2006 Cooperative Research Award (07-072):
Development of a Juvenile Shrimp Trap for use in Establishing a Juvenile Abundance Index for the Gulf of Maine Northern Shrimp, *Pandalus borealis*.

Date of Submission:

Project Leader: Rebecca Jones
Gulf of Maine Research Institute/ University of Maine
350 Commercial St
Portland, Maine 04101
207-228-1687
Rebecca.j.jones@maine.edu
Abstract: A trap to target juvenile shrimp for use in obtaining a juvenile *Pandalus borealis* abundance index intended for management purposes was tested in the Gulf of Maine. There is a need for a more reliable juvenile (1/2 – 1 ½ year old, 4-18 mm) shrimp abundance index in the management process in order to set the season 2-3 years in advance. The Atlantic States Marine Fisheries Council annual summer shrimp survey sampling gear has a 50% capture rate of small shrimp. Our trap failed to attract juvenile Northern shrimp, however the net used to determine where the juvenile were located provided important spatial/temporal information on juveniles.

Introduction

The fishery landings for Northern shrimp in the Gulf of Maine are subject to drastic fluctuations. Variability in migratory behavior and recruitment success hinder the ability of the management panel to accurately predict the coming fishing year more than one season in advance. Setting fishing limits only a few months before a season does not allow the infrastructure of buyers and processors to become confident in the level of product they will produce, which is a hindrance in the establishment of a reliable fishery. For example, there have been several seasons for which the catch quota for the fishery was set high, but the landings were not worth any reasonable amount due to a lack of buyers and processors. A greater year time frame would allow the industry to strengthen the infrastructure and with the work that NAMA has started for increasing the public demand through awareness, a more reliable and profitable fishery could redevelop.

Annual trawl surveys conducted through ASMFC and NMFS sample the adult populations for acquiring the numbers needed in setting the fishing effort. However, juvenile shrimp (~1 ½ years age) are only 50% recruited to the survey gear and the survey does not sample depth strata shallower than 50 fathoms, making the surveys inadequate sources of data for the abundance of smaller juveniles, which undermines the accurate determination of a juvenile index (pers. comm. Daniel Schick; Shumway 1985; Clark 2000). This past season of 2005-6 was set for two years instead of one, an unprecedented event. During communications with Margaret Hunter of Maine Department of Marine Fisheries it was expressed that the setting of a season two years in advance was an unusual event but that the Technical Committee has been asked by the section chair to consider putting together a management plan that would allow doing that on a regular basis. A reliable juvenile index is necessary if this new management plan is to be effective.

In addition to developing a means to measure juvenile northern shrimp abundance, there is a need for understanding the early life history and juvenile migratory patterns. ME DMR and ASMFC identified the research priorities of Northern shrimp to include a focus on the life history patterns of juveniles i.e. the timing of their stage transitions and migrations, how those migrations are affected by oceanographic conditions, preferred bottom types, and how temperature and salinity affects growth to name a few. There is increasing evidence that a warming trend is occurring in the global environment. By not fully understanding the early life history of Northern shrimp, which are at the southern most extent of their habitat, we would be unable to detect changes that may occur from a warming trend and would be unprepared for potential negative impacts on the fishery (Apollonio 1986; Haynes 1969; Richards 1996; Wieland 2003).
Objective

The intent of this research was to develop the tool that would be used in assessing juvenile Northern shrimp abundances for the further development of a juvenile shrimp index. The tool we intended to develop was a modified lobster trap that would retain the juvenile shrimp from that year’s cohort and the second year shrimp that had not yet migrated offshore (4-18 mm). A juvenile index would be used by state managers in the setting of fishery limits of shrimp approximately a year in advance of the actual fishery opening date. Modified traps could be used by coastal lobster fishermen that were part of a program during the summer-fall, similar to the ME state juvenile lobster survey that is conducted each year. Furthermore, the modified traps would allow researchers to understand the “black box” that is the juvenile period of the *Pandalus borealis* life history and how the climate is affecting that important stage of the shrimp.

Participants

Kelo Pinkham, of Boothbay, was extremely valuable to the success of this project. He designed and built the beam trawls that were used by both regions. His knowledge of the beam trawl use helped the southern Maine fisherman, Brad Parady, become efficient in the use of the trawl. Kelo's knowledge of the shrimp population in the Boothbay/Pemaquid region also enabled the discovery of the juvenile shrimp distribution. Brad's knowledge of the bottom in the York/Kittery area allowed us to explore all the suitable and unsuitable habitats for the juvenile shrimp without losing the trawl. Brad's expertise is in lobster but his working knowledge of the area and his keen interest to learn made him valuable as well.

Methods (Planned and Executed)

Two regions were chosen to be sampled for Northern shrimp juveniles (Figure 1). Kittery and the Boothbay region were chosen due to their large shrimp fisheries. Also, a recent study by a UNH graduate student in the Kittery region had established a location of shrimp larvae which possibly would mean a local population of juveniles.

Our plan was to use the beam trawl (BT) catch as a representation of the shrimp abundance in an area of adequate shrimp abundance and then compare the traps catch after a 24 hour soak. To be confident of how representative the BT catch was for the area, seven replicate tows for each location was conducted. The correlation between the beam trawl and trap catches would be examined. Ideally, we wanted to be able to detect at least a 40% correlation between the BT and traps with a power of 80% so consequently the sample size would have to have been 35. Soak time would be 24 hours and the sampling effort was divided up between both participants. Kelo Pinkham would do 17 sets and Bradford Parady would do 17 sets, how many sets per day would be up to the discretion of the fisherman. The sampling period was to be between the months of April-August, which is when the young of the year shrimp are settling from the water column.

Both regions were surveyed with identical BT’s that were built by Kelo Pinkham who had built several in the past for ME DMR. The trawl nets were lined with approximately a 1cm x 1cm woven mesh liner. This liner did not allow juvenile shrimp to escape. A Nordmore grate was not used because of the need to retain all of the species (finfish and crustacean) in the area in order to assess the potential predators of the shrimp population. The trawl catch was processed immediately and any bycatch was thrown back after measurement for a high rate of survival. The trawl net was towable by a
pot haulers, which was how Brad Parady used the net. However, Kelp Pinkham’s boat F/V Bad Penny was outfitted with a gantry which is what he used. Tows were standardized to within 15 minutes and on average swept an area of 0.5 mile. Bottom types were not standardized with the exception of having to avoid rocky outcrops and boulder bottom due to the nature of the net used. Once an area where the catch of juvenile pink shrimp was above 30 individuals, a set of three trap trawls were deployed in the middle of the beam trawl swept area to fish for 24 hours.

The same trap design from the previous Project Development Grant for shrimp traps were used. To review, they were standard lobster traps lined with a 1cm mesh and outfitted with a “V” shaped, wire covered vent at the top. No side vents were left open. The wire-covered vent opening was used because of the greater predator/by-catch exclusion results that we saw in comparison with the standard wide vent and the narrow vent styles from the previous study. However, we reserved the right to modify the traps to achieve greater sampling efficiency as the need arouse within the sampling scheme. Kelo did try altering some of the traps by placing the vent on the side, in an effort to increase the traps catch rate. Traps were baited with a mixture of menhaden and herring. Bait bags were hung snugly to the side of the vent on the top of the trap. The bait used worked well in the Seacoast region and was also recommended by traditional shrimp fishermen in the Midcoast region.

The catch for both sampling regions were treated the same. All by-catch was separated by species, weighed, counted and then discarded. Species classified as “by-catch” consisted of fish and decapods, such as crabs and other non Pandalus borealis shrimp species such as Pandalus montagui and Dichelopandalus leptocerus. The P. borealis catch was randomly sub-sampled where applicable in a 0.5 kg sub-sample instead of the intended 1kg. That amount proved to yield sufficient shrimp numbers for an adequate length frequency histogram. Carapace lengths of shrimp < 18mm were measured in the sub-samples. Samples from Boothbay were intended to be measured by an observer from AIS, however it was more adequate to have the student that was hired through University of New Hampshire to conduct the shrimp staging and carapace measurements with the Principal Investigator.

How the shrimp behave around the trap and if predators lurk around the trap were to be demonstrated with camera work. Win Watson of UNH was allowing us to use his Lobster Trap Video system for filming in the shallower locations. We planned on setting the camera for 24 hours on several occasions with a red light for illumination to focus on the top of the trap where the vent is located. It was to be best to get both night and day hours to determine if there was a difference in the shrimp behavior toward the trap since adult shrimp are known to rise up off the bottom during night hours and settle on the bottom during daylight hours (Shumway 1985). Videos were to be analyzed for presence or absence of predators, amount of time that predators loitered around the traps influencing any shrimp entrants and any entering or exiting of the trap by shrimp species. There is a low probability that shrimp would be visible in enough detail to identify them, so all species will have to be pooled together as Pandalidae. Unfortunately, none of that planned research occurred due to the shrimp populations being located in much deeper low light level areas that a camera could be adequately used.

One last variable we intended to explore was the saturation limit of the traps. At what point have enough shrimp entered the trap that the catch rate starts to decline or plateau? To test this we were to set and haul a trap on 24 hour incremental soaks repeatedly until we hit a saturation point. The trap catch would be weighed in its entirety and then all shrimp will be pooled and sub-sampled for
identification, counting and measuring. This test was to be conducted a few times per region involved. However, this step was never done due to no catches in the shrimp traps, as will be discussed in the following sections.

We intended work in both regions to be complete by the end of the 2007 season. However, the work in Boothbay was the only region that completed its work. After various issues and set backs in Kittery, the work was postponed until 2008. Kelo Pinkham was able to conduct 109 Beam trawl tows and 53 trap sets. Bradford Parady completed 85 Beam trawl tows and 70 trap sets. Kittery sampling was completed by September 2008.

Data Collected Schematic:

<table>
<thead>
<tr>
<th>Beam Trawl Data</th>
<th>Trap Data</th>
<th>Beam Trawl Sub-sample</th>
<th>Trap Sub-sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude/ Longitude</td>
<td>Tow duration</td>
<td>Distance covered</td>
<td>Species</td>
</tr>
<tr>
<td>Distance Swept</td>
<td>Species</td>
<td>Weight of catch (kg)</td>
<td>Length of By-catch Species (in)</td>
</tr>
<tr>
<td>Shrimp ID</td>
<td>Time Soak</td>
<td>Total Weight (kg)</td>
<td>Lat/Long</td>
</tr>
<tr>
<td>Carapace Length (mm)</td>
<td>By-Catch Weight</td>
<td>By-Catch Length</td>
<td>Shrimp ID</td>
</tr>
<tr>
<td>By-Catch Species</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results and Conclusions:

Beam trawls were very efficient in locating juvenile *Pandalus borealis* within the coastal environment. The trawls sampled a total of 2,688.65 kg of shrimp species (Table 1). Shrimp species found in both regions were *Pandalus borealis*, *Dichelopandalus leptocerus*, *Pandalus montagui*, *Lebbeus polaris*, *Eualus fabricii*, *Lebbeus groenlandicus*, and *Lebbeus microcerus*. Bycatch from the beam trawls consisted of the dominant species (>4% contribution) American plaice, lobster, rock crab, monkfish, silver hake and wrymouth (Table 2).

Large numbers of juvenile shrimp of two year classes, 4-18+ mm carapace length (CL), were well represented in the catches (Figure 2). CL was taken only from the Beam trawl sub-samples with 18mm as the cut off due to that being the size range of the juvenile stage. Shrimp larger than that have transitioned to the male phase of their life history (Shumway 1985) (Figure 3). This transitional size was confirmed by the PI when examining the samples. There appeared to be no selectivity of the beam trawl between the to size classes (<18>mm) (Figure 4). Two size classes are evident when examining
the CL distribution. The first size class of 4-8 mm are the young of the year.

Larvae hatched from eggs released by females in the coastal region, spend approximately 4 months in the water column after which they settle to the bottom as juveniles. Juveniles are thought to stay in the coastal region through their second year (Shumway 1985). Second year shrimp which are in the size range of 8 to ~18mm, are indeed in the region throughout the summer (Figure 5). Once shrimp metamorphose to males at approximately 18mm, it is thought they begin their migration offshore. If the traps had worked, we had hopes of conclusively showing this metamorphosis and offshore migration by placing traps into the Jefferys Ledge region and sampling throughout the year. However, with the beam trawl we were able to get a very interesting snapshot of the coastal juvenile populations. With the advent of climate change potentially increasing the coastal waters temperature, that has severe implications for the shrimp fishery. Warmer water would lead to smaller shrimp which would lead to less fecundity in the breeding females (Apollonio 1986). Much of the data for the life history of Northern shrimp in the Gulf of Maine is at least 20 years old. There is a great need to update that data with what is occurring now, if not for fisheries management than for the advancement of the understanding of this interesting species. How does the temperature/climate variability affect metamorphosis? How has the current temperature regime effects compare to the data from the ’80’s?

Bottom type for each trawl was recorded. The most catch was found to be on mud to mud mix bottom (Figure 6). The increased bycatch weight on the mud/ bottom type was due to monkfish. East of the Isles of Shoals, mud/ bottom type, was found to have an increased number of juvenile and adult monkfish. Haynes and Wigley 1969, found that shrimp of all stages are mainly benthic detritus feeders. The smaller size classes appeared to be more rare on the gravel bottom. All the other bottom types had both size classes present. Average size per bottom type was approximately 15mm (Figure 7).

Despite the positive performance of the modified traps during a Project Development Grant that was completed before this full award, those same traps consistently failed to attract juvenile Northern shrimp (Table 3). “Shrimp” catch in the traps consistently were Dichelopandalus and Pandalus montagui and other species from the Hippolytidae family. Bycatch consisted of cunner, juvenile redfish, hagfish and small lobster.

The original design was with the vent on the top only. However, traps with side vent style did not yield any Pandalus borealis juveniles either. Since the region was too deep for using the video camera, it is unclear as to why other species entered the trap but not Pandalus borealis. This result does not compare well with an experimental pot created for research in Alaska (McBride 1967). They designed a 4 tunnel-style entrance, round pot that consistently caught shrimp in the CL size ranges of 6.0-27.5 (mm) in numbers over 100. Unfortunatley, this trap design was not found until after the field work was over. The mesh of the McBride traps was of a 1/2cm oval mesh, a little larger which possibly allows the bait odor plume to distribute. It is possible that the liner used in our traps was too small (1-2mm) to allow adequate water flow which would allow distribution of the bait odor plume.

Another possibility was that the shrimp were primarily feeding on benthic detritus and were not attracted to the bait used as the other species were. This however is unlikely since large number of shrimp were sampled in the baited traps designed by McBride and Barr 1967). Since we adjusted the vents to a side location on some of the trawls we eliminated the possibility that they would not crawl to
the top of a trap. Also since other shrimp species were entering the trap it is unlikely that a predator was preying on the shrimp as they entered the trap.

**Future Research:**

There is a great void of current research into the life history of Northern shrimp in the Gulf of Maine. Either more effort to develop a survey tool be allocated into the continuation of the shrimp trap design (using McBride’s design) or use of the beam trawl to follow a population of Northern shrimp throughout a year. Management has allowed year around fishing due to the strength of the current population. This allows the infrastructure of processing plants and a market interest to develop. Therefore, there is less of an immediate need to research shrimp in the light of aiding management in the regulation of this fishery. The emphasis of research should shift to the updating of life history data and how the life history is affected by climate change.

**Participants:**

**Kelo Pinkham**  
167 West Side Rd.  
Trevett, ME 04571  
Phone: (207) 633-6315

**Bradford Parady**  
F/V Angela and Ashley  
12 Chauncey Creek Rd  
Kittery Point ME 03905  
Phone: (207) 337-3141 or (207) 439-6708

**Impacts and applications:**

The original audience for this project was the ASMFC Technical Committee. The committee was interested in acquiring a tool to help in the juvenile assessment for the purpose of improving the committee’s forecasting power of the fishery. However, the traps did not function as planned. Further improvements of the design such as different mesh liner, could be tested but it is unknown if that would help their performance. The beam trawl worked exceptionally well in sampling the population. It is not known if the Technical Committee would find the beam trawl a useful tool to employ for juvenile assessments since there is potential gear conflict with the lobster and fishermen. Traps were more lucrative because they would not create any conflicts and local fishermen trained in the sampling could tend them. Also the traps could be used in areas of the Maine coast that are impossible to drag a net through. Without further development of the current design of the traps, there is no application.

**Partnerships:**

If it were not for the fishermen, this project would not have been possible to execute.

**Data:**

Data has not been submitted yet to the database but will be by the end of October 2010.
**Pictures:**
Kelo Pinkham’s Beam Trawl, Brad Parady and Kelo Pinkham working on the trawl for use on Brad’s boat.
Shrimp Traps: Narrow and wide vent styles, work with Brad Parady setting.
Working with Brad Parady, the smallest Northern shrimp sampled by bean trawl, various trap scenes
Bibliography:


Table 1: Summary of bycatch, shrimp and subsample weights for all of the Beam trawls completed in both regions.

<table>
<thead>
<tr>
<th></th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Bycatch (kg)</td>
<td>1535.65</td>
</tr>
<tr>
<td>Total shrimp (kg)</td>
<td>2688.65</td>
</tr>
<tr>
<td>Subsample (kg)</td>
<td>409.09</td>
</tr>
</tbody>
</table>

Table 2: Table of bycatch caught with the beam trawl from both regions, Kittery and Boothbay.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number</th>
<th>% of Total Specie Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Plaice</td>
<td>127</td>
<td>34.37%</td>
</tr>
<tr>
<td>Lobster</td>
<td>59</td>
<td>17.17%</td>
</tr>
<tr>
<td>Rock Crab</td>
<td>62</td>
<td>12.30%</td>
</tr>
<tr>
<td>Monkfish</td>
<td>35</td>
<td>6.06%</td>
</tr>
<tr>
<td>Silver Hake</td>
<td>71</td>
<td>4.55%</td>
</tr>
<tr>
<td>Wrymouth</td>
<td>61</td>
<td>4.15%</td>
</tr>
<tr>
<td>OTHER (&lt;4%)</td>
<td>290</td>
<td>21.41%</td>
</tr>
</tbody>
</table>

Table 3: Total catch for bycatch, shrimp and subsample for the traps.

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Bycatch (kg)</th>
<th>Total shrimp (kg)</th>
<th>Subsample (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sum</td>
<td>Sum</td>
<td>Sum</td>
</tr>
<tr>
<td>Boothbay</td>
<td>23.15</td>
<td>12.6</td>
<td>5.7</td>
</tr>
<tr>
<td>Kittery</td>
<td>8.49</td>
<td>5.37</td>
<td>7.3</td>
</tr>
</tbody>
</table>
Figure 1: Map of the two regions sampled. Red dots indicate trap set locations and blue dots indicate beam trawls.

Figure 2: Histogram showing all of the P. Borealis carapace length data from all of the subsamples from th Beam trawl catches.
Figure 3: A diagram showing the typical life history of Northern shrimp in the Gulf of Maine. (Reproduced from Shumway 1985)
Figure 4: Total number of shrimp per size class sampled with the beam trawl by date.
Figure 5: Size distribution (CL mm) of shrimp from the Beam trawl subsamples over the months of sampling.

Figure 6: Total average catch of shrimp and bycatch by bottom type sampled from both regions.
Figure 7: Average carapace length distribution of *P. Borealis* sampled with the beam trawl over the different bottom types from both regions.