Lummi Intertidal Baseline Inventory

Appendix B:
Large Bivalve Survey

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Two species of horse clams are present on Lummi Reservation Tidelands (*Tresus capax* and *Tresus nuttallii*), which live up to 12 – 18 inches deep in the substrate. The tip of a horse clam siphon may have leather-like siphonal plates that provide an attachment surface for small growths of macroalgae. Mated pairs of commensal pea crabs (*Pinnixa faba*) often live in the mantle cavity of horse clams.

A. *Tresus capax*

B. The tip of a horse clam siphon showing siphonal plates and the openings of the exhalant aperture (left) and the inhalant aperture (right).

C. A dense field of horse clam siphon ‘shows’ in Hale Passage

Executive Summary

To determine the range and abundances of horse clams and geoducks on the Reservation, the LIBI conducted two types of visual survey methods that identified and counted the number of horse clam and geoduck siphons that were visible across the Lummi Reservation tidelands.

The LIBI was able to determine the distribution and relative abundance of horse clams using these sampling methods; however the estimate of absolute horse clam abundance calculated from these results was unexpectedly low relative to estimates derived from the excavated samples. The difference in abundance estimates is thought to be due to the exclusion of smaller individuals from the counts during the visual survey. Smaller individuals were excluded to avoid the accidental inclusion of other smaller species.

Geoducks were sparsely distributed and were present only at very low densities. The locations of individual geoducks that were encountered are mapped within this report, but no abundance estimate is made because this species was not present in samples.

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1.0 Introduction

Geoduck clams (*Panopea abrupta*) and horse clams (*Tresus* spp.) are large bivalve species that are of particular interest to tribal members. Horse clams are currently harvested for ceremonial and subsistence purposes. Geoduck clams are similarly valued for ceremonial and subsistence harvest, and some Lummi fishermen also participate in commercial geoduck harvesting beyond the boundaries of the Lummi Reservation. There is also the potential for commercial aquaculture of geoduck clams on Reservation tidelands, and one trial geoduck plot was planted in Lummi Bay during 2009.

One of the primary goals of the LIBI is to document the presence, relative abundance, and preferred habitats of horse clams and geoducks on the Lummi tidelands. Confidence in the results of the Intertidal Biota Survey (Appendix A) for horse clams and geoduck clams was low because the depths excavated in that survey were thought to be too shallow to reliably sample these deep-dwelling species. Adult horse clams are typically found ranging from 12 to 36 inches below the surface, while geoduck clams can be found as deep as 40 inches (Harbo 2001). The LIBI Intertidal Biota Survey methodology restricted the depth of the substrate being excavated to 12 inches in order to obtain more than one sample per tide. Moreover, these species are typically found at very low unit densities. This means that very large areas would need to be excavated to detect their presence in most situations, which would have been too time-consuming to be practicable with the limited tidal windows.

Accordingly, a parallel sampling effort was conducted to better describe horse clam and geoduck clam distribution and abundance.

2.0 Methods

Standard methods used to assess populations of large, deep-dwelling clams by state and tribal agencies in Washington State have involved underwater visual surveys for subtidal geoducks. Visual counts of siphon ‘shows’ while diving are conducted in shore-perpendicular transects that are 6 feet wide and broken into 150 foot sections (Bradbury *et al*. 2000). Such surveys are typically restricted to subtidal areas with depth ranges from –18 ft MLLW to –70 ft MLLW.

For the LIBI, the intertidal nature of the area that was surveyed, along with the expense of dive surveys, precluded the use of this approach to assess horse clams and geoducks.

Based on a review of the literature and verbal communications with agency representatives, no large-scale surveys that were designed specifically to assess wild populations of *intertidal* geoduck and horse clam populations have been conducted in Washington State. As a result, there has been no standard methodology established for this type of survey, and horse clams and intertidal geoducks are only encountered incidentally while conducting generalized baseline surveys that target all species. However, some geoduck-specific surveys have been conducted in intertidal aquaculture plots in British Columbia (Campbell *et al*. 2004). In those surveys, transects were identified along which a series of large quadrats were placed at regular intervals, and siphon shows were counted within each quadrat. In addition, a "show-factor" was measured in dedicated plots, in order to be able to estimate how many animals were present but were not seen in the quadrats. "Show-factor" represents the number of siphons visible above the sediment and is expressed as a percentage of the total number of individuals that are known to be present.

For the purpose of assessing horse clam and geoduck populations on the Lummi Reservation, a hybrid methodology of the methods used by the subtidal surveys conducted by WDFW method and the quadrat approach used by Campbell *et al*. (2004) was adopted. Neither approach alone was logistically feasible in this situation due to the very large area that had to be covered, the variable nature of the terrain, the considerable expense of dive surveys, and the range of other objectives to be met with the limited resources available.

For the majority of the Lummi Reservation shoreline, a transect/quadrat methodology akin to Campbell *et al.* (2004) was adopted. However, for the extremely large expanse of Lummi Bay where horse clam unit densities were particularly low, this method was deemed too imprecise and an alternative method based loosely on the WDFW transect method was adopted.

In all cases, the general approach to counting these species consisted of counting siphon 'shows' visually. Clam siphons can usually be readily distinguished from similar looking organisms, such as anemones. In most cases the difference is apparent, but differences in response to tactile stimuli can also be used when visual characteristics are insufficient, such as when the siphon tip remains below the substrate surface. This stimulus consists simply of probing the 'siphon' with a finger. If the organism is a clam the siphon will usually retract rapidly when probed, sometimes accompanied by a spurt of water. Other organisms that may also cause a similar-sized hole in the sand, such as anemones, invariably retract much less vigorously than horse clams and feel distinctly different to the touch.

Large-diameter holes (> 1.5 inches) were generally presumed to be horse clams and this was verified wherever possible using the finger test. Smaller diameter holes were generally assumed to be softshell clams (*Mya arenaria*) or polychaete worms and were not counted. This assumption is likely to have excluded sub-adult horse clams and geoduck clams, which have smaller siphons, from the counts.

One limiting factor to using a siphon identification/count-based methodology in intertidal surveys is that the clam siphons are typically partly or completely retracted during low tide, obscuring siphonal characteristics. In the present study, it was assumed that all large clam siphons that were seen were horse clams, unless siphonal characteristics were visible and a different identification could be assessed. This means that some geoduck clams may have been misidentified as horse clams. Figure B.1 is an example of abundant siphon shows at a site along Hale Passage.

Figure B.1. View of Abundant Siphon Shows at a Site Along Hale Passage

2.1 General Transect/Quadrat Methodology

With the exception of Lummi Bay, we conducted the survey along a series of shore-perpendicular transects that were spaced at intervals of approximately 200 paces along most of the Reservation tidelands. Along each transect, up to 5 quadrats were placed at roughly equal intervals down the shore. The location of the first quadrat was determined non-randomly by selecting the position of the first large siphon observed while walking down the shore. The location of the remaining four quadrats were determined by visually dividing the remainder of the transect distance into equal intervals, ensuring that the last quadrat would be located at the edge of the water. On some steep beaches, the number of quadrats was sometimes reduced to ensure that at least 10 feet separated the quadrats (dictated by the precision of the handheld Garmin Etrex Venture GPS receiver). In the event that no horse clams or geoducks were observed while walking down the shore, a single quadrat was placed at the edge of the water and a zero value was recorded.

Each quadrat consisted of a 3×3 ft square PVC frame (Figure B.2). For each quadrat the following was recorded (Figure B.3):

- The sequential transect and quadrat number for that crew member on that day
- Date and Time
- The latitude and longitude of the quadrat in degrees and decimal minutes
- The dominant substrate category represented in that quadrat
- The percent cover category for eelgrass and algae separately, along with the dominant taxon present in each category.
- The number of large bivalve siphon shows present within the quadrat.

Figure B.2. PVC Quadrat (3×3 ft) Used for Enumerating Siphon Densities in the Large Bivalve Survey

Horse clam distribution survey fieldsheet Start Location ____________________ **Page:**

Observer __________ Date __________ Stop Location ____________________

		Location (Lat/Long or WP)	Dominant Substrate Class	Eelgrass Cover	Algae Cover	Horse Count	Horse Index	Flags
Tans: Time:	Quad:	Lat 48°: Long 122°:	Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:		None Low Med. High V. High	
Tans: Time:	Quad:	Lat 48°: Long 122°:	Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:		None Low Med. High V. High	
Tans: Time:	Quad:	Lat 48°: Long 122°:	Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:		None Low Med. High V. High	
Tans: Time:	Quad:	Lat 48°: Long 122°:	Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:		None Low Med. High V. High	
Tans: Time:	Quad:	Lat 48°: Long 122°:	Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:		None Low Med. High V. High	
Tans: Time:	Quad:	Lat 48°: Long 122°:	Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:		None Low Med. High V. High	
Tans: Time:	Quad:	Lat 48°: Long 122°:	Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:		None Low Med. High V. High	

FLAGS:

Figure B.3. Field Data Form Used in the Large Bivalve Survey

A subjective index of abundance was also estimated for each quadrat. However, the index was quickly abandoned as it became apparent that the index values used were being determined by the counts of siphons in the quadrat, making the index redundant.

2.2 Lummi Bay Horse Clam Transect Methodology

Because the densities of horse clams and geoducks in Lummi Bay were typically very low, a 3×3 ft quadrat was found to be far too small to have any probability of detecting horse clams there, even if they were present. At the same time, larger quadrats would have been too unwieldy to carry. Furthermore, in some cases the length of the shore-perpendicular transects in Lummi Bay exceeded one mile. Only 5 ‘point’ observations distributed over this distance would have been too coarse to provide useful information about spatial patterns in distribution. Accordingly, the survey methodology in Lummi Bay was changed to reflect these challenges.

Instead of using quadrats placed along a transect line, the 15 transect lines were themselves divided into a total of 150 shorter transects (sub-transects) which terminated at each 0.5-ft elevation contour line. A 3 ft-wide strip along each subtransect was used as the sampling area. The transects were placed in advance of the field work using ArcMap GIS software guided by the LiDAR beach elevation data to limit the survey effort between +2 ft and –2.5 ft MLLW, where horse clams were expected to be found (Don Rothaus WDFW, personal comment). Transect placement was ad-hoc. Transects were generally spaced approximately 0.2 miles apart and placed so as to follow the shortest route down the shore from the starting point while simultaneously avoiding two large channels that would have prevented field crews from following the planned course.

The start, end, and mid-points of each of the sub-transects were determined in advance of field work using the tideland elevation maps (Appendix H). Sub-transect end points were uploaded into hand-held GPS units along with the linear transect that was to be walked during the survey.

In the field, one person carried a 3-ft wide PVC quadrat as a measure of the required sampling area width and counted every large clam siphon that occurred between the sub-transect end points. To ensure that the observers did not need to look up while walking, and to guide them along the correct transect line, another field team member walked behind the primary surveyor while checking their path on the hand-held GPS.

When the end point of each sub-transect was reached, the field crew recorded the number of siphons seen, and assessed the overall substrate type. The field crew also estimated the percentage of the sub-transect that was covered by eelgrass or macro algae and the percentage of the sub-transect that provided sufficient visibility to allow siphons to be counted if present (Fig. B.3). Thick eelgrass and macro algae sometimes obscured clam siphons and meant that only a portion of the sub-transect area could reliably be counted. In order to attempt to correct for this bias, siphon counts were adjusted based on the percentage of ground that was sufficiently visible.

If no part of a sub-transect could reliably be counted, then the data for that sub-transect was excluded from further analysis. To convert the siphon counts to densities, the length of each sub-transect was determined using the ArcMap GIS Measure tool, and multiplied by the sub-transect width to determine the area represented by each sub-transect.

For spatial analysis purposes, the mid-point of each sub-transect was used for mapping and analyzing the data. Because sub-transects were pre-stratified based on shore elevation contours that were 0.5 ft apart, the elevation of the midpoint was used to represent the elevation of each observation.

Horse Clam Survey

Transect Number Transect Width 3 ft

Segment Spatial Information		Segment Scale Data				
Starting Waypoint	Ending Waypoint	Siphon Count	% of Transect with Good Visibility	Dominant Substrate	Eelgrass Cover	Algae Cover
				Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:
				Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:
				Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:
				Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:
				Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:
				Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:
				Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:
				Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:
				Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:
				Clay Mud Mud/Sand Sand Sand/Gravel Gravel Gravel/Cobble Cobble Boulder Other	None 25% 50% 75% 100% Dom. Type:	None 25% 50% 75% 100% Dom. Type:

Figure B.4. Field Data Form Used in the Large Bivalve Survey of Lummi Bay

2.3 Data Analysis

The results from the two survey methodologies provided a set of geo-referenced ‘point’ locations along with the densities of large bivalves observed at each location. Some of the Lummi Bay transects overlapped with the sites of the transect/quadrat method. Because the Lummi Bay transect method was judged to be superior on this terrain, quadrat data that overlapped with the Lummi Bay transect method data were discarded. The final data used in the remainder of this analysis are shown in Figure B.5.

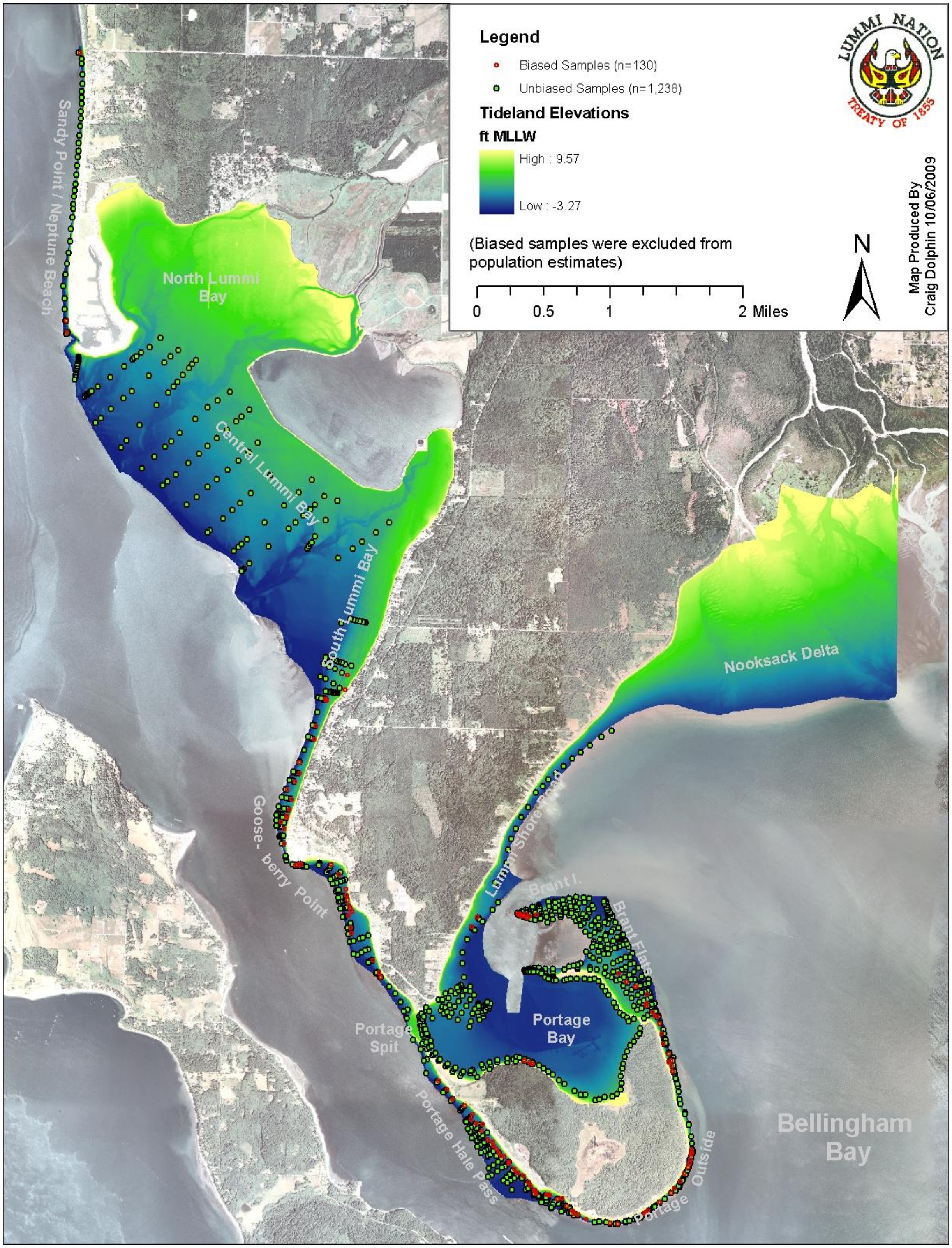

Figure B.5. Large Bivalve Survey Sites

2.3.1 Calculation of Clam Distribution Limits

The location of the top-most quadrat in each transect of the transect/quadrat method was based on the location of the first horse clam siphon observed while walking down the shore. These data were used to determine where the upper limits of the species distribution were.

The points were extracted from the raw data and the elevation of each of the points was determined from the LiDAR-derived digital elevation model (Appendix H) using the Surface Spot tool in the 3D Analyst Tools software extension for ArcGIS 9.3 software. The 95^{th}-percentile elevation of these points was used to define the upper limit of the clam population.

For the purpose of calculating abundance, the lower limit of the population was assumed to be at the water's edge.

2.3.2 Calculation of Abundance

To calculate clam abundance, the points from Lummi Bay were combined with the unbiased transect/quadrat data (after the biased topmost quadrat was removed).

Because the placement of points was not randomly determined, and sampling density varied across the tidelands, a simple arithmetic average of the data values would have resulted in significant bias if more samples were collected in areas where clam densities were unusually high, or unusually low. Consequently, spatial analysis of the data was undertaken in order to remove potential spatial bias in the survey design. The software used in this analysis was ArcMap 9.3 (ESRI) with the 'Create Thiessen Polygon' tool in the Analysis Toolbox.

The survey-data shapefile was used to generate Thiessen polygons that were bounded by the vertical distribution limits identified in the preceding section. The value field in the Thiessen polygon layer was populated with the unit density of siphon shows found in the survey. The result of this step was a polygon shapefile with one polygon surrounding the area represented by each of the survey points, and a field containing the unit density of siphons observed.

2.3.3 Calculation of the Area Represented by each Survey Point

The Xtools extension to ArcGIS 9.3 was used to calculate the area of each Thiessen Polygon in acres and in square feet. This added the area values into two additional fields in the attribute table for the Thiessen polygon layer.

2.3.4 Further operations necessary for analysis

The attribute table of the Thiessen polygon layer was exported into a dbf-file in order to import the data into Microsoft Excel for mathematical operations.

First, the area column was summed to derive a grand total for the area surveyed. Then a 'Proportion' column was created that divided each polygon's area by the area of all polygons combined (5 decimal places). The values in the 'Proportion' column were checked to ensure that they properly summed to 1.

Another new column was created named 'Proportion Squared'. This column contained values calculated by squaring the values in the 'Proportion' column.

The final column multiplied the value in the proportion column by the corresponding value in the column containing the siphon unit density values.

2.3.5 Calculation of the Spatially Weighted Average Population Density

The spatially weighted average clam population density can be represented by the equation:

$$X_i = \sum_{i=1}^{n} w_i * x_i \quad \text{(Equation 1)}$$

Where X_i represents the spatially weighted average clam density, w_i represents the proportion of the total area represented by each Thiessen polygon, and x_i represents the siphon unit density found in each Thiessen polygon. In terms of the spreadsheet discussed above, this means that the spatially weighted average clam density could be determined by summing all values in the final column.

2.3.6 Calculation of the precision of the estimate

Precision is a measure that compares the size of the 95% confidence intervals around the mean to the magnitude of the mean, and is usually expressed as a percentage. The lower the precision value, the more precise the estimate is thought to be.

95% Confidence Intervals are calculated by the following equation:

$$\mathbf{95\%\ C.I. = 1.96 * Std.Error} \quad \text{(Equation 2)}$$

And the Standard Error is calculated using the equation:

$$\mathbf{Std.Error} = \frac{s}{\sqrt{n}} \quad \text{(Equation 3)}$$

…where *s* equals the standard deviation of the sample values and *n* equals the number of observations/samples in the data set.

However, the standard deviation of the raw samples cannot be used to compute Equation 3 because that equation requires a spatially weighted standard deviation.

The spatially weighted Variance (Var_w) can be calculated using the following formula:

$$\mathbf{Var_w} = s^2 . \left(\sum_{i=1}^{n} w_i^2\right) \quad \text{(Equation 4)}$$

…where s^2 is the variance of the observations, and w_i is the proportion of the total area represented by each Thiessen Polygon.

In terms of the spreadsheet detailed above, s^2 is calculated using the spreadsheet function VAR on the siphon density values. The value within the brackets is calculated by summing all the values in the 'Proportion Squared' column. The weighted variance is the product of these two values.

The weighted standard deviation (s_w) can be calculated by calculating the square root of the weighted variance.

Once the weighted standard deviation is known, the spatially-weighted standard error of the weighted mean can be calculated using Equation 3. Finally, the spatially-weighted 95% confidence interval can be calculated using Equation 2.

The precision of the survey is determined by dividing the 95% confidence interval (calculated in Equation 2), by the average clam density (obtained from Equation 1), and multiplying the resulting value by 100%.

3.0 Results

In total 1,502 observations of large bivalve population densities were made across the Lummi Reservation tidelands. Out of this total, 1,176 observations were used to calculate the average population density of horse clams in the surveyed area. There were also 130 observations that documented the location of the top-most siphon encountered along a shore-perpendicular transect. The remainder of the observations were excluded from analysis due either to redundancy, caused by overlap in the area where the two methods were used, or because the observations did not conform to the sampling design of the overall study (for example, some ad-hoc shore-parallel transect sampling of horse clam populations on sand bars was done).

3.1 Horse Clams

Figure B.6 shows the range and frequency of elevations for the topmost horse clam siphon show on the Lummi Reservation tidelands. The upper limit of horse clam distributions on the tidelands was based on the 95th percentile of these data, which corresponds to a beach elevation of +1.08 ft MLLW.

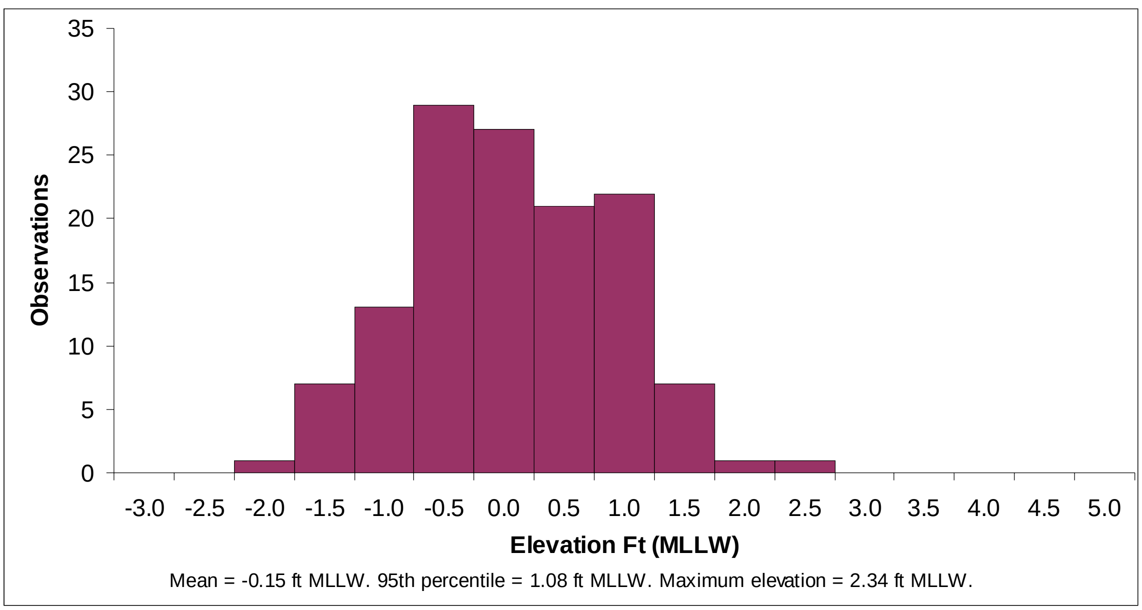

Figure B.6. Histogram of Topmost Horse Clam Siphon Elevations

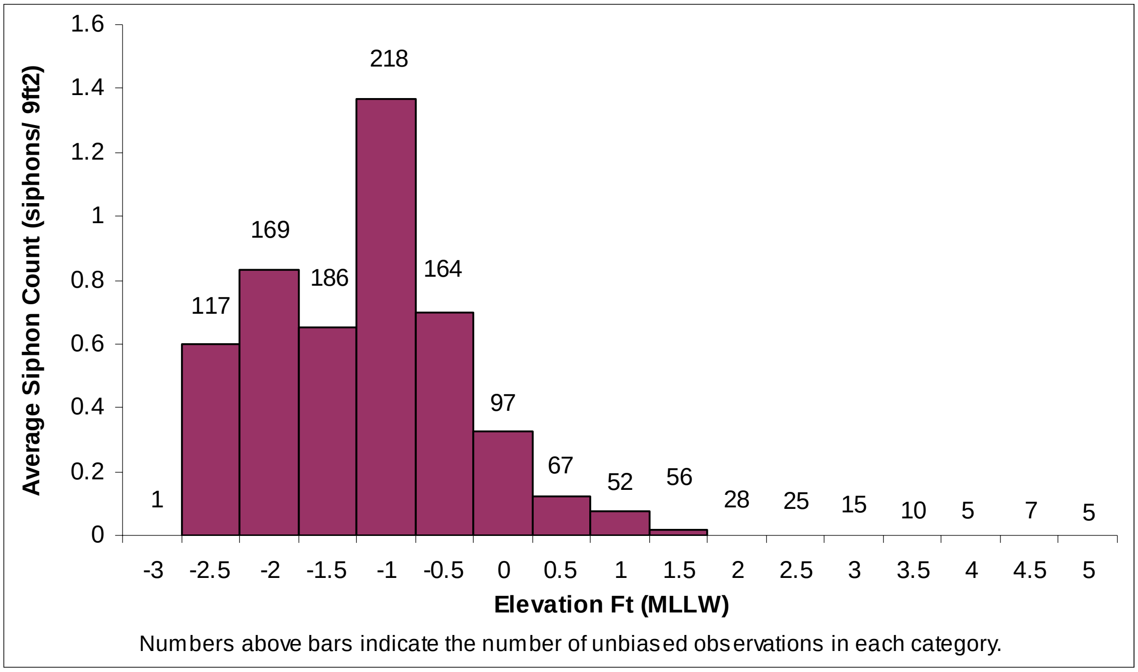

Figure B.7. Histogram of Unbiased Horse Clam Counts Versus Elevation

Figure B.7 shows the average horse clam siphon density versus elevation for unbiased transect/quadrat results. Table B.1 shows the results of the Thiessen polygon abundance estimate and Figure B.8 shows the relative densities of horse clams across the Reservation tidelands.

Table B.1. Horse Clam Abundance Calculated from Siphon Shows Using the Thiessen Polygon Spatial Analysis Method

Total Area (ft^2)	121,220,403
Unweighted Mean Density (siphons/ft^2)	0.073
X_i Weighted Mean Density (siphons/ft^2)	0.019
Estimated Siphon Count	**2,245,122**
s_w	0.194
$\Sigma(w_i^2)$	0.008
Estimate Precision	188%
Lower 95% Confidence Limit	0
Upper 95% Confidence Limit	6,465,244

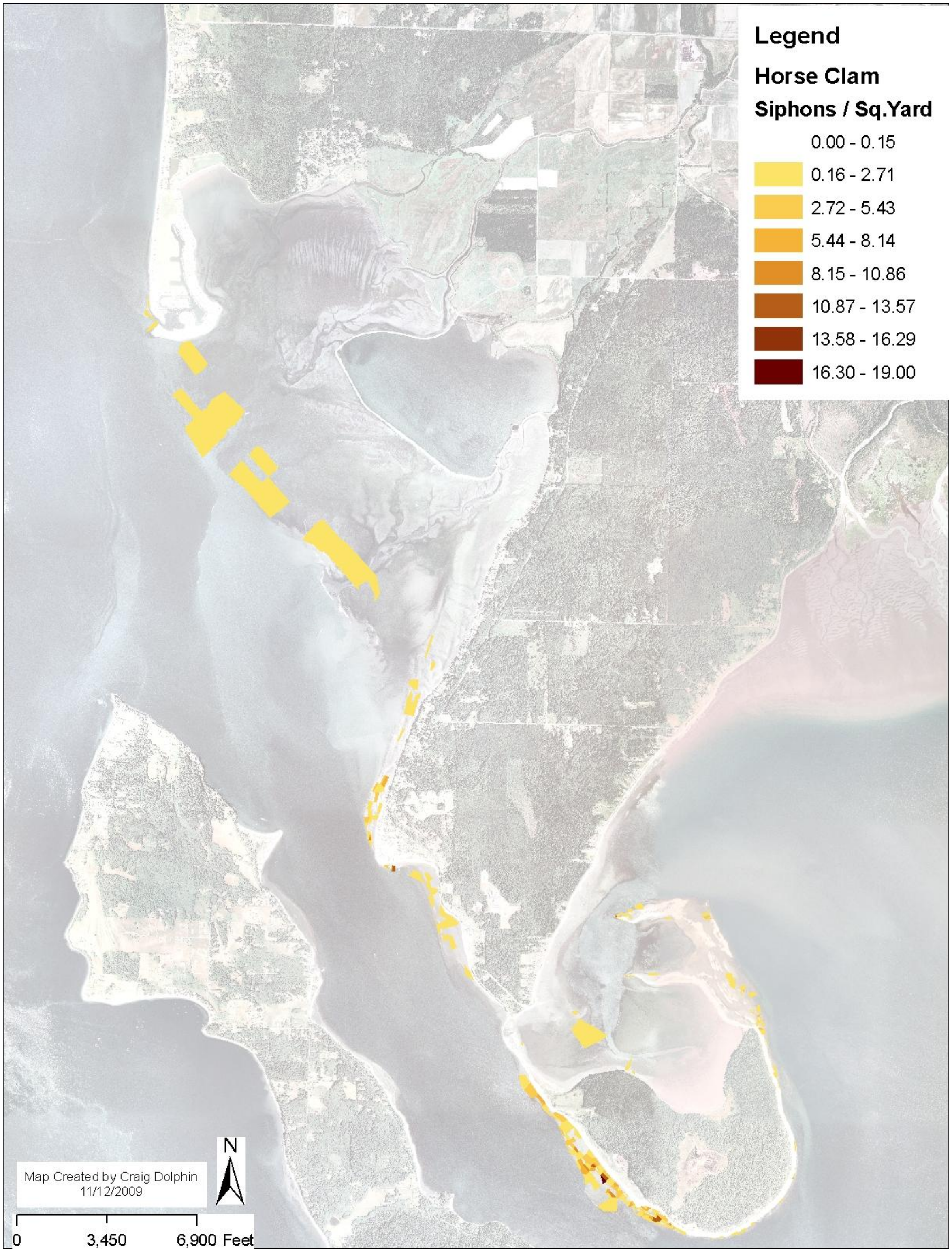

Figure B.8. Thiessen Polygons Showing Horse Clam Population Densities

3.2 Geoduck clams

Recognizable geoduck clams were not encountered during the formal sampling portion of the survey. However, during the course of the large bivalve survey fieldwork, at least three geoducks were found while traveling between transects or while scouting out terrain in the scoping phase of the project. Figure B.9 shows the locations of these encounters.

The highest beach elevation for a geoduck clam encounter was –1.17 ft MLLW, and the lowest observed was –2.45 ft MLLW. Because no geoduck clams were sampled it was not possible to calculate a population estimate for this species.

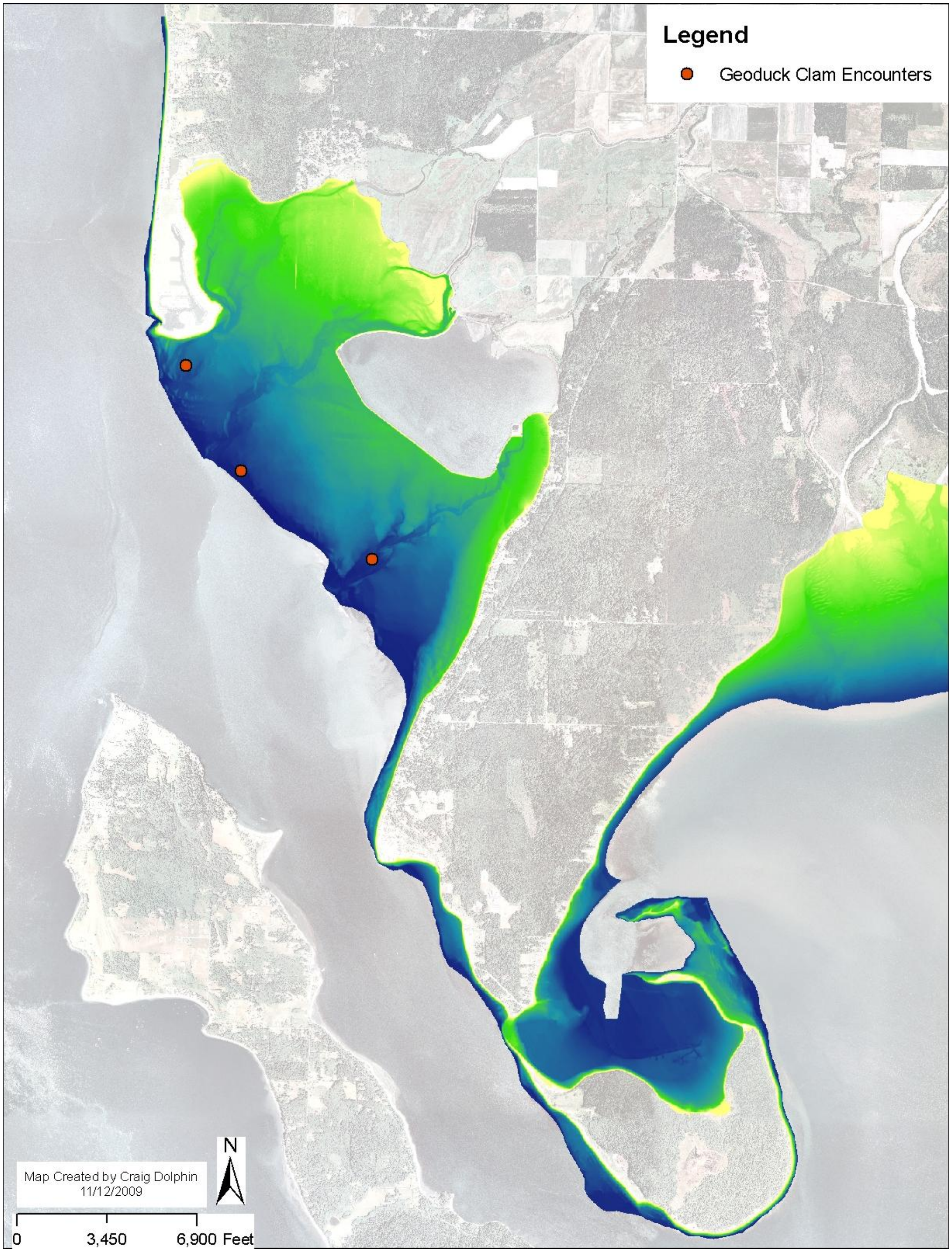

Figure B.9. Locations of Geoduck Clam Encounters

4.0 Discussion

Horse clams were found at low tidal elevations around much of the Lummi Reservation except on the Nooksack delta and adjacent sections of Lummi Shore Road. Generally, horse clams were concentrated on discrete sand bars near the water's edge, but populations were also observed in lower densities throughout beach areas at lower tidal elevations.

The highest horse clam population densities were found along Hale Passage on Portage Island, with intermediate densities observed at Brant Flat, in the bays on Brant Island, near the Sandy Point marina channel entrance, and along Gooseberry Point near the cable crossing and ferry terminal. Large areas containing relatively low population densities were observed along the exposed margins of Lummi Bay. Very low population densities were also observed inside Portage Bay in deep soft mud that was unsafe to traverse. Horse clams were also present at the extreme low fringe of the tidelands around the outside of Portage Island.

The results of the siphon count survey provided an efficient alternative to the Intertidal Biota Survey results. The comparative speed of the sampling meant that a much greater sampling density was achieved: 1,176 unbiased observations were recorded within the vertical range of horse clams compared to just 366 observations made in the Intertidal Biota Survey that were spread out across a much wider vertical elevation range. This resulted in a much-improved ability to detect the presence of horse clam populations when they were present in an area. Based on this experience, Figure B.8 best represents the distribution of horse clam populations around the Reservation compared to the equivalent horse clam distribution map that is shown in Appendix A (Figure A.18). In particular, additional beds of horse clams were detected at Brant Flat, Brant Island, Gooseberry Point, near the Sandy Point marina channel, and inside Portage Bay using this method that were not detected in the Intertidal Biota Survey.

The estimated upper range of the population from the siphon count survey (+1.08 ft MLLW) corresponded closely with the population distribution observed in the Intertidal Biota Survey data. In the siphon count survey, a +1.08 foot elevation was the 95th percentile of the topmost clam distribution. In the Intertidal Biota Survey, this elevation corresponds to the 96th percentile for the overall horse clam population.

Unexpectedly, the estimate of abundance for the horse clam population derived from the siphon count method (2.2 million individuals) was only about half of that obtained from the Intertidal Biota Survey results (5.1 million individuals).

One explanation for this difference is that these results were not adjusted to incorporate the potential show factor, which is commonly done when assessing subtidal geoduck populations. A show factor was not applied because show factor data for intertidal horse clams were not available. If the 'default' show factor of 75%, used for subtidal geoduck clams was applied to these results, then the population estimate would increase to nearly

3 million horse clams from 2.25 million in Table B.1. Even so, this estimate represents only about 60% of the 5.1 million horse clams estimated from the Intertidal Biota Survey.

Another explanation is that, even though the Intertidal Biota Survey excavation depth would have potentially missed deep-dwelling adult horse clams, the visual survey was even more biased towards not counting juvenile horse clams. Clams with smaller siphon holes were excluded to prevent smaller clam species from being included in the counts and skewing the population results for horse clams. Even using the criteria in this study, there were a small number of siphon shows that were originally counted as horse clams, but that later analysis suggests were most likely to be large eastern softshell clams. These data were excluded from the final results.

However, it should be noted that the confidence limits around both estimates are very large. This means that the estimates are not statistically different even though the absolute difference is quite large, and even though there are obvious limitations to both methodologies used. It is expected that the abundance estimates for horse clams, using either method, will be biased towards low abundance because both methods exclude a portion of the population.

Geoduck clams were encountered only incidentally during the study. This means that no estimates of abundance can be made from the survey data. However, the 3 observations of recognizable intertidal geoducks suggest that they inhabit a similar elevation range, and have similar habitat preferences as horse clams. It is also possible that some siphons counted as horse clams in the study were actually geoduck clams that could not be distinguished while retracted. However, the subjective impression of the survey crew is that such instances would be relatively uncommon in the data.

5.0 References

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