**Final Report on the Benthic Survey**

**of the Upper Mill River**

**After Mill Pond Restoration**

**Gloucester, MA**

Final Report

June 2, 2011

Salem Sound
COASTWATCH

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# Acknowledgements

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Christian Krahfrost, staff scientist at the Massachusetts Bays National Estuary Program (MBP), was invaluable in assisting with the development of the sampling plan with randomly generated transects in 2008 and 2009.

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Lastly but critically important to the project were Lois and William Bairstow who gave us access to the study area through their property and provided water for cleaning the samples.

Thank you all,
Barbara Warren

[1] Funding came from the Massachusetts Wetlands Restoration Program, which In July 2009 became part of the Division of Ecological Restoration in the MA Department of Fish and Game.

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## *Introduction*

A benthic survey of large (> 5 mm) infauna was conducted in the upper Mill River, Gloucester, MA in the fall of 2008, 2009 and 2010 in order to provide a benchmark for monitoring restoration management efforts at a tidally restricted wetland habitat. The upper portion of the Mill River had been "ponded" since 1677. The current tide gate was installed in 1989 during the re-construction of Washington Street. Mill Pond existed as a brackish impoundment until the Mill River tide gate was opened in April 2004, restoring partial tidal flow to Mill Pond. The goal of this study was to document ecological changes in the upper Mill River by monitoring the benthic community structure of the intertidal flats, focusing particularly on the establishment of *Mya arenaria* (soft-shell clams).

Salem Sound Coastwatch (SSCW) received funding in 2008 from the Office of Coastal Zone Management's Wetlands Restoration Program[2] to conduct a benchmark *M. arenaria* survey in the upper Mill River. The Corporate Wetlands Restoration Program with a Bruce J. Anderson Foundation grant contributed funds for all three years of the study.

The 2008 benthic survey report is available on the Salem Sound Coastwatch website.[3] After reviewing the results from the first year, changes were made to the benthic survey methods used in 2009 and 2010. This report will explain the alterations in data collection methods and present the results for all three years. Slight changes in methods allowed for an increase in collected samples from n=68 to n=72, while reducing the sampling effort by half, resulting in sampling being completed in one and a half days with 18 people, compared to the 2008 effort of three days and 21 volunteers.

## *Site Background*

The Mill River follows in a northerly direction into the Annisquam River, which flows into the Ipswich Bay. A tide gate at Washington Street (Route 127) created a severe tidal restriction, impounding the Mill River. The resulting Mill Pond wetland system was fresh water dominated, had extensive stands of *Phragmites australis*, obstructed ditches, and accumulation of fine sediment extending north from Washington Street to Dr. Osman Babson Road, which crosses the upper Mill River further upstream. Downstream of the Washington Street Bridge, the Mill and Annisquam Rivers are open to shellfish harvesting.

Beginning in April 2004, the Washington Street tide gate was left in an open position to restore partial tidal flow to approximately 24 acres and improve ecological conditions within the upper Mill River. The Louis Berger Group, Inc. (Berger)[4] conducted initial restoration design services for Division of Ecological Restoration, which included a bathymetric survey of Mill Pond. It was determined that modifications could be made to the existing openings and not affect the structural integrity of the existing bridge. The installation of the additional tidegate was delayed. Therefore, all three years of data collection were under the one tidegate restriction and current tide gate operation plan. Increased salinity and added tidal flushing to upstream marsh habitat from another tidegate should benefit more marine ecological functions.

The proposed tide gate operation plan requires the City of Gloucester to regulate the flow of water and water storage in the upper Mill River during major rainfall events by adjusting the gates. Under normal operating conditions, the gates will be suspended in an open position, but an adaptive management strategy will be undertaken with the gates opened or closed as needed to balance the benefits of

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[2] Funding came from the Massachusetts Wetlands Restoration Program, which In July 2009 became part of the Division of Ecological Restoration in the MA Department of Fish and Game.
[3] http://www.salemsound.org/UpperMill RiverBenthicSurveyReport08.pdf
[4] The Louis Berger Group, Inc., Wetland Restoration Technical Services Mill Pond Restoration – Gloucester Initial Restoration Design Services Final Report. July 13, 2007

increased tidal flow with the potential flooding to abutting properties. Further recommendations include additional monitoring of the tidal prism and changes to habitat conditions (e.g., fringing marsh vegetation, porewater salinity, fish and shellfish surveys) in order to document the effects of the increased tidal flow. To this effect, Salem Sound Coastwatch undertook this benthic shellfish and worm survey in the fall of 2008, 2009 and 2010. Under another contract from DER, SSCW is monitoring vegetation and pore water salinity in the marsh in 2010 and 2011.

## *Methods*

### Study Site

In 2008, members of the Mill Pond Advisory Group[5] (MPAG) walked the site to determine the accessibility of the mudflat and evaluate other logistical issues. Based on site reconnaissance and GIS orthophotos, the site was categorized and delineated into four areas[6] (Figures 1 and 2).

"Lower" – area closest to Washington Street
"Middle" – south of the Spartina marsh
"Upper" – northeast of Dr. Osman Babson Road
"Inaccessible Resource"

The Lower, Middle and Upper regions were stratified based on hydrodynamics – the distance from the tide gate. Salinity levels near Washington Street were in the 30 ppt range, while levels in the Upper region near the Dr. Osman Babson Road were around 20 ppt or lower.

Because of accessibility issues, the MPAG concluded that the sampling effort should concentrate on the southwestern portion of mudflats. The rest of the intertidal area was determined to be an "inaccessible resource" and was not sampled due to limited vehicular and foot access to the flat's northeast side as well as the lack of a water source for cleaning samples.

A homogenous substrate within the Lower, Middle and Upper polygons was assumed, and no further stratification for sampling was undertaken. The "inaccessible resource polygon" has an area of 45453.9 meter$^2$ and a perimeter of 2056.5 meters. Therefore, seventy-five percent (74.9%) of the intertidal mudflat (historic Mill Pond) was not sampled. Characteristics of the three sampling areas are listed in Table 1. Figures 1 and 2 show the area sampled in 2008 and the location of inaccessible polygons.

In 2009 and 2010, no sampling took place in the Upper polygon (#3) based on the 2008 results and an evaluation by the MPAG of the effort required and value-added from sampling in the upper region. Eliminating this section allowed for more focused monitoring in the Lower and Middle polygons (#1 & #2).

[5] Appendix 1 for MPAG members and affiliation
[6] Areal resources assessment type (Stevens and Olsen, 2004)


**Figure 1**. Three 2008 sampled polygons for the Upper Mill River mudflat benthic survey.
1= Lower, 2= Middle, and 3=Upper

**Table 1.**: Dimensions of the three polygons sampled in 2008 at the Upper Mill River mudflat

| 1. "Lower" | 2. "Middle" | 3. "Upper" |
|---|---|---|
| Area: 6677 $m^2$ | Area: 8260 $m^2$ | Area: 327 $m^2$ |
| Perimeter: 579 m | Perimeter: 545 m | Perimeter: 105 m |
| 65 squares | 79 squares | 7 squares |


**Figure 2**. Upper Mill River Mudflat "Inaccessible Resource" in light yellow

## Sampling Methods

In 2009, the number of randomly selected transects based on area resulted in eighteen (18) transects rather than the thirteen (13) transects in 2008. Figure 3 are maps of transects; transect coordinates for available in Appendices for each year. Because of the more focused monitoring in 2009 and 2010, one more transect was added to the lower section for a total of eight, and four more transects were added in the middle region for a total of ten. One of the requirements for the randomly selected transects was the area had not been sampled in previous years because the sampling process removed mud and all organisms. Live organisms were returned to the mudflat but not to the original collection site.

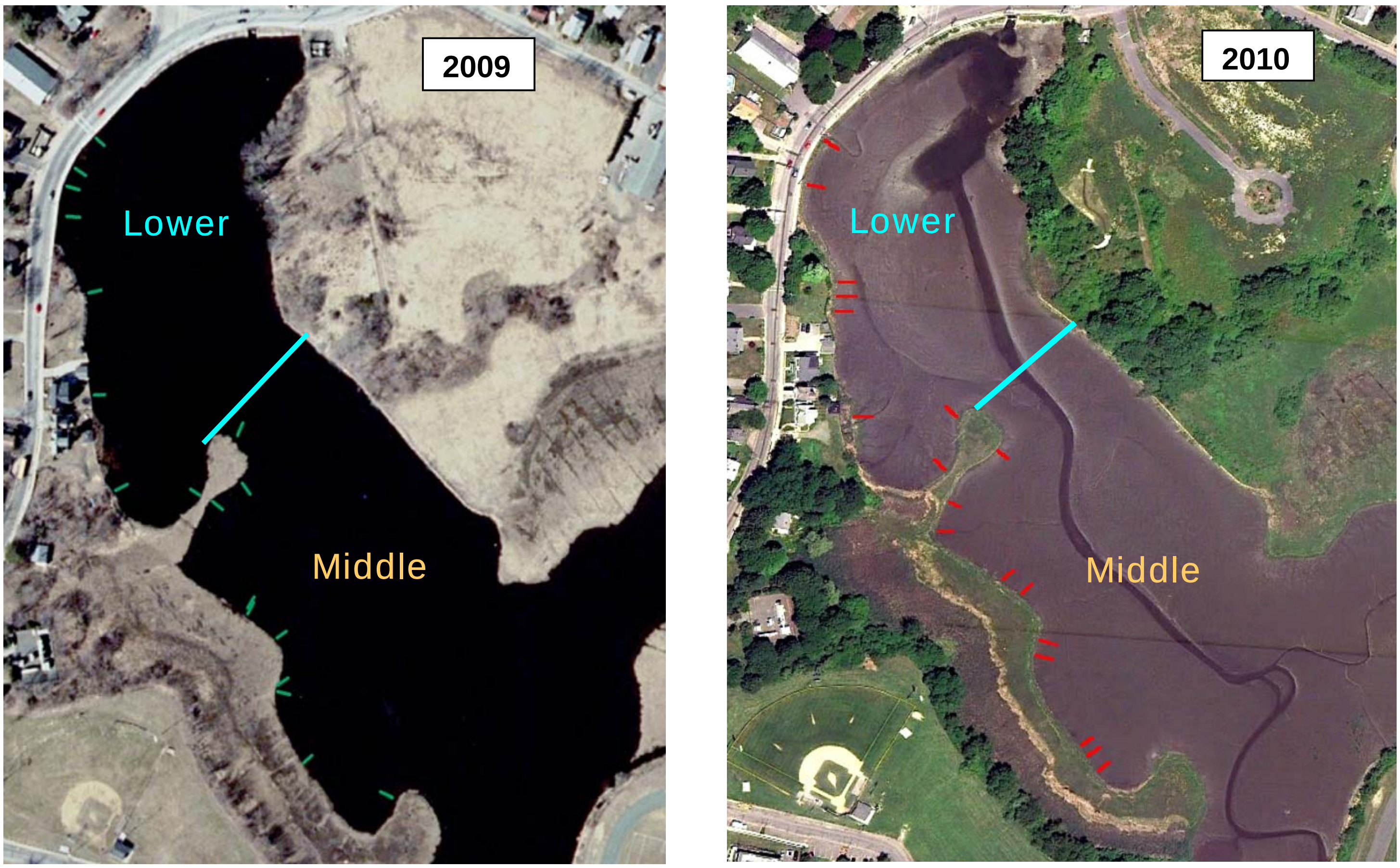


**Figure 3**. Upper Mill River random transects sampled with 2009 and 2010.

The method for generating transect locations was the same for all three years. Transects were selected for each polygon (using the grid produced from the pattern provided with ArcView 9.1) and assigning sequential numbers to the squares along the perimeter of each polygon. A random sequential number generator was used to select each shoreline square and transects were then drawn perpendicular to the shore out to the outer edge of the delineated accessible polygon. Shoreline perpendicular transects have been used in *M. arenaria* surveys by Mathiessen (MADMF, no date) and others (e.g., Sullivan, 2007).

Transects were staked using a GPS before the sampling began. Wooden posts were placed at the estimated mean high water. The position of each post was recorded using WAAS-enabled GPS, and the compass bearing perpendicular to the shoreline was recorded. Posts were removed at the end of sampling.

The number and location of stations along transects were changed for the 2009 survey. Sampling methods were identical in 2010. An additional layer of stratification was employed based on the 2008 results since in 2008 soft-shell clams were found only at one-meter stations. To increase the probability of collecting enough *M. arenaria* to facilitate statistical analyses (sample size N>20), it was decided to focus future sampling efforts to the nearshore region (1-7 meters from the shore line). This was the major difference in methods from 2008 when samples were collected one meter from the post and then every 5-meters until the inaccessible area was encountered which resulted in 2 to 11 samples with transect lengths varying from 5 to 50 meters (see Appendix 7). With these method changes, four samples were collected from each transect and all transects were seven meters in length. Two samples were randomly selected from meters 1, 2, 3, or 4 along transect (i.e., the inner stations) and two randomly selected from meters 5, 6, or 7 (the outer stations). This resulted in 72 samples being collected in 2009 and again in 2010 compared to 68 in 2008.

At each station, a 25.4 cm x 25.4 cm x 25.4 cm deep sample (0.016 $m^3$) was dug with a square shovel and placed in a 20 L bucket. ID tags were placed on top of each bucket to label transect number and meters from the post (e.g. 12-4: Transect #12, Station 4 m). Buckets were relayed to the processing station where the contents were sieved through a 5 mm hardware cloth screen. All living animals were placed in a container with sample's ID tag. The number and type of organisms retained on the screen were tallied and recorded on a data sheet and a photograph was taken of each sample. For *M. arenaria* and *Macoma balthica* (duck clam), shell length was measured to the nearest millimeter using a ruler. All organisms were returned to the mudflat at the end of each sampling day.

The benthic survey took place on two days; times are listed in Appendix 3. The flat-bottom canoe was used to collect all samples. The use of the boat provided added stability and afforded safer access to the mudflat.

Eric Hutchins, Christian Krahfrost and Ryan DuBois in 2009 removing sample buckets from the boat.

## Data Analysis

In 2008, 68 samples were collected and processed over three day. Seventy-two samples were collected and processed over one and a half days in both 2009 and 2010. Table 2 shows that the targeted sampling areas and sampling effort for the last two years conformed well to the original design. Data from field sheets were entered into an Excel spreadsheet the following day after collection. The data spreadsheets for all three years are in the Appendices 5, 6, 7. Analysis of Variance, Tukey HSD and Kruskal-Wallis tests were run to determine significance where appropriate.

**Table 2.** Number of sampled sites, percentage of area targeted, and actual percentage of area sampled in 2009 and 2010.

| **Sampling Areas (Polygons)** | **Target Sampling Design** | **Number of Samples** | **Completed Sampling** |
|---|---|---|---|
| Lower | 45% | 32 | 44% |
| Middle | 55% | 40 | 56% |
| **Total:** | 100% | 72 | 100% |

In 2009, the density of *M. arenaria* was estimated in the various stratified areas of the upper Mill River as provided in Table 3 to evaluate the stratification of the transect design. No discernable difference was found in the density of *M. arenaria* between the inner stations (1- 4 meter transect locations) and the outer stations (5 – 7 meter transect locations) and thus was an unnecessary level of stratification in the sampling design. Further, no *M. arenaria* were collected in the middle region of the study area. However, it was decided to retain the sampling design in 2010 in order to have two years of data obtained by the same sampling protocol.

**Table 3.** Estimated number of *M. arenaria* within the sampled regions of the upper Mill River, 2009. Values in parentheses represent the standard error of the means.

| ocation | Inner Samples | Outer Samples | *M. arenaria* Density$_{Inner}$ ($m^2$) | *M. arenaria* Density$_{Outer}$ ($m^2$) | Total Area ($m^2$) * | Lower Estimate | Mean | Upper Estimate |
|---|---|---|---|---|---|---|---|---|
| Lower | 14 | 15 | 0.056 (±0.030) | 0.060 (± 0.045) | 2789 | 56 | 162 | 268 |
| * Actual area samples | | | | | | | | |

# Results

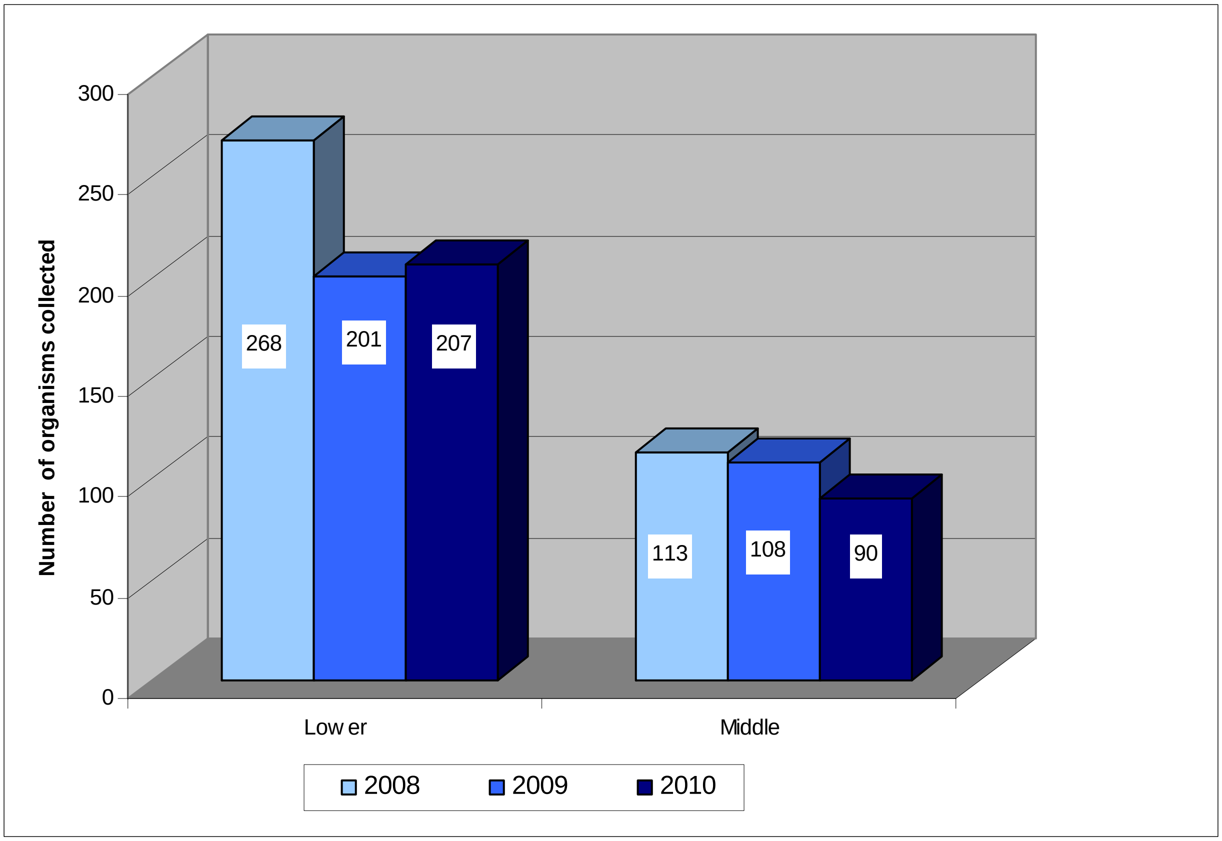


**Figure 4.** The total number of infauna organisms (>5mm) collected from the Lower and Middle study areas of the Upper Mill River, Gloucester, MA, for each of the three years of the benthic survey.

## 1. Species Abundance and Richness.

An analysis of differences in species (counting how many individuals of each species were recorded) across the three years showed no significant difference in the total number of individual organisms (>5 mm) collected in the three survey years (Totals: 2008=381, 2009=309, 2010=297). The Kruskal-Wallis[7] test results for differences in species diversity across the three years were not statistically significant (Table 4), whether the sampled areas were looked at as a whole or separated into the Lower and Middle areas, indicating that there was no statistical difference between the years.

**Table 4.** Results from Kruskal-Wallis Test

| | | |
|---|---|---|
| Middle + Lower | H=0.5 | p = 0.7788 |
| Lower | H=0.47 | p = 0.7906 |
| Middle | H=0.18 | p = 0.9139 |
| H is the statistic representing differences between the three years. In this case, the p-values greater than 0.05 indicate that the differences between years are not statistically significant. | | |

[7] a non-parametric test, which is equivalent to an Analysis of Variance (ANOVA for parametric data)

Each survey year, the same four species of mollusks were found: two bivalves, *Mya arenaria* (soft-shell clam), *Malcoma balthica* (duck clam), and two gastropods, *Littorina littorea* (common periwinkle) and *Ilyanassa obsoleta* (mud snail). In addition, Nereididae (clam worms), Oligochaetes (worms) and Tanaids (small infauna crustaceans) were found and classified to family level. Green crabs (*Carcinus maenas*) were collected in 2009 and 2010, and three Palaemonid shrimp were found in 2010. Figure 5 lists the number of each species or family for each year.

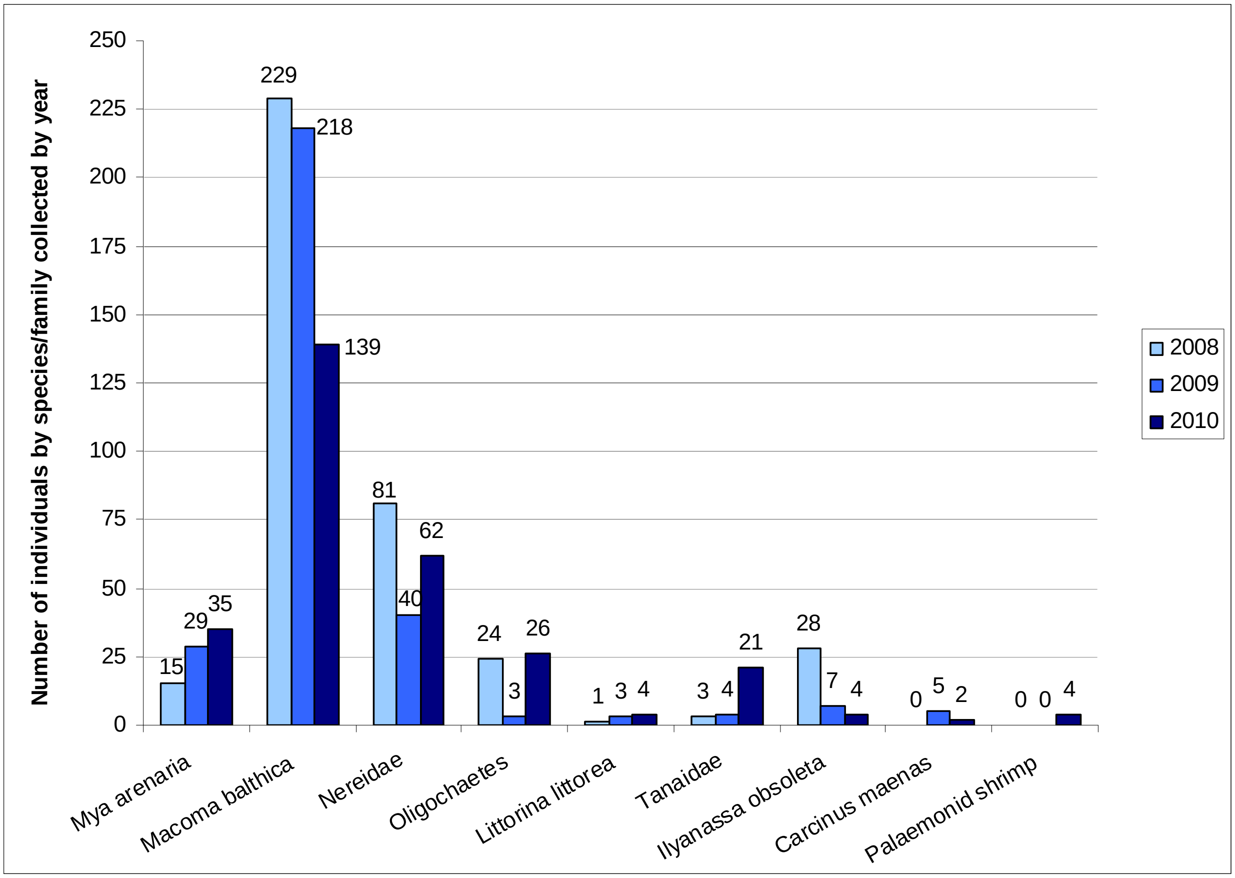


**Figure 5.** The abundance of infauna organisms (>5mm) observed in the mudflat habitat of the Upper Mill River, Gloucester, MA, by year sampled.

## 2. Community composition.

All upper Mill River organisms collected require marine habitats.
*Macoma balthica* were the most abundant. The number of *M. balthica* collected over the three years actually decreased from 229 individuals in 2008, 218 in 2009, down to 139 in 2010. The number of *Mya arenaria* collected increased each year going from 15, 29, to 35 with a 233% increase over the three years of the study. Polychaetes Nereids were always the second most abundant organisms (81, 40, 62 total individuals). The details of benthic infauna observations for upper Mill River are provided in Tables 5 through 7.

**Table 5.** Infauna data from Upper Mill River mudflat habitat, Fall 2008

A. *Mya arenaria* (soft-shell clam) Data -2008

| Location | # of samples | *Mya arenaria* | Size Range | Average Size |
|---|---|---|---|---|
| Lower | 26 | 13 | 24 to 70 mm | 57.23 mm |
| Middle | 39 | 2 | 4 and 10 mm | 7 mm |
| Upper | 2 | 0 | | |
| Total | 67 | **15** | | |

B. *Macoma balthica* (duck clam) Data -2008

| Location | # of samples | *Macoma balthica* | Size Range | Average Size |
|---|---|---|---|---|
| Lower | 26 | 172 | 8 to 30 mm | 22.7 mm |
| Middle | 39 | 57 | 10 to 34 mm | 26.6 mm |
| Upper | 2 | 2 | 22 and 32 mm | 27 mm |
| Total | 67 | **231** | | |

C. Other Organisms Data -2008

| Location | # of samples | Nereidae (clam worms) | Oligochaetes | *Littorina littorea* (common periwinkle) | Tanaidacea (infauna crustaceans) | *Ilyanassa obsoleta (mud snail)* |
|---|---|---|---|---|---|---|
| Lower | 26 | 36 | 17 | 1 | 3 | 26 |
| Middle | 39 | 45 | 7 | 0 | 0 | 2 |
| Upper | 2 | 0 | 0 | 0 | 0 | 0 |
| Totals | 67 | **81** | **24** | **1** | **3** | **28** |

**Table 6.** Infauna data from Upper Mill River mudflat habitat, Fall 2009

A. *Mya arenaria* (soft-shell clam) Data -2009

| Location | # of Samples | *Mya arenaria* | Size Range | Average size |
|---|---|---|---|---|
| Lower | 32 | 29 | 11 - 80 mm | 48.8 mm |
| Middle | 40 | 0 | | |
| Total | 72 | **29** | | |

B. *Macoma balthica* (duck clam) Data -2009

| Location | *Macoma balthica* | Size Range | Average size |
|---|---|---|---|
| Lower | 140 | 5 to 33 mm | 19 mm |
| Middle | 78 | 8 to 33 mm | 20 mm |
| Total | **218** | | |

C. Other Organisms Data -2009

| Location | Nereidae Clam Worms | Oligochaetes | *Littorina littorea* | Tanaidacea | *Ilyanassa obsoleta* | *Carcinus maenas* |
|---|---|---|---|---|---|---|
| Lower | 18 | 2 | 3 | 1 | 5 | 3 |
| Middle | 22 | 1 | 0 | 3 | 2 | 2 |
| Totals | **40** | **3** | **3** | **4** | **7** | **5** |

**Table 7.** Infauna data from Upper Mill River mudflat habitat, Fall 2010

A. *Mya arenaria* (soft-shell clam) Data -2010

| Location | # of Samples | *Mya arenaria* | Size Range | Average size |
|---|---|---|---|---|
| Lower | 32 | 34 | 3 - 93 mm | 67 mm |
| Middle | 40 | 1 | 9 mm | |
| Total | 72 | **35** | | |

B. *Macoma balthica* (duck clam) Data -2010

| Location | # of Samples | *Macoma balthica* | Size Range | Average size |
|---|---|---|---|---|
| Lower | 32 | 86 | 6 to 32 mm | 22 mm |
| Middle | 40 | 53 | 7 to 37 mm | 25 mm |
| Total | 72 | **139** | | |

C. Other Organisms Data -2010

| | Nereidae Clam Worms | Oligochaetes | *Littorina littorea* | Tanaidacea | *Ilyanassa obsoleta* | *Carcinus maenas* | Palaemonid *shrimp* |
|---|---|---|---|---|---|---|---|
| Lower | 39 | 26 | 2 | 14 | 3 | 2 | 1 |
| Middle | 23 | 0 | 2 | 7 | 1 | 0 | 3 |
| Totals | **62** | **26** | **4** | **21** | **4** | **2** | **4** |

### 3. Distribution of All Organisms.

The Lower section always had the most individuals, 2008=70%, 2009=65% and 2010=70%, even though the Lower section was only 45% of the area sampled and thus had two fewer transects.

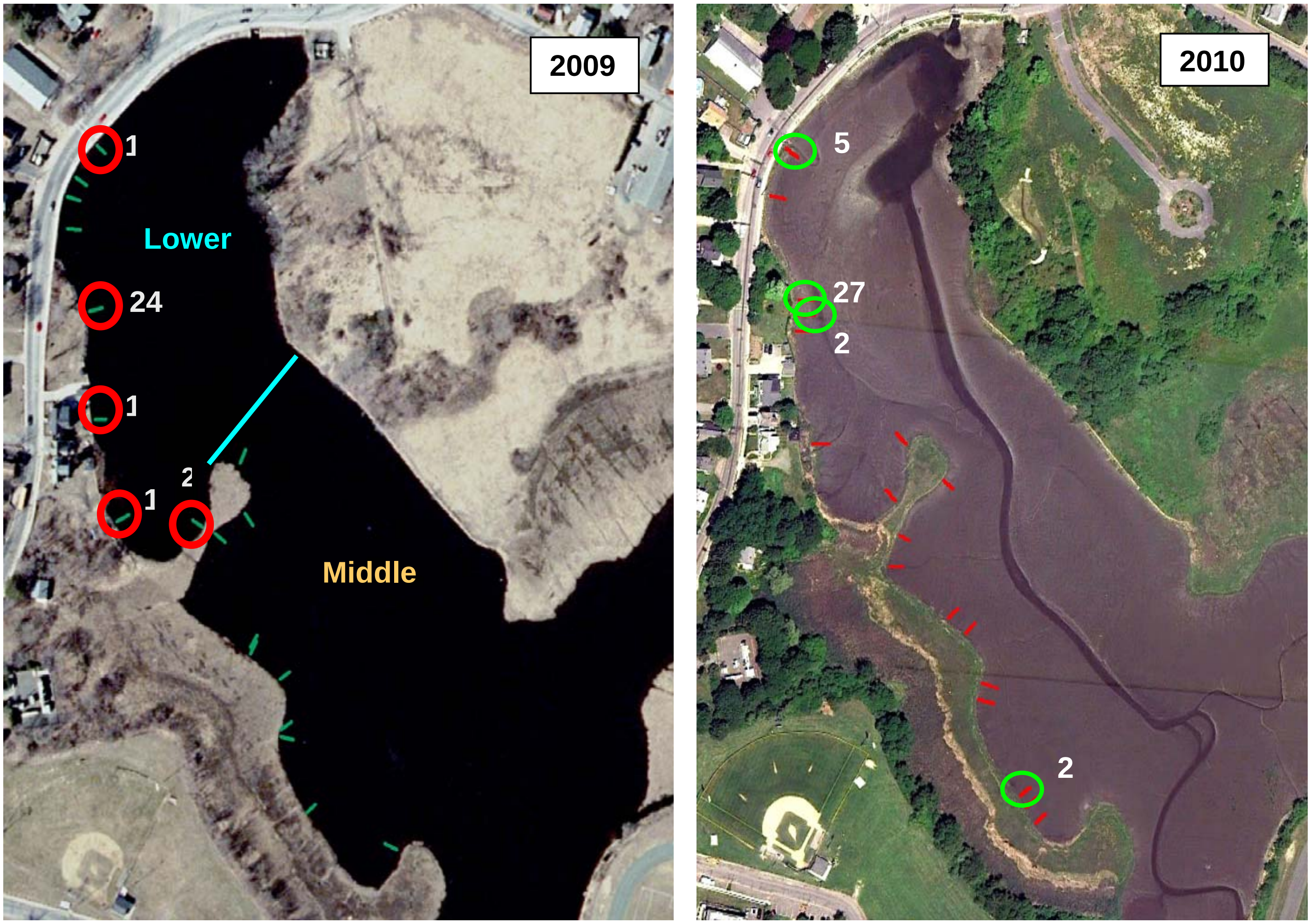


**Figure 6**. Distribution and number of *Mya arenaria* collected from the Upper Mill River mudflats with 2009 random transects on left and 2010 random transects on right.

## 4. Distribution of *Mya arenaria*.

All settled *M. arenaria* were found in the Lower section (Figure 6). In 2008 and 2010, the only *M. arenaria* collected in the Middle section were 10 mm or less. In 2009 and 2010 when sampling took place between 1 and 7 meters from the high tide line, *M. arenaria* were distributed across the length of the transects. In contrast, in 2008 when sampling was conducted every 5 meters from 1 to 50 meters, *M. arenaria* were found only in samples collected at the one-meter transect stations. Distribution details for each year are listed in Table 8. The transect labels in Table 8 represents the year and the meter location on the transect, i.e. MP08-11.1 = Mill Pond Year 2008 transect 11, 1 meter from high tide line and MP10-03-6 = Mill Pond Year 2010 transect 3, 6 meters from high tide line.

**Table 8.** Distribution, number and shell size of *Mya arenaria* in the Upper Mill River sampling area, Gloucester

Fall 2008 Total *Mya arenaria* = 15

| Transect | Number | Shell Size (mm) | | | |
|---|---|---|---|---|---|
| MP08-04.1 | 2 | *66* | *59* | | |
| | | | | | |
| MP08-11.1 | 1 | *24* | | | |
| | | | | | |
| MP08-34.1 | 3 | *68* | *65* | *65* | |
| | | | | | |
| MP08-39.1 | 3 | *54* | *57* | *42* | |
| | | | | | |
| MP08-43.1w | 4 | *52* | *62* | *60* | *70* |
| | | | | | |
| MP08-71.1 | 1 | *10* | | | |
| | | | | | |
| MP08-103.1 | 1 | *4* | | | |

Fall 2009 Total *Mya arenaria* = 29

| Transect | Number | Shell size (mm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MP09-01-6 | 1 | *76* | | | | | | | | | | |
| | | | | | | | | | | | | |
| MP09-05-1 | 7 | *63* | *64* | *65* | *25* | *22* | *11* | *12* | | | | |
| MP09-05-4 | 3 | *33* | *65* | *70* | | | | | | | | |
| MP09-05-6 | 3 | *68* | *45* | *20* | | | | | | | | |
| MP09-05-7 | 11 | *70* | *60* | *63* | *57* | *63* | *60* | *54* | *80* | *76* | *70* | *60* |
| | | | | | | | | | | | | |
| MP09-06-2 | 1 | *13* | | | | | | | | | | |
| | | | | | | | | | | | | |
| MP09-07-1 | 1 | *22* | | | | | | | | | | |
| | | | | | | | | | | | | |
| MP09-08-4 | 2 | *11* | *18* | | | | | | | | | |

Fall 2010 Total *Mya arenaria* =  35

| Transect | Number | Shell size (mm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MP10-01-2 | 1 | *3* | | | | | | | | | | | |
| MP10-01-4 | 1 | *73* | | | | | | | | | | | |
| MP10-01-5 | 3 | *65* | *76* | *74* | | | | | | | | | |
| | | | | | | | | | | | | | |
| MP10-03-1 | 3 | *70* | *72* | *50* | | | | | | | | | |
| MP10-03-3 | 5 | *70* | *73* | *84* | *74* | *75* | | | | | | | |
| MP10-03-5 | 12 | *25* | *65* | *82* | *79* | *74* | *83* | *75* | *70* | *76* | *65* | *67* | *62* |
| MP10-03-6 | 7 | *62* | *59* | *78* | *93* | *58* | *66* | *83* | | | | | |
| | | | | | | | | | | | | | |
| MP10-04-6 | 2 | *50* | *38* | | | | | | | | | | |
| | | | | | | | | | | | | | |
| MP10-16-7 | 1 | *9* | | | | | | | | | | | |

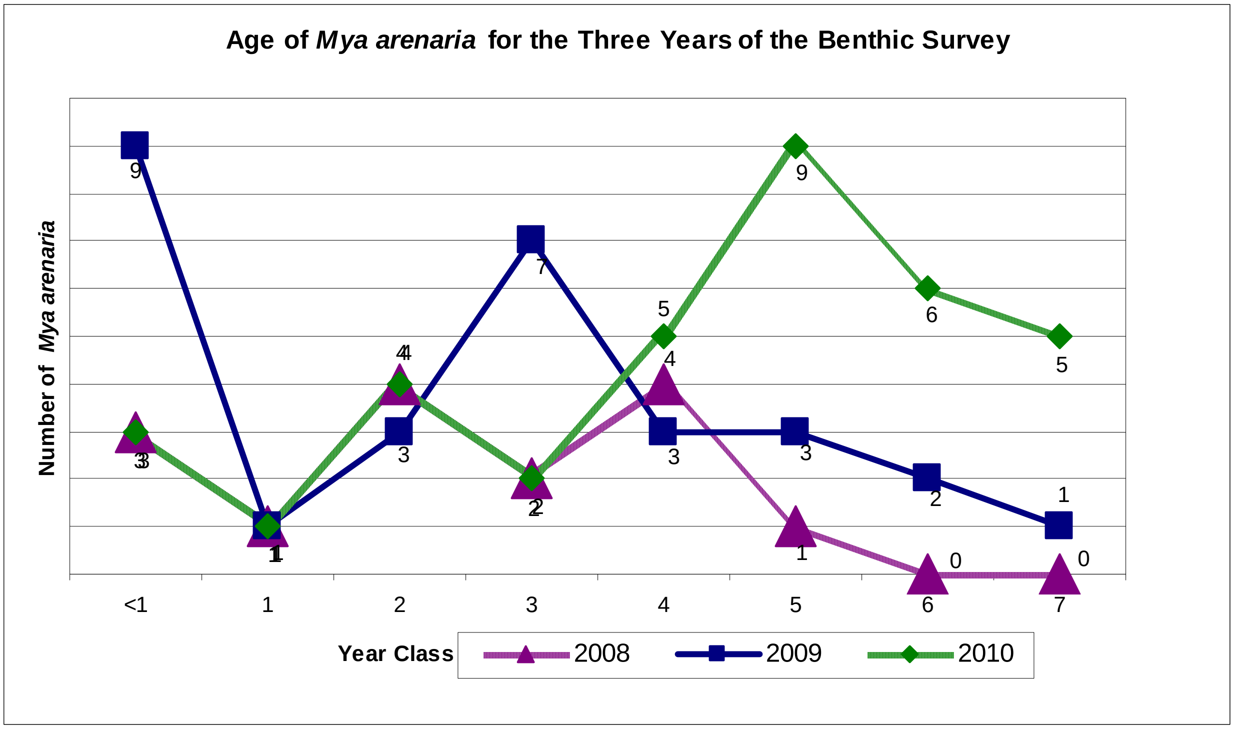


**Figure 7.** Age range of *Mya arenaria* in the Upper Mill River sampling area, Gloucester, MA, for the three years of sampling.

## 5. Size-Age Class of *Mya arenaria*.

*M. arenaria* shell length was measured to the nearest millimeter using a ruler at the time of sampling. The age classes were estimated using a life table established for Gloucester *M. arenaria* (D. Brousseau, 1978; Appendix 4). Table 9 shows the range in size class and the number collected for each year. An ANOVA found a significant difference in sizes across the three years of the study ($p = 0.012$), which is demonstrated in Figure 7. This shows *M. arenaria* shifting to larger-sized year classes by 2010.

Combining the three years of data, 77% of *M. arenaria* were sexually mature and the average shell length of *M. arenaria* was 56 mm. Each year, young of the year were found. In 2008, four were immature (<45mm), in 2009 ten and four in 2010.

**Table 9**. Age and shell length range of *Mya arenaria* in the Upper Mill River sampling area, Gloucester, MA, for the three years of sampling.

| Years old | Size class (mm) | 2008 | 2009 | 2010 |
|---|---|---|---|---|
| <1 | 2.0 - 29.9 | 3 | 9 | 3 |
| 1 | 30.0 - 44.9 | 1 | 1 | 1 |
| 2 | 45.0 - 59.9 | 4 | 3 | 4 |
| 3 | 60.0 - 64.9 | 2 | 7 | 2 |
| 4 | 65.0 - 69.9 | 4 | 3 | 5 |
| 5 | 70.0 - 74.9 | 1 | 3 | 9 |
| 6 | 75.0 - 79.9 | 0 | 2 | 6 |
| 7 | 80.0 - 84.9+ | 0 | 1 | 5 |
| | Total Number | 15 | 29 | 35 |

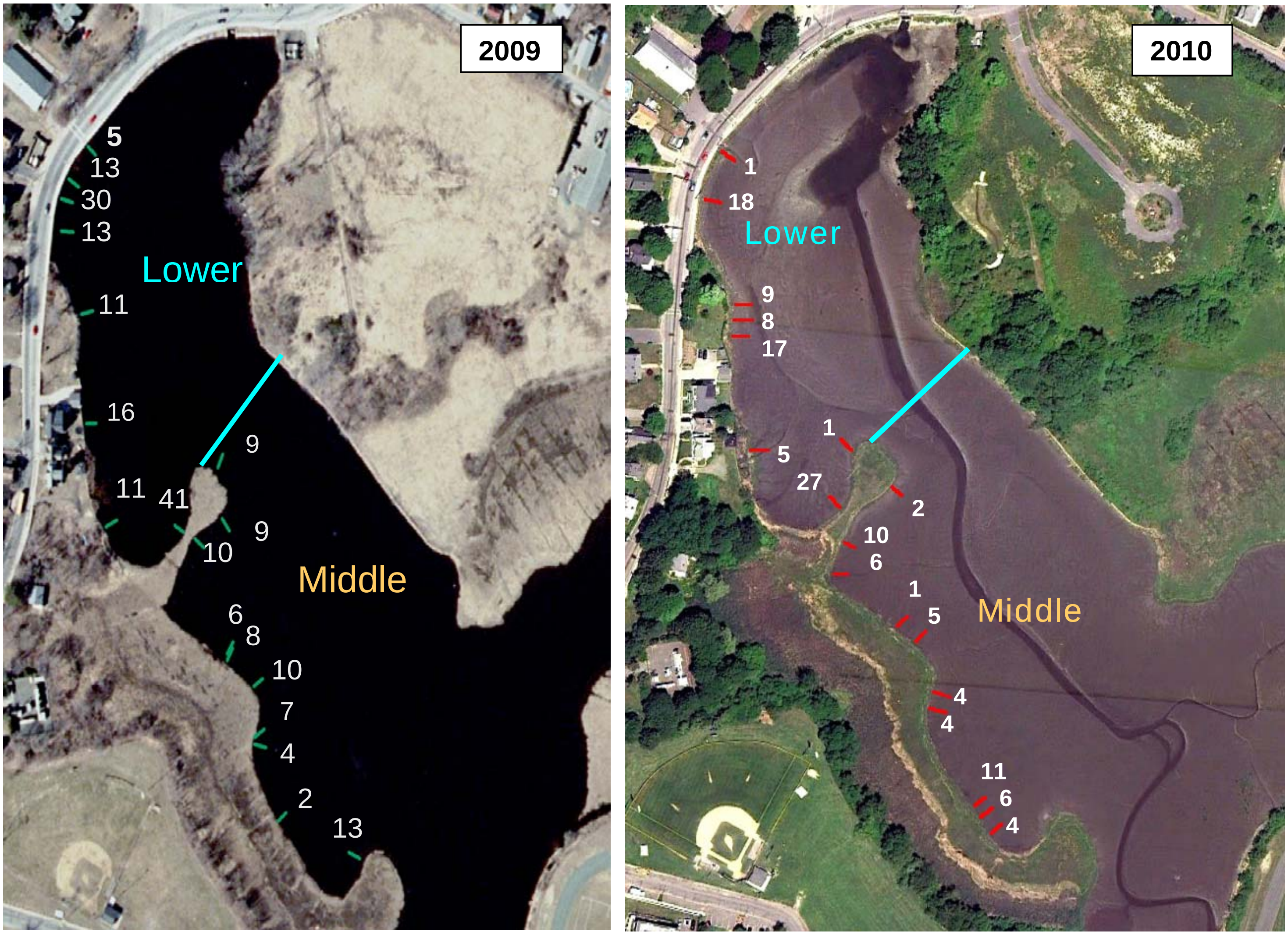


**Figure 8**. Distribution of *Macoma balthica* collected from the Upper Mill River mudflats in 2009 and 2010.

## 6. Distribution and Size Class of *Macoma balthica*.

*M. balthica* were found in every transect for all three years; see Figure 8.

There was no size distinction for *M. balthica* between the areas sampled. However, an ANOVA found a significant difference in sizes between the three study years ($p < 0.0001$). Post-hoc analysis showed a significantly smaller size class of *M. balthica* in 2009 ($p<0.01$) indicating an influx of recruits. Mean shell size was 19.45 mm in 2009, while mean shell size in 2008 and 2010 were 23.17 mm and 23.30 mm, respectively.

## *Discussion*

Seventy-two samples were collected and processed over 1½ days in 2009 and again in 2010, while 68 samples were collected in 2008. Table 2 shows the percentage of targeted sampling areas and the sampling effort. Actual sample collection conformed well to the original design with 44% of the Lower section and 56% of the Middle section being sampled.

The study was designed to determine if the soft-shell clams, *Mya arenaria,* had colonized the Upper Mill River after partial tidal flow was restored and if possible to estimate their population by to replicating the 2008 sampling design and effort in the following two years. When thirteen *M. arenaria* were collected in 2008 and all within one meter of the shoreline, as noted in Sampling Method (p. 5), the sampling effort was refined to focus effort closer to shore since sample sizes of greater than twenty (n>20) improve population estimates. However, when all three years of data were compared, no significant difference was found in the total number of individuals collected over the three years and so all data was presented in the analysis.

The benthic survey of large (> 5 mm) infauna, clearly, found marine organisms recolonizing the mudflat of the upper Mill River with the return of even partial tidal flushing to the area. Observations of the salt marsh also show *Spartina patens* and *S. alterniflora* growing readily in the lower and middle reaches of upper Mill River peninsulas. Sixty-nine percent of the organisms collected were located in the Lower portion nearest the tide gate and source of salt water, which justified the hydrodynamic stratification in the benthic sampling into Lower and Middle areas. Since *M. arenaria* density has been observed to be positively correlated with salinity (Thelen 2007), early colonization by marine species was expected to be more likely in the lower reaches of the upper Mill River if anywhere since it is closest to the source for tidal exchange. Indeed, all settled *M. arenaria* were found in the Lower area.

Dauer (1993) identified *M. arenaria* as an ''equilibrium species,'' that is, a relatively long-lived species that dominates community biomass in undisturbed habitats. Brousseau (1978; see Appendix 4) found that the Gloucester *M. arenaria* population reaches sexual maturity at 45mm shell length, and their reproductive values remain high during adult life with increasing reproductive rates in older clams. By estimating the age classes of *M. arenaria* with Brousseau's Gloucester *M. arenaria* life table, the three years of data confirm that colonization occurred soon after the tide gate was opened in 2004. In 2008, 10 *M. arenaria* were sexually mature (> 45 mm in length), and 3 young of the year (YOY) were collected. In 2009, 20 were sexually mature, while in this year, 9 individuals were YOY. In 2010, 32 were sexually mature with 3 YOY. The significant difference in size-age classes that showed a shift to older individuals in 2010 bodes well for the site since fecundity of *M. arenaria* increases dramatically with age. If salinity levels remain consistent or increase with the addition of a second tide gate, the density of *M. arenaria* would be expected to increase which validates the importance of future monitoring.

*Macoma balthica* was the dominant species in all three years of the study. *M. balthica* is a species of small saltwater clam in the family Tellinidae, which lives in muddy bays and is quite tolerant of low levels of salinity. Its shell color normally varies between pink, purple, yellow, and white, but the Mill River specimens have blackened shells possibly from sulphide-rich sediments (Budd 2001). Not a filter feeder, *M. balthica* lives a few centimeters below the surface and sweeps over the mud with a long inhalent siphon, like a vacuum cleaner. The tidal restriction and muddy conditions of upper Mill River continue to provide a good habitat for *M. balthica*, although a decrease in their numbers was seen in 2010 as well as a statistically significant reduction in shell size in 2009. It is not clear if these changes in population and size are normal population variations or a reflection of a changing intertidal habitat with the return of partial tidal flushing; again another reason for future monitoring.

The ability to assess the changes in population sizes of infauna requires a more thorough sampling design, though the present method does provide a useful means of observing general differences in populations across the three years and is an informative proxy for complete sampling of the Mill Pond. The study area was limited because the inaccessible areas were beyond the means of sampling logistics and the resources available for this monitoring initiative. However, changes in the *M. arenaria* population may still be comparable from year-to-year if the comparisons are restricted to the area sampled. Thus, the sampling design was changed only minimally in 2009 to allow for annual comparisons of the recolonization by *M. arenaria* in the sampled-accessible areas. Extrapolating the survey data to estimate the mean number of *M. arenaria* in the sampled area translates to a mean of 56 individuals in 2009 and 66 individuals per meter squared in 2010. It is highly probable that *M. arenaria* have colonized some of the "inaccessible" areas and that any estimate of their population would be an underestimation. Dave Sargent, Gloucester's shellfish warden, reports increasing numbers of *M. arenaria* and *Mytilus edulis* (blue mussels) in the northeasterly portion of the Mill River, near the tidegate. This anecdotal evidence of *M. arenaria* siphon holes in the inaccessible sampling areas of the study site (Figure 2. p. 4) suggests that *M. arenaria* are more numerous than this study has found.

Since *M. arenaria* is sensitive to salinity levels, it is recommended that when future monitoring is undertaken, dataloggers be placed in the study area to record daily variability and provide the chemical data needed to compare the upstream and downstream regions of the study area. In addition, establishing a characterization of the benthic substrate type (sand, mud, cobble, peat) before or shortly after the second tide gate is installed would create a baseline sediment map that could be used in future studies to better understand mudflat conditions and help determine any correlations of *M. arenaria* densities with benthic substrate changes as the marsh matures and the area experiences increased tidal flow.

## *Conclusion*

Three years of benthic shellfish and worm population assessments in the upper Mill River since partial tidal flow restoration found a return of benthic marine species. By monitoring the community structure of the intertidal mudflats in the restored Mill Pond, data collected in 2008, 2009 and 2010 have provided a benchmark from which to document future ecological changes in the study area. The initial findings are very encouraging. *Mya arenaria* immediately recolonized the newly exposed mudflats in 2004, based on the age of collected *M. arenaria.* The significant increase over the three years in larger-sized year classes of *M. arenaria* offers the potential for increased seed populations since *M. arenaria* increases fecundity ten-fold from 1.5 years to 7 years of age.

However, community recovery in restored estuarine ecosystems is largely dependent on the level of tidal exchange. Estuarine structure and function return relatively quickly when tidal flow is unrestricted. It remains to be seen if sites with only partial tidal exchange fully recover without additional modification of the hydrologic regime (Thelen 2007; Burdick et al. 1997). It appears that the levels of salinity at the mudflat are affecting the density and location of saline sensitive marine species, such as *M. arenaria*. When a second tide gate is installed, the tidal dampening from the lower Mill River to the upper Mill River at Washington Street should be reduced, which should result in increased salinity and added tidal flushing to the upstream estuarine habitat and thus should benefit marine ecological functions. This study has provided an excellent baseline for future studies of the Mill Pond, now the tidal upper Mill River.

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# *Appendices*

## Appendix 1: Mill Pond Advisory Group

**2008**
Barbara Warren – SSCW Executive Director, Mass Bays Program Regional Coordinator
Christian Krahfrost – Staff Scientist, Mass Bays Program
Dave Sargent – Gloucester Shellfish Warden
Eric Hutchins – NOAA Restoration
Max Schenk – Gloucester Health Department
Susan Redlich – Corporate Wetlands Restoration Partnership Manager
Tim Smith – Office of Coastal Zone Management's Wetlands Restoration Program

**2009**
Barbara Warren – SSCW Executive Director, Mass Bays Program Regional Coordinator
Christian Krahfrost – Staff Scientist, Mass Bays Program
Dave Sargent – Gloucester Shellfish Warden
Eric Hutchins – NOAA Restoration
Max Schenk – Gloucester Health Department

**2010**
Barbara Warren – SSCW Executive Director, Mass Bays Program Regional Coordinator
Christian Krahfrost – Staff Scientist, Mass Bays Program
Dave Sargent – Gloucester Shellfish Warden
Eric Hutchins – NOAA Restoration Center
Bryan DeAngelis – NOAA Restoration Center

## Appendix 2: Sampling Dates and Tides

**2008**
Reconnaissance Day - August 8 at 10:00 am to noon (Low tide at 10:590 am, HT = 1.3 ft?)

Study Sampling Days
September 25, Thursday starting at NOON (Low tide at 2:30 pm, HT = 0.8)
October 7, Tuesday starting at 10:00 am (Low tide at 11:18 am, HT = 2.3)
October 8, Wednesday starting at 11:00 am (Low tide at 12:17 pm, HT = 2.2)

**2009**
Study Sampling Days
September 23, Wednesday starting at 8:45am – 2:30 pm
LT 8:51am (0.65); HT 3:12pm (9.66)
September 24, Thursday starting at 8:30 am – 11:30am
LT 9:40am (1.19); HT 4:02pm (9.18)

**2010**
Study Sampling Days
November 15, Monday starting at 9:00am – 3:30pm
LT 12:14 pm (1.69); HT 6:13 am (8.09)
November 16, Thursday starting at 9:00 am – 121:30pm
LT 1:08pm (1.46); HT 7:02am (8.29)

# Appendix 3: Sampling Protocol

A scientific collection permit was obtained from MA Division of Marine Fisheries before the survey began.

## Transect Locations

Transects are randomly generated before going into the field and then transect locations were adjusted as needed in the field. A new set of randomly generated transects will be surveyed for each future study year.

On or before the first field day, transects are located by placing wooden posts at the correct coordinates and mean high water mark (see Table 2 & 3). If transect locations need to be adjusted in the field, the position of each post is recorded using WAAS-enabled GPS. A compass is used to record the direction of the transect perpendicular to the shoreline. Posts are removed at the end of sampling.

## Jobs and Number of Workers

The sampling can be divided into two different activities with separate teams of workers.

1. Digging team of 3-4 people
    - Ideally four people to a team: digger, 3 relayers
    - Minimum 3 people per dig site

2. Cleaning and Recording station: 4 or more people
    - Cleaning sample with running water (3-8 people)
    - Identifying of organisms, measuring clams, and recording data (1-2 people)

## Collecting Samples from the Mudflat

Sampling begins one meter from estimated mean high water. In 2008, samples were taken every 5 meters along each transect until conditions made it impossible to sample any farther. In 2009, two samples were randomly selected from meters 1, 2, 3, or 4, and two from meters 5, 6, or 7 for a total of four stations from 1 to 7 meters along each transect. All transects are run perpendicular to land edge. Because of the difficulty of working in the mucky substrate, a flat-bottomed canoe proved to be the best way to access the mudflat. Without a canoe, sampling may be limited to two or three samples near the shoreline.

At each sample station, a 1-foot x 1-foot square sample is dug with a square shovel (25.4 cm x 25.4 cm x 25.4 cm deep sample (0.016 $m^3$) and placed in a 5-gallon bucket (20 L). In 2008, it was determined that one bucket per sample site was adequate for a representative sample. Buckets are very heavy and the appropriate people must be found for this task. A pole placed through the bucket handle so that two people could carry a bucket is another method that may be employed. Buckets are relayed to the sample processing station. The relayer returns to digger with empty bucket(s) and repeats the process.

## Processing Samples

At the sample processing station, the buckets remain in queue until the cleaning crew is ready to clean another sample. The contents of the bucket are placed in the cleaning box and washed with running water and sieved through a ¼ inch hardware cloth screen (5 mm). The bucket's ID tag is placed in an empty contents box. All living animals are placed in this container and given to the recording station.

## Recording Data

The data recorder identifies organisms and fills in a datasheet for each sample using the ID tag number. The number and type of clams are tallied on a data sheet and shell length is measured in millimeters using a ruler. Other organisms are counted and recorded on the same datasheet, but not measured.

After the datasheet is complete, each sample is photographed with its ID tag and placed in the urn bucket. When sampling is completed for the area, the collected organisms are returned to the mudflat without concentrating them in one area. All organisms will be returned upstream of tide gate within Mill Pond.

## EQUIPMENT

Scientific collection permit from MA Division of Marine Fisheries

1 Compasses
1 WAAS-enabled GPS unit
20 Wooden stakes to mark transects

Flat-bottomed Canoe

Ropes with knots marking every 5 meters to measure transect lengths
2 1ft x 1 ft quadrats: (dig one foot deep)
2 square shovel
20 5-gallon buckets
80 ID tags to go in buckets (waterproof paper and pencil)

2 sieves with 3/8 –1/4 inch mesh (Hardware cloth and 2x6 wooden sides)
2 Sawhorses and two 2x4's 8 feet long for cleaning table
Water from Neighbor: William and Bairstow
200 feet of garden hose + splitter and 2 sections of garden hose
2 Nozzle with adjustable spray and shut off
15 Rubber gloves

3 millimeter rulers for measuring clams
20 plastic content boxes
Clipboards, pencils and waterproof paper
Camera(s)
80 Data sheets
ID sheet for worms, shellfish
Recorder station: needs table top and stool

Appropriate clothing/gear for field samplers (get really muddy!)

# Appendix 4. Life Table of *Mya arenaria* from D. Brousseau (1978).

Table 5. *Mya arenaria*. Life table

| Size-class (mm) | Age (years)[a] | Survival ($l_x$) | $\frac{l_x + l_{x+1}}{2}$ | Life expectancy ($e_x$) | Mortality ($q_x$) | Fecundity ($m_{x+0.5}$) |
|---|---|---|---|---|---|---|
| 2.0– 4.9 | 0.143 | 0.557 | 0.610 | 0.769 | 0.885 | – |
| 5.0– 9.9 | 0.286 | 0.662 | 0.731 | 1.820 | 0.675 | – |
| 10.0–14.9 | 0.428 | 0.800 | 0.800 | 3.562 | 0.400 | – |
| 15.0–19.9 | 0.571 | 0.800 | 0.817 | 4.602 | 0.400 | – |
| 20.0–24.9 | 0.714 | 0.834 | 0.867 | 6.336 | 0.333 | – |
| 25.0–29.9 | 0.857 | 0.900 | 0.934 | 8.248 | 0.199 | – |
| 30.0–34.9 | 1.000 | 0.968 | 0.973 | 9.178 | 0.062 | – |
| 35.0–39.9 | 1.333 | 0.978 | 0.971 | 8.758 | 0.045 | – |
| 40.0–44.9 | 1.667 | 0.963 | 0.965 | 8.143 | 0.075 | 7,379 |
| 45.0–49.9 | 2.000 | 0.966 | 0.970 | 7.758 | 0.066 | 13,589 |
| 50.0–54.9 | 2.333 | 0.973 | 0.968 | 7.268 | 0.055 | – |
| 55.0–59.9 | 2.666 | 0.962 | 0.957 | 6.665 | 0.078 | 18,835 |
| 60.0–64.9 | 3.000 | 0.952 | 0.951 | 6.186 | 0.098 | 33,605 |
| 65.0–69.9 | 4.000 | 0.949 | 0.959 | 5.794 | 0.101 | 36,624 |
| 70.0–74.9 | 5.000 | 0.969 | 0.977 | 5.386 | 0.059 | 46,034 |
| 75.0–79.9 | 6.000 | 0.984 | 0.948 | 4.690 | 0.031 | 56,986 |
| 80.0–84.9 | 7.000+ | 0.911 | | 3.830 | 0.176 | 72,125 |

[a] Birth time ($t_0$) = July.

# Appendix 5. 2010 Data

## 2010 Sampled Transect

| Transect Lower | Site Name Meters | Start Latitude | Start Longitude | Compass Bearing |
|---|---|---|---|---|
| **1 - Lower** | | | | |
| 1 | 2, 4, 5, 7 | $42^o$ 37' 55.8" N | $70^o$ 40' 41.9" W | $126^o$ |
| 2 | 1, 2, 5, 6 | $42^o$ 37' 55.0" N | $70^o$ 40' 42.4" W | $100^o$ |
| 3 | 1, 3, 5, 6 | $42^o$ 37' 53.3" N | $70^o$ 40' 41.8" W | $106^o$ |
| 4 | 2, 3, 6, 7 | $42^o$ 37' 53.0" N | $70^o$ 40' 41.7" W | $110^o$ |
| 5 | 1, 3, 5, 7 | $42^o$ 37' 52.8" N | $70^o$ 40' 41.7" W | $104^o$ |
| 6 | 2, 4, 5, 6 | $42^o$ 37' 51.0" N | $70^o$ 40' 41.3" W | $82^o$ |
| 7 | 1, 4, 6, 7 | $42^o$ 37' 50.1" N | $70^o$ 40' 39.4" W | $322^o$ |
| 8 | 1, 2, 5, 7 | $42^o$ 37' 51.0" N | $70^o$ 40' 39.1" W | $288^o$ |
| | | | | |
| **2 - Middle** | | | | |
| 9 | 3, 4, 5, 6 | $42^o$ 37' 50.5" N | $70^o$ 40' 38.3" W | $138^o$ |
| 10 | 2, 3, 6, 7 | $42^o$ 37' 49.6"N | $70^o$ 40' 39.4 " W | $128^o$ |
| 11 | 1, 4, 6, 7 | $42^o$ 37' 49.0" N | $70^o$ 40' 39.7" W | $86^o$ |
| 12 | 2, 4, 5, 6 | $42^o$ 37' 48.2" N | $70^o$ 40' 38.1" W | $56^o$ |
| 13 | 1, 4, 5, 7 | $42^o$ 37' 48.0" N | $70^o$ 40' 37.6" W | $51^o$ |
| 14 | 1, 3, 6, 7 | $42^o$ 37' 47.2" N | $70^o$ 40' 37.5" W | $111^o$ |
| 15 | 2, 3, 6, 7 | $42^o$ 37' 47.0" N | $70^o$ 40' 37.5" W | $121^o$ |
| 16 | 1, 4, 6, 7 | $42^o$ 37' 45.3" N | $70^o$ 40' 36.3" W | $65^o$ |
| 17 | 1, 4, 6, 7 | $42^o$ 37' 45.1" N | $70^o$ 40' 36.3" W | $46^o$ |
| 18 | 1, 2, 5, 7 | $42^o$ 37' 44.8" N | $70^o$ 40' 35.9" W | $59^o$ |

## 2010 Upper Mill River *Mya arenaria* Results Table

| 2010 | | Soft Shell Clams | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | Number | Width (mm) | | | | | | | | | | | |
| **Lower** | MP10001-2 | 1 | 3 | | | | | | | | | | | |
| | MP10001-4 | 1 | 73 | | | | | | | | | | | |
| | MP10001-5 | 3 | 65 | 76 | 74 | | | | | | | | | |
| | MP10001-7 | 0 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | MP10002-1 | 0 | | | | | | | | | | | | |
| | MP10002-2 | 0 | | | | | | | | | | | | |
| | MP10002-5 | 0 | | | | | | | | | | | | |
| | MP10002-6 | 0 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | MP10003-1 | 3 | 70 | 72 | 50 | | | | | | | | | |
| | MP10003-3 | 5 | 70 | 73 | 84 | 74 | 75 | | | | | | | |
| | MP10003-5 | 12 | 25 | 65 | 82 | 79 | 74 | 83 | 75 | 70 | 76 | 65 | 67 | 62 |
| | MP10003-6 | 7 | 62 | 59 | 78 | 93 | 58 | 66 | 83 | | | | | |
| | | | | | | | | | | | | | | |
| | MP10004-2 | 0 | | | | | | | | | | | | |
| | MP10004-3 | 0 | | | | | | | | | | | | |
| | MP10004-6 | 2 | 50 | 38 | | | | | | | | | | |
| | MP10004-7 | 0 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | MP10005-1 | 0 | | | | | | | | | | | | |
| | MP10005-3 | 0 | | | | | | | | | | | | |
| | MP10005-5 | 0 | | | | | | | | | | | | |
| | MP10005-7 | 0 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | MP10006-2 | 0 | | | | | | | | | | | | |
| | MP10006-4 | 0 | | | | | | | | | | | | |
| | MP10006-5 | 0 | | | | | | | | | | | | |
| | MP10006-6 | 0 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | MP10007-1 | 0 | | | | | | | | | | | | |
| | MP10007-4 | 0 | | | | | | | | | | | | |
| | MP10007-6 | 0 | | | | | | | | | | | | |
| | MP10007-7 | 0 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | MP10008-1 | 0 | | | | | | | | | | | | |
| | MP10008-2 | 0 | | | | | | | | | | | | |
| | MP10008-5 | 0 | | | | | | | | | | | | |
| | MP10008-7 | 0 | | | | | | | | | | | | |
| **Lower** | **Total** | **34** | | | | | | | | | | | | |

| **2010** | | **Soft Shell Clams** | | | | |
|---|---|---|---|---|---|---|
| **Middle** | Site | Number | Width (mm) | | | |
| | MP10009-3 | 0 | | | | |
| | MP10009-4 | 0 | | | | |
| | MP10009-5 | 0 | | | | |
| | MP10009-6 | 0 | | | | |
| | | | | | | |
| | MP10010-2 | 0 | | | | |
| | MP10010-3 | 0 | | | | |
| | MP10010-6 | 0 | | | | |
| | MP10010-7 | 0 | | | | |
| | | | | | | |
| | MP10011-1 | 0 | | | | |
| | MP10011-4 | 0 | | | | |
| | MP10011-6 | 0 | | | | |
| | MP10011-7 | 0 | | | | |
| | | | | | | |
| | MP10012-2 | 0 | | | | |
| | MP10012-4 | 0 | | | | |
| | MP10012-5 | 0 | | | | |
| | MP10012-6 | 0 | | | | |
| | | | | | | |
| | MP10013-1 | 0 | | | | |
| | MP10013-4 | 0 | | | | |
| | MP10013-5 | 0 | | | | |
| | MP10013-7 | 0 | | | | |
| | | | | | | |
| | MP10014-1 | 0 | | | | |
| | MP10014-3 | 0 | | | | |
| | MP10014-6 | 0 | | | | |
| | MP10014-7 | 0 | | | | |
| | | | | | | |
| | MP10015-2 | 0 | | | | |
| | MP10015-3 | 0 | | | | |
| | MP10015-6 | 0 | | | | |
| | MP10015-7 | 0 | | | | |
| | | | | | | |
| | MP10016-1 | 0 | | | | |
| | MP10016-4 | 0 | | | | |
| | MP10016-6 | 0 | | | | |
| | MP10016-7 | 1 | 9 | | | |
| | | | | | | |
| | MP10017-1 | 0 | | | | |
| | MP10017-4 | 0 | | | | |
| | MP10017-6 | 0 | | | | |
| | MP10017-7 | 0 | | | | |
| | | | | | | |
| | MP10018-1 | 0 | | | | |
| | MP10018-2 | 0 | | | | |
| | MP10018-5 | 0 | | | | |
| | MP10018-7 | 0 | | | | |
| Middle | Total | 1 | | | | |

## 2010 Upper Mill River *Macoma balthica* Results Table

| **2010** | **Duck Clams** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | Number | Width (mm) | | | | | | | | | | | | | | | |
| Lower | MP10001-2 | **0** | | | | | | | | | | | | | | | | |
| | MP10001-4 | **0** | | | | | | | | | | | | | | | | |
| | MP10001-5 | **0** | | | | | | | | | | | | | | | | |
| | MP10001-7 | **1** | 9 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP10002-1 | **5** | 18 | 25 | 17 | 27 | 20 | | | | | | | | | | | |
| | MP10002-2 | **7** | 30 | 21 | 21 | 24 | 21 | 18 | 20 | | | | | | | | | |
| | MP10002-5 | **4** | 28 | 30 | 20 | 9 | | | | | | | | | | | | |
| | MP10002-6 | **2** | 36 | 6 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP10003-1 | **1** | 20 | | | | | | | | | | | | | | | |
| | MP10003-3 | **1** | 15 | | | | | | | | | | | | | | | |
| | MP10003-5 | **4** | 31 | 21 | 20 | 21 | | | | | | | | | | | | |
| | MP10003-6 | **3** | 23 | 25 | 24 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP10004-2 | **2** | 26 | 27 | | | | | | | | | | | | | | |
| | MP10004-3 | **3** | 28 | 28 | 30 | | | | | | | | | | | | | |
| | MP10004-6 | **2** | 26 | 28 | | | | | | | | | | | | | | |
| | MP10004-7 | **1** | 26 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP10005-1 | **1** | 24 | | | | | | | | | | | | | | | |
| | MP10005-3 | **7** | 28 | 16 | 25 | 23 | 20 | 28 | 24 | | | | | | | | | |
| | MP10005-5 | **6** | 26 | 21 | 18 | 20 | 16 | 18 | | | | | | | | | | |
| | MP10005-7 | **3** | 23 | 25 | 22 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP10006-2 | **0** | | | | | | | | | | | | | | | | |
| | MP10006-4 | **0** | | | | | | | | | | | | | | | | |
| | MP10006-5 | **1** | 29 | | | | | | | | | | | | | | | |
| | MP10006-6 | **4** | 26 | 18 | 9 | 8 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP10007-1 | **4** | 22 | 9 | 14 | 20 | | | | | | | | | | | | |
| | MP10007-4 | **9** | 32 | 31 | 29 | 29 | 27 | 20 | 17 | 19 | 17 | | | | | | | |
| | MP10007-6 | **6** | 31 | 30 | 19 | 17 | 29 | 11 | | | | | | | | | | |
| | MP10007-7 | **8** | 26 | 20 | 23 | 22 | 20 | 27 | 25 | 22 | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP10008-1 | **0** | | | | | | | | | | | | | | | | |
| | MP10008-2 | **0** | | | | | | | | | | | | | | | | |
| | MP10008-5 | **1** | 8 | | | | | | | | | | | | | | | |
| | MP10008-7 | **0** | | | | | | | | | | | | | | | | |
| Lower | Total | **86** | | | | | | | | | | | | | | | | |

| **2010** | **Duck Clams** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Site | Number | Width (mm) | | | | | |
| Middle | MP10009-3 | **2** | 8 | 15 | | | | |
| | MP10009-4 | **0** | | | | | | |
| | MP10009-5 | **0** | | | | | | |
| | MP10009-6 | **0** | | | | | | |
| | | | | | | | | |
| | MP10010-2 | **2** | 23 | 24 | | | | |
| | MP10010-3 | **3** | 21 | 30 | 21 | | | |
| | MP10010-6 | **3** | 25 | 30 | 30 | | | |
| | MP10010-7 | **2** | 25 | 31 | | | | |
| | | | | | | | | |
| | MP10011-1 | **0** | | | | | | |
| | MP10011-4 | **2** | 27 | 27 | | | | |
| | MP10011-6 | **2** | 27 | 31 | | | | |
| | MP10011-7 | **2** | 26 | 32 | | | | |
| | | | | | | | | |
| | MP10012-2 | **0** | | | | | | |
| | MP10012-4 | **1** | 14 | | | | | |
| | MP10012-5 | **0** | | | | | | |
| | MP10012-6 | **0** | | | | | | |
| | | | | | | | | |
| | MP10013-1 | **0** | | | | | | |
| | MP10013-4 | **1** | 30 | | | | | |
| | MP10013-5 | **3** | 19 | 28 | 19 | | | |
| | MP10013-7 | **1** | 20 | | | | | |
| | | | | | | | | |
| | MP10014-1 | **0** | | | | | | |
| | MP10014-3 | **3** | 20 | 30 | 20 | | | |
| | MP10014-6 | **0** | | | | | | |
| | MP10014-7 | **1** | 31 | | | | | |
| | | | | | | | | |
| | MP10015-2 | **1** | 18 | | | | | |
| | MP10015-3 | **1** | 29 | | | | | |
| | MP10015-6 | **1** | 26 | | | | | |
| | MP10015-7 | **1** | 28 | | | | | |
| | | | | | | | | |
| | MP10016-1 | **0** | | | | | | |
| | MP10016-4 | **4** | 23 | 25 | 25 | 26 | | |
| | MP10016-6 | **2** | 35 | 28 | | | | |
| | MP10016-7 | **5** | 11 | 27 | 26 | 32 | 35 | |
| | | | | | | | | |
| | MP10017-1 | **0** | | | | | | |
| | MP10017-4 | **1** | 24 | | | | | |
| | MP10017-6 | **2** | 17 | 7 | | | | |
| | MP10017-7 | **3** | 37 | 30 | 29 | | | |
| | | | | | | | | |
| | MP10018-1 | **0** | | | | | | |
| | MP10018-2 | **1** | 24 | | | | | |
| | MP10018-5 | **2** | 31 | 13 | | | | |
| | MP10018-7 | **1** | 31 | | | | | |
| Middle | Total | **53** | | | | | | |

# Appendix 6. 2009 Data

## 2009 Sampled Transect Characteristics for the Lower Polygon

| Transect | Site Name | Start | Start | Compass |
|---|---|---|---|---|
| Lower | Meters | Latitude | Longitude | Bearing |
| 1 | MP09001-3 | 42°37'56.2"N | 70°40'41.7"W | 143° |
| | MP09001-4 | | | |
| | MP09001-5 | | | |
| | MP09001-6 | | | |
| | | | | |
| 2 | MP09002-1 | 42°37'55.7"N | 70°40'42.2"W | 139° |
| | MP09002-2 | | | |
| | MP09002-5 | | | |
| | MP09002-7 | | | |
| | | | | |
| 3 | MP09003-2 | 42°37'55.4"N | 70°40'42.4"W | 120° |
| | MP09003-3 | | | |
| | MP09003-6 | | | |
| | MP09003-7 | | | |
| | | | | |
| 4 | MP09004-1 | 42°37'54.9"N | 70°40'42.4"W | 111° |
| | MP09004-4 | | | |
| | MP09004-6 | | | |
| | MP09004-7 | | | |
| | | | | |
| 5 | MP09005-1 | 42°37'53.6"N | 70°40'41.9"W | 92° |
| | MP09005-4 | | | |
| | MP09005-6 | | | |
| | MP09005-7 | | | |
| | | | | |
| 6 | MP09006-2 | 42°37'51.9"N | 70°40'41.8"W | 102° |
| | MP09006-4 | | | |
| | MP09006-5 | | | |
| | MP09006-6 | | | |
| | | | | |
| 7 | MP09007-1 | 42°37'50.3"N | 70°40'41.3"W | 79° |
| | MP09007-4 | | | |
| | MP09007-5 | | | |
| | MP09007-7 | | | |
| | | | | |
| 8 | MP09008-2 | 42°37'50.2"N | 70°40'39.3"W | 318° |
| | MP09008-4 | | | |
| | MP09008-5 | | | |
| | MP09008-6 | | | |

## 2009 Sampled Transect Characteristics for the Middle Polygon

| Transect Middle | Site Name Meters | Start Latitude | Start Longitude | Compass Bearing |
|---|---|---|---|---|
| 9 | MP09009-1 | 42°37'51.2"N | 70°40'38.4"W | 42° |
| | MP09009-3 | | | |
| | MP09009-6 | | | |
| | MP09009-7 | | | |
| | | | | |
| 10 | MP09010-1 | 42°37'50.4"N | 70°40'38.3"W | 158° |
| | MP09010-3 | | | |
| | MP09010-5 | | | |
| | MP09010-7 | | | |
| | | | | |
| 11 | MP09011-2 | 42°37'50.1"N | 70°40'39.0"W | 143° |
| | MP09011-3 | | | |
| | MP09011-6 | | | |
| | MP09011-7 | | | |
| | | | | |
| 12 | MP09012-2 | 42°37'48.3"N | 70°40'38.2"W | 48° |
| | MP09012-3 | | | |
| | MP09012-6 | | | |
| | MP09012-7 | | | |
| | | | | |
| 13 | MP09013-1 | 42°37'48.2"N | 70°40'38.2"W | 44° |
| | MP09013-4 | | | |
| | MP09013-6 | | | |
| | MP09013-7 | | | |
| | | | | |
| 14 | MP09014-1 | 42°37'47.8"N | 70°40'37.5"W | 70° |
| | MP09014-3 | | | |
| | MP09014-5 | | | |
| | MP09014-6 | | | |
| | | | | |
| 15 | MP09015-1 | 42°37'46.9"N | 70°40'37.5"W | 120° |
| | MP09015-4 | | | |
| | MP09015-6 | | | |
| | MP09015-7 | | | |
| | | | | |
| 16 | MP09016-1 | 42°37'45.7"N | 70°40'36.9"W | 65° |
| | MP09016-2 | | | |
| | MP09016-5 | | | |
| | MP09016-6 | | | |
| | | | | |
| 17 | MP09017-1 | 42°37'47.0"N | 70°40'37.5"W | 70° |
| | MP09017-2 | | | |
| | MP09017-5 | | | |
| | MP09017-7 | | | |
| | | | | |
| 18 | MP09018-2 | 42°37'45.1"N | 70°40'34.8"W | 310° |
| | MP09018-4 | | | |
| | MP09018-5 | | | |
| | MP09018-7 | | | |

## 2009 Upper Mill River *Mya arenaria* Results Table

| **2009** | | **Soft Shell Clams** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | Number | Width (mm) | | | | | | | | | | |
| **Lower** | MP09001-3 | 0 | | | | | | | | | | | |
| | MP09001-4 | 0 | | | | | | | | | | | |
| | MP09001-5 | 0 | | | | | | | | | | | |
| | MP09001-6 | 1 | 76 | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | MP09002-1 | 0 | | | | | | | | | | | |
| | MP09002-2 | 0 | | | | | | | | | | | |
| | MP09002-5 | 0 | | | | | | | | | | | |
| | MP09002-7 | 0 | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | MP09003-2 | 0 | | | | | | | | | | | |
| | MP09003-3 | 0 | | | | | | | | | | | |
| | MP09003-6 | 0 | | | | | | | | | | | |
| | MP09003-7 | 0 | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | MP09004-1 | 0 | | | | | | | | | | | |
| | MP09004-4 | 0 | | | | | | | | | | | |
| | MP09004-6 | 0 | | | | | | | | | | | |
| | MP09004-7 | 0 | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | MP09005-1 | 7 | 63 | 64 | 65 | 25 | 22 | 11 | 12 | | | | |
| | MP09005-4 | 3 | 33 | 65 | 70 | | | | | | | | |
| | MP09005-6 | 3 | 68 | 45 | 20 | | | | | | | | |
| | MP09005-7 | 11 | 70 | 60 | 63 | 57 | 63 | 60 | 54 | 80 | 76 | 70 | 60 |
| | | | | | | | | | | | | | |
| | MP09006-2 | 1 | 13 | | | | | | | | | | |
| | MP09006-4 | 0 | | | | | | | | | | | |
| | MP09006-5 | 0 | | | | | | | | | | | |
| | MP09006-6 | 0 | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | MP09007-1 | 1 | 22 | | | | | | | | | | |
| | MP09007-4 | 0 | | | | | | | | | | | |
| | MP09007-5 | 0 | | | | | | | | | | | |
| | MP09007-7 | 0 | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | MP09008-2 | 0 | | | | | | | | | | | |
| | MP09008-4 | 2 | 11 | 18 | | | | | | | | | |
| | MP09008-5 | 0 | | | | | | | | | | | |
| | MP09008-6 | 0 | | | | | | | | | | | |
| | | **29** | | | | | | | | | | | |

| 2009 | | Soft Shell Clams | | | | |
|---|---|---|---|---|---|---|
| **Middle** | Site | Number | Width (mm) | | | |
| | MP09009-1 | 0 | | | | |
| | MP09009-3 | 0 | | | | |
| | MP09009-6 | 0 | | | | |
| | MP09009-7 | 0 | | | | |
| | | | | | | |
| | MP09010-1 | 0 | | | | |
| | MP09010-3 | 0 | | | | |
| | MP09010-5 | 0 | | | | |
| | MP09010-7 | 0 | | | | |
| | | | | | | |
| | MP09011-2 | 0 | | | | |
| | MP09011-3 | 0 | | | | |
| | MP09011-6 | 0 | | | | |
| | MP09011-7 | 0 | | | | |
| | | | | | | |
| | MP09012-2 | 0 | | | | |
| | MP09012-3 | 0 | | | | |
| | MP09012-6 | 0 | | | | |
| | MP09012-7 | 0 | | | | |
| | | | | | | |
| | MP09013-1 | 0 | | | | |
| | MP09013-4 | 0 | | | | |
| | MP09013-6 | 0 | | | | |
| | MP09013-7 | 0 | | | | |
| | | | | | | |
| | MP09014-1 | 0 | | | | |
| | MP09014-3 | 0 | | | | |
| | MP09014-5 | 0 | | | | |
| | MP09014-6 | 0 | | | | |
| | | | | | | |
| | MP09015-1 | 0 | | | | |
| | MP09015-4 | 0 | | | | |
| | MP09015-6 | 0 | | | | |
| | MP09015-7 | 0 | | | | |
| | | | | | | |
| | MP09016-1 | 0 | | | | |
| | MP09016-2 | 0 | | | | |
| | MP09016-5 | 0 | | | | |
| | MP09016-6 | 0 | | | | |
| | | | | | | |
| | MP09017-1 | 0 | | | | |
| | MP09017-2 | 0 | | | | |
| | MP09017-5 | 0 | | | | |
| | MP09017-7 | 0 | | | | |
| | | | | | | |
| | MP09018-2 | 0 | | | | |
| | MP09018-4 | 0 | | | | |
| | MP09018-5 | 0 | | | | |
| | MP09018-7 | 0 | | | | |
| | Total | 0 | | | | |

## 2009 Upper Mill River *Macoma balthica* Results Table

| 2009 | | Duck Clams | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | Number | Width (mm) | | | | | | | | | | | | | | | |
| Lower | | | | | | | | | | | | | | | | | | |
| | MP09001-3 | 0 | | | | | | | | | | | | | | | | |
| | MP09001-4 | 1 | 32 | | | | | | | | | | | | | | | |
| | MP09001-5 | 2 | 8 | 11 | | | | | | | | | | | | | | |
| | MP09001-6 | 2 | 11 | 9 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP09002-1 | 4 | 29 | 28 | 13 | 11 | | | | | | | | | | | | |
| | MP09002-2 | 6 | 32 | 33 | 31 | 24 | 10 | 10 | | | | | | | | | | |
| | MP09002-5 | 2 | 11 | 13 | | | | | | | | | | | | | | |
| | MP09002-7 | 1 | 10 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP09003-2 | 10 | 32 | 31 | 30 | 28 | 19 | 13 | 11 | 13 | 10 | 11 | | | | | | |
| | MP09003-3 | 12 | 30 | 29 | 31 | 26 | 12 | 14 | 7 | 12 | 14 | 9 | 15 | 14 | | | | |
| | MP09003-6 | 2 | 31 | 12 | | | | | | | | | | | | | | |
| | MP09003-7 | 6 | 10 | 14 | 15 | 12 | 11 | 10 | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP09004-1 | 3 | 10 | 8 | 12 | | | | | | | | | | | | | |
| | MP09004-4 | 3 | 33 | 27 | 10 | | | | | | | | | | | | | |
| | MP09004-6 | 2 | 24 | 21 | | | | | | | | | | | | | | |
| | MP09004-7 | 5 | 35 | 27 | 9 | 5 | 10 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP09005-1 | 2 | 24 | 21 | | | | | | | | | | | | | | |
| | MP09005-4 | 1 | 22 | | | | | | | | | | | | | | | |
| | MP09005-6 | 4 | 20 | 22 | 20 | 14 | | | | | | | | | | | | |
| | MP09005-7 | 4 | 19 | 9 | 8 | 9 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP09006-2 | 3 | 23 | 26 | 9 | | | | | | | | | | | | | |
| | MP09006-4 | 6 | 34 | 33 | 27 | 18 | 18 | 21 | | | | | | | | | | |
| | MP09006-5 | 6 | 9 | 9 | 9 | 30 | 23 | 29 | | | | | | | | | | |
| | MP09006-6 | 1 | 29 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP09007-1 | 0 | | | | | | | | | | | | | | | | |
| | MP09007-4 | 2 | 28 | 29 | | | | | | | | | | | | | | |
| | MP09007-5 | 6 | 28 | 28 | 29 | 30 | 21 | 10 | | | | | | | | | | |
| | MP09007-7 | 3 | 21 | 23 | 10 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP09008-2 | 9 | 30 | 20 | 25 | 24 | 22 | 26 | 26 | 29 | 9 | | | | | | | |
| | MP09008-4 | 6 | 30 | 27 | 26 | 25 | 11 | 18 | | | | | | | | | | |
| | MP09008-5 | 10 | 13 | 25 | 25 | 31 | 31 | 24 | 21 | 10 | 13 | 9 | | | | | | |
| | MP09008-6 | 16 | 31 | 26 | 23 | 21 | 27 | 28 | 10 | 12 | 6 | 14 | 12 | 14 | 10 | 10 | 13 | 12 |
| | | **140** | | | | | | | | | | | | | | | | |

| 2009 | Duck Clams | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Site | Number | Width (mm) | | | | | |
| Middle | | | | | | | | |
| | MP09009-1 | 1 | 22 | | | | | |
| | MP09009-3 | 0 | | | | | | |
| | MP09009-6 | 2 | 10 | 9 | | | | |
| | MP09009-7 | 6 | 28 | 8 | 9 | 7 | 9 | 10 |
| | | | | | | | | |
| | MP09010-1 | 1 | 26 | | | | | |
| | MP09010-3 | 1 | 12 | | | | | |
| | MP09010-5 | 3 | 22 | 19 | 12 | | | |
| | MP09010-7 | 4 | 32 | 17 | 14 | 12 | | |
| | | | | | | | | |
| | MP09011-2 | 1 | 21 | | | | | |
| | MP09011-3 | 1 | 22 | | | | | |
| | MP09011-6 | 4 | 9 | 9 | 33 | 31 | | |
| | MP09011-7 | 4 | 32 | 31 | 19 | 18 | | |
| | | | | | | | | |
| | MP09012-2 | 1 | 12 | | | | | |
| | MP09012-3 | 1 | 25 | | | | | |
| | MP09012-6 | 4 | 17 | 20 | 19 | 22 | | |
| | MP09012-7 | 0 | | | | | | |
| | | | | | | | | |
| | MP09013-1 | 0 | | | | | | |
| | MP09013-4 | 0 | | | | | | |
| | MP09013-6 | 3 | 33 | 15 | 13 | | | |
| | MP09013-7 | 5 | 32 | 30 | 18 | 19 | 12 | |
| | | | | | | | | |
| | MP09014-1 | 2 | crushed | | | | | |
| | MP09014-3 | 4 | 8 | 15 | 20 | 25 | | |
| | MP09014-5 | 2 | 25 | 18 | | | | |
| | MP09014-6 | 2 | 30 | 25 | | | | |
| | | | | | | | | |
| | MP09015-1 | 3 | 25 | 25 | 10 | | | |
| | MP09015-4 | 0 | | | | | | |
| | MP09015-6 | 0 | | | | | | |
| | MP09015-7 | 4 | 14 | 17 | 17 | 30 | | |
| | | | | | | | | |
| | MP09016-1 | 1 | 26 | | | | | |
| | MP09016-2 | 0 | | | | | | |
| | MP09016-5 | 2 | 31 | 18 | | | | |
| | MP09016-6 | 1 | 32 | | | | | |
| | | | | | | | | |
| | MP09017-1 | 2 | 21 | 25 | | | | |
| | MP09017-2 | 0 | | | | | | |
| | MP09017-5 | 0 | | | | | | |
| | MP09017-7 | 0 | | | | | | |
| | | | | | | | | |
| | MP09018-2 | 5 | 27 | 27 | 25 | 22 | 12 | |
| | MP09018-4 | 4 | 27 | 31 | 16 | 18 | | |
| | MP09018-5 | 3 | 19 | 20 | 13 | | | |
| | MP09018-7 | 1 | 12 | | | | | |
| | Total | **78** | | | | | | |

## Appendix 7. 2008 Data

Upper Mill River random transect locations sampled in 2008.

## Sampled Transect Characteristics from 2008

| Transect # | Transect Length (m) | # of samples | Start Lon | Start Lat | Bearing (Deg.) | Date Sampled 2008 |
|---|---|---|---|---|---|---|
| 4 | 10 | 3 | -70.67806 | 42.63239 | 146 | 10/08 |
| 11 | 5 | 2 | -70.67842 | 42.63200 | 120 | 10/08 |
| 18 | 5 | 2 | -70.67847 | 42.63186 | 112 | 10/08 |
| 34 | 25 | 6 | -70.67828 | 42.63150 | 102 | 10/07 |
| 39 | 20 | 5 | -70.67833 | 42.63136 | 92 | 10/07 |
| 43nw | 20 | 3 | -70.67833 | 42.63125 | 162 | 10/08 |
| 43se | 20 | 6 | -70.67754 | 42.63067 | 340 | 9/25 |
| 71 | 30 | 7 | -70.67728 | 42.63069 | 132 | 10/07 |
| 103 | 15 | 4 | -70.67714 | 42.62997 | 62 | 9/25 |
| 113 | 25 | 6 | -70.67711 | 42.62972 | 126 | 10/07 |
| 126 | 50 | 11 | -70.67689 | 42.62933 | 72 | 10/07 |
| 129 | 50 | 11 | -70.67672 | 42.62992 | 58 | 10/07 |
| 146 | | 2 | -70.67681 | 42.62789 | 160 | 10/07 |
| Total = 13 | | Total = 68 | | | | |

## 2008 Upper Mill River *Mya arenaria* Results Table

| 2008 | Soft-Shelled Clams | | | | | |
|---|---|---|---|---|---|---|
| | Site | Number | Width (mm) | | | |
| **Lower** | | | | | | |
| | MP081008-4.1 | 2 | 66 | 59 | | |
| | MP081008-4.6 | 0 | | | | |
| | MP081008-4.11 | 0 | | | | |
| | | | | | | |
| | MP081008-11.1 | 1 | 24 | | | |
| | MP081008-11.6 | 0 | | | | |
| | | | | | | |
| | MP081008-18.1 | Rocks | | | | |
| | MP081008-18.6 | 0 | | | | |
| | | | | | | |
| | MP081007-34.1 | 3 | 68 | 65 | 65 | |
| | MP081007-34.6 | 0 | | | | |
| | MP081007-34.11 | 0 | | | | |
| | MP081007-34.16 | 0 | | | | |
| | MP081007-34.21 | 0 | | | | |
| | MP081007-34.26 | 0 | | | | |
| | | | | | | |
| | MP081007-39.1 | 3 | 54 | 57 | 42 | |
| | MP081007-39.6 | 0 | | | | |
| | MP081007-39.11 | 0 | | | | |
| | MP081007-39.16 | 0 | | | | |
| | MP081007-39.21 | 0 | | | | |
| | | | | | | |
| | MP080925-43.1 | 0 | | | | |
| | MP080925-43.6 | 0 | | | | |
| | MP080925-43.11 | 0 | | | | |
| | MP080925-43.16 | 0 | | | | |
| | MP080925-43.21 | 0 | | | | |
| | MP080925-43.26 | 0 | | | | |
| | | | | | | |
| | MP081008-43.1w | 4 | 52 | 62 | 60 | 70 |
| | MP081008-43.6w | 0 | | | | |
| | MP081008-43.11w | 0 | | | | |
| | | | | | | |

**2008** ***Mya arenaria***

| 2008 | Soft-Shelled Clams | | | | | |
|---|---|---|---|---|---|---|
| **Middle** | Site | Number | Width (mm) | | | |
| | MP081007-71.1 | 1 | 10 | | | |
| | MP081007-71.6 | 0 | | | | |
| | MP081007-71.11 | 0 | | | | |
| | MP081007-71.16 | 0 | | | | |
| | MP081007-71.21 | 0 | | | | |
| | MP081007-71.26 | 0 | | | | |
| | MP081007-71.31 | 0 | | | | |
| | | | | | | |
| | MP080925-103.1 | 1 | 4 | | | |
| | MP080925-103.6 | 0 | | | | |
| | MP080925-103.11 | 0 | | | | |
| | MP080925-103.16 | 0 | | | | |
| | | | | | | |
| | MP081007-113.1 | 0 | | | | |
| | MP081007-113.6 | 0 | | | | |
| | MP081007-113.11 | 0 | | | | |
| | MP081007-113.16 | 0 | | | | |
| | MP081007-113.21 | 0 | | | | |
| | MP081007-113.26 | 0 | | | | |
| | | | | | | |
| | MP081007-126.1 | 0 | | | | |
| | MP081007-126.6 | 0 | | | | |
| | MP081007-126.11 | 0 | | | | |
| | MP081007-126.16 | 0 | | | | |
| | MP081007-126.21 | 0 | | | | |
| | MP081007-126.26 | 0 | | | | |
| | MP081007-126.31 | 0 | | | | |
| | MP081007-126.36 | 0 | | | | |
| | MP081007-126.41 | 0 | | | | |
| | MP081007-126.46 | 0 | | | | |
| | MP081007-126.51 | 0 | | | | |
| | | | | | | |
| | MP081007-129.1 | 0 | | | | |
| | MP081007-129.6 | 0 | | | | |
| | MP081007-129.11 | 0 | | | | |
| | MP081007-129.16 | 0 | | | | |
| | MP081007-129.21 | 0 | | | | |
| | MP081007-129.26 | 0 | | | | |
| | MP081007-129.31 | 0 | | | | |
| | MP081007-129.36 | 0 | | | | |
| | MP081007-129.41 | 0 | | | | |
| | MP081007-129.46 | 0 | | | | |
| | MP081007-129.51 | 0 | | | | |
| | | | | | | |
| **Upper** | Site | Number | Width (mm) | | | |
| | MP081007-146.1 | 0 | | | | |
| | MP081007-146.6 | 0 | | | | |

## 2008 Upper Mill River *Macoma balthica* Results Table

| | Site | Number | Width (mm) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lower** | MP081008-4.1 | 0 | | | | | | | | | | | | | | | | |
| | MP081008-4.6 | 4 | 25 | 21 | 26 | 25 | | | | | | | | | | | | |
| | MP081008-4.11 | 4 | 30 | 12 | 12 | 29 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP081008-11.1 | 1 | 23 | | | | | | | | | | | | | | | |
| | MP081008-11.6 | 5 | 31 | 27 | 20 | 19 | 8 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP081008-18.1 | | Rocks | | | | | | | | | | | | | | | |
| | MP081008-18.6 | 3 | 33 | 29 | 27 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP081007-34.1 | 1 | 27 | | | | | | | | | | | | | | | |
| | MP081007-34.6 | 3 | 22 | 26 | 20 | | | | | | | | | | | | | |
| | MP081007-34.11 | 8 | 19 | 25 | 26 | 23 | 25 | 25 | 24 | 24 | | | | | | | | |
| | MP081007-34.16 | 12 | 29 | 26 | 28 | 28 | 21 | 27 | 26 | 17 | 29 | 24 | 22 | 26 | | | | |
| | MP081007-34.21 | 12 | 28 | 25 | 27 | 23 | 25 | 27 | 14 | 18 | 22 | 25 | 25 | 22 | | | | |
| | MP081007-34.26 | 6 | 24 | 25 | 24 | 25 | 25 | 21 | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP081007-39.1 | 2 | 23 | 14 | | | | | | | | | | | | | | |
| | MP081007-39.6 | 9 | 26 | 25 | 25 | 21 | 20 | 22 | 24 | 19 | 20 | | | | | | | |
| | MP081007-39.11 | 9 | 29 | 28 | 26 | 25 | 24 | 23 | 20 | 28 | 29 | 29 | 18 | 20 | 13 | | | |
| | MP081007-39.16 | 9 | 27 | 28 | 27 | 30 | 25 | 23 | 23 | 25 | 23 | | | | | | | |
| | MP081007-39.21 | 13 | 23 | 27 | 24 | 25 | 8 | 28 | 23 | 23 | 24 | 25 | 17 | 26 | 24 | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP080925-43.1 | 3 | 23 | 5 | 10 | | | | | | | | | | | | | |
| | MP080925-43.6 | 16 | 23 | 24 | 20 | 20 | 21 | 18 | 20 | 22 | 19 | 22 | 18 | 8 | 5 | 5 | 5 | 4 |
| | MP080925-43.11 | 8 | 20 | 18 | 24 | 22 | 17 | 19 | 22 | 17 | | | | | | | | |
| | MP080925-43.16 | 13 | 20 | 20 | 20 | 24 | 24 | 20 | 18 | 20 | 17 | 19 | 14 | 15 | 15 | | | |
| | MP080925-43.21 | 9 | 25 | 23 | 21 | 20 | 27 | 21 | 23 | 15 | 16 | | | | | | | |
| | MP080925-43.26 | 7 | 25 | 24 | 24 | 23 | 24 | 23 | 20 | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | MP081008-43.1w | 1 | 17 | | | | | | | | | | | | | | | |
| | MP081008-43.6w | 6 | 28 | 30 | 25 | 32 | 20 | 24 | | | | | | | | | | |
| | MP081008-43.11w | 8 | 28 | 19 | 19 | 22 | 27 | 25 | 27 | 25 | | | | | | | | |
| | Total | 172 | | | | | | | | | | | | | | | | |

**2008** ***Macoma balthica***

| | Site | Number | Width (mm) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Middle** | | | | | | | | | |
| | MP081007-71.1 | 2 | 10 | 16 | | | | | |
| | MP081007-71.6 | 2 | 29 | 19 | | | | | |
| | MP081007-71.11 | 2 | 32 | 30 | | | | | |
| | MP081007-71.16 | 0 | | | | | | | |
| | MP081007-71.21 | 1 | 34 | | | | | | |
| | MP081007-71.26 | 2 | 25 | 34 | | | | | |
| | MP081007-71.31 | 2 | 36 | 19 | | | | | |
| | | | | | | | | | |
| | MP080925-103.1 | 4 | 15 | 17 | 13 | 11 | | | |
| | MP080925-103.6 | 3 | 20 | 23 | 21 | | | | |
| | MP080925-103.11 | 6 | 22 | 22 | 20 | 25 | 25 | 16 | |
| | MP080925-103.16 | 7 | 29 | 25 | 25 | 25 | 20 | 12 | 25 |
| | | | | | | | | | |
| | MP081007-113.1 | 1 | 27 | | | | | | |
| | MP081007-113.6 | 0 | | | | | | | |
| | MP081007-113.11 | 1 | 28 | | | | | | |
| | MP081007-113.16 | 3 | 13 | 26 | 30 | | | | |
| | MP081007-113.21 | 0 | | | | | | | |
| | MP081007-113.26 | 0 | | | | | | | |
| | | | | | | | | | |
| | MP081007-126.1 | 0 | | | | | | | |
| | MP081007-126.6 | 1 | 24 | | | | | | |
| | MP081007-126.11 | 2 | 37 | 21 | | | | | |
| | MP081007-126.16 | 0 | | | | | | | |
| | MP081007-126.21 | 1 | 26 | | | | | | |
| | MP081007-126.26 | 0 | | | | | | | |
| | MP081007-126.31 | 1 | 34 | | | | | | |
| | MP081007-126.36 | 0 | | | | | | | |
| | MP081007-126.41 | 3 | 33 | 30 | 34 | | | | |
| | MP081007-126.46 | 1 | 30 | | | | | | |
| | MP081007-126.51 | 5 | 33 | 28 | 31 | 29 | 30 | | |
| | | | | | | | | | |
| | MP081007-129.1 | 0 | | | | | | | |
| | MP081007-129.6 | 0 | | | | | | | |
| | MP081007-129.11 | 2 | 31 | 21 | | | | | |
| | MP081007-129.16 | 0 | | | | | | | |
| | MP081007-129.21 | 0 | | | | | | | |
| | MP081007-129.26 | 1 | 33 | | | | | | |
| | MP081007-129.31 | 0 | | | | | | | |
| | MP081007-129.36 | 0 | | | | | | | |
| | MP081007-129.41 | 2 | 24 | 34 | | | | | |
| | MP081007-129.46 | 1 | 31 | | | | | | |
| | MP081007-129.51 | 1 | 36 | | | | | | |
| | Total | 57 | | | | | | | |
| | | | | | | | | | |

**2008** ***Macoma balthica***

| | Site | Number | Width (mm) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Upper** | | | | | | | | | | | | | | | | | | |
| | MP081007-146.1 | 0 | | | | | | | | | | | | | | | | |
| | MP081007-146.6 | 2 | 22 | 32 | | | | | | | | | | | | | | |
| | Total | 2 | | | | | | | | | | | | | | | | |