Fishery Data Series No. 11-37

Southeast Alaska 2009 Geoduck Stock Assessment

by

Jan Rumble

and

Chris Siddon

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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

FISHERY DATA SERIES NO. 11-37

SOUTHEAST ALASKA 2009 GEODUCK STOCK ASSESSMENT

By
Jan Rumble and Chris Siddon
Alaska Department of Fish and Game, Division of Commercial Fisheries, Douglas

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

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Jan Rumble
and
Chris Siddon
Alaska Department of Fish and Game, Division of Commercial Fisheries,
802 Third Street, Douglas, Alaska 99824, USA

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ABSTRACT

Geoduck stock assessment surveys were conducted in Nakat Inlet (101-11), North Kirk Point to Bullhead Cove (101-23), Portillo Channel (103-50), Southern Gravina (101-29), and Lower Cordova Bay (102-10 and 103-11) to estimate geoduck clam biomass. These areas included two new commercial areas identified through industry reconnaissance and four existing commercial areas. Two of the four existing areas were subsequently combined, resulting in a total of five fishery areas surveyed in 2009. The existing areas were resurveyed by reconnaissance divers to identify high density commercial geoduck beds. Surveys were conducted by Alaska Department of Fish and Game (ADF&G) divers from May to August 2009 using the ADF&G's *R/V Kestrel*. Estimates of biomass were calculated for each area and guideline harvest levels were based on a 2% annual harvest rate. Individual fishing areas were opened for the 2009/2010 season based on the results of paralytic shellfish poison (PSP) testing conducted by the Department of Environmental Conservation. The first openings occurred on October 1, 2009. The total guideline harvest level for the 2009/2010 season was 630,900 pounds.

Key words: Geoduck clam, *Panopea generosa*, Southeast Alaska, dive surveys, stock assessment, fishery

INTRODUCTION

STOCK ASSESSMENT

Before 1997, geoduck clam (*Panopea generosa*) stock assessment surveys in Southeast Alaska were limited in scope. Stock assessment surveys were first completed in Southeast Alaska in 1982 at Noyes Island and in 1988 and 1989 at Biorka Island, Kah Shakes, and Gravina Island. Although commercial fisheries have been ongoing in these areas since 1985, no additional surveys were conducted until 1997. Beginning in 1997, established commercial harvest areas were resurveyed, as were several new areas.

The largest growth in the geoduck clam fishery occurred between the 2005/06 and 2009/10 seasons due to; 1) federal funding through the Nearshore Marine Research grants, which funded survey costs; 2) reconnaissance surveys, conducted by members of the Southeast Alaska Regional Dive Fisheries Association (SARDFA); and 3) implementation of a fishery logbook program. These have allowed identification and mapping of new geoduck clam beds both within existing fishing areas and in new areas being discovered and surveyed. To date, a total of 38 distinct commercial fisheries have been identified and surveyed in Southeast Alaska (Figure 1).

Principal goals of this project this year were to: 1) conduct a biomass assessment survey prior to opening a commercial fishery in two new areas, and 2) conduct biomass estimates in four existing commercial fishing areas to potentially open them to commercial fishing in the 2009/2010 season.

Existing fishery areas that were surveyed in 2009 were Nakat Inlet in Subdistrict 101-11, North Kirk Point to Bullhead Cove in Subdistrict 101-23 and Portillo Channel in Subdistrict 103-50 (Figure 2). The two new areas surveyed were Southern Gravina Island in Subdistrict 101-29 and Lower Cordova Bay in Subdistrict 102-10 and 103-11. All of these stock assessment surveys were developed using reconnaissance information to more accurately identify areas of commercially harvestable geoduck abundance.

FISHERY

Prior to the 1991/1992 season, interest and harvest for geoduck clams was minimal. After that time the fishery began to develop. Exvessel value and the number of divers began to increase in Southeast Alaska during the 1992/1993 season when local interest and participation by divers from Washington state increased. Participation fluctuated in the late 1990s due to decreasing exvessel value of processed product. Prior to the 2003/04 season, the primary fishery product was processed and was valued substantially less than live product. However, changes in paralytic shellfish poisoning (PSP) testing protocol by the Alaska Department of Environmental Conservation (ADEC) beginning with the 2003/04 season, allowed for over 90% percent of the harvested product to be sold live, which increased the value and generated increased effort in the fishery. During the last three seasons 100% of the harvest has been sold as live product. The exvessel value of the fishery for the 2007/08 season was estimated at $2.0 million dollars in Southeast Alaska.

METHODS AND PROCEDURES

SCUBA SURVEYS

Density estimates of geoduck clam beds were made by scuba divers surveying 2-meter-wide transects. There are 3 types of transects that may be used depending on the area being surveyed: Type I, II, and III; these transects serve as the primary sampling unit for the survey. Type I transects run perpendicular to shore and are used along straight shorelines (not coves or bays). Transects extend to a minimum target depth of 17m/55 feet sea water (fsw) below mean lower low water (MLLW). Dives to the target depth include the majority of geoduck habitat in which commercial divers normally operate. Transect dives are limited to a maximum depth of 21 m (70 fsw) because deeper dives severely limit total bottom time for scuba divers and pose safety risks when conducted repetitively over several days. Transect length varies depending on the slope of the bottom.

For Type I transects, 2 divers swim as a team along each transect, both divers holding a 1-meter rod (a 2.1cm diameter white PVC tube) in a horizontal position perpendicular to the census path. One of the divers has a 10m line, a weight, and a compass mounted on the transect rod to maintain the predetermined compass bearing. The second diver has a writing slate with a data form attached to the rod. As soon as geoduck clams are found, the diver with the weight drops the weight and both divers swim and count geoduck clams under their respective rods until the line becomes taut. If the transect start is far from where the divers first dropped down, a pelican float is deployed to mark the true start of the transect and that latitude and longitude is recorded by the tender on the surface. The diver with the weight gives geoduck counts to the diver with the datasheet who writes them down. Then the diver with the weight pulls the line and weight to the next starting position. Type I transects were used in all areas surveyed in 2009, except Portillo Channel.

Type II transects are used where high density geoduck clam beds have been identified and do not reach the target depth of 17m (55 fsw). Transects are placed to bisect the bed and divers begin transects on one edge of the bed and are called to the surface after they have reached the other edge of the bed. Similar to Type I transects, there are 2 divers, both collecting data under 1-meter rods with 1 diver recording data and the other diver measuring the 10 meter segments. This method was used for some of the beds in Portillo Channel.

Type III transects are used in coves and bays where a reasonable estimate of seabed area can be made. A buoyed anchor is dropped on a transect location where divers descend and survey a predetermined measured distance. Beginning at the anchor, a 1-m^2 PVC frame is flipped along a compass heading (generally toward the mouth of the bay), and all geoduck clams within each frame are counted and recorded. Type III transects were not used during the 2009 survey season.

In addition to recording the geoduck clam count for each transect segment (up to 10 meters), divers also recorded data for start and stop depths, substrate type, percent vegetative cover, vegetative type, and the presence of other species of interest including horse clams, sea urchins, sea cucumbers, and abalone. Vegetative type was recorded for the 2 most common types on each transect, with the most prevalent type listed first. Substrates were coded using a key that groups various algae and intertidal plant species into categories (Appendix A). Similarly, substrate type was recorded as "percent cover" for up to 2 types and was coded accordingly (Appendix B).

SHOW FACTOR ADJUSTMENTS

Geoduck clams can be difficult to count when they are hidden below the substrate. For this reason the true clam density may be underestimated. The method described below, used to estimate the true density of geoduck clams from visual counts, is patterned after the methods used by the Washington Department of Fish and Wildlife (Bradbury et al. 2000). This method was originally introduced by Goodwin (1977) who coined the term "show factor." A "show" is either a siphon visible above the substrate or a depression in the substrate that can be identified as having been made by a clam siphon. A complete description of the show plot method used by the department is provided by Larson, et al. (2001).

Collecting data necessary for calculating show factors is labor intensive and requires that divers be able to visit a site continuously for periods of 7 to 9 days. The remoteness of most geoduck clam fisheries in Southeast Alaska prohibits establishing show factors specific for individual geoduck clam harvest areas. Data collected to develop show factors began in Southeast Alaska in 1998 and the overall average show factor derived from that work was 0.80. This value compensates for retracted or covered geoduck clam siphons not visible during surveys. The overall affect of using a show factor correction is an increased estimate of biomass.

GUIDELINE HARVEST LEVEL CALCULATION

The guideline harvest level, GHL, in a fishery management area is a product of estimated geoduck clam biomass and an applied harvest rate. Before the harvest rate is applied, biomass is adjusted by geoduck clam show factor and precision inference of the biomass estimate. The number of geoduck clams in a given bed is calculated as the product of the geoduck clam bed density, the average geoduck clam weight as recorded from the fishery, and the total area of beds in the specific fishery management area. A fishery management area may consist of one or many geoduck clam beds and the total area is the sum of the area of all of these beds. The area of the beds is estimated using ArcGIS.

GEODUCK BIOMASS ESTIMATES

Geoduck clam biomass in a fishery management area, $B_{T,}$ is calculated using average geoduck clam density, average weight, and total area of beds.

The estimate of total geoduck clam biomass in an area is calculated as:

$$B_T = N_T W_{T,} \qquad (1)$$

where:

N_T = total geoduck clam abundance (number of geoduck clams),

W_T = estimated mean weight per geoduck clam (in pounds).

The variance of the biomass estimate is the product of the variance of the geoduck clam abundance and the weight squared:

$$Var(B_T) = W_T^2\, Var(N_T)\ . \qquad (2)$$

The variance of weights was assumed to be zero. Preliminary analysis showed although not zero, these estimates are >6 orders of magnitude smaller than the variances of the biomass estimates and thus have little influence on the overall variance estimates.

Total geoduck clam abundance, $N_{T,}$ in a fishery management area is calculated as a product of density and area. In a fishery management area, the total area is determined by using the locations and lengths of the transects made in each bed where:

$$N_T = \sum_{a=1}^{n} N_a\ , \qquad (3)$$

and having variance:

$$Var(N_T) = \sum_{a=1}^{n} Var(N_a)\ . \qquad (4)$$

Geoduck abundance in a bed a is defined as:

$$N_a = \sum_{a=1}^{n} D_a A_a\ ,$$

where:

D_a = estimated density of geoduck clams (number per square meter) in bed a,

A_a = total estimated bed area (in square meters) in bed a.

The variance of geoduck clam abundance, N_a, is equal to the product of the variance of the density times the area squared:

$$Var(N_a) = A_a^2\, Var(D_a)\ . \qquad (5)$$

Geoduck clam density for a given bed was calculated using a stratified design with two strata based on density; transect parts with densities equal to or less than .25 geoduck clams per meter and transect parts with densities greater than .25 parts per meter. This was meant to separate non-geoduck habitat and geoduck habitat.

$$D_a = \frac{\sum_{h=1}^{2} A_h d_{ah}}{A_a}\ , \qquad (6)$$

where:

A_h = area (m^2) of strata h

d_{ah} = geoduck clam density (m^{-2}) in bed a and strata h.

The variance estimate geoduck clam density is calculated as:

$$Var(D_a) = \frac{\sum_{h=1}^{2}(A_h)^2 var(d_{ah})}{(A_a)^2}. \qquad (7)$$

Finally, the density of strata h is calculated as:

$$d_{ah} = \frac{\sum_{i=1}^{n} d_{ahi}}{n}, \qquad (8)$$

where:

$$d_{ahi} = \sum_{i=1}^{n} \frac{c_i}{kL_i}, \qquad (9)$$

with:

c_i = number of geoduck clams counted within each transect *i*,

L_i =length of transect i (m),

n = number of transects,

k = 2 (width (m) of transect),

and its variance:

$$Var(d_{ah}) = \frac{\sum_{i=1}^{n} (d_{ahi} - \bar{d}_{ah})^2}{n}. \qquad (10)$$

GEODUCK WEIGHT ESTIMATES

Geoduck clam weight estimates were generated using data collected from the 3 previous commercial fisheries. Because port sampling data was recorded by subdistrict and not fishery area, average weights were calculated from the subdistricts closest or included in the fishery management areas.

Mean weight per geoduck clam within a given area is estimated as:

$$W = \frac{\sum w_i}{n}, \qquad (11)$$

where:

W = estimated mean weight per geoduck clam,

w_i = weight of the *i*th geoduck clam from the available data,

n_w = sample n for weight.

GEODUCK AREA ESTIMATES

Geoduck fishery areas consist of multiple beds that have been defined by density information collected by industry reconnaissance, fishery logbook data, and previous surveys. After boundaries of the beds have been defined, the area of these beds was determined using ArcGIS.

Complete fishery management area is calculated as:

$$A = \sum_{i=1}^{n} A_i \quad , \tag{12}$$

where:

A = total area (m^2),

A_i = area of bed i (m^2) determined by ArcGIS.

GUIDELINE HARVEST LEVEL

The guideline harvest level for a fishery management area is an adjustment of the biomass by 2 constants: harvest rate and show factor, which are both consistent across all fisheries and years. In addition, precision of the biomass estimates are used to adjust the biomass and precision is calculated for each fishery management area:

$$\mathrm{GHL}_{fishery} = \mathrm{B}_{adj}\ \mathrm{H} \quad , \tag{13}$$

where:

$\mathrm{GHL}_{fishery}$ = geoduck GHL estimate,

B_{adj} = precision adjusted biomass estimate,

H = harvest rate, 2% annually or 4% if fishery is fished every other year,

and:

$$\mathrm{B}_{adj} = \mathrm{B}_{fishery}\ \mathrm{P}_{B} \quad , \tag{14}$$

where:

$\mathrm{B}_{fishery}$ = biomass estimate of fishery,

P_B = percent precision of density estimate.

Once a biomass and variance are calculated for each strata they are summed to provide an overall biomass and variance of the entire fishery management area. Uncertainty in the biomass estimate is expressed as the percent precision. This index is equal to the lower bound of the one-sided 90% confidence interval expressed as a percent of the biomass and calculated as:

$$\mathrm{P}_{B} = 100\left(1 - t_{\alpha}\frac{s}{\mathrm{B}_{bed}\sqrt{n}}\right) , \tag{15}$$

where:

P_B = percent precision of the density estimate,

s = standard deviation of the mean biomass estimate (δ_B, from Equation 6, above).

t_α = t-value from Student's distribution for a one-sided interval with significance, level α = 10%,

B_{bed} = estimated total geoduck clam biomass per bed area from equation 5, above,

n = number of transects.

SHOW FACTOR ADJUSTMENT

The guideline harvest levels adjusted for a show factor is calculated as:

$$GHL_F = \frac{GHL_{fishery}}{F}, \qquad (16)$$

where:

GHL_F = show factor adjusted guideline harvest level (GHL) estimate,

$GHL_{fishery}$ = geoduck GHL estimate,

F = show factor, or 0.80.

The show factor, F, is the ratio of geoduck clam shows visible during a single observation of any defined area and the true abundance of harvestable geoduck clams within that area:

$$F = n / N, \qquad (17)$$

where:

n = the number of visible shows within a defined area (show plot),

N = the absolute number of harvestable geoduck clams within the area.

RESULTS

STOCK ASSESSMENT SURVEYS/GUIDELINE HARVEST LEVELS

In 2009, geoduck clam stock assessment surveys were conducted in Lower Cordova Bay, Nakat Bay, Southern Gravina, Kirk Point/Bullhead Cove, and Portillo Channel. Surveys began in Lower Cordova Bay on May 29, 2009 and were completed in Portillo Channel on August 8, 2009 (Table 1). Charts of each survey area, geoduck beds and transects within these areas are included in Figures 3–11. Corresponding survey site transect coordinates are listed in Appendices C1–C5. Site locations with transect numbers and corresponding geoduck abundance and transect lengths are listed in Appendices D1–D5. The department was successful in completing all of the surveys and transects that were planned for the 2009 assessment season. The weather was good during the surveys, generally overcast and winds less than 10 mph. During the survey in Nakat Inlet, specifically in the Lord Sitklan Islands area, the weather was very warm, about 65–70 degrees F, and sunny with no wind.

Lower Cordova Bay

Lower Cordova Bay was surveyed by the department for the first time in 2009. Transects were placed in geoduck clam beds that were identified by industry reconnaissance survey work in 2006. The department surveyed 60 transects in this area. The biomass estimate and associated GHL is summarized in Table 2. In order to open this area to commercial fishing, ADEC is required to conduct water quality tests at different sites in a fishing area. For the 2009/2010 fishing season, ADEC did not have sufficient water quality information to open this area but is in the process of setting up new testing sites.

Nakat Bay

Nakat Bay was surveyed by the department for the first time in August 1999 and opened to commercial fishing in the 1999/2000 and again in 2001/2002 (Table 2). For the next three fishery rotations, Nakat Inlet was split into 2 fisheries—Cape Fox and Lord/Sitklan Islands—with separate guideline harvest levels. In the most recent 2009/2010 season, the area was combined again for easier management of smaller guideline harvest levels. Guideline harvest levels by fishing season from 1999/2000 to 2009/2010 are shown in Table 3. Reconnaissance surveys conducted by an industry diver in April 2009 provided information to more closely define the geoduck beds in Nakat Bay and redefine the transects used in the 2009 department survey. Eleven beds with 53 transects were surveyed in the area in 2009.

Southern Gravina

Reconnaissance of Southern Gravina was first conducted in 2009. The information collected and documented was used to develop the stock assessment survey conducted by the department. Four geoduck clam beds with 20 dispersed transects were surveyed and data was used to estimate biomass and calculate the guideline harvest level for the fishery. ADEC water quality stations in this area already existed so commercial harvest was permitted for the 2009/2010 season.

North Kirk Point/Bullhead Cove

Prior to 2003, North Kirk Point/Bullhead Cove was called the Kah Shakes geoduck fishery. The first harvest recorded for the Kah Shakes fishery was the 1991/92 season and the first department survey conducted in Kah Shakes was in August 1997. In 2009, a reconnaissance survey was conducted defining four commercial geoduck clam beds. The department collected data from 27 transects, which were used to estimate biomass and the fishery was open with a guideline harvest level of 15,400 pounds (Table 2).

Portillo Channel

Portillo Channel was first surveyed by the department in 2001 and opened that year as part of an area including Bucareli Bay, Port Real Marina and Ulloa Channel for a guideline harvest level of 88,917 pounds. In 2003, Port Real Marina and Portillo Channel were combined into one area for a guideline harvest level of 72,300 pounds. In 2005, Portillo Channel alone became a fishery and had a guideline harvest level of 72,100 pounds and in 2007 it increased to 77,300 pounds. A reconnaissance survey was conducted in 2005 defining seven commercial geoduck clam beds. This information was used in 2009 to design a survey with 74 transects. Data from these transects led to a biomass estimate and a guideline harvest level of 30,100 pounds, a large reduction from the GHL in 2007 (Table 2).

DISCUSSION

The Southeast Alaska total guideline harvest level for geoduck clams for the 2009/10 season was 619,500 pounds, the third highest on record. The method used to calculate the quotas has gradually been migrating from a shoreline based model to an area based model in order to increase the precision of the estimate. There were only 5 fisheries open during the 2009/10 season where the GHL was calculated using the older shoreline based method: Nehenta Bay, Middle Gravina Island, Vallenar Bay, Port Real Marina, and Symonds Bay. Nehenta Bay and Taigud and Kolosh Islands were the only fishery areas that had low precision levels (34% and 53%, respectively). The rest of the precision levels ranged between 65% and 88%.

Fishery management areas have changed over the years because of boundaries for water quality testing required by ADEC and to maintain manageable guideline harvest levels. Nakat Bay had a higher GHL in the first 2 seasons it was opened than it did in subsequent seasons. When it was split into 2 subareas, the precision was lower, which reduced the GHL. Then when it was combined again, the GHL was not as high as in 1999/2000 and 2001/2002 seasons, even though the precision increased. Another area that has changed over time is the current Kirk Point/Bullhead Cove fishery. Prior to 2003, the Kirk Point/Bullhead Cove geoduck clam fishery was called the Kah Shakes fishery. The northern boundary was closer to Boca de Quadra making it a larger area. The guideline harvest level was also larger for Kah Shakes, 35,402 pounds in 2001 compared to the GHL for Kirk Point/Bullhead Cove which was 14,900 pounds for the 2003 season. For the four seasons the fishery was open, the guideline harvest level was around 15,000 pounds, which included the GHL generated from the most recent 2009 assessment.

During all geoduck surveys, evidence of sea otter presence is noted for all transects. During the 2009 survey of Portillo Channel, 70 out of 74 transects had notable sea otter presence recorded which may be the probable cause of the large decrease in geoduck abundance and subsequent decreases in the GHL. The GHL calculated from the 2009 survey was less than half of what it was for the previous calculation in 2001. In Lower Cordova Bay, more than half of the 60 transects had obvious signs of sea otter disturbance. Obvious signs include large holes in the substrate where otters have dug through the seafloor as well as geoduck clam shell debris left from where otters have pulled up the clams, eaten the meat and discarded the shells. None of the other areas surveyed showed obvious signs of sea otter presence directly on the survey transects.

Lower Cordova Bay and Southern Gravina were new survey areas so there are no trends related to historical harvest or survey development.

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TABLES AND FIGURES

Table 1.–Dates of 2009 geoduck clam stock assessment surveys conducted in Southeast Alaska.

Survey area	Survey Leg	Survey Dates
Lower Cordova Bay	I	May 29–31
Nakat Bay	II	June 12–14
	IV	July 11–12
Southern Gravina	III	June 24–26
Kirk Point/Bullhead Cove	III	June 29–30
Portillo Channel	V	July 22–24
	VI	August 8

Table 2.–Estimates of density, weight and biomass of geoduck clams from five areas surveyed in Southeast Alaska in 2009.

	Nakat Bay	**Kirk Point/ Bullhead Cove**	**Portillo Channel**	**Southern Gravina**	**Lower Cordova Bay**
Number of Transects	53	27	74	20	60
Transect Spacing (m)	50–100	70	77	50	150
Total Area m^2	307,688	202,906	674,623	93,887	529,600
Total Geoduck Estimate (nos.)	266,039	179,815	271,139	142,176	163,294
Variance of Estimated Total	979,283,086	529,988,805	657,359,632	298,218,262	345,313,094
Standard Variance of the Mean	0.017913373	.022388118	.005461697	0.046499504	0.008460734
Precision of Total Estimate (nos.)	84.8%	83.3%	87.8%	83.4%	83.4%
Average Weight g (lb) [a]	983 (2.16)	930 (2.05)	1,145 (2.52)	1,141 (2.51)	1,505 (3.31)
Variance of Average Weight [a]	0.00093659	0.00114338	0.00024076	0.00067632	.00198238
Biomass Estimate (lb)	575,831	368,366	684,025	357,318	541,252
90% Coefficient of Variation	14.5%	15.9%	10.7%	14.8%	12.6%
90% Two-Tail Precision (biomass)	85.5%	84.1%	89.3%	85.2%	87.4%
Lower Bounds Biomass Est. (lb)	492,465	309,793	611,057	304,574	473,131
Upper Bounds Biomass Est. (lb)	659,198	426,938	756,992	410,062	609,372
Show Factor Adjustment	0.80	0.80	0.80	0.80	0.80
Target Harvest Rate	4%	4%	4%	4%	4%
Precision Adjusted Quota (lb)	24,418	15,344	30,024	14,908	22,582

[a] Weight values from previous fisheries, at least 3 seasons.

Table 3.–Guideline harvest levels for geoduck clams by season in District 101-11.

Fishery Name	**1999/2000**	**2001/02**	**2003/04**	**2005/06**	**2007/08**	**2009/10**
Nakat Bay	39,500	34,385				24,400
Cape Fox			13,900	15,500	15,500	
Lord/Sitklan Islands			11,800	13,300	12,200	

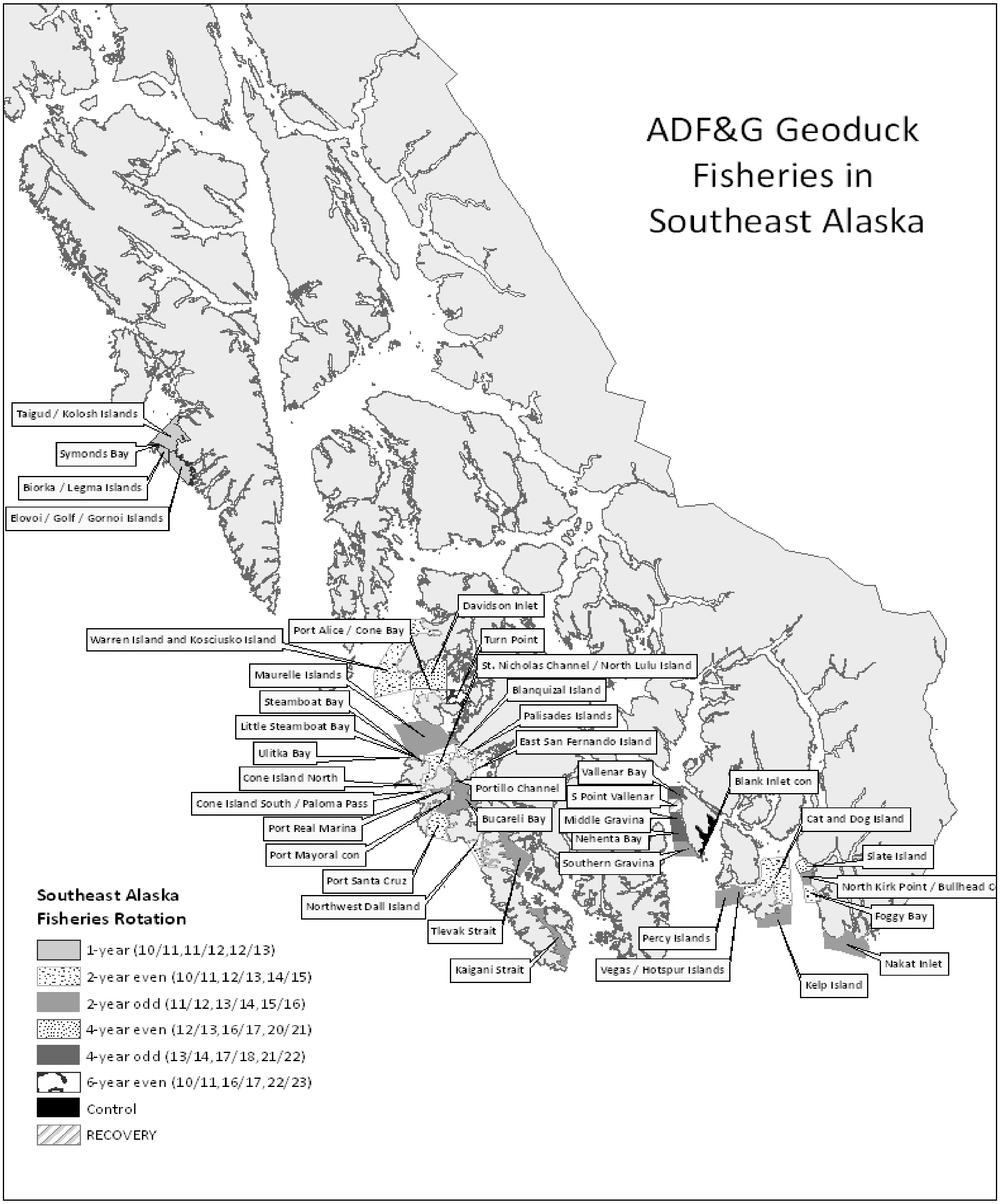

Figure 1.–Southeast Alaska geoduck clam commercial fishery areas.

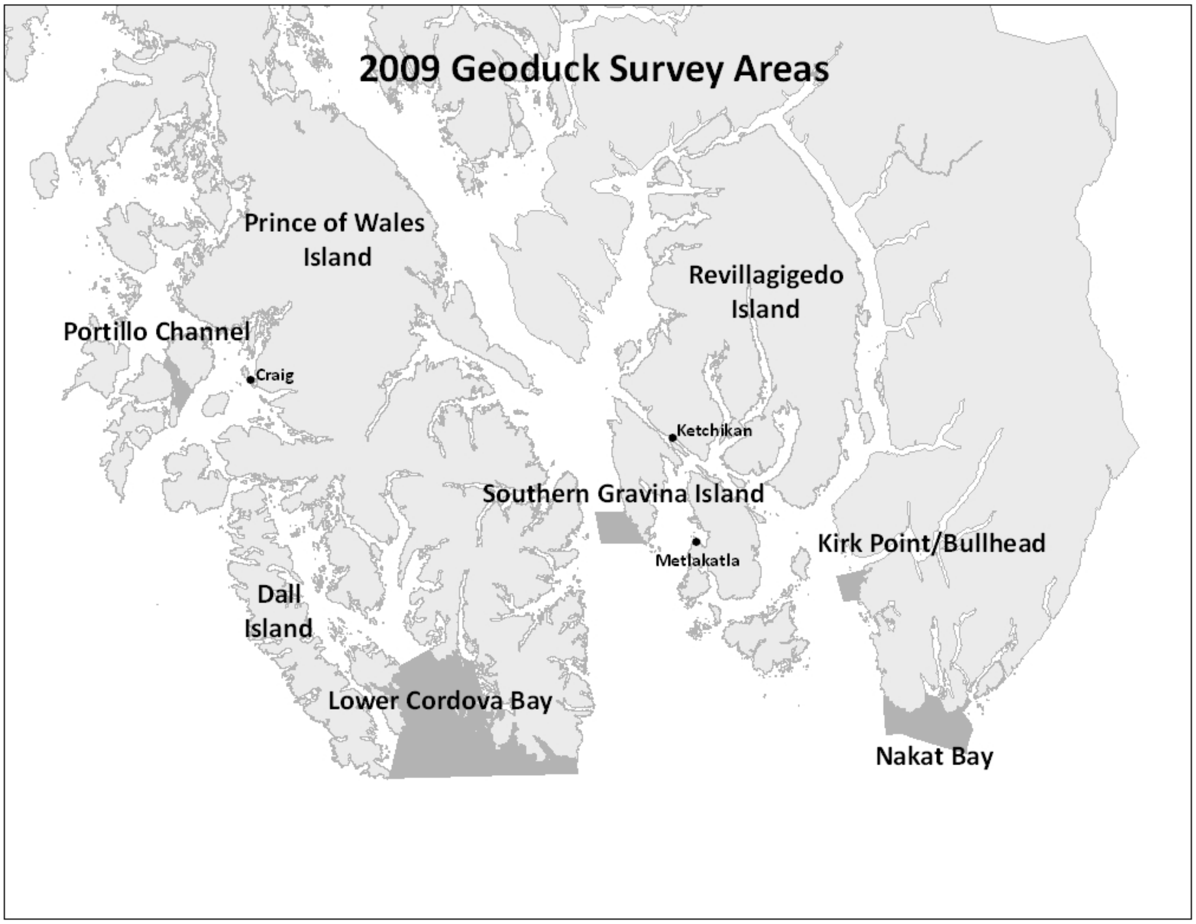

Figure 2.–2009 Southeast Alaska geoduck clam survey areas.

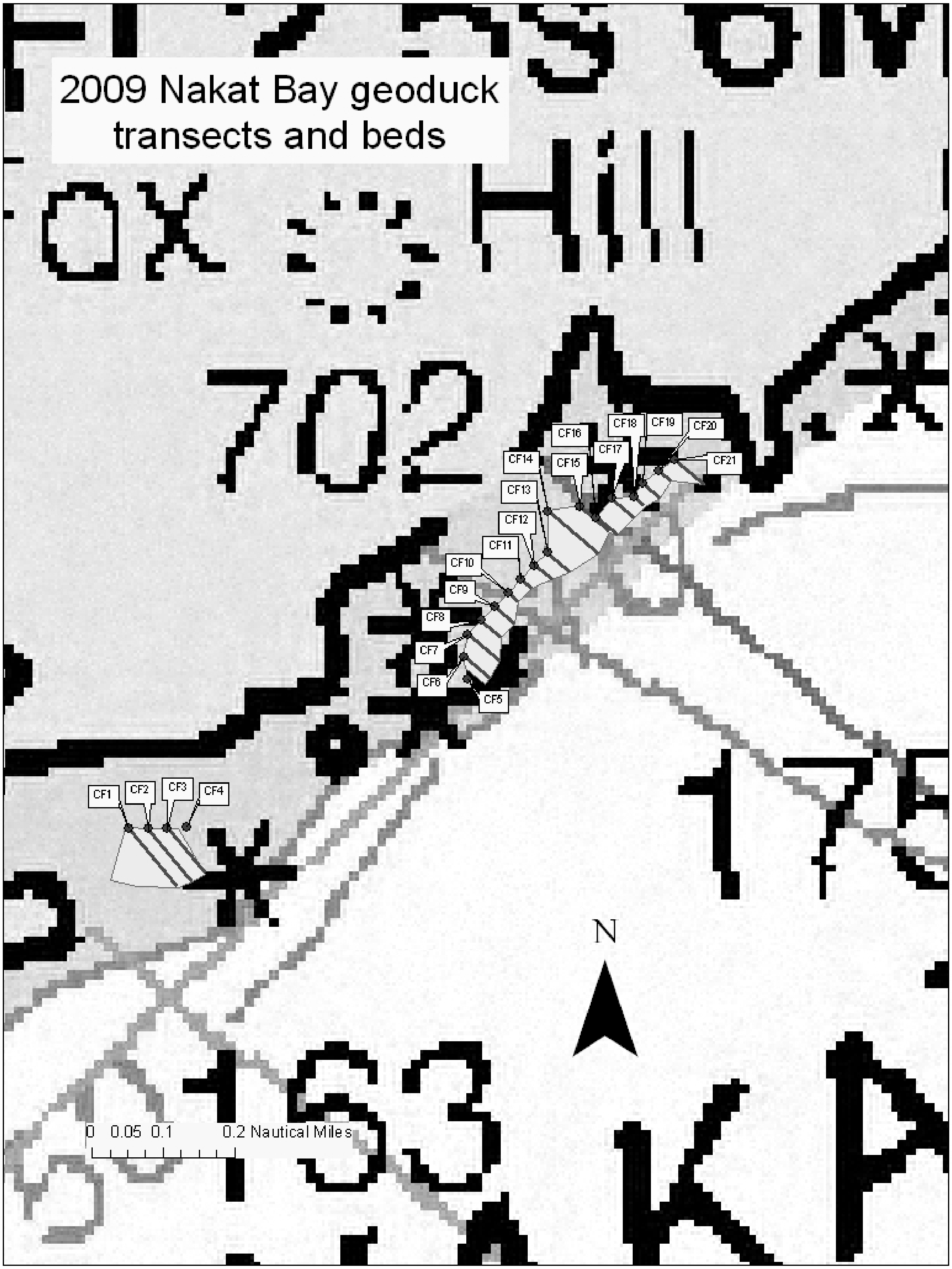

Figure 3.–Geoduck clam stock assessment transects locations and beds for Nakat Bay in 2009.

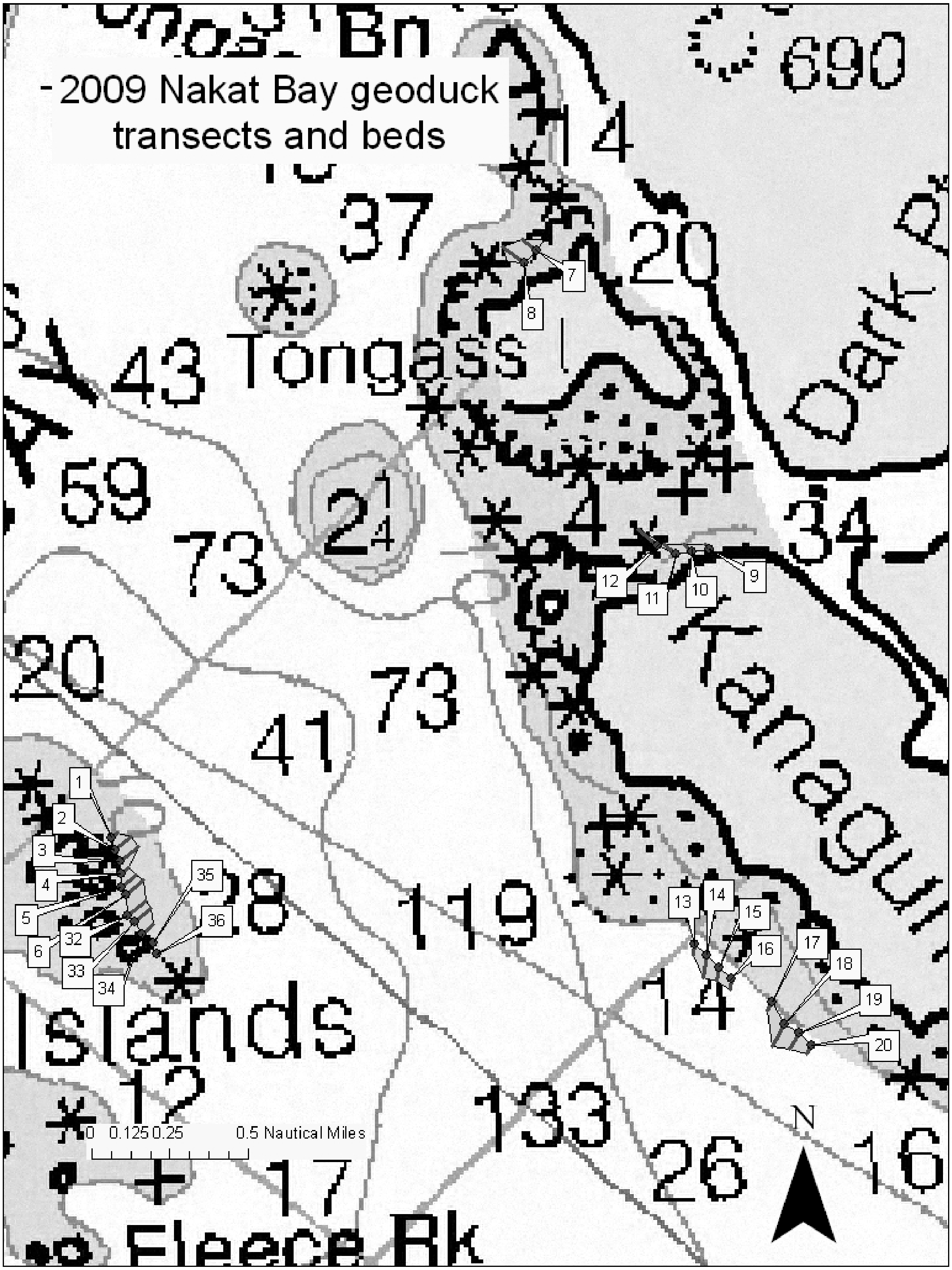

Figure 4.–Geoduck clam stock assessment transects locations and beds for Nakat Bay in 2009.

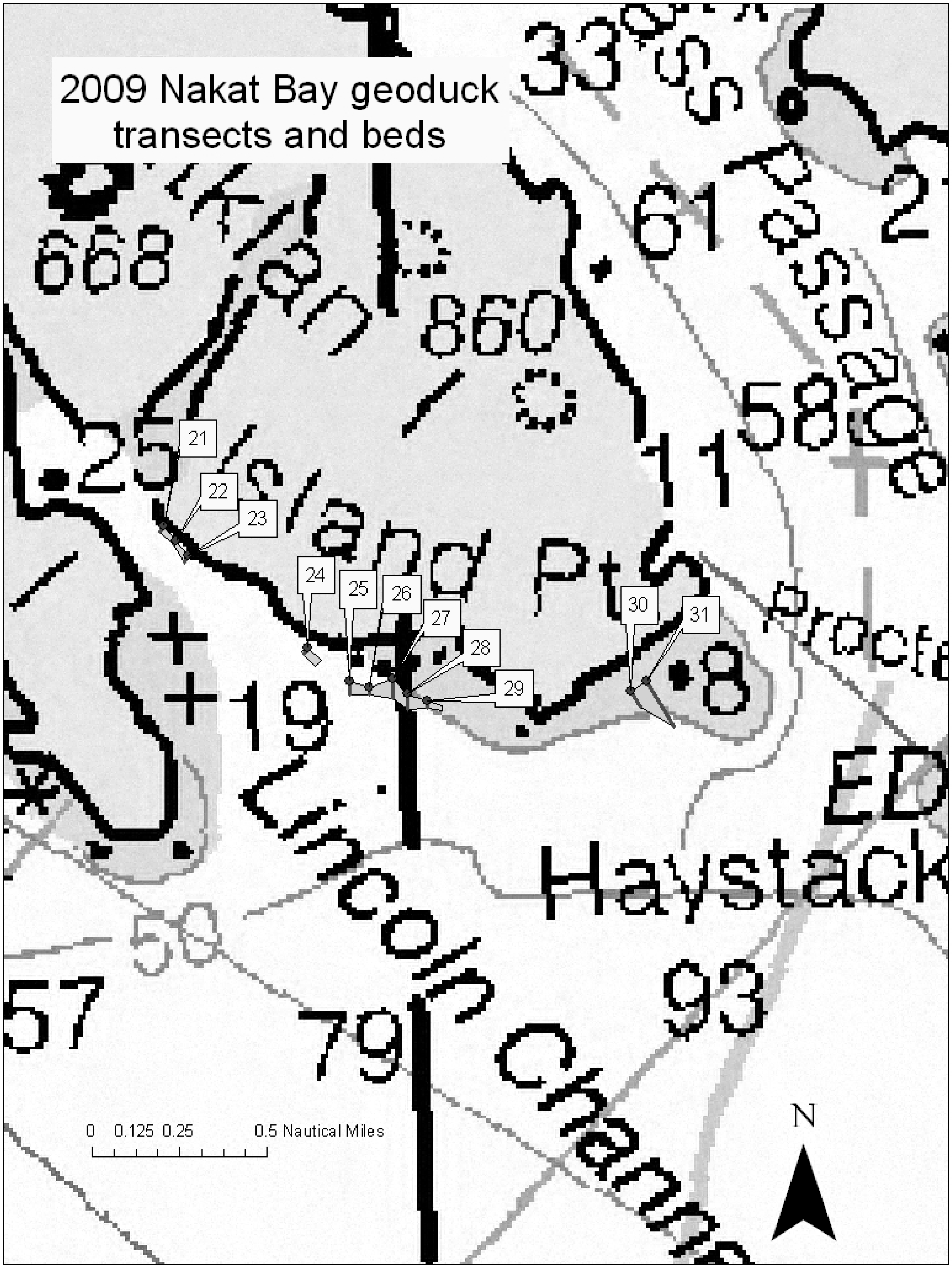

Figure 5.–Geoduck clam stock assessment transects locations and beds for Nakat Bay in 2009.

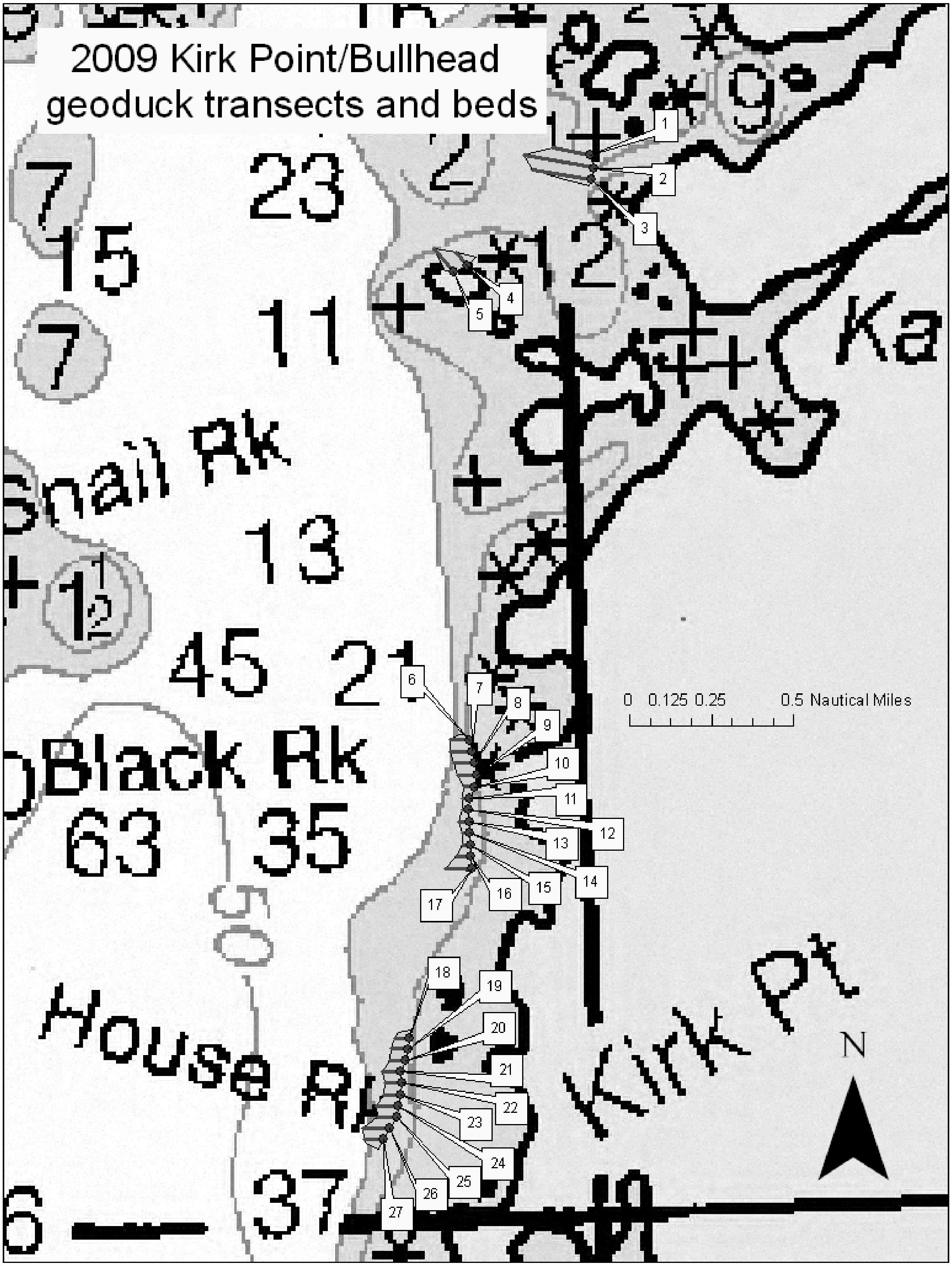

Figure 6.–Geoduck clam stock assessment transects locations and beds for Kirk Point/Bullhead in 2009.

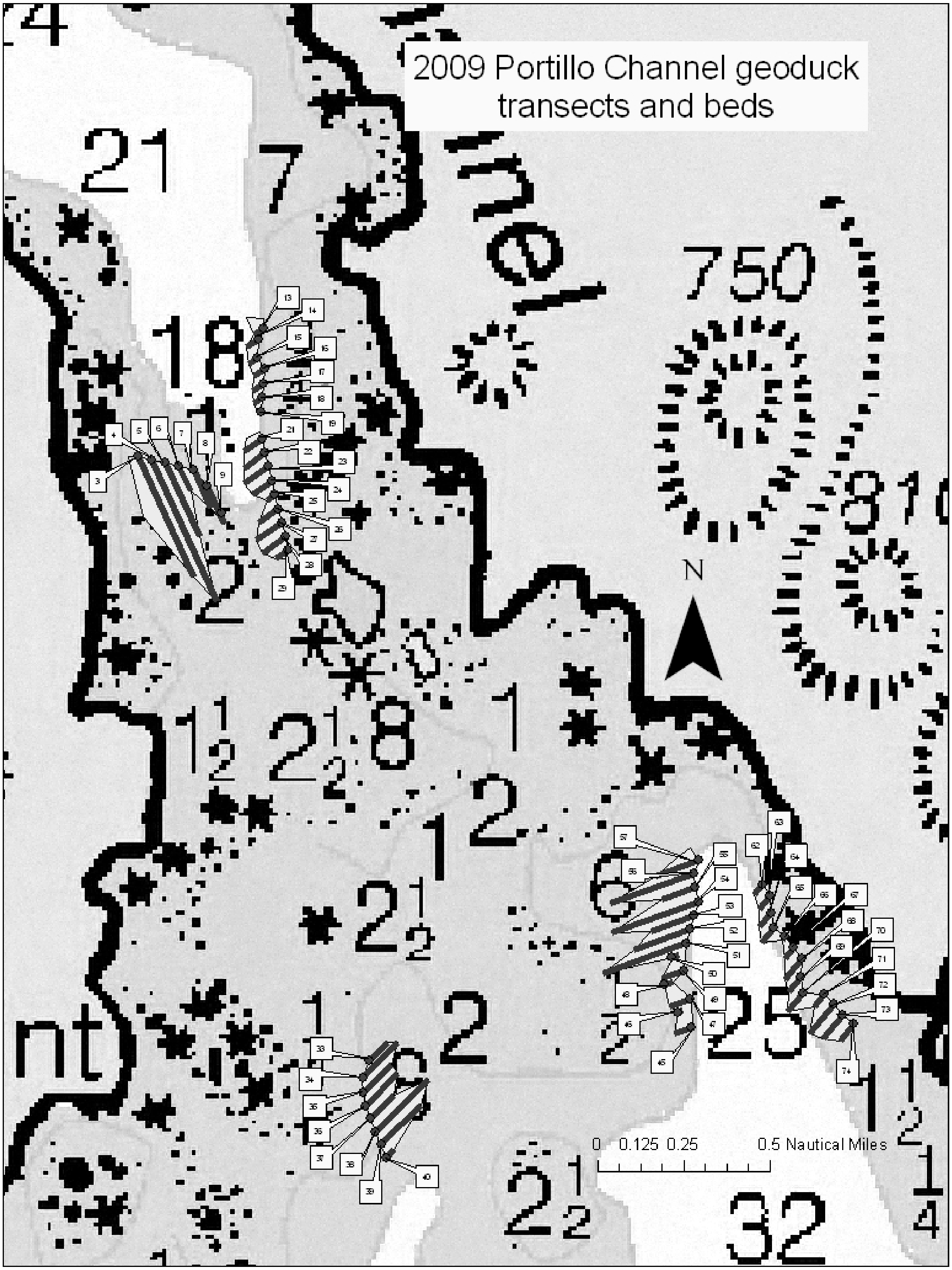

Figure 7.–Geoduck clam stock assessment transects locations and beds for Portillo Channel in 2009.

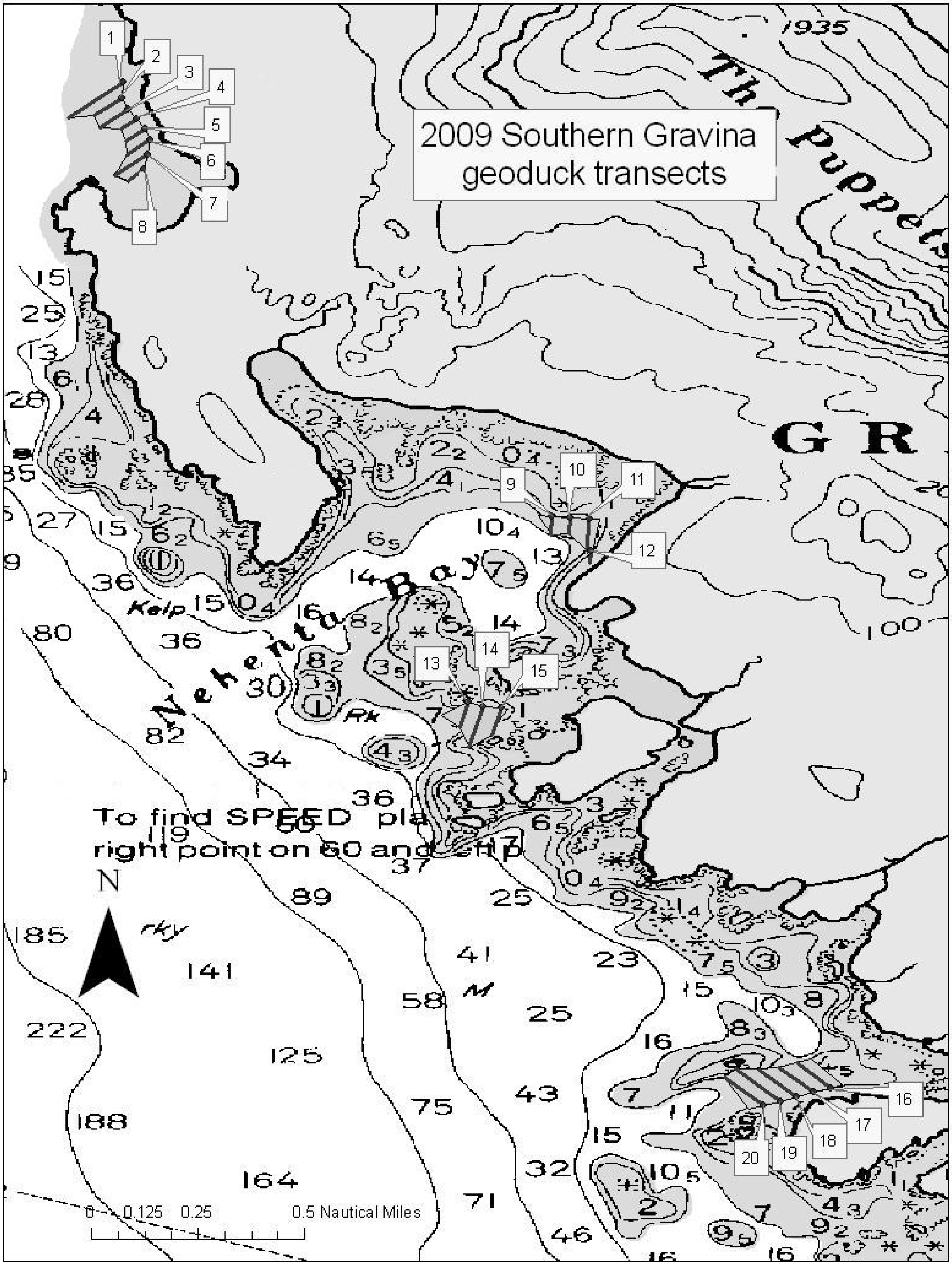

Figure 8.–Geoduck clam stock assessment transects locations and beds for Southern Gravina in 2009.

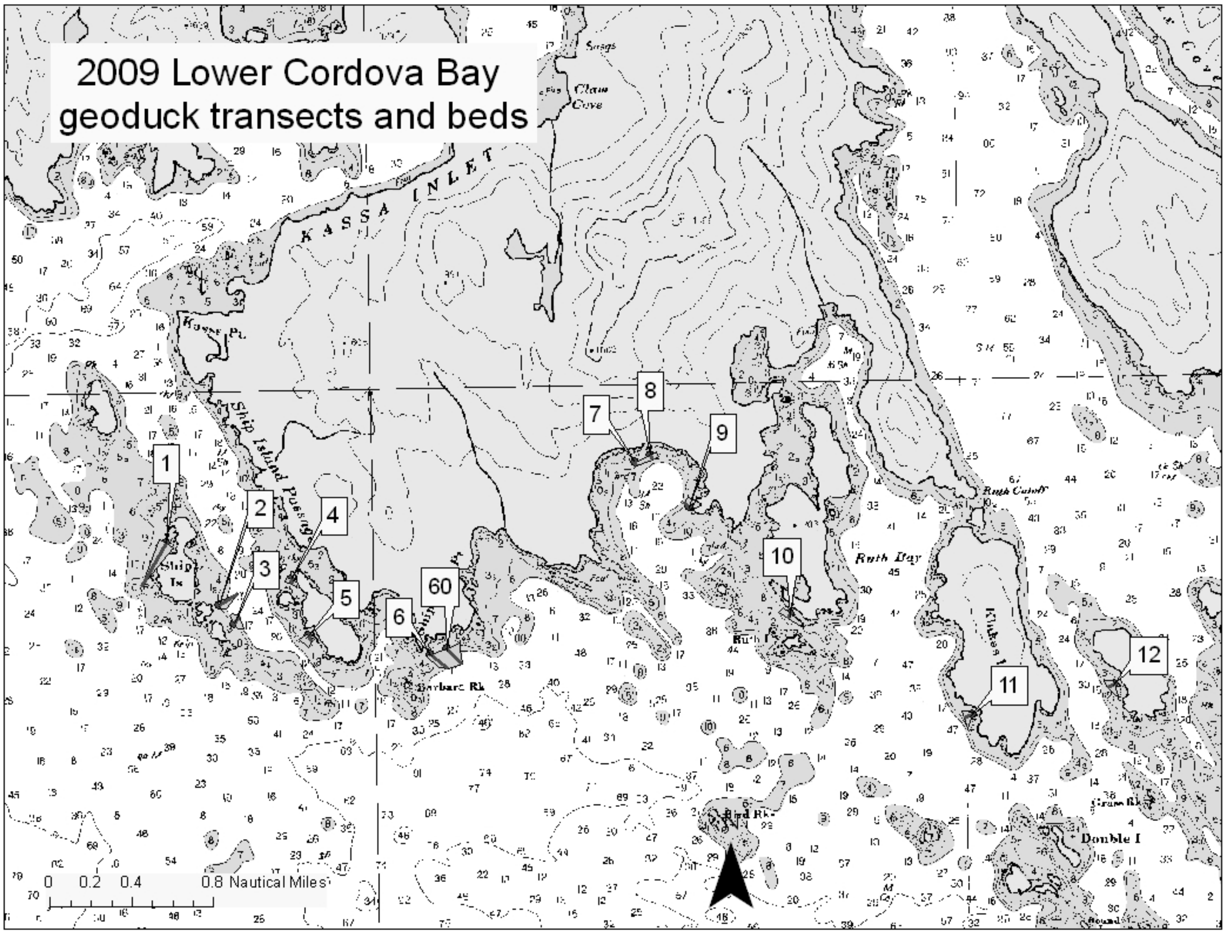

Figure 9.–Geoduck clam stock assessment transects locations and beds for Lower Cordova Bay in 2009.

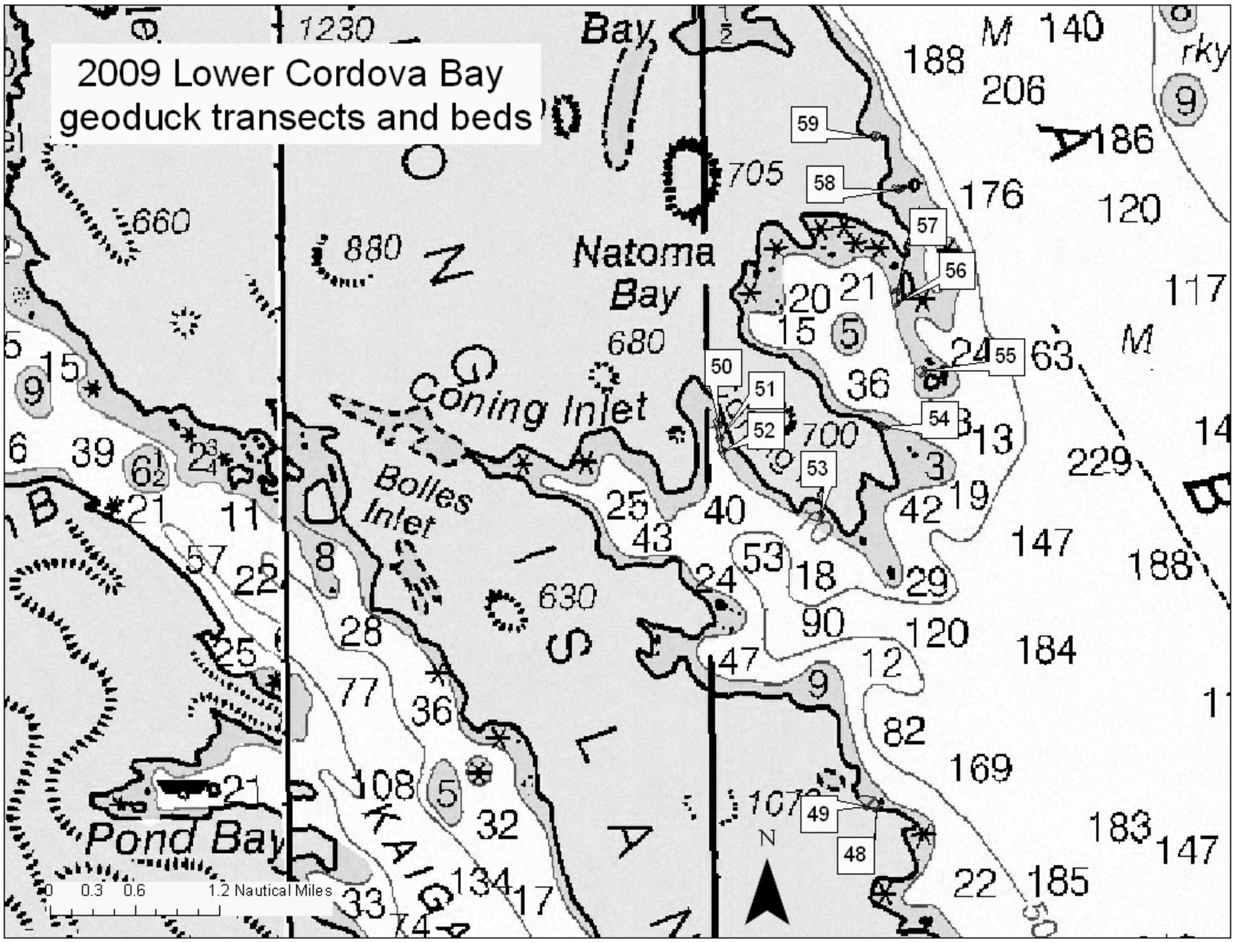

Figure 10.–Geoduck clam stock assessment transects locations and beds for Lower Cordova Bay in 2009.

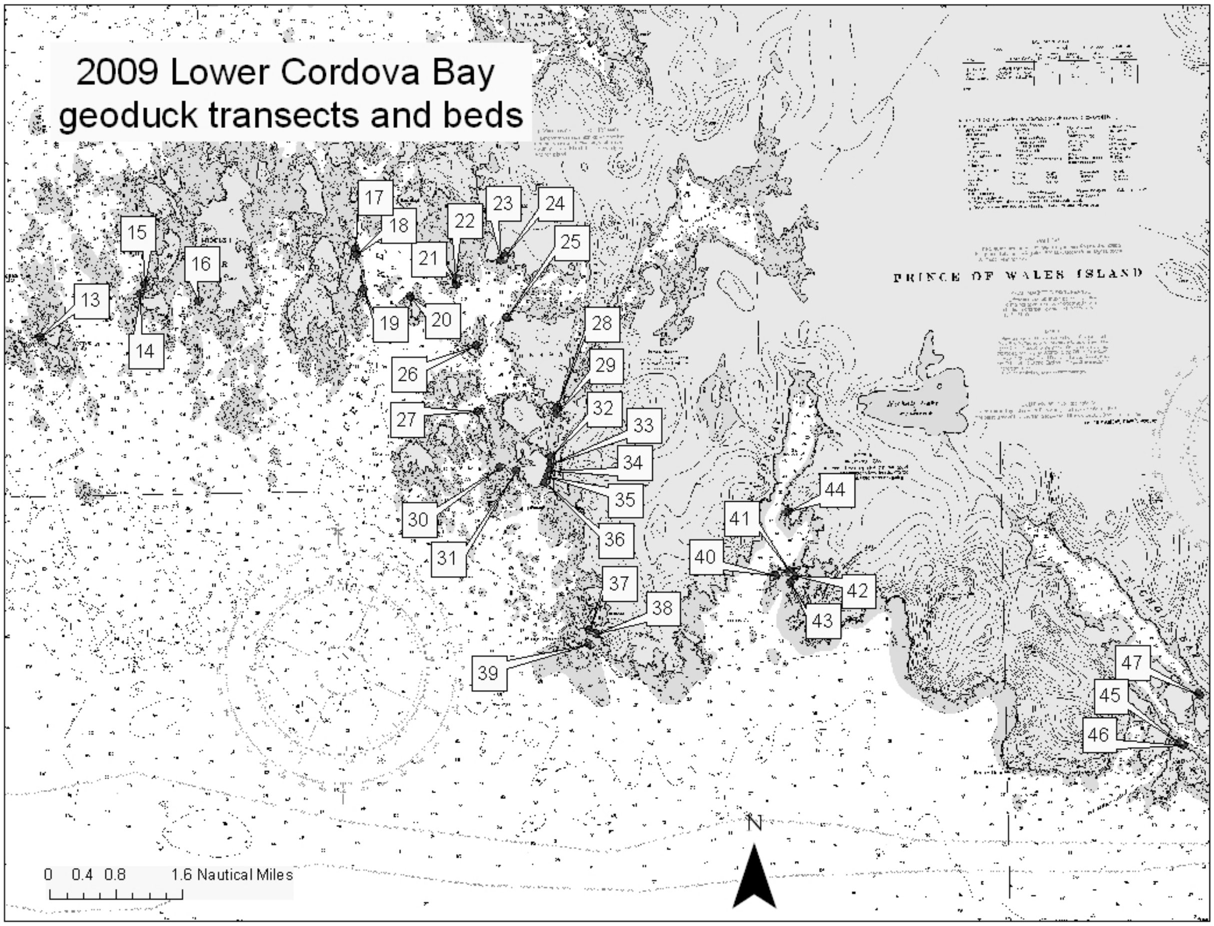

Figure 11.–Geoduck clam stock assessment transects locations and beds for Lower Cordova Bay in 2009.

APPENDICES

Appendix A1.–Key to vegetative substrate types used for geoduck clam stock assessment surveys.

Code	Expanded code	Species included	Latin names
AGM	Agarum	Sieve kelp	*Agarum clathratum*
ALA	Alaria	Ribbon kelps	*Alaria marginata, A. nana, A. fistulosa*
ELG	Eel grass	Eel grass, surfgrasses	*Zostera marina, Phyllospadix serrulatus, P. scouleri*
FIL	Filamentous algae	Sea hair	*Enteromorpha intestinalis*
FIR	Fir kelp	Black pine, Oregon pine (red algae)	*Neorhodomela larix, N.oregona*
FUC	Fucus	Rockweed	*Fucus gardneri*
HIR	Hair kelp	Witch's hair, stringy acid kelp	*Desmarestia aculeata, D. viridis*
LAM	Laminaria	split kelp, sugar kelp, suction-cup kelp	*Laminaria bongardiana, L. saccharina, L. yezoensis (when isolated and identifiable)*
LBK	Large Brown Kelps	Five-ribbed kelp, three-ribbed kelp, split kelp, sugar kelp, sea spatula, sieve kelp, ribbon kelp	*Costaria costata, Cymathere triplicata, Laminaria spp., Pleurophycus gardneri, Agarum, Alaria spp.*
MAC	Macrocystis	Small perennial kelp	*Macrocystis sp.*
NER	Nereocystis	Bull kelp	*Nereocystis leutkeana*
RED	Red algae	All red leafy algae (red ribbons, red blades, red sea cabbage, Turkish washcloth)	*Palmaria mollis, P. hecatensis, P. callophylloides, Dilsea californica, Neodilsea borealis, Mastocarpus papillatus, Turnerella mertensiana*
ULV	Ulva	Sea lettuce	*Ulva fenestrata, Ulvaria obscura*
COR	Coralline algae	Coral seaweeds (red algae)	*Bossiella, Corallina, Serraticardia*

Appendix B1.–Key to bottom types used for geoduck clam stock assessment surveys**.**

Code	**Expanded code**	**Definition**
RCK	Bedrock	Various rocky substrates > 1 m in diameter
BLD	Boulder	Substrate between 25 cm and 1 m
CBL	Cobble	Substrate between 6 cm and 25 cm
GVL	Gravel	Substrate between 0.4 cm and 6 cm
SND	Sand	Clearly separate grains of < 0.4 cm
MUD	Mud	Soft, paste-like material
SIL	Silt	Fine organic dusting (very rarely used)
BAR	Barnacle	Area primarily covered with barnacles
SHL	Shell	Area primarily covered with whole or crushed shells
MUS	Mussels	Area primarily covered with mussels
WDY	Woody debris	Any submerged bark, logs, branches or root systems

Appendix C1.–Nakat Bay geoduck clam transect coordinates.

Transect	Latitude	Longitude	Transect	Latitude	Longitude
CF1	54.76604	-130.84047	10	54.76146	-130.72920
CF2	54.76602	-130.83969	11	54.76136	-130.73074
CF3	54.76601	-130.83891	12	54.76188	-130.73242
CF6	54.76973	-130.82666	13	54.74054	-130.73050
CF7	54.77024	-130.82644	14	54.73989	-130.72941
CF8	54.77055	-130.82588	15	54.73925	-130.72832
CF9	54.77086	-130.82533	16	54.73862	-130.72722
CF10	54.77116	-130.82477	17	54.73725	-130.72356
CF11	54.77147	-130.82421	18	54.73604	-130.72257
CF12	54.77179	-130.82364	19	54.73560	-130.72122
CF13	54.77209	-130.82307	20	54.73486	-130.72015
CF14	54.77304	-130.82300	21	54.73490	-130.68517
CF15	54.77313	-130.82173	22	54.73419	-130.68419
CF16	54.77285	-130.82109	23	54.73346	-130.68323
CF17	54.77328	-130.82043	24	54.72881	-130.67371
CF18	54.77329	-130.81953	25	54.72713	-130.67039
CF19	54.77361	-130.81914	26	54.72683	-130.66877
CF20	54.77386	-130.81848	27	54.72716	-130.66689
CF21	54.77411	-130.81783	28	54.72643	-130.66567
1	54.74749	-130.78392	29	54.72607	-130.66411
2	54.74686	-130.78355	30	54.72613	-130.64735
3	54.74623	-130.78317	31	54.72655	-130.64597
4	54.74557	-130.78310	32	54.74330	-130.78270
5	54.74484	-130.78320	33	54.74297	-130.78206
6	54.74446	-130.78271	34	54.74230	-130.78140
7	54.77784	-130.74238	35	54.74180	-130.78044
8	54.77722	-130.74356	36	54.74120	-130.78010
9	54.76157	-130.72766			

Appendix C2.–Kirk Point and Bullhead Cove geoduck clam transect coordinates.

Transect	**Latitude**	**Longitude**
1	55.05409	-130.99658
2	55.05340	-130.99631
3	55.05280	-130.99662
4	55.04869	-131.00785
5	55.04841	-131.00910
6	55.02459	-131.00923
7	55.02401	-131.00906
8	55.02341	-131.00888
9	55.02278	-131.00868
10	55.02221	-131.00902
11	55.02162	-131.00941
12	55.02107	-131.00955
13	55.02046	-131.00953
14	55.01987	-131.00955
15	55.01927	-131.00952
16	55.01869	-131.00952
17	55.01808	-131.00946
18	55.00959	-131.01554
19	55.00903	-131.01574
20	55.00845	-131.01595
21	55.00788	-131.01615
22	55.00730	-131.01636
23	55.00673	-131.01656
24	55.00615	-131.01677
25	55.00557	-131.01698
26	55.00505	-131.01763
27	55.00450	-131.01821

Appendix C3.–Portillo Channel geoduck clam transect coordinates.

Transect	Latitude	Longitude	Transect	Latitude	Longitude
3	55.48184	-133.42839	38	55.44919	-133.40834
4	55.48170	-133.42720	39	55.44856	-133.40788
5	55.48157	-133.42604	40	55.44794	-133.40744
6	55.48140	-133.42484	45	55.45419	-133.38139
7	55.48123	-133.42366	46	55.45500	-133.38200
8	55.48043	-133.42247	47	55.45554	-133.38148
9	55.47911	-133.42128	48	55.45600	-133.38300
13	55.48804	-133.41766	49	55.45691	-133.38204
14	55.48752	-133.41809	50	55.45800	-133.38200
15	55.48662	-133.41812	51	55.45823	-133.38186
16	55.48604	-133.41756	52	55.45890	-133.38151
17	55.48537	-133.41765	54	55.46025	-133.38080
18	55.48470	-133.41776	55	55.46093	-133.38108
19	55.48401	-133.41788	56	55.46161	-133.38115
21	55.48269	-133.41779	57	55.46227	-133.38075
22	55.48200	-133.41753	62	55.46108	-133.37528
23	55.48134	-133.41725	63	55.46049	-133.37467
24	55.48066	-133.41696	64	55.45970	-133.37458
25	55.47999	-133.41670	65	55.45896	-133.37436
26	55.47931	-133.41642	66	55.45852	-133.37344
27	55.47864	-133.41616	67	55.45799	-133.37268
28	55.47797	-133.41576	68	55.45746	-133.37196
29	55.47730	-133.41565	69	55.45656	-133.37212
33	55.45264	-133.40882	70	55.45581	-133.37193
34	55.45181	-133.40944	71	55.45572	-133.37015
35	55.45111	-133.40938	72	55.45524	-133.36933
36	55.45044	-133.40923	73	55.45474	-133.36852
37	55.44981	-133.40879	74	55.45429	-133.36758

Appendix C4.–Southern Gravina geoduck clam transect coordinates.

Transect	**Latitude**	**Longitude**
1	55.18192	-131.80602
2	55.18134	-131.80605
3	55.18090	-131.80582
4	55.18052	-131.80549
5	55.18014	-131.80516
6	55.17970	-131.80496
7	55.17912	-131.80507
8	55.17852	-131.80518
9	55.16497	-131.78922
10	55.16493	-131.78850
11	55.16489	-131.78776
12	55.16361	-131.78770
13	55.15773	-131.79247
14	55.15755	-131.79191
15	55.15747	-131.79120
16	55.14264	-131.77832
17	55.14247	-131.77898
18	55.14229	-131.77963
19	55.14212	-131.78027
20	55.14194	-131.78092

Appendix C5.–Lower Cordova Bay geoduck clam transect coordinates.

Transect	Latitude	Longitude	Transect	Latitude	Longitude
1	54.90444	-132.52908	31	54.75331	-132.33521
2	54.89934	-132.52188	32	54.75596	-132.32306
3	54.89776	-132.51972	33	54.75462	-132.32310
4	54.90132	-132.51158	34	54.75334	-132.32355
5	54.89670	-132.50930	35	54.75209	-132.32426
6	54.89501	-132.49197	36	54.75085	-132.32508
7	54.91036	-132.46265	37	54.72106	-132.31058
8	54.91095	-132.46052	38	54.72024	-132.30839
9	54.90667	-132.45512	39	54.71815	-132.31069
10	54.89779	-132.44103	40	54.73119	-132.24585
11	54.88928	-132.41562	41	54.73227	-132.24056
12	54.89158	-132.39546	42	54.73126	-132.23905
13	54.78205	-132.49973	43	54.72983	-132.24056
14	54.79044	-132.46474	44	54.74419	-132.24071
15	54.79231	-132.46288	45	54.69590	-132.10659
16	54.78884	-132.44467	46	54.69521	-132.10492
17	54.79879	-132.38949	47	54.70530	-132.09903
18	54.79745	-132.38926	48	54.80680	-132.63240
19	54.79054	-132.38704	49	54.80710	-132.63423
20	54.78903	-132.37079	50	54.85243	-132.66357
21	54.79118	-132.35471	51	54.85080	-132.66321
22	54.79260	-132.35480	52	54.84934	-132.66273
23	54.79575	-132.33883	53	54.84155	-132.64289
24	54.79686	-132.33740	54	54.85189	-132.63019
25	54.78427	-132.33720	55	54.85839	-132.62123
26	54.77890	-132.34790	56	54.86644	-132.62680
27	54.76538	-132.34792	57	54.86770	-132.62670
28	54.76598	-132.32049	58	54.87990	-132.62590
29	54.76462	-132.32048	59	54.88607	-132.63062
30	54.75419	-132.34044	60	54.89546	-132.48976

Appendix D1.–Nakat Bay geoduck clam survey transect information.

Transect number	Total geoduck clams	Transect length (m)	Transect number	Total geoduck clams	Transect length (m)
CF1	890	195	9	50	35
CF2	231	180	10	62	70
CF3	110	155	11	128	89
CF4	0	113	12	171	145
CF5	0	10	13	17	70
CF6	696	87	14	70	128
CF7	846	107	15	3	85
CF8	833	65	16	0	65
CF9	709	66	17	68	60
CF10	234	35	18	7	150
CF11	227	37	19	38	113
CF12	60	59	20	3	60
CF13	84	75	21	23	30
CF14	79	170	22	28	25
CF15	254	105	23	1	40
CF16	124	74	24	85	40
CF17	209	80	25	215	70
CF18	81	40	26	46	40
CF19	2	60	27	135	100
CF20	39	40	28	204	80
CF21	37	100	29	26	40
1	4	50	30	92	102
2	32	120	31	1	280
3	25	140	32	496	145
4	91	60	33	397	130
5	262	120	34	146	90
6	382	130	35	0	100
7	179	110	36	4	110
8	424	160			

Appendix D2.–Kirk Point and Bullhead Cove geoduck clam survey transect information.

Transect number	Total geoduck clams	Transect length (m)
1	60	220
2	165	400
3	116	335
4	246	100
5	114	175
6	363	113
7	165	128
8	1	120
9	117	115
10	30	60
11	0	45
12	0	35
13	0	60
14	0	45
15	1	45
16	0	85
17	73	155
18	230	89
19	388	95
20	401	95
21	284	100
22	614	102
23	526	97
24	541	129
25	635	110
26	626	154
27	689	115

Appendix D3.–Portillo Channel geoduck clam survey transect information.

Transect number	Total geoduck clams	Transect length (m)	Transect number	Total geoduck clams	Transect length (m)
3	509	710	39	0	300
4	865	840	40	0	60
5	24	440	45	2	100
6	67	150	46	6	30
7	659	225	47	28	120
8	1208	228	48	4	50
9	0	10	49	79	126
13	61	60	50	0	35
14	209	78	51	222	480
15	79	60	52	89	325
16	106	70	53	30	250
17	36	70	54	30	500
18	72	58	55	47	188
19	29	17	56	183	480
21	193	120	57	209	246
22	654	140	62	27	76
23	503	159	63	8	90
24	102	127	64	6	100
25	93	50	65	0	100
26	450	130	66	3	20
27	306	165	67	8	75
28	283	160	68	9	143
29	186	80	69	23	100
33	2	140	70	14	130
34	12	267	71	19	83
35	13	215	72	115	205
36	156	250	73	34	165
37	559	180	74	5	114
38	0	400			

Appendix D4.–Southern Gravina geoduck clam survey transect information.

Transect number	**Total geoduck clams**	**Transect length (m)**
1	104	205
2	230	104
3	333	107
4	103	60
5	109	75
6	123	85
7	347	122
8	11	60
9	21	80
10	8	72
11	0	140
12	91	55
13	668	117
14	1,228	180
15	234	115
16	325	138
17	728	140
18	1,431	153
19	1,588	180
20	706	157

Appendix D5.–Lower Cordova Bay geoduck clam survey transect information.

Transect number	**Total geoduck clams**	**Transect length (m)**	**Transect number**	**Total geoduck clams**	**Transect length (m)**
1	35	460	31	0	75
2	6	200	32	5	60
3	137	80	33	89	64
4	0	40	34	103	50
5	126	66	35	0	30
6	0	200	36	19	65
7	7	30	37	129	80
8	48	45	38	349	50
9	0	70	39	13	90
10	33	47	40	410	133
11	59	80	41	0	150
12	154	78	42	130	50
13	224	50	43	23	80
14	135	90	44	0	150
15	1	100	45	0	100
16	2	100	46	0	50
17	24	11	47	0	175
18	3	50	48	0	50
19	249	50	49	37	150
20	0	80	50	21	40
21	82	63	51	9	42
22	0	110	52	11	50
23	152	125	53	46	86
24	129	66	54	15	50
25	242	90	55	15	97
26	34	15	56	2	59
27	34	45	57	0	3
28	48	50	58	4	33
29	0	61	59	1	80
30	13	90	60	41	200