Fishery Data Series No. 17-01

Southeast Alaska 2016 Herring Stock Assessment Surveys

by

Kyle Hebert

March 2017

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. 17-01

SOUTHEAST ALASKA 2016 HERRING STOCK ASSESSMENT SURVEYS

by
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March 2017

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This document should be cited as follows:
Hebert, K. 2017. Southeast Alaska 2016 herring stock assessment surveys. Alaska Department of Fish and Game, Fishery Data Series No. 17-01, Anchorage.

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ABSTRACT

Pacific herring, *Clupea pallasii*, is important to many marine species found in Southeast Alaska and is also harvested in fisheries for commercial bait, commercial sac roe, commercial spawn-on-kelp, subsistence spawn-on-branches, subsistence spawn-on-kelp, personal use, and research/cost-recovery purposes. The Southeast Alaska Herring Management plan (5 AAC 27.190(3)) requires the Alaska Department of Fish and Game to assess the abundance of mature herring for each stock before allowing commercial harvest. Included here are results of stock assessment surveys completed primarily during 2016, including summaries of herring spawn deposition surveys and age-weight-length sampling, which are the principle model inputs used to forecast herring abundance. In 2016 spawn deposition surveys were conducted in Sitka Sound, Craig, Ernest Sound, Seymour Canal, and Lynn Canal. Spawn deposition surveys were not conducted in several other major spawning areas in 2016, due to either lack of funding or little or no observed spawn. The total cumulative shoreline in state waters where spawn was documented during aerial surveys in 2016, combined for all areas, was 104.8 nautical miles. In 2016, post-fishery spawn deposition biomass estimates, combined for all surveyed stocks, totaled 86,357 tons.

During the 2015–2016 season, a commercial winter bait fisheries was opened in Craig with a guideline harvest level of 954 tons. A commercial purse seine sac-roe fishery was opened in Sitka Sound with a guideline harvest level of 14,741 tons. A commercial spawn-on-kelp fishery was open in Craig, with an allocation of 692 tons. There were no commercial gillnet fisheries opened in 2016. No commercial fisheries were opened in Seymour Canal, Hobart Bay-Port Houghton, Hoonah Sound, Tenakee Inlet, West Behm Canal, Kah Shakes/Cat Island, or Lynn Canal. Herring harvested commercially during the 2015–2016 season totaled just over 10,700 tons, not including herring pounded for spawn-on-kelp fisheries.

Key words: Pacific herring, *Clupea pallasii,* Southeast Alaska, spawning populations, dive surveys, stock assessment, fishery

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) instituted a herring research project in 1971 to evaluate herring *Clupea pallasii* stocks in Southeast Alaska. This project was developed in response to greater demands on the resource by the commercial bait and developing sac roe fisheries. The goal of the project is to provide the biological data necessary for the scientific management of the region's herring stocks.

A variety of survey techniques have been used in the past to assess herring stocks in Southeast Alaska, including aerial visual estimates, hydroacoustic surveys, and spawn deposition surveys using scuba gear. Data generated during these stock assessment surveys, along with data collected for age, weight, and length estimates, are used directly in the management of all commercial herring fisheries conducted in Southeast Alaska. Data are input into one of two different stock assessment models used to estimate spawning biomass and to forecast mature herring abundance. These models include an age-structured analysis (ASA) model and a biomass accounting model.

Historically biomass estimates and abundance forecasts of mature herring in Southeast Alaska were based on either hydroacoustic surveys or the product of estimates of egg density and area of spawn deposition (called "spawn deposition" method). Currently the ASA model is used for herring populations with longer (i.e., generally a minimum of 10 years) time series of stock assessment data and the biomass accounting model may be used for all other stocks where fisheries occur. These two models are not mutually exclusive of the spawn deposition method. Spawn deposition data is an important element of ASA and biomass accounting models. A primary difference between the two approaches is the amount of data required to conduct the respective analyses. Biomass estimates derived from the spawn deposition method use only the most recent spawn deposition data, and do not factor in trends in age composition or weight at age. A conversion factor based on an estimate of the number of eggs per ton of herring, is applied to the total egg estimate to compute spawning biomass. In contrast, the ASA model uses a time series of age compositions and weight at age in conjunction with estimates of spawn deposition to estimate biomass. Biomass accounting, which does not require a data time series, is based on spawn deposition estimates adjusted for natural mortality, age-specific growth, and recruitment. A more detailed explanation of the ASA and biomass accounting models and how the objective estimates are used in these models are provided by Carlile et al. (1996).

Since 1993, and when data has allowed, the ASA model has been used to estimate and forecast the abundance of herring for four major Southeast Alaska herring stocks: Sitka, Seymour Canal, Revillagigedo Channel (also called "Revilla Channel," which refers to the greater Kah Shakes/Cat Island and Annette Island spawning areas), and Craig. The ASA model was used for Tenakee Inlet beginning in 2000. For these five potential commercial harvest areas or spawning populations, the time series of data has been sufficient to permit the use of ASA for hind casting historical biomass and forecasting future biomass. Other areas, which may support significant herring fisheries but lack data time series suitable for ASA, are candidates for biomass accounting. This simpler modeling approach began in 1996 and has been used to generate forecasts for West Behm Canal, Ernest Sound, Hobart Bay/Port Houghton, and Hoonah Sound. Age-structured analysis and biomass accounting models are mentioned here to provide historical perspective and because they are important elements of the overall stock assessment of herring in Southeast Alaska. Although results from these models are not discussed in this report, the key data inputs for these models are presented. The primary intent of this report is to document data collected during winter 2015 through spring 2016 and to provide historical perspective by presenting general trends in Southeast Alaska herring populations.

The principal outputs from all models are forecasts of mature herring biomass and age compositions for the ensuing year. Biomass forecasts are compared to stock-specific threshold biomass levels to determine whether a fishery will be allowed in a particular area. Biomass forecasts are coupled with appropriate exploitation rates to determine the allowable harvests, and allocations for commercial quotas for each fishery are determined by the appropriate regulations and management plans.

METHODS AND PROCEDURES

AERIAL AND SKIFF SURVEYS

A combination of aerial and skiff surveys were used to record spawning activities during the spring, to document spawn timing, and estimate the distance of shoreline that received herring spawn for all major spawning areas (Figure 1), and for many minor spawning areas in Southeast Alaska. Aerial surveys typically commenced prior to the historical first date of spawning for each stock. In addition to documenting herring spawn and herring schools, estimates of numbers and locations of herring predators, such as birds, sea lions, and whales were recorded. Once concentrations of predators were observed, generally indicating presence of herring, aerial and skiff surveys were conducted more frequently (i.e., daily or multiple flights per day) to ensure accurate accounting of herring distribution and herring spawn. The shoreline where herring spawn (milt) was observed was documented on a paper chart during each survey and then later transferred to computer mapping software to measure shoreline receiving spawn. A chart containing the cumulative shoreline that received spawn during the duration of the spawning event was used as the basis for targeting and designing the spawn deposition dive surveys.

SPAWN DEPOSITION SURVEYS

Optimal timing of spawn deposition surveys is about 10 days after the first significant spawning day of the season in each spawning area. This usually allows adequate time for herring to complete spawning and marine mammals to leave the area while minimizing the time eggs are subjected to predation or wave action that may remove eggs from the spawning area. To account for egg loss from the study site prior to the survey, a 10% correction factor is applied to inflate the estimate of total egg deposition. This value is an estimate based on several studies that have been conducted to estimate herring egg loss from deposition areas in British Columbia (for example see Schweigert and Haegele [2001]; Haegele [1993a-b]) and in Prince William Sound. These studies found that the extent of egg loss due to predation and physical environmental stresses depends upon several things, including length of time since deposition, depth, and kelp type. Historically, a correction factor based on 10% egg loss prior to survey has been used in Southeast Alaska, British Columbia, and Prince William Sound; however, some more recent studies suggest that 25–35% may be more appropriate. Since length of time since egg deposition is key to the extent of egg loss, a serious attempt was made to conduct surveys within 10 days; however, at times surveys were delayed to balance survey schedule times for other spawning areas, or to accommodate schedules of survey participants. Surveys conducted substantially after the 10-day period may tend to result in underestimates of egg deposition and mature biomass.

Shoreline Measurement

Spawn documented during aerial surveys was transcribed in ArcGIS (version 10)[1] over raster images of nautical charts published by the National Oceanic and Atmospheric Administration, using the NAD 1983 datum. Spawn was drawn to conform to the shoreline so that any given segment of shoreline that received spawn had an approximately equal chance of being sampled during the dive survey. This required that shoreline features be smoothed without adhering closely to the shore on a small scale, but also without drawing sweeping straight lines that did not adequately capture enough detail to design a meaningful survey.

Shoreline measurement, and consequently transect placement, can be subjective at times, depending on the location of spawn deposition relative to the shoreline, bottom contour and depth, and map resolution. Fine measurement of a convoluted shoreline may substantially increase measurements of spawn but may not be appropriate for instances when spawn deposition does not closely follow the shoreline. In such situations, less resolution is used for measurements and transects are placed perpendicular to a “theoretical” shoreline so they intersect the spawn in a meaningful way. Conversely, spawn may closely follow a convoluted shoreline, requiring finer resolution of measurements, and transects are placed perpendicular to the actual shoreline contingent upon physical features such as depth, bottom slope, and distance to the opposite shore. For example, a steep sloped shoreline with a narrow band of spawn habitat (e.g., some areas of Sitka Sound) requires much finer shoreline mapping as opposed to an area with a broad gentle slope (e.g., Craig) interspersed with rocks and reefs at some distance from shore.

Although the same procedure and patterns of drawing spawn were followed as in past years, the process requires that judgment be used based on knowledge and experience of the local spawning areas. The intent of drawing a smoothed spawn line is to produce a survey area that is oriented along the spawn and is such that transects laid perpendicularly to the spawn line will

[1] This and subsequent use of product names in this publication are included for completeness but do not constitute product endorsement.

sample egg density throughout the entire width of the spawn, without biasing the estimate. A second objective of measuring the spawn observed along shorelines is to obtain an estimate of spawn length, which factors into the estimate of overall spawn area, and is discussed more below.

Once the spawn shoreline was established, a single linear measurement of the shoreline was made using XTools Pro, a measuring tool extension used within ArcGIS. The shoreline was divided evenly into 0.10 nautical mile segments, which were then randomly selected for transect placement. Therefore, transects were placed no closer than 0.10 nmi relative to each other.

Sample Size

The number of transects selected was proportional to the linear distance of spawn and followed at a minimum the average of suggested sampling rates listed in Table 1. Sampling rates in Table 1 were estimated using data from previous surveys. The statistical objective of the spawn deposition sampling was to estimate herring egg densities (per quadrate) so that the lower bound of a 90% confidence interval was at least within 30% of the mean egg density. This would also achieve the objective of estimating the total spawn deposition at a particular location with the specified precision. A one-sided confidence interval was used because there is more of a concern with avoiding overestimating, rather than avoiding underestimating the densities of spawn deposition. The number of transects were frequently increased beyond the minimum suggested rate to increase transect spatial distribution, potentially reduce variance, and efficiently use scheduled vessel time.

The minimum target number of transects is estimated as follows:

$$n = \frac{\left(S_b^2 - \frac{S_2^2}{\overline{M}} + \frac{S_2^2}{\overline{m}} \right)}{\left(\frac{x\bar{d}}{t_\alpha} \right)^2 + \frac{S_b^2}{N}}; \tag{1}$$

where

n = number of transects needed to achieve the specified precision;

S_b^2 = estimated variance in egg density among transects;

S_2^2 = estimated variance in egg density among quadrates within transects;

$\overline{M}$ = estimated mean width of spawn;

$\overline{m}$ = estimated mean number of 0.1 m quadrates per transect;

x = specified precision, expressed as a proportion (i.e., 0.3 = 30%);

$\bar{d}$ = overall estimated mean egg density;

t_a = critical t value for a one-sided, 90% confidence interval; and

N = estimated total number of transects possible within the spawning area.

Field Sampling

Transect direction was determined by comparing the physical features of the actual dive location to a chart depicting the spawn along the shoreline, and then setting a compass bearing perpendicular to the spawn shoreline. Transects began at the highest point of the beach where eggs were observed and continued down to a depth in the sub tidal zone where no further egg deposition was observed, or to a maximum of 21 m (70 fsw) of depth. The section of each transect that was above the waterline was surveyed by walking until reaching a depth in the water that required diving (usually about 2 feet), at which point diving commenced. Dives were limited to 21 m because deeper dives severely limit total bottom time for scuba divers and pose safety risks when conducting repetitive dives over several days. All diving was conducted in compliance with procedures and guidelines outlined in the ADF&G Dive Safety Manual (Hebert 2006). Normally, little if any herring egg deposition occurs deeper than 21 m.

A two-stage sampling design, similar to that of Schweigert et al. (1985), was used to estimate the density of herring eggs. The field sampling procedure entailed two-person dive teams swimming along transects and recording visual estimates of the number of eggs within a 0.1 m^2 sampling frame placed on the bottom at 5-meter intervals. To help estimate the number of eggs, estimators used a reference of 40,000 eggs per single layer of eggs within the sampling frame, which was determined mathematically using measurements of average egg diameter and frame dimensions. Addition data recorded included substrate type, primary vegetation type upon which eggs were deposited (Appendices A and B, respectively), percent vegetation coverage within the sampling frame, and depth. Since sampling frames were spaced equidistant along transects, the record of the number of frames was also used to compute transect length.

VISUAL ESTIMATE CORRECTION

Since visual estimates rather than actual counts of eggs within the sampling frame are recorded, measurement error occurs. To minimize bias and the influence of measurement error on estimates of egg deposition within each frame, estimator-specific correction coefficients were applied to adjust egg estimates either up or down depending on an estimators tendency to underestimate or overestimate. Correction coefficients were estimated by double sampling (Jessen 1978) frames independent of those estimates obtained along regular spawn deposition transects. Samples for correction coefficients were collected by visually estimating the number of eggs within a 0.1 m^2 sampling frame and then collecting all of the eggs within the frame for later more precise estimation in a laboratory. To collect the eggs, divers removed the vegetation (e.g., kelp) along with the eggs and preserved them with 100% salt brine solution. Approximately ten samples each (of varying egg density) of five vegetation categories were collected. Vegetation categories included eelgrass (ELG), fir kelp (FIR), leafy brown kelp (LBK), rockweed (FUC), and hair kelp (HIR) (see Appendix A.1 for species within each category). Samples were transported to the ADF&G Mark, Tag and Age Laboratory, where analysis was conducted within the following few months. Lab estimates were made for each sample by stripping eggs from vegetation, counting the number of eggs within two or three subsamples (typically about 1,000 eggs), and then measuring the volume of subsamples and samples to calculate total eggs by proportion.

Correction coefficients were calculated as the ratio of sums of laboratory estimates to an estimator's visual estimates. To reduce potential of highly variable correction coefficients, minimum sample size guidelines were used. Data from the years 2014, 2015, and 2016 were used if there were at least a total of 6 samples for each estimator and kelp type, with at least three samples in at least two of the 3 years. If this was not satisfied, then samples from prior years were added until the minimum sampling guideline was met. The intent of these sampling guidelines was to achieve a reasonably adequate sample size to minimize variation, but also to develop correction coefficients that reflected an estimator's tendency to estimate high or low in the most recent years.

Estimator/kelp-specific correction coefficients were applied to egg estimates when the appropriate kelp type matched. For example, the "large/leafy brown kelp" correction coefficient was applied when kelp types that fit that description were encountered, and the "eelgrass" correction coefficient was applied when eelgrass was encountered. When loose eggs or eggs adhering to bare rock were encountered within the frame, an estimator-specific correction coefficient based on the average of all estimator/kelp-specific correction coefficients was applied.

ESTIMATES OF TOTAL EGG DEPOSITION

Total egg deposition for a particular spawning area (t_i) was estimated as follows:

$$t_i = a_i \bar{d}_i , \quad (2)$$

where a_i is the estimated total area (m^2) on which eggs have been deposited; and $\bar{d}_i$ is the estimated mean density of eggs per 0.1 m^2 quadrate, extrapolated to 1 m^2 area (eggs/m^2) at spawning area *i*. The total area on which eggs have been deposited (a_i) is then estimated as

$$a_i = l_i \bar{w}_i , \quad (3)$$

where l_i is the total length of shoreline receiving spawn (determined from aerial and skiff surveys); and w_i is the mean width of spawn, as determined by the mean length of transects conducted at spawning area *i*.

The mean egg density (eggs/m^2) at area *i* ($\bar{d}_i$) is calculated as,

$$\bar{d}_i = 10 \cdot \left[\frac{\sum_h \sum_j \sum_k v_{hijk} c_{hk}}{\sum_h m_{hi}} \right], \quad (4)$$

where v_{hij} is the visual estimate of egg numbers by estimator *h*, at area *i*, quadrate *j*, on kelp type *k*. The c_{hk} term refers to a diver-specific, kelp-specific correction factor to adjust visual estimates made by estimator *h* on kelp type *k; m_{hi}* is the number of quadrates visually estimated by estimator *h* at area *i*. Since egg estimates are made within 0.1 m quadrates, multiplying by 10 expresses the mean density in per 1.0 m^2. Estimator/kelp-specific correction factors (c_{hk}) are calculated as follows:

$$c_{hk} = \frac{r_{hk}}{q_{hk}} , \quad (5)$$

where q_{hk} is the sum of visual estimates of eggs for estimator *h* on kelp type *k*, and r_{hk} is the sum of laboratory estimates of eggs collected from quadrates that were visually estimated by estimator *h* on kelp type *k*.

SPAWNING BIOMASS ESTIMATION

The total number of eggs per spawning area is a key element used in forecasting herring spawning biomass. Although estimated spawning biomass is not an input for the ASA or biomass accounting models, it does provide a static value in a given year (unlike ASA-derived estimates, which change with each model run), which is useful for comparison among years to track broad, relative changes in abundance.

The conversion of eggs to spawning biomass is calculated either using the stock-specific fecundity-to-weight relationship for the areas where fecundity estimates are available (Sitka Sound, Seymour Canal, Craig, Kah Shakes/Cat Island), or for all other stocks, the fecundity-to-weight relationship from the closest spawning stock where fecundity estimates are available (Table 2). The estimate for each area is calculated as follows:

$$b = h_{\bar{g}} * \bar{g}\,, \tag{6}$$

where

b = estimated total spawning biomass;

$h_{\bar{g}}$ = number of fish of mean weight in the area; and,

$\bar{g}$ = mean weight of fish for each area, weighted by age composition

The number of fish of mean weight ($h_{\bar{g}}$) is calculated as follows:

$$h_{\bar{g}} = \frac{\left(\frac{t}{L}\right) * 2}{f_{\bar{g}}}\,, \tag{7}$$

where

L = egg loss correction factor (0.9), which accounts for an estimated 10% egg mortality between the time eggs are deposited and spawn deposition surveys are conducted; and,

$f_{\bar{g}}$ = estimated fecundity of fish of mean weight, using equations listed in Table 2.

AGE AND SIZE

Herring samples were collected from a combination of skiff surveys, aerial surveys, research surveys, commercial fisheries, and test fisheries from major stocks located throughout Southeast Alaska. Collection gear varied with location and may have included purse seines, gillnets, cast nets, or bottom trawls. Cast nets were used when fish were in shallow water during active spawning. Herring sampled from commercial fisheries were collected from individual harvesters or tenders while on the fishing grounds. Dates, gear used, and geographic locations of all samples were recorded.

Based on multinomial sampling theory (Thompson 1987), a sample size of 511 ages is considered sufficient to assure age composition estimates that deviate no more than 5% (absolute basis) from the true value, with an alpha level of 0.10 (i.e., the chances of rejecting a true value is about 10 percent). The minimum sampling goal was set at about 525 fish to ensure that at least 500 readable scales would be obtained for aging, from each commercial fishery (i.e., purse seine or gillnet samples) and each spawning stock (i.e., cast net samples).

All samples were packaged and labeled in five-gallon buckets and frozen for later processing in the laboratory. After thawing samples in the laboratory, the standard length (mm) of each fish (tip of snout to posterior margin of the hypural plate) was measured. Fish were weighed on an electronic balance to the nearest tenth of a gram.

A scale was removed from each fish for age determination. The preferred location is on the left side anterior to the dorsal fin or beneath the left pectoral fin. Scales were cleaned and dipped in a solution of 10% mucilage and placed unsculptured side down on glass slides. Aging was conducted by viewing scale images on a microfiche projector to count annuli. Age data for early years (1980–1998) were obtained by viewing scales through a dissecting microscope, varying the light source for optimum image of the annuli. Ages from 1999 to present were determined by mounting scales on a microfiche reader to project a larger scale image to more easily see annuli. Each fish was assigned an anniversary date for each completed growing season. All samples were collected before growth resumed in the spring, and scales were aged based on the number of summer growth periods observed. For example, if a herring hatched in the spring of 2011 and was collected in the fall of 2012, 2 growing seasons had occurred (age-2). If the herring had been collected in the spring of 2013 before growth had resumed, it was also recorded as age-2. Scales were spot-checked by a second reader for age verification, and if agreement between readers was less than 80%, the entire sample was re-aged. For a detailed description of aging methods see Oxman and Buettner (*In prep*).

Condition Factor

Condition factor (CF) was calculated to provide a general indication of overall condition of fish based on body proportion. Condition factor was based on the method described in Nash et al. (2006) and was estimated as follows:

$$CF = \left(\frac{w}{l^3}\right) * 100, \qquad (8)$$

where

w = whole body wet weight in grams; and,

l = standard length in millimeters.

Sea Temperature

Daily sea surface temperature was recorded in spawning areas for most stocks using submerged Onset Stowaway Tidbit temperature loggers. Depth of temperature recorders ranged from about 10 ft MLLW to 20 ft MLLW. Temperature was recorded daily at 6-hour intervals for a minimum of 1 year and up to 16 years, depending on spawning area. Daily mean temperature was calculated and for each spawning area, and mean, minimum and maximum sea temperature values were calculated for each year using datasets that spanned an entire year (365 consecutive days). Overall annual mean temperature was calculated as the mean of all daily values. Mean annual minimum temperatures and mean annual maximum temperatures were calculated as the mean of the minimum or maximum values that occurred during each annual cycle.

Commercial Fisheries

During the 2015–2016 season, only three commercial herring fisheries were conducted in Southeast Alaska, from two spawning areas: Sitka Sound and Craig. Products resulting from these fisheries included food and bait, sac roe, and spawn on kelp. Threshold biomass levels have been established for each commercially exploited stock in Southeast Alaska, which are intended to reduce the risk of sharp declines in abundance due to recruitment failure, and to maintain adequate herring abundance for predators. Commercial harvest of herring is not permitted unless the forecast of mature herring meets or exceeds the threshold. For Sitka Sound and West Behm Canal, threshold levels were based on 25% of estimated average unfished biomass as determined through simulation models (Carlile 1998a, 2003). In the case of Sitka Sound, the threshold was subsequently increased by the Board of Fisheries on two occasions (1997 and 2009) to provide additional protection to the stock and to help alleviate concerns over adequate subsistence opportunities to harvest the resource. For the Tenakee Inlet stock, 25% of the average unfished biomass was estimated; however, because the value was lower than the existing threshold of 3,000 tons, the existing threshold was retained (Carlile 1998b). For all other stocks in Southeast Alaska, thresholds were established after considering estimates of abundance, historical knowledge of stock size and distribution, and manageability of minimum quotas. Threshold levels during the 2015–2016 season ranged from 2,000 tons (Hoonah Sound and Hobart Bay) to 25,000 tons (Sitka Sound). This season the threshold for Hoonah Sound was increased from 1,000 tons to 2,000 tons to bring it in line with the minimum threshold of all other areas in Southeast Alaska.

Management Strategy

The following management plan was in place for the 2015–2016 Southeast Alaska commercial herring fisheries. It was adopted by the Alaska Board of Fisheries at its January 1994 meeting.

5 AAC 27.190. *HERRING MANAGEMENT PLAN FOR STATISTICAL AREA A.* For the management of herring fisheries in Statistical Area A, the department:

(1) shall identify stocks of herring on a spawning area basis;

(2) shall establish minimum spawning biomass thresholds below which fishing will not be allowed;

(3) shall assess the abundance of mature herring for each stock before allowing fishing to occur;

(4) except as provided elsewhere, may allow a harvest of herring at an exploitation rate between 10 percent and 20 percent of the estimated spawning biomass when that biomass is above the minimum threshold level;

(5) may identify and consider sources of mortality in setting harvest guidelines;

(6) by emergency order, may modify fishing periods to minimize incidental mortalities during commercial fisheries.

Although there are several other regulations within the Alaska Administrative Code that pertain to specific herring fisheries in Southeast Alaska, the above general management plan represents the over-arching principals with which all herring fisheries must comply in the region.

RESULTS

AERIAL AND SKIFF SURVEYS

Aerial and skiff surveys of herring activity, herring spawn, and marine mammal/bird activity were conducted at major stock locations beginning on March 11, 2016, in Sitka Sound and ending on May 9, 2016, in Tenakee Inlet. Notes of activity related to herring or herring spawning were recorded in logs, which are presented in Appendix C. Surveys or observations were conducted by staff in each area office (Ketchikan, Petersburg, Sitka, Juneau, Haines, Yakutat) and covered major and traditional herring spawning locations within each management area. Occasionally, private pilots or local residents reported observations of active spawning. Spawning timing for each major spawning area, including dates of first, last, and major spawning events, is summarized in Figure 2. Aerial surveys were conducted in several minor spawning areas, but no spawn deposition surveys were completed in these areas due to the low level of spawning, or in the case of some areas (e.g., Bradfield Canal), because surveys conducted in previous years revealed that only a narrow band of spawning habitat exists resulting in relatively low egg deposition (see Appendix C). ADF&G also completed aerial surveys of Annette Island Reserve, while en route to other spawning areas located in state waters.

SPAWN DEPOSITION SURVEYS

During spring 2016, spawn deposition surveys were conducted in Sitka Sound, Craig, Ernest Sound, Lynn Canal, and Seymour Canal. Surveys of areas began in Sitka Sound on April 1 and were completed in Seymour Canal on May 8 (Table 3). Survey site locations, spawn, and transect locations are presented in Appendix D. Egg estimates by transect for each spawning area are presented in Table 4. Spawn deposition surveys were not conducted in West Behm Canal, Revilla Channel, or Hobart Bay/Port Houghton areas due to reduced budgets in 2016. Spawn deposition surveys were planned, but not completed in Hoonah Sound or Tenakee Inlet, due to lack of spawn recorded along shorelines in the traditional spawning areas.

Although total herring spawning biomass, combined for all areas, was similar in 2016 the prior two years, it declined for most spawning areas between 2015 and 2016. The relative stability of biomass at the two largest spawning areas (Sitka Sound and Craig) over the past year had a large influence on the apparent overall stability in the region. Excluding Sitka Sound, herring spawning biomass in the region declined substantially over the past year and is at the lowest level seen for several decades. A summary of the 2016 survey results, including spawn mileage, average transect length, area of egg deposition, egg density, estimated egg deposition, and estimated spawning biomass is presented in Table 5. For comparison of 2016 spawning stock abundance to prior years, estimates of historical spawning biomass are presented in Figures 3–8.

The total documented spawn for major spawning areas in state waters where aerial surveys were conducted in Southeast Alaska in 2016 was 104.8 nmi (Table 5). This did not include spawning around Annette Island Reserve (where about 0.6 nmi was observed), or several minor spawning areas in Southeast Alaska, or Yakutat (see Appendix C for a detailed accounting of other minor spawn areas throughout Southeast Alaska).

Visual Estimate Correction

Minimum sample size guidelines (at least 3 samples per kelp type for the most recent 3 years) were met using data from 2014 through 2016 for all (10 of 10) estimators. Correction coefficients applied to 2016 spawn deposition visual estimates ranged from 0.592 to 1.775 and are presented in Table 6.

Visual review of plots depicting observed versus laboratory estimates of eggs suggest there exist linear relationships for some estimators, but a non-linear relationship for others caused by a tendency to underestimate when egg numbers in sample frames are high. A similar non-linear pattern has been observed for aerial estimates of salmon in streams (see Jones et al. 1998), although correction coefficients were calculated as a straight ratio of known to estimated values. For herring egg correction coefficients presented here, values were calculated as an overall ratio of values summed across the entire range of lab-estimated and visually estimated values, which was considered to adequately correct visual estimates, although values may be biased low due to the non-linear relationship.

AGE AND SIZE

A combined total of 5,184 herring were sampled from all stocks and gear types (cast net, purse seine, and pound) during the 2015–2016 season. Of those, 5,115 herring were processed to determine age, weight, length and sex. The reduction of sample size was due to fish that could not be aged due to regenerated scales, or due to data that was otherwise unusable.

Samples of the spawning population were taken using cast nets from Craig, Ernest Sound, Seymour Canal, Sitka Sound, West Behm Canal, and Lynn Canal. Samples of the spawning population were collected throughout the geographic extent of the active spawn in most spawning areas (Figures 9–17). For most spawning areas, collection of samples from the spawning population was also distributed throughout the duration of spawning, or was focused on the most intense spawning events (Figure 2).

Samples were obtained from commercial and test fisheries for all areas where fisheries were conducted in 2015–2016. Fisheries sampled included Craig winter bait and spawn on kelp, Sitka sac roe, and Sitka winter test fishery. Samples were obtained opportunistically from vessels or tenders, during or shortly after the fishery openings. Sample locations during fisheries are also shown in Figures 9–19.

The minimum sample goal of 500 aged fish per sampling event (gear-fishery combination) was met or exceeded for nearly every area/fishery, with the sole exception of West Behm Canal, where only 419 ages were obtained from samples (Tables 7 and 8).

Age Composition

Age composition data was obtained for the majority of major stocks in the region, but due to either reduced budgets in 2016, or lack of observed spawning, samples were not collected for several areas. Herring samples were obtained from Sitka Sound, Craig, Ernest Sound, Seymour Canal, Lynn Canal, and West Behm Canal. Samples were not obtained from Hobart Bay/Port Houghton, or Revilla Channel due to reduced budgets. Samples were not obtained from Hoonah Sound or Tenakee Inlet due to absence of observed spawning. Frequency distributions of herring ages from sampled spawning areas are presented in Tables 9–18 and Figures 20–29.

As is typical, distributions of ages were similar among most southern stocks. Ernest Sound, West Behm Canal, and Craig areas all had similar age distributions, with the proportion of age-4 herring the greatest in each distribution, age-3 herring second greatest, and all other age classes at relatively small proportions. Age distributions of Ernest Sound and West Behm Canal were more similar to each other than to Craig, where the proportion of age-4 herring was substantially greater than age-3 herring. The age distribution of Craig was more similar to that of Sitka Sound (geographically a northern area) than southern areas, possibly due to the shared outer coastal marine environment.

Age distributions varied between the only two northern areas that were sampled in 2016, but not greatly. Both areas shared relatively high proportions of age-4, age-7 and age-8 herring, and relatively low proportions of ages 5 and 6. Although age samples were not obtained from Tenakee Inlet, Hoonah Sound, Hobart Bay/Port Houghton, age compositions from prior years suggest that the 2016 age distributions were likely similar to other northern stocks (see Figures 30–38 for age distribution time series for all stocks). By projecting forward age classes from previous years (and assuming that survival and maturity rates are similar to recent past), it is apparent that there would be relatively high proportions of age 4 and 7 herring and low proportions of age 5 and 6 herring present in Hobart Bay/Port Houghton and Tenakee Inlet during 2016. This age composition would be consistent with the other northern stocks that were sampled in 2016. Since age data has not been collected for Hoonah Sound for the past two years, it is more difficult to speculate about the current age composition.

The proportions of age-3 herring entering the mature population each year seem to fluctuate in a similar, cyclical pattern among stocks in the region, with high and low years synchronized in many instances in value, trajectory, or both (Figure 39). When northern and southern stocks are viewed separately, the synchronized pattern is even more apparent within each group (Figures 40 and 41). In 2015 a very high proportion of age-3 herring was observed for all stocks; however in 2016 a relatively low to moderate proportion of mature age-3 herring were observed in most spawning areas.

The relationship between the latitude of spawning stocks and the proportion of mature age-3 herring continues to be relatively strong (Table 19, Figure 42). The mean proportion of age-3 herring in the mature population has been consistently lower for higher latitude stocks and higher for lower latitude stocks, and the coefficient of determination suggests a strong correlation at $r^2 = 0.82$ (Figure 43). There is also a moderate correlation between the mean proportion of age-3 mature herring and the mean minimum annual sea temperature ($r^2 = 0.68$) (Figure 44). A weak relationship exists between the mean proportion of age-3 herring and the mean annual sea surface temperature ($r^2 = 0.50$) (Figure 45). Although there is no linear correlation between the mean proportion of age-3 herring and the mean maximum annual sea temperature, graphic display reveals a possible curvilinear relationship (dome-shaped), suggesting the possibility of an optimal temperature for recruitment of mature age-3 herring, around 16.5º C (Figure 46).

Size at Age

Based on cast net samples in 2016, there is a clear distinction between mean weight at age for all age-classes for Sitka Sound spawning herring, and all other herring spawning areas in Southeast Alaska (Figure 47). Although herring at age 3 from some areas are comparable in size, the divergence between Sitka Sound herring weight at age and other stocks in the region increases greatly with age, as Sitka Sound herring attain a substantially higher average weight by age 8 and typically by age 6. Excluding Sitka Sound, there also appears to be a difference in weight at age among other major Southeast Alaska stocks. Herring from some stocks appear to have consistently higher mean weights at age, across all ages, than others. For example, in 2016 Craig herring had consistently higher weight at age across age groups than other stocks, while Ernest Sound and West Behm Canal herring consistently had the lowest weight at age. Tests to determine whether differences were statistically significant were not performed as the primary intent of this report is to present 2016 data with general observations of trends and characterization of stocks. Herring samples were not obtained from the Tenakee Inlet, Hoonah Sound, Hobart Bay/Port Houghton, Revilla Channel, or Yakutat areas in 2016.

Mean length at age among spawning areas has a pattern similar to weights at age. Although the distinction between Sitka Sound herring mean length at age and other Southeast Alaska stocks is clear, it is not as great as observed for mean weight at age (Figure 48). The rankings of stocks both for mean length at age, and mean weight at age are similar. This is not surprising as weight is highly correlated with length. The separation gap between Sitka Sound and other stocks (for both length and weight) increases with age. This is likely an indication that growth rate for Sitka Sound herring is greater than for other stocks in the region. The differences could be a result of different environmental conditions, genetic composition, or an interaction between the two.

Trends in weight at age over time are variable among stocks (Figures 49–58). For most stocks, a common pattern is evident: weight of age-3 herring has been stable over the past few decades, while those of older ages appear to have gradually declined. The decline appears to be more pronounced for older age classes. Although the mean weight at age of herring is less now than it was 30 years ago; weight generally declined during the late 1980s to the early to mid-2000s but then appears to have stabilized over the past 15 years. The exception is Sitka Sound, where weight at age appears to have increased over the past 20 years, following a period of low weight at age in the early 1990s. However, data presented here only dates back to the late 1980s, which coincided with the period of low weight and condition of Sitka area herring. Another pattern that is apparent is that weight at age of age-4+ herring may have declined more in the southernmost stocks (e.g., Craig, West Behm Canal, Revilla Channel) than in northernmost stocks (e.g., Tenakee Inlet, Lynn Canal, Hoonah Sound).

To understand whether changes in weight at age are due solely to body mass or instead (or also) due to changes in length at age, it is helpful to calculate condition factors. Condition factors were calculated to index the physical dimensions of herring (i.e., weight-to-length ratio) over time, to roughly gauge herring health, and were calculated for all major stocks (Figures 59–68). Data obtained from cast net samples during active spawn events were used to calculate condition factors. Weight estimates derived from samples taking from actively spawning herring probably produce lower average values that contain more variability than would be expected from pre-spawning fish sampled during the commercial fishery; however, the overall trends in condition factor are expected to be the same. Other benefits of using data from cast net samples are that they provide a more complete and consistent time series and bias is expected to be lower than for fishery-dependent data that may be influenced by targeting larger fish.

Mean condition factors of herring from most stocks on Southeast Alaska follow the same general pattern over the last two decades: relatively low in the early 1990s, peaking in the early 2000s, followed by a decline until about 2007. Starting in 2008, condition factors for most stocks increased sharply, peaking in 2010 and then declined sharply to 2012. The condition factors calculated for 2016 are variable among areas and not substantially different from those observed in 2015. An exception is Sitka Sound, where condition factors in 2016 were notably higher than in 2015 across all ages.

Sitka Sound Winter Test Fishery

A test fishery was prosecuted with harvests on February 5–6 and March 4, 6–7, 2016. Sampling was conducted in Sitka Sound on February 4th and 5th, 2016, using a commercial vessel and purse seine, contracted by the department. The purpose of the Sitka winter sampling is to provide data to update the estimates of weight at age that are used in the preliminary forecast of the population, thereby allowing calculation of the final ASA-model forecast. The Sitka winter test fishery does not cover a wide geographical area or sample from a large number of herring schools, and therefore is not expected to provide an accurate estimate of age composition. However, winter estimates of weight at age are thought to increase accuracy of forecasts. Department analysis has shown that using weight at age from the winter immediately preceding the spring of the forecast results in the most accurate forecasts. For 2016, the preliminary forecast of mature herring was 78,372, with a preliminary GHL of 15,674 tons. After updating with weight at age from test fishery samples, the final forecast was 74,707 tons and the final GHL was 14,941 tons.

COMMERCIAL FISHERIES

Commercial harvest was permitted in an area only if the forecasted spawning biomass met or exceeded a minimum threshold (Table 20). If that threshold was met or exceeded, then a sliding-scale harvest rate of between 10 and 20 percent of the forecasted spawning biomass was calculated to determine the appropriate harvest level. For Sitka Sound, the allowable harvest rate ranges from 12 to 20 percent of the forecasted spawning biomass. A summary of locations, harvest levels, and periods of harvest is presented in Table 21.

Sac Roe Fisheries

The only commercial sac roe fishery that was announced in 2016 was for the Sitka Sound area. There were no sac roe fisheries announced for West Behm Canal, Hobart Bay-Port Houghton, Kah Shakes-Cat Island, or Lynn Canal areas because spawning biomass was estimated to be below threshold. Although the spawning biomass in Seymour Canal was forecast to be above threshold in 2016, the age composition was forecast to be dominated by age-4 herring, which are too small to be accessible to gillnet gear, and consequently the fishery was not opened.

Sitka Sound

The sac roe fishery was placed on two-hour notice on March 17 at 11:00 AM. The GHL was 14,941 tons. This season the fishery was conducted as a competitive derby-style fishery for all openings. There were three days when openings were held during the 2016 fishery. The first opening was on March 17 from 2:45 PM until 5:05 PM in the northwest part of Sitka Sound along the Kruzof Island shoreline. Preliminary hails estimated approximately 3,700 tons were harvested during the first opening. The second opening occurred on March 19 from 3:15 PM until 5:15 PM in the waters of Krestof Sound and Nakwasina Passage. Approximately 5,100 tons were harvested during the second opening. The third and final day of the fishery occurred on March 23 in northern Sitka Sound and Krestof Sound from 1:30 PM until 2:30 PM and from 2:55 PM until 7:00 PM, and also in Salisbury Sound from 5:00 PM until 6:20 PM. Approximately 1,000 tons were harvested during the last opening. The 2015–16 season was announced closed on March 28 via VHF radio at 4:00 PM.

The total harvest for the season was 9,833 tons, which fell short the GHL of 14,941tons by over 5,000 tons. Failure to harvest the GHL was due to lack of opportunities to harvest marketable sac roe product, as a result of extensive active spawning events that occurred starting on March 23, 2016 and continuing through March 26, 2016.

Seymour Canal

There was no commercial fishery in the Seymour Canal area during the 2015–2016 season, as the forecasted age composition was dominated by age-4 herring, which were deemed too small to prosecute an effective gillnet fishery. The mature biomass was forecasted to be 5,113 tons, which was above the threshold of 3,000 tons.

West Behm Canal

There were no commercial fisheries in the West Behm Canal area during the 2015–2016 season, as the biomass was assumed to be below threshold.

Hobart Bay-Port Houghton

There were no commercial fisheries in the Hobart Bay-Port Houghton area during the 2015–2016 season, as the forecast was below threshold.

Kah Shakes-Cat Island

There were no commercial fisheries in the Kah Shakes-Cat Island area during the 2015–2016 season, as the biomass was assumed to be below threshold.

Lynn Canal

There were no commercial fisheries in the Lynn Canal area during the 2015–2016 season, as the biomass was assumed to be below threshold

Winter Bait Fisheries

During the 2015–2016 season, the only winter food and bait fishery was in the Craig area. Other winter bait areas were closed as forecasts were below threshold.

Craig

The fishery was opened in the Craig area on October 19, 2015 and was closed by regulation on February 29, 2016. The bait allocation was 954 tons, which was by regulation 60% of the total GHL of 1,590 tons. A total of 898 tons of herring were harvested and three permit holders participated in the fishery.

Ernest Sound

There were no commercial fisheries in Ernest Sound during the 2015–16 season as the forecast was below threshold.

Tenakee Inlet

There were no commercial fisheries in Tenakee Inlet during the 2015–16 season as the forecast was below threshold.

Spawn-on-Kelp Pound Fisheries

The only area open to the commercial harvest of spawn on kelp (SOK) during the 2015–2016 season was Craig. The other SOK areas in the region, Hoonah Sound, Ernest Sound, and Tenakee Inlet, were not opened during the 2015–2016 season as the forecasted mature biomass was below threshold.

Craig

A total of 46 closed pounds were actively fished, of which 1 was a single-permit pound, 7 were double-permit pounds, and 38 were triple-permit pounds. In the past, the fishery has been dominated by single-permit pounds, with very few triple-permit pounds. The opposite pattern observed during the 2016 fishery may have been due to new kelp allocation regulations approved at the 2015 Board of Fisheries meeting that were designed with incentive for permit holders to team-up and use fewer pound structures and consequently less herring. A total of 129 permits registered and participated in the fishery. Total harvest and value are confidential due to fewer than three processors participating in the fishery.

Hoonah Sound

There was no commercial fishery in Hoonah Sound during the 2015–16 season as the forecast was below threshold.

Ernest Sound

There were no commercial fisheries in Ernest Sound during the 2015–16 season as the forecast was below threshold.

Tenakee Inlet

There were no commercial fisheries in Tenakee Inlet during the 2015–16 season as the forecast was below threshold

Bait Pound (Fresh Bait and Tray Pack) Fisheries

During the 2015–2016 season, no herring were harvested for fresh bait pounds or tray-pack in Southeast Alaska.

Test Fisheries

The sole herring test fishery conducted in Southeast Alaska during the 2015–2016 season was in Sitka Sound, for bait, using purse seine gear to harvest during February 5–6 and March 3,6,7, 2016. A total of 200 tons of herring were harvested from the western part of Sitka Sound, between Crow Island and Kruzof Island.

DISCUSSION

Spawn Deposition

After a period of building since about the late 1990s and peaking during 2008–2011, herring spawning biomass in Southeast Alaska has undergone a period of decline. The total combined spawning biomass estimated in 2016 for all of Southeast Alaska is at a level similar to that of the late 1990s, which proceeded the period of building herring biomass. The 2016 total estimated spawning population biomass in Southeast Alaska, as calculated from spawn deposition estimates, was similar to that of 2015, but with an increase of 8% relative to 2015. The apparent stability in the region between 2015 and 2016 is largely attributable to stability in the two largest stocks, Sitka Sound and Craig, which typically account for about 80% of the spawning biomass in Southeast Alaska. Nearly all other spawning areas underwent a substantial decline since 2015, or remained at a very low level compared to prior years. Surprisingly, at some spawning areas there was either an extremely low or complete lack of spawn activity (e.g., Tenakee Inlet, Hoonah Sound, and Hobart Bay-Port Houghton), and at other areas spawning biomass was far lower than expected compared to 2015 estimates (e.g., Seymour Canal and Lynn Canal). Spawning biomass decreased between 2015 and 2016 at three of the five areas where spawn deposition surveys were conducted. For these areas the decreases are considered substantial (arbitrarily defined here as a minimum of 20% change). Because in 2016 spawn deposition surveys were not conducted at all areas that are usually surveyed, due to budget reductions or very low levels of observed spawn, aerial surveys and observations from private pilots provided some information for gauging the relative extent of spawn activity at areas that were not surveyed. These areas included Tenakee Inlet, Hoonah Sound, Hobart Bay-Port Houghton, West Behm Canal, and Revilla Channel (Kah Shakes-Cat Island). The spawning areas where substantial decreases were observed, or presumed due to very low or lack of observed spawning, include Tenakee Inlet, Hoonah, Hobart Bay-Port Houghton, Revilla Channel, Lynn Canal, Ernest Sound, and Seymour Canal. Although the error surrounding biomass estimates was not calculated, the magnitudes of the decreases were large enough that they probably reflect meaningful changes in the spawning population levels. For a perspective on the relative spawning biomass at each area where a spawn deposition survey was conducted in the region, along with relative proportion of harvest, see Figure 69.

It is difficult to characterize changes in spawning biomass in the West Behm Canal area over the past year. In 2016, 4.3 nmi of spawn were observed in the traditional spawning area, which is an increase from 2015, when only 1.0 nmi of spawn was observed. However, in 2015 substantial spawning activity was observed in atypical areas that were in the vicinity of West Behm Canal, but not in the area normally associated with West Behm Canal. In these atypical areas of spawning (e.g., Mountain Point at the southeast end of Tongass Narrows, and Nehetna Bay at southwest Gravina Island), spawn mileage totaled around 8 nmi, which was close to the value of 7.2 nmi observed for the traditional West Behm Canal spawning grounds in 2014. Therefore, it may be erroneous to conclude that spawning biomass increased between 2015 and 2016, based solely on the increase in traditional area spawn mileage from 1.0 nmi to 4.3 nmi, because of the possibility that herring shifted spawning area in 2015.

The sole area where spawning biomass apparently increased between 2015 and 2016 was Sitka Sound. The increase was considered substantial, increasing 34% relative to 2015. It is unknown why the spawning biomass has apparently increased in Sitka Sound over the past year, while all other areas have apparently decreased, or at best did not change appreciably over the past year.

The decrease in estimated spawning biomass at most areas over the past year may be due to actual changes in the herring population; however, it must be acknowledged that it could also be a function of estimate variation, or a combination of both. Because error estimates were not calculated for spawn deposition estimates, it is possible that the changes in biomass were due, at least in part, to estimate error. However, the consistency of the decrease in biomass observed around the region, each determined through an independent survey, make it unlikely that estimate error could be the major cause for the general decline and low level of herring in the region.

Estimates of spawning biomass presented in this report are based primarily on egg deposition estimates (as opposed to model-derived results), which are useful for providing a general, broad brush view of trends in mature herring biomass but should not necessarily be considered the most accurate estimate of biomass in any given year. For all major herring stocks in Southeast Alaska, the results of ASA or biomass accounting models are considered to provide more reliable estimates of spawning biomass, and are the basis for forecasting herring abundance and setting harvest levels. A primary reason that the ASA model provides more reliable estimates is that it incorporates other sources of data (primarily age composition), and combines a long time series of data to estimate spawning biomass, whereas spawn deposition-derived estimates rely on only a single year of spawn deposition data. An advantage of using biomass estimates derived from spawn deposition is that they provide a time series of fixed historical values, as opposed to

ASA hind cast estimates derived from single model runs, which may be less intuitive since they change with each model run. Additionally, in some years modeling may not be completed for some stocks due to inadequate data or a very low level of spawning, which may leave gaps in the time series of estimates. Since spawn deposition surveys are conducted annually, biomass estimates derived from egg deposition provide a consistent and comparable time series to gauge trends.

Despite short-term trends indicating a decline in Southeast Alaska herring biomass over the past several years, there is still an increasing trend over the period 1980 to 2016; (Figure 8). This is true whether or not the largest stock in the region, Sitka Sound, is included. The regional spawning biomass estimated for 2016 is 90% of the long-term average (1980–2015), for all stocks combined, but only 33% for all stocks combined excluding Sitka Sound. The long-term trend of spawning biomass for the majority of individual spawning areas where data is available in Southeast Alaska is still increasing due principally to several years of high biomass levels in the most recent decade; however, the long-term trend is decreasing for a couple of areas (Figures 3–7).

For the second year in a row, a large proportion of spawn mileage that was observed in Revilla Channel was in the Kah Shakes-Cat Island area (11.9 nmi) and a small proportion of spawn was observed around Annette Island (0.6 nmi). The spawning location within the Revilla Channel area, comprised of the state waters around Kah Shakes-Cat Island and the waters surrounding Annette Island Reserve, shifted dramatically in 2015. A large proportion of spawn had not been observed in the Kah Shakes-Cat Island area since 2001, but had been observed in Annette Island Reserve waters during that time. However, in 2015 a relatively high level of spawning was observed in state waters (in vicinity of Kah Shakes Cove, Cat Island and Mary Island), and no spawning was observed in Annette Island Reserve waters. Prior to 2001, the largest proportion of herring spawn was routinely observed in state waters. Because the State of Alaska has no authority to enter Annette Island Reserve waters to conduct herring surveys, spawning biomass estimates for this area are based on conversions from observed miles of spawn, and suggest that herring biomass peaked in the early to mid-2000s and has declined to a relative low level since then.

Combined, spawn deposition estimates for 2016 suggest that herring spawning biomass in Southeast Alaska is at a moderate level relative to the period 1980–2015. However, when spawning areas are considered separately, spawning biomass for most areas is currently at a low or very low level.

Age Composition

For all stocks, estimates of age composition in 2016 continued to follow patterns that are generally expected; that is to say that the proportion of cohort sizes either grew or declined as a result of increases due to maturation or decreases due to natural mortality and that no surprising or abrupt changes were observed in relative cohort strength (see Figures 30–39). These patterns lend support to the assumption that the method of aging scales from 2016 samples was consistent with those methods used in prior years, which has been a concern in prior years (see Hebert 2012a and 2012b).

The observed proportions of mature age-3 herring were variable among stocks but relatively low for most stocks in 2016, which follows a year of very high age-3 recruitment in 2015. The relatively low proportion of mature age-3 herring observed in 2016 offers some insight to future biomass levels, and increases the likelihood of a decrease as a result of this relatively weak cohort, assuming that survival rate remains relatively steady in coming years. However, decreasing mature biomass is not a foregone conclusion, for at least two reasons. First, the strong 2012 brood year (age 4 in 2016) has not yet fully matured and gains from fish maturing could exceed losses from natural mortality. Second, it is possible that a strong age-3 spawning component may manifest in 2017, although a weak age-3 component may be equally probable and there is currently no means to forecast this.

The proportion of age-3 herring in the mature population typically fluctuates widely for most stocks in the region, but some patterns are evident. Although the proportion of mature age-3 herring is different among stocks in any given year, it is common for the direction of change to be the same from year to year. In other words, in years when the proportion of age-3 fish is high or low for one stock, it is usually relatively high or low for all or most stocks. This suggests that age-3 recruitment into the mature segment of each stock is influenced by a common factor (e.g., biological or physical conditions in the marine environment). The scale of influence may be broader than Southeast Alaska, as time periods have been observed in the past when Sitka Sound and Prince William Sound displayed very similar recruitment patterns (Carls and Rice 2007).

Patterns of age composition, and in particular proportions of age-3 herring over time are also evident among stock groups within the region, which suggest that similar marine conditions may be present among certain areas within the region (Figure 70). The proportion of mature age-3 herring within each stock appears to be related to the latitude of the spawning stock. There appear to be two areas within the region where the mean proportion of age-3 herring is similar. For stocks south of latitude 56 degrees (Craig, West Behm Canal, Ernest Sound, and Kah Shakes), the mean proportion of age-3 herring is relatively high (range of 22–31%), but for stocks at 57 degrees and northward (Sitka, Hobart Bay, Seymour Canal, Hoonah Sound, Tenakee Inlet, and Lynn Canal) the proportions are relatively low (range of 13–17%). The latitudinal split is further supported by age compositions observed in 2016, which were similar among all southern stocks for which data was collected, and somewhat similar among northern areas where data was collected, particularly those located in inside waters (Seymour Canal and Lynn Canal). One stock where age compositions do not typically match either southern or northern areas, is Sitka Sound, and reasons for this are unknown. In 2016 the similarity of age composition between Sitka Sound and Craig suggest that there may be a common influence on herring by the outer coastal marine environment that these two areas share.

There continues to be an inverse relationship between latitude and sea surface temperature in Southeast Alaska, which is somewhat expected. The mean proportion of age-3 herring is generally highest where mean annual temperature and mean minimum temperature are highest; however, since the correlation is weak, other factors linked to latitude may play a role as well. Interestingly, the mean maximum sea temperature appears to have a non-linear relationship to the mean proportion of age-3 herring. This relationship suggests that perhaps an optimal maximum sea temperature exists around 16.5°C and at higher or lower sea temperature, the mean proportion of mature age-3 herring is less. It is beyond the scope of this report to further explore if an actual relationship exists between recruitment success and sea temperature, or consider biological explanations of such a relationship; however, the patterns in the data are suggestive enough to warrant additional investigation.

ACKNOWLEDGMENTS

Herring and egg samples were processed at the ADF&G Mark, Tag, and Age Laboratory, and overseen by Detlef Buettner. Sara Miller (Region I Biometrician) assisted with herring age and size data processing, and Sherri Dressel (Statewide Herring Fishery Scientist) advised on and reviewed calculation of spawn deposition estimates. Many department divers and boat officers contributed to the successful completion of the spawn deposition dive surveys. Divers included Jeff Meucci, Bo Meredith, Sherri Dressel, Troy Thynes, Scott Kelley, Dave Gordon, Justin Breese, Eric Coonradt, Mike Donnellan, and Kyle Hebert.

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TABLES AND FIGURES

Table 1.–Transect sampling rates used for 2016 herring spawn deposition surveys.

Area	Estimated Target Transects per Nautical Mile of Spawn[a]			
	Based on 1994 Analysis	Based on 1997 Analysis	Based on 2000 Analysis	Average
Sitka	0.2	0.6	0.3	0.4
West Behm Canal	—	0.4	1.7	1.1
Seymour Canal	2.8	2.4	1.2	2.1
Craig	0.8	3.1	1.3	1.7
Hobart/Houghton	4.5	1.7	3.6	3.3
Ernest Sound	1.9	5	3.5	3.5
Hoonah Sound	2.9	1	0.7	1.5
Tenakee Inlet	5.1	1.2	1.6	2.6
Average	2.6	1.9	1.7	2.1

[a] Values represent the number of transects that will produce a lower bound of the one-sided 90% confidence interval that is within 30% of the mean egg density.

Table 2.–Fecundity relationships used for estimating 2016 herring spawning biomass for stocks in Southeast Alaska.

Sampling year	Stock sampled	Fecundity equation	Stocks to which Fecundity Equation was applied in 2011
2005	Sitka Sound	fecundity = -3032.0 + 198.8*weight	Sitka, Tenakee Inlet, Hoonah Sound
1996	Seymour Canal	fecundity = -1573.3 + 222.4*weight	Seymour Canal, Hobart Bay/Port Houghton, Lynn Canal
1996	Craig	fecundity = -1092.3 + 210.5*weight	Craig
1996	Kah Shakes/Cat Island	fecundity = -1310.0 + 202.1*weight	Ernest Sound, West Behm Canal

Table 3.–Dates of 2016 herring spawn deposition surveys conducted in Southeast Alaska.

Survey area	Survey Leg	Survey Dates
Kah Shakes/Cat Island	NA	No Survey
West Behm Canal	NA	No Survey
Craig	I	April 8–9
Sitka Sound	I	April 1–3, 20–21
Ernest Sound	I	April 26–27
Hobart Bay/Port Houghton	NA	No Survey
Hoonah Sound	NA	No Survey
Tenakee Inlet	NA	No Survey
Lynn Canal	II	May 7
Seymour Canal	II	May 8

Table 4.–Summary of herring egg estimates (in thousands) by transect for 2016 spawn deposition surveys conducted in Sitka Sound.

	Sitka Sound 1st Survey		Sitka Sound 2nd Survey	
Transect Number	Egg estimate	Frame count	Egg estimate	Frame count
1	40	6	58	6
2	1,978	15	1,134	9
3	174	7	976	6
4	1,178	26	0	1
5	1,479	20	378	12
6	330	23	289	8
7	695	12	720	6
8	39	9	124	6
9	470	8	19	5
10	197	9	201	8
11	32	10	107	5
12	213	15	1,093	10
13	434	22	4,192	42
14	473	31	972	12
15	1,746	29	2,969	28
16	541	5	—	—
17	297	18	—	—
18	162	5	—	—
19	94	12	—	—
20	140	5	—	—
21	3,155	20	—	—
22	383	18	—	—
23	873	17	—	—
24	5,525	79	—	—
25	5,715	108	—	—
26	3,268	55	—	—
27	1,611	33	—	—
28	804	24	—	—
29	731	6	—	—
30	694	23	—	—
31	4,691	33	—	—
32	—	—	—	—
33	668	38	—	—
34	60	10	—	—
35	420	5	—	—
36	1.088	8	—	—
37	83	6	—	—
38	263	11	—	—
39	1,046	13	—	—
40	113	8	—	—
41	909	5	—	—
42	304	6	—	—
43	545	16	—	—
44	459	10	—	—
45	352	10	—	—
46	209	11	—	—
47	880	6	—	—
48	0	1	—	—
49	0	2	—	—
50	0	1	—	—

Note: Em dashes indicate no survey transects planned or completed.

Table 5.–Summary of herring egg estimates (in thousands) by transect for 2016 spawn deposition surveys conducted in Southeast Alaska (excluding Sitka Sound).

	Craig		Ernest Sound		Hobart/Houghton		Hoonah Sound		Seymour Canal		Tenakee Inlet		Kah Shakes/Cat Is.		Lynn Canal	
Transect Number	egg estimate	frame count	egg estimate	frame count	egg estimate	frame count	egg estimate	frame count	egg estimate	frame count	frame count	frame count	egg estimate	frame count	egg estimate	frame count
1	0	1	0	1	—	—	—	—	119	16	—	—	—	—	722	17
2	14	10	81	16	—	—	—	—	43	25	—	—	—	—	0	1
3	170	28	64	14	—	—	—	—	20	16	—	—	—	—	2	5
4	689	32	50	12	—	—	—	—	0	1	—	—	—	—	0	8
5	1,247	52	112	9	—	—	—	—	5	6	—	—	—	—	703	9
6	2,611	7	144	12	—	—	—	—	38	16	—	—	—	—	1	3
7	276	7	73	13	—	—	—	—	10	8	—	—	—	—	0	1
8	67	9	46	12	—	—	—	—	15	10	—	—	—	—	0	1
9	45	4	19	6	—	—	—	—	49	10	—	—	—	—	1	4
10	960	12	34	8	—	—	—	—	66	5	—	—	—	—	0	4
11	542	38	3	2	—	—	—	—	12	5	—	—	—	—	0	1
12	635	17	108	17	—	—	—	—	0	5	—	—	—	—	5	5
13	36	5	42	6	—	—	—	—	13	6	—	—	—	—	3	3
14	9	4	11	5	—	—	—	—	0	1	—	—	—	—	0	1
15	329	6	356	27	—	—	—	—	5	7	—	—	—	—	3	5
16	963	13	38	5	—	—	—	—	15	15	—	—	—	—	22	4
17	0	1	109	7	—	—	—	—	0	1	—	—	—	—	0	1
18	0	1	0	1	—	—	—	—	16	20	—	—	—	—	0	1
19	1	3	0	1	—	—	—	—	0	1	—	—	—	—	0	1
20	1,755	28	0	1	—	—	—	—	0	1	—	—	—	—	0	1
21	767	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22	937	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23	13	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
24	2,293	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25	0	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26	35	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
27	456	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28	191	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—
29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Note: Em dashes indicate no survey transects planned or completed.

Table 6.–Summary of results of herring spawn deposition surveys in Southeast Alaska for 2016.

Spawning Stock[b]	Number of Transects Completed	Average Length of Transects (m)	Nautical Miles of Spawn Observed	Area of Survey (m^2)	Average Egg Density ($eggs/m^2$)	Total eggs in survey area (trillions)	Mean weight (g) (weighted by age composition) of fish in spawning population	Estimated fecundity of fish of mean weight	Estimated number of fish	Post-fishery mature biomass (tons)
Craig	28	65	12.3	1,488,810	410,944	0.680	87.0	17,227	78,923,917	7,571
Ernest Sound	20	44	4.4	356,510	73,741	0.029	44.9	8,362	6,986,514	346
Hobart/Houghton	—	—	0	—	—	—	—	—	—	—
Hoonah Sound	—	—	0	—	—	—	—	—	—	—
Seymour Canal	20	44	4.3	397,023	24,385	0.011	76.8	15,500	1,388,047	117
Sitka Sound total	64	80	63.3	9,428,167	592,993	5.979	102.0	17,248	693,350,609	77,973
[a]Sitka Sound – 1st	49	89	47.8	7,858,905	523,655	4.573	—	—	—	—
[a]Sitka Sound – 2nd	15	55	15.5	1,569,261	806,823	1.407	—	—	—	—
Tenakee Inlet	—	—	0	—	—	—	—	—	—	—
Kah Shakes/Cat Is.	—	—	11.9	—	—	—	—	—	—	—
West Behm Canal	—	—	4.3	—	—	—	—	—	—	—
Lynn Canal	20	20	4.3	151,308	192,332	0.032	86.2	17,607	3,672,983	349
Total	152	—	104.8	11,821,817	—	6.732	—	—	784,322,070	86,357
Average	30	57	—	2,364,363	374,982	1.346	79.4	15,189	—	—

[a] Two separate surveys were conducted in Sitka in 2016 because of two distinct spawning events, so final estimates of egg deposition were calculated by summing estimates from each survey.

Note: Em dashes indicate data not available due to lack of survey (no funding or little or no spawn observed), or a total/average is not appropriate.

Table 7.–Correction coefficients used for herring spawn deposition estimates in Southeast Alaska in 2016.

	Estimator initials[a]									
Kelp type	BM	DG	JB	JM	KH	SD	TT	EC	SK	MD
Eelgrass	0.813	0.912	1.115	0.952	0.823	0.839	0.990	1.509	0.785	1.325
n =	28	28	28	28	28	28	28	27	28	18
Fucus	1.008	1.576	1.231	0.872	1.238	1.307	1.356	1.562	1.358	1.168
n =	28	28	28	28	28	28	28	28	28	18
Fir kelp	0.869	0.861	0.775	0.845	1.028	0.830	1.121	1.741	0.621	1.187
n =	29	29	29	28	29	28	29	29	29	18
Hair kelp	1.048	1.105	1.308	1.020	0.862	1.068	1.472	1.775	0.997	1.565
n =	32	32	32	32	32	32	32	32	32	18
Large brown kelp[b]	0.592	1.321	0.876	0.661	0.927	0.774	1.079	1.504	0.910	0.797
n =	25	25	24	25	25	25	25	25	25	17
Average[c]	0.866	1.115	1.061	0.870	0.976	0.964	1.204	1.618	0.934	1.208

[a] All data from years 2014 through 2016.

[b] Values applied to genera *Laminara*, *Agarum*, *Alaria*, *Cymethere*, *Costaria*, and *Macrocystis*.

[c] Values are applied to estimates of eggs that are loose, on rock, or on unclassified kelp types.

Table 8.–Summary of samples collected from Southeast Alaska herring stocks in 2015–16.

	Commercial Fishery			Survey	Test Fishery	
Stock	Herring gillnet	Pound	Purse seine	Cast net	Purse seine	Total
Craig	–	531	530	530	–	1,591
Ernest Sound	–	–	–	532	–	532
Hobart/Houghton	–	–	–	–	–	–
Hoonah Sound	–	–	–	–	–	–
Lynn Canal	–	–	–	528	–	528
Seymour Canal	–	–	–	514	–	514
Sitka Sound	–	–	528	532	528	1,588
Tenakee Inlet	–	–	–	–	–	–
West Behm Canal	–	–	–	431	–	431
Revilla Channel	–	–	–	–	–	–
Yakutat	–	–	–	–	–	–
Total	–	531	1,058	3,067	528	5,184

Note: Em dashes indicate that no samples were collected in 2016, either due to lack of funding or observed spawning.

Table 9.–Summary herring samples aged for Southeast Alaska stocks in 2015–16.

	Commercial Fishery			Survey	Test Fishery	
Stock	Herring gillnet	Pound	Purse seine	Cast net	Purse seine	Total
Craig	–	519	526	522	–	1,567
Ernest Sound	–	–	–	522	–	522
Hobart/Houghton	–	–	–	–	–	–
Hoonah Sound	–	–	–	–	–	–
Lynn Canal	–	–	–	521	–	521
Seymour Canal	–	–	–	510	–	510
Sitka Sound	–	–	525	530	521	1,576
Tenakee Inlet	–	–	–	–	–	–
West Behm Canal	–	–	–	419	–	419
Revilla Channel	–	–	–	–	–	–
Yakutat	–	–	–	–	–	–
Total	–	519	1,051	3,024	521	5,115

Note: Em dashes indicate that no samples were collected in 2016, either due to lack of funding or observed spawning.

Table 10.–Summary of age, weight, and length for the Sitka Sound herring stock in 2015–16.

		Age Category						
Gear type/season	Parameter	3	4	5	6	7	8+	Total
survey cast net–spring	number of fish	12	429	18	39	6	26	530
	percent age composition	2%	81%	3%	7%	1%	5%	100%
	average weight (g)	57.6	83.6	90.3	112.3	106.1	153.2	100.5
	standard dev. of weight (g)	10.9	14.0	18.2	22.9	33.4	18.6	19.7
	average length (mm)	170	190	195	208	210	235	201
	std. dev. of length (mm)	8.2	7.9	9.5	11.2	302	17.4	10.3
commercial purse seine–spring	number of fish	9	392	19	68	10	27	525
	percent age composition	17%	2%	24%	8%	9%	40%	100%
	average weight (g)	64.2	94.9	104.2	132.5	148.6	178.5	120.5
	standard dev. of weight (g)	8.4	14.3	17.7	22.7	28.0	28.9	20.0
	average length (mm)	170	193	200	213	218	236	205
	std. dev. of length (mm)	4.1	8.4	9.3	11.0	13.4	12.7	9.8
test fishery purse seine–winter	number of fish	12	393	27	55	15	19	521
	percent age composition	2%	75%	5%	11%	3%	4%	100%
	average weight (g)	67.5	88.0	98.6	123.8	140.3	171.4	114.9
	standard dev. of weight (g)	16.5	12.8	16.8	23.1	36.4	19.3	20.8
	average length (mm)	172	190	197	209	217	238	204
	std. dev. of length (mm)	12.2	8.3	11.8	12.9	18.0	11.0	12.4

Table 11.–Summary of age, weight, and length for the Craig herring stock in 2015–16.

		Age Category						
Gear type/season	Age category	3	4	5	6	7	8+	Total
survey cast net spring	number of fish	78	339	16	41	17	31	522
	percent age composition	15%	65%	3%	8%	3%	6%	100%
	average weight (g)	62.9	74.6	89.3	101.1	104.0	110.1	90.3
	standard dev. of weight (g)	10.5	13.6	13.0	15.5	16.6	19.1	14.7
	average length (mm)	172	182	190	199	201	206	192
	std. dev. of length (mm)	8.6	8.8	6.6	8.3	8.8	8.4	8.2
commercial pound – spring	number of fish	98	317	17	39	22	26	519
	percent age composition	19%	61%	3%	8%	4%	5%	100%
	average weight (g)	69.2	82.4	100.3	104.1	116.6	136.8	101.6
	standard dev. of weight (g)	10.9	14.5	18.7	17.3	17.2	21.0	16.6
	average length (mm)	174	183	192	198	203	212	194
	std. dev. of length (mm)	9.2	8.8	8.7	9.1	9.3	8.3	8.9
commercial seine–winter	number of fish	72	312	25	65	24	28	526
	percent age composition	14%	59%	5%	12%	5%	5%	100%
	average weight (g)	77.7	89.1	92.1	108.5	126.2	127.2	103.5
	standard dev. of weight (g)	13.8	14.6	14.9	15.3	21.4	20.7	16.8
	average length (mm)	175	182	184	195	204	206	191
	std. dev. of length (mm)	9.4	8.8	8.8	8.3	10.8	10.9	9.5

Table 12.–Summary of age, weight, and length for the Hobart Bay/Port Houghton herring stock in 2015–16.

		Age Category						
Gear type/season	Parameter	3	4	5	6	7	8+	Total
survey cast net–spring	number of fish							
	percent age composition							
	average weight (g)	NO SAMPLES OBTAINED						
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							
commercial gillnet–spring	number of fish							
	percent age composition	NO FISHERY						
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							

Table 13.–Summary of age, weight, and length for the Ernest Sound herring stock in 2015–16.

		Age Category						
Gear type/season	Parameter	3	4	5	6	7	8+	Total
survey cast net–spring	number of fish	233	249	14	15	7	4	522
	percent age composition	45%	48%	3%	3%	1%	1%	100%
	average weight (g)	40.3	46.1	58.2	63.2	70.6	79.9	59.7
	standard dev. of weight (g)	7.5	8.7	9.8	9.0	10.8	23.1	11.5
	average length (mm)	154	162	175	182	185	186	174
	std. dev. of length (mm)	8.1	8.5	10.9	9.4	5.3	8.3	8.4
commercial pound–spring	number of fish	NO FISHERY						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							
commercial seine–winter	number of fish	NO FISHERY						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							

Table 14.–Summary of age, weight, and length for the Hoonah Sound herring stock in 2015–16.

		Age Category						
Gear type/season	Parameter	3	4	5	6	7	8+	Total
survey cast net–spring	number of fish	NO SAMPLES OBTAINED						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							
commercial pound –spring	number of fish	NO FISHERY						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							

Table 15.–Summary of age, weight, and length for the Tenakee Inlet herring stock in 2015–16.

Gear type/season	Parameter	Age Category 3	4	5	6	7	8+	Total
survey cast net–spring	number of fish	NO SAMPLES OBTAINED						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							
commercial pound–spring	number of fish	NO FISHERY						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							
commercial seine–winter	number of fish	NO FISHERY						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							

Table 16.–Summary of age, weight, and length for the Seymour Canal herring stock in 2015–16.

Gear type/season	Parameter	Age category 3	4	5	6	7	8+	Total
survey cast net–spring	number of fish	87	142	29	28	157	67	510
	percent age composition	17%	28%	6%	5%	31%	13%	100%
	average weight (g)	52.3	74.1	68.5	84.0	86.3	92.4	76.3
	standard dev. of weight (g)	9.2	14.4	13.0	20.2	18.4	17.2	15.4
	average length (mm)	162	182	175	188	191	196	182
	variance of length (mm)	9.1	10.6	10.4	13.0	12.5	11.6	11.2
commercial gillnet–spring	number of fish	NO FISHERY						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							

Table 17.–Summary of age, weight, and length for the West Behm Canal herring stock in 2015–16.

		Age category						
Gear type/season	Parameter	3	4	5	6	7	8+	Total
survey cast net–spring	number of fish	150	208	23	20	17	1	419
	percent age composition	36%	50%	5%	5%	4%	0%	100%
	average weight (g)[a]	50.6	62.1	69.9	73.6	80.2	107.1	73.9
	standard dev. of weight (g)	10.8	13.8	13.5	10.7	11.6	–	12.1
	average length (mm)	163	174	181	188	191	205	184
	std. dev. of length (mm)	9.3	11.0	12.6	9.5	8.9	–	10.2
commercial gillnet–spring	number of fish	NO FISHERY						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							

[a] Weights are probably biased low due to required additional sample handling that resulted in loss of weight.

Table 18.–Summary of age, weight, and length for the Lynn Canal herring stock in 2015–16.

		Age category						
Gear type/season	Parameter	3	4	5	6	7	8+	Total
survey cast net–spring	number of fish	25	112	44	55	160	125	521
	percent age composition	5%	21%	8%	11%	31%	24%	100%
	average weight (g)	60.8	75.2	78.0	81.4	91.5	99.5	81.1
	standard dev. of weight (g)	9.2	15.7	12.3	14.2	19.6	17.9	14.8
	average length (mm)	167	179	181	186	192	199	184
	std. dev. of length (mm)	8.8	11.6	9.7	9.4	12.0	11.0	10.4

Table 19.–Summary of age, weight, and length for the Revilla Channel herring stock in 2015–16.

		Age category						
Gear type/season	Parameter	3	4	5	6	7	8+	Total
survey cast net–spring	number of fish	NO SAMPLES OBTAINED						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							

Table 20.–Summary of age, weight, and length for the Yakutat herring stock in 2015–16.

Gear type/season	Parameter	Age category 3	4	5	6	7	8+	Total
survey cast net–spring	number of fish							
	percent age composition							
	average weight (g)		NO SAMPLES OBTAINED					
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							

Table 21.–Proportion of mature age-3 herring (cast net, 1988–2016), latitude, and sea temperature (2000–2016) of herring spawning stocks in Southeast Alaska.

Stock	Latitude (decimal degrees)	Median proportion of mature age-3 herring	Mean proportion of mature age-3 herring	Mean annual sea temperature (^{o}C)	Mean minimum annual sea temperature (^{o}C)	Mean maximum annual sea temperature (^{o}C)
Kah Shakes	55.0300	23%	31%	8.6	5.9	14.7
Craig	55.4770	17%	22%	9.3	3.5	16.6
WBC	55.4846	26%	31%	9.0	4.9	15.0
Ernest Sound	55.8307	39%	31%	—	—	—
Sitka	57.0079	10%	17%	8.7	4.2	15.7
Hobart Bay	57.4308	7%	14%	7.1	3.1	15.2
Seymour Canal	57.5923	12%	15%	6.8	2.4	14.2
Hoonah Sound	57.6001	7%	16%	8.0	1.0	18.0
Tenakee Inlet	57.7381	11%	13%	7.8	1.0	17.8
Lynn Canal	58.6402	12%	13%	7.2	2.6	15.4

Table 22.–Summary of Southeast Alaska herring target levels for the 2015–16 season.

Area	Minimum spawning biomass threshold (tons)	Forecast (tons)	Target Exploitation Rate (%)	Guideline harvest level (tons)[a]
Craig	5,000	12,303	12.9	1,590
Ernest Sound	2,500	1,207	0.0	—
Hobart Bay/Port Houghton	2,000	50	0.0	—
Hoonah Sound	2,000[b]	313	0.0	—
Seymour Canal[c]	3,000	5,113	11.4	584
Sitka Sound	25,000	74,707	20.0	14,941
Tenakee Inlet	3,000	2,223	0.0	—
West Behm Canal	6,000	—	0.0	—
Lynn Canal	5,000	—	0.0	—
Kah Shakes/Cat Island	6,000	—	0.0	—

[a] Represents total target exploitation for all fisheries on a particular stock; actual allocations by fishery are determined according to Alaska Administrative Code Title 5 under 5 AAC 27.160, 27.185, and 27.190.

[b] Threshold increased from 1,000 tons to 2,000 tons this season to bring into line with the minimum threshold applied to all other stocks in Southeast Alaska.

[c] Published GHL was reduced to zero as a conservative measure, due to forecast of predominantly young/small fish that would be inaccessible to gillnets.

Table 23.–Summary of commercial herring harvest during the 2015–16 season. Blacked out values signify confidential data due to fewer than three participants (either permit holders or processors).

Fishery	Gear	Area	District	Opening[a]	Closing[b]	Harvest (tons)[c]
Winter food and bait	Purse seine	Craig	3/4	19-Oct-15	29-Feb-16	898
Winter food and bait	Purse seine	Tenakee Inlet	12	Not Open		–
Winter food and bait	Purse seine	Ernest Sound	7	Not Open		–
Winter food and bait	Purse seine	Hobart Bay	10	Not Open		–
Sub-total						898
Sac roe	Purse seine	Sitka Sound	13	17-Mar-16	28-Mar-16	9,833
Sac roe	Purse seine	Lynn Canal	11	Not Open		–
Sac roe	Gillnet	Seymour Canal	11	Not Open		–
Sac roe	Gillnet	Hobart Bay	10	Not Open		–
Sac roe	Gillnet	Kah Shakes	1	Not Open		–
Sac roe	Gillnet	West Behm Canal	1	Not Open		–
Sub-total						9,833
Spawn on kelp	Pound	Hoonah Sound	13	Not Open		–
Spawn on kelp	Pound	Tenakee Inlet	12	Not Open		–
Spawn on kelp	Pound	Ernest Sound	7	Not Open		–
Spawn on kelp	Pound	Craig	3	17-Mar-16	1-Apr-16	[d]
Sub-total						[d]
Test fishery-bait	Purse seine	Sitka	13	5-Feb-16	7-Mar-16	200

[a] For spawn-on-kelp fisheries, represents start of seining and transferring herring into pounds.

[b] For spawn-on-kelp fisheries, represents end of removing SOK from pounds.

[c] Values expressed in tons of whole herring, except for spawn-on-kelp fisheries, values are tons of eggs-on-kelp product.

[d] Confidential data due to fewer than three processors participating in the fishery.

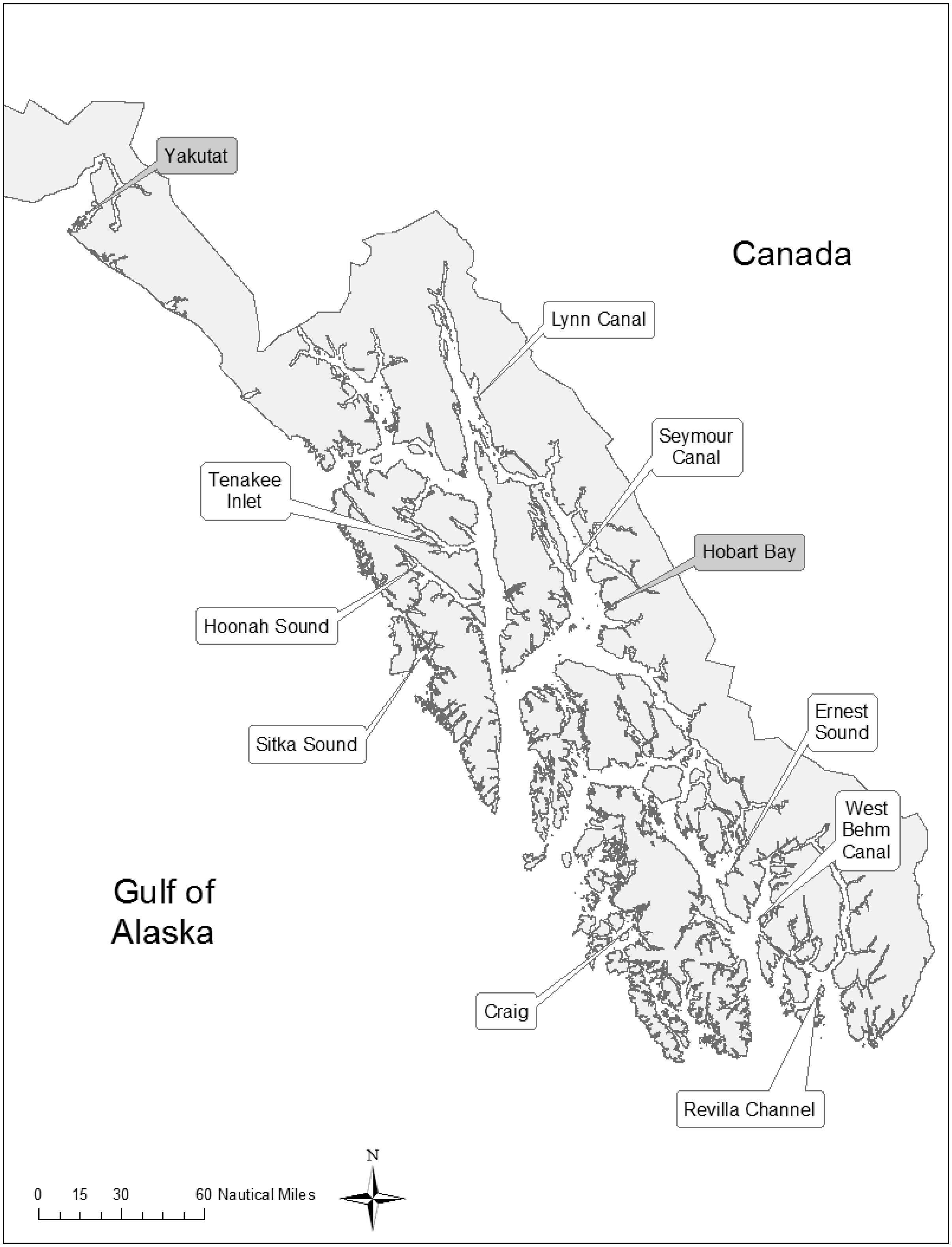

Figure 1.–Locations of major herring spawning areas in Southeast Alaska. Labels with shading indicate where no aerial surveys, spawn deposition surveys, or age-size sampling of herring was conducted during the 2015–16 fishery season.

Stock	17-Mar	18-Mar	19-Mar	20-Mar	21-Mar	22-Mar	23-Mar	24-Mar	25-Mar	26-Mar	27-Mar	28-Mar	29-Mar	30-Mar	31-Mar
Craig						0.1	ns	ns	2.3	4.0	6.0	6.7	2.2	0.9	0.2
Sitka Sound	0.0	0.9	0.2	1.3	2.8	6.8	15.6	17.3	##	16.1	2.6	0.0	0.0	0.0	0.0
West Behm Canal												0.0	ns	ns	0.0
Revilla Channel			0.0	ns	ns	0.0	ns	ns	ns	ns	ns	0.0	0.5	2.0	4.0
Ernest Sound															
Hoonah Sound															
Tenakee Inlet															
Hobart/Houghton	No aerial surveys completed in 2016														
Seymour Canal															
Lynn Canal															
Yakutat	No aerial surveys completed in 2016														
Haines	No aerial surveys completed in 2016														

Stock	1-Apr	2-Apr	3-Apr	4-Apr	5-Apr	6-Apr	7-Apr	8-Apr	9-Apr	10-Apr	11-Apr	12-Apr	13-Apr	14-Apr	15-Apr	16-Apr	17-Apr	18-Apr	19-Apr	20-Apr	21-Apr	22-Apr	23-Apr	24-Apr	25-Apr	26-Apr	27-Apr	28-Apr	29-Apr	30-Apr	1-May	2-May
Craig																																
Sitka Sound	0.0	5.9	2.3	5.7	3.8	1.6																										
West Behm Canal	ns	0.1	0.0	2.3	0.0	1.5	1.1																									
Revilla Channel	5.0																															
Ernest Sound				0.1	0.0	0.0	0.0	ns	0.0	0.3	0.8	0.1	0.0	ns	0.0	ns	ns	ns	ns	0.0	ns	0.0										
Hoonah Sound																		ns	0.0	ns	ns	ns	ns	ns	0.0	ns						
Tenakee Inlet															0.0	ns	ns	ns	0.0	ns	ns	0.0	ns	ns	0.0	ns	ns	0.0				
Hobart/Houghton																																
Seymour Canal															0.0	ns	ns	ns	0.0	ns	0.0	ns	ns	ns	0.3	0.5	3.4	1.4	0.5	ns		
Lynn Canal															0.0	ns	ns	ns	0.0	0.5	3.0	0.3	ns	ns	0.0	0.0	ns	0.0	ns	ns	ns	ns
Yakutat																																
Haines									0.1	ns	ns	ns	ns	ns	ns	0.1																

continued	3-May	4-May	5-May	6-May	7-May	8-May	9-May	10-May	11-May	12-May	13-May	14-May	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May	23-May	24-May	25-May	26-May	27-May	28-May	29-May	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	6-Jun	7-Jun	8-Jun	9-Jun	10-Jun
Hoonah Sound																																							
Tenakee Inlet	0.0																																						
Seymour Canal	0.0																																						
Lynn Canal	0.0	0.8	0.3	0.0	ns	0.0																																	

Figure 2.–Spawn timing of herring stocks in Southeast Alaska during spring 2016. Values indicate daily measurements of nautical miles of active spawn recorded during aerial surveys. Shaded area depict dates when cast-net samples were taken. Boxed areas indicate duration of spawning (first to last dates of observed spawn).

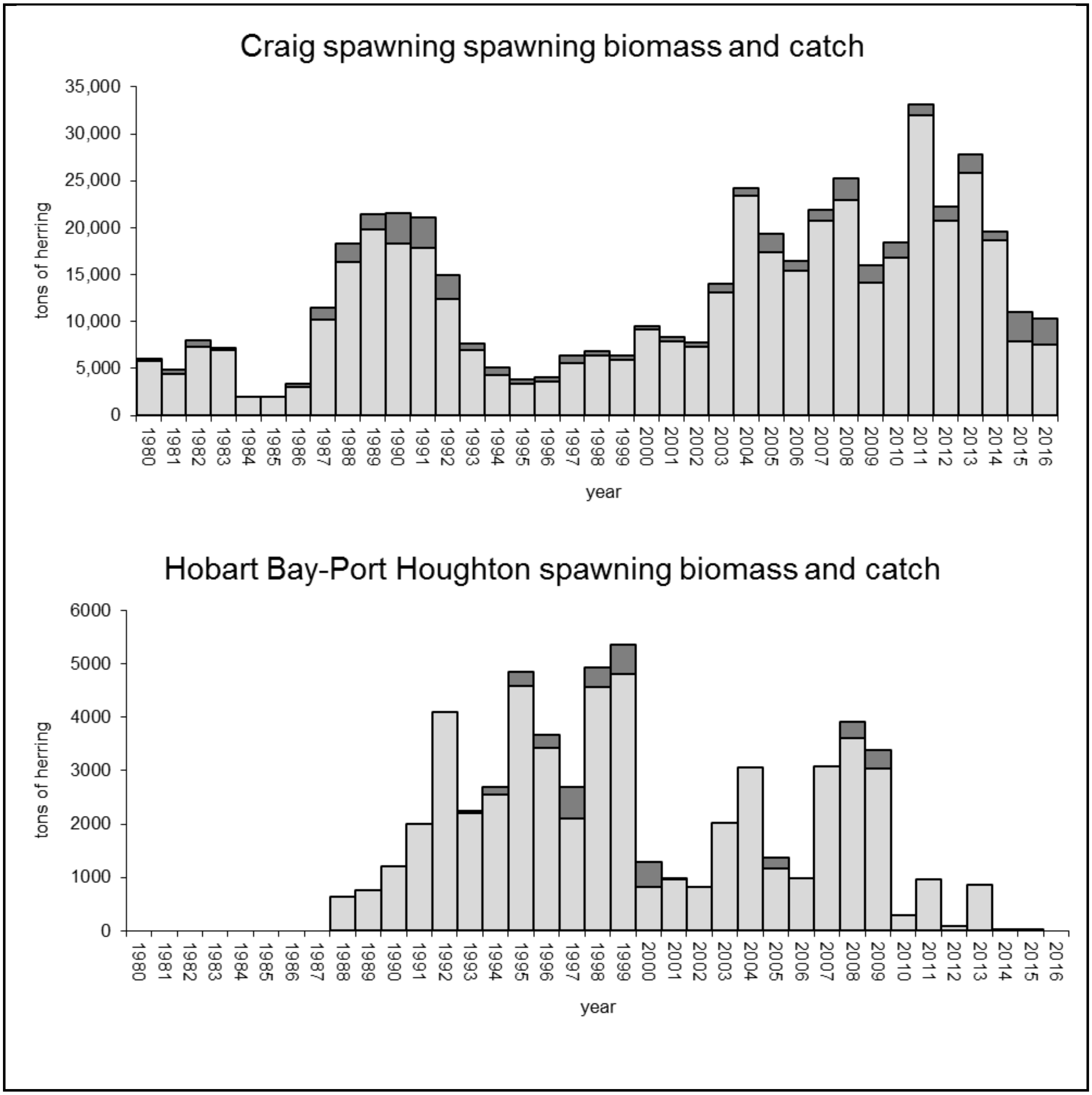

Figure 3.–Herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys, and catch (dark gray bars) for stocks in the Craig and Hobart Bay-Port Houghton areas, during 1980–2016.

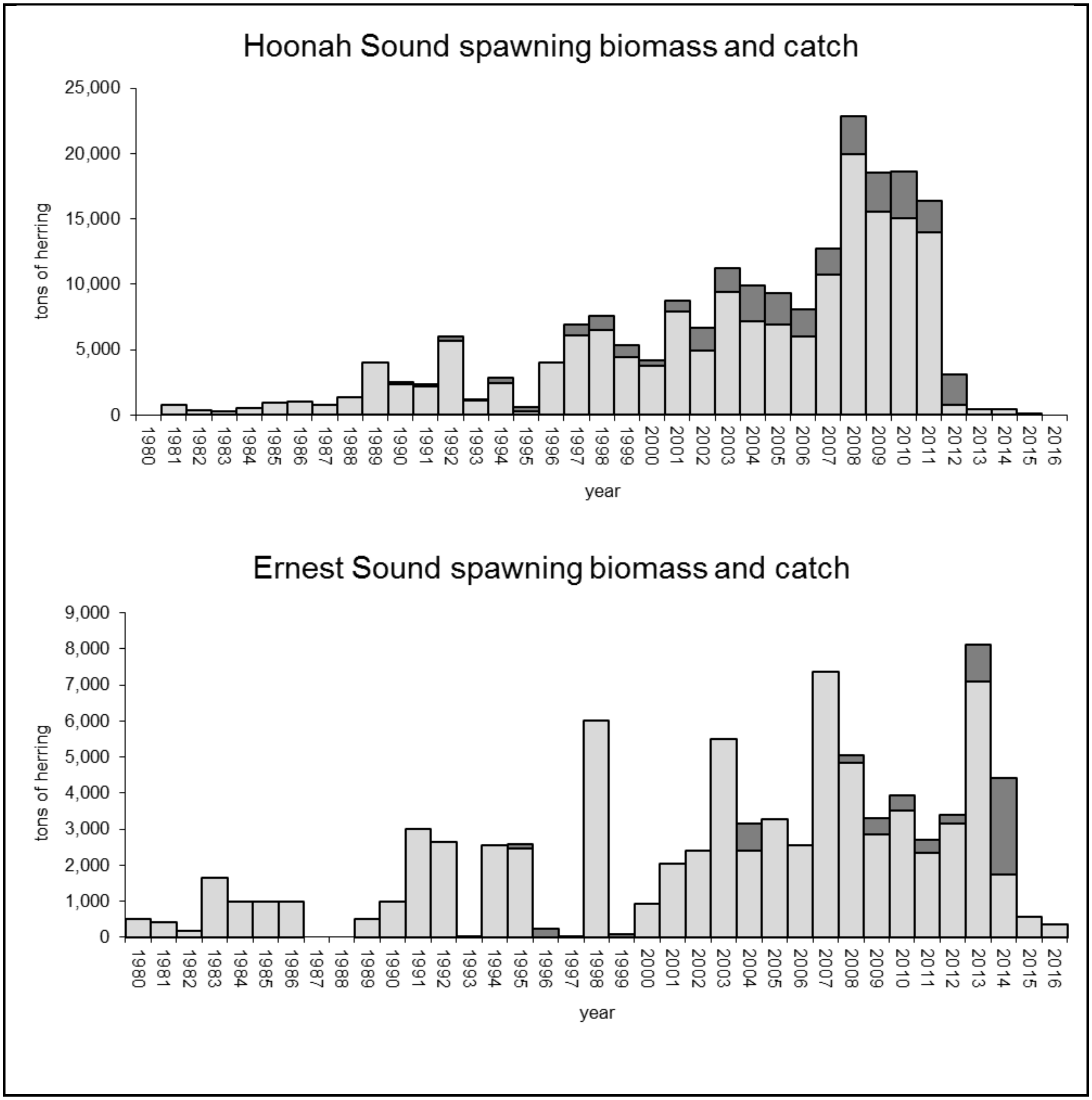

Figure 4.–Herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys or hydroacoustic surveys, and catch (dark gray bars) for stocks in the Hoonah Sound and Ernest Sound areas, during 1980–2016.

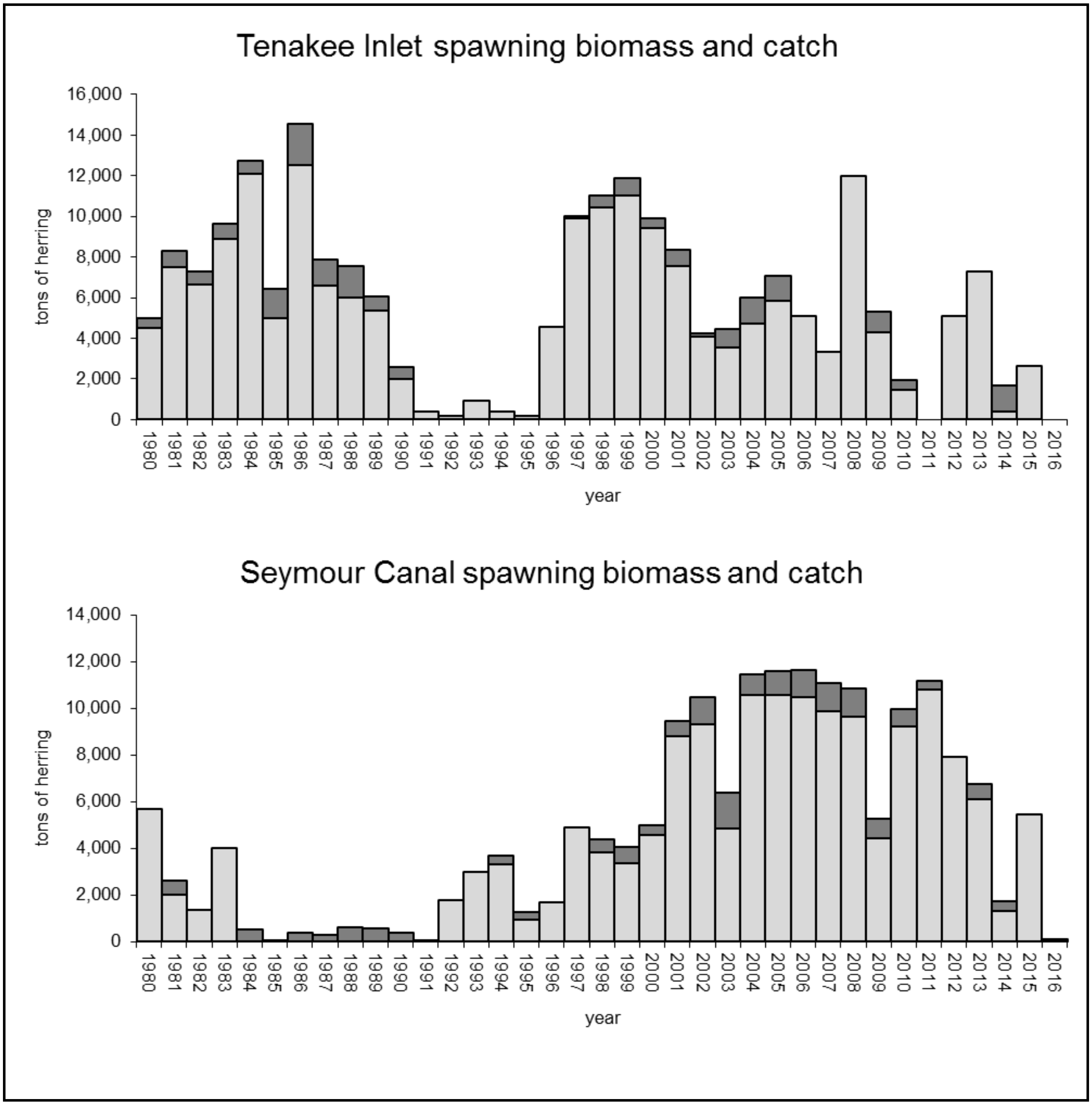

Figure 5.–Herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys or hydroacoustic surveys, and catch (dark gray bars) for stocks in the Tenakee Inlet and Seymour Canal areas, during 1980–2016.

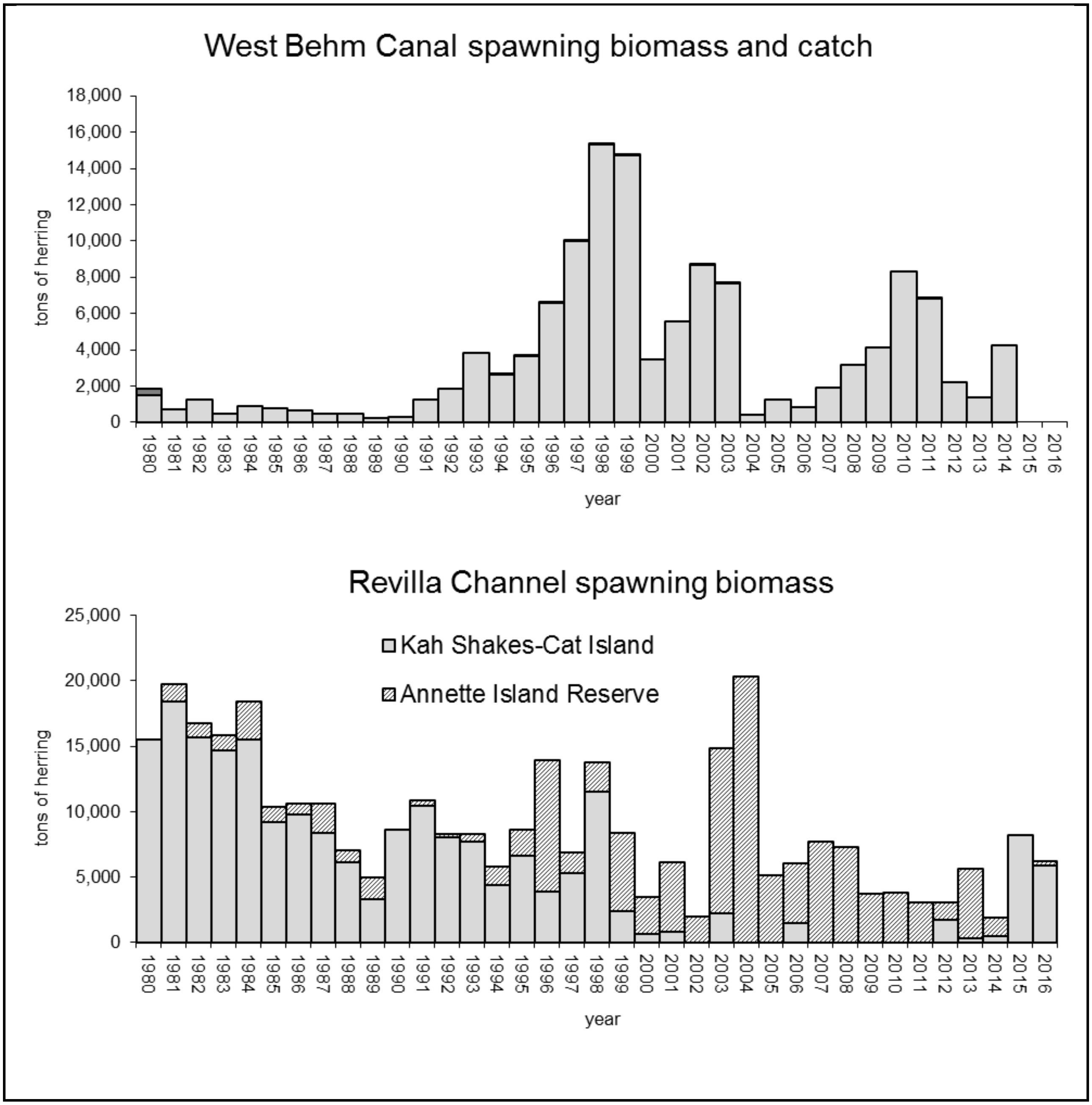

Figure 6.–Herring post-fishery spawning biomass, based on spawn deposition surveys or hydroacoustic surveys for stocks in the West Behm Canal and Revilla Channel (Kah Shakes-Cat Island-Annette Island) areas, during 1980–2016. Annette Island spawning biomass estimates were made as the product of the length of observed linear shoreline spawn mileage and a fixed approximated value of 500 tons of herring per nautical mileage of shoreline, based on the estimated mean value over the period 1991-2000.

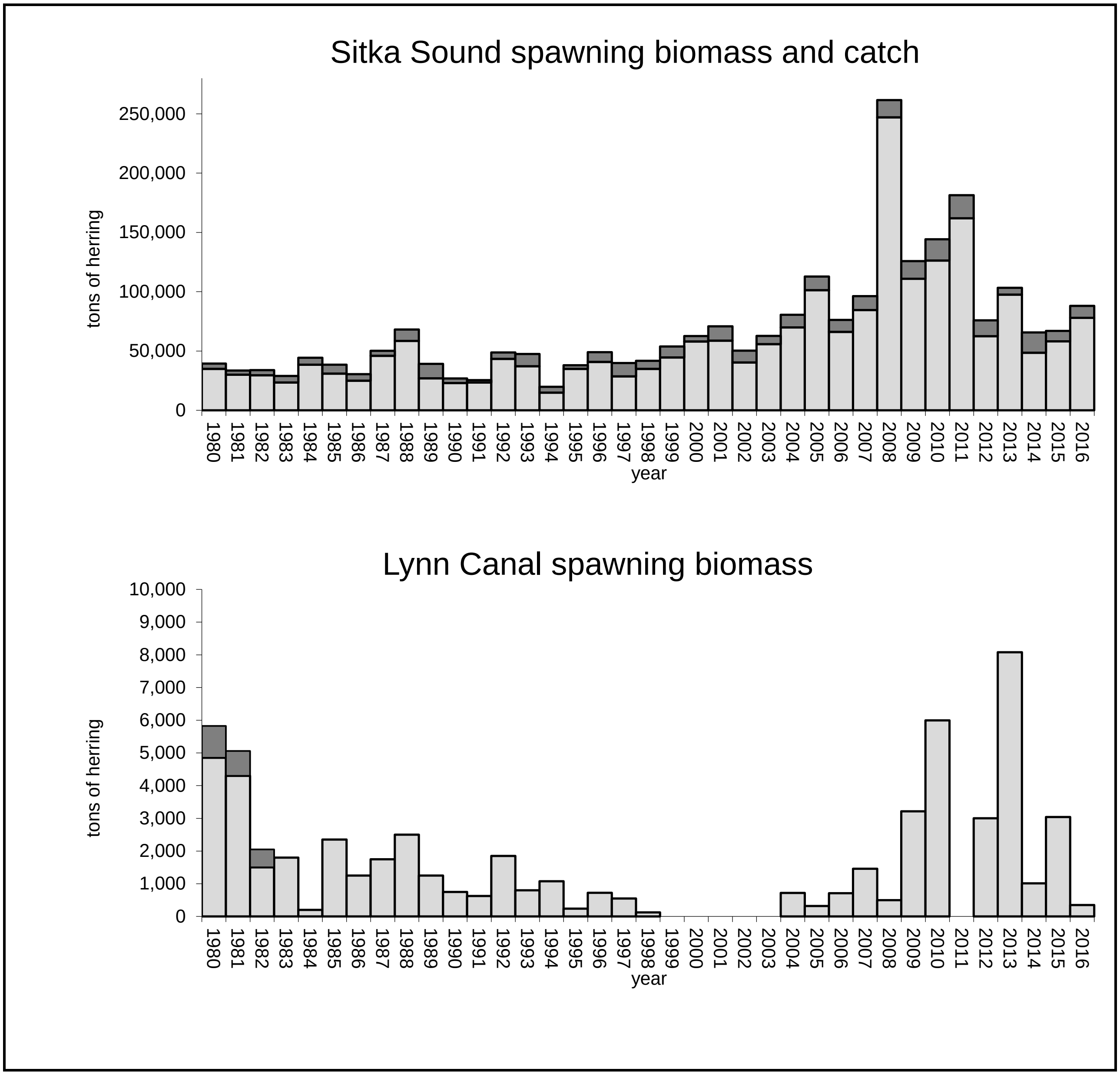

Figure 7.–Herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys, and catch (dark gray bars) for stock in the Sitka Sound and Lynn Canal areas, during 1980–2016. Estimates of spawning biomass for Lynn Canal prior to 2004 were made using a variety of methods (e.g., hydroacoustics or visual estimates of spawn density converted to biomass), and results should be viewed as approximations.

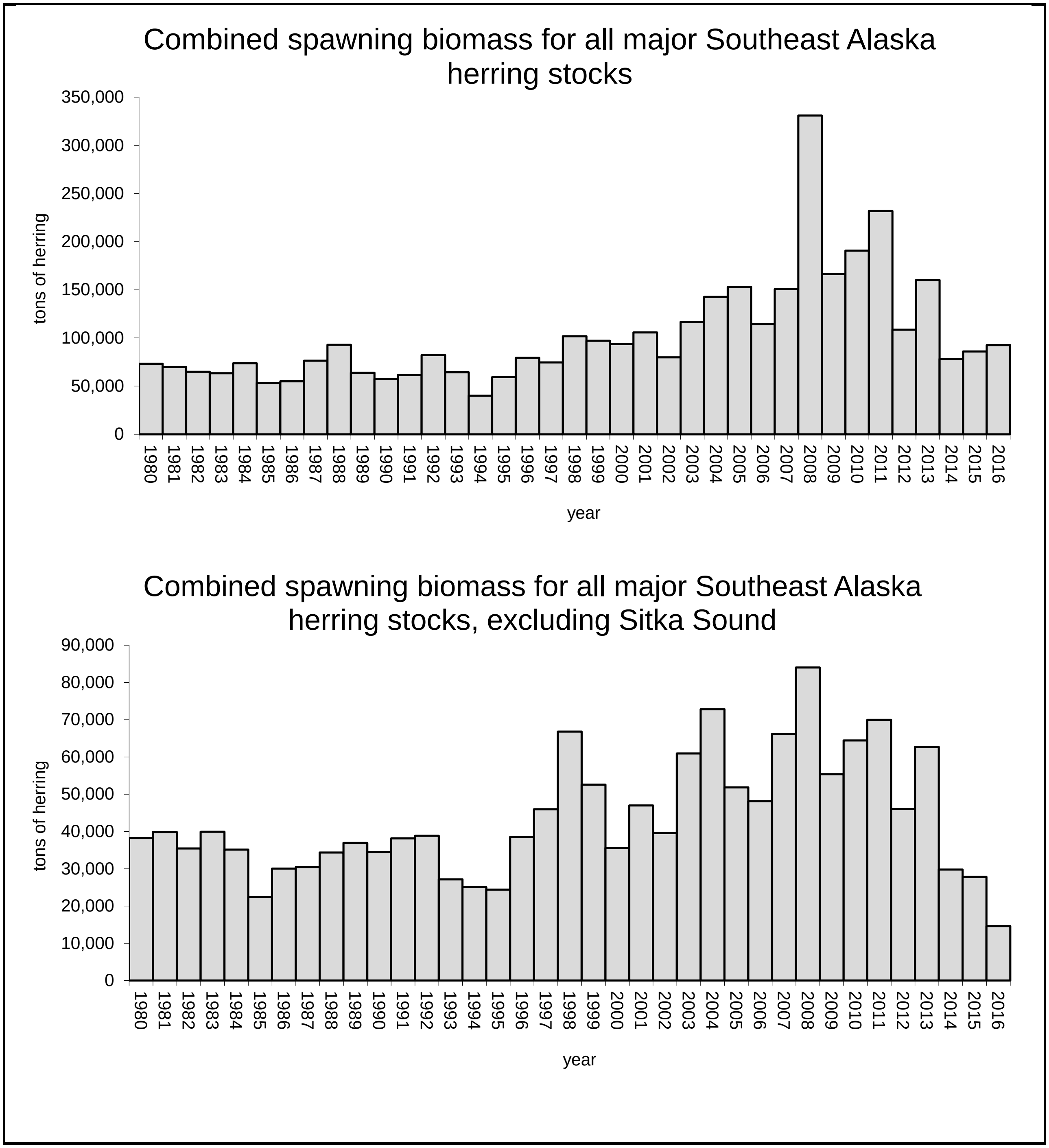

Figure 8.–Combined post-fishery spawning biomass, based on spawn deposition surveys or hydroacoustic surveys, for major herring stocks in Southeast Alaska, during 1980–2016.

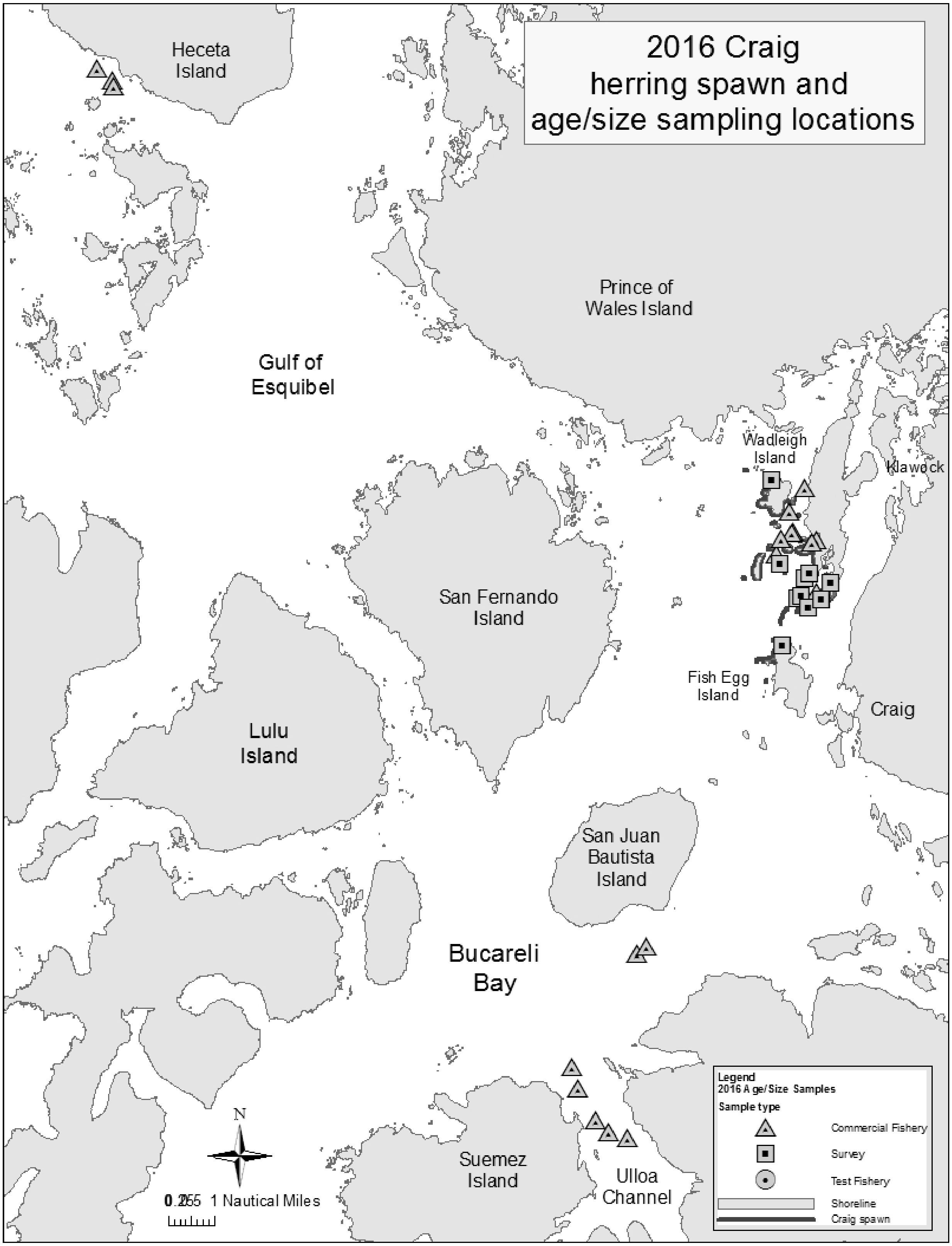

Figure 9.–Locations of herring samples collected for estimates of age and size for the Craig herring stock, 2015/2016. Cumulative herring spawn denoted by thick gray line along shoreline.

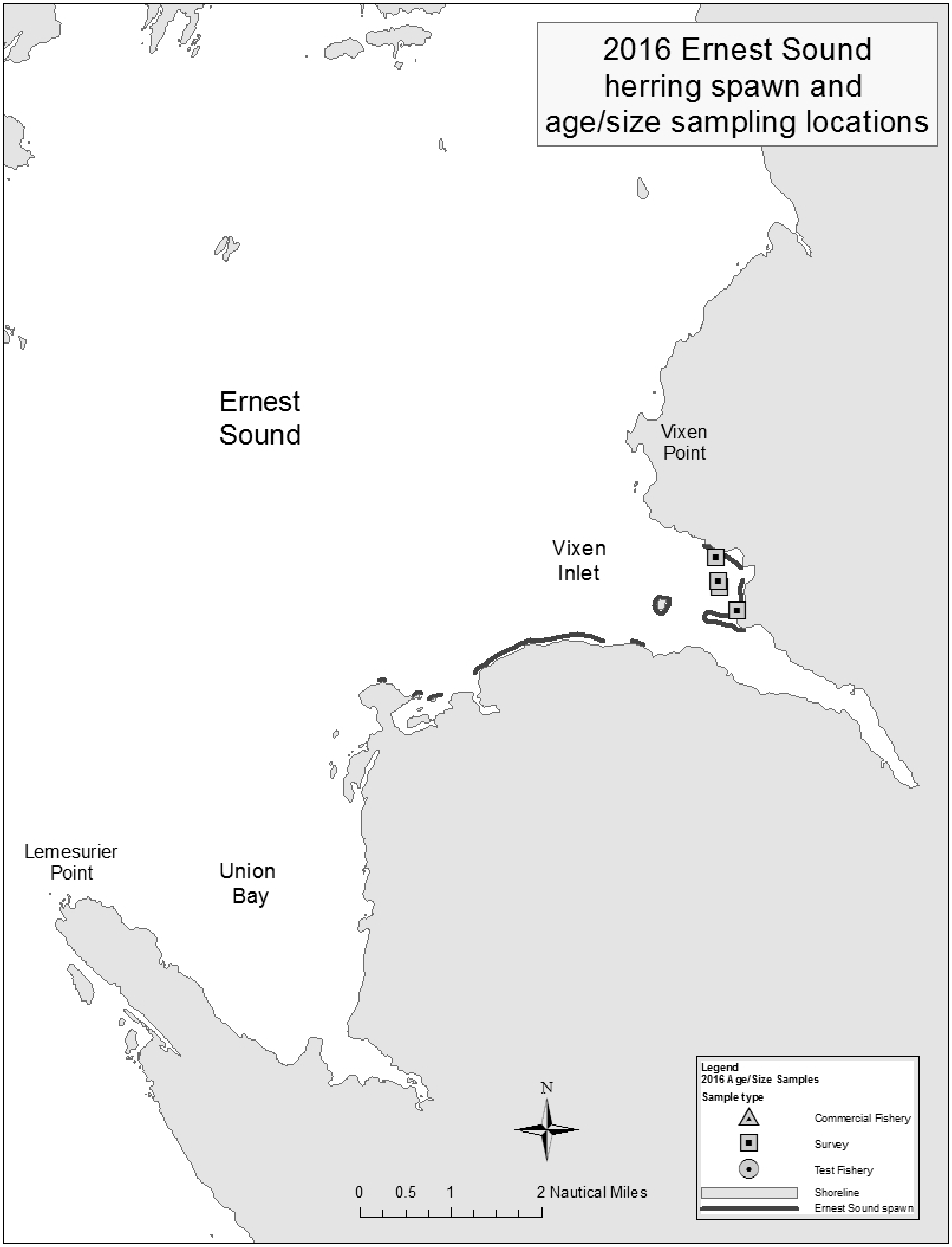

Figure 10.–Locations of herring samples collected for estimates of age and size for the Ernest Sound herring stock, 2016. Cumulative herring spawn denoted by thick gray line along shoreline.

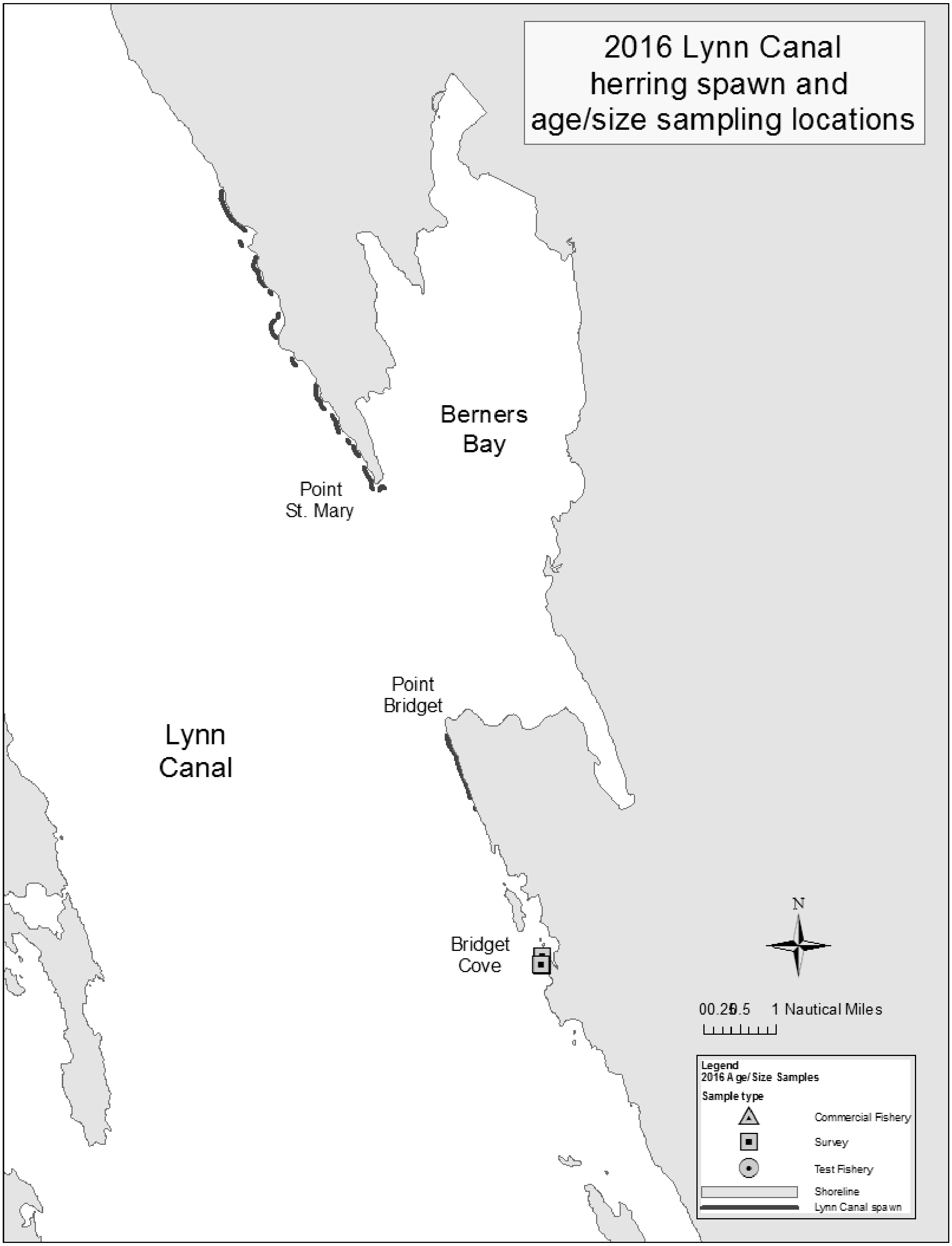

Figure 11.–Location of herring spawn for the Lynn Canal herring stock, 2016. Cumulative herring spawn denoted by thick gray line along shoreline.

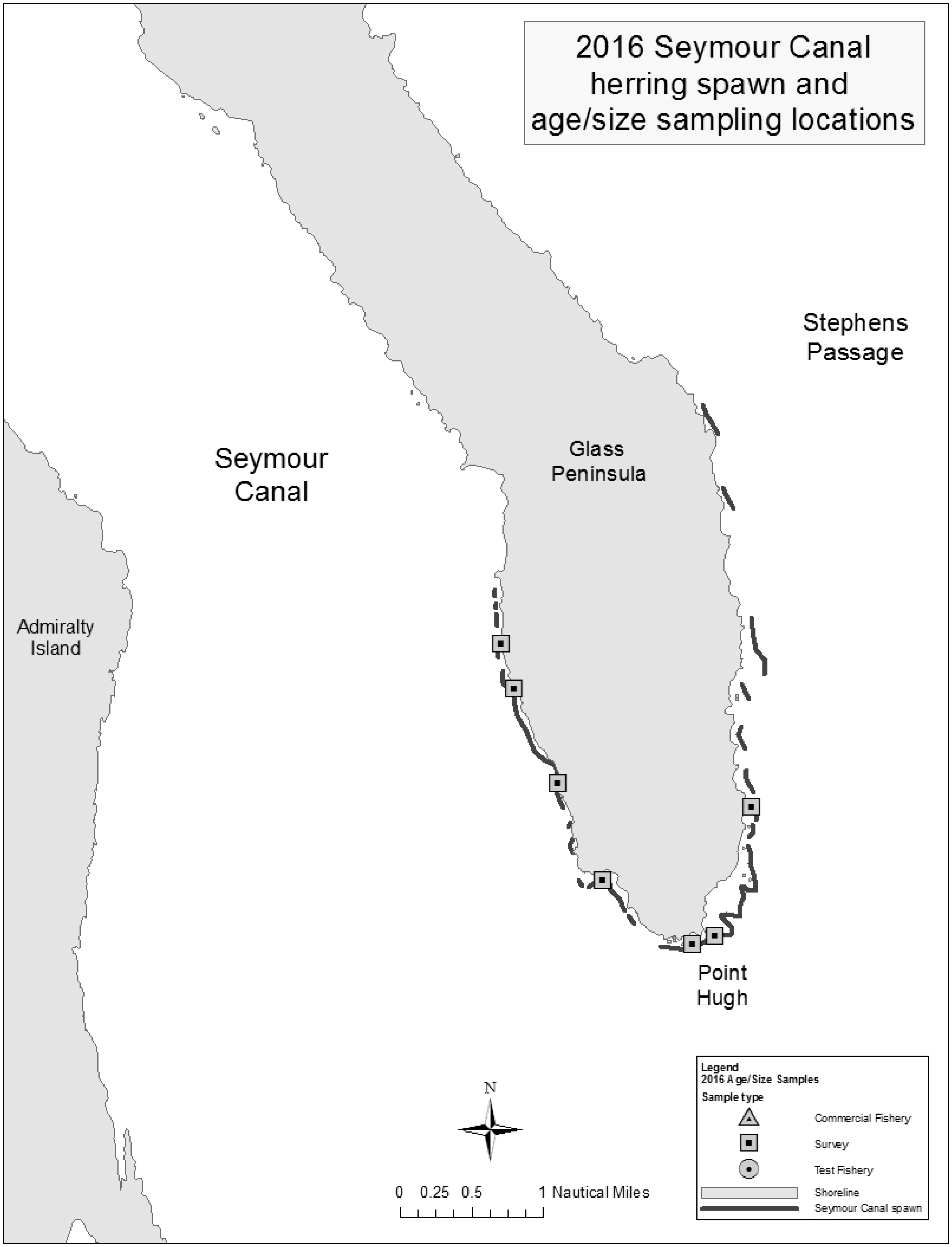

Figure 12.–Locations of herring samples collected for estimates of age and size for the Seymour Canal herring stock, 2016. Cumulative herring spawn denoted by thick gray line along shoreline.

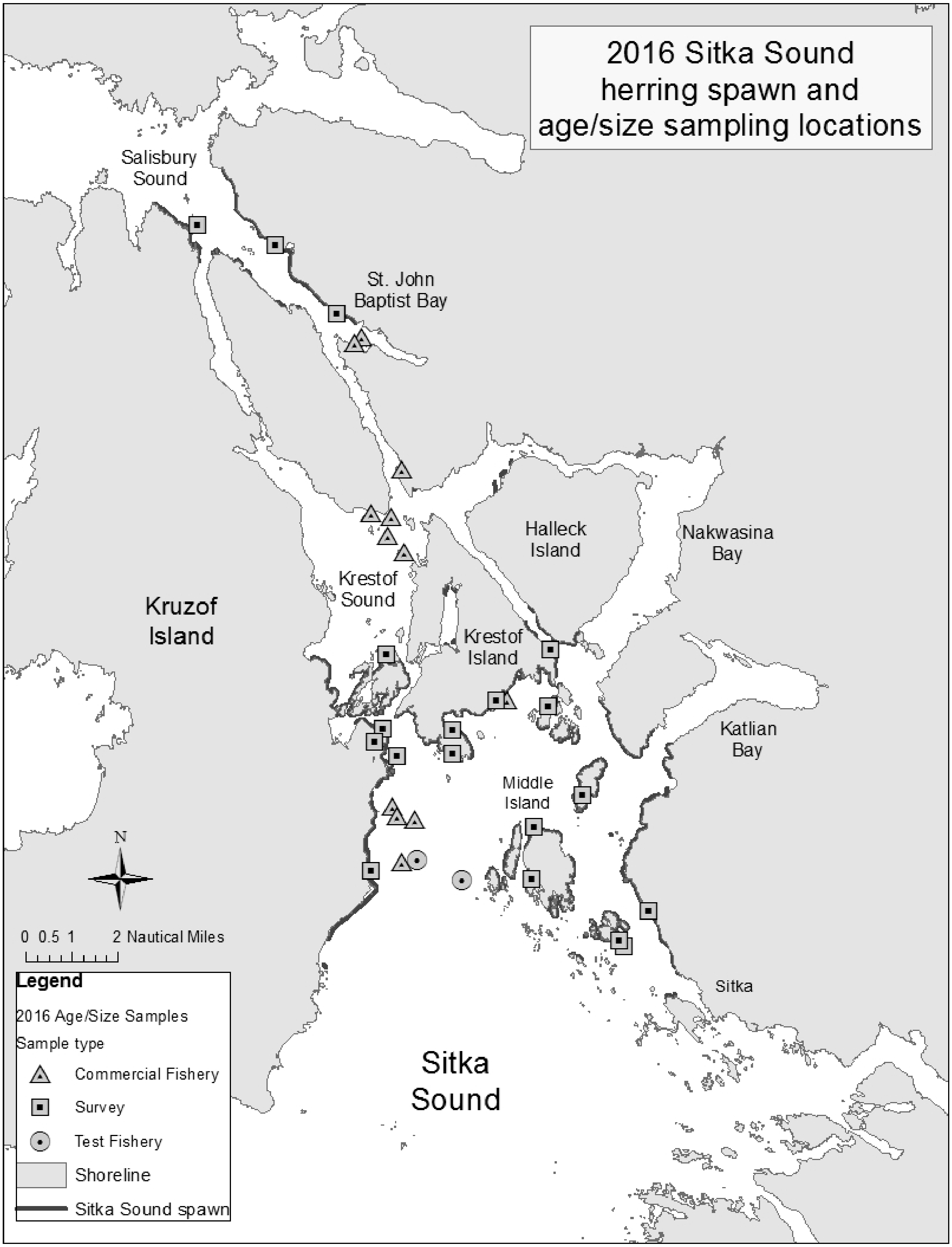

Figure 13.–Locations of herring samples collected for estimates of age and size for the Sitka Sound herring stock, 2016. Cumulative herring spawn denoted by thick gray line along shoreline.

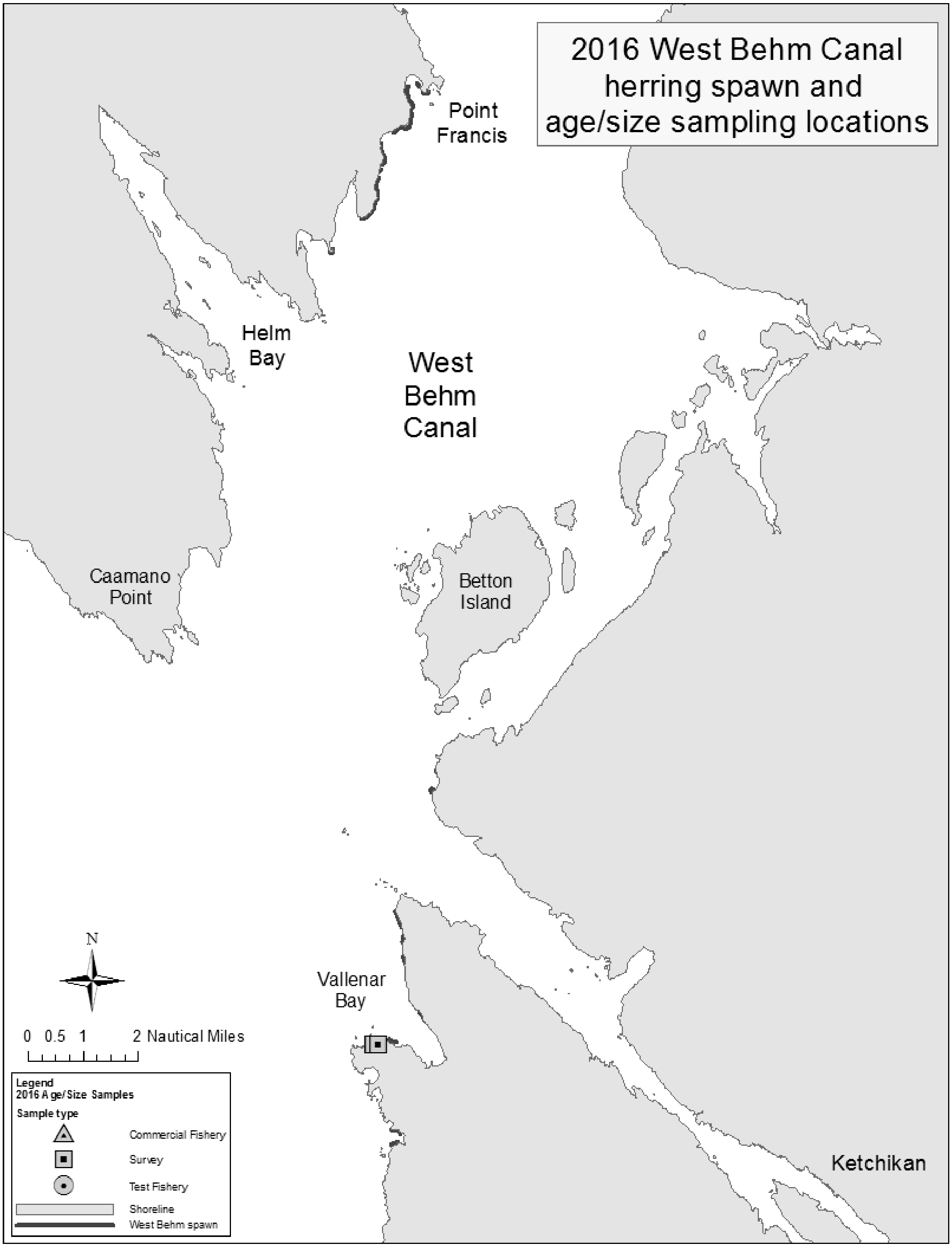

Figure 14.–Locations of herring samples collected for estimates of age and size for the West Behm Canal herring stock, 2016. Cumulative herring spawn denoted by thick gray line along shoreline.

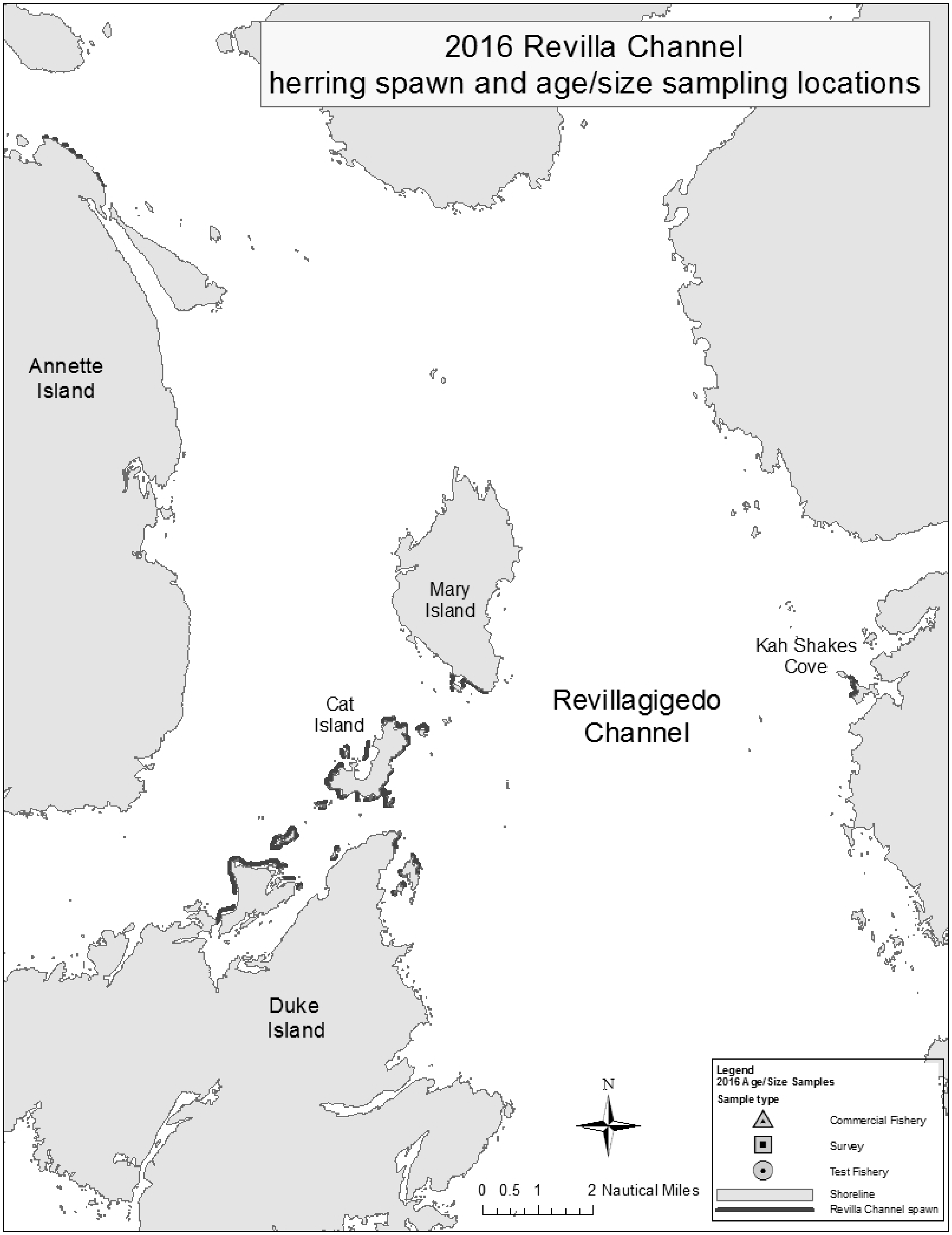

Figure 15.–Locations of herring samples collected for estimates of age and size for the Revilla Channel herring stock, 2016 (including Annette Island Reserve). Cumulative herring spawn denoted by thick gray line along shoreline.

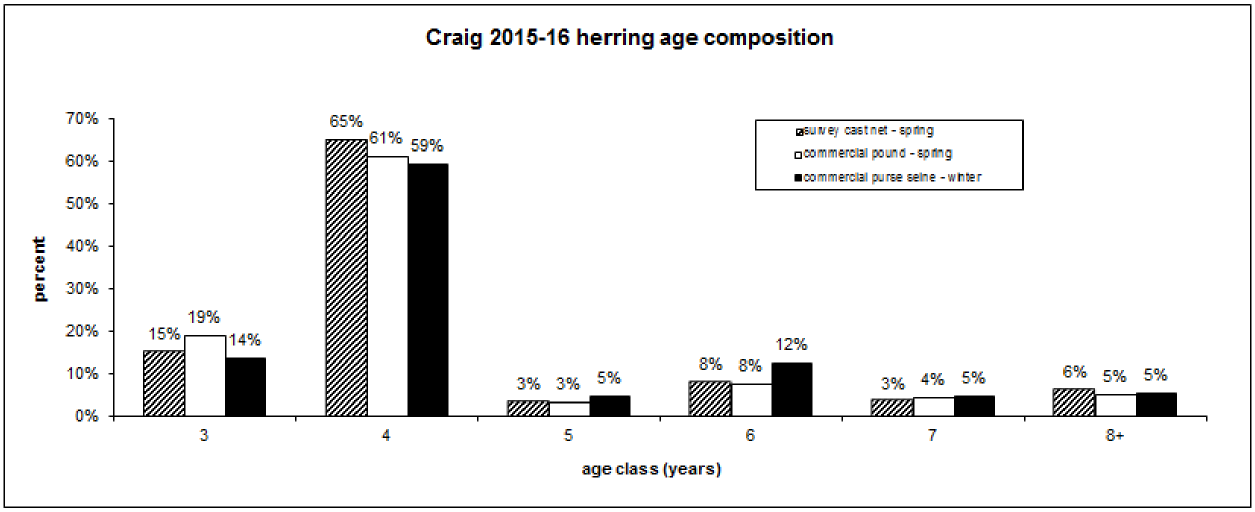

Figure 16.–Age composition for Craig herring stock in 2015–16.

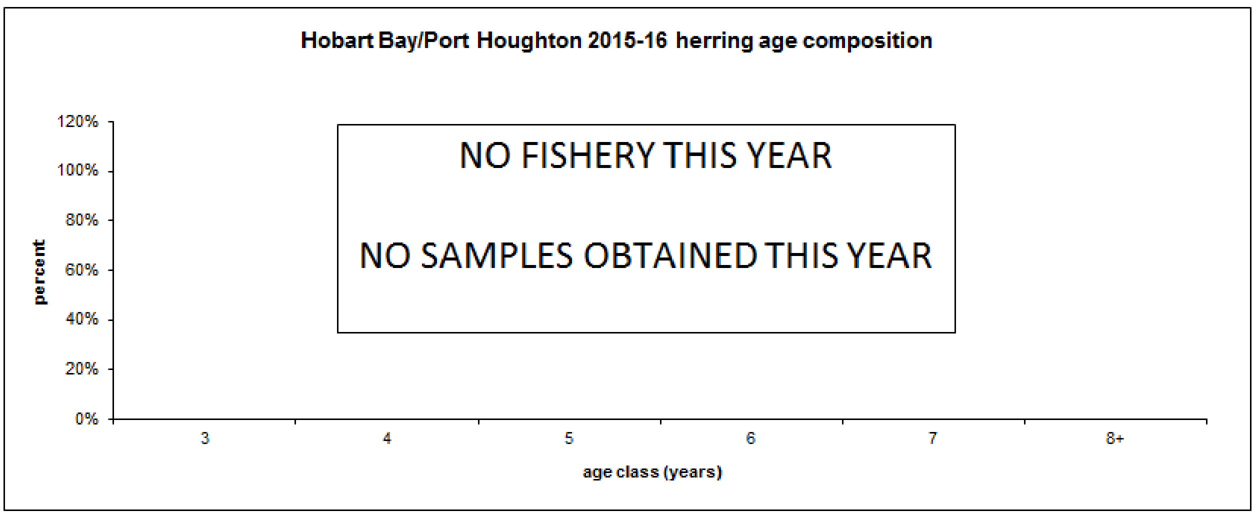

Figure 17.–Age composition for Hobart Bay/Port Houghton herring stock in 2015–16. No samples were obtained 2015–16.

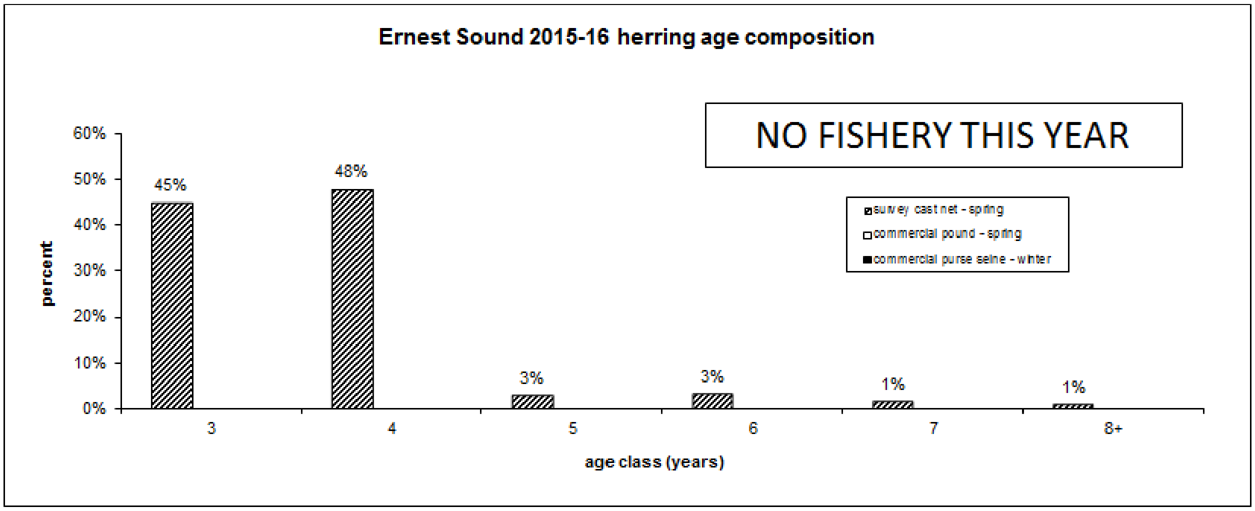

Figure 18.–Age composition for Ernest Sound herring stock in 2015–16. No commercial fishery samples obtained as no commercial fishery was opened in 2015–16.

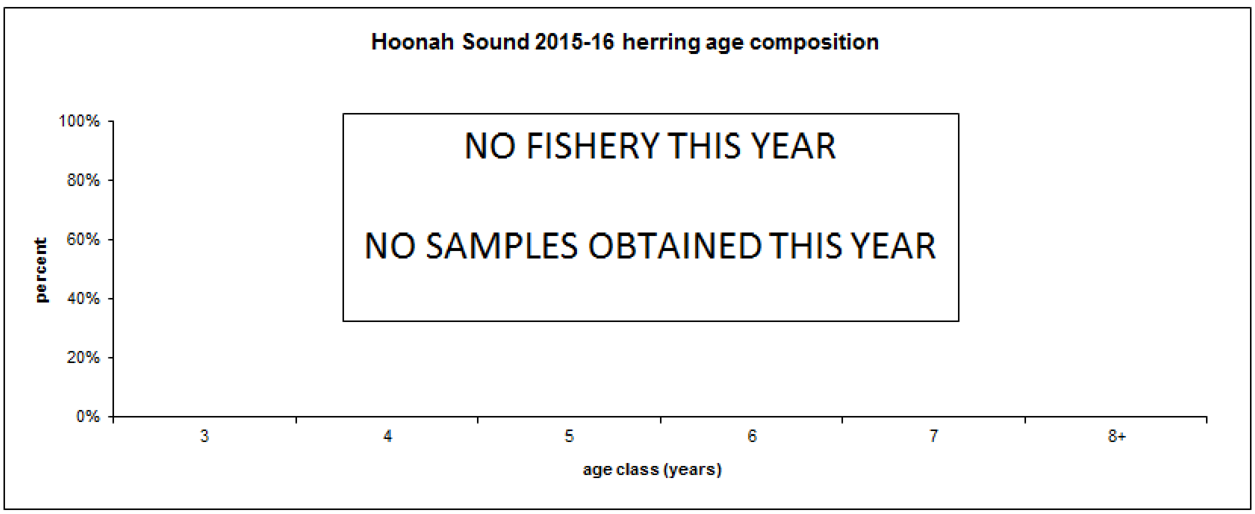

Figure 19.–Age composition for Hoonah Sound herring stock in 2015–16. No samples were obtained in 2015–16.

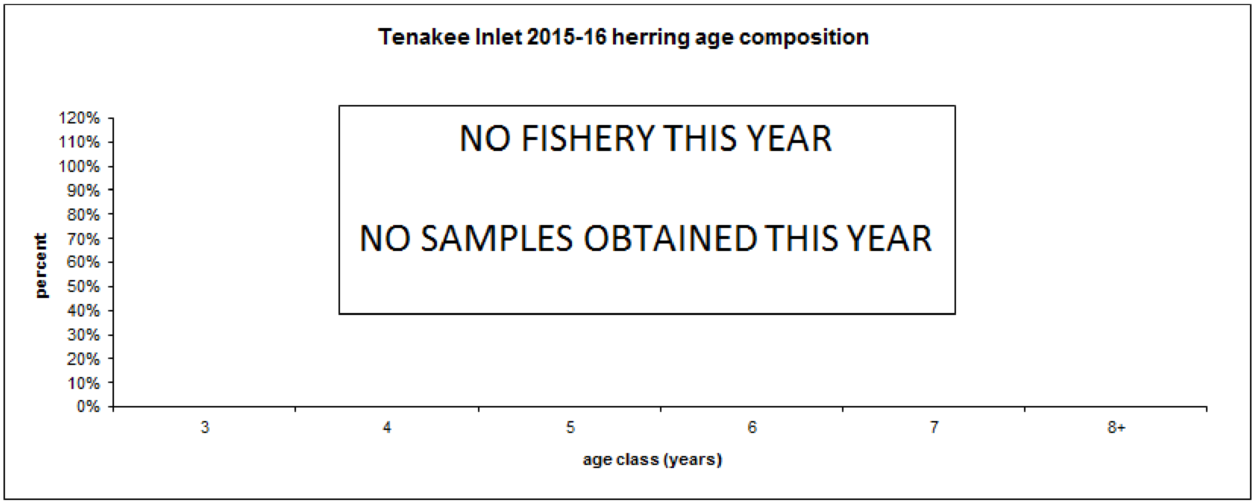

Figure 20.–Age composition for Tenakee Inlet herring stock in 2015–16. No samples obtained in 2015–16.

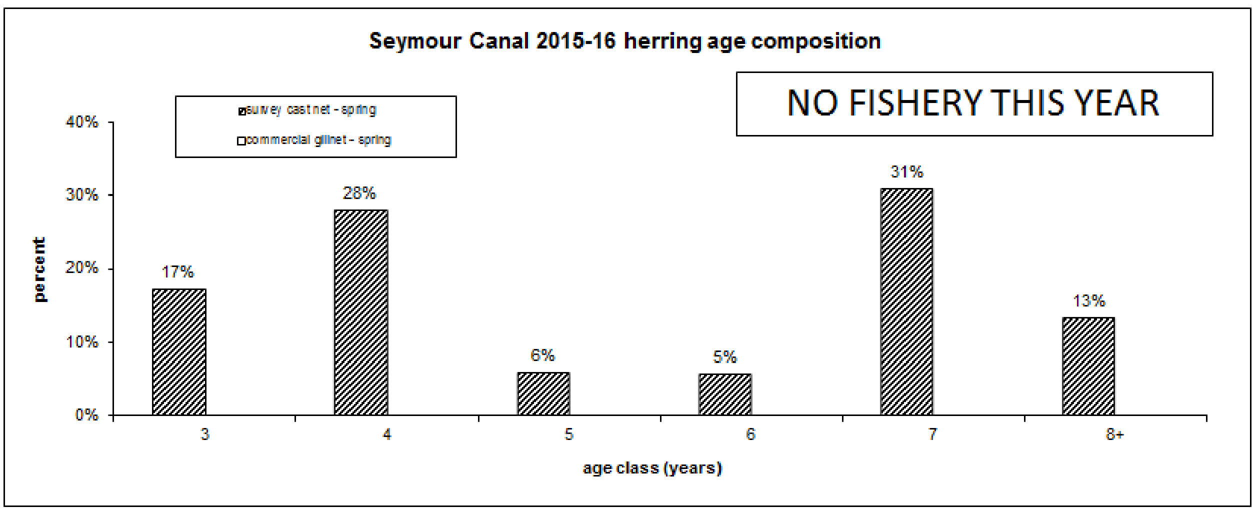

Figure 21.–Age composition for Seymour Canal herring stock in 2015–16. No commercial fishery samples obtained as no commercial fishery was opened in 2015–16.

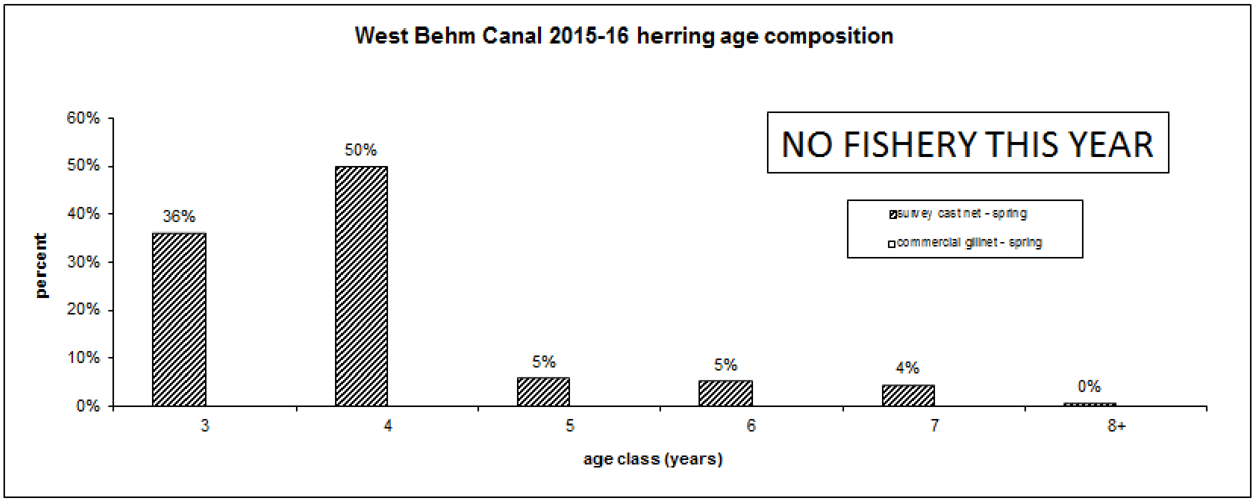

Figure 22.–Age composition for West Behm Canal herring stock in 2015–16. No commercial fishery samples were obtained as no commercial fishery was opened in 2015–16.

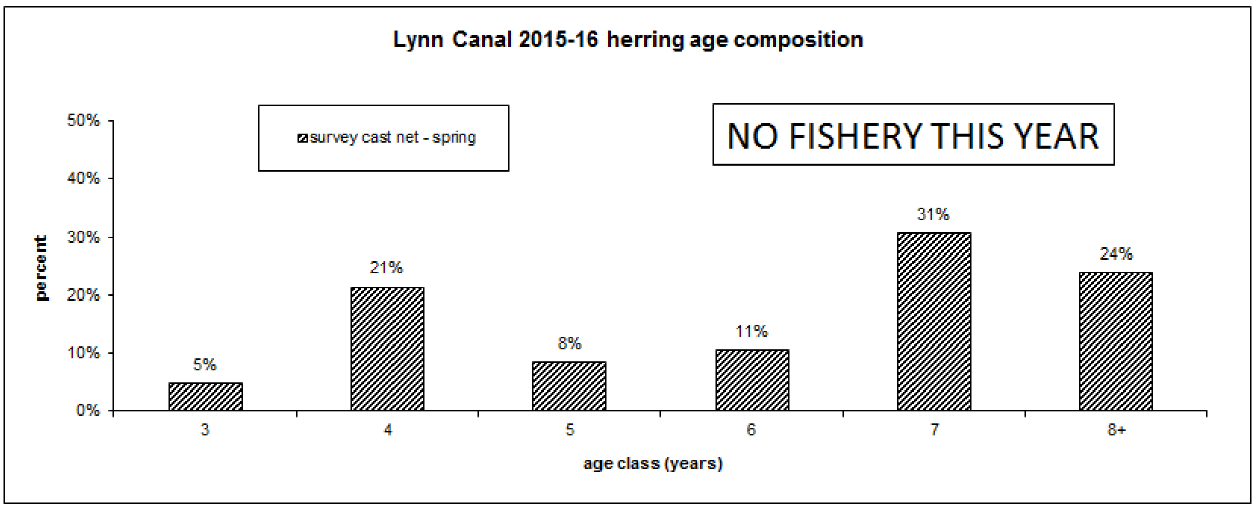

Figure 23.–Age composition for Lynn Canal herring stock in 2015–16. No commercial fishery samples obtained as no commercial fishery was opened in 2015–16.

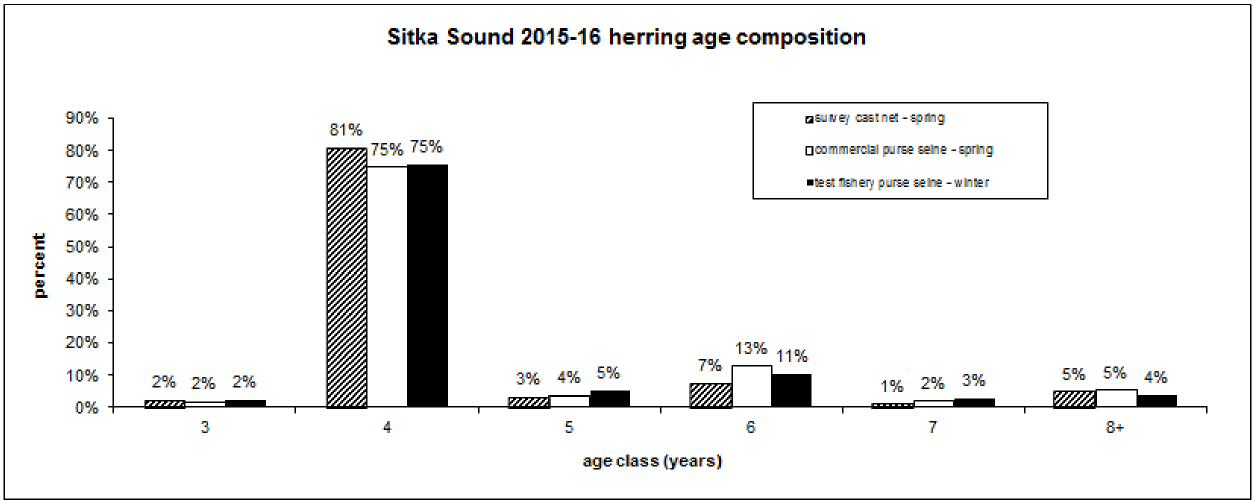

Figure 24.–Age composition for Sitka Sound herring stock in 2015–16.

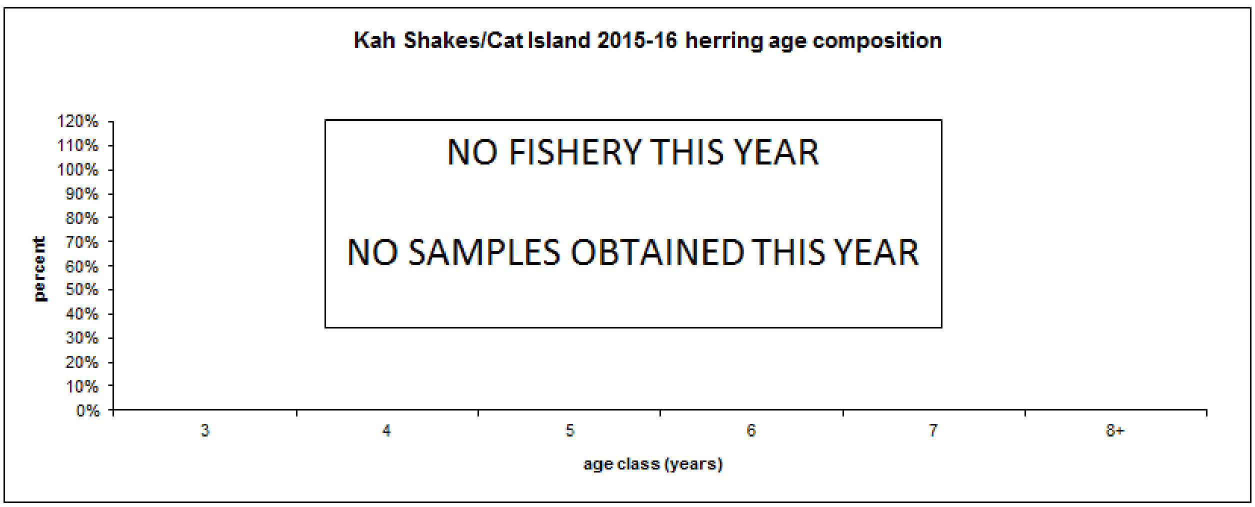

Figure 25.–Age composition for Revilla Channel herring stock (state waters only) in 2015–16. No samples obtained in 2015–16.

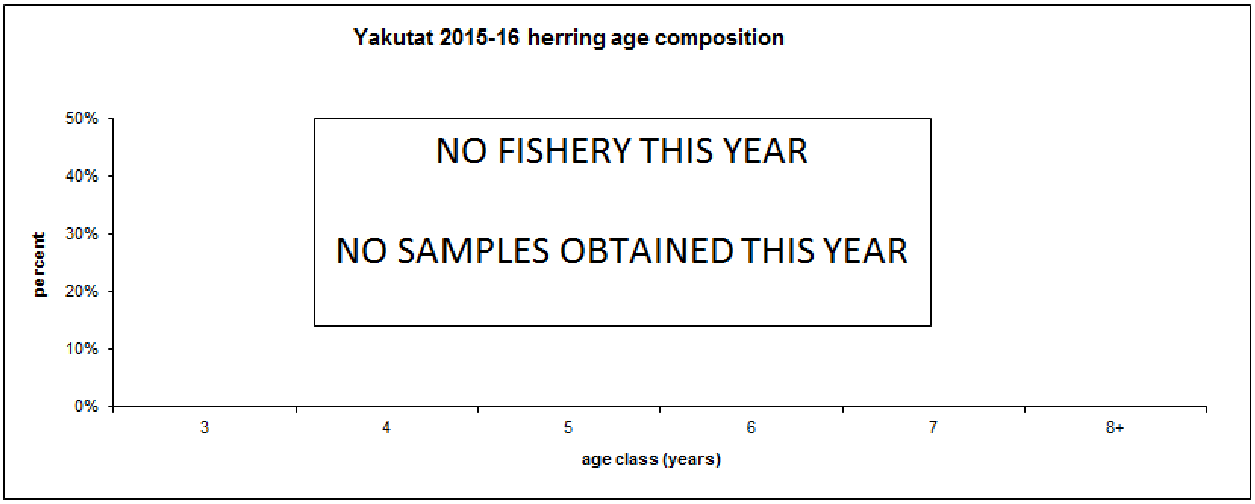

Figure 26.–Age composition for Yakutat Bay herring stock in 2015–16. No samples were obtained in 2015–16.

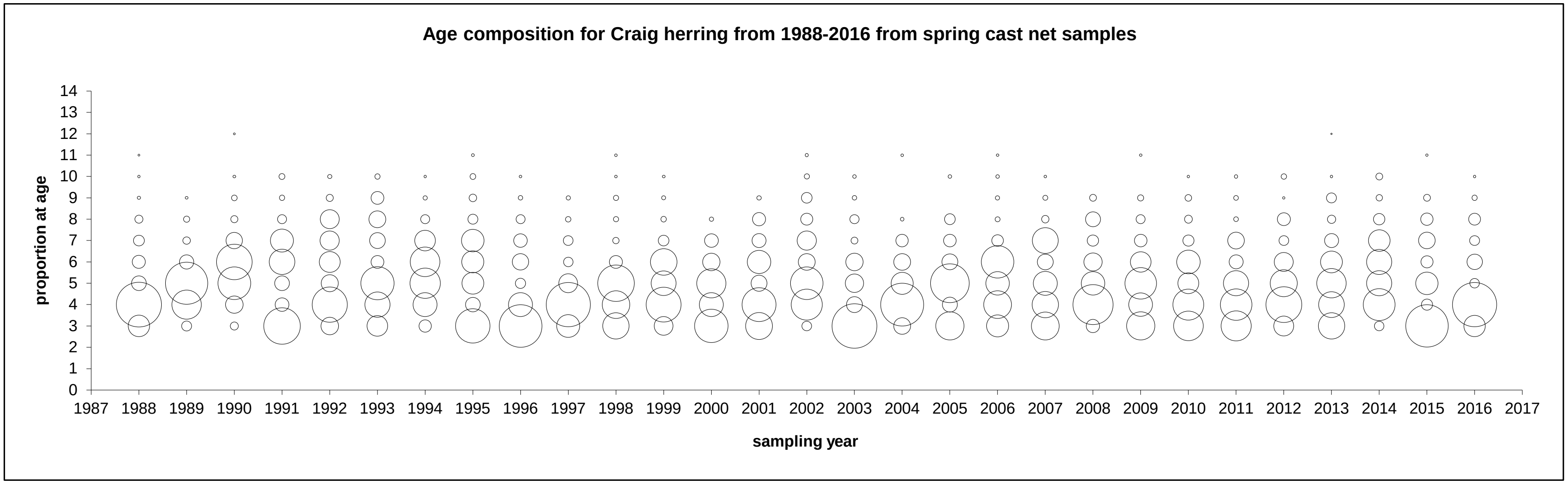

Figure 27.–Age composition from sampling data for the Craig herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

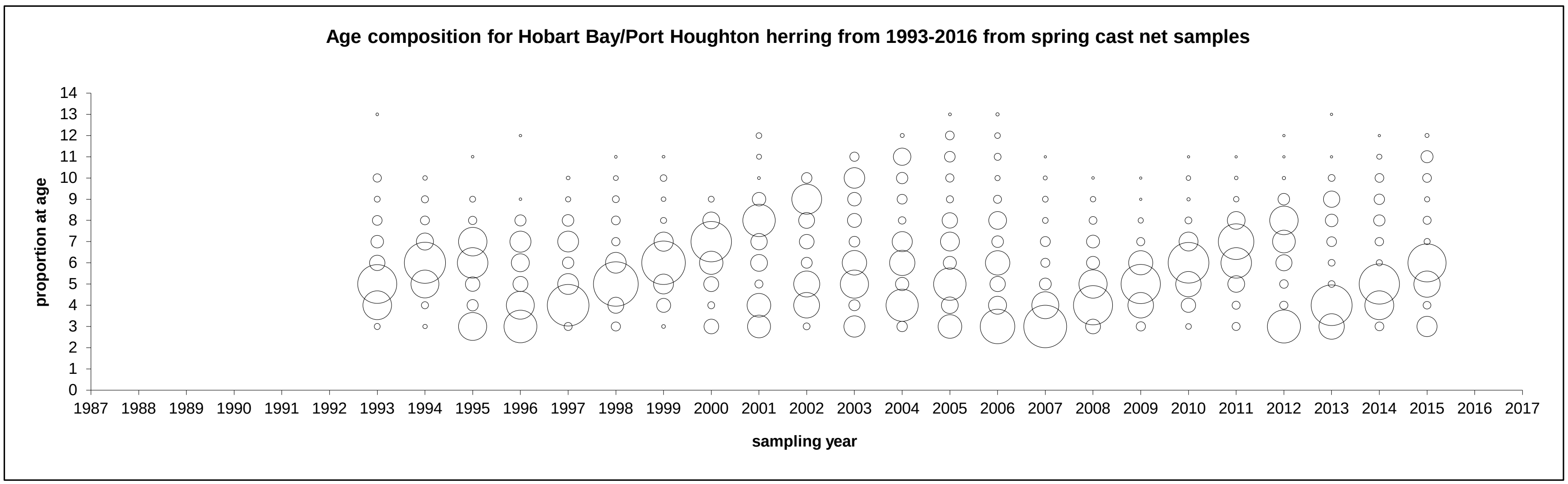

Figure 28.–Age composition from sampling data for the Hobart Bay/Port Houghton herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

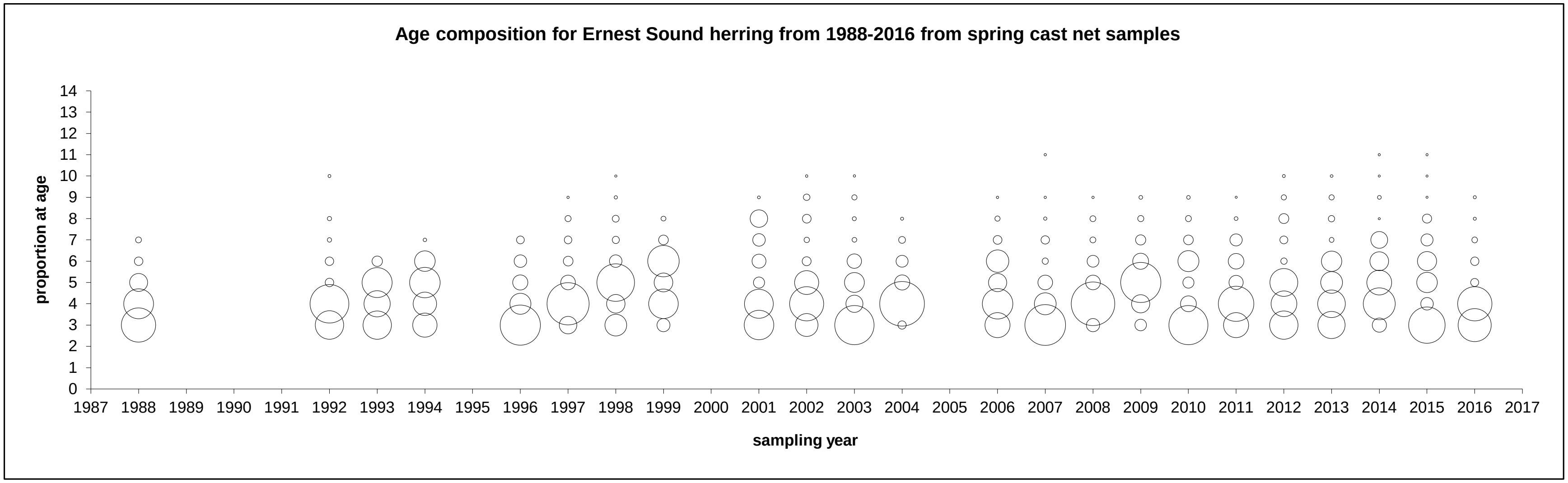

Figure 29.–Age composition from sampling data for the Ernest Sound herring stock.

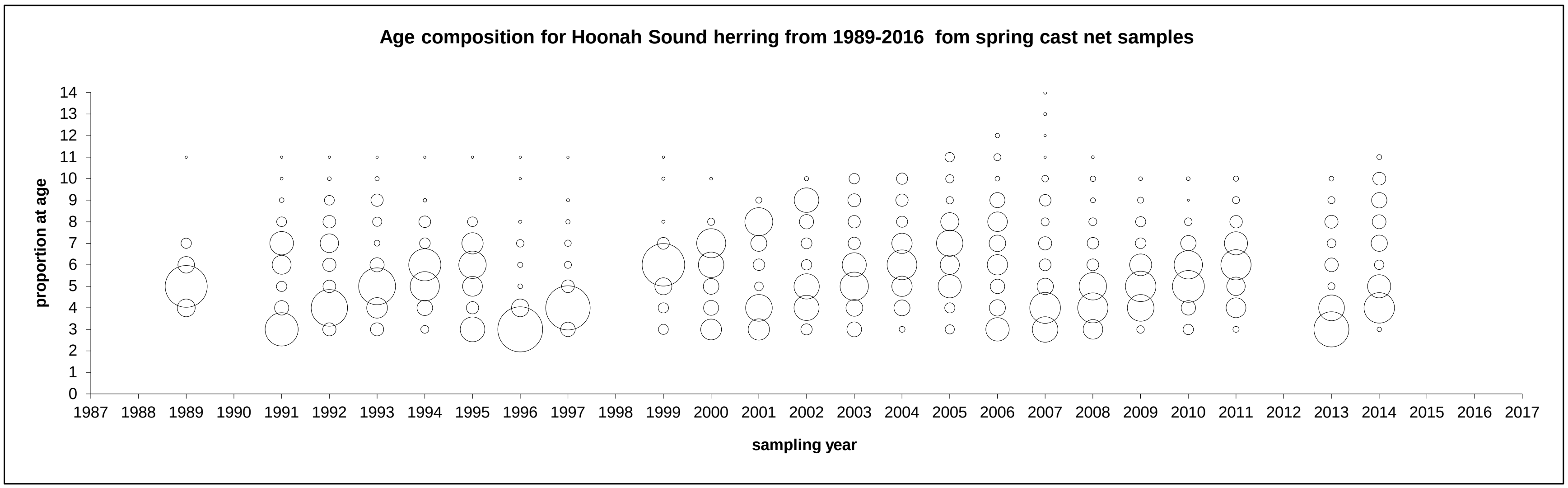

Figure 30.–Age composition from sampling data for the Hoonah Sound herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

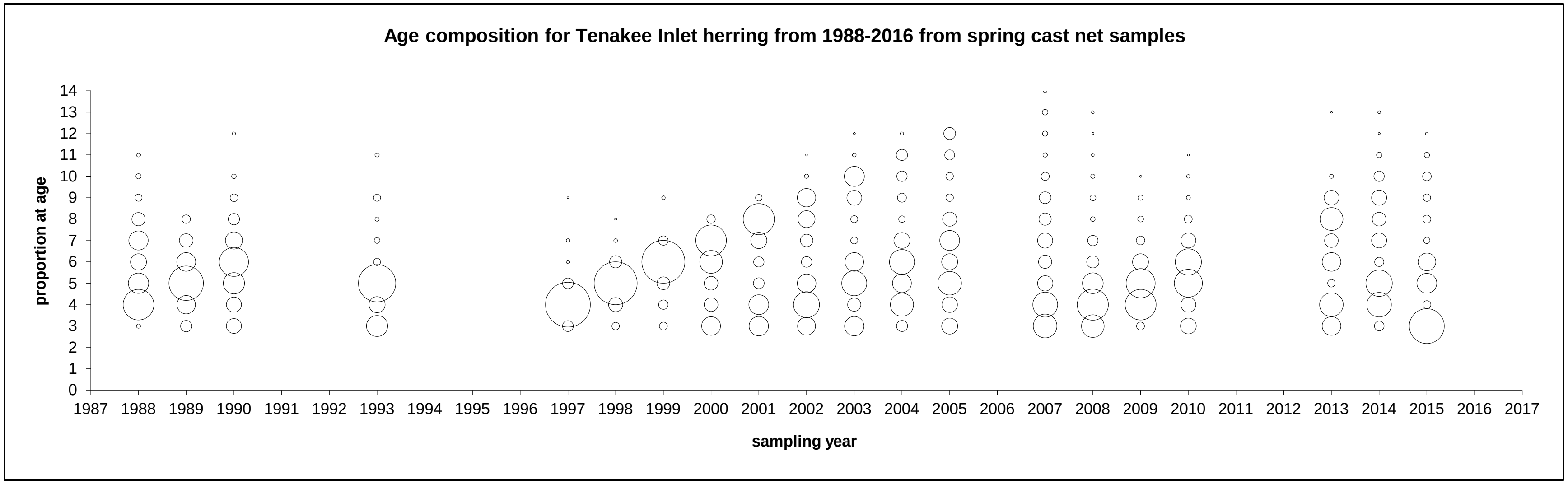

Figure 31.–Age composition from sampling data for the Tenakee Inlet herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

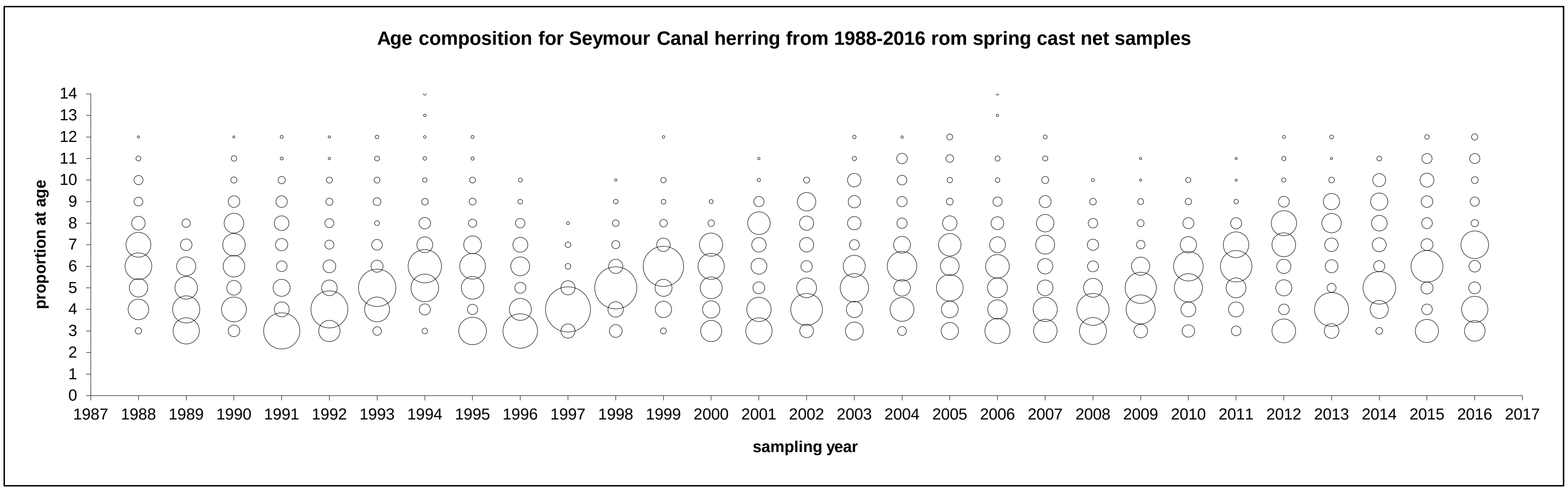

Figure 32.–Age composition from sampling data for the Seymour Canal herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

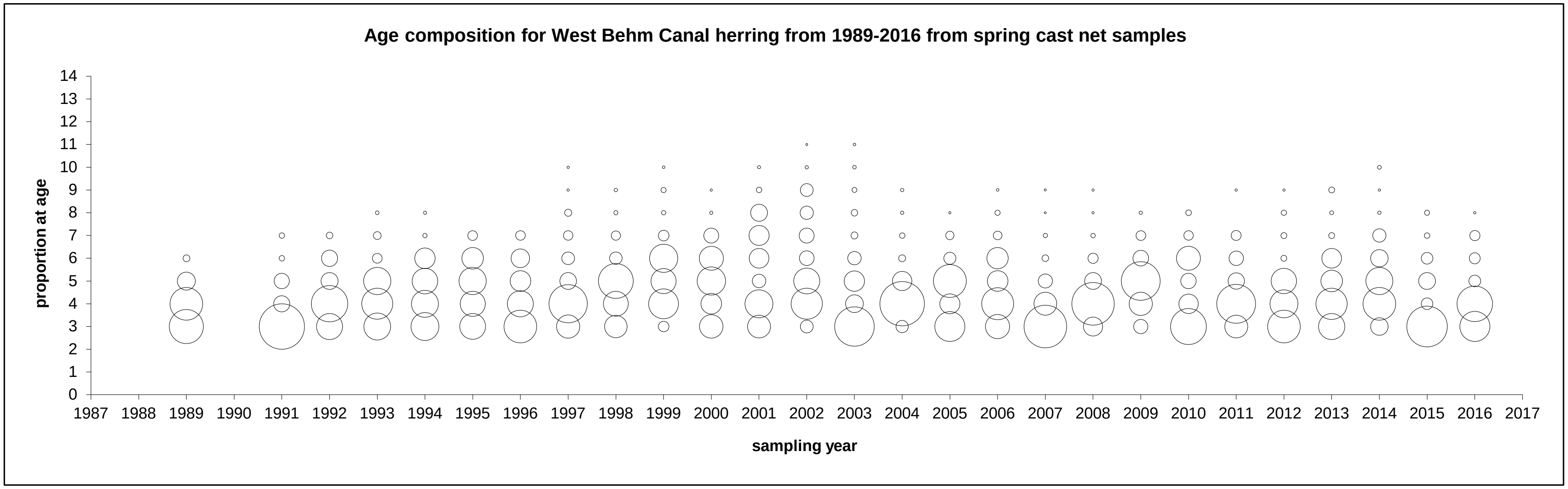

Figure 33.–Age composition from sampling data for the West Behm Canal herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

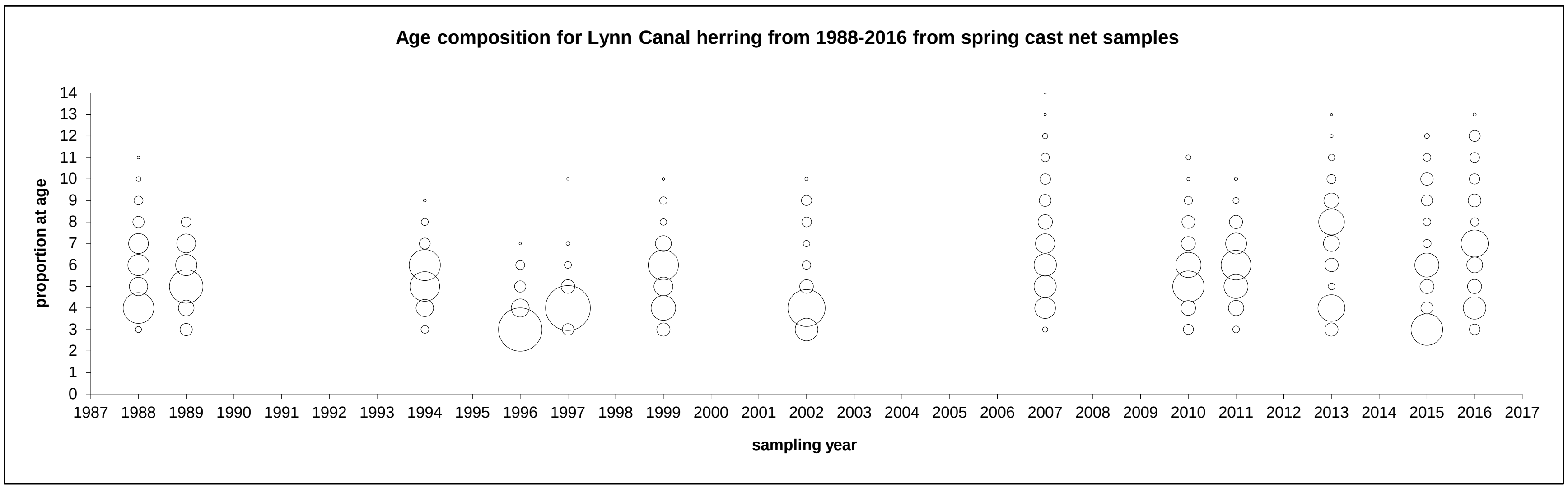

Figure 34.–Age composition from sampling data for the Lynn Canal herring stock.

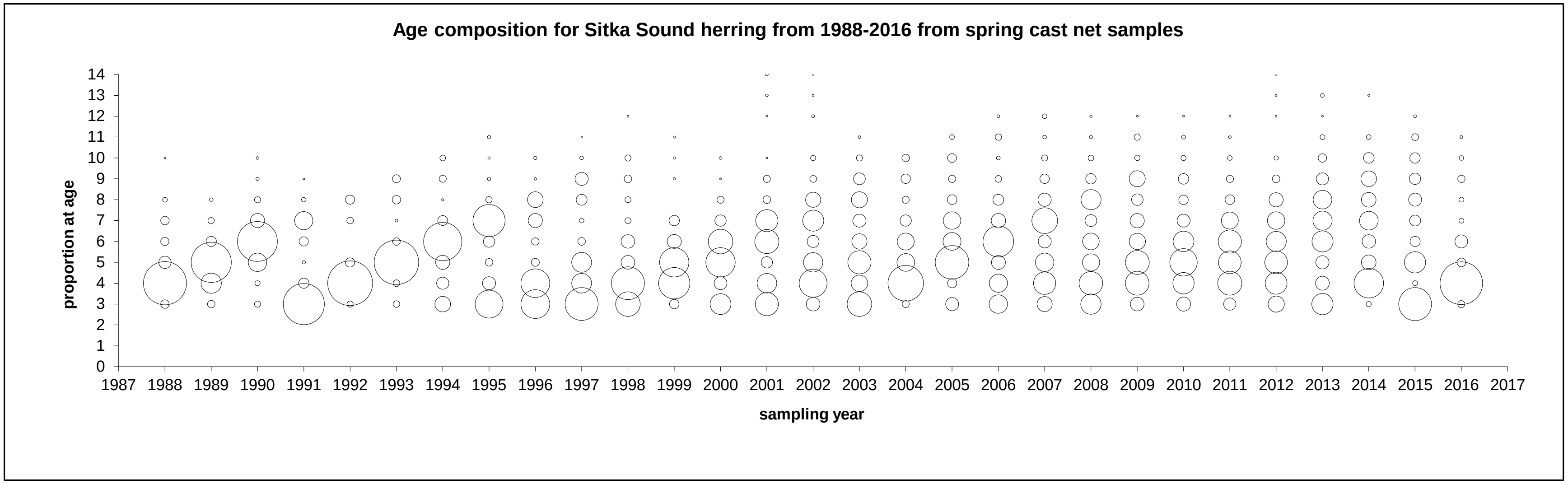

Figure 35.–Age composition from sampling data for the Sitka Sound herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

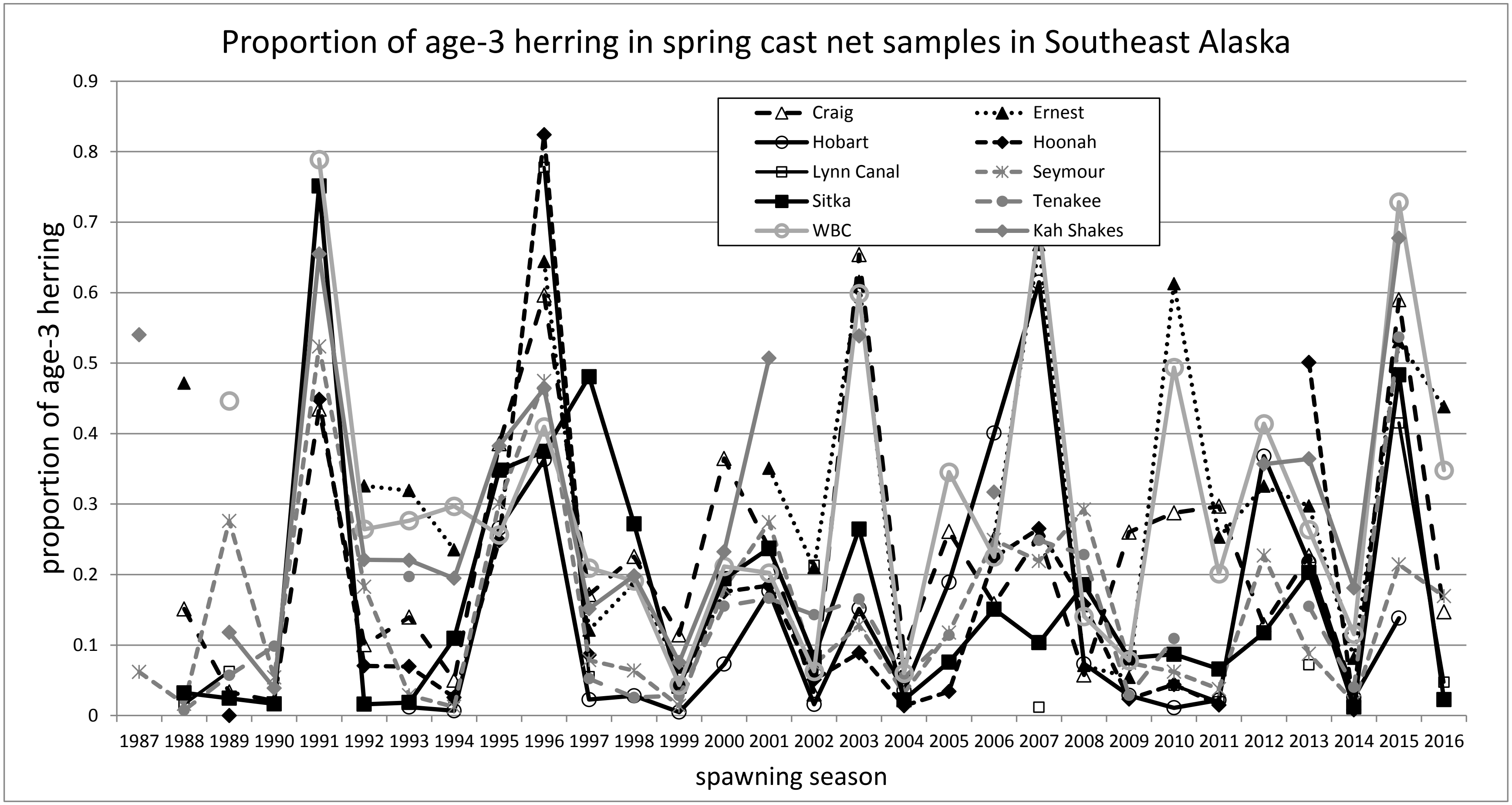

Figure 36.–Proportion of age-3 herring in spring cast nest samples of spawning populations for stocks in Southeast Alaska.

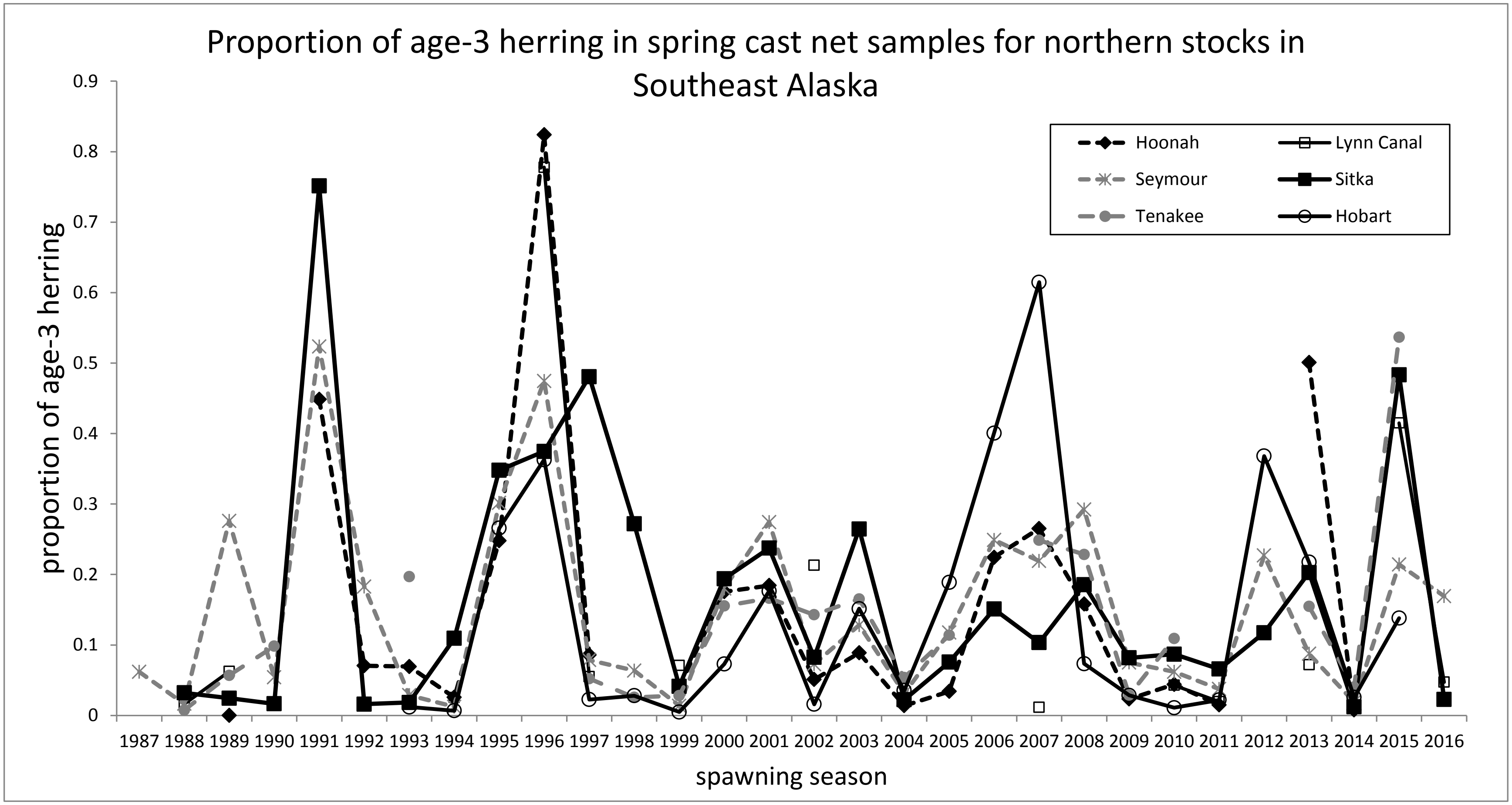

Figure 37.–Proportion of age-3 herring in spring cast nest samples of spawning populations for northern stocks in Southeast Alaska.

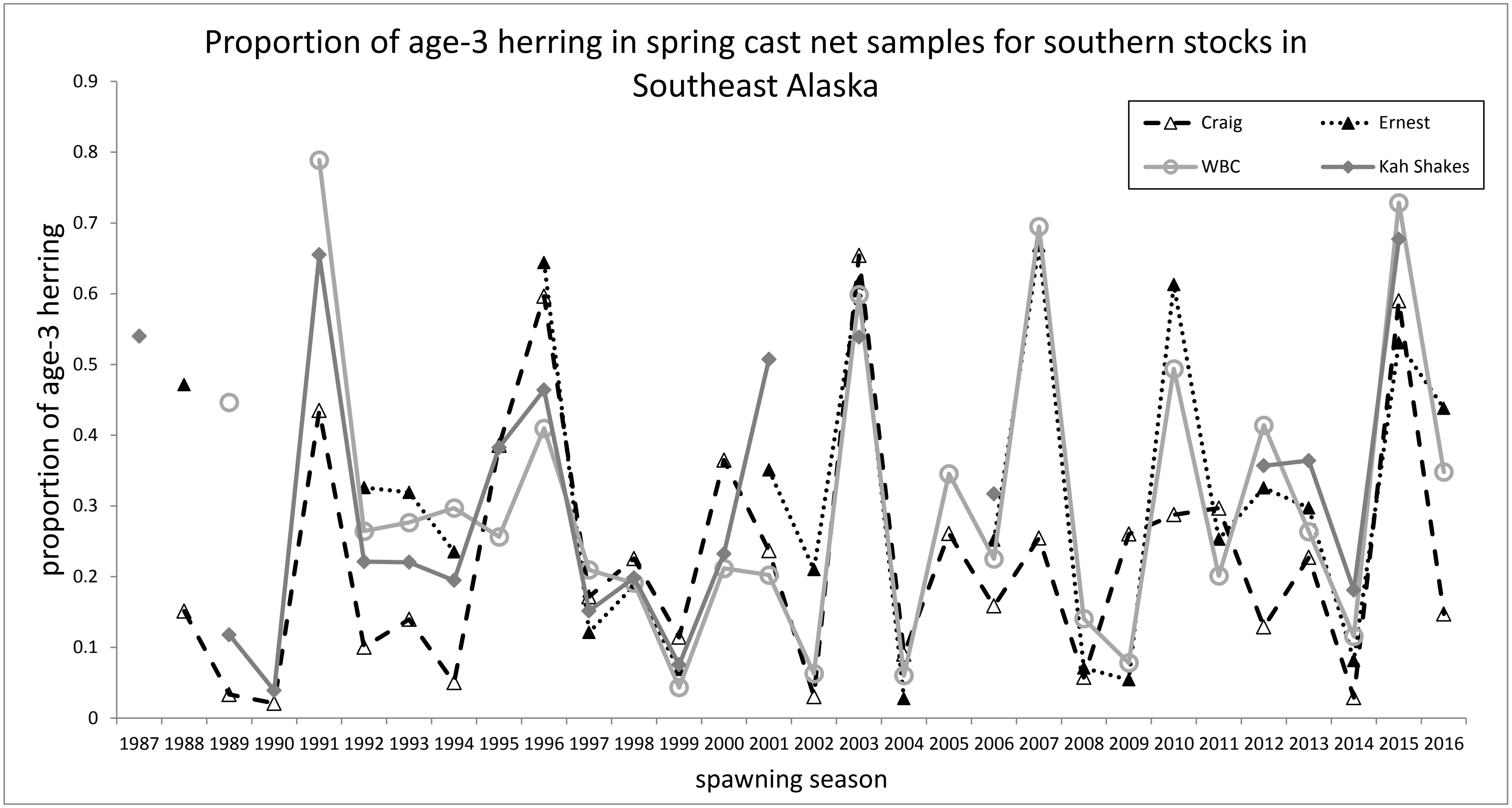

Figure 38.–Proportion of age-3 herring in spring cast nest samples of spawning populations for southern stocks in Southeast Alaska.

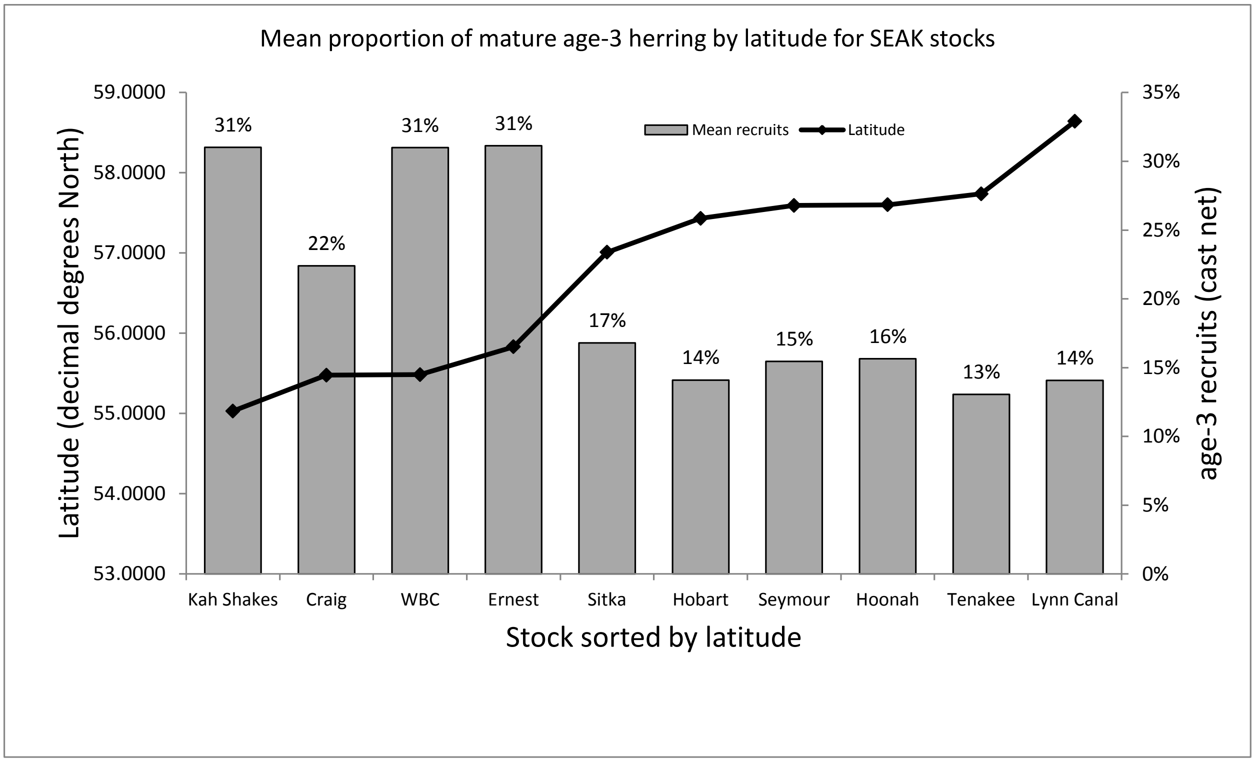

Figure 39.–Mean proportion of age-3 herring in spring cast nest samples (1988–2016) and latitude of spawning populations for stocks in Southeast Alaska.

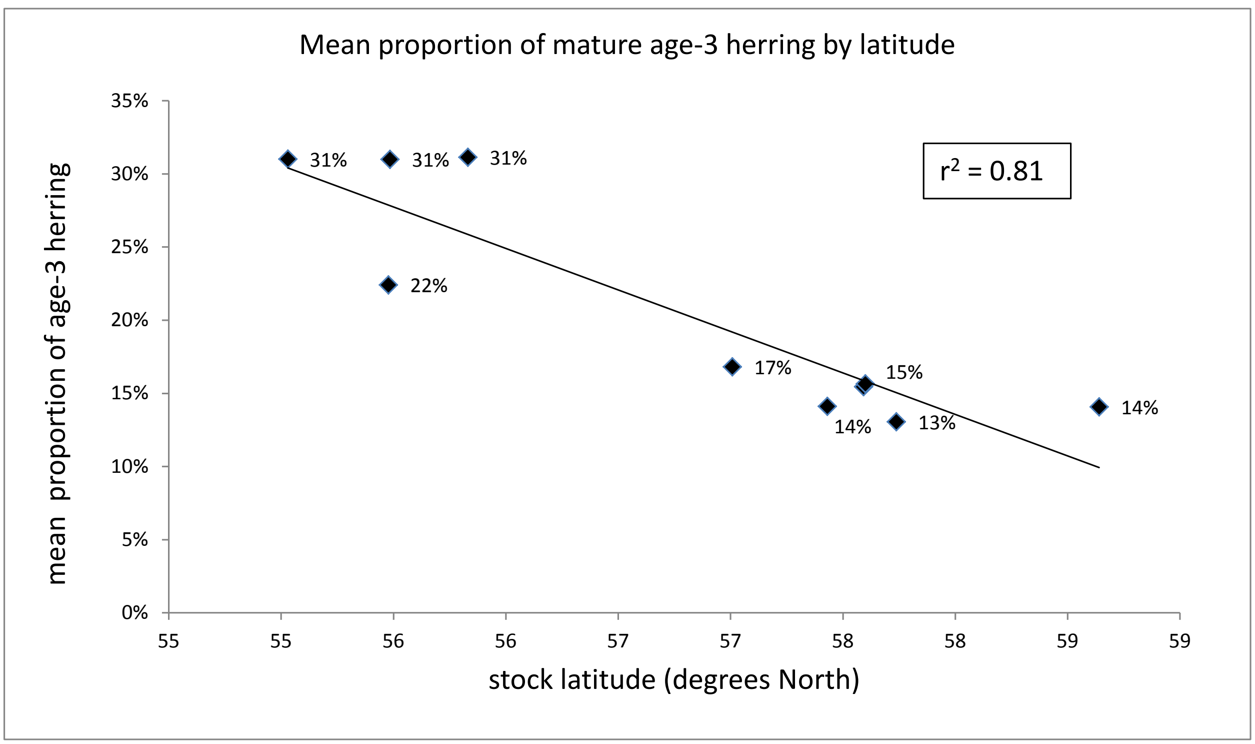

Figure 40.–Mean proportion of age-3 herring in spring cast nest samples versus stock latitude of spawning stocks in Southeast Alaska.

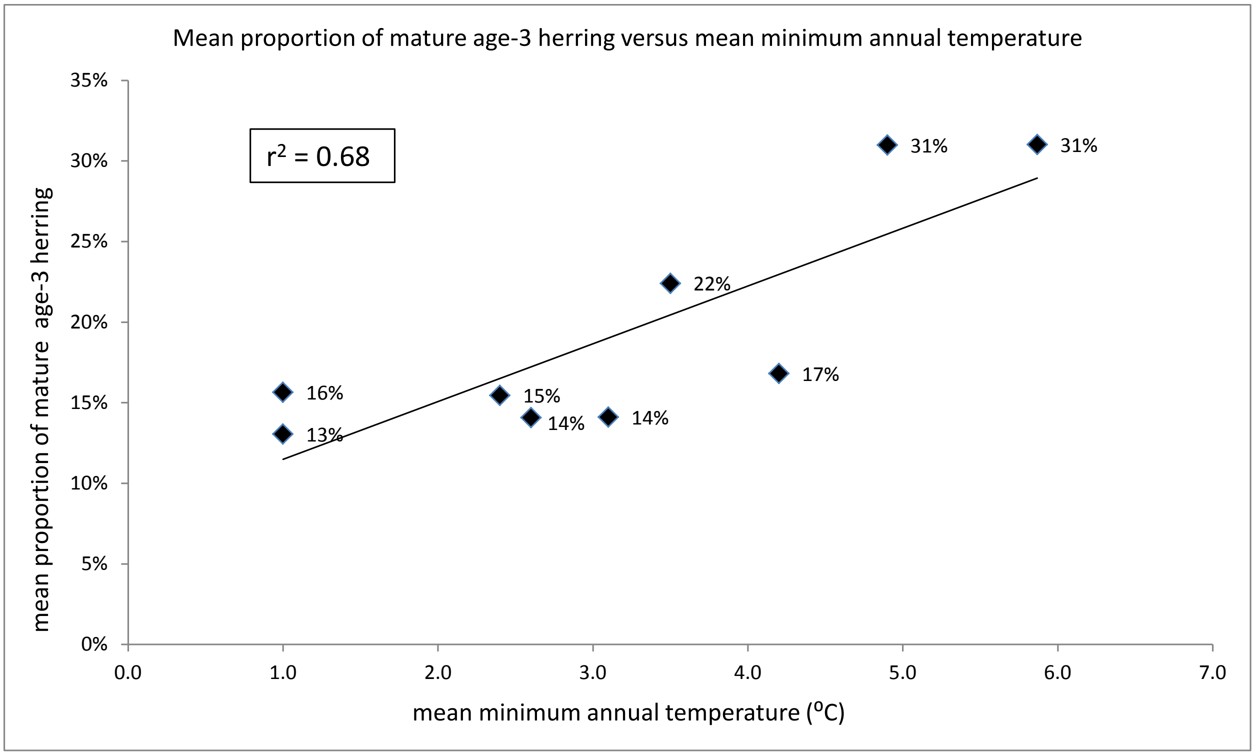

Figure 41.–Mean proportion of age-3 herring in spring cast nest samples versus mean minimum annual sea water temperature at location of spawning stocks in Southeast Alaska.

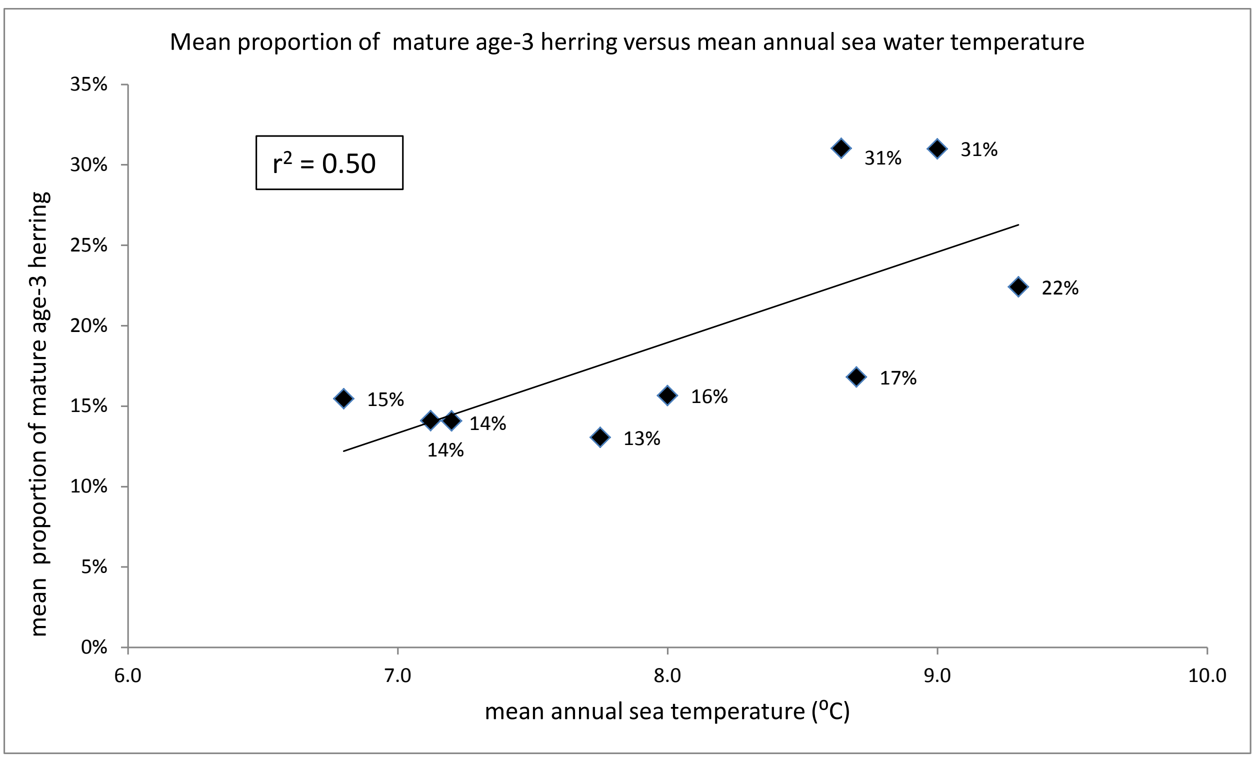

Figure 42.–Mean proportion of age-3 herring in spring cast nest samples versus mean annual sea water temperature at location of spawning stocks in Southeast Alaska.

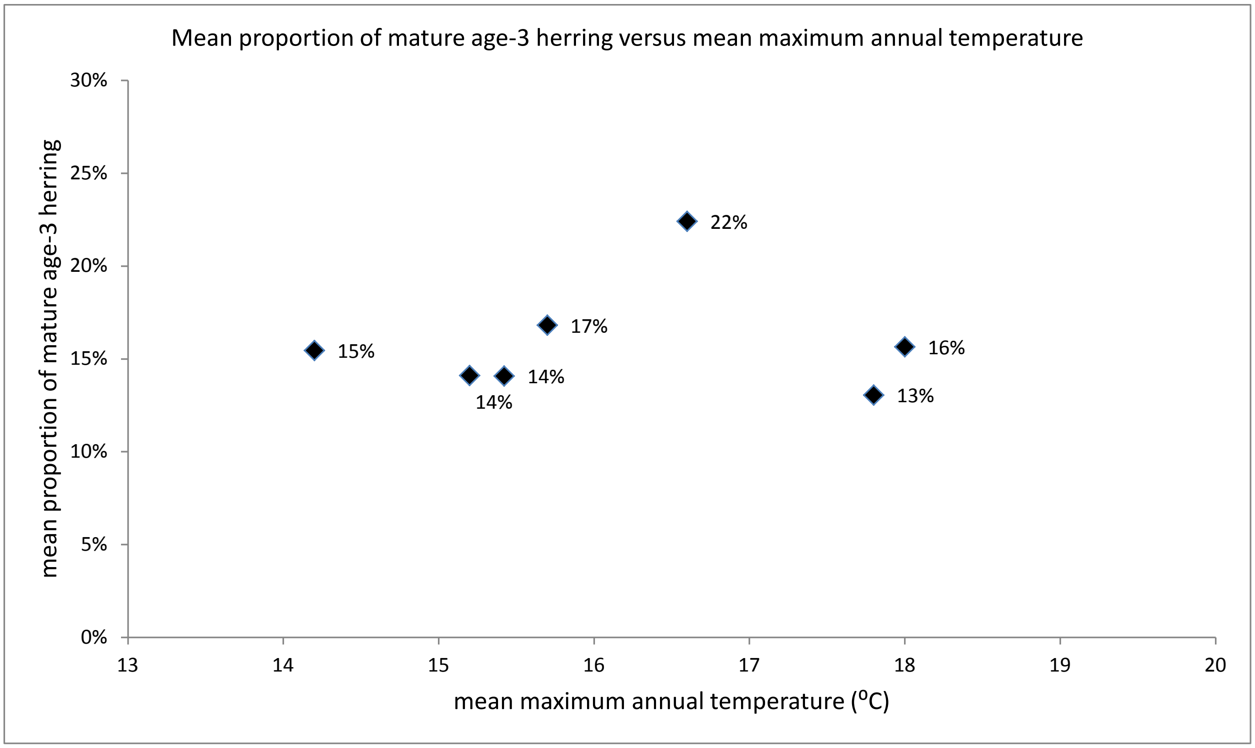

Figure 43.–Mean proportion of age-3 herring in spring cast nest samples versus mean maximum annual sea water temperature at location of spawning stocks in Southeast Alaska.

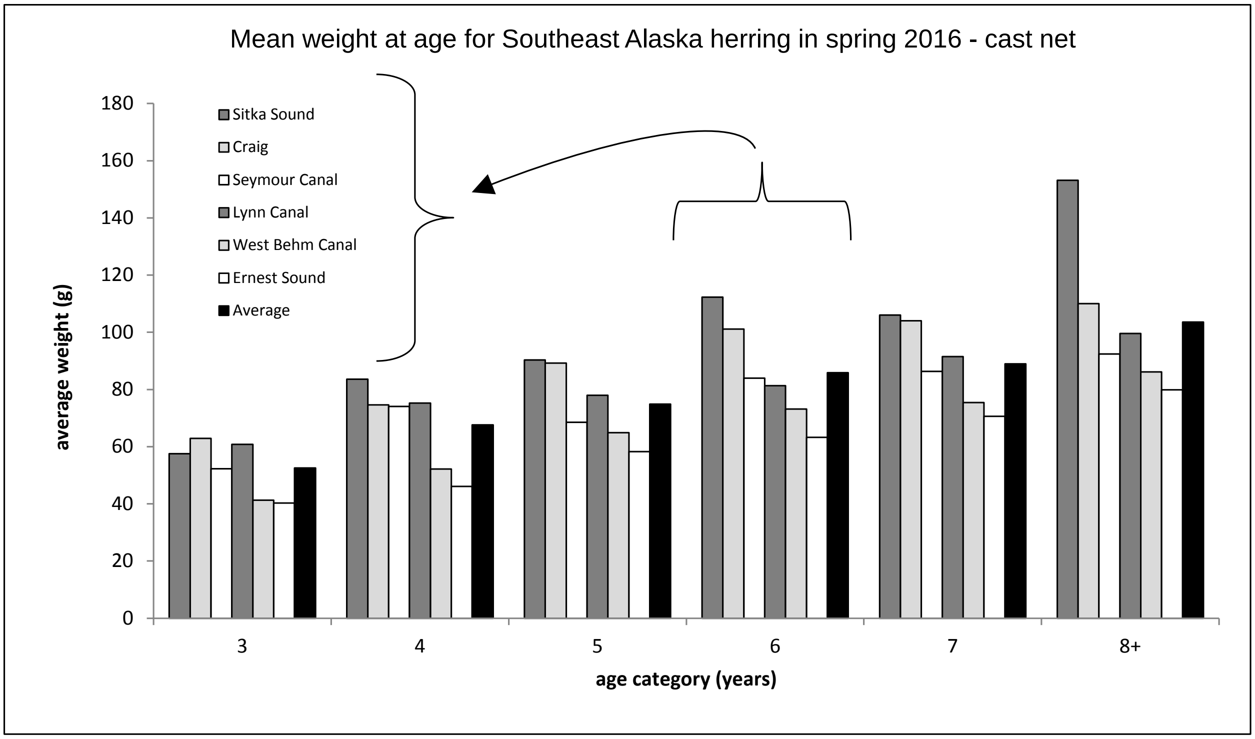

Figure 44.–Mean weight-at-age for Southeast Alaska herring stocks in spring 2016, sorted by age-6.

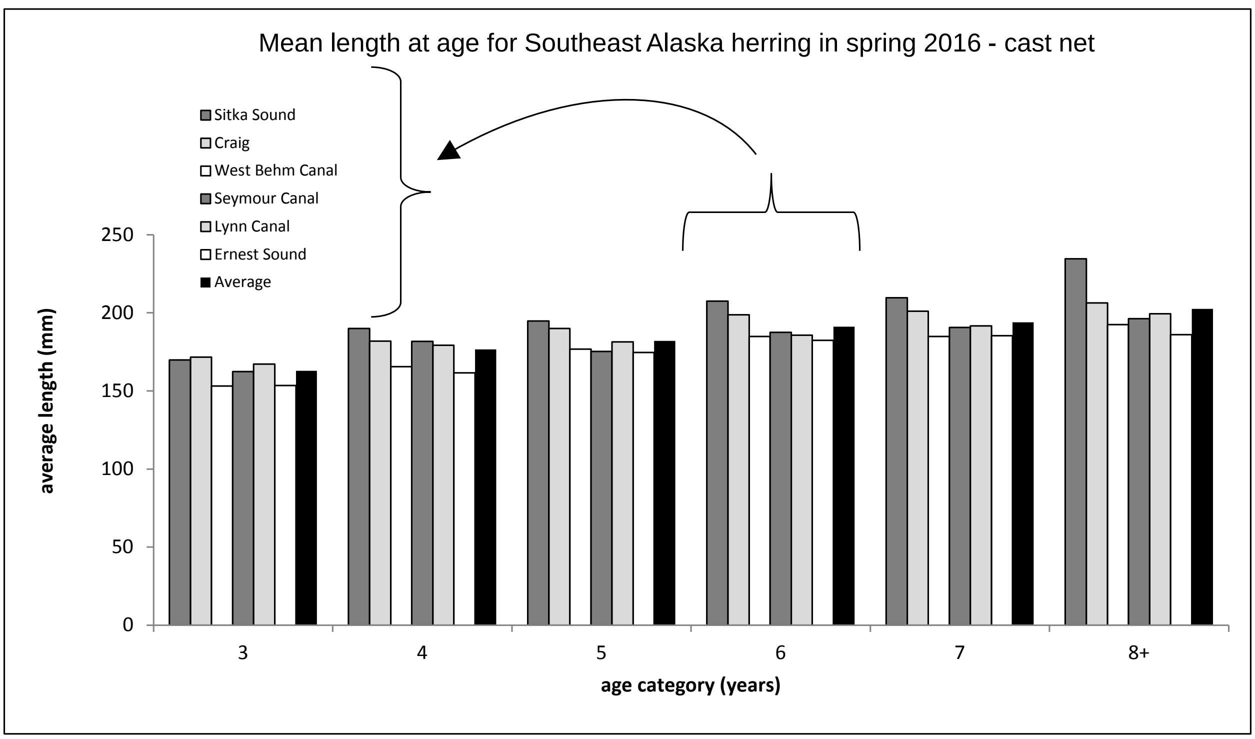

Figure 45.–Mean length at age for Southeast Alaska herring stocks in spring 2016, sorted by age-6.

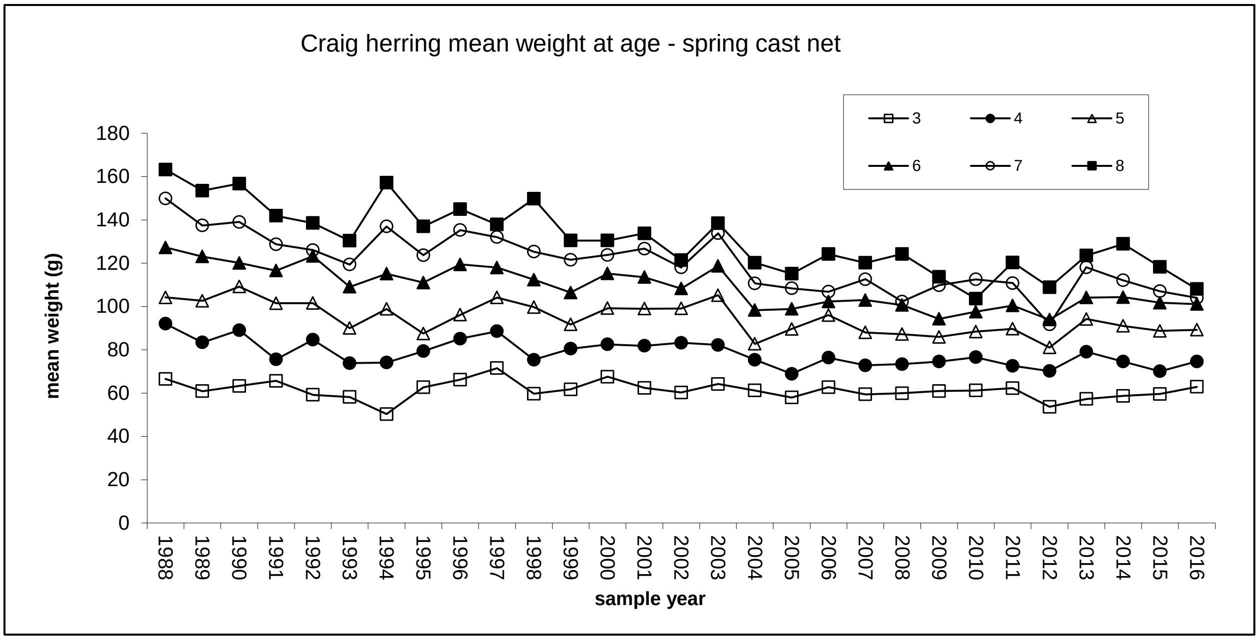

Figure 46.–Mean weight-at-age of the Craig herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

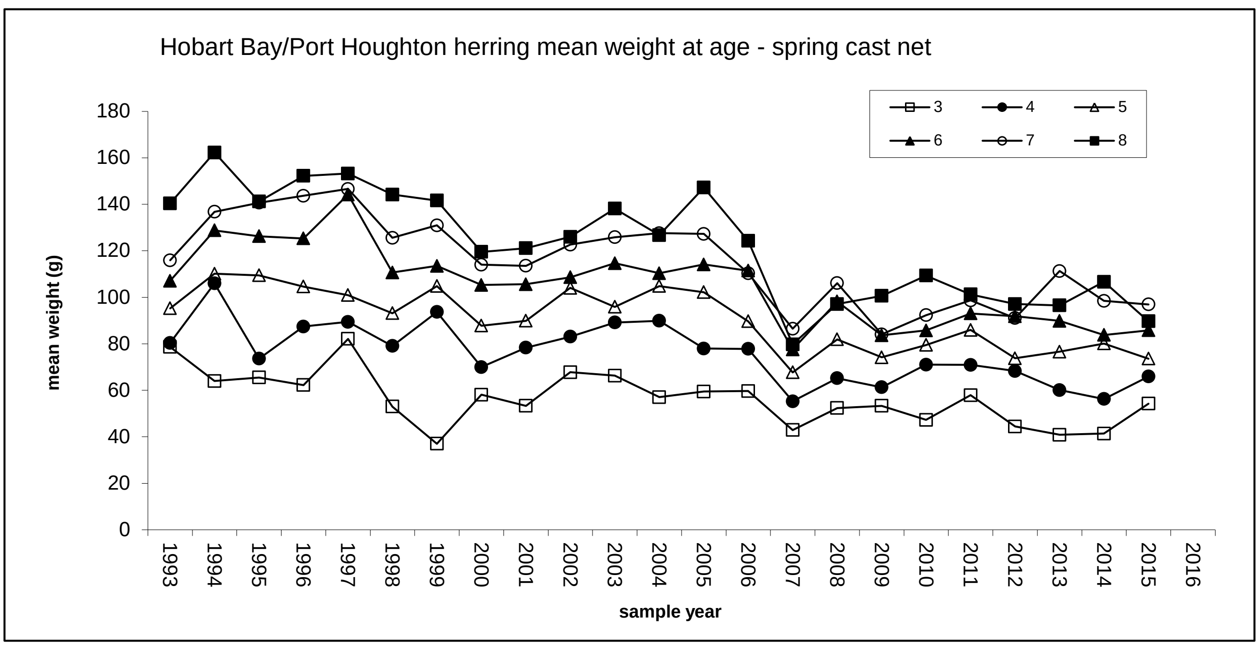

Figure 47.–Mean weight at age of the Hobart Bay/Port Houghton herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

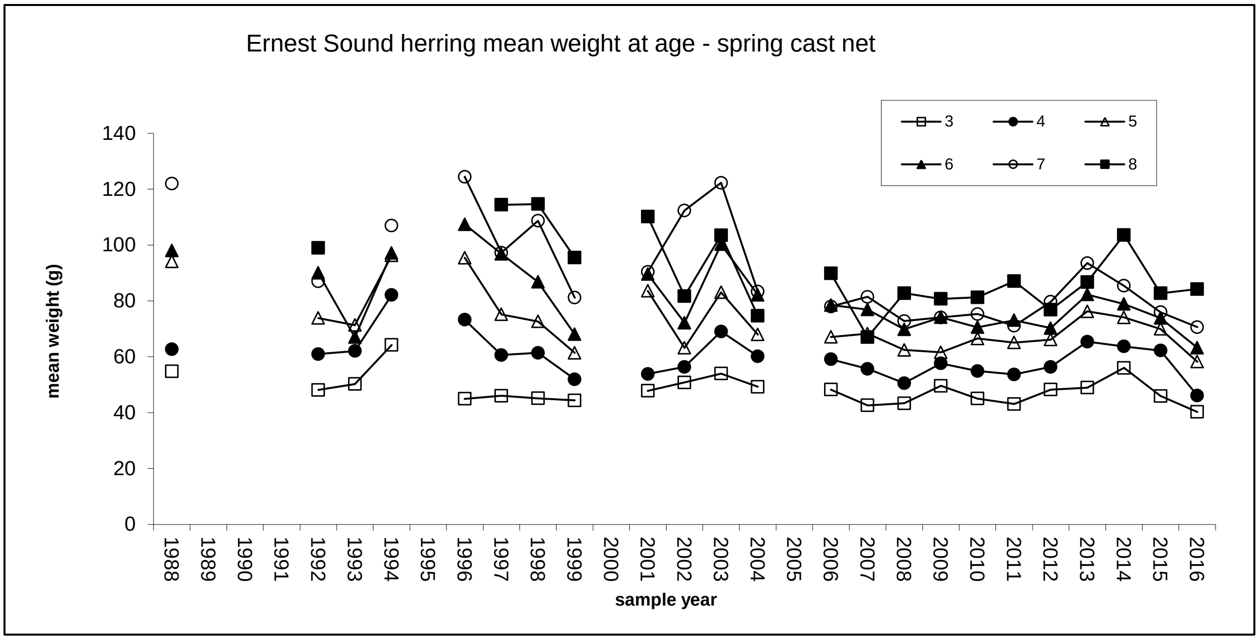

Figure 48.–Mean weight at age for the Ernest Sound herring spawning population.

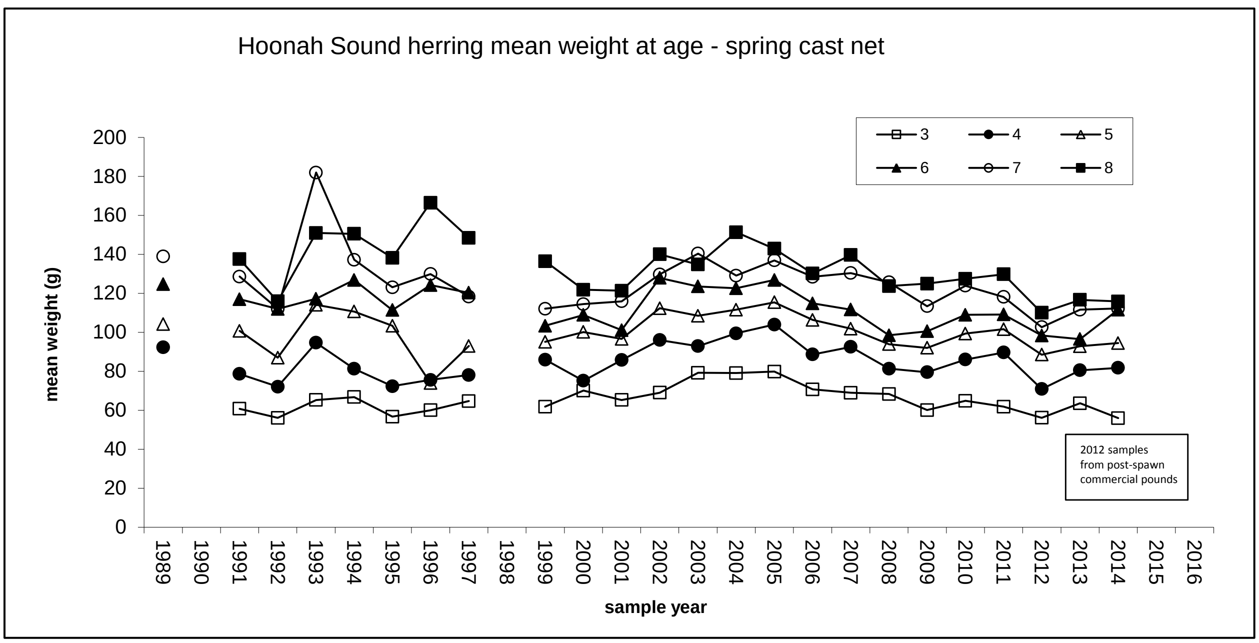

Figure 49.–Mean weight at age for the Hoonah Sound herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

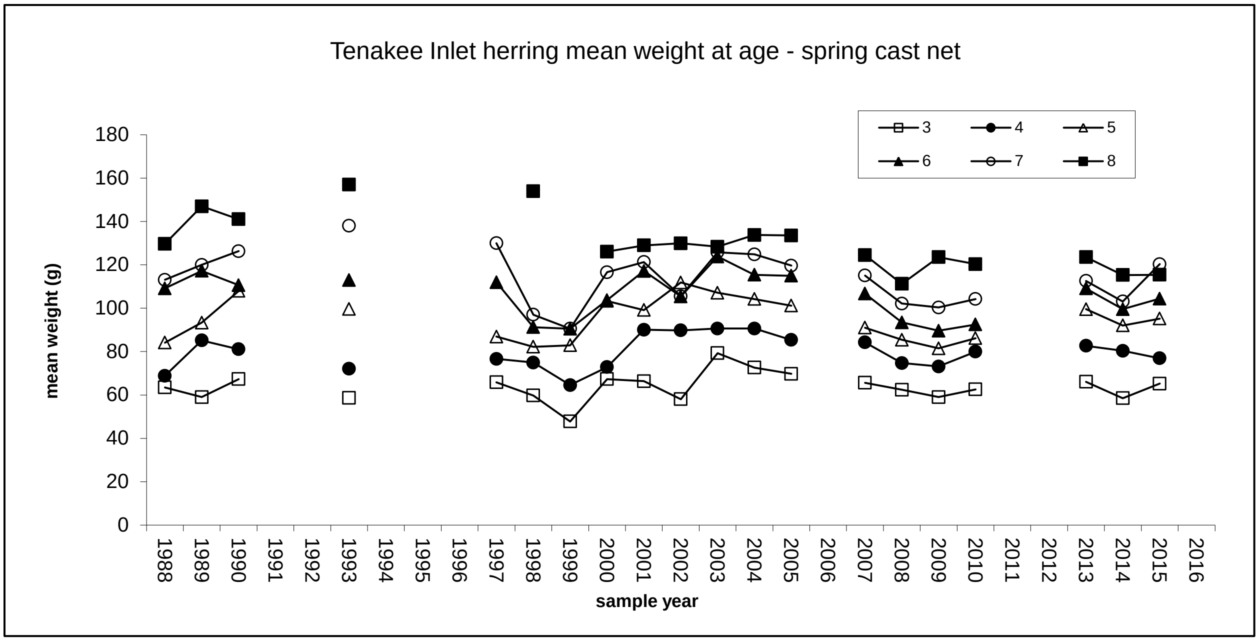

Figure 50.–Mean weight at age for the Tenakee Inlet herring stock. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

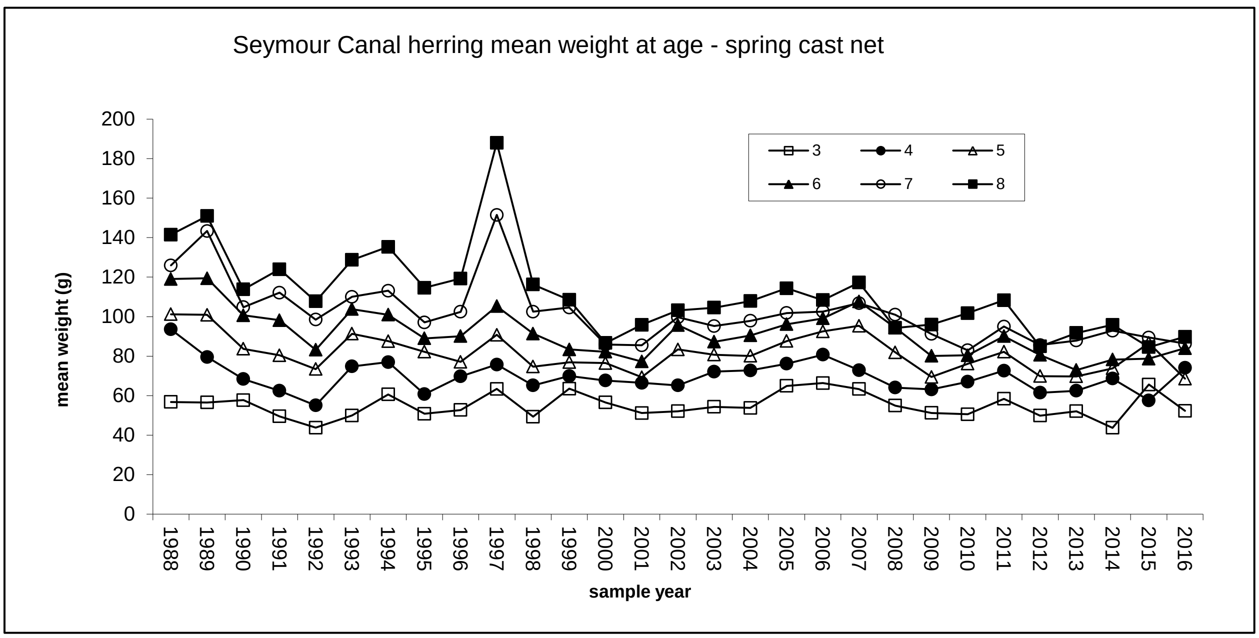

Figure 51.–Mean weight at age for the Seymour Canal herring stock. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

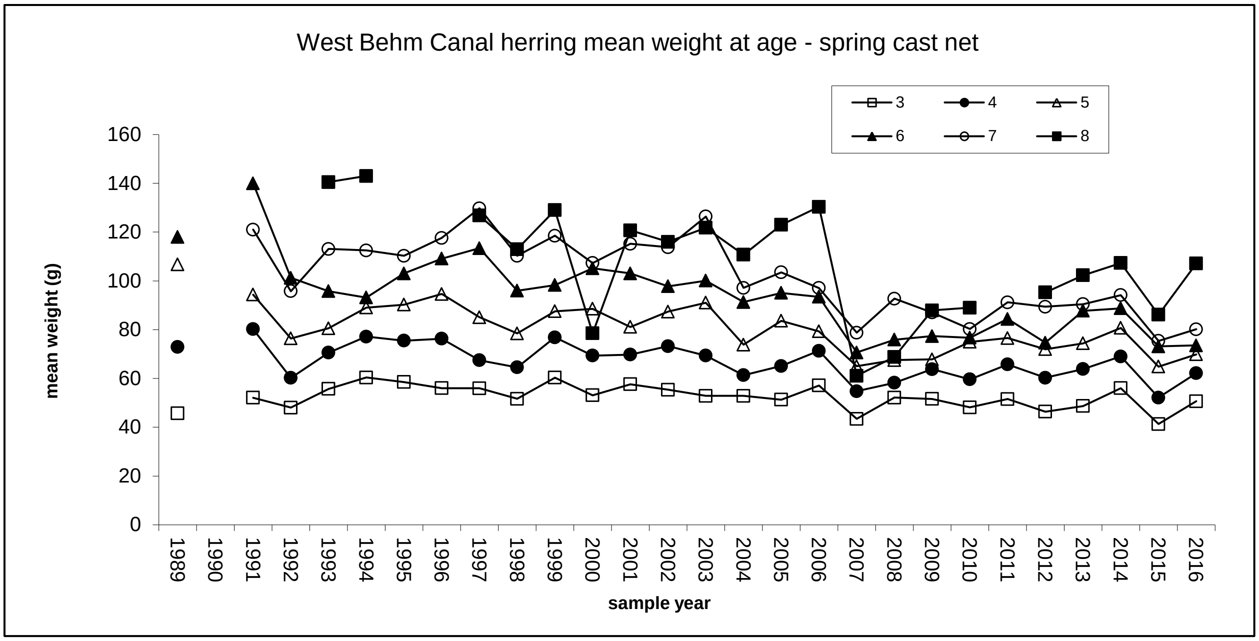

Figure 52.–Mean weight at age for the West Behm Canal herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli. 2015 weights are likely biased low due to required additional sample handling that resulted in loss of weight.

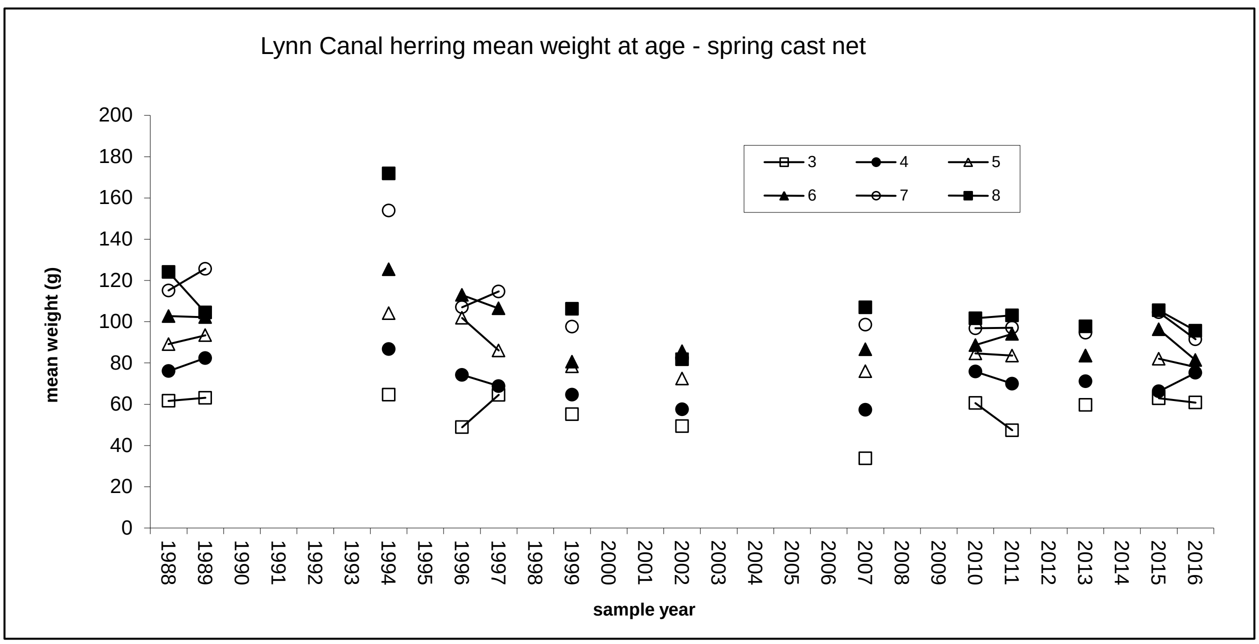

Figure 53.–Mean weight at age for the Lynn Canal herring spawning population.

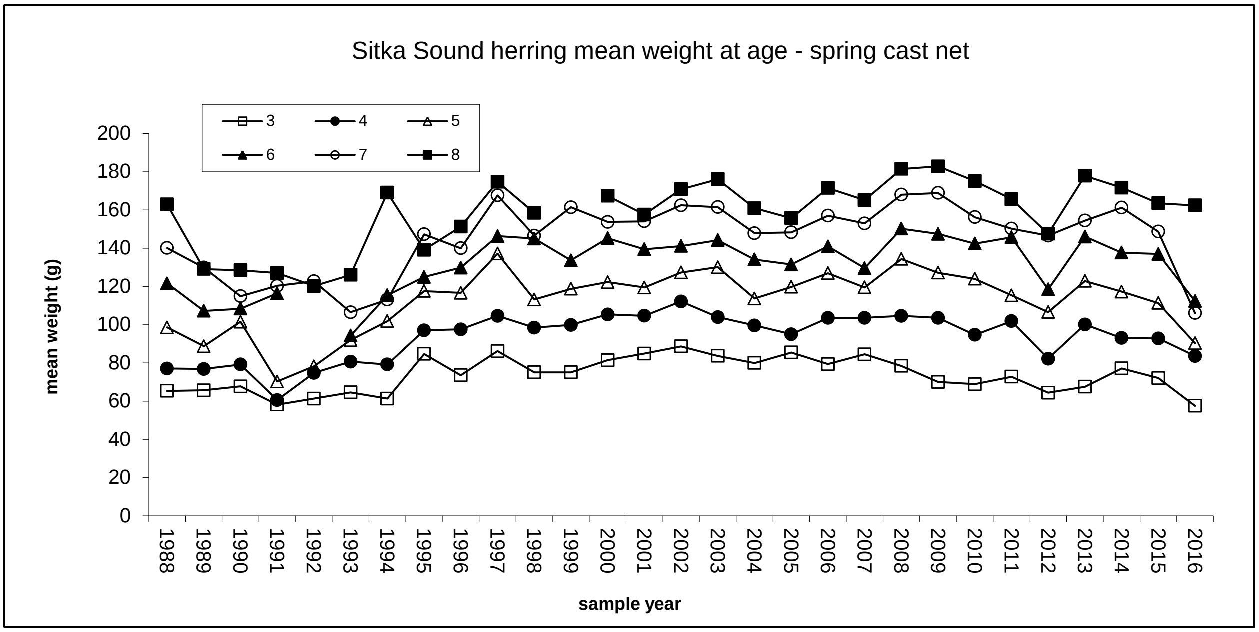

Figure 54.–Mean weight at age for the Sitka Sound herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

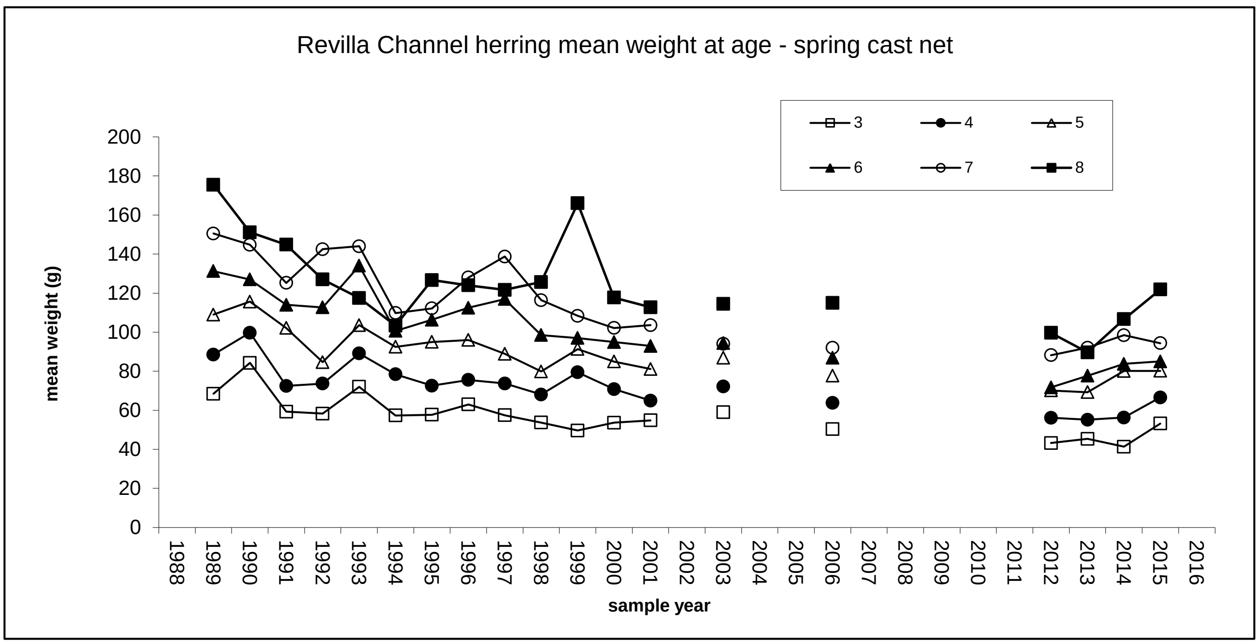

Figure 55.–Mean weight at age for the Revilla Channel herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

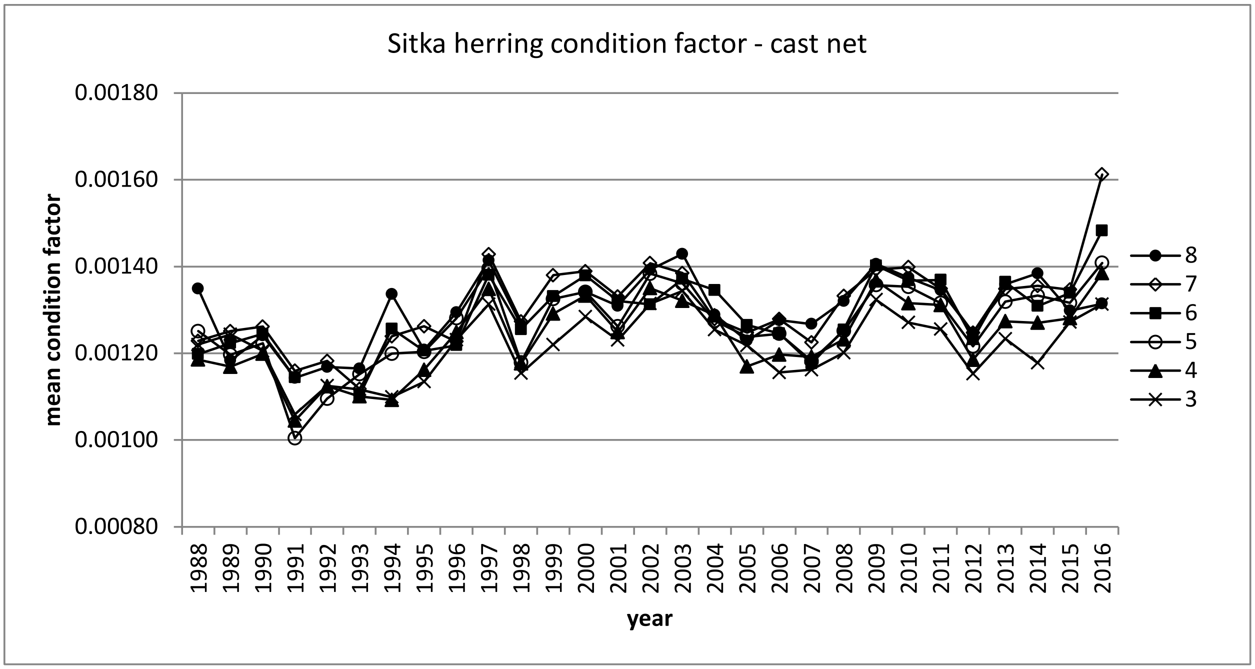

Figure 56.–Mean condition factors of age-3 through age-8 herring for the Sitka Sound spawning population, based on spring cast net samples taken during active spawning. 2016 values may be biased high due to length measurements that were likely underestimated.

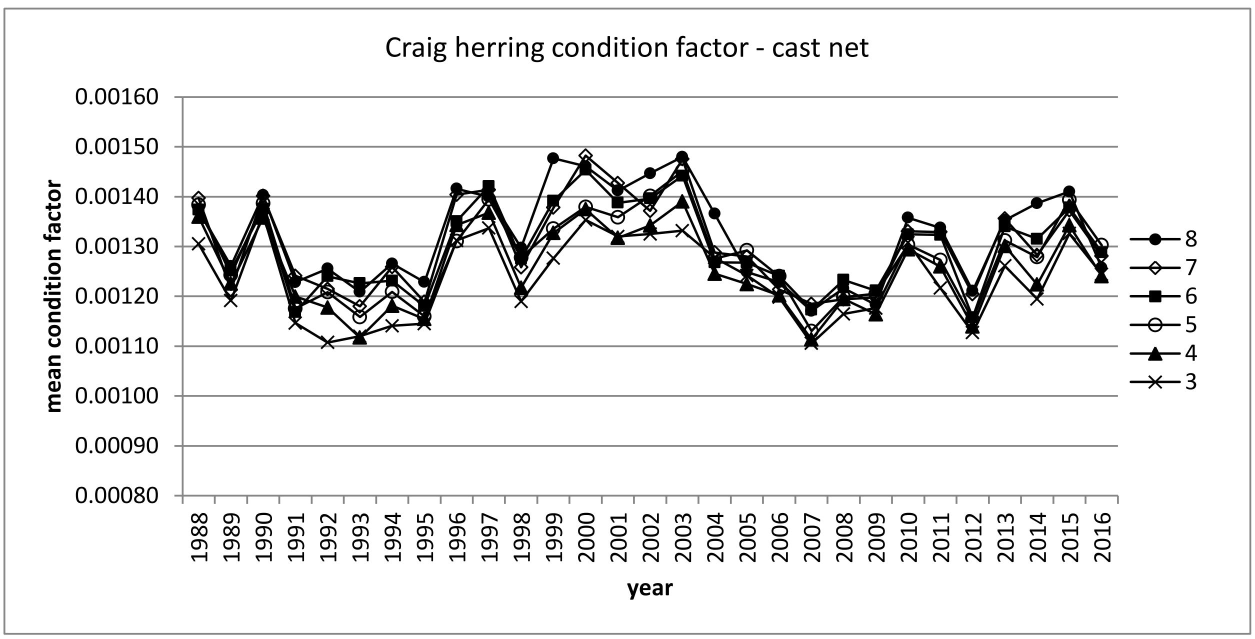

Figure 57.–Mean condition factors of age-3 through age-8 herring for the Craig spawning population, based on spring cast net samples taken during active spawning.

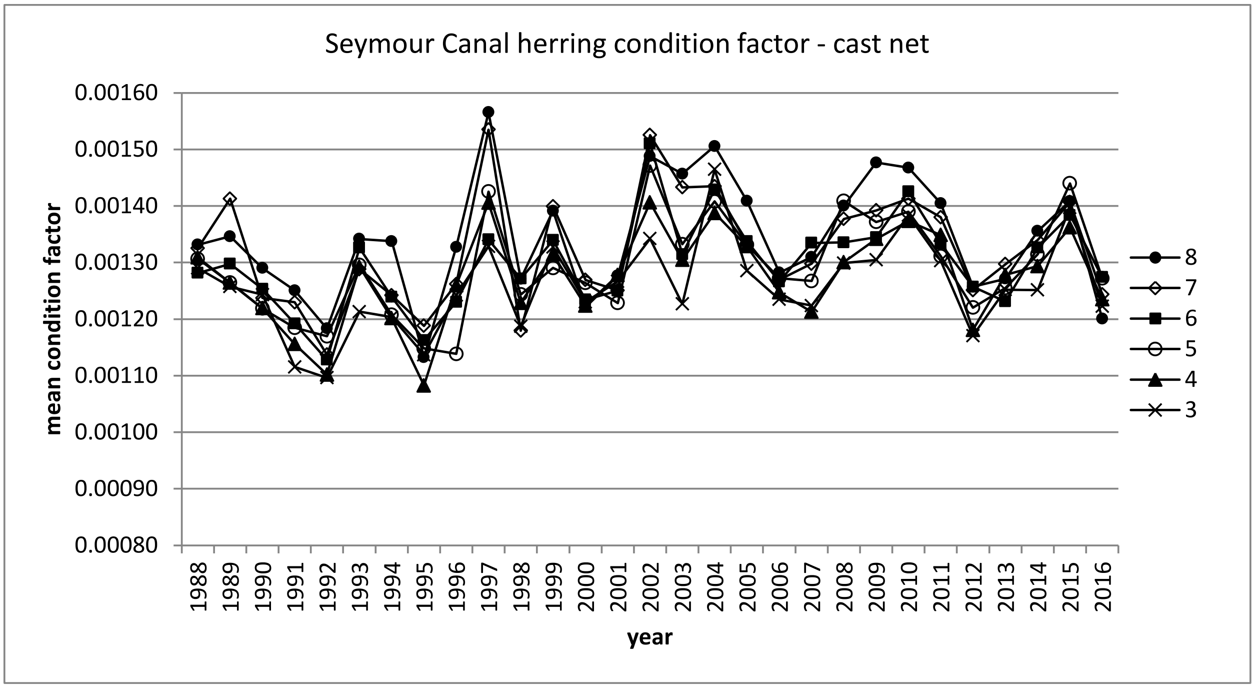

Figure 58.–Mean condition factors of age-3 through age-8 herring for the Seymour Canal spawning population, based on spring cast net samples taken during active spawning.

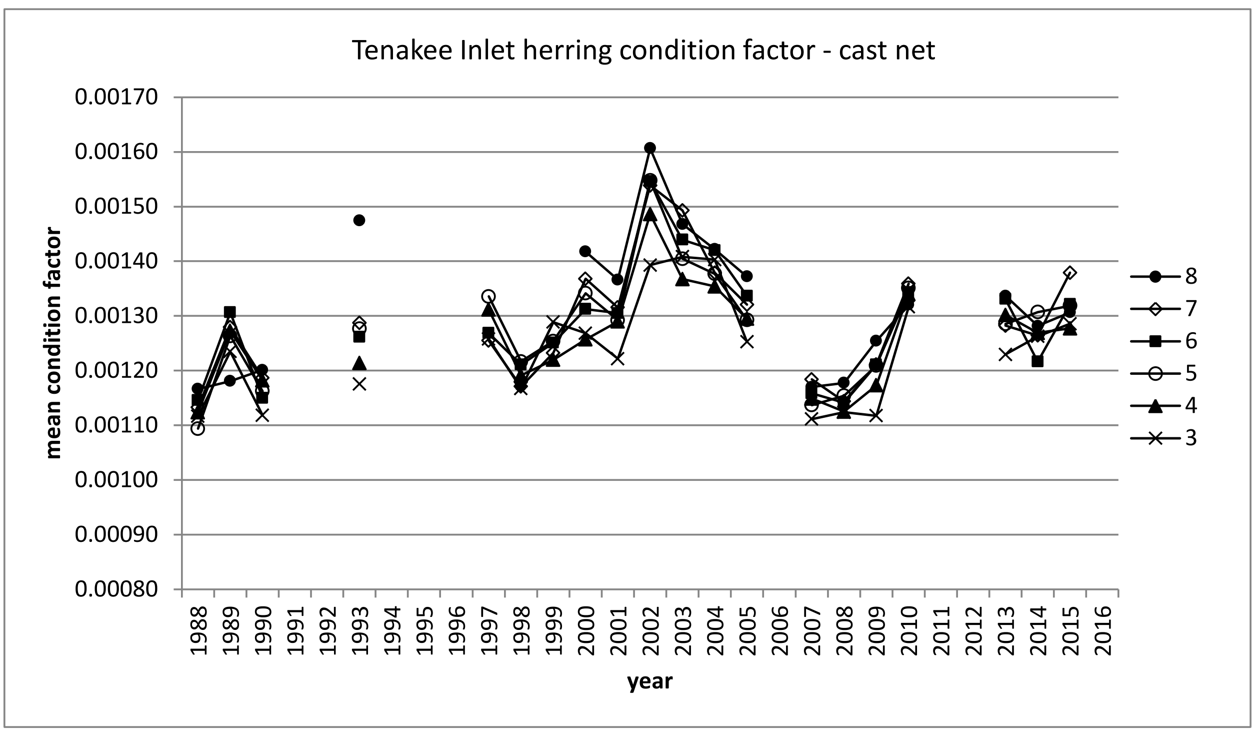

Figure 59.–Mean condition factors of age-3 through age-8 herring for the Tenakee Inlet spawning population, based on spring cast net samples taken during active spawning.

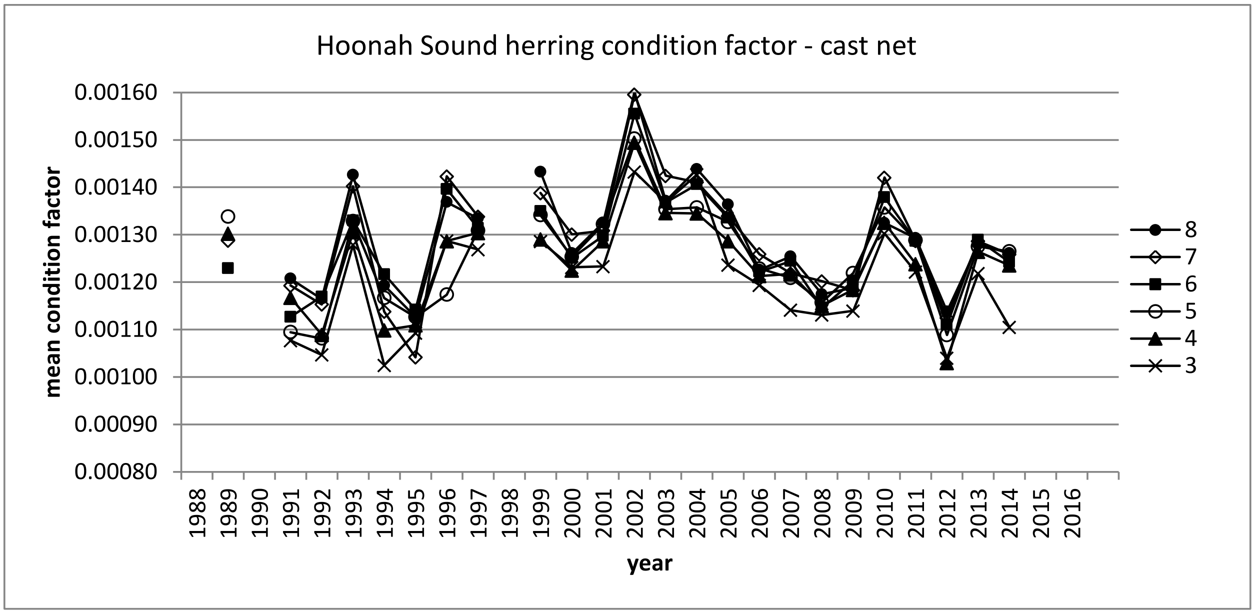

Figure 60.–Mean condition factors of age-3 through age-8 herring for the Hoonah Sound spawning population, based on spring cast net samples taken during active spawning.

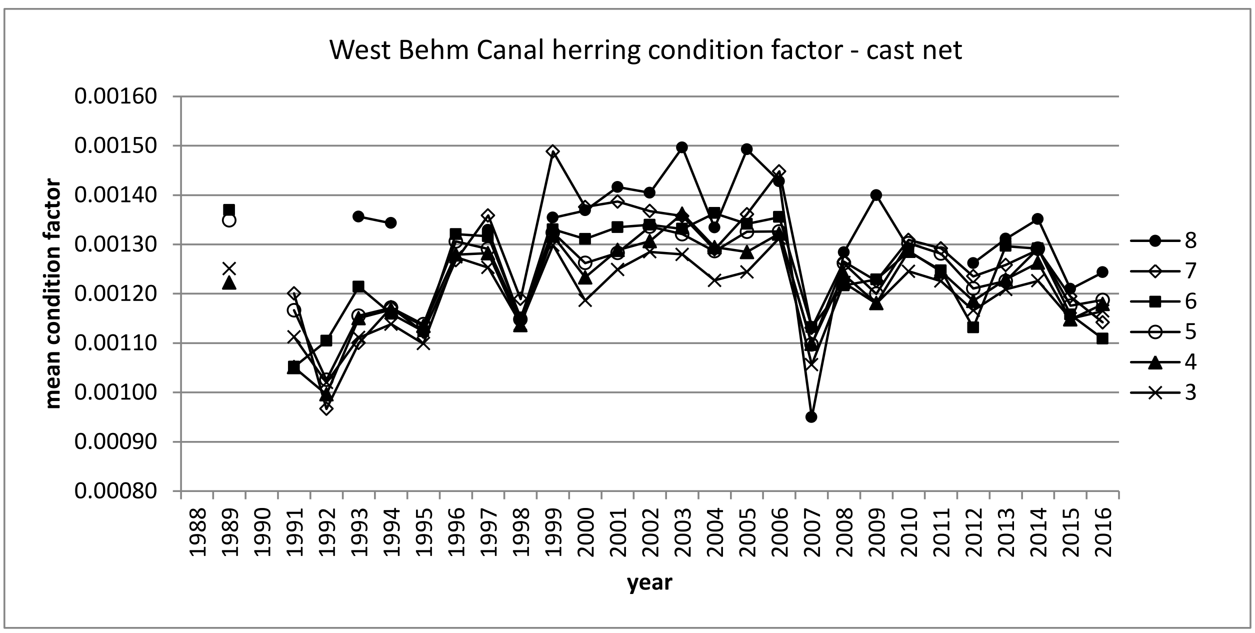

Figure 61.–Mean condition factors of age-3 through age-8 herring for the West Behm Canal spawning population, based on spring cast net samples taken during active spawning. 2015 condition factors are likely biased low due to required additional sample handling that resulted in loss of weight.

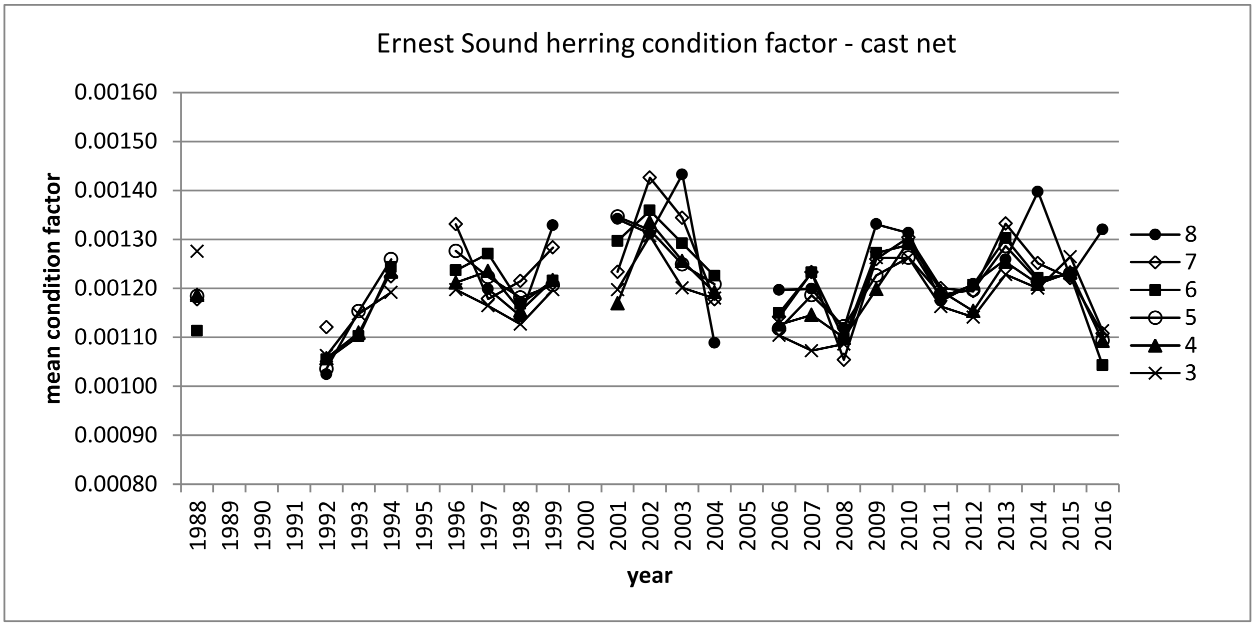

Figure 62.–Mean condition factors of age-3 through age-8 herring for the Ernest Sound spawning population, based on spring cast net samples taken during active spawning.

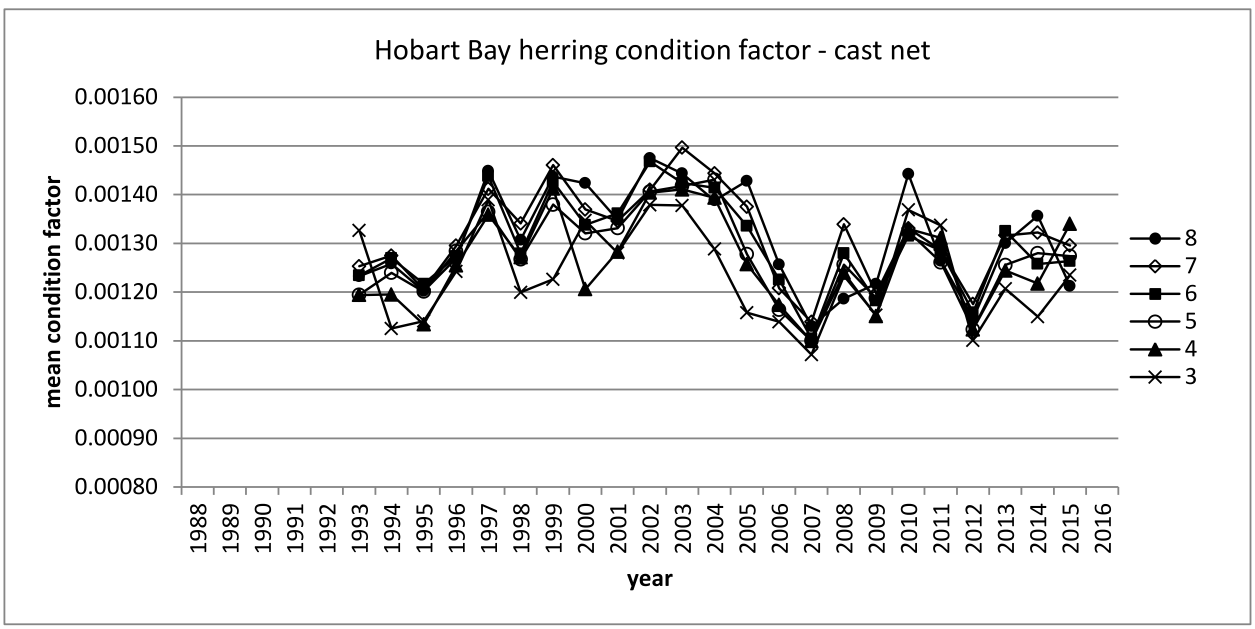

Figure 63.–Mean condition factors of age-3 through age-8 herring for the Hobart Bay spawning population, based on spring cast net samples taken during active spawning.

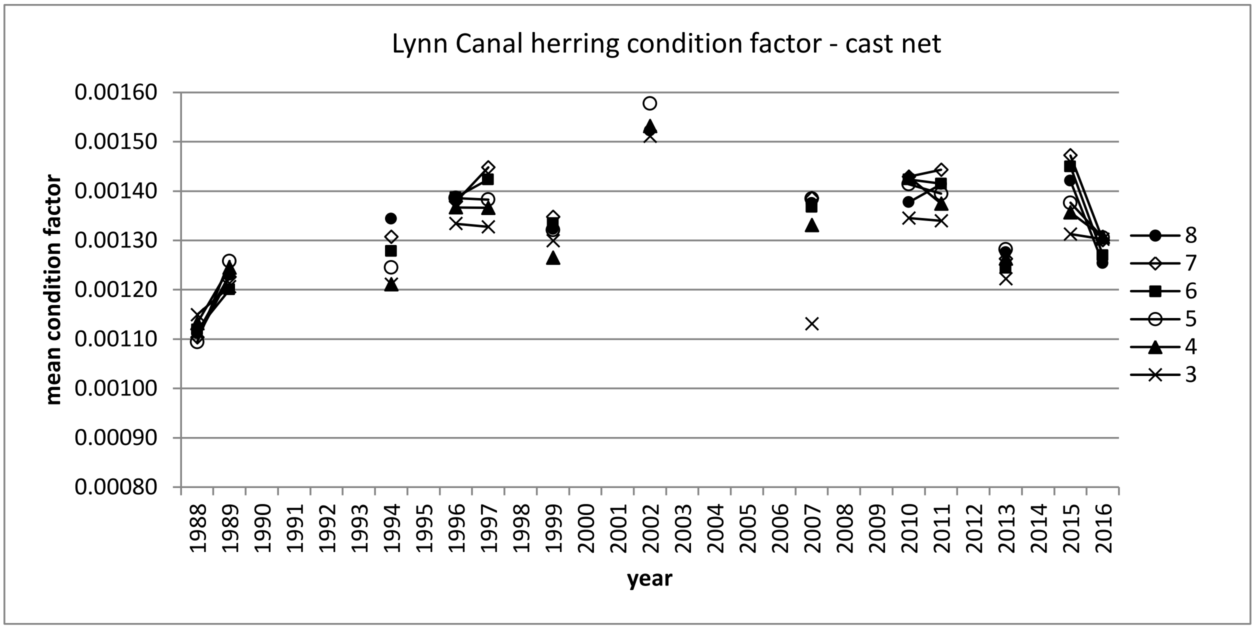

Figure 64.–Mean condition factors of age-3 through age-8 herring for the Lynn Canal spawning population, based on spring cast net samples taken during active spawning.

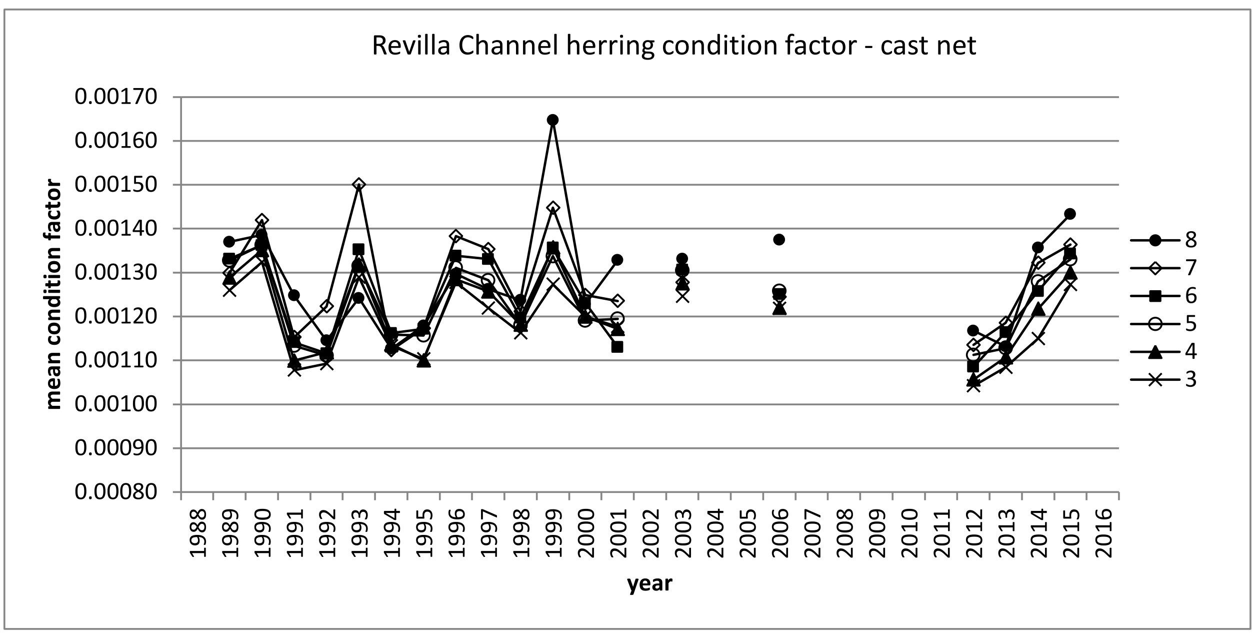

Figure 65.–Mean condition factors of age-3 through age-8 herring for the Revilla Channel spawning population, based on spring cast net samples taken during active spawning.

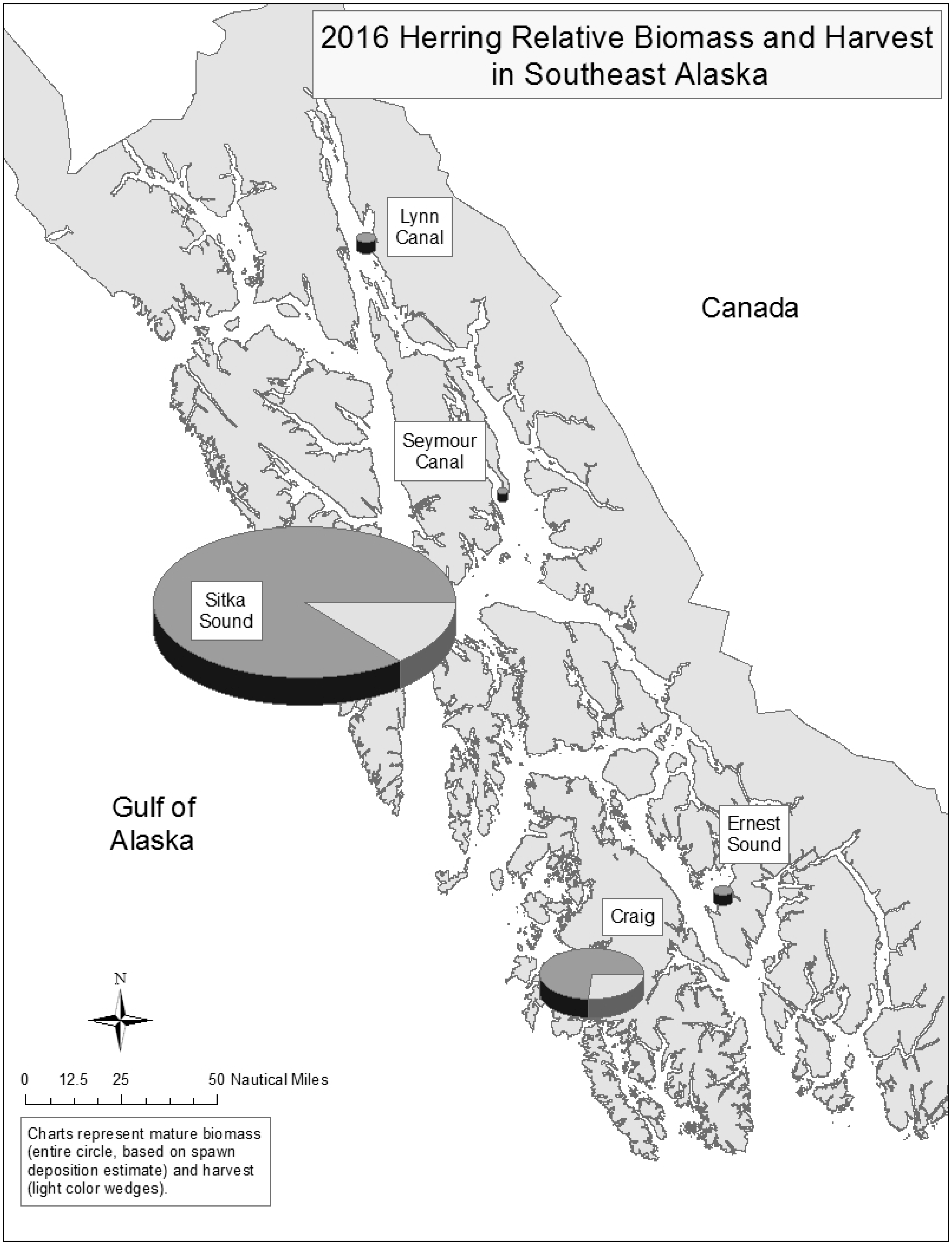

Figure 66.–Relative magnitude of herring spawning stocks and harvest levels in Southeast Alaska, based on biomass estimates converted from spawn deposition estimates. White wedges are intended to provide approximate indication of relative harvest, but do not represent actual exploitation rate.

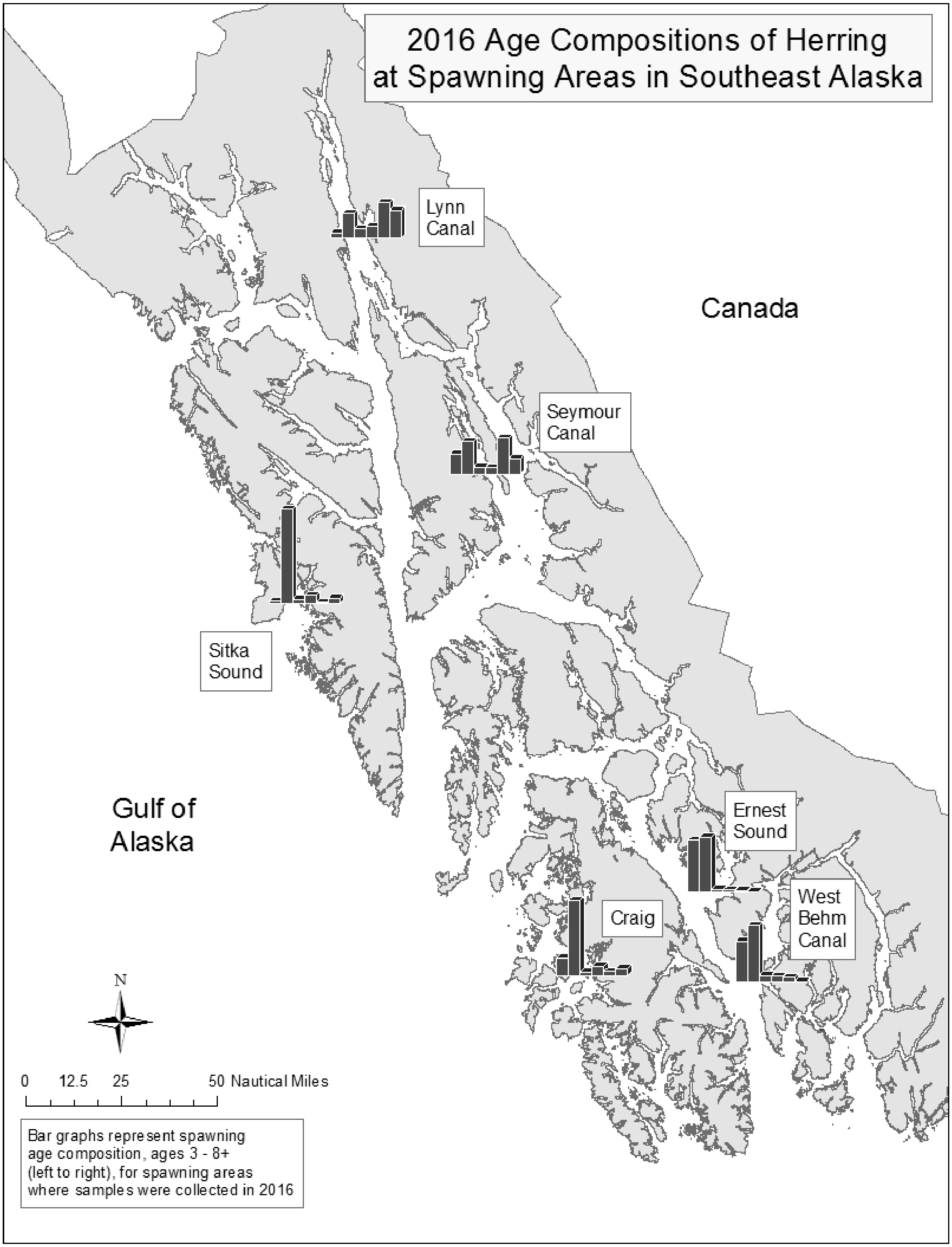

Figure 67.–Regional comparison of age composition of herring spawning stocks in Southeast Alaska from cast net sampling.

APPENDIX A: KEY TO VEGETATIVE SUBSTRATE TYPES USED FOR HERRING SPAWN DEPOSITION SURVEY

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	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 B: KEY TO BOTTOM TYPES USED FOR HERRING SPAWN DEPOSITION SURVEY

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: SPAWN SURVEYS BY DATE

Appendix C1.–Aerial and skiff herring spawn surveys by date, in Revilla Channel, Craig, and West Behm Canal (Ketchikan Management Area), Southeast Alaska in 2016.

Total spawn documented by ADFG in Revilla Channel for 2016 is 12.5 nautical miles. 11.9 nmi of spawn in state waters and 0.6 nmi of spawn on Annette Island.

Total spawn documented by ADFG in Craig for 2016 was 12.3 nautical miles.

Total spawn documented by ADFG in West Behm Canal for 2016 is 4.3 nautical miles.

Revilla Channel

March 19, 2016	No activity.
March 22, 2016	No activity.
March 28, 2016	No activity.
March 29, 2016	**0.5 nmi of spawn.**
March 30, 2016	**2 nmi of spawn.**
March 31, 2016	**4 nmi of spawn.**
April 1, 2016	**5 nmi of spawn.**

Craig

March 16, 2016	Large numbers of predators in the Craig area.
March 18, 2016	Large numbers of predators in the Craig area.
March 19, 2016	Decreased predator activity.
March 20, 2016	Increased predator activity. Schools of herring observed.
March 21, 2016	Schools of herring throughout the area.
March 22, 2016	**Spot spawn**. Predators and herring observed throughout the area.
March 24, 2016	Predators and herring observed throughout the area.
March 25, 2016	**2.3 nmi of spawn.** Predators and herring observed.
March 26, 2016	**4.0 nmi of spawn.** Predators and herring throughout the area**.**
March 27, 2016	**6.0 nmi of spawn.**
March 28, 2016	**6.7 nmi of spawn.**
March 29, 2016	**2.2 nmi of spawn.**
March 30, 2016	**0.9 nmi of spawn.**
March 31, 2016	**0.2 nmi of spawn.**
April 1, 2016	The department estimates that the spawning event is over.

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West Behm	
March 28, 2016	No activity.
March 31, 2016	Minimal predator activity.
April 2, 2016	**Spot Spawn.**
April 3, 2016	**No activity.**
April 4, 2016	**2.3 nmi of spawn.**
April 5, 2016	**No activity.**
April 6, 2016	**1.5 nmi of spawn.**
April 7, 2016	**1.1 nmi of spawn.**
April 8, 2016	The department estimates that the spawning event is over.

Appendix C2.–Aerial and skiff herring spawn surveys by date, in Sitka Sound and Hoonah Sound (Sitka Management Area), Southeast Alaska in 2016.

March 11: 10:00–11:15. Gordon/Coonradt. Today's aerial survey covered Sitka Sound north of Cape Burunof and Salisbury Sound. Spotting conditions were broken clouds with winds ESE 15–25. No herring or herring spawn was observed. The highest concentration of marine mammals was seen near Bieli Rock where numerous whales were seen working in deeper waters west of Bieli Rock with approximately 300 sea lions in several large groups holding off the rock piles. Four whales were in deeper waters between Big Gavanski Island and Promisla Bay; three whales were off Harbor Point, two whales in Nakwasina Sound and one whale in Katlian Bay. South of Sitka there were a number of whales scattered from Eastern Channel to Vitskari Rocks. In Salisbury Sound, three whales were seen in the vicinity of St. John Baptist Bay.

March 15: 9:00–10:00. Gordon/Jensen. Today's aerial survey coved Sitka Sound and south to Cape Burunof and north to Hayward Strait. Herring predators were concentrated in the areas west and north of Crow Island and in the Promisla Bay and Eastern Bay area. There was very little herring predator activity inside the island groups and along the Halibut Point Road shoreline. South of Sitka there was bird activity as well as several whales observed in the waters between Makhnati Island and Kulichkof Rock.

The Alaska Department of Fish and Game announced today that the Sitka Sound sac roe herring fishery will be on 2-hour notice effective 11:00 a.m., Thursday, March 17, 2016.

- *F/V Ace*, 10:30 a.m., Eastern Bay, 50 tons, 4.9% mature roe; 2.9% immature roe, 97 gm.
- *F/V Perseverance*, 12:30 p.m., N. Siganaka Isl., 200 tons, 9.9% mature roe; 2.4% immature roe, 118 gm.

March 16: 9:00–10:00. Coonradt. Today's aerial survey coved Sitka Sound and south to West Crawfish Inlet and north to Salisbury Sound. Herring predators were concentrated in the areas west and north of Crow Island and in the Promisla Bay and Eastern Bay area. There was very little herring predator activity inside the island groups and along the Halibut Point Road shoreline. South of Sitka there was no activity.

March 17: 08:00–09:15 Gordon/Dressel/Hebert. Today's aerial survey covered Sitka Sound north of Cape Burunof. Spotting conditions were broken clouds with calm winds. No spawn was observed. Herring predator activity was concentrated in northern Sitka Sound in the Hayward Strait area, in Promisla and Eastern Bays, and off Bieli Rock. Little activity was observed in areas south of Sitka.

- *F/V Wind Walker*, 8:00 a.m., W. Siganaka Isl., 250 tons, 10.9% mature roe; 0.7% immature roe, 119 gm.
- *F/V Hukilau*, 9:00 a.m., Gavanski Isl., 300 tons, 11.5% mature roe; 1.1% immature roe, 109 gm.
- *F/V Perseverance*, 10:00 a.m., Mountain Pt., 300 tons, 10.8% mature roe; 1.2% immature roe, 133 gm.

-continued-

- *F/V Confidence*, 9:45 a.m., Brents Beach, 30 tons, 7.5% mature roe; 1.2% immature roe, 107 gm.
- *F/V Invincible*, 12:00 p.m., Mountain Pt., 500 tons, 11.1% mature roe; 0.7% immature roe, 121 gm.

The Sitka Sound herring sac roe fishery was opened today in northwest Sitka Sound from 2:45 p.m. to 5:05 p.m. Preliminary hails from processors put the total harvest at 3,735 tons. The area opened included the waters of Sitka Sound along the Kruzof Island shoreline south of 57° 08.23′N latitude, north of 57° 05.00′N. latitude and west of 135° 32.00′W. longitude.

March 18: 08:00–09:10 Coonradt. Today's aerial survey coved Sitka Sound and south to Windy Pass. Spotting conditions were generally good with calm wind, and clear skies. A total **0.9 nautical miles of spawn** was recorded on Mountain Point and Inner Point. Herring predators were concentrated off the Kruzof Island shoreline between Inner Point and Mountain Point. There was little activity noted in the areas south of Sitka to Windy Pass.

For today, plans are to stand down on seeking a fishing opportunity to allow for processing of yesterday's harvest.

March 19: 08:00–09:15 Gordon/Gray. Today's aerial survey covered Sitka Sound north of Cape Burunof. Spotting conditions were clear skies with light winds. No herring were observed during today's aerial survey. There were several small areas of spawn observed near Halibut Point as well as a small spawn on the north side of Little Gavanski Island **totaling 0.2 nautical miles**. A major concentration of herring continues to stage off the Kruzof Island shoreline between Inner Point and Mountain Point.

- *F/V Ace*, 8:00 a.m., SE. Siganaka Isl., 50 tons, 9.2% mature roe; 1.4% immature roe, 110 gm.
- *F/V Kalliste*, 10:00 a.m., Promisla Bay, Unk, 9.5% mature roe; 1.1% immature roe, 106 gm.
- *F/V Optimus*, Unk, N. Inner Pt., 250 tons, 10.0% mature roe; 1.1% immature roe, 104 gm.
- *F/V Sequel*, Unk, Mountain Pt., 250 tons, 11.3% mature roe; 1.1% immature roe, 113 gm.
- *F/V Ace*, 11:00 a.m., N Krestof Sound, 50 tons, 12.4% mature roe; 0.4% immature roe, 116 gm.

The Sitka Sound herring sac roe fishery was opened in Krestof Sound from 3:15 p.m. to 5:15 p.m. Preliminary hails from processors put the total harvest at 5,100 tons. The area opened included the waters of Krestof Sound and Nakwasina Passage south of 57° 15.00 N latitude, north of 57° 09.40′N. latitude and west of 135° 30.00′W. longitude.

March 20: 09:00–10:10 Coonradt/Harris/Skeek. Today's aerial survey covered Sitka Sound south of Cape Burunof including Salisbury Sound. Spotting conditions were broken clouds with southeast winds at 15 knots. Active herring spawn was observed around Kamenoi Point **totaling 1.3 nautical miles**. Herring Schools were visible in north Krestof Sound, Sukoi Inlet and in St. John Baptist Bay. A major concentration of herring predators was observed off the Kruzof Island shoreline between Mountain Point and Rob Point, and in Salisbury Sound.

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<u>March 21</u>: 8:00–9:30 Coonradt/Gordon/Hebert. Today's aerial survey covered Sitka Sound north of Cape Burnof including Salisbury Sound. Spotting conditions were overcast skies with calm winds. A total **2.7 nautical miles of spawn** was recorded in Sitka Sound between Inner Point and Port Krestof, with smaller areas of spawn on north Middle Island, Little Gavanski Island, Rob Point, Mud Bay and in Nakwasina Passage. Today's aerial survey showed large schools of herring in Crescent Bay, Sukoi Inlet, Salibury Sound and St. John Baptist Bay. Major concentrations of herring predators continue to stage in Hayward Strait, Krestof Sound and Salisbury Sound.

- *F/V Anika*, 10:45 a.m., Salisbury Snd, Unk, 9.8% mature roe; 1.2% immature roe, 95 gm.
- *F/V Optimus*, Unk, S. Salisbury Snd., 100 tons, 11.3% mature roe; 0.8% immature roe, 104 gm.
- *F/V Anika*, Unk, Krestof Snd, Unk, 10.6% mature roe; 1.2% immature roe, 111 gm.
- *F/V Optimus*, 12:00 p.m., NE Krestof Snd, 200 tons, 11.6% mature roe; 0.4% immature roe, 115 gm.

<u>March 22</u>: 13:00–13:45 Gordon. Today's aerial survey covered Sitka Sound north of West Cape Burunof and south of Neva Strait. Spotting conditions were overcast skies and sw winds 15–25. A total **6.8 nautical miles of spawn** was recorded in Sitka Sound between Inner Point and Port Krestof, with smaller areas of spawn on north Middle Island, Little Gavanski Island, Kresta Point and Mud Bay. Today's aerial survey showed large schools of herring in Sukoi Inlet, Salisbury Sound and St. John Baptist Bay. An industry pilot also reported herring schools in southern Olga Strait to Starrigavan Bay. Major concentrations of herring predators were observed off of Inner Point, in Eastern Bay, in Hayward Strait, Krestof Sound and in Salisbury Sound.

- *F/V Star Shadow*, 12:45 p.m., Crescent Bay, 50 ton, 11.0% mature roe; 0.6% immature roe, 108 gm.

<u>March 23</u>: 08:00–09:405 Coonradt/Gordon/Harris. Today's aerial survey covered Sitka Sound north of West Crawfish Inlet and south of Salisbury Sound. Spotting conditions were overcast skies and SW winds 10–15. A total **11.6 nautical miles of spawn** was recorded in Sitka Sound between Inner Point and Port Krestof, with smaller areas of spawn on north Middle Island, Little Gavanski Island, Kresta Point and Mud Bay. Today's aerial survey showed large schools of herring in Sukoi Inlet, Salisbury Sound and St. John Baptist Bay. An industry pilot also reported herring schools in southern Olga Strait to Starrigavan Bay. Major concentrations of herring predators were observed off of Inner Point, in Eastern Bay, in Hayward Strait, Krestof Sound and in Salisbury Sound.

- *F/V Optimus*, 10:30 a.m., NE Krestof Sound, 100 tons, 8.0% mature roe; 1.6% immature roe, 101 gm.

The Sitka Sound herring sac roe fishery was opened in northern Sitka Sound and Krestof Sound from 1:30 p.m. to 2:30 p.m. and from 2:55 p.m. to 7:00 p.m. In addition, the Salisbury Sound area was opened from 5:00 p.m. to 6:20 p.m.

<u>March 24:</u> 08:00–09: 40 Gordon/Coonradt/Harris. Today's aerial survey covered a broad area including the Windy Pass area to the south and outer Salisbury Sound to the north. Spotting conditions were clear skies and calm winds. Vessel and aerial surveys were unable to locate a

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sufficient concentration of pre-spawning herring to prosecute a fishery. A total of **17.3 nautical miles of active spawn** was mapped bringing the total cumulative shoreline with spawn to 26.0 nautical miles. Fewer herring predators were noted in the traditional spawning areas near Sitka. South of Sitka few predators were observed near-shore areas. Six humpback whales observed well offshore south of Vitskari Rocks. North of Sitka there were three whales in Nakwasina Passage, three whales observed in northern Krestof Sound, and one whale in Katlian Bay. In Salisbury Sound several whales were seen in St John Baptist Bay, and eight whales were observed in outer Salisbury Sound near Kalinin Bay.

March 25: **09:00–10:00** Gordon. Today's aerial survey covered Sitka Sound from Cape Burunof to Salisbury Sound. Spotting conditions were overcast skies and calm winds. A total **20.6 nautical miles of active spawn** was recorded in the Sitka Sound area. No herring schools were observed today. Major concentrations of herring predators were observed off Nakwasina Passage and in Salisbury Sound. Cumulative spawn mileage to date in the Sitka Sound area is 36.8 nmi.

The *R/V Kestrel* surveyed northern Sitka Sound and Salisbury Sound finding a concentration of herring in lower Salisbury Sound and St. John Baptist Bay. No concentration of pre-spawning herring was seen in northern Sitka Sound and fewer herring predators were noted in the traditional spawning areas near Sitka.

March 26: **08:00–9:15** Gordon. Today's aerial survey covered Sitka Sound from Cape Burunof to Salisbury Sound. Spotting conditions were overcast skies and southwest winds 10–15 knots. Today's aerial survey found a total of **16.1 nautical mile of spawn**. Most of this spawn was seen in Eastern Bay, Promisla Bay, and the Magoun Islands with spawn continuing in spots on south Middle Island, Kasiana Island and on the Halibut Point Road shoreline. The total cumulative spawn to date is 42.0 nautical miles. Smaller groups of sea lions were seen among the smaller islands south of Middle Island with a concentration of sea lions still present at Inner Point.

- *F/V Emily Nicole*, 11:50 a.m., St. John Bay, 100 ton, 8.6% mature roe; 1.4% immature roe, 98 gm.
- *F/V Nicholas Michael*, 9:45 a.m., Gilmer Cove, 150 tons, 9.3% mature roe; 1.5% immature roe, 99 gm.
- *F/V Ace*, 11:30 a.m., Kane Isl., 20 ton, 9.6% mature roe; 1.8% immature roe, 96 gm.

March 27: **08:00–9:20** Gordon. Today's aerial survey covered Sitka Sound from Windy Pass to Salisbury Sound. Spotting conditions were overcast skies and calm winds, with mist. Approximately **2.6 nmi of spawn** was recorded around the Magoun Islands and in the Eastern Bay area. Additionally, herring schools were observed in Sukoi Bay. Herring predators continue to be concentrated in Salisbury Sound with the highest concentrations north of Kane Islands.

March 28: **08:00–9:20** Gordon. Today's aerial survey covered Sitka Sound from Cape Burunof to Salisbury Sound. Spotting conditions were overcast skies and calm winds, with rain. No herring spawn was observed on today's flight.

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Coonradt/Coltharp. A skiff survey was conducted covering areas of northern Sitka Sound. Approximately **4.5 nmi of old spawn** was recorded in the Northern Sitka Sound and Hayward Strait area.

- *F/V Shadowfax*, 10:30 a.m., St. John Bay, 60 ton, 10.7% mature roe; 1.0% immature roe, 97 gm.
- *F/V Optimus*, Unk, S. Kane Isl, Unk, 10.6% mature roe; 0.8% immature roe, 100 gm.

The Alaska Department of Fish and Game announced at 4:00 p.m. today on marine VHF radio that the Sitka Sound sac roe herring fishery will be closed for the remainder of the season. Recent test samples were showing an increasing mix of smaller herring decreasing the value of additional harvest. The decision to close the fishery was made in consultation with industry representatives.

March 29: No aerial survey was conducted today.

March 30: Coltharp. No aerial survey was conducted today. A skiff survey was conducted covering areas of northern Sitka Sound. Approximately **0.6 nmi of old spawn** was recorded around Crow Island.

March 31: No aerial survey was conducted today.

April 1: A private pilot conducted an aerial survey of Sitka Sound north of Cape Burunof and Salisbury Sound. Spotting conditions were overcast skies and southwest winds 25 knots with rain and hail. Approximately **0.8 nmi of active spawn** was recorded in Olga Strait and Salisbury Sound.

April 2: A private pilot conducted an aerial survey of Sitka Sound north of Cape Burunof and Salisbury Sound. Approximately **5.9 nmi of active spawn** was recorded. Active spawn was observed in northern Sitka Sound and in Salisbury Sound.

April 3: No flight due to an unavailability of planes. A skiff survey mapped approximately **2.4 nmi of active spawn**. Active spawn was observed in northern Sitka Sound and in Salisbury Sound.

April 4: **0900:00–10:00** Jensen. Today an aerial survey was conducted of Sitka Sound north of Sitka to Salisbury Sound. Spotting conditions were overcast skies and southwest winds 25 knots with rain. Approximately **5.7 nmi of active spawn** was observed in northern Sitka Sound and in Salisbury Sound.

April 5: **09:00–10:00** Gordon. Today an aerial survey was conducted of Sitka Sound north of Cape Burnof to Salisbury Sound. Spotting conditions were overcast skies and east 15–20 winds. Approximately **4.3 nmi total active spawn** was observed in northern Sitka Sound and in Salisbury Sound.

April 6: **09:00–10:00** Coonradt. Today an aerial survey was conducted of Sitka Sound north of Cape Burunof to Salisbury Sound. Spotting conditions were overcast skies and east 15–20 winds.

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Approximately **1.8 nmi total active spawn** was observed in northern Sitka Sound and in Salisbury Sound.

April 11: Coonradt/Jensen. No aerial survey was conducted today. A skiff survey was conducted covering areas of northern Sitka Sound. Approximately **3.5 nmi of old spawn** was recorded in northern Sitka Sound.

April 12: Gordon/Bayne. No aerial survey was conducted today. A skiff survey was conducted covering areas of northern Sitka Sound. Approximately **1.9 nmi of old spawn** was recorded in Salisbury Sound.

The cumulative spawn mileage in Sitka Sound for the 2016 season is approximately 63.3 nmi.

April 19: **09:00-10:15** Coonradt. Today's aerial survey covered Northern Sitka Sound, Slocum Arm and Hoonah Sound. Spotting conditions were clear skies with southeast winds 10–15 knots. No herring or herring spawn was observed in Slocum Arm. However a small spot spawn was observed in Whiting Harbor, and several small herring schools were observed in St. John Baptist Bay and one school was observed on the NE side of Emmons Island. Herring predators were distributed as follows: NE side of Emmons Island – 9 sea lions, and St. John Baptist Bay – 20 sea lions actively feeding.

April 25: **09:30–10:30** Coonradt. Today's aerial survey covered Northern Sitka Sound and Hoonah Sound. Spotting conditions were overcast skies with southwest winds 15–25 knots. No herring or herring spawn was observed. No herring predators were observed.

Appendix C3.–Aerial and skiff herring spawn surveys by date, at Bradfield Canal, Ernest Sound, Ship Island, Zimovia Strait and Eastern Passage, and Bear Creek, within Petersburg-Wrangell Management Area in Southeast Alaska, 2016.

Bradfield Canal

Not Surveyed in 2016.

Vixen Inlet/ Union Bay/Emerald Bay

Total miles of spawn: ~4.4 nm

Spawning dates: 4/7 through 4/11

Peak spawning: 4/8

4/4 1 spot spawn, 1 school of herring observed, 73 Sea Lions.

4/5 No herring spawn, 3 herring schools, 72 sea lions.

4/6 No herring spawn, 1 herring school, 22 sea lions.

4/9 No herring spawn or schools observed, 107 sea lions, 2 whales.

4/10 **0.3 nm of active spawn**, 56 sea lions, 1 whale.

4/11 **0.75 nm of active spawn**, 88 sea lions, 2 whales.

4/12 1 spot spawn, 2 schools of herring, 67 sea lions.

4/13 No herring spawn or schools observed, 30 sea lions, 5,000 scoters.

4/15 No herring spawn or schools observed, 48 sea lions, 1 whale, 800 gulls.

4/20 No herring spawn or schools observed, 3,000 scoters.

4/22 No herring spawn or schools observed, 4.4 nm eggs documented by skiff, 5,000 scoters.

Onslow/Stone/Brownson Island/Canoe Pass

Total miles of spawn: 0.0 nm

4/4 No herring activity.

4/6 No herring activity.

4/9 No herring activity.

4/10 No herring spawn, 1 herring school, 3 sea lions, 1 whale.

4/11 No herring spawn, 1 herring school, 10 sea lions.

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4/13 No herring activity, 1 sea lion, 500 scoters.

4/15 No herring activity.

Zimovia St. and Eastern Passage

Total miles of spawn: ~5.0 nm

Spawning dates: 4/4 through 4/14

Peak spawning: 4/5

3/18 Report of active spawn 8 mile beach by local resident.

4/4 **1.0 nm of active spawn** with herring schools, 36 sea lions, 1,000 gulls. 1,000 scoters.

4/5 **1.5 nm of active spawn** with herring schools, 34 sea lions, 1,000's gulls, 1,000's scoters.

4/6 No herring spawn or schools observed, 1,000's gulls, 1,000's scoters.

4/7 1.5 nm eggs observed on the beach between 4 and 5.5 Mile Zimovia Hwy.

4/8 Report of ~1.0 nm active spawn on southern Woronkofski Island by local resident.

4/14 Report of active spawn between 8 and 9 mile beach by local resident.

Bear Creek: Not Surveyed in 2016.

Farragut Bay: Not Surveyed in 2016.

Hobart Bay: Not Surveyed in 2016.

Port Houghton: Not Surveyed in 2016.

Sunset Cove/Windham Bay: Not Surveyed in 2016.

Gambier Bay/Pybus Bay: Not Surveyed in 2016.

Port Camden: Not Surveyed in 2016.

Tebenkof Bay: Not Surveyed in 2016.

Appendix C4.–Aerial and skiff herring spawn surveys by date, in Seymour Canal (Juneau Management Area), in Southeast Alaska, 2016.

Number of times surveyed: 9

Total miles of spawn: 4.8

Spawning dates: 4/26–4/29

Peak spawn: 4/27

4/15: No herring or herring spawn; 55 SL, 30 of them at Pt Hugh, 5 whales. Good vis.

4/19: No herring or herring spawn; 124 SL, 55 of them at Pt Hugh, 12 whales. Excellent vis.

4/21: No herring or herring spawn; 68 SL, 32 of them at Pt Hugh, no whales. Good vis.

4/25: herring on beach S of cloverleaf rocks and at Pt Hugh with associated **spot spawns**; one **spot spawn** just S of D10/11 Boundary. 220 SL, 7 whales. Good vis.

4/26: **0.5 nm active spawn** in several sections and herring on beach between Pt Hugh and Cloverleaf Rocks; **spot spawns** by D10/11 boundary. 125 SL and 10 whale observed.

4/27: **3.4 nm active spawn** between D10/11 boundary and Pt Hugh Light. Many sealions and 16 whales observed. Very good visibility.

4/28: **1.4 nm active spawn** predominantly at Pt Hugh; 200 SL, 4 whales. Good to Fair vis.

4/29: **0.5 nm active spawn** at Pt Hugh; 65 SL, 1 whale. Fair vis due to SE15.

5/3: No herring or herring spawn, few predators, lots of birds.

Appendix C5.–Aerial and skiff herring spawn surveys by date, in Tenakee Inlet (Juneau Management Area), in Southeast Alaska, 2016.

Number of times surveyed: 9

Total miles of spawn: 0

Spawning dates: --

Peak spawn: --

4/15: No herring or herring spawn; 76 SL, 50 of them at Cannery Pt, 4 whales. Good vis.

4/19: No herring or herring spawn; 89 SL, 50 of them at Cannery Pt, 1 whale. Excellent vis.

4/22: No herring or herring spawn; 68 SL, 100 at Cannery Pt, 2 whale offshore in Finn Cove, Excellent vis.

4/25: No herring or herring spawn; 78 SL, 70 at Cannery Pt. 2 whales near Crab Bay. N of Basket Bay 40 SL and three collections of birds on the beach.

4/28: No herring or herring spawn; 130 SL at Cannery Pt, 10 elsewhere, 1 whale. Good to fair vis.

5/3: No herring or herring spawn; 150 SL at Cannery Pt, 2 elsewhere, 1 whale. Good vis.

5/4: One small school of herring S of Corner Pt: 100 SL at Cannery Pt. Good vis.

5/8: No herring or herring spawn; 50 sea lions at Cannery Pt., 4 near Saltery no whales. Excellent vis.

5/9: No herring or herring spawn; 50 sea lions at Cannery Pt., no whales. Excellent vis.

Appendix C6.–Aerial and skiff herring spawn surveys by date, in Lynn Canal (Juneau Management Area), in Southeast Alaska, 2016.

Number of times surveyed: 13

Total miles of spawn: 4.3

Spawning dates: 4/20–4/22; 5/4–5/5

Peak spawn: 4/21; 5/4

4/15: No herring spawn, small school in Tee Harbor; 320 SL, 290 of them in Slate Cove, 8 whales. Good vis.

4/19: No herring spawn, 2 small school by ferry terminal; 45 SL, 2 whales. Excellent vis. Good crowd at Benjamin Island.

4/20: Wildlife biologist reported **0.5 nm active spawn** north of Pt St Mary in the afternoon; beautiful day, excellent vis.

4/21: Approximately **3 nm active spawn** from Pt Saint Mary north; 48 sea lions and 1 whale observed, virtually no predators south of Bridget Cove. Good to excellent vis.

4/22: Approximately **0.25 nm active** and dissipating spawn mid-way between Pt St Mary and Pt Sherman; 33 sea lions and one whale observed, virtually no predators south of Bridget Cove. Several small schools of herring were observed near Auke Cape and in Indian Cove as well as in Tee Harbor. Excellent vis.

4/25: No herring or herring spawn; 6 sea lions in Berners Bay, 6 near Pt Bridget and 4 whale near Bridget Cove. Good vis.

4/26: Ward Air pilot reported no herring or predators.

4/28: No herring or herring spawn; 4 SL and one whale in Berners Bay, 5SL and 1 whale Pt Bridget to Sunshine Cove. Good to fair vis.

5/3: No herring or herring spawn; 11SL, 2 whale. Good to fair vis.

5/4: **0.8 nm of active spawn** S of Pt Bridget, several good schools in S Bridget Cove.

5/5: **0.25 nm active spawn** in S Bridget Cove.

5/6: No herring or herring spawn observed.

5/8: No herring or herring spawn observed.

Appendix C7.–Aerial and skiff herring spawn surveys by date, in Port Frederick, Oliver Inlet, and Stephens Passage (Juneau Management Area), in Southeast Alaska, 2016.

Port Frederick

Number of times surveyed: 7

Total miles of spawn: 0

4/15: No herring or herring spawn; 12 SL. Good vis.

4/19: No herring or herring spawn; 9 SL. Excellent vis.

4/25: No herring or herring spawn; 4 SL, 2 whales, close to the beach by the Narrows.

4/28: Schools of herring in Narrows and Salt Lake Bay, no herring spawn; 5 SL, good to fair vis.

5/3:   No herring or herring spawn; 8 SL, 1 whale. Good to fair vis.

5/4:   One small school in the Narrows, no spawn or predators observed. Good vis.

5/8: No herring, herring spawn or predators observed.

Oliver Inlet

Number of times surveyed: 6

Total miles of spawn: 0

4/15: No herring or herring spawn observed; no predators. Good vis.

4/19: No herring or herring spawn observed; no predators. Excellent vis.

4/27: No herring or herring spawn observed; no predators. Good vis.

4/28: No herring or herring spawn observed; no predators. Good vis.

4/29: No herring or herring spawn observed; no predators. Excellent vis.

5/3:   Small school of herring in entrance, no spawn or predators. Good vis

Freshwater Bay

5/4: No herring or herring spawn observed; no predators. Good vis.

Stephens Passage

4/28: No herring or herring spawn observed; no predators. Good vis.

Holkum Bay

4/25: No herring or herring spawn; 6 SL and 2 whales, both sleeping.

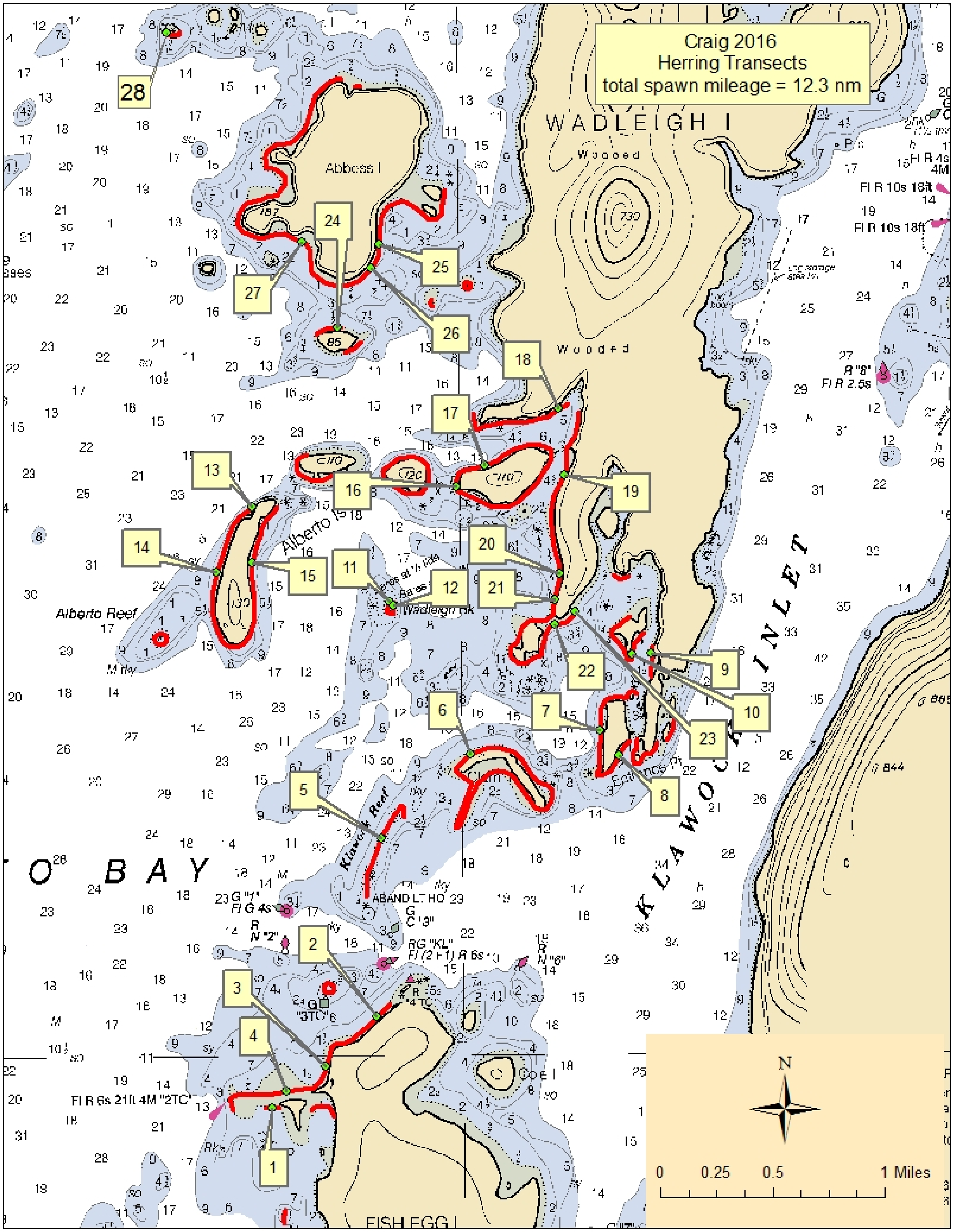
Appendix C8.–Aerial and skiff herring spawn surveys by date, in the Yakutat Management Area, in Southeast Alaska, 2016.

Yakutat Bay

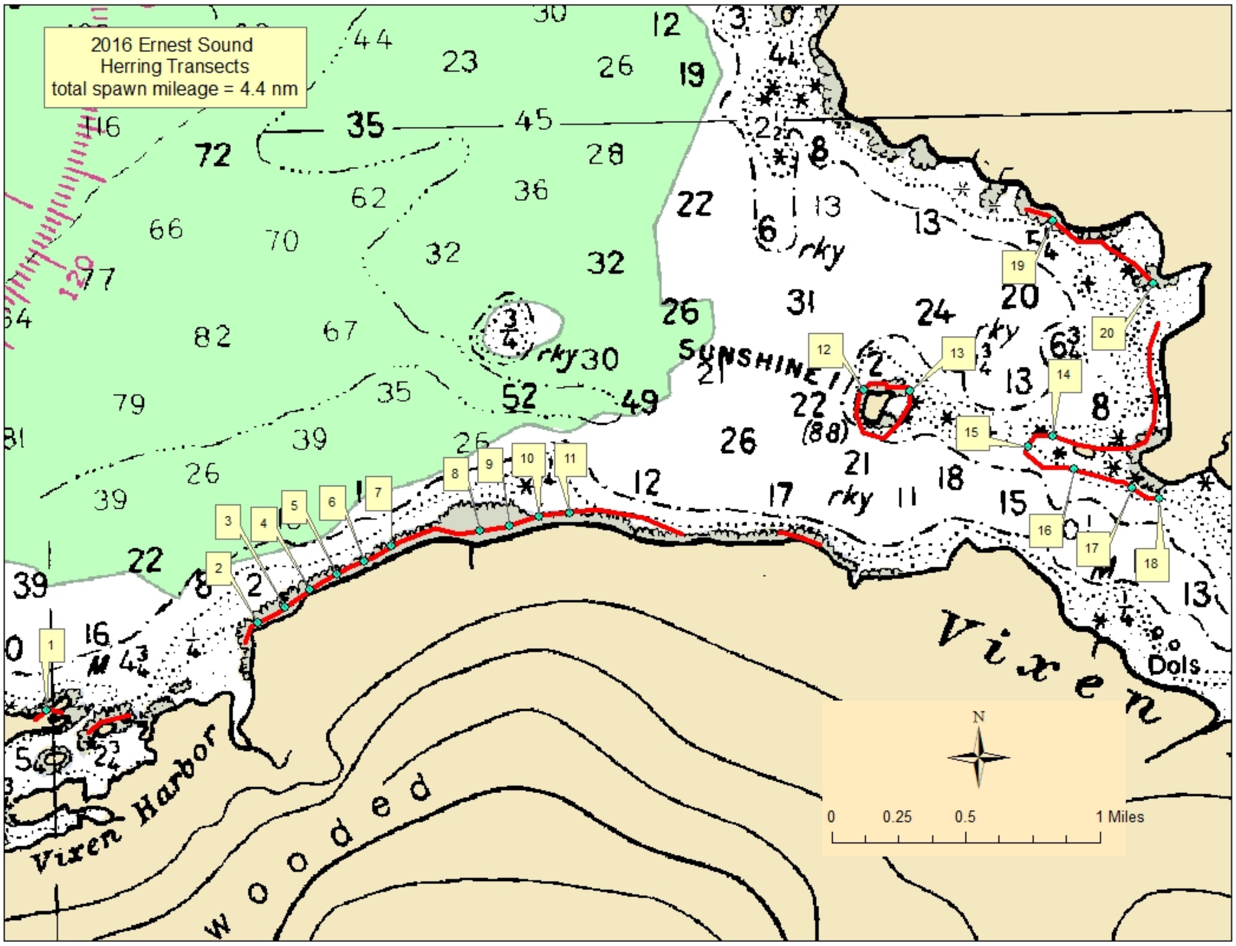
There were no aerial survey flights conducted in 2016. Total miles of spawn for the season are unknown.

APPENDIX D: SPAWN AND SPAWN DEPOSITION SURVEY TRANSECT LOCATIONS

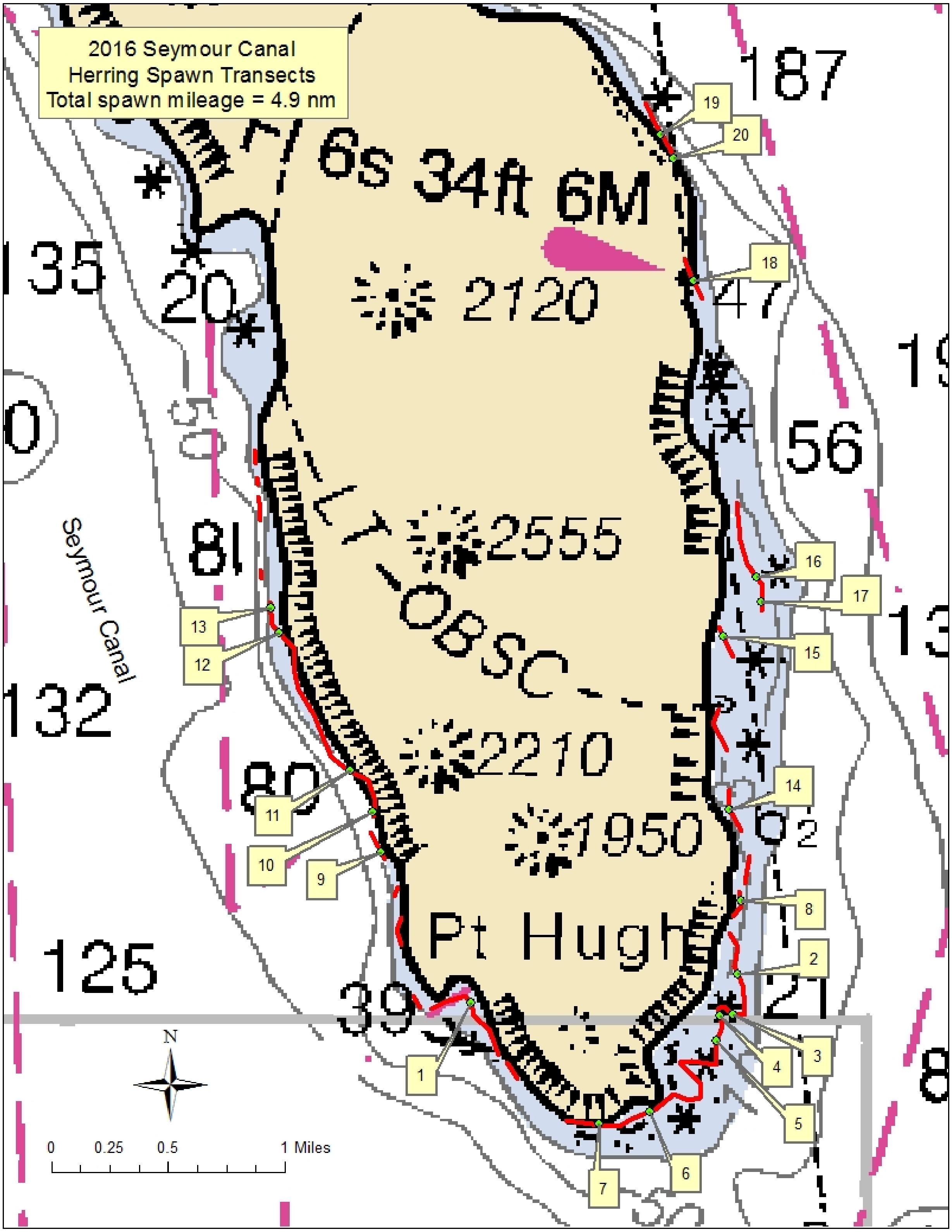
Appendix D1.–Spawn (heavy gray line) and spawn deposition survey transect locations (numbered labels) for the Craig herring stock in 2016.



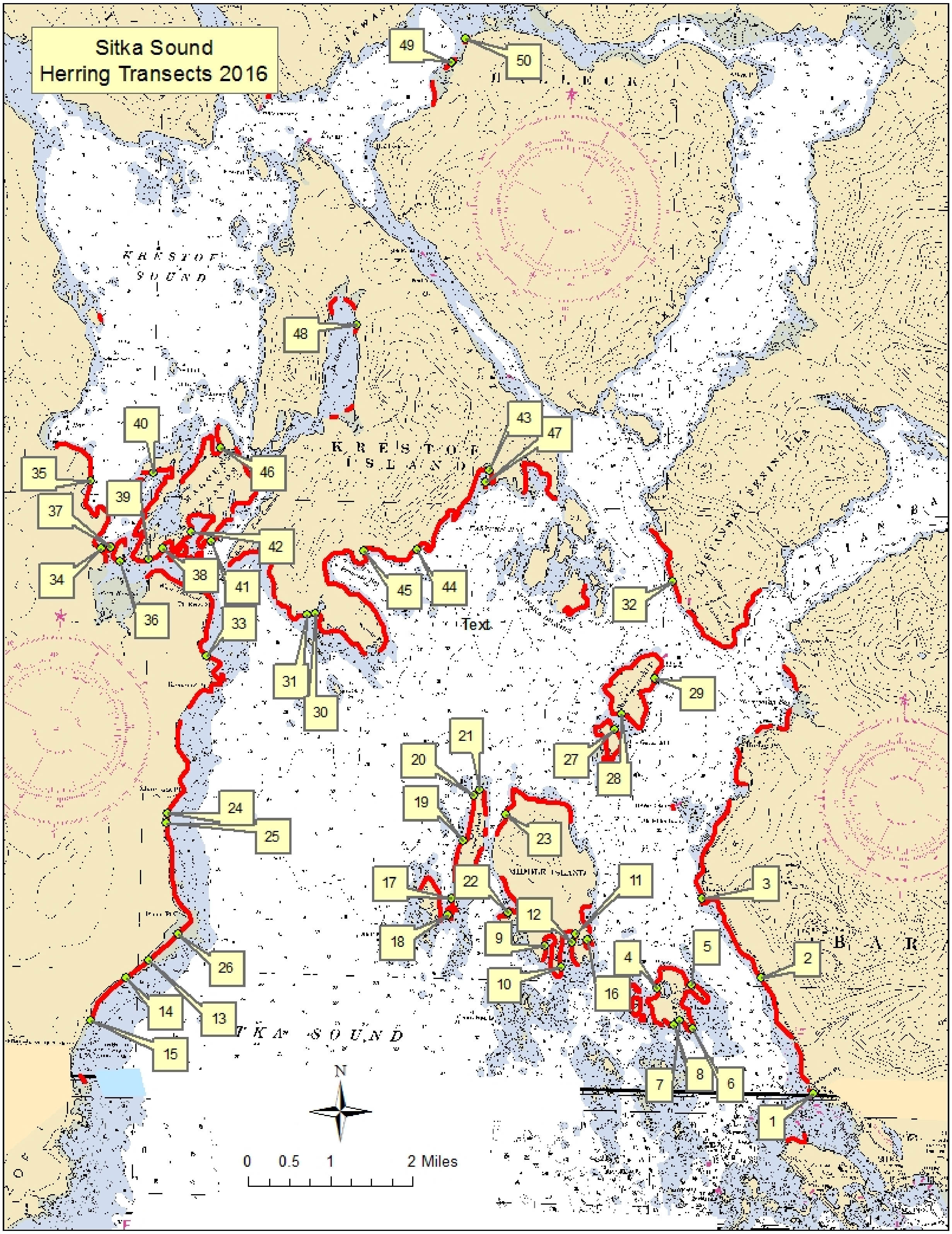
Appendix D2.–Spawn (heavy gray line) and spawn deposition survey transect locations (numbered labels) for the Ernest Sound herring stock in 2016.



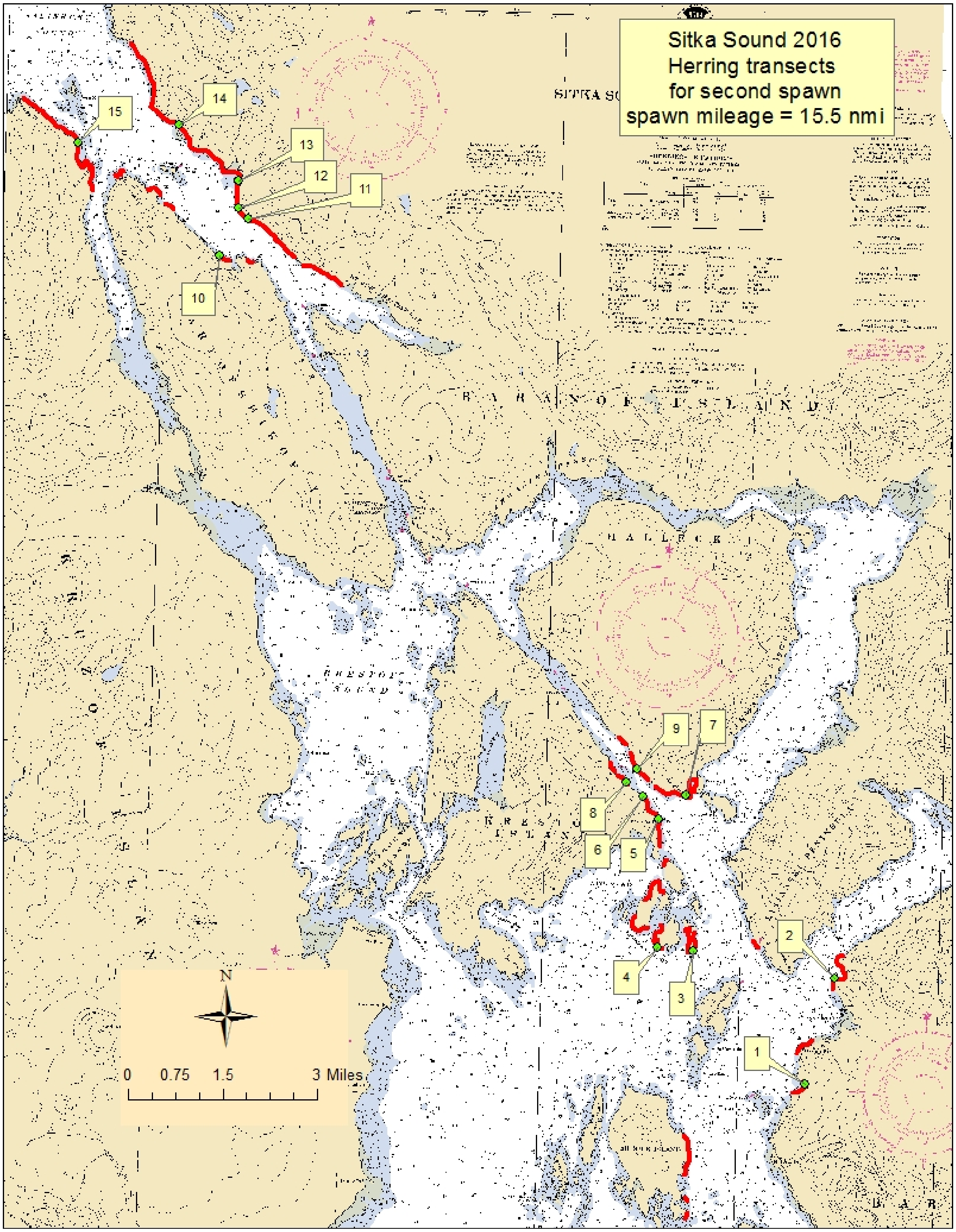
Appendix D3.–Spawn (heavy gray line) and spawn deposition survey transect locations (numbered labels) for the Seymour Canal herring stock in 2016.



Appendix D4.–Spawn (heavy gray line) and spawn deposition survey transect locations (numbered labels) for the Sitka Sound herring stock first survey in 2016.



Appendix D5.–Spawn (heavy gray line) and spawn deposition survey transect locations (numbered labels) for the Sitka Sound herring stock second survey in 2016.



Appendix D6.–Spawn (heavy gray line) and spawn deposition survey transect locations (numbered labels) for the Lynn Canal herring stock in 2016.