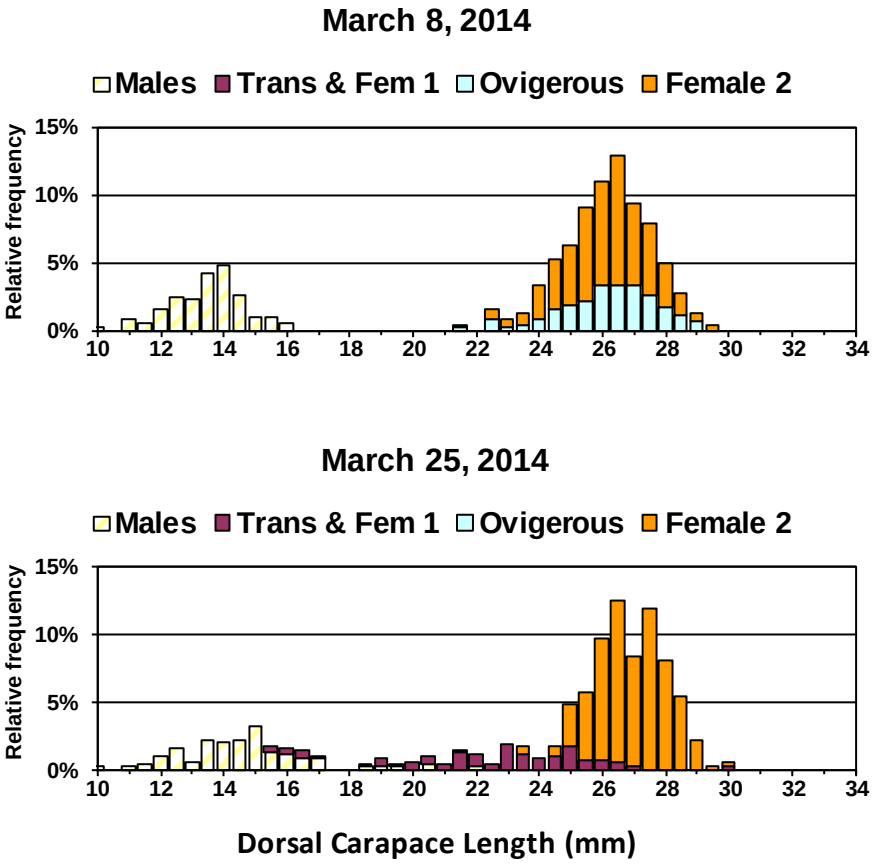


Figure 2 continued. Northern shrimp size-sex-stage frequency distributions from 2014 samples.

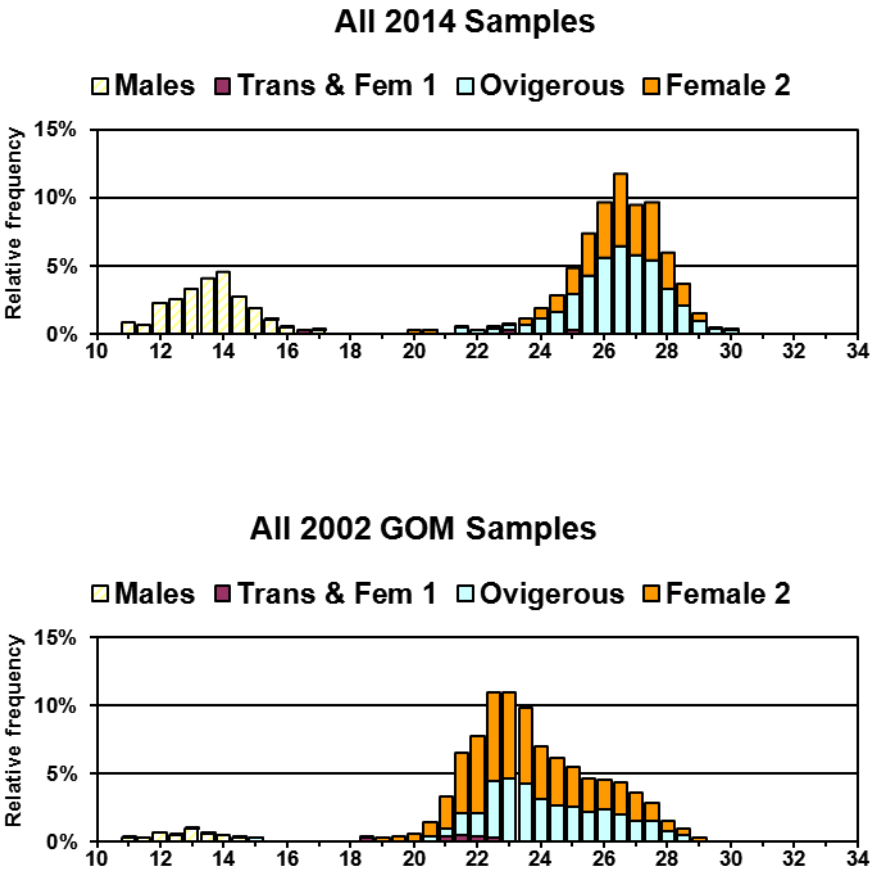


Figure 3. Comparing 2014 Pemaquid Point northern shrimp sample size-sex-stage frequency distributions (top) with 2002 Gulf of Maine fishery samples (bottom).

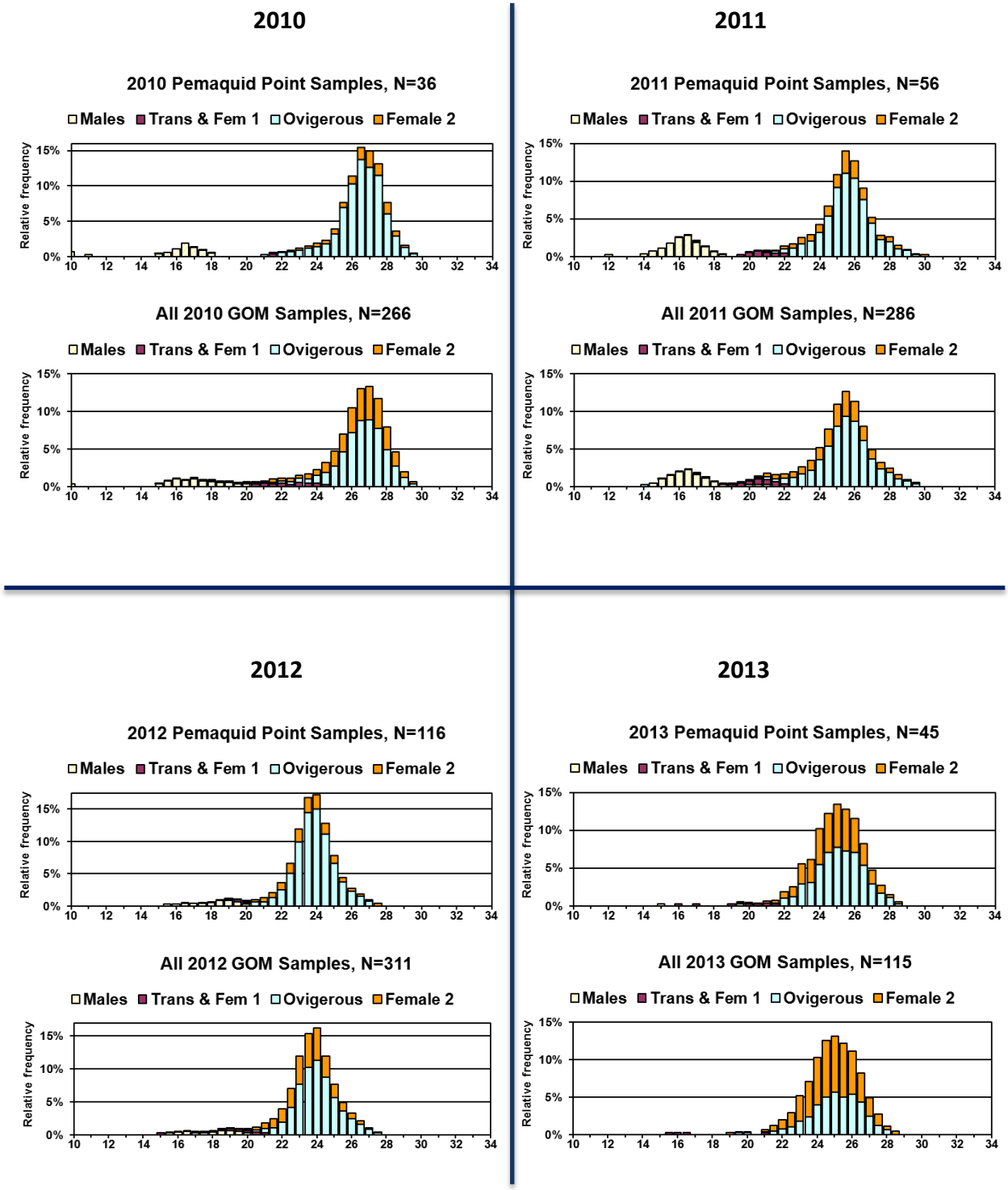


Figure 4. Comparing 2010–2013 Pemaquid area sample size-sex-stage frequency distributions with all 2010–2013 Gulf of Maine fishery samples.

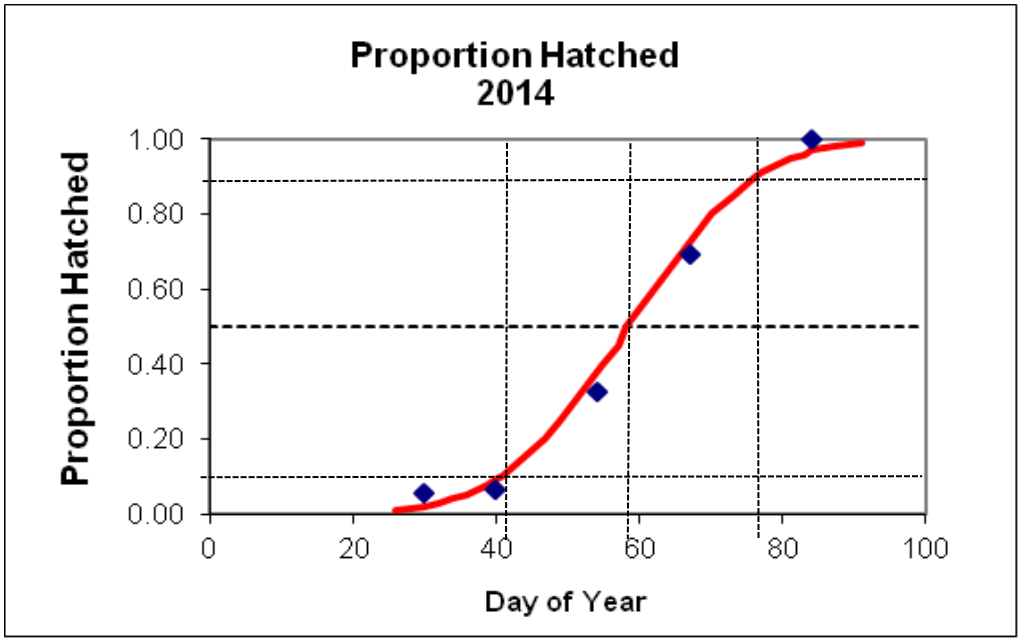


Figure 5. Observed mean proportion hatched by sampling day (diamonds) over time (Day of Year 1 = January 1) vs. fitted curve (line). Vertical dotted lines indicate estimated dates of 10%, 50%, and 90% egg hatch (initiation, median, and completion respectively).

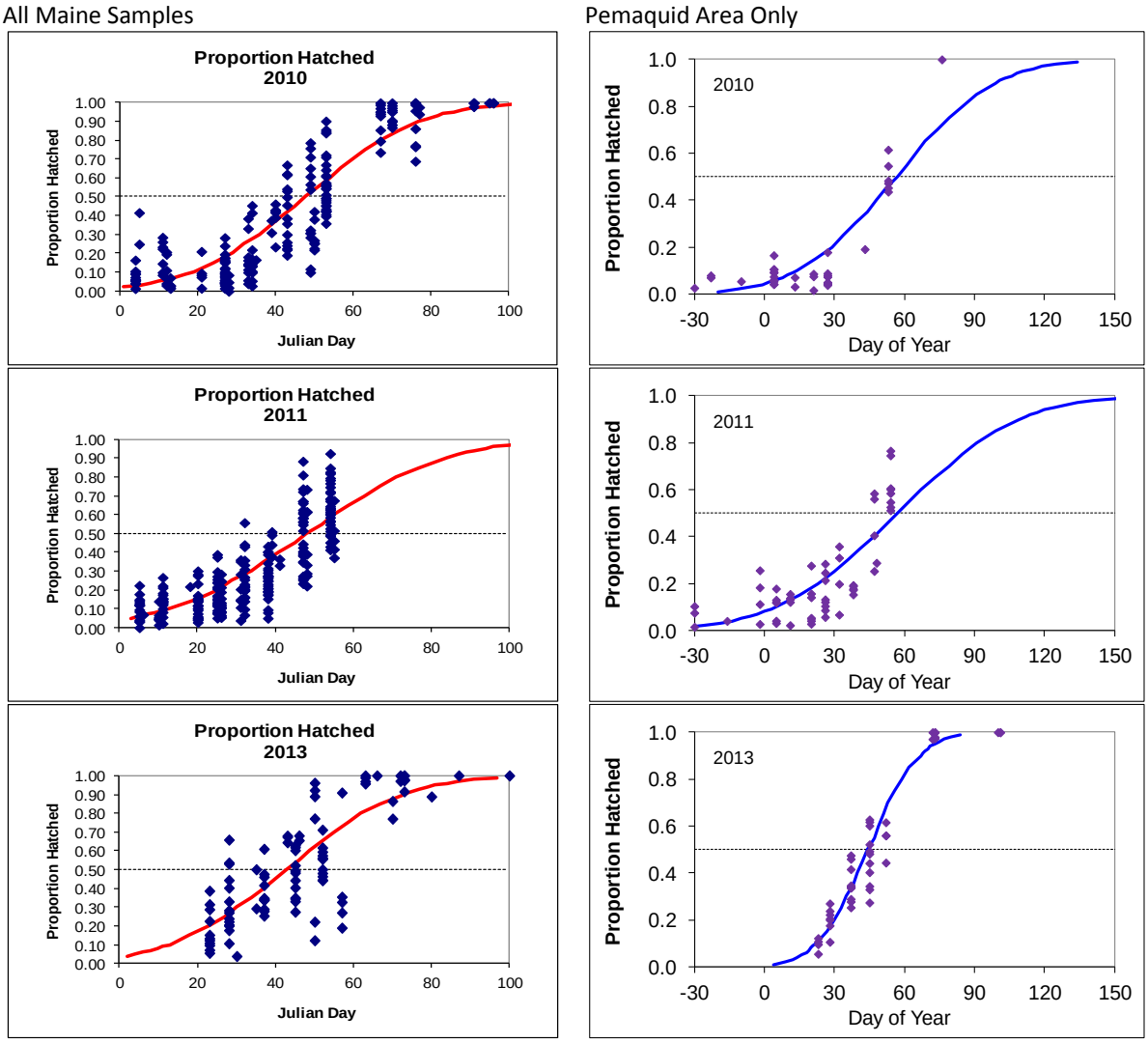
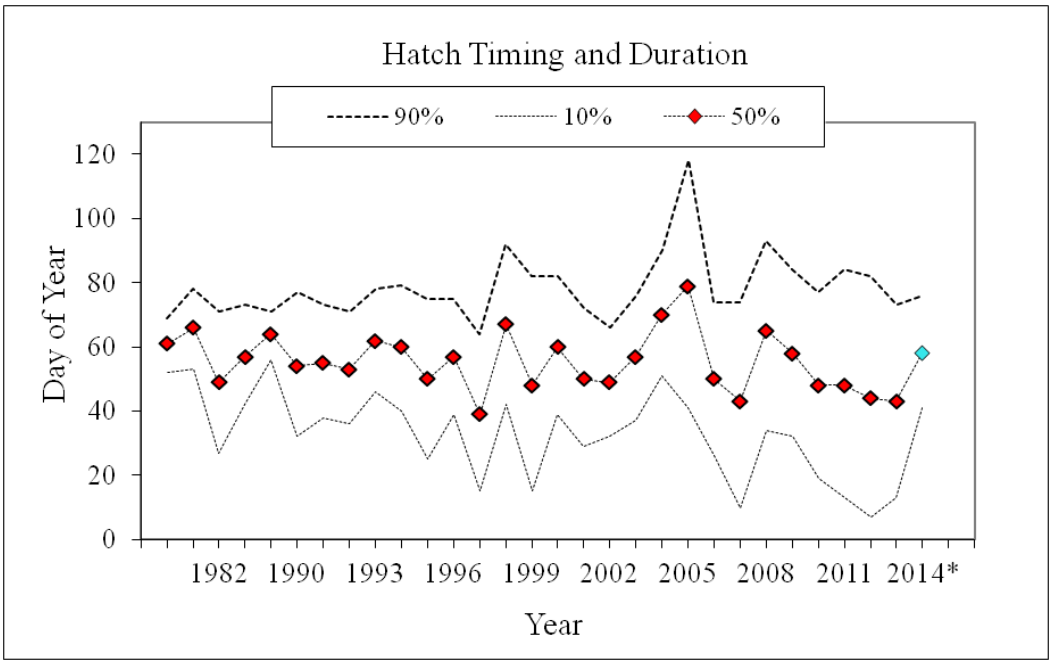
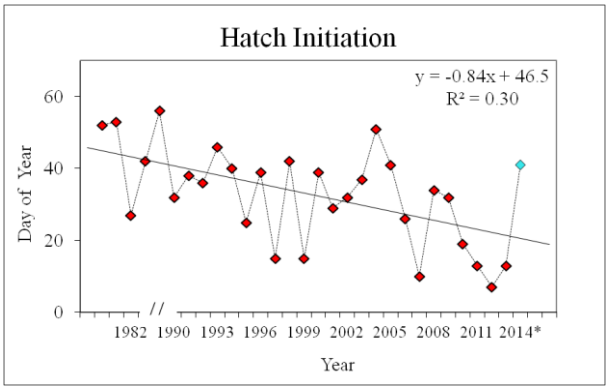


Figure 6. 2010–2013 proportion hatched by day of the year (Day of Year 1 = January 1) from all Maine commercial samples (left) and from just the Pemaquid area (right). 2012 is not shown because Pemaquid samples were not collected after February 15 (day 46).





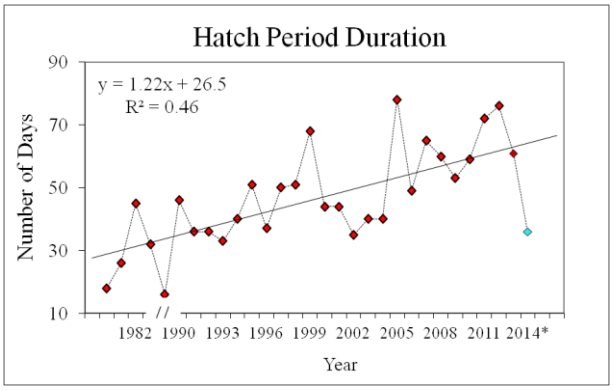


Figure 7. **Top**: Estimated hatch timing (10%=initiation, 50%=midpoint, 90%=completion), 1980–1983 and 1989–2014. Modified from Whitmore *et al* 2013, Figure 20E.
Bottom Left: Day of the year of hatch initiation. **Bottom Right**: Duration (number of days) of hatching period (difference between start and completion dates inclusive).
Modified from Richards 2012, Figure 5 A, D.