Freshwater Mussel Bed Size, Mussel Density, and Population Age Structure in Upper Bear Creek, King County, Washington

Washington Trout

July 2002

Report To: The Bear Creek Water Tenders

ACKNOWLEDGEMENTS

This project was made possible through the persistence of Wendy Walsh and funding provided by the Bear Creek Water Tenders. Wendy Walsh and Doug Weber acquired landowner permission for Washington Trout crews to access the study reaches. King County Department of Natural Resources and Parks Water Land Resources Division collected mussel information that greatly assisted this project during a 2001 habitat assessment of Bear and Cottage Lake Creeks, and created a functional geographic information system (GIS) to display the mussel data. A special thanks to Dick Schaetzel, who volunteered in excess of thirty hours to assist Washington Trout crews with the survey fieldwork.

SUMMARY

Western pearlshell freshwater mussels (*Margaritifera falcata*) inhabit Bear Creek in King County, Washington. Washington Trout determined *M. falcata* bed size, density, and population age structure at a sub-sample of ten known freshwater mussel beds on Bear Creek. The results of this study provide a baseline against which future surveys of bed size, density, and population age structure can be compared to document changes in the health of the Bear Creek mussel population and commensurate changes in the biological integrity of the Bear Creek basin.

INTRODUCTION

During summer 2001, King County Water and Land Resources Division performed a habitat assessment in Bear Creek and Cottage Lake Creek and two of their tributaries to characterize the habitat quality, primarily for salmonids (Fevold and Vanderhoof, 2001). During the assessment, mussel bed locations were noted, and bed densities, sizes, and individual mussel sizes were estimated. While the King County mussel survey was not comprehensive because of scope of work and access permission limitations, it does provide a gross, extensive survey of mussel bed locations throughout much of the Bear Creek sub-basin.

Using these data, Washington Trout identified a representative subsample of ten mussel beds, and in Spring 2002 performed an intensive survey of bed size, mussel density, physical channel characteristics, and population age structure at each of the ten subsample locations. Because freshwater mussels are intolerant of compromised water quality and have a parasitic relationship with salmonids, measurable changes in mussel bed size, locations, densities, and population age structure can be used as a biological monitoring tool, a constituent index for watershed biological integrity and salmonid distribution.

METHODOLOGY

During the initial phase of this project in summer 2001, King County Department of Natural Resources and Parks Water Land Resources Division crews recorded the locations of observed mussel bed using Global Positioning Systems while they conducted habitat surveys along several reaches of Bear and Cottage Lake Creeks (Figure 1). Washington Trout used these extensive data to select spatially representative sites for intensive study, allowing limited resources to be focused on areas that are representative of the system as a whole. Washington Trout identified a subsample of ten reference mussel beds (units) in Upper Bear Creek that were spatially diverse, logistically accessible, and defined by stream habitat bifurcations (Figure 1). Prior to the surveys, site landowners were contacted to request permission to access the stream through their property. An underwater viewing box was used to enable the surveyors to accurately count those mussels in deep or turbulent stream reaches.

At each of the ten sites, the following tasks were performed:

- A Global Positioning System (GPS) point was collected to document the exact location of the reference mussel bed unit.
- The length and average wetted width of the habitat unit that comprised the mussel bed was measured.

At those sites where the number of mussels in the unit was not prohibitive (fewer than 50 live or dead mussels within the unit), the following tasks were performed:

- All of the dead mussels (one dead mussel per two shell halves) within the unit were counted, and their location relative to the midline of the bed was recorded.
- All of the live mussels were counted and measured along their longest axis to the nearest millimeter using either metric calipers or a measuring trough.
- A substrate elevation cross-section was performed by stretching a measuring tape across a representative area of the unit, perpendicular to flow, and measuring the water depth to the nearest centimeter at set intervals along the tape.
- All live and dead mussels were returned to their original location and position.

At those sites where the number of mussels in the unit was prohibitive (more than 50 live or dead mussels within the unit), the following tasks were performed (Figure 2):

- A series of three evenly spaced transects were established perpendicular to flow within the unit.
- Starting at the left-bank side of the downstream most transect, 1/16-meter square quadrats (0.25m by 0.25m) were placed end to end along the downstream side of each transect across the entire wetted width of the channel.
- All dead mussels within each quadrat were counted.
- All live mussels were counted and measured along their longest axis to the nearest millimeter using either metric calipers or a measuring trough.
- A substrate elevation cross-section was performed at each transect by measuring the water depth to the nearest centimeter at set intervals along each transect.
- All live and dead mussels were returned to their original location and position.

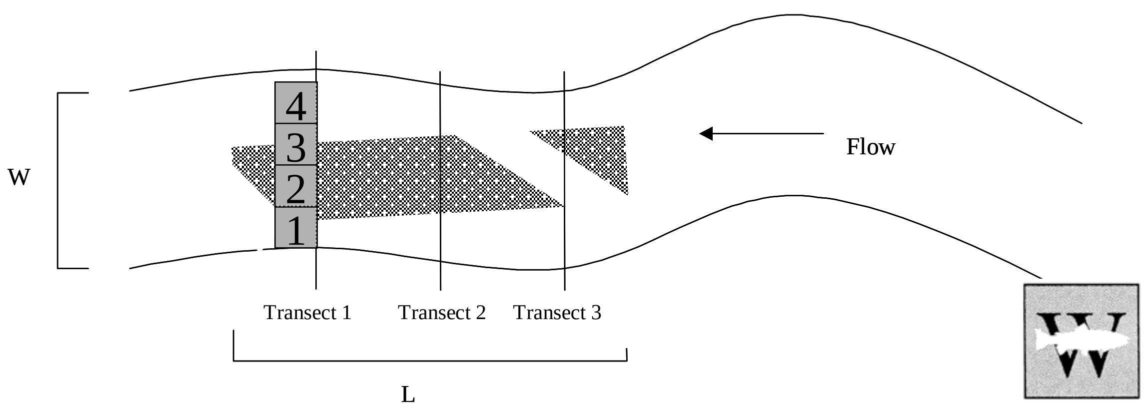


Figure 2. Schematic diagram of mussel bed subsampling procedure.

RESULTS

Washington Trout identified ten spatially representative mussel beds in the Upper Bear Creek drainage (Units 1 through 10), and in Spring 2002 performed an intensive survey of bed size, mussel density, physical channel characteristics, and population age structure at each of the ten subsample locations (Figure 1). In Units 5, 6, 7, 9,and 10, all live mussels within the identified habitat unit were counted and measured. In Units 1,2,3,4, and 8, mussel densities precluded measuring every live mussel, so the subsampling technique was employed. In Unit 1, 7 quadrats had live mussel densities that were so great that it would have been impossible to replace them appropriately after measuring them, so live mussels were enumerated in situ and not measured.

Live mussel densities ranged from 0 per m^2 (Unit 8) to 110.52 per m^2 (Unit 1). Live mussel densities were significantly greater in Units 1, 2, 3, and 4 than in the six downstream-most units. Dead mussel densities ranged from 0 per m^2 (Unit 10, where only 1 live mussel was observed) to 6.64 per m^2 (Unit 2) (Table 1).

Table 1. Bed habitat area; subsample area; live, dead, and total mussel counts; and mussel density estimates at each of the ten mussel beds that were sampled.

Unit #	Bed Habitat Area (m2)	# Quadrates sampled	Area sampled (m2)	Live Mussels counted	Dead Mussels counted	Total Mussels counted	Est. Bed Density Live per m2	Est. Bed Density Dead per m2
1	69	65	4.0625	449	34	483	110.52	8.37
2	68	59	3.6875	128	98	226	34.71	26.58
3	73	56	3.5	180	30	210	51.43	8.57
4	743	107	6.6875	201	111	312	30.06	16.60
5	100	n/a	100	9	9	18	0.09	0.09
6	37	n/a	37	47	1	48	1.27	0.03
7	49	n/a	49	3	22	25	0.06	0.45
8	80	78	4.875	0	20	20	0.00	4.10
9	181	n/a	181	3	13	16	0.02	0.07
10	134	n/a	134	1	0	1	0.01	0.00

Of the mussels counted at Units 7, 8, and 9, 88%, 100%, and 81% were dead, respectively. 50% of the mussels that were observed in Unit 5 were dead, and fewer than 43% were dead in each of the remaining sites (Figure 3).

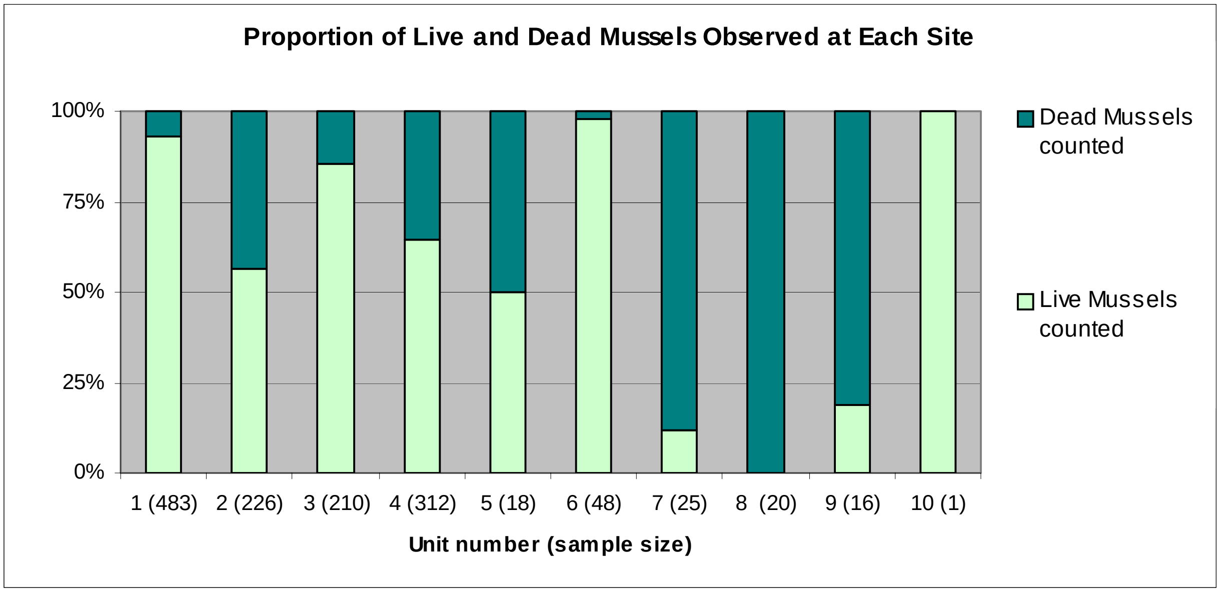


Figure 3. Proportion of live and dead mussels counted at each site.

Population Age Structure

The length of the longest shell axis of Bear Creek *M. falcata* has been determined to reflect the age of the mussel in the relationship:

Shell length (mm) = 30.632[ln(x)] - 27.583 (r^2 = 0.87; Toy, 1998)

The youngest live mussel observed within the study quadrats during this survey was approximately 5 years old (20mm), found in Unit 4. One 3.5 and one 3 year old live mussel (10-mm and 7-mm, respectively) were found in Unit 4 outside of the study quadrats. The oldest mussel that was observed was approximately 124 years old (120mm), found in Unit 2. Similar to Toy's observations, Washington Trout observations reflect a scarcity of young (<15 years old, or 55mm) mussels in Bear Creek. Figures 4 thorough 12 are shell length histogram graphs for the live *M. falcata* surveyed at the Washington Trout study sites. Note that the frequency axis scale is not the same for each graph, and that the black line represents the moving average. It was not possible to create length histograms for Units 8 and 10 because insufficient numbers of mussels were observed.

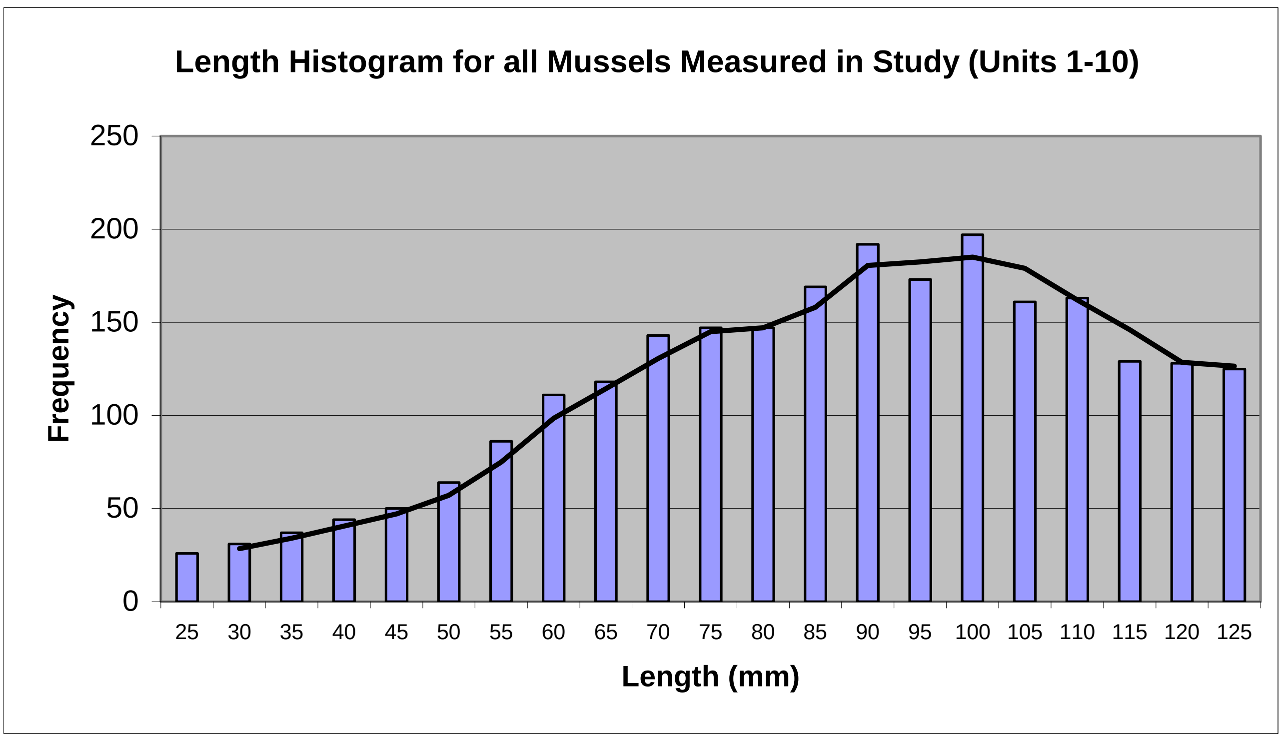


Figure 4. Bear Creek *M. falcata* length histogram totaled for all ten subsample Units. The dark line represents the moving average.

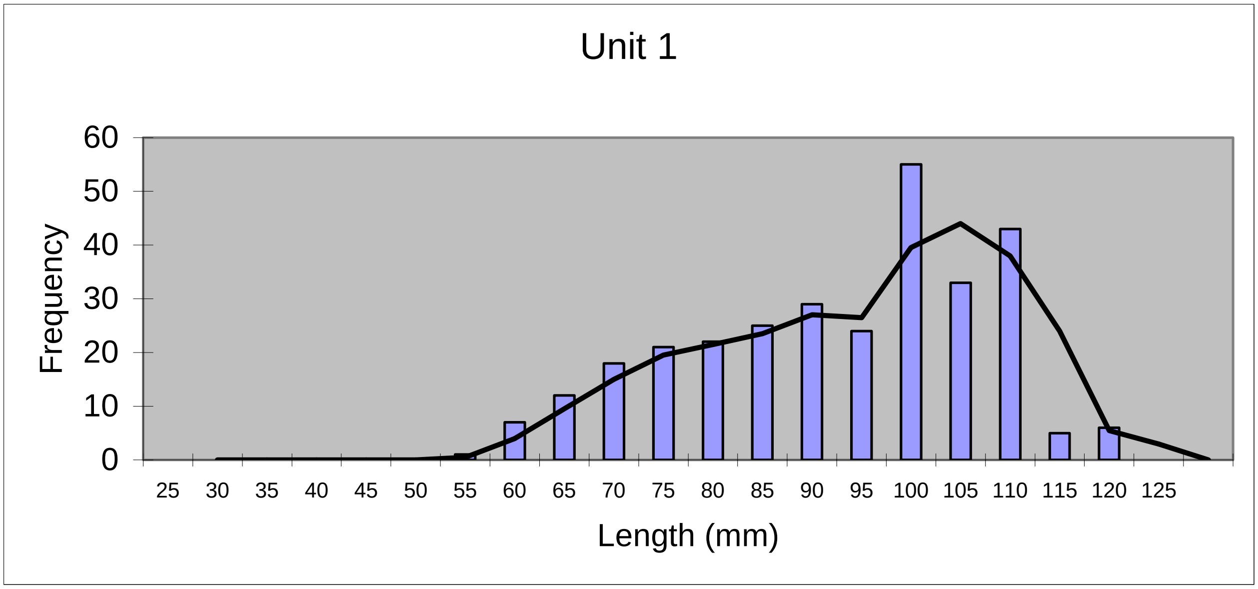


Figure 5. Bear Creek *M. falcata* length histogram at Unit 1. The dark line represents the moving average.

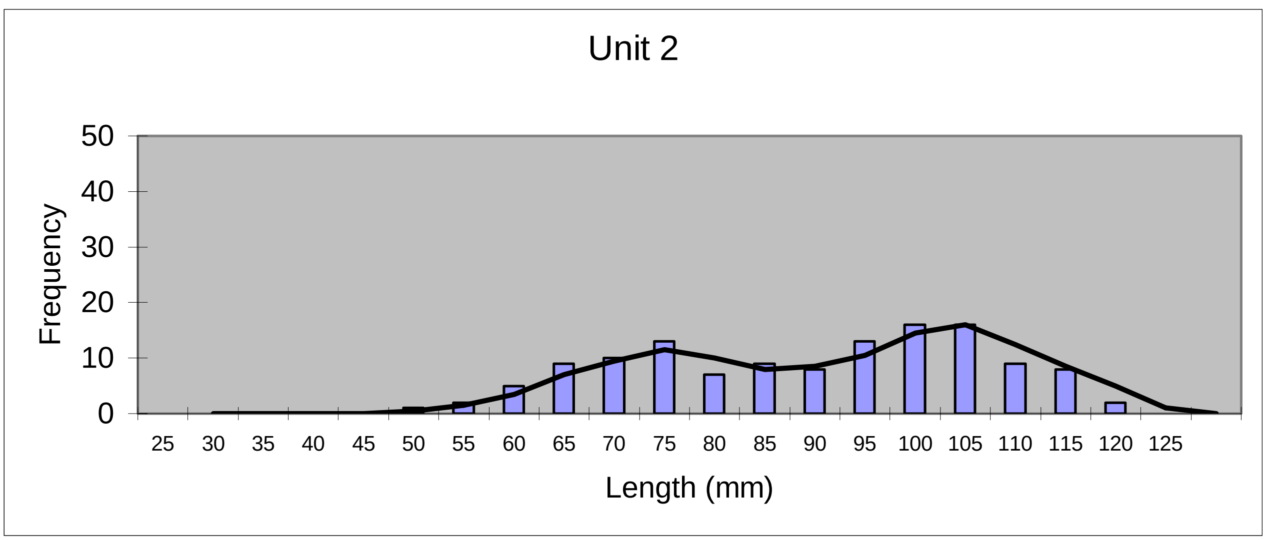


Figure 6. Bear Creek *M. falcata* length histogram at Unit 2. The dark line represents the moving average.

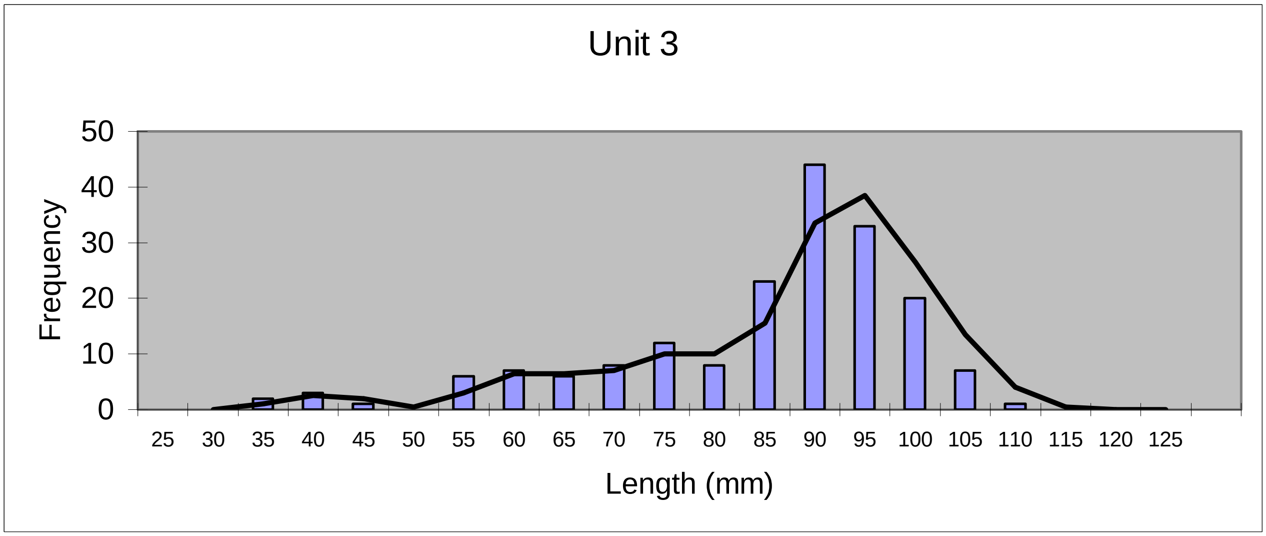


Figure 7. Bear Creek *M. falcata* length histogram at Unit 3. The dark line represents the moving average.

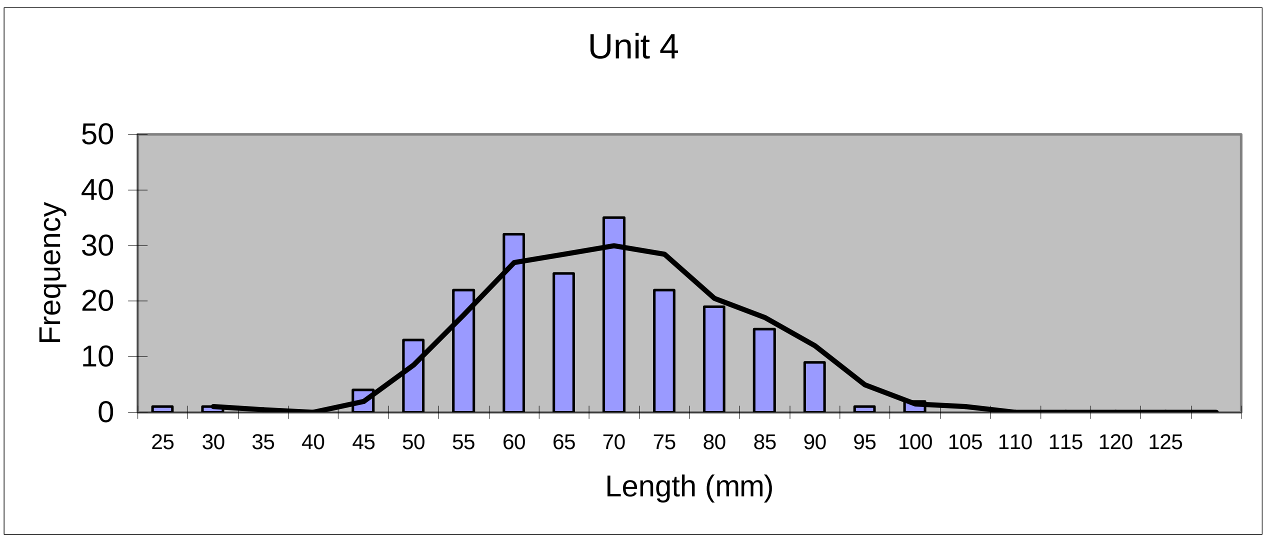


Figure 8. Bear Creek *M. falcata* length histogram at Unit 4. The dark line represents the moving average.

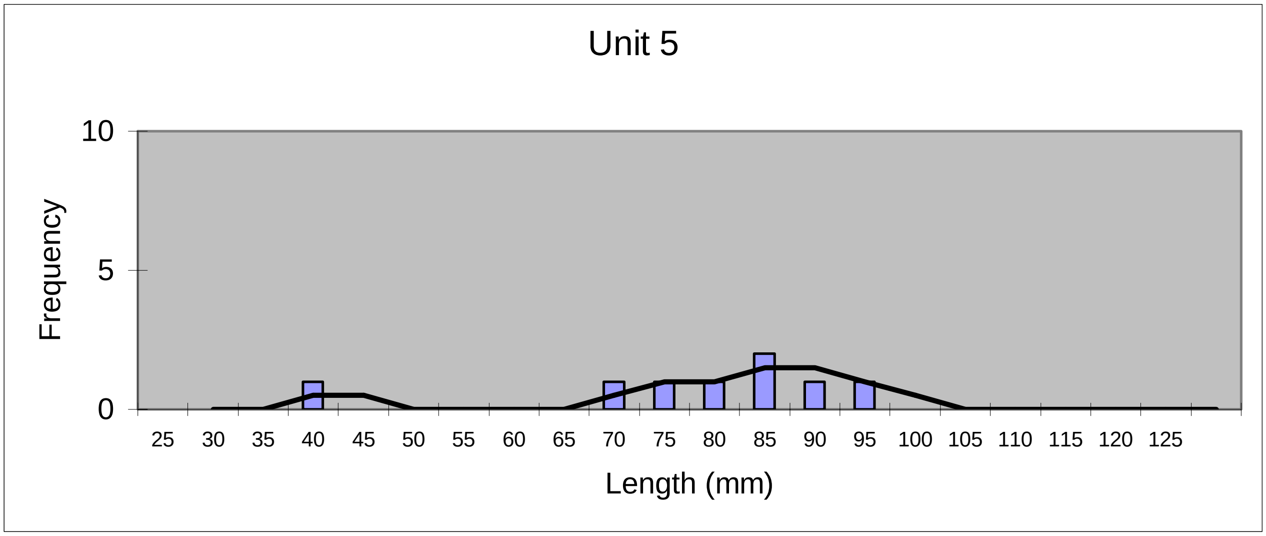


Figure 9. Bear Creek *M. falcata* length histogram at Unit 5. The dark line represents the moving average.

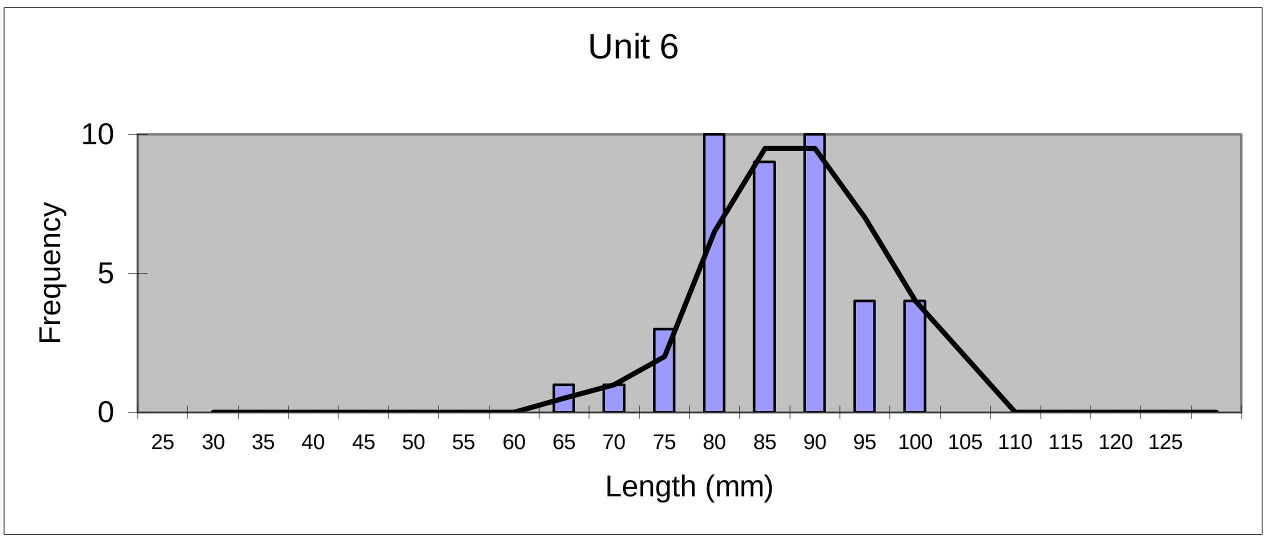


Figure 10. Bear Creek *M. falcata* length histogram at Unit 6. The dark line represents the moving average.

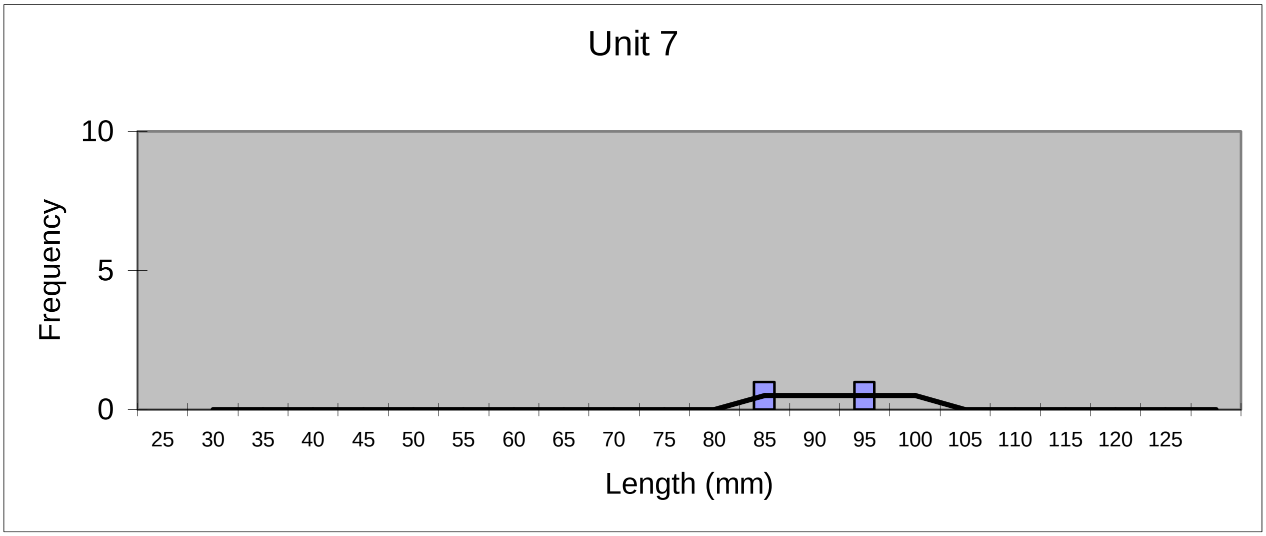


Figure 11. Bear Creek *M. falcata* length histogram at Unit 7. The dark line represents the moving average.

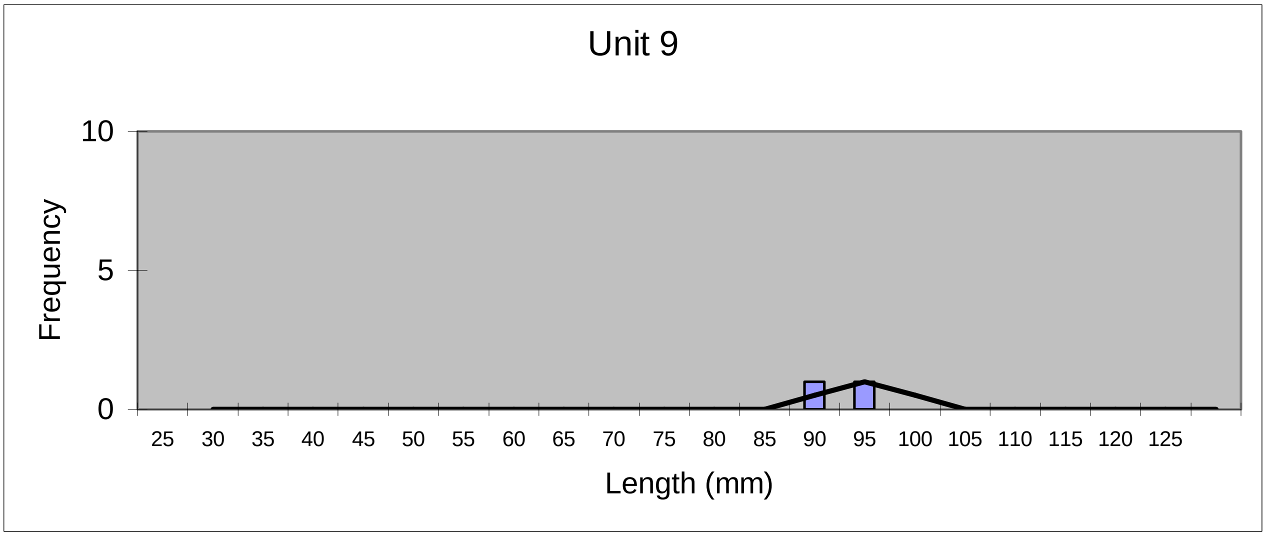
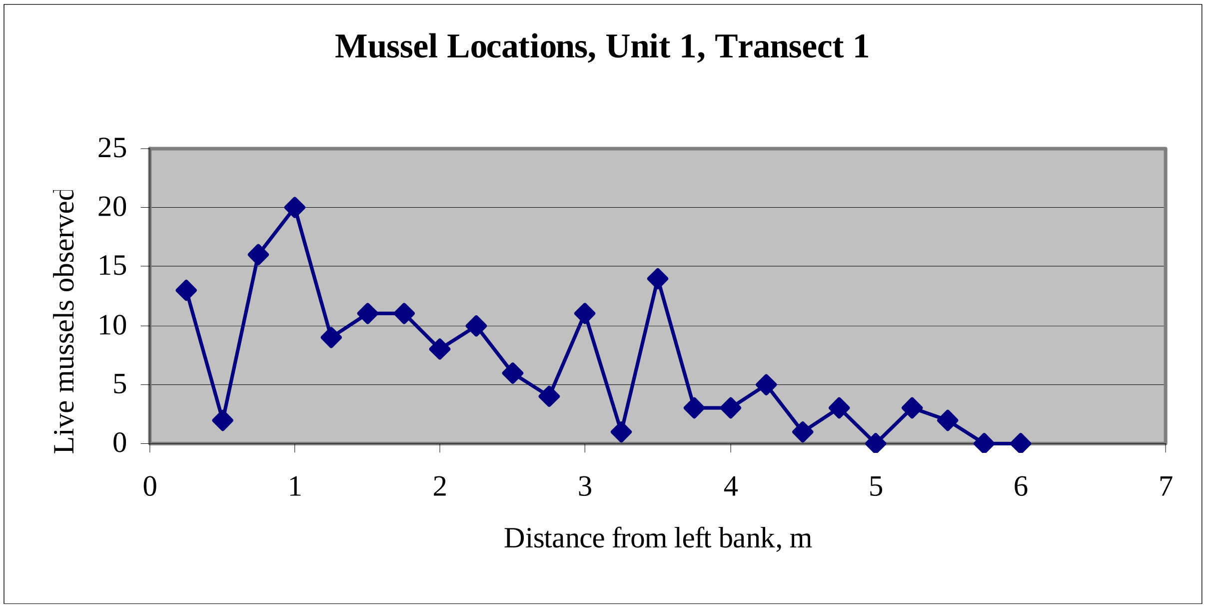


Figure 12. Bear Creek *M. falcata* length histogram at Unit 9. The dark line represents the moving average.

Mussel Habitat Choice - live mussel positioning along channel cross-section
Channel cross-sectional relative elevations were collected at each transect at each of the ten units. Live mussel densities varied with distance across each transect (likely a function of water velocity, substrate characteristics, and/or water depth), as demonstrated in Figures 13 through 30. These data will provide a baseline against which to monitor gross changes in channel morphology and positioning preferences of the mussels at the ten sample Units.



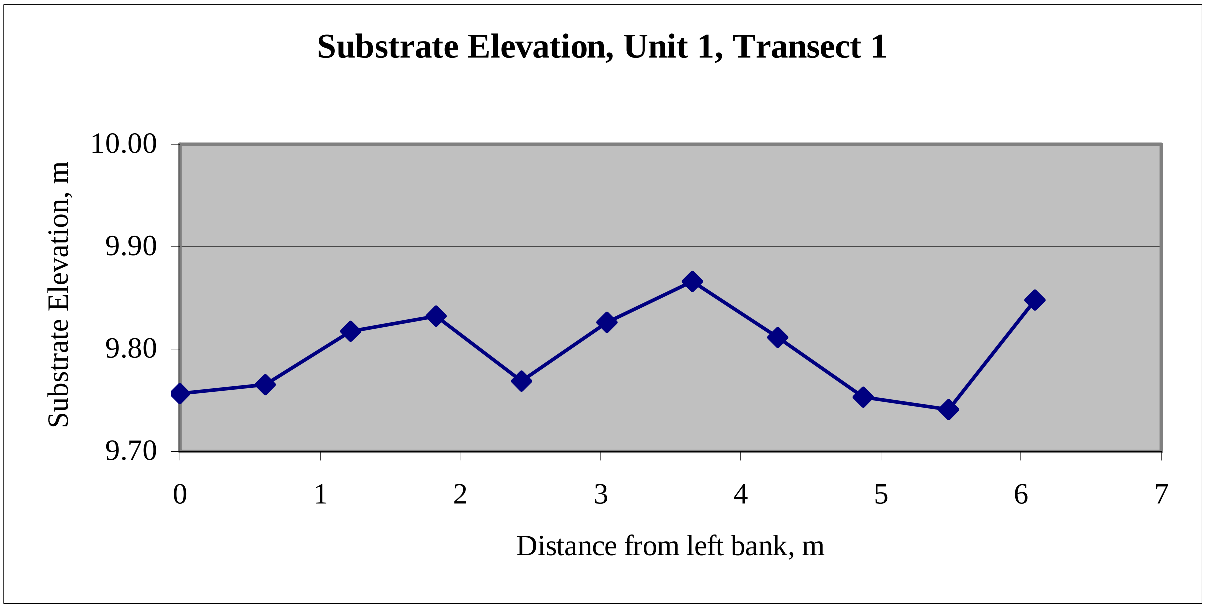
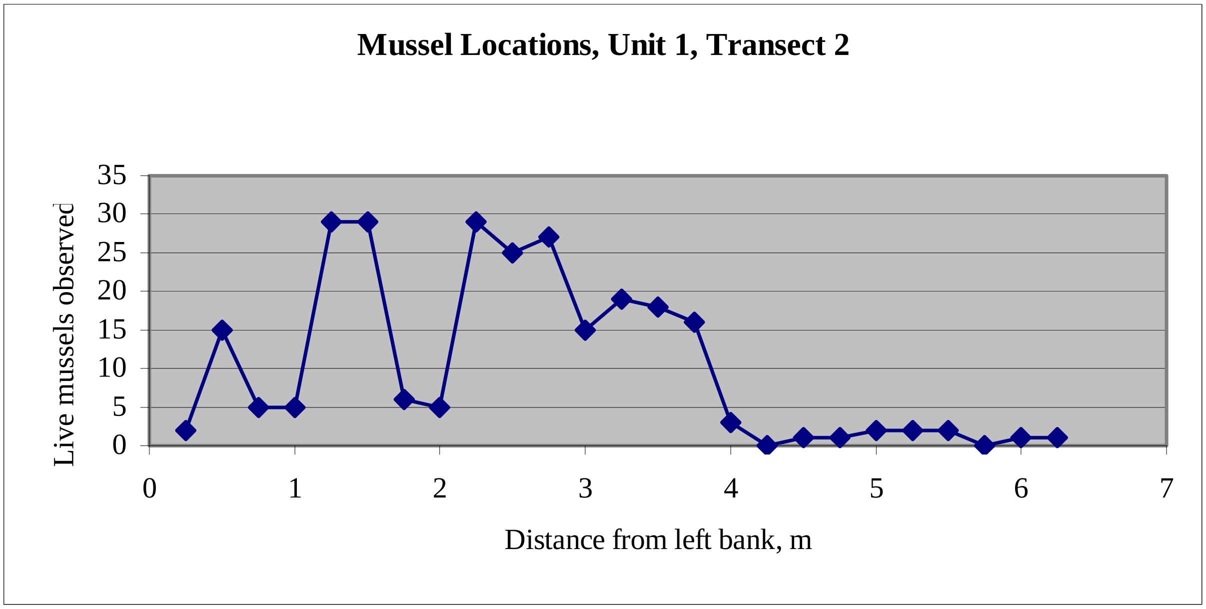


Figure 13. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



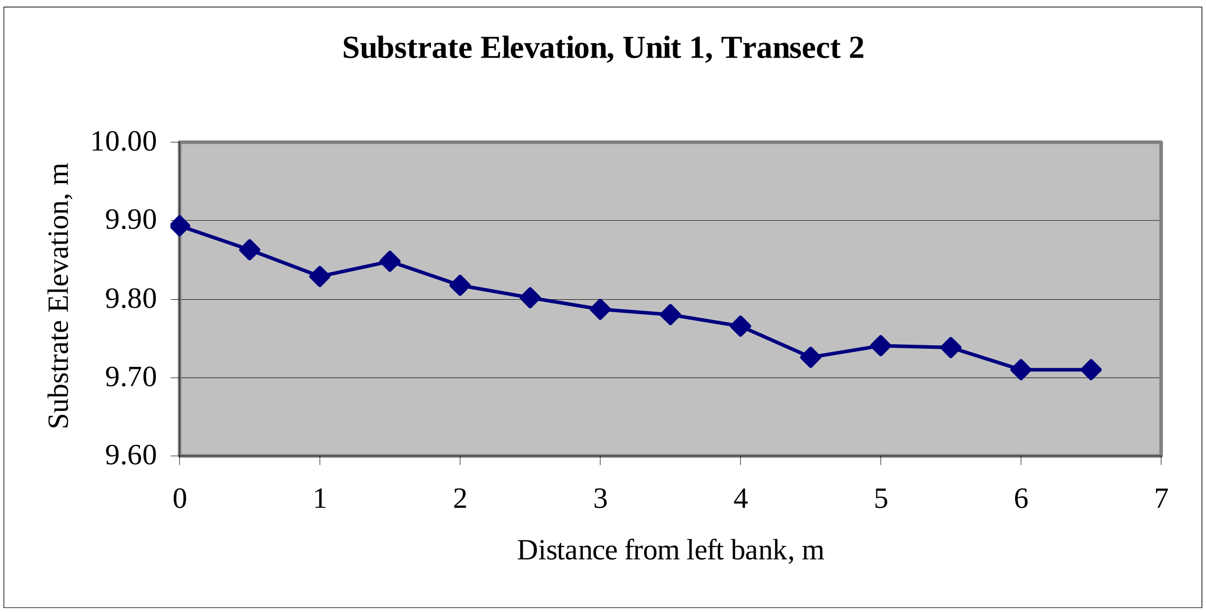
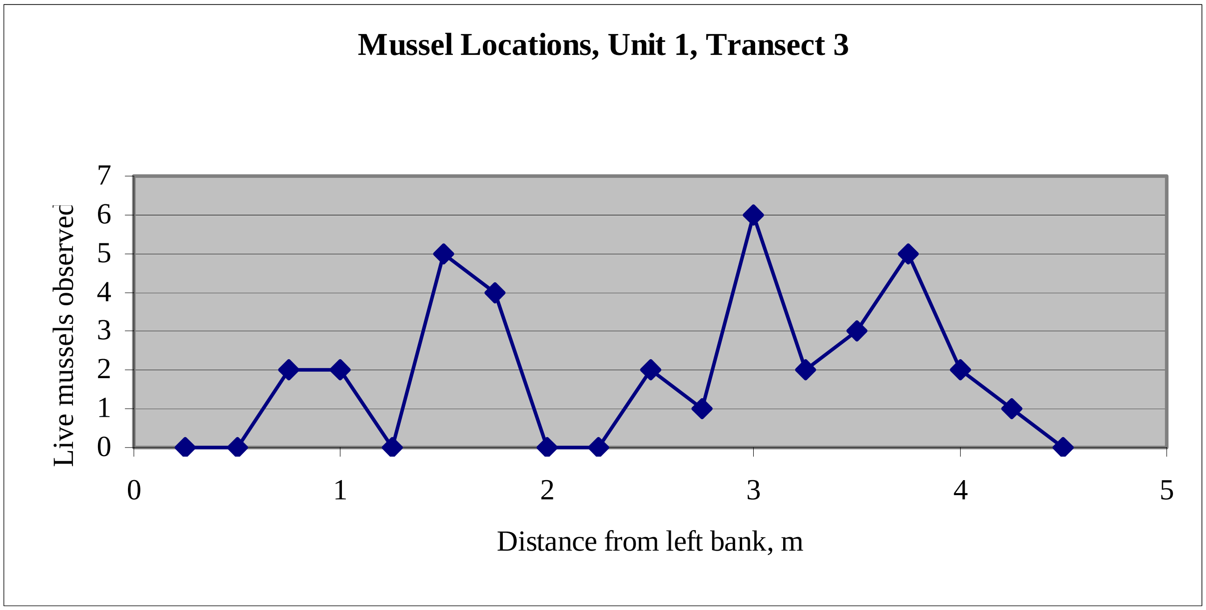


Figure 14. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



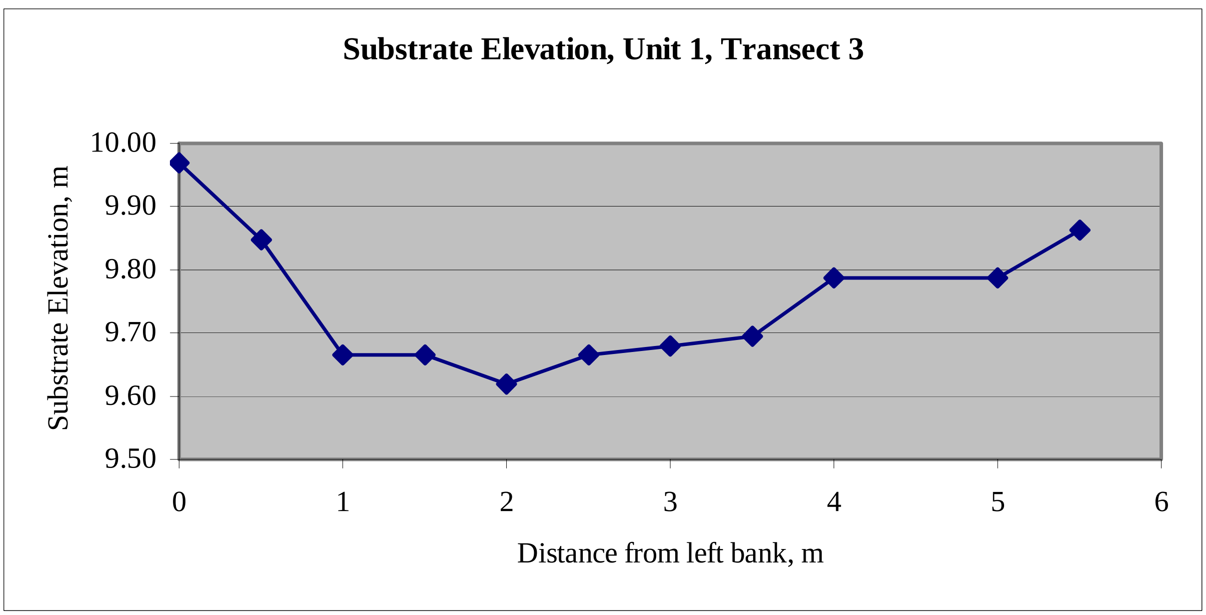
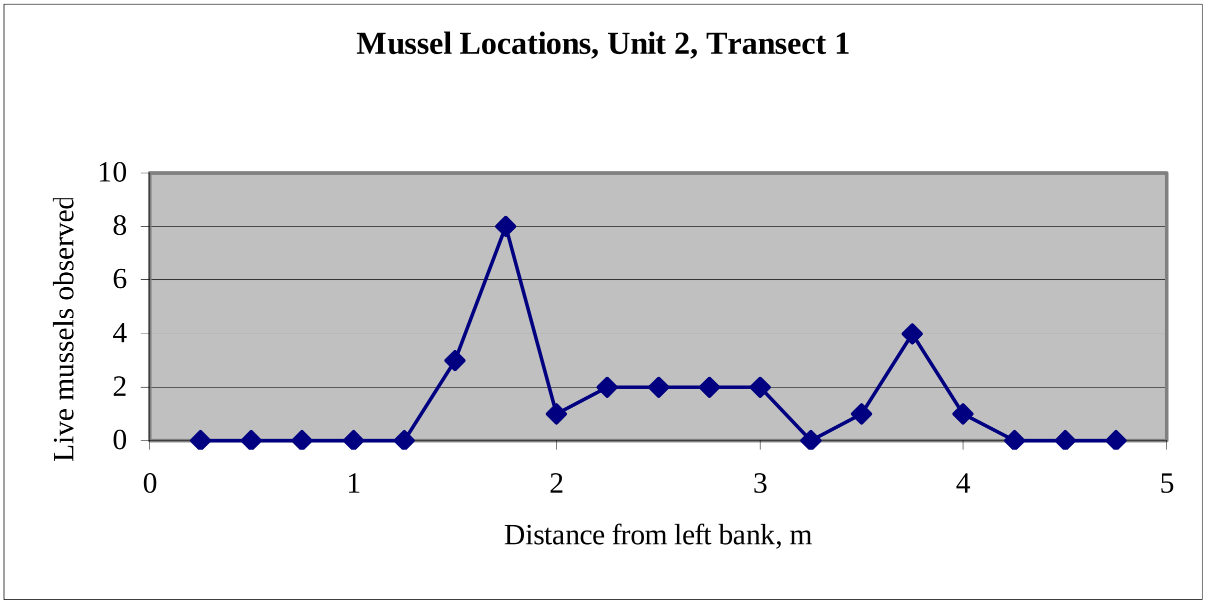


Figure 15. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



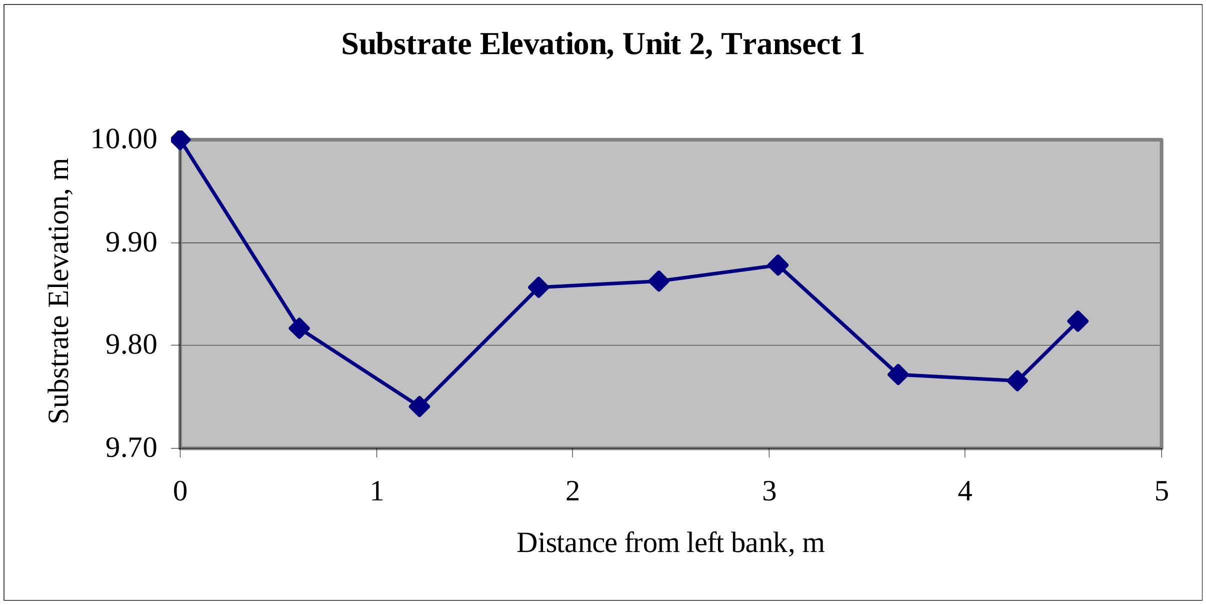
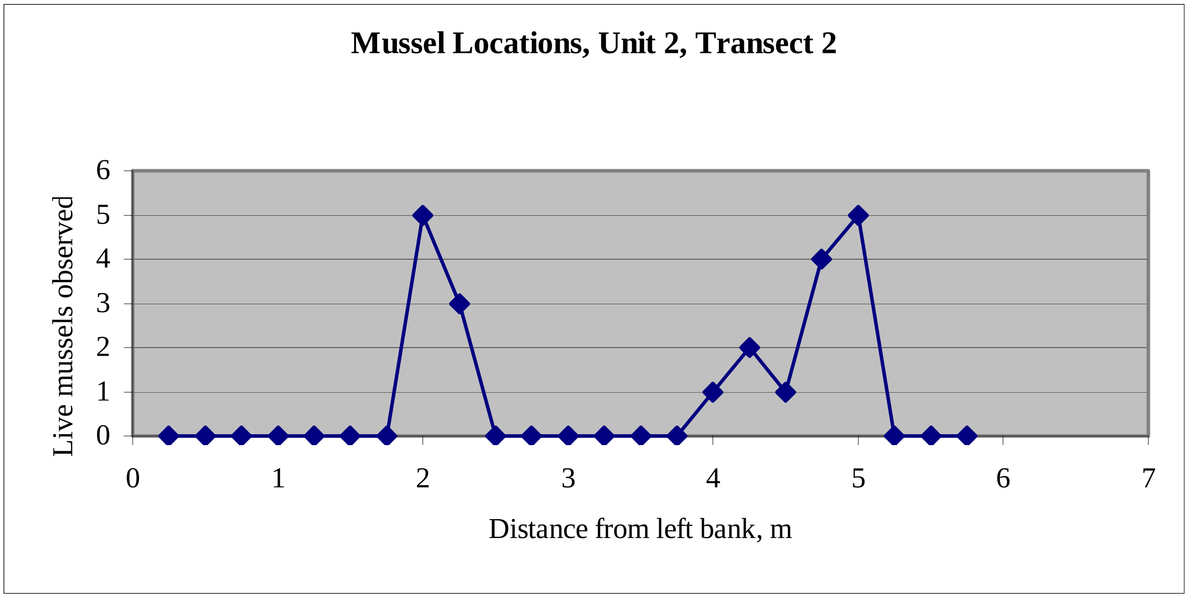


Figure 16. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



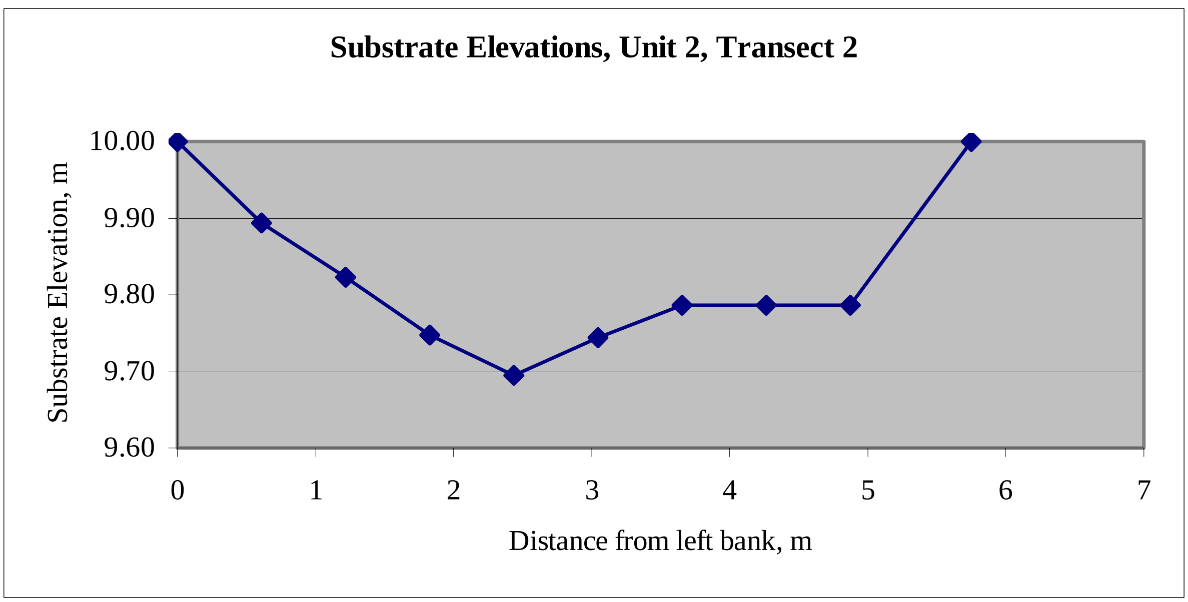
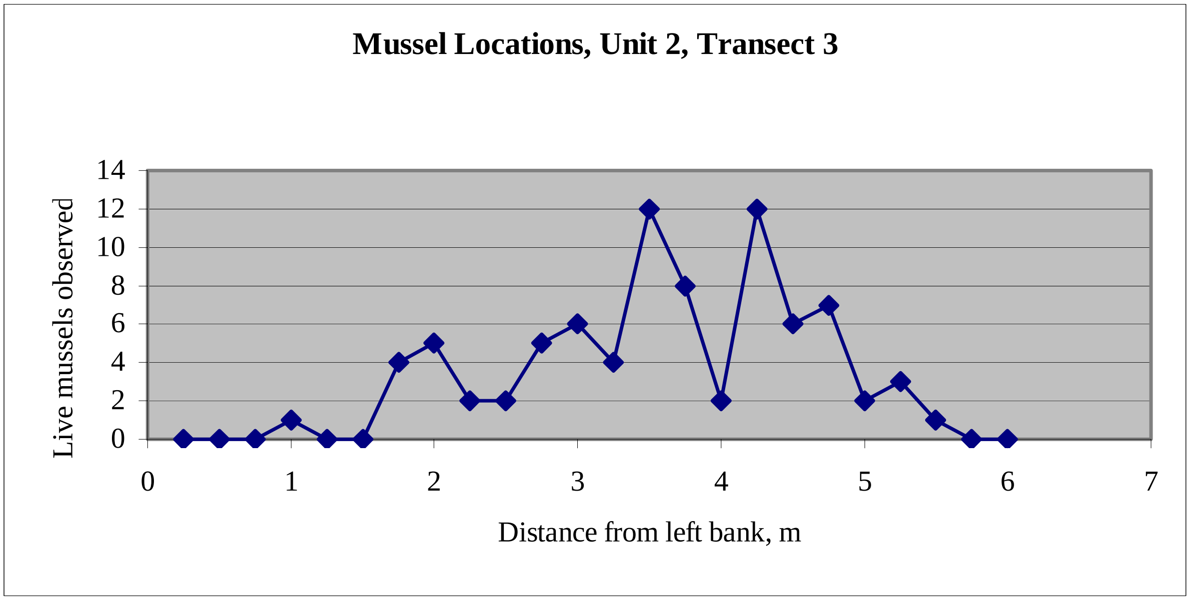


Figure 17. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



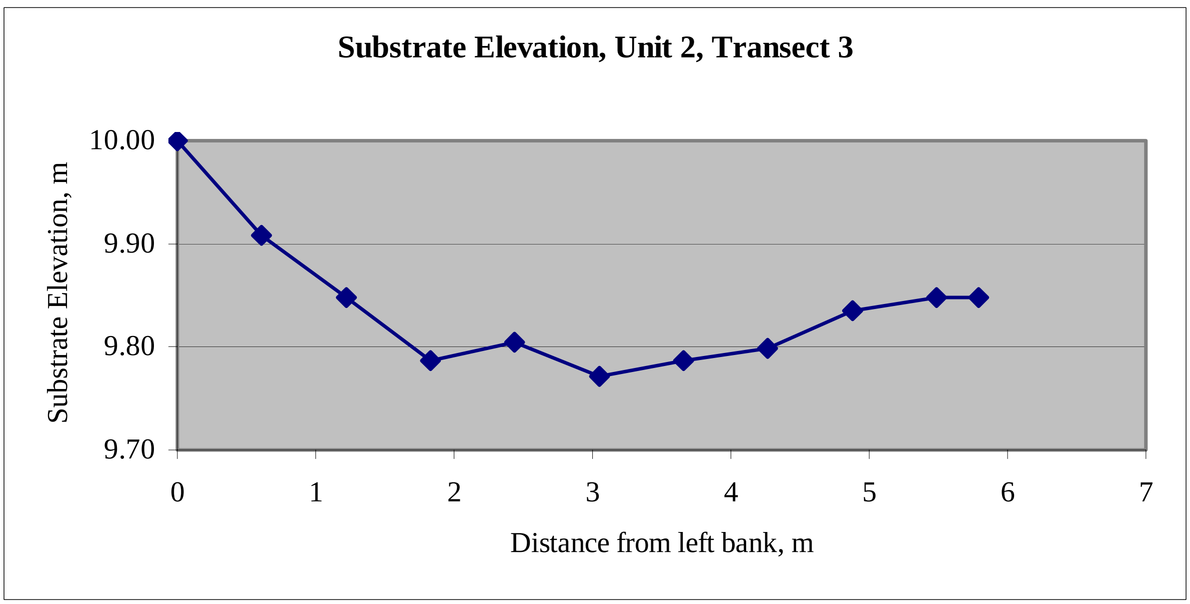
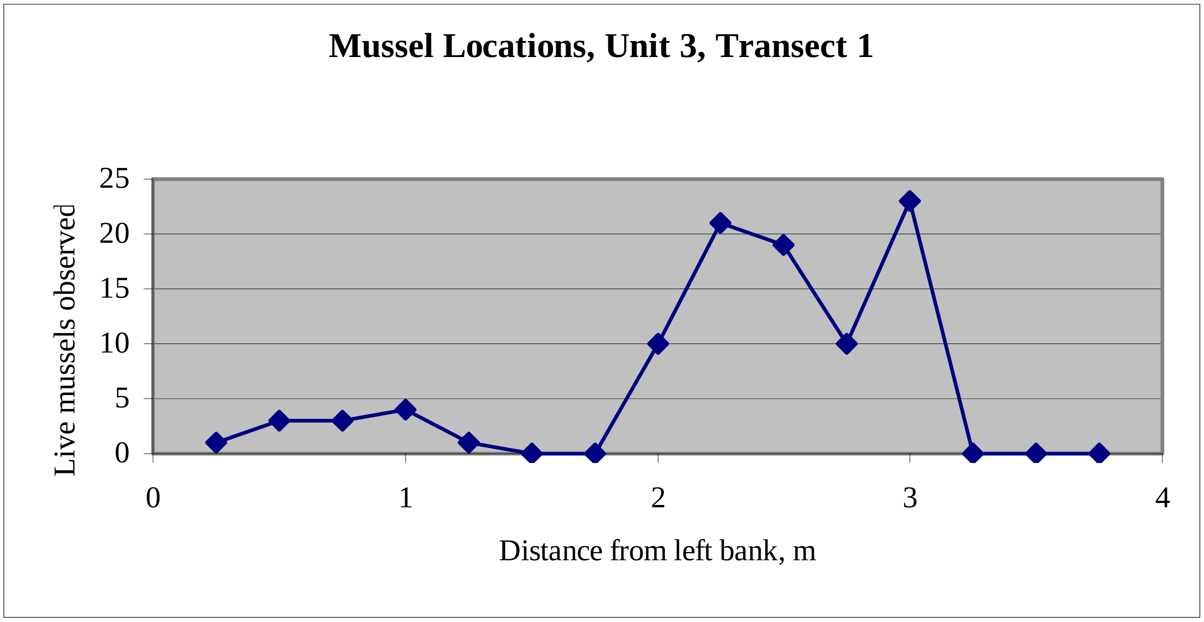


Figure 18. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



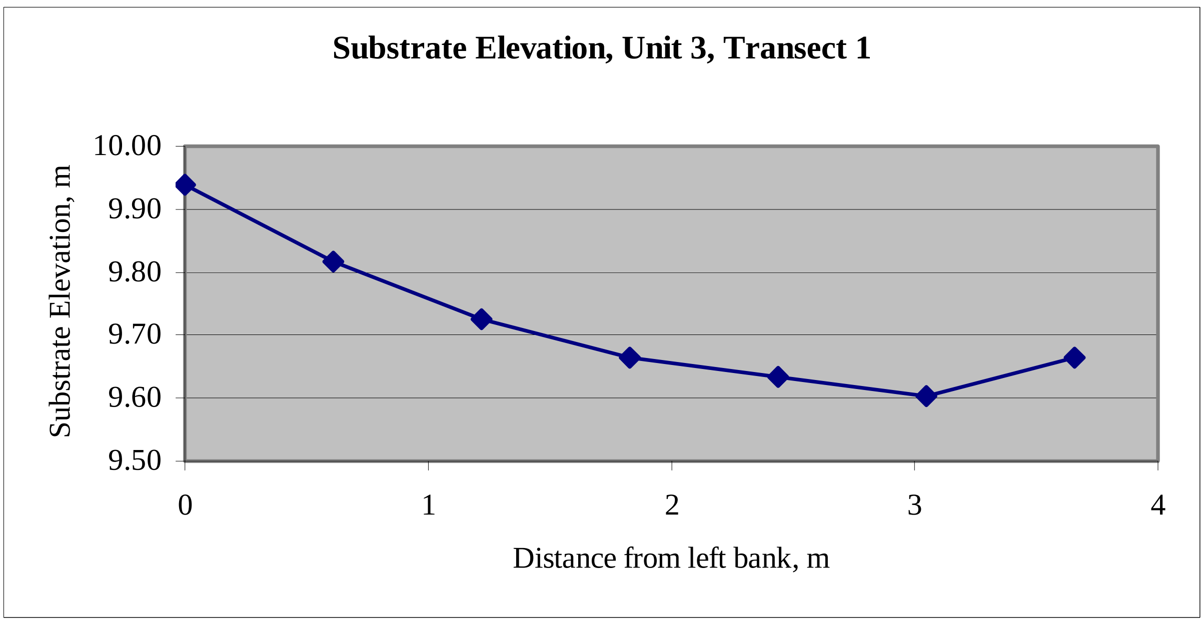
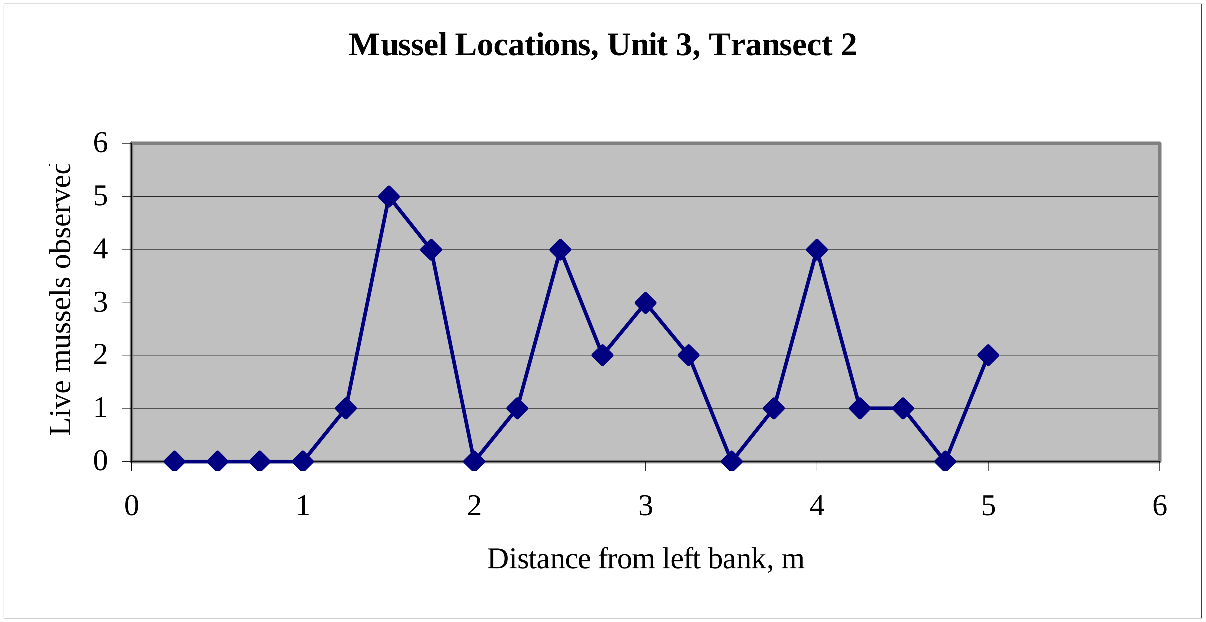


Figure 19. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



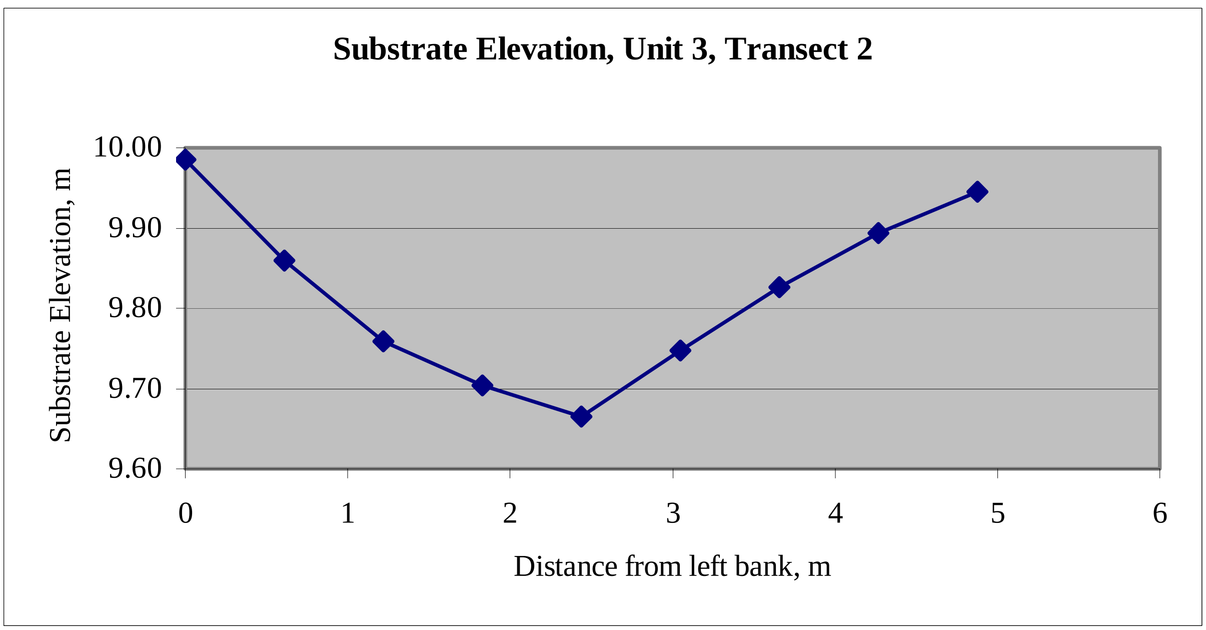
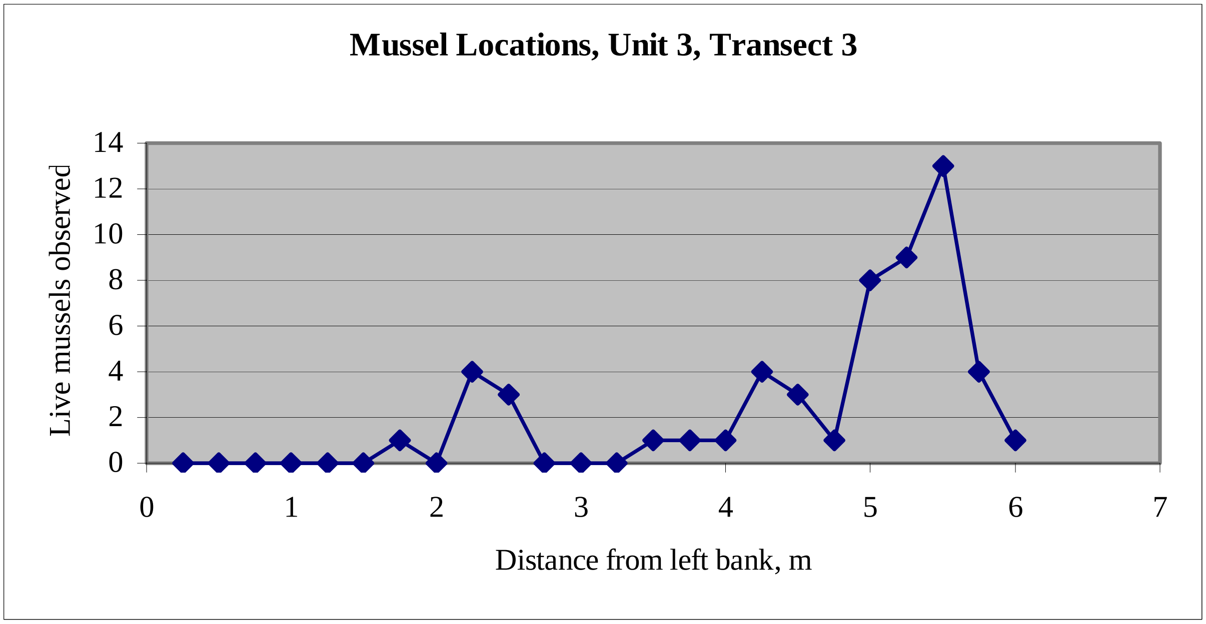


Figure 20. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



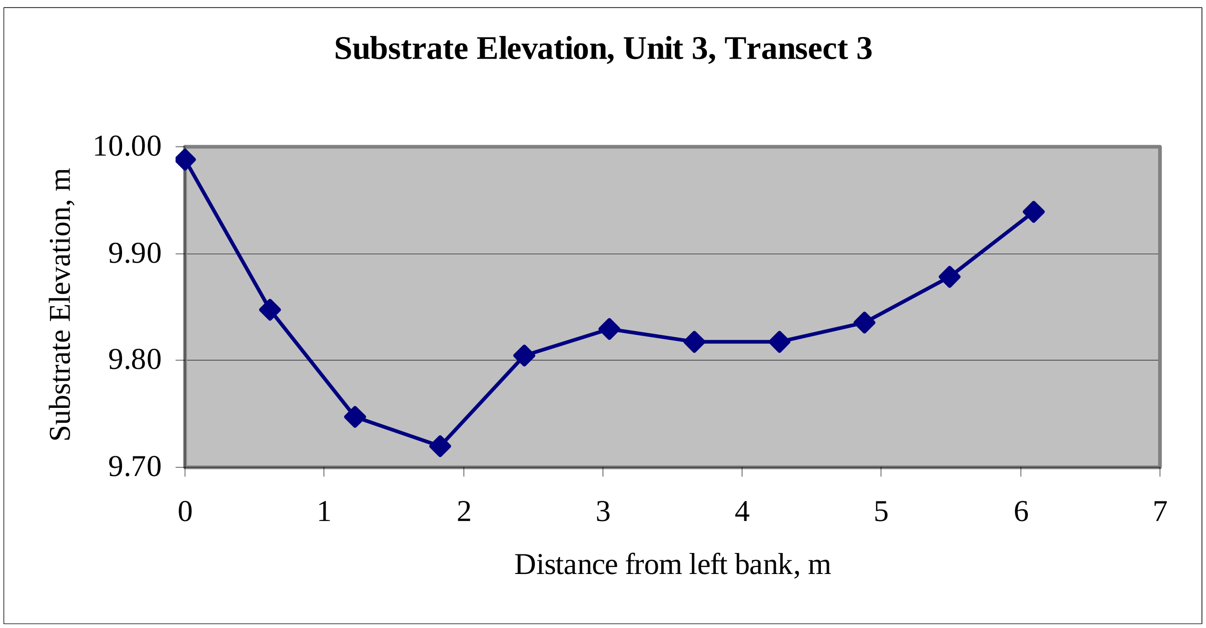
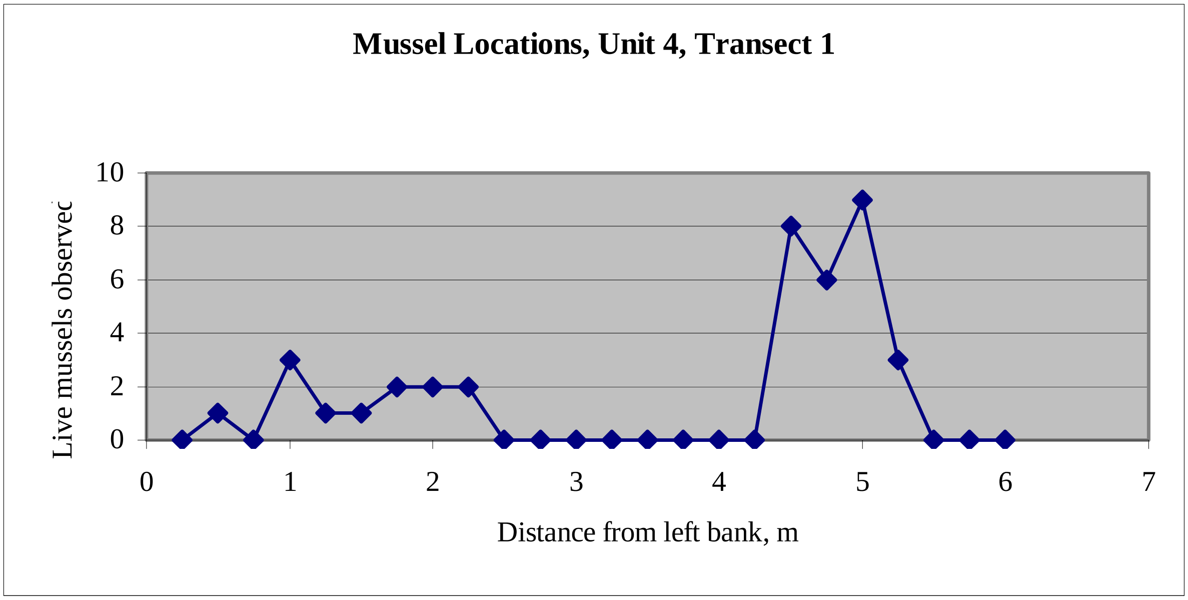


Figure 21. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



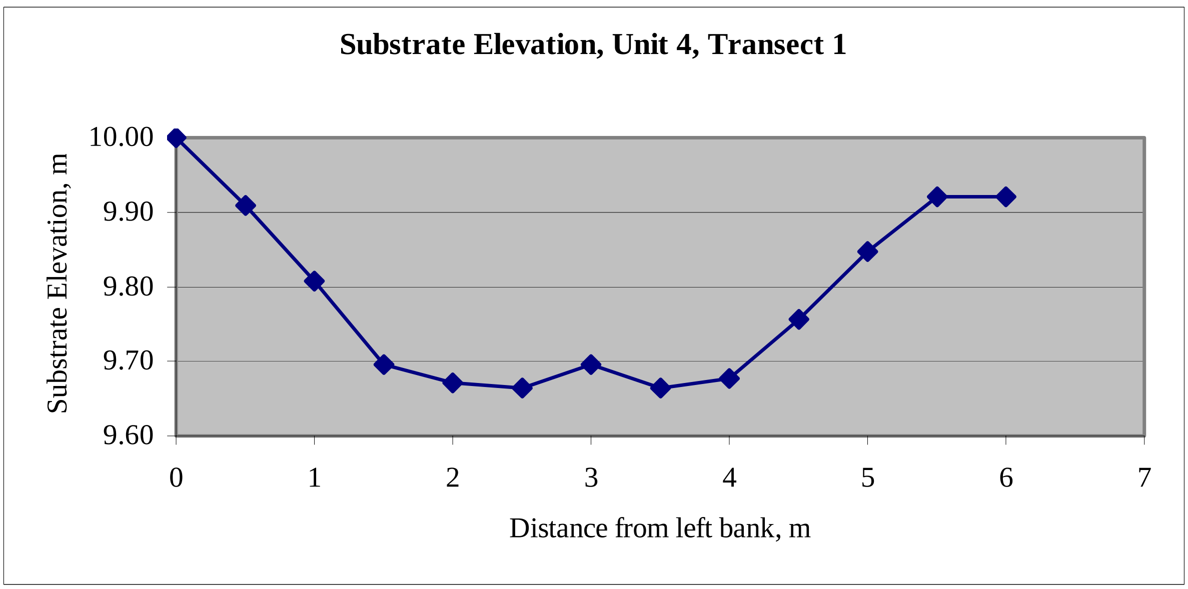
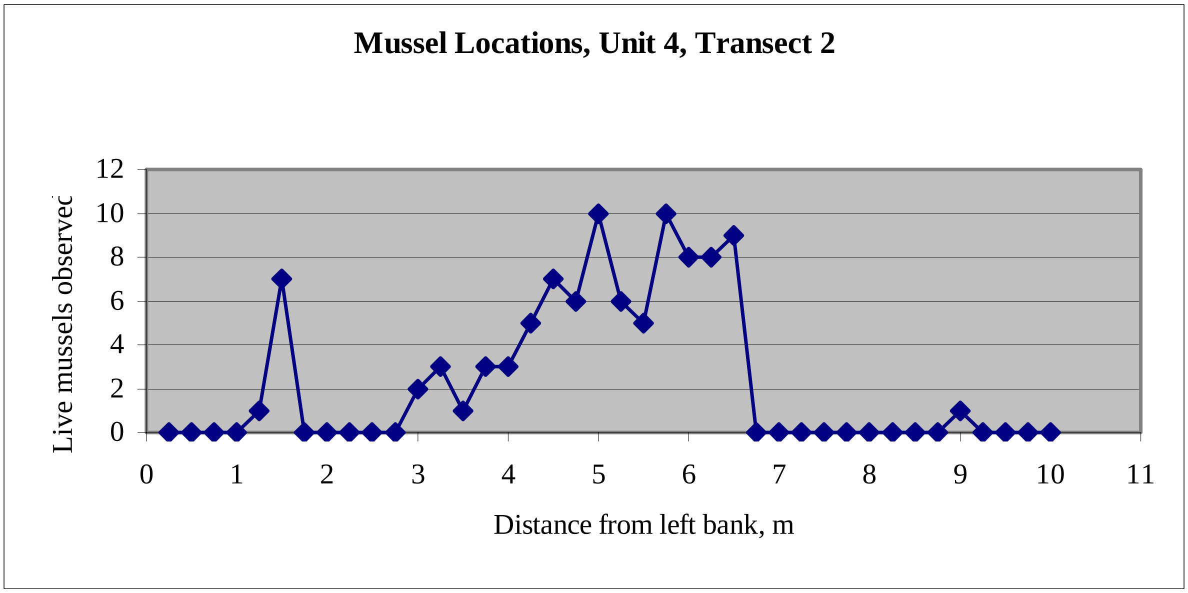


Figure 22. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



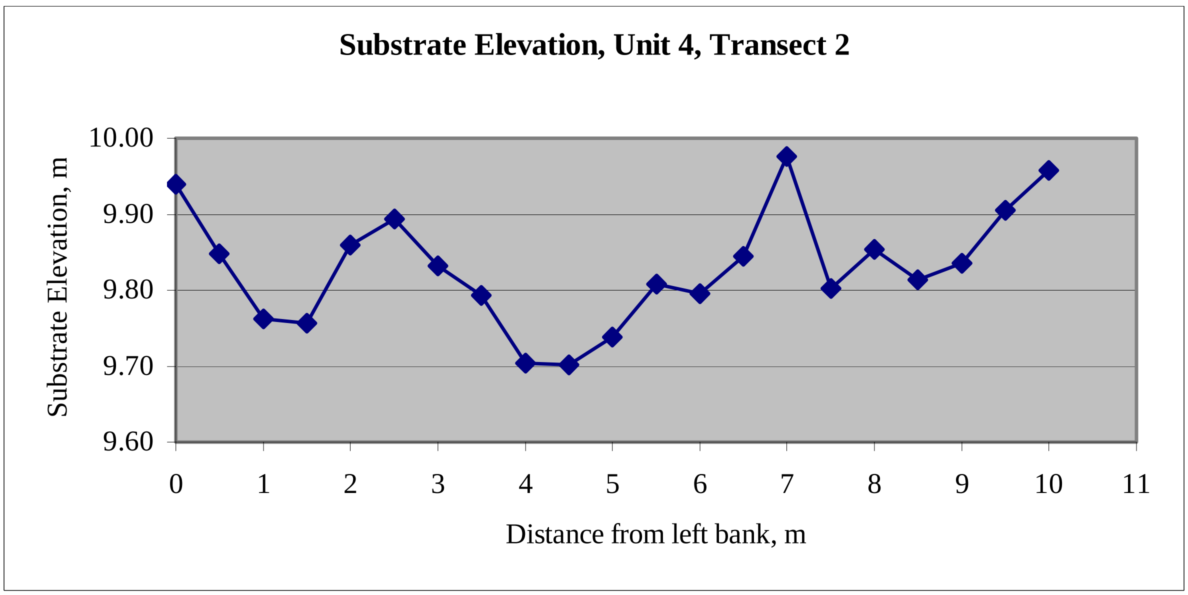
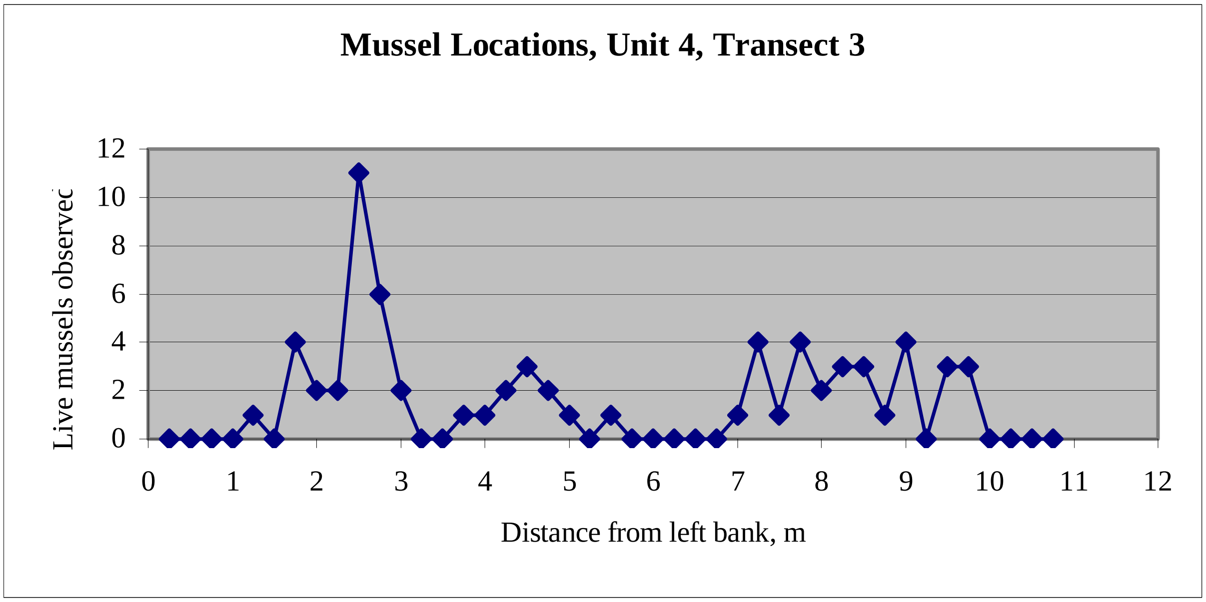


Figure 23. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



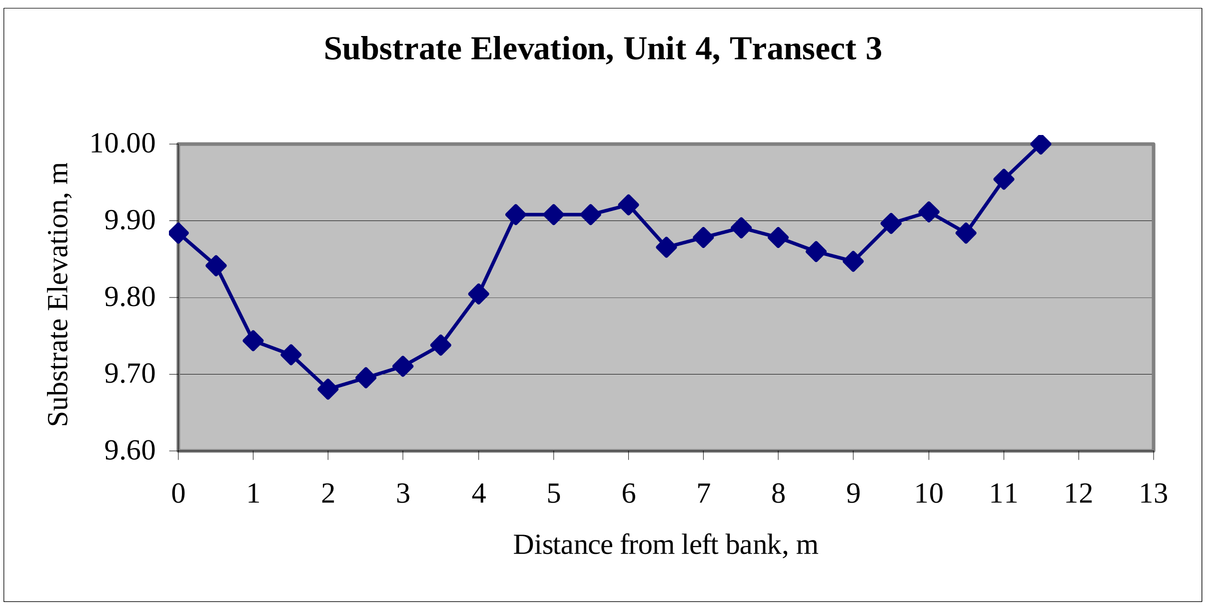
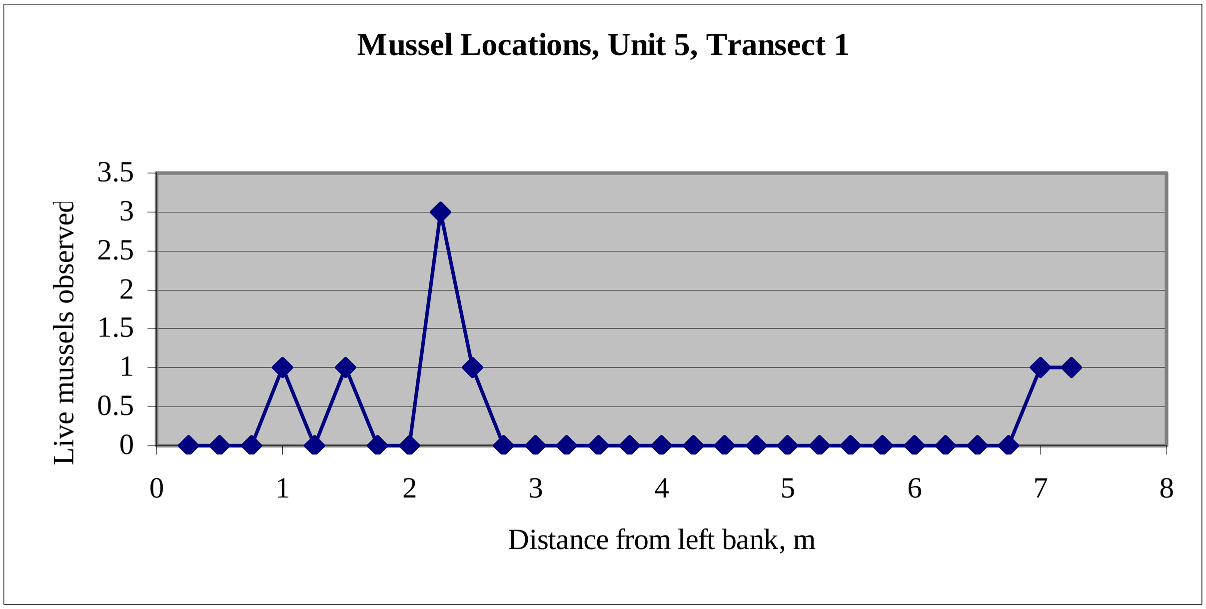


Figure 24. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



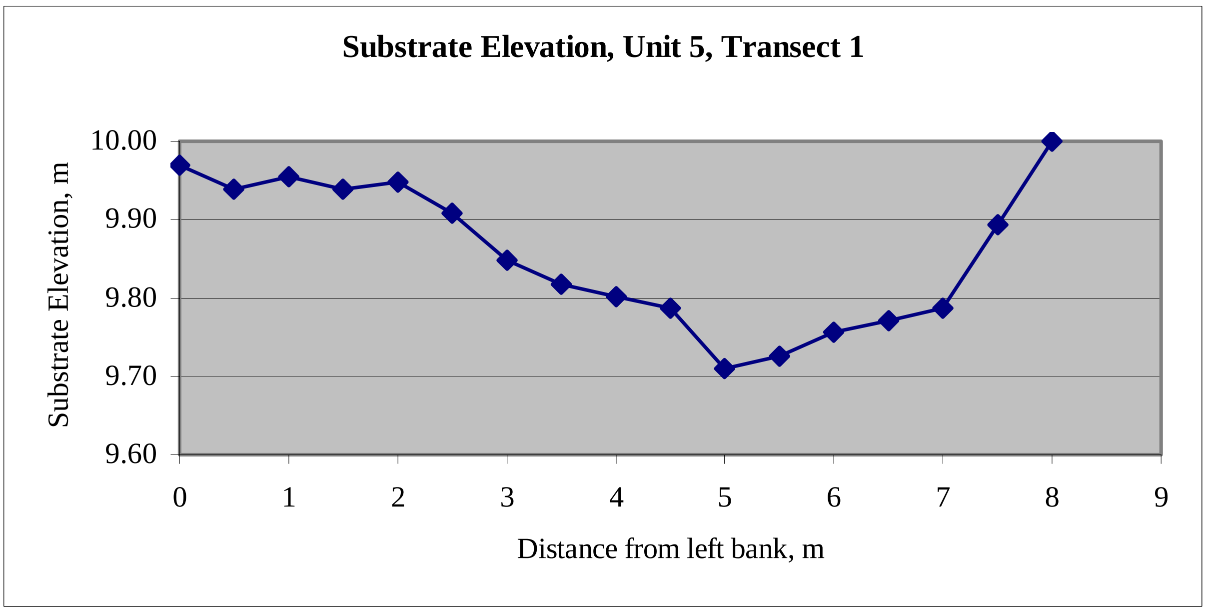
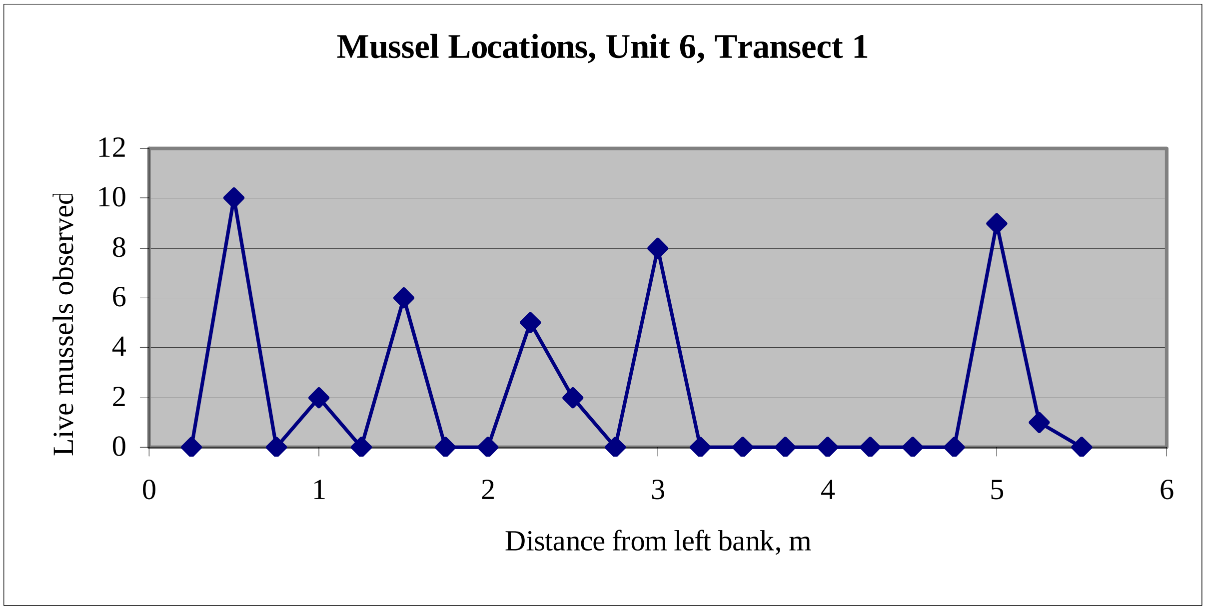


Figure 25. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



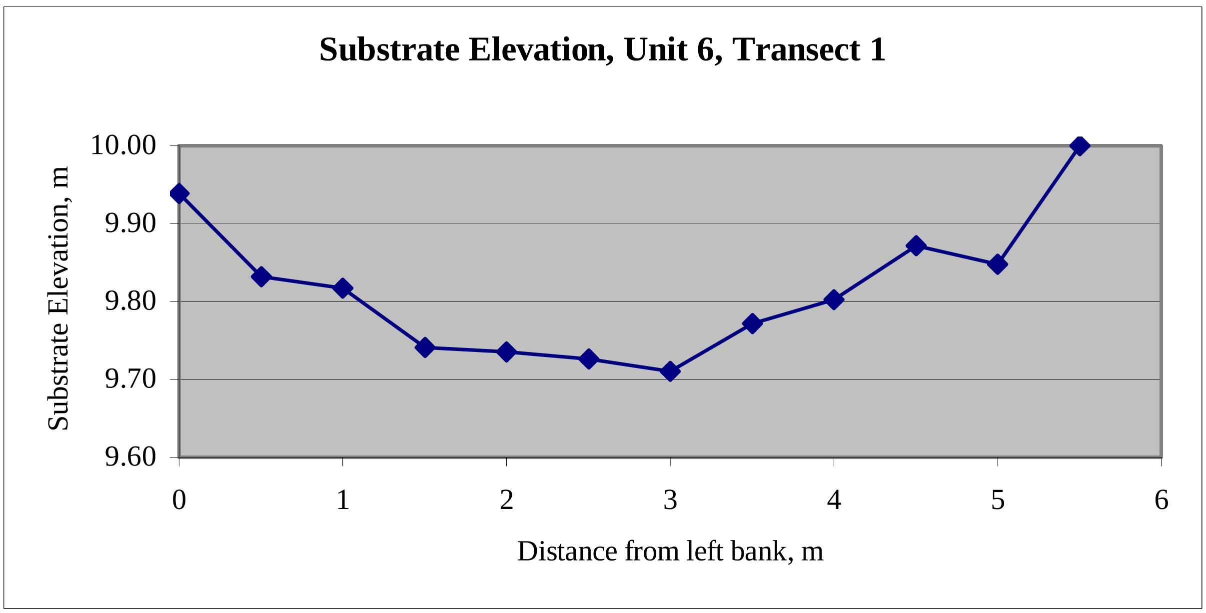
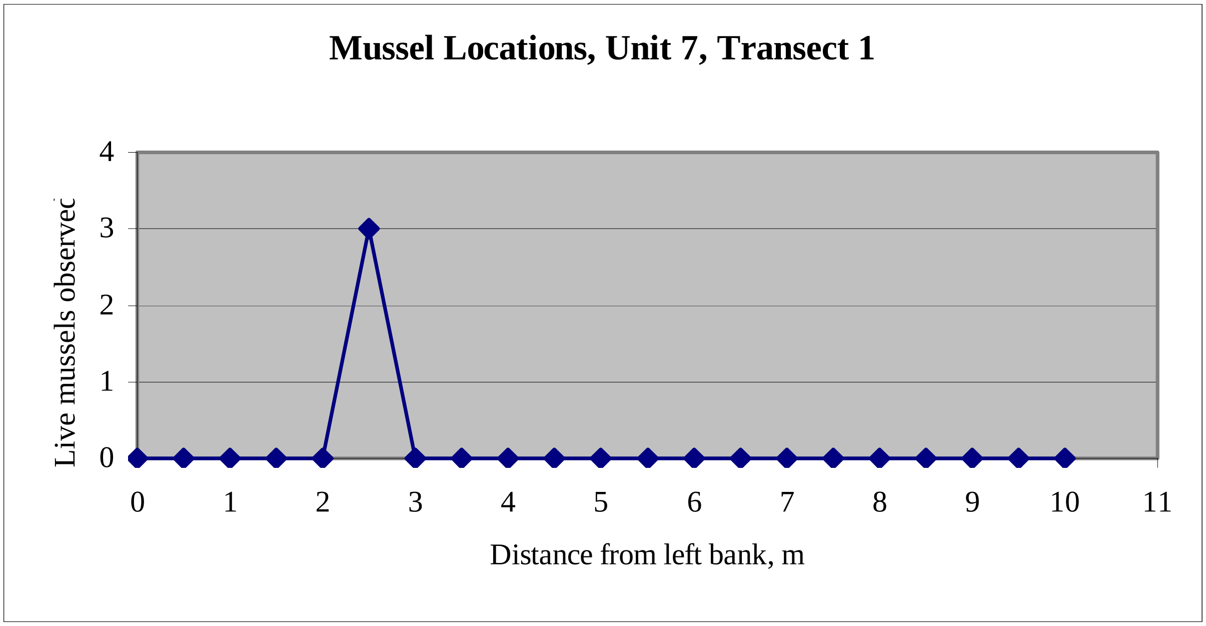


Figure 26. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



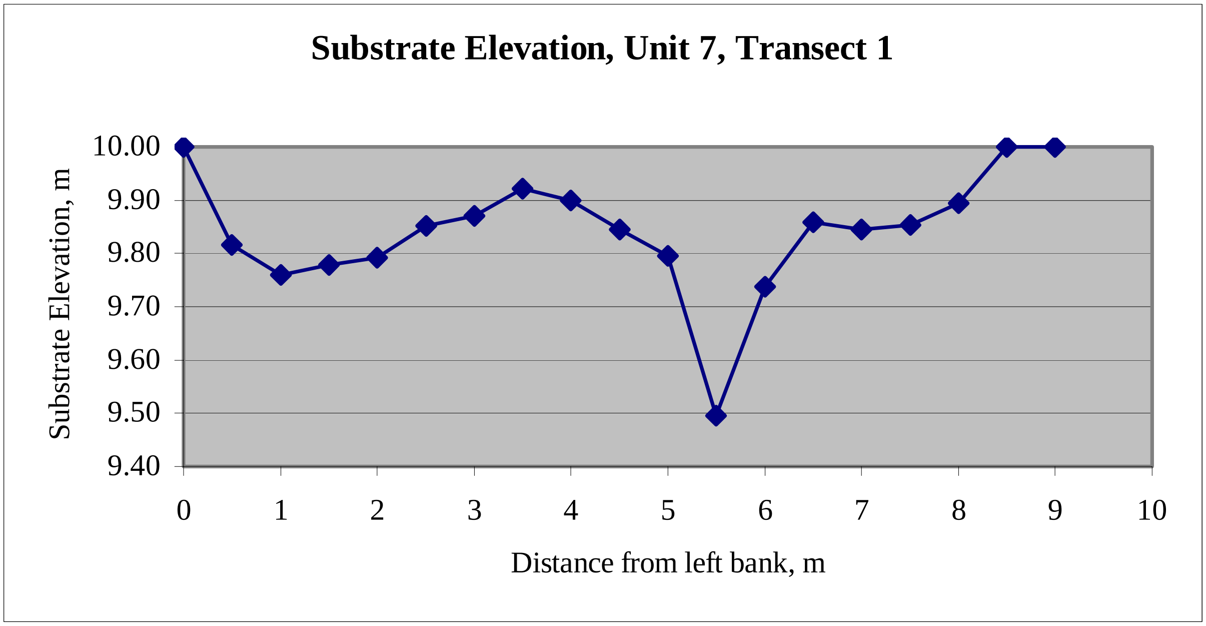


Figure 27. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.

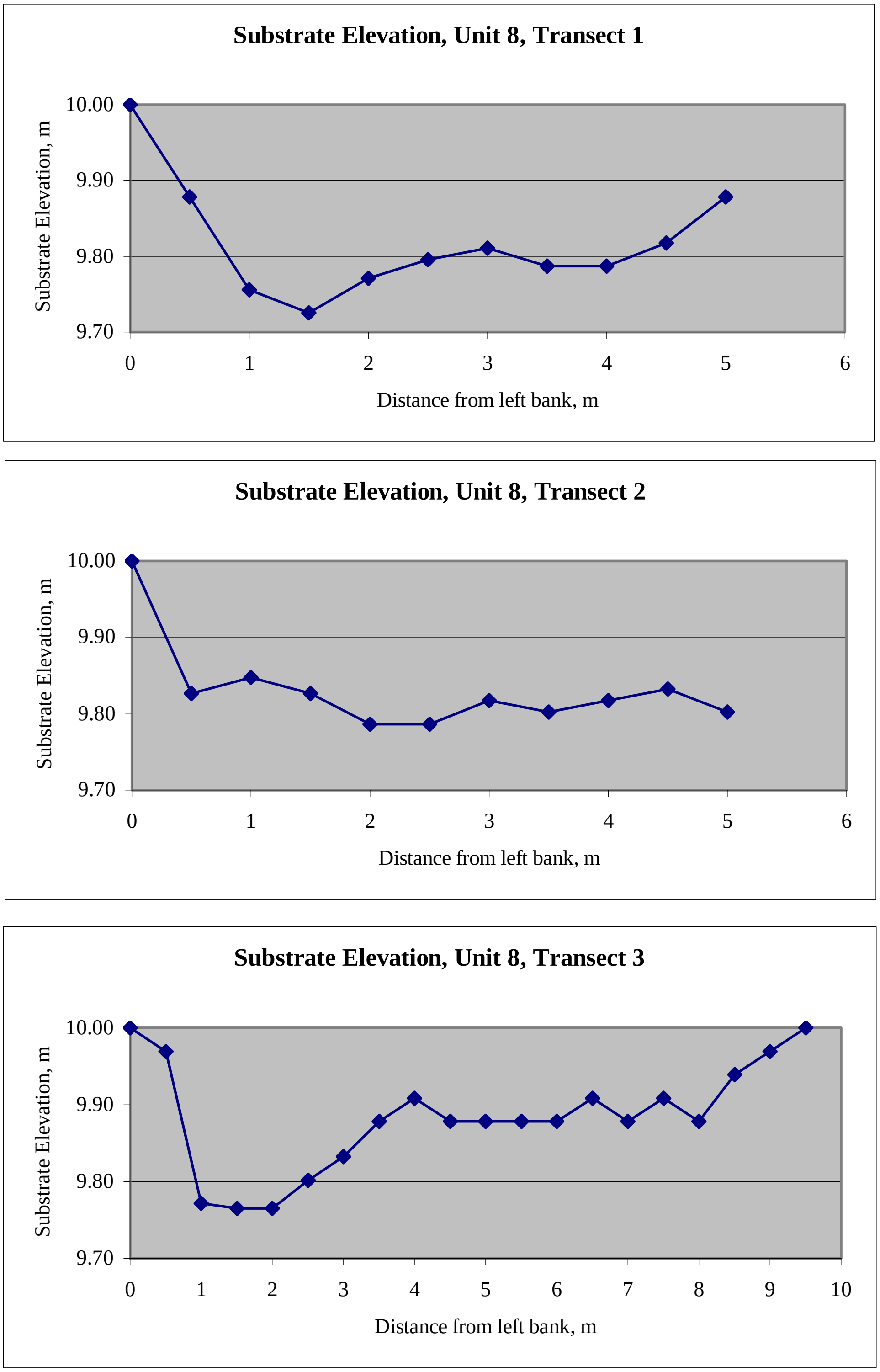
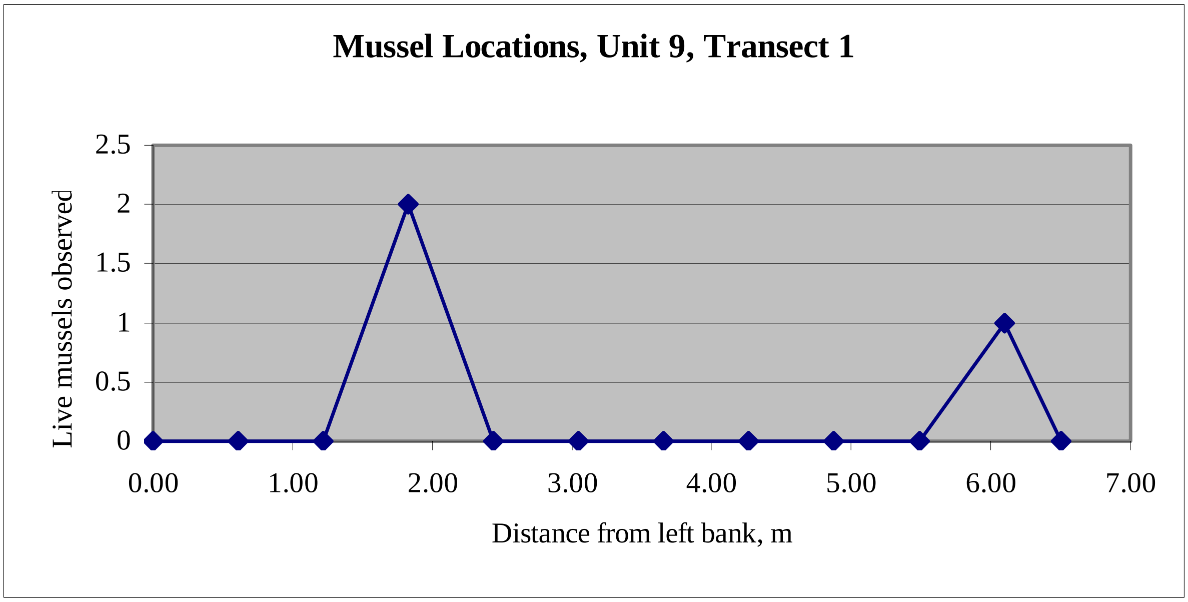


Figure 28. No live mussels were observed at Unit 8. The cross-sectional profile of the habitat unit at the three transects performed at Unit 8 are presented here. The water surface elevation is 10m.



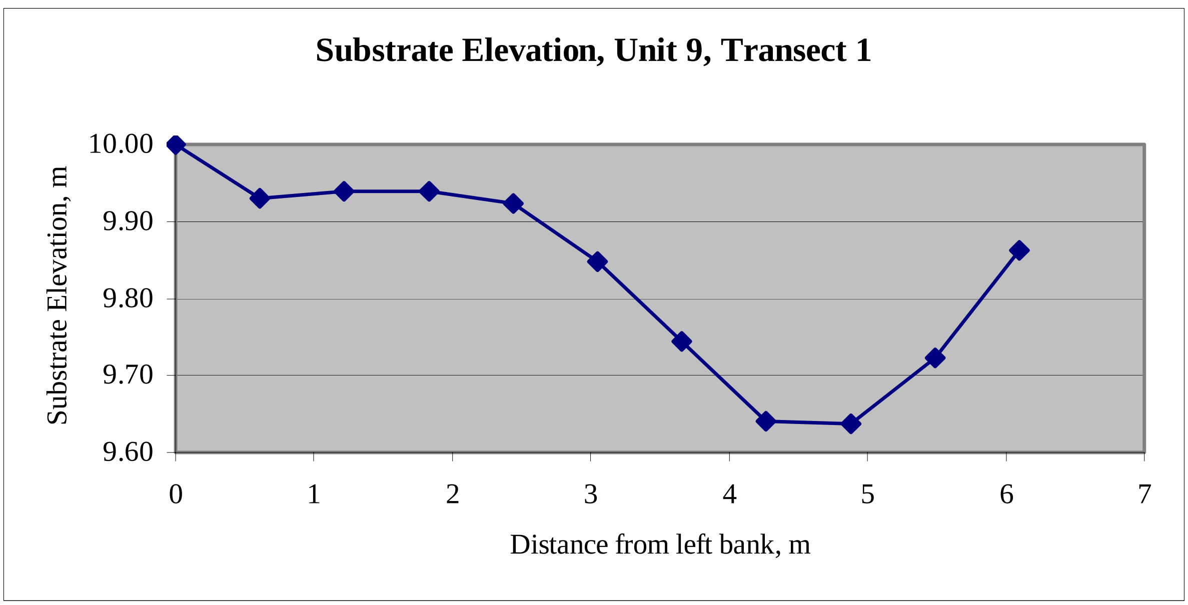
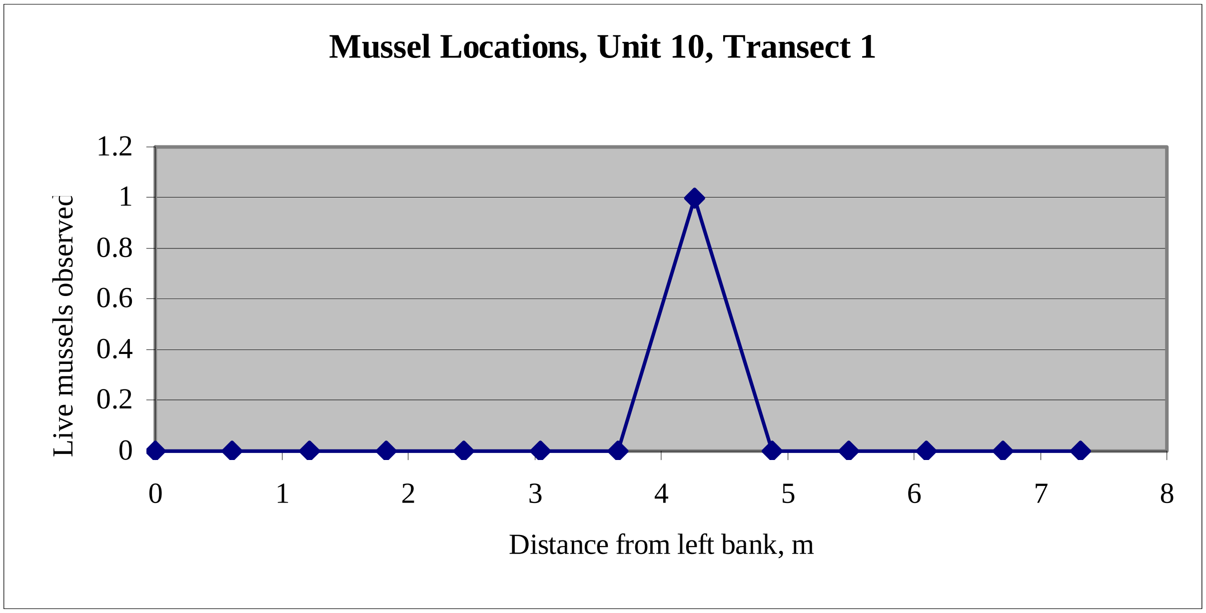


Figure 29. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.



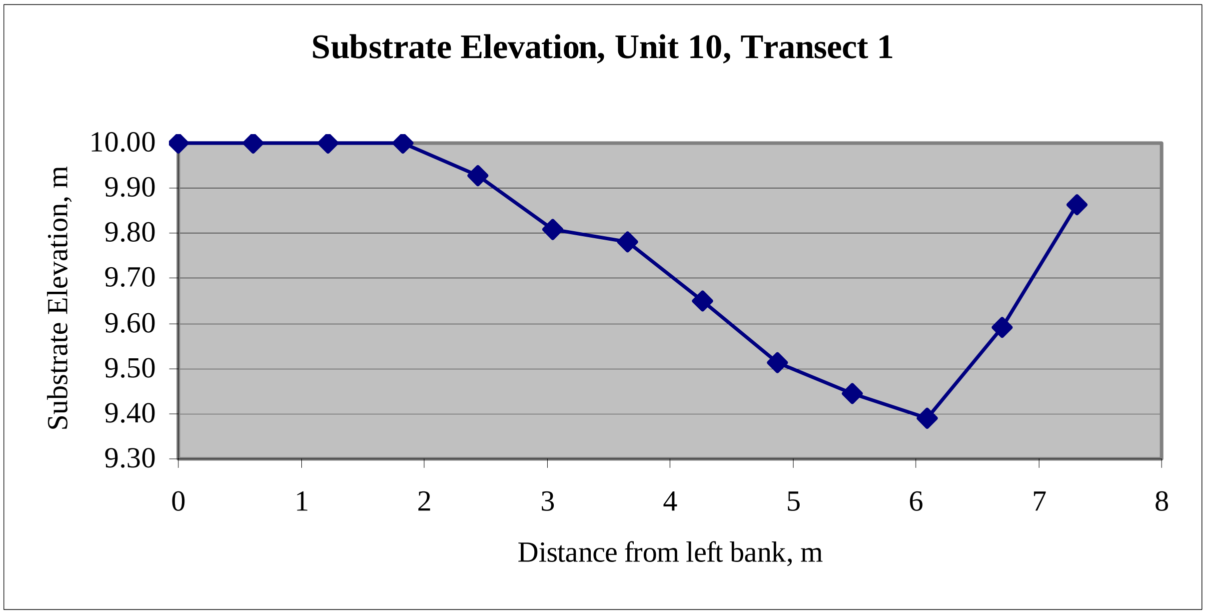


Figure 30. The upper graph presents the density and cross-channel positioning of live mussels observed across the transect (0.0 meters is the left bank edge of the habitat unit facing downstream). The lower graph presents the cross-sectional profile of the habitat unit at the transect. The water surface elevation is 10m.

Discussion

This report provides a baseline characterization of the freshwater mussels in Bear Creek against which future surveys of bed size, density, and population age structure can be compared to document changes in the health of the Bear Creek mussel population and commensurate changes in the biological integrity of the Bear Creek basin.

Live mussel densities were greatest at the four upstream-most sites (average density was 14 mussels per square meter), and were significantly lower at the remaining 6 sites surveyed (average density was 0.25 mussels per square meter). Additionally, the proportion of dead mussels observed was greatest at Units 7, 8, and 9. This abrupt change in mussel density and increase in the relative abundance of dead mussels may be attributed to a number of factors - identifying and prioritizing those factors was outside the scope of this project but will be facilitated when King County Department of Natural Resources releases the results of its <u>Bear and Cottage Lake Creek Habitat Assessment.</u> Potential factors contributing to the decreased mussel density and increased proportion of dead mussels at the downstream study sites may include, but are not limited to:

- <u>Habitat factors</u> - gradient, water temperature, Dissolved Oxygen, instream complexity, and substrate characteristics.

- <u>Biological factors</u> - predation, mussel recruitment, salmonid spawning disturbance, beaver activity and associated changes in habitat, abundance of salmonid vectors, and other inter- and intra-specific interactions.
- <u>Anthropogenic factors</u> - the introduction of herbicides and/or pesticides, increased siltation, and riparian management practices.

Consistent with other observations (Toy, 1998), Washington Trout observations reflect a scarcity of young (<15 years old, or 55mm) mussels in Bear Creek. It remains to be determined whether this is a real or apparent condition - it is recommended that additional time be spent surveying those habitats thought to be preferred by juvenile freshwater mussels. If additional surveys yield the same results, there is cause for concern that the vast majority of the freshwater mussels observed are greater than 20 years old, and that the Bear Creek population of *M. falcata* may not currently be reproducing effectively. It is also recommended that efforts be made to coordinate with the Washington Department of Fish and Wildlife (WDFW) to survey a subsample of juvenile salmonids to document the presence and abundance of glochidia on the gills of salmonids at the WDFW screw trap site on Bear Creek.

References

Fevold, K., and Vanderhoof, J. 2002. Freshwater Mussels found in Bear and Cottage Lake Creeks during Habitat Assessments in 2001. King County Department of Natural Resources, Water and Land Resources Division. Seattle, WA 98104

Toy, K. A. 1998. Growth, reproduction, and habitat preference of the freshwater mussel, Margaritifera margaritifera falcata, in western Washington. Thesis. University of Washington. Seattle, Washington.