report and ADFG (1995) suggests that recruitment into the minimal legal size class occurs at an earlier age than suggested by Feder and Paul (1973) or Nickerson (1977).

3.5. Bivalve inventory results for the village of Chenega. Mr. Jeff Hetrick (CRRC) conducted interviews with tribal elders prior to undertaking the 1996 surveys. Based on those interviews, an intertidal area in Crab Bay located at 60^{o} 04.24' N by 147^{o} 59.80' W was selected for inventory (Figure 38). Steve Ward, Gail Evanoff, Vern Totemoff, Meadow Christensen, Kean and Donia from the village of Chenega participated in the bivalve survey. Similar to other villages, residents stated a preference for cockles, butter and native littleneck clams. They noted that traditional shellfish resources had been depleted for several years, for unknown reasons. Chenega had adequate boat and human resources and there was some interest in participating in the study. Village residents expressed more interest in having shellfish to eat. The presence of a CRRC Flupsy in Chenega may stimulate additional interest.

Figure 38. Intertidal area in Crab Bay near the village of Chenega surveyed for bivalves on June 29, 1996.

3.5.1. Beach characterization. The beach surveyed in 1996 is accessible from the village by either boat or four-wheel drive vehicle via an overland route. The survey area is outlined in Figure (38). The total area of the bay is approximately 40 acres. However, an un-named stream enters from the north (Figure 38). Numerous, abandoned stream channels were observed running across a broad expanse of the intertidal. These channels suggested that much of the area was unsuitable for clam culture because of the periodic scouring effect of the stream. The bay contains a patchy distribution of eelgrass (*Zoostera marina*) at tidal levels below ca. – 2.0' MLLW. Numerous excavations, attributed to sea otters by village residents, were observed. Starfish (*Pycnopodia helianthoides*) and drills (*Nucella lamellosa*) were present, but in low numbers. The surveyed area measured approximately 115' wide by 236' deep (Figures 38 and 39). It laid in front of a substantial berm, which was currently carrying the stream well to the east. It appeared to be relatively stable and there was no evidence of recent stream erosion in the surveyed area. Much of the bay's substrate was composed of broken shale that was too hard for burrowing species. The surveyed area contained a suitable mix of fines and gravel for hardshell clams. Beach substrates were biologically active with large numbers of *Nereis sp.* and sipunculids. A preliminary reconnaissance survey supported the author's visual assessment that the chosen area contained the highest abundance of bivalves in this bay.

As described in Figure (39), three transects (A, B and C) were laid out normal to the beach and a fourth transect was examined parallel to the beach at the 0.0' MLLW tide level. Four samples were collected on transects A and D and six samples on Transects B and C for a total of 20, 0.1 m^2 quadrats.

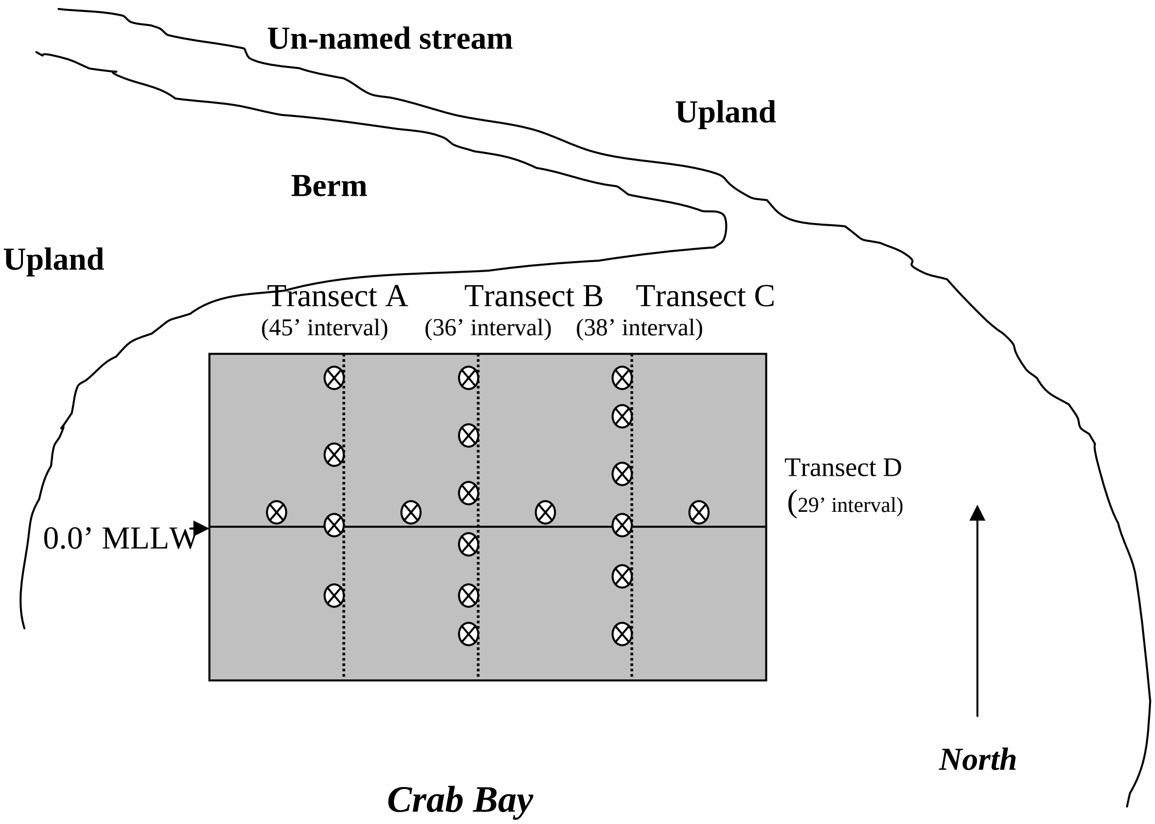

Figure 39. Schematic diagram of the Village of Chenega shellfish beach on Crab Bay. The beach has surveyed on June 29, 1996.

The beach considered suitable for native littleneck clam production had a very shallow slope ranging from 2% along Transect A to 1% along Transect C. The reduction oxidation potential discontinuity was deeper than 10 cm at all stations. Eight sediment samples were evaluated for sediment grain size and total volatile solids. These samples contained 57.5 ± 8.3% gravel, 33.6 ± 8.5% sand, 8.5 ± 2.6% silt and clay, and 2.8 ± 0.8 percent total volatile solids. Macroalgae (*Fucus* and *Enteromorpha*) contributed to the TVS content.

3.5.2. Water column characterization. Water temperature was 13.8 ^{o}C and salinity varied from 28.0 ppt at Transect (A), located furthest from the stream to 25.0 ppt at Transect C, which was closest to the stream. Currents at slack tide were measured parallel to the beach at 2.5 cm/sec. The pH varied between 7.75 and 7.76.

The three water samples collected at this beach averaged 6.7 mg TSS/L and 3.8 mg TVS/L Turbidity (nephelometric units) varied between 0.69 and 1.00 NTU. These values suggest moderate quantities of organic seston and suspended inorganic particulates. These results provide no basis for eliminating this beach from consideration for enhancement.

3.5.3. Bivalves observed in sediment samples from Crab Bay. One hundred and nine (109) living bivalves were retrieved from samples at Crab Bay. These bivalves are enumerated in Table (13). Clams were not found in sufficient abundance to support subsistence harvests.

Table 13. Summary of bivalves collected in 20, 0.1 m^2 samples at Crab bay near the Village of Chenega on June 29, 1996.

Species	Number
Protothaca staminea (native littleneck clam)	97
Saxidomus giganteus (butter clam)	6
Clinocardium nuttallii (Nuttall's cockle)	6
Total living bivalves	**109**

Butter Clams. Six butter clams were observed in these samples. Their length-frequency distribution is provided in Figure (40). Most of the observed butter clams were new recruits less than two years old. Only one legal size butter clam was observed in the 20 samples. Descriptive statistics for a limited number of variables are presented in Table (14).

Table 14. Summary descriptive statistics for living butter clams retrieved from Crab Bay sediment samples near the Village of Chenega on June 29, 1996.

	Valid N	Mean	Minimum	Maximum	Std. Dev.
Length (mm)	6	12.80	3.82	46.5	16.6
Whole weight (g)	5	4.33	0.14	21.4	9.6
Age	6	2.17	0.00	8.0	2.9
Dry Condition Factor	2	0.38	0.01	0.69	0.44

Non-linear regression was accomplished on aged living and empty butter clam valves to determine von Bertalanffy model coefficients. Residuals were normally distributed (Kolmogorov-Smirnov; d = 0.054; P is n.s. @ $\alpha = 0.05$) and there was no evidence of heteroscedasticity. The resulting equation explained 96.13% of the variation and the ANOVA determined probability that the regression coefficients were all equal to zero was P = 0.000. A broad range of clam lengths and ages were included in the analysis (many of which were measured from empty valves) and the longest clam (123.4 mm maximum length) exceeded the maximum predicted by the von Bertalanffy equation. This expression is likely a good predictor of butter clam length as a function of age.

$$\text{Length of butter clams in Crab Bay, Chenega (mm)} = 113.5(1 - \exp^{(-0.0672 \times \text{age in years})})$$

The paucity of living butter clams with valve lengths $\geq$ 38 mm attests to the lack of a subsistence resource on this beach. It should be noted that despite the fact that most of the observed butter clams were new recruits, recent recruitment was very low at this beach (2.0/m^2 in 1995). Therefore, predator control (especially starfish and sea otters) may have a minor, but positive affect on the number of butter clams eventually available for subsistence harvest.

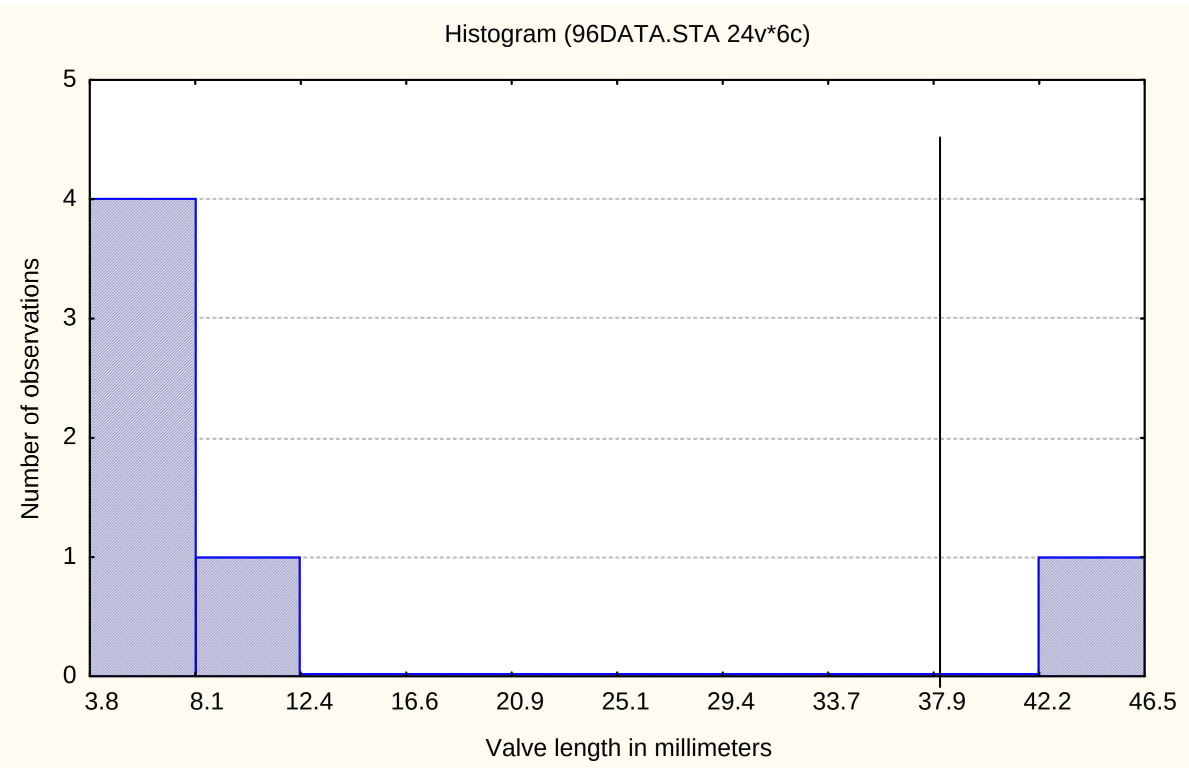

Figure 40. Length frequency histogram for butter clams (*Saxidomus giganteus*) collected in 20, 0.1 m^2 samples at the Chenega Village shellfish beach on June 29, 1996. The thin vertical line locates the legal limit (>38 mm).

Cockles. Six cockles (*Clinocardium nuttallii*) were observed in these samples. Summary statistics are presented in Table (15) and a length-frequency histogram is provided in Figure (41).

Table 15. Summary descriptive statistics for living cockles sampled in 20, 0.1 m^2 quadrats at the Chenega Village shellfish beach in Crab Bay on June 29, 1996.

	Valid N	Mean	Minimum	Maximum	Std. Dev.
Valve length (mm)	6	27.90	11.56	49.09	13.36
Whole weight (gm)	6	7.20	0.26	23.92	8.65
Age (years)	5	2.40	2.00	4.00	0.89
Dry Condition Factor	4	0.34	0.232	0.41	0.08

The largest cockle had a valve length of 49.1 mm and weighed 23.9 grams. Only one legal size cockle (valve length $\geq$ 38 mm) was observed in the 20 samples. There is currently no opportunity for subsistence harvest of cockles at this Chenega Village beach.

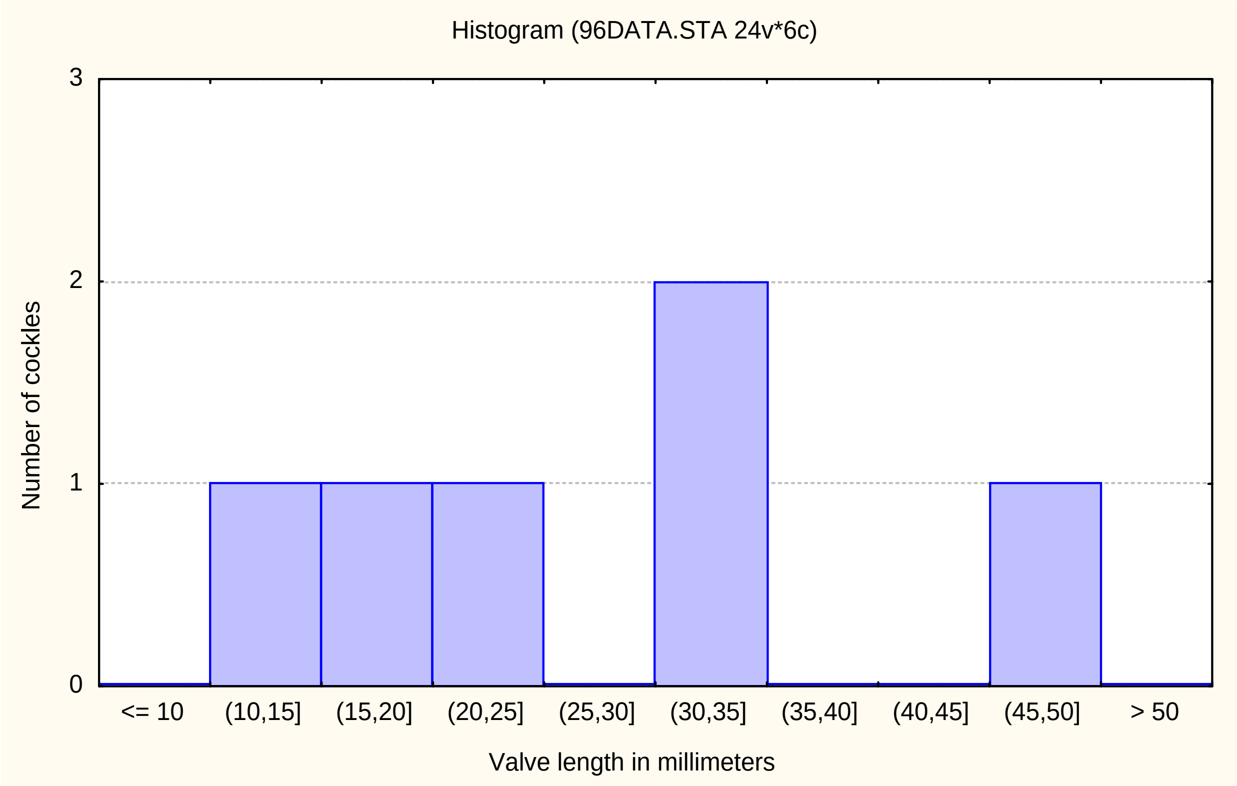

Figure 41. Length-frequency histogram for living cockles (*Clinocardium*) collected in 20, 0.1 m^2 samples during the bivalve survey in Crab Bay near the village of Chenega on June 29, 1996.

Native littleneck clams. Ninety-seven (97) native littleneck clams were observed in Crab Bay sediment samples. Very pronounced circular sculpture, apparently not associated with growth checks was observed in eight of these clams. Summary statistics describing native littleneck clams are presented in Table (16).

Table 16. Summary descriptive statistics for living native littleneck clams sampled in 20, 0.1 m^2 quadrats at the Chenega Village shellfish beach in Crab Bay on June 29, 1996.

	Valid N	Mean	Minimum	Maximum	Std. Dev.
Valve length (mm)	97	21.89	2.63	47.90	7.68
Whole weight (gm)	97	5.64	0.036	25.84	3.77
Age (years)	95	4.00	0.00	7.00	4.41
Dry Condition Factor	82	0.28	0.19	0.40	0.08

Figure (42) presents an age - frequency histogram for Crab Bay native littleneck clams. The native littleneck population is dominated by three and four year old clams that likely settled in 1992 and 1993. Figure (42) suggests that recruitment is sporadic at this site (or juvenile survival is poor). It appears that relatively strong year classes set in 1992 and 1993 but that recruitment since then has been minor. Juvenile clams should be found at a minimum density of 20 to 30 per 0.1 m^2 for optimum production. Current recruitment is estimated at 3.5 per 0.1 m^2 - or about 15% of optimum. This is close to the value of four recruits per m^2 observed at Tatitlek in the 1995 survey (Brooks, 1995).

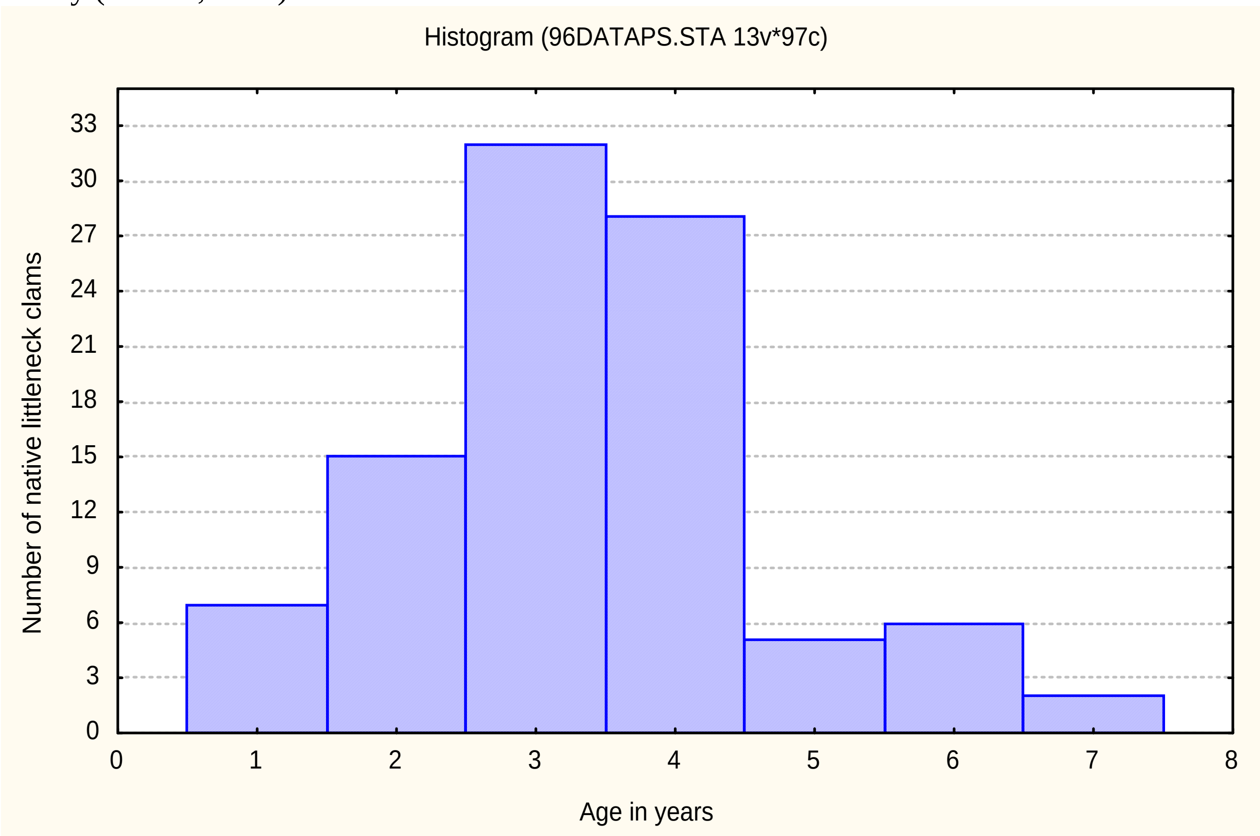

Figure 42. Age – frequency histogram for littleneck clams collected in 20, 0.1 m^{-2} quadrats at Crab Bay on June 29, 1996.

Further examination of the population was accomplished using the length - frequency histogram provided in Figure (43), which indicates that larger clams are being eliminated from the population, either by predation or because of local harvest. Fewer than five legal size littleneck clams (valve length >38 mm) were obtained in the entire survey. Insufficient edible shellfish (butter, native littleneck clam and cockles) are available at this site for subsistence harvests. This suggests that under natural conditions, shellfish production at this site is limited primarily by inadequate recruitment, and perhaps by overharvest or predation.

3.5.4. Bivalve distribution as a function of tidal height. Figure (44) describes the distribution of native littleneck clams as a function of tidal height in Crab Bay. This figure supports previous surveys indicating that the optimum tidal elevation for native littleneck clams is ca. 0.0' MLLW. It should be noted that the substrate changes to primarily sand at tidal elevations less than -1.5' at this beach. Therefore, it was expected that native littleneck and butter clams would be absent below this elevation. It is also interesting to note that both butter clams and native littleneck clams were found at tidal elevations near +3.0' MLLW. The data for native littleneck clams suggests that the area between -1.5' and +0.5' is suitable for native littleneck clam production on this beach.

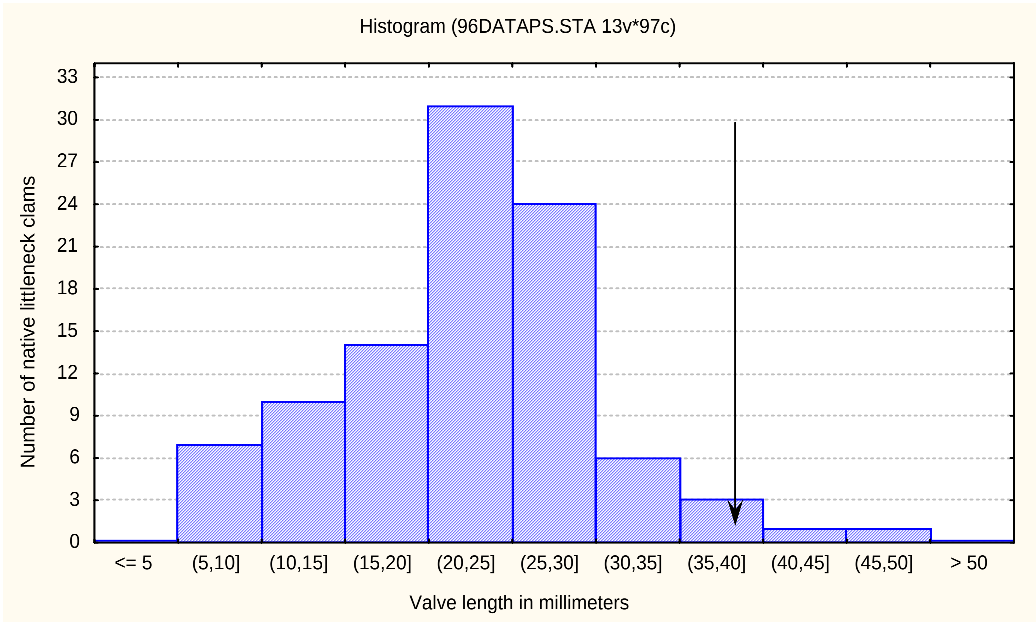

Figure 43. Length - frequency histogram for littleneck clams collected in 20, 0.1 m^2 quadrats at Crab Bay on June 29, 1996. The thin vertical line represents the minimum legal size of 38 mm.

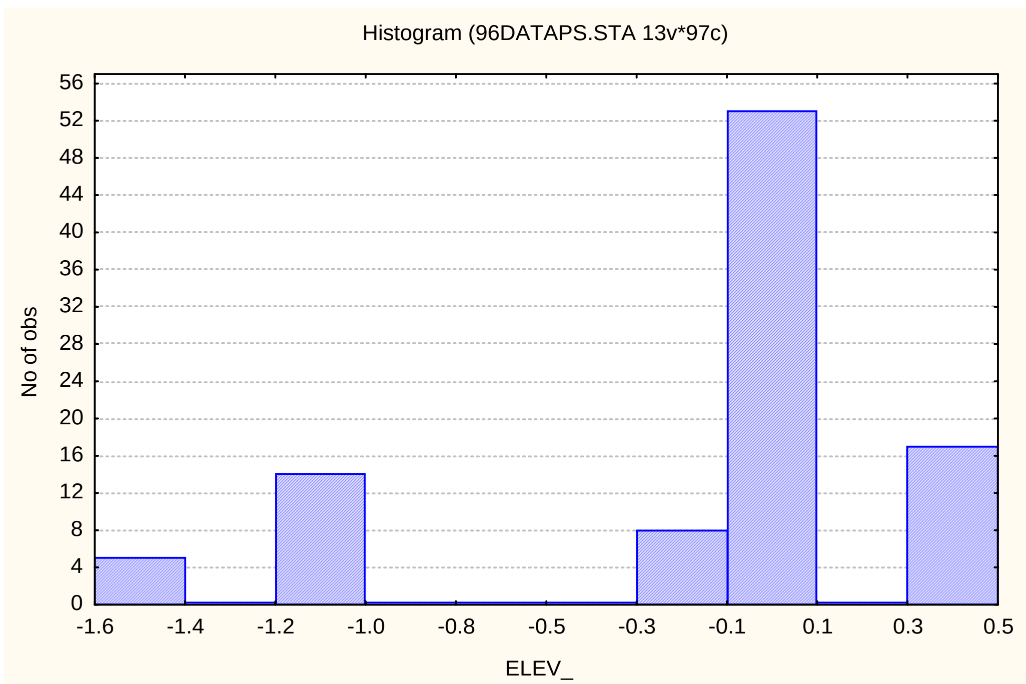

Figure 44. Tidal elevation – clam frequency histogram for littleneck clams collected in 20, 0.1 m^2 quadrats in Crab Bay near the village of Chenega on June 29, 1996.

3.5.5. Influence of environmental factors on growth of native littleneck clams. The physicochemical and biological variables evaluated in this study were included in a square matrix providing Pearson correlation coefficients. This matrix suggested that biological parameters such as length, average annual incremental shell growth, whole-animal weight, wet tissue weight, and condition factor were not strongly dependent on environmental factors within the tested strata. Even though some of the correlation coefficients are significant, the corresponding Coefficients of Determination indicate that they explained a very small part of the variation in dependent physiological variables. This conclusion was supported by cluster analysis, principle components analysis, regression analysis and Analysis of Variance. Only AGE was a truly significant factor effecting clam size, growth and condition. A summary of the most pertinent correlation's is provided in Table (17).

Table 17. Summary of most relevant Pearson correlation coefficients. The probability (p) that the coefficient equals zero is also provided. Significant coefficients (at $\alpha = 0.05$) are bolded. For all variables, the valid number of cases was 88.

	Tidal elevation	**Sediment TVS**	**Salinity**
Length	0.013 P = 0.290	**0.088** **p = 0.005**	**0.352** **p = 0.000**
Growth increment	0.009 P = 0.370	0.000 P = 0.990	0.001 P = 0.730
Whole animal weight	0.008 P = 0.410	**0.220** P = 0.000	**0.550** P = 0.000
Age	0.017 P = 0.230	**0.090** **P = 0.004**	**0.310** **P = 0.000**
Dry Condition Factor	0.013 P = 0.290	0.016 P = 0.230	**0.120** **p = 0.001**

Clam length was positively correlated with sediment total volatile solids (TVS) and salinity. There was a moderate size stream flowing into Crab Bay behind a berm lying between the upland and the intertidal. This stream entered the bay to the east where it was having a small effect on salinity during this summer sampling period. It likely has a much larger effect during the winter and spring. In addition, it possibly breaches the berm periodically resulting in a disruption of intertidal sediments, which either buries or exposes clams. There was evidence of several old stream channels meandering across the eastern part of this beach. The presence of this stream likely reduces the number of older clams in its meander plain. This is suggested by the positive correlation between length, whole-animal weight, and age, with salinity in Table (18). The positive correlation between dry condition factor and salinity is likely because higher condition has been observed in older clams and older clams were more prevalent in the western part of the survey area where salinities are highest and the stream has least influence. If the budget had allowed a determination of actual internal valve volume, rather than relying on length, then this correlation would likely not have been as significant. However, it can also be postulated that periodically reduced salinities may reduce feeding times, resulting in the positive correlation between salinity and condition factor.

Physiological parameters (length, wet tissue weight, condition index, whole animal weight) were not significantly correlated with tidal elevation. That is likely the result of the rather narrow intertidal band within which *Protothaca sp.* was found on this beach (-1.6' to + 0.5' MLLW) with the large majority of the littleneck clams being found at 0.0' MLLW.

Average growth increments were calculated by dividing the valve length by the clam's age. This procedure should be viewed as a crude approximation of growth because it does not recognize that incremental growth is negatively correlated with age ($r^2_a = -0.16$; $P = 0.000$). However, for purposes of determining the average growth increment as a function of tidal height, it gives a reasonable assessment of the optimum tidal height at which to cultivate clams on this beach. This information is presented graphically in Figure (45). The line represents a best polynomial fit to the data with 95% confidence limits on the mean displayed. Figure (45) suggests that within the tidal range investigated (which includes all elevations at which clams were found in this survey), native littleneck valve growth is acceptable for culture purposes. A decline in incremental growth was observed at tidal elevations below ca. –1.0' MLLW. These observations are consistent with those reported by Brooks (1995b) for beaches near Tatitlek, Port Graham and Nanwalek.

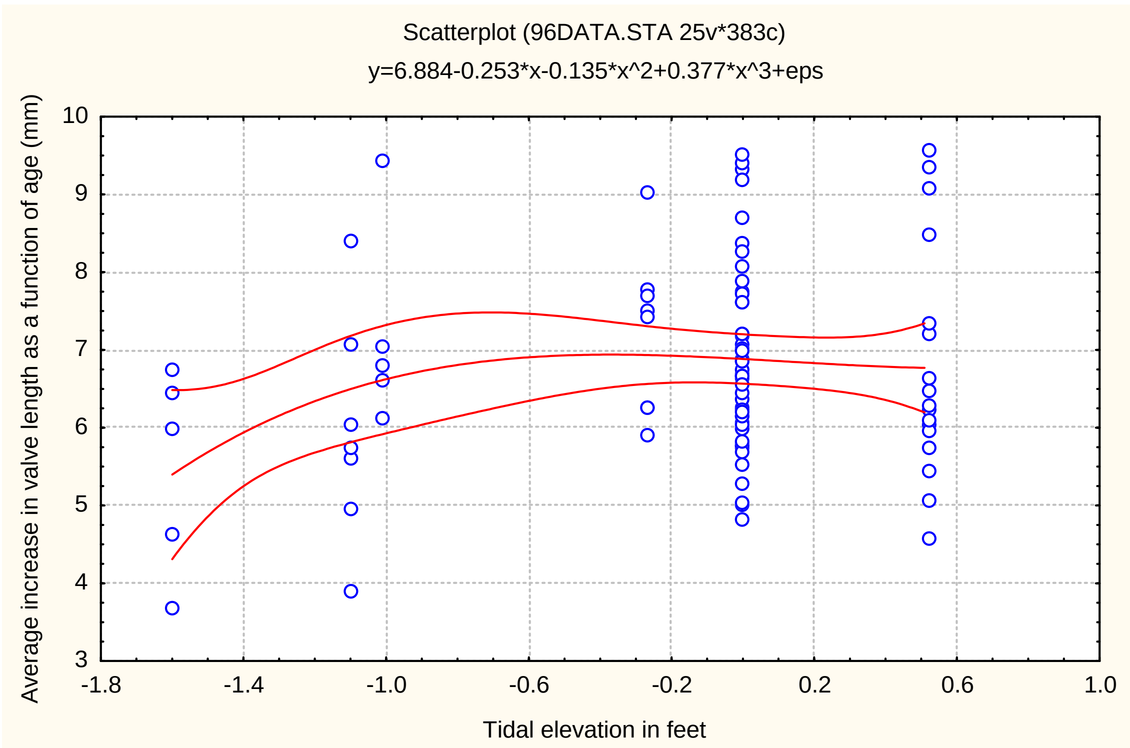

Figure 45. Growth increments (mm/year) as a function of tidal height (feet above MLLW) for native littleneck clams (*Protothaca staminea*) collected in 20, 0.1 m^2 quadrats at the Chenega Village shellfish beach on June 29, 1996. Ninety-five percent confidence limits on regression predictions are provided.

3.5.6. Age at length determination for native littleneck clams at Chenega. Regression coefficients were developed for the von Bertalanffy model using non-linear regression. The resulting regression explained 87.2% of the variation and the ANOVA determined probability that the regression coefficients were all equal to zero was $P = 0.000$. The regression residuals were not significantly different from a normal distribution (Kolmogorov-Smirnov, $d = 0.0508$), P is n.s. at $\alpha = 0.05$). However, some caution is in order because no clam valves exceeding 47.9 mm were included in the database. In Puget Sound, native littleneck clams grow to lengths in excess of 65 mm (Brooks, unpublished). However, native littleneck clams older than seven years were not observed at Crab Bay for unknown reasons. A scattergram, including the regression line is provided in Figure (46). The von Bertalanffy equation, and accompanying scatterplot, suggests that native littleneck clams begin recruiting into the legal size population at six years of age and the average age of recruitment is seven years.

Native littleneck von Bertalanffy model for Crab Bay   Length = 55.9(1 - exp$^{-0.155 \text{ x age in years}}$)

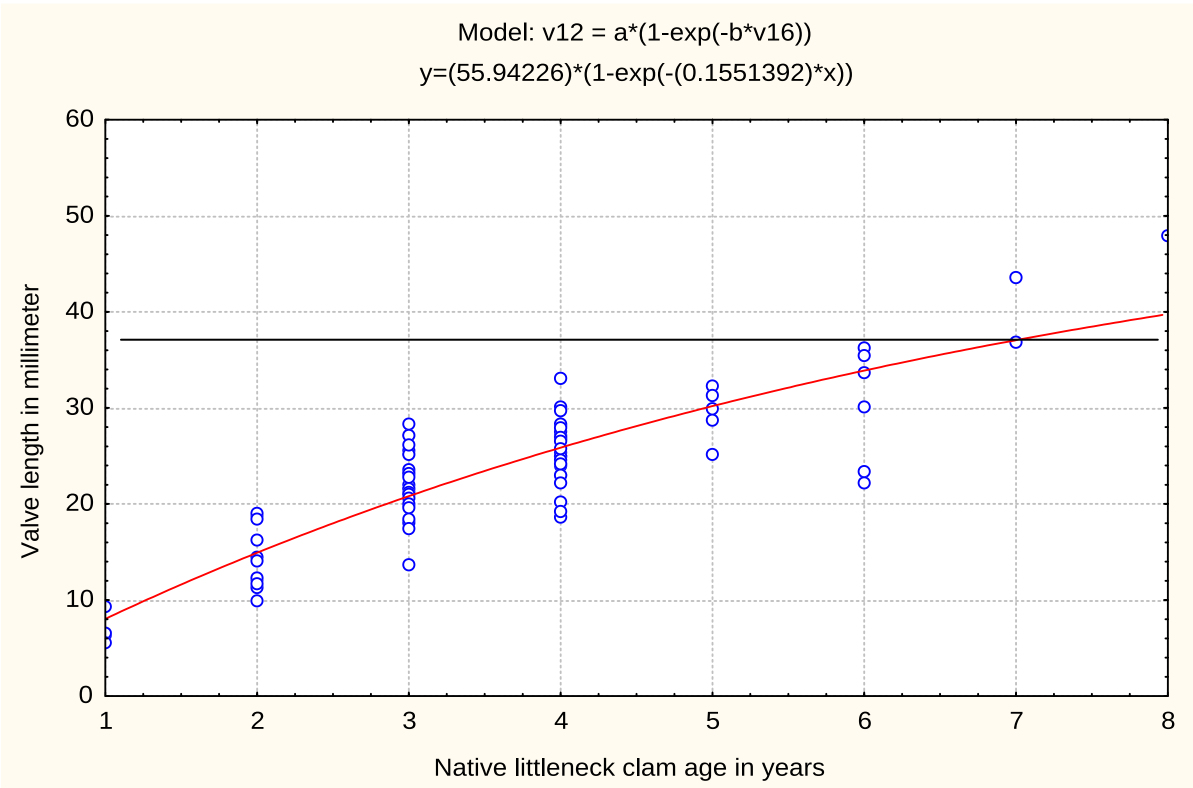

Figure 46. Length (mm) versus age (years) for native littleneck clams (*Protothaca staminea*) collected in 20, 0.1 m^2 quadrats at Chenega Village on June 29, 1996. The solid horizontal line represents the minimum legal size limit ($\geq$ 38 mm).

3.5.7. Wet tissue analysis. A length - wet tissue weight histogram is provided in Figure (47) and an age - wet tissue weight histogram in Figure (48). These results are consistent with those presented earlier and demonstrate that wet tissue weights are increasing exponentially near 38 mm valve length. This suggests that if predation and/or disease can be controlled, then the clams should be allowed to grow to at least 45 mm prior to human harvest.

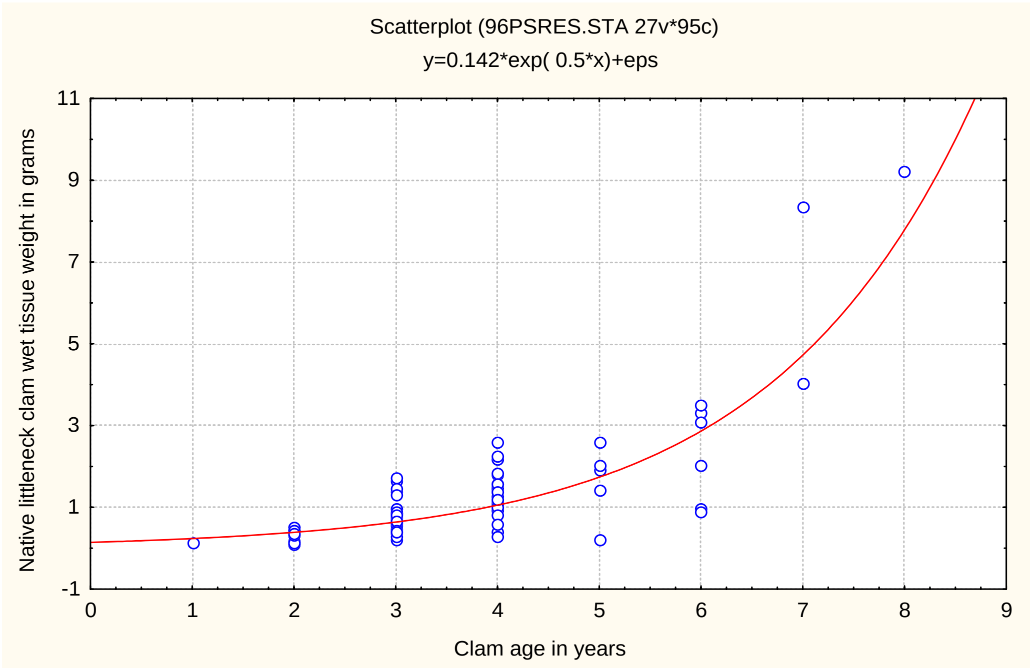

Figure 47. Wet tissue weight (grams) versus age (years) for native littleneck clams (*Protothaca staminea*) collected in 20, 0.1 m^2 quadrats at the Chenega Village shellfish beach on Crab Bay surveyed on June 29, 1996.

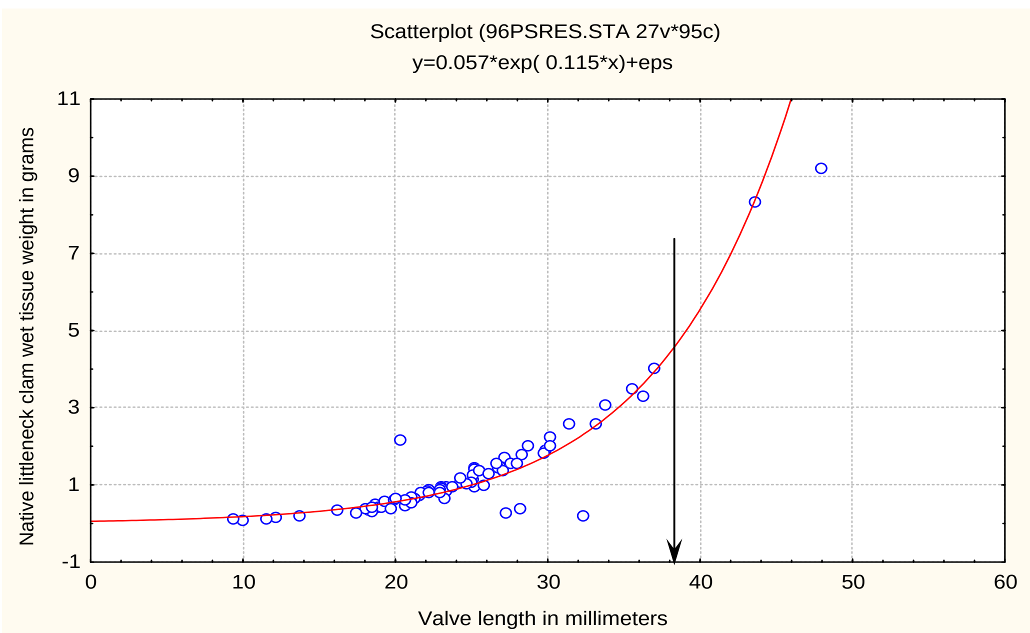

Figure 48. Wet tissue weight (grams) versus length (mm) for native littleneck clams (*Protothaca staminea*) collected in 20, 0.1 m^2 quadrats at the Chenega Village shellfish beach on June 29, 1996. The vertical solid line represents the minimum legal harvest size.

An examination of the length-frequency data provided in Figure (43) suggests that clams are being removed from the population at between four and five years of age and at a size of ca. 30 to 32 mm. Figure (48) indicates that wet tissues are accumulating rapidly between ca. 25 mm and at least 43 mm. A clam that is 8 years old with a valve length of approximately 42 to 45 mm will have wet tissue weights of approximately 7.5 grams. This is significantly higher than the wet tissue weight of 4.5 grams associated with a six-year-old clam just reaching the current minimum harvest size of 38 mm. Reducing the minimum harvest size to 30 to 32 mm (a size preceding the heaviest predation) would result in a harvest of approximately 2.5 grams wet tissue weight per clam. This discussion suggests that reducing the minimum harvest size is not an appropriate management tool to increase the subsistence food value of the existing clam population at Crab Bay. These conclusions are identical to those resulting from an analysis of the Tatitlek, Port Graham and Nanwalek data reported in Brooks (1995b).

3.5.8. Predator density at Chenega. Very few starfish were observed on this beach at the time of the survey. A small number of drills (*Nucella lamellosa*) were present in a patchy distribution throughout the bay. The intertidal associated with Crab Bay was covered with holes approximately 0.5 m in diameter and 15 to 20 cm deep. Village residents noted that some harvesting has occurred there. However, they associated most of the holes with sea otter predation. It was not possible to partition larger clam losses between human harvest and predation based on observation and the information received. However, several areas appeared to have been heavily disrupted.

3.5.9. Shellfish sanitation. Three water samples were collected at Chenega and shipped, on ice to Aquatic Environmental Sciences where they were examined for fecal coliform bacteria using the five tube MPN system. Observed fecal coliform levels were <2 in all three samples indicating no evidence of contamination during the period of this survey. Shellfish enhancement should coincide with the collection of sufficient water samples to certify this beach in accordance with procedures established in the National Shellfish Sanitation Program, Part I.

3.5.10. Summary, conclusions and recommendations for native littleneck clam enhancement at Crab Bay near the village of Chenega. The following conclusions and recommendations are based on this survey and analysis:

- **Shellfish biomass available for harvest.** There is currently no bivalve biomass available for harvest at this Chenega Village beach. The small number of cockles collected during the survey suggests that this species is adapted to this environment and could be cultured, pending development of hatchery, nursery, and grow-out methods.

- **Beach suitability.** The Crab Bay beach contains greater than ten acres of ground suitable for native littleneck clam and cockle enhancement or culture. The physical and chemical parameters examined in this survey are all within acceptable limits. Clam growth, density and size suggest non-significant differences in culture potential over the area of surveyed beach. The small number of legal size clams observed in this survey suggest that both a predator control program and a harvest management plan will be essential to optimizing future harvests. Enhancement of the eastern third of this beach is not recommended because of the potential for disruption associated with a change in the existing stream channel.

- **Predation.** Significant starfish predation was not observed in this survey. Sea otters were not observed preying on bivalves at any beach. The nature of the intertidal disturbances suggests that they were associated either with human harvest or with sea otters. Drills were observed, albeit in low numbers. Any effort at beach enhancement should include a predator watch and removal of starfish, drills, drill egg cases, and crabs. Predation by sea otters should be documented, when and if it occurs. Clam and oyster cages are fairly rigid and capable of excluding starfish, large drills and all but the most aggressive crabs. However, it is unlikely that these plastic mesh cages would discourage a determined sea otter. Caged bivalves should be examined periodically and predators removed before they can consume large quantities of shellfish.

- **Recruitment** of native littleneck clams to the beach on Crab Bay occurred in low numbers in each of the last eight-year classes. No year classes were missing. However, recruitment, or at least survival of juvenile clams until June 29, 1996, was too low and inadequate in each year class to provide for sustained, subsistence shellfish harvests.

- **Age at harvest.** The age length analysis suggests that native littleneck clams recruit to the legal size population at an average of seven years. The wet tissue weight – length, and wet tissue weight – age, analysis indicates that harvesting at a valve length less than 38 mm would be an inefficient use of the resource. This beach would likely benefit from development of a harvest management plan by elders in the Village of Chenega.

- **Butter clams.** *Saxidomus giganteus* recruited in small numbers to this beach. However, few butter clams survived past the juvenile stage. The reasons for this were not determined. Due to the lack of hatchery and nursery technology, and propensity to retain brevetoxins, butter clam enhancement is not recommended at this time.

- **Cockles** are a traditional (and preferred) shellfish for native Alaskans'. The intertidal area of Crab Bay provides suitable substrates for cockle enhancement once culture methods are developed.

3.6. Bivalve inventory results for the village of Ouzinke. The Village of Ouzinke provided a very warm welcome to the CRRC study team. The people of Ouzinke were enthusiastic and eager to participate in this study and expressed a desire for enhanced subsistence shellfish resources. This exuberance carried through to the work at hand, which was undertaken in a professional and dedicated manner. The author whishes to express his sincere appreciation to the following participants who made this survey extremely enjoyable. A special thank-you to my guide, Mr. Roger Larionoff whose knowledge of the local area was invaluable.

Roger Larionoff	Paul Panamarioff	Maria Skonberg	Lylia Pestrikoff
Melody Anderson	David Pestrikoff	Bill Boskofsky	Sandra Muller


Ouzinke shellfish study crew

The people of Ouzinke expressed a great deal of interest in the intensive or semi-intensive culture of clams and cockles for subsistence purposes. The surveyed beach lies across *Narrow Strait* at a distance of approximately 2.7 kilometers from the village near Precoda Island (locally referred to as Cat Island). It was relatively small, but suitable for culture purposes. The strait and beach are reasonably well protected and should be accessible during most of the year. Numerous other small beaches, suitable for enhancement, were observed near Ouzinke. Brief reconnaissance surveys indicated that several of these beaches currently held harvestable numbers of butter clams (*Saxidomus giganteus*). There was a suitable beach situated in front of the Village. However, the number of people and heavy use suggested that it might not meet National Shellfish Sanitation Program requirements for an *Approved Harvest Classification*. Sea otter predation was not evident on any of the several beaches examined near Ouzinke.

3.6.1. Beach characterization. The surveyed beach is located at 57^o 48.12' N and 152^o 30.05'W. The area judged suitable as native littleneck clam habitat measured 50 to 70' feet wide by 120 feet long (0.17 acres). It was bounded on the west by a cobble field and on the east by a small stream flowing through fine sediments. Brown kelp (*Fucus cf. distichus* and *Laminaria cf. saccharina.)* was abundant in the nearshore area. The beach contained large quantities of broken butter clam (*Saxidomus giganteus*) shells. No "otter pits" were observed on this beach. Beach substrates consisted of mixed gravel (28 to 51%), sand (44 to 67%), and lesser amounts of silt and clay (5 to 6%). This mix is suitable for native littleneck clams. This beach is not suitable for cockles. However, a discontinuous eelgrass meadow within Camel Bay contained numerous cockleshells and appeared prime habitat for *Clinocardium* enhancement.

Figure (49) is a photograph of the beach. The inset is a silver fox that remained within 10 to 20 feet of the author during sample collection – enticed by an occasional shore crab thrown to him.

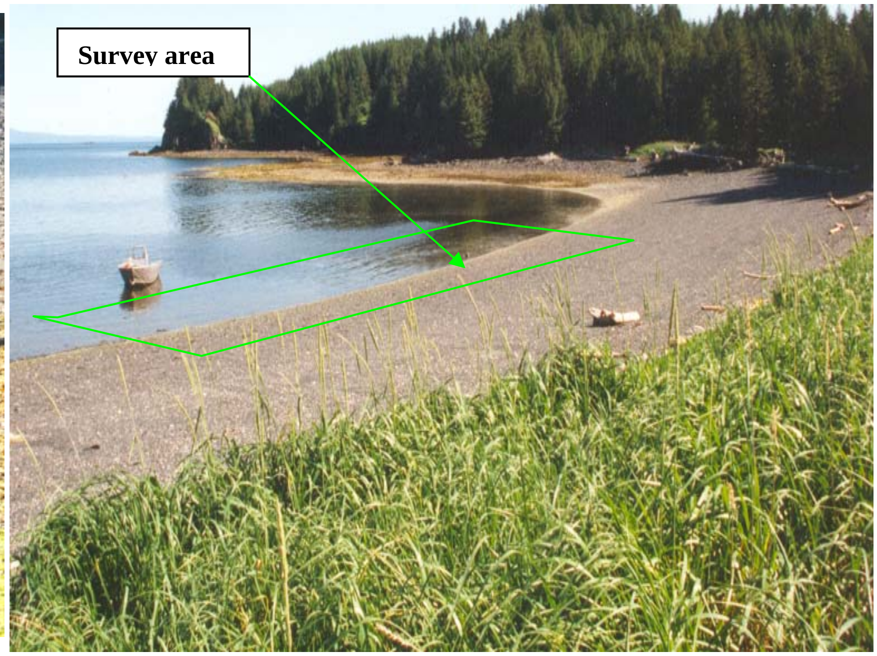

Figure 49. Subsistence harvest beach located on the northern side of Narrow Strait near the native village of Ouzinke. The inset depicts the algae covered substrate typical of this beach.

Figure (50) describes the four transects (A, B, C and D) that were examined in the most suitable clam habitat observed at this beach. Six 0.1 m^2 shellfish samples were collected at 10' intervals (with a random start) along Transects A, B and C. Four 0.1 m^2 shellfish samples were collected along Transect D, surveyed at the 0.0' MLLW tidal elevation. A single sediment sample was analyzed, at a randomly chosen sample station, on each of transects A, C and D. This design resulted in a total of 22 shellfish and 3 sediment samples. In addition, the valves from 22 empty butter, softshell and littleneck clams were collected to supplement the age-length database. Data resulting from the analysis of empty valves was used only to determine coefficients for the von Bertalanffy model.

The beach considered suitable for native littleneck clam production had a shallow slope (2%) and aerobic sediments to a depth of greater than 20 cm. The foreshore consisted of a sand and gravel dunefield that had been stabilized by vegetation. This foreshore separates two embayments. A significant amount of seawater was observed percolating through intertidal sediments in the survey area.

Three sediment samples were evaluated for sediment grain size and total volatile solids. Sediments averaged 41.2 $\pm$ 29.6 % gravel, 53.2 $\pm$ 29.3% sand, 5.6 $\pm$ 1.7% fines (silt and clay) and 1.92 $\pm$ 0.85% TVS. Sediment composition on the surveyed portion of this beach is suitable for native littleneck culture. However, sediments on either side of the surveyed area are either too coarse or too fine to provide optimum culture conditions.

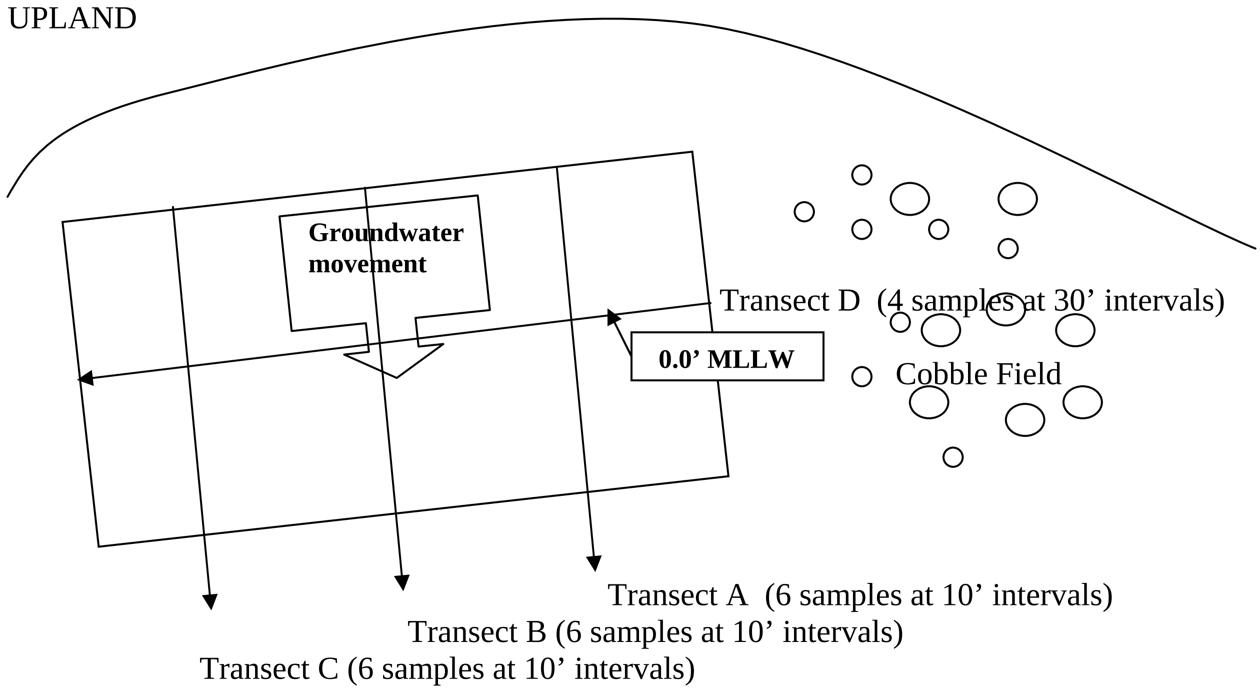

Figure 50. Schematic diagram of the Ouzinke Village shellfish beach located on the southern shore of Narrow Strait. The beach has surveyed on July 2, 1996.

3.6.2. Water characterization. The water temperature was 13.2 ^{o}C and salinity 31.2 ppt. Currents measured on the early ebb tide averaged 3.9 cm/sec and flowed east. The three water samples collected at this beach averaged 6.43 mg TSS/L and 2.33 mg TVS/L. These values suggested moderate to low levels of both primary productivity and suspended inorganic particulates. They do not suggest any reason why this beach would not be suitable for clam enhancement.

3.6.3. **Bivalve population characterization.** Eighty-three living bivalves were collected in the 22 systematic random samples from this beach (Table 18). An additional 19 bivalves were collected in random samples.

Table 18. Summary of bivalves collected in 22, 0.1 m^2 samples at the Ouzinke Village beach at Narrow Strait on July 2, 1996.

Species	Number
Protothaca staminea (native littleneck clams)	19
Saxidomus giganteus (butter clams)	61
Mya truncata (truncate softshell clams)	3

Softshell, butter and native littleneck clams have potential as subsistence shellfish resources. Local villagers stated a preference for butter clams, native littleneck clams and cockles. Of these, only the butter and native littleneck clams were found on the surveyed beach. Large, empty valves of *Clinocardium nuttallii* were observed in an eelgrass meadow and intertidal area at Camel Bay (local name) located three kilometers west of the surveyed beach.

Butter Clams. Sixty-one (61) butter clams were observed in these samples. Over half of the observed butter clams were new recruits less than two years old. Twenty-two legal size butter clams were observed in the 22 samples. Descriptive statistics for a limited number of variables are presented in Table (19). Figure (51) provides a length-frequency summary for butter clams collected during this survey. A vertical line is displayed at the minimum legal size of 38 mm valve length.

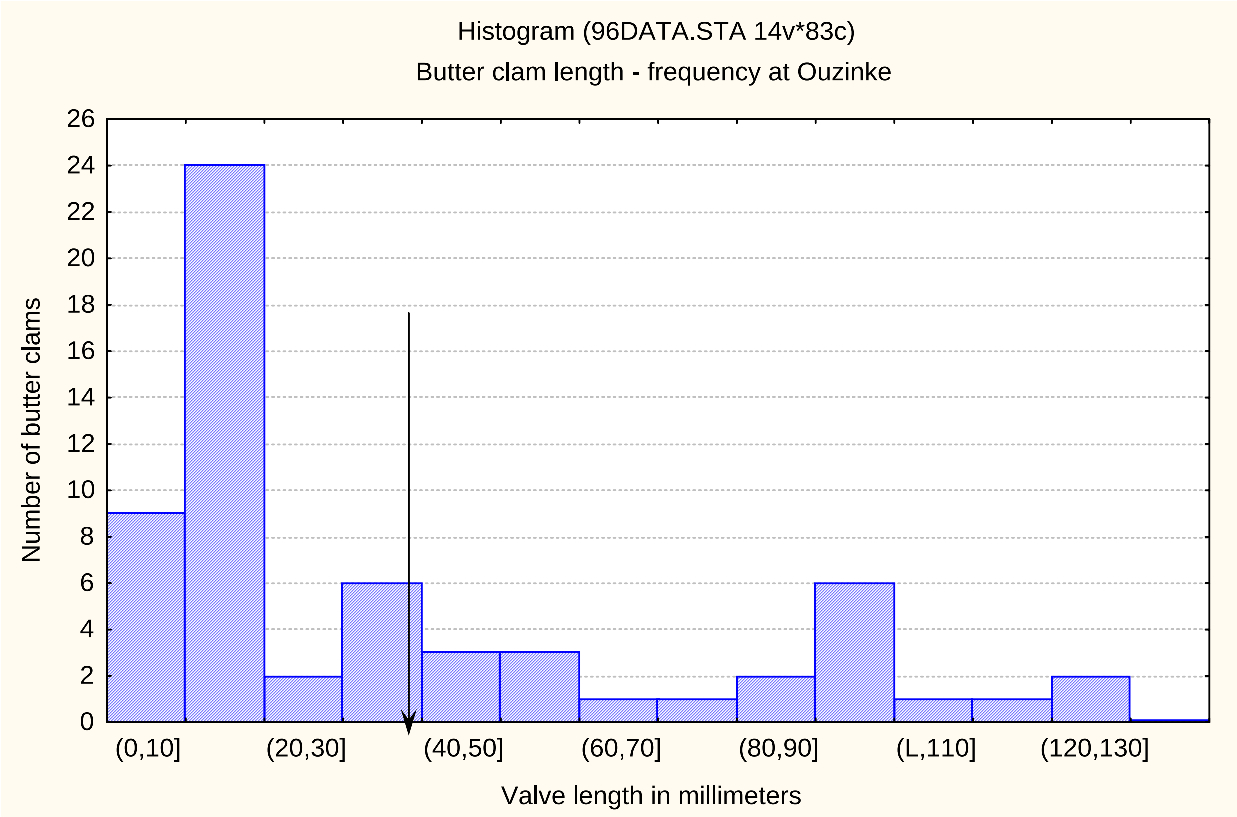

Figure 51. Length frequency histogram for butter clams (*Saxidomus giganteus*) collected in 22, 0.1 m^2 samples at the Ouzinke Village shellfish beach on July 2, 1996. The vertical line locates the legal limit ($\geq$38 mm).

Non-linear regression was accomplished on aged living and empty butter clam valves to determine coefficients for the von Bertalanffy model. The resulting equation explained 94.1% of the variation and the ANOVA determined probability that the regression coefficients were all equal to zero was P = 0.000. Residuals in the analysis were not significantly different from a normal distribution (Kolmogorov-Smirnov; d = 0.087; p = n.s. @ α = 0.05). Observed and predicted values are presented in Figure (52).

The resulting Von Bertalanffy growth equation for Ouzinke is compared with the results from Tatitlek and Nanwalek below. Large clams were not observed at either Passage Island or Tatitlek, but were observed in this survey. The larger asymptotic size predicted for Ouzinke may be due to the inclusion of larger clams in the database or it may reflect reduced predation (or other hypotheses). Living butter clams as large as 123 mm valve length were collected at Ouzinke. However, the valves on several of these were too worn for aging. The smaller coefficient on age suggests that butter clams grow more quickly at Ouzinke than at either Passage Island or Tatitlek or it may result from the inclusion of older and larger clams in this database.

Length of butter clams at Ouzinke (mm) $= 171.3(1 - \exp^{-0.050 \text{ x age in years}})$

Length of butter clams at Passage Island (mm) $= 84.4(1 - \exp^{-0.126 \text{ x age in years}})$

Length of butter clams at Tatitlek (mm) $= 126.5(1 - \exp^{-0.075 \text{ x age in years}})$

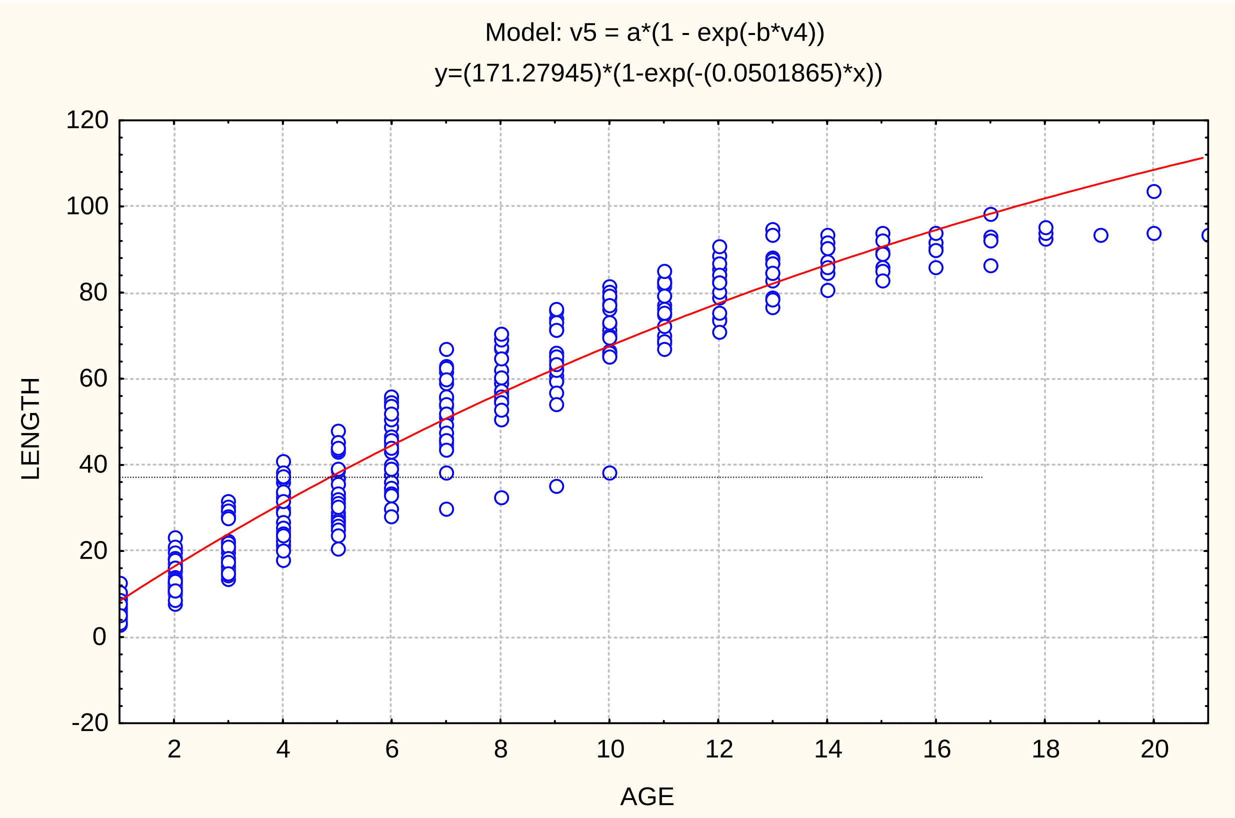

Figure 52. Solution to the von Bertalanffy model for butter clams collected in 22, 0.1 m^2 samples at the Ouzinke Village shellfish beach on July 2, 1996. The horizontal line represents the minimum legal size (38 mm).

Table 19. Summary descriptive statistics for living butter clams sampled at the Ouzinke Village's shellfish beach on July 2, 1996.

	Valid N	Mean	Minimum	Maximum	Std. Dev.
Length (mm)	61	37.9	4.22	123.4	35.3
Whole weight (g)	61	53.3	0.16	444.1	104.3
Age	60	6.1	0.00	21.0	5.7
Dry Condition Factor	34	0.9	0.13	2.2	6.2

An age-frequency histogram for butter clams is presented in Figure (53). Butter clams appeared to recruit into the legal size population at between age four and seven years (mean = 5.0 years). Recruitment of butter clams to this Ouzinke beach appears to occur regularly, but not in sufficient numbers to sustain subsistence harvests. If recruitment in 1994 and 1995 was indicative of other years, a significant proportion of the new recruits appear to have survived and entered the harvestable population. A number of hypotheses could be invoked to explain the higher survival in this location. It is remote from the Exxon Valdez oil spill and may represent undisturbed conditions. However, presumptive otter pits were not found on this beach and very few drills or starfish were observed. Therefore, it is also possible that reduced predation is responsible for the increased number of large clams. Numerous other hypotheses could be invoked. None of these was investigated as part of this study.

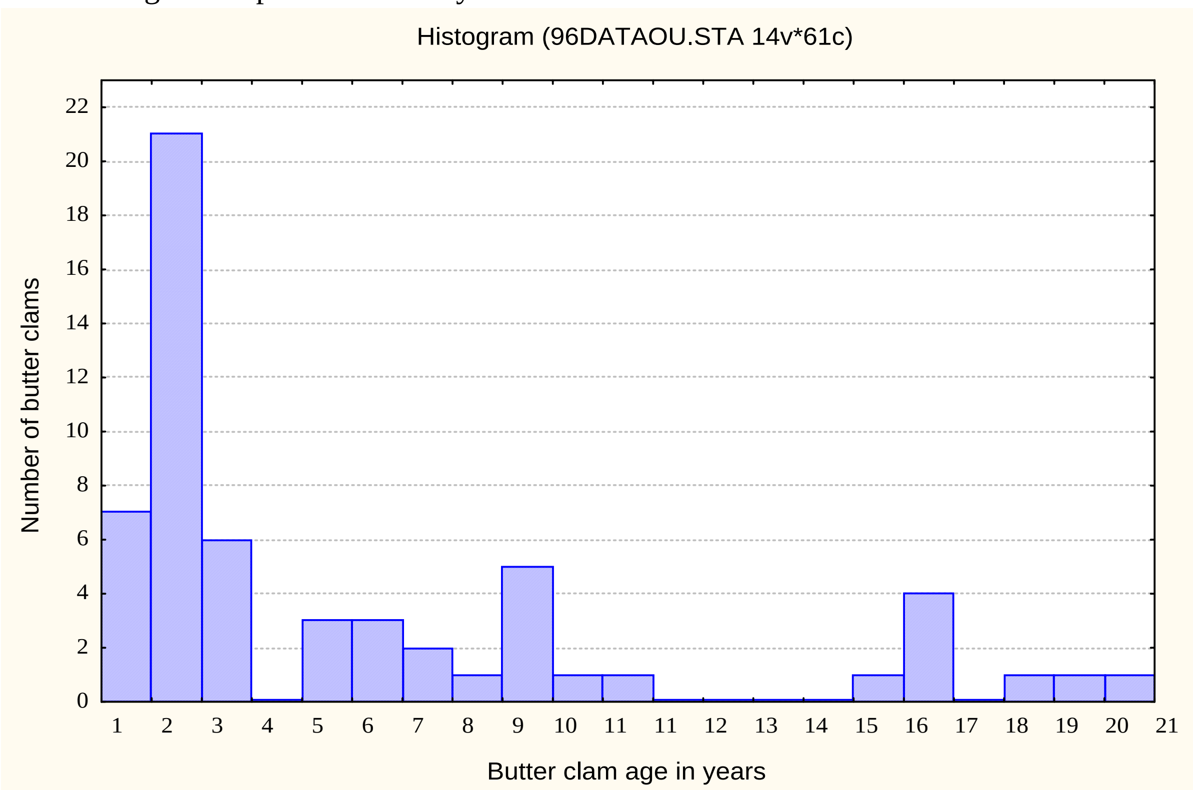

Figure 53. Age-frequency histogram for butter clams (*Saxidomus giganteus*) collected in 22, 0.1 m^2 samples at the Ouzinke Village, Narrow Strait, shellfish beach on July 2, 1996.

Butter clams were growing and apparently surviving well on this Ouzinke beach. However, because of their propensity to retain paralytic shellfish poisons and lack of adequate hatchery technology, this species is not considered appropriate for enhancement. It should be noted that recruitment of butter clams is low but occurs regularly on this beach. This suggests that significant harvests of any kind would quickly deplete the standing biomass. A sound harvest management plan, developed and implemented by the elders of the Village of Ouzinke could help sustain these stocks.

3.6.4. Harvestable biomass of butter clams at Ouzinke. This is the first beach surveyed by the CRRC study team that contained subsistence quantities of shellfish. The average sample weight of butter clams in each sample was 93.1 grams. The harvestable biomass (including 95% confidence limits on the mean), within the 60’ x 120’ survey area was 670.3 $\pm$ 297.3 kilograms. Most of these clams were collected near 0.0’ MLLW.

3.6.5. Native littleneck clams. Nineteen (19) native littleneck clams were observed in the 22 samples collected at the Ouzinke shellfish beach on Narrow Straits. Summary statistics describing littleneck clams are presented in Table (20).

Table 2o. Summary descriptive statistics for living native littleneck clams sampled in 22, 0.1 m^2 quadrats at the Ouzinke Village’s beach on Narrow Strait on July 2, 1996.

	Valid N	Mean	Minimum	Maximum	Std. Dev.
Length (mm)	19	29.6	6.97	55.01	16.61
Whole wt. (g)	19	12.1	0.07	43.03	13.91
Age (years)	19	4.9	1.00	11.00	3.36
Dry Condition	14	0.48	0.23	0.79	0.18
Wet Tissue Wt (g)	14	6.96	0.55	18.53	5.83

The largest native littleneck clam had a valve length of 55 mm and weighed 43 grams (10.5 per pound). Eight (8) legal size native littleneck clams were obtained from the 22 quadrats included in the systematic random sample. That is less than one legal size clam per square foot and demonstrates the lack of subsistence littleneck harvest available on this beach. Figure (54) suggests steady, but low recruitment (or survival of recruits past settlement) at this beach.

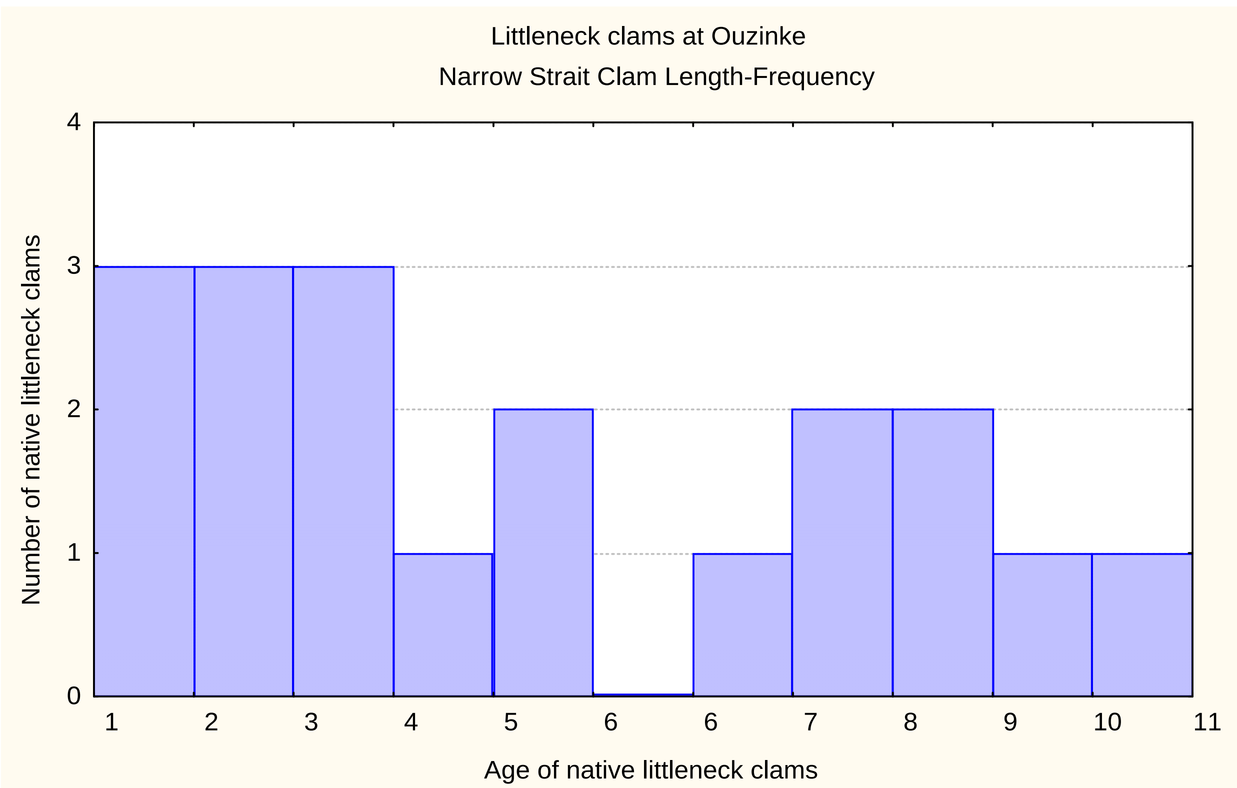

Figure 54. Age – frequency histogram for littleneck clams collected in 22, 0.1 m^2 quadrats at the Ouzinke shellfish beach on July 2, 1996.

Further examination of the population was accomplished using the length - frequency histogram provided in Figure (55). These two histograms suggest that recruitment is generally reliable but low at this site. It also appears reasonable to conclude that (assuming current recruitment reflects past recruitment) survival is good. The frequency observed in each of the year classes in Figure (51) should be divided by 2.2 to obtain the number of recruits per square meter. Doing this suggests that recruitment in 1993, 1994 and 1995 resulted in between one and two littleneck clams surviving per square meter until 1996. This is far below the minimum of 200 to 300 clams per square meter needed to fully utilize a quality habitat such as this. It appears that supplemental seed would benefit future bivalve harvests at this beach.

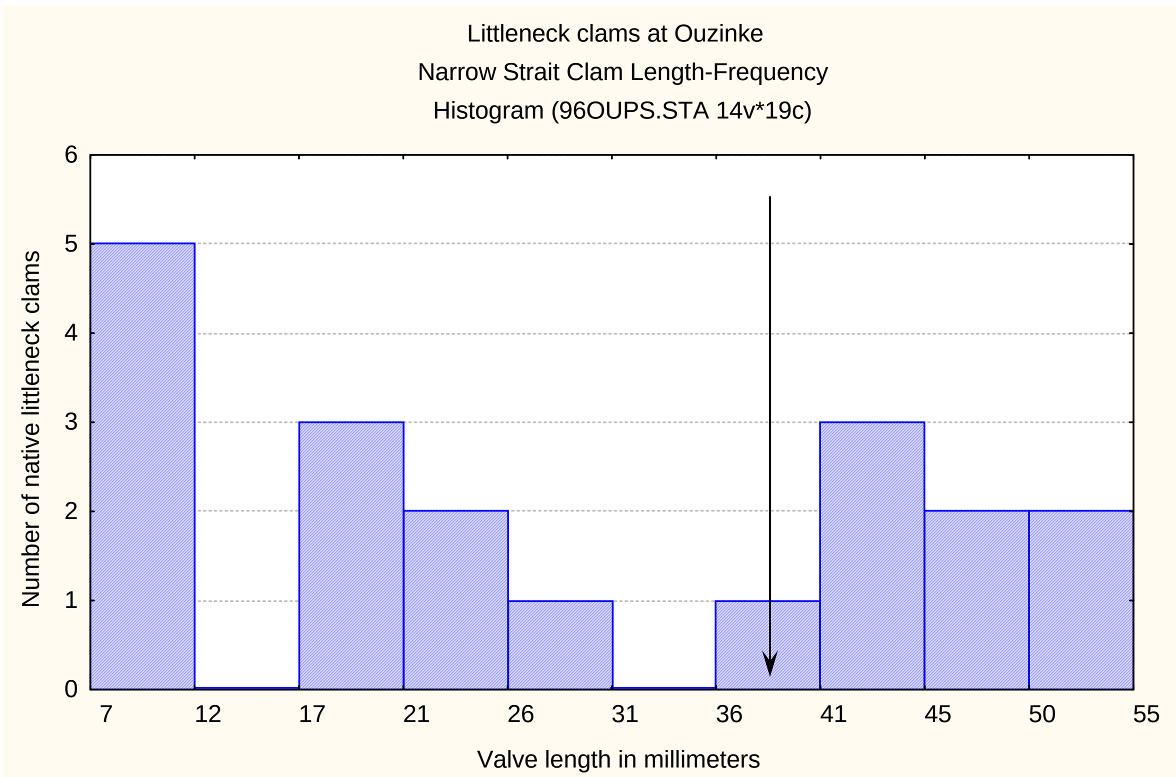

Figure 55. Length - frequency histogram for littleneck clams collected in 22, 0.1 m^2 samples collected at this Ouzinke beach on July 2, 1996. The vertical line represents the minimum legal size of 38 mm.

Current clam densities are insufficient to warrant subsistence harvests of littleneck clams at this Ouzinke beach. However, a few littleneck clams will be retrieved during a butter clam harvest. Older native littleneck clams are present as a significant proportion of recent recruitment. However, too few native littleneck clams were obtained in this survey to warrant any conclusion regarding survival. The relative absence of predators suggests that extensive cultivation without a need for predator exclusion netting may be appropriate on this beach.

Figure (56) describes the distribution of native littleneck and butter clams as a function of tidal height at this Ouzinke beach. Unlike other beaches surveyed in this study, most of the littleneck clams were found at relatively low intertidal elevations. This may reflect reduced starfish predation. However, the few native littleneck clams retrieved did not provide a basis for drawing significant conclusions.

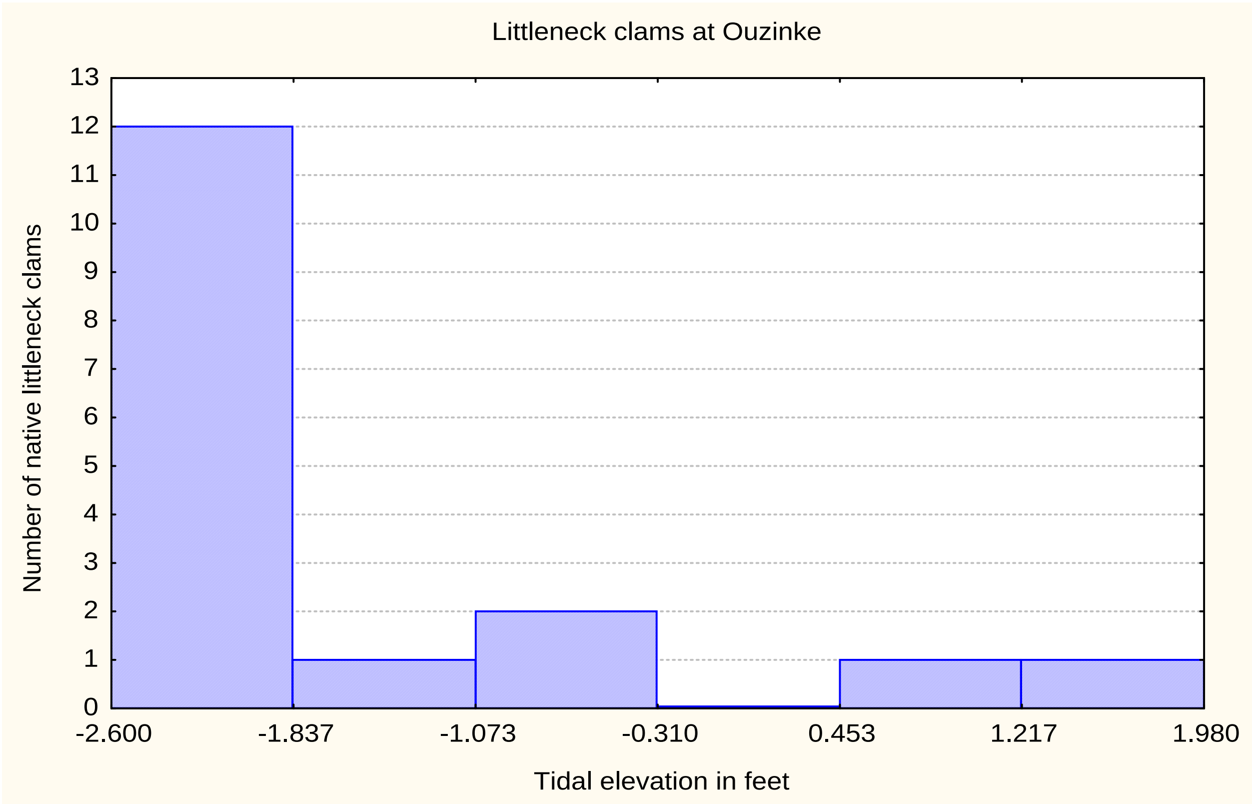

Figure 56. Tidal elevation - frequency histogram for littleneck clams collected in 22, 0.1 m^2 quadrats at the Village of Ouzinke shellfish beach on Narrow Strait on July 2, 1996.

3.6.6. Age-length analysis for native littleneck clams at Ouzinke. Regression coefficients were developed for the von Bertalanffy model using nonlinear regression. The resulting equation explained 93.7% of the variation and the ANOVA determined probability that the regression coefficients were all equal to zero was P = 0.000. The residuals were not significantly different from a normal distribution (Kolmogorov-Smirnov; d = 0.11; p = n.s. @ α = 0.05). Clam lengths to 55 mm were available for the analysis. Predicted and observed values of valve length, as a function of age, are presented, together with the regression line in Figure (57). This equation was solved for a length of 38 mm to obtain the average age of recruitment into the legal size population. Based on the von Bertalanffy model, the average age of recruitment to a size $\geq$ 38 mm was 6.13 years. The unexpectedly high maximum length of 73.8 mm may be associated with higher growth rates throughout the lifespan of this species in this part of Alaska. Under any circumstances, clams with valve lengths longer than 55 mm were not included in the database and extrapolation to lengths greater than that is inappropriate.

$$\text{Native littleneck clam length at Ouzinke (mm)} = 73.8(1 - \exp^{-0.118*\text{age in years}})$$

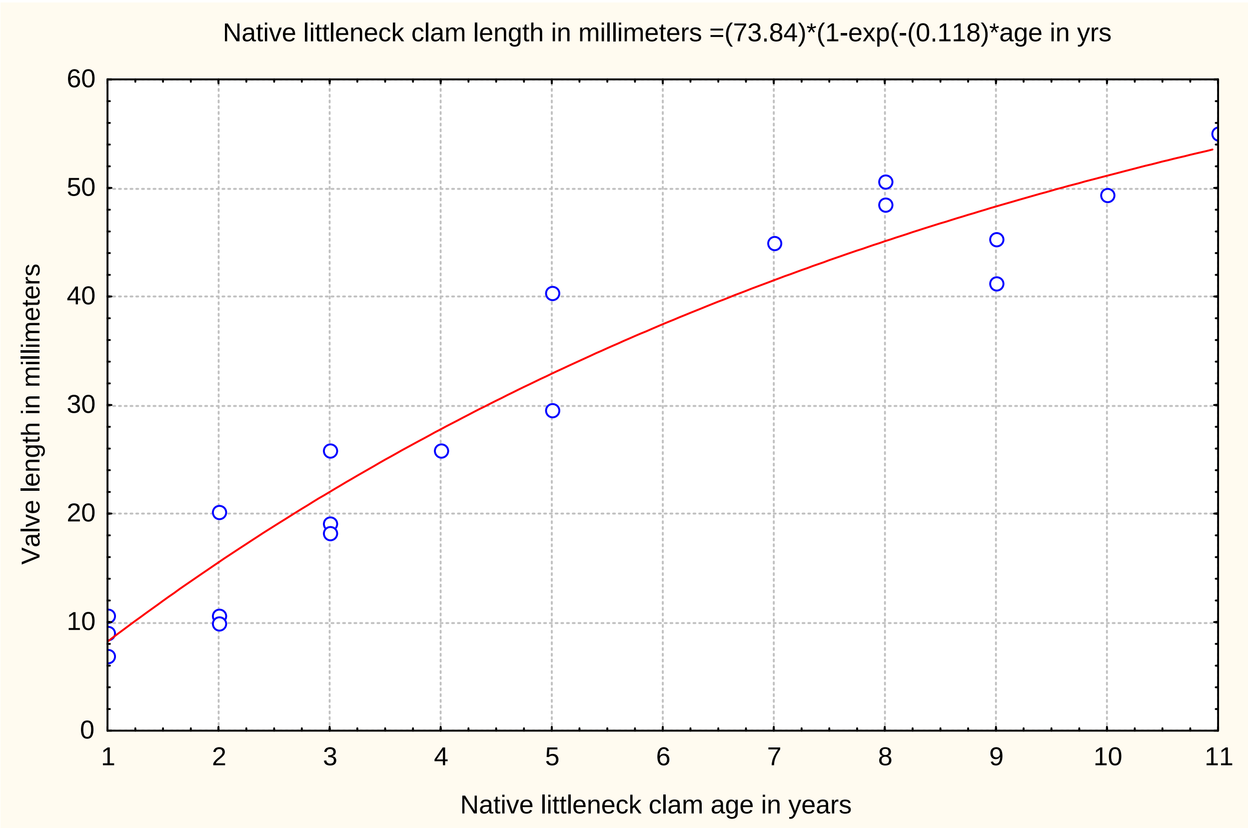

Figure 57. Valve length (mm) as a function of age (years) for native littleneck clams (*Protothaca staminea*) collected in 22, 0.1 m^2 quadrats at the Ouzinke shellfish beach on Narrow Strait on July 2, 1996.

3.6.7. Bacteriological water quality at the Ouzinke shellfish beach on Narrow Strait. Three water samples were collected at the survey beach and returned to Aquatic Environmental Sciences at 4^{o}C where they were examined for fecal coliform bacteria using the five tube MPN method. Fecal coliform bacteria were < 2/100 ml in all samples. This analysis does not satisfy the needs of the National Shellfish Sanitation Program. However, it suggests that there is no continuing source of fecal coliform bacteria at this beach. Certification should be obtained for the receiving water from responsible agencies prior to any major enhancement effort.

3.6.8. Summary, conclusions and recommendations for native littleneck clam enhancement at the village of Ouzinke's, Narrow Strait shellfish beach. Based on this survey and analysis, the following conclusions can be reached:

- **Shellfish biomass available for harvest.** There is currently a significant shellfish biomass available for harvest on this beach and on several other beaches in the local area. Butter clams comprise the majority of the harvestable biomass. The total biomass on this single beach has been estimated at 670.3 $\pm$ 297.3 kilograms. The majority of these are large (older) butter clams. The apparent low clam recruitment level suggests that subsistence harvests would quickly deplete the standing stock. This could be avoided by invoking a locally supported management plan.

- **Beach suitability for bivalve enhancement.** The surveyed Ouzinke beach contains approximately one- fifth acre of ground suitable for native littleneck clam enhancement or culture. The physical and chemical parameters examined in this survey are all within acceptable limits. The beach is readily accessible from the village. The apparent absence of large numbers of predators makes this area unique among the five village beaches surveyed in 1995 and 1996. There is an opportunity here to implement a more extensive enhancement trial.

  The observation of a significant flow of saltwater from the interdunal area above the beach is a positive aspect of this beach that will reduce the potential desiccation and overheating in the summer and freezing during winter low tides. Nearly all aspects of native littleneck growth are enhanced by significant amounts of interstitial water movement.

- **Bivalve predation.** Evidence of significant predation on bivalves was not observed in this survey.

- **Bivalve recruitment.** Recently past bivalve recruitment to this Ouzinke beach has been too low to sustain long-term subsistence or recreational harvests.

- **Native littleneck clams (*Protothaca staminea*).** Few native littleneck clams were observed in samples from this Ouzinke beach. The reason is thought to be poor juvenile recruitment. The age length analysis suggests that native littleneck clams recruit to the legal size population at approximately 6.5 years of age.

- **Butter clams (***Saxidomus giganteus*) also recruit in low numbers to this beach. Growth appeared somewhat faster than for native littleneck clams and butter clams entered the legal size population at approximately 5.0 years of age. There was a harvestable standing biomass of butter clams on this, and several other beaches in the area. However, the large biomass consists of older clams that will not be quickly replaced following harvest.

- **Cockles (*Clinocardium nuttallii*)** are a traditional (and preferred) shellfish for Alaskan natives. The primary beach surveyed in this effort was too rocky, with too few fines, to warrant cockle enhancement. However, excellent cockle habitat was observed in Camel Lagoon approximately 3 kilometers west of the surveyed beach.

- **Mussels (*Mytilus edulis trossulus*)** were not observed in abundance on any of the surveyed beaches in the Ouzinke area. Unless local sources of seed are identified, mussel culture would require the importation of hatchery produced seed or seed collected from other locations.