Regional Operational Plan SF.2A.2013.10

Cook Inlet Razor Clam Study, 2013

by

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and

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May 2013

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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Alaska Department of Fish and Game
Division

May 2013

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Signature Page

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Project leader(s):	*Carol Kerkvliet and Michael Booz*
Division, Region, and Area	*Sport Fish, Region II, Homer*
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Approval

Title	Name	Signature	Date
Project leader	Carol Kerkvliet		4-16-13
Biometrician	Patricia Hansen		4/16/13
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INTRODUCTION

Beaches along the east side of Cook Inlet (Figure 1) provide the largest sport fishery for the Pacific razor clam, *Siliqua patula* (Dixon) in Alaska. This fishery is confined primarily to an 81 km section of beach bounded by the Kasilof River to the north and the Anchor River to the south.

The Alaska Department of Fish and Game (ADF&G) began monitoring this clam population in 1965 following the 1964 earthquake that caused subsidence of beaches in the Cook Inlet Area (Nelson unpublished). Initial studies included creel surveys, digger distribution surveys, and length-at-age analyses (Nelson unpublished). Annual digger distribution and proxy length and age of harvested clams are ongoing. Since 1977, annual harvest and fishery participation have been estimated with the Statewide Harvest Survey (SWHS) (Mills 1979-1980, 1981a-b, 1982-1994, Howe et al. 1995, 1996, 2001 a-d, Walker et al. 2003, Jennings et al. 2004, 2006a-b, 2007, 2009 a-b, 2010 a-b and 2011 a-b; Jennings et al In prep). Harvest has been apportioned by beach since 1977 using digger distribution estimates. Clam abundance was first estimated by Szarzi (1991). Szarzi estimated mean density (number per m^2), total abundance, and age and length composition of the population for Clam Gulch and Ninilchik beaches, and performed a catch-age analysis (CAGEAN) for Clam Gulch with data collected in 1988 and 1989. The data required for the catch-age analysis included harvest and age composition by beach, auxiliary information such as abundance, instantaneous fishing mortality, and estimates of natural mortality (Deriso et al. 1985, 1989). Clam density and abundance and length and age composition of the population were estimated for Clam Gulch again in 1990 (Athons 1992), 1999 (Szarzi et al. 2010) and 2008 (Szarzi and Hansen 2009). Density and abundance and length and age composition of the population at Ninilchik were estimated in 1990 through 1993, 1998, 2001, 2003, 2005, 2011 and 2012 (Szarzi 1991, Athons 1992, Athons and Hasbrouck 1994, Szarzi et al. 2010, Szarzi and Hansen 2009, and Kerkvliet et al. *in prep*).

Harvest was fairly stable between 1973 and 2004, varying between approximately 520,000 in 2004 and 1.3 million clams in 1995. The harvest declined to 349,180 clams in 2007, the lowest harvest reported since the inception of the SWHS (Figure 2). Use patterns since 1977 have changed; Clam Gulch received an average of 59% of the total annual effort from 1977-1985 (Athons and Hasbrouck 1994). Ninilchik has been consistently more popular than Clam Gulch since 1986, and since 2006 over 60% or the area harvest has been taken from the Ninilchik Beach (Table 1).

Shifts in effort and harvest are likely due to changes in abundance of clams among beaches and to the changes in availability of larger clams at Ninilchik (Athons 1992, Athons and Hasbrouck 1994, Szarzi et al. 2010). The growth rate is greater in the southern beaches resulting in clams that are larger at age at Ninilchik than at Clam Gulch (Nelson unpublished, Szarzi et al. 2010). Diggers shifted south to Ninilchik to take advantage of the larger clams found there through 1995. The average size of clams in department samples at Ninilchik declined after 1994; likely the result of new year-classes recruiting to harvestable size. The smaller average size of clams at Ninilchik was probably the impetus for diggers moving back to Clam Gulch after 1995. In 2005, a new age class appeared in large numbers in the Clam Gulch beach in conjunction with a die off of older, larger-sized clams coinciding with a decline in digger effort there and an increase at Ninilchik beaches and beaches south of

Ninilchik. Lower than average growth rates at beaches between Set Net Access and Cohoe beaches including Clam Gulch beach between 2005-2007 depressed clam sizes extending the period that diggers dug elsewhere to avoid small clams. From 2004-2011, the trend reversed again as more diggers moved from Clam Gulch back to Ninilchik and for the first time also more diggers moved south to Whiskey Gulch and Happy Valley.

Harvest estimates by beach are more precise after 1989 because more flights were conducted each year to estimate digger distribution. Harvest rates were 60% and 43% for exploitable sized clams (clams >80 mm) on the Ninilchik beach in 1989 and 1990 (Table 2; Szarzi 1991), respectively, raised concerns about over-exploitation of Ninilchik clams. Harvest rate declined to 17% in 1991 (Athons 1992) and 16% for 1992 (Athons and Hasbrouck 2004) as clams in the 1988 year class grew to harvestable size. The harvest rate increased to 30% in 1998 (Szarzi et al. 2010) because the 1988 year class was no longer present on the beaches in significant numbers. The harvest rate was 26% in 2001, 14% in 2003 (Szarzi et al. 2010) and 16% in 2005 (Szarzi 2009), perhaps due to the decline in harvest coupled with the appearance of another year class in the harvestable sized population.

Potential over-exploitation continues to be a concern at Ninilchik because exploitation rates peak periodically at higher levels between recruitment events. In contrast, harvest rates on the northern beaches at Clam Gulch have been relatively low since 1988 (Table 3). A new very large year class from broodyear (BY) 2008 appeared in large numbers in the Ninilchik beach in 2009-2010.

On November 17, 2010 large numbers of dead razor clams were reported washed up along the Ninilchik beach. In 2011 razor clam abundance was estimated on the Ninilchik North and South beach to assess impact of the recently observed die-off, through a cooperative agreement between department staff and Alaska Pacific University (APU) staff and students, (Table 2). The 2011 razor clam abundance was above average and the Ninilchik South beach accounting for approximately 59% of the total razor clam abundance. Approximately 81% of the razor clams estimated on the south beach were age-3 clams from BY2008. In 2012, razor clam abundance at Ninilchik South Beach was also assessed through a cooperative agreement between department staff and APU. The estimated abundance was roughly half of the 2011 estimate but within the historical range of abundances for Ninilchik South beach.

The regulations allow diggers to take the first 60 clams dug per day. This has been the limit since 1962, except from 2000 to spring 2003 when the daily bag limit was lowered to 45 clams because of concerns by local residents that the 60 clam limit encouraged the waste of clams. The possession limit was lowered from three to two daily bag limits in 2000 and is currently 120 clams.

Although the Eastside razor clam fishery is not thought to be at risk of over-exploitation (Szarzi and Hansen 2009), the large harvests, shifts in digger distribution and lack of information about the causes of population changes, prompt managers to continue seeking methods of forecasting the effect of harvest and high mortality events on future abundance of razor clams.

OBJECTIVES

1. Estimate the proportion of digger effort and the number of razor clams harvested at six beaches such that the estimates by beach are within the levels of precision give below 95% of the time:

	Relative Precision (%)	
Beach	Effort	Harvest
Whiskey Gulch	10	18
Happy Valley	7	17
Ninilchik	2	15
Oil Pad	8	17
Clam Gulch	12	16
Cohoe	10	18

2. Estimate the harvest of razor clams by age at Cohoe, Clam Gulch, Oil Pad Access, and Ninilchik such that absolute precision of the estimated harvest for any age is within 755 clams at Cohoe; 3,615 clams at Clam Gulch; 1,369 clams at Oil Pad Access; and 38,795 clams at Ninilchik 90% of the time
3. Estimate the abundance of razor clams on a section of the Ninilchik South Beach such that the estimate is within 20% of the true value 90% of the time.

SECONDARY OBJECTIVES

1. Estimate mean length-at-age for the major age classes.
2. Collect 150 ageable clams from Deep Creek and Whisky Gulch beach.
3. Assess spatial distribution and abundance of razor clams using ArcGIS mapping software for Ninilchik South Beach.

STUDY DESIGN

ESTIMATED HARVEST BY BEACH:

Six beaches along the east side of the Kenai Peninsula will be sampled for this project: Whiskey Gulch, Happy Valley, Ninilchik, Oil Pad Access, Clam Gulch, and Cohoe (Figure 1). Ninilchik beach is divided into three sub-beaches: Ninilchik Bar, Deep Creek to Lehman's (Ninilchik South Beach), and Lehman's to Set Net Access (Ninilchik North Beach). Clam Gulch is also divided into three sub-beaches: Tower to Bluff, Bluff to A-frame, and A-frame to South Extension, for a total of ten sampling sites. The Ninilchik Bar is located off the main beach between Deep Creek and the Ninilchik River and is only available to diggers on foot when the tide is lower than minus three feet. Lehman's is the first set of set net cabins that are located approximately 5.2 km north of the Ninilchik River. A beach access road is also present at this location. Set Net Access refers to a beach access road, located approximately 13.7 km south of the Clam Gulch access road. The Clam Gulch Tower is a communications tower, which is located on the bluff above the beach approximately 3.2 km south of the Clam Gulch Access Road. Bluff refers to a section of non-vegetated bluff located approximately 0.4 km south of Clam Gulch. The A-Frame is a set net cabin located approximately 1.6 km north of Clam Gulch. Southern Extension refers to where the southern extension of Cohoe Loop Road turns inland away from the bluff approximately 6.4 km north of Clam Gulch.

Harvest by beach will be estimated using total harvest from the Statewide Harvest Survey, apportioned to beach using relative numbers of diggers per beach. Digger counts will be adjusted by a relative digger success rate for each beach based on the estimates derived from digger interview survey conducted in 2009. Estimates will be calculated for each of two tidal strata and then combined. The first strata will include tides ranging from -1.0 to -2.9 feet and the second will include tides of -3.0 feet and lower. Between early April and late August 2013, 39 tides will be from -1.0 through -2.9 ft and 25 tides will be -3.0 ft or lower. A total of 14 flights will be made in 2013: 7 flights with tides of -1.0 through -2.9 ft and 7 flights with tides of -3.0 ft and lower (Table 4, Appendix A). Therefore, a digger count will be scheduled for approximately every 39/7 = 5.6 (5^{th} or 6^{th}) tide ranging from -1.0 through -2.9 ft and every 25/7 = 3.6 (3^{rd} or 4^{th}) tide of -3.0 ft and lower. Within each stratum, the tides selected for surveys will be over the entire season including shoulder (April and August) and peak (May-July) seasons and will include both weekday and weekend surveys. Although there are additional groupings of surveys within each stratum, only the tide strata will be used to apportion harvest by beach.

Data from aerial surveys of beaches in 2012 and overall estimates of razor clam harvest for 2007-2011 (Jennings et al. 2009 a-b, 2010 a-b, 2011 a-b and in prep) were used to calculate expected levels of precision for 2013 (Table 4). Estimates are expected to meet the precision criteria in Objective 1. Estimates will be more precise at the two stretches of beach used historically for catch-age analysis: Tower to A-Frame (at Clam Gulch) and Deep Creek to Lehman's (at Ninilchik South Beach).

Age composition has been estimated since 1977 on the east side beaches (Nelson unpublished). Six beaches will be sampled for age composition in 2013: Cohoe, Clam Gulch, Oil Pad Access, and Ninilchik, Deep Creek, and Whisky Gulch. Assuming 13 aerial counts will be conducted; sampling a minimum of 300 ageable clams per beach will achieve the absolute precision levels specified in Objective 2 (Table 5). Szarzi (1991) recommended 300 clams be sampled per beach to estimate age composition and mean length-at-age for the major age classes with adequate precision for use in catch-age analysis, should such an analysis be conducted.

ESTIMATED NINILCHIK SOUTH BEACH ABUNDANCE:

The Ninilchik South beach study area begins at the southern edge of the Ninilchik River mouth and extends 1.6 km south and is bounded by the gravel's edge at the top (east) and Cook Inlet at the bottom (west). The study area is divided into a 5x26 grid with 5 locations running north to south (perpendicular to the water line) and 26 stratum running east to west (parallel to the water line, Figure 3). Sample sites are located within each of the 130 grid cells. The sample sites are rectangular areas 5.53 m long by 0.79 m wide and within a site there are 7 possible 0.5 m^2 circular plots.

Abundance will be estimated independently for each stratum using a two-stage sampling design. The primary units are sites and the secondary units are plots within a site (Figure 3).

The first sample site, located within Location 1, Stratum 1, will be chosen randomly, all subsequent samples will be chosen systematically. Randomization for the first site will take place both parallel and perpendicular to the shoreline. Starting in the NW corner of the study area, the location of the first site will be determined by the intersection of two randomly chosen points; the first being a randomly chosen point along a 227 m line parallel to the shoreline and the second being a randomly chosen point along a 15.2 m line perpendicular to the shoreline. Subsequent samples will be taken systematically every 227 m along the line parallel to the beach (north to south) and every 15.2 m perpendicular to the beach (west to east).

At least three and up to seven 0.5 m^2 circular plots will be sampled at each sampling site. The number of plots sampled per site will depend on the tidal range, the rate at which the tide falls, and the beach substrate.

A systematic random sample will be used instead of a random sample because of the sampling time limitations due to tides and difficulty moving the pump long distances. The assumption is made that the systematic random sample can be treated as a simple random sample for the calculation of variance.

This same sample design was used to estimate abundance of razor clams in 2011 and 2012. Data collected in 2011 and 2012 was used to estimate the number of sites per stratum needed to meet the objective criteria of the razor clam abundance estimate. In 2011, 3 sites were sampled per stratum and the abundance and relative precision of the abundance estimate for the south beach was estimated to be 28%. A Monte Carlo simulation was used to add sites to each stratum and the abundance and relative precision was recalculated after each addition. Using this method we estimated that sampling 5 sites per stratum on Ninilchik South beach (maximum of 130 total sites, 390 – 910 total plots) would give an estimate with a relative precision of 20%., had a relative precision of 23%. When the 2012 data collected by ADF&G was combined with the data collected by APU, the realized abundance estimate, having sampled 10 sites per stratum, had a relative precision of 17%. The same sample size and sampling design used in 2012 will be In 2012 the realized abundance estimate, having sampled 5 sites per stratum used again in 2013 and we expect the relative precision to be similar to 2012.

ArcGIS will be used to assess spatial distribution and abundance of razor clams on Ninilchik South beach. This assessment will allow for a post stratification of the sampling to improve the abundance estimate and its variance. Possible stratifications include strata both perpendicular and parallel to the gravel's edge.

DATA COLLECTION

ESTIMATED HARVEST BY BEACH:

Aerial counts of clam diggers will be used to estimate proportion of diggers by beach following the project schedule (Appendix A). Days when flights cannot be made will be rescheduled on a similar tide level. Counts will be made of the specific beach areas as outlined in the aerial survey data sheet (Appendix B). The count will originate at Anchor River within ±15 minutes of low water at Deep Creek/Ninilchik and proceed north. As it is impossible to distinguish diggers from non-diggers, all persons associated with digging activity will be included in the count, even those traveling along the beach on all-terrain vehicles. Persons in highway vehicles and those associated with commercial fishing activities will not be included.

Age and size composition of the harvest will be estimated from clams hand dug from the six specified beaches. Samplers will walk throughout the beach area in a manner that mimics an average clam digger, rather than sampling from a relatively small specific area of beach. All clams dug will be retained regardless of size or condition, in compliance with State regulation.

Samples will be dug at Clam Gulch Beach between one quarter mile south to one half mile north of the access road. Oil Pad Access Beach will be sampled with half of the specimens obtained from the northern end and the other half obtained from the southern end of the beach. Half of the Ninilchik Beach sample will be dug south of the Ninilchik River. The second half of the Ninilchik sample will be dug north of the Ninilchik River. Additional clams will be taken from the Ninilchik Bar. Clams will be sampled from the northern end of Deep Creek beach within 2 miles of the Deep Creek access. Whisky Gulch samples will be dug 1 mile south of Stariski Creek.

A total of 350 clams will be dug at each beach to estimate age, total length, and length-at-age. At the Ninilchik Bar a total of 175 clams will be taken; at Cohoe, Deep Creek and Whisky Gulch beaches a total of 150 clams will be taken. Clams dug on the subsections of beach will be kept separate (Appendix C). This level of sampling will ensure that the target of 300 samples will be met by compensating for breakage in processing. As only one shell is required from each clam for measuring and aging, a clam with one unbroken shell can be utilized. Total length will be measured as closely as possible from clams that are broken and not ageable. Clams will be processed by removing the body from the shell, separating the two halves of the shell, retaining one half for aging and measuring, and bleaching the specimens to remove the periostracum to facilitate aging. Shells will be soaked in a 25% or 50% household bleach solution depending on shell size until most of the periostracum is removed but the heavy layers along the annuli remain. Shells less than 80 mm will be soaked in the weaker solution to prevent over bleaching. The bleach solution will then be poured off, the shells rinsed in water and dried for aging and measuring. Bags with clam shells for aging will be labeled with date collected, beach location, and number of shells. Overall length and length at each annulus will be measured to the nearest 0.01 mm and input directly into an Excel spreadsheet using Mitutoyo Digimatic Calipers.

Aging of each shell will follow methods described by Nelson (unpublished) following the recommendations of Coggins (1994). Three "expert" agers have established a training set of 150 razor clam shells collected in 2000 from Clam Gulch Beach and Ninilchik Beach. That age set has been supplemented with clams aged by experts in 2002 and 2003. The training set was aged three times by each expert to determine the modal age of the clam for each reader. Once a neophite ager attains an 80% repeatability on the training set (Coggins 1994:19), the shells collected in 2012 will be aged by the new ager.

Age will be determined for each shell at least two times by the new ager. Each reading of each shell will be independent: after determining age for the entire sample, the shells will be rearranged and age determined again so that the new ager has no idea of the age assigned to any shell during a previous examination. Any previous age determination will be unknown to the ager each time a sample is aged. The age of a clam will be considered final when the ages from two independent readings agree and the measurements of the annuli for each of the two readings are within ±2 mm of one another.

Time permitting, the technician that initially aged the shells in the training set will re-age the shells in the training set following the procedure detailed here. This approach will allow minimizing between-reader variability in comparing age composition with that of previous agers and evaluation of within-reader variability. Age composition will be estimated by using the age of each sample from the two readings. If two readings of the shell aren't the same, those shells will be aged again.

ESTIMATED NINILCHIK SOUTH BEACH ABUNDANCE:

Sampling to estimate abundance of razor clams at the Ninilchik South Beach will occur on days listed in Appendix D1. On a given day of sampling, all sites within a location will be sampled. Locations will be numbered from north to south and the order in which they are sampled will be scheduled to ensure that different tide height across the entire sample area (Figure 5; Appendix D1). The first sample site, located within Location 1, Stratum 1, will be chosen randomly and all subsequent samples will be taken systematically. After sampling 3-7 plots at the first site in Location 1, Stratum 1, the remaining sites within Location 1 (stratum 2–26) will be sampled every 15.2 m perpendicular to the beach (west to east). For all subsequent sampling days the location all sample sites will be 227 m south of the previous sample. If a sample site falls within a known coal seam with no razor clam habitat, the site will be moved approximately 100 m further south. On each sampling day the first sampling site will be located using a GPS and the coordinates listed in Appendix D2. Data will be entered on the data sheets in Appendix D3.

In addition to the sampling planned by the Department, students and staff from APU will provide additional sampling. Locations 1A-5A will be sampled using existing state equipment. Locations 1B-5B will be sampled using APU equipment. Sampling equipment will consist of a 4-cycle Honda pump with 30 m of firehose on the inlet (output) side and 12 m of stiff plastic hose on the outlet (intake) side (Figure 3). The outlet hose has a metal tube or "wand" attached to direct the flow of water into the substrate enclosed by a 0.5 m^2 sampling ring. This sampling equipment is described in greater detail by Szarzi (1991). APU sampling equipment will consist of the same components as described above.

A 0.5 m^2 sampling ring will be used to define the sample area for each plot. For each plot, substrate will be assessed for presence or absence of coal, clay, and/or gravel. The wand will be used to evaluate compaction using the following method. At full water pressure the wand will be balanced vertically on the beach, without any downward pressure at the center of the plot for 5 seconds to allow water from the wand to dig a hole that wand will drop into. The depth that the wand sinks will be measured to the nearest 10 cm (start depth). Once the plot is emulsified, the depth of the probe will again be measured to the nearest 10 cm (end depth). Compaction will be estimated as the difference between start depth and end depth.

The wand will be repeatedly inserted into the substrate inside the sample ring as far as the wand will penetrate. The substrate enclosed in the ring will be loosened such that all clams within the ring (sample area) will be flushed to the surface. Sampling will cease when the entire area within the ring is fluid and no clams have surfaced for approximately one minute.

A hand-held net with 2 mm mesh will be used to strain the loosened substrate to search for small clams not readily visible. All clams encountered inside the ring will be measured and then released. An attempt will be made to sample seven plots at each sample site before moving 15.2 m to the next site. A marker stake or flag will be placed at each site where less than seven plots were obtained with remaining plots sampled as the incoming tide floods the beach. The length of each clam captured from each plot will be recorded onto the datasheets.

A survey grade GPS (Trimble® AG132) will be used to collect GPS coordinates of the Ninilchik South Study area and at each sampled site. To define the study area, GPS coordinates will be collected along the transition from gravel to sand (starting side of study area) and along the water's line during slack tide of each survey. GPS coordinates will also be collected along the along the water's line during slack tide of the most extreme minus tides (-5.6 ft) of the season on May 7 and June 5. Additionally any areas that are not suitable razor clam habitat (large coal seams or areas with mostly gravel) will be surveyed, mapped and potentially removed from the sample area.

DATA REDUCTION

Digger counts will be recorded on an Aerial Survey Form (Appendix B), entered into an Excel workbook file, and converted to the angler count format in Appendix E for archiving. The survey form will be inspected for completeness and legibility after the completion of each flight. A clearly legible digger count should be recorded for each beach or sub-beach, including a zero for any beach or sub-beach where no diggers were observed. Counts key-punched into the workbook file will be compared to those on the survey form to edit any errors and note any counts that seem extraordinarily small or large. Counts in the workbook and mark-sense files will be compared to ensure all count data was properly converted into mark-sense format.

Age and length data will be directly recorded into an Access database containing the historical data and stored in three tables with the information detailed in the column headings in Appendix E for analysis.

Abundance data will be recorded on water proof data sheets (Appendix D3). Data collected for each Location will be recorded separately. After sampling the data will be proofed and entered into an Excel workbook.

The project biologist will examine each file for completeness (e.g., total length and length for each age – annulus – are recorded). Age data will be summarized by beach or sub-beach to detect any aberrant ages (e.g., < 0, ≥ 15). Minimum and maximum length by age will also be inspected for each beach or sub-beach to find any errors.

All count, age, length and digger success data along with an explanation of file structures will be archived on the Sport Fish network hard drive at O:\DSF\SprotF\Clam\razor clams\2013. Field notebooks and data sheets will be stored in the Homer office until final data analysis and archiving is complete.

All GPS data will be recorded directly into a handheld data logger and post processed in the Homer ADF&G office immediately after the survey is complete. Data will imported into ArcGIS and proofed against already collected GPS data. All GPS point data for the study area will be used to develop a polygon layer for the study. The estimate of area for Ninilchik South Beach will be produced from the polygon layer in ArcGIS. The GPS point data for the sampled sites will be converted into a point layer within ArcGIS and will include other sampling data such as number of sampled plots, number of clams found, and habitat information.

DATA ANALYSIS

ESTIMATED HARVEST BY BEACH:

Harvest by beach will be estimated by apportioning the total harvest estimate from the Statewide Harvest Survey. Aerial counts of diggers will be collected as a stratified, two-stage sampling design with high-low tides (-1.0 to –2.9 ft) and low-low tides (-3.0 ft and lower) as the two strata, flights as the primary units, and diggers as the secondary units. Primary units (flight days) will not be chosen randomly, but will be spread out systematically through time.

Success rate of diggers varies by beach, so a crude adjustment for success rate will be made to estimate harvest by beach. Digger counts for each beach will be multiplied by the relative digger success rate ($\hat{I}_b$) estimated for each beach based on digger interviews conducted in 2009 (Appendix F) to give adjusted digger counts:

$$d_{tbk} = \hat{I}_b A_{tbk} ; \tag{1}$$

where:

d_{tbk} = the adjusted digger count during flight k on beach b in tidal stratum t;

$\hat{I}_b$ = the harvest success rate for beach b; and

A_{tbk} = the number of diggers counted during flight k on beach b in tidal stratum t.

The relative harvest on beach b during flight k of tidal stratum t will be estimated by:

$$r_{tbk} = \frac{d_{tbk}}{d_{tk}} ; \tag{2}$$

where:

d_{tk} = the total adjusted digger count during flight k in tidal stratum t;

$= \sum_{b=1}^{n} d_{tbk}$; and

n = the total number of beaches.

The average relative harvest on beach b in tidal stratum t ($\bar{r}_{tb}$) will be estimated, incorporating the sample weights (w_{tk}) that adjust the proportions for different total numbers of diggers during different flights:

$$\bar{r}_{tb} = \frac{\sum_{k=1}^{c_t} w_{tk} r_{tbk}}{c_t} ; \tag{3}$$

where:

w_{tk} = the sample weight of flight k in tidal stratum t,

$$= \frac{d_{tk}}{\bar{d}_t};$$

$$\bar{d}_t = \frac{\sum_{k=1}^{c_t} d_{tk}}{c_t}; \text{ and,}$$

c_t = the number of flights taken in tidal stratum t.

The number of diggers is probably related to the size of the minus tide. Since heights of tides run in cycles and selection of flights is not random, but "pseudo-systematic", number of diggers (sample weights) are probably cyclic. Therefore a successive difference estimator (Wolter 1985) will be used to estimate the variance of $\bar{r}_{tb}$:

$$\hat{V}[\bar{r}_{tb}] = \left\{1 - \frac{c_t}{m_t}\right\}\left\{\frac{\sum_{k=2}^{c_t}\left(w_{tk}r_{tbk} - w_{tb(k-1)}r_{tb(k-1)}\right)^2}{2c_t\left(c_t - 1\right)}\right\}; \quad (4)$$

where:

m_t = the number of tides in tidal stratum t.

The average relative harvest on beach b ($\bar{r}_b$) will then be estimated, incorporating stratum weights (W_t) that adjust the proportions for different numbers of tides and different average numbers of diggers in each tidal stratum:

$$\bar{r}_b = \sum_{t=1}^{2} W_t \bar{r}_{tb}; \quad (5)$$

where:

$\hat{W}_t$ = the weight for tidal stratum t,

$$= \frac{m_t \bar{d}_t}{\sum_{t=1}^{2} m_t \bar{d}_t}.$$

The estimated harvest for beach b ($\hat{H}_b$) is:

$$\hat{H}_b = \bar{r}_b \hat{H}; \quad (6)$$

where:

$\hat{H}$ is the estimate of harvest of razor clams between Kasilof and Anchor Point from the 2011 Statewide Harvest Survey.

Its variance is estimated following Goodman (1960):

$$\hat{V}\left[\hat{H}_b\right] = \bar{r}_b^2\hat{V}\left[\hat{H}\right] + \hat{H}^2\hat{V}\left[\bar{r}_b\right] - \hat{V}\left[\hat{H}\right]\hat{V}\left[\bar{r}_b\right]; \tag{7}$$

where:

$\hat{V}\left[\hat{H}\right]$ is the variance of the Statewide Harvest Survey estimate; and

$$\hat{V}\left[\bar{r}_b\right] = \sum_{t=1}^{2}\hat{W}_t^2\hat{V}\left[\bar{r}_{tb}\right]. \tag{8}$$

To estimate the harvest by age class, the proportion of clams in age class i on beach b will be estimated by:

$$\hat{p}_{bi} = \frac{n_{bi}}{n_b}; \tag{9}$$

where:

n_{bi} = the number of clams sampled of age class i from beach b; and

n_b = the total number of ageable clams in the sample from beach b.

The variance of the proportion will be estimated by (Cochran 1977):

$$\hat{V}\left[\hat{p}_{bi}\right] = \frac{\hat{p}_{bi}\left(1-\hat{p}_{bi}\right)}{n_b - 1}. \tag{10}$$

Harvest of age class i on beach b will be estimated by:

$$\hat{H}_{bi} = \hat{p}_{bi}\hat{H}_b; \tag{11}$$

with variance (Goodman 1960):

$$\hat{V}\left[\hat{H}_{bi}\right] = \hat{p}_{bi}^2\hat{V}\left[\hat{H}_b\right] + \hat{H}_b^2\hat{V}\left[\hat{p}_{bi}\right] - \hat{V}\left[\hat{p}_{bi}\right]\hat{V}\left[\hat{H}_b\right]. \tag{12}$$

Currently the variance around the relative digger success rate $\left(\hat{I}_b\right)$ is ignored. This will cause an underestimate in the variances of all calculations that use, or are derived from, the relative digger success rate. An attempt will be made to incorporate a closed form estimate of the $V\left(\hat{I}_b\right)$ where appropriate. If no closed form estimate can be found, bootstrapping and/or simulations will be used to estimate the variance.

ESTIMATED ABUNDANCE NINILCHIK SOUTH BEACH:

The number of clams ≥80 mm in each stratum will be estimated as:

$$\hat{N}_b = S_b \hat{\bar{N}}_b \tag{13}$$

where:

S_b = the number of possible sites in area stratum *b*,

$\hat{\bar{N}}_b$ = mean estimated abundance of sites in area stratum *b,*

$$\hat{\bar{N}}_b = \frac{\sum_{i=1}^{s_b} \hat{N}_{bi}}{s_b} \tag{14}$$

s_b = the number of sites sampled in area stratum *b,*

$\hat{N}_{bi}$ = the estimated abundance of clams in site *i,* area stratum *b,*

$$\hat{N}_{bi} = P_{bi} \hat{\bar{N}}_{bi} \tag{15}$$

P_{bi} = the number of possible plots at site *i* in area stratum *b*

$\hat{\bar{N}}_{bi}$ = mean estimated abundance of plots in site *i,* area stratum *b,*

$$\hat{\bar{N}}_{bi} = \frac{\sum_{j=1}^{p_{bi}} \hat{N}_{bij}}{p_{bi}} \tag{16}$$

$\hat{N}_{bij}$ = the estimated abundance in plot *j*, site *i,* area stratum *b,*

p_{bi} = the number of plots sampled at site *i* in area stratum *b*

with variance:

$$Var\left[\hat{N}_b\right] = \left(1 - f_{1b}\right) S_b^2 \frac{s_{1b}^2}{s_b} + f_{1b}^{-1} P_{bi}^2 \sum_{i=1}^{s_b} \left[\left(1 - f_{2bi}\right) \frac{s_{2bi}^2}{p_{bi}} \right] \tag{17}$$

where:

$$s_{1b}^2 = \frac{\sum_{i=1}^{s_b} \left(\hat{N}_{bi} - \hat{\bar{N}}_b\right)^2}{s_b - 1}$$ the variance among sites,

$$s_{2bi}^2 = \frac{\sum_{j=1}^{p_{hi}} \left(\hat{N}_{bij} - \hat{N}_{bi(j-1)}\right)^2}{p_{bi} - 1}$$ the variance among plots within a site,

$f_{1b} = \frac{s_b}{S_b}$ the number of sites sampled in a stratum relative to the total possible sites, and

$f_{2bi} = \frac{p_{bi}}{P_{bi}}$ the number of plots sampled in a site relative to the total possible plots.

The abundance of clams on the entire south beach will be the sum of the number of clams in each stratum:

$$\hat{N}_a = \sum_{b=1}^{B} \hat{N}_b \tag{18}$$

The variance of abundance of clams on the south beach will be estimated by:

$$V\left(\hat{N}_a\right) = \sum_{b=1}^{B} V\left(\hat{N}_b\right). \tag{19}$$

Adjacent strata with similar clam densities may be combined to reduce the variance of the overall abundance estimate. Evaluation to determine if strata should be combined will include testing for differences in mean clams per site between strata (2-sample t-test) and examination of changes in the abundance estimate.

ANNUAL EXPLOITATION RATE:

Annual exploitation will be computed by dividing the total estimate of harvest of the abundance sample area by the total estimate of abundance for this same area. Survey estimates of exploitation rates will be converted to instantaneous fishing mortality by solving the Baranov catch equation (Deriso et al. 1989) for fishing mortality using abundance estimates from the density samples.

SCHEDULES AND REPORTS

A schedule for conducting digger counts and collecting shells for age and length data appears in Appendix A. Processing and aging shells will occur inseason as time permits and during August. A report summarizing the results of data collected in 2009 - 2013 will be completed by March, 2014 and published in the ADF&G Sport Fishery Data Series.

RESPONSIBILITIES

List of Personnel and Duties:

1. Carol Kerkvliet, Assistant Area Management Biologist, ADF&G
   Duties: Project leader. Overall project supervision. Will prepare operational plan, administer the project budget, hire seasonal field staff, assist with field sampling, conduct digger counts, and write the report.

2. Patricia Hansen, Biometrician, ADF&G
   Duties: Technically reviews study design, sampling methods, and data analysis of operational plan, and reviews report. Will provide assistance in drafting operational plan and technical assistance inseason should changes in the design be necessary.

3. Michael Booz, Fisheries Biologist I, Project Assistant, ADF&G
   Duties: Assist with operational planning, train project technicians, participate in project activities and assist with data analysis, summarization and reporting.
4. Tim Blackmon, Fisheries Technician III
   Duties: Crew leader. Oversee and participate in the collection of field data as outlined in operational plan, including biological sampling and specimen processing. Responsible for maintenance and repair of sampling equipment.
5. Brad Harris PhD, Assistant Professor of Marine Biology
   Duties: Schedule Alaska Pacific University students to assist area staff with five days of field sampling. Responsible for insuring that the students collect the field data as outlined in the operational plan, including biological sampling and specimen processing.
6. Other assisting personnel
   Duties: Will collect field data as outlined in operational plan, including biological sampling and specimen processing. Responsible for maintenance and repair of sampling equipment.

BUDGET

Line Item	Category	Budget ($K)
100	Personal Services	0.0
200	Travel	0.0
300	Contractual Services	4.0
400	Commodities	0.0
500	Equipment	0.0
Total		4.0

Budget Manager: Carol Kerkvliet

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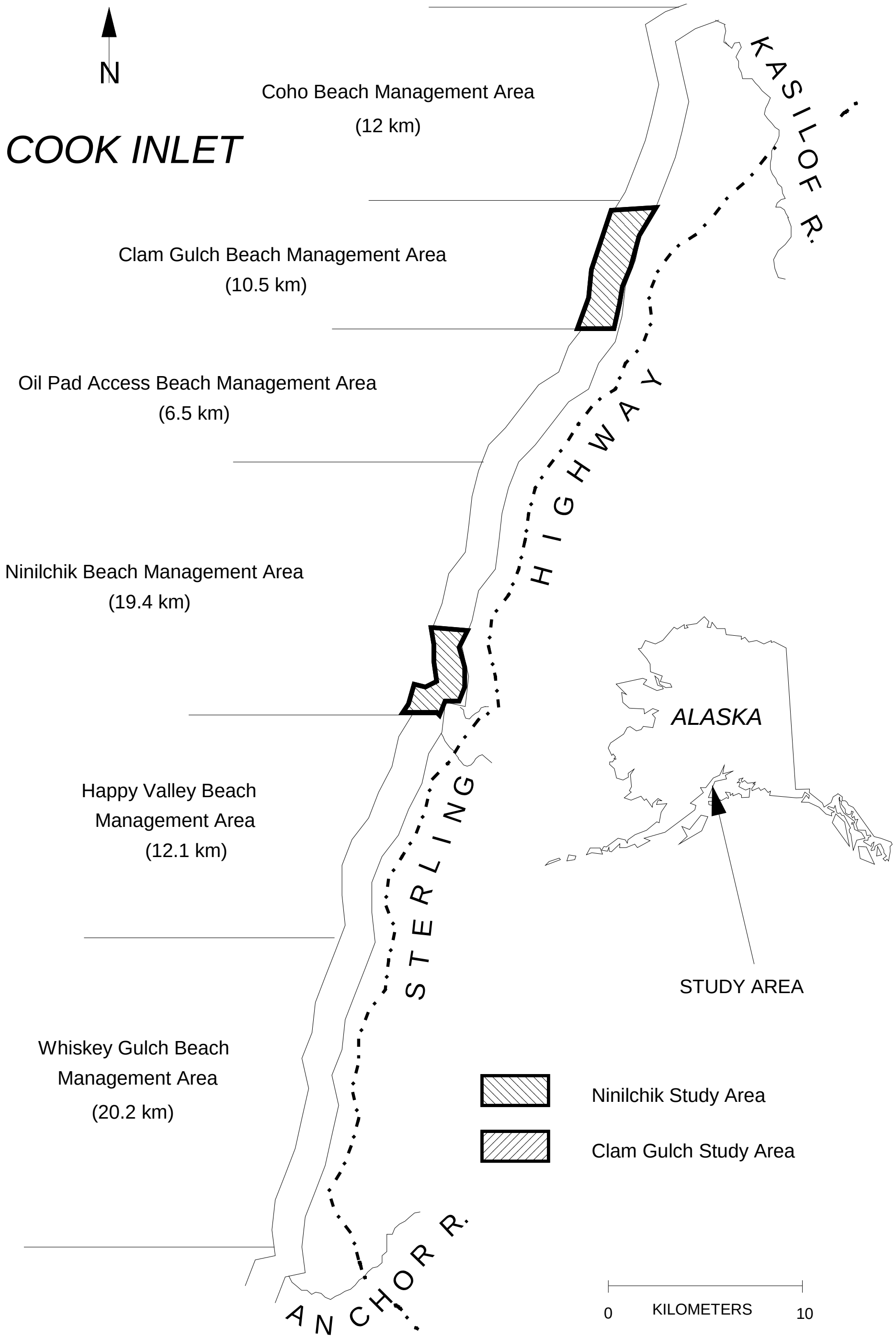

Figure 1.–Map of Kenai Peninsula showing Eastside beaches.

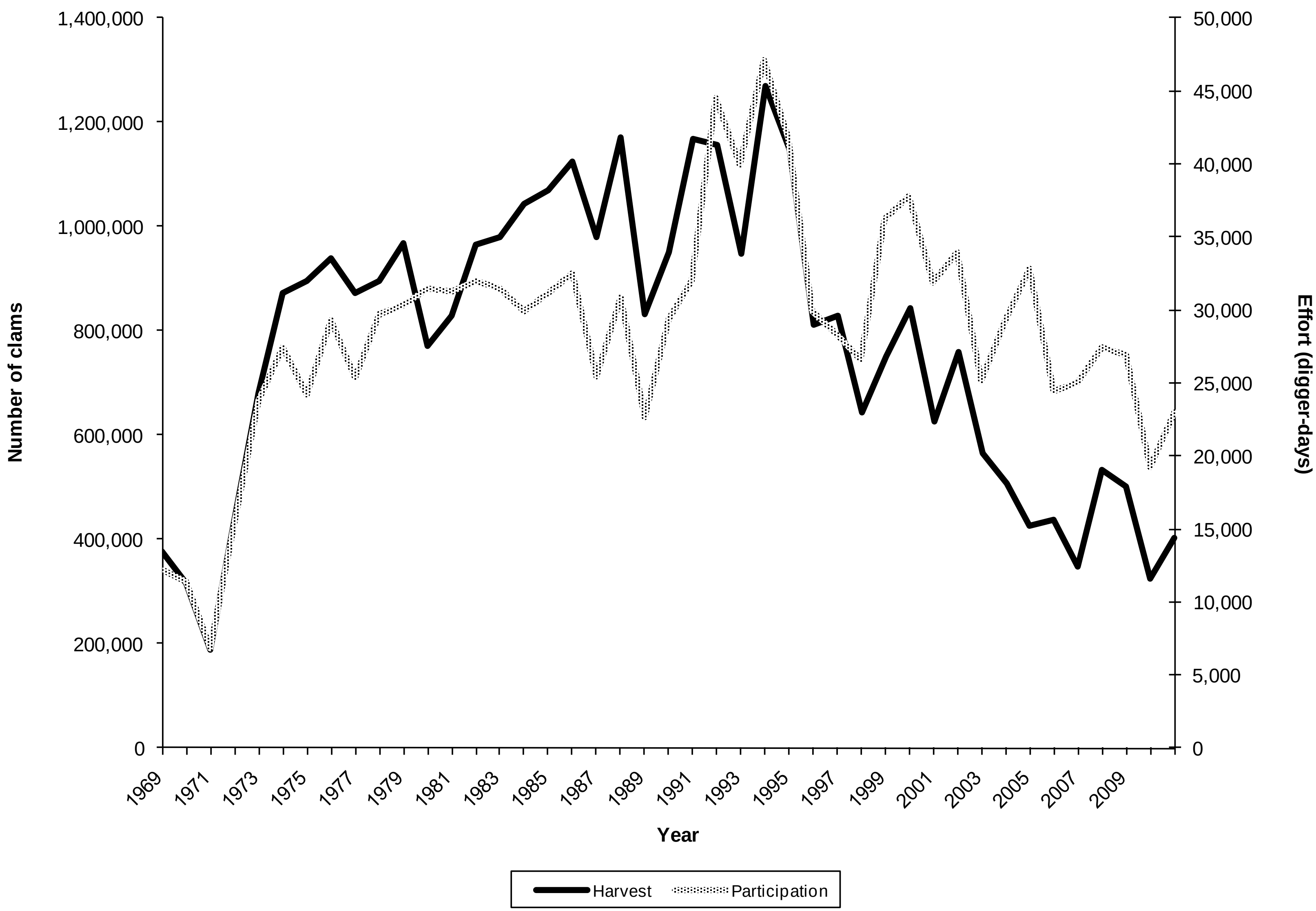

Figure 2.–Harvest and participation in the recreational razor clam fishery on eastside Cook Inlet beaches, 1969-2011.

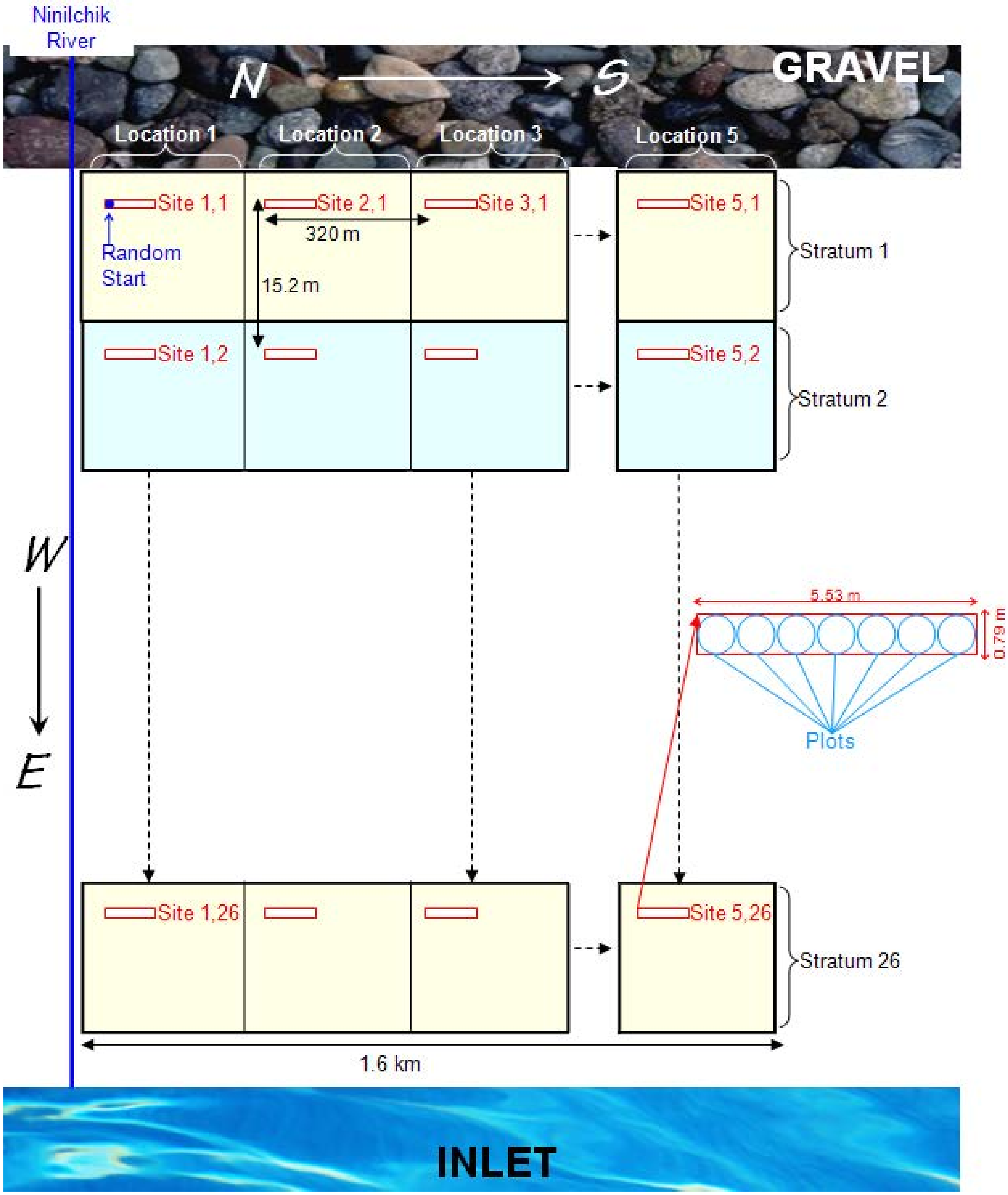

Figure 3.–Diagram of density pump plot/site/stratum sample design (not to scale).

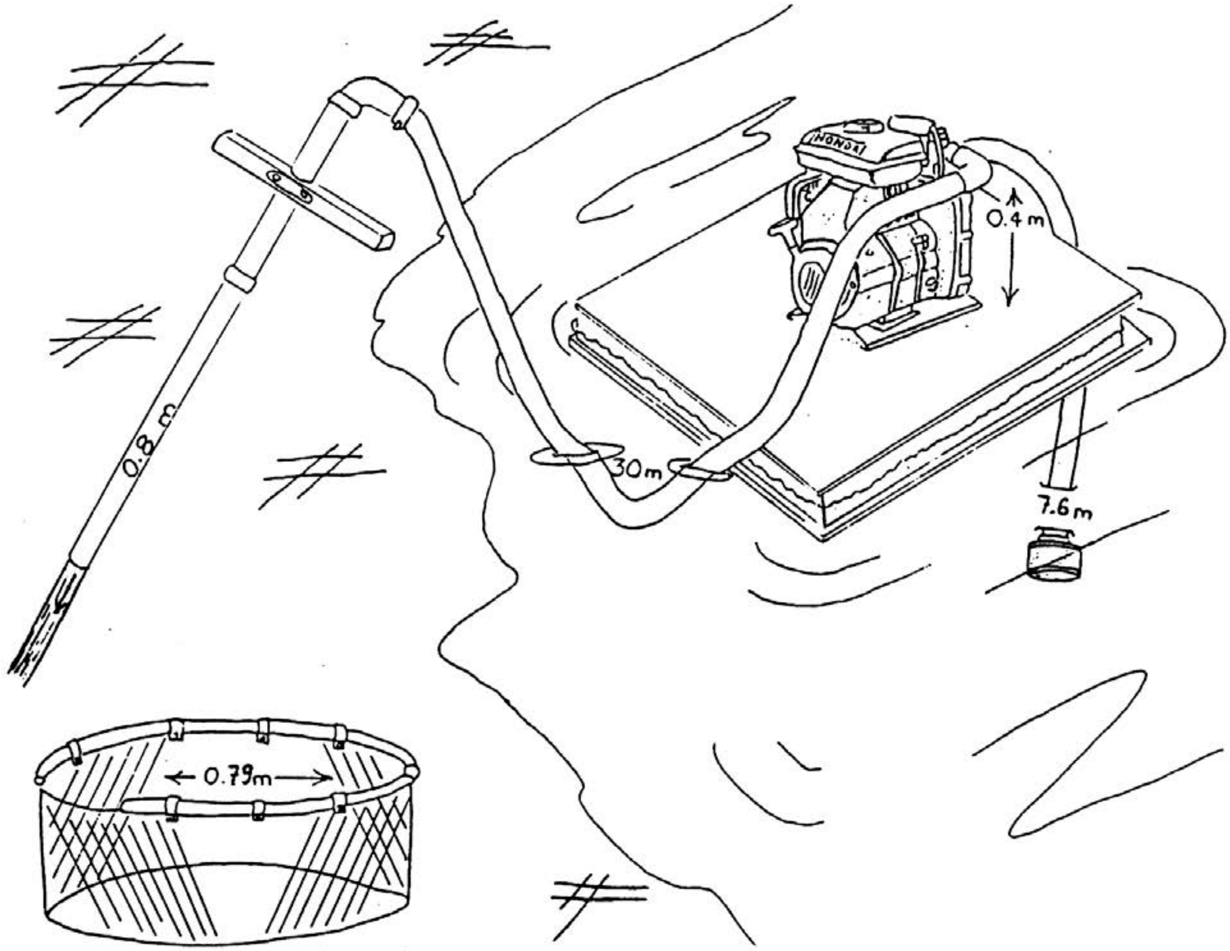

Figure 4.–Diagram of density pump generator and sample ring.

Figure 5.–Ninilchik South Beach sampling locations.

Table 1.–Percentage of razor clam harvest by beach in the eastside Cook Inlet adjusted for relative success rate, 2004-2011.

		Beach Area					
Year	No. of surveys	Cohoe	Clam Gulch	Oil Pad	Ninilchik	Happy Valley	Whiskey Gulch
2004	12	1.2	30.5	16.2	44.8	5.1	2.3
2005	13	0.9	26.4	10.0	53.2	6.3	3.3
2006	14	0.3	18.1	7.4	62.9	6.7	4.6
2007	14	0.5	12.2	3.5	68.1	9.8	6.0
2008	15	0.3	12.7	4.2	68.0	10.6	4.2
2009	12	0.7	5.9	4.3	74.5	11.1	3.4
2010	12	1.1	10.6	7.5	60.0	12.5	8.2
2011	13	1.1	8.4	4.1	75.0	9.4	2.0
Average	13	0.8	15.6	7.1	63.3	8.9	4.2

Table 2.–Estimates of harvest, total abundance and exploitation rate of razor clams from Deep Creek to Lehman's at Ninilchik.

Year	Ninilchik Harvest (H)						Total Ninilchik Abundance (N)						Ninilchik Exploitation (E)					
	South [a]	se(H)	North [b]	se(H)	Total [c]	se(H)	South [a]	se(N)	North [b]	se(N)	Total [c]	se(N)	South	se(E)	North	se(E)	Total [c]	se(E)
1989[d]	NA		NA		334,389	18139	NA		NA		1,922,958	291,507	NA		NA		17	3
1990	NA		NA		321,354	26,342	765,393	151,054	1,731,726	387,083	2,497,119	415,512	NA		NA		13	2
1991	NA		NA		354,583	20,952	359,121	61,864	1,925,040	358,419	2,284,161	363,719	NA		NA		16	3
1992	NA		NA		563,709	24,690	367,525	64,457	3,384,287	995,770	3,751,812	997,854	NA		NA		15	4
1998	NA		NA		287,423	15,845	557,532	88,693	960,216	92,412	1,517,748	128,088	NA		NA		19	2
2001	NA		NA		219,972	12,371	679,297	81,756	763,019	124,378	1,442,316	148,842	NA		NA		15	2
2003	NA		NA		210,385	14,293	907,637	234,998	3,479,560	604,036	4,387,197	648,139	NA		NA		5	1
2005	NA		NA		220,171	15,042	1,137,633	137,392	1,366,433	461,404	2,504,066	481,426	NA		NA		9	2
2011	145,801	12,458	175,970	14,001	326,451	24,998	1,724,792	378,807	1,197,529	275,290	2,922,321	429,751	8	2	15	4	11	2
2012	Not Available						786,209	81,069	Not Available									
Average					315,382	19,186	809,460	142,232	1,850,976	412,349	2,581,078	433,871					13	2

Year	Ninilchik Harvest (H)						Ninilchik Abundance (N) of clams>80 mm						Ninilchik Exploitation (E)					
	South [a]	se(H)	North [b]	se(H)	Total [c]	se(H)	South [a]	se(N)	North [b]	se(N)	Total [c]	se(N)	South	se(E)	North	se(E)	Total [c]	se(E)
1989[d]	NA		NA		334,389	18139	NA		NA		559,252	113,278	NA		NA		60	13
1990	NA		NA		321,354	26,342	159,151	38,329	582,311	198,513	741,462	202,179	NA		NA		43	12
1991	NA		NA		354,583	20,952	305,853	60,606	1,823,126	349,973	2,128,979	355,182	NA		NA		17	3
1992	NA		NA		563,709	24,690	302,460	61,361	3,342,597	1,000,220	3,645,057	1,002,100	NA		NA		15	4
1998	NA		NA		287,423	15,845	368,058	70,718	596,052	155,082	964,109	170,445	NA		NA		30	6
2001	NA		NA		219,972	12,371	290,741	63,158	541,710	97,513	832,451	116,180	NA		NA		26	4
2003	NA		NA		210,385	14,293	300,586	91,075	1,231,898	322,909	1,532,484	335,507	NA		NA		14	3
2005	NA		NA		220,171	15,042	517,167	73,120	858,999	339,802	1,376,166	347,580	NA		NA		16	4
2011	145,801	12,458	175,970	14,001	326,451	24,998	1,563,869	372,696	1,136,374	263,080	2,700,243	2,769,269	9	2	15	4	12	12
2012	Not Available						742,314	77,034	Not Available									
Average					315,382	19,186	505,578	100,900	1,264,133	340,886	1,608,911	601,302					26	7

NA indicates data is not available

Note: Abundance and exploitation rate estimates and their standard errors are corrected from previous publications

[a] South is defined as beach section from Deep Creek to the Ninilchik River.

[b] North is defined as beach section from the Ninilchik River to Lehman's Point.

[c] Total is defined as beach section from Deep Creek to Lehman's Point.

[d] Harvest estimated as the product of the proportion of average total beach harvest that occurred in 1990-1999 in the smaller beach area and the average harvest of the entire beach in 1990-1999. Variance estimated as the product of the square of the harvest estimate and the average squared coefficient of variation (CV).

Table 3.–Estimates of harvest (H), exploitable (> 80mm) and total abundance (N), and exploitation rate (Exp) of the population with standard errors of razor clams from Tower to A-frame at Clam Gulch Beach.

Beach	Year	H	se(H)	N	se(N)	Exp	se(Exp)
Total	1988[a]	286,375	14,646	7,240,569	999,223	0.040	0.006
	1989[a]	224,173	11,465	8,093,750	540,227	0.028	0.002
	1999	185,144	10,286	9,191,769	587,435	0.020	0.002
	2008[b]	40,077		3,608,278	347,627	0.011	
Exploitable	1988[a]	286,375	14,646	2,463,695	607,132	0.116	0.292
	1989[a]	224,173	11,465	4,773,362	371,752	0.047	0.004
	1999	185,144	10,286	4,052,949	217,262	0.046	0.004
	2008[b]	40,077		1,391,378	192,506	0.029	

Note: Abundance and exploitation rate estimates and their standard errors are corrected from previous publications that contained estimates for a larger beach area.

[a] Harvest estimated as the product of the proportion of average total beach harvest that occurred in 1990-1999 in the smaller beach area and the average harvest of the entire beach in 1990-1999 in the smaller beach area and the average harvest of the entire beach in 1990-1999.

[b] Harvest estimated from 2007.

Table 4.–Expected estimate, standard error (SE), and percent relative precision (RP) of relative digger effort (R_b) and razor clam harvest (H_b) by beach based on number of aerial counts of diggers during two tidal strata in 2013.

	Number aerial counts[a]		Effort			Harvest[b]		
Beach	-1.0 to -2.9	≤ -3.0	Rb	SE	RP[c]	Hb	SE	RP[c]
1. Whiskey Gulch	7	7	0.0178	0.0009	10	7,959	731	18
2. Happy Valley			0.0884	0.0032	7	39,494	3,385	17
3A. Ninilchik Bar			0.0060	0.0013	43	2,699	624	45
3B. Deep Creek to Lehmans			0.7246	0.0083	2	323,724	25,475	15
3C. Lehmans to Access			0.0045	0.0009	38	1,988	418	41
3. Ninilchik total			0.7351	0.0084	2	328,412	25,486	15
4. Oil Pad Access			0.0478	0.0020	8	21,351	1,891	17
5A. Tower to Bluff			0.0441	0.0042	19	19,683	2,406	24
5B. Bluff to A-frame			0.0351	0.0040	22	15,690	2,171	27
5C. A-frame to S. Extension			0.0141	0.0013	18	6,312	752	23
5. Clam Gulch total			0.0933	0.0059	12	41,685	3,327	16
6. Cohoe			0.0176	0.0009	10	7,866	736	18

[a] Tidal stratum of tides between -1.0 to -2.9 (n = 7 in 2013) and those of -3.0 and lower (n = 7 in 2013).

[b] Based on estimated average harvest from 2008-2011 of 446,767 razor clams and average squared coefficient of variation of 0.0061 (K. Sundet, Alaska Department of Fish and Game, Anchorage, personal communication).

[c] Relative precision of both estimates based on a 95% confidence interval.

Table 5.–Expected estimates, variances, and precision of harvest of razor clams by age and beach in 2013.

			2012 data[b]			Expected 2013 Estimates						
Beach	Hb[a]	Var(H[b])	Age	n_{bi}	Prop	Age	p_{bi}	Var(p_{bi})	H_{bi}	Var(H_{bi})	RP[c]	AP[d]
Ninilchik (not including Bar)												
	325,713	649,142,555	1	0	0.00	1	0.00	0.00000	0	0		
			2	0	0.00	2	0.00	0.00000	0	0		
			3	6	0.02	3	0.02	0.00006	6,107	6,716,258	0.70	4,263
			4	293	0.92	4	0.02	0.00006	5,993	6,588,410	0.70	4,222
			5	1	0.00	5	0.90	0.00031	292,639	556,176,265	0.13	38,795
			6	14	0.04	6	0.00	0.00001	999	1,084,129	1.71	1,713
			7	5	0.02	7	0.04	0.00014	13,983	15,685,208	0.47	6,515
			8	1	0.00	8	0.02	0.00005	4,994	5,476,402	0.77	3,850
			9	0	0.00	9	0.00	0.00001	999	1,084,129	1.71	1,713
			10+	0	0.00	10+	0.00	0.00000	0	0		
			Sum	320	1.00		1.00					
Oil Pad Access (North and South)												
	21,351	3,577,084	1	0	0.00	1	0.00	0.00000	0	0		
			2	1	0.00	2	0.00	0.00001	62	4,377	1.77	109
			3	111	0.32	3	0.00	0.00001	61	4,364	1.77	109
			4	110	0.32	4	0.32	0.00073	6,810	692,528	0.20	1,369
			5	49	0.14	5	0.32	0.00072	6,749	684,414	0.20	1,361
			6	46	0.13	6	0.14	0.00040	3,006	253,926	0.28	829
			7	24	0.07	7	0.13	0.00038	2,822	236,027	0.28	799
			8	4	0.01	8	0.07	0.00021	1,473	114,144	0.38	556
			9	2	0.01	9	0.01	0.00004	245	17,660	0.89	219
			10+	0	0.00	10+	0.01	0.00002	123	8,762	1.25	154
			Sum	347	1.00		1.00					
Clam Gulch (Tower to A-frame)												
	35,373	10,504,051	1	0	0.00	1	0.00	0.00000	0	0		
			2	25	0.08	2	0.08	0.00025	2,881	380,060	0.35	1,014
			3	8	0.03	3	0.07	0.00023	2,646	345,958	0.37	968
			4	202	0.66	4	0.02	0.00008	847	102,970	0.62	528
			5	48	0.16	5	0.60	0.00080	21,379	4,829,301	0.17	3,615
			6	11	0.04	6	0.14	0.00041	5,080	727,044	0.28	1,403
			7	11	0.04	7	0.03	0.00011	1,164	143,461	0.54	623
			8	2	0.01	8	0.03	0.00011	1,164	143,461	0.54	623
			9	0	0.00	9	0.01	0.00002	212	25,060	1.23	260
			10+	0	0.00	10+	0.00	0.00000	0	0		
			Sum	307	1.00		1.00					
Cohoe												
	7,866	542,261	1	0	0.00	1	0.00	0.00000	0	0		
			2	9	0.05	2	0.05	0.00034	419	22,291	0.59	246
			3	15	0.09	3	0.05	0.00032	397	21,085	0.60	239
			4	80	0.47	4	0.08	0.00052	661	35,511	0.47	310
			5	63	0.37	5	0.45	0.00166	3,525	210,712	0.21	755
			6	2	0.01	6	0.35	0.00153	2,776	161,545	0.24	661
			7	0	0.00	7	0.01	0.00007	88	4,628	1.27	112
			8	0	0.00	8	0.00	0.00000	0	0		
			9	0	0.00	9	0.00	0.00000	0	0		
			10+	0	0.00	10+	0.00	0.00000	0	0		
			Sum	169	1.00		1.00					

[a] Expected razor clam harvest and variance assuming 7 aerial counts during tides between -1.0 and -2.9 feet and 7 counts during tides of -3 feet and lower.

[b] Number and proportion of razor clams of each age class in 2012.

[c] Relative precision of estimated harvest by age on each beach with a 90% confidence interval.

[d] Absolute precision of the estimated harvest calculated as the product of the estimated harvest and relative precision.

Appendix A.–Razor clam sampling schedule, 2013.

Date	Day	Time	Tide (Ft)	Tide Strata	Groupings Day	Groupings Season	Aerial Survey	Age Length	Pump Abundance
4/9	Tuesday	9:32 AM	-2.0	low	weekday	shoulder	x		
4/11	Thursday	10:09 AM	-2.6	low	weekday	shoulder			
4/12	Friday	10:45 AM	-2.7	low	weekday	shoulder			
4/13	Saturday	11:19 AM	-2.3	low	weekend	shoulder			
4/14	Sunday	11:54 AM	-1.5	low	weekend	shoulder			
4/24	Wednesday	9:03 AM	-1.6	low	weekday	shoulder			
4/25	Thursday	9:44 AM	-3.2	high	weekday	shoulder			x
4/26	Friday	10:25 AM	-4.4	high	weekday	shoulder			x
4/27	Saturday	11:08 AM	-4.9	high	weekend	shoulder	x		x
4/28	Sunday	11:53 AM	-4.6	high	weekend	shoulder			x
4/29	Monday	12:41 PM	-3.7	high	weekday	shoulder			x
4/30	Tuesday	1:34 PM	-2.3	low	weekday	shoulder			
5/7	Tuesday	8:33 AM	-1.0	low	weekday	peak			
5/8	Wednesday	9:12 AM	-1.8	low	weekday	peak			
5/9	Thursday	9:48 AM	-2.3	low	weekday	peak			
5/10	Friday	10:23 AM	-2.5	low	weekday	peak			
5/11	Saturday	10:57 AM	-2.3	low	weekend	peak			
5/12	Sunday	11:31 AM	-1.8	low	weekend	peak	x		
5/13	Monday	12:07 PM	-1.0	low	weekday	peak			
5/23	Thursday	8:37 AM	-2.3	low	weekday	peak		WG	
5/24	Friday	9:22 AM	-4.1	high	weekday	peak		CGN	
5/25	Saturday	10:07 AM	-5.2	high	weekend	peak	x		
5/26	Sunday	10:53 AM	-5.7	high	weekend	peak			
5/27	Monday	11:40 AM	-5.5	high	weekday	peak	x		
5/28	Tuesday	12:29 PM	-4.6	high	weekday	peak		NINBAR	
5/29	Wednesday	1:19 PM	-3.2	high	weekday	peak		COHOE	
5/30	Thursday	2:14 AM	-1.4	low	weekday	peak			
6/6	Thursday	8:52 AM	-1.1	low	weekday	peak	x		
6/7	Friday	9:29 AM	-1.6	low	weekday	peak			
6/8	Saturday	10:04 AM	-2.0	low	weekend	peak			
6/9	Sunday	10:38 AM	-2.1	low	weekend	peak	x		
6/10	Monday	11:12 AM	-1.9	low	weekday	peak			
6/11	Tuesday	11:47 AM	-1.5	low	weekday	peak			

CGS - Clam Gulch South
CGN - Clam Gulch North
NN - Ninilchik North
SN - Set Net Access
OP - Oil Pad Access
NS - Ninilchik South
CO - Cohoe
NB - Ninilchik Bar
DC – Deep Creek

-Continued-

Appendix A. Continued.

Date	Day	Time	Tide (Ft)	Tide Strata	Groupings Day	Groupings Season	Aerial Survey	Age Length	Pump Abundance
6/21	Friday	8:16 AM	-2.4	low	weekday	peak	x		
6/22	Saturday	9:06 AM	-4.1	high	weekend	peak			
6/23	Sunday	9:53 AM	-5.3	high	weekend	peak			
6/24	Monday	10:40 AM	-5.9	high	weekday	peak	x	HAPPY	
6/25	Tuesday	11:26 AM	-5.7	high	weekday	peak		DC	
6/26	Wednesday	12:12 PM	-4.8	high	weekday	peak		SNA	
6/27	Thursday	12:59 PM	-3.3	high	weekday	peak			
6/28	Friday	1:47 PM	-1.4	low	weekday	peak			
7/7	Sunday	9:47 AM	-1.2	low	weekend	peak			
7/8	Monday	10:20 AM	-1.7	low	weekday	peak			
7/9	Tuesday	10:52 AM	-1.8	low	weekday	peak			
7/10	Wednesday	11:25 AM	-1.7	low	weekday	peak			
7/11	Thursday	11:58 AM	-1.2	low	weekday	peak			
7/20	Saturday	8:01 AM	-1.9	low	weekend	peak	x		
7/21	Sunday	8:52 AM	-3.6	high	weekend	peak	x		
7/22	Monday	9:40 AM	-4.8	high	weekday	peak		OPA	
7/23	Tuesday	10:25 AM	-5.3	high	weekday	peak		NS	
7/24	Wednesday	11:08 AM	-5.1	high	weekday	peak	x	NN	
7/25	Thursday	11:51 AM	-4.2	high	weekday	peak			
7/26	Friday	12:33 PM	-2.6	low	weekday	peak			
8/6	Tuesday	9:57 AM	-1.0	low	weekday	shoulder			
8/7	Wednesday	10:28 AM	-1.4	low	weekday	shoulder			
8/8	Thursday	10:59 AM	-1.4	low	weekday	shoulder			
8/9	Friday	11:31 AM	-1.0	low	weekday	shoulder			
8/18	Sunday	7:47 AM	-1.1	low	weekend	shoulder			
8/19	Monday	8:38 AM	-2.6	low	weekday	shoulder		CGS	
8/20	Tuesday	9:23 AM	-3.6	high	weekday	shoulder	x	DC	
8/21	Wednesday	10:05 AM	-4.0	high	weekday	shoulder			
8/22	Thursday	10:46 AM	-3.7	high	weekday	shoulder			
8/23	Friday	11:25 AM	-2.7	low	weekday	shoulder			
8/24	Saturday	12:04 PM	-1.1	low	weekend	shoulder	x		

CGS - Clam Gulch South
CGN - Clam Gulch North
NN - Ninilchik North
SN - Set Net Access
OP - Oil Pad Access
NS - Ninilchik South
CO - Cohoe
NB - Ninilchik Bar
DC – Deep Creek

Appendix B.–Data entry forms and file formats for digger count, age-length, and abundance data.

Field form for razor clam digger counts:

RAZOR CLAM DIGGER COUNTS BY AREA

Date____________ Tide______________ Time_____________

1 Whiskey Gulch
Anchor River to Happy Creek ________

2. Happy Valley
Happy Creek to Deep Creek ________

3. Ninilchik
Deep Creek to Set Net Access ________

A. Ninilchik Bar ________
B. Deep Creek to Ninilchik River ________
C. Ninilchik River to Lehman's ________
D. Lehman's to Access ________

4. Oil Pad Access
Set Net Access to Clam Gulch Tower ________

A. Set Net Access to A-frame ________
B. A frame to Clam Gulch Tower ________

5. Clam Gulch
Tower to S. extension of Cohoe Lp. Rd. ________

A. Tower to bluff ________
B. Bluff to A frame ________
C. A frame to S. Ext. ________

6. Cohoe
S. extension of Cohoe Lp. Rd to Kasilof R. ________

Total ________

Appendix C.–Data entry instructions for clam digger counts, length-at-age data and abundance data.

The goal is to enter each set of data into separate files in a database format, with each line a complete record. The attached pages will serve as examples.

Digger count file format directions:

Enter beach number using the following designations:

11 = Whiskey Gulch

21 = Happy Valley

31 = Ninilchik Bar

32 = Ninilchik, Deep Creek to Lehman's

33 = Ninilchik, Lehman's to Access

41 = Oil Pad Access

51 = Clam Gulch, Tower to Bluff

52 = Clam Gulch, Bluff to A Frame

53 = Clam Gulch, A Frame to Southern Ext. of Cohoe Lp.

61 = Cohoe

Enter date as yymmdd, without any spaces. Because the tides are negative, the Worksheet Global Default Other International Negative should be set so that a negative sign instead of parenthesis is printed around negative values. Tidal strata is either 1 for tides between -1.0 through –2.9 feet or 2 for tides of -3.0 feet or lower. Count is actual diggers counted on the beach.

Length-at-age file format directions:

Line is a unique line number for each line.

Beach areas are designated as follows. The first number is the beach, the second number is the sublocation and the third number is the section:

11 Whiskey Gulch: Anchor River to Happy Cr.
21 Happy Valley: Happy Creek to Deep Creek
31 Ninilchik Bar
321 Ninilchik South: Deep Creek to Ninilchik River
322 Ninilchik North: Ninilchik River to Lehman's
33 Lehman's to Set Net Access
411 Set Net Access
412 Oil Pad Access
51 Tower to Bluff
521 Clam Gulch South: Bluff to A frame
522 Clam Gulch North: North of Clam Gulch Access Road
53 A frame to South extension Cohoe Loop
61 South extension of Cohoe loop to Kasilof River

Enter date as yymmdd, without any spaces. Because the tides are negative, the Worksheet Global Default Other International Negative should be set so that a negative sign instead of parenthesis is printed around negative values. Age, total length and length at annulus are input directly into an ASCII file using the automatic calipers. This data is then imported into an Excel workbook.

Abundance file format directions:

Line is a unique line number for each line. Beach area and subarea will be entered using designations as listed above for the length-at-age format. For 2011 all sampling will be conducted on beach 3, subarea 2 and subarea 3. Site location is broken into two columns, one for N or S of the Ninilchik River and one for the mile number from the Ninilchik River if south of the Ninilchik River or the mile number south from Leman's if north of the Ninilchik River. Time is the time digging the quadrat was started. Distance is the distance in feet from the gravel's edge where the quadrat is being dug sampling takes place. Enter date as mmddyy, without any spaces. Because tides are negative, be sure the format of cells in which tide is entered is set so that a negative sign (rather than parentheses) is printed around negative values. Sample number is for each quadrat dug at a specific distance from the gravel's edge along the transect and may have a value of up to 7 for each sample location. The number of clams <80 mm and ≥80 mm in length (this will always be one) as well as total length of each clam is entered.

Appendix D.–Abundance sampling schedule, locations, and data entry form.

Appendix D1.–Abundance start time and sample date for each Location.

Date	Tide Height (ft)	Slack low tide time	Leave office Time	Approximate start time	ADF&G location	Apu location
4/25	-3.1	9:59AM	5:45AM	6:45AM	4	2B
4/26	-4.3	10:40AM	6:40AM	7:40AM	2	4B
4/27	-4.8	11:23AM	7:15AM	8:15AM	1	3B
4/28	-4.5	12:08PM	8:00AM	9:00AM	5	5B
4/29	-3.6	12:56PM	8:45AM	9:45AM	3	1B

Appendix D2.–Abundance sampling start location and compass heading.

	Start		Site 1	Site 2-26	Start GPS		Stop GPS	
Location	distance (m)	Heading	distance (m)	distance (m)	Latitude	Longitude	Latitude	Longitude
1	139	150	12.5	15.2	60.051872	-151.670083	60.053751	-151.676084
1B	251	150	12.5	15.2	60.050990	-151.671032	60.052879	-151.677145
2	363	150	12.5	15.2	60.050098	-151.671996	60.051966	-151.678116
2B	475	150	12.5	15.2	60.049169	-151.672833	60.051026	-151.678984
3	587	150	12.5	15.2	60.048265	-151.673696	60.050113	-151.679814
3B	699	150	12.5	15.2	60.047343	-151.674522	60.049176	-151.680657
4	811	150	12.5	15.2	60.046391	-151.675298	60.048275	-151.681453
4B	923	150	12.5	15.2	60.045462	-151.676099	60.047340	-151.682210
5	1035	150	12.5	15.2	60.044566	-151.677062	60.046415	-151.683085
5B	1335	135	12.5	15.2	60.042125	-151.682202	60.044706	-151.687085

Appendix D 3.–Page 1 of data entry form for abundance sampling.

Ninilchik South Beach Razor Clam Abundance Sampling

Date: April____, 2013 Location No:_________ Crew:________________________________ Page 1 of 7

Site	Time	Plot	Sediment 1/			Wand Depth		PSI	Total	Clam Size (mm)												Clams on Back
			Coal	Clay	Gravel	Start 2/	End 3/		Clams	1	2	3	4	5	6	7	8	9	10	11	12	4/
1		1																				
1		2																				
1		3																				
1		4																				
1		5																				
1		6																				
1		7																				
Position:										Comments:												
2		1																				
2		2																				
2		3																				
2		4																				
2		5																				
2		6																				
2		7																				
Position:										Comments:												
3		1																				
3		2																				
3		3																				
3		4																				
3		5																				
3		6																				
3		7																				
Position:										Comments:												
4		1																				
4		2																				
4		3																				
4		4																				
4		5																				
4		6																				
4		7																				
Position:										Comments:												

1/ YES for present; No for absent

2/ Wand depth to nearest 10 cm after 5 seconds.

3/ Wand depth to nearest 10 cm after plot is emulsified.

4/ Yes = more lengths on back

Appendix E.–Razor clam file formats

Razor clam digger count file format

Beach	Year	Month	Day	Date	Tide	Strata	Count
11							
21							
31							
32							
33							
41							
51							
52							
53							
61							

Razor clam length-at-age file format (column headings)

Month, Day, Year, Beach, Sub_Loc, Subloc2, Age, Tot_Len, AN1, AN2, AN3, AN6,…,AN15, Clam_Number

Razor clam abundance file format (column headings)

Line, Beach, SubArea, Loc. N/S, Loc. M., Time, Dist, Date, Tide, Sample, No_clams <80_mm, No_clams ≥80_mm, Length

Appendix F.–Estimation of digger success.

Relative digger success for each beach ($\hat{I}_b$) (Table E1) was estimated by dividing the average harvest on May 26, 2009 of each beach by the average harvest on May 26, 2009 of the most successful beach:

$$\hat{I}_b = \frac{\bar{x}_b}{max_b(\bar{x}_b)} \tag{1}$$

where:

$\bar{x}_b$ = the harvest on May 26 on beach b

$$= \frac{\sum_{i=1}^{f_b} x_{bi}}{f_b} \tag{2}$$

where:

x_{bi} = the number of clams harvested on May 26 by digger i on beach b, and

f_b = the number of diggers interviewed on beach b.

In previous years I_b was not estimated but was based on biological intuition and was considered a constant.

Table E1. Estimated relative success rate of diggers on eastern Cook Inlet beaches, 2009.

Count area	Number of people interviewed	Number clams dug	Average clams/digger	Relative Success: 2009 estimate	Relative Success: Historical assumed value
Ninilchik	427	17,117	40	1.0	1.0
Oil Pad Access	68	1,874	28	0.7	1.0
Cohoe Beach	29	784	27	0.7	0.5
Happy Valley	161	3,265	20	0.5	0.5
Clam Gulch	155	2,631	17	0.4	1.0
Whiskey Gulch	85	928	11	0.3	0.5