Exxon Valdez Oil Spill
Restoration Project Annual Report

Nanwalek/Port Graham/Tatitlek Subsistence Clam Restoration

Restoration Project 95131
Annual Report

This annual report has been prepared for peer review as part of the *Exxon Valdez* Oil Spill Trustee Council restoration program for the purpose of assessing project progress. Peer review comments have not been addressed in this annual report.

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Study History: This project was initiated at the request of villages impacted by the *Exxon Valdez* oil spill. Restoration Project 95131 was funded at a pilot level for FY95. This is the first annual report for the Nanwalek/Port Graham/Tatitlek Clam Restoration Project.

Abstract: Clams were once a major subsistence resource in the native communities of Nanwalek and Port Graham in lower Cook Inlet and Tatitlek in Prince William Sound. The importance of clams as a subsistence food source has been greatly reduced as a result of a lack of confidence by villagers in the safety of shellfish after the *Exxon Valdez* oil spill. In addition, local clam populations have been on the decline in recent years as a result of sea otter predation and changing currents and beach patterns. The 1995 objectives were to identify clam species to use in restoration efforts, identify and clear clam brood stock for hatchery use, demonstrate hatchery and nursery capabilities to produce clam seed for 1996 and to identify and survey restoration sites near the project villages.

Key Words: Enhancement, *Exxon Valdez* oil spill, hatchery, Lower Cook Inlet, Prince William Sound, *Protothaca staminea,* surveys.

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EXECUTIVE SUMMARY

Clams were once a major subsistence resource of the native communities of Nanwalek and Port Graham in lower Cook Inlet and Tatitlek in Prince William Sound. Local clam populations have been decreasing in recent years and their contribution to the subsistence harvest has been greatly reduced. There are probably several reasons for this including changes in currents and beach patterns, increasingly heavy sea otter predation and the *Exxon* Valdez oil spill. The oil spill impacted wild clam populations and their importance as a subsistence food in two ways. First, some clam beds suffered from direct oiling. Second, even though many clams were not directly impacted by the oil, they have a tendency to accumulate, concentrate and store toxic contaminants from non-lethal amounts of oil. This has badly eroded confidence of the villagers in the healthfulness of the remaining wild clam populations as a subsistence food.

1995 was the first year of the project. The projects goal is to provide the project villages with safe, reliable, easily accessible sources of clams for subsistence use. The 1995 objectives were to identify clam species to use in the restoration effort, identify and clear from the Alaska Department of Fish and Game Pathology section broodstock for hatchery use, demonstrate hatchery and nursery techniques by producing 10 mm seed stock from at least one of the selected clam species and identify enhancement/restoration sites near the project villages.

After consultation with the native villagers, experts in clam production techniques and a literature search, littleneck clams *Protothaca staminea* and cockles *Clinocardium nuttali* were selected as the species that will be used in the restoration effort. The butter clam *Saxidomus giganteus,* a popular species with the Native villagers, was rejected because of its slow growth characteristics and propensity to retain the Paralytic Shellfish Poison toxin for extended periods. Littleneck clam brood stock for both Nanwalek/Port Graham and Tatitlek have been cleared for use in the Qutekcak Shellfish Hatchery in Seward. A Nanwalek/Port Graham brood source of cockles has been cleared for hatchery use, but clearance for a Tatitlek cockle brood source is being withheld pending further analysis by the state fish pathologist. Approximately 20,000 5 mm littleneck clam seed have been produced in the Qutekcak Shellfish hatchery and a 10,000 10 mm clams was produced by the adjoining nursery system. No hatchery work has yet been done with cockles.

Several sites were selected near each of the villages as possible candidates for enhancement/restoration. After extensive interviewing of villagers and reviewing areas, beach sites were identified in each of the three villages. These sites underwent extensive sampling for resident bivalve populations, substrate type, biological and physical factors and enhancement/restoration potentials described for each.

INTRODUCTION

The clam resources of lower Cook Inlet were once an important food source for Native peoples of Lower Cook Inlet and Prince William Sound. The abundance of native shellfish has been greatly diminished in recent years by sea otter predation and changes and shifts of current patterns. This in conjunction with the erosion of confidence in consuming native shellfish as a result of the contamination of *Exxon Valdez* oil spill was the impetus for this project.

The purpose of this project is to establish populations of clams in areas readily accessible from the villages of Tatitlek, Nanwalek and Port Graham. These clams will be used as a source for subsistence food to replace the natural resource that has been lost or depleted.

OBJECTIVES

The study described herein had three objectives:

(1) Develop and improve hatchery techniques for the littleneck clam (*Protothaca staminea),* the cockle (*Clinocardiumj nutalli)* and, if the resources allow, the butterclam (*Saxidomus gigantus*). Produce a 5 mm seed in the hatchery within 19 weeks after spawning.

(2) Develop techniques to grow 5 mm littleneck clam seed from the hatchery to an out planting size if 10 mm - 15 mm within 12 weeks. Review needs and possible alternatives of substrate for nursery and growout.

(3) Describe current bivalve populations through interviews and resource assessments. Locate sites for future enhancement efforts.

METHODS

Hatchery/Nursery

The Qutekcak Shellfish Hatchery has been in operation since October 1993. The hatchery has pioneered techniques for culturing the native littleneck clam *Protothaca staminea* . The details of these techniques are outlined in Culture of the Alaskan Native Littleneck Clam (Appendix 1) and the Qutekcak Shellfish Hatchery Manual. (Appendix 2). A brief description of the processes follows:

Broodstock are brought in from the field and placed in mildly aerated 60 liter tanks and held at 16-18^0 C. They were fed 4-6 times a day with mixtures of *Tahitian isochrysis* and *Chaetoceros calcitrans* at approximately 50,000 cells/ml. The water is changed out every three days to remove metabolites and waste products. Maturation was monitored by sampling gonadal tissue once a week. Photographs were taken of the developing gonads to develop an index of maturity for future use. Attempts were made to induce spawning through thermal shocks. Most of the spawning activity was not induced. The clams, which are trickle spawners, released gametes sporadically from April through August.

After a spawning event the larvae were filtered and then transferred to aerated 60 liter tanks heated to 16 to 18^0 C. It took the littleneck clam larvae approximately 4 weeks to reach 240 *u*m. At this point they were transferred to 130 liter airlift tanks, where the temperature was maintained at 14-16^0 C. Larvae were fed a mixture of *Tahitian isochrysis, Chaetoceros calcitrans, Thalassiosira puedonana* and *Tetraselmis suecica* 2-3 times a day at cell densities of 50,000 to 75,000 cells/ml. The newly set clams spent almost 2 months in the airlift station. The flow was changed from downwell to upwell for 4 hours daily to remove metabolites and waste products. Water is changed every three days to remove metabolites. The clams are fed a mixture of algae at a density of 70,000 cells/ml. The clams were fed whenever the algae mix was cleared.

All of the littleneck clams were retained for culture. No culling or removing of slow growers occurred. When sorted, littleneck clams that exceeded 1 mm in length were transferred to a vertical flow through "Heath" incubator. Clams less than 1 mm we retained in the airlift station.

The vertical flow system has a reservoir and a pump below the bottom tray. The pump delivers water to the top of the stack and the water cascades from one layer to the next by up flowing through a screen and then falling to the next level. Makeup water and feed is applied to the reservoir. The feeding and care in the vertical system was the similar as in the airlift station. The water would cascade from one tray to the next. The trays were shuffled daily to make sure feed availability was distributed evenly. The clams were fed to 5 mm which took approximately 6 weeks.

When the littleneck clams reach 5 mm they are transferred to an outdoor seawater pond (Hetrick & Joseph; Paul, et al.). The algal community in the pond is managed by flow rates of incoming saltwater and fertilization. The saltwater comes from a 270 foot line 60 meters deep anchored in Resurrection Bay. The seawater is nutrient rich and devoid of most organisms. Nitrogen, phosphorous and silica are added to the pond as additional nutrients. The pond is aerated to allow for adequate mixing and prevent thermal stratification.

The littleneck clams are cultured on floating plywood containers utilizing sand as a substrate. The plywood containers are 4 feet long with 6 inch sides. Algae rich water passively flows through the containers presenting food for the juvenile littleneck clams.

The seed will be grown to 10+ mm by October and then overwintered in the pond before being transferred to the participating villages for planting in 1996.

The hatchery submitted samples of littleneck clams and cockles from Tatitlek and lower Cook Inlet to the Alaska Department of Fish and Game for a disease review.

Field Surveys

A preliminary trip was made to each of the villages to interview locals and review local beaches and habitat to identify sites which may have potential for enhancement and restoration. The preliminary review was also used as a baseline for describing boundaries for the Clam Restoration Project 95131 Environmental Assessment. Based on these interviews and beach surveys, sites were selected near each of the villages. In addition individuals from each of the villages were solicited to assist in the sampling operation. A contact was identified in each of the villages.

A detailed description of the beach survey protocol is available (Appendix 3) A brief description of the sampling protocol is presented below.

Beach surveys were conducted at low tides (minimum -1.5 MLLW). The survey area was marked, measured and random plots staked out for digging. Each test plot involved removing $0.1m^2$ of substrate. A total of 24 plots were sampled at each beach. The substrate was later sieved on 1/4" screen followed by a 1 mm sieve. All shellfish from these samples were measured, shucked and weighed.

Additional sediment samples were taken to determine sediment grain size and total volatile solids. Water samples were collected for temperature, salinity, dissolved oxygen and total suspended solids.

The beach characteristics were also recorded to include slope, area, substrate color and type, macro algae, presence of predators, and evidence of excessive littoral or log damage. Photographic records were kept of all sampling.

Shellfish samples were collected from each site and submitted to Alaska Department of Environmental Conservation (ADEC) for analysis for toxins which cause Paralytic Shellfish Poisoning.

RESULTS

Hatchery

In the summer of 1994 a small batch of about 7,000 littleneck clams *(Protothaca staminea)* was successfully spawned and grown in the hatchery. As far as is known this was the first successful production of this species in a hatchery. When this project began in February of 1995 these clams were earmarked for nursery studies that would begin that summer.

This first batch of littleneck clams were from Tatitlek broodstock which was certified for hatchery use in the spring of 1994. After this project was initiated the first step was to obtain more broodstock into the hatchery so that seed clam production could continue.

When the hatchery first began operations a training program in clam hatchery techniques was set up with Taylor United of Sheldon, Washington. The training program consisted of four one week sessions for hatchery staff at one of Taylor's hatcheries. The training program was put on hold in August 1994, after two sessions were completed, until it was known whether or not the clam restoration project would be funded. After the project became operational the remainder of the training was completed.

The first spawn occurred in mid May and on June 8 larvae from this spawn began to set. The larvae did not survive well and only around 3,000 survived through set. Littleneck clams are trickle spawners and between late May and July 23 the broodstock spawned five more times. Survival through the set improved with the subsequent spawnings and by July 23 there was an estimated 30,00 set clams in the airlift tanks plus an unknown amount of larvae.

A power outage during the night of July 23 shut down the water heating system causing the water temperature to plummet from 14^0 C to 5^0 C. The thermal shock killed all the set clams and the larvae in the hatchery. The thermal shock also stressed the broodstock enough to stop them from further spawning.

In early May clam samples from Kachemak Bay (Port Graham/Nanwalek area) were sent to the state to be certified as broodstock for the hatchery. This stock was certified for use in the hatchery mid July. Immediately after the power outage Kachemak Bay broodstock was brought into the hatchery. These clams spawned almost immediately upon being placed in the conditioning tanks and had produced about 30,000 set clams by August 20. These clams will become the seed stock that will be used in the growth/mortality and predator control studies scheduled for FY96.

In September heavy rains in the Seward area caused flooding at the hatchery site. This flooding caused the nursery to be filled with silt and the hatchery water supply too became heavily laden with silt. In spite of the water supply problems and the damage that was done to the nursery pond, the staff was able to save most of the hatchery and nursery stock by bringing everything into the hatchery and putting it on recirculation until the water supply cleared up. All the broodstock were lost.

Hatchery broodstock certification of the cockle (*Clinocardium nutalli)* was initiated in FY 95. Samples from Kachemak Bay and Tatitlek were submitted. The Kachemak Bay stock has been certified however, an unknown parasite was found in the Tatitlek stock and certification is being withheld. Samples of other stocks that would be permitted for use in Tatitlek will be submitted for certification during the FY 96 field season.

Nursery

The hatchery seed produced from the 1994 spawn was placed in the nursery pond adjacent to the hatchery in April, 1995 and held there until severe flooding forced their removal in September. The seed ranged from 4 mm to 10 mm when placed in the pond with an average size of 5.5 mm.

Growth of the seed in the pond was less than expected, especially during the early part of the summer. From April through June the seed grew hardly at all. It appeared the algal composition was less than optimal with the larger sized species (mostly pennate diatoms) predominating. Adjustments in the flow rates into the pond and the fertilizer mix began to change the species composition and by the end of June seed growth was noticeably better. Seed growth in July and August was satisfactory although maintaining good growth required constant analysis of the algal composition in the pond and adjustments as necessary to maintain a satisfactory species mix.

When the heavy rains and flooding in September forced the removal of the seed from the pond their length ranged from 7 mm to 17 mm and averaged 11.5 mm.

Field Surveys

The results of the field work done in 1995 is extensively outlined in "Baseline Surveys of Tidelands Near the Tatitlek, Nanwalek, Port Graham villages by Dr. Kenn Brooks (Appendix 4). This report provides the basis for ADF&G and tribal personnel to develop management plans for these beaches. The field work for this project was completed between August 25 and August 29, 1995. A brief summary is presented below.

<u>Passage Island - Nanwalek</u>
The physical and chemical parameters at Passage Island are ideal for native littleneck clams. The substrate is adequate and the strong currents provide sufficient food. All harvestable size clams were absent from the sampled area. Evidence of predation was heavy. Also smaller clams 3-4 mm had substantial mortality from drills.

The recruitment for the area is very low which supports the need for additional enhancement. The site appears to be limited in clam production because of inconsistent recruitment and predation on clams 4 -5 years old which are almost of a harvestable size. Presently, there are not enough clams in the area to warrant a harvest.

<u>Murphy's Slough - Port Graham</u>
Initially, the beaches surrounding Duncan and Tulcan Slough were identified for survey. However, test digging found a complete absence of butter clams and littleneck clams at both sites. A nearby beach at Murphy's Slough was selected as the best opportunity because of its

relative protection from the elements, its large size (almost five acres) and a substrate of mixed gravel, mud and significant quantities of broken shale. It appeared to hold great promise as shellfish habitat, especially for cockles.

Recruitment has failed at Murphy's Slough and other areas near Port Graham. No littleneck clams or cockles were found. Like other areas sampled during the survey predation appears to be the cause. The physical, biological and chemical parameter suggests that Murphy's Slough has tremendous potential for both native littleneck clams and cockles.

Tatitlek Village beach-Tatitlek

The Tatitlek Village beach contains approximately one acre of ground suitable for native littleneck clam restoration/enhancement. There were other areas not surveyed that appeared suitable for cockle enhancement. The Tatitlek Village beach contained considerably more clams than other areas surveyed however all of the clams were small (< 20 mm) indicating that predation was probably cropping off the larger individuals. Growth rates for the clams appeared to be similar to other areas sampled during the 1995 field season. Predator control, like at the other sites, will be the largest challenge to the project. Recruitment is consistent but not adequate at Tatitlek.

The samples submitted from Tatitlek, Port Graham and Nanwalek for the toxin which causes Paralytic Shellfish Poisoning (PSP) were processed by the Alaska Department of Environmental Conservation (ADEC). All of the samples had values of less than 32 mu which is the lower threshold of detection with the mouse bioassay (Appendix 5).

DISCUSSION

The first year of the project demonstrated that it is possible to produce littleneck clam seed in an Alaskan hatchery. Most of the objectives set for FY 95 were met; the lone exception being not having a certified cockle broodstock for Tatitlek. However, this year also demonstrated that many improvements are needed to make the hatchery and nursery systems reliable, efficient and cost effective.

The hatchery needs to develop the techniques for controlling the spawning of clams to fit the entire production cycle and the dynamics of the hatchery. The techniques for increasing the survival from larvae to set must be improved as well as methods for accelerating growth in order to take advantage of summer nursery capabilities. Hatchery procedures need to be updated and policies put in place to ensure that the facility is running properly and its activities accountable. To help accomplish all this an experienced shellfish hatchery technician will be brought in to work in the hatchery full-time.

For FY 96 hatchery and nursery operations will still concentrate on littleneck clam culture. To ensure that the development of culture techniques for cockles does not fall behind schedule an aquaculture specialist in Washington state has been contracted to develop procedures for the hatchery culture of cockles so that this technology can be brought into the hatchery in time to produce cockle seed for FY 97 filed season.

An effective and efficient nursery system must be developed. Different nursery systems, both in the nursery pond and in the filed, will need to be tested to find the best approach (s) to produce clam seed from the nursery. A Fluidized Upwelling System (FLUPSY) will be available at Chenega Bay and Tatitlek to assist in nursering the clams. FLUPSY's are proven methods of efficiently culturing juvenile shellfish. The FLUPSY's should reduce the densities in the Seward pond and offer an opportunity for taking advantage of the natural productivity of Prince William Sound.

Producing seed that is large enough to plant will eliminate the need for overwintering seed stock. Over wintering the seed stock is expensive since it involves pumping water and labor. It is also risky since the pond can freeze and the lack of food availability could cause mortality or poor condition of the shellfish.

The field work proceeded very well in 1995. All three areas surveyed: Murphy's Slough at Port Graham, Passage Island near Nanwalek and Tatitlek Village beach all are suitable for shellfish enhancement and restoration. Each have different characteristics and resident populations which will further the understanding of the requirements of the life cycle of the littleneck clam. The field surveys provided an introduction of the project to the residents of the villages and placed a foundation for enhancing the beaches in 1996.

The results of the field survey have been used to develop an enhancement plan for each of the villages in 1996 focusing on growth and mortality studies. These are major steps into achieving the goal of providing a sustainable clam subsistence harvest at the villages.

CONCLUSIONS

The clam restoration project achieved many of the goals set out in the 1995 Detailed Project Description. Techniques have been further refined to produce seed stock of the littleneck clam *Protothaca staminea*. Approximately 30,000 littleneck clams have been nurseried to over 10 mm. These will be used in the enhancement and restoration efforts at Nanwalek/Port Graham and Tatitlek during the 1996 field season. Cockle brood stock have been identified and certified and techniques are being developed for their culture. Many of the operational problems with the hatchery have been solved.

Sites have been identified and baseline surveys completed for beaches selected for enhancement and restoration.

ACKNOWLEDGMENTS

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Environmental Assessment (Restoration Project 95131).

Appendix 1

Hetrick, J. 1995. Shellfish Culture Manual: Qutekcak Shellfish Hatchery.

SHELLFISH CULTURE MANUAL

QUTEKCAK SHELLFISH HATCHERY

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August 1995

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I. INTRODUCTION

The Qutekcak Shellfish Hatchery (QSH) is operated by the Qutekcak Native Tribe in Seward, Alaska. Funding for the start of the operation came from many sources including grants from the American Native Administration (ANA), U.S. Forest Service (USFS) and the Bureau of Indian Affairs (BIA). Additional contractual work has been funded by the *Exxon Valdez* Oil Spill restoration effort under project 95131 Nanwalek/Port Graham/Tatitlek Clam Restoration.

The Qutekcak Shellfish Manual is an attempt by staff to outline basic operational methods for performing shellfish culture. It is intended to serve several purposes 1) Outline basic procedures 2) Review and outline changes over time and 3) Invite review from peers. The manual is intended to be a working document and should be reviewed annually. This is the first draft of the manual and many sections are incomplete and lack sufficient detail. Subsequent editions will expand on the current document.

It is understood that the procedures used will continually be modified to accommodate advances in shellfish culture, changes in the floor plan and design of the facility and allow for improved efficiencies.

The manual is not intended to be an in depth document on shellfish culture techniques which are available from numerous sources, but rather an application of those principles to the operation at QSH.

II. WATER SYSTEM/I.M.S. FACILITY

A. IMS WATER SYSTEM LAYOUT

The water source for Qutekcak Shellfish Hatchery is from a 60 meter deep intake which brings up nutrient rich seawater void of many organisms and is well suited for shellfish culture.

The Institute of Marine Science (IMS) utilizes two saltwater intakes to operate its wet labs. The primary pump system for the hatchery and nursery is on the west side of the warehouse/office. The 4 inch intake runs 400 feet to a depth of 270 feet. There are two 5 hp low pressure pumps located in the small outbuilding. The 4" intake is necked to 3" prior to the pump is increased from 2" to 3" on the delivery side. The 3" inch water lines runs east along the outside of the warehouse and serves the nursery pond, hatchery, and tankfarm prior to joining the main distribution valve. From here it can be valved to any portion of the complex. In 1994 a standby generator was installed to operate the pump and facility during electrical outages.

The second pump system is located on the east side of the silver research lab. It has an 8 inch line which runs 400 feet to a depth of 270 feet. The primary use of this water is for the silver research lab although it can also be valved to supply any portion of the complex.

The staff at IMS operates all of the major valving. Occasionally water supply and pressure are low because of heavy use and tidal fluctuations. The maintenance staff should be contacted when problems arise. Valving at the nursery pond and hatchery are performed by QSH staff.

B. Hatchery System

The water supply for the hatchery is on the west side below the stainless sinks and tabletops. The 2" line is made of ABS. A valve exterior to the building allows the system to be shut off if necessary. The 2" line runs along the west side of the hatchery and goes overhead along half the north wall. Valves allow for filling the head boxes and hose outlets.

The different options for water use are many. The system although sometimes cumbersome, allows for any combination of heated/unheated, filtered/unfiltered water use around the hatchery. Hot and cold freshwater is available at all of the sinks.

1. Head Tanks

The head boxes are 220 gallon fiberglass tanks supported by a wooden frame. The head boxes are filled manually by 2" valves from the overhead delivery. The water is run through 20 micron cloth bags which are contained in two inverted 5 gallon buckets. The tanks have overflow hoses which drain into a sink.

2. Heaters

Head box A is heated by a 1 Kw bayonet heater operated by a temperature controller. The operator sets the temperature on the controller and the heater maintains that temperature. It takes approximately 4 hours to heat the 220 gallon headbox.

Head box B is heated by a 1.5 kW portable heater which circulates water through the heater and tank with an 0.5 hp pump. It takes 4 hours to heat the 220 gallon head box. The heater can also be used as a flow through and can heat the water a delta of 6C/1gpm.
Plumbing leaving the head boxes is 1" and is delivered throughout the facility with a 1 Hp pump.

3. Filters/ Ultraviolet System

The system is set up to allow for all water to be filtered and passed through Ultraviolet (U.V.) light if necessary. There are two filter canisters with 10 um and 2 um cartridges. The filters need to be changed on a regular basis. The Ultraviolet light is a 2500 nanogram system that needs 4 seconds of retention time to be effective. The U.V. is effective in killing bacteria and viruses. The bulb has an effective life of 6 months. The unit should turned on only when water is flowing through it.

The filters and U.V. can be used to disinfect both heated and unheated water.

4. Hoses

There are many hose outlets in the facility. Hot and cold freshwater is available at all of the sinks. A saltwater hose is located at the end of the filter/UV system. Another 3/4 " line runs at the end of the 4" line. This is unfiltered and unheated water which is generally used for the algae system.

5. Drains

The drain system is not well suited for a hatchery. The building was originally designed to be used as a research lab. A 4" line runs parallel with the saltwater delivery line and exits to the facility drain. All of the sinks are connected to this line and system. The I.M.S. facility is connected to the city sewer system.

Water which is spilled or used for wash down flows into a sump in the middle of the hatchery floor. The sump has a 1 hp pump on a float switch which pumps water into an access port on the 4' drain line. Water used for culturing clams is required to be disinfected. Application of chlorine (100 ml chlorox) is sufficient for this purpose.

III. ALGAE CULTURE

Hatchery production of larval and juvenile bivalves requires a reliable supply of high quality algae.

The techniques for raising these species are well documented. Algae is cultured in three phases 1) stock cultures 2) primary (20 liter carboys) 3) production (200 liter Kalwal tanks).

Algae cultures go through three phases of growth; lag phase, exponential phase and stationary phase. Algae in the exponential phase is of the highest quality for inoculating additional algal cultures and for shellfish nutrition.

The techniques used at QSH follow NRAC Fact Sheet No. 160-1993 Growing Microalgae to Feed Bivalve Larvae.

A. STOCK CULTURES

1. System Setup

The goal of retaining stock cultures is to have inoculant available for transfer to the second phase of production (carboy units) and have a source that is free of contamination to be made available if a culture goes bad. Generally, several flasks of the same species are held to insure that a source is always available.

Two sets of stock culture exist 1) backups for restarting culture lines and 2) active cultures to be used to inoculate carboys.
The cultures are maintained in 500 ml ehrlemeyer flasks with a paper towel plug. The towel prohibits contamination and allows for respiration.

The backup cultures are retained on a window sill in the office. The inoculating cultures are placed on a counter top in front of florescent lighting to stimulate growth. When handling and transferring the cultures care is taken not to come into contact with any of the algae culture or sterile areas of the glassware.

2. Maintenance

The backup cultures are shaken daily to prohibit the algae cells from clumping and allow for equal exposure of the cells to light and nutrients in the water. Every several days some of the culture is removed and additional sterile water added to maintain 250-300 ml volume in the flask.

Water for stock cultures is sterilized with chlorine (2-5ppm) and deactivated with sodium thiosulfate. Sterile water is stored in 5 gallon carboys.

The inoculating cultures are taken from the stock cultures. 250 mls of inoculant is added to 250 mls of sterile enriched seawater. F2 media is an of the shelf blend of salts and nutrients available for algae culture. It is common in the algae culture industry and available from many sources.

The cultures are placed in front of the florescent lighting (about 6 inches) and have air bubbled into them from the compressor. After 3-4 days the cultures should be dense enough to inoculate the carboys.

3. Starting New Cultures

Stock cultures are available commercially from laboratories and from other shellfish hatcheries.

Stock cultures are received via express delivery. The new culture should be acclimated to room temperature. A flask should be thoroughly disinfected before adding F2 enriched seawater. F2 chemicals are available preweighed from aquaculture vendors. It may take a week or more for the culture to show signs of significant growth.

B. PRIMARY PRODUCTION

1.System Setup

The Carboy system is the second phase of the algae production system. The goal of the carboys is to produce contaminant free algae to inoculate the production Kalwal tubes.

The Carboys are 20 liter plastic containers which have air bubbled into them to keep the cells afloat and allow for transfer of oxygen. The air is delivered by a 0.5 Hp compressor and manifold system. The air to each carboy is regulated by a Teflon stopcock valve. The tubing enters the carboy through the lid and is attached to glass rods inside the carboy. The tubing is positioned so that the air will slightly touch the bottom of the flask.

The carboys are positioned on a lab top and illuminated with two 8 foot 100 watt soft florescent lights.

The cultures are inoculated from stock culture flasks. Approximately 250 mls of stock culture are added to the carboys. This transfer is conducted under a sterile laboratory hood to prevent the contamination of both the stock culture and the carboy.
The stock culture flask is refilled with sterile seawater for the next use.

2. Maintenance

The Carboys are sterilized and filled to 2.5 gallons with chlorinated and dechlorinated seawater. The culture is enriched with F2 media at 1ml/liter or 10 mls. They are then inoculated with 250 mls from the stock culture system. After 3-4 days the algae should be dense enough the be used to inoculate the kalwal tubes.

3. Harvesting

When the culture reaches the appropriate density (3-6 million cells per ml) it is transferred to the production system. The carboy is carried over to a prepared Kalwal tube and dumped in. Care is taken not to contaminate the Kalwal tube.

4. Cleaning and Disinfection

The carboys are cleaned and disinfected after each use. The carboys are rinsed in a chlorine solution and scrubbed with a bottle brush. After cleaning the carboys are thoroughly rinsed in preparation for reuse. The chlorinated seawater added for the next culture cycle is a further disinfectant.

C. PRODUCTION/ KALWAL TUBES

The purpose of the production system is to produce large quantities of high nutritional value algae for feeding larvae, nursery animals and Brood stock. QSH uses Kalwal tubes a transparent plastic tube designed for algae production and shellfish production.

1. Systems

The Kalwal tubes are positioned in cells. Each cell has three sides illuminated with pairs of 4' florescent lights. Each pair of lights can be turned off to reduce the intensity or perform maintenance. Air is delivered to the kalwal tubes from a 4 Hp compressor and manifold system. A valve on the main manifold is used to regulate airflow in each of the tubes.

QSH uses batch culture techniques for producing algae. 20 liter carboys are used to inoculate 200 liter Kalwal tanks for production feeding. Generally, it takes 4-6 days for a culture to reach its maximum density and several more days to harvest the culture for feed. Several species are always in production to insure all nutrient requirements are met for the juvenile shellfish under culture.

2. Maintenance

Water used for Kalwal tanks is chlorinated (2-5ppm) for 24 hours and deactivated with sodium thiosulfate. After the kalwal tubes are inoculated they need to be observed for contamination and growth. The culture should take 4-6 days to reach maximum cell density. Maximum cell density is different for each species.

The pH of the culture is important and should be kept in the 7.4 to 8.2 range. The pH is measured with litmus paper. If the pH begins to get too high, a CO^2 system is available. CO^2 acts as a buffer and also adds carbon which is utilized as a nutrient. Generally a 60 second blast will be sufficient to reduce the pH to within the appropriate range.

3. Harvesting

When the algae culture begins to reach its maximum cell density it is harvested and can be fed to shellfish in the hatchery. A valve on the bottom of the Kalwal tube is used to drain the culture into 5 gallon buckets. The culture is used until it has been completely drained. The buckets are then carried to the appropriate culture vessel for feed.

4. Cleaning and Disinfection

After a culture is used the kalwal tubes are scrubbed with a bottle brush, chlorinated, dechlorinated and rinsed for future use.
The large opening at the top of the tubes allows for adequate desiccation which is an effective sterilization method.

The hatchery staff also keeps several liters of preserved Chaetacerous on hand to supplement feeding of setting larvae and as a back up in case cultures become contaminated. The preserved algae is at a density of 10×10^8.

D. OUTDOOR CULTURE

The up welling pond area is equipped with two 10,000 gallon fiberglass tanks suitable for outdoor algae culture. This technique has only been attempted experimentally. The tanks are filled with raw unfiltered seawater and chlorinated. A transparent plastic tarp is spread over the tanks to act retain heat and provide protection from airborne contaminants. After the tanks are acclimated pure culture from the hatchery Chaetacerous is used to inoculate the tanks. When the cultures reach a desired density they are pumped to nursery animals to supplement feed from the pond.

E. SAMPLING

The algae cultures are sampled periodically to confirm the densities of algae. Although a visual inspection is usually adequate to determine if a culture is suitable for feed, counts are useful in recording densities and for testing various techniques. A hemocytometer is used to sample cultures. Three wells are read and the data recorded in a algae logbook.

IV. BROOD STOCK HOLDING AND CONDITIONING

The gonadal development of shellfish can be controlled by feeding rates and temperatures. When properly conditioned, shellfish can be induced to spawn by manipulating the temperature or other factors. The conditioning and spawning of the shellfish can be expedited with proper holding of the shellfish for the remainder of the production cycle.

A. HOLDING

Broodstock being held for future use are kept on ambient water and fed a maintenance diet within the hatchery. The brood stock are held in 60 liter totes with air bubbled into them through glass tubes. The water is changed daily by dumping the used water down the drain and refilling the totes with water from the unheated/filtered supply line.

The brood stock are fed 5 gallons of available algae mix twice a day.

Brood stock are also held in the nursery pond in culture nets or trays and brought into the hatchery for the conditioning process.

B. CONDITIONING

At QSH brood stock are conditioned in static 60 liter tanks. Water temperature is controlled through aquarium heaters and changed daily. During the spawning season the clams are held at 16 - 18^{0} C. During the winter months the temperature is lowered to 8 - 10^{0} C. Brood stock are held in family units of ten in mesh bags which help keep pressure on the hinges. Families are marked to record the spawning history and track the development of the progeny. Brood stock are fed daily to maintain body weight and when ready to spawn are fed to saturation. Prior to the spawning cycle temperatures are raised to accelerate gametogenesis. Gamete development is tracked by dissecting brood stock to assess development. Gamete quality has been the most important factor at QSH in determining the success at setting.

C. PRODUCTION SCHEDULE

Broodstock Conditioning	8 weeks
Spawning-Larvae Culture	4 weeks
Setting	1 week
Primary Culture to 2 mm	6 weeks
Secondary Culture to 5 mm	8 weeks

V. LARVAL CULTURE

The purpose of the larvae culture system is to prepare the fertilized gametes for the setting process. The larvae are very delicate and the setting survival is directly related to their feeding and care.

A. SYSTEMS

1. Clams

QSH has utilized 60 liter tanks for culturing littleneck clams. The staff was unsuccessful in utilizing the airlift system for culturing and setting clam larvae.

Littleneck clams have spawning episodes at regular cycles throughout the production year. To induce spawning, clams are removed from the brood stock tanks and allowed to dry for several hours. They are then placed in water baths at 22 - 24^0 C. Hatchery personnel watch for the appearance of spawn in the tank. This process is often repeated until the clams are induced to spawn.

When the shellfish have finished spawning the water is filtered and the fertilized eggs placed in the 60 liter larvae culture tanks. Notations are made identifying the families and if possible the individuals involved in spawning.

The larvae are fed several times a day at 50,000 cells/ml. The development of the larvae are tracked daily by microscopic examination. After almost 4 weeks of development, the larvae reach 240 um and are ready to set.

2. Oysters

Oyster larvae are cultured in the air lift system. 2-3 million larvae are placed in the tanks and put on the down well mode. QSH has been unable to successfully condition oysters to spawn. To date all the larvae has been purchased from certified sources out of state. The procedures used are outlined in Remote Setting and Nursery Culture for Shellfish, Washington Sea Grant, February 1991 and Advances in the Remote Setting of Oyster Larvae Gordon and Bruce Jones, British Columbia Marine Resources Ministry of Environment, Fisheries Branch, August 1986.

B. RECEIVING/ACCLIMATION

Clam larvae cannot be imported into the state of Alaska, however the Pacific oyster can be. Larvae shipments are coordinated with certified hatcheries in the Pacific Northwest. The larvae are shipped express. The larvae should not be out of the water for more than 24 hours or the setting survival goes down dramatically.

When the larvae reach the hatchery they are removed from the coolers and allowed to gradually warm up. As they approach the ambient air temperature they are placed in a flask of 16- 18^0 to further acclimate them. After an hour at his temperature they are transferred a second time into a flask at 20-22^0 C which will be the temperature of the airlift tanks.

A small sample is taken to verify the estimate of larvae from the hatchery. The same method used to count algae (hemocytometer) is used for the larvae.

The larvae are divided into 2-3 million groups, by either weight or volume.

The larvae are then freed from their wrapping and allowed to swim in a flask. When most of the larvae are up and swimming they are placed in the airlift tanks, which is set at a gentle flow in the down well mode.

C. SETTING

The clam larvae stay in the 60 liter tanks until they begin setting on the bottom and walls of the tank. They are then transferred to the airlift system and placed on a gentle down well mode.

The setting process is slow with littleneck clams. One of the most important variables for successful setting appears to be the time in which the clams are placed from the larvae tanks to the setting system. When the majority of the larvae are sessile and appear to be pedal feeding they are transferred to the airlift system on the down welling mode. Ground oyster shell sifted at 150um is placed on a 120um nitex screen. Up to 2 million larvae are placed on the 1500cm2 screen in a 130 liter airlift system. The clams are fed 70,000 cells/ml three times daily and finish the setting process in approximately seven days.

D. MAINTENANCE

1. Cleaning

The shellfish are washed daily. The culture tank is removed from the airlift tank and taken to a nearby sink. Freshwater is used, however the temperature must be adjusted to ambient so the shellfish are not thermally shocked. The rinsing of the shellfish and screen prevents clumping and helps distribute the shellfish evenly. Rinsing also prevents the screens from clogging.

2. Changing water

The water in the airlift tanks is changed every 3-4 days. The culture tank is removed and the tank is drained and then washed down. Sometimes a light 2-3 ppm chlorine solution is used to disinfect the tank. Care is taken to make sure no chlorine residue is left in the tank. The tank is refilled and the water brought to the appropriate temperature.

3. Temperature

The airlift tank is kept between 16 -18^0 C for clams and up to 20 C for oysters. The water is usually preheated in the Head box. The temperature is kept in the tank with portable aquaria heaters which are regulated by a temperature controller.

4. Feeding

The shellfish are fed as often as necessary during working hours. Generally, 1 gallon of mixture is fed to the tank. When the cells are cleared they are fed again. This is as many as 5 -6 times a day.

5. Record Keeping

A daily log is kept regarding the feeding amount and species, water temperature and any activity such as cleaning or sorting.

E. SORTING/ENUMERATION

No sorting or enumeration of larvae is attempted until the animals set. Over stocking the airlift tanks has not been a problem. Oyster larvae are reweighed after receiving them from an outside hatchery. Clam spawnings have not produced sufficient larvae to cause concern.

VI. POST SET

A. SYSTEMS

Both clams and oysters are cultured in the airlift tanks after setting. The flow is switched from down well to upwell regularly to allow for the flushing of metabolites. After the shellfish have completely set the airlift system is kept on the upwell mode except for a daily downwell flush.

B. MAINTENANCE

1. Cleaning

The shellfish are washed daily. The culture tank is removed from the airlift tank and taken to a nearby sink. Freshwater is used, however the temperature must be adjusted to ambient so the shellfish are not thermally shocked. The rinsing of the shellfish and screen prevents clumping and helps distribute the shellfish evenly. Rinsing also prevents the screens from clogging.

2. Changing water

The water in the airlift tanks is changed every 3-4 days. The culture tank is removed and the tank is drained. It is then washed down. Sometimes a light 2-3 ppm chlorine solution is used to disinfect the tank. Care is taken to make sure no chlorine residue is left in the tank. The tank is refilled and the water brought to the appropriate temperature.

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The airlift tank is kept between 16 -18^0 C for clams and up to 20^0 C for oysters. The water is usually preheated in the head box. The temperature is kept in the tank with portable aquaria heaters which are regulated by a temperature controller.

4. Feeding

The shellfish are fed as often as necessary during working hours. Generally, 1 gallon of mixture is fed to the tank. When the cells are cleared they are fed again. This is as often as 5 -6 times a day.

5. Record Keeping

A daily log is kept regarding the feeding amount and species, water temperature and any activity such as cleaning or sorting.

C. SORTING/ENUMERATION

After 3-4 weeks in the airlift system the shellfish are sorted and enumerated. A 1 mm screen is used to sort the larger animals to be placed in the heath system. Smaller animals are put back into the airlift. Because QSH has had so few animals it has not been culling and discarding the smaller and slower growing animals.

Samples are taken of 100 shellfish and an average weight per shellfish calculated. This number is then used to get the number of shellfish by taking the total weight and dividing it by the sample average. All samples are done in triplicate.

D. CLEANING AND DISINFECTION

The airlift tanks are cleaned and disinfected with a mild 2-5 ppm chlorine solution. The tanks are rinsed thoroughly and allowed to dry before reuse. All utensils are disinfected and stored.

VII. PRENURSERY

A. SYSTEMS

QSH utilizes "Heath" incubators for its prenursery. Shellfish screened on 1 mm mesh are placed in the Heath trays. Food and makeup water is placed in the reservoir at the bottom of the system. The water is pumped to the top tray and allowed to cascade through each tray until it reaches the reservoir. The trays are stocked very lightly, just enough to cover the surface of screens. Feed is added to the reservoir and the clams are fed to saturation. 200,000 clams require up to 40 liters of algae a day at densities of 3,000,000 cells/ml.

B. MAINTENANCE

1. Cleaning

The trays are washed and screens cleaned every other day to prevent the shellfish from clumping and to keep the flow evenly distributed through the tray. The trays are removed and gently sprayed with warm fresh water.

2. Changing Water

The water is changed every week. Because of evaporation and splashing 3-5 gallons of makeup water (~25% of total volume) is added daily.

3. Temperature

The temperature of the water is not manuipulated. The water is heated by the ambient air which ranges from 10-13^0 C.

4. Feeding

The shellfish are fed as often as they can clear the algae mix during working hours. When the trays are all full, the shellfish can clear 2-3 gallons in less than an hour.

5. Record Keeping

A daily log book is maintained outlining the amount and type of algae fed, water temperature and any activity such as cleaning or sorting.

C. SORTING/ENUMERATION

After almost six weeks of culture the clams are sorted through screens. Those that are 5 mm or greater are transferred to an outdoor nursery system for secondary culture.

Growth rates of the clams are highly variable requiring constant sorting to insure that smaller clams are not out competed by their cohorts. Size groups are maintained in different trays of the heath systems.

When the shellfish approach 5 mm they are sorted on a 5 mm screen and enumerated. The same technique is used as in larvae sampling. Shellfish greater than 5 mm are transferred to the nursery pond outside. The smaller animals are retained in the prenursery for additional feeding.

D. PRODUCTION SCHEDULE FOR LITTLENECK CLAMS

A. Broodstock Conditioning	8 weeks
B. Spawning- Larvae culture	4 weeks
C. Setting	1 week
D. Primary Culture to 2mm	6 weeks
E. Secondary Culture to 5mm	8 weeks

VIII. NURSERY

A. SYSTEMS

The QSH utilizes a 1 million liter pond to culture algae for its nursery. The 10 meter by 10 meter pond is 3 meters at its deepest point. Raw seawater from a 60 meter deep intake is pumped into the pond to bring in nutrient rich water. The flow is controlled to allow for adequate flushing yet maintain the ambient air temperature. An air pump is used to bubble and circulate water in the pond for adequate mixing and prohibit stratification.

The flora of the pond changes seasonally with Chatecerous dominating in the early months of the summer and pennate diatoms taking over after July. Natural cell densities in Resurrection Bay are 5,000 cells/ml while the pond is manipulated to produce over 250,000 cells/ml for feeding the shellfish.

Algae rich water is pumped from the pond to rearing troughs. The water upwells through culture bins and flows back into the pond.

Clams from the hatchery that are 5 mm or greater are transferred to shallow raceways adjacent to the pond. Water is pumped into the raceways and flows through the clam upwell tanks. The clams are seeded at 50 cm^2 initially on 1 mm vexar screen. The screens are cleaned and the clams stirred several times a week. Experimentation is ongoing to determine which system and substrate perform the best.

Many species of clams require substrate to support their hinges when they reach a certain size. To, date this has not been noticed in the native littlenecks, however this will be closely observed and if necessary substrate, both natural and artificial will need to be added.

Oysters are cultured in the flow through bins.

B. MAINTENANCE

1. Cleaning

The rearing troughs and bins need to be cleaned daily. The shellfish are stirred and the screens brushed to allow for even flow.

Debris is removed from the pond as needed. The pond liner also needs to be scrubbed occasionally and the heavy macro algae removed. Also grass clippings and trash need to be kept from the pond.

2. Changing water

The water is changed by valving 5-8 g.p.m. from the raw seawater to enter the pond from the deep intake. This allows for a change over of the entire volume of the pond within 2 days. For major cleaning the pumps that are used to supply the troughs are replumbed into the sump. The pond is drawn down and allowed to dry. This allows for a fresh start in inoculating the pond.

3. Temperature

Water temperature and salinity are monitored daily. Temperature and salinity can be controlled by adjusting the flow rate. Low flows allow for the water to heat up and take advantage of the summers heat and light. High flows are used to replenish the nutrient in the pond and flush metabolites. Many years of experience will allow the operators to maximize production.

4. Fertilization

Nitrogen and phosphorous levels are checked weekly. The pond is fertilized daily in an attempt to keep nitrate levels at 3.0- 3.5 ppm and phosphate at 1.2 to 1.5 ppm. Equally important is keeping the ratio 7 N:P. Chemistry levels are monitored with a "Hach" kit and verified by sending water samples to professional labs for verification.

5. Record Keeping

A daily log book is kept which records temperature, salinity and any other water chemistry performed. Secchi disc readings are also done daily. The amounts of fertilizer, time of application and daily weather are also recorded.

C. SORTING/ENUMERATION

Shellfish are sorted and counted as needed. Oysters are sorted and sized for sales. Batches are set aside until the sales order is met. The clams do not need to be sorted until it is time to transport them into the field. Generally cohorts are kept together and their growth is uniform.

D. CLEANING AND DISINFECTION

The rearing troughs and pond utensils are cleaned at the end of the growing season. A light chlorine mix 2- 5 ppm is used to disinfect the utensils. Desiccation during storage is also a good disinfectant.

Appendix 2

Pacific Rim Mariculture. 1995. Survey Protocols for the Tatitlek, Nanwalek and Port Graham Shellfish Restoration Program.

Pacific Rim Mariculture
644 Old Eaglemount Road
Port Townsend, WA 98368
(360) 732-4464

Survey Protocols for the
Tatitlek, Nanwalek and Port Graham Village
Shellfish Restoration Program

EVOS DPD Project #95131

Introduction. The purpose of this project is to establish populations of clams in areas that are readily accessible from the villages of Tatitlek, Nanwalek and Port Graham. These clams will be used as a source for subsistence food to replace the natural clam resource that has been lost or depleted. There are numerous techniques that can be used to enhance shellfish populations, particularly clam populations. The enhancement of local clam populations for subsistence requires knowledge of the following:

Accessibility to tribal members. This factor should be addressed through onsite interviews with tribal elders. Traditionally valuable beaches should be identified and those with reasonable access examined for suitability. The more intensive the intended shellfish culture method, the more accessible must be the beach.

At each of these three villages, a list of appropriate beaches should be developed and prioritized based on past use and accessibility. Existing information including maps, photographs (aerial or local), current data, weather, including water and air temperatures, tidal heights, etc. should be collected for these beaches and analyzed prior to a site visit. Beach evaluation must be done at low tide and therefore should be accomplished as efficiently as possible.

Beach profile. The slope and extent of the potential enhancement area should be determined during a site visit. This will involve the use of a transit. All elevations will be based on a visual assessment of Mean High Water (the drift line) and the predicted height of the tide at a predetermined time. It will take approximately one hour per 20 acre beach to accomplish this. This element includes a stratification of the beach and an assessment of the culture potential within each strata.

Substrate characterization. Native littleneck clams (*Protothaca staminea*) prefer a mixed substrate of gravel, sand and mud. They burrow to approximately 8 inches. Intensive culture techniques generally require finer substrates with few cobbles (> 2 to 3 inches diameter). At each site a series of four to eight sediment samples should be collected for sediment grain size analysis. In addition, the depth of the unconsolidated substrate should be determined. Depths should exceed 12 inches. This allows for adequate water retention and flow from high beach areas to cultivated areas during low tides.

The beach must be stable and fines (silt and clay) should comprise at least 5 to 10 percent of the matrix. Total Volatile Solids (organic material) should represent at least one percent of the sediment dry weight. Areas where only sand and gravel are found, or where there is evidence of significant sediment transport, require that clams be contained within cages. Otherwise they will be washed out of the sediment.

Native littleneck clams will grow adequately in anaerobic sediments. However, in optimum conditions, the depth of the redox potential discontinuity (RPD) should be at least 2 cm and preferably greater than seven to ten centimeters. A deep RPD suggests adequate pore water movement which is desired during low tides, particularly during winter to prevent freezing.

The potential for storm damage and catastrophic loss must be assessed. This is particularly important for intensive cultures where the investment in terms of time and dollars can be high. Knowledge gained from local elders can be invaluable. An understanding of storm tracks, fetch, upland vegetation, the presence of logs and debris, and beach slope and composition can be used in assessing this factor. Intensive cultures should not be placed in areas subject to log damage, high winds or excessive sediment transport.

Human resources available to tend intensive shellfish cultures should be determined. Some techniques require a significant investment in time and energy. These techniques should be reserved for easily accessible beaches of optimum substrate composition. In addition, different villages may partition there time differently. In some, the intensive culture of shellfish may be a rewarding and appropriate activity. In others, village members may have outside jobs with little time to devote to caring for intensive shellfish cultures. Enhancement methods must recognize village needs and desires - they must "fit" with the villages lifestyle. Recommendation of specific enhancement techniques should only follow a careful determination of the villages needs and desires.

I am unaware of adequate information describing native littleneck growth rates in southeast Alaska. Growth can be very site specific and variable. It depends on genetic factors, tidal height and a host of site specific environmental factors. Understanding the growth characteristics of shellfish in a particular region will allow villagers to optimize shellfish harvests in an area where appropriate growing space is a limiting factor.

All clams (>2 mm) should be accounted for. Some areas may have excellent growth but limited recruitment because of current patterns. Recruitment can be assessed by evaluating length frequency and age frequency histograms. However, this requires that the clams be carefully aged, wet tissues weighed, and valve lengths measured. Once sieved, this information can be obtained in the laboratory.

Clam survey and enhancement assessment during 1995. Many of the above assessment needs can be satisfied during the summer of 1995. I recommend the following:

1. Interviews. A list of questions should be developed (see enclosure 1). Tribal elders should be contacted at each of these villages and interviewed to answer as many of the questions as possible. This activity will require three days (one day at each village). The interviews could be conducted the day before a low tide series. This would allow beach surveys on each of the next two days.

Based on these interviews, three potential beaches near each village should be identified for survey. If the interviews can be conducted early enough, available information should be obtained and reviewed before scheduling a second visit. Because it is the middle of June, I suspect this will not be possible. This information can be reviewed following the field work and prior to making recommendations regarding enhancement activities.

2. Beach surveys should be scheduled to coincide with a reasonably low tide (preferable a minus tide). Depending on travel time between beaches, a crew of four should be able to survey two beaches in two consecutive days. Each of the beaches should be surveyed in the following manner:

1. The crew should arrive on the first beach at least four hours prior to low tide. Upon arrival, a series of test digs will be made to help stratify the beach. Test digs will begin at a height where no clams are anticipated and proceed waterward until the first clams are encountered. At that point a systematic survey, normal to the beach line, will begin. Addition test digs will be made when more than one strata is evident. The width of the beach will be divided by eight and a random number between one and the quotient determined. The first sample will be taken at that point. Addition samples will be collected at intervals equal to the quotient. Each sample will involve the removal of all substrate from a 0.1 m^2 quadrat to a depth of 20 centimeters. Quadrats used in these samples are constructed of aluminum and are driven into the substrate to form rigid walls and prevent sloughing. Buckets will be prenumbered on the outside and have an identical inside label that will follow the sample until processing is finished. Three of these normal transects will be run on the beach at equal intervals along its length. That will result in the collection of 24 quantitative samples.

In addition, where appropriate, a forth systematic random sample will be collected along a transect running parallel to the beach. Eight samples will be collected along this transect. If the beach contains more than one strata, then additional parallel transects will be examined running through the center of each strata.

A sediment sample will be collected from the top four inches of the substrate at randomly selected stations along each of the orthogonal transects. The RPD will be measured at each of these points and a second sediment sample retained for total volatile solids analysis. The substrate will be characterized to include the following (see appendix 2):

A. Substrate color
B. Presence of attached macroalgae
C. Presence of predators
D. Evidence of excessive littoral drift or log damage
E. Oily sheen
F. Odor (hydrogen sulfide, ammonia or petroleum)
G. Suitability for specific culture techniques.
H. A photographic record of the site will be made to include at least 20 pictures describing the general area, shoreline, fetch, and substrate type.
I. A small drogue will be placed in the water on arrival and its progress along the shoreline monitored during the period of study to assess currents.
J. A transit or theodolyte will be used to measure the elevation of the water height at a specific time and of each sample station on the transects run orthogonal to the beach. (See Appendix 2).
K. Water temperature, dissolved oxygen and salinity will be measured. A 500 ml water sample will be retained for total suspended solids and total volatile solids analysis.
L. At a minimum, each beach survey will include:

1. 12 shellfish samples
2. 4 sediment samples (50 gm each) for sediment grains size analysis
3. 4 sediment samples for Total Volatile Solids analysis.
4. One 500 ml water sample

3. Sample processing. Buckets or bags containing the substrate removed from the quadrat will be moved to the high tide line. They will then be sieved in a 1/4″ sieve followed by a 1 mm sieve. All clams will be removed from each of these sieves and placed in prelabeled, one gallon, ZIPLOCK™ bags. The free label in the bucket or bag will follow the sample into the ZIPLOCK™ bag.

All samples will be place on ice, in a cooler and shipped via overnight mail to Aquatic Environmental Sciences, 644 Old Eaglemount Road, Port Townsend, WA. Samples will be frozen at AES while awaiting processing.

All clams in each sample will be individually aged, weighed and their valve length measured to the nearest 0.1 mm. Wet tissues in clams with valve lengths greater than 20 mm will then be shucked, weighed, dried, and a dry tissue condition factor determined. Tissue drying is accomplished at 90 °C.

Sediment grain size will be determined using the sieve and pipette method. Sediments greater than 1 cm will be pooled. Additional sieves sizes will include 2 mm, 1 mm, 500 μm, 125 μm, 63 μm. Silt (>3.9 μm) and clay (<3.9 μm) will be differentiated using the pipette method.

Sediment Total Volatile Solids will be determined by drying a sediment sample at 103 ± 2 °C until no further weight reduction is observed and then ashing the sample at 550 °C until no further weight loss is recorded.

Water Total Suspended Solids and Total Volatile Solids. A 0.45 μm glass filter is ashed at 550°C and weighed. A 350 ml sample of thoroughly mixed water is suction filtered and the residue dried at 103 ± 2 °C to determine TSS. Total volatile solids is determined following ashing of the sample at 550 °C.

Report. Output from this study will be provided in three separate reports, one for each of the villages of Tatitlek, Port Graham and Nanwalek. These reports will consist of the following:

1. Village desires. A review of village desires expressed by elders. This will include statements of understanding regarding the desired intensity of culture, culture methods and village harvest needs.

2. Physical and Chemical Characteristics. A summary of the physical characteristics of each beach as it relates to the beach's potential for shellfish production. This section will detail the physical and chemical data collected and will describe what that data tells us about the beach's potential for clam culture. This section will also include a description of the beach profile, observed currents, beach stability, exposure, etc.

3. Evaluation of Current Clam Populations. This section will provide a detailed analysis of the current clam population on each beach. For clams greater than 1 cm, the report will differentiate butter clams (*Saxidomus giganteus*) and native littleneck clams (*Protothaca stamineai*). It will include the following:

a. A description of clam density on the beach as a function of stratum and tidal height. This analysis will present information describing the size and numbers of clams at each tidal height within each stratum.

b. A description of observed clam growth on the beach as a function of stratum and tidal height. This will be determined from length - frequency, and age - frequency and age - length histograms. A predictive equation will be developed using nonlinear regression techniques.

c. A length - weight relationship will be determined by tidal height. The resulting relationship will be of the form weight = α length$^{\beta}$.

d. Regression coefficients for the von Bertalanfy equation will be determined and the equation used, together with length weight data, to identify optimum harvest size.

e. The number and biomass of harvestable clams on the beach will be estimated together with 95% confidence intervals.

f. Either ANOVA or regression techniques will be used to determine if their are significant differences in average length or weight as a function of tide height and strata.

4. Recommendations. An analysis of the potential of each beach to support extensive and intensive clam production. This portion of the report will identify attributes and problems associated with each potential site. In addition, we will make recommendations for specific enhancement techniques, based on the expressed desires of tribal elders. If desired, these recommendations will be presented to tribal elders and changes made as required.

The report will conclude with a set of detailed protocols to assess growth, mortality, and harvest potential for each enhancement technique recommended.

Appendix 3

Review of clam restoration projects (95131 and 96131) sponsored by
Exxon Valdez Trustee Council, October 1995

APPLIED marine SCIENCES

November 11, 1995

To: Molly McCammon, Executive Director

From: Robert Spies, Chief Scientist

Re: Review of the clam Restoration Project (95131 and 96131) sponsored by the Exxon *Valdez* Trustee Council, October 26, 1995

Introduction

The clam restoration project was started in 1995 as a pilot project to determine if little-neck clams could be spawned and the offspring raised in the Qutekcak hatchery in Seward for the purposes of reseeding the clam beds around the villages of Tatitlek, Chenega Bay and Port Graham/Nanwalek. On October 26, 1995 a review was held in Seward, Alaska to determine the progress on the project as a result of the first season's field work. Progress during the 1995 field season was presented by Ms. Carmen Young, the hatchery manager, and Ms. Patty Brown-Schwalkenberg, the Project Director. Dr. Charles Peterson and Mr. Joe Huber, both experienced in shellfish biology and aquaculture, were the peer reviewers for the session. Also in attendance were: Mr. Walter Meganek, Jr. and Mr. Simeon Kavashnikoff from Port Graham; Ms. Martha Vlasoff from the Chugach Regional Resources Commission; Dr. Joseph Sullivan and Mr. Dan Moore from the Department of Fish and Game.

The purpose of the review was to evaluate progress achieved during the 1995 field season and to see if further work is warranted. The Trustee Council will consider funding for 1996 at their December meeting for FY1996.

The goals of the 1995 work were to:

1. Establish the feasibility of spawning and raising little-neck clams in the Qutekcak hatchery in Seward.

2. Identify suitable intertidal sites for testing establishment of clam beds.

There is a proposal in the 1996 work plan package for extension of this program through FY 1997. The proposal for 1996 is for $373K and includes plans for larger-scale hatchery production. In 1996 there is interest in expanding the number of villages involved to include Eyak and Ouzinkie. The species may be expanded to include butter and razor clams.

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Summary and recommendation

This project was successful during 1995 in spawning adult littleneck clams, raising larvae and initiating the growth of seed in the Qutekcak clam hatchery in Seward. Optimal conditions for mariculture of this species are still to be determined for Alaska, and continued support by the Trustee Council should be based on attaining this goal before full production is attempted. Any further Trustee-sponsored development should also make liberal use of outside expertise and this should be reflected in a revised proposal for 96131, as this is a key ingredient for attaining a successful result in the near term. Further development is best carried out once the new hatchery is completed, but it is not certain when this will occur, so close coordination of the proposed Trustee-sponsored work with hatchery construction is merited. In addition, the Trustee Council needs to consider the economic viability of the entire hatchery operation so that its investment in developing clam mariculture technology for restoring shellfish resources is not compromised. In consideration of the above, I recommend that the institutional and economic factors involved in a sustainable shellfish hatchery operation receive further consideration before you make a final recommendation on continuation of this project in 1997.

Detailed findings

After a day-long session the reviewers reached the following general conclusions. These are only the results of one day of consultation and it is strongly advised that continuing significant technical help be obtained to address these and likely other issues.

1. Raising little-neck clams in the Qutekcak hatchery is technically feasible.

2. Our confidence in the ability of hatchery personnel to raise large numbers of clams on a consistent basis will be strengthened once optimal nursery conditions have been defined. We see no reason that with further work optimal conditions can not be defined for Alaska using valuable experience gained with this species elsewhere. It is also probable that other species can be likewise cultured.

3. The hatchery personnel seemed capable and eager to learn. It is essential that the help of outside experts be used to minimize the number of years it will take hatchery personnel to reach sustainable maximum production. This must be a substantial involvement, probably about 5 weeks a year, divided into two or more extended visits to the hatchery. Extensive help will be needed to correct several serious problems with the present facility.

A. A scientific understanding of the environmental conditions needed to successfully manipulate the little-neck clams on a repeatable basis into spawning is needed. This needs to come from both the scientific literature and from spawning trials at the hatchery. Hatchery personnel have been able to initially spawn clams in the reproductive season, but have not been able to recondition brood stock to spawn a second time.

B. Changes must be made to the design of the algal culture chambers to optimize food production. These include using additional vertically-oriented light banks and developing a better understanding of nutrient and micronutrient limitation. One present culture (the 3H) suffered from what we recognize as a silica deficiency (or else the genetic composition of the culture is suspect). In addition some consideration should be given to use of a skylight to maximize ambient natural light. There are better types of light available for culturing algae faster. Larger diameter growth cylinders may be appropriate.

C. Better isolation of algal production chambers from larval feeding tanks is needed to reduce risks of contamination. In addition a separate room should be set aside for the conditioning of brood-stock clams so that their environment can be manipulated to condition them and to trigger spawning at the desired time. Some implementation of formal protocols (e.g., hand washing and implementation of foot-boot sterilization) to prevent transfer of contaminants is needed.

D. Water sterilization should be done by autoclave, not by microwave (which appears to alter the water). A large volume autoclave is needed.

E. The nursery operation in the outside pond is relatively ineffective because of the less-than-optimal production of phytoplankton and inefficient water circulation for maximum optimization of food. Consideration should be given to moving the nursery operation indoors where cultured algae can be fed to the growing seed clams in upweller and downweller systems and raceways, using recirculated and heated water.

F. The evaluation of the architectural plans for the new hatchery by Joe Huber produced a number of suggestions for further consideration before the hatchery is constructed. The building should be designed to isolate in separate rooms the algal culture, the larval feeding, and the conditioning areas. Greenhouse roofing and south walls should be considered for installation around the algal culture area. A backup generator should be added with sufficient power to run the facility. This should be wired so that it will automatically be triggered if there is a power failure. The air temperature control and circulation system needs to be designed to allow separate temperature conditions in each room, depending on the optimal conditions for the different culture conditions. The water heater needs to run on a boiler rather than the present electrical source so as to generate heat at a minimal cost.

4. Initial evaluation has identified promising grow-out sites, but field tests of growout is premature at this time. Project personnel should continue to consider alternatives for coping with predation (e.g., low density stocking , use of rocks) and emphasize conditions that best mimic natural conditions.

5. Even after the clams are successfully grown out on beaches near the participating villages, it is highly unlikely that natural spawn from the transplanted clams will be successful in sustaining an increased local level of natural clam recruitment that would make the clam beds self-sustaining in the future. The factor or factors (e.g., sea otter predation) that are currently operating to keep clam populations in check cannot be counted on to change in the near future. Therefore, the probability of establishing self sustaining clam beds appears to be quite low in the near future and we should not be building false expectations in this regard. Some careful further thought accompanied by economic analyses about the long-term support of this program seems necessary.

6. Roles and responsibilities among Qutekcak hatchery CRRC, ADF&G, EVOS Trustee Council and others need clarification with respect to the construction, transition, and long-term operation and maintenance of a new facility. This should go hand-in-hand with an economic analysis. This goal is probably best accomplished by a meeting with key personnel from EVOS, CRRC and ADF&G before the Trustee meeting in December.

EVOS Agency Personnel	AMS Reviewers	Project personnel
J. Sullivan	A. Gunther	P. Brown-Schwallenberg
S. Senner	P. Peterson	D. Daisy
D. Moore	J. Huber	C. Young
S. Schubert		M. Barrier
M. Vlassoff		J. Hetrick
J. Cochran		

Appendix 4

Brooks, K. 1995. Baseline Shellfish Survey of Tidelands near the Tatitlek, Nanwalek and Port Graham Villages.

Project Title

Baseline shellfish survey of tidelands near the Tatitlek, Nanwalek and Port Graham Villages

in support of the

Nanwalek/Port Graham/Tatitlek Clam Restoration Project
Exxon Valdez Oil Spill Trustee Council
Project Number 95131

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Report Date:

December 13, 1995

Baseline shellfish survey of tidelands near the Tatitlek, Nanwalek and Port Graham Villages

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Baseline shellfish survey of tidelands near the Tatitlek, Nanwalek and Port Graham Villages

Introduction. This baseline survey of shellfish populations at traditional harvest beaches near the Alaskan villages of Tatitlek, Nanwalek and Port Graham was undertaken to develop an understanding of existing shellfish resources and their potential for enhancement. In addition, this survey was designed to provide insight into the preferred environments and recruitment of valuable clam species as well as their growth and age at recruitment to harvest size. The surveys were completed between August 25, 1995 and August 29, 1995. The results of those surveys are documented in this report.

Background. Historically, clams have provided an important subsistence food source in the Native villages of Tatitlek, Nanwalek and Port Graham as well as many other villages located within the area affected by the Exxon Valdez oil spill. However, clam populations have declined markedly at these villages in the recent past. The reasons for those declines are not well documented - but the loss of a traditional food source on Native villages is significant. In response to concerns expressed by Village elders, the Chugach Regional Resource Commission (CRRC), in cooperation with the Alaska Department of Fish and Game, requested and received funding from the *Exxon Valdez* Oil Spill Trustee Council to re-establish populations of clams in areas that are readily accessible from the villages of Tatitlek, Nanwalek and Port Graham (EVOS Project 95131).

Intertidal populations of native little neck clams (*Protothaca staminea*), butter clams (*Saxidomus giganteus*) and cockles (*Clinocardium nuttallii*) have not been intensively managed by either federal or state agencies in the past. Consequently there is little information regarding the life history and population dynamics of these species in cold Alaskan waters.

Littleneck clam life history. The littleneck clam (*Protothaca staminea*), occurs in estuaries, bays, sloughs and open coastlines along the Pacific coast of North America. It primarily inhabits the intertidal zone from approximately -2' MLLW to +3' MLLW. However, it is infrequently found at subtidal depths. It ranges from the Aleutian Islands to Socorro Island, Mexico (Fitch, 1953).

Reproduction. Sexual maturity appears to be size, rather than age, dependent, and is reached at a valve length of 25 to 35 mm (Quayle, 1943). Reproductive competence is achieved between the second and eighth year of life (Paul and Feder, 1973). In Prince William Sound, Feder, *et al.* (1979) observed limited spawning in late May or early June with a major release of gametes between June and July. Female *Protothaca staminea* gonads were observed in a spawning phase from early June through September. In contrast, males were in spawning condition throughout most of the year. Spawning appears to be temperature related (Quayle 1943) and an examination of USFWS (1968) suggests that the sea surface temperatures are warming rapidly from less than 8 °C to >10 °C during June or July of each year.

Larval clams are planktonic for three to four weeks. Therefore, they are dispersed over large areas by wind and tidally driven currents. Successful recruitment is dependent on a wide range of environmental parameters and varies significantly from year to year. Large year classes are separated by either missing or subdued year classes (Rodnick and Li, 1983). Maximum life span has previously been reported at 13 years (Fitch, 1953; Paul *et al.*, 1976; Rudy and Rudy, 1970). However, ADFG (1995) reports native littleneck clams to 14 years of age.

Littleneck clams grow continuously throughout their lives. However, growth slows as the clams age and is highly dependent on local environmental conditions; including tidal height, currents, food availability, temperature and salinity. (Qualyle and Bourne, 1972). Maximum valve length in Washington State appears to be approximately 68 mm (Brooks, unpublished data). In highly productive areas of Puget Sound, native littleneck clams can reach 38 mm valve length in 3 years. For Kachemak Bay, Alaska, ADFG (1995) reports a minimum time of five years to reach the minimum legal size of 38 mm.

In Washington State, the manila clam (*Tapes japonica*) is the favored aquaculture species because of a longer shelf life, reliable opening on cooking and ease of seed production. Little work has been devoted to the hatchery production of native littleneck clam seed because of problems encountered in carrying the clams through metamorphosis. In 1994, the Qutekcak Native Tribe, with the assistance of Mr. Jeff Hetrick, was able to successfully spawn and raise small quantities of native littleneck clam seed at their Seward hatchery. This is a significant development in making enhancement of depleted clams resources in Alaska a reality. Further work at the Seward hatchery is being pursued and nursery techniques are being developed.

Habitat characterization. Littleneck clams are most abundant in substrates containing a mixture of sediment grain sizes. Goodwin (1973) found highest littleneck clam densities in substrates consisting of broken shell. Sand, pea gravel, gravel, and rocky substrates all contained moderately high numbers of clams. Substrates consisting of primarily mud are unsuitable for native littleneck clams.

Quayle (1960) states that littleneck clams in British Columbia are concentrated at "about the half-tide level," but notes that they occur in reduced numbers at subtidal depths. Amos (1966) reported highest littleneck clam densities between -3.0' and +4.0' (MLLW). Goodwin (1973) found significant quantities of native littleneck clams at subtidal depths in Puget Sound. However, there was a general decrease in the observed biomass of both littleneck and butter clams with depth and very few clams of either species were found at depths greater than 30 feet.

In addition to water depth, Goodwin (1973) documented a positive correlation between current speed and littleneck and butter clam standing crops. The information in Table 1. Is taken from Goodwin (1973).

Table 1. Relationship between current speed and the biomass of hardshell clams observed in Puget Sound, Washington By Goodwin (1973).

Current Speed ($cm\text{-}sec^{-1}$)	$g\text{-}m^{-2}$ (butter clams)	$g\text{-}m^{-2}$ (littleneck clams)
0.0 to 25.3	808	252
25.3 to 50.7	671	145
50.7 to 101.3	710	353
> 101.3	1580	646

Rodnick and Li (1983) developed a Habitat Suitability Index (HIS) Model for the littleneck clam (*Protothaca staminea*). They concluded that littleneck clams prefer a mixed substrate of gravel, sand and mud and that this species burrows to approximately 15 cm. Other habitat factors considered important to native littleneck clams included currents (optimum 77.1 to 154.3 cm/sec) and tidal level (optimum -0.75 m to + 1.0 m or -2.46 ft. to +3.28 ft). Rodnick and Li (1983) cite Nickerson's (1977) observation that native littleneck clams enjoyed greatest recruitment at tidal heights between -0.43m and +0.43 m on three beaches in Galena Bay, Prince William Sound. This observation is consistent with that of Amos (1966) and Paul *et al.* (1976) who concluded that maximum clam densities are recorded near the 0.0' tide level. Lastly, Rodnick and Li (1983) note that thermal stress causes death at a few degrees below 0°C and above 35°C.

Intensive culture of intertidal bivalves places additional constraints on several environmental parameters. These techniques generally require finer substrates with few cobbles (> 2 to 3 inches diameter) than is optimum for feral populations of *Protothaca staminea*. Suitable beaches must be stable and fines (silt and clay) should comprise approximately 5 to 10 percent of the matrix. Total Volatile Solids (organic material) should represent at least one percent of the sediment dry weight. Areas where only sand and gravel are found, or where there is evidence of significant sediment transport, require that clams be contained within cages. Otherwise they will either be washed out of the sediment or smothered.

Native littleneck clams will grow adequately in anaerobic sediments. However, in optimum conditions, the depth of the redox potential discontinuity (RPD) should be at least 2 cm and preferably greater than seven to ten centimeters. A deep RPD suggests adequate pore water movement which is desired during low tides, particularly during winter to prevent freezing.

The potential for storm damage and catastrophic loss must be assessed. This is particularly important for intensive cultures where the investment in time and money can be high. Knowledge gained from local elders can be invaluable. An understanding of storm tracks, fetch, upland vegetation, the presence of logs, debris, and beach slope and composition can be used in assessing this factor. Intensive cultures should not be placed in areas subject to log damage, high winds or excessive sediment transport.

Human resources available to tend intensive shellfish cultures should be determined. Some techniques require a significant investment in time and energy. These techniques should be reserved for easily accessible beaches of optimum substrate composition. In addition, different villages may partition there time differently. In some, the intensive culture of shellfish may be a rewarding and appropriate activity. In others, village members may have outside jobs with little time to devote to caring for intensive shellfish cultures. Enhancement methods must recognize village needs and desires - they must "fit" with the village's lifestyle. Recommendation of specific enhancement techniques should only follow a careful determination of the villages needs and desires.

All clams (>2 mm) should be accounted for in surveys. Some areas may have excellent growth but limited recruitment because of current patterns. Recruitment can be assessed by evaluating length frequency and age frequency histograms. However, this requires that the clams be carefully aged, wet tissues weighed, and valve lengths measured.

Commercial clam harvest management. The Alaska Department of Fish and Game (ADFG, 1995) conducted clam surveys for native littleneck clams (*Protothaca staminea*) in Kachemak Bay in the Southern District of the Cook Inlet Management Area. The purpose of this study was to examine the affects of commercial harvests from Department of Environmental Conservation certified beaches. This ADFG study did not examine small clams (< ≈ 15 mm) in the 1992 - 1994 surveys. Therefore, ratios of sublegal:legal clams are skewed toward the legal clams. They observed clams from age three to age 14 and found that minimum legal size (38 mm valve length) was achieved in *Protothaca staminea* between the ages of 5 and 10 years. They concluded that growth was variable and slow.

In addition, ADFG (1995) concluded that recruitment was sporadic and that native littleneck clam populations are characterized by generally low to moderate recruitment with periodically strong year classes. The study did not examine intersite length-frequency or age-frequency distributions to determine if strong year classes occurred during the same years on all surveyed beaches in Kachemak Bay - suggesting that strong recruitment was a function of generally favorable environmental conditions - or if strong year classes were present on only a few beaches in any one year - suggesting that variable wind and current patterns, or other stochastic processes, may concentrate shellfish larvae at different beaches in different years. ADFG (1995) did find significant quantities of shellfish on all beaches in Kachemak Bay and their estimates of the number of legal and sublegal (>15 mm) size clams per square meter are provided in Table 2.

Table 2. Numbers per square meter of legal (≥38 mm valve length) and sublegal (<38 mm valve length) clams (*Protothaca staminea*) observed on five beaches in Kachemak Bay by the Alaska Department of Fish and Game in 1994.

Beach (year)	# legal size clams	# sub-legal size clams
Chugachik (1994)	36.4	42.8
Jakolof Bay East (1993)	19.0	1.3
Jakolof Bay West (1993)	17.9	10.5
Tutka (1993)	13.6	4.8
Halibut Cove (1994)	77.5	96.5
Sadie Cove (1993)	27.6	35.2

Other findings of interest in the ADFG (1995) report include the following:

a. *Protothaca staminea* were generally found buried in sediment to depths of 25 to 31 cm. However, clams were found at unspecified depths greater than this.
b. The biomass of clams at the most heavily harvested beaches (Chugachik and Jakolof) is slowly declining as shown in Table 3.
c. Clam growth is highly variable and clams reach minimum harvest size ($\geq$ 38 mm) at ages between 5 and ten years.

ADFG (1995) examined several years of data at sampled beaches and compared changes in available biomass of legal size clams with department harvest records. The results are summarized in Table 3. This information suggests that, while beach response to harvest is variable, the beaches examined in their study could not sustain harvests greater than perhaps 10 to 15% per year. This seems reasonable when the median age to recruitment into the legal size population is 7.5 years. Adding a natural annual mortality of even 2% per year means that a maximum sustainable yield would be on the order of 11% per year.

Table 3. Changes observed in ADFG estimates of the biomass (reported in pounds) of legal size clams found on five beaches in Kachemak Bay between 1990 and 1994.

Beach	Year (biomass)	Year (biomass)	Percent Harvest	% Biomass Change
Chugachik	1992 (249,929)	1994 (131,485)	10.8% ('92); 20.5% ('94)	-47.4%
Jakolof	1992 (110,025)	1993 (108,227)	16.9% ('92); 12.0% ('93)	-1.6%
Sadie Cove	1993 (95,506)	1994 (135,467)	none reported	+41.8%

ADFG (1995) data suggests that an adequate management plan will be essential to the development of a sustainable subsistence shellfish resource anywhere in Alaska. In addition, the available information suggests that a significant time lag, at least four to five years, will occur before seed planted on intertidal beaches reaches a minimum legal size.

Materials and methods

Survey site selection and development of an understanding of village goals, desires and resources. Mr. Jeff Hetrick (EVOS Project 95131 Project Team) conducted interviews with tribal elders prior to undertaking this field trip. Based on these interviews, the following specific beaches were identified for survey.

Village	Beach Name	Latitude	Longitude
Nanwalek	Passage Island	59° 22.11' N	151° 52.53' W
Port Graham	Murphy Slough	59° 20.58' N	151° 48.19' W
Tatitlek	Tatitlek	60° 51.82' N	146° 41.15' W

Upon arrival at each village, Village goals and desires were discussed with tribal elders and/or shellfish experts. Specific questions included the following:

1. Reasons for choosing the sites to be sampled.
2. Traditional village use of shellfish and sources of supply
3. Accessibility of each site for tending of intensively grown shellfish resources
4. Resources (Villager time, boats, etc.) available to the project.
5. Review recent shellfish harvests at the beach to be surveyed
6. Village understanding of the current condition of local shellfish resources
7. Village understanding of the reasons that shellfish are no longer abundant
8. Investigation of alternate beaches for survey
9. Village preferences for mussels, cockles, native littleneck clams, butter clams, horse clams and soft-shell clams (*Mya truncata*).
10. Traditional predator control measures used by the Village.

Tides and weather. These surveys were undertaken late in the year (August) after low spring tides had ended. Weather at Passage Island and Murphy Slough was partly cloudy with light and variable winds. A front came through Tatitlek during the end of the survey. The lowered atmospheric pressure may have resulted in a higher than predicted tide. However, conditions were such that the actual predicted tides were likely close to the predicted tides shown in Table 4.

Table 4. Predicted low tides during intertidal surveys conducted at Passage Island, Murphy Slough and Tatitlek, Alaska on 26 and 27 August, 1995.

Beach	Date	Survey Time	Low Tide Time	Height of the Low Tide
Passage Island	08/26/95	0930 - 1230	0917	-1.3' MLLW
Murphy Slough	08/26/95	0600 - 0945	0917	-1.3' MLLW
Tatitlek	08/27/95	0630 - 1100	0841	-0.9' MLLW

Little environmental documentation describing the surveyed areas was obtained. Monthly Mean Sea Surface Temperatures, published by the U.S. Department of the Interior for years 1949 to 1962 (USFWS, 1968) suggest that mean low water temperatures of 4° to 5° C occur in this area from December through March of each year. Low tides, which occur at night in December and January in this region certainly exacerbate the low temperature stress experienced by intertidal fauna. Mean high temperatures of 12° to almost 15° C occur in July and August.

Beach Profile. The slope and extent of areas with potential for clam production were determined during each survey. This was accomplished by placing a properly leveled transit at the lowest point inundated at low tide. The elevation of each sample station was then determined relative to this reference point. The height, above Mean Lower Low Water (MLLW), was calculated assuming that the actual low tide equaled the predicted low tide. In view of the benign weather, this seems a reasonable assumption.

Substrate characterization. Four to twelve sediment samples were taken from randomly chosen sample stations at each beach surveyed. The depth of the Reduction Oxidation Potential Discontinuity (RPD) was determined using a clear corer and centimeter rule. Approximately 250 grams of surficial sediment (upper 2 centimeters of the sediment column) were placed in centrifuge vials and stored on ice. Large cobble and gravel greater than 2 cm diameter was excluded from the samples - but noted on the data sheets.

Sediment grain size samples were stored at 4°C until they were analyzed. The sediments were dried in an oven at 92 °C and processed using the dry sieve and pipette method (Tetratech, 1987). The sieves used for the sediment analysis had mesh openings of 2, 0.89, 0.25 and 0.063 mm. Particles passing the 0.063 mm sieve were analyzed by sinking rates in a column of water (pipette analysis). Complete grain size analysis data are provided in Appendix 1. In addition, the following qualitative substrate characteristics were noted:

A. Substrate color
B. Presence of attached macroalgae
C. Evidence of excessive littoral drift or log damage
E. Oily sheen
F. Odor (hydrogen sulfide, ammonia or petroleum)

Sediment Total Volatile Solids. A separate, 50 gram surficial sediment sample, consisting only of that fraction smaller than coarse sand was taken from the top two centimeters, placed in scintillation vials and stored on ice. These samples were dried at 103 $\pm$ 2 °C in aluminum boats that had been pre-cleaned by ashing at 550 °C for 30 minutes. Drying continued until no further weight reduction was observed. The samples were then ashed at 550 °C until no further weight loss was recorded. Total Volatile Solids were calculated as the difference between the dried and ashed weights.

Water Total Suspended Solids (TSS) and Total Volatile Solids (TVS). Three 500 ml water samples were collected at each sample beach. Samples were collected at mid depth from undisturbed water with a minimum depth of one meter. Samples were placed on ice and shipped via overnight express to Aquatic Environmental Sciences' laboratory. A 0.45 µm glass filter was ashed at 550°C and weighed. A 350 ml sample of thoroughly mixed water was suction filtered and the residue dried at 103 $\pm$ 2 °C to determine TSS. Total volatile solids were determined following ashing of the sample at 550 °C.

Dissolved oxygen was monitored *in-situ* with a YSI Model 57 Oxygen Meter. The probe had a new membrane and was calibrated with water saturated air immediately prior to each measurement.

Salinity and temperature were monitored, *in-situ*, with a YSI Model 33 SCT meter that was calibrated at 0.0 and 29.6 ppt the day prior to sampling.

pH was determined using a dual point calibrated (pH 7 and 10) JENCO mP-Vision 6009 meter. The pH meter was calibrated just prior to each set of measurements.

Current speeds were measured by placing a drogue in the water and measuring its movement as a function of time. These point estimates of current speed are of minimal value but they do provide an indication of minimum current speeds within an hour of slack tide.

Shellfish population estimates. Each survey began with a series of test digs to define the highest beach level at which clams were found and to stratify the beach by substrate type, where appropriate. This information formed the basis of a systematic random survey, beginning at the highest elevation on the beach at which clams were found. This procedure was reversed at Passage Island because the crew arrived there at low tide. The number of transects, and the number of samples per transect, were determined based on the area of the beach and the time available for collecting samples. The length and width of the productive area was measured using a 300' fiberglass tape. The length was divided by the number of transects plus one to obtain a transect interval. A random number between zero and the interval length was then selected and the first transect placed at the random distance from the margin of the productive beach. Additional transects were started at the specified intervals. Each transect was run normal to the water-line. The width of the beach was divided by the number of samples to be collected on each transect plus one to obtain a sample station interval. The first sample was taken at a random distance (between zero and the calculated sample interval) from the highest point at which clams were observed. Additional samples were taken at the specified interval. Red wire flags were labeled with the sample station designation and placed in the substrate at the appropriate point by the survey crew. These flags followed each sample until sieving and picking of clams was complete.

Individual samples were collected with the aid of 3/32" thick aluminum plate quadrats that cover 0.1 m^2. The quadrats are pushed down into the sample hole during excavation. This prevents sloughing of the sides and provides a precise sample size. Each sample was dug to a depth at which no additional clams were obtained. In some cases native littleneck clams were obtained at depths to 30 cm.

Sample processing. A Write in the Rain™ label was placed in each sample bag with the substrate removed from the quadrat. The samples were then placed in boats for transport to a suitable picking location. All samples were sieved on 6.4 and 1.0 mm sieves. All clams, and whole clam shells, were removed from each of these sieves and placed in pre-labeled, one gallon, ZIPLOCK™ bags. Where juvenile clams (< 6 mm valve length) were observed, the entire sample retained on the 1.0 mm sieve was retained for picking under a dissecting microscope. The free label placed in the bags during field sampling followed the sample into the ZIPLOCK™ bag. All samples were placed on blue ice in a cooler and shipped via overnight mail to Aquatic Environmental Sciences for processing

All clams in each sample were aged using the techniques described by Feder and Paul (1973), weighed, and their valve length measured to the nearest 0.1 mm. Clams were placed on preprinted acetate data sheets and photocopied. Measurements made from the photocopied data sheets were not significantly different from those made with calipers (paired sample *t*-test, $\alpha = 0.05$, $N = 36$). No correction factor was necessary or applied to the lengths taken from the photocopied data sheets. All clam shells were numbered and have been archived in storage bags, by sample code, for future reference.

Wet tissues in clams with valve lengths greater than ca. 15 mm were shucked, weighed, dried at 90 °C, and a dry tissue condition factor (1000*Dry tissue weight)/Length$^{2.1}$) determined. Additional age-length data was obtained from whole native littleneck and butter clam shells collected at Tatitlek.

Data Analysis. Data was entered into a STATISTICA™ database. All discrete data was log transformed. Proportional data was transformed by calculating the Arc Sine of the square root of the proportion. An α of 0.05 was used in all statistical testing and 95% confidence limits are reported where appropriate.

Results

Tatitlek Village

Village desires. Mr. Steve Totemoff and Mr. Gary Kompkoff were consistent in their comments that shellfish, particularly butter and native littleneck clams, have historically been an important subsistence food source. They noted that local shellfish resources had been depleted and commented that sea otter predation was a major concern. The Village of Tatitlek has an ongoing floating aquaculture industry focusing on the Pacific oyster (*Crassostrea gigas*). The Village has adequate boat and human resources. Villagers indicated that they were willing to expend significant effort to restore their shellfish resources. The beach surveyed in 1995 is located immediately adjacent to the village and is depicted in Figure 1. The beach measures 100 feet wide by 350 feet long. It is bounded on the north by sand and mud substrates covered with a healthy eel grass (*Zoostera cf. Japonica*) bed. The substrate is hardened by boulders and rock outcroppings to the south. The area in between contains excellent substrate for native littleneck clams. It would not be suitable for cockles. However, cockles could be grown on the sandy substrates in areas not covered with eel grass or on beaches near the ferry terminal located to the southeast.

Beach characterization. As described in Figure 1, two transects (A and B) were examined in the sandy, eel grass dominated strata and six transects (C, D, E, F, G and H) were established on the gravel - cobble beach. Four sample stations were established at 22 to 24' intervals on transects A through F and H run normal to the beach line. Transect G was run parallel to the beach at a tidal elevation of +0.5' (MLLW) with a sample station interval of 60'. A total of 35 shellfish samples were collected on seven transects at Tatitlek.

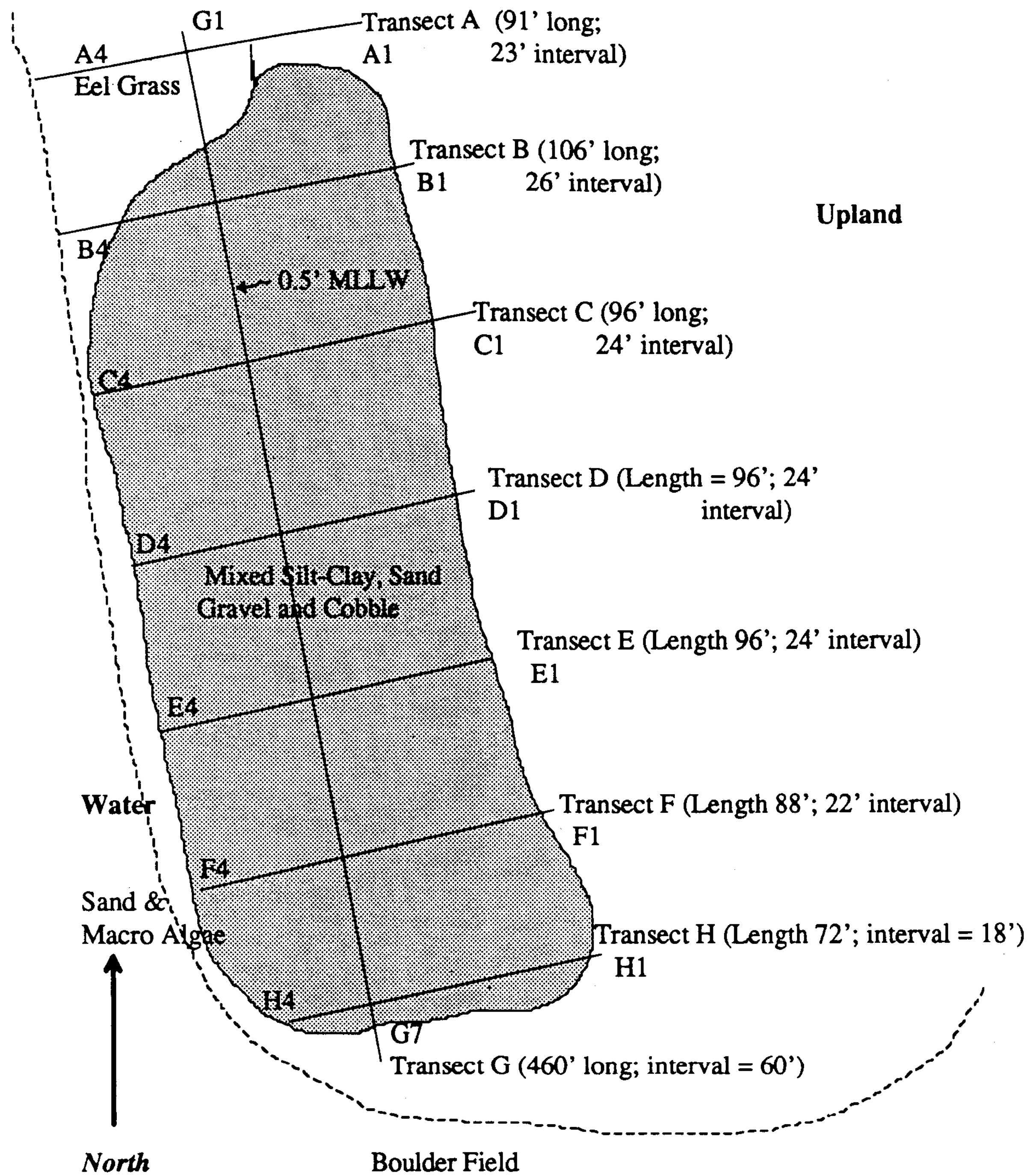


Figure 1. Schematic diagram of the Tatitlek Village shellfish beach The beach has surveyed in August of 1995.

The beach considered suitable for native littleneck clam production has a shallow slope (3.6%) and well oxygenated substrates to a depth of at least 10 cm. Ten sediment samples were evaluated for sediment grain size and total volatile solids. The results of these analyses are presented in Appendix 1. Tatitlek clam beach sediments are 65.7%

gravel, 25.87% sand and 8.33% fines (silt and clay). Sediment Total Volatile Solids content is presented for all Village beaches in Appendix 2. The Tatitlek clam beach contains an average of 1.31 $\pm$ 0.65 percent volatile solids. As might be expected, Total Volatile Solids were moderately well correlated (Pearson Correlation Coefficient = 0.39, P = 0.000) with the proportion fines observed in the sediment.

Conditions in the sandy eel grass meadow were quite different. The Reduction-Oxidation Potential Discontinuity was located at depths as shallow as 4 cm. This was accompanied by a slight hydrogen sulfide smell. Sediments were composed of 8.7 percent gravel, 53.57 % sand and 37.7 % fines (silt and clay). Total Volatile Solids were slightly higher in sediments under the eel grass beds at 1.7 $\pm$ 0.11 percent. The presence of hydrogen sulfide can be attributed to reduced pore water circulation in the fine grained sediments.

Water Column Characterization. Water conditions at Tatitlek were ideal for shellfish culture. Water temperature was 12.0 °C, salinity 26.0 ppt and dissolved oxygen was 12.5 ppm which is slightly supersaturated. Currents at slack tide were measured parallel to the beach (085 °Magnetic) at 9.4 $cm\text{-}sec^{-1}$. However, Village sources stated that currents are generally strong at this location and can exceed six knots (304 $cm\text{-}sec^{-1}$) during strong tidal exchanges.

Water column analyses of Total Suspended Solids (TSS) and Total Volatile Solids (TVS) are presented in Appendix 2. The three water samples collected at this beach averaged 3.27 $mg\text{-}L^{-1}$ TSS and 2.3 $mg\text{-}L^{-1}$ TVS. These values suggest moderate primary productivity and few suspended inorganic particulates.

Shellfish Population Characterization. A total of 660 living bivalves were collected in samples at Tatitlek. The distribution of these is provided in Table 5 and pertinent variables from the database are presented in Appendix 3.

Table 5. Summary of bivalves collected in 35, 0.1 m^2 samples at the Tatitlek Village beach on August 27, 1995.

Species	Number
Protothaca staminea (native littleneck clam)	480
Macoma inquinata (indented macoma)	72
Saxidomum giganteus (butter clam)	97
Macoma nasuta (bentnose macoma)	4
Hiatella arctica (Arctic hiatella)	4
Mya truncata (truncate softshell)	1
Tresus cf. capax (fat gaper)	1
Clinocardium nuttallii (Nuttall cockle)	1
unidentified	1

Gaper, butter and native littleneck clams and cockles 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 in reasonable abundance.

Butter Clams. A total of 97 butter clams were observed in these samples. Their length-frequency distribution is provided in Figure 2. Most of the observed clams were new recruits less than two years old. Only three legal size butter clams were observed in all 35 samples. Descriptive statistics for a limited number of variables are presented in Table 6.

Table 6. Summary descriptive statistics for living and dead butter clams sampled at the Tatitlek Village beach on August 27, 1995. Samples include 103 empty butter clam valves which were measured and aged.

	Valid N	Mean	Minimum	Maximum	Std.Dev.
Length (mm)	200	34.32025	2.000000	79.00000	23.45211
Whole weight (gms)	97	2.43192	.001200	47.87960	6.88371
Age	200	4.52500	0.000000	12.00000	3.46836
Dry Condition Factor	45	.19823	.007153	.93780	.16061

Non-linear regression was accomplished on aged living and empty butter clam valves to determine von Bertalanfy equation coefficients. The resulting equation explained 92.89% of the variation and the ANOVA determined probability that the regression coefficients were all equal to zero was P = 0.000. The residuals appear normal. However, some caution is in order because no clam valves exceeding 79 mm were included in the data base. Therefore, the maximum size of 126 mm is not well determined.

Von Bertalanfy Equation $\textbf{Length} = \mathbf{126.5(1 - exp^{-0.075 \times age})}$

Because of their propensity to retain paralytic shellfish poisons and lack of adequate hatchery technology, this species is not considered appropriate for enhancement. Therefore, it will not receive further attention in this report. However, the paucity of legal size butter clams attests to the need for enhancement of subsistence shellfish resources. It should be noted that recruitment of butter clams is low, but occurs regularly, at this beach. Therefore, predator control (especially starfish and sea otters) can have a minor, but positive affect on the number of butter clams eventually available for subsistence harvest. An age frequency histogram is provided in Figure 3.

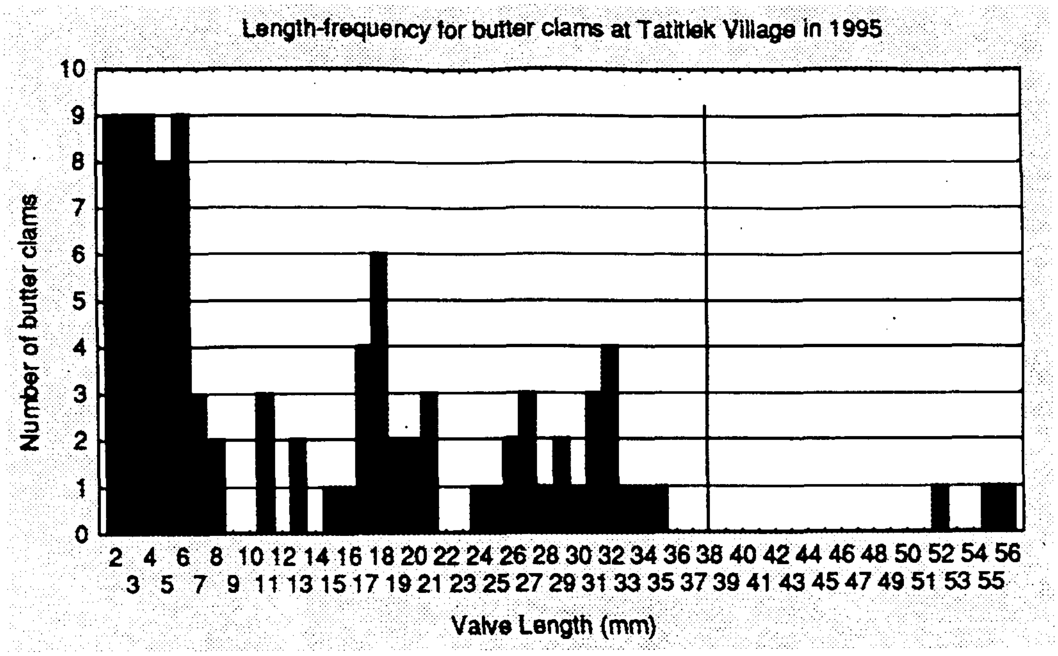


Figure 2. Length frequency histogram for butter clams (*Saxidomus giganteus*) collected in 35, 0.1 m^2 samples at the Tatitlek Village shellfish beach on August 27, 1995. The thin vertical line locates the legal limit (>38 mm).

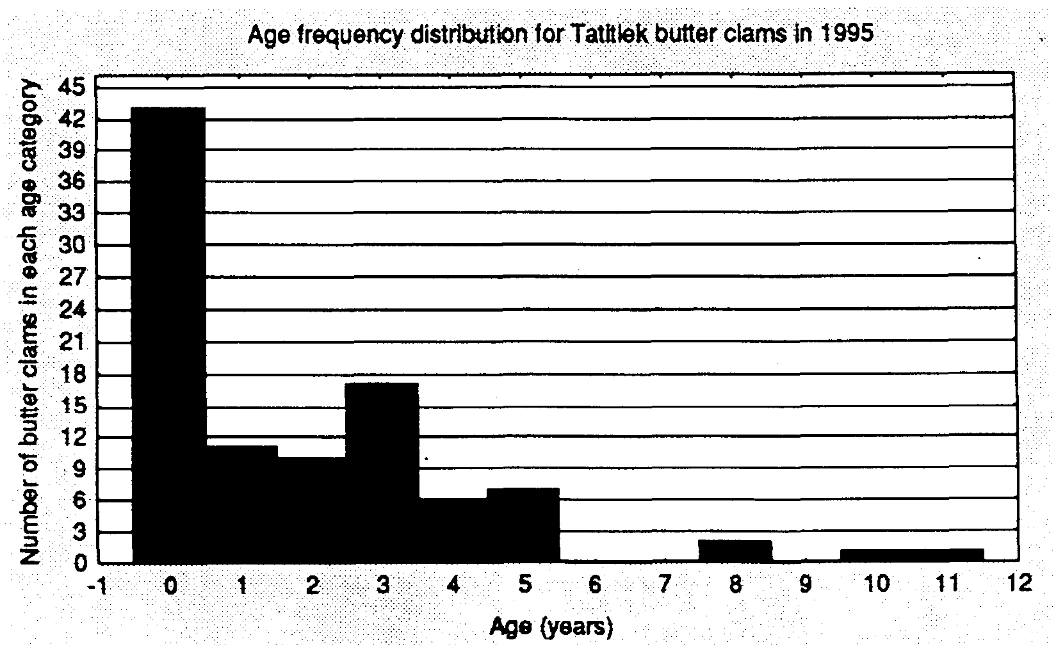


Figure 3. Age-frequency histogram for butter clams (*Saxidomus giganteus*) collected in 35, 0.1 m^2 samples at the Tatitlek Village shellfish beach on August 27, 1995.

Native littleneck clams. A total of 480 native littleneck clams were observed in these samples. Summary statistics describing littleneck clams are presented in Table 7.

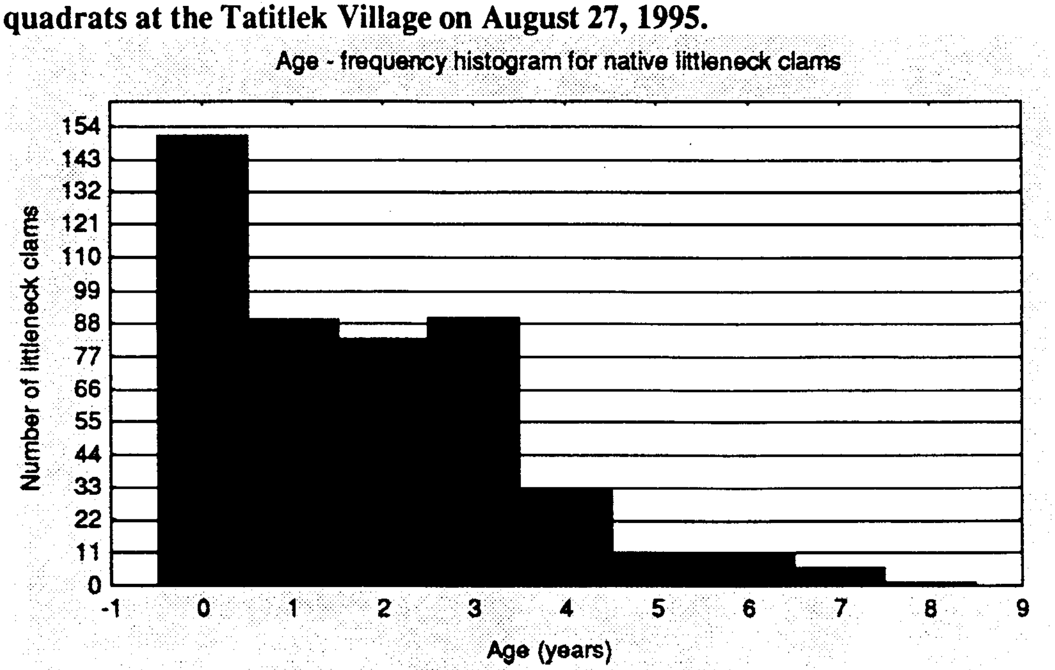
Table 7. Summary descriptive statistics for living native littleneck clams sampled in 35, 0.1 m^2 quadrats at the Tatitlek Village beach on August 27, 1995.

	Valid N	Mean	Minimum	Maximum	Std.Dev.
Elevation (feet above MLLW)	476	.83767	-1.10000	3.11666	.83480
Valve length (mm)	579	17.16922	1.80000	45.00000	11.19862
Whole weight (gm)	472	2.02461	.00080	19.34800	3.45216
Dry tissue weight (gm)	264	.68697	.08560	3.02260	.69229
Wet tissue weight (gm)	264	1.69195	.09650	8.11260	1.60496
Age (years)	576	1.95139	0.00000	8.00000	1.72684
Dry Condition Factor	263	.17797	.01616	.65178	.12385

The largest native littleneck clam had a valve length of 45 mm and weighed only 19.34 grams. A total of 17 legal size clams (valve length ≥ 38 mm) were observed in all 35 samples. This equates to a density of approximately 73.9 $g\text{-}m^{-2}$ or 0.016 pounds per square foot. This is approximately one tenth of the minimum density for commercial harvest and is probably one tenth of the density appropriate for practical subsistence harvests. The conclusion is that there is currently no opportunity for subsistence harvest of butter or native littleneck clams at this Tatitlek Village beach.

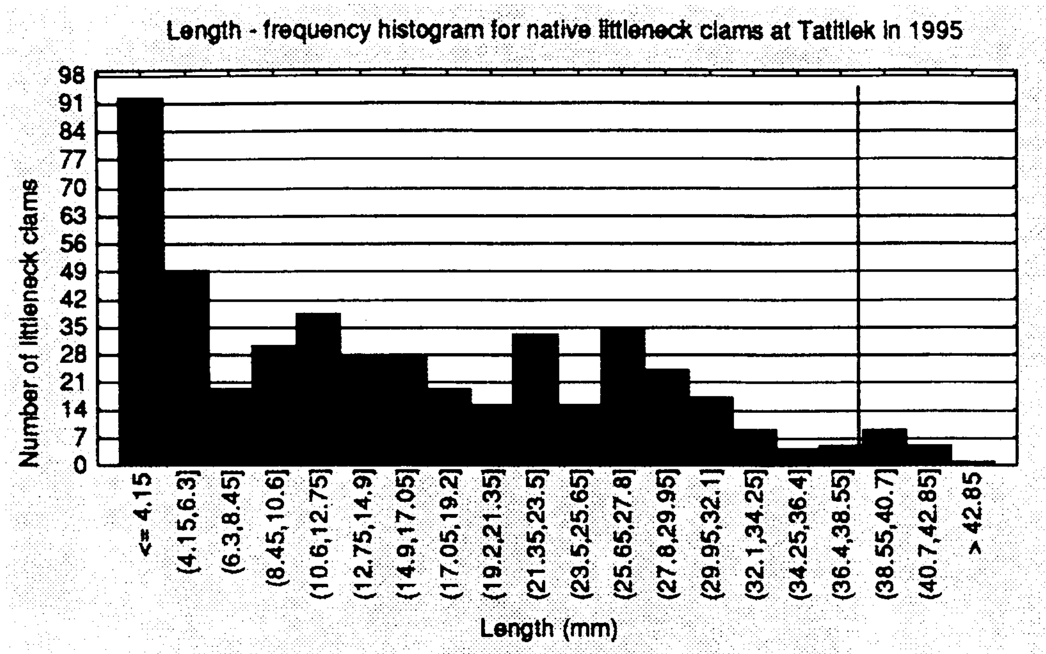
Suitability of the Tatitlek Village beach for shellfish enhancement and growth. Existing native littleneck resources at Tatitlek are dominated by new recruits. Figure 4 presents an age - frequency histogram for Tatitlek native littleneck clams.

Figure 4. Age - frequency histogram for littleneck clams collected in 35, 0.1 m^2 quadrats at the Tatitlek Village on August 27, 1995.



Further examination of the population was accomplished using the length - frequency histogram provided in Figure 5.

Figure 5. Length - frequency histogram for littleneck clams collected in 35, 0.1 m^2 quadrats at the Tatitlek Village on August 27, 1995. The thin vertical line represents the minimum legal size of 38 mm.



Comparison of Figures 4 and 5 clearly shows the correspondence between the length and age of the first four year classes. Furthermore, these figures suggest that predation, from a variety of sources is taking nearly all legal size clams. Recruitment is low but fairly steady. This suggests that under natural conditions, shellfish production at this site is limited by both predation and low recruitment. Juvenile clams should be found at a minimum density of 20 to 30 per 0.1 m^2 for optimum production. Current recruitment is approximately 4 per 0.1 m^2 - or about 15% of optimum.

Figures 6 and 7 compare the distribution of butter and native littleneck clams as a function of tidal height at Tatitlek. These figures are interesting in that they indicate an optimum tidal range of approximately 0.0' to 2.0' (MLLW) for native littleneck clams and an optimum of 0.0' to 1.0' (MLLW) for butter clams. It should be noted that the substrate changes to primarily sand at tidal elevations less than -1.5' at this beach. Therefore, it is not unexpected that native littleneck and butter clams are absent below -1.5' (MLLW). That is probably more a function of changes in the substrate composition than a function of tidal height. It is also interesting to note that both butter clams and native littleneck clams are found at tidal elevations near +3.0' (MLLW). The data for native littleneck clams suggests that the area between -1.0' and +2.5' is suitable for native littleneck clam production on this beach.

Figure 6. Tidal elevation - frequency histogram for littleneck clams collected in 35, 0.1 m^2 quadrats at the Tatitlek Village shellfish beach on August 27, 1995.

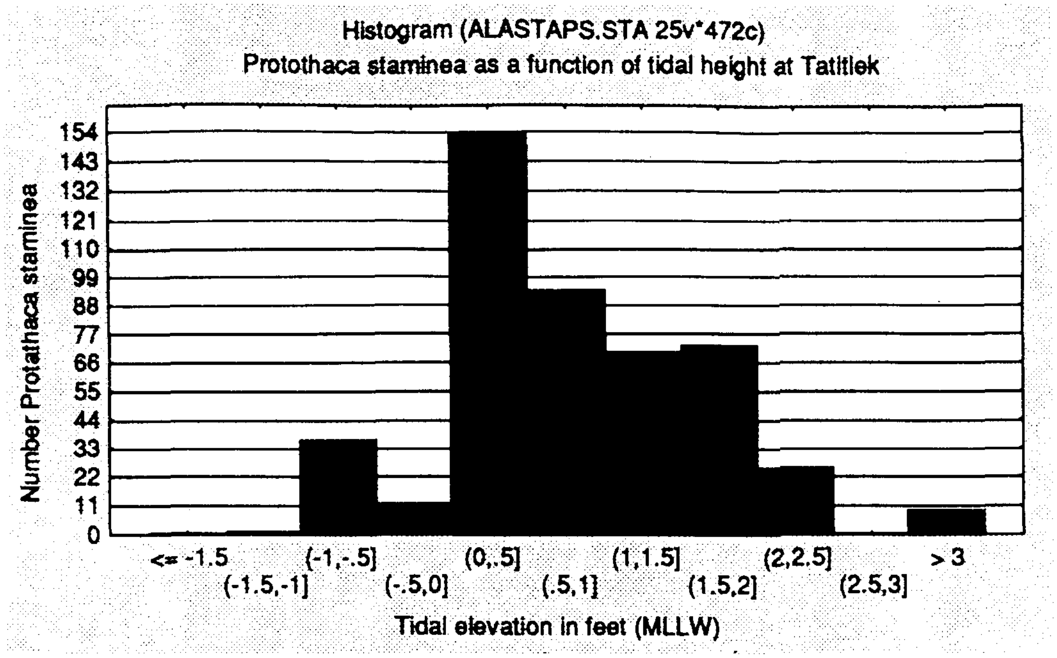
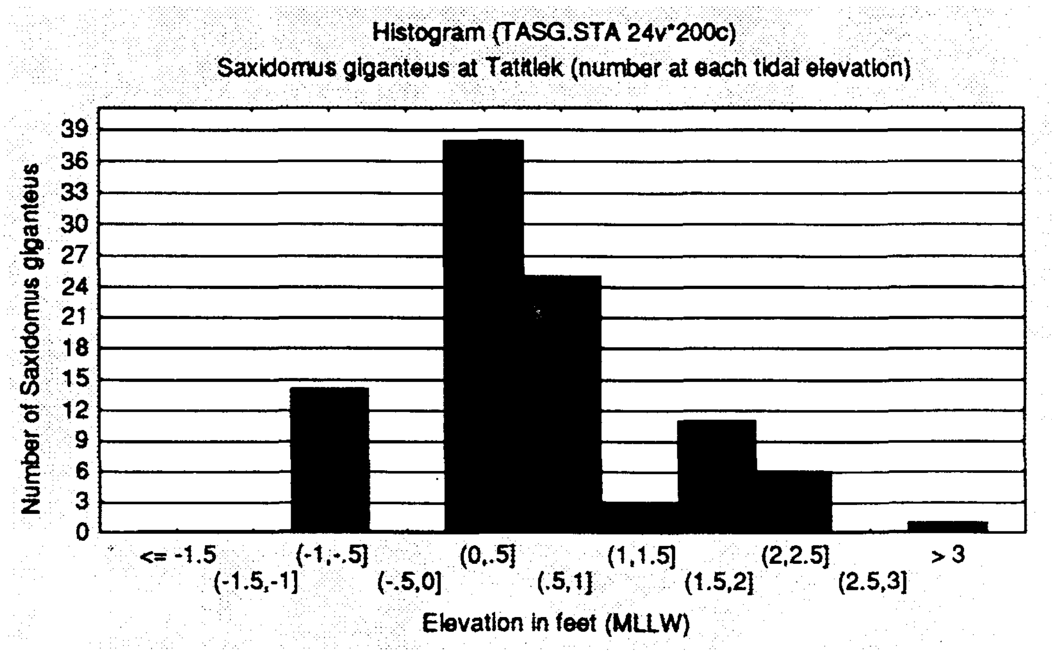


Figure 7. Tidal height - frequency histogram for butter clams (*Saxidomus giganteus*) collected in 35, 0.1 m^2 quadrats at the Tatitlek Village shellfish beach on August 27, 1995.



Environmental influence on clam size, age and growth. All 25 variables were included in a square matrix providing Pearson correlation coefficients. This matrix suggests that biological parameters such as length, incremental length growth, whole animal weight, wet tissue weight and condition factor are 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 explain 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 8.

Table 8. 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.

	Station	Tidal elevation	Sediment TVS	RPD
Length	.0164 N=576 p=.695	**-.1021** N=576 **p=.014**	**.2045** N=172 **p=.007**	**.3139** N=576 **p=.000**
Length Growth Increment	**.1051** N=423 **p=.031**	-.0071 N=423 p=.884	**-.1851** N=121 **p=.042**	.0382 N=423 p=.433
Whole Animal Weight	-.0684 N=576 p=.101	**-.1198** N=576 **p=.004**	**.1621** N=172 **p=.034**	**.2615** N=576 **p=.000**
Age	-.0483 N=576 p=.247	-.0598 N=576 p=.152	**.2683** N=172 **p=.000**	**.2968** N=576 **p=.000**
Dry Condition Factor	**-.1104** N=363 **p=.035**	**-.1635** N=363 **p=.002**	.1094 N=98 p=.284	**.2145** N=363 **p=.000**

Clam length is negatively correlated with tidal elevation (larger clams at lower tidal levels) and positively correlated with sediment TVS and RPD (larger clams found where there is more organic material in the sediments accompanied by high oxygen availability.

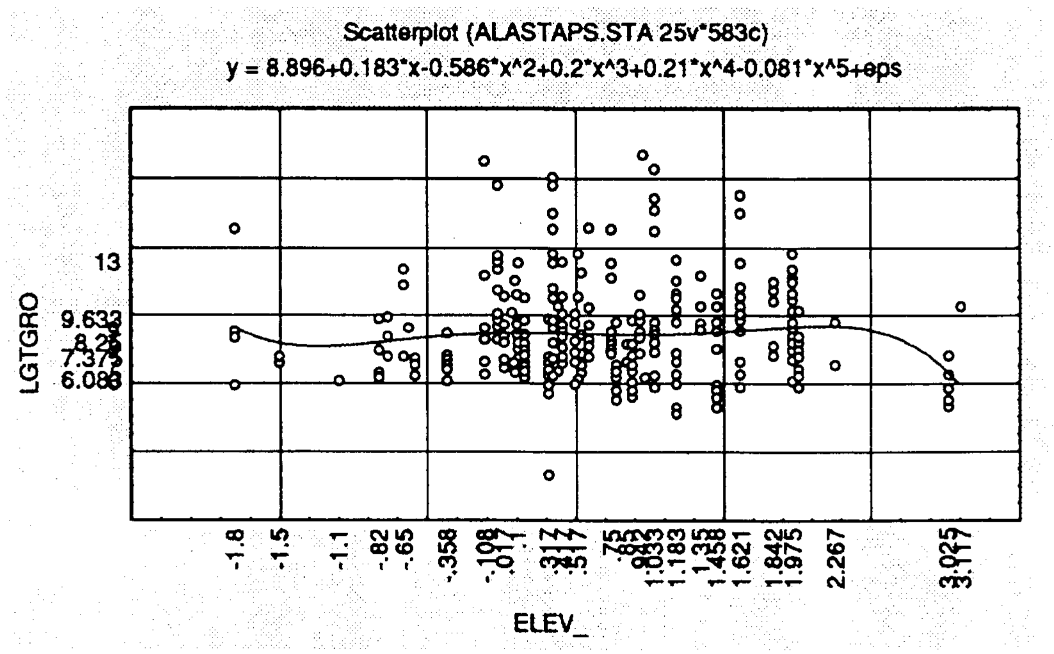
Clam growth (as measured by the average annual incremental increase in length), is negatively correlated with sediment TVS, but not strongly influenced by any of these parameters.

As might be expected, there is a small negative correlation between whole animal weight and tidal elevation (larger clams at lower elevations). Whole animal weight was positively correlated with sediment TVS, depth of the RPD and the proportion sand in the substrate (larger clams with increased TVS, increased sediment oxygen and higher proportions of sand in the sediment). From a physical point of view the positive correlation between proportion silt-clay and TVS was expected.

Dry weight condition factor was positively correlated with length, whole animal weight, age and depth of the RPD. In other words, there is more nutrition in clams that are larger, older and those that weight more. In contrast the dry weight condition factor was negatively correlated with tidal elevation and the rate of valve growth. This implies that clams are in better condition at lower tidal elevations and that clams whose valves grow more quickly in length, don't necessarily have more edible tissues.

Average growth increments were calculated by dividing the valve length by clam age. This information is presented graphically in Figure 8. The line represents a best polynomial fit to the data. Figure 8 suggests that within the tidal range investigated (which includes all elevations at which clams were found in this survey), native littleneck valve growth is constant. Clams at the highest elevation (>3.0' MLLW) are growing more slowly that those found at intermediate elevations. Likewise there is a suggestion that clams would grow more quickly at tidal elevations < -1.8' MLLW. However, there are too few data points at either extreme of the database to make a definitive statement. What is of interest, is that on the Tatitlek beach, clam growth is fairly constant throughout the range of tidal elevations at which clams were found. This suggests that the entire area of surveyed beach is suitable for enhancement.

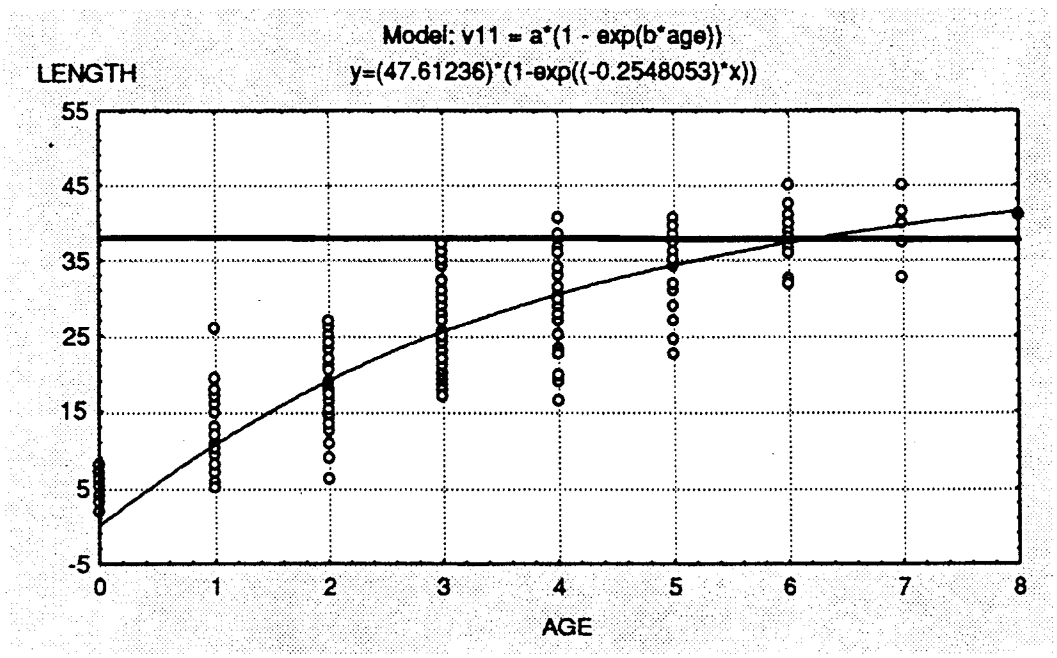
Figure 8. Growth increments (mm/year) as a function of tidal height (feet above MLLW) for native littleneck clams (*Protothaca staminea*) collected in 35, 0.1 m^2 quadrats at the Tatitlek Village shellfish beach on August 27, 1995.



Age Length analysis. Regression coefficients were developed for the von Bertalanfy equation 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 residuals appear normal. However, some caution is in order because no clam valves exceeding 45 mm were included in the data base. In Puget Sound, native littleneck clams grow to lengths in excess of 65 mm. However, clams older than 8 years were not observed at Tatitlek, presumably because of predation. Therefore, it appears that this analysis, while valid for the Tatktlek Village beach in 1995, is most probably biased by predatory removal of older aged clams.

Native littleneck von Bertalanfy equation **Length = 47.61(1 - exp$^{-0.2548 \times age}$)**

Figure 9. Length (mm) versus age (years) for native littleneck clams (*Protothaca staminea*) collected in 35, 0.1 m^2 quadrats at the Tatitlek Village on August 27, 1995. The solid horizontal line represents the minimum legal size limit (≥ 38 mm).



The von Bertalanfy equation, and accompanying scatterplot, suggests that clams recruit into the legal size population, at between 4 years and >7.0 years. The average age at recruitment is six years.

Edible tissue versus clam length analysis. A length - wet tissue weight histogram is provided in Figure 10 and an age - wet tissue weight histogram in Figure 11. One of the possible management options involves harvesting clams at a lower minimum size. However a careful examination of Figures 10 and 11 suggests that this is not a viable alternative.

List of tables continued: ***Page***

Figure 10. Length (mm) versus wet tissue weight (in grams) for native littleneck clams (*Protothaca staminea*) collected in 35, 0.1 m^2 quadrats at the Tatitlek Village shellfish beach on August 27, 1995. The vertical solid line represents the minimum legal size.

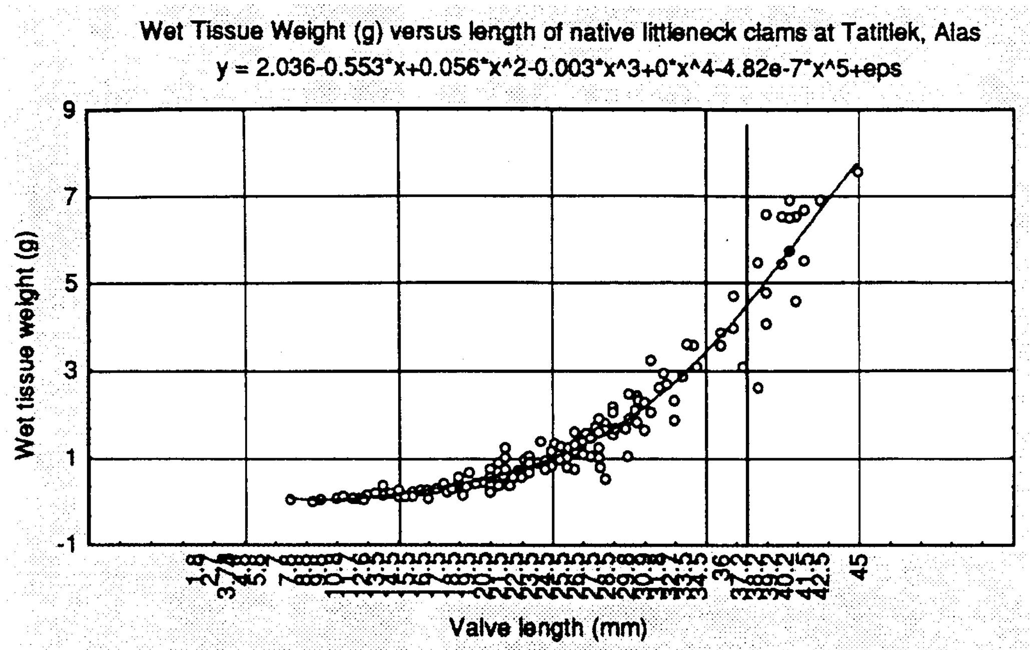
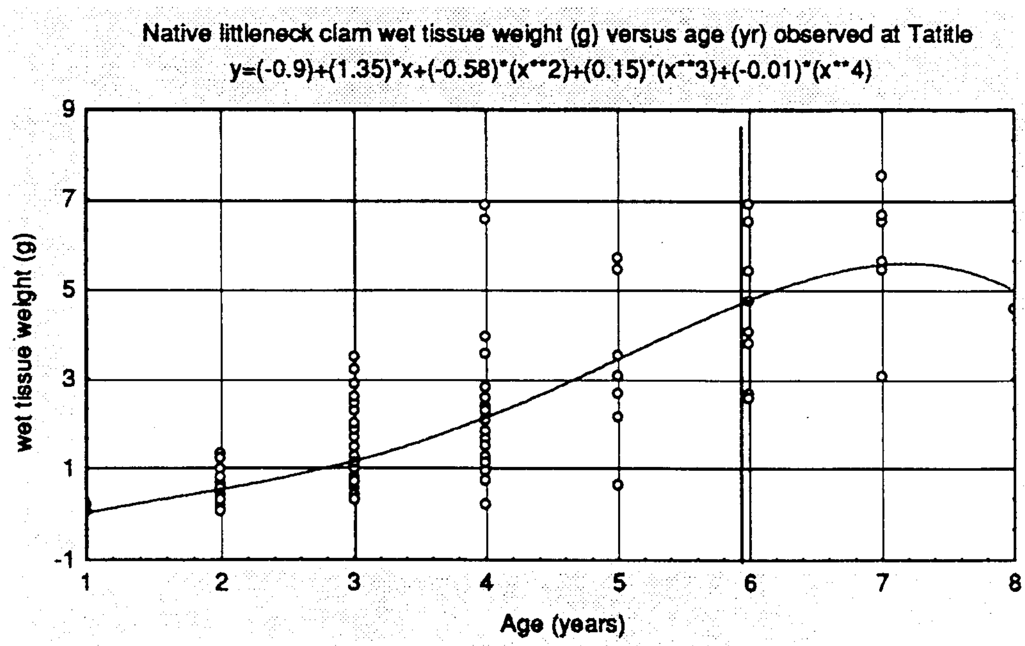


Figure 11. Age (yr) versus wet tissue weight (g) for native littleneck clams (*Protothaca staminea*) collected in 35, 0.1 m^2 quadrats at the Tatitlek Village shellfish beach on August 27, 1995. The vertical solid line represents the minimum legal size.



An examination of the data density in Figure 10 suggests that clams are being removed by predation at approximately 31 to 32 mm. That length is coincident with the point in the curve where wet tissue weight is beginning to increase significantly as a function of age. Even at 38 mm, clams are still well within the exponential growth phase. 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 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.

In contrast, the data presented in Figure 11 suggests that native littleneck clams should be harvested shortly after they reach minimum legal size. However, there is a paucity of data at the larger sizes and the polynomial regression is heavily influenced by the single data point representing an eight year old clam with relatively low wet tissue weight (perhaps due to recent spawning). Therefore, any conclusions based on the information in Figure 11 should be considered preliminary. These data suggest that a growth and mortality study of caged (protected from predators) clams could provide valuable additional information regarding the biomass of wet tissues available for subsistence harvests as a function of time.

Predator density. Predators were very obvious at the Tatitlek Village beach. Numerous small round holes (approximately 0.6 meters in diameter and 15 centimeters deep) were found on the beach. Villagers' assured us that these pits were created by sea otters and that no harvests had been conducted at this site for several years. Many of the pits still had freshly broken shell in the immediate vicinity. At some locations these pits covered significant areas. However, their distribution was patchy. In addition, large numbers of starfish, particularly the sun star (*Pycnopodia helianthoides*) were observed at the +0.5' MLLW tide level and below. In an attempt to estimate the role of predation on this beach, three randomly selected stations were established on transect G. At each station, a single quadrat (3 m x 3 m) was established and the number of presumed otter pits and starfish were counted. The results are presented in Table 9. This superficial examination suggests that both starfish and sea otters are having a significant impact on shellfish resources. Interestingly, although there was a significant amount of *Fucus sp.* on this beach, only one small urchin (~2.0 cm diameter) was observed.

Table 9. Number of starfish (*Pycnopodia helianthoides, Pisaster ochraceus*) and presumed sea otter (*Enhydra lutris*) pits observed at the Tatitlek Village shellfish beach on August 27, 1995. All counts are provided in numbers per square meter.

Sample Station	Sea Otter Pits	*Pycnopodia*	*Pisaster*
G2	0.44	1.0	0
G3	0.22	0.22	0
G6	0.0	0.56	0.11

Shellfish biomass available for harvest in each strata. There is currently no clam biomass available for harvest at this Tatitlek Village beach. However, there are significant quantities of small mussels (*Mytilus edulis trossulus*), along the extreme high tide line. In many parts of the world, blue mussels are considered a delicacy. Villagers suggested that this is not a traditional food. However, their sheer volume at this site, and their acceptance in other parts of the world, suggest that this could be a valuable subsistence resource. This is particularly true because mussels are most amenable to floating culture. The seed could be harvested from these high intertidal areas where the mussel grows slowly, and placed in lantern nets at the Village's oyster culture facility - or away from piling on the new ferry terminal.

Summary conclusions and recommendations for shellfish enhancement at the Village of Tatitlek. Based on this survey and analysis, the following conclusions can be reached:

1. **Beach suitability.** The Tatitlek Village Beach contains approximately one 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. Clam growth, density and size suggest non-significant differences in culture potential over the area of surveyed beach. Assuming that the predation problem is solved, there are several physical enhancement practices that could be employed here to increase natural recruitment and to make this very rocky beach more amenable to intensive clam culture.

2. **Habitat suitability index (HIS) inputs.** It appears that clams can be successfully grown to a tidal elevation of at least 2.1' MLLW. Native littleneck clams appear to grow to larger sizes in sediments which contain at least 1.0% TVS. The presence of moderate quantities of sand and fines (silt-clay) were not factors determining the presence, or growth, of the clam population. Nearly all aspects of native littleneck growth are enhanced by significant amounts of interstitial water movement as evidenced by the presence of oxygen at depth.

Native littleneck clams were found at depths (>15 cm) exceeding those previously reported. This may be a regional adaptation for survival during cold winter, night-time, low tides. Typically, cultured clams are protected from potential predators by placing them in sturdy mesh bags. These bags are then partially buried in the substrate. If Alaskan littleneck clams dig deeper to avoid freezing in winter, the placement of clams in bags at shallow depths could jeopardize the cultures. Therefore consideration should be given to placing bags at lower tidal elevations or to burying the bags deeper in the substrate.

3. **Predation.** Significant starfish predation was observed in this survey. In addition, while sea otters were not observed preying on shellfish, the evidence observed during this survey suggests that they are significant predators on local shellfish resources. If confirmed, sea otter predation presents a new dimension to predator control. 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. Reasonable and effective methods to control sea otter predation presents a real challenge.

4. **Recruitment** to the Tatitlek Village beach occurred in low numbers in each of the last eight year classes. No year classes were missing. However, recruitment (or at least survival until August 27, 1995) is too low and inadequate in each year class to stock this beach at optimum densities. Villagers' reported high currents (up to six knots) suggesting that high cultured clam density will not deplete phytoplankton here.

5. **Age at harvest.** The age length analysis suggests that native littleneck clams recruit to the legal size population at between 4 and >7.0 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. There is some evidence that optimum biomass could be realized by harvesting native littleneck clams shortly after they reach the minimum legal size. However, there is often significant mortality in undersized clams not taken during a harvest. Therefore, harvests should be delayed until most of the clams have reached the minimum legal size (~7.0 years). Harvests should then be concentrated in specific areas and should take all of the legal size clams. This recommendation should be made part of an overall management plan for the beach. Development of a management plan was not part of the current effort and should await completion of adequate growth and mortality studies. However, the data collected herein provides direction for the development of interim plans.

6. **Butter clams.** *Saxidomus giganteus* also recruits, although more sporadically, to this beach. However, few butter clams survive to harvest size. Due to the lack of hatchery and nursery technology, and propensity to retain brevetoxins, butter clam enhancement is not recommended at this time.

7. **Cockles** are a traditional (and preferred) shellfish for Alaskan Villages. The primary beach surveyed in this effort is too rocky, with too few fines, to warrant cockle enhancement. The beach lying to the northwest is sandy and suitable for cockle production. However, this beach is covered with a luxurious eel grass (*Zoostera cf. japonica*) bed. Disruption of the ecologically valuable eel grass bed in an effort to enhance the cockle resource is not recommended. There are additional beaches, in the vicinity of the new ferry terminal and dock, which are suitable for cockle enhancement.

8. **Mussels.** The presence of large quantities of blue mussel (*Mytilus edulis trossulus*) seed should not be overlooked. These mussels are eagerly sought in other parts of the world. If the copious seed supply were removed from the high intertidal, placed in lantern nets, and submerged continually at the Villages aquaculture facility, or from the new ferry terminal, it could quickly provide as much shellfish as the village might desire.

9. **Clams available for harvest.** There is currently no harvestable population of clams at the Tatitlek Village beach.

10. **Shellfish enhancement potential.** In Puget Sound, it is possible to grow greater than 0.5 pounds of native littleneck clams per square foot, in a three year growout period, on similar ground. Because of the slower growth in cold Alaskan waters, yield is probably lower at perhaps 0.10 pounds per square foot per year (0.6 pcf in 6 years). The total yield for this beach would then be on the order of 3,500 pounds per year or 35 pounds per person per year assuming the Village supports 100 people. These estimates are very tentative and carefully controlled age and growth studies are required before accurate estimates can be made.

Based on experience in other parts of the world, it is quite possible that the grow-out time to minimum legal harvest size can be reduced by at least one year and perhaps two years. This requires nursery techniques in addition to hatchery production of seed. However, reduction of the age at recruitment into the legal size population by one or two years from the current average of six years is possible and could mean the difference between a successful enhancement project and a failed one.

Summary. The beach at Tatitlek is of excellent quality for growing littleneck clams. It should be emphasized that intensive cultivation techniques will be needed to reduce the time needed to grow a legal size clam. Six to seven years is simply too long to expect people to tend a shellfish culture before they realize any benefit.

Sustained subsistence harvests will require additional seed of the largest possible size, development of effective predatory control measures, and a well designed management plan. Optimizing solutions to these problems will require site specific studies to develop an understanding of clam growth and mortality, effective predator control (especially for sea otters) and tidal elevation versus culture depth requirements to prevent freezing during cold winter night-time tides. It should be emphasized that any enhancement plan must solve the currently unacceptable predation rates on shellfish stocks. Without effective predator control, any enhancement plan will be futile.

The easiest and quickest way to increase the supply of subsistence shellfish is to utilize the mussel resource by placing seed in lantern nets and submerging them continuously where they will quickly grow to an adequate size. Based on the Villagers' lack of interest in mussels, any mussel culture effort should be combined with efforts to increase the Villagers' perception of mussels as a valuable (and delicious) source of food.

Results

Nanwalek Village

Village desires. A considerable amount of time was spent with Mr. Dale Bowers who was very helpful and expressed a great deal of desire to re-establish a subsistence shellfishery in the vicinity of Nanwalek. In addition to Passage Island which is a traditional harvest area, Mr. Bowers identified other beaches which could be candidates for enhancement. The beach closest to the village lies at a low tidal elevation and is very exposed to a long fetch across Cook Inlet. Primarily for the second reason, we decided to survey the beach at Passage Island.

Mr. Bowers expressed concern that traditional shellfish resources were depleted and unable to supply village needs. He felt that sea otter predation was a major problem. The Village has adequate boat and human resources and indicated a willingness to expend significant effort to restore their shellfish resources. Passage Island is about 11.5 nautical miles from the village. Passage to the island is along a very rugged coastline which is exposed to the weather. Tending a shellfish culture at Passage Island from Port Graham is problematical, especially in winter.

Beach characterization. The beach measures 130 feet wide by 140 feet long (0.42 acres). It is bounded on the west by a boulder field and by deep water on all other sides. Brown kelp (*Laminaria sp.)* is abundant in the nearshore area. The beach contained large quantities of broken horse clam (*Tresus capax*) and butter clam (*Saxidomus giganteus*) shells. There were many "otter pits" on this beach. Together with the broken clam shells, these pits suggest that this beach is heavily used by sea otters. Its relative remoteness from either Nanwalek or Port Graham, will make otter control difficult. The area contains good substrate for native littleneck clams. It would not be suitable for cockles. Although Passage Island provides some protection, the site is exposed to storm winds from the southeast and has the appearance of a high energy environment. It will be difficult, but not impossible, to maintain an intensive clam culture at this site.

As desc ibed in Figure 12, three transects (A, B and C) were examined in the most suitable (as clam habitat) part of the beach. Six shellfish and three sediment samples were analyzed on each of these transects giving a total of 18 shellfish and nine sediment samples. In addition, 19 bivalves were collected in a random dig to supplement the physiological data. These cases were included in those analyses not correlated with either environmental parameters or sample station.

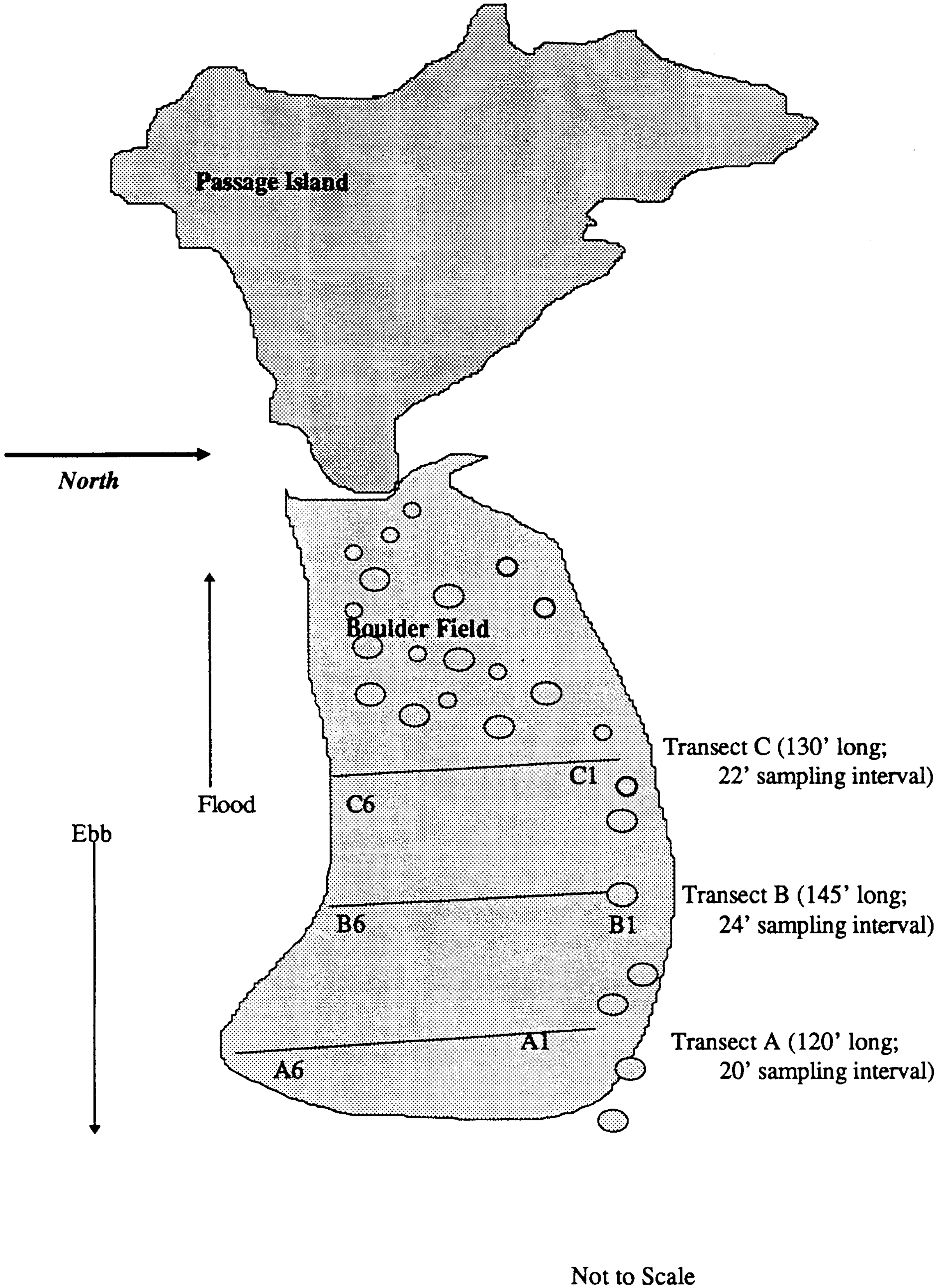


Figure 12. Schematic diagram of the Nanwalek Village shellfish beach at Passage Island. The beach has surveyed in August of 1995.

The beach considered suitable for native littleneck clam production has a shallow slope (2.3%) and well oxygenated substrates to a depth of greater than 20 cm. Nine sediment samples were evaluated for sediment grain size and total volatile solids. The results of these analyses are presented in Appendices 1 and 2. Passage Island clam beach sediments are 52.1 $\pm$ 39.3 % gravel, 38.7 $\pm$ 34.6% sand and 9.2 $\pm$ 4.83 % fines (silt and clay). Sediment composition was highly variable with the percent gravel ranging from 16 to 80.6%. Sediment composition at this beach is suitable for native littleneck culture.

Sediment Total Volatile Solids content is presented for all Village beaches in Appendix 2. The Passage Island clam beach contains an average of 1.30 $\pm$ 0.89 percent volatile solids. Total volatile solids at this beach are within an ideal range for native littleneck clams. There was a very rich infauna at this site. Invertebrates were significantly larger than usually found in Puget Sound.

Water Column Characterization. Water conditions at Passage Island were ideal for aquaculture. Water temperature was 12.0 °C, salinity 30.2 ppt and dissolved oxygen was 11.4 ppm which is saturated. Currents near slack flood tide were measured parallel to the beach (090 °Magnetic) at 2.8 $cm\text{-}sec^{-1}$. However, Village sources stated that currents are generally strong at this location. The constriction of Port Graham into two channels around Passage Island suggests strong currents with phytoplankton well distributed to significant depths - enhancing the potential for clam culture at subtidal elevations.

Water column analyses of Total Suspended Solids (TSS) and Total Volatile Solids (TVS) are presented in Appendix 2. The three water samples collected at this beach averaged 8.77 $mg\text{-}L^{-1}$ TSS and 3.23 $mg\text{-}L^{-1}$ TVS. These values suggest good primary productivity and moderate suspended inorganic particulates.

Shellfish Population Characterization. A total of 162 living bivalves were collected in the systematic random samples collected at Passage Island. An additional 19 bivalves were collected in random samples and 49 empty butter and native littleneck clam shells were collected to supplement the age - length and length - weight analysis. The distribution of shellfish obtained from the systematic survey is provided in Table 10.

Table 10. Summary of bivalves collected in 18, 0.1 m^2 samples at the Nanwalek Village beach at Passage Island on August 26, 1995.

Species	Number
Protothaca staminea (native littleneck clam)	105
Macoma inquinata (indented macoma)	4
Saxidomum giganteus (butter clam)	37
Macoma nasuta (bentnose macoma)	6
Macoma balthica (Baltic macoma)	2
Hiatella arctica (Arctic hiatella)	1
Mya truncata (truncate softshell)	2
Other	5
	1

Gaper, butter and native littleneck clams and cockles 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 Passage Island.

Butter Clams. A total of 41 butter clams were observed in these samples. Their length-frequency distribution is provided in Figure 13. Most of the observed clams were new recruits less than two years old. Only 6 legal size butter clams were observed in all 18 samples. Descriptive statistics for a limited number of variables are presented in Table 11. A vertical line is displayed at the minimum legal size of 38 mm valve length.

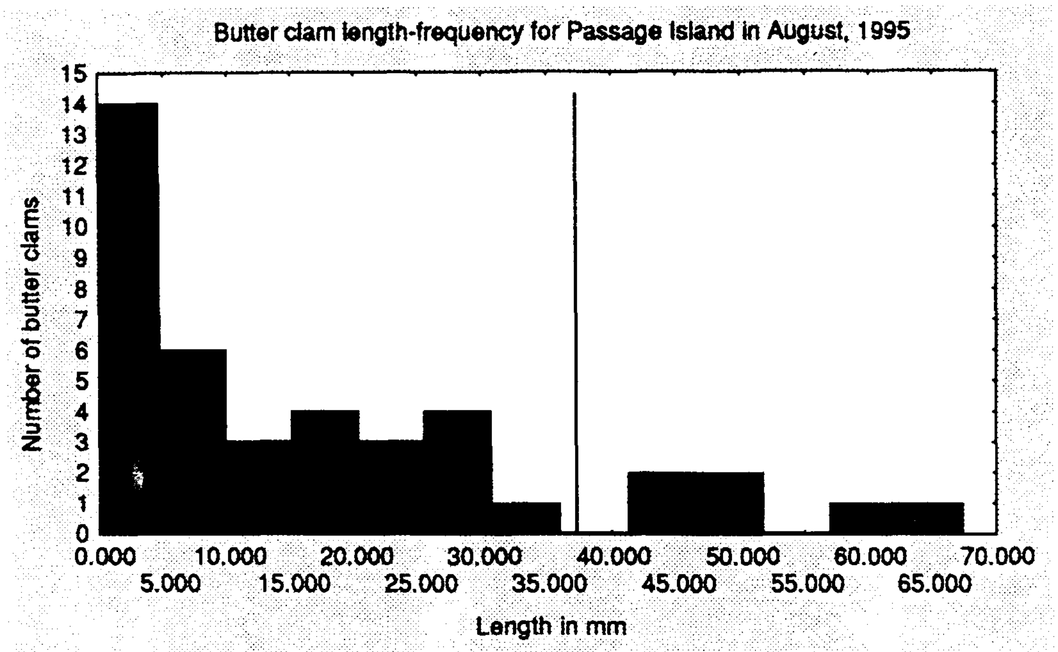


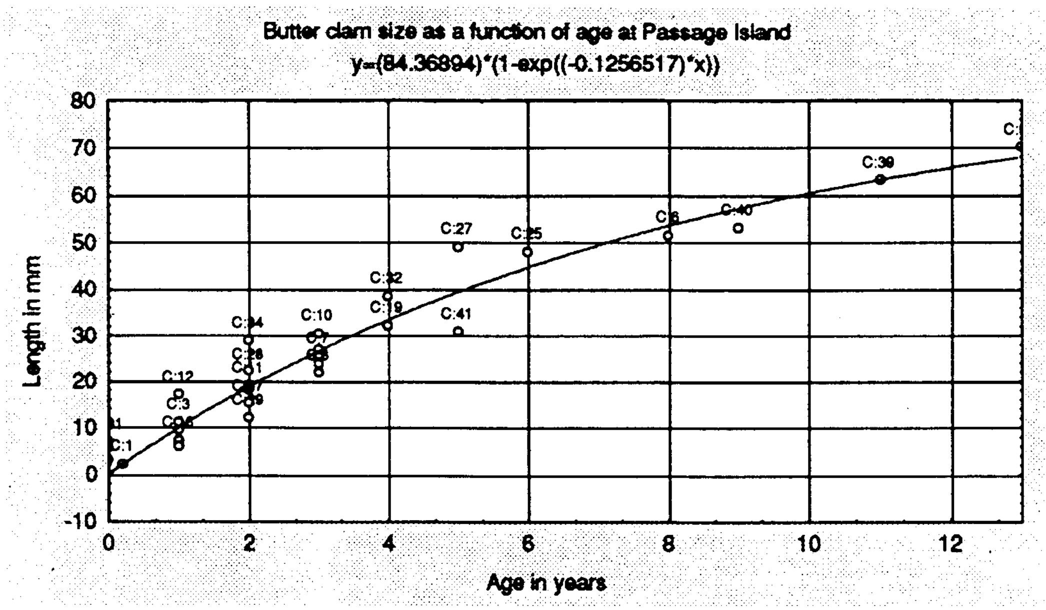
Figure 13. Length frequency histogram for butter clams (*Saxidomus giganteus*) collected in 18, 0.1 m^2 samples at Nanwalek Village's, Passage Island, shellfish beach on August 26, 1995. The thin vertical line locates the legal limit (>38 mm).

Table 11. Summary descriptive statistics for living butter clams sampled at the Nanwalek Village's Passage Island beach on August 26, 1995.

	Valid N	Mean	Minimum	Maximum	Std.Dev.
Length (mm)	41	19.97	2.00	70.00	18.19
Whole weight (gms)	41	7.22	0.0024	77.00	16.14
Age	41	2.65	0.00	13.00	3.08
Dry Condition Factor	20	0.25	0.06	0.58	0.15

Non-linear regression was accomplished on aged living and empty butter clam valves to determine coefficients for the von Bertalanfy equation. The resulting equation explained 94.7% of the variation and the ANOVA determined probability that the regression coefficients were all equal to zero was P = 0.000. Observed and predicted values are presented in Figure 14.

Figure 14. Solution to the von Bertalanfy equation for butter clams collected in eighteen, 0.1 m^2 quadrats at Passage Island, Alaska, in August, 1995.



The resulting Von Bertalanfy equation for Passage Island is compared with the results from Tatitlek. The results of the Passage Island data reflect the paucity of large clams in these samples. In addition, the larger coefficient on age suggests that butter clams grow more quickly at Passage Island than at Tatitlek.

Length (Passage Island) $= \mathbf{84.4(1 - exp^{-0.126 \times age})}$

Length (Tatitlek) $= \mathbf{126.5(1 - exp^{-0.075 \times age})}$

An age-frequency histogram for butter clams is presented in Figure 15. Butter clams recruit into the legal size population at between age four and five (mean = 4.75 years). However, very few reach a legal size. Most of the mortality occurs at ages less than three years. This suggests that predators such as drills, starfish or birds are taking these small clams. From the presence of otter pits on the beach, the otters are exacerbating the situation by taking the few remaining legal size clams. Recruitment of butter clams to Passage Island appears to occur regularly, but not in sufficient numbers to sustain a healthy population in the presence of natural predation and mortality.

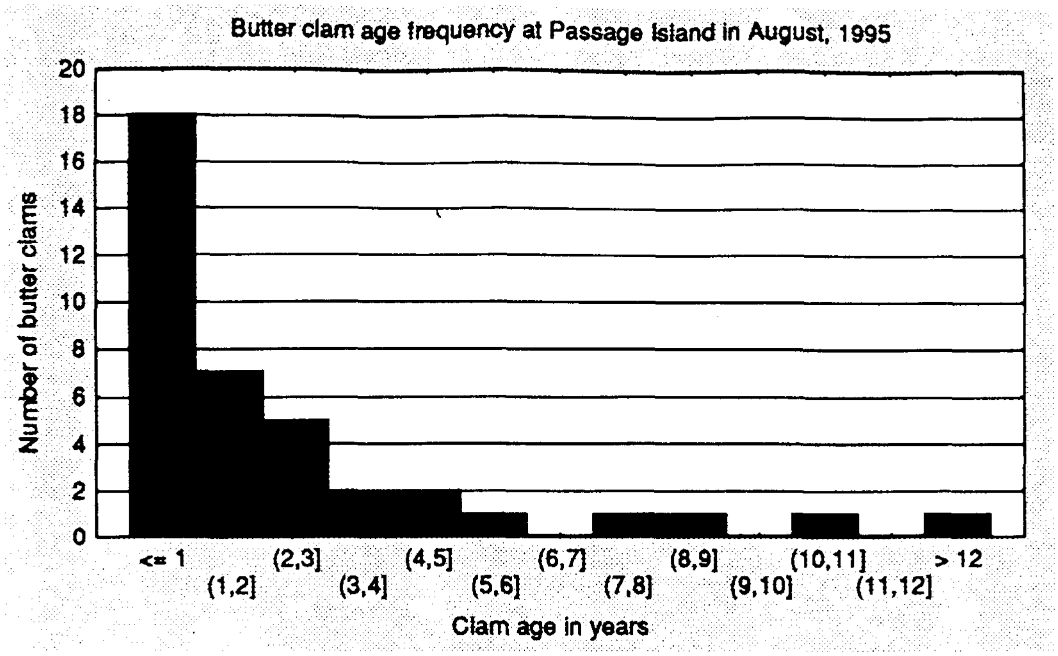


Figure 15. Age-frequency histogram for butter clams (*Saxidomus giganteus*) collected in 18, 0.1 m^2 samples at Nanwalek Village's, Passage Island, shellfish beach on August 26, 1995.

Butter clams are growing well on Passage Island. However, because of their propensity to retain paralytic shellfish poisons and lack of adequate hatchery technology, this species is not considered appropriate for enhancement. Therefore, it will not receive further attention in this report. It should be noted that recruitment of butter clams is low, but occurs regularly, at this beach. Therefore, predator control (especially starfish and drills) can have a minor, but positive affect on the number of butter clams eventually available for subsistence harvests.

Native littleneck clams. A total of 105 native littleneck clams were observed in the eighteen samples from Passage Island. Seven additional littleneck clams were obtained in the random digging efforts. Summary statistics describing littleneck clams are presented in Table 12.

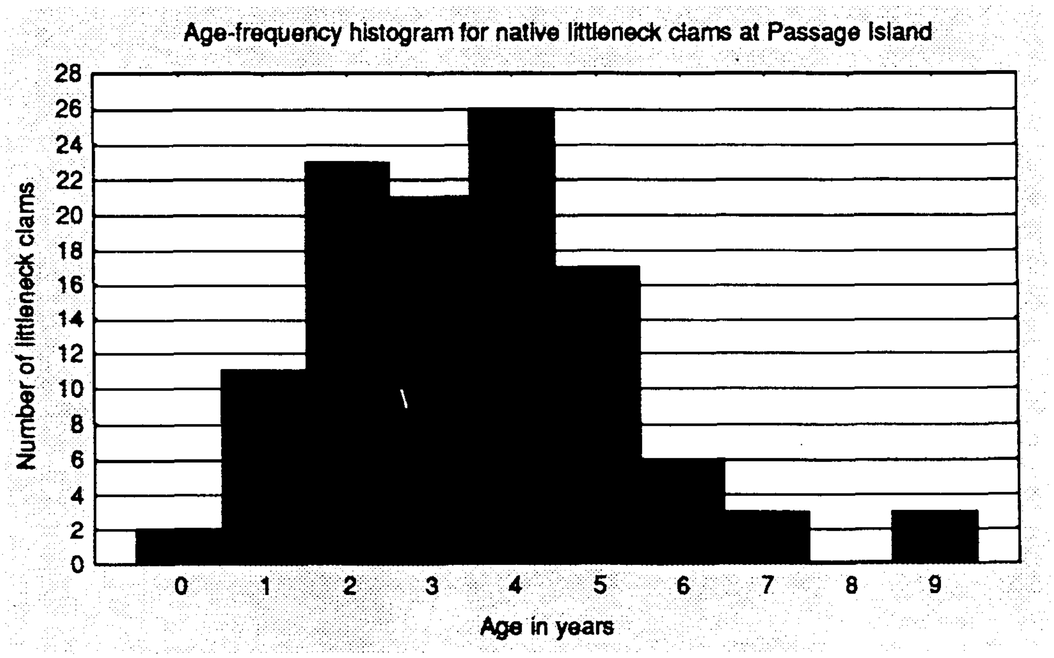
Table 12. Summary descriptive statistics for living native littleneck clams sampled in 18, 0.1 m^2 quadrats at the Nanwalek Village's beach at Passage Island on August 26, 1995.

	Valid N	Mean	Minimum	Maximum	Std.Dev.
Tidal height (ft)	18	.09868	-1.80000	1.03330	.723592
Length (mm)	112	26.06607	2.30000	52.00000	9.788756
Whole wt. (g)	112	6.02968	.00140	31.90000	6.082377
Age (years)	112	3.50893	0.00000	9.00000	1.800878
Dry Condition	101	.26733	.05131	.50748	.104420
Wet Tis. Wt (g)	101	1.80339	.03050	7.95820	1.652882

The largest native littleneck clam had a valve length of 52 mm and weighed 31 grams (15 per pound). A total of eight (8) legal size clams were obtained from the 18 quadrats included in the systematic random sample. That is less than one legal size clam per square foot and demonstrates the complete lack of subsistence harvest available on the Village beach at Passage Island.

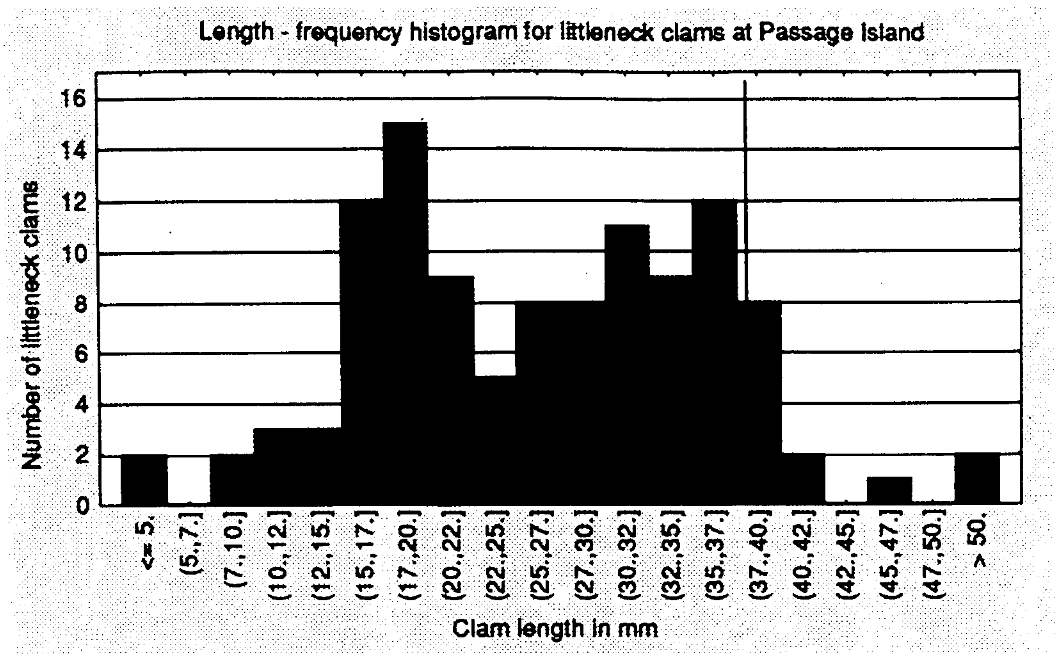
Suitability of Passage Island for shellfish enhancement and growth. From a physical and chemical point of view, the beach at Passage Island is ideal for native littleneck clams. The strong currents passing this point contribute significant food to the rich infaunal community. An age frequency histogram for native littleneck clams on Passage Island is presented in Figure 16. The 1994 and 1995 year classes are very low suggesting sporadic recruitment. However, this is confounded by the presence of significant numbers of drilled (probably by *Nucella lamellosa*) clam shells in the size range three to four mm. Older clams appear to be removed from the population shortly after reaching legal size (4 to 5 years).

Figure 16. Age - frequency histogram for littleneck clams collected in 18, 0.1 m^2 quadrats at Passage Island on August 27, 1995.



Further examination of the population was accomplished using the length - frequency histogram provided in Figure 17. This histogram confirms that recruitment past the juvenile stage has been very low in the last two years. The frequency observed in each of the year classes in Figure 16 should be divided by 1.8 to obtain the number of recruits per square meter. Doing this suggests that recruitment, on average, is approximately 13 clams per square meter - far below the minimum of 200 to 300 clams per square meter needed to fully utilize a quality habitat such as this. Therefore, this site requires supplemental seed before reaching even minimal production.

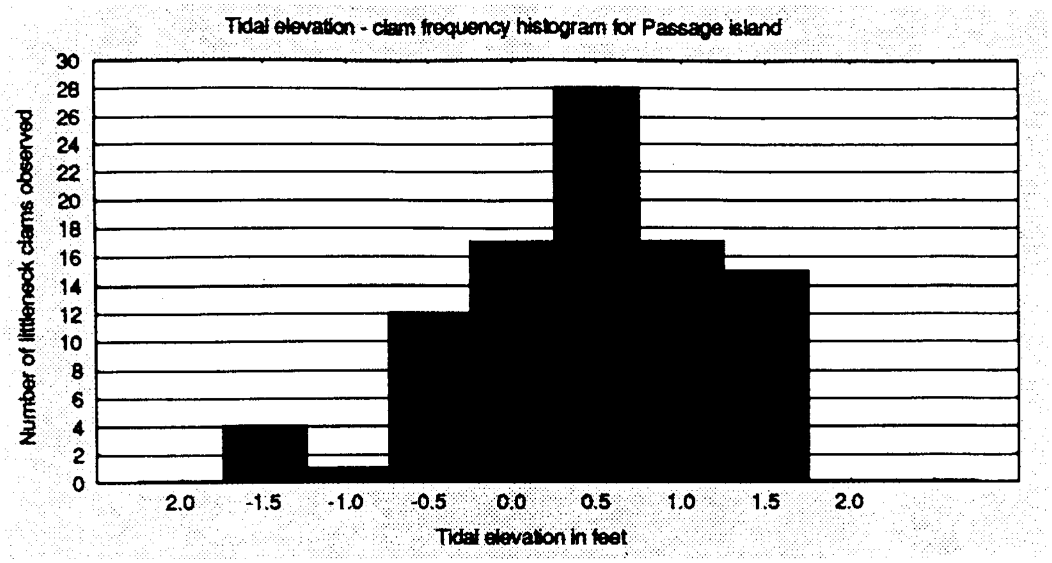
Figure 17. Length - frequency histogram for littleneck clams collected in 18, 0.1 m^2 quadrats at the Passage Island shellfish beach on August 26, 1995. The thin vertical line represents the minimum legal size of 38 mm.



Current clam densities are insufficient to warrant subsistence harvests at Passage Island. Given that recruitment is enhanced, comparison of Figures 16 and 17 suggests that predation will still remove legal size clams from the Passage Island population before harvest at minimum legal size. Starfish and drills are relatively easy to control. However, this beach will be difficult to protect from sea otters because there are no villagers living within sight of the beach. If Passage Island is to become a valuable shellfish resource for the Village of Nanwalek, then reliable predator control measures must be developed. Seeding the beach without predator control will simply supply sub legal size clams for sea otters, starfish and gulls.

Figure 18 examines the distribution of native littleneck clams as a function of tidal height at Passage Island. Most of the clams are found within a narrow tidal range of -0.5' to +1.5' MLLW. Substrates to -1.8' MLLW were included in this survey. However, very few clams were found at these lower elevations. Most of the surveyed beach (0.42 acres) lies within an ideal tidal elevation and there is sufficient room for a moderate enhancement project.

Figure 18. Tidal elevation - frequency histogram for littleneck clams collected in 18, 0.1 m^2 quadrats at Passage Island on August 26, 1995.

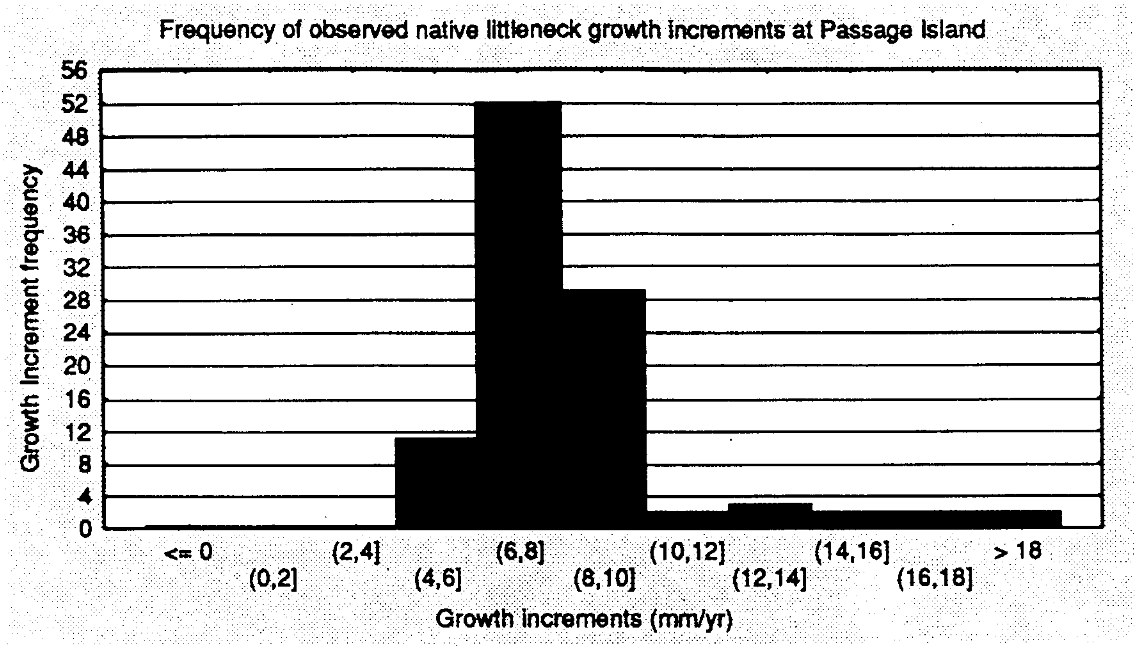


Environmental influence on clam size, age and growth. Parameters with variation were included in a square matrix providing Pearson correlation coefficients. This matrix suggests that biological parameters such as length, length growth increments, whole animal weight, wet tissue weight and condition factor are not strongly dependent on environmental factors within the tested strata. This conclusion is consistent with that from the Tatitlek data. However, it must be remembered that the survey was restricted to that area of the beach in which we expected to find native littleneck clams. We can state that the physical and chemical conditions on these "most favorable beaches" do not significantly influence clam growth or physiology. However, that statement is constrained to these "most favorable beaches" and does not apply to the area in general.

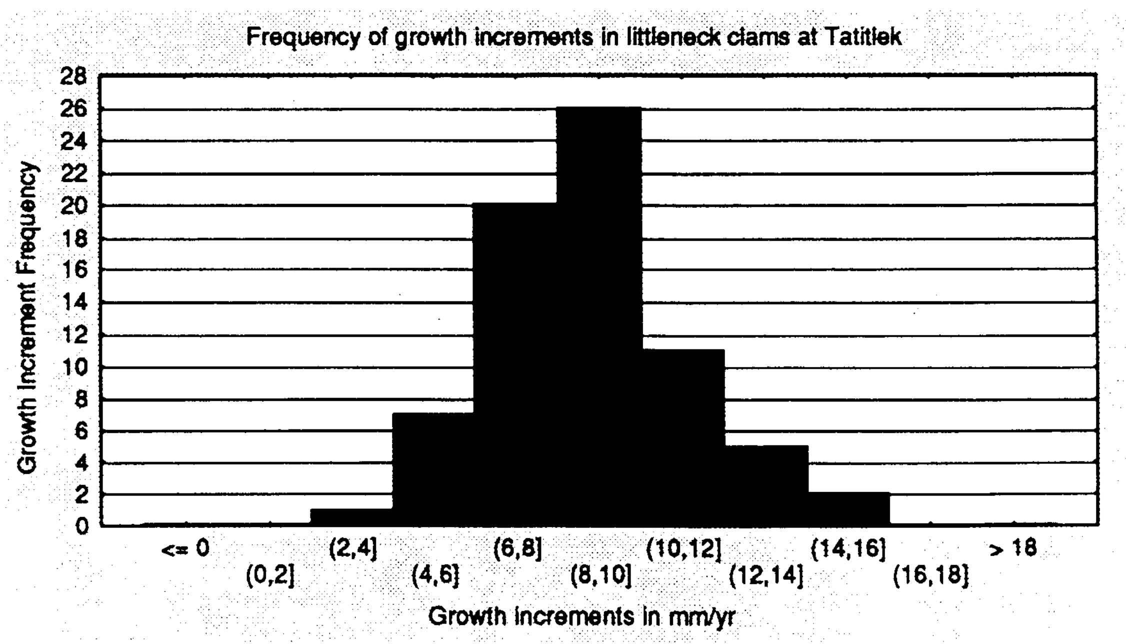
Clam growth as a function of age and length. Average growth increments were calculated by dividing the valve length by clam age and examined as a function of age. This information is presented graphically in Figure 19. The line represents an exponential best fit. Native littleneck clams appear to recruit into the legal size population at an age of between four and five years. As seen in Figure 19a and 19b, growth rates for littleneck clams at Tatitlek and Passage Island are similar.

Figure 19. Frequency of observed incremental growth (mm/year) in native littleneck clams (*Protothaca staminea*) at (a) Passage Island and (b) Tatitlek, Alaska on August 26 and 27, 1995.

(a) Passage Island growth increments.



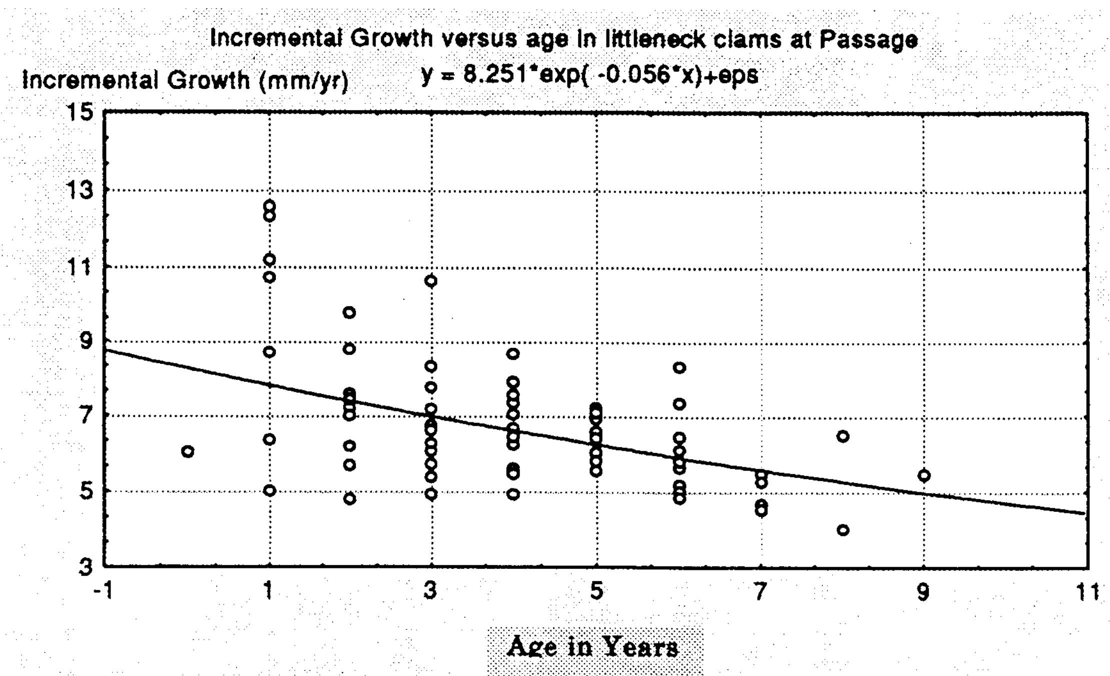
(b) Tatitlek growth increments



Incremental growth of native littleneck clams at Passage Island is described in Figure 20. Some clams in the 10 to 15 mm size range appear to have achieved that size in a single year. In other clams of the same size, their is a distinct growth check at about 1.5 mm, suggesting minimal growth during the first year. Perhaps those clams were spawned late in the year and over-wintered just after metamorphosis. The larger clams, without the check at 1.5 mm, probably spawned early in the spring or summer and enjoyed an entire growing season before winter. This, in part, explains the large variation observed in growth increments for the one year old clams. In addition, this observation suggests that conditioning native littleneck clams to spawn early in the year (February) and placing them in nurseries for optimum growth to 10 mm prior to seeding in the fall may significantly (by one year) decrease the growout time required to harvest legal size clams.

Manila clams (*Tapes japonica*) have been observed to grow adequately to a valve length of approximately 25 mm in suspended culture. Significant mortality and deformity (they grow into small, walnut shaped, clams) dictates that Manila clams be placed in suitable substrate after reaching a valve length of ca. 25 mm. It is possible that native littleneck clams may respond similarly. If so, then clams could be raised in floating nurseries, where they are less susceptible to predation, until reaching 25 mm and then planted to enhance beaches like Passage Island. If that is possible, then legal size clams could be produced in perhaps two or three years of field culture.

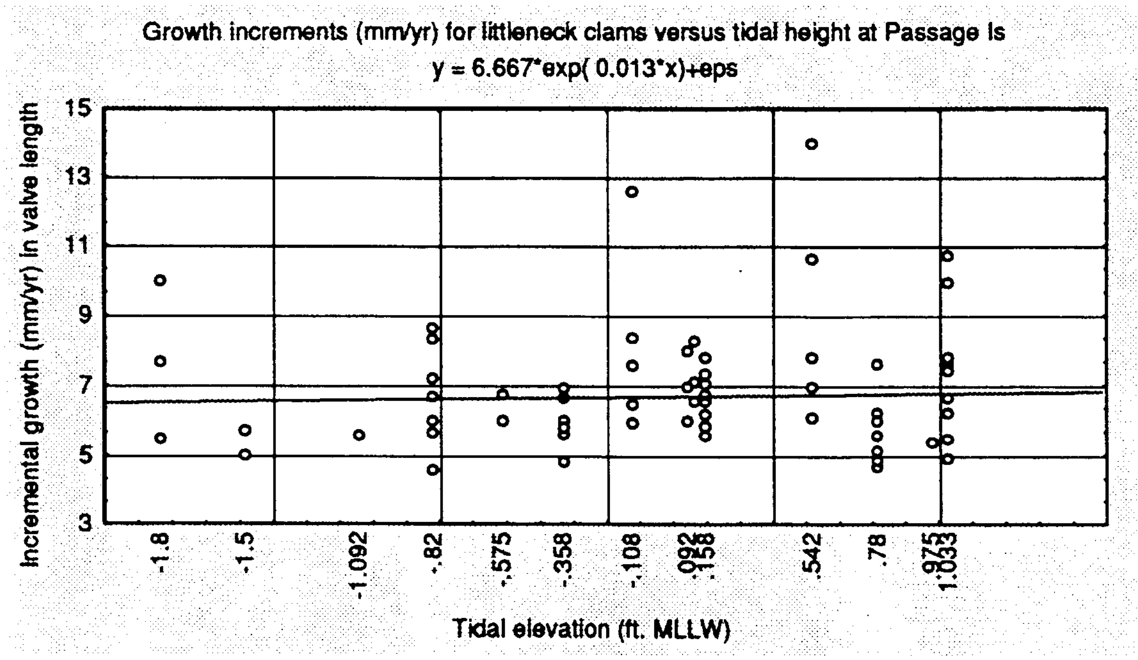
Figure 20. Growth increments (mm/year) as a function of age (years) for native littleneck clams (*Protothaca staminea*) collected in 18, 0.1 m^2 quadrats at Passage Island, Alaska on August 26, 1995.



The data in Figure 20 suggests that incremental growth in valve length decreases significantly after age six. However, few large clams were obtained in this survey and caution is advised in developing management decisions based on the reduced incremental growth rate observed in older clams. Native littleneck valve shape changes with age and the clams depth increases more, in comparison with length, in older clams. Therefore, wet tissue weight may continue to increase significantly in older clams, even though growth in valve length slows. It is the edible tissues that are of most importance to subsistence shellfish farmers. Wet tissue weight will be discussed in a later section of this report.

Within the area surveyed on Passage Island, clam growth does not appear to be a function of tidal height. The observed growth increments are plotted against tidal height in Figure 22. The regression coefficients are not statistically significant.

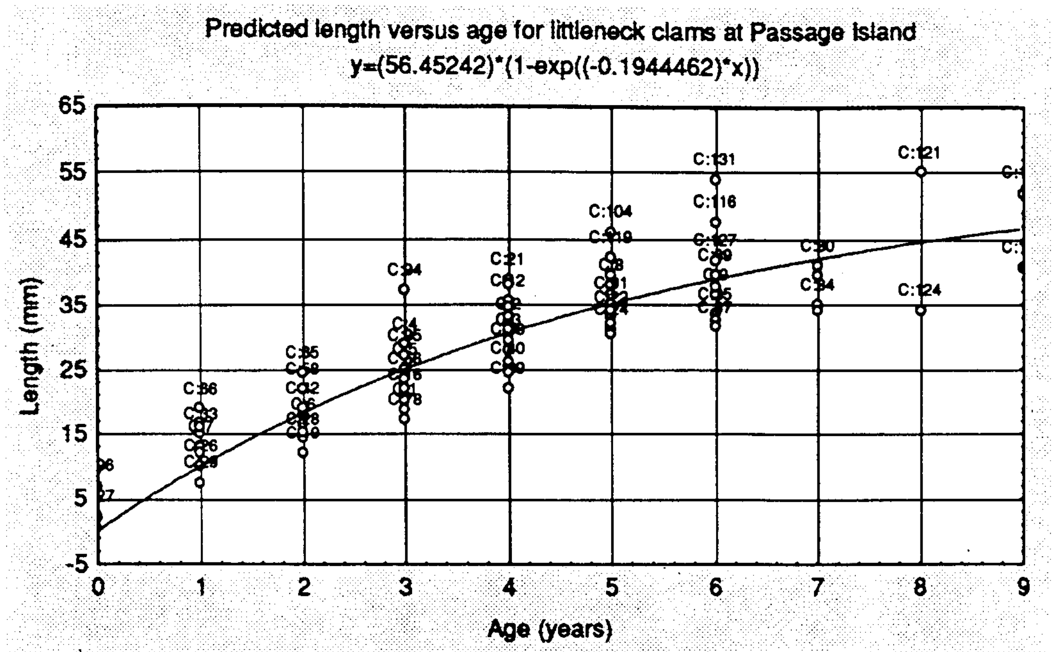
Figure 21. Growth increments (mm/year) as a function of tidal height (feet above MLLW) for native littleneck clams (*Protothaca staminea*) collected in 18, 0.1 m^2 quadrats at Passage Island, Alaska on August 26, 1995.



Age - Length analysis. Regression coefficients were developed for the von Bertalanfy equation using non-linear regression. The resulting equation explained 81.2% of the variation and the ANOVA determined probability that the regression coefficients were all equal to zero was P = 0.000. The residuals appear normal. A full range of clam valve lengths were available for the analysis and it appears valid. Predicted and observed values of valve length, as a function of age, are presented, together with the regression line in Figure 22. This equation was solved for a length of 38 mm to obtain the average age of recruitment into the legal size population. The average age of recruitment is 5.76 years. This is approximately one year longer than was required for butter clams at Passage Island.

Native littlenneck von Bertalanfy equation **Length = 56.45**$(\exp^{-0.194 * age})$

Figure 22. Valve length (mm) as a function of age (years) for native littleneck clams (*Protothaca staminea*) collected in 18, 0.1 m^2 quadrats at Passage Island, Alaska on August 26, 1995.



Edible tissue versus clam length analysis. A length - wet tissue weight histogram is provided in Figure 23 and an age - wet tissue weight histogram in Figure 24. One of the possible management options involves harvesting clams at a lower minimum size. However a careful examination of Figures 23 and 24 suggests that this is not a viable alternative.

Figure 23. Length (mm) versus wet tissue weight (grams) for native littleneck clams (*Protothaca staminea*) collected in 18, 0.1 m^2 quadrats at Passage Island on August 26, 1995. The vertical solid line represents the minimum legal size.

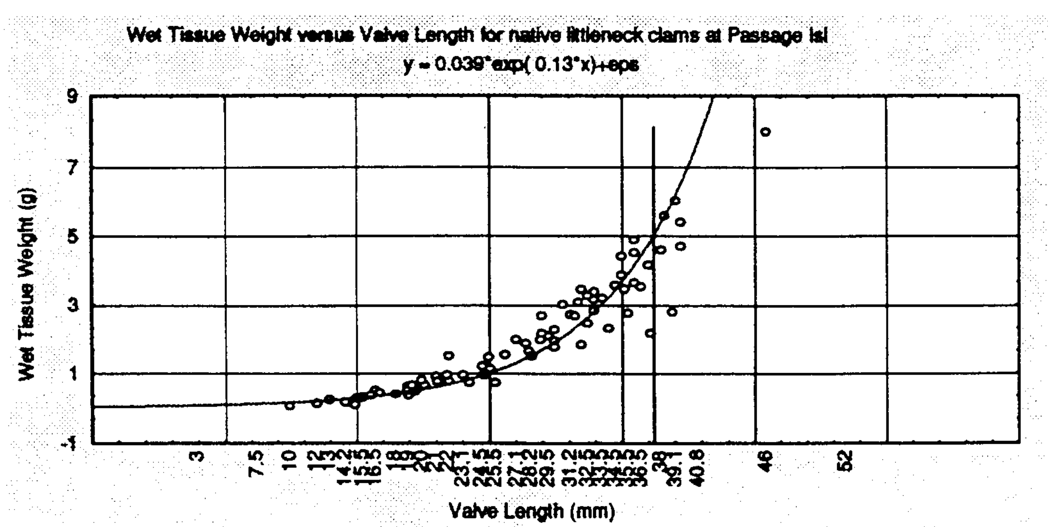
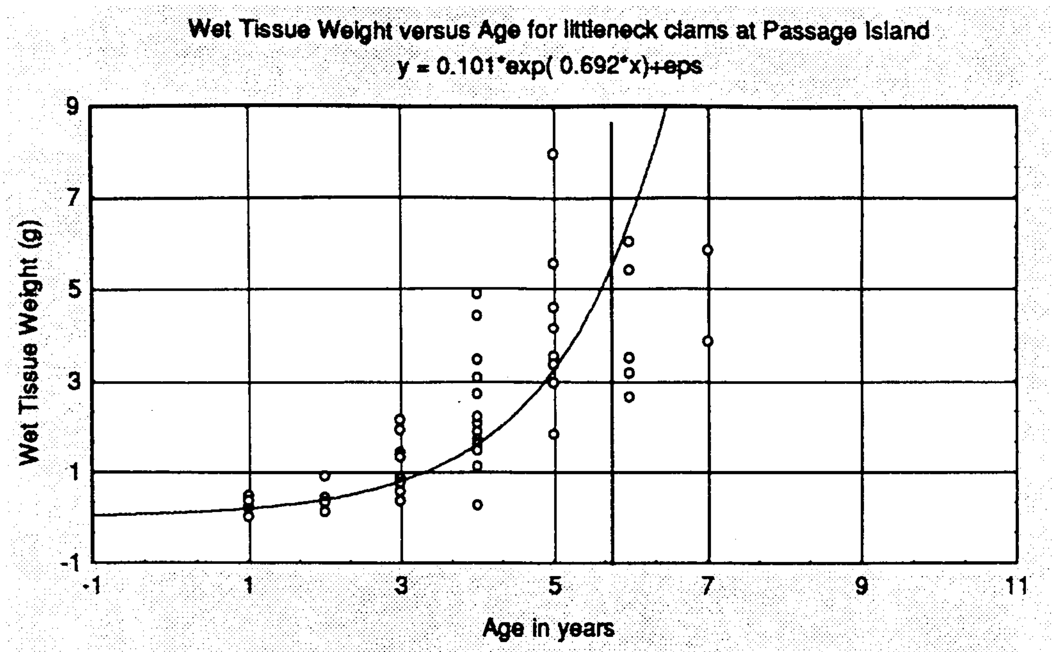


Figure 24. Age (yr) versus wet tissue weight (g) for native littleneck clams (*Protothaca staminea*) collected in 18, 0.1 m^2 quadrats at Passage Island on August 27, 1995. The vertical solid line represents the minimum legal size.



An examination of the data density in Figure 24 suggests that clams are being removed by predation at approximately 38 to 40 mm. There are too few data points for clams larger than 38 mm valve length to verify the suggested decrease in wet tissue gain at ages greater than five or six years. However, the available data suggests that growth is exponential to at least six years. Furthermore, this data suggests that harvests should be conducted shortly after clams reach the minimum legal size of 38 mm. First, because predation is constantly removing clams - there are very few large clams in the samples and second because there is a hint that wet tissue weight growth decreases after age six.

The information in Figure 24 should be considered preliminary. A growth and mortality study of caged (protected from predators) clams will provide valuable additional information regarding the biomass of wet tissues available for subsistence harvests as a function of time.

Predator density. Predators were not very obvious on Passage Island beaches. Small drills (cf. *Nucella lamellosa*) were observed, as were numerous (100's) of very small (<4 mm) drilled clam shells. Numerous, small round pits (approximately 0.6 meters in diameter and 15 centimeters deep) were found on the beach. These pits were very similar to those observed at Tatitlek and are likely associated with sea otter predation. Villagers' assured us that these pits were from sea otters and that no harvests had been conducted at this site for several years.

Shellfish biomass available for harvest in each strata. There is currently no clam biomass available for harvest at this Passage Island beach.

Summary conclusions and recommendations for shellfish enhancement at the Village of Nanwalek's Passage Island shellfish beach. Based on this survey and analysis, the following conclusions can be reached:

1. **Beach suitability.** The Passage Island beach contains approximately one- half 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. Clam growth, density and size suggest non-significant differences over the area of surveyed beach. Assuming that the predation problem is solved, there are several physical enhancement practices that could be employed here to increase natural recruitment and to make this very rocky beach more amenable to intensive clam culture. These practices are similar to those appropriate to the Tatitlek beach. The remoteness of this beach from the immediate view of the village presents additional challenges in terms of security, accessibility and predator control. The village needs to carefully consider those factors in deciding the appropriateness of expending considerable resources on enhancement at Passage island.

2. **Habitat suitability index (HIS) inputs.** It appears that clams can be successfully grown to a tidal elevation of at least 1.5 to 2.0' MLLW. Native littleneck clams appear to grow to larger sizes in sediments which contain at least 1.0% TVS. The presence of moderate quantities of sand and fines (silt-clay) were not factors determining the presence or health of the clam population. Nearly all aspects of native littleneck growth are enhanced by significant amounts of interstitial water movement as evidenced by the presence of oxygen at depth.

Native littleneck clams were found at depths (25 cm) exceeding those previously reported. This may be a regional adaptation for survival during cold winter night-time low tides. Typically, clams are protected from potential predators by placing them in sturdy, plastic, bags. These bags are then partially buried in the substrate. If littleneck clams dig deeper to avoid freezing in winter, the placement of clams in bags at shallow depths could jeopardize the cultures. Therefore consideration should be given to placing bags at lower tidal elevations or to burying the bags deeper in the substrate. This database provides sufficient information to make valuable contributions to the U.S. Fish and Wildlife Services Native Littleneck Habitat Suitability Index.

3. **Predation.** Significant starfish predation was not observed in this survey. Sea otters and native oyster drills (*Nucella lamellosa*) appear to be depleting the clam population on Passage Island. The drills are relatively easy to deal with - the sea otters present a real challenge at a relatively isolated beach such as this.

4. **Recruitment** to the Passage Island beach occurs in low number in all of at least the last five to eight year classes. No year classes were missing. However, recruitment

(or at least survival until August 27, 1995) is low and inadequate in each year class to stock this beach at optimum densities.

5. **Age at harvest.** The age length analysis suggests that native littleneck clams recruit to the legal size population at approximately 5.75 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. There is some evidence that optimum biomass could be realized by harvest shortly after the clams reach the minimum legal size. However, there is often significant mortality in undersized clams not taken during a harvest. Therefore, harvests should be delayed until most of the clams have reached the minimum legal size (~7.0 years). Harvests should then be concentrated in specific areas and take all of the legal size clams. These recommendations should be made part of an overall management plan for the beach. Development of a management plan was not part of the current effort and should await completion of adequate growth and mortality studies. However, the data collected herein provides direction for the development of interim plans.

6. **Butter clams** (*Saxidomus giganteus*) also recruit to this beach. Growth is somewhat faster than for native littleneck clams and butter clams enter the legal size population at approximately 4.75 years. Very few have survived to harvest size. Due to the lack of hatchery and nursery technology, and propensity to retain brevetoxins, butter clam enhancement is not recommended at this time.

7. **Cockles** are a traditional (and preferred) shellfish for Alaskan Villages. The primary beach surveyed in this effort is too rocky, with too few fines, to warrant cockle enhancement.

8. **Mussels.** As was found at Tatitlek, the presence of blue mussel (*Mytilus edulis trossulus*) seed should not be overlooked as a potential source of subsistence food.

9. **Clams available for harvest.** There is currently no harvestable population of clams at the Tatitlek Village beach.

10. **Beach potential.** In Puget Sound, it is possible to grow greater than 0.5 pounds of native littleneck clams per square foot, in a three year growout, on similar ground. Because of the slower growth in cold Alaskan waters, that yield is probably lower at perhaps 0.10 pounds per square foot per year (0.6 pcf in 6 years). The total yield for this beach would then be on the order of 1,820 pounds per year. These estimates are very tentative and require carefully controlled age and growth studies before accurate estimates can be made.

Based on experience in other parts of the world, it is quite possible that the grow-out time to legal harvest size can be reduced by at least one and perhaps two years. This requires nursery techniques in addition to hatchery production of seed. However, reduction of the natural age at recruitment into the legal size population by one or two years from the current average of six years is possible and could mean the difference between a successful enhancement project and a failed one.

Summary. The beach at Passage Island is of excellent quality for growing littleneck clams. It should be emphasized that intensive cultivation techniques will be needed to reduce the time needed to grow a legal size clam. Six to seven years is simply too long to expect people to tend a shellfish culture before they realize any benefit.

Sustained subsistence harvests will require additional seed, development of effective predator control measures, and a well designed management plan. Optimizing solutions to these problems will require site specific studies to develop an understanding of clam growth and mortality, effective predator controls (especially for sea otters) and tidal elevation versus culture depth requirements to prevent freezing during cold winter night-time low tides. It should be emphasized that any enhancement plan must solve the currently unacceptable predation rates on shellfish stocks. Without effective predator control, any enhancement plan will be futile.

Murphy Slough - Port Graham

Village desires. Conditions in Port Graham were discussed with Mr. Pat Norman and local salmon hatchery personnel. Typical of other villages, Mr. Norman expressed a sincere interest in re-establishing a subsistence clam fishery in the vicinity of Port Graham. Everyone interviewed expressed the opinion that previous dumping of hundreds of tons (estimated by interviewees) of herring in Port Graham (by the abandoned cannery) changed the nature of the bay. Evidently these dead herring were considered an unusable biproduct of the local roe fishery. After taking roe, the herring were simply dumped into the bay. Apparently this created a mass of dead fish as deep as five feet in the center of the bay. Dissolved oxygen was significantly reduced and the productivity of the bay diminished in following years. Other factors contributing to the decline in shellfish production were the increase in sea otters and the 1964 earthquake. Cockles appear to have been particularly affected. The once plentiful population has disappeared and Mr. Norman was particularly interested in re-established a cockle fishery.

Beach characterization. Initially, the beaches surrounding Duncan and Tulcan Sloughs were identified for survey. However, test digging on the evening of August 25, 1995, suggested a complete paucity of either butter clams or native littleneck clams in either of these sloughs. This is an interesting bay. It is expansive, relatively shallow, and is crisscrossed by several streams. The substrate is composed of moderate quantities of fines (silt-clay) and significant quantities of small (<3 to 5 cm) broken shale. The angular nature of the shale results in a more tightly packed substrate that may inhibit recruitment. No butter or littleneck clams were found anywhere in Duncan or Tulcan Sloughs. The clam in greatest abundance was the truncated softshell (*Mya truncata*). These clams were 4 to 6 cm in valve length. They could provide the basis for a very limited subsistence shellfishery. However, this species does not appear to be prized and the clam density was very low - making the fishery problematical.

Because of the paucity of shellfish in Duncan Slough, a beach located around the point to the east of Tulcan Slough was surveyed. This is also a large beach, measuring 200' wide and 1000' long and covering approximately five acres. The beach slopes gradually into deep water and is very well protected from storm winds. The substrate is composed of moderately coarse, broken, shale. It is not compacted and a significant quantity of pore water was present. This appears to be an outstanding beach for shellfish enhancement or intensive culture.

Figure 25 describes the three transects (A, B and C) examined in the most suitable (as clam habitat) part of the beach. Four shellfish samples were collected on each transect (12 total) and a total of four sediment samples were analyzed from randomly chosen sample stations.

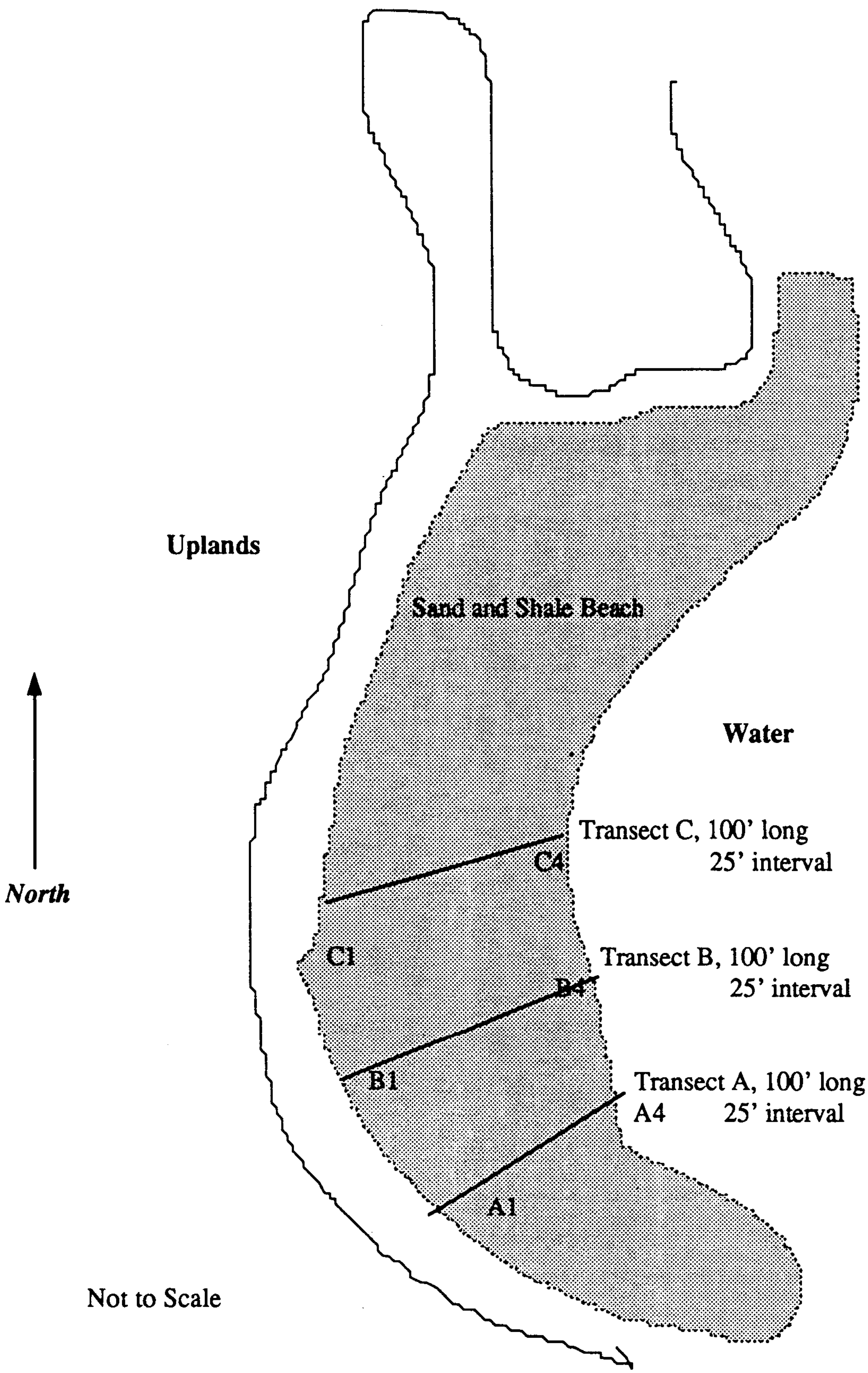


Figure 26. Schematic diagram of the Port Graham Village shellfish beach at Murphy Slough. The beach has surveyed in August of 1995.

The beach considered suitable for native littleneck clam production has a moderately shallow slope (3.9%). The substrate is loose and contains significant amounts of pore water. It was well oxygenated to a depth of greater than 20 cm. Four sediment samples were evaluated for sediment grain size and total volatile solids. The results of these analyses are presented in Appendix 3. Murphy Slough beach sediments are 66.8 $\pm$ 27.8 % gravel, 21.3 $\pm$ 22.3% sand and 11.9 $\pm$ 5.6 % fines (silt and clay). Sediment composition at this beach is suitable for native littleneck culture.

Sediment Total Volatile Solids content is presented for all Village beaches in Appendix 2. The Murphy Slough clam beach contains an average of 1.21 $\pm$ 0.99 percent volatile solids. Total volatile solids at this beach are within an ideal range for native littleneck clams.

Water Column Characterization. Water conditions at Murphy Slough were acceptable for aquaculture. Water temperature was a little colder than at other beaches (10.8 °C) and salinity was 29.5 ppt. Dissolved oxygen was unexpectedly low at 7.9 ppm. Currents near slack flood tide were measured parallel to the beach at less than 3 cm/sec. This slough is located near the head of Port Graham. Strong currents are not anticipated and shellfish growth may inhibited by an insufficient volume of phytoplankton rich water flowing over the bed.

Water column analyses of Total Suspended Solids (TSS) and Total Volatile Solids (TVS) are presented in Appendix 2. The three water samples collected at this beach averaged 15.2 $mg\text{-}L^{-1}$ TSS and 4.6 $mg\text{-}L^{-1}$ TVS suggesting a moderate quantity of inorganic and organic material in the water column. However, there is a paucity of bivalves in this bay and the addition of significant numbers may deplete phytoplankton resources. The establishment of several acres of intensive culture may not have an effect. However, there is a very large area available for shellfish culture throughout the head of Port Graham. Clam growth should be monitored closely to insure that shellfish production does not exceed the supply of phytoplankton.

Shellfish Population Characterization. Shellfish were not abundant at this site and a total of 65 living bivalves were collected in nine systematic random samples at Murphy Slough near Port Graham. An additional 41 empty bivalve shells were collected at random locations on the beach. The distribution of shellfish obtained from the systematic survey is provided in Table 13.

Table 13. Summary of living bivalves collected in 9, 0.1 m^2 samples at the Port Graham Village beach at Murphy Slough on August 26, 1995.

Species	Number
Macoma inquinata (indented macoma)	2
Saxidomum giganteus (butter clam)	39
Macoma nasuta (bentnose macoma)	17
Mya truncata (truncate softshell)	4
Clinocardium nuttallii (Nuttal's cockle)	2
Other	1

Gaper, butter and native littleneck clams and cockles have potential as subsistence shellfish sources. Local villagers stated a preference for butter clams, native littleneck clams and cockles. Of these, only the butter clam was found in Port Graham. However, all of the 39 butter clams collected were new recruits with valve lengths of less than 3.5 mm. The deposit feeding bentnose clam, *Macoma nasuta* has a preference for sandy sediments and tolerates low levels of dissolved oxygen. Most of the relatively large (to 38 mm) clams were of the genus *Macoma*. This species is not considered a valuable human food. The four softshell clams collected in these samples ranged in size from 27 to 51 mm valve length. However, their abundance was too low to warrant subsistence harvests.

Approximately 20 acres of what Port Graham residents identified as traditional shellfish beaches were examined in this survey. Clams were essentially absent from Duncan slough and Tulcan slough. Traditional subsistence species were essentially absent from Murphy Slough. A third beach located approximately three nautical miles east of Murphy slough was also investigated. This beach is small and was qualitatively sampled by digging a large area. Only a few butter clams were recovered together with perhaps two dozen soft shell clams.

No beaches currently supporting a subsistence fishery were identified in this survey. Native littleneck clams were absent in nearly all samples and only two cockles were observed. A small number of butter clam recruits were observed at Murphy Slough. The number was too small to adequately populate the beach. Because of the paucity of clams taken in Port Graham, a meaningful analysis of the population is not possible.

The head of Port Graham is relatively shallow and contains an extensive intertidal area that appeared suitable for clam production. Because this survey was conducted on a marginal low tide, the suitable substrate lying at elevations less than -1.8' MLLW were not surveyed. It is possible that subsistence quantities of clams are available at these lower elevations. The following comments regarding the paucity of shellfish resources in Port Graham are offered in light of that caveat.

Summary conclusions and recommendations for shellfish enhancement at Port Graham. Based on this survey and analysis, the following conclusions can be reached:

1. **Beach suitability.** Several beaches in the vicinity of Port Graham are ideal for the intensive culture of shellfish. The bottom is relatively flat, firm, but not packed, and in some areas like Murphy Slough, contains significant quantities of interstitial water with a very deep RPD. Phytoplankton supply may ultimately limit shellfish production in this protected and (probably) poorly flushed bay. Of all the beaches examined in this survey, Port Graham presents the best opportunity for cockle enhancement.

The low value of dissolved oxygen in the water column is troubling. A dive survey of the bottom of this bay would be valuable in assessing benthic conditions - particularly in the area where large quantities of dead herring were reported to have been deposited.

2 **Recruitment** appears to have failed in Port Graham. No littleneck clam and few butter clam juveniles were observed. Cockles, once plentiful according to Village sources, were nearly absent and no juveniles were observed. The near term re-

establishment of a subsistence shellfish resource will require supplementing recruits with outside sources of seed.

3 Predation. Like other beaches surveyed in 1995, the intertidal at Murphy Slough was pock marked with what appeared to be otter pits. There were numerous broken butter clam shells lying next to these pits. This suggests that otters may be taking the few clams that reach legal size. Juvenile (< 5 mm) butter clam shells were observed with drill holes in them. However, only a few drills (cf. *Nucella lamellosa*) were observed. Predation is a factor in depletion of the shellfish resources in Port Graham. Adequate predator control or exclusion will be a necessity for any enhancement project.

4. Enhancement species. The beaches surveyed in Port Graham did not contain large quantities of cobble and rock characteristic of native littleneck clam habitat. Manila clams (*Tapes japonica*) are raised in sand in France and in mud in Willapa Bay Washington. Therefore, it is reasonable to believe that even though native littleneck clams were not observed in the 1995 samples, a native littleneck clam enhancement project may have a reasonable chance of success.

Port Graham is ideal for cockles. In addition to being a preferred food by Villagers, cockles appear to grow rapidly in Alaskan waters. The few cockle shells that were collected suggest that a minimum legal size of 38 mm could be achieved within three to four years. In Puget Sound, Washington, feral populations of cockles (*Clinocardium nuttallii*) appear to reach commercial size ($\geq$ 38 mm) in about two years. The combination of cockle and native littleneck enhancement could provide a reasonably short term supply of cockles (within three years) and a longer term supply (within five to seven years) of subsistence shellfish. Cockles are not commonly raised in intensive culture and to the best of my knowledge, no commercial hatcheries are producing seed. I strongly recommend a literature search and inexpensive experimentation into the commercial production of cockle seed for enhancement purposes. In addition, young cockles (<1.5 cm valve length) should be collected, placed in cages in Port Graham and their growth and mortality evaluated over a two year period.

Mussel (*Mytilus edulis trossulus*) seed is present in the upper parts of the intertidal. These mussels could be caged and hung from buoys in the bay to provide an almost immediate (one year) supply of shellfish. However, like the other Villages, mussels do not appear to be a traditional source of shellfish and some experimentation and outreach would be required. The high potential productivity associated with blue mussels should be explored, at least on an experimental basis, by the Port Graham Village.

5. Clams available for harvest. There is currently no harvestable population of clams at the beaches (and tidal elevations) surveyed in Port Graham.

6. Beach potential. There is far more suitable intertidal area available in Port Graham than could be used in a subsistence shellfish enhancement project. It is reasonable to suggest that phytoplankton and detrital production will ultimately limit shellfish production here - not the physical environment. Enhancement efforts should include careful growth and mortality studies to quantify growth and to determine at what shellfish density phytoplankton production begins to affect growth. Insufficient quantities of large clams were obtained to estimate growth, and therefore potential shellfish production, in Port Graham.

Summary. There are currently no clam or cockle resources available for harvest on the Port Graham beaches surveyed. Otter and drill predation, coupled with a recruitment failure, appear to have decimated local clam and cockle populations. Numerous intertidal areas in the immediate vicinity of the Port Graham Village appear ideally suited to intensive shellfish production. The beach at Passage Island is of excellent quality for growing littleneck clams.

Because of the paucity of existing clams on Port Graham beaches, enhancement should begin with carefully designed and evaluated (but inexpensive) growth and mortality studies using cockle seed collected elsewhere, native littleneck clam seed from the Qutekcak Hatchery and mussel seed collected from the intertidal. No substrate preparation would be required in the surveyed areas.

A dive survey of the deeper parts of Port Graham should be conducted to evaluate the presence of previously reported deep layers (up to five feet deep) of herring deposited during the herring fishery. It seems improbable that the biomass would still be there. However, the low dissolved oxygen levels observed in the bay suggest some significant source of biological oxygen demand.

General Recommendations For Shellfish Enhancement At Tatitlek, Nanwalek (Passage Island) and Port Graham (Murphy Slough)

Nanwalek and Tatitlek. The Nanwalek beach at Passage Island and the Tatitlek Beach are typical of preferred native littleneck clam habitat. Both beaches are fairly exposed, have high currents and are covered with large rock. These physical conditions offer the promise of relatively fast native littleneck growth and high survival. Intensive culture requires areas of relatively uniform substrate from which cobble larger than 7.5 cm has been removed. This will require some hand labor. If the rock is strategically placed, it can help retain water during low tides and encourage recruitment of wild larvae. Both of these beaches are recommended for native littleneck clam enhancement. The project should start with perhaps 25,000 juvenile clams approximately six to 10 mm in length. The enhancement effort should include a carefully designed growth and mortality study to examine, over a five year period, the growth and survival of native littleneck clams in intensive culture at each site. These initial studies should also determine the optimum depth requirements (as a function of tidal height) for growing clams in cold Alaskan waters. In addition, local blue mussel (*Mytilus edulis trossulus*) seed should be collected and placed in suspended culture. Growth and mortality studies should be conducted on these mussels to estimate potential production.

Port Graham. There are several beaches in Port Graham that can be used for shellfish culture. The beach at Murphy Slough has an ideal substrate. Cockles and native littleneck clams should be placed in cages at this site for growth and mortality studies. In addition, mussel seed should be similarly evaluated in deeper water. No substrate modification is required at Murphy Slough.

Predator Control. Control of starfish and drills is easily accomplished. Sea Otter control presents a significant problem. There are a number of potential non destructive methodologies that could be investigated. The literature did not reveal any reference to this subject. However, netting, caging, camouflage, noise, etc. should be investigated to avoid the more obvious and destructive methods of sea otter control.

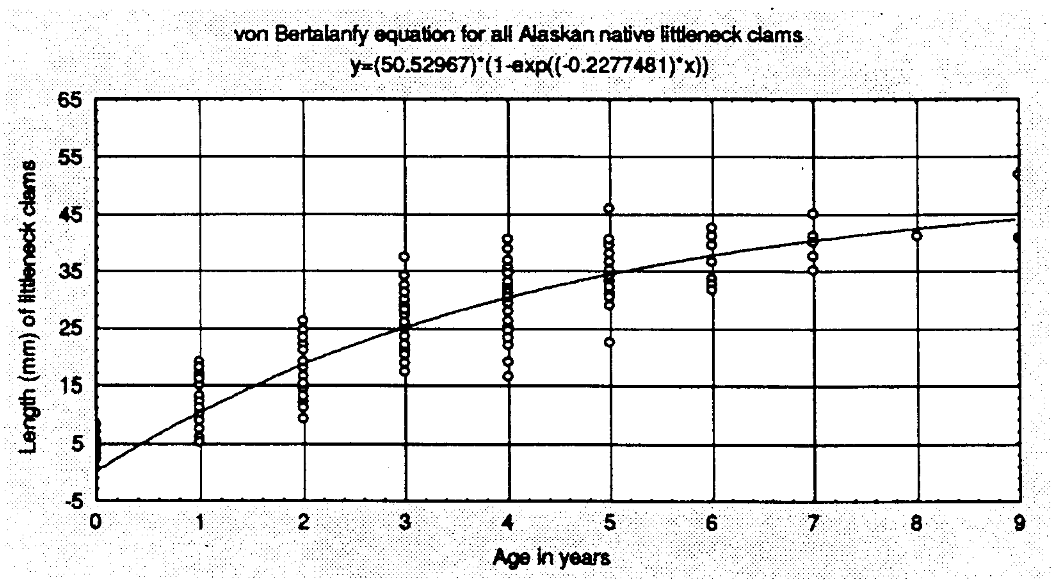
Seed Production. The Qutekcak hatchery should be supported in its efforts to develop a reliable source of native littleneck clam seed. In addition, CRRC should investigate the potential for raising native littleneck clams to the largest size possible in floating nurseries. Lastly, a literature search for information on the hatchery production and culture of cockles should be undertaken. Existing information should then be used as a basis for the experimental scale development of a cockle seed hatchery.

Village Training. The growth and mortality studies should be conducted by the respective villages. A five day training program should be provided to each village. That program would include both classroom discussions of shellfish biology, protocols for conducting the growth and mortality studies, distribution of needed equipment and field work to actually begin the studies.

Harvest Management Plan. Harvest management of shellfish resources in Alaska is of special importance because of the slow growth, particularly of native littleneck clams. Individual management plans should be developed by each village to insure that shellfish produced in enhancement projects are harvested in a sustainable way.

Figure 26 presents a scatterplot of all native littleneck clams measured and aged in this 1995 survey. The scatterplot is fitted with a non linear solution to the von Bertalanfy equation. The results indicate that native littleneck clams enter the legal population at an age greater than four and only half of the clams are greater than 38 mm by age seven. Four years is a long time to maintain a culture and control predators before a harvest is enjoyed. That, in part, is the reason for emphasizing development of enhancement techniques for the faster growing cockle and encouraging the villages to utilize the easily enhance, existing, mussel resource.

Figure 26. Scatterplot describing length of native littleneck clam valves as a function of age in 1995 samples collected at shellfish beaches in the vicinity of Tatitlek and Nanwalek in Alaska. A non linear solution to the von Bertalanfy equation is provided and the resulting regression plotted on the graph.



Feder and Paul (1973) found minor variations in the incremental growth of valves in littleneck clams from Prince William Sound. They found an average age of recruitment into the legal size population of 8 to 10 years. That is on the high end of the 5 to 10 year age at recruitment estimated by ADFG (1995). Examination of Figure 26 suggests that native littleneck clams reach a minimum size of 38 mm at an age between five years and >9 years. Solving the von Bertalanfy equation given in Figure 26 for age at a length of 38 mm suggests that the average clam reaches a minimum legal size at 6.12 years of age. These estimates are all similar on the top end but this report and ADFG (1995) suggests that recruitment into the minimal legal size class occurs at an earlier age that suggested by Feder and Paul (1973).

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Appendix 1 Sediment Grain Size

Tatitlek

Percent of total sediment dry weight

Sample	Gravel % >2 mm	Sand 1 % >1mm	Sand 2 % > 250 mic	Sand 3 % >63 Mic	Total Sand %	Silt % >3.9 Mic	Clay % <3.9 Mic
TA A3	0.62	0.86	3.07	55.94	59.87	27.08	12.43
TA A4	16.82	0.88	3.29	43.11	47.27	25.55	10.35
TA B3	59.25	6.58	14.77	9.79	31.14	6.33	3.28
TA C2	75.84	3.87	6.03	5.82	15.72	5.55	2.89
TA D2	78.77	4.37	7.95	3.72	16.04	3.37	1.82
TA E3	56.46	12.15	19.15	4.36	35.66	4.41	3.47
TA F4	84.15	1.98	4.29	3.61	9.88	3.07	2.90
TA G1	52.22	3.03	11.79	20.63	35.46	8.02	4.30
TA G5	57.25	13.55	17.80	2.97	34.32	4.99	3.44
TA H3	61.62	12.22	13.25	3.24	28.71	5.49	4.17
AVG. Eel	8.72	0.87	3.18	49.53	53.57	26.31	11.39
AVG. Clam	65.70	7.22	11.88	6.77	25.87	5.15	3.28

Passage Island and Murphy Slough

Sample	Gravel % >2 mm	Sand 1 % >1mm	Sand 2 % > 250 mic	Sand 3 % >63 Mic	Total Sand %	Silt % >3.9 Mic	Clay % <3.9 Mic
PI A2	16.21	1.51	39.74	29.10	70.34	7.72	5.73
PI A4	73.00	1.43	6.73	9.45	17.60	5.56	3.84
PI A6	52.06	7.07	26.23	5.51	38.81	3.28	5.85
PI B1	46.66	1.60	26.91	14.10	42.61	5.19	5.54
PI B3	72.39	1.16	6.37	12.28	19.81	3.56	4.24
PI B5	45.43	4.01	19.63	22.54	46.18	3.91	4.48
PI C2	43.87	0.78	18.03	27.92	46.74	5.01	4.38
PI C3	47.97	1.48	13.82	26.59	41.89	6.86	3.28
PI C6	80.61	6.33	8.51	0.31	15.15	1.81	2.44
MS A1	47.28	12.18	15.99	8.85	37.02	10.61	5.09
MS A4	78.22	6.13	4.18	1.45	11.75	5.86	4.17
MS B2	65.22	10.67	9.25	2.10	22.02	8.36	4.41
MS C3	76.31	9.94	3.65	0.70	14.30	5.03	4.37

Appendix 1 Sediment Grain Size

Tatitlek

Percent of total sediment dry weight

Sample	Gravel % >2 mm	Sand 1 % >1mm	Sand 2 % > 250 mic	Sand 3 % >63 Mic	Total Sand %	Silt % >3.9 Mic	Clay % <3.9 Mic
TA A3	0.62	0.86	3.07	55.94	59.87	27.08	12.43
TA A4	16.82	0.88	3.29	43.11	47.27	25.55	10.35
TA B3	59.25	6.58	14.77	9.79	31.14	6.33	3.28
TA C2	75.84	3.87	6.03	5.82	15.72	5.55	2.89
TA D2	78.77	4.37	7.95	3.72	16.04	3.37	1.82
TA E3	56.46	12.15	19.15	4.36	35.66	4.41	3.47
TA F4	84.15	1.98	4.29	3.61	9.88	3.07	2.90
TA G1	52.22	3.03	11.79	20.63	35.46	8.02	4.30
TA G5	57.25	13.55	17.80	2.97	34.32	4.99	3.44
TA H3	61.62	12.22	13.25	3.24	28.71	5.49	4.17
AVG. Eel	8.72	0.87	3.18	49.53	53.57	26.31	11.39
AVG. Clam	65.70	7.22	11.88	6.77	25.87	5.15	3.28

Passage Island and Murphy Slough

Sample	Gravel % >2 mm	Sand 1 % >1mm	Sand 2 % > 250 mic	Sand 3 % >63 Mic	Total Sand %	Silt % >3.9 Mic	Clay % <3.9 Mic
PI A2	16.21	1.51	39.74	29.10	70.34	7.72	5.73
PI A4	73.00	1.43	6.73	9.45	17.60	5.56	3.84
PI A6	52.06	7.07	26.23	5.51	38.81	3.28	5.85
PI B1	46.66	1.60	26.91	14.10	42.61	5.19	5.54
PI B3	72.39	1.16	6.37	12.28	19.81	3.56	4.24
PI B5	45.43	4.01	19.63	22.54	46.18	3.91	4.48
PI C2	43.87	0.78	18.03	27.92	46.74	5.01	4.38
PI C3	47.97	1.48	13.82	26.59	41.89	6.86	3.28
PI C6	80.61	6.33	8.51	0.31	15.15	1.81	2.44
MS A1	47.28	12.18	15.99	8.85	37.02	10.61	5.09
MS A4	78.22	6.13	4.18	1.45	11.75	5.86	4.17
MS B2	65.22	10.67	9.25	2.10	22.02	8.36	4.41
MS C3	76.31	9.94	3.65	0.70	14.30	5.03	4.37

Appendix (2)

Total Suspended and Total Volatile Solids Determinations

Appendix (3)

Partial data base providing appropriate parameters examined during the 1995 baseline survey of shellfish resources at the Villages of Nanwalek, Tatitlek and Port Graham, Alaska

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

data file: ALASKAC.STA [900 cases with 19 variables]

VARIABLE SPECIFICATIONS:

No	Name	Format	MD Code	Long Label
1	SITE	9.3	-9999	
2	STATION	8.3	-9999	
3	ELEV_	8.3	-9999	
4	SED_TVS	8.4	-9999	
5	H2O_TSS	8.3	-9999	
6	H2O_TVS	8.3	-9999	
7	SPECIES	8.3	-9999	
8	LENGTH	8.4	-9999	
9	WHOLE_WT	8.4	-9999	
10	AGE	4.1	-9999	
11	DRY_COND	8.6	-9999	=(v13 - v16)*1000/v11^2.1
12	OXYGEN	6.1	-9999	
13	TURBID	6.2	-9999	
14	RPD	4.1	-9999	
15	ADJWETWT	5.3	-9999	=v14-v16
16	TGRAVEL	5.3	-9999	=ArcSin((V22/100)**0.5)
17	TSAND	5.3	-9999	=ArcSin((V23/100)**0.5)
18	TFINES	5.3	-9999	=ArcSin((V24/100)**0.5)
19	GROINC	5.3	-9999	=v8/v10

VARIABLES AND THEIR TEXT VALUES:

Var 1: SITE - (-9999)

Text	Numeric	Long label
SITE	100	
PI	101	
MS	102	
TA	103	

Var 2: STATION - (-9999)

Text	Numeric	Long label
A1	100	
PI	101	
A2	102	
A3	103	
A4	104	
A5	105	
A6	106	
A7	107	
B1	108	
B2	109	
B3	110	
B4	111	
B5	112	
B6	113	

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

Var 2: STATION (continued)

Text	Numeric	Long label
B7	114	
C1	115	
C2	116	
C3	117	
C4	118	
C5	119	
C6	120	
D1	121	
D2	122	
D3	123	
D4	124	
E1	125	
E2	126	
E3	127	
E4	128	
F1	129	
F2	130	
F3	131	
F4	132	
G1	133	
G2	134	
G3	135	
G4	136	
G5	137	
G6	138	
G7	139	
H1	140	
H2	141	
H3	142	
H4	143	
SHELL	144	
RANDOM	145	

Var 3: ELEV_ - (-9999)

Text	Numeric	Long label
A1	100	
A2	101	
S	102	

Var 4: SED_TVS - (-9999)
No text values

Var 5: H2O_TSS - (-9999)
No text values

Var 6: H2O_TVS - (-9999)

Text	Numeric	Long label
H2O_TVS	100	

Var 7: SPECIES - (-9999)

Text	Numeric	Long label
SPECIES	100	
PS	101	
SG	102	
ST	103	
MN	104	
MB	105	
MI	106	
DIP	107	
OTHER	108	
HA	109	
MT	110	
_S	111	
SP	112	
CC	113	
CN	114	
KPS	115	
POS	116	
SGMN	117	
TC	118	
S	119	

Var 8: LENGTH - (-9999)

Text	Numeric	Long label
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MI	101	
MN	102	

Var 9: WHOLE_WT - (-9999)

Text	Numeric	Long label
CL	100	
MN	101	

Var 10: AGE - (-9999)
No text values

Var 11: DRY_COND - =(v13 - v16)*1000/v11^2.1 (-9999)
No text values

Var 12: OXYGEN - (-9999)
No text values

Var 13: TURBID - (-9999)

Text	Numeric	Long label
TURBIDIT	100	

Var 14: RPD - (-9999)
No text values

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

Var 15: ADJWETWT - =v14-v16 (-9999)
No text values

Var 16: TGRAVEL - =ArcSin((V22/100)**0.5) (-9999)
No text values

Var 17: TSAND - =ArcSin((V23/100)**0.5) (-9999)
No text values

Var 18: TFINES - =ArcSin((V24/100)**0.5) (-9999)
No text values

Var 19: GROINC - =v8/v10 (-9999)
No text values

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
1	PI	A1	.975		.009	.003	PS	18.8000	1.6430	3.0	.255091	11.4	2.28	20.0	.600				6.267
2	PI	A1	.975		.009	.003	SG	2.2000	.0045	.2		11.4	2.28	20.0					11.00
3	PI	A2	.117	.0178	.009	.003	SG	2.4000	.0024	.2		11.4	2.28	20.0		.414	.995	.376	12.00
4	PI	A2	.117	.0178	.009	.003	PS	32.0000	8.1274	4.0	.357006	11.4	2.28	20.0	3.446	.414	.995	.376	8.000
5	PI	A2	.117	.0178	.009	.003	PS	29.5000	5.3792	4.0	.224698	11.4	2.28	20.0	2.071	.414	.995	.376	7.375
6	PI	A2	.117	.0178	.009	.003	PS	28.9000	5.9654	3.0	.309445	11.4	2.28	20.0	1.949	.414	.995	.376	9.633
7	PI	A2	.117	.0178	.009	.003	PS	25.0000	3.9006	3.0	.320874	11.4	2.28	20.0	1.439	.414	.995	.376	8.333
8	PI	A2	.117	.0178	.009	.003	PS	16.5000	1.0386	2.0	.170116	11.4	2.28	20.0	.460	.414	.995	.376	8.250
9	PI	A2	.117	.0178	.009	.003	PS	13.0000	.5773	1.0	.124076	11.4	2.28	20.0	.225	.414	.995	.376	13.00
10	PI	A2	.117	.0178	.009	.003	SG	11.0000	.2023	1.0	.062423	11.4	2.28	20.0	.077	.414	.995	.376	11.00
11	PI	A2	.117	.0178	.009	.003	SG	2.5000	.0050			11.4	2.28	20.0		.414	.995	.376	
12	PI	A2	.117	.0178	.009	.003	SG	2.0000	.0054			11.4	2.28	20.0		.414	.995	.376	
13	PI	A3	-.358		.009	.003	SG	51.5000	28.6153	8.0	.576793	11.4	2.28	20.0	10.56				6.438
14	PI	A3	-.358		.009	.003	PS	38.0000	15.3090	5.0	.412511	11.4	2.28	20.0	4.587				7.600
15	PI	A3	-.358		.009	.003	PS	36.5000	11.5631	6.0	.339961	11.4	2.28	20.0	3.497				6.083
16	PI	A3	-.358		.009	.003	PS	36.5000	11.5924	5.0	.350700	11.4	2.28	20.0	3.538				7.300
17	PI	A3	-.358		.009	.003	PS	36.0000	12.0802	5.0	.361546	11.4	2.28	20.0	3.610				7.200
18	PI	A3	-.358		.009	.003	PS	35.5000	9.5383	4.0	.268150	11.4	2.28	20.0	2.711				8.875
19	PI	A3	-.358		.009	.003	PS	30.0000	7.1001	4.0	.296615	11.4	2.28	20.0	1.900				7.500
20	PI	A3	-.358		.009	.003	PS	30.0000	5.9020	4.0	.261821	11.4	2.28	20.0	1.732				7.500
21	PI	A3	-.358		.009	.003	PS	30.0000	6.0305	4.0	.261109	11.4	2.28	20.0	2.234				7.500
22	PI	A3	-.358		.009	.003	PS	21.0000	2.1802	3.0	.197510	11.4	2.28	20.0	.874				7.000
23	PI	A3	-.358		.009	.003	PS	20.2000	2.0011	3.0	.191432	11.4	2.28	20.0	.612				6.733
24	PI	A3	-.358		.009	.003	PS	18.0000	1.0505	2.0	.142631	11.4	2.28	20.0	.349				9.000
25	PI	A3	-.358		.009	.003	PS	12.0000	.2736	2.0	.171703	11.4	2.28	20.0	.115				6.000
26	PI	A4	-.820	.0129	.009	.003	PS	39.5000	13.6149	5.0	.346797	11.4	2.28	20.0	4.701	1.024	.433	.312	7.900
27	PI	A4	-.820	.0129	.009	.003	PS	38.8000	9.1156	4.0	.247646	11.4	2.28	20.0	2.756	1.024	.433	.312	9.700
28	PI	A4	-.820	.0129	.009	.003	PS	33.0000	9.7901	5.0	.394414	11.4	2.28	20.0	3.138	1.024	.433	.312	6.600
29	PI	A4	-.820	.0129	.009	.003	PS	31.7000	8.1386	4.0	.321315	11.4	2.28	20.0	3.050	1.024	.433	.312	7.925
30	PI	A4	-.820	.0129	.009	.003	PS	31.2000	7.3446	5.0	.291005	11.4	2.28	20.0	2.674	1.024	.433	.312	6.240
31	PI	A4	-.820	.0129	.009	.003	PS	29.0000	5.6698	3.0	.399167	11.4	2.28	20.0	2.140	1.024	.433	.312	9.667
32	PI	A4	-.820	.0129	.009	.003	SG	25.5000	3.4135	3.0	.264087	11.4	2.28	20.0	1.462	1.024	.433	.312	8.500
33	PI	A4	-.820	.0129	.009	.003	ST	26.0000	3.0715	3.0	.226301	11.4	2.28	20.0	1.224	1.024	.433	.312	8.667
34	PI	A4	-.820	.0129	.009	.003	MN	22.0000	2.1923	3.0	.328527	11.4	2.28	20.0	.978	1.024	.433	.312	7.333
35	PI	A4	-.820	.0129	.009	.003	SG	21.8000	1.1475	3.0	.129719	11.4	2.28	20.0	.402	1.024	.433	.312	7.267
36	PI	A4	-.820	.0129	.009	.003	PS	10.0000	.1205	1.0	.062752	11.4	2.28	20.0	.042	1.024	.433	.312	10.00
37	PI	A4	-.820	.0129	.009	.003	PS	2.3000	.0014	0.0		11.4	2.28	20.0		1.024	.433	.312	
38	PI	A5	-1.500		.009	.003	MB	13.5000	.6685	3.0	.125619	11.4	2.28	20.0	.209				4.500
39	PI	A5	-1.500		.009	.003	PS	14.2000	.6638	2.0	.127420	11.4	2.28	20.0	.157				7.100
40	PI	A5	-1.500		.009	.003	MB	13.0000	.4340	4.0	.103015	11.4	2.28	20.0	.129				3.250

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
41	PI	A5	-1.500		.009	.003	MI	10.7000	.1927	1.0	.101990	11.4	2.28	20.0	.073				10.70
42	PI	A5	-1.500		.009	.003	SG	9.5000	.1920	1.0	.092005	11.4	2.28	20.0	.052				9.500
43	PI	A5	-1.500		.009	.003	DIP	7.2000	.1406	2.0		11.4	2.28	20.0					3.600
44	PI	A5	-1.500		.009	.003	PS	7.5000	.0591	1.0		11.4	2.28	20.0					7.500
45	PI	A6	-1.800	.0068	.009	.003	PS	41.0000	17.7727	7.0	.507479	11.4	2.28	20.0	5.815	.806	.673	.307	5.857
46	PI	A6	-1.800	.0068	.009	.003	PS	36.0000	11.6099	4.0	.315874	11.4	2.28	20.0	4.858	.806	.673	.307	9.000
47	PI	A6	-1.800	.0068	.009	.003	PS	34.5000	9.0242	4.0	.350712	11.4	2.28	20.0	3.531	.806	.673	.307	8.625
48	PI	A6	-1.800	.0068	.009	.003	SG	30.5000	6.5064	3.0	.334079	11.4	2.28	20.0	2.808	.806	.673	.307	10.17
49	PI	A6	-1.800	.0068	.009	.003	SG	19.0000	1.2395	2.0	.176641	11.4	2.28	20.0	.731	.806	.673	.307	9.500
50	PI	A6	-1.800	.0068	.009	.003	SG	17.0000	.8285	1.0	.133713	11.4	2.28	20.0	.458	.806	.673	.307	17.00
51	PI	A6	-1.800	.0068	.009	.003	MN	17.0000	1.5647	2.0	.241883	11.4	2.28	20.0	.627	.806	.673	.307	8.500
52	PI	A6	-1.800	.0068	.009	.003	SG	18.0000	.8298	2.0	.116971	11.4	2.28	20.0	.382	.806	.673	.307	9.000
53	PI	A6	-1.800	.0068	.009	.003	MN	18.5000	1.0344	2.0	.166737	11.4	2.28	20.0	.514	.806	.673	.307	9.250
54	PI	A6	-1.800	.0068	.009	.003	PS	15.0000	.4613	1.0	.094922	11.4	2.28	20.0	.248	.806	.673	.307	15.00
55	PI	A6	-1.800	.0068	.009	.003	MN	13.0000	.3039	2.0	.087906	11.4	2.28	20.0	.166	.806	.673	.307	6.500
56	PI	A6	-1.800	.0068	.009	.003	MN	10.7500	.1965	1.0	.060734	11.4	2.28	20.0	.071	.806	.673	.307	10.75
57	PI	A6	-1.800	.0068	.009	.003	OTHER	10.1000	.2193	1.0	.069233	11.4	2.28	20.0	.046	.806	.673	.307	10.10
58	PI	B1	.780	.0186	.009	.003	PS	35.0000	13.0230	7.0	.477287	11.4	2.28	20.0	3.831	.752	.711	.334	5.000
59	PI	B1	.780	.0186	.009	.003	PS	33.5000	10.8516	6.0	.401094	11.4	2.28	20.0	3.159	.752	.711	.334	5.583
60	PI	B1	.780	.0186	.009	.003	PS	32.5000	9.2327	6.0	.375247	11.4	2.28	20.0	2.446	.752	.711	.334	5.417
61	PI	B1	.780	.0186	.009	.003	PS	31.5000	8.8768	6.0	.390637	11.4	2.28	20.0	2.642	.752	.711	.334	5.250
62	PI	B1	.780	.0186	.009	.003	PS	28.0000	4.6515	4.0	.300995	11.4	2.28	20.0	1.628	.752	.711	.334	7.000
63	PI	B1	.780	.0186	.009	.003	PS	22.0000	5.9352	4.0	.433486	11.4	2.28	20.0	1.461	.752	.711	.334	5.500
64	PI	B1	.780	.0186	.009	.003	HA	33.0000	3.9225	5.0	.150567	11.4	2.28	20.0	1.516	.752	.711	.334	6.600
65	PI	B1	.780	.0186	.009	.003	PS	25.1000	3.9915	4.0	.304971	11.4	2.28	20.0	1.397	.752	.711	.334	6.275
66	PI	B1	.780	.0186	.009	.003	PS	20.0000	1.7968	3.0	.183987	11.4	2.28	20.0	.777	.752	.711	.334	6.667
67	PI	B1	.780	.0186	.009	.003	PS	19.0000	1.0106	2.0	.113909	11.4	2.28	20.0	.347	.752	.711	.334	9.500
68	PI	B1	.780	.0186	.009	.003	SG	17.5000	1.0380	2.0	.153776	11.4	2.28	20.0	.324	.752	.711	.334	8.750
69	PI	B1	.780	.0186	.009	.003	PS	14.0000	.5432	2.0	.070143	11.4	2.28	20.0	.084	.752	.711	.334	7.000
70	PI	B1	.780	.0186	.009	.003	SG	11.5000	.2964	1.0	.069890	11.4	2.28	20.0	.059	.752	.711	.334	11.50
71	PI	B1	.780	.0186	.009	.003	SG	7.2000	.0565	1.0		11.4	2.28	20.0		.752	.711	.334	7.200
72	PI	B1	.780	.0186	.009	.003	SG	6.0000	.0434	1.0		11.4	2.28	20.0		.752	.711	.334	6.000
73	PI	B1	.780	.0186	.009	.003	SG	6.1000	.0422	1.0		11.4	2.28	20.0		.752	.711	.334	6.100
74	PI	B1	.780	.0186	.009	.003	PS	3.0000	.0077	0.0		11.4	2.28	20.0		.752	.711	.334	
75	PI	B2	.158		.009	.003	PS	35.0000	10.6562	4.0	.388557	11.4	2.28	20.0	.261				8.750
76	PI	B2	.158		.009	.003	PS	36.0000	12.1610	5.0	.422747	11.4	2.28	20.0	4.506				7.200
77	PI	B2	.158		.009	.003	PS	33.0000	8.6963	4.0	.351108	11.4	2.28	20.0	2.789				8.250
78	PI	B2	.158		.009	.003	MT	34.0000	6.0020	3.0	.203189	11.4	2.28	20.0	2.352				11.33
79	PI	B2	.158		.009	.003	SG	32.1000	6.1634	4.0	.309260	11.4	2.28	20.0	2.743				8.025
80	PI	B2	.158		.009	.003	PS	28.2000	4.6703	4.0	.285544	11.4	2.28	20.0	1.468				7.050
81	PI	B2	.158		.009	.003	PS	27.8000	5.2383	4.0	.343791	11.4	2.28	20.0	1.856				6.950
82	PI	B2	.158		.009	.003	PS	28.1000	3.8825	4.0	.302924	11.4	2.28	20.0	1.464				7.025
83	PI	B2	.158		.009	.003	PS	25.5000	4.2386	3.0	.303021	11.4	2.28	20.0	.715				8.500
84	PI	B2	.158		.009	.003	PS	25.0000	3.2908	3.0	.210244	11.4	2.28	20.0	1.347				8.333
85	PI	B2	.158		.009	.003	PS	24.8000	3.6217	3.0	.399690	11.4	2.28	20.0	1.390				8.267
86	PI	B2	.158		.009	.003	PS	25.1000	3.2060	4.0	.321301	11.4	2.28	20.0	1.121				6.275
87	PI	B2	.158		.009	.003	PS	24.6000	3.2868	3.0	.229124	11.4	2.28	20.0	.912				8.200
88	PI	B2	.158		.009	.003	PS	23.5000	2.7645	3.0	.165598	11.4	2.28	20.0	.690				7.833
89	PI	B2	.158		.009	.003	PS	23.1000	2.7396	3.0	.272438	11.4	2.28	20.0	.904				7.700
90	PI	B2	.158		.009	.003	PS	21.9000	2.5274	2.0	.230464	11.4	2.28	20.0	.911				10.95
91	PI	B2	.158		.009	.003	SP	21.2000	2.3067	3.0	.289852	11.4	2.28	20.0	.746				7.067
92	PI	B2	.158		.009	.003	PS	19.9000	1.6400	3.0	.193049	11.4	2.28	20.0	.562				6.633
93	PI	B2	.158		.009	.003	PS	19.2000	1.4585	2.0	.187939	11.4	2.28	20.0	.443				9.600
94	PI	B2	.158		.009	.003	PS	18.0000	1.0031	2.0	.150490	11.4	2.28	20.0	.377				9.000
95	PI	B2	.158		.009	.003	PS	15.2000	.7931	2.0	.124300	11.4	2.28	20.0	.235				7.600
96	PI	B2	.158		.009	.003	OTHER	5.9000	.0152	0.0		11.4	2.28	20.0					

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
97	PI	B2	.158		.009	.003	SG	3.0000	.0050	0.0		11.4	2.28	20.0					
98	PI	B2	.158		.009	.003	SG	3.1000	.0070	0.0		11.4	2.28	20.0					
99	PI	B2	.158		.009	.003	SG	2.5000	.0034	0.0		11.4	2.28	20.0					
100	PI	B2	.158		.009	.003	SG	2.9000	.0043	0.0		11.4	2.28	20.0					
101	PI	B2	.158		.009	.003	SG	2.4000	.0029	0.0		11.4	2.28	20.0					
102	PI	B3	-.108	.0095	.009	.003	PS	29.0000	6.0655	4.0	.437292	11.4	2.28	20.0	2.646	1.018	.461	.283	7.250
103	PI	B3	-.108	.0095	.009	.003	PS	24.5000	3.3126	2.0	.302234	11.4	2.28	20.0	1.022	1.018	.461	.283	12.25
104	PI	B3	-.108	.0095	.009	.003	PS	18.9000	1.5276	1.0	.217628	11.4	2.28	20.0	.469	1.018	.461	.283	18.90
105	PI	B3	-.108	.0095	.009	.003	MI	13.8000	.4087	2.0	.142570	11.4	2.28	20.0	.199	1.018	.461	.283	6.900
106	PI	B4	-.575		.009	.003	SG	48.0000	22.0938	6.0	.518983	11.4	2.28	20.0	9.619				8.000
107	PI	B4	-.575		.009	.003	PS	37.0000	11.3439	5.0	.382769	11.4	2.28	20.0	4.118				7.400
108	PI	B4	-.575		.009	.003	PS	32.0000	5.4771	5.0	.237198	11.4	2.28	20.0	1.824				6.400
109	PI	B4	-.575		.009	.003	PS	21.0000	1.9796	3.0	.164731	11.4	2.28	20.0	.778				7.000
110	PI	B4	-.575		.009	.003	PS	22.0000	1.9380	3.0	.240859	11.4	2.28	20.0	.743				7.333
111	PI	B4	-.575		.009	.003	SG	9.1000	.1503	1.0		11.4	2.28	20.0					9.100
112	PI	B5	-1.092	.0119	.009	.003	SG	49.0000	22.4091	5.0	.418166	11.4	2.28	20.0	7.366	.740	.747	.294	9.800
113	PI	B5	-1.092	.0119	.009	.003	PS	30.5000	6.9046	5.0	.370435	11.4	2.28	20.0	2.975	.740	.747	.294	6.100
114	PI	B5	-1.092	.0119	.009	.003	SG	22.0000	1.9870	2.0	.238281	11.4	2.28	20.0	.852	.740	.747	.294	11.00
115	PI	B5	-1.092	.0119	.009	.003	SG	12.0000	.2234	2.0		11.4	2.28	20.0		.740	.747	.294	6.000
116	PI	B5	-1.092	.0119	.009	.003	SG	9.2000	.1467	1.0		11.4	2.28	20.0		.740	.747	.294	9.200
117	PI	B5	-1.092	.0119	.009	.003	MN	8.0000	.0569	0.0		11.4	2.28	20.0		.740	.747	.294	
118	PI	B5	-1.092	.0119	.009	.003	SG	6.8000	.0437	0.0		11.4	2.28	20.0		.740	.747	.294	
119	PI	B6	-1.967		.009	.003	SG	38.5000	11.0937	4.0	.492380	11.4	2.28	20.0	5.034				9.625
120	PI	B6	-1.967		.009	.003	MI	19.0000	1.1626	3.0	.177673	11.4	2.28	20.0	.502				6.333
121	PI	B6	-1.967		.009	.003	MI	19.0000	.4201	2.0	.073050	11.4	2.28	20.0	.196				9.500
122	PI	B6	-1.967		.009	.003	OTHER	8.0000	.0757	2.0	.054573	11.4	2.28	20.0	.028				4.000
123	PI	C1	1.033		.009	.003	PS	19.0000	1.5871	2.0	.232770	11.4	2.28	20.0	.536				9.500
124	PI	C1	1.033		.009	.003	PS	18.2000	1.4670	2.0	.191986	11.4	2.28	20.0	.464				9.100
125	PI	C1	1.033		.009	.003	PS	18.5000	1.4652	2.0	.199255	11.4	2.28	20.0	.479				9.250
126	PI	C1	1.033		.009	.003	PS	19.2000	1.6668	3.0	.238406	11.4	2.28	20.0	.614				6.400
127	PI	C1	1.033		.009	.003	PS	19.5000	1.3940	2.0	.187781	11.4	2.28	20.0	.430				9.750
128	PI	C1	1.033		.009	.003	PS	18.5000	1.1187	1.0	.169138	11.4	2.28	20.0	.395				18.50
129	PI	C1	1.033		.009	.003	PS	17.2000	1.1818	3.0	.197611	11.4	2.28	20.0	.389				5.733
130	PI	C1	1.033		.009	.003	PS	17.5000	1.2339	2.0	.222938	11.4	2.28	20.0	.473				8.750
131	PI	C1	1.033		.009	.003	PS	18.0000	1.1341	2.0	.187015	11.4	2.28	20.0	.410				9.000
132	PI	C1	1.033		.009	.003	PS	16.8000	1.1255	1.0	.183572	11.4	2.28	20.0	.396				16.80
133	PI	C1	1.033		.009	.003	PS	16.1000	1.0064	1.0	.239596	11.4	2.28	20.0	.347				16.10
134	PI	C1	1.033		.009	.003	PS	16.6000	.9971	2.0	.152352	11.4	2.28	20.0	.353				8.300
135	PI	C1	1.033		.009	.003	PS	15.5000	.8312	2.0	.195882	11.4	2.28	20.0	.287				7.750
136	PI	C1	1.033		.009	.003	PS	15.5000	.7799	2.0	.130693	11.4	2.28	20.0	.240				7.750
137	PI	C1	1.033		.009	.003	PS	15.1000	.6954	2.0	.136732	11.4	2.28	20.0	.217				7.550
138	PI	C1	1.033		.009	.003	PS	14.9000	.6274	1.0	.057071	11.4	2.28	20.0	.088				14.90
139	PI	C1	1.033		.009	.003	PS	9.5000	.2297	1.0	.051311	11.4	2.28	20.0	.031				9.500
140	PI	C2	.542	.0162	.009	.003	PS	39.5000	14.7987	6.0	.301223	11.4	2.28	20.0	5.393	.724	.753	.311	6.583
141	PI	C2	.542	.0162	.009	.003	PS	38.2000	14.7013	5.0	.396420	11.4	2.28	20.0	5.555	.724	.753	.311	7.640
142	PI	C2	.542	.0162	.009	.003	PS	35.2000	8.8645	5.0	.287160	11.4	2.28	20.0	3.439	.724	.753	.311	7.040
143	PI	C2	.542	.0162	.009	.003	PS	35.0000	10.1482	4.0	.327573	11.4	2.28	20.0	4.400	.724	.753	.311	8.750
144	PI	C2	.542	.0162	.009	.003	PS	33.0000	8.1231	5.0	.256210	11.4	2.28	20.0	3.362	.724	.753	.311	6.600
145	PI	C2	.542	.0162	.009	.003	PS	37.2000	4.3904	3.0	.153971	11.4	2.28	20.0	2.141	.724	.753	.311	12.40
146	PI	C2	.542	.0162	.009	.003	PS	27.1000	4.1046	3.0	.337839	11.4	2.28	20.0	1.971	.724	.753	.311	9.033
147	PI	C2	.542	.0162	.009	.003	MT	24.0000	2.1341	3.0	.143654	11.4	2.28	20.0	1.360	.724	.753	.311	8.000
148	PI	C3	.158	.0165	.009	.003	PS	26.2000	4.7246	4.0	.331458	11.4	2.28	20.0	1.513	.765	.704	.324	6.550
149	PI	C3	.158	.0165	.009	.003	PS	24.5000	3.8550	4.0	.320020	11.4	2.28	20.0	1.166	.765	.704	.324	6.125
150	PI	C3	.158	.0165	.009	.003	SG	23.8000	2.5310	3.0	.251511	11.4	2.28	20.0	.989	.765	.704	.324	7.933
151	PI	C3	.158	.0165	.009	.003	PS	18.0000	1.3160	2.0	.211519	11.4	2.28	20.0	.442	.765	.704	.324	9.000
152	PI	C4	.092		.009	.003	PS	39.1000	15.9059	6.0	.409688	11.4	2.28	20.0	6.006				6.517

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
153	PI	C4	.092		.009	.003	PS	31.2000	6.6930	4.0	.293918	11.4	2.28	20.0	2.729				7.800
154	PI	C4	.092		.009	.003	SG	28.9000	2.2035	2.0	.144715	11.4	2.28	20.0	1.077				14.45
155	PI	C4	.092		.009	.003	PS	15.0000	.6218	2.0	.112889	11.4	2.28	20.0	.261				7.500
156	PI	C4	.092		.009	.003	PS	12.0000	.2875	1.0		11.4	2.28	20.0					12.00
157	PI	C4	.092		.009	.003	SG	5.5000	.0172	0.0		11.4	2.28	20.0					
158	PI	C5	-.108		.009	.003	PS	46.0000	18.6463	5.0	.503695	11.4	2.28	20.0	7.958				9.200
159	PI	C5	-.108		.009	.003	PS	34.0000	11.1204	4.0	.305817	11.4	2.28	20.0	2.289				8.500
160	PI	C5	-.108		.009	.003	PS	32.5000	9.1912	5.0	.423105	11.4	2.28	20.0	3.264				6.500
161	PI	C5	-.108		.009	.003	SG	27.0000	4.5067	3.0	.319852	11.4	2.28	20.0	1.703				9.000
162	PI	C6	-1.800	.0070	.009	.003	SG	15.0000	.8070	2.0	.215608	11.4	2.28	20.0	.337	1.115	.400	.208	7.500
163	MS	A3	.725		.015	.005	MN	32.6000	7.2656	9.0	.303434	7.9	6.24	20.0	2.818				3.622
164	MS	A3	.725		.015	.005	MN	28.8000	4.2602	8.0	.249158	7.9	6.24	20.0	1.787				3.600
165	MS	A3	.725		.015	.005	MN	27.9000	3.6915	6.0	.241102	7.9	6.24	20.0	1.567				4.650
166	MS	A3	.725		.015	.005	MN	23.2000	1.5270	4.0	.190206	7.9	6.24	20.0	.680				5.800
167	MS	A3	.725		.015	.005	MN	16.0000	.6001	4.0	.138546	7.9	6.24	20.0	.318				4.000
168	MS	A4	-.242	.0194	.015	.005	MN	34.0000	6.4755	6.0	.246235	7.9	6.24	20.0	3.068	1.085	.350	.322	5.667
169	MS	A4	-.242	.0194	.015	.005	MN	32.3000	5.7829	5.0	.283110	7.9	6.24	20.0	2.504	1.085	.350	.322	6.460
170	MS	A4	-.242	.0194	.015	.005	MN	31.0000	5.1421	5.0	.071600	7.9	6.24	20.0	2.137	1.085	.350	.322	6.200
171	MS	A4	-.242	.0194	.015	.005	MN	30.0000	3.3716	5.0	.200142	7.9	6.24	20.0	1.342	1.085	.350	.322	6.000
172	MS	A4	-.242	.0194	.015	.005	MN	31.5000	4.4434	6.0	.183220	7.9	6.24	20.0	1.742	1.085	.350	.322	5.250
173	MS	A4	-.242	.0194	.015	.005	MN	29.0000	3.5017	5.0	.207947	7.9	6.24	20.0	1.644	1.085	.350	.322	5.800
174	MS	A4	-.242	.0194	.015	.005	MN	25.2000	1.9245	4.0	.130348	7.9	6.24	20.0	.883	1.085	.350	.322	6.300
175	MS	A4	-.242	.0194	.015	.005	MN	2.1000	.0032	0.0		7.9	6.24	20.0		1.085	.350	.322	
176	MS	B4	-.883		.015	.005	MT	47.0000	19.3688	6.0	.871605	7.9	6.24	20.0	11.56				7.833
177	MS	B4	-.883		.015	.005	MT	27.0000	1.2633	3.0	.090963	7.9	6.24	20.0	.560				9.000
178	MS	B4	-.883		.015	.005	MI	18.1000	.1426	2.0	.042500	7.9	6.24	20.0	.096				9.050
179	MS	B4	-.883		.015	.005	SG	3.5000	.0060	0.0		7.9	6.24	20.0					
180	MS	B4	-.883		.015	.005	SG	3.1000	.0103	0.0		7.9	6.24	20.0					
181	MS	B4	-.883		.015	.005	SG	2.7000	.0178	0.0		7.9	6.24	20.0					
182	MS	C2	2.375		.015	.005	MT	51.0000	17.6940	8.0	.343628	7.9	6.24	20.0	8.932				6.375
183	MS	C3	1.058	.0087	.015	.005	MT	41.0000	6.7576	7.0	.253186	7.9	6.24	20.0	3.229	1.062	.388	.312	5.857
184	MS	C3	1.058	.0087	.015	.005	MN	32.5000	5.6109	6.0	.247179	7.9	6.24	20.0	2.248	1.062	.388	.312	5.417
185	MS	C3	1.058	.0087	.015	.005	MN	30.3000	5.9546	8.0	.212498	7.9	6.24	20.0	2.085	1.062	.388	.312	3.788
186	MS	C3	1.058	.0087	.015	.005	MN	29.1000	3.9872	7.0	.256608	7.9	6.24	20.0	1.537	1.062	.388	.312	4.157
187	MS	C3	1.058	.0087	.015	.005	MN	28.0000	2.2372	5.0	.225130	7.9	6.24	20.0	1.222	1.062	.388	.312	5.600
188	MS	C3	1.058	.0087	.015	.005	CC	23.5000	3.3812		.219873	7.9	6.24	20.0	.756	1.062	.388	.312	
189	MS	C4	-.517		.015	.005	MI	38.0000	7.7625	4.0	.314557	7.9	6.24	20.0	3.313				9.500
190	MS	C4	-.517		.015	.005	CN	19.0000	1.2857	1.0	.820472	7.9	6.24	20.0	.398				19.00
191	MS	C4	-.517		.015	.005	SG	2.8000	.0041	0.0		7.9	6.24	20.0					
192	MS	C4	-.517		.015	.005	SG	2.1000	.0021	0.0		7.9	6.24	20.0					
193	MS	C4	-.517		.015	.005	SG	3.0000	.0049	0.0		7.9	6.24	20.0					
194	MS	C4	-.517		.015	.005	SG	3.0000	.0030	0.0		7.9	6.24	20.0					
195	MS	C4	-.517		.015	.005	SG	2.0000	.0030	0.0		7.9	6.24	20.0					
196	MS	C4	-.517		.015	.005	SG	2.9000	.0037	0.0		7.9	6.24	20.0					
197	MS	C4	-.517		.015	.005	SG	2.0000	.0025	0.0		7.9	6.24	20.0					
198	MS	C4	-.517		.015	.005	SG	2.5000	.0034	0.0		7.9	6.24	20.0					
199	MS	C4	-.517		.015	.005	SG	2.5000	.0021	0.0		7.9	6.24	20.0					
200	MS	C4	-.517		.015	.005	SG	2.1000	.0028	0.0		7.9	6.24	20.0					
201	MS	C4	-.517		.015	.005	SG	2.5000	.0029	0.0		7.9	6.24	20.0					
202	MS	C4	-.517		.015	.005	SG	2.8000	.0044	0.0		7.9	6.24	20.0					
203	MS	C4	-.517		.015	.005	SG	2.5000	.0019	0.0		7.9	6.24	20.0					
204	MS	C4	-.517		.015	.005	SG	2.9000	.0041	0.0		7.9	6.24	20.0					
205	MS	C4	-.517		.015	.005	SG	2.4000	.0024	0.0		7.9	6.24	20.0					
206	MS	C4	-.517		.015	.005	SG	2.4000	.0037	0.0		7.9	6.24	20.0					
207	MS	C4	-.517		.015	.005	SG	2.5000	.0036	0.0		7.9	6.24	20.0					
208	MS	C4	-.517		.015	.005	SG	2.5000	.0012	0.0		7.9	6.24	20.0					

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
209	MS	C4	-.517		.015	.005	SG	2.0000	.0026	0.0		7.9	6.24	20.0					
210	MS	C4	-.517		.015	.005	SG	3.0000	.0033	0.0		7.9	6.24	20.0					
211	MS	C4	-.517		.015	.005	SG	2.2000	.0030	0.0		7.9	6.24	20.0					
212	MS	C4	-.517		.015	.005	SG	2.0000	.0020	0.0		7.9	6.24	20.0					
213	MS	C4	-.517		.015	.005	SG	3.0000	.0038	0.0		7.9	6.24	20.0					
214	MS	C4	-.517		.015	.005	SG	2.9000	.0023	0.0		7.9	6.24	20.0					
215	MS	C4	-.517		.015	.005	SG	2.9000	.0044	0.0		7.9	6.24	20.0					
216	MS	C4	-.517		.015	.005	SG	2.2000	.0042	0.0		7.9	6.24	20.0					
217	MS	C4	-.517		.015	.005	SG	2.2000	.0024	0.0		7.9	6.24	20.0					
218	MS	C4	-.517		.015	.005	SG	2.3000	.0016	0.0		7.9	6.24	20.0					
219	MS	C4	-.517		.015	.005	SG	2.1000	.0031	0.0		7.9	6.24	20.0					
220	MS	C4	-.517		.015	.005	SG	2.5000	.0027	0.0		7.9	6.24	20.0					
221	MS	C4	-.517		.015	.005	SG	2.7000	.0028	0.0		7.9	6.24	20.0					
222	MS	C4	-.517		.015	.005	SG	2.5000	.0019	0.0		7.9	6.24	20.0					
223	MS	C4	-.517		.015	.005	SG	2.5000	.0022	0.0		7.9	6.24	20.0					
224	MS	C4	-.517		.015	.005	SG	2.6000	.0029	0.0		7.9	6.24	20.0					
225	MS	C4	-.517		.015	.005	SG	2.3000	.0020	0.0		7.9	6.24	20.0					
226	MS	C4	-.517		.015	.005	SG	2.1000	.0019	0.0		7.9	6.24	20.0					
227	TA	A1	2.267		.015	.005	PS	9.5000	.0964	1.0		12.5	.92	20.0					9.500
228	TA	A1	2.267		.015	.005	PS	7.0000	.0727	1.0		12.5	.92	20.0					7.000
229	TA	A1	2.267		.015	.005	SG	6.0000	.0460	0.0		12.5	.92	20.0					
230	TA	A1	2.267		.015	.005	PS	5.5000	.0383	0.0		12.5	.92	20.0					
231	TA	A1	2.267		.015	.005	SG	5.0000	.0255	0.0		12.5	.92	20.0					
232	TA	A1	2.267		.015	.005	PS	4.9000	.0174	0.0		12.5	.92	20.0					
233	TA	A1	2.267		.015	.005	PS	5.1000	.0384	0.0		12.5	.92	20.0					
234	TA	A1	2.267		.015	.005	SG	4.1000	.0184	0.0		12.5	.92	20.0					
235	TA	A1	2.267		.015	.005	PS	5.0000	.0191	0.0		12.5	.92	20.0					
236	TA	A1	2.267		.015	.005	PS	4.1000	.0205	0.0		12.5	.92	20.0					
237	TA	A1	2.267		.015	.005	PS	3.2000	.0120	0.0		12.5	.92	20.0					
238	TA	A1	2.267		.015	.005	SG	3.2000	.0144	0.0		12.5	.92	20.0					
239	TA	A1	2.267		.015	.005	PS	3.2000	.0129	0.0		12.5	.92	20.0					
240	TA	A1	2.267		.015	.005	PS	3.1000	.0099	0.0		12.5	.92	20.0					
241	TA	A1	2.267		.015	.005	SG	2.8000	.0079	0.0		12.5	.92	20.0					
242	TA	A1	2.267		.015	.005	PS	3.0000	.0071	0.0		12.5	.92	20.0					
243	TA	A1	2.267		.015	.005	PS	3.0000	.0072	0.0		12.5	.92	20.0					
244	TA	A1	2.267		.015	.005	SG	3.0000	.0068	0.0		12.5	.92	20.0					
245	TA	A2	1.621		.015	.005	PS	40.0000	14.7451	7.0	.460541	12.5	.92	20.0	6.527				5.714
246	TA	A2	1.621		.015	.005	PS	39.0000	11.5001	6.0	.319554	12.5	.92	20.0	4.050				6.500
247	TA	A2	1.621		.015	.005	PS	29.0000	4.5915	3.0	.195041	12.5	.92	20.0	1.493				9.667
248	TA	A2	1.621		.015	.005	SG	26.0000	3.1780	4.0	.201525	12.5	.92	20.0	1.269				6.500
249	TA	A2	1.621		.015	.005	SG	32.2000	5.0643	8.0	.324626	12.5	.92	20.0	2.086				4.025
250	TA	A2	1.621		.015	.005	PS	23.2000	2.1791	2.0	.113961	12.5	.92	20.0	.654				11.60
251	TA	A2	1.621		.015	.005	PS	21.0000	2.1886	2.0	.149345	12.5	.92	20.0	.719				10.50
252	TA	A2	1.621		.015	.005	PS	19.0000	1.5252	2.0	.117417	12.5	.92	20.0	.417				9.500
253	TA	A2	1.621		.015	.005	PS	19.0000	1.1629	2.0	.101321	12.5	.92	20.0	.365				9.500
254	TA	A2	1.621		.015	.005	SG	19.2000	1.0544	3.0	.084381	12.5	.92	20.0	.415				6.400
255	TA	A2	1.621		.015	.005	PS	18.0000	1.2880	2.0	.144018	12.5	.92	20.0	.403				9.000
256	TA	A2	1.621		.015	.005	PS	16.0000	.7785	1.0	.020723	12.5	.92	20.0	.207				16.00
257	TA	A2	1.621		.015	.005	SG	18.0000	.7622	3.0	.064958	12.5	.92	20.0	.232				6.000
258	TA	A2	1.621		.015	.005	SG	16.8000	.8655	2.0	.106082	12.5	.92	20.0	.242				8.400
259	TA	A2	1.621		.015	.005	PS	14.5000	.5970	2.0	.060792	12.5	.92	20.0	.169				7.250
260	TA	A2	1.621		.015	.005	SG	15.5000	.7715	2.0	.070885	12.5	.92	20.0	.217				7.750
261	TA	A2	1.621		.015	.005	PS	17.0000	.3016	1.0	.016160	12.5	.92	20.0	.073				17.00
262	TA	A2	1.621		.015	.005	SG	18.0000	.4190	1.0	.038605	12.5	.92	20.0	.159				18.00
263	TA	A2	1.621		.015	.005	PS	15.0000	.5733	2.0	.047122	12.5	.92	20.0	.114				7.500
264	TA	A2	1.621		.015	.005	PS	13.0000	.4151	1.0	.173981	12.5	.92	20.0	.133				13.00

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
265	TA	A2	1.621		.015	.005	PS	13.0000	.3917	1.0	.128197	12.5	.92	20.0	.093				13.00
266	TA	A2	1.621		.015	.005	PS	11.0000	.2552	1.0	.044216	12.5	.92	20.0	.071				11.00
267	TA	A2	1.621		.015	.005	PS	11.0000	.2309	1.0	.037064	12.5	.92	20.0	.055				11.00
268	TA	A2	1.621		.015	.005	SG	11.0000	.2240	2.0	.007153	12.5	.92	20.0	.003				5.500
269	TA	A2	1.621		.015	.005	PS	11.4000	.3302	1.0	.065151	12.5	.92	20.0	.099				11.40
270	TA	A2	1.621		.015	.005	PS	10.0000	.1826	1.0		12.5	.92	20.0					10.00
271	TA	A2	1.621		.015	.005	PS	11.1000	.2021	1.0	.060610	12.5	.92	20.0	.093				11.10
272	TA	A2	1.621		.015	.005	SG	3.0000	.0191	0.0		12.5	.92	20.0					
273	TA	A2	1.621		.015	.005	PS	4.0000	.0197	0.0		12.5	.92	20.0					
274	TA	A2	1.621		.015	.005	SG	3.0000	.0213	0.0		12.5	.92	20.0					
275	TA	A2	1.621		.015	.005	SG	4.0000	.0195	0.0		12.5	.92	20.0					
276	TA	A2	1.621		.015	.005	PS	4.0000	.0176	0.0		12.5	.92	20.0					
277	TA	A2	1.621		.015	.005	PS	4.0000	.0240	0.0		12.5	.92	20.0					
278	TA	A2	1.621		.015	.005	PS	2.1000	.3040	0.0		12.5	.92	20.0					
279	TA	A2	1.621		.015	.005	PS	2.5000	.0317	0.0		12.5	.92	20.0					
280	TA	A3	.850	.0174	.015	.005	SG	35.0000	7.9287	5.0	.288500	12.5	.92	4.0	3.326	.079	.885	.680	7.000
281	TA	A3	.850	.0174	.015	.005	SG	32.0000	6.3092	5.0	.267858	12.5	.92	4.0	2.749	.079	.885	.680	6.400
282	TA	A3	.850	.0174	.015	.005	PS	29.0000	4.9148	4.0		12.5	.92	4.0		.079	.885	.680	7.250
283	TA	A3	.850	.0174	.015	.005	PS	16.5000	.8999	2.0	.139589	12.5	.92	4.0	.261	.079	.885	.680	8.250
284	TA	A3	.850	.0174	.015	.005	PS	14.2000	.5917	2.0	.123237	12.5	.92	4.0	.165	.079	.885	.680	7.100
285	TA	A3	.850	.0174	.015	.005	PS	4.5000	.0178	0.0		12.5	.92	4.0		.079	.885	.680	
286	TA	A4	.027	.0166	.015	.005	SG	17.0000	1.1530	2.0	.189232	12.5	.92	20.0	.418	.423	.758	.642	8.500
287	TA	A4	.027	.0166	.015	.005	MI	10.2000	.1812	1.0	.095247	12.5	.92	20.0	.073	.423	.758	.642	10.20
288	TA	A4	.027	.0166	.015	.005	MI	3.0000	.0043	0.0		12.5	.92	20.0		.423	.758	.642	
289	TA	A4	.027	.0166	.015	.005	SG	3.0000	.0028	0.0		12.5	.92	20.0		.423	.758	.642	
290	TA	A4	.027	.0166	.015	.005	PS	2.5000	.0029	0.0		12.5	.92	20.0		.423	.758	.642	
291	TA	A4	.027	.0166	.015	.005	SG	2.0000	.0025	0.0		12.5	.92	20.0		.423	.758	.642	
292	TA	B1	-.025		.015	.005	PS	27.8000	4.5220	3.0	.235968	12.5	.92	10.0	1.683				9.267
293	TA	B1	-.025		.015	.005	PS	29.0000	4.7289	3.0	.217287	12.5	.92	10.0	1.526				9.667
294	TA	B1	-.025		.015	.005	PS	30.0000	4.9985	3.0	.233195	12.5	.92	10.0	1.881				10.00
295	TA	B1	-.025		.015	.005	PS	28.0000	3.7677	3.0	.130709	12.5	.92	10.0	.984				9.333
296	TA	B1	-.025		.015	.005	PS	28.0000	4.5052	3.0	.211053	12.5	.92	10.0	1.684				9.333
297	TA	B1	-.025		.015	.005	PS	25.2000	3.5750	2.0	.209036	12.5	.92	10.0	1.319				12.60
298	TA	B1	-.025		.015	.005	PS	25.6000	3.3266	3.0	.177081	12.5	.92	10.0	1.246				8.533
299	TA	B1	-.025		.015	.005	PS	26.1000	3.5067	2.0	.213255	12.5	.92	10.0	1.218				13.05
300	TA	B1	-.025		.015	.005	PS	26.9000	3.2051	2.0	.174799	12.5	.92	10.0	1.216				13.45
301	TA	B1	-.025		.015	.005	PS	22.8000	2.2427	2.0	.124813	12.5	.92	10.0	.702				11.40
302	TA	B1	-.025		.015	.005	PS	17.5000	1.0589	1.0	.083142	12.5	.92	10.0	.311				17.50
303	TA	B1	-.025		.015	.005	MI	19.2000	.7453	3.0	.075499	12.5	.92	10.0	.246				6.400
304	TA	B1	-.025		.015	.005	MI	12.3000	.6143	2.0	.136798	12.5	.92	10.0	.191				6.150
305	TA	B1	-.025		.015	.005	MI	15.0000	.3428	2.0	.067123	12.5	.92	10.0	.135				7.500
306	TA	B1	-.025		.015	.005	MI	14.0000	.2570	1.0	.049766	12.5	.92	10.0	.095				14.00
307	TA	B1	-.025		.015	.005	MI	14.0000	.3818	2.0	.094438	12.5	.92	10.0	.163				7.000
308	TA	B1	-.025		.015	.005	MI	12.5000	.2184	1.0	.128762	12.5	.92	10.0	.101				12.50
309	TA	B1	-.025		.015	.005	MI	12.0000	.1818	2.0	.122413	12.5	.92	10.0	.077				6.000
310	TA	B1	-.025		.015	.005	MI	12.2000	.2030	2.0	.083184	12.5	.92	10.0	.092				6.100
311	TA	B1	-.025		.015	.005	PS	10.0000	.1672	1.0	.038922	12.5	.92	10.0	.038				10.00
312	TA	B1	-.025		.015	.005	MI	20.0000	.7614	2.0	.097644	12.5	.92	10.0	.343				10.00
313	TA	B1	-.025		.015	.005	MI	10.8000	.1085	1.0	.110829	12.5	.92	10.0	.045				10.80
314	TA	B1	-.025		.015	.005	MI	8.2000	.0828	1.0	.067481	12.5	.92	10.0	.030				8.200
315	TA	B1	-.025		.015	.005	MI	8.1000	.0652	1.0	.087789	12.5	.92	10.0	.021				8.100
316	TA	B1	-.025		.015	.005	MI	10.0000	.1101	1.0	.124710	12.5	.92	10.0	.049				10.00
317	TA	B2	.078		.015	.005	PS	42.5000	17.4310	6.0	.474857	12.5	.92	15.0	6.909				7.083
318	TA	B2	.078		.015	.005	PS	41.0000	15.9593	6.0	.563246	12.5	.92	15.0	6.534				6.833
319	TA	B2	.078		.015	.005	PS	39.0000	12.7932	6.0	.417959	12.5	.92	15.0	4.765				6.500
320	TA	B2	.078		.015	.005	PS	30.5000	5.8122	4.0	.280385	12.5	.92	15.0	2.404				7.625

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
321	TA	B2	.078		.015	.005	MI	21.0000	1.2118	3.0	.086965	12.5	.92	15.0	.466				7.000
322	TA	B2	.078		.015	.005	MI	21.0000	1.3286	4.0	.234972	12.5	.92	15.0	.624				5.250
323	TA	B2	.078		.015	.005	PS	14.0000	.3908	2.0	.041537	12.5	.92	15.0	.357				7.000
324	TA	B3	1.183	.0133	.015	.005	PS	45.0000	18.5663	7.0	.592791	12.5	.92	15.0	7.564	.878	.592	.315	6.429
325	TA	B3	1.183	.0133	.015	.005	PS	41.5000	19.3480	7.0	.651779	12.5	.92	15.0	6.683	.878	.592	.315	5.929
326	TA	B3	1.183	.0133	.015	.005	PS	36.8000	13.1239	6.0	.511652	12.5	.92	15.0	4.686	.878	.592	.315	6.133
327	TA	B3	1.183	.0133	.015	.005	PS	23.0000	2.6895	3.0	.152110	12.5	.92	15.0	.564	.878	.592	.315	7.667
328	TA	B3	1.183	.0133	.015	.005	PS	22.5000	2.4943	5.0	.188811	12.5	.92	15.0	.632	.878	.592	.315	4.500
329	TA	B3	1.183	.0133	.015	.005	PS	23.5000	2.2690	3.0	.139187	12.5	.92	15.0	.671	.878	.592	.315	7.833
330	TA	B3	1.183	.0133	.015	.005	PS	20.5000	1.7842	2.0	.143903	12.5	.92	15.0	.442	.878	.592	.315	10.25
331	TA	B3	1.183	.0133	.015	.005	PS	16.5000	.9662	4.0	.100460	12.5	.92	15.0	.206	.878	.592	.315	4.125
332	TA	B3	1.183	.0133	.015	.005	PS	16.0000	.7805	2.0	.052399	12.5	.92	15.0	.120	.878	.592	.315	8.000
333	TA	B3	1.183	.0133	.015	.005	PS	14.5000	.6253	2.0	.115759	12.5	.92	15.0	.236	.878	.592	.315	7.250
334	TA	B3	1.183	.0133	.015	.005	PS	13.2000	.4811	1.0	.079812	12.5	.92	15.0	.088	.878	.592	.315	13.20
335	TA	B3	1.183	.0133	.015	.005	PS	12.5000	.4262	2.0	.070596	12.5	.92	15.0	.070	.878	.592	.315	6.250
336	TA	B3	1.183	.0133	.015	.005	PS	12.0000	.3950	1.0	.077456	12.5	.92	15.0	.085	.878	.592	.315	12.00
337	TA	B3	1.183	.0133	.015	.005	PS	11.2000	.3586	1.0	.086401	12.5	.92	15.0	.072	.878	.592	.315	11.20
338	TA	B3	1.183	.0133	.015	.005	PS	10.9000	.3265	1.0	.039770	12.5	.92	15.0	.023	.878	.592	.315	10.90
339	TA	B3	1.183	.0133	.015	.005	PS	11.5000	.2117	1.0	.026653	12.5	.92	15.0	.020	.878	.592	.315	11.50
340	TA	B3	1.183	.0133	.015	.005	PS	9.5000	.1924	1.0	.020347	12.5	.92	15.0	.009	.878	.592	.315	9.500
341	TA	B3	1.183	.0133	.015	.005	PS	4.0000	.0123	0.0		12.5	.92	15.0		.878	.592	.315	
342	TA	B3	1.183	.0133	.015	.005	SG	5.0000	.0127	0.0		12.5	.92	15.0		.878	.592	.315	
343	TA	B3	1.183	.0133	.015	.005	PS	3.8000	.0082	0.0		12.5	.92	15.0		.878	.592	.315	
344	TA	B4	.067		.015	.005	SG	26.0000	4.6789	3.0	.467874	12.5	.92	7.0	2.259				8.667
345	TA	B4	.067		.015	.005	MI	28.0000	2.4921	4.0	.192407	12.5	.92	7.0	1.153				7.000
346	TA	B4	.067		.015	.005	MI	28.0000	2.7085	6.0	.193595	12.5	.92	7.0	1.253				4.667
347	TA	B4	.067		.015	.005	MI	21.8000	.9828	3.0	.097714	12.5	.92	7.0	.432				7.267
348	TA	B4	.067		.015	.005	SG	6.9000	.6108	2.0	.396508	12.5	.92	7.0	.224				3.450
349	TA	B4	.067		.015	.005	SG	17.0000	.7599	2.0	.085232	12.5	.92	7.0	.315				8.500
350	TA	B4	.067		.015	.005	SG	13.0000	.4722	3.0	.056773	12.5	.92	7.0	.103				4.333
351	TA	B4	.067		.015	.005	MI	12.1000	.1932	2.0	.154365	12.5	.92	7.0	.098				6.050
352	TA	B4	.067		.015	.005	PS	10.1000	.1571	1.0	.042007	12.5	.92	7.0	.039				10.10
353	TA	B4	.067		.015	.005	PS	5.0000	.0276	0.0		12.5	.92	7.0					
354	TA	B4	.067		.015	.005	PS	4.0000	.0145	0.0		12.5	.92	7.0					
355	TA	B4	.067		.015	.005	PS	3.5000	.0093	0.0		12.5	.92	7.0					
356	TA	B4	.067		.015	.005	PS	3.1000	.0104	0.0		12.5	.92	7.0					
357	TA	B4	.067		.015	.005	PS	3.4000	.0089	0.0		12.5	.92	7.0					
358	TA	B4	.067		.015	.005	PS	2.7000	.0046	0.0		12.5	.92	7.0					
359	TA	B4	.067		.015	.005	PS	2.0000	.0027	0.0		12.5	.92	7.0					
360	TA	B4	.067		.015	.005	PS	2.0000	.0016	0.0		12.5	.92	7.0					
361	TA	C1	1.975		.015	.005	PS	36.8000	10.3232	4.0	.312233	12.5	.92	10.0	3.935				9.200
362	TA	C1	1.975		.015	.005	PS	36.0000	9.8628	4.0	.284707	12.5	.92	10.0	3.553				9.000
363	TA	C1	1.975		.015	.005	PS	30.6000	5.4846	3.0	.228855	12.5	.92	10.0	2.276				10.20
364	TA	C1	1.975		.015	.005	PS	27.0000	3.6954	2.0	.192681	12.5	.92	10.0	1.354				13.50
365	TA	C1	1.975		.015	.005	PS	26.0000	3.0248	3.0	.195437	12.5	.92	10.0	1.003				8.667
366	TA	C1	1.975		.015	.005	PS	26.0000	3.0236	3.0	.092592	12.5	.92	10.0	.786				8.667
367	TA	C1	1.975		.015	.005	PS	27.0000	3.3630	3.0	.128059	12.5	.92	10.0	1.418				9.000
368	TA	C1	1.975		.015	.005	PS	23.5000	2.2087	3.0	.106965	12.5	.92	10.0	.736				7.833
369	TA	C1	1.975		.015	.005	PS	16.6000	.8286	2.0	.050967	12.5	.92	10.0	.244				8.300
370	TA	C1	1.975		.015	.005	HA	19.9000	.7396	4.0	.096056	12.5	.92	10.0	.311				4.975
371	TA	C1	1.975		.015	.005	PS	14.7000	.5057	2.0	.040675	12.5	.92	10.0	.087				7.350
372	TA	C1	1.975		.015	.005	PS	15.0000	.5882	2.0	.093905	12.5	.92	10.0	.129				7.500
373	TA	C1	1.975		.015	.005	PS	12.2000	.2654	2.0	.021450	12.5	.92	10.0	.048				6.100
374	TA	C1	1.975		.015	.005	PS	12.8000	.3333	2.0	.016555	12.5	.92	10.0	.047				6.400
375	TA	C1	1.975		.015	.005	PS	12.1000	.3569	1.0	.051100	12.5	.92	10.0	.078				12.10
376	TA	C1	1.975		.015	.005	PS	12.6000	.2973	1.0	.021023	12.5	.92	10.0	.052				12.60

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
377	TA	C1	1.975		.015	.005	PS	10.8000	.1827	1.0		12.5	.92	10.0					10.80
378	TA	C1	1.975		.015	.005	PS	8.9000	.1427	1.0		12.5	.92	10.0					8.900
379	TA	C1	1.975		.015	.005	PS	12.6000	.2489	1.0		12.5	.92	10.0					12.60
380	TA	C1	1.975		.015	.005	PS	12.2000	.2851	1.0		12.5	.92	10.0					12.20
381	TA	C1	1.975		.015	.005	PS	11.0000	.2532	1.0		12.5	.92	10.0					11.00
382	TA	C1	1.975		.015	.005	PS	9.5000	.1365	1.0		12.5	.92	10.0					9.500
383	TA	C1	1.975		.015	.005	PS	11.0000	.1935	1.0		12.5	.92	10.0					11.00
384	TA	C1	1.975		.015	.005	PS	9.6000	.1790	1.0		12.5	.92	10.0					9.600
385	TA	C1	1.975		.015	.005	PS	11.2000	.2168	1.0		12.5	.92	10.0					11.20
386	TA	C1	1.975		.015	.005	PS	11.3000	.2075	1.0		12.5	.92	10.0					11.30
387	TA	C1	1.975		.015	.005	PS	11.9000	.1942	1.0		12.5	.92	10.0					11.90
388	TA	C1	1.975		.015	.005	PS	9.1000	.1328	1.0		12.5	.92	10.0					9.100
389	TA	C1	1.975		.015	.005	PS	9.8000	.1514	1.0		12.5	.92	10.0					9.800
390	TA	C1	1.975		.015	.005	PS	8.1000	.1074	1.0		12.5	.92	10.0					8.100
391	TA	C1	1.975		.015	.005	PS	10.0000	.1862	1.0		12.5	.92	10.0					10.00
392	TA	C1	1.975		.015	.005	PS	9.8000	.1483	1.0		12.5	.92	10.0					9.800
393	TA	C1	1.975		.015	.005	PS	9.0000	.1266	1.0		12.5	.92	10.0					9.000
394	TA	C1	1.975		.015	.005	PS	9.0000	.1003	1.0		12.5	.92	10.0					9.000
395	TA	C1	1.975		.015	.005	PS	3.0000	.0186	0.0		12.5	.92	10.0					
396	TA	C1	1.975		.015	.005	PS	2.5000	.0081	0.0		12.5	.92	10.0					
397	TA	C1	1.975		.015	.005	PS	3.7800	.0136	0.0		12.5	.92	10.0					
398	TA	C1	1.975		.015	.005	PS	3.0000	.0100	0.0		12.5	.92	10.0		1.057	.408	.295	
399	TA	C2	1.458	.0103	.015	.005	SG	56.2000	27.8710	8.0	.317809	12.5	.92	4.0	9.442	1.057	.408	.295	7.025
400	TA	C2	1.458	.0103	.015	.005	PS	29.0000	6.5794	5.0	.315784	12.5	.92	4.0	2.147	1.057	.408	.295	5.800
401	TA	C2	1.458	.0103	.015	.005	PS	24.0000	1.8743	3.0		12.5	.92	4.0		1.057	.408	.295	8.000
402	TA	C2	1.458	.0103	.015	.005	MI	24.0000	1.3166	6.0	.067973	12.5	.92	4.0	.331	1.057	.408	.295	4.000
403	TA	C2	1.458	.0103	.015	.005	HA	29.5000	2.0245	5.0	.141634	12.5	.92	4.0	.919	1.057	.408	.295	5.900
404	TA	C2	1.458	.0103	.015	.005	MI	23.3000	1.2980	5.0	.110247	12.5	.92	4.0	.389	1.057	.408	.295	4.660
405	TA	C2	1.458	.0103	.015	.005	MI	20.2000	1.1841	6.0	.120484	12.5	.92	4.0	.498	1.057	.408	.295	3.367
406	TA	C2	1.458	.0103	.015	.005	MI	21.0000	1.2930	4.0	.122085	12.5	.92	4.0	.415	1.057	.408	.295	5.250
407	TA	C2	1.458	.0103	.015	.005	MI	21.2000	1.2724	5.0	.104924	12.5	.92	4.0	.526	1.057	.408	.295	4.240
408	TA	C2	1.458	.0103	.015	.005	MI	21.0000	1.3941	5.0	.122085	12.5	.92	4.0	.422	1.057	.408	.295	4.200
409	TA	C2	1.458	.0103	.015	.005	MI	20.0000	1.0564	5.0	.105797	12.5	.92	4.0	.372	1.057	.408	.295	4.000
410	TA	C2	1.458	.0103	.015	.005	MI	21.2000	1.2306	5.0	.050986	12.5	.92	4.0	.251	1.057	.408	.295	4.240
411	TA	C2	1.458	.0103	.015	.005	MI	20.2000	1.1361	4.0	.068770	12.5	.92	4.0	.249	1.057	.408	.295	5.050
412	TA	C2	1.458	.0103	.015	.005	MI	21.0000	1.1774	6.0	.090142	12.5	.92	4.0	.353	1.057	.408	.295	3.500
413	TA	C2	1.458	.0103	.015	.005	MI	21.2000	1.2630	5.0	.074430	12.5	.92	4.0	.331	1.057	.408	.295	4.240
414	TA	C2	1.458	.0103	.015	.005	MI	21.0000	1.2773	5.0	.108204	12.5	.92	4.0	.406	1.057	.408	.295	4.200
415	TA	C2	1.458	.0103	.015	.005	MI	18.9000	.8480	6.0	.098485	12.5	.92	4.0	.251	1.057	.408	.295	3.150
416	TA	C2	1.458	.0103	.015	.005	MI	19.2000	.5498	4.0		12.5	.92	4.0		1.057	.408	.295	4.800
417	TA	C2	1.458	.0103	.015	.005	MI	17.8000	.7469	4.0	.098449	12.5	.92	4.0	.261	1.057	.408	.295	4.450
418	TA	C2	1.458	.0103	.015	.005	SG	18.0000	.9572	2.0	.136620	12.5	.92	4.0	.410	1.057	.408	.295	9.000
419	TA	C2	1.458	.0103	.015	.005	MI	19.2000	.9566	4.0	.107192	12.5	.92	4.0	.400	1.057	.408	.295	4.800
420	TA	C2	1.458	.0103	.015	.005	MI	18.0000	.7389	6.0	.098709	12.5	.92	4.0	.232	1.057	.408	.295	3.000
421	TA	C2	1.458	.0103	.015	.005	MI	16.0000	.5592	3.0	.106574	12.5	.92	4.0	.244	1.057	.408	.295	5.333
422	TA	C2	1.458	.0103	.015	.005	MI	16.5000	.5434	5.0	.071043	12.5	.92	4.0	.160	1.057	.408	.295	3.300
423	TA	C2	1.458	.0103	.015	.005	MI	15.0000	.4515	3.0	.102719	12.5	.92	4.0	.156	1.057	.408	.295	5.000
424	TA	C2	1.458	.0103	.015	.005	PS	11.0000	.3196	2.0		12.5	.92	4.0		1.057	.408	.295	5.500
425	TA	C2	1.458	.0103	.015	.005	PS	11.2000	.3897	1.0		12.5	.92	4.0		1.057	.408	.295	11.20
426	TA	C2	1.458	.0103	.015	.005	PS	11.0000	.2673	2.0		12.5	.92	4.0		1.057	.408	.295	5.500
427	TA	C2	1.458	.0103	.015	.005	PS	10.8000	.2428	2.0		12.5	.92	4.0		1.057	.408	.295	5.400
428	TA	C2	1.458	.0103	.015	.005	MI	9.0000	.1293	1.0		12.5	.92	4.0		1.057	.408	.295	9.000
429	TA	C2	1.458	.0103	.015	.005	PS	9.0000	.1282	1.0		12.5	.92	4.0		1.057	.408	.295	9.000
430	TA	C2	1.458	.0103	.015	.005	PS	8.0000	.1364	1.0		12.5	.92	4.0		1.057	.408	.295	8.000
431	TA	C2	1.458	.0103	.015	.005	PS	9.0000	.1684	2.0		12.5	.92	4.0		1.057	.408	.295	4.500
432	TA	C2	1.458	.0103	.015	.005	PS	9.0000	.1731	1.0		12.5	.92	4.0		1.057	.408	.295	9.000

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
433	TA	C2	1.458	.0103	.015	.005	PS	9.5000	.1748	1.0		12.5	.92	4.0		1.057	.408	.295	9.500
434	TA	C2	1.458	.0103	.015	.005	PS	9.5000	.2068	1.0		12.5	.92	4.0		1.057	.408	.295	9.500
435	TA	C2	1.458	.0103	.015	.005	PS	10.5000	.1675	1.0		12.5	.92	4.0		1.057	.408	.295	10.50
436	TA	C2	1.458	.0103	.015	.005	PS	9.0000	.1314	1.0		12.5	.92	4.0		1.057	.408	.295	9.000
437	TA	C2	1.458	.0103	.015	.005	MI	9.2000	.1099	1.0		12.5	.92	4.0		1.057	.408	.295	9.200
438	TA	C2	1.458	.0103	.015	.005	PS	9.0000	.1076	1.0		12.5	.92	4.0		1.057	.408	.295	9.000
439	TA	C2	1.458	.0103	.015	.005	PS	8.2000	.1083	0.0		12.5	.92	4.0		1.057	.408	.295	
440	TA	C2	1.458	.0103	.015	.005	PS	8.1000	.0946	1.0		12.5	.92	4.0		1.057	.408	.295	8.100
441	TA	C2	1.458	.0103	.015	.005	PS	8.0000	.0750	0.0		12.5	.92	4.0		1.057	.408	.295	
442	TA	C2	1.458	.0103	.015	.005	PS	8.2000	.1039	0.0		12.5	.92	4.0		1.057	.408	.295	
443	TA	C2	1.458	.0103	.015	.005	PS	7.0000	.0654	0.0		12.5	.92	4.0		1.057	.408	.295	
444	TA	C2	1.458	.0103	.015	.005	PS	7.5000	.0799	0.0		12.5	.92	4.0		1.057	.408	.295	
445	TA	C2	1.458	.0103	.015	.005	PS	6.2000	.0522	0.0		12.5	.92	4.0		1.057	.408	.295	
446	TA	C2	1.458	.0103	.015	.005	PS	6.0000	.0373	0.0		12.5	.92	4.0		1.057	.408	.295	
447	TA	C2	1.458	.0103	.015	.005	PS	6.0000	.0368	0.0		12.5	.92	4.0		1.057	.408	.295	
448	TA	C2	1.458	.0103	.015	.005	PS	5.0000	.0315	0.0		12.5	.92	4.0		1.057	.408	.295	
449	TA	C2	1.458	.0103	.015	.005	PS	5.8000	.0344	1.0		12.5	.92	4.0		1.057	.408	.295	5.800
450	TA	C2	1.458	.0103	.015	.005	PS	6.1000	.0572	1.0		12.5	.92	4.0		1.057	.408	.295	6.100
451	TA	C2	1.458	.0103	.015	.005	PS	6.0000	.0425	1.0		12.5	.92	4.0		1.057	.408	.295	6.000
452	TA	C2	1.458	.0103	.015	.005	PS	5.1000	.0272	1.0		12.5	.92	4.0		1.057	.408	.295	5.100
453	TA	C2	1.458	.0103	.015	.005	PS	5.8000	.0406	0.0		12.5	.92	4.0		1.057	.408	.295	
454	TA	C2	1.458	.0103	.015	.005	PS	5.0000	.0310	0.0		12.5	.92	4.0		1.057	.408	.295	
455	TA	C2	1.458	.0103	.015	.005	OTHER	5.8000	.0237	0.0		12.5	.92	4.0		1.057	.408	.295	
456	TA	C2	1.458	.0103	.015	.005	PS	4.0000	.0129	0.0		12.5	.92	4.0		1.057	.408	.295	
457	TA	C2	1.458	.0103	.015	.005	PS	4.0000	.0103	0.0		12.5	.92	4.0		1.057	.408	.295	
458	TA	C2	1.458	.0103	.015	.005	PS	4.1000	.0180	0.0		12.5	.92	4.0		1.057	.408	.295	
459	TA	C2	1.458	.0103	.015	.005	PS	4.0000	.0120	0.0		12.5	.92	4.0		1.057	.408	.295	
460	TA	C2	1.458	.0103	.015	.005	PS	4.1000	.0134	0.0		12.5	.92	4.0		1.057	.408	.295	
461	TA	C2	1.458	.0103	.015	.005	PS	4.0000	.0097	0.0		12.5	.92	4.0		1.057	.408	.295	
462	TA	C2	1.458	.0103	.015	.005	PS	3.8000	.0107	0.0		12.5	.92	4.0		1.057	.408	.295	
463	TA	C2	1.458	.0103	.015	.005	PS	3.9000	.0103	0.0		12.5	.92	4.0		1.057	.408	.295	
464	TA	C2	1.458	.0103	.015	.005	PS	3.1000	.0073	0.0		12.5	.92	4.0		1.057	.408	.295	
465	TA	C2	1.458	.0103	.015	.005	PS	3.1000	.0095	0.0		12.5	.92	4.0		1.057	.408	.295	
466	TA	C2	1.458	.0103	.015	.005	PS	3.0000	.0034	0.0		12.5	.92	4.0		1.057	.408	.295	
467	TA	C2	1.458	.0103	.015	.005	PS	2.8000	.0057	0.0		12.5	.92	4.0		1.057	.408	.295	
468	TA	C2	1.458	.0103	.015	.005	PS	2.5000	.0040	0.0		12.5	.92	4.0		1.057	.408	.295	
469	TA	C3	.883		.015	.005	PS	40.0000	16.8589	6.0	.459806	12.5	.92	10.0	5.418				6.667
470	TA	C3	.883		.015	.005	PS	41.0000	16.7104	8.0	.377727	12.5	.92	10.0	4.576				5.125
471	TA	C3	.883		.015	.005	PS	37.5000	12.3728	7.0	.279481	12.5	.92	10.0	3.060				5.357
472	TA	C3	.883		.015	.005	PS	36.0000	11.5518	6.0	.396757	12.5	.92	10.0	3.822				6.000
473	TA	C3	.883		.015	.005	PS	32.5000	8.0069	6.0	.312550	12.5	.92	10.0	2.665				5.417
474	TA	C3	.883		.015	.005	PS	33.0000	5.1418	4.0	.240351	12.5	.92	10.0	1.827				8.250
475	TA	C3	.883		.015	.005	PS	30.4000	5.8057	4.0	.289708	12.5	.92	10.0	2.061				7.600
476	TA	C3	.883		.015	.005	PS	30.5000	4.8613	4.0	.290314	12.5	.92	10.0	1.802				7.625
477	TA	C3	.883		.015	.005	PS	27.0000	3.9463	4.0	.197416	12.5	.92	10.0	1.265				6.750
478	TA	C3	.883		.015	.005	PS	25.0000	2.1512	3.0	.162235	12.5	.92	10.0	.818				8.333
479	TA	C3	.883		.015	.005	PS	20.1000	1.4309	3.0	.107995	12.5	.92	10.0	.408				6.700
480	TA	C3	.883		.015	.005	PS	19.2000	1.5220	2.0	.162504	12.5	.92	10.0	.506				9.600
481	TA	C3	.883		.015	.005	PS	15.1000	.6422	2.0	.100961	12.5	.92	10.0	.176				7.550
482	TA	C3	.883		.015	.005	PS	14.0000	.5706	2.0	.094830	12.5	.92	10.0	.161				7.000
483	TA	C3	.883		.015	.005	PS	13.0000	.4089	2.0	.069593	12.5	.92	10.0	.097				6.500
484	TA	C3	.883		.015	.005	PS	11.0000	.2457	2.0	.065674	12.5	.92	10.0	.053				5.500
485	TA	C3	.883		.015	.005	PS	7.2000	.0651	1.0		12.5	.92	10.0					7.200
486	TA	C3	.883		.015	.005	PS	7.8000	.0688	1.0		12.5	.92	10.0					7.800
487	TA	C3	.883		.015	.005	SG	6.5000	.0349	0.0		12.5	.92	10.0					
488	TA	C3	.883		.015	.005	PS	6.1000	.0281	0.0		12.5	.92	10.0					

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
489	TA	C3	.883		.015	.005	PS	4.5000	.0123	0.0		12.5	.92	10.0					
490	TA	C3	.883		.015	.005	PS	4.0000	.0139	0.0		12.5	.92	10.0					
491	TA	C3	.883		.015	.005	PS	4.2000	.0103	0.0		12.5	.92	10.0					
492	TA	C3	.883		.015	.005	PS	4.0000	.0127	0.0		12.5	.92	10.0					
493	TA	C3	.883		.015	.005	SG	4.1000	.0075	0.0		12.5	.92	10.0					
494	TA	C3	.883		.015	.005	PS	3.2000	.0056	0.0		12.5	.92	10.0					
495	TA	C3	.883		.015	.005	PS	2.1000	.0047	0.0		12.5	.92	10.0					
496	TA	C3	.883		.015	.005	SG	4.0000	.0029	0.0		12.5	.92	10.0					
497	TA	C4	-.754		.015	.005	MI	38.0000	2.5522	7.0	.084476	12.5	.92	10.0	.771				5.429
498	TA	C4	-.754		.015	.005	MI	30.0000	2.1925	5.0	.157915	12.5	.92	10.0	.969				6.000
499	TA	C4	-.754		.015	.005	PS	26.0000	2.8904	3.0	.167136	12.5	.92	10.0	1.064				8.667
500	TA	C4	-.754		.015	.005	MI	27.2000	2.0433	3.0	.169415	12.5	.92	10.0	.905				9.067
501	TA	C4	-.754		.015	.005	MI	29.0000	1.8409	4.0	.139594	12.5	.92	10.0	.618				7.250
502	TA	C4	-.754		.015	.005	MI	27.0000	1.6392	5.0	.140984	12.5	.92	10.0	.753				5.400
503	TA	C4	-.754		.015	.005	MI	25.0000	1.4142	5.0	.139390	12.5	.92	10.0	.476				5.000
504	TA	C4	-.754		.015	.005	SG	20.0000	.9917	3.0	.136554	12.5	.92	10.0	.407				6.667
505	TA	C4	-.754		.015	.005	MI	20.5000	.5096	4.0	.079516	12.5	.92	10.0	.166				5.125
506	TA	C4	-.754		.015	.005	PS	14.9000	.4968	2.0	.061541	12.5	.92	10.0	.162				7.450
507	TA	C4	-.754		.015	.005	PS	9.8000	.1594	1.0	.042266	12.5	.92	10.0	.045				9.800
508	TA	C4	-.754		.015	.005	PS	10.1000	.2075	1.0	.083236	12.5	.92	10.0	.063				10.10
509	TA	C4	-.754		.015	.005	MI	6.0000	.0259	0.0		12.5	.92	10.0					
510	TA	C4	-.754		.015	.005	PS	6.0000	.0362	0.0		12.5	.92	10.0					
511	TA	C4	-.754		.015	.005	PS	5.5000	.0443	0.0		12.5	.92	10.0					
512	TA	C4	-.754		.015	.005	PS	5.0000	.0245	0.0		12.5	.92	10.0					
513	TA	C4	-.754		.015	.005	PS	5.0000	.0177	0.0		12.5	.92	10.0					
514	TA	C4	-.754		.015	.005	MI	3.1000	.0112	0.0		12.5	.92	10.0					
515	TA	C4	-.754		.015	.005	PS	4.9000	.0173	0.0		12.5	.92	10.0					
516	TA	C4	-.754		.015	.005	PS	4.1000	.0190	0.0		12.5	.92	10.0					
517	TA	C4	-.754		.015	.005	PS	3.1000	.0150	0.0		12.5	.92	10.0					
518	TA	C4	-.754		.015	.005	PS	2.9000	.0182	0.0		12.5	.92	10.0					
519	TA	C4	-.754		.015	.005	PS	4.1000	.0153	0.0		12.5	.92	10.0					
520	TA	C4	-.754		.015	.005	PS	3.9000	.0127	0.0		12.5	.92	10.0					
521	TA	C4	-.754		.015	.005	PS	3.9000	.0072	0.0		12.5	.92	10.0					
522	TA	C4	-.754		.015	.005	PS	4.1000	.0180	0.0		12.5	.92	10.0					
523	TA	C4	-.754		.015	.005	PS	4.0000	.0148	0.0		12.5	.92	10.0					
524	TA	C4	-.754		.015	.005	PS	4.5000	.0085	0.0		12.5	.92	10.0					
525	TA	C4	-.754		.015	.005	PS	2.2000	.0019	0.0		12.5	.92	10.0					
526	TA	D2	.942	.0085	.015	.005	PS	38.5000	17.0796	5.0	.561362	12.5	.92	10.0	5.468	1.092	.412	.230	7.700
527	TA	D2	.942	.0085	.015	.005	PS	38.5000	7.0922	4.0	.226568	12.5	.92	10.0	2.570	1.092	.412	.230	9.625
528	TA	D2	.942	.0085	.015	.005	PS	27.0000	4.6115	3.0	.271016	12.5	.92	10.0	1.376	1.092	.412	.230	9.000
529	TA	D2	.942	.0085	.015	.005	PS	25.8000	4.1784	3.0	.269402	12.5	.92	10.0	1.369	1.092	.412	.230	8.600
530	TA	D2	.942	.0085	.015	.005	PS	28.5000	2.0696	3.0	.076180	12.5	.92	10.0	.532	1.092	.412	.230	9.500
531	TA	D2	.942	.0085	.015	.005	PS	18.2000	1.1177	2.0	.091476	12.5	.92	10.0	.223	1.092	.412	.230	9.100
532	TA	D2	.942	.0085	.015	.005	MI	17.0000	.8889	2.0	.118074	12.5	.92	10.0	.396	1.092	.412	.230	8.500
533	TA	D2	.942	.0085	.015	.005	MI	18.5000	.8915	2.0	.149714	12.5	.92	10.0	.375	1.092	.412	.230	9.250
534	TA	D2	.942	.0085	.015	.005	PS	11.1000	.2009	1.0	.051678	12.5	.92	10.0	.047	1.092	.412	.230	11.10
535	TA	D2	.942	.0085	.015	.005	PS	10.0000	.2743	1.0	.051631	12.5	.92	10.0	.042	1.092	.412	.230	10.00
536	TA	D2	.942	.0085	.015	.005	SG	5.2000	.0228	0.0		12.5	.92	10.0		1.092	.412	.230	
537	TA	D2	.942	.0085	.015	.005	SG	5.1000	.0212	0.0		12.5	.92	10.0		1.092	.412	.230	
538	TA	D2	.942	.0085	.015	.005	SG	5.1000	.0181	0.0		12.5	.92	10.0		1.092	.412	.230	
539	TA	D3	.317		.015	.005	PS	32.0000	6.3073	6.0	.293132	12.5	.92	10.0	2.572				5.333
540	TA	D3	.317		.015	.005	PS	23.2000	2.5660	4.0	.189256	12.5	.92	10.0	.944				5.800
541	TA	D3	.317		.015	.005	PS	23.5000	2.5896	4.0	.245228	12.5	.92	10.0	1.044				5.875
542	TA	D3	.317		.015	.005	SG	25.0000	2.2616	5.0	.135331	12.5	.92	10.0	.902				5.000
543	TA	D3	.317		.015	.005	MN	25.2000	1.9025	5.0	.162964	12.5	.92	10.0	.883				5.040
544	TA	D3	.317		.015	.005	PS	22.5000	1.8357	4.0	.156257	12.5	.92	10.0	.730				5.625

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
545	TA	D3	.317		.015	.005	MI	26.0000	1.4053	5.0	.114272	12.5	.92	10.0	.690				5.200
546	TA	D3	.317		.015	.005	MI	24.0000	1.3830	4.0	.111057	12.5	.92	10.0	.620				6.000
547	TA	D3	.317		.015	.005	PS	19.5000	1.0355	2.0	.075425	12.5	.92	10.0	.329				9.750
548	TA	D3	.317		.015	.005	PS	19.2000	1.2835	3.0	.173001	12.5	.92	10.0	.522				6.400
549	TA	D3	.317		.015	.005	MI	19.0000	.7692	2.0	.093479	12.5	.92	10.0	.292				9.500
550	TA	D3	.317		.015	.005	PS	18.5000	.7730	3.0	.080750	12.5	.92	10.0	.302				6.167
551	TA	D3	.317		.015	.005	MI	20.1000	.8933	3.0	.117346	12.5	.92	10.0	.394				6.700
552	TA	D3	.317		.015	.005	SG	21.8000	1.3802	4.0	.124771	12.5	.92	10.0	.553				5.450
553	TA	D3	.317		.015	.005	PS	17.9000	.8785	3.0	.076248	12.5	.92	10.0	.270				5.967
554	TA	D3	.317		.015	.005	SG	17.0000	.7699	2.0	.093052	12.5	.92	10.0	.297				8.500
555	TA	D3	.317		.015	.005	MI	16.2000	.5039	2.0	.064028	12.5	.92	10.0	.189				8.100
556	TA	D3	.317		.015	.005	MI	17.6000	.5046	2.0	.052103	12.5	.92	10.0	.213				8.800
557	TA	D3	.317		.015	.005	PS	15.0000	.7055	2.0	.201370	12.5	.92	10.0	.221				7.500
558	TA	D3	.317		.015	.005	PS	15.1000	.5678	2.0	.058170	12.5	.92	10.0	.177				7.550
559	TA	D3	.317		.015	.005	PS	14.2000	.4811	2.0	.049066	12.5	.92	10.0	.137				7.100
560	TA	D3	.317		.015	.005	PS	14.1000	.4425	2.0	.054819	12.5	.92	10.0	.132				7.050
561	TA	D3	.317		.015	.005	PS	13.5000	.4130	2.0	.049486	12.5	.92	10.0	.197				6.750
562	TA	D3	.317		.015	.005	PS	12.5000	.3781	2.0	.049715	12.5	.92	10.0	.159				6.250
563	TA	D3	.317		.015	.005	PS	12.8000	.3202	2.0	.043516	12.5	.92	10.0	.091				6.400
564	TA	D3	.317		.015	.005	MI	13.0000	.3316	2.0	.185427	12.5	.92	10.0	.124				6.500
565	TA	D3	.317		.015	.005	SG	11.0000	.1318	1.0	.066325	12.5	.92	10.0	.074				11.00
566	TA	D3	.317		.015	.005	SG	8.0000	.0377	0.0		12.5	.92	10.0					
567	TA	D3	.317		.015	.005	PS	5.0000	.0185	0.0		12.5	.92	10.0					
568	TA	D3	.317		.015	.005	PS	5.0000	.0415	0.0		12.5	.92	10.0					
569	TA	D3	.317		.015	.005	PS	5.0000	.0231	0.0		12.5	.92	10.0					
570	TA	D3	.317		.015	.005	PS	5.0000	.0209	0.0		12.5	.92	10.0					
571	TA	D3	.317		.015	.005	PS	4.5000	.0176	0.0		12.5	.92	10.0					
572	TA	D3	.317		.015	.005	PS	4.2000	.0201	0.0		12.5	.92	10.0					
573	TA	D3	.317		.015	.005	PS	3.2000	.0109	0.0		12.5	.92	10.0					
574	TA	D3	.317		.015	.005	PS	3.8000	.0116	0.0		12.5	.92	10.0					
575	TA	D3	.317		.015	.005	PS	4.0000	.0105	0.0		12.5	.92	10.0					
576	TA	D3	.317		.015	.005	PS	3.8000	.0092	0.0		12.5	.92	10.0					
577	TA	D3	.317		.015	.005	PS	3.2000	.0095	0.0		12.5	.92	10.0					
578	TA	D3	.317		.015	.005	PS	2.5000	.0047	0.0		12.5	.92	10.0					
579	TA	D3	.317		.015	.005	PS	2.5000	.0041	0.0		12.5	.92	10.0					
580	TA	D3	.317		.015	.005	PS	2.0000	.0023	0.0		12.5	.92	10.0					
581	TA	D4	-.650		.015	.005	MI	16.5000	.7316	3.0	.128489	12.5	.92	10.0	.266				5.500
582	TA	D4	-.650		.015	.005	PS	15.0000	.6634	2.0	.071869	12.5	.92	10.0	.255				7.500
583	TA	D4	-.650		.015	.005	PS	12.6000	.3605	1.0		12.5	.92	10.0					12.60
584	TA	D4	-.650		.015	.005	PS	11.7000	.3659	1.0	.069690	12.5	.92	10.0	.070				11.70
585	TA	D4	-.650		.015	.005	PS	11.7000	.3301	1.0	.061693	12.5	.92	10.0	.078				11.70
586	TA	D4	-.650		.015	.005	PS	6.3000	.0432	0.0		12.5	.92	10.0					
587	TA	D4	-.650		.015	.005	PS	4.7000	.0143	0.0		12.5	.92	10.0					
588	TA	D4	-.650		.015	.005	PS	4.0000	.0098	0.0		12.5	.92	10.0					
589	TA	D4	-.650		.015	.005	PS	4.1000	.0087	0.0		12.5	.92	10.0					
590	TA	D4	-.650		.015	.005	PS	3.9000	.0061	0.0		12.5	.92	10.0					
591	TA	D4	-.650		.015	.005	PS	3.0000	.0022	0.0		12.5	.92	10.0					
592	TA	D4	-.650		.015	.005	PS	3.2000	.0050	0.0		12.5	.92	10.0					
593	TA	D4	-.650		.015	.005	PS	2.9000	.0053	0.0		12.5	.92	10.0					
594	TA	E1	3.025		.015	.005	PS	23.0000	2.3028	5.0	.129176	12.5	.92	15.0	.545				4.600
595	TA	E1	3.025		.015	.005	PS	19.0000	1.3350	4.0		12.5	.92	15.0					4.750
596	TA	E1	3.025		.015	.005	PS	19.8000	1.2650	4.0		12.5	.92	15.0					4.950
597	TA	E1	3.025		.015	.005	PS	17.0000	.5421	3.0		12.5	.92	15.0					5.667
598	TA	E1	3.025		.015	.005	PS	15.2000	.6089	2.0	.082427	12.5	.92	15.0	.163				7.600
599	TA	E1	3.025		.015	.005	PS	15.3000	.6772	2.0		12.5	.92	15.0					7.650
600	TA	E1	3.025		.015	.005	PS	13.0000	.5623	2.0		12.5	.92	15.0					6.500

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
601	TA	E1	3.025		.015	.005	PS	12.5000	.3233	2.0	.087002	12.5	.92	15.0	.081				6.250
602	TA	E2	1.633		.015	.005	PS	39.0000	15.9308	4.0	.499181	12.5	.92	15.0	6.558				9.750
603	TA	E2	1.633		.015	.005	PS	40.5000	16.0639	4.0	.399081	12.5	.92	15.0	6.896				10.13
604	TA	E2	1.633		.015	.005	PS	18.0000	1.1655	2.0	.081140	12.5	.92	15.0	.382				9.000
605	TA	E2	1.633		.015	.005	PS	13.1000	.2841	1.0		12.5	.92	15.0					13.10
606	TA	E2	1.633		.015	.005	PS	11.2000	.2059	1.0		12.5	.92	15.0					11.20
607	TA	E3	.750	.0114	.015	.005	MT	39.0000	11.2237	6.0	.495306	12.5	.92	15.0	6.284	.850	.640	.285	6.500
608	TA	E3	.750	.0114	.015	.005	PS	34.1000	5.1085	4.0		12.5	.92	15.0		.850	.640	.285	8.525
609	TA	E3	.750	.0114	.015	.005	PS	33.0000	6.4106	4.0	.261065	12.5	.92	15.0	2.298	.850	.640	.285	8.250
610	TA	E3	.750	.0114	.015	.005	PS	29.1000	4.1934	4.0	.196333	12.5	.92	15.0	1.654	.850	.640	.285	7.275
611	TA	E3	.750	.0114	.015	.005	PS	28.8000	4.3086	4.0	.197293	12.5	.92	15.0	1.511	.850	.640	.285	7.200
612	TA	E3	.750	.0114	.015	.005	PS	29.1000	4.3051	4.0	.226007	12.5	.92	15.0	1.599	.850	.640	.285	7.275
613	TA	E3	.750	.0114	.015	.005	PS	28.5000	4.1592	3.0	.243777	12.5	.92	15.0	1.756	.850	.640	.285	9.500
614	TA	E3	.750	.0114	.015	.005	SG	28.0000	3.3993	3.0	.221656	12.5	.92	15.0	1.474	.850	.640	.285	9.333
615	TA	E3	.750	.0114	.015	.005	PS	27.0000	3.5320	3.0	.176106	12.5	.92	15.0	1.291	.850	.640	.285	9.000
616	TA	E3	.750	.0114	.015	.005	PS	27.2000	3.4057	3.0	.197683	12.5	.92	15.0	1.565	.850	.640	.285	9.067
617	TA	E3	.750	.0114	.015	.005	PS	27.5000	3.2001	3.0	.145337	12.5	.92	15.0	1.026	.850	.640	.285	9.167
618	TA	E3	.750	.0114	.015	.005	PS	27.1000	3.4295	3.0	.188743	12.5	.92	15.0	1.221	.850	.640	.285	9.033
619	TA	E3	.750	.0114	.015	.005	PS	25.0000	3.2202	3.0	.242830	12.5	.92	15.0	1.356	.850	.640	.285	8.333
620	TA	E3	.750	.0114	.015	.005	PS	24.0000	2.3842	3.0	.139990	12.5	.92	15.0	.896	.850	.640	.285	8.000
621	TA	E3	.750	.0114	.015	.005	PS	23.0000	2.0670	3.0	.127380	12.5	.92	15.0	.724	.850	.640	.285	7.667
622	TA	E3	.750	.0114	.015	.005	PS	21.0000	1.6012	3.0	.136635	12.5	.92	15.0	.564	.850	.640	.285	7.000
623	TA	E3	.750	.0114	.015	.005	PS	21.1000	1.5726	3.0	.135444	12.5	.92	15.0	.618	.850	.640	.285	7.033
624	TA	E3	.750	.0114	.015	.005	PS	21.9000	1.7405	3.0	.120515	12.5	.92	15.0	.601	.850	.640	.285	7.300
625	TA	E3	.750	.0114	.015	.005	PS	19.7000	1.5520	2.0	.150521	12.5	.92	15.0	.674	.850	.640	.285	9.850
626	TA	E3	.750	.0114	.015	.005	SG	17.0000	.6482	1.0	.159518	12.5	.92	15.0	.361	.850	.640	.285	17.00
627	TA	E3	.750	.0114	.015	.005	PS	16.9000	.8093	2.0	.084712	12.5	.92	15.0	.254	.850	.640	.285	8.450
628	TA	E3	.750	.0114	.015	.005	PS	15.0000	.6111	1.0	.069496	12.5	.92	15.0	.169	.850	.640	.285	15.00
629	TA	E3	.750	.0114	.015	.005	PS	14.8000	.6080	1.0	.070088	12.5	.92	15.0	.175	.850	.640	.285	14.80
630	TA	E3	.750	.0114	.015	.005	PS	13.0000	.3241	1.0	.057231	12.5	.92	15.0	.085	.850	.640	.285	13.00
631	TA	E3	.750	.0114	.015	.005	SG	11.0000	.2247	1.0	.064374	12.5	.92	15.0	.065	.850	.640	.285	11.00
632	TA	E3	.750	.0114	.015	.005	PS	12.1000	.3531	1.0	.072924	12.5	.92	15.0	.101	.850	.640	.285	12.10
633	TA	E3	.750	.0114	.015	.005	SG	6.2000	.0398	0.0		12.5	.92	15.0		.850	.640	.285	
634	TA	E3	.750	.0114	.015	.005	PS	4.4000	.0221	0.0		12.5	.92	15.0		.850	.640	.285	
635	TA	E3	.750	.0114	.015	.005	PS	4.8000	.0204	0.0		12.5	.92	15.0		.850	.640	.285	
636	TA	E3	.750	.0114	.015	.005	PS	4.1000	.0122	0.0		12.5	.92	15.0		.850	.640	.285	
637	TA	E3	.750	.0114	.015	.005	PS	4.0000	.0130	0.0		12.5	.92	15.0		.850	.640	.285	
638	TA	E3	.750	.0114	.015	.005	PS	3.8000	.0125	0.0		12.5	.92	15.0		.850	.640	.285	
639	TA	E3	.750	.0114	.015	.005	PS	3.0000	.0103	0.0		12.5	.92	15.0		.850	.640	.285	
640	TA	E3	.750	.0114	.015	.005	PS	3.1000	.0071	0.0		12.5	.92	15.0		.850	.640	.285	
641	TA	E3	.750	.0114	.015	.005	SG	3.1000	.0068	0.0		12.5	.92	15.0		.850	.640	.285	
642	TA	E3	.750	.0114	.015	.005	PS	3.0000	.0089	0.0		12.5	.92	15.0		.850	.640	.285	
643	TA	E3	.750	.0114	.015	.005	SG	2.0000	.0059	0.0		12.5	.92	15.0		.850	.640	.285	
644	TA	E3	.750	.0114	.015	.005	PS	2.5000	.0049	0.0		12.5	.92	15.0		.850	.640	.285	
645	TA	E3	.750	.0114	.015	.005	PS	2.1000	.0029	0.0		12.5	.92	15.0		.850	.640	.285	
646	TA	E3	.750	.0114	.015	.005	PS	2.5000	.0028	0.0		12.5	.92	15.0		.850	.640	.285	
647	TA	E3	.750	.0114	.015	.005	PS	2.5000	.0042	0.0		12.5	.92	15.0		.850	.640	.285	
648	TA	E4	.017		.015	.005	PS	34.2000	10.3649	5.0	.378583	12.5	.92	15.0	3.529				6.840
649	TA	E4	.017		.015	.005	TC	35.0000	4.0285	4.0	.184954	12.5	.92	15.0	1.728				8.750
650	TA	E4	.017		.015	.005	SG	30.5000	5.6442	3.0	.291307	12.5	.92	15.0	2.147				10.17
651	TA	E4	.017		.015	.005	PS	28.5000	6.4022	4.0	.258484	12.5	.92	15.0	1.637				7.125
652	TA	E4	.017		.015	.005	PS	26.0000	4.2269	3.0	.256311	12.5	.92	15.0	1.314				8.667
653	TA	E4	.017		.015	.005	PS	22.0000	4.5390	3.0	.406942	12.5	.92	15.0	1.209				7.333
654	TA	E4	.017		.015	.005	PS	28.0000	4.4810	3.0	.195332	12.5	.92	15.0	1.234				9.333
655	TA	E4	.017		.015	.005	PS	25.0000	3.8304	3.0	.293739	12.5	.92	15.0	1.259				8.333
656	TA	E4	.017		.015	.005	PS	25.8000	3.8722	3.0	.203408	12.5	.92	15.0	.884				8.600

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
657	TA	E4	.017		.015	.005	PS	22.0000	2.2400	2.0	.156983	12.5	.92	15.0	.560				11.00
658	TA	E4	.017		.015	.005	PS	17.0000	1.0114	2.0	.113383	12.5	.92	15.0	.256				8.500
659	TA	E4	.017		.015	.005	PS	7.0000	.0574	0.0		12.5	.92	15.0					
660	TA	E4	.017		.015	.005	PS	6.0000	.0273	0.0		12.5	.92	15.0					
661	TA	E4	.017		.015	.005	PS	5.8000	.0256	0.0		12.5	.92	15.0					
662	TA	E4	.017		.015	.005	PS	4.0000	.0134	0.0		12.5	.92	15.0					
663	TA	E4	.017		.015	.005	PS	3.0000	.0090	0.0		12.5	.92	15.0					
664	TA	F1	3.117		.015	.005	PS	21.0000	.9405	2.0	.041308	12.5	.92	15.0	.218				10.50
665	TA	F1	3.117		.015	.005	SG	8.0000	.1135	0.0		12.5	.92	10.0					
666	TA	F2	1.842		.015	.005	PS	40.5000	13.8609	5.0	.389523	12.5	.92	10.0	5.731				8.100
667	TA	F2	1.842		.015	.005	PS	34.2000	8.6685	3.0	.294567	12.5	.92	10.0	3.499				11.40
668	TA	F2	1.842		.015	.005	PS	32.3000	7.0622	3.0	.304710	12.5	.92	10.0	2.896				10.77
669	TA	F2	1.842		.015	.005	PS	15.1000	.9981	2.0	.156457	12.5	.92	10.0	.341				7.550
670	TA	F2	1.842		.015	.005	PS	16.0000	.7043	2.0	.062464	12.5	.92	10.0	.213				8.000
671	TA	F2	1.842		.015	.005	PS	11.9000	.2770	1.0		12.5	.92	10.0					11.90
672	TA	F3	.100		.015	.005	CN	59.0000	38.4260	3.0	.462046	12.5	.92	10.0	14.07				19.67
673	TA	F3	.100		.015	.005	SG	34.1000	7.2964	4.0	.274571	12.5	.92	10.0	2.948				8.525
674	TA	F3	.100		.015	.005	PS	31.0000	4.9856	4.0	.205425	12.5	.92	10.0	1.607				7.750
675	TA	F3	.100		.015	.005	SG	32.0000	4.3895	4.0	.169733	12.5	.92	10.0	1.788				8.000
676	TA	F3	.100		.015	.005	SG	29.1000	3.5232	3.0	.198188	12.5	.92	10.0	1.519				9.700
677	TA	F3	.100		.015	.005	PS	28.1000	4.2774	3.0	.231525	12.5	.92	10.0	1.648				9.367
678	TA	F3	.100		.015	.005	PS	26.5000	3.0642	3.0	.199676	12.5	.92	10.0	1.139				8.833
679	TA	F3	.100		.015	.005	PS	23.5000	2.0360	2.0	.136546	12.5	.92	10.0	.673				11.75
680	TA	F3	.100		.015	.005	PS	22.3000	1.5372	2.0	.073711	12.5	.92	10.0	.379				11.15
681	TA	F3	.100		.015	.005	PS	22.5000	1.8652	2.0	.117916	12.5	.92	10.0	.559				11.25
682	TA	F3	.100		.015	.005	PS	15.5000	.4814	2.0	.055379	12.5	.92	10.0	.123				7.750
683	TA	F3	.100		.015	.005	PS	4.9000	.0281	0.0		12.5	.92	10.0					
684	TA	F3	.100		.015	.005	SG	4.8000	.0272	0.0		12.5	.92	10.0					
685	TA	F3	.100		.015	.005	PS	4.0000	.0086	0.0		12.5	.92	10.0					
686	TA	F4	-.617	.0154	.015	.005	PS	9.2000	.1384	1.0	.050156	12.5	.92	10.0	.034	1.161	.320	.247	9.200
687	TA	F4	-.617	.0154	.015	.005	SG	7.3000	.0753	1.0		12.5	.92	10.0		1.161	.320	.247	7.300
688	TA	F4	-.617	.0154	.015	.005	SG	7.0000	.0690	1.0		12.5	.92	10.0		1.161	.320	.247	7.000
689	TA	F4	-.617	.0154	.015	.005	SG	6.1000	.0511	0.0		12.5	.92	10.0		1.161	.320	.247	
690	TA	F4	-.617	.0154	.015	.005	SG	6.1000	.0437	0.0		12.5	.92	10.0		1.161	.320	.247	
691	TA	F4	-.617	.0154	.015	.005	SG	6.9000	.0449	1.0		12.5	.92	10.0		1.161	.320	.247	6.900
692	TA	F4	-.617	.0154	.015	.005	SG	7.8000	.0379	1.0		12.5	.92	10.0		1.161	.320	.247	7.800
693	TA	F4	-.617	.0154	.015	.005	SG	5.5000	.0209	1.0		12.5	.92	10.0		1.161	.320	.247	5.500
694	TA	F4	-.617	.0154	.015	.005	SG	6.0000	.0307	1.0		12.5	.92	10.0		1.161	.320	.247	6.000
695	TA	F4	-.617	.0154	.015	.005	PS	5.0000	.0219	0.0		12.5	.92	10.0		1.161	.320	.247	
696	TA	F4	-.617	.0154	.015	.005	SG	4.5000	.0198	0.0		12.5	.92	10.0		1.161	.320	.247	
697	TA	F4	-.617	.0154	.015	.005	SG	4.1000	.0134	0.0		12.5	.92	10.0		1.161	.320	.247	
698	TA	F4	-.617	.0154	.015	.005	PS	3.5000	.0098	0.0		12.5	.92	10.0		1.161	.320	.247	
699	TA	F4	-.617	.0154	.015	.005	PS	3.4000	.0099	0.0		12.5	.92	10.0		1.161	.320	.247	
700	TA	F4	-.617	.0154	.015	.005	PS	3.3000	.0086	0.0		12.5	.92	10.0		1.161	.320	.247	
701	TA	F4	-.617	.0154	.015	.005	SG	3.1000	.0057	0.0		12.5	.92	10.0		1.161	.320	.247	
702	TA	F4	-.617	.0154	.015	.005	SG	2.1000	.0034	0.0		12.5	.92	10.0		1.161	.320	.247	
703	TA	G1	.600	.0187	.015	.005	MI	39.0000	7.0366	6.0		12.5	.92	4.2		.808	.638	.359	6.500
704	TA	G1	.600	.0187	.015	.005	MI	36.8000	5.1873	7.0		12.5	.92	4.2		.808	.638	.359	5.257
705	TA	G1	.600	.0187	.015	.005	SG	27.0000	4.1423	4.0		12.5	.92	4.2		.808	.638	.359	6.750
706	TA	G1	.600	.0187	.015	.005	MI	25.0000	2.2313	4.0		12.5	.92	4.2		.808	.638	.359	6.250
707	TA	G1	.600	.0187	.015	.005	SG	21.5000	1.8178	3.0		12.5	.92	4.2		.808	.638	.359	7.167
708	TA	G1	.600	.0187	.015	.005	SG	20.5000	1.6598	3.0		12.5	.92	4.2		.808	.638	.359	6.833
709	TA	G1	.600	.0187	.015	.005	SG	19.5000	1.4756	2.0		12.5	.92	4.2		.808	.638	.359	9.750
710	TA	G1	.600	.0187	.015	.005	MN	20.2000	.9342	2.0		12.5	.92	4.2		.808	.638	.359	10.10
711	TA	G1	.600	.0187	.015	.005	MN	19.2000	.8355	2.0		12.5	.92	4.2		.808	.638	.359	9.600
712	TA	G1	.600	.0187	.015	.005	PS	17.1000	1.0707	2.0		12.5	.92	4.2		.808	.638	.359	8.550

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
713	TA	G1	.600	.0187	.015	.005	PS	15.0000	.7932	2.0		12.5	.92	4.2		.808	.638	.359	7.500
714	TA	G1	.600	.0187	.015	.005	MN	17.2000	.6480	2.0		12.5	.92	4.2		.808	.638	.359	8.600
715	TA	G1	.600	.0187	.015	.005	MI	12.0000	.2331	2.0		12.5	.92	4.2		.808	.638	.359	6.000
716	TA	G2	.417		.015	.005	PS	30.0000	5.7778	3.0	.336785	12.5	.92	10.0	1.976				10.00
717	TA	G2	.417		.015	.005	PS	30.0000	6.6468	3.0	.390636	12.5	.92	10.0	2.451				10.00
718	TA	G2	.417		.015	.005	PS	28.0000	5.0430	3.0	.277504	12.5	.92	10.0	1.618				9.333
719	TA	G2	.417		.015	.005	PS	27.0000	4.4637	3.0	.276837	12.5	.92	10.0	1.463				9.000
720	TA	G2	.417		.015	.005	PS	27.5000	4.8195	3.0	.241596	12.5	.92	10.0	1.455				9.167
721	TA	G2	.417		.015	.005	PS	26.5000	4.2930	3.0	.268116	12.5	.92	10.0	1.289				8.833
722	TA	G2	.417		.015	.005	PS	27.0000	3.9932	3.0	.241320	12.5	.92	10.0	1.321				9.000
723	TA	G2	.417		.015	.005	PS	26.5000	4.4730	3.0	.427467	12.5	.92	10.0	1.585				8.833
724	TA	G2	.417		.015	.005	PS	24.2000	3.8216	3.0	.285199	12.5	.92	10.0	1.351				8.067
725	TA	G2	.417		.015	.005	PS	26.0000	4.1781	3.0	.265389	12.5	.92	10.0	1.204				8.667
726	TA	G2	.417		.015	.005	PS	25.0000	3.9754	3.0	.251991	12.5	.92	10.0	1.157				8.333
727	TA	G2	.417		.015	.005	PS	27.5000	3.1972	3.0	.197358	12.5	.92	10.0	1.039				9.167
728	TA	G2	.417		.015	.005	PS	28.2000	2.9266	3.0	.116523	12.5	.92	10.0	.762				9.400
729	TA	G2	.417		.015	.005	PS	24.2000	3.2531	3.0	.209088	12.5	.92	10.0	.907				8.067
730	TA	G2	.417		.015	.005	PS	21.5000	2.4092	3.0	.258025	12.5	.92	10.0	.895				7.167
731	TA	G2	.417		.015	.005	PS	22.0000	2.4976	3.0	.195053	12.5	.92	10.0	.713				7.333
732	TA	G2	.417		.015	.005	PS	22.0000	2.2023	3.0	.231910	12.5	.92	10.0	.733				7.333
733	TA	G2	.417		.015	.005	PS	22.5000	2.4530	3.0	.167687	12.5	.92	10.0	.560				7.500
734	TA	G2	.417		.015	.005	PS	22.0000	1.8444	3.0	.164263	12.5	.92	10.0	.502				7.333
735	TA	G2	.417		.015	.005	PS	22.0000	2.1608	2.0	.173364	12.5	.92	10.0	.625				11.00
736	TA	G2	.417		.015	.005	PS	17.5000	1.4635	2.0	.158436	12.5	.92	10.0	.342				8.750
737	TA	G2	.417		.015	.005	SG	18.2000	1.3573	2.0	.123323	12.5	.92	10.0	.432				9.100
738	TA	G2	.417		.015	.005	PS	13.1000	.5330	1.0	.089657	12.5	.92	10.0	.113				13.10
739	TA	G2	.417		.015	.005	PS	13.8000	.6018	2.0	.134493	12.5	.92	10.0	.135				6.900
740	TA	G2	.417		.015	.005	PS	13.0000	.5264	1.0	.097063	12.5	.92	10.0	.127				13.00
741	TA	G2	.417		.015	.005	SG	13.2000	.4894	1.0	.093114	12.5	.92	10.0	.178				13.20
742	TA	G2	.417		.015	.005	PS	11.1000	.3068	1.0	.065714	12.5	.92	10.0	.056				11.10
743	TA	G2	.417		.015	.005	PS	10.0000	.2277	1.0	.048454	12.5	.92	10.0	.020				10.00
744	TA	G2	.417		.015	.005	PS	8.0000	.1130	1.0	.046958	12.5	.92	10.0	.024				8.000
745	TA	G2	.417		.015	.005	PS	3.0000	.0063	0.0		12.5	.92	10.0					
746	TA	G2	.417		.015	.005	PS	2.8000	.0075	0.0		12.5	.92	10.0					
747	TA	G2	.417		.015	.005	PS	2.0000	.0008	0.0		12.5	.92	10.0					
748	TA	G3	.383		.015	.005	SG	33.0000	7.8213	5.0	.292719	12.5	.92	10.0	3.061				6.600
749	TA	G3	.383		.015	.005	PS	28.2000	4.6865	3.0	.280411	12.5	.92	10.0	1.687				9.400
750	TA	G3	.383		.015	.005	PS	25.5000	3.4421	3.0	.209690	12.5	.92	10.0	.965				8.500
751	TA	G3	.383		.015	.005	PS	22.5000	2.3656	3.0	.169713	12.5	.92	10.0	.618				7.500
752	TA	G3	.383		.015	.005	MN	26.0000	1.6014	4.0	.140651	12.5	.92	10.0	.678				6.500
753	TA	G3	.383		.015	.005	PS	20.1000	1.7738	3.0	.173452	12.5	.92	10.0	.527				6.700
754	TA	G3	.383		.015	.005	PS	21.0000	.9185	2.0		12.5	.92	10.0					10.50
755	TA	G3	.383		.015	.005	SG	18.0000	1.0636	3.0	.135927	12.5	.92	10.0	.360				6.000
756	TA	G3	.383		.015	.005	PS	8.1000	.1106	0.0	.037094	12.5	.92	10.0	.012				
757	TA	G3	.383		.015	.005	PS	5.8000	.0267	0.0		12.5	.92	10.0					
758	TA	G3	.383		.015	.005	SG	5.0000	.0175	0.0		12.5	.92	10.0					
759	TA	G3	.383		.015	.005	PS	4.1000	.0117	0.0		12.5	.92	10.0					
760	TA	G3	.383		.015	.005	SG	4.1000	.0040	0.0		12.5	.92	10.0					
761	TA	G3	.383		.015	.005	SG	2.0000	.0013	0.0		12.5	.92	10.0					
762	TA	G3	.383		.015	.005	SG	2.0000	.0014	0.0		12.5	.92	10.0					
763	TA	G3	.383		.015	.005	SG	2.0000	.0017	0.0		12.5	.92	10.0					
764	TA	G3	.383		.015	.005	SG	2.0000	.0012	0.0		12.5	.92	10.0					
765	TA	G4	.350		.015	.005	SG	31.0000	4.2645	5.0	.202473	12.5	.92	15.0	1.876				6.200
766	TA	G4	.350		.015	.005	SG	29.0000	3.3517	4.0	.141886	12.5	.92	15.0	1.364				7.250
767	TA	G4	.350		.015	.005	SG	27.4000	2.9182	3.0	.197631	12.5	.92	15.0	1.498				9.133
768	TA	G4	.350		.015	.005	PS	26.0000	3.0376	2.0	.162117	12.5	.92	15.0	1.211				13.00

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
769	TA	G4	.350		.015	.005	PS	25.8000	2.6623	2.0	.207424	12.5	.92	15.0	.972				12.90
770	TA	G4	.350		.015	.005	MI	27.0000	2.1525	4.0	.109018	12.5	.92	15.0	.843				6.750
771	TA	G4	.350		.015	.005	PS	27.5000	3.4116	3.0	.155969	12.5	.92	15.0	1.063				9.167
772	TA	G4	.350		.015	.005	PS	23.0000	2.1291	2.0	.165235	12.5	.92	15.0	.807				11.50
773	TA	G4	.350		.015	.005	PS	27.0000	2.8842	2.0	.172061	12.5	.92	15.0	1.051				13.50
774	TA	G4	.350		.015	.005	MI	26.0000	1.8156	4.0	.149408	12.5	.92	15.0	.761				6.500
775	TA	G4	.350		.015	.005	SG	27.0000	2.5011	3.0	.150356	12.5	.92	15.0	1.090				9.000
776	TA	G4	.350		.015	.005	MI	25.5000	1.4681	3.0	.133601	12.5	.92	15.0	.696				8.500
777	TA	G4	.350		.015	.005	PS	25.0000	2.3393	3.0	.160611	12.5	.92	15.0	.886				8.333
778	TA	G4	.350		.015	.005	PS	21.9000	1.7805	2.0	.185443	12.5	.92	15.0	.678				10.95
779	TA	G4	.350		.015	.005	PS	22.1000	1.4877	3.0	.143777	12.5	.92	15.0	.478				7.367
780	TA	G4	.350		.015	.005	PS	19.3000	1.3622	2.0	.115414	12.5	.92	15.0	.453				9.650
781	TA	G4	.350		.015	.005	MI	21.0000	1.0415	3.0	.155366	12.5	.92	15.0	.340				7.000
782	TA	G4	.350		.015	.005	PS	21.0000	1.5947	2.0	.127102	12.5	.92	15.0	.672				10.50
783	TA	G4	.350		.015	.005	PS	23.5000	2.1129	2.0	.135885	12.5	.92	15.0	.898				11.75
784	TA	G4	.350		.015	.005	PS	22.0000	2.0266	2.0	.145607	12.5	.92	15.0	.992				11.00
785	TA	G4	.350		.015	.005	SG	21.5000	1.3635	3.0	.146283	12.5	.92	15.0	.638				7.167
786	TA	G4	.350		.015	.005	PS	21.5000	1.4586	2.0	.073062	12.5	.92	15.0	.377				10.75
787	TA	G4	.350		.015	.005	PS	19.2000	1.1933	3.0	.080545	12.5	.92	15.0	.362				6.400
788	TA	G4	.350		.015	.005	SG	18.5000	.9323	3.0	.114796	12.5	.92	15.0	.365				6.167
789	TA	G4	.350		.015	.005	PS	18.0000	.8552	2.0	.076517	12.5	.92	15.0	.301				9.000
790	TA	G4	.350		.015	.005	PS	19.0000	1.3423	2.0	.101527	12.5	.92	15.0	.533				9.500
791	TA	G4	.350		.015	.005	PS	18.0000	.8877	1.0	.047158	12.5	.92	15.0	.231				18.00
792	TA	G4	.350		.015	.005	PS	16.0000	.6530	1.0	.069569	12.5	.92	15.0	.199				16.00
793	TA	G4	.350		.015	.005	PS	15.0000	.6658	1.0	.083396	12.5	.92	15.0	.192				15.00
794	TA	G4	.350		.015	.005	PS	13.0000	.3549	1.0	.049905	12.5	.92	15.0	.089				13.00
795	TA	G4	.350		.015	.005	PS	13.2000	.3051	1.0		12.5	.92	15.0					13.20
796	TA	G4	.350		.015	.005	PS	17.5000	.3087	1.0		12.5	.92	15.0					17.50
797	TA	G4	.350		.015	.005	PS	11.0000	.2305	1.0		12.5	.92	15.0					11.00
798	TA	G4	.350		.015	.005	PS	7.1000	.0489	0.0		12.5	.92	15.0					
799	TA	G4	.350		.015	.005	PS	7.1000	.0530	0.0		12.5	.92	15.0					
800	TA	G4	.350		.015	.005	PS	6.5000	.0566	0.0		12.5	.92	15.0					
801	TA	G4	.350		.015	.005	PS	8.2000	.0981	0.0		12.5	.92	15.0					
802	TA	G4	.350		.015	.005	PS	6.1000	.0454	0.0		12.5	.92	15.0					
803	TA	G4	.350		.015	.005	PS	6.0000	.0420	0.0		12.5	.92	15.0					
804	TA	G4	.350		.015	.005	SG	6.5000	.0416	0.0		12.5	.92	15.0					
805	TA	G4	.350		.015	.005	PS	6.5000	.0517	0.0		12.5	.92	15.0					
806	TA	G4	.350		.015	.005	PS	5.8000	.0333	0.0		12.5	.92	15.0					
807	TA	G4	.350		.015	.005	PS	5.1000	.0343	0.0		12.5	.92	15.0					
808	TA	G4	.350		.015	.005	PS	6.0000	.0328	0.0		12.5	.92	15.0					
809	TA	G4	.350		.015	.005	SG	5.0000	.0217	0.0		12.5	.92	15.0					
810	TA	G4	.350		.015	.005	PS	5.0000	.0283	0.0		12.5	.92	15.0					
811	TA	G4	.350		.015	.005	PS	4.1000	.0158	0.0		12.5	.92	15.0					
812	TA	G4	.350		.015	.005	PS	2.5000	.0148	0.0		12.5	.92	15.0					
813	TA	G4	.350		.015	.005	SG	3.8000	.0066	0.0		12.5	.92	15.0					
814	TA	G5	.517	.0148	.015	.005	SG	55.0000	47.8796	10.0	.937804	12.5	.92	15.0	17.54	.858	.626	.295	5.500
815	TA	G5	.517	.0148	.015	.005	SG	52.5000	38.7406	11.0	.582114	12.5	.92	15.0	14.11	.858	.626	.295	4.773
816	TA	G5	.517	.0148	.015	.005	PS	34.5000	7.4999	5.0	.407906	12.5	.92	15.0	3.056	.858	.626	.295	6.900
817	TA	G5	.517	.0148	.015	.005	PS	31.0000	6.7005	5.0	.291124	12.5	.92	15.0	2.263	.858	.626	.295	6.200
818	TA	G5	.517	.0148	.015	.005	SG	31.5000	7.9252	5.0	.268442	12.5	.92	15.0	2.339	.858	.626	.295	6.300
819	TA	G5	.517	.0148	.015	.005	PS	21.0000	2.0241	3.0	.151519	12.5	.92	15.0	.624	.858	.626	.295	7.000
820	TA	G5	.517	.0148	.015	.005	PS	26.5000	2.2285	3.0	.114819	12.5	.92	15.0	.719	.858	.626	.295	8.833
821	TA	G5	.517	.0148	.015	.005	PS	13.5000	.5049	1.0	.086284	12.5	.92	15.0	.105	.858	.626	.295	13.50
822	TA	G5	.517	.0148	.015	.005	PS	11.0000	.2822	1.0	.074778	12.5	.92	15.0	.091	.858	.626	.295	11.00
823	TA	G5	.517	.0148	.015	.005	PS	5.0000	.0185	0.0		12.5	.92	15.0		.858	.626	.295	
824	TA	G5	.517	.0148	.015	.005	PS	4.0000	.0114	0.0		12.5	.92	15.0		.858	.626	.295	

Appendix 3, 1995 Tatitlek, Nanwalek and Port Graham Shellfish Data

	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
825	TA	G5	.517	.0148	.015	.005	PS	4.0000	.0142	0.0		12.5	.92	15.0		.858	.626	.295	
826	TA	G5	.517	.0148	.015	.005	PS	3.0000	.0128	0.0		12.5	.92	15.0		.858	.626	.295	
827	TA	G6	.496		.015	.005	PS	41.5000	13.6336	7.0	.481443	12.5	.92	15.0	5.485				5.929
828	TA	G6	.496		.015	.005	PS	36.2000	8.9131	5.0	.291487	12.5	.92	15.0	3.528				7.240
829	TA	G6	.496		.015	.005	PS	33.8000	8.9691	4.0	.359368	12.5	.92	15.0	3.562				8.450
830	TA	G6	.496		.015	.005	PS	30.9000	5.8208	4.0	.273858	12.5	.92	15.0	2.206				7.725
831	TA	G6	.496		.015	.005	PS	29.9000	5.1698	3.0	.273936	12.5	.92	15.0	1.951				9.967
832	TA	G6	.496		.015	.005	PS	29.0000	5.5828	4.0	.244629	12.5	.92	15.0	2.023				7.250
833	TA	G6	.496		.015	.005	PS	29.9000	2.7866	3.0	.154407	12.5	.92	15.0	1.013				9.967
834	TA	G6	.496		.015	.005	PS	22.6000	2.3056	3.0	.112953	12.5	.92	15.0	.722				7.533
835	TA	G6	.496		.015	.005	PS	21.7000	1.7254	2.0	.117708	12.5	.92	15.0	.573				10.85
836	TA	G6	.496		.015	.005	PS	18.9000	.9370	2.0	.089513	12.5	.92	15.0	.357				9.450
837	TA	G6	.496		.015	.005	MI	18.0000	.9285	3.0	.130379	12.5	.92	15.0	.398				6.000
838	TA	G6	.496		.015	.005	MI	14.0000	.3323	2.0	.080331	12.5	.92	15.0	.093				7.000
839	TA	G6	.496		.015	.005	PS	5.0000	.0286	0.0		12.5	.92	15.0					
840	TA	G6	.496		.015	.005	PS	3.0000	.0216	0.0		12.5	.92	15.0					
841	TA	G6	.496		.015	.005	SG	3.2000	.0091	0.0		12.5	.92	15.0					
842	TA	G6	.496		.015	.005	SG	2.5000	.0068	0.0		12.5	.92	15.0					
843	TA	G7	.600		.015	.005	PS	31.1000	5.6298	3.0	.269146	12.5	.92	15.0	2.287				10.37
844	TA	G7	.600		.015	.005	SG	32.5000	5.4635	3.0	.195243	12.5	.92	15.0	2.613				10.83
845	TA	G7	.600		.015	.005	PS	28.1000	3.9857	3.0	.184621	12.5	.92	15.0	1.592				9.367
846	TA	G7	.600		.015	.005	PS	31.5000	4.9147	3.0	.318334	12.5	.92	15.0	2.011				10.50
847	TA	G7	.600		.015	.005	PS	28.0000	4.4531	3.0	.232625	12.5	.92	15.0	1.871				9.333
848	TA	G7	.600		.015	.005	SG	31.0000	3.7650	5.0	.151467	12.5	.92	15.0	1.607				6.200
849	TA	G7	.600		.015	.005	PS	24.5000	2.5075	3.0	.122563	12.5	.92	15.0	.920				8.167
850	TA	G7	.600		.015	.005	PS	24.5000	2.4572	3.0	.087476	12.5	.92	15.0	.730				8.167
851	TA	G7	.600		.015	.005	PS	22.1000	1.4227	3.0	.098706	12.5	.92	15.0	.572				7.367
852	TA	G7	.600		.015	.005	PS	15.1000	.5351	1.0	.062516	12.5	.92	15.0	.139				15.10
853	TA	G7	.600		.015	.005	PS	8.5000	.0740	0.0		12.5	.92	15.0					
854	TA	G7	.600		.015	.005	SG	4.3000	.0120	0.0		12.5	.92	15.0					
855	TA	H1	2.017		.015	.005	PS	40.5000	15.6630	6.0	.615296	12.5	.92	10.0	6.511				6.750
856	TA	H1	2.017		.015	.005	PS	40.2000	16.3212	7.0	.486493	12.5	.92	10.0	5.661				5.743
857	TA	H1	2.017		.015	.005	PS	33.5000	9.2474	4.0	.324011	12.5	.92	10.0	2.834				8.375
858	TA	H1	2.017		.015	.005	PS	31.4000	6.8244	4.0	.255152	12.5	.92	10.0	2.048				7.850
859	TA	H1	2.017		.015	.005	PS	32.0000	8.1568	5.0	.340848	12.5	.92	10.0	2.671				6.400
860	TA	H1	2.017		.015	.005	PS	29.8000	6.0745	4.0	.249245	12.5	.92	10.0	1.669				7.450
861	TA	H1	2.017		.015	.005	PS	27.8000	5.1256	4.0	.264547	12.5	.92	10.0	1.783				6.950
862	TA	H1	2.017		.015	.005	PS	26.0000	3.7276	3.0	.161583	12.5	.92	10.0	.924				8.667
863	TA	H1	2.017		.015	.005	PS	25.1000	3.9443	4.0	.215734	12.5	.92	10.0	1.128				6.275
864	TA	H1	2.017		.015	.005	PS	15.0000	.7151	2.0	.073564	12.5	.92	10.0	.140				7.500
865	TA	H1	2.017		.015	.005	PS	15.2000	.6616	2.0	.074184	12.5	.92	10.0	.129				7.600
866	TA	H1	2.017		.015	.005	PS	14.0000	.4481	2.0	.057603	12.5	.92	10.0	.085				7.000
867	TA	H1	2.017		.015	.005	PS	10.2000	.2675	1.0	.060958	12.5	.92	10.0	.054				10.20
868	TA	H2	1.350		.015	.005	PS	31.5000	9.7665	3.0	.392421	12.5	.92	10.0	3.200				10.50
869	TA	H2	1.350		.015	.005	PS	31.8000	7.6183	3.0	.304783	12.5	.92	10.0	2.591				10.60
870	TA	H2	1.350		.015	.005	PS	28.2000	5.2181	3.0	.278880	12.5	.92	10.0	1.326				9.400
871	TA	H2	1.350		.015	.005	PS	27.2000	5.0665	3.0	.274134	12.5	.92	10.0	1.522				9.067
872	TA	H2	1.350		.015	.005	PS	27.0000	4.0207	3.0	.199291	12.5	.92	10.0	1.178				9.000
873	TA	H2	1.350		.015	.005	PS	12.2000	.3947	1.0	.047609	12.5	.92	10.0	.044				12.20
874	TA	H2	1.350		.015	.005	PS	4.5000	.0157	0.0		12.5	.92	10.0					
875	TA	H3	.958	.0146	.015	.005	SG	24.2000	2.1476	3.0	.146883	12.5	.92	10.0	.951	.903	.565	.316	8.067
876	TA	H3	.958	.0146	.015	.005	PS	19.3000	.4843	1.0	.030950	12.5	.92	10.0	.135	.903	.565	.316	19.30
877	TA	H3	.958	.0146	.015	.005	HA	4.0000	.0063	0.0		12.5	.92	10.0		.903	.565	.316	
878	TA	H3	.958	.0146	.015	.005	PS	3.5000	.0099	0.0		12.5	.92	10.0		.903	.565	.316	
879	TA	H4	-1.100		.015	.005	MI	8.2000	.1075	1.0		12.5	.92	10.0					8.200
880	TA	H4	-1.100		.015	.005	MI	9.5000	.1000	1.0		12.5	.92	10.0					9.500

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	1 SITE	2 STATION	3 ELEV_	4 SED_TVS	5 H2O_TSS	6 H2O_TVS	7 SPECIES	8 LENGTH	9 WHOLE_WT	10 AGE	11 DRY_COND	12 OXYGEN	13 TURBID	14 RPD	15 ADJWE	16 TGRAV	17 TSAND	18 TFINE	19 GROIN
881	TA	H4	-1.100		.015	.005	PS	8.8000	.1377	0.0		12.5	.92	10.0					
882	PI	RANDOM					SG	70.0000	77.0000	13.0									5.385
883	PI	RANDOM					SG	63.0000	54.4000	11.0									5.727
884	PI	RANDOM					SG	53.0000	39.6000	9.0									5.889
885	PI	RANDOM					MT	55.5000	40.6000	9.0									6.167
886	PI	RANDOM					PS	52.0000	28.5000	9.0									5.778
887	PI	RANDOM					PS	52.0000	31.9000	9.0									5.778
888	PI	RANDOM					MT	54.0000	25.6000	7.0									7.714
889	PI	RANDOM					MT	50.5000	16.7000	7.0									7.214
890	PI	RANDOM					MT	49.0000	13.2000	8.0									6.125
891	PI	RANDOM					MT	45.0000	14.5000	6.0									7.500
892	PI	RANDOM					MT	43.0000	17.5000	6.0									7.167
893	PI	RANDOM					PS	40.8000	22.5000	9.0									4.533
894	PI	RANDOM					PS	39.5000	21.0000	7.0									5.643
895	PI	RANDOM					PS	34.1000	14.7000	5.0									6.820
896	PI	RANDOM					PS	35.5000	10.7000	5.0									7.100
897	PI	RANDOM					PS	31.5000	8.7000	4.0									7.875
898	PI	RANDOM					MT	37.5000	8.6000	6.0									6.250
899	PI	RANDOM					SG	30.8000	6.3000	5.0									6.160
900	PI	RANDOM					MT	41.0000	9.8000	4.0									10.25