Fishery Data Series No. 10-77

Southeast Alaska Sea Cucumber Stock Assessment Surveys in 2009

by

Kyle Hebert

November 2010

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. 10-77

SOUTHEAST ALASKA SEA CUCUMBER STOCK ASSESSMENT SURVEYS IN 2009

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ABSTRACT

The Alaska Department of Fish and Game drafted the first sea cucumber (*Parastichopus californicus)* fishery management plan prior to the fall commercial fishing season in 1990. The plan called for specific fishing areas to be opened to commercial fishing on a 3-year rotational basis, assessment surveys to be conducted prior to fishing, weekly fishing periods, and a number of control areas where commercial fishing would not be allowed. Assessment surveys are conducted using SCUBA diving to count sea cucumbers on 2-meter wide transects, and collect samples for estimates of average weight. During the 2009 survey season, a total of 321 transects were completed during 17 sea cucumber population assessment surveys conducted in commercial fishery areas in Southeast Alaska. These areas represent approximately one-third of the sea cucumber commercial fishery areas in the region, which are surveyed triennially. An additional 106 transects were completed during surveys in 5 different control areas that are closed to commercial harvest. Some of the commercial fishing areas have been surveyed up to 7 times, providing a time series to follow trends in abundance, weight, and biomass. Other areas, usually those with the lowest densities of sea cucumbers, have been surveyed on only one occasion. In 2009, the highest biomass of sea cucumbers was found in Subdistrict 106-30 at 2,751,555 pounds (1,249,206 kg), and the lowest biomass was found in Subdistrict 102-80, at 412,988 pounds (187,497 kg).

Key words: sea cucumber, *Parastichopus californicus,* Southeast Alaska, dive surveys, stock assessment, fishery

INTRODUCTION

The commercial sea cucumber *Parastichopus californicus* fishery expanded rapidly in the late 1980s and in 1989 the fishery exceeded the ability of the department to manage by a permit system. The department closed the fishery in May 1990 and reopened it in October 1990 following development of the Southeast Alaska Sea Cucumber Commercial Fisheries Management Plan (5 AAC 38.140). This management plan was initially developed in 1990 (ADF&G 1990) and adopted into regulations (5 AAC 38.140.) by the Alaska Board of Fisheries (ADF&G 1991, 1992). The management plan is based on a conservative policy of sustained yield (Woodby et al. 1993) and seeks both to protect subsistence opportunities and provide for sustained commercial fishing harvests. To protect subsistence opportunities, the cucumber management plan established 18 areas closed to commercial fishing (5 AAC 38.140 (k)). There are also provisions to prevent the use of diving gear in the subsistence (5 AAC 02.020 (1)) and personal use (5 AAC 77.010 (l)(3)) fisheries in those areas.

This document describes population assessment surveys and results for sea cucumber surveys in Southeast Alaska during the 2009 survey season, and additionally includes result for surveys conducted in 1991, 1994, 1997, 2000, 2003, 2006 seasons. The intent is to characterize the status of sea cucumber stocks and trends for areas in this fishery rotation (henceforth called the 1991/2009 rotation). Surveys conducted during 2009 represent approximately one-third of all commercial fishery areas in Southeast Alaska. The overall goals of the sea cucumber stock assessment survey program are to estimate the total number and average weight of sea cucumbers in both commercial harvest areas, and control areas (areas closed to commercial harvest), and to establish a biologically acceptable harvest level for areas opened to commercial fishing.

Fishing areas are opened on a 3-year rotational basis. The rationale for rotational fisheries in this instance is to reduce costs: survey and management costs are incurred only once every 3 years for any fished area. The rotational system was not implemented to allow an area to rest between harvests. Rotational harvest was considered unnecessary because harvest biomass is limited by a conservative exploitation rate approach (Larson et al. 2001a). Annual commercial fishery guideline harvest levels are calculated as the product of the lower 90% confidence limit on the biomass estimate and the annual target exploitation rate of 0.064, multiplied by 3 to adjust for triennial harvest. This results in a harvest rate of about 19.2% every 3 years. However, because the lower bound confidence limit is used, it is likely that the effective harvest rate is below this. Other aspects of the survey provide added conservative measures. These include surveys restricted to 50 ft (mean lower low water) of depth even though sea cucumbers are observed deeper, and, probable minimum sea cucumber counts along transects, due to limitations from kelp coverage and underwater visibility.

Although estimates of biomass and the harvest rate for sea cucumbers are considered to be conservative, there is currently not a control rule in the management plan designed to trigger a reduction in harvest rate or fishery closure. Trends in density, average weight, and biomass are considered when making decisions about commercial fishery openings; however the ability to accurately target a guideline harvest level based on expected fishing effort has been the main consideration in the decision.

METHODS AND PROCEDURES

SEA CUCUMBER POPULATION ASSESSMENT SURVEYS

Objectives

The primary objective of the sea cucumber assessment survey program is to conduct a population assessment survey once every 3 years in each potential fishing area (Figure 1) to estimate the sea cucumber biomass available for commercial harvest. The statistical objective is to estimate the biomass in survey areas such that the lower bound of the one-sided 90% confidence interval is within 30% of the mean value (70% precision). The estimated average weight of sea cucumbers in an area should have a precision level greater than 80%. A second objective is the conduct population assessment surveys every year in several control areas (Figure 2), which are closed to the commercial fishery, to monitor population changes in the absence of harvest.

Sampling Methods

Selection of Commercial Fishery Areas and Survey Areas

Stock assessment surveys of sea cucumber populations in 2009 comprise one of three fishing area rotational groups. Population assessment surveys were conducted in many of the same fishing areas as in 1991, 1994, 1997, 2000, 2003, 2006. However, if survey results revealed low sea cucumber abundance that precluded a commercial fishery in any year, then that area was generally not sampled in subsequent years. Conversely, additional new areas have been added over the years and have been surveyed only once or twice in recent years. The selection of fishing areas was decided through negotiation with the sea cucumber industry with an emphasis on providing areas each year near the major communities within the range of commercially viable sea cucumber populations. These communities are Ketchikan, Craig, Wrangell, Petersburg, and Sitka. To provide for stability in the industry, areas were further adjusted to provide for an equal amount of guideline harvest level in each year for each of the three rotations. Once an area was included as part of one fishing area rotational group, it remained attached to that rotation and was not subsequently surveyed or fished as part of another rotational group.

Abundance Estimates: The SCUBA Survey Method

Abundance estimates are initiated by SCUBA divers counting all sea cucumbers along 2-meter-wide strip transects running perpendicular to shore. A set of paired transects (two 2-meter-wide transects for each sampling location) serve as the primary sampling unit. Transects extend from the water's edge to 15 m (50 ft) below mean lower low water (MLLW). Transect length varies depending on slope of the bottom. An effort is made to limit exposure to actual depths greater than 18.5 meters because deeper dives severely limit total bottom times for SCUBA divers and pose safety risks when conducted repetitively over several days. The majority of the sea cucumber harvests by commercial divers occur at less than 15 meters depth.

To complete transects, both divers swim along the transect holding a 2-meter rod (a 2.1-cm diameter white PVC tube) in a horizontal position, perpendicular to the census path. Transect direction is maintained by reference to a compass mounted on the rod. Transect pairs are separated by approximately 5 meters or by the limits of visibility of dive partner for safety reasons. Divers slowly progress along each transect searching beneath kelp and between rocks to obtain accurate counts of sea cucumbers. In some areas where there is heavy kelp cover or poor underwater visibility, counts are probably underestimated because some sea cucumbers may be obscured from a diver's view.

At the end of each transect, divers record sea cucumber counts, end depth, predominant vegetative cover and substrate types, the presence of other species of interest (including geoducks, sea urchins and abalone), and any other interesting observations. Presence of vegetation in each segment is recorded as percent cover for up to 2 types. Substrate type is recorded for the 2 most common types on each segment, with the most prevalent type listed first. Definitions of the substrate types and vegetation types recorded during the assessment surveys are included in Appendices A and B. The beginning and ending times for each transect are recorded to allow for later standardization to mean lower low water (MLLW). During the first years of stock assessment surveys, estimates of sea cucumber density and habitat type by depth were recorded (see Larson et al. 2001a; Larson et al 2001b; Hebert et al. 2001a; Hebert et al. 2001b).

The State of Alaska–owned research vessel *R/V Kestrel* was used to support all sea cucumber dive surveys during 2009. In addition to the vessel crew of 3, 6 divers are generally assigned to each cruise, allowing two 3-person dive teams to operate simultaneously. Two aluminum skiffs, which have been enhanced for diving purposes, accompany the support vessel. All diving is conducted from these skiffs.

Due to the nature of the described dive surveys (multiple dives per day, reverse-profile to 70 feet of sea water, multi-day diving), 36% Nitrox was used for all diving conducted in 2009 to reduce the risk of barotrauma injury due to prolonged bottom times. Nitrox is produced onboard via a membrane equipped low-pressure compressor. All diving was conducted in accordance with the Alaska Department of Fish and Game's Dive Safety Manual (Hebert 2006).

Location and Number of Transect Samples

Transect pairs were systematically distributed along the shorelines of each survey area. The location of the first transect pair was randomly chosen, and subsequent transect pairs were located at equal intervals along the shoreline. The distance between transect pairs equals the total length of shoreline divided by the number of transect pairs allocated to each area. The number of transects planned for each area may varied depending on the variety of habitat quality and size of the area. Large areas with more habitat variety may require more transects to achieve the precision goal of the lower bound 90% confidence interval meeting or exceeding 70 percent of the point estimate. Generally the number of transect pairs required to achieve precision goals vary between 15 and 25. Locations of transects completed in 2009 are presented in Appendix C (commercial areas) and Appendix D (control areas).

Transect locations are permanent. If multiple past surveys have resulted in counts of zero on any given transect, that transect may not be sampled and assumed to be zero for purposes of density calculations. Alternatively, if several adjacent transects result in counts of zero, those transects and the corresponding shoreline may be removed from the survey design and considered to be not sea cucumber habitat. Most transect locations are revisited each rotational cycle, allowing paired comparisons of abundance between years without the added variability, due to location effects, that would result from assigning new locations each year. Although this is the current practice, alternative sampling methods may improve evaluation of fluctuations of sea cucumber population levels (Clark et al. 2009). There are no permanent markers at the transect sites to show the survey team where to dive. Transect sites are located using nautical charts showing transect locations supplemented by the use of differential global positioning satellite (DGPS) navigation device. Relocation is generally accurate to within 20 meters depending on the scale of the nautical chart used.

Average Weights

Individual sea cucumbers were collected and weighed in each survey area to estimate average weight of cucumbers. Average sea cucumber weight was estimated in each area for 2 reasons: 1) to compare average weights between years to determine if any significant change in size has occurred; and 2) to convert abundance estimates from number of sea cucumbers to biomass. In 2009, 12 to 15 sea cucumbers were collected along all odd-numbered transects completed in commercial fishery areas. In control areas, approximately 40 sea cucumbers were sampled at designated sampling sites that were not at transect locations. Control areas are sampled differently to avoid potentially impacting transect counts from annual collections. Individual sea cucumbers were eviscerated, drained, and then weighed to the nearest gram.

Statistical Analysis

The average number of sea cucumbers per linear meter of shoreline, d, and henceforth called "density" was calculated as:

$$d = \sum_{i=1}^{n} \frac{C_i}{4n} \qquad (1)$$

where:

i = transect index,

C_i = the total count of sea cucumbers in a transect pair, and

n = the number of transect pairs.

Division by 4 takes into account the 2 transects of 2 meters width each.

The variance of the mean, σ_d^2, is estimated as:

$$\sigma_d^2 = \frac{\sum_{i=1}^{n}\left(d - \frac{C_i}{4}\right)^2}{(n-1)n} \qquad (2)$$

Confidence limits about *d* were calculated using a *t*-value with *n*-1 degrees of freedom.

Average weight for transect *i*, (W_i) and associated variance of the mean weight (σ_W^2,) for m_i sea cucumbers sampled on transect *i* was estimated as,

$$W_i = \sum_{j=1}^{m_i} \frac{w_{ij}}{m_i}, \qquad (3)$$

$$\sigma_W^2 = \frac{\sum_{i=1}^{m}\left(W - w_{ij}\right)^2}{(m-1)m}. \qquad (4)$$

The estimated mean weight for the entire subdistrict (W_A) and associated variance of this mean weight are calculated as follows:

$$W_A = \sum_{i=1}^{k} \frac{W_i}{k}, \qquad (5)$$

$$\sigma_{W_A}^2 = \frac{\sum_{i=1}^{k}\left(W_i - W_A\right)^2}{(k-1)k}, \qquad (6)$$

where *k* equals the number of transects from which a cucumber sample was taken for weight measurements. The average weight and precision of this estimate were used to expand the estimated number of sea cucumbers in an area to the biomass of the population.

Biomass estimates and associated precision were estimated as a product of 2 random variables (Goodman 1960). The total number of sea cucumbers in a subdistrict (N_c) is the product of the average number of sea cucumbers per meter of shoreline and the total estimated length of shoreline (*L*):

$$N_C = Ld, \qquad (7)$$

and,

$$\sigma_{N_C}^2 = \sigma_d^2 L^2. \qquad (8)$$

The shoreline length estimate is assumed to be measured without error.

The biomass (B_c) is estimated as,

$$B_C = N_C W_A \quad (9)$$

Biomass variance is estimated as,

$$\sigma_{B_C}^2 = (\sigma_d^2 W_A^2 + \sigma_{W_A}^2 d^2 - \sigma_d^2 \sigma_{W_A}^2) L^2 \quad (10)$$

Degrees of freedom associated with the *t*-value for the precision of the biomass estimates are not known, but can be estimated through simulation. The quotas were calculated as the lower 90% confidence limit of the biomass estimate, multiplied by 3 to account for the 3-year rotational openings, and then by 0.064, which is the annual target harvest rate.

RESULTS AND DISCUSSION

COMMERCIAL FISHERY AREAS

Density, Weight, and Biomass

In 2009 the density of sea cucumbers in commercial fishery areas ranged from 31.7, in Subdistrict 102-80, to 2.8 in Subdistrict 103-80 (Table 1; Figure 3). Density of sea cucumbers is variable among fishery areas and among years, and there is no clear trend for most areas (Figures 4–8). Although there may be visual trends of point estimates for some areas, they are often not supported statistically due to overlapping confidence intervals. However, in at least one area, Subdistrict 103-80, density has steadily declined since the first survey in 1991. The reason for this decline is almost certainly due to sea otter predation. Although it is difficult to prove sea otter predation as the cause, observations of large numbers of sea otters have been made in this area, and other invertebrate species, which are known sea otter prey (e.g. red sea urchins and geoducks), have also declined in the area. Cordova Bay (Subdistricts 103-21, -30 and Subdistricts 103-23, -25) is another area where sea cucumber density has declined, likely due to sea otter predation. However, only 3 or 4 surveys have been conducted in this area, making it difficult to statistically verify trends.

Average sea cucumber weight measured in 2009 ranged from 136 grams in Subdistrict 102-80, to 302 grams in Subdistricts 105-32;109-43 (Table 2; Figure 9). Average weight appears to be stable over time for most areas, and possibly increasing in some areas (Figures 10–14). There are no areas in the 1991/2009 rotation where there is evidence of declining average weight. There appears to be a slight negative relationship between density and average weight among areas surveyed in 2009, though the correlation coefficient is relatively low (r^2=0.42), suggesting the possibility that sea cucumber weight is a function of density. Clark et al. (2009) examined trends for all 3 Southeast Alaska fishery rotations combined, and found that density had declined in more areas than not, and average weight had increased. If there is a causal relationship, this may result in biomass estimates remaining stable, even when density declines.

The highest estimate of biomass in 2009 was in Subdistrict 106-30, at 2,751,555 pounds (1,249,206 kg) and the lowest was in Subdistrict 103-80, at 412,988 pounds (187,497 kg) (Table 3; Figure 15). Biomass estimates are derived from estimates of density and average weight and provide an estimate of overall population levels. Biomass level is directly proportional to the length of shoreline in a given area (Table 4; Figure 16), except in areas where sea otters are present, where density is disproportionately low. An example of this exception may be found in Subdistricts 103-21, -30, where the shoreline length is the highest among areas in the 1991/2009 rotation. However, biomass estimates are about one-third that of the highest biomass estimate in the rotation, made in Subdistrict 106-30. Although the biomass point estimate in Subdistrict 106-30 was the highest in 2009, and usually is the highest in this rotation, the variation around the point estimate was relatively high, producing a wide confidence interval. Subdistrict 102-60 also produced a high biomass estimate, but with a narrower confidence interval than Subdistrict 106-30. Due to uncertainty (high variance) surrounding the point estimates, it is possible that a higher biomass was present in Subdistrict 102-60 in 2009.

Although tracking estimates of sea cucumber biomass over time may be an acceptable way to observe trends in overall population levels, it must be done with caution. The reason for this is that biomass estimates are calculated using the length of shoreline for each area, which may fluctuate for a variety of reasons (see Table 4). Reasons may include adding to or combining of fishery areas (e.g. Subdistricts 101-10, -11), or opening or closing areas to the commercial fishery by the Board of Fisheries (e.g. Subdistrict 101-90, -95 and Subdistricts 112-11, -21). The addition or removal of sections of shoreline from survey areas results in changes in biomass estimates that are not a result of changes in population levels. For this reason, shoreline changes must be considered when evaluating trends in biomass.

Biomass appears to be relatively stable in most areas of the 1991/2009 rotation, over the period since biomass estimate have been made (1994–2009), with the exception of the aforementioned areas where sea otters may have impacted populations (Figures 17–21). Subdistrict 103-80 (south of Heceta Island, west of Prince of Wales Island), and the Cordova Bay areas (Subdistricts 103-21, -30 and Subdistricts 103-23, -25) appear to be the areas in this rotation most affected by sea otter predation. Although this report includes two additional survey years, see Clark et al., 2009, for prior analysis of sea cucumber population trends in Southeast Alaska, including statistical test of significance.

Guideline Harvest Levels

Appropriate harvest levels are currently calculated using a harvest rate of 19.2%, applied to the lower bound of the 90% confidence interval surrounding the biomass estimate. Potential GHLs, based on this calculation are presented in Table 5. The actual GHLs that have been used for fishery management are shown in Table 6. These values may differ slightly in recent years due to rounding up or down for ease of reporting in news releases. Actual GHLs from earlier years differed from potential GHLs because the survey was relatively new and results were used to help guide setting appropriate harvest levels, rather than determine GHLs. In many cases, but not all, GHLs during early years were set higher than those calculated using the current harvest rate.

The area in the 1991/2009 rotation with the highest GHL is Subdistrict 102-60 (southern portion of Kasaan Bay and Skowl Arm on east Prince of Wales Island) and the second highest GHL is in Subdistrict 106-30 (Figure 22). These 2 areas comprised 37% of the total regional GHL established for the 2009/2010 fishing season. Subdistricts 101-10, -11 (Nakat Bay area) also contributed greatly to the regional GHL. These top 3 areas combined comprised 47% of the 2009/2010 regional GHL.

Observation of trends in GHLs over time is fundamentally different than observing trends in biomass or population level. This is because biomass estimates are considered with estimates of error, whereas GHLs are not. If estimates of error (e.g. confidence intervals) overlap, it may not be possible to conclude that the biomass in an area has undergone a statistically significant declined or increased. However, it is noticeable when there are fluctuations or trends in GHLs. Because GHLs are calculated in proportion to biomass (and precision), which is derived from shoreline, the same cautions apply to considering fluctuations in GHLs as for biomass. That is, if shoreline values used to calculate biomass and GHL have changed, they must be considered when viewing fluctuations in GHL.

When 2009/2010 GHLs are compared to those established for the 2006/2007 commercial fishery, approximately half of areas are greater and half of areas are less (Figures 23–27). Trends in GHL levels are more difficult to evaluate over longer periods of time, because of changes in methods used to establish GHLs and changes in shoreline used in estimates of biomass. For example, for the period 1991 to 2009, more areas appear to have declining trends in GHLs than increasing, however more areas had higher GHLs established in early years than would have been using the current harvest rate of 19.2%. In those cases, although GHLs have declined, they are not necessarily an indication of population decline, because GHLs targeted during early years of the fishery may have been set higher than was appropriate.

CONTROL AREAS

Control areas are survey sites in subdistricts or portions of subdistricts that have been closed to commercial harvest by the Board of Fisheries and are surveyed using very similar techniques as those used to survey commercial fishery areas. The intent is to monitor these areas to evaluate fluctuations of sea cucumber density, weight, and biomass with the assumption that there is no commercial harvest. Population trends in these areas help determine the extent that fluctuations in the environmental contribute to fluctuations of populations.

Five control areas have been consistently surveyed annually since 2000, and 3 of these since 1998 (see Figure 2). Trends in sea cucumber density among control areas are mixed, with some areas in decline (e.g. Subdistrict 101-27 south of Ketchikan and Subdistrict 113-41 control near Sitka), and some apparently stable (Table 7; Figure 28). There are no control areas where density appears to be increasing. There are 3 control areas where sea otters are known to be in the general area (Subdistricts 103-40 control, 103-60 control, 113-41 control). Of these areas, only Subdistrict 113-41 control appears to have decreased over time. It is unclear why sea cucumber populations in other control areas where sea otters reside have not been affected. The apparent decline in sea cucumber density in some control areas suggests that if there are declines in commercial fishery areas, they are not necessarily due exclusively to fishery mortality.

Sea cucumber average weight within control areas appears to be steady or increasing (Table 8; Figure 29). Variation of point estimates of average weight is considerably smaller than that of density estimates, making detection of or absence of trends more conclusive.

Biomass estimates in control areas follow very similar patterns over time as density estimates (Figure 30). This is because biomass estimates are calculated directly from density and average weight estimates, and average weight has remained stable over time. Variance (expressed as confidence intervals in Figure 30) has remained at a relatively low level in control areas. The statistical objective of maintaining the percent precision at least within 70% of the point estimate of biomass has been achieved or exceeded in most areas for most years. This result increases confidence that trends observed in populations are real, as opposed to being uncertain due to estimate error.

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TABLES AND FIGURES

Table 1.–Average sea cucumbers per meter of shoreline ("density") from surveys in commercial fishery subdistricts of Southeast Alaska.

Survey year	101-10,11	101-25	101-30	101-90,95	102-20	102-60	102-80	103-21,30	103-23,25	103-40-001	103-60,70
1991	15.7			16.1	16.1		18.1			12.3	
1994	15.3			16.0	16.3		27.8			21.3	
1997	12.8			11.7	10.8		13.0			14.0	
2000	11.5	26.6	5.2	14.3	11.2		19.2	12.0			
2003	9.7	24.3		12.1	12.8	19.0	13.9	12.7	16.9		
2006	11.6	15.3		14.2	7.9	18.2	18.0	9.9	13.0		5.7
2009	9.9	14.0		13.5	10.3	16.3	31.7	5.1	7.9		6.8

Survey year	103-80	105-32, 109-43[a]	106-30	109-30	109-44,45	110-21,22, 24	112-11,21[a]	112-41,42	112-43-48	113-62,66	113-71,72,73
1991	16.3						7.7			9.4	6.6
1994	13.0		40.3		3.3		14.8			9.5	3.6
1997	13.2		31.6			2.6	6.7	20.0	12.1	7.5	
2000	7.1		24.9	3.6			8.1	15.1	9.3	7.1	
2003	4.4	6.6	19.7				6.7	10.1	10.7	9.4	
2006	3.2	4.4	37.8	4.0		1.7	7.8	13.5	10.5	5.5	
2009	2.8	5.1	29.2	4.4			5.5	13.6	9.3	10.0	

[a] Estimates indicated as made in 2009 were actually made in 2008.

Table 2.–Average sea cucumber weight (grams) from surveys in commercial fishery subdistricts of Southeast Alaska.

Survey year	101-10,11	101-25	101-30	101-90,95	102-20	102-60	102-80	103-21,30	103-23,25	103-40-001	103-60,70
1994	163			184	202		106			141	
1997	195			109	170		116			156	
2000	225	234	164	129	174		112	262			
2003	210	248		120	191	252	144	220	258		
2006	203	265		154	191	248	146	245	258		234
2009	256	229		156	225	244	136	285	244		250

Survey year	103-80	105-32, 109-43[a]	106-30	109-30	109-44,45	110-21,22, 24	112-11,21[a]	112-41,42	112-43-48	113-62,66	113-71,72,73
1994	261		235		272		213			191	188
1997	248		168			251	211	187	210	199	
2000	271		176	229			178	160	211	199	
2003	269	361	209				219	229	245	246	
2006	260	342	160	238		261	221	215	256	210	
2009	222	302	186	228			201	180	227	255	

[a] Estimates indicated as made in 2009 were actually made in 2008.

Table 3.–Total sea cucumber biomass in pounds for Southeast Alaska fishery subdistricts.

Survey year	**101-10,11**	**101-25**	**101-30**	**101-90,95**	**102-20**	**102-60**	**102-80**	**103-21,30**	**103-23,25**	**103-40-001**	**103-60,70**
1994	846,398			953,175	749,454		282,046			1,203,509	
1997	849,065			414,239	420,088		145,029			878,077	
2000	880,310	901,278	317,423	401,896	445,846		205,193	1,756,797			
2003	688,588	872,823		317,398	556,943	2,623,919	192,568	1,563,991	1,598,856		
2006	1,094,100	586,397		478,372	345,069	2,474,132	252,271	1,361,160	1,231,955		613,642
2009	1,174,826	460,718		682,718	530,279	2,180,314	412,988	812,028	708,735		778,424

Survey year	**103-80**	**105-32, 109-43**[a]	**106-30**	**109-30**	**109-44,45**	**110-21,22, 24**	**112-11,21**[a]	**112-41,42**	**112-43-48**	**113-62,66**	**113-71, 72,73**
1994	882,207		4,787,882		157,296		863,460				254,882
1997	847,915		2,683,870			204,313	384,657	426,739	680,373	450,508	
2000	499,816		2,226,827	159,296			395,001	276,422	524,544	428,400	
2003	307,196	345,968	2,080,876				398,447	266,161	703,980	700,633	
2006	213,424	220,340	3,062,842	183,364		133,873	677,365	332,076	723,092	351,734	
2009	161,406	223,963	2,751,555	190,502			435,081	280,397	564,216	772,241	

[a] Estimates indicated as made in 2009 were actually made in 2008.

Table 4.–Linear shoreline measurement in meters of cucumber habitat used to estimate biomass in Southeast Alaska fishery subdistricts.

Survey year	**101-10,11**	**101-25**	**101-30**	**101-90,95**	**102-20**	**102-60**	**102-80**	**103-21,30**	**103-23,25**	**103-40-001**	**103-60,70**
1994	154,170			146,956	103,453		43,522			182,107	
1997	154,170			146,956	103,453		43,522			182,107	
2000	154,170	65,561	170,795	99,221	103,453		43,522	254,311			
2003	154,170	65,561		99,221	103,453	249,021	43,522	254,311	166,400		
2006	211,146	65,561		99,221	103,453	249,021	43,522	254,311	166,400		208,164
2009	211,146	65,561		146,956	103,453	249,021	43,522	254,311	166,400		208,164

Survey year	**103-80**	**105-32, 109-43**[a]	**106-30**	**109-30**	**109-44,45**	**110-21, 22, 24**	**112-11,21**[a]	**112-41,42**	**112-43-48**	**113-62-66**	**113-71,72,73**
1994	117,787		229,833		80,932		124,269	51,970			170,014
1997	117,787		229,833			141,403	124,269	51,970	121,801	137,344	
2000	117,787		229,833	87,380			124,269	51,970	121,801	137,344	
2003	117,787	66,035	229,833				124,269	51,970	121,801	137,344	
2006	117,787	66,035	229,833	87,380		141,403	178,634	51,970	121,801	137,344	
2009	117,787	66,035	229,833	87,380			178,634	51,970	121,801	137,344	

[a] Estimates indicated as made in 2009 were actually made in 2008.

Table 5.–Potential commercial harvest levels in pounds based on 6.2% annual harvest rate for fishery subdistricts in Southeast Alaska. The abbreviation “nf” signifies no fishery in that area and year.

Survey year	**101-10,11**	**101-25**	**101-30**	**101-90,95**	**102-20**	**102-60**	**102-80**	**103-21,30**	**103-23,25**	**103-40-001**	**103-60,70**
1991	140,684			125,870	93,328		26,154			103,776	
1994	104,683			119,341	93,980		31,856			188,088	
1997	102,465			57,712	55,333		17,527			121,167	
2000	124,962	101,863	nf	61,183	56,876		24,345	213,359			
2003	82,400	102,988		46,290	74,795	360,430	23,327	202,603	209,634		
2006	141,935	72,284		70,281	45,998	333,824	27,396	169,902	159,704		77,539
2009	163,252	59,954		98,178	61,597	322,526	48,253	90,145	101,528		102,550

Survey year	**103-80**	**105-32, 109-43**[a]	**106-30**	**109-30**	**109-44,45**	**110-21,22, 24**	**112-11,21**[a]	**112-41,42**	**112-43-48**	**113-62,66**	**113-71,72,73**
1991	119,496						60,022			79,973	23,980
1994	121,590		547,969		15,796		118,308			13,479	23,514
1997	100,693		254,775			nf	58,349	40,884	68,973	nf	
2000	58,875		297,150	nf			60,108	35,874	60,323	27,391	
2003	36,703	30,676	251,505				59,406	36,573	78,996	41,354	
2006	21,606	25,864	191,648	21,404		nf	92,350	42,979	72,659	31,319	
2009	9,951	24,493	259,818	23,955			49,558	27,412	62,662	68,748	

[a] Estimates indicated as made in 2009 were actually made in 2008.

Table 6.–Actual commercial fishery guideline harvest levels (GHLs) in pounds for fishery subdistricts in Southeast Alaska. The abbreviation “nf” signifies no fishery in that area and year.

Survey year	101-10,11	101-25	101-30	101-90,95	102-20	102-60	102-80	103-21,30	103-23,25	103-40-001	103-60,70
1991	154,026			158,782	106,546		45,617			66,792	
1994	118,000			123,700	102,700		31,500			152,800	
1997	114,750			67,200	52,090		17,700			119,760	
2000	125,000	101,900	nf	61,200	56,900		24,300	213,400			
2003	82,400	103,000		46,300	74,800	360,400	23,300	202,600	209,600		
2006	141,900	72,300		70,300	46,000	333,800	27,400	169,900	159,700		77,500
2009	163,300	60,000		98,200	61,600	322,500	48,200	90,100	101,500		102,600

Survey year	103-80	105-32, 109-43[a]	106-30	109-30	109-44,45	110-21, 22, 24	112-11,21[a]	112-41,42	112-43-48	113-62-66	113-71,72,73	Total
1991	130,458						66,439			78,155	45,107	851,922
1994	135,100		471,300		18,100		120,900			54,400	22,500	1,351,000
1997	118,220		245,430			nf	47,760	40,100	69,400	nf		892,410
2000	58,900		297,200	nf			60,100	35,900	60,300	27,400		1,122,500
2003	36,700	30,700	251,500				59,400	36,600	79,000	41,400		1,637,700
2006	21,600	25,900	191,600	21,400		nf	92,400	43,000	72,700	31,300		1,598,700
2009	10,000	24,500	259,800	24,000			49,600	27,400	62,700	68,700		1,574,700

[a] Values indicated as established in 2009 were actually made in 2008.

Table 7.–Average sea cucumbers per meter of shoreline ("density") from surveys in control area subdistricts of Southeast Alaska.

Survey year	101-27	103-40	103-60	106-30	113-41
1998	20.0		14.4	29.3	
1999	15.2		13.3	31.7	
2000	16.8	10.1	17.3	23.5	7.8
2001	16.3	11.6	14.1	21.9	5.6
2002	10.3	4.4	7.1	16.9	6.0
2003	18.6	12.2	18.6	18.8	5.9
2004	10.9	7.8	14.9	26.2	5.4
2005	14.3	9.3	13.3	24.2	5.1
2006	12.4	11.0	13.9	26.7	4.2
2007		8.9	11.8	48.1	3.7
2008	7.4	7.9	10.6		
2009	8.8	8.3	12.1	14.2	3.9

Table 8.–Average sea cucumber weight (grams) from surveys in control area subdistricts of Southeast Alaska.

Survey year	101-27	103-40	103-60	106-30	113-41
1998	257		223	261	
1999	228		220	259	
2000	239	274	209	262	232
2001	232	327	254	292	238
2002		238	225	313	223
2003	252	228	238	306	208
2004	255	203	214	325	216
2005	250	266	230	312	212
2006	262	239	229	296	215
2007		288	224	303	216
2008	214	258	227		
2009	238	316	246	336	257

Table 9.–Total sea cucumber biomass in pounds for control area subdistricts in Southeast Alaska.

Survey year	101-27	103-40	103-60	106-30	113-41
1998	612,270		137,474	530,015	
1999	413,499		125,361	568,353	
2000	477,039	116,442	155,340	425,977	92,398
2001	451,499	159,574	153,273	444,202	68,155
2002		44,510	68,943	365,979	68,023
2003	559,192	117,606	189,921	400,348	62,403
2004	331,954	66,205	137,145	590,642	59,557
2005	425,248	104,025	131,672	523,007	55,041
2006	388,922	111,011	136,595	548,668	45,943
2007		107,616	113,221	1,013,444	40,397
2008	188,146	86,083	103,390		
2009	248,582	110,654	127,312	331,118	50,701

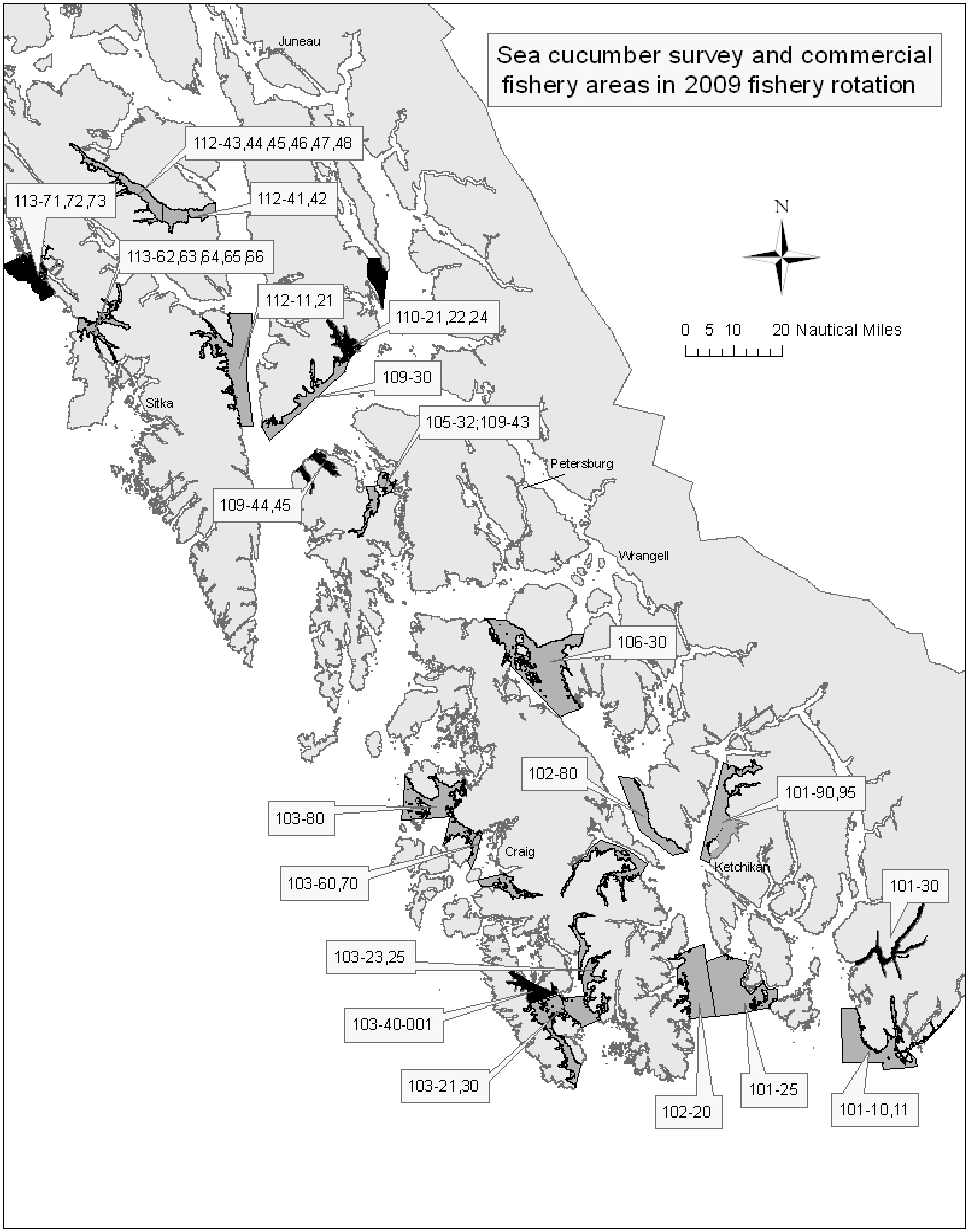


Figure 1.–Location of Southeast Alaska sea cucumber commercial fishery subdistricts in 1991/2009 fishery rotation. Areas shaded gray represent areas surveyed in 2009 and opened in 2009/2010 commercial fishery. Areas shaded black represent areas surveyed or fished prior to 2009/2010 season.

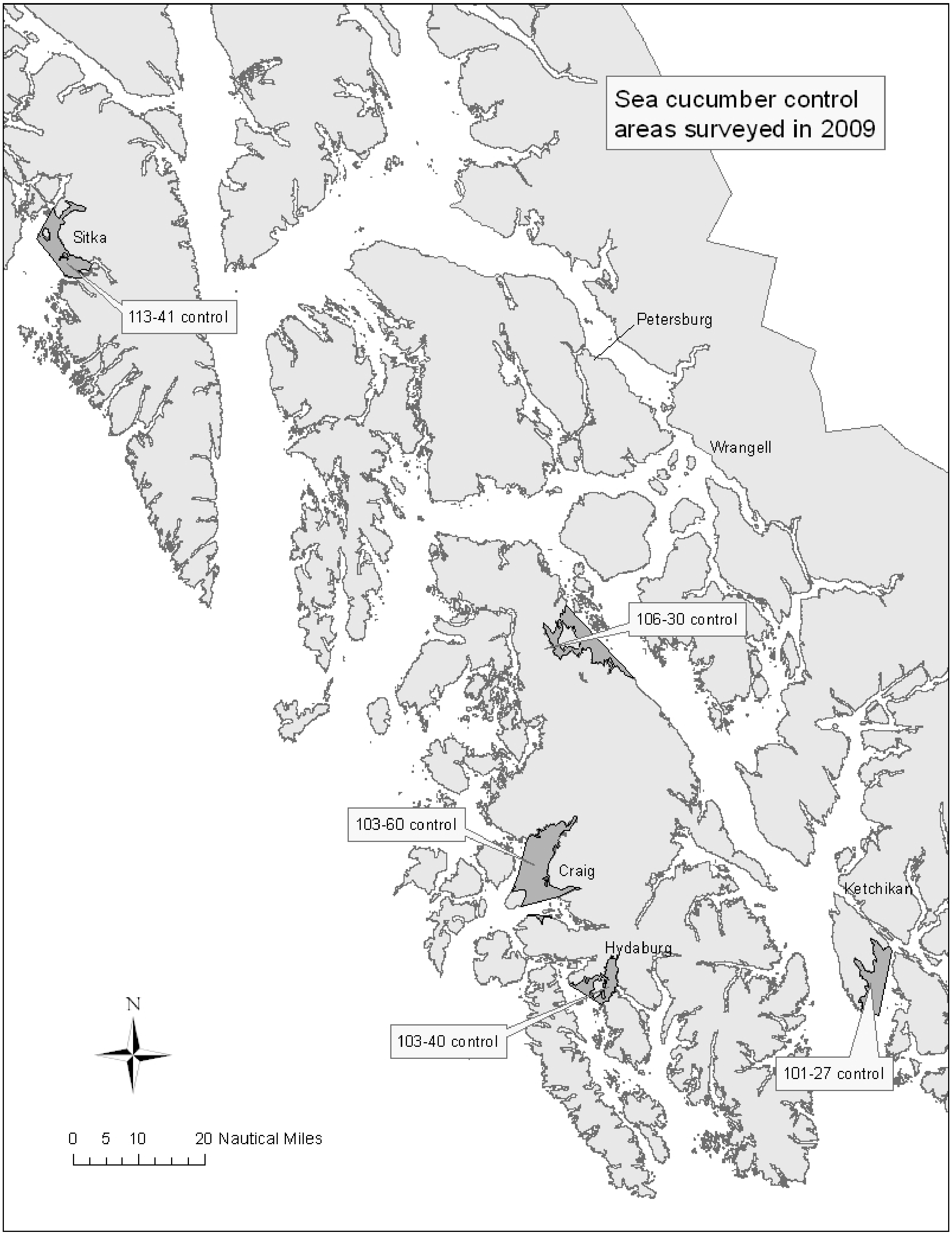


Figure 2.–Location of sea cucumber control (closed to commercial harvest) areas in Southeast Alaska

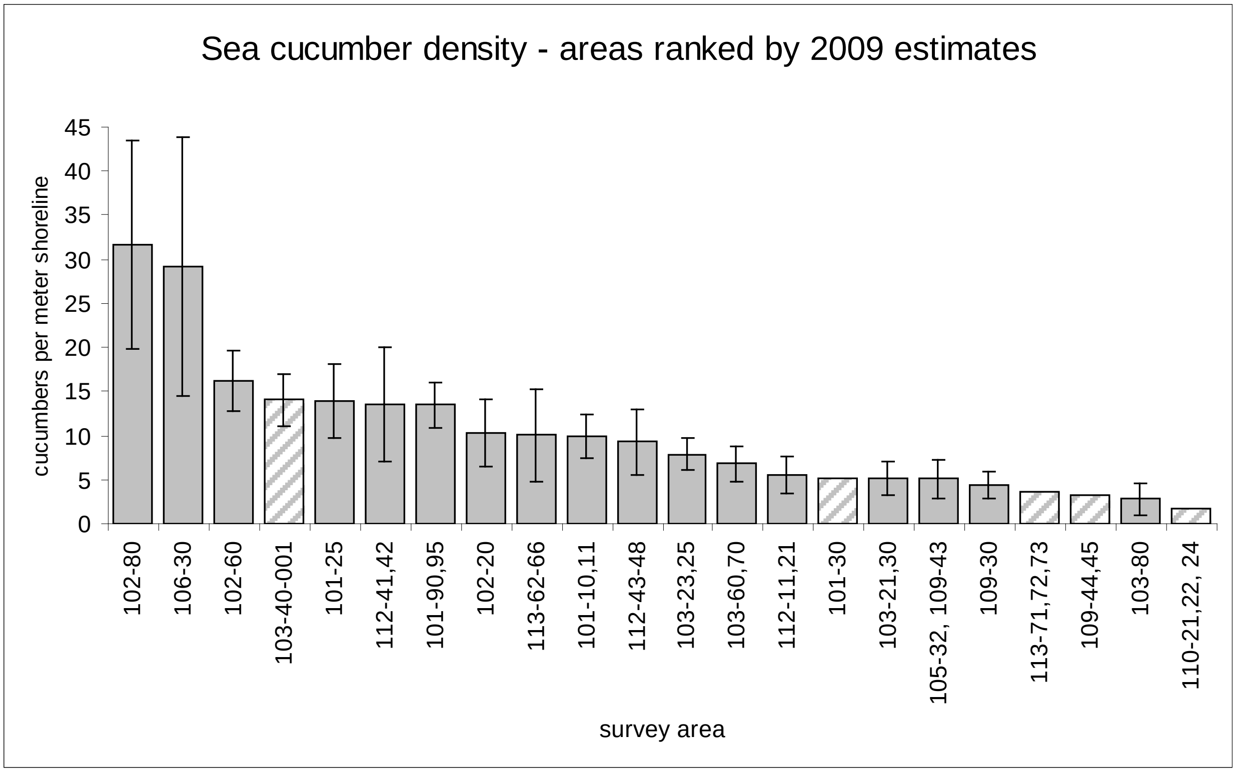


Figure 3.–Estimated sea cucumbers per meter of shoreline in Southeast Alaska, ranked by survey area using 2009 estimates. Bars with patterns represent values from surveys prior to 2009 as no survey was conducted in 2009. Error bars represent 90% confidence intervals.

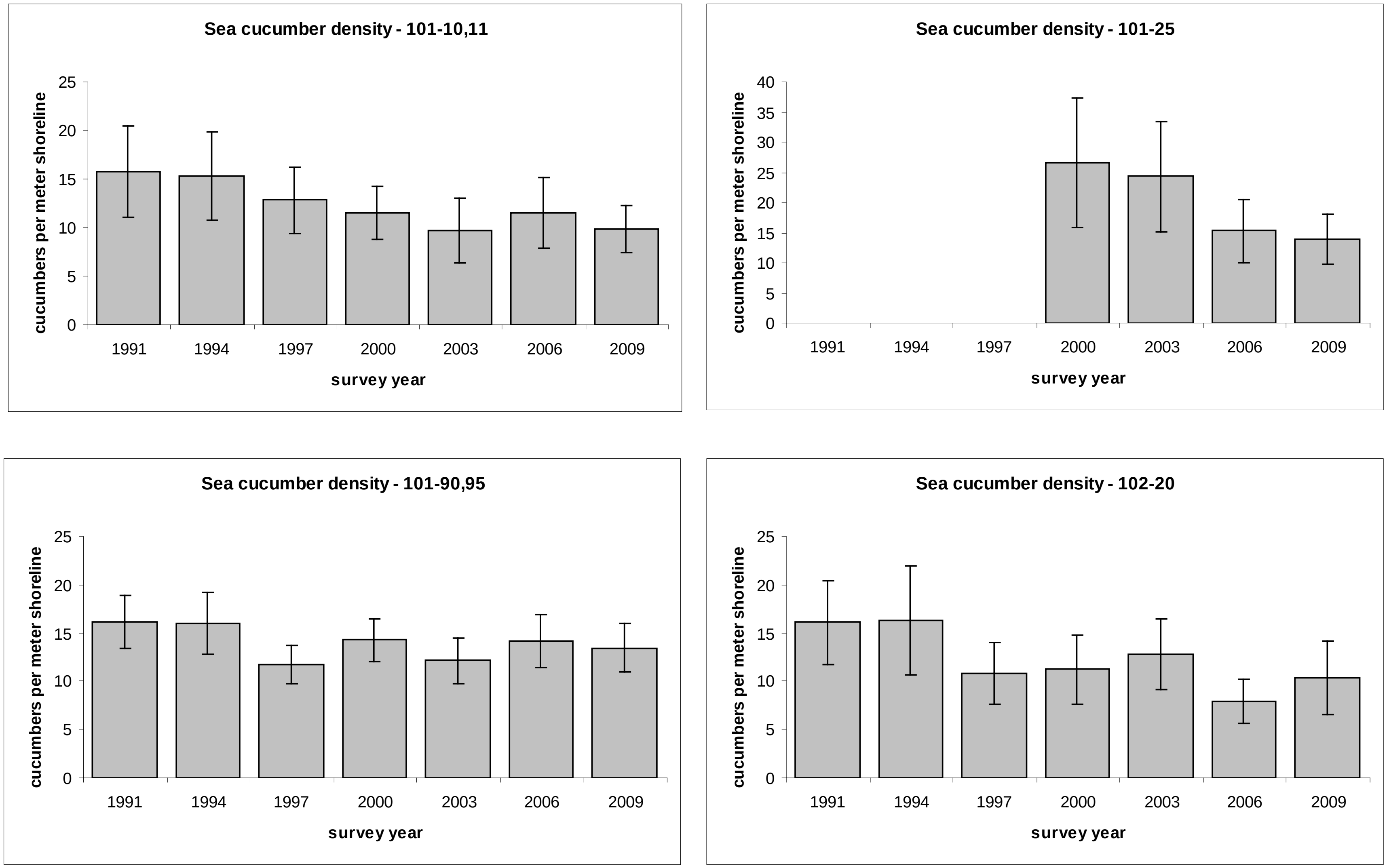


Figure 4.–Average number of sea cucumbers per meter of shoreline from surveys in commercial fishery Subdistricts 101-10,11, Subdistrict 101-25, Subdistricts 101-90,95, and Subdistrict 102-20 in Southeast Alaska. Error bars represent 90% confidence intervals.

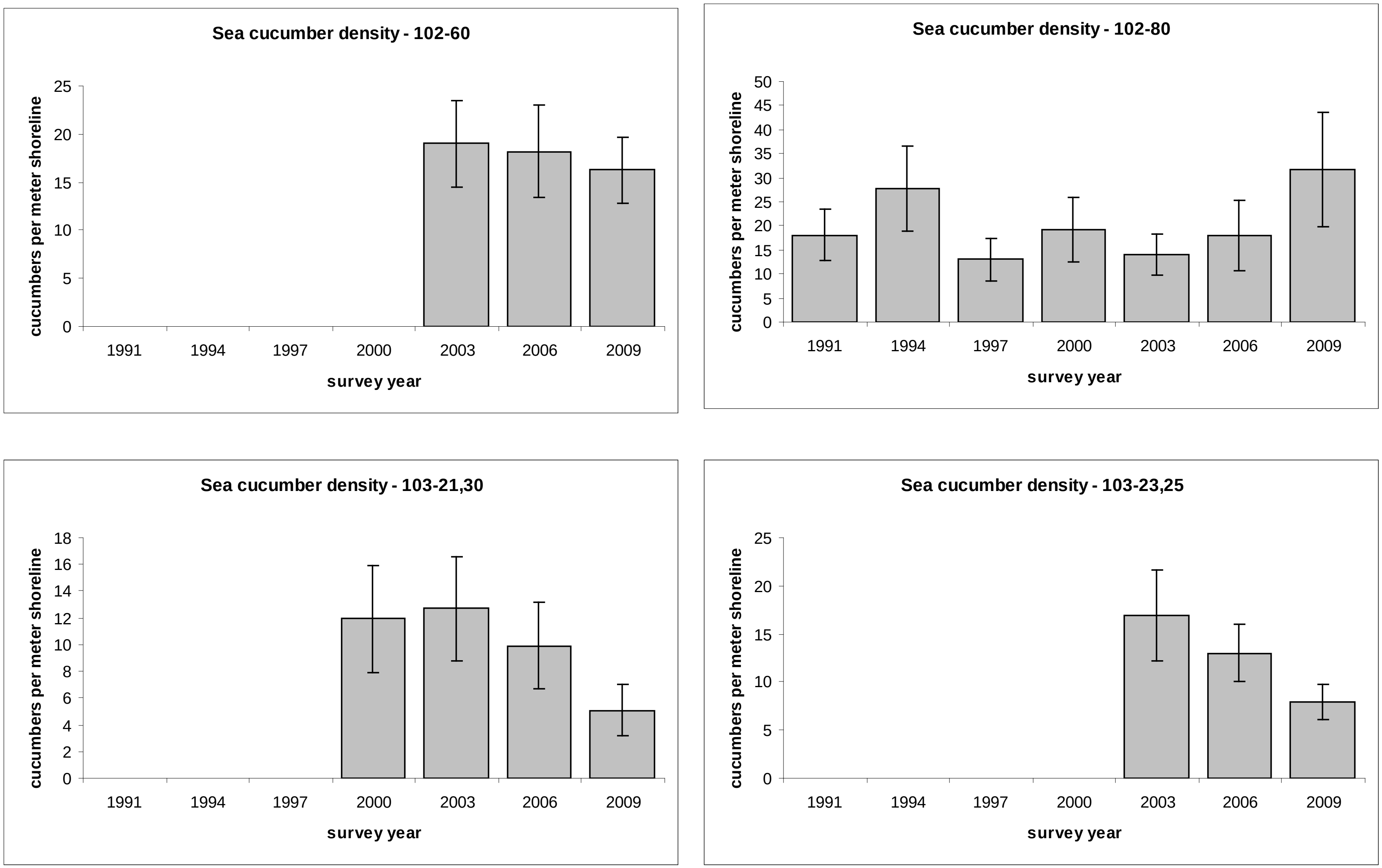


Figure 5.–Average number of sea cucumbers per meter of shoreline from surveys in commercial fishery Subdistrict 102-60, Subdistrict 102-80, Subdistricts 103-21,30, and Subdistricts 103-23,25 in Southeast Alaska. Error bars represent 90% confidence intervals.

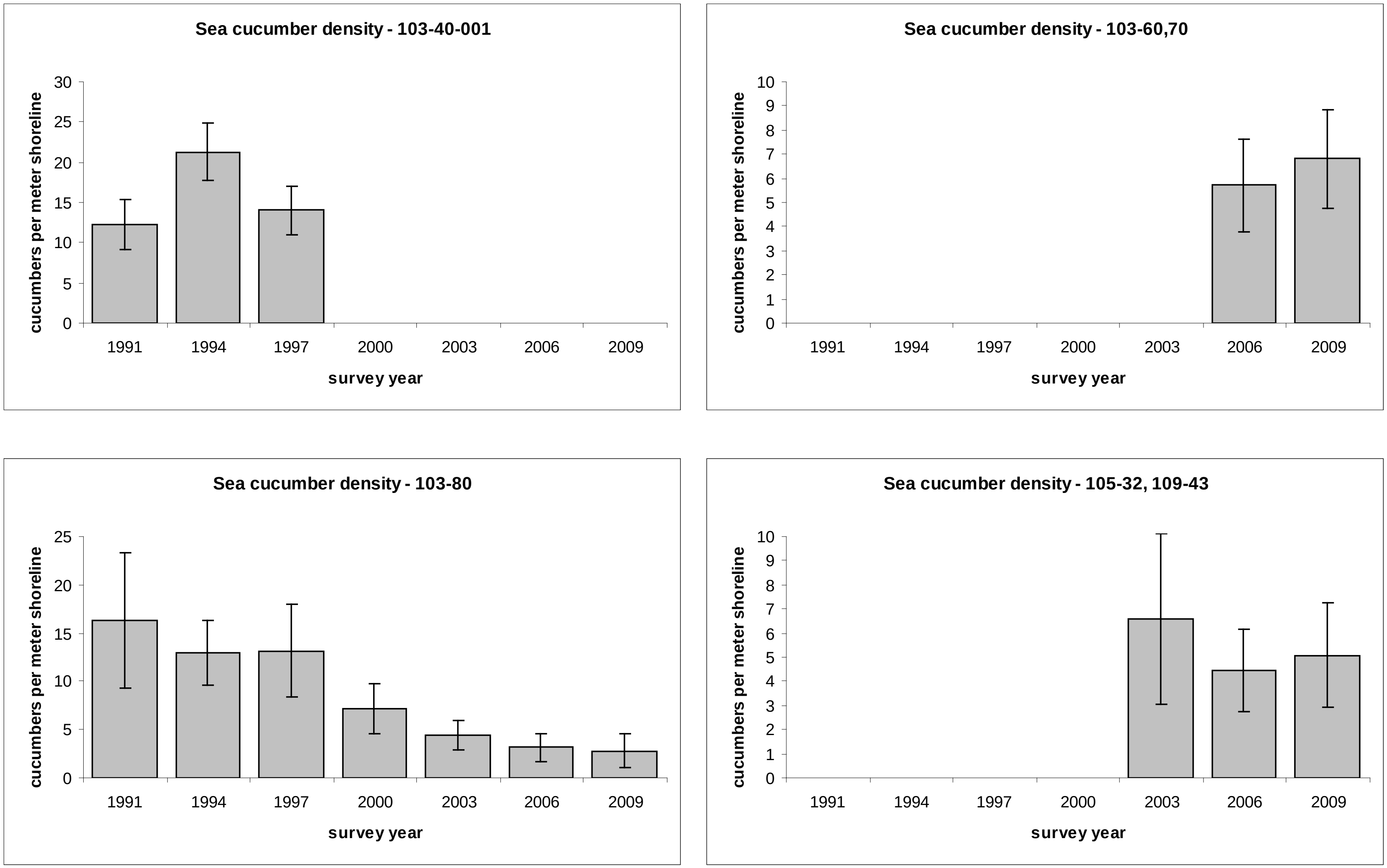


Figure 6.–Average number of sea cucumbers per meter of shoreline from surveys in commercial fishery Subdistrict 103-40-001, Subdistricts 103-60,70, Subdistrict 103-80, and Subdistricts 105-32,109-43 in Southeast Alaska. Error bars represent 90% confidence intervals.

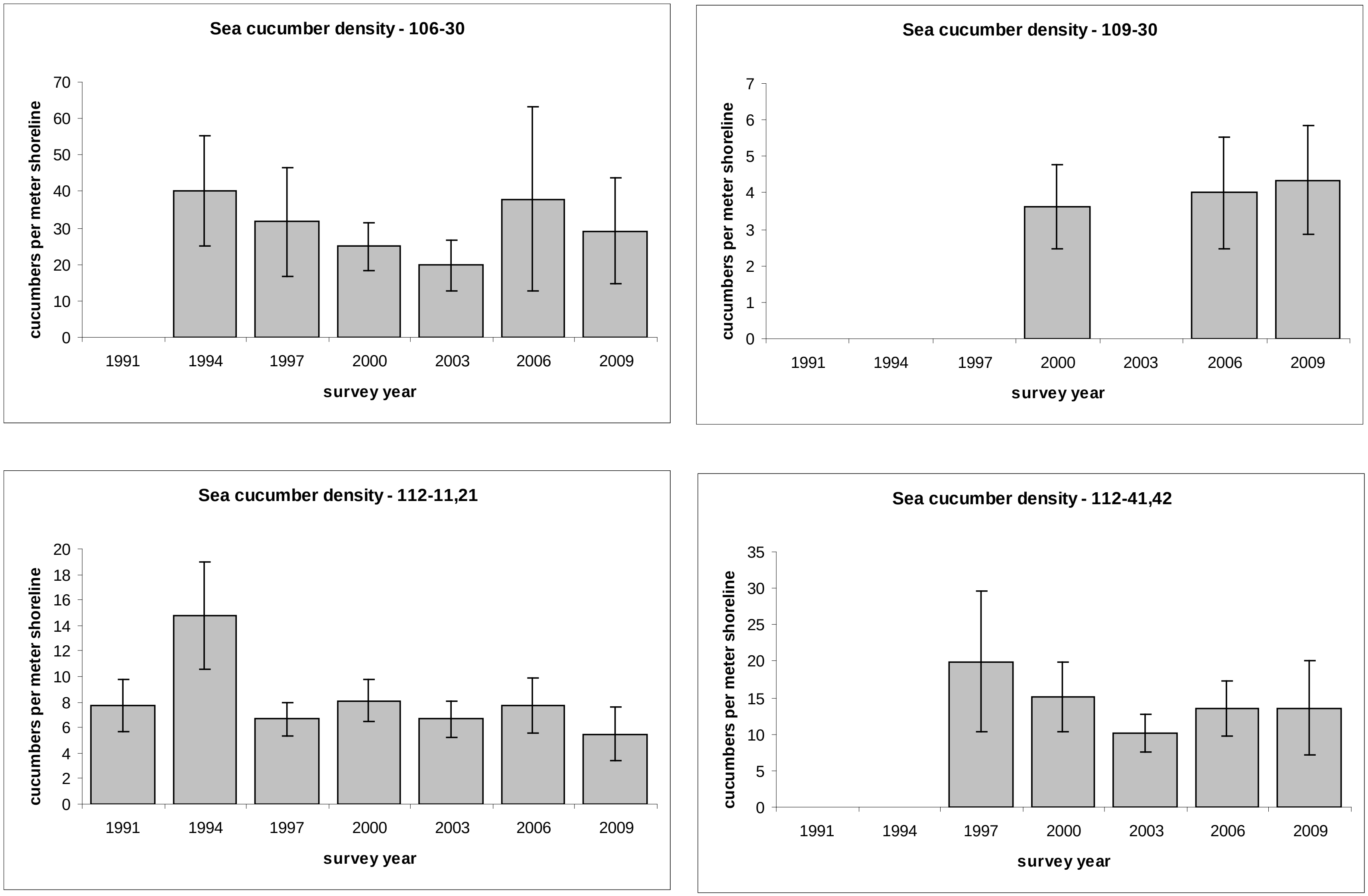


Figure 7.–Average number of sea cucumbers per meter of shoreline from surveys in commercial fishery Subdistrict 106-30, Subdistrict 109-30, Subdistricts 112-11,21, and Subdistricts 112-41,42 in Southeast Alaska. Error bars represent 90% confidence intervals.

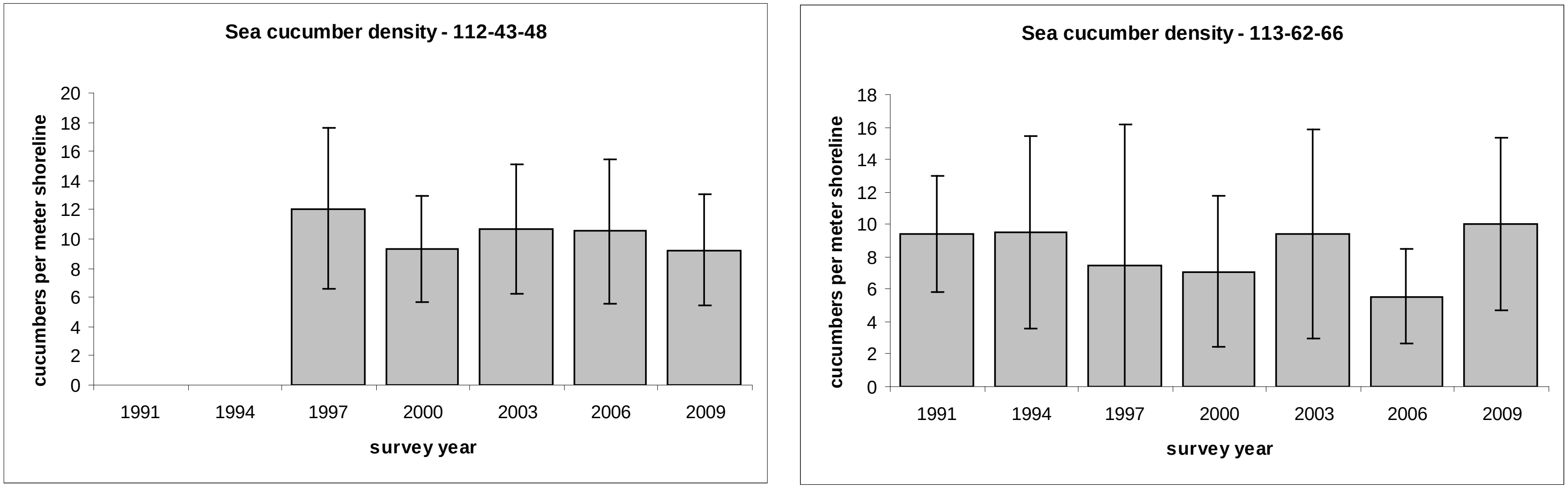


Figure 8.–Average number of sea cucumbers per meter of shoreline from surveys in commercial fishery Subdistricts 112-43 through 112-48, and Subdistricts 113-62 through 113-66 in Southeast Alaska. Error bars represent 90% confidence intervals.

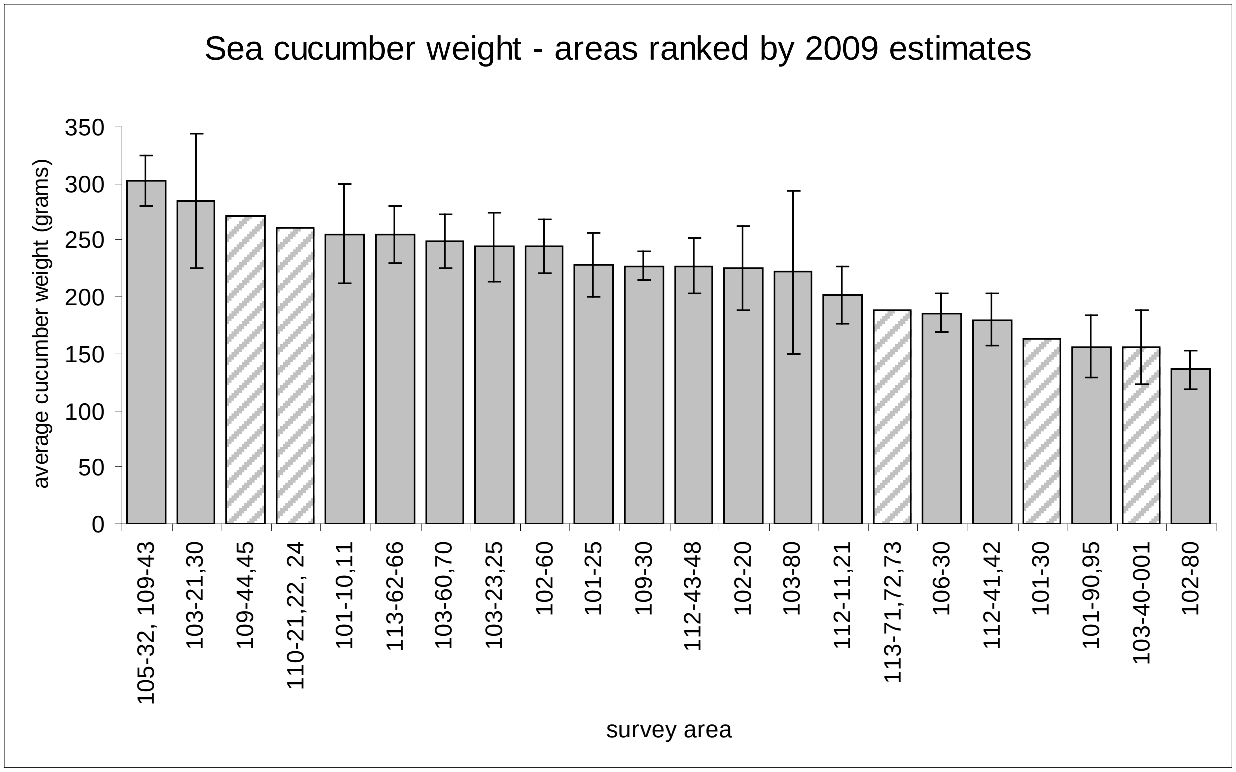


Figure 9.–Estimated sea cucumbers average weight in Southeast Alaska, ranked by survey area using 2009 estimates. Bars with patterns represent values from surveys prior to 2009 as no survey was conducted in 2009. Error bars represent 90% confidence intervals.

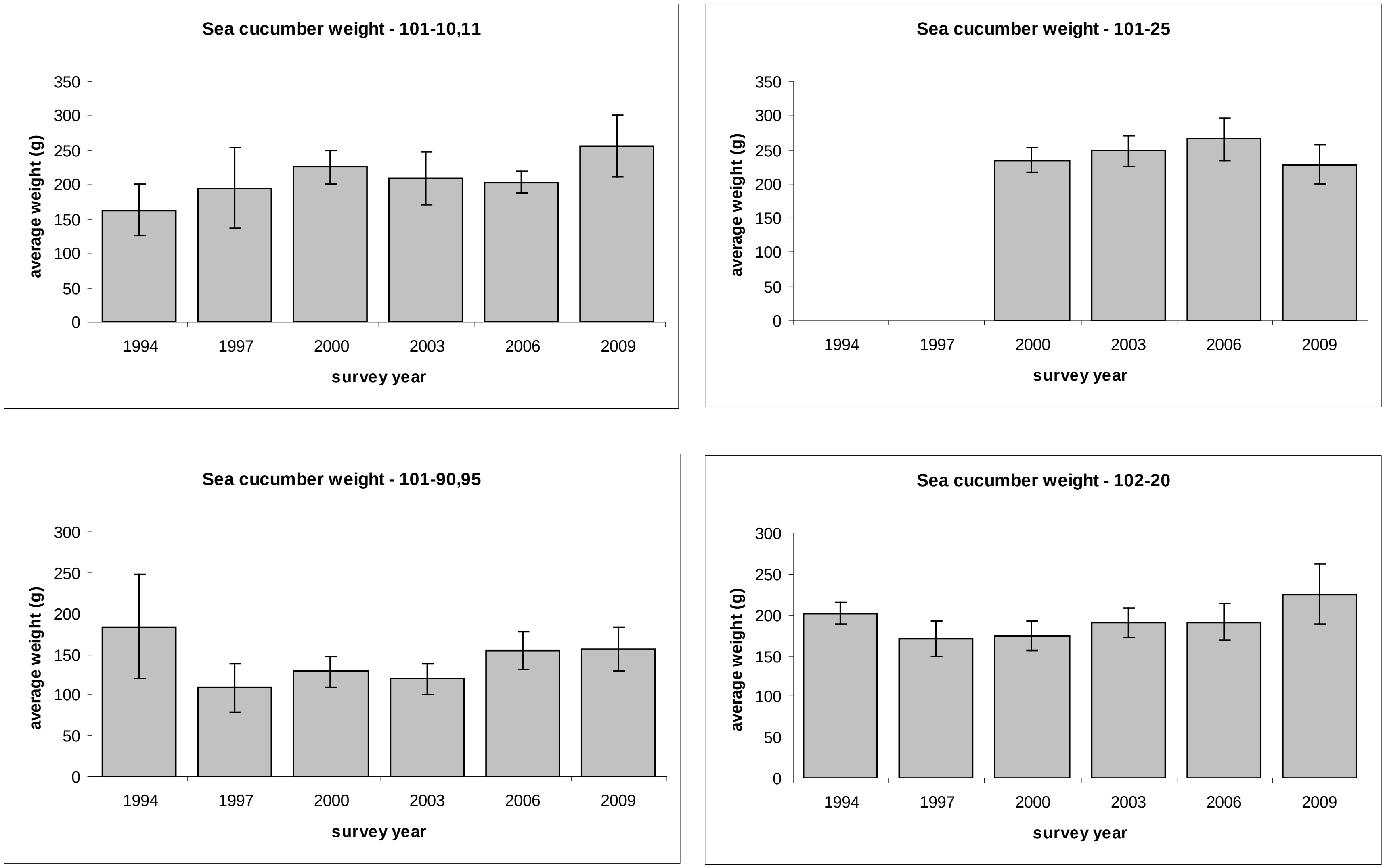


Figure 10.–Average sea cucumber weight (grams) from surveys in commercial fishery Subdistricts 101-10,11, Subdistrict 101-25, Subdistricts 101-90,95, and Subdistrict 102-20 in Southeast Alaska. Error bars represent 90% confidence intervals.

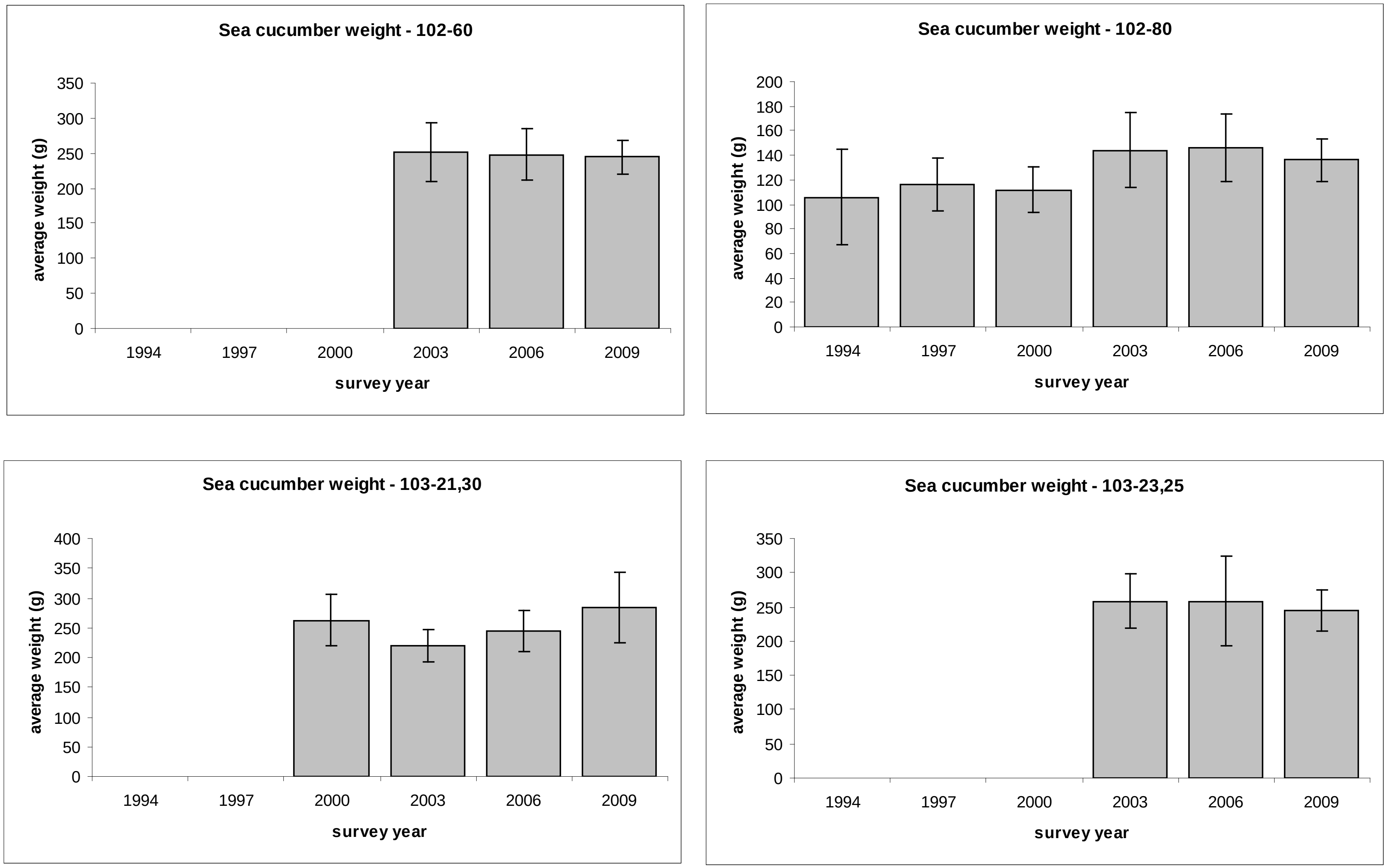


Figure 11.–Average sea cucumber weight (grams) from surveys in commercial fishery Subdistrict 102-60, Subdistrict 102-80, Subdistricts 103-21,30, and Subdistricts 103-23,25 in Southeast Alaska. Error bars represent 90% confidence intervals.

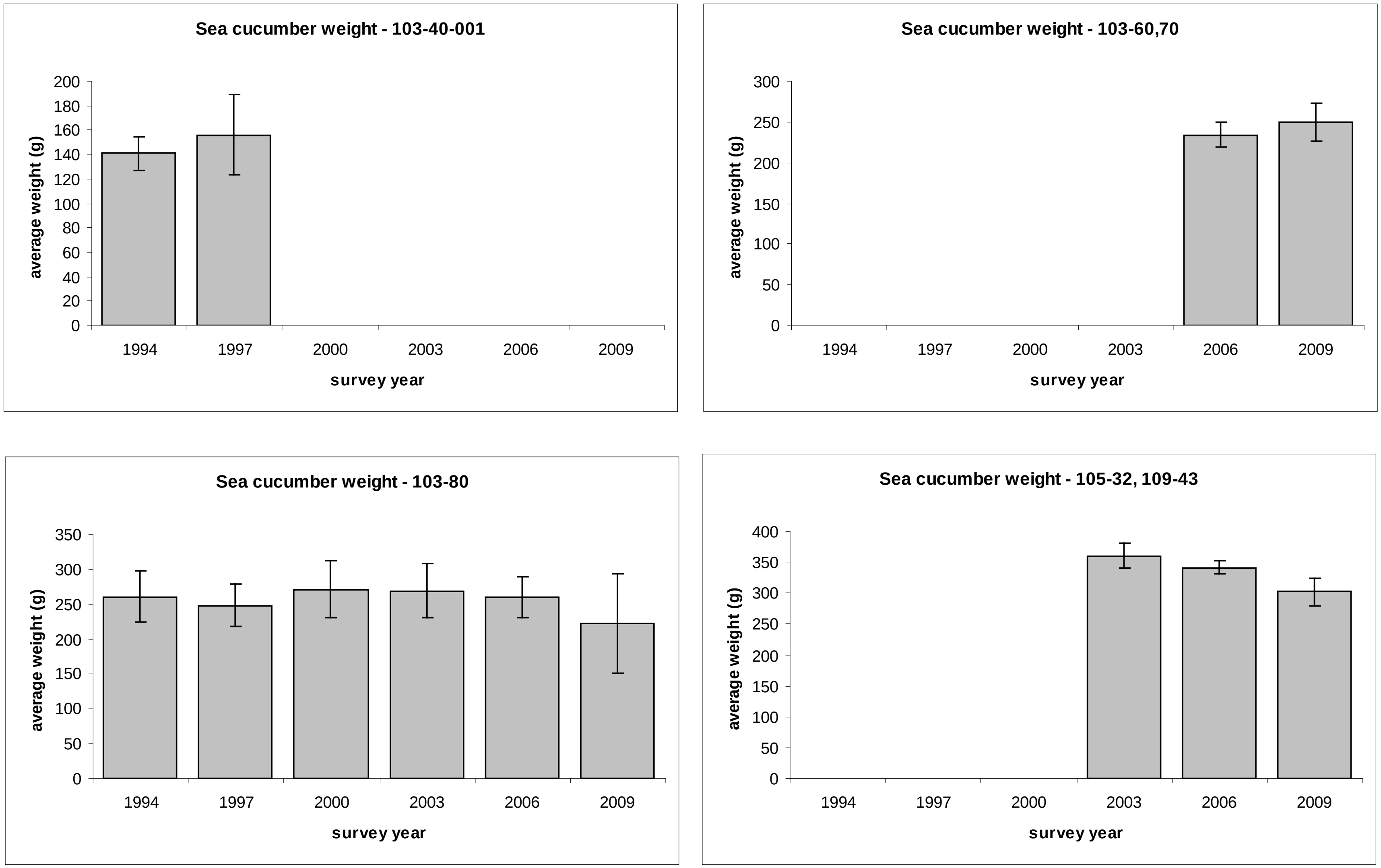


Figure 12.–Average sea cucumber weight (grams) from surveys in commercial fishery Subdistrict 103-40-001, Subdistricts 103-60, -70, Subdistrict 103-80, and Subdistricts 105-32, and 109-43 in Southeast Alaska. Error bars represent 90% confidence intervals.

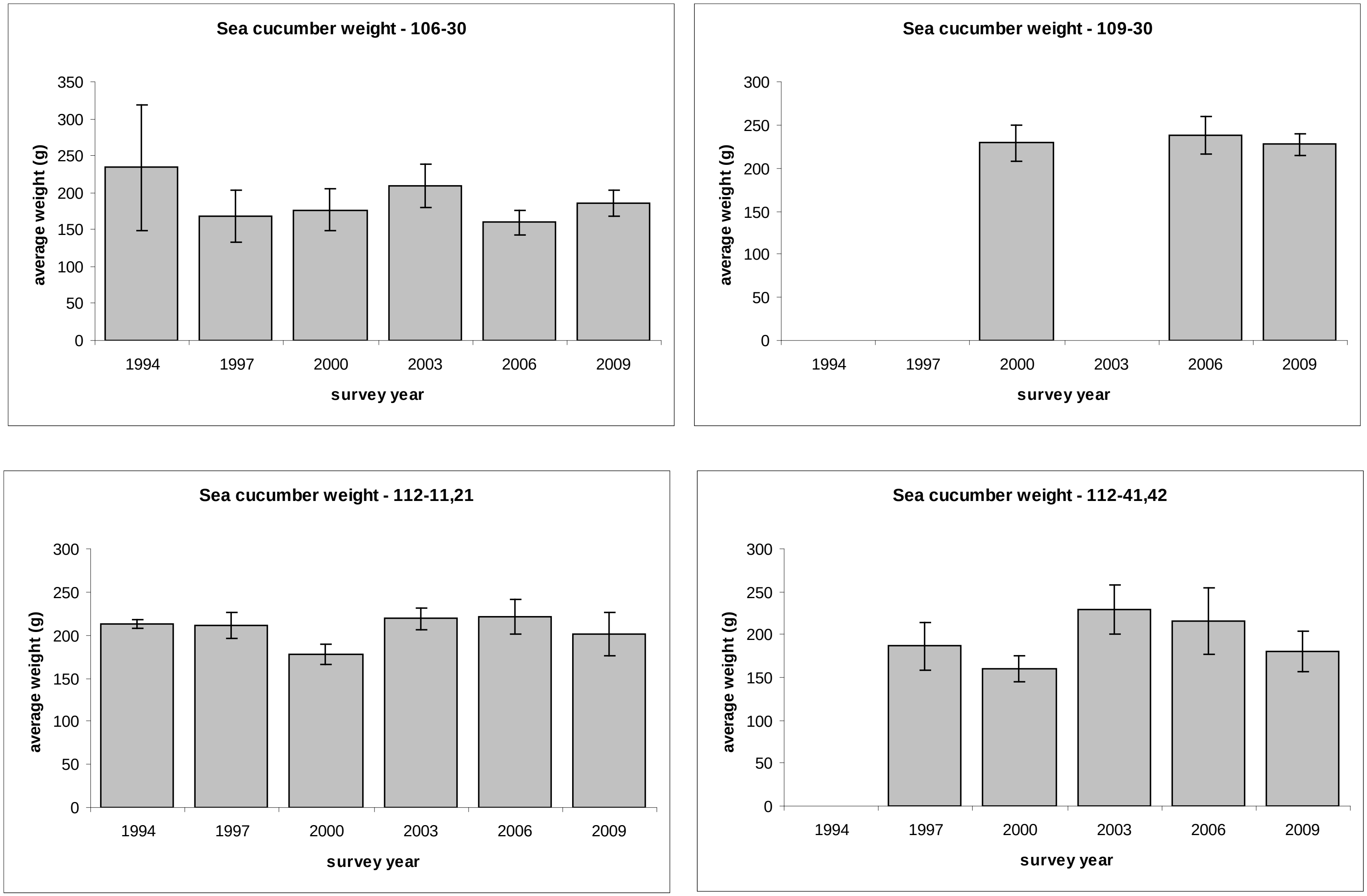


Figure 13.– Average sea cucumber weight from surveys in commercial fishery Subdistrict 106-30, Subdistrict 109-30, Subdistricts 112-11, -21, and Subdistricts 112-41, -42 in Southeast Alaska. Error bars represent 90% confidence intervals.

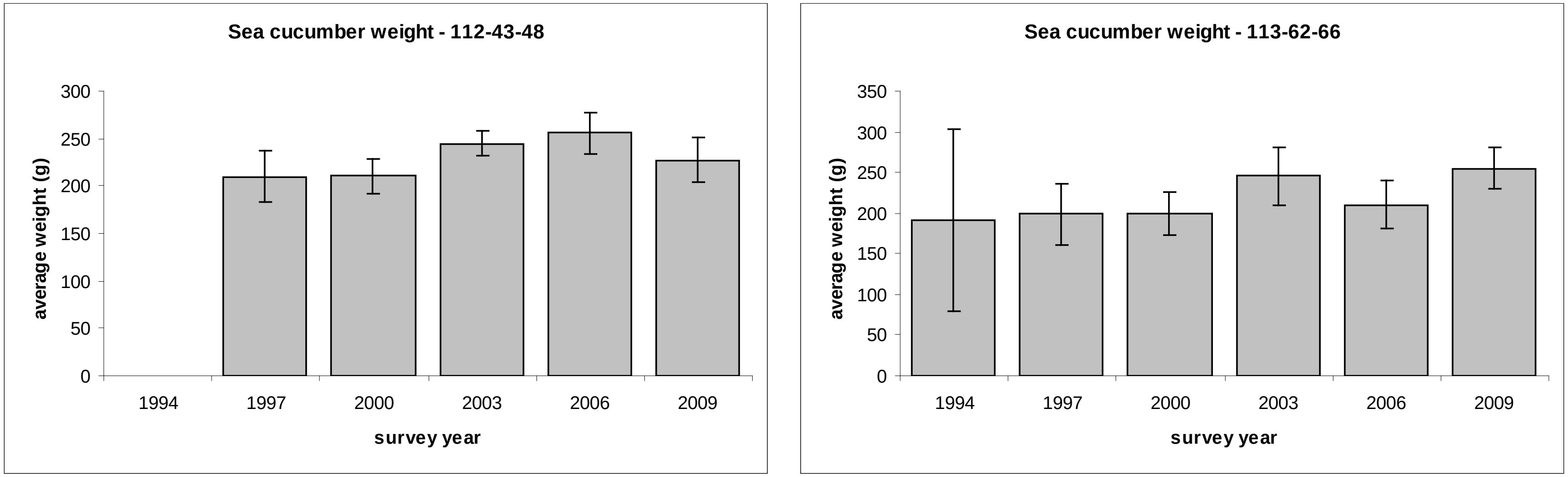


Figure 14.–Average sea cucumber weight (grams) from surveys in commercial fishery Subdistricts 112-10, -11 and Subdistrict 101-25 in Southeast Alaska. Error bars represent 90% confidence intervals.

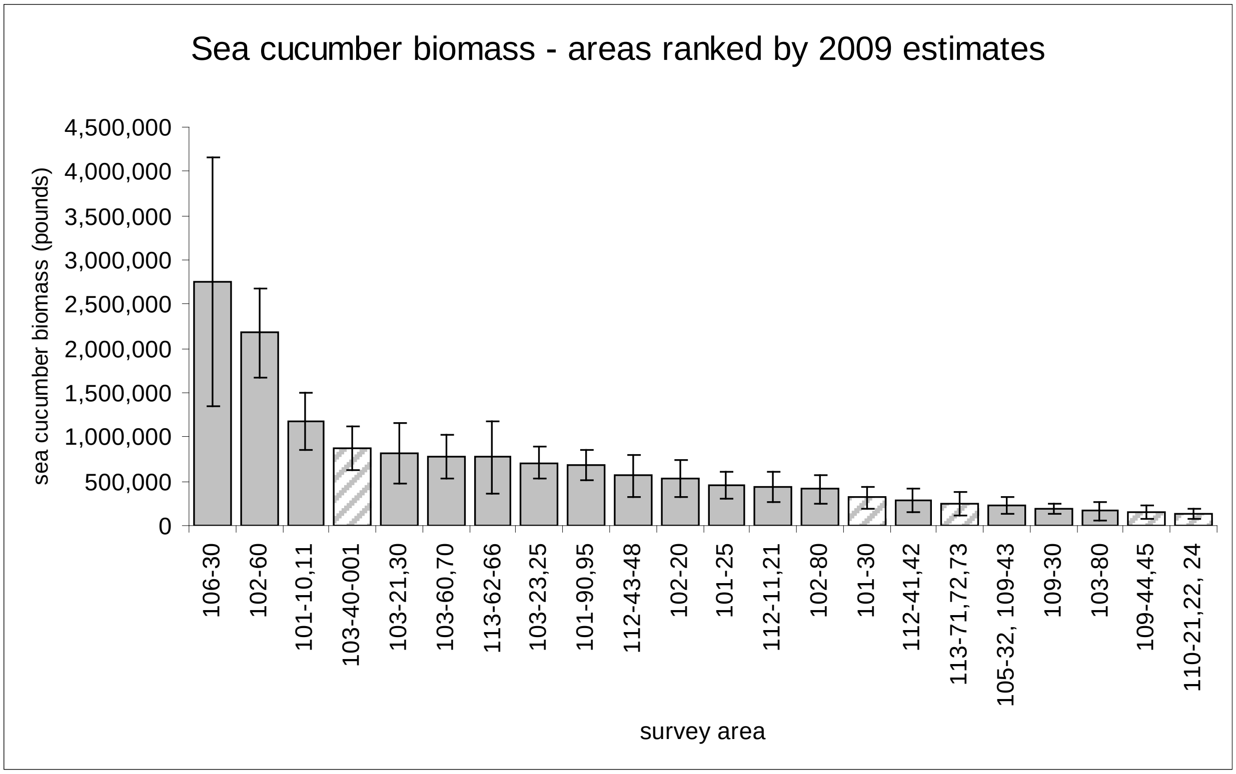


Figure 15.–Estimated sea cucumber biomass (ranked using 2009 results) in Southeast Alaska. Bars with patterns represent values from surveys prior to 2009. Bars with patters represent values from surveys prior to 2009, as no survey was conducted in 2009. Error bars represent 90% confidence intervals.

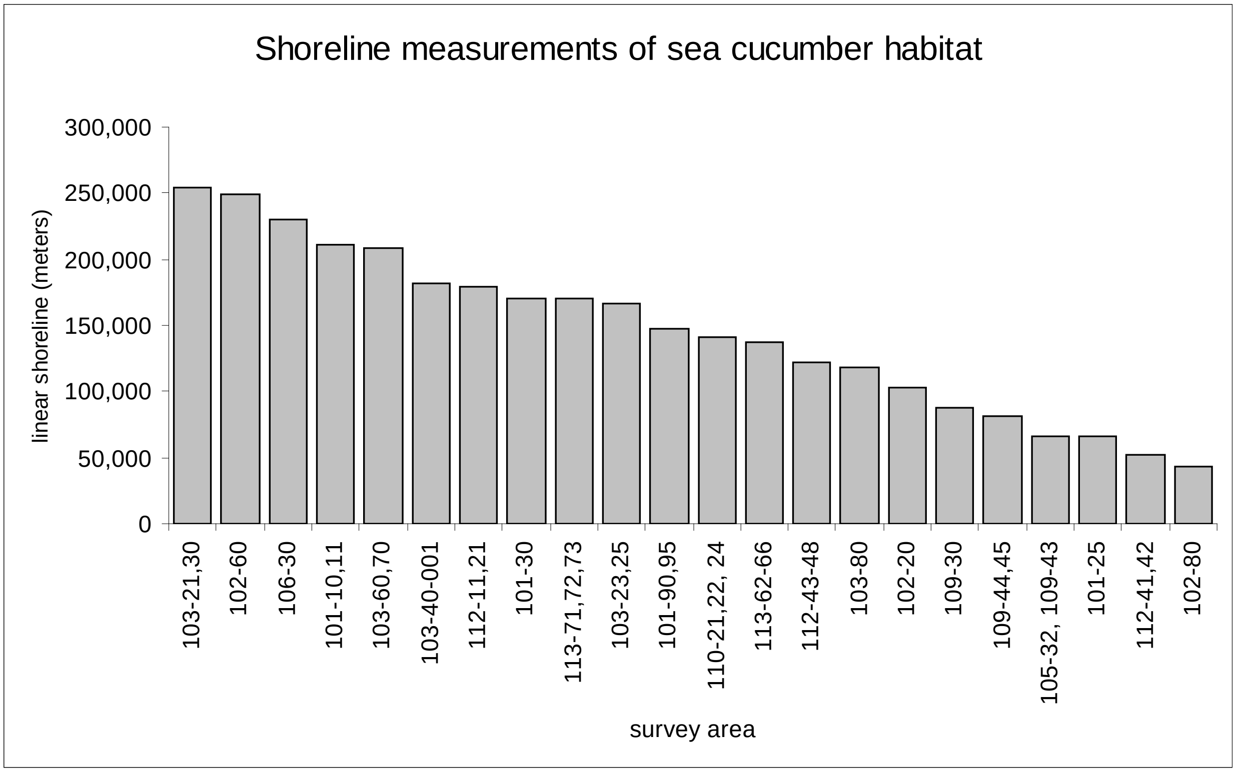


Figure 16.–Estimated sea cucumber habitat shoreline in Southeast Alaska. Bars with patterns represent values from surveys prior to 2009.

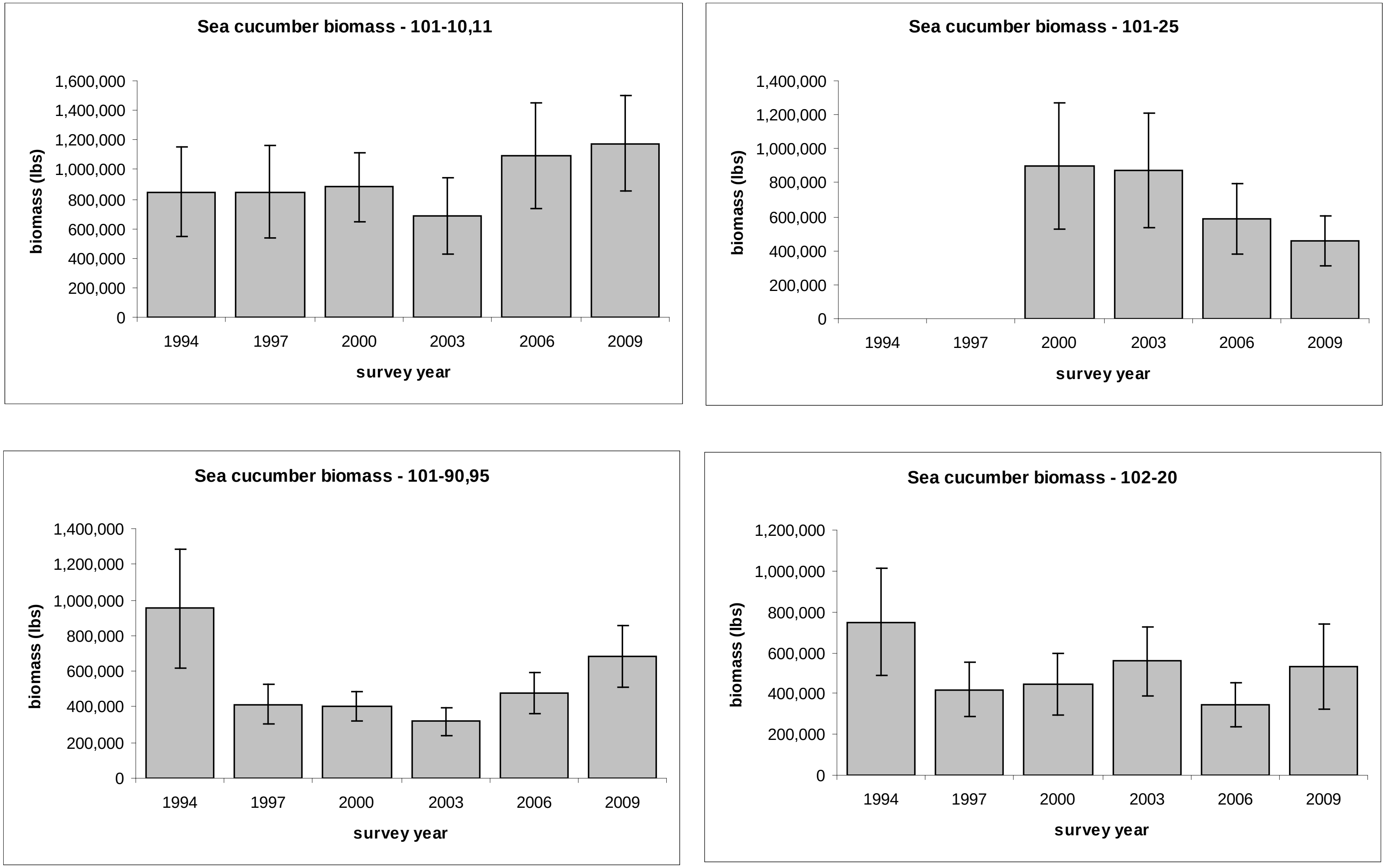


Figure 17.–Total sea cucumber biomass (pounds) from surveys in commercial fishery Subdistricts 101-10, -11, Subdistrict 101-25, Subdistricts 101-90, -95, and Subdistrict 102-20 in Southeast Alaska. Error bars represent 90% confidence intervals.

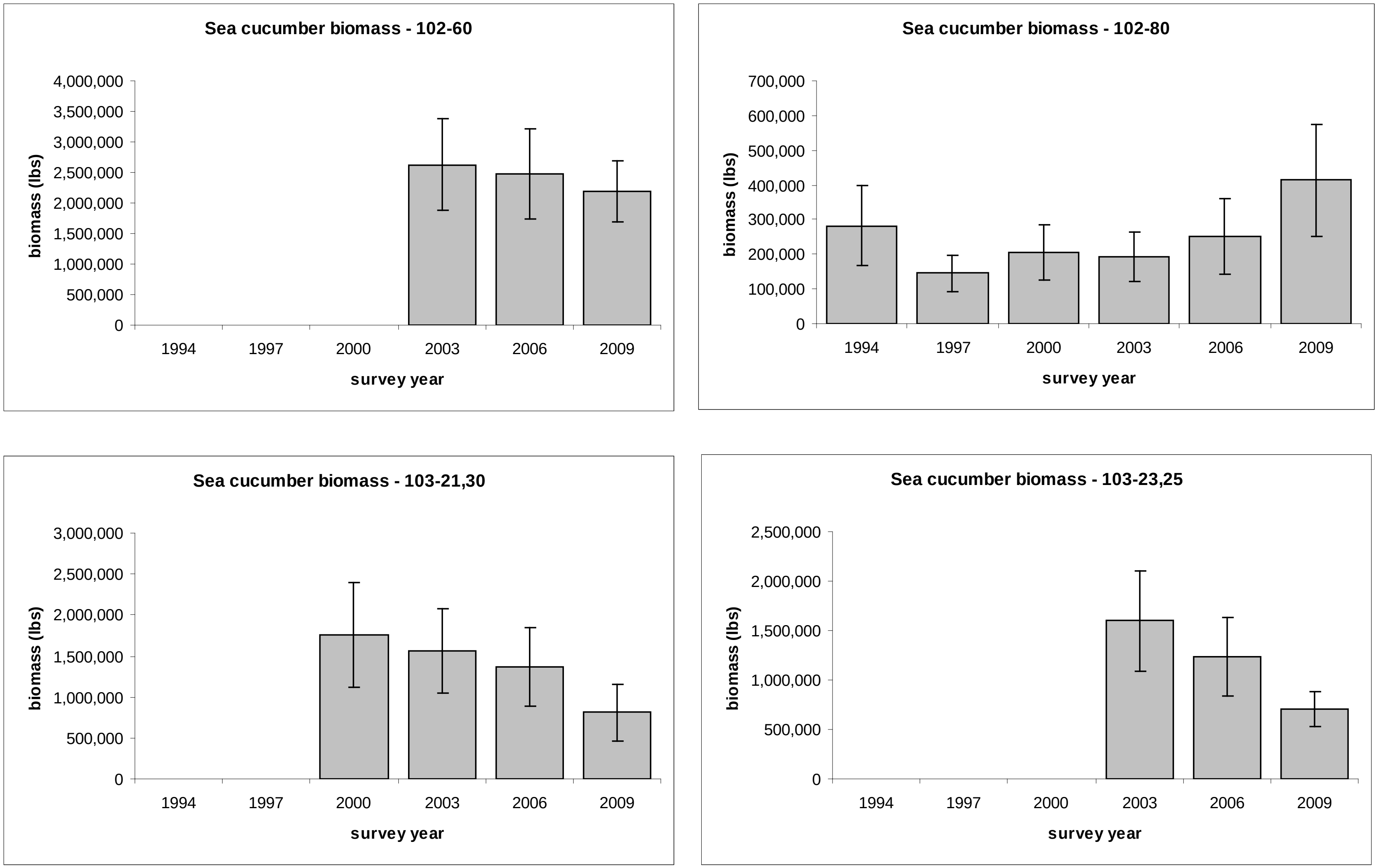


Figure 18.–Total sea cucumber biomass (pounds) from surveys in commercial fishery Subdistrict 102-60, Subdistrict 102-80, Subdistricts 103-21, -30, and Subdistricts 103-23, -25 in Southeast Alaska. Error bars represent 90% confidence intervals.

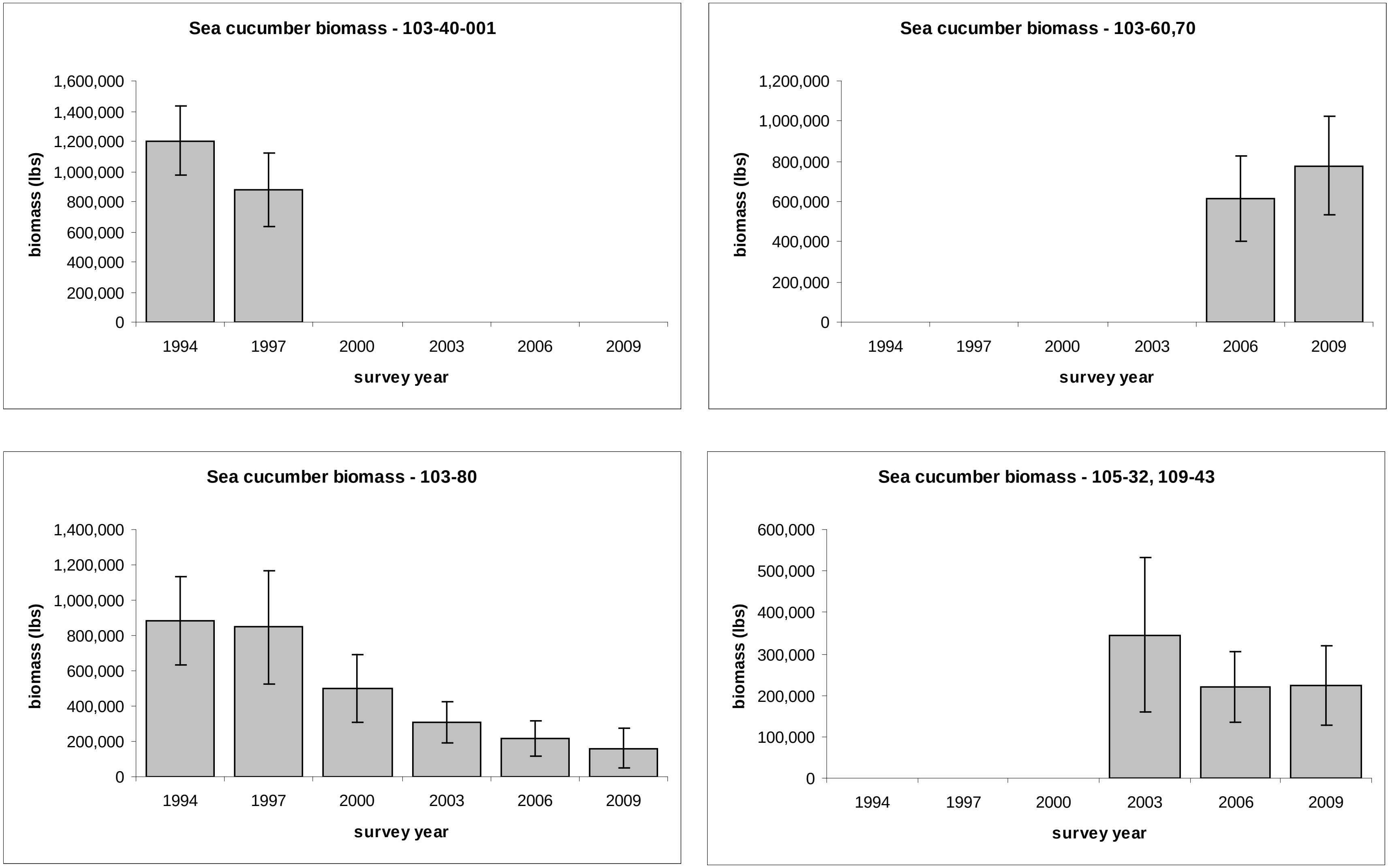


Figure 19.–Total sea cucumber biomass (pounds) from surveys in commercial fishery Subdistrict 103-40-001, Subdistricts 103-60, -70, Subdistrict 103-80, and Subdistricts 105-32,109-43 in Southeast Alaska. Error bars represent 90% confidence intervals.

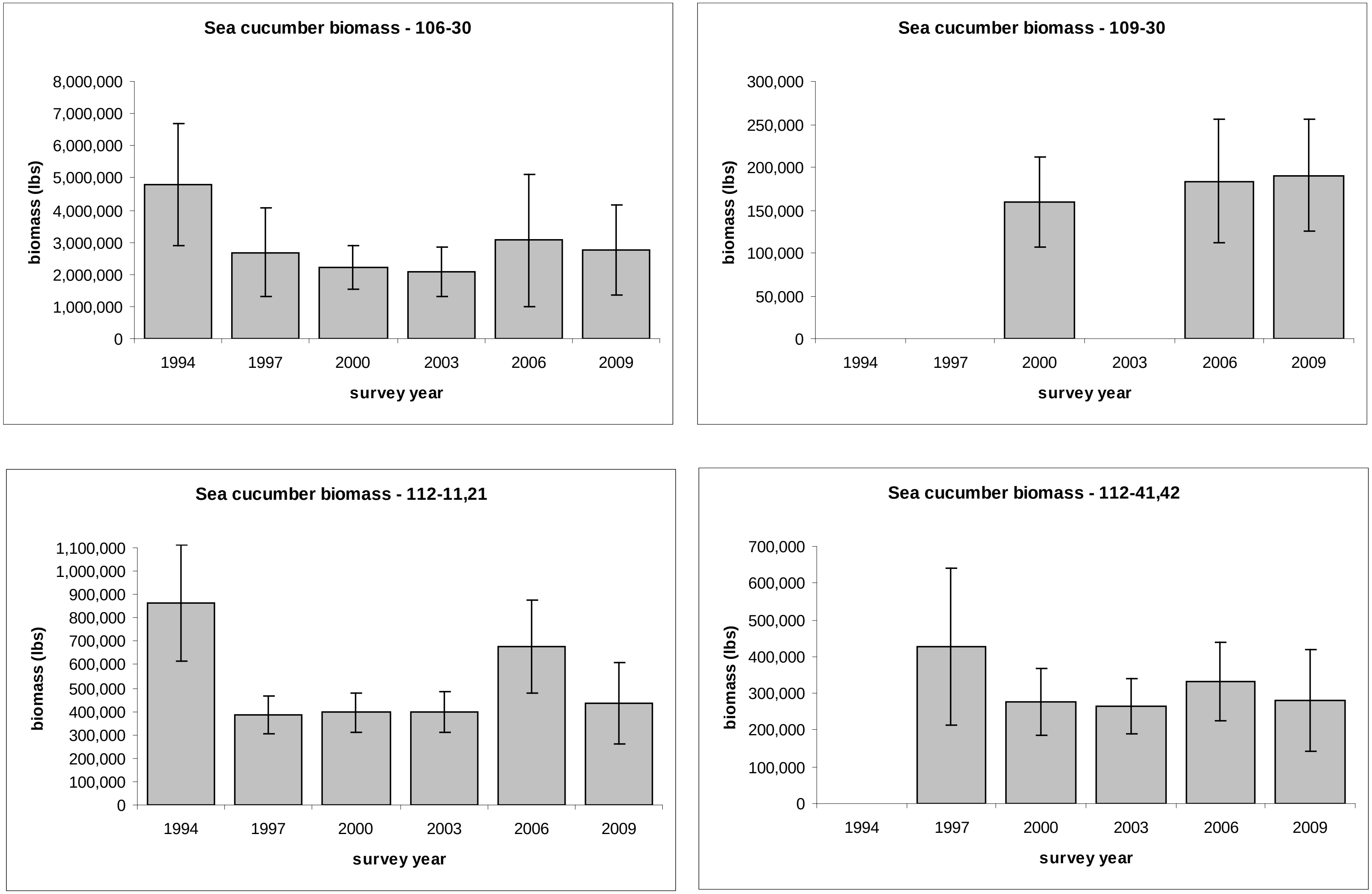


Figure 20.–Total sea cucumber biomass (pounds) from surveys in commercial fishery Subdistrict 106-30, Subdistrict 109-30, Subdistricts 112-11, -21, and Subdistricts 112-41, -42 in Southeast Alaska. Error bars represent 90% confidence intervals.

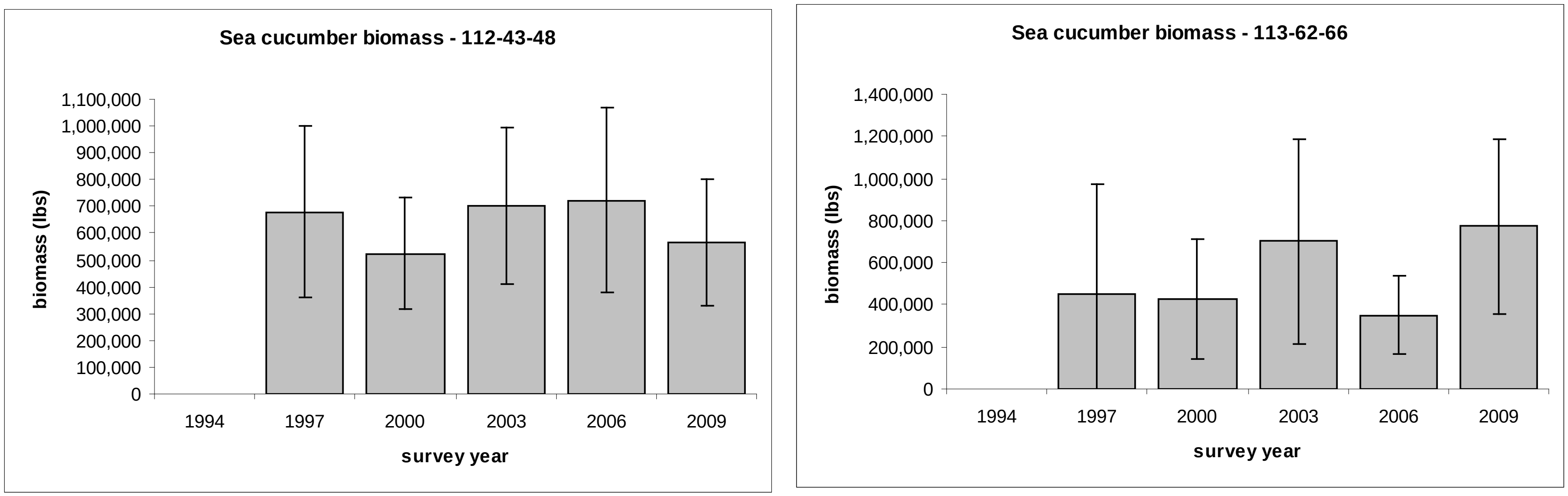


Figure 21.–Total sea cucumber biomass (pounds) from surveys in commercial fishery Subdistricts 112-43 through 112-48, and Subdistricts 113-62 through 113-66 in Southeast Alaska. Error bars represent 90% confidence intervals.

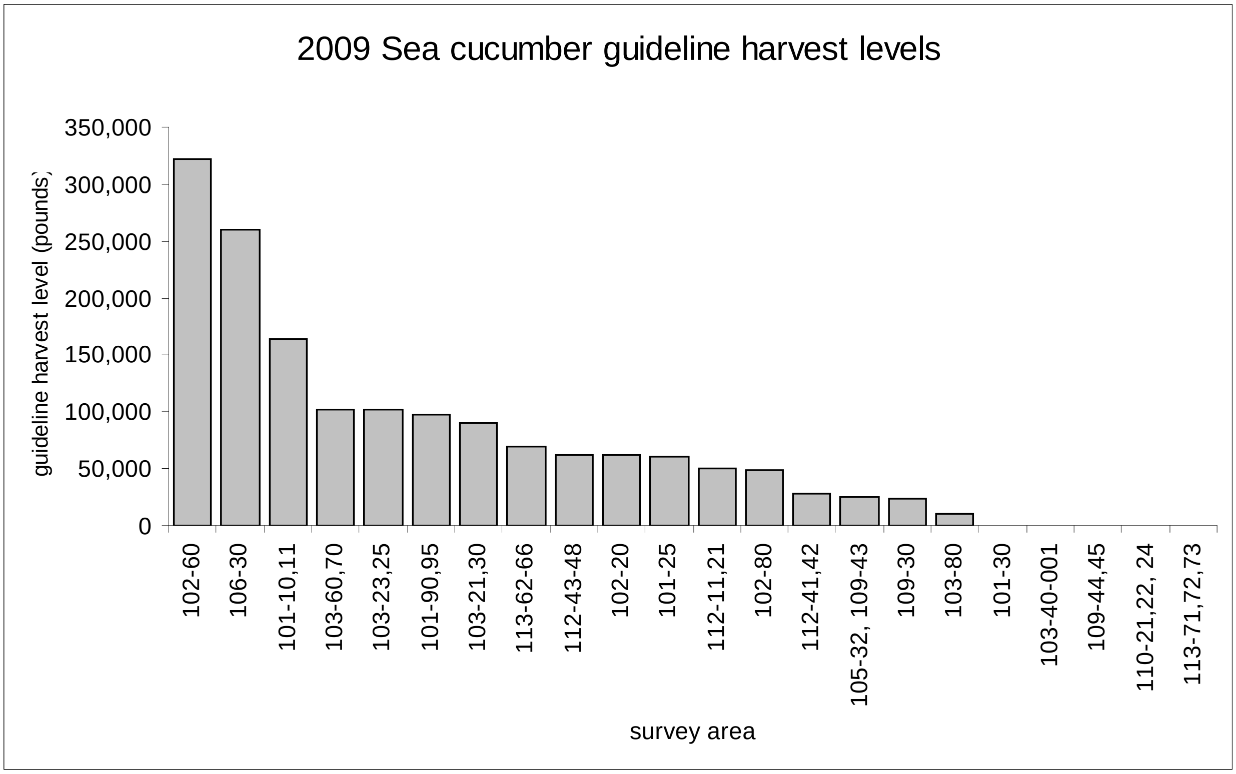


Figure 22.–Sea cucumber commercial fishery guideline harvest levels established for the 2009/2010 fishing season.

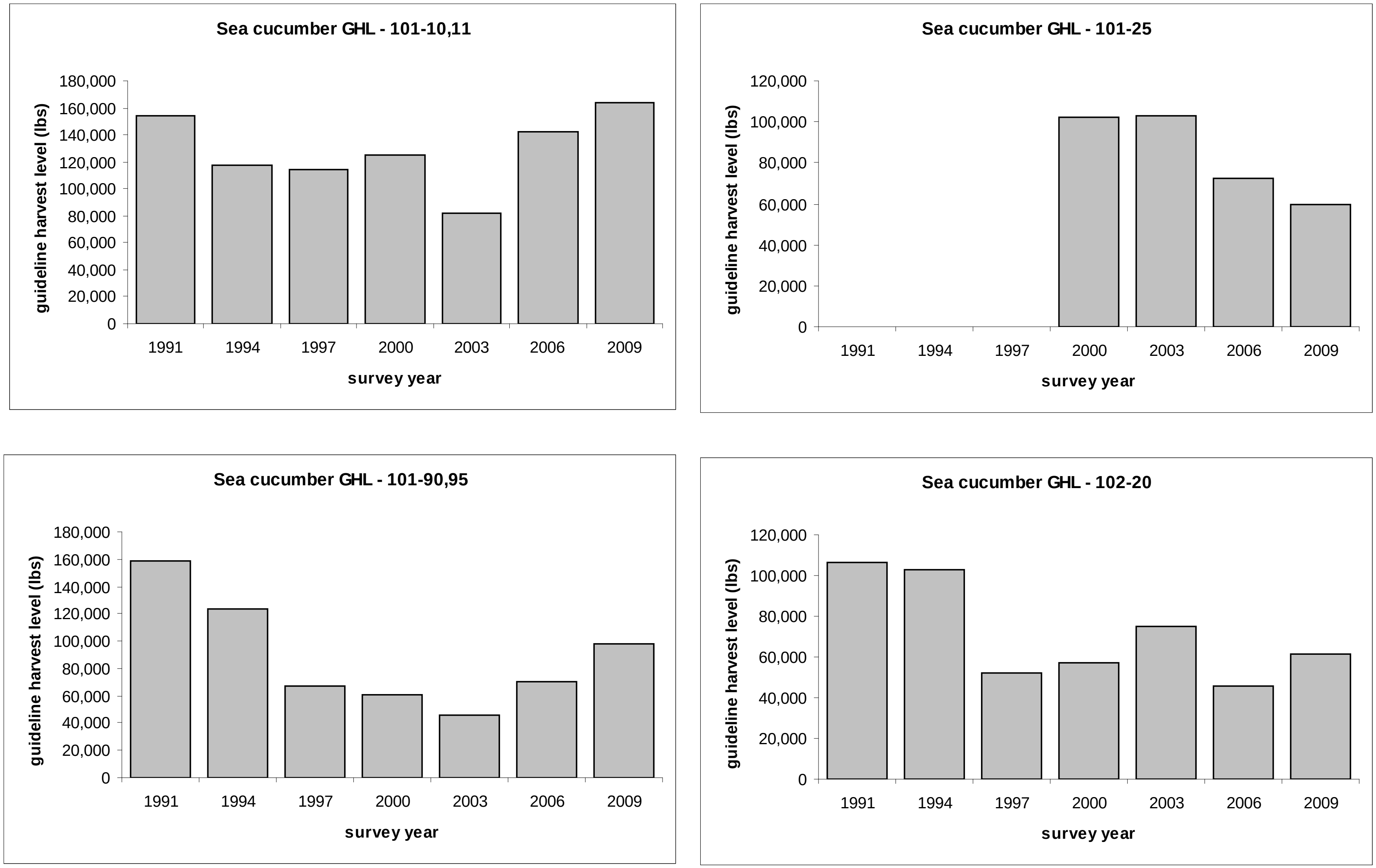


Figure 23.–Actual commercial fishery guideline harvest levels (GHLs) in pounds for fishery Subdistricts 101-10,11, Subdistrict 101-25, Subdistricts 101-90, -95, and Subdistrict 102-20, in Southeast Alaska.

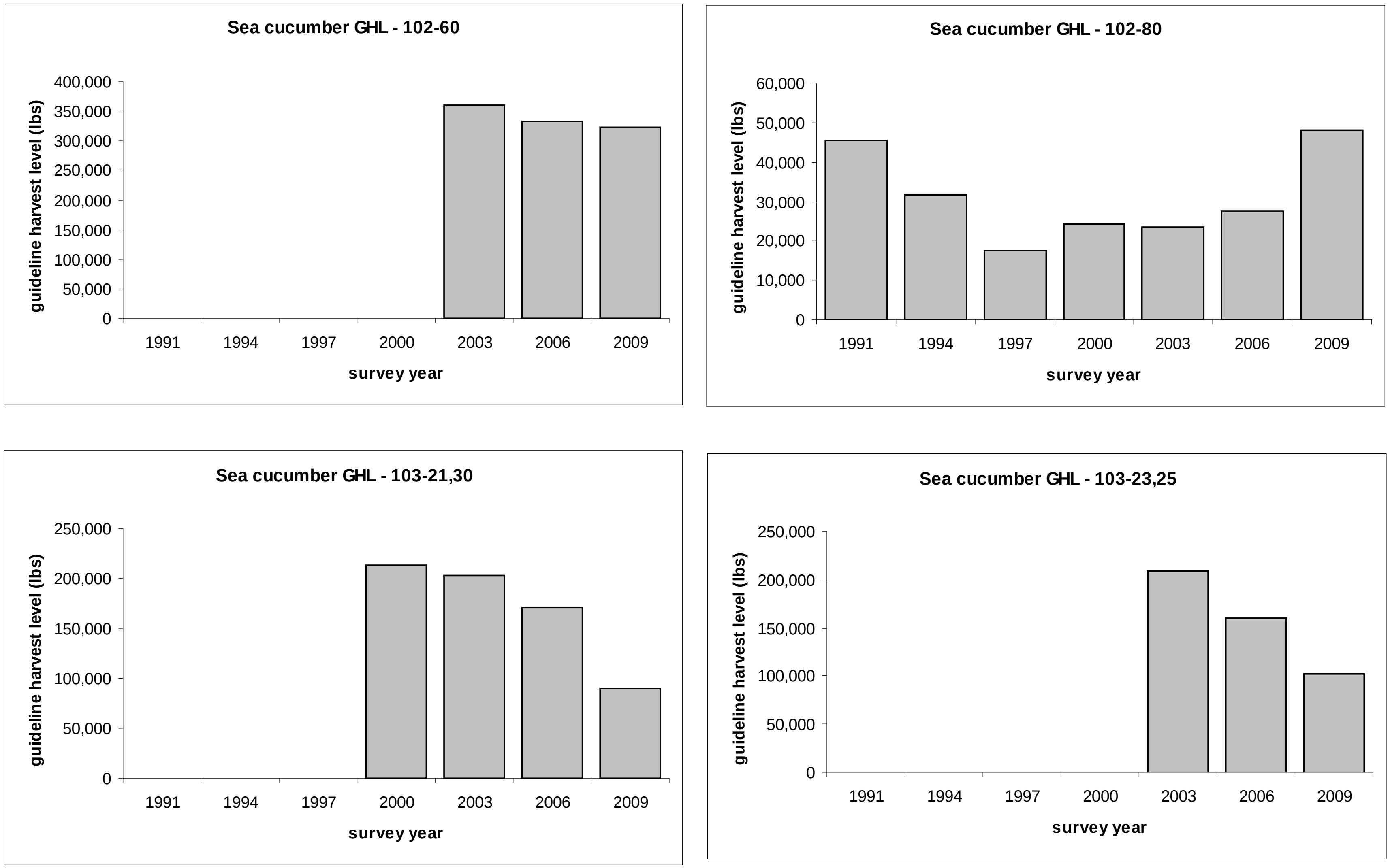


Figure 24.–Actual commercial fishery guideline harvest levels (GHLs) in pounds for fishery Subdistrict 102-60, Subdistrict 102-80, Subdistricts 103-21, -30, and Subdistricts 103-23, -25, in Southeast Alaska.

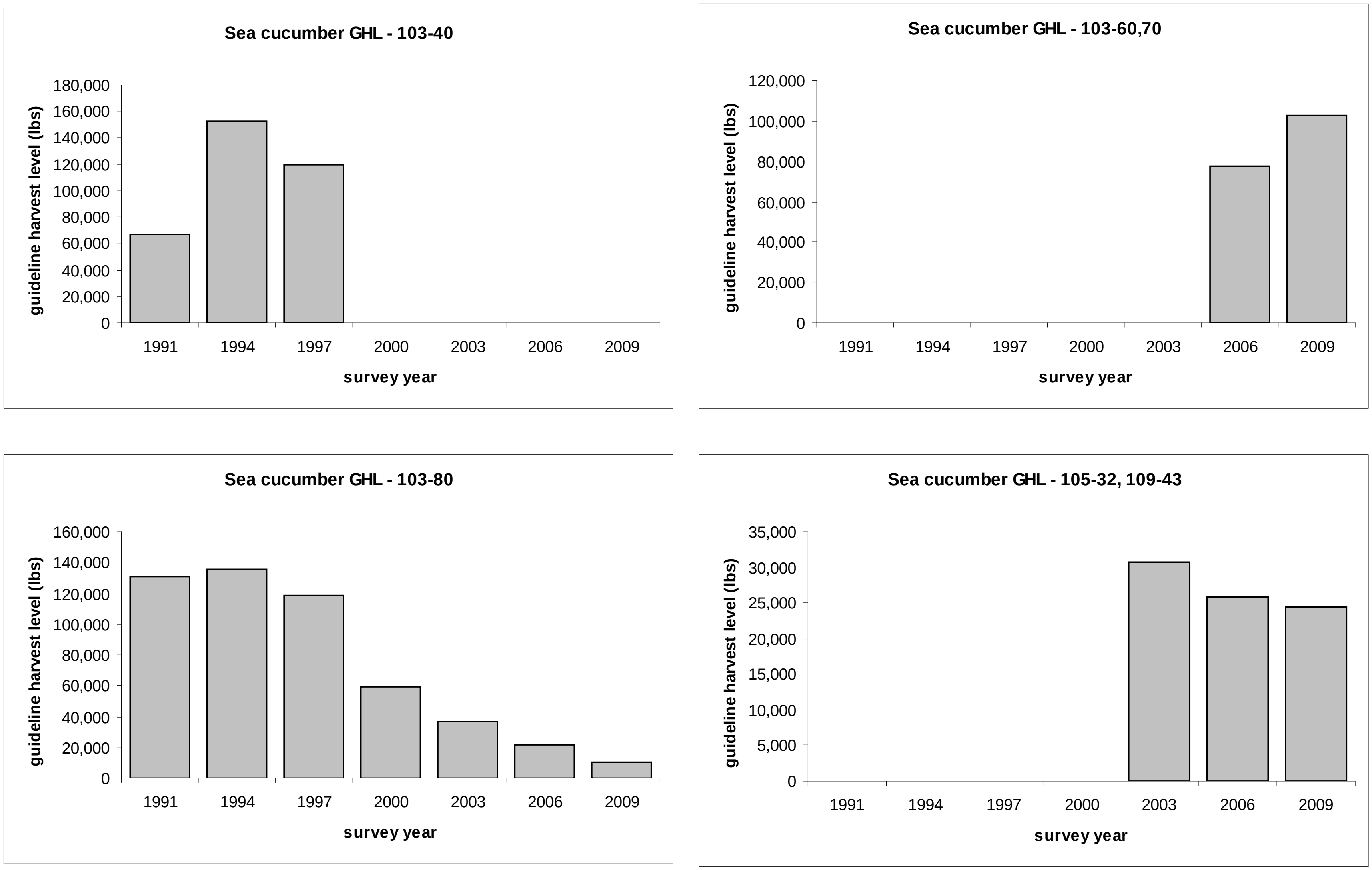


Figure 25.–Actual commercial fishery guideline harvest levels (GHLs) in pounds for fishery Subdistrict 103-40, Subdistrict 103-60, -70, Subdistrict 103-80, and Subdistricts 105-32,109-43, in Southeast Alaska.

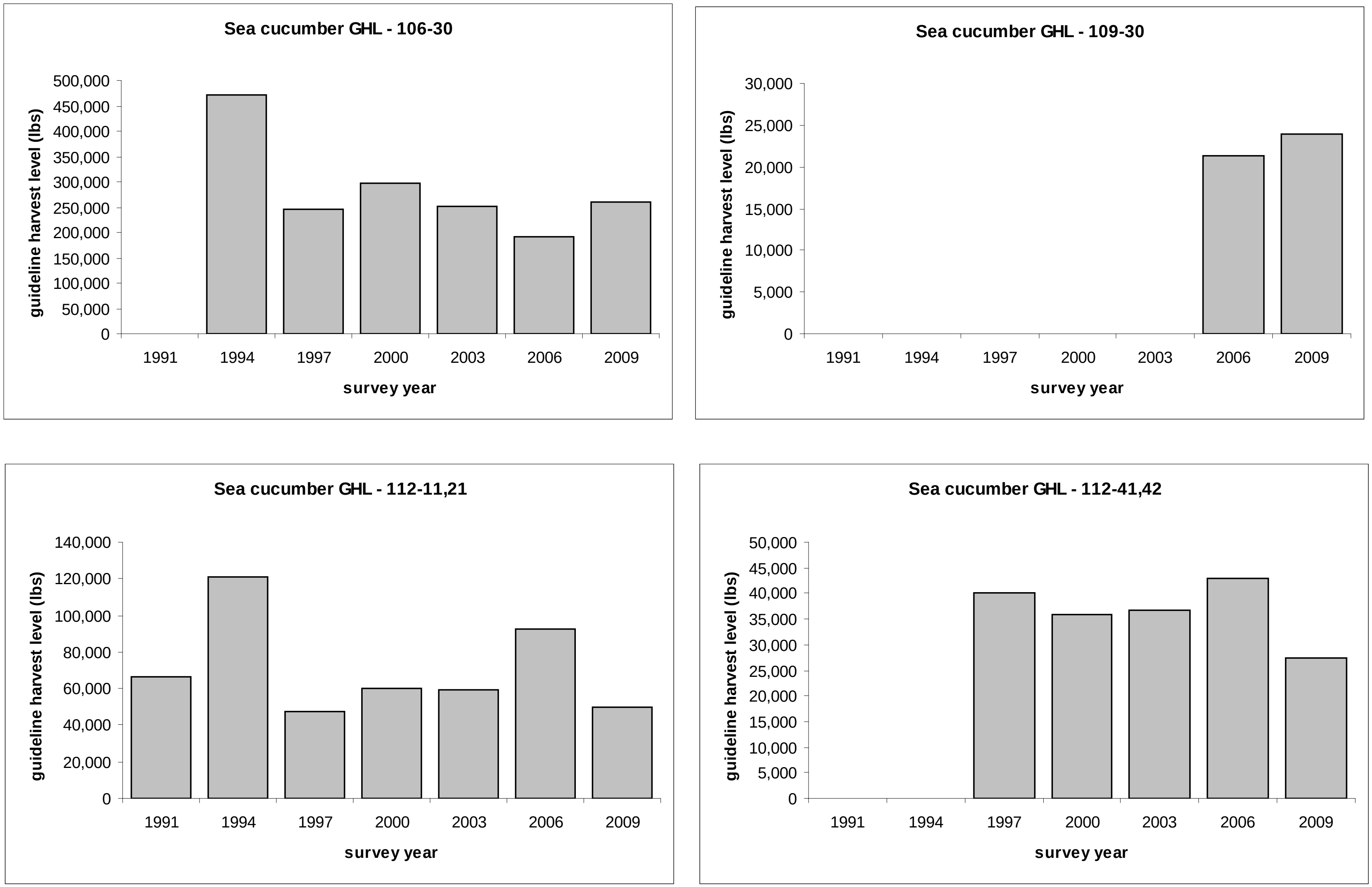


Figure 26.–Actual commercial fishery guideline harvest levels (GHLs) in pounds for fishery Subdistrict 106-30, Subdistrict 109-30, Subdistricts 112-11, -21, and Subdistricts 112-41, -42, in Southeast Alaska.

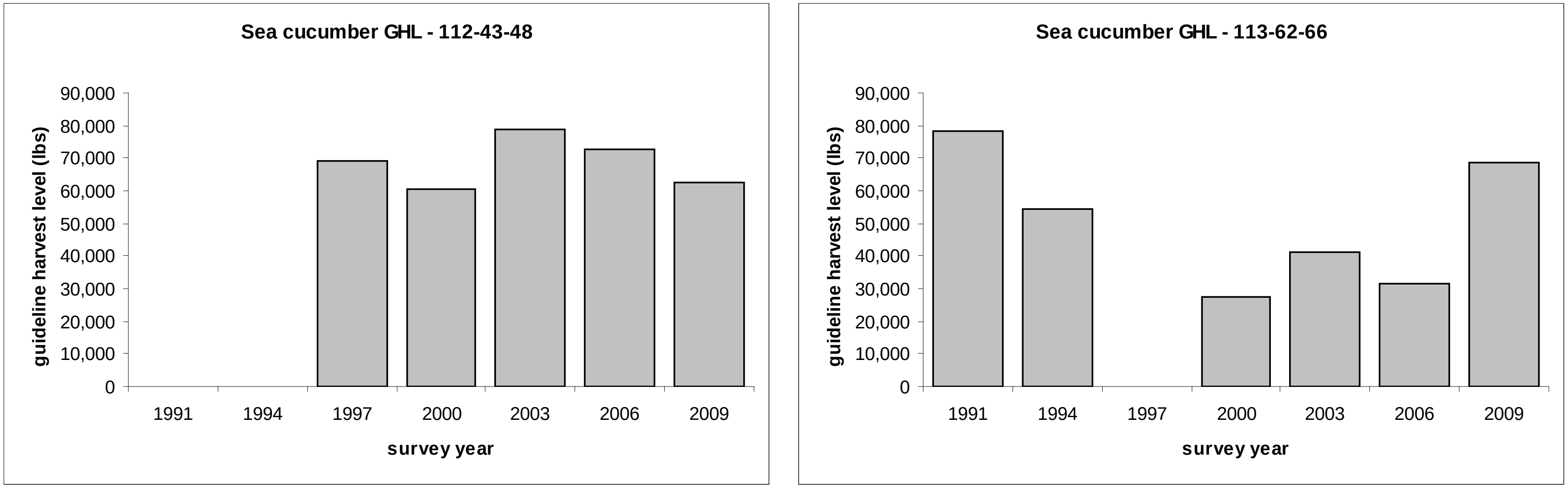


Figure 27.–Actual commercial fishery guideline harvest levels (GHLs) in pounds for fishery Subdistricts 112-43 through 112-48, and Subdistricts 113-62 through 113-66, in Southeast Alaska.

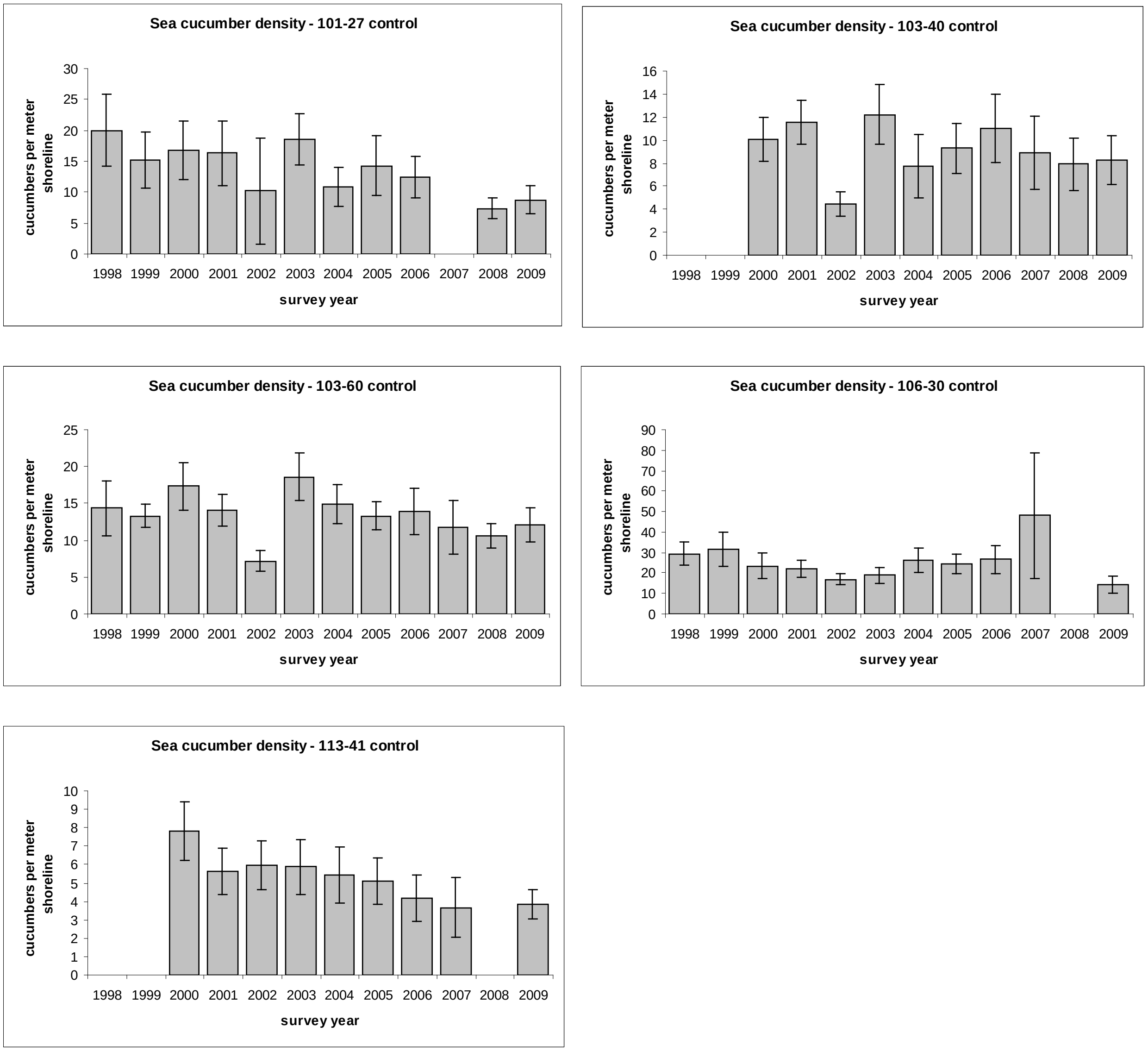


Figure 28.–Average number of sea cucumbers per meter of shoreline from surveys in control area (closed to commercial harvest) Subdistrict 101-27, Subdistrict 103-40, Subdistrict 103-60, Subdistrict 106-30, and Subdistrict 113-41 in Southeast Alaska. Error bars represent 90% confidence intervals.

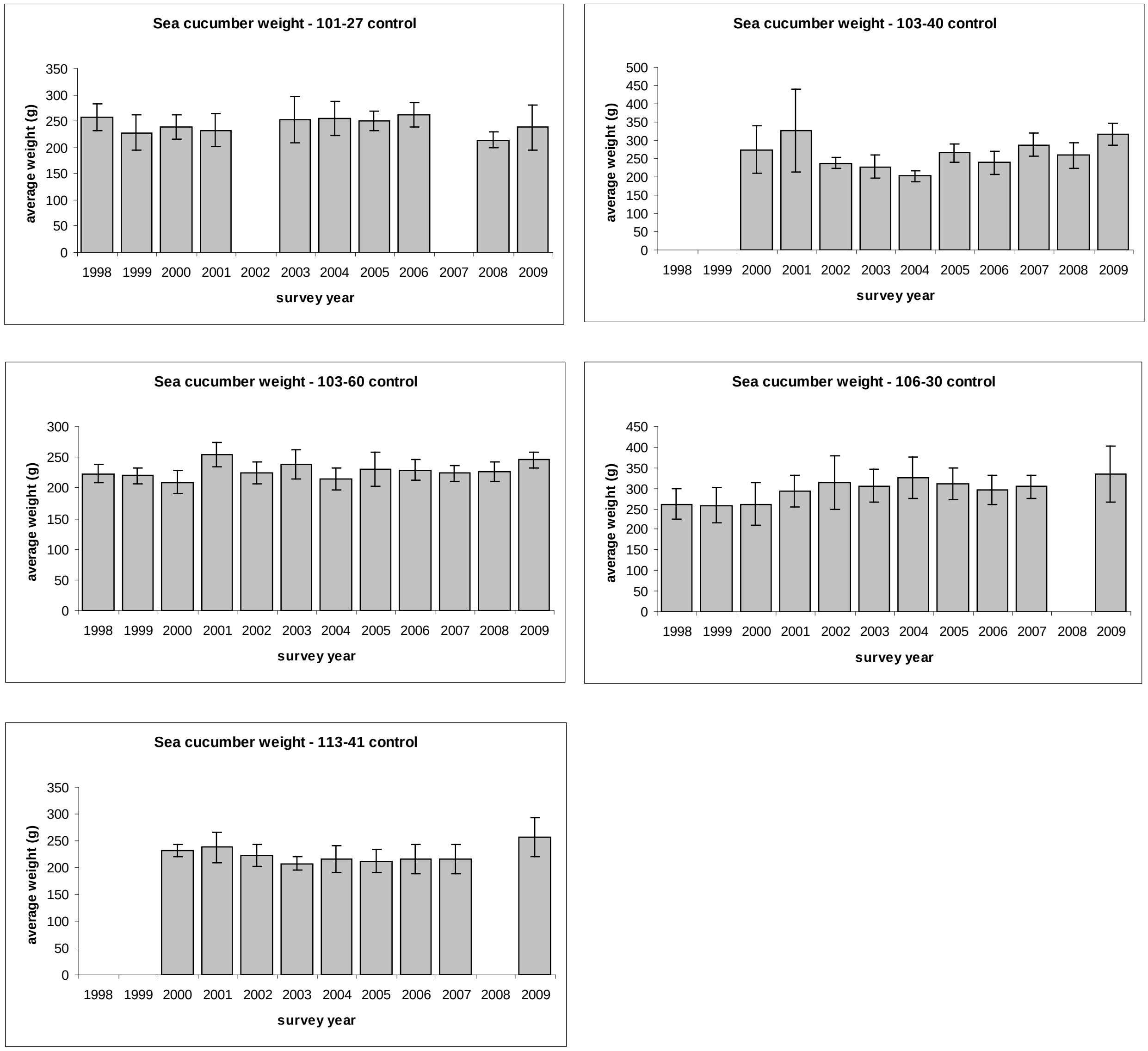


Figure 29.–Average sea cucumbers weight (grams) from surveys in control area (closed to commercial harvest) Subdistrict 101-27, Subdistrict 103-40, Subdistrict 103-60, Subdistrict 106-30, and Subdistrict 113-41 in Southeast Alaska. Error bars represent 90% confidence intervals.

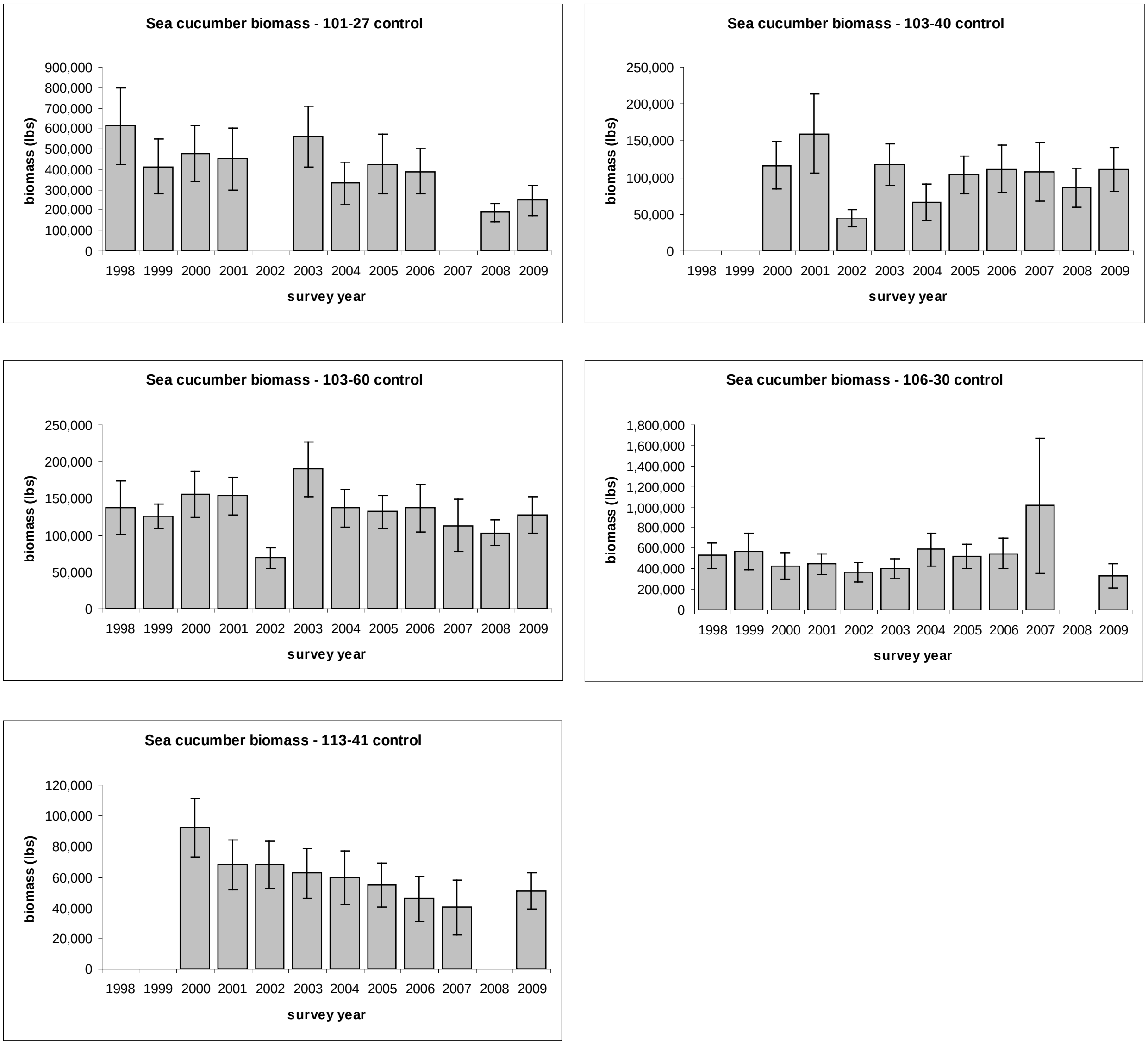


Figure 30.–Total sea cucumber biomass (pounds) from surveys in control area (closed to commercial harvest) Subdistrict 101-27, Subdistrict 103-40, Subdistrict 103-60, Subdistrict 106-30, and Subdistrict 113-41 in Southeast Alaska. Error bars represent 90% confidence intervals.

APPENDIX A: KEY TO SUBSTRATE TYPES

Appendix A1.–Key to vegetative substrate types used for herring spawn deposition survey.

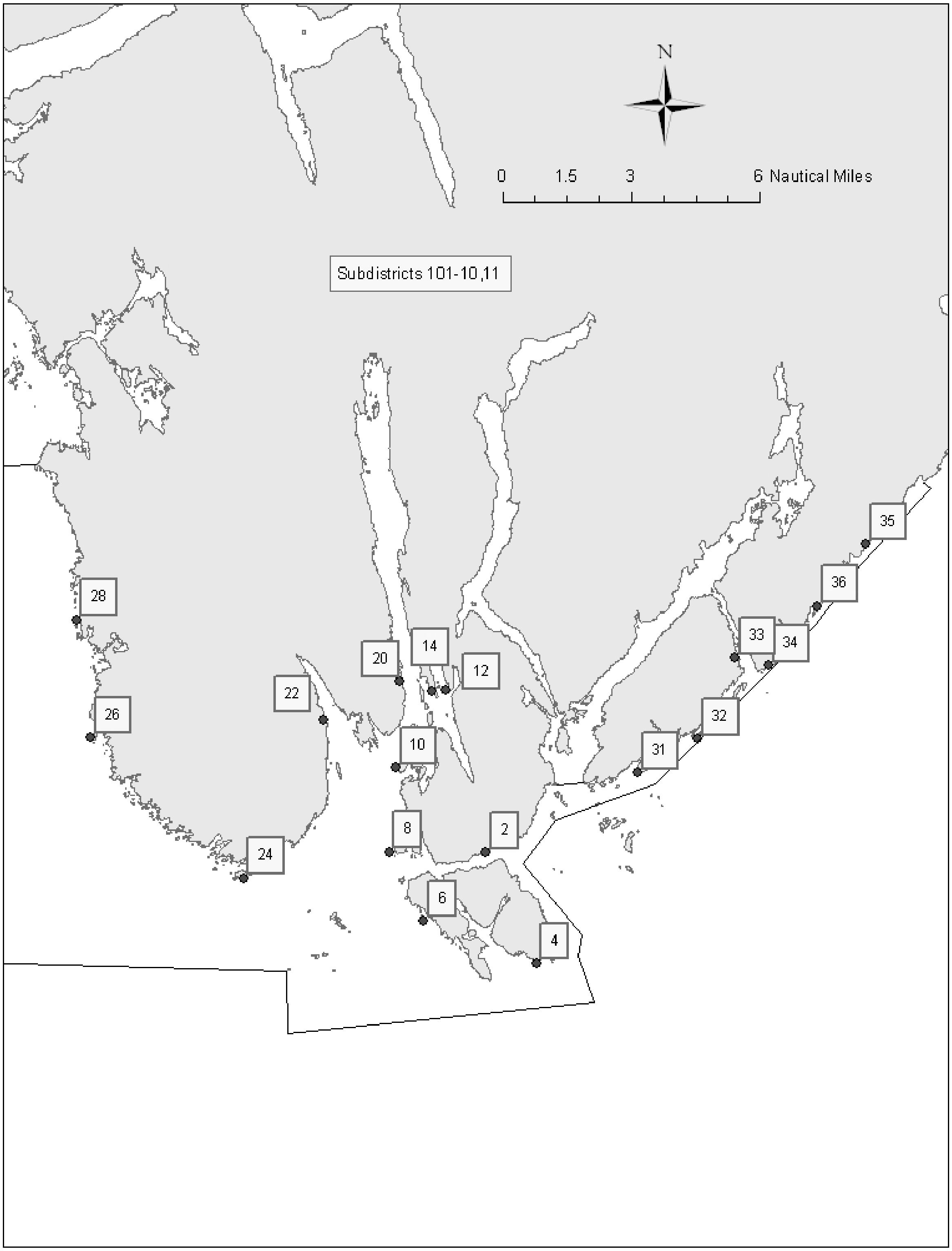
Code	Expanded code	Species included	Latin names
AGM	Agarum	Sieve kelp	*Agarum clathratum*
ALA	Alaria	Ribbon kelps	*Alaria marginata, A. nana, A. fistulosa*
ELG	Eel grass	Eel grass, surfgrasses	*Zostera marina, Phyllospadix serrulatus, P. scouleri*
FIL	Filamentous algae	Sea hair	*Enteromorpha intestinalis*
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	5-ribbed kelp, 3-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 B: KEY TO BOTTOM TYPES

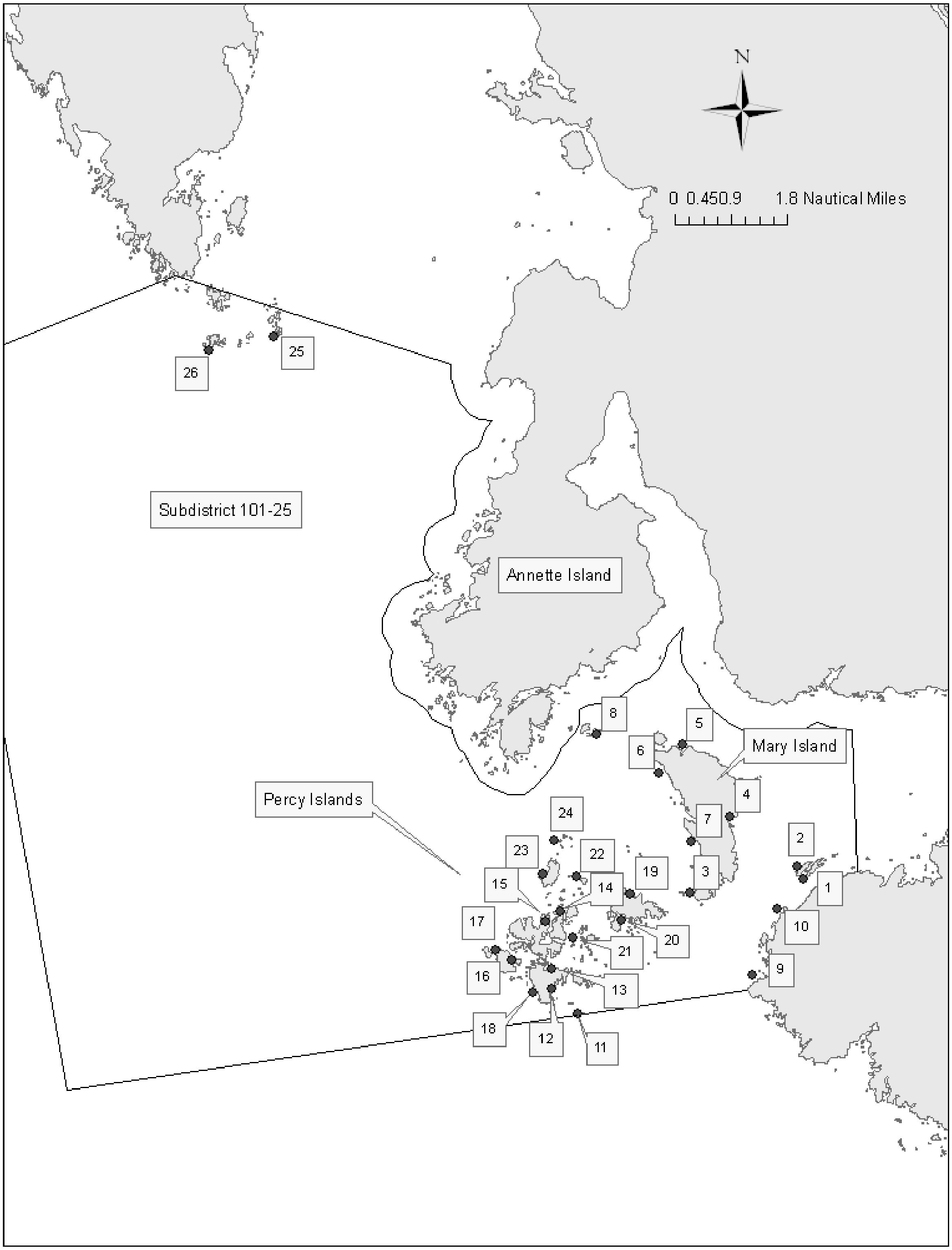
Appendix B1.–Key to bottom types used for herring spawn deposition survey.

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

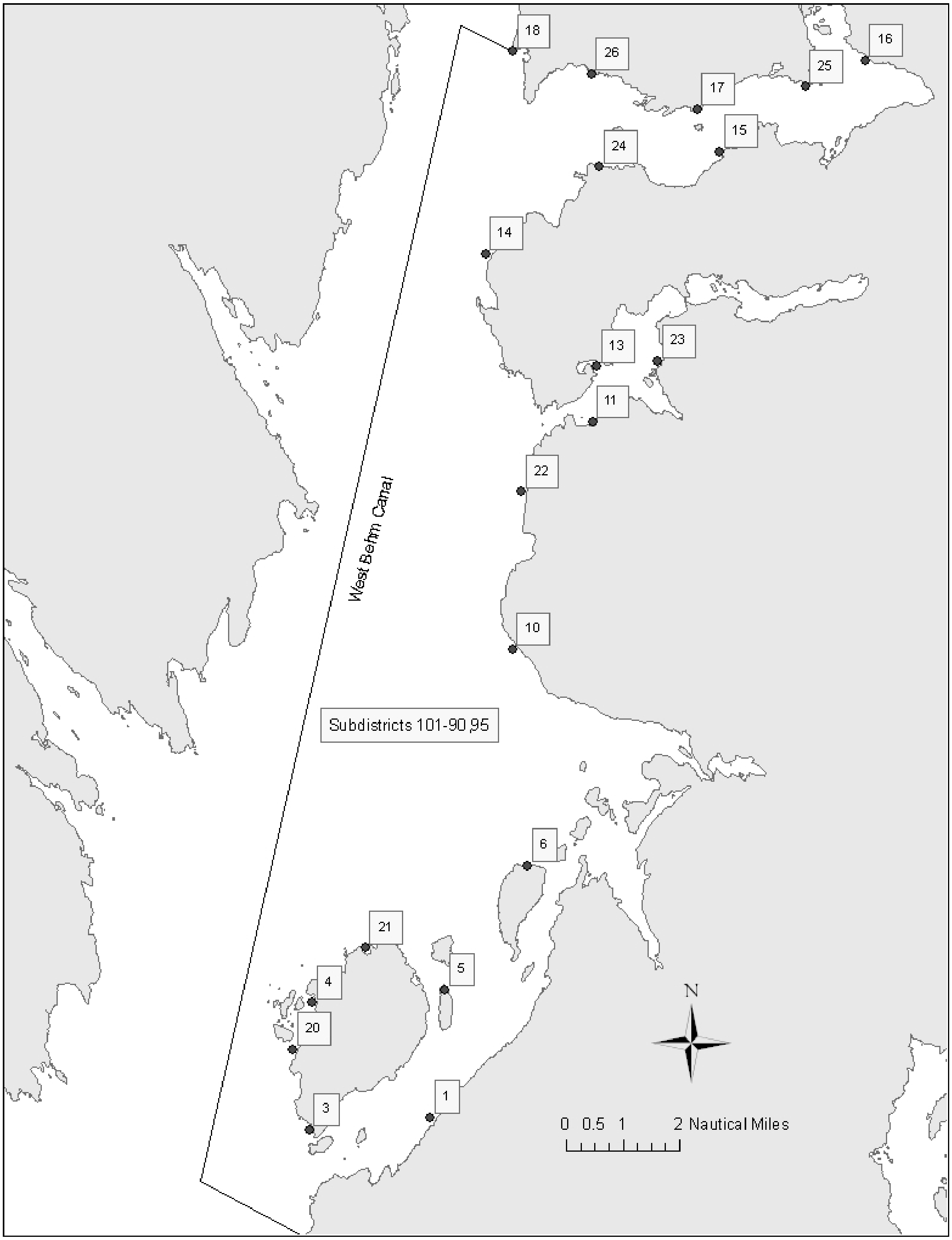
APPENDIX C: MAPS DISPLAYING LOCATIONS OF COMMERCIAL FISHERY AREAS TRANSECTS SURVEYED IN 2009



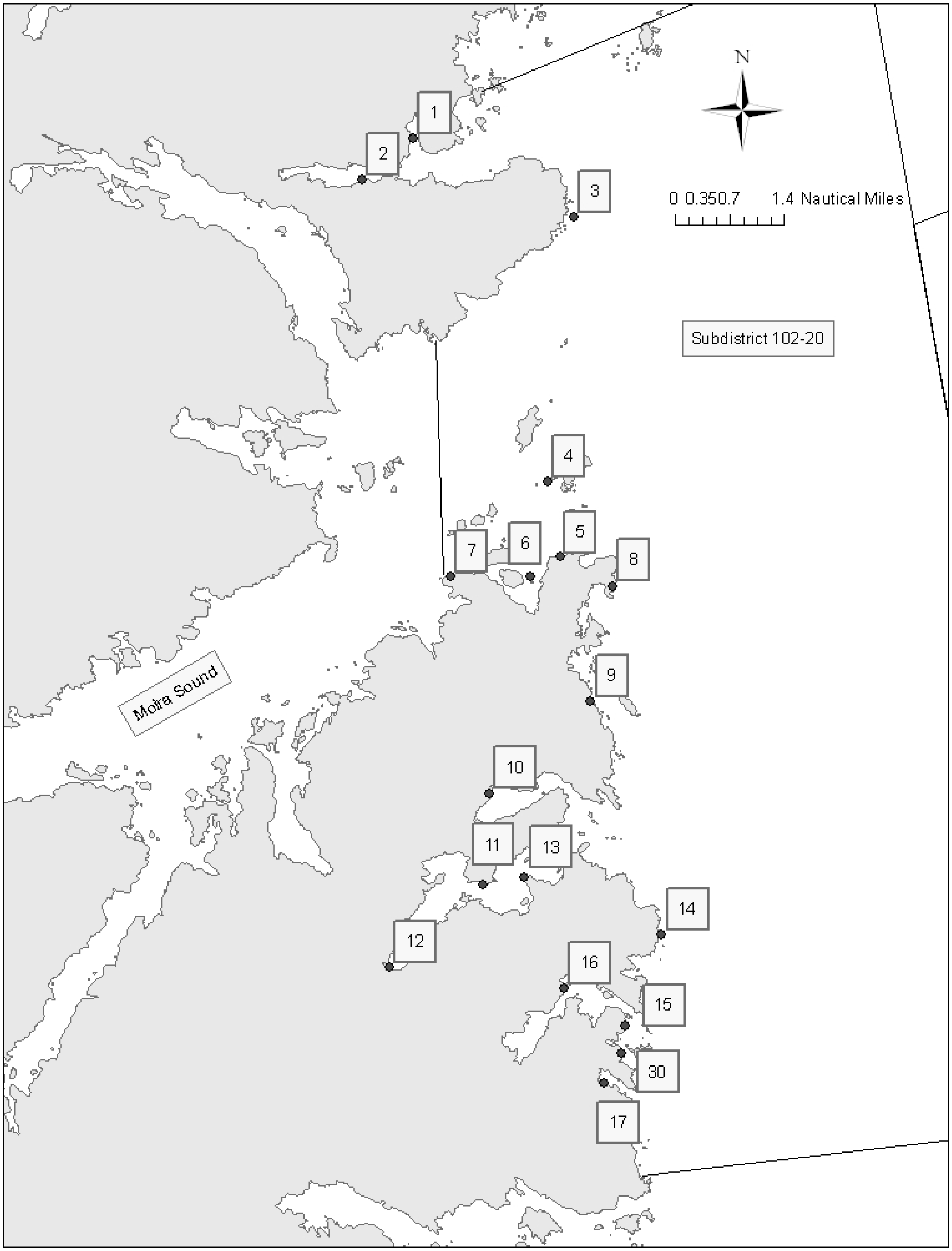
Appendix C1.–Location of transects surveyed in 2009 for commercial fishery Subdistricts 101-10,11. Black line indicates fishery area boundary.



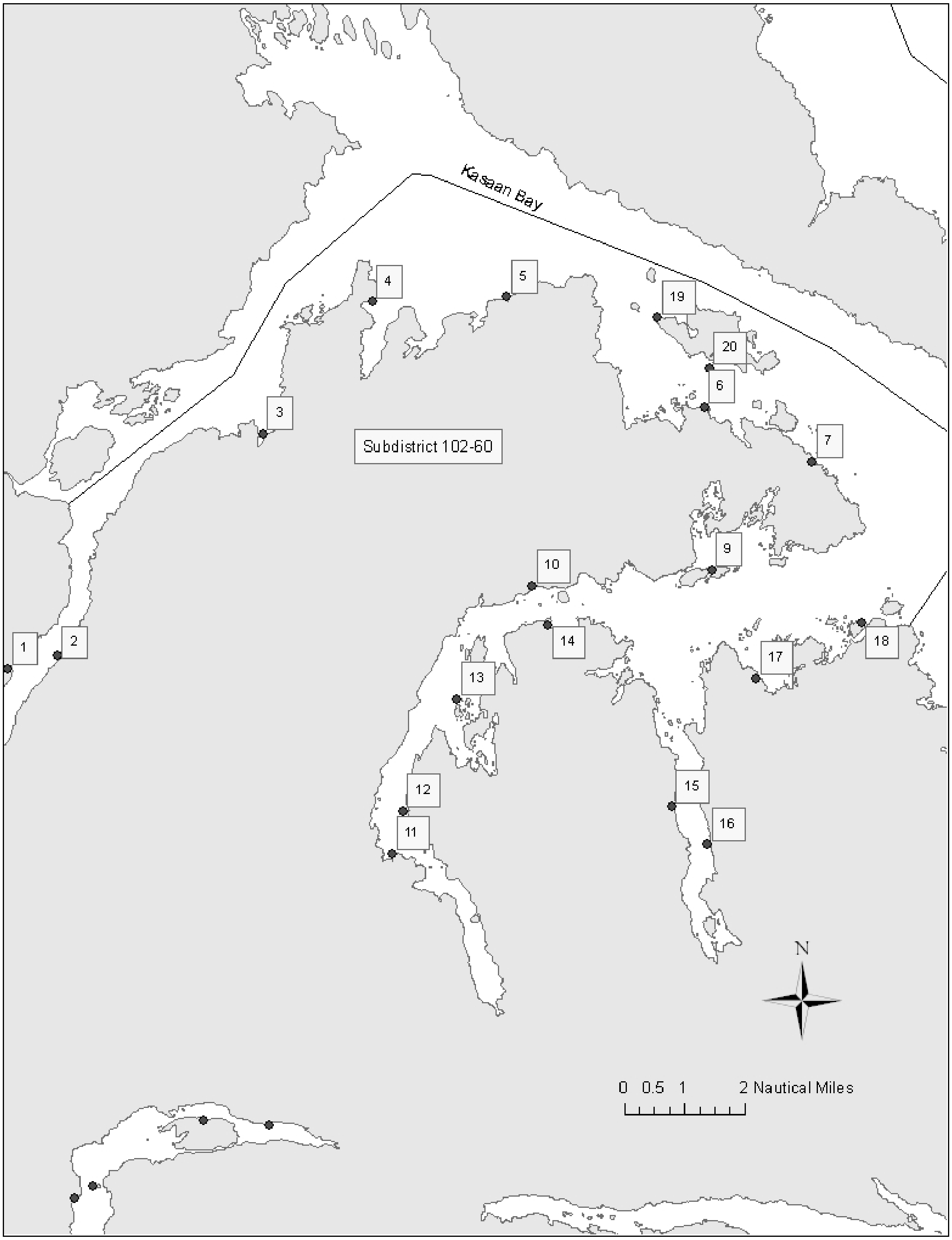
Appendix C2.–Location of transects surveyed in 2009 for commercial fishery Subdistrict 101-25. Black line indicates fishery area boundary.



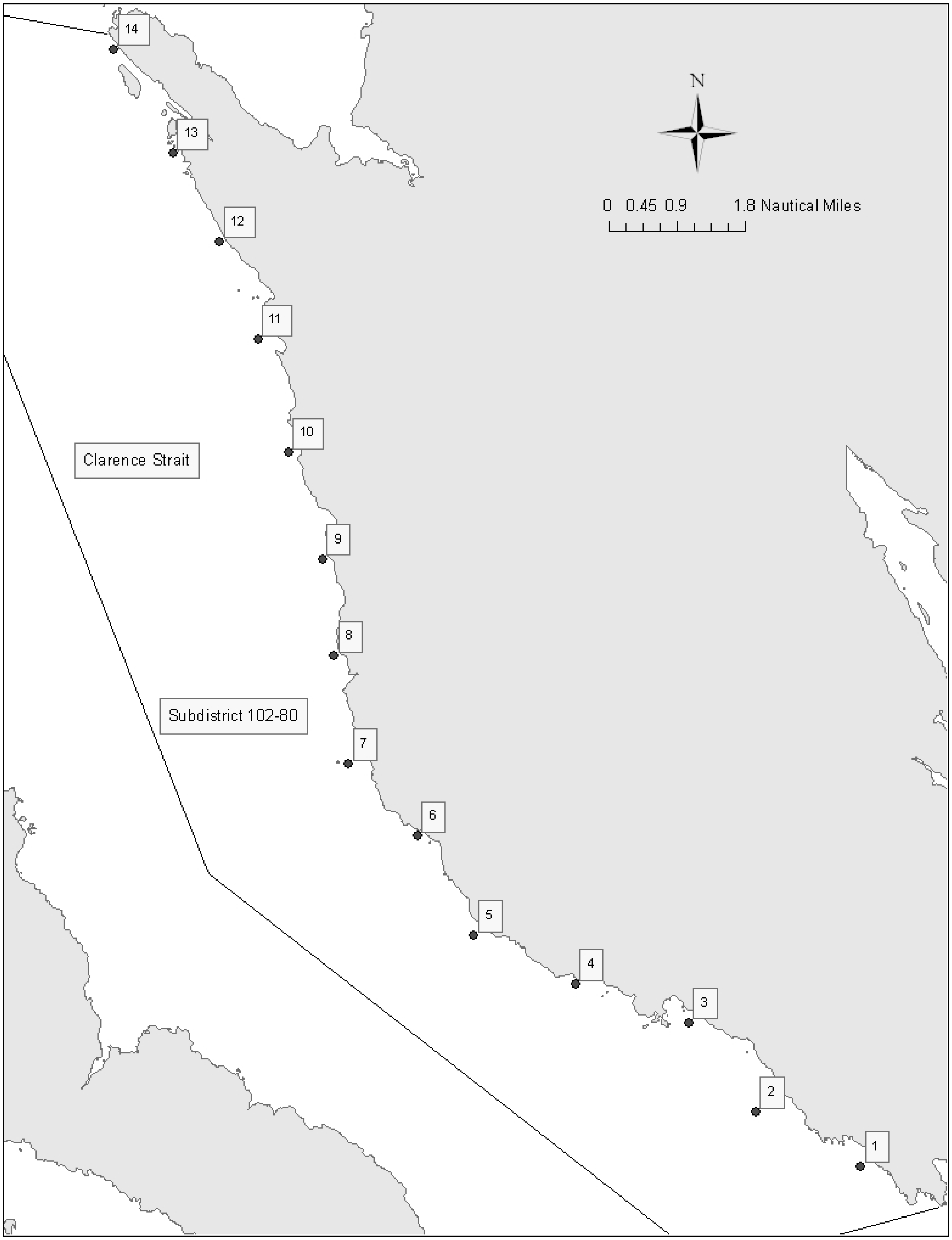
Appendix C3.–Location of transects surveyed in 2009 for commercial fishery Subdistricts 101-90,95. Black line indicates fishery area boundary.



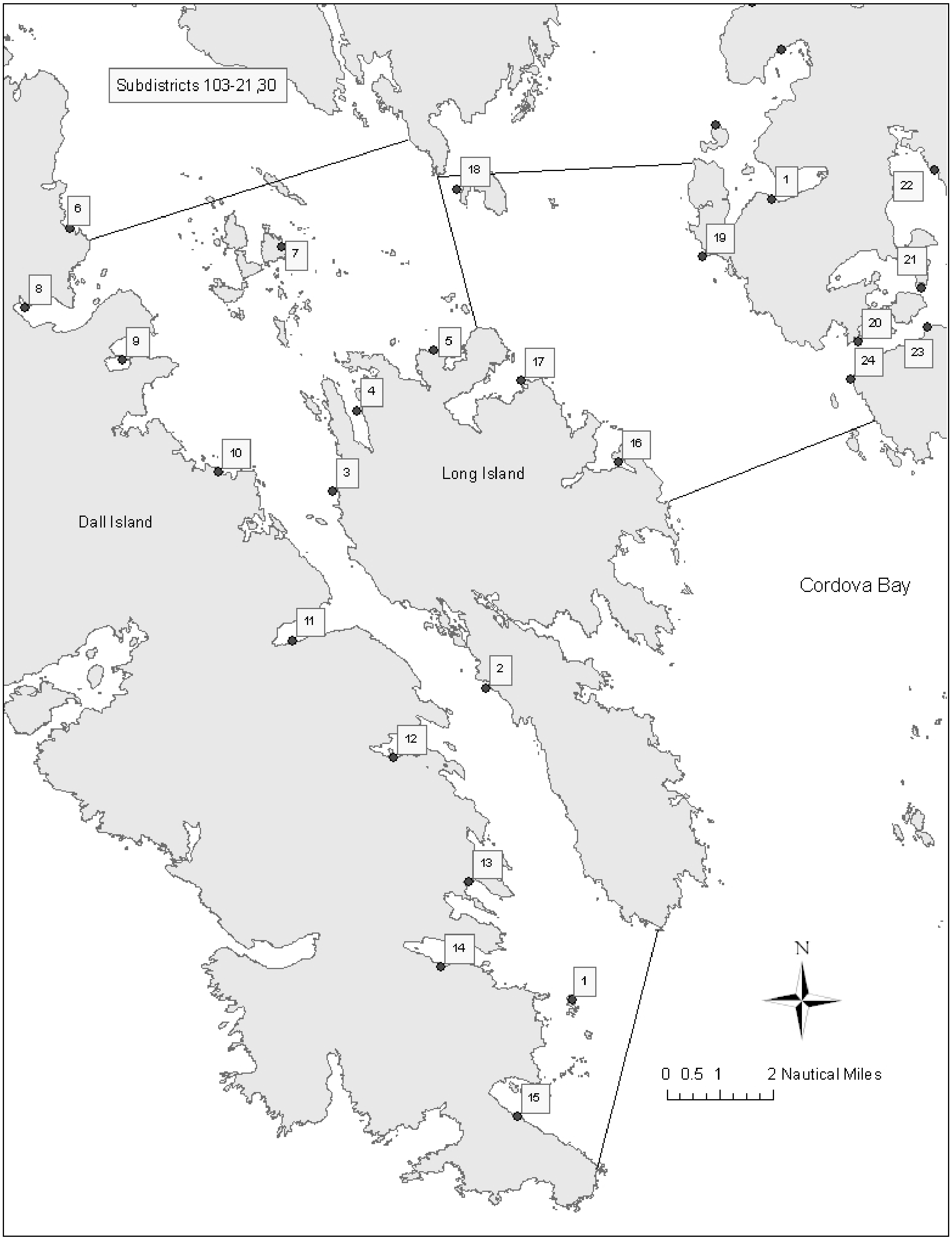
Appendix C4.– Location of transects surveyed in 2009 for commercial fishery Subdistrict 102-20. Black line indicates fishery area boundary.



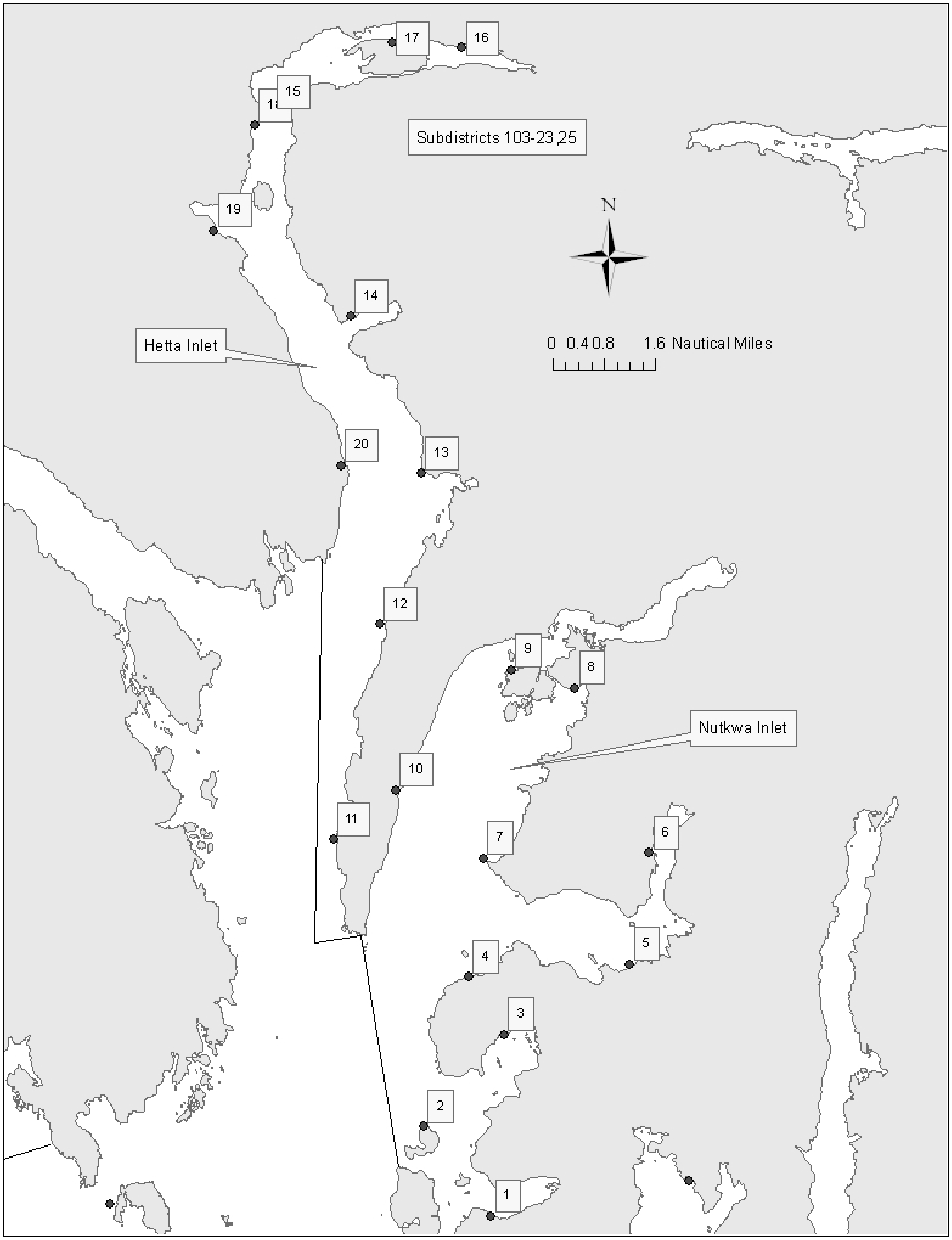
Appendix C5.–Location of transects surveyed in 2009 for commercial fishery Subdistrict 102-60. Black line indicates fishery area boundary.



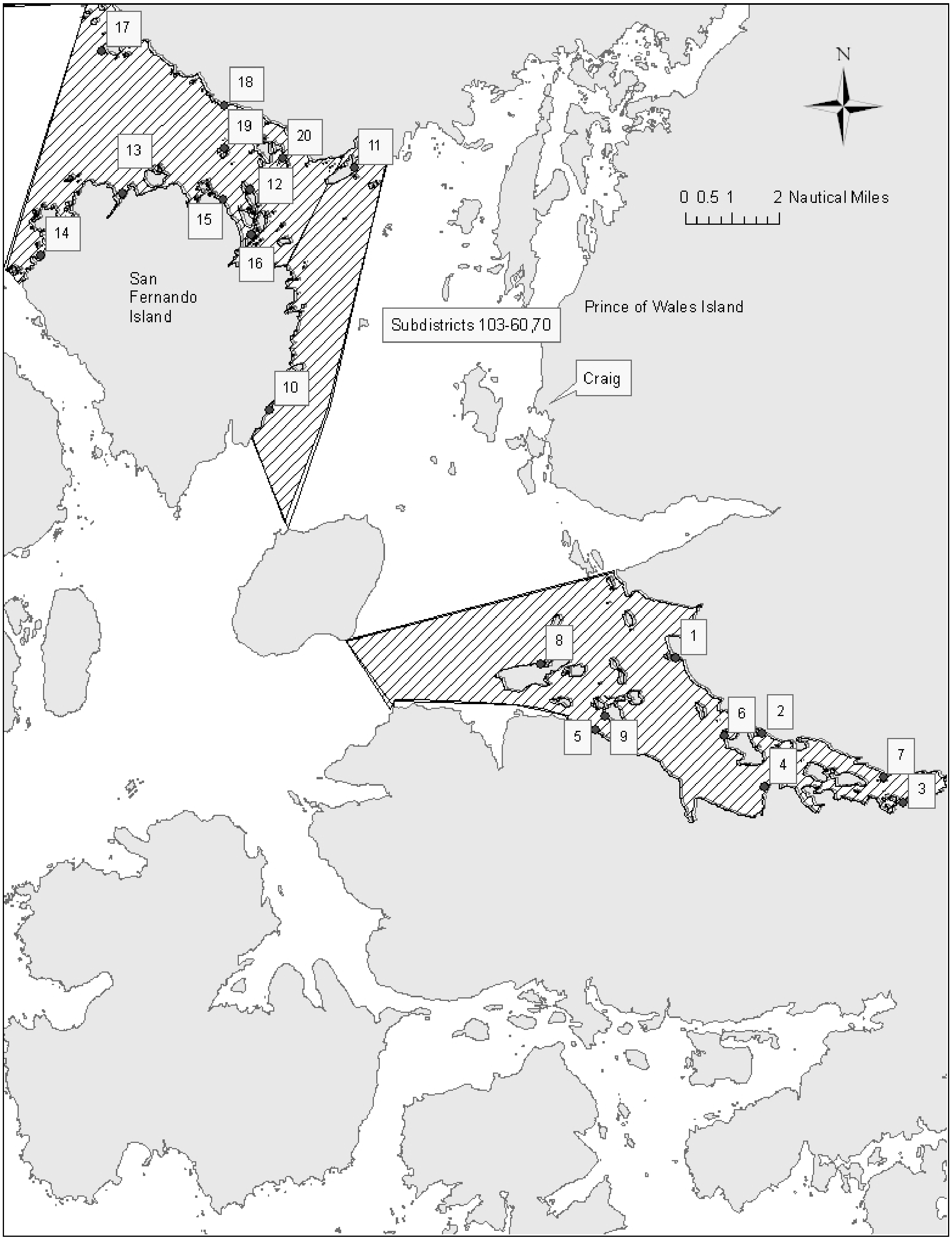
Appendix C6.–Location of transects surveyed in 2009 for commercial fishery Subdistrict 102-80. Black line indicates fishery area boundary.



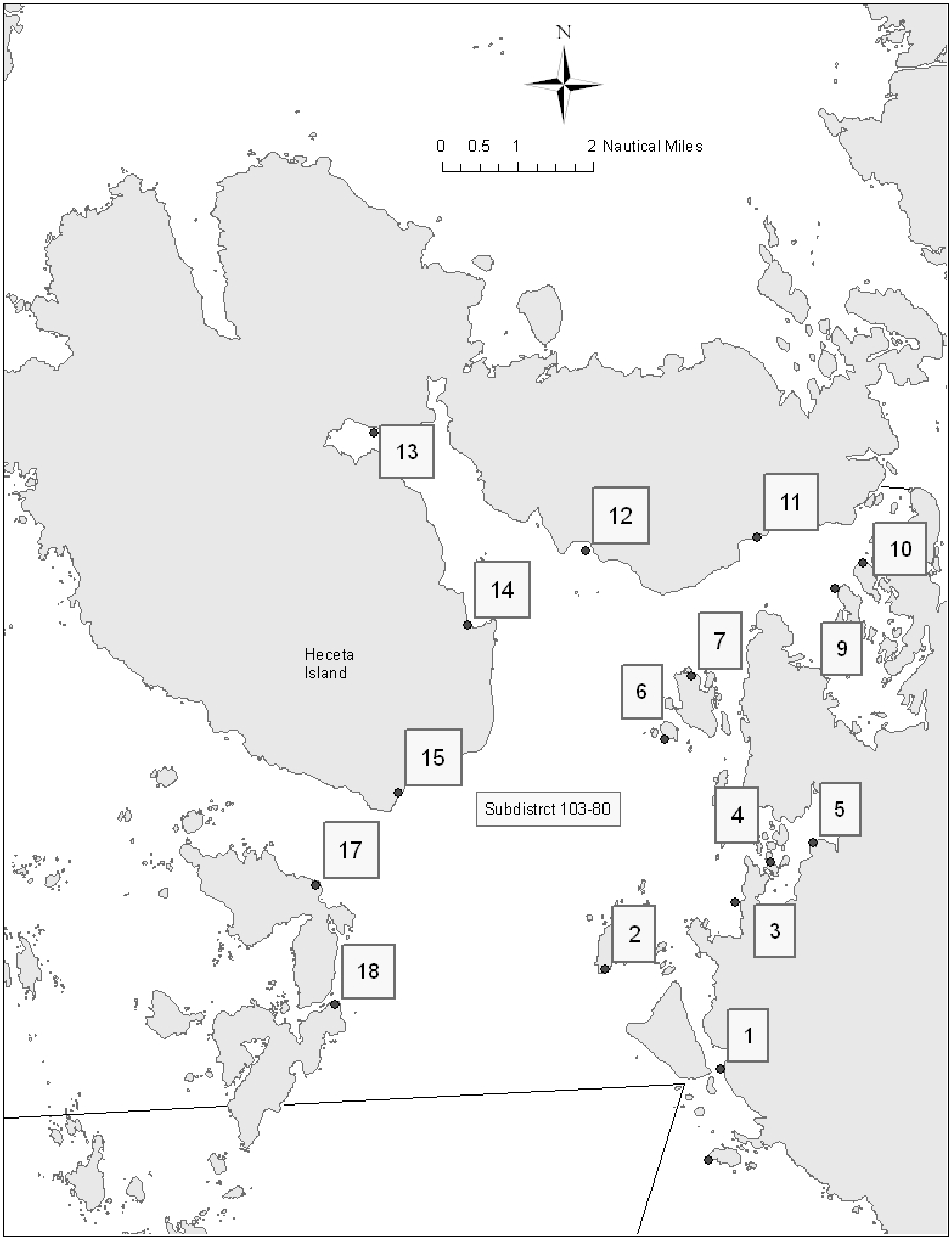
Appendix C7.–Location of transects surveyed in 2009 for commercial fishery Subdistricts 103-21,30. Black line indicates fishery area boundary.



Appendix C8.–Location of transects surveyed in 2009 for commercial fishery Subdistricts 103-23,25. Black line indicates fishery area boundary.

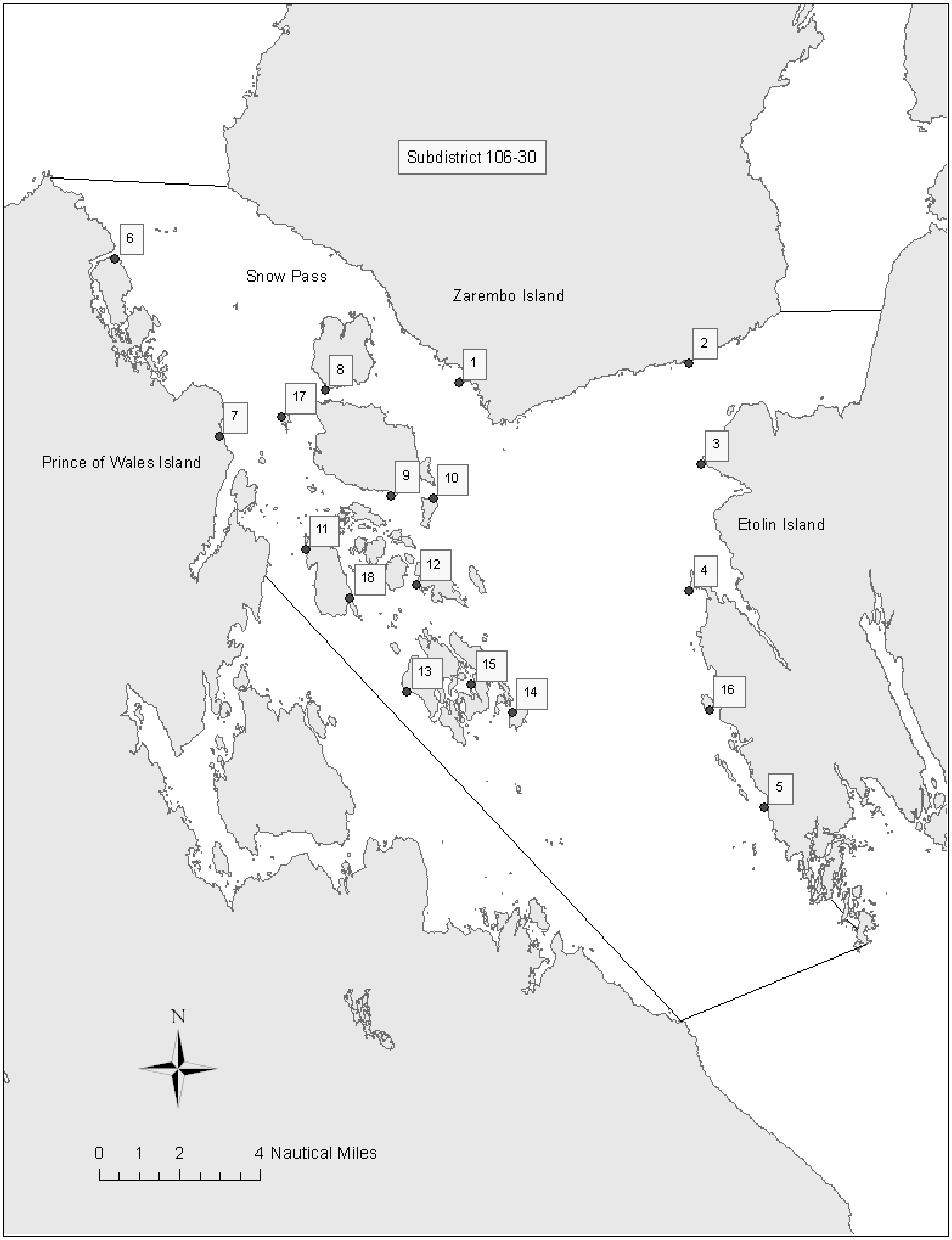


Appendix C9.–Location of transects surveyed in 2009 for commercial fishery Subdistricts 103-60,70. Black line indicates fishery area boundary.

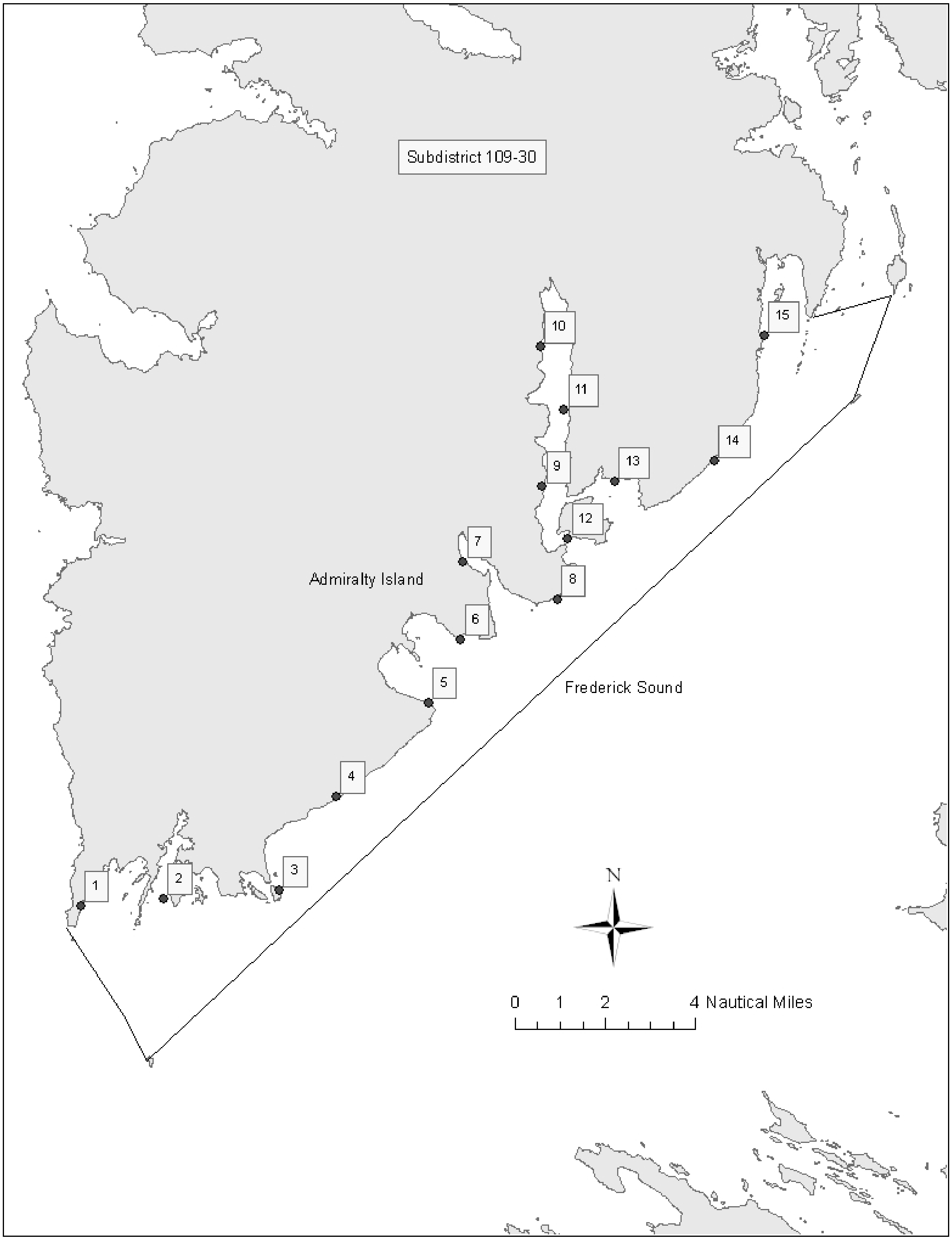


Appendix C10.–Location of transects surveyed in 2009 for commercial fishery Subdistrict 103-80. Black line indicates fishery area boundary.

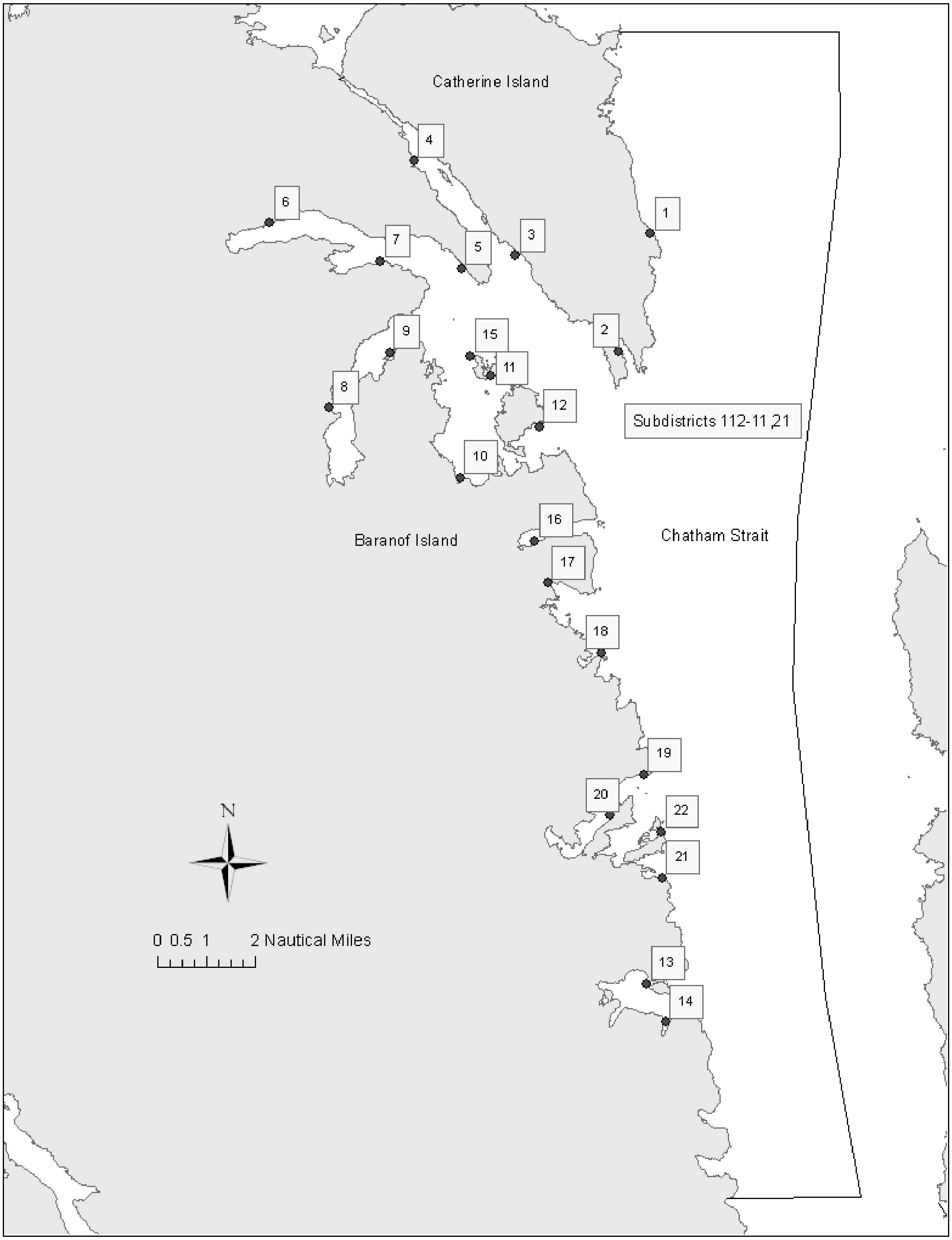
Appendix C11.–Location of transects surveyed in 2009 for commercial fishery Subdistricts 105-32, and 109-43. Black line indicates fishery area boundary.



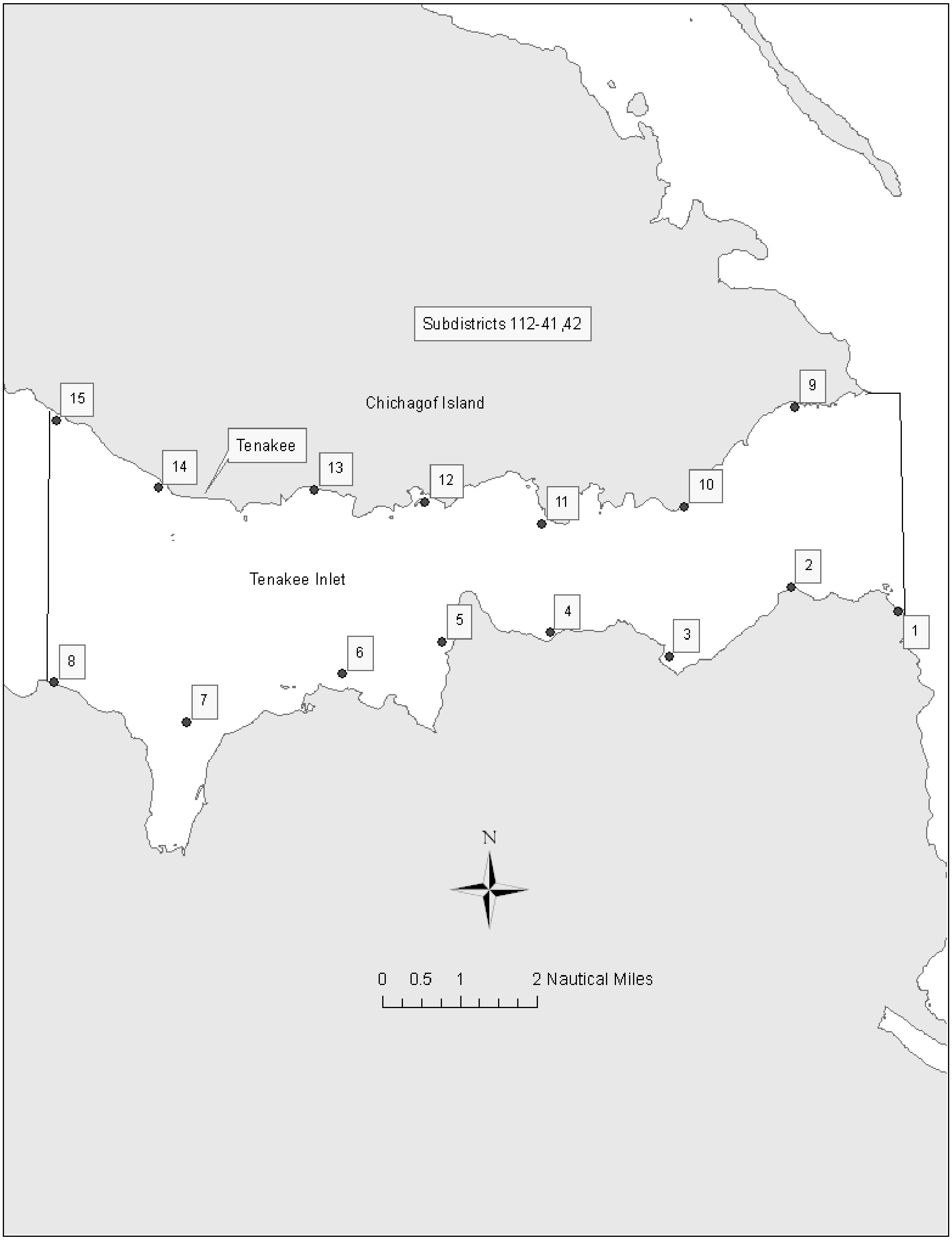
Appendix C12.–Location of transects surveyed in 2009 for commercial fishery Subdistrict 106-30. Black line indicates fishery area boundary**.**



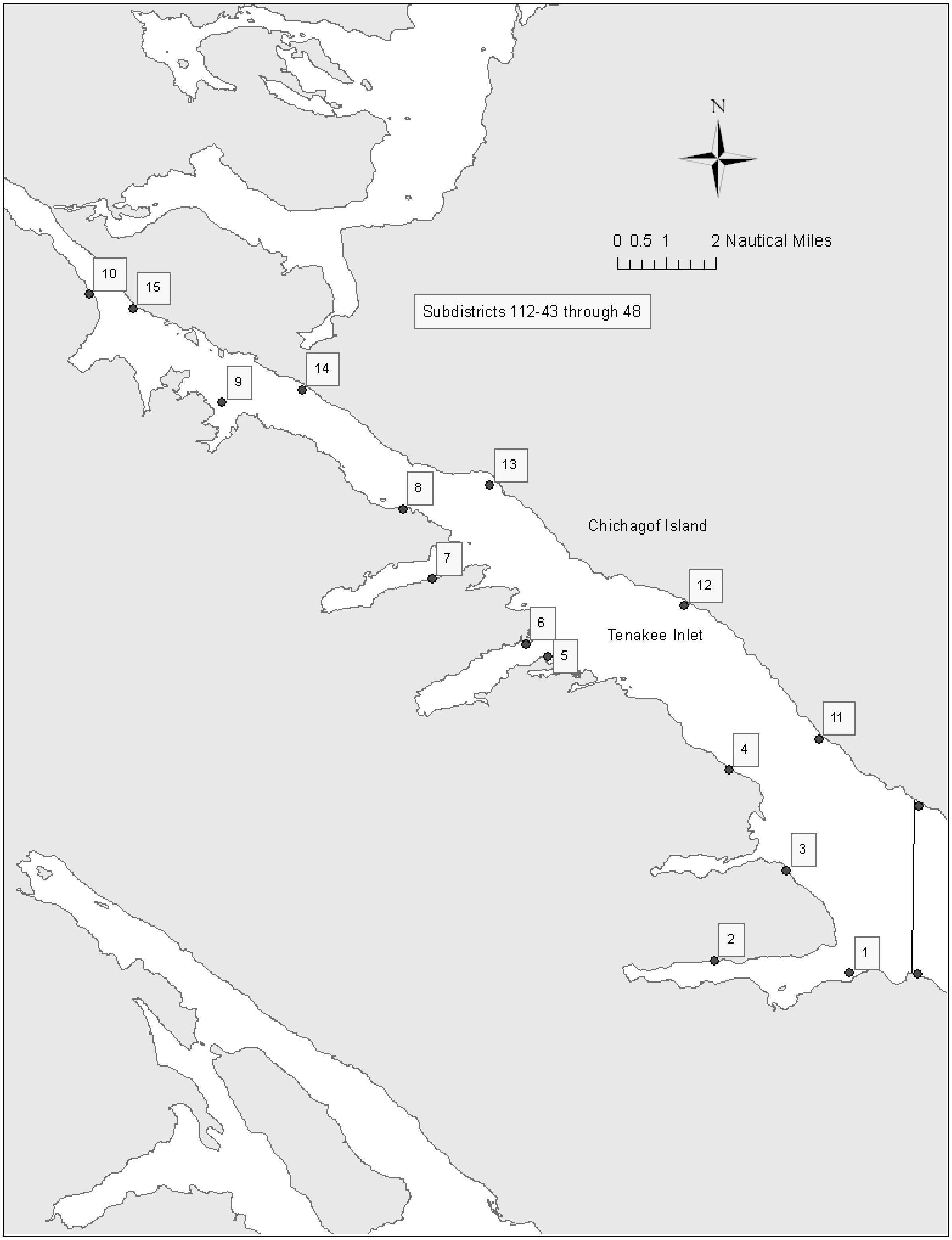
Appendix C13.–Location of transects surveyed in 2009 for commercial fishery Subdistrict 109-30. Black line indicates fishery area boundary**.**



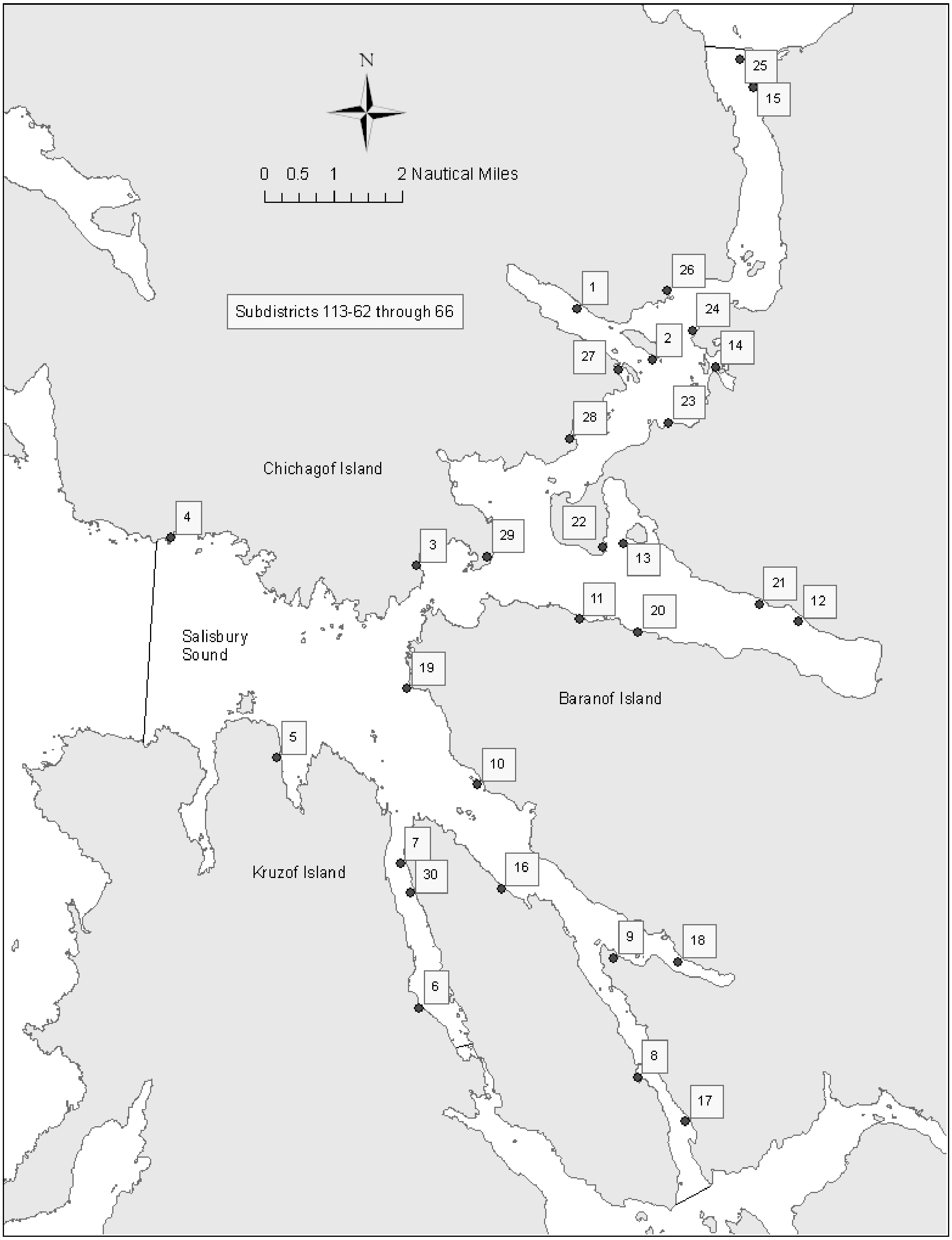
Appendix C14.–Location of transects surveyed in 2009 for commercial fishery Subdistricts 112-11, and 112-21. Black line indicates fishery area boundary**.**



Appendix C15.–Location of transects surveyed in 2009 for commercial fishery Subdistricts 112-41, and 112-42. Black line indicates fishery area boundary.

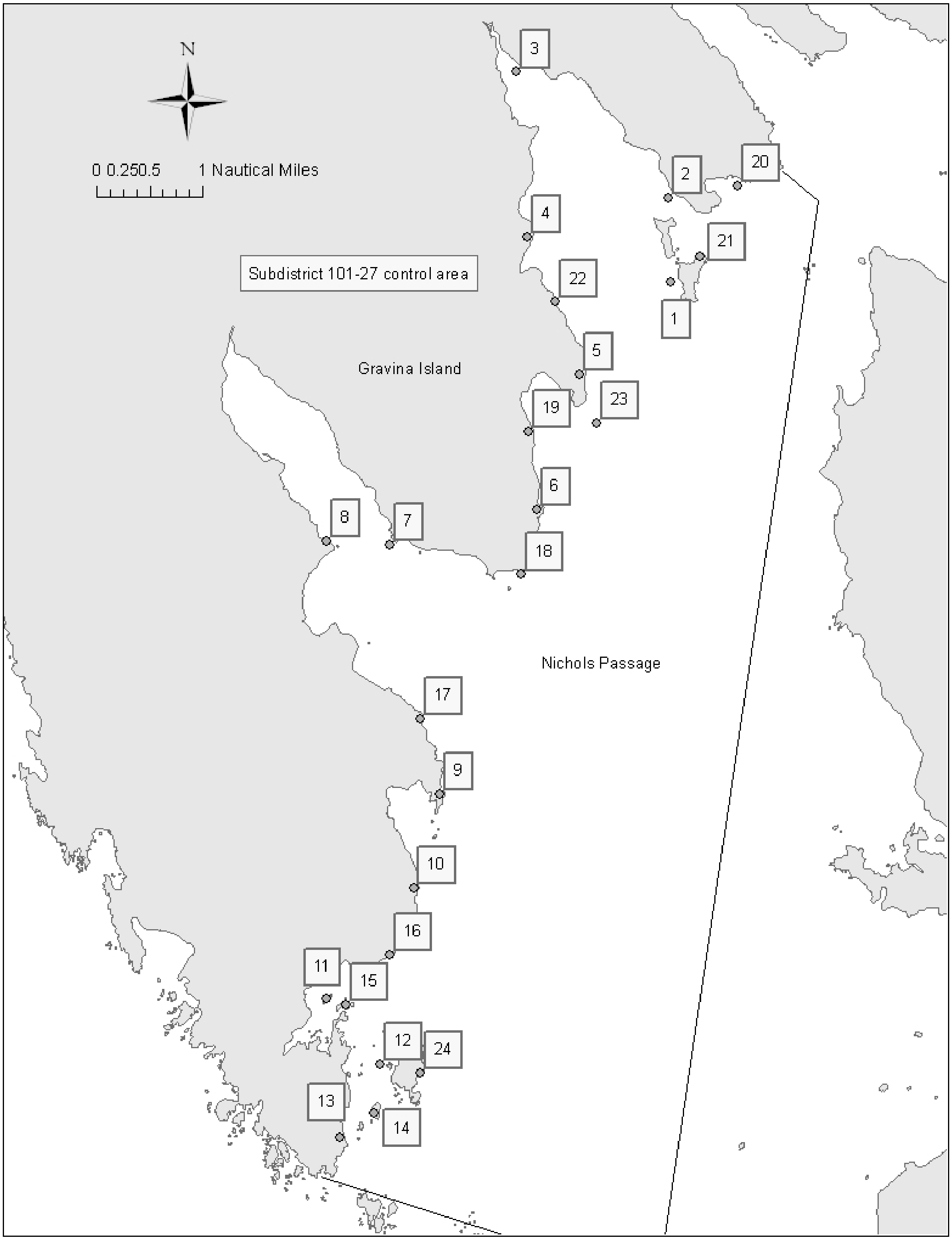


Appendix C16.–Location of transects surveyed in 2009 for commercial fishery Subdistricts 112-43,-44,-45,-46,-47, and-48. Black line indicates fishery area boundary.

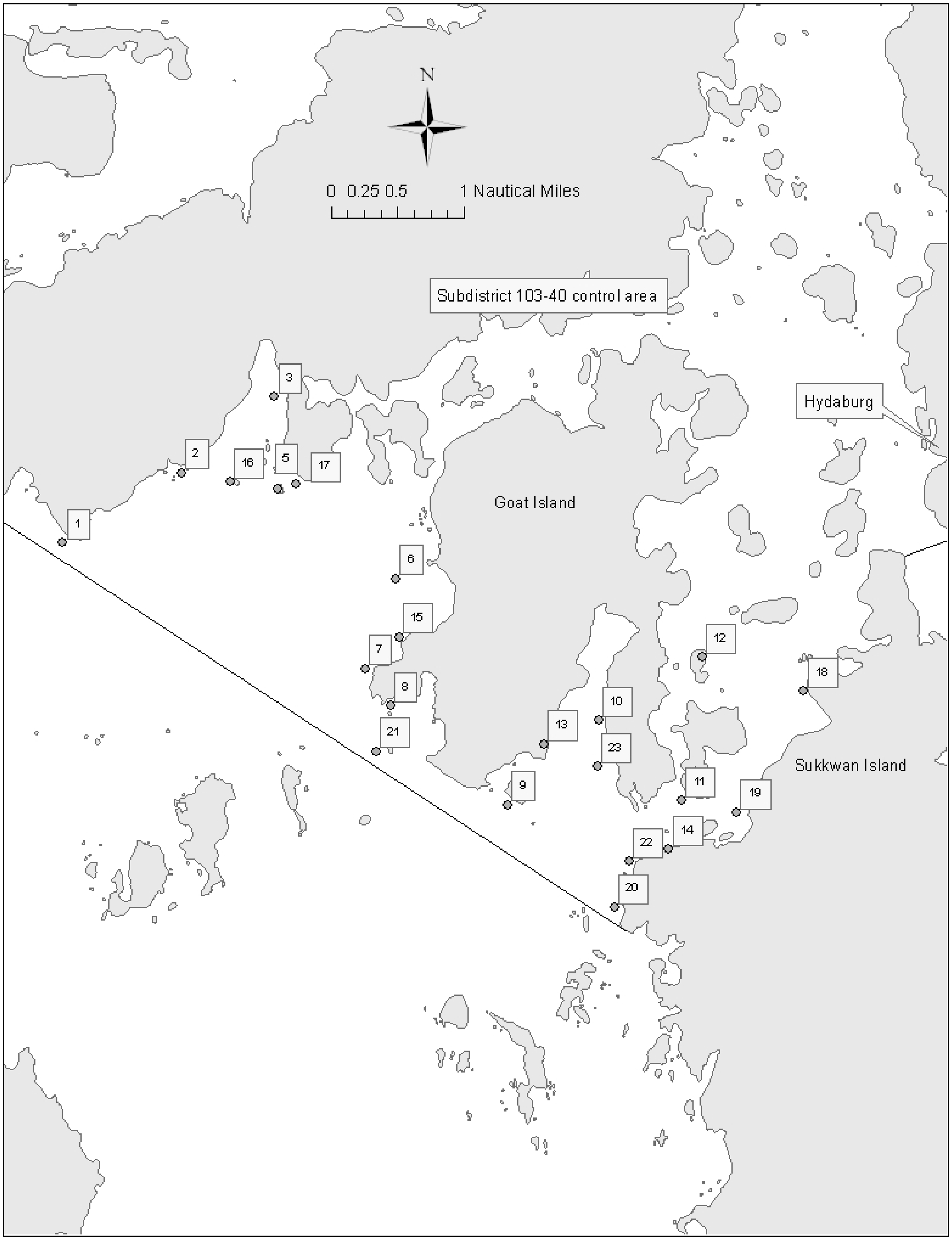


Appendix C17.–Location of transects surveyed in 2009 for commercial fishery Subdistricts 113-62,-63,-64,-65, and -66. Black line indicates fishery area boundary.

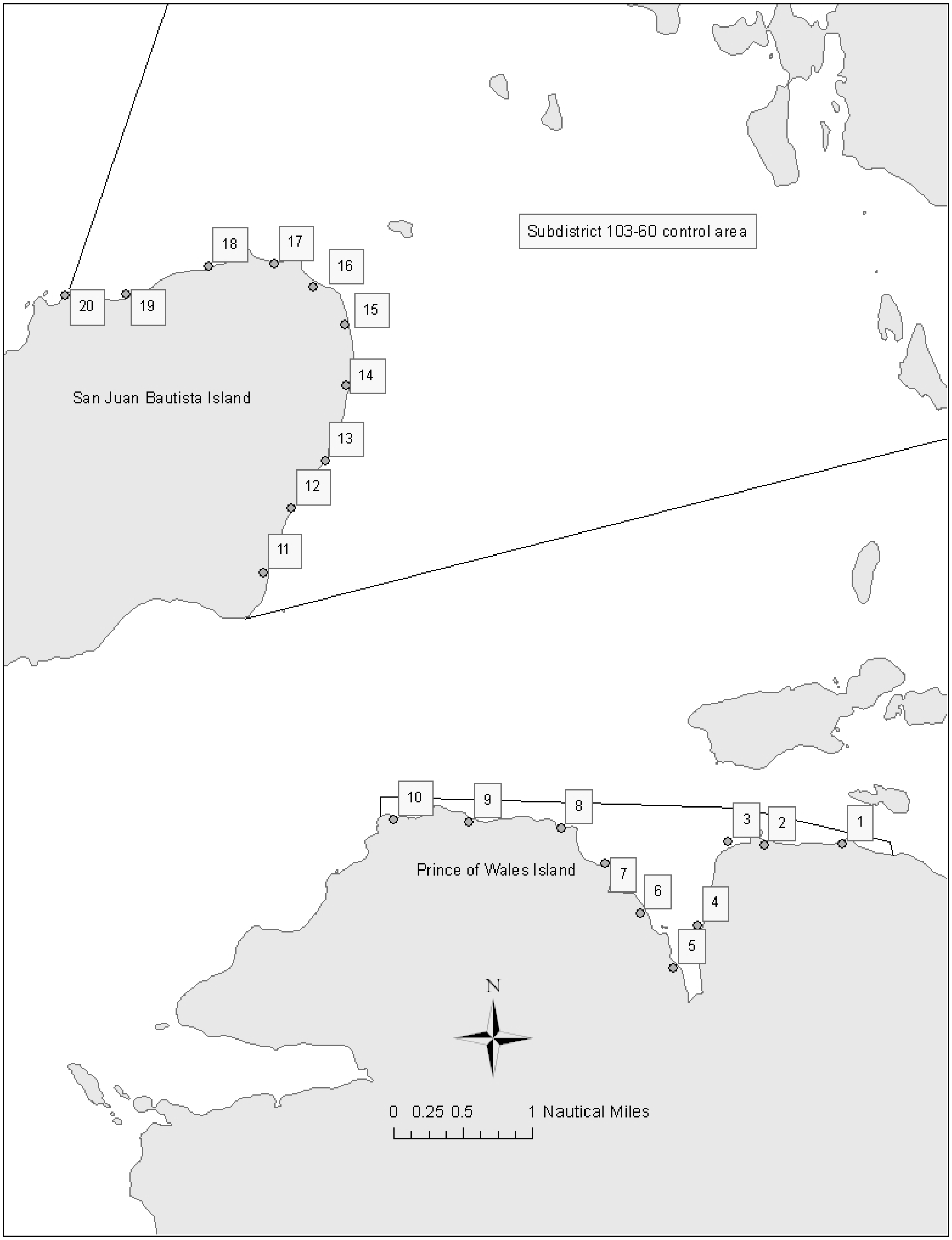
APPENDIX D: MAPS DISPLAYING CONTROL AREAS AND LOCATIONS OF TRANSECTS SURVEYED IN 2009



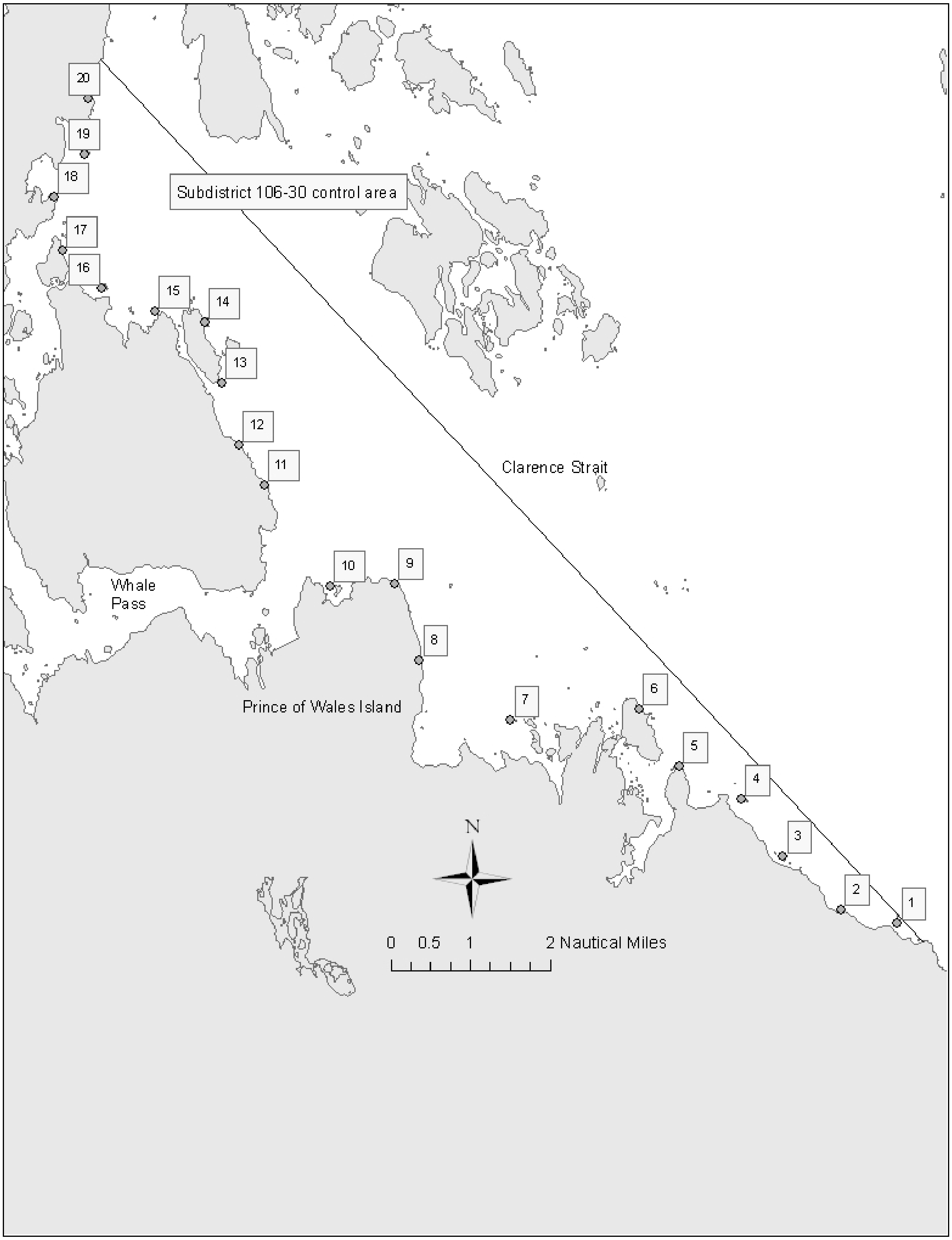
Appendix D1–Location of transects surveyed in 2009 for control area subdistrict 101-27. Black line indicates survey area boundary.



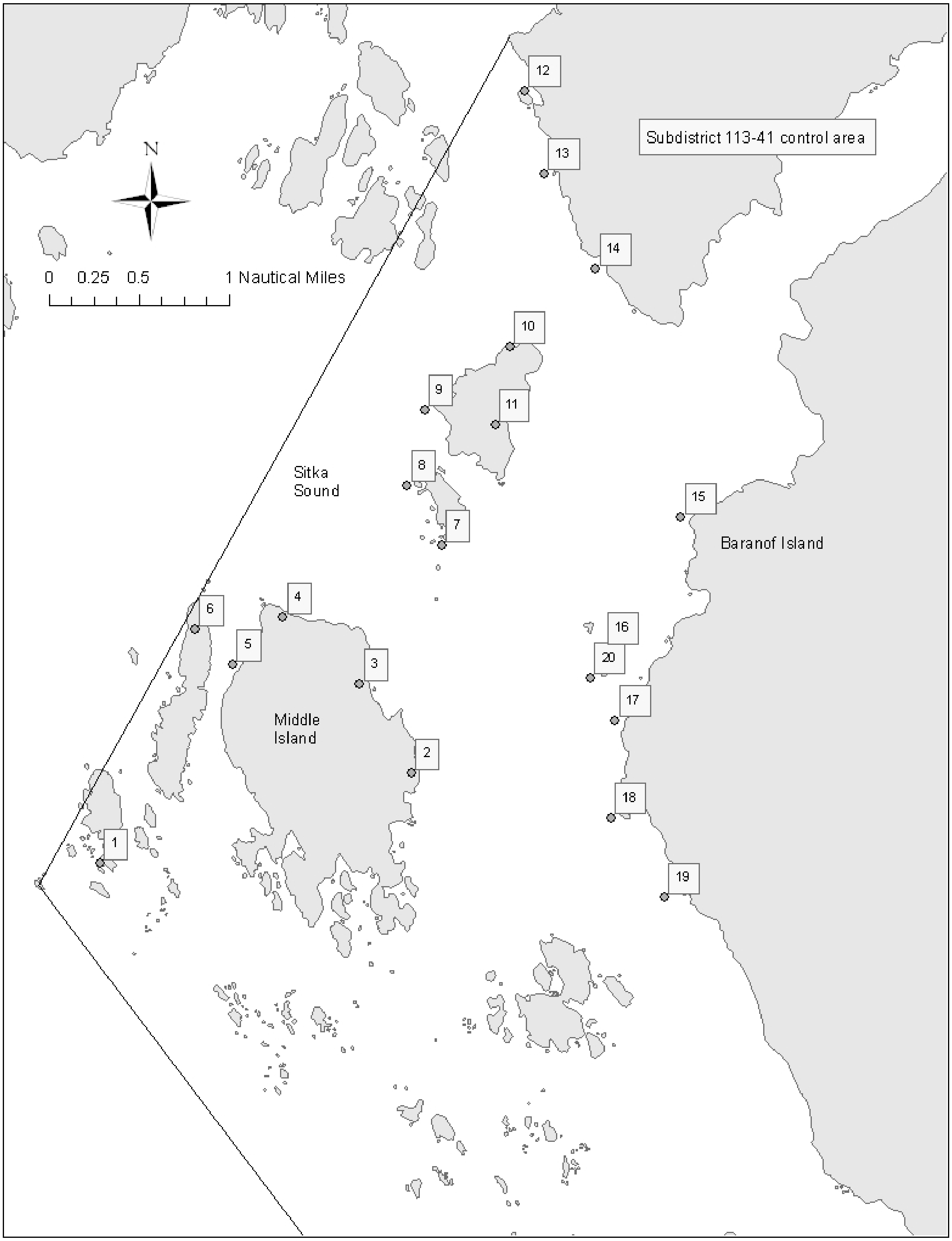
Appendix D2.–Location of transects surveyed in 2009 for control area Subdistrict 103-40. Black line indicates survey area boundary.



Appendix D3.–Location of transects surveyed in 2009 for control area Subdistrict 103-60. Black line indicates survey area boundary.



Appendix D4.–Location of transects surveyed in 2009 for control area Subdistrict 106-30. Black line indicates survey area boundary.



Appendix D5.–Location of transects surveyed in 2009 for control area Subdistrict 113-41. Black line indicates survey area boundary.