Fishery Data Series No. 20-23

Southeast Alaska 2019 Herring Stock Assessment Surveys

by

Kyle Hebert

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

FISHERY DATA SERIES NO. 20-23

SOUTHEAST ALASKA 2019 HERRING STOCK ASSESSMENT SURVEYS

by
Kyle Hebert
Alaska Department of Fish and Game, Division of Commercial Fisheries, Douglas

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

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Kyle Hebert
Alaska Department of Fish and Game, Division of Commercial Fisheries,
802 3rd St., Douglas, AK 99811-0024, USA

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

Pacific herring *Clupea pallasii* are important prey for many marine species found in Southeast Alaska and are harvested in commercial fisheries (bait, sac roe, spawn-on-kelp), and for subsistence, personal use, and research 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 2019, including summaries of herring spawn deposition surveys and age-weight-length sampling, which are the principle model inputs used to forecast herring abundance. In 2019, spawn deposition surveys were conducted only for Sitka Sound, Craig, and Revilla Channel area stocks. Spawn deposition surveys were not conducted in several other traditionally major spawning areas due to lack of funding, although aerial surveys of spawning were continued on a limited basis. The shoreline in state waters where spawn was documented during aerial surveys in 2019, combined for all areas, was 111.0 nautical miles. Post-fishery spawn deposition biomass estimates, combined for all surveyed stocks, totaled 169,514 tons. During the 2018–2019 season, a commercial winter bait fishery was opened in Craig with a guideline harvest level (GHL) of 2,344 tons. A commercial purse seine sac-roe fishery was planned in Sitka Sound with a GHL of 12,869 tons; however, no openings were announced due to high abundance of young/small herring that were below desired marketable size. A commercial spawn-on-kelp fishery was open in Craig with an allocation of 2,911 tons of herring. There were no other commercial fisheries opened in 2019. Herring harvested commercially during the 2018–2019 season totaled 995 tons, not including herring pounded for spawn-on-kelp fisheries or spawn-on-kelp products.

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

INTRODUCTION

Pacific herring *Clupea pallasii* have been the target of commercial fisheries in Alaska since 1878, with harvests growing to multi-million pounds annually by 1882 (Cobb 1905). As fisheries developed, the desire for better knowledge and understanding of herring populations grew, leading to the initiation of research programs. Initially, study was focused on observations made from trends in commercial catch, especially during the height of the large-scale reduction fishery that peaked in 1930. As questions arose about the cause of fluctuations in catch, the lack of herring availability, and the impact of commercial fishing on herring, and as fishery science theory developed worldwide, scientific techniques were applied to herring populations in Alaska. Quantitative, fishery-independent study of herring began in Alaska by the early 1930s and research was carried out by the U.S. Department of Commerce, Bureau of Fisheries. Rounsefell and Dahlgren (1935) measured spawning levels by area and attempted to differentiate spawning populations in Southeast Alaska through analyzing vertebrae counts and growth rates and through tag-recapture studies. By the 1940s, the importance of age class strength became recognized for monitoring and predicting herring abundance, and research was largely conducted by the U.S. Department of the Interior, Fish and Wildlife Service (USFWS). Estimates and forecasts of abundance and yield by age became mainstays of management during this time. By 1953, programs were in place for standardized, detailed collection of data from spawning grounds, including aerial surveys, measurements of spawn along shoreline, egg density, and egg mortality, which enabled estimation of spawning biomass (Grice and Wilimovsky 1957). The USFWS continued to lead herring research in Alaska after Alaska statehood in 1959, operating under a cooperative agreement with the State of Alaska during 1960 and 1961. However, in 1962 the cooperative agreement was discontinued, and herring spawn surveys conducted by USFWS were suspended. Starting in 1963 the Alaska Department of Fish and Game (ADF&G) began conducting aerial surveys in the Craig/Hydaburg and Sitka areas, which were later expanded to other important herring spawning areas.

The Alaska Department of Fish and Game instituted a full research project in 1971 to evaluate herring 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 was to provide the biological data necessary for scientific-based 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 using vessels, 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 currently analyzed using one of two different stock assessment models used to estimate and to forecast mature herring abundance and biomass. These models include an age-structured analysis (ASA) model and a biomass accounting model.

Since 1971 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 or had been sufficient to permit the use of ASA for hindcasting 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 2018 through spring 2019 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 (maximum of 20%) 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 was 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. Historical spawning dates by stock are presented in Figures 2–11. 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 primarily to gauge presence of herring or spawn. Once concentrations of predators were observed, aerial and skiff surveys were conducted more frequently (e.g., 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 depicting 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, which continues to be used in Alaska for time series consistency; however, some more recent studies suggest that 25–35% egg loss may be more accurate. Because 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 simultaneous spawning events in multiple 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. Historical dates of spawn deposition surveys are presented in Table 1.

Shoreline Measurement and Transect Orientation

Spawn documented during aerial surveys was transcribed in ArcGIS (version 10.3)[1] over raster images of nautical charts published by the National Oceanic and Atmospheric Administration, using the NAD 1983 datum and State Plane Alaska FIPS 5001 (ft) Projected Coordinate System. 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 a tradeoff so that shoreline features could be smoothed without adhering too 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 to sample across the spawn zone. 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 steeply sloped shoreline with a narrow band of spawn habitat (e.g., typical 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.

Another consideration is that termination of transects while still in the egg zone may be necessary if spawn is present on the opposing shoreline. Transects are halted at the midpoint of opposing shoreline to prevent oversampling areas where a potential transect could have been placed. Similarly, transects that are surveyed within small coves are terminated at a central convergence point where potential transects would meet. Transects are terminated for these two situations to minimize bias due to unequal sampling probability of the spawn zone, although it is unlikely that bias would be eliminated without further corrections (Li et al. 2011). A theoretical example of a spawn line drawn along the shore, and how the layout of potential transects are considered for these instances, is presented in Figure 12.

The same procedure and patterns of drawing spawn were followed as in past years; however, the process requires that judgment be used based on experience and knowledge 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 sample egg density throughout the entire width of the spawn, while minimizing bias to the estimated egg abundance. 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. For the Sitka Sound and Craig areas, standardized baseline representations of herring spawn shoreline have been developed and were used for analyses presented here. These baseline

1 Use of product names in this publication are included for completeness but do not constitute product endorsement.

maps provide a predetermined line for drawing spawn in the current year that is consistent with prior years. The baseline maps were developed using documented historical spawn and local knowledge of the area to produce what was deemed the most sensible representation of shoreline for use in herring aerial surveys and spawn deposition surveys.

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 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 2. Sampling rates in Table 2 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 estimate. 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 actual transects selected for a survey are frequently increased beyond the minimum suggested rate to increase transect spatial distribution, potentially reduce variance, and make efficient use of scheduled vessel time.

The minimum target number of transects is estimated as follows:

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

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%);
$\overline{d}$	=	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 the depth in the subtidal zone where no further egg deposition was observed, or to a maximum of 21 m (70 ft) 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 per day, 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. Eggs throughout the entire water column were included if they were within the dimensions of the frame. Situations where eggs were found on vertical canopy kelps such as *Macrocystis* spp. required divers to swim up along the length of the kelp to estimate eggs while maintaining reference to the sampling frame. To help estimate the number of eggs, estimators used the standard 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. Additional data recorded included bottom 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 estimator's 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 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 in 100% salt brine solution. Approximately ten samples for each of the five vegetation categories were collected, and attempts were made to collect samples of varying egg density and varying total egg abundance within each vegetation type. Vegetation categories included eelgrass (ELG), fir kelp (FIR), large/leafy brown kelp (LBK), rockweed (FUC), and hair kelp (HIR) (see Appendix A1 for species within each category). Samples were transported to the ADF&G Mark, Tag and Age Laboratory in Juneau, 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 all laboratory estimates to all visual estimates, within each kelp type, for each estimator. To reduce potential of highly variable correction coefficients, minimum sample size guidelines were used. Data from the last three years were pooled if there were at least a total of six samples for each estimator and kelp type, with at least three samples in at least two of the three 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/vegetation-specific correction coefficients were applied to egg estimates when the appropriate vegetation 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 eggs were encountered that were loose in the water column, were adhering to bare rock, or were on vegetation types that were not were similar to the categories sampled for calibration of egg estimates, an estimator-specific correction coefficient based on the average of all estimator/vegetation-specific correction coefficients was applied.

Estimates of Total Egg Deposition

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

$$t_i = a_i \bar{d}_i, \tag{2}$$

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

$$a_i = l_i \bar{w}_i, \tag{3}$$

where l_i is the total length of shoreline (m) that received spawn (determined from aerial and skiff surveys); and w_i is the mean width of spawn (m), 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

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

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

$$c_{hk} = \frac{r_{hk}}{q_{hk}}, \tag{5}$$

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

SPAWNING BIOMASS ESTIMATION

The total number of eggs per spawning area is a key element used in assessing and forecasting herring spawning biomass. Although spawning biomass calculated directly from egg deposition 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 general trends 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 3). 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 3.

AGE AND SIZE

Herring samples were collected from a combination of skiff/spawn surveys, aerial/spawn surveys, commercial fisheries, and test fisheries (when prosecuted) from major stocks located throughout Southeast Alaska. Sample 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 provide 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 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 at the ADF&G Mark, Tag and Aging Laboratory in Juneau, Alaska. 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, then two 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.

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 Onset Stowaway Tidbit temperature loggers that were submerged to depths ranging from about 10 ft mean lower low water (MLLW) to 20 ft MLLW. Temperature has been recorded daily at 6-hour intervals for up to 19 years in some spawning areas. Daily mean, minimum, and maximum sea temperature was calculated for each spawning area. 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.

HARVEST STRATEGY

Allowable harvest levels for commercial herring fisheries in Southeast Alaska are set based on a harvest strategy that involves a graduated harvest rate paired with a minimum threshold of mature herring. When herring biomass is forecasted to be at or above threshold, a harvest rate between 10–20% is applied to the biomass forecast. For most herring stocks, the harvest rate may be set at 10% when the biomass forecast is at threshold and at a maximum of 20% when the forecast is six times the threshold or greater. In the Sitka Sound area, the harvest rate is set at 12% when the forecast is at threshold, and at a maximum of 20% when the forecast is twice the threshold or greater. Maximum harvest rates used for herring in Southeast Alaska are based on studies in Alaska and elsewhere that concluded a maximum 20% harvest rate is sufficiently conservative to maintain healthy stocks of herring when paired with appropriate thresholds (Zheng et al. 1993; Doubleday 1985). The sliding scale element of the harvest rate calculation used for Southeast Alaska herring was included as an additional precautionary measure to reduce the harvest rate as stock biomass approached threshold.

Threshold biomass levels have been established for each commercially exploited stock in Southeast Alaska and 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 analyses using simulation models to estimate 25% of the average unfished biomass (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 resulting value was lower than the 3,000-ton threshold that existed at that time, the existing threshold was retained (Carlile 1998b). For all other stocks in Southeast Alaska, thresholds were established using a less quantitative approach of reviewing historical estimates of abundance, historical knowledge of stock size fluctuation and distribution, and manageability of minimum quotas. Threshold levels during the 2018–2019 season ranged from 2,000 tons (Hoonah Sound and Hobart Bay) to 25,000 tons (Sitka Sound).

Management Plan

The following management plan was in place for the 2018–2019 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 Southeastern Alaska Area**. For the management of herring fisheries in the Southeastern Alaska Area, 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.

Additionally, the following regulation was in effect to set harvest levels in Sitka Sound:

5 AAC 27.160 Quotas and guideline harvest levels for Southeastern Alaska Area.

(g) The guideline harvest level for the herring sac roe fishery in Sections 13-A and 13-B shall be established by the department and will be a harvest rate percentage that is not less than 12 percent, not more than 20 percent, and within that range shall be determined by the following formula:

$$\text{Harvest Rate Percentage} = 2 + 8\left[\frac{\text{Spawning Biomass (in tons)}}{20{,}000}\right]$$

The fishery will not be conducted if the spawning biomass is less than 25,000 tons.

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 requirements for setting harvest levels for herring fisheries 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, 2019, in Sitka Sound and ending on May 23, 2019, in Seymour Canal. Notes of activity related to herring or herring spawning were recorded in logs (see Appendix C). Surveys or observations were conducted by staff from each area office (Ketchikan, Petersburg, Sitka, Juneau, Haines, and Yakutat) and covered major or traditional herring spawning locations within each management area. Occasionally, private pilots or local residents may report observations of active spawning. Spawning timing for each major spawning area, including dates of first, last, and major spawning events, is summarized in Figure 13. ADF&G also completed aerial surveys of Annette Island Reserve while en route to other spawning areas located in state waters.

The total documented spawn for major spawning areas in state waters where aerial surveys were conducted in Southeast Alaska in 2019 was 111.0 nmi. This did not include spawning around Annette Island Reserve, or numerous minor spawning areas in Southeast Alaska or Yakutat (see Appendix C for a detailed accounting of other minor spawn areas throughout Southeast Alaska). The highest levels of spawn were observed in the Sitka Sound area (55.8 nmi) and in the Craig area (28.9 nmi). Spawning observed in other survey areas ranged from 0 nmi in Hoonah Sound to 8.2 nmi in Ernest Sound.

SPAWN DEPOSITION SURVEYS

During spring 2019, spawn deposition dive surveys were conducted only in Sitka Sound, Craig, and Revilla Channel (Kah Shakes–Cat Island). The first survey was conducted on April 6 in the Revilla Channel area, the survey of Craig was conducted during April 9–10, and the survey of Sitka Sound was conducted during April 12–15 (Table 4). Specific locations of survey sites, observed spawn, and transect locations are presented in Appendix D. Egg estimates by transect for each spawning area are presented in Table 5.

Due to budget reductions in 2019, spawn deposition surveys were not conducted in Seymour Canal, Tenakee Inlet, Lynn Canal, Hoonah Sound, West Behm Canal, Ernest Sound, or Hobart Bay–Port Houghton. Although aerial surveys were conducted in several minor spawning areas, no spawn deposition dive surveys were completed in these areas due to the low level of spawning, or in the case of some areas, because surveys conducted in previous years (e.g., Bradfield Canal) revealed that only a narrow band of spawning habitat exists resulting in relatively low egg deposition (see Appendix C).

In the Sitka Sound and Craig areas, egg deposition estimates were considerably higher in 2019 than in 2018, approximately doubling in each area. For both areas, this was largely a result of much higher spawn mileage, resulting in a larger area of egg deposition. Egg density was also higher in each area, but not substantially higher. Estimated spawning biomass for these areas also increased considerably from 2018, at least doubling in each area. A summary of the 2019 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 6. For comparison of 2019 spawning stock abundance to prior years, estimates of historical spawning biomass are presented in Figures 14–19.

Visual Estimate Correction

Minimum sample size guidelines (at least 3 samples per vegetation type for 3 years) were met using data from 2017 through 2019 for 5 of 6 estimators, and using data from 2016, 2018, and 2019 for one estimator. Correction coefficients applied to 2019 spawn deposition visual estimates ranged from 0.67 to 1.35 and are presented in Table 7.

Visual review of plots depicting observed versus laboratory estimates of eggs suggest there exist linear relationships for some estimators, but nonlinear relationships for others caused by a tendency to underestimate when egg numbers in sample frames are high. A similar nonlinear pattern has been observed for aerial estimates of salmon in streams (see Jones et al. 1998); however, correction coefficients were also calculated as straight ratios 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. However, because nonlinear relationships probably exist that bias correction coefficients low, the result is that estimates of egg abundance are also probably biased low.

AGE AND SIZE

A combined total of 4,295 herring were sampled from all stocks and gear types (cast net, purse seine, and pound) during the 2018–2019 season. Of those, 4,287 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 populations in Craig and Sitka Sound were taken using cast nets. Those samples were collected throughout the geographic extent of the active spawn (Figures 20 and 21), and throughout the duration of spawning, focusing on the most intense spawning events when feasible (Figure 13).

Samples were also obtained from all commercial fisheries that were conducted in 2018–2019. Fisheries sampled included Craig winter bait and Craig spawn-on-kelp. Samples were obtained opportunistically from vessels or tenders during, or shortly after, the fishery openings. Sample locations during fisheries are shown in Figures 20 through 24.

The minimum sample goal of 500 aged fish per sampling event (gear-fishery combination) was exceeded for every area/fishery (Tables 8 and 9).

Age Composition

Age composition data from spawning populations were obtained for only five stocks in the region in 2019: Sitka Sound, Craig, Revilla Channel, Ernest Sound, and Seymour Canal. Samples were not obtained from Tenakee Inlet, Lynn Canal, Hoonah Sound, Hobart Bay–Port Houghton, or West Behm Canal due to reduced budgets. Frequency distributions of herring ages from sampled spawning areas are presented in Tables 10–20 and Figures 25–35.

Observed age distributions for all sampled areas were similar in that age-3 herring dominated all spawning populations. Proportions of age-3 herring ranged from 57% in Seymour Canal to 81% in Craig. For each of the areas sampled, the proportion of age-3 herring was the highest observed over the last three decades. It is not unusual to see similar age distributions for Craig and Sitka Sound, which may be because of similar outer coastal marine environments influencing recruitment and the populations in general. Historical age compositions of spawning populations are presented in Figures 36–44.

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 magnitude, trajectory, or both (Figure 45). When northern and southern stocks are viewed separately, the synchronized pattern is even more apparent within each group (Figures 46 and 47). For example, 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. Samples were obtained for only five areas in 2019, and it appears that age-3 proportions for all sampled stocks were much higher than in 2018, and unusually high compared to the last several decades.

The relationship between the latitude of spawning stocks and the proportion of mature age-3 herring continues to be relatively strong (Table 21, Figure 48). 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 $r^2 = 0.84$ (Figure 49). There is also a moderate correlation between the mean proportion of age-3 mature herring and the mean minimum annual sea temperature ($r^2 = 0.70$) (Figure 50).

Size at Age

Based on cast net samples in 2019, there remains a clear distinction between mean weight-at-age for Sitka Sound and other spawning stocks of herring in Southeast Alaska (Figure 51). Sitka Sound herring attained a higher average weight than other stocks by age 3, and the divergence increased with each age group.

Mean length-at-age among spawning areas has a pattern similar to weight-at-age. Although the distinction between Sitka Sound herring mean length-at-age and other Southeast Alaska stocks is usually clear, it is not as great as observed for mean weight-at-age for other herring stocks (Figure 52).

Trends in weight-at-age over time are variable among stocks (Figures 530–62). 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 remained stable or slightly increased over the past 20 years, following a period of low weight-at-age in the early 1990s. However, data presented here only date 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 have been calculated to roughly gauge herring health using the physical dimensions of herring (i.e., weight-to-length ratio) over time (Figures 63–72). Data obtained from cast net samples during active spawn events were used to calculate condition factors, because a more complete and consistent data set exists for cast net samples that can be compared across stocks. 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. Another benefit of using data from cast net samples is that 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 2019 for stock where data was available are not notably different from those observed over the past three decades.

COMMERCIAL FISHERIES

Commercial harvest was permitted in an area only if the forecasted spawning biomass met or exceeded a minimum threshold (Table 22). 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.

During the 2018–2019 fishing 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. A summary of locations, harvest levels, and periods of harvest is presented in Table 23.

Sac Roe Fisheries

The only commercial sac roe fishery that was announced in 2019 was for the Sitka Sound area. There were no sac roe fisheries announced for Seymour Canal, West Behm Canal, Hobart Bay–Port Houghton, or Kah Shakes–Cat Island areas because estimates of spawning biomass and forecasts were not conducted, primarily due to budget cuts. Lynn Canal was historically a sac roe fishery area; however, the Board of Fisheries rescinded regulations allowing a fishery in that area at its January 2018 meeting in Sitka.

Sitka Sound

The sac roe fishery was placed on two-hour notice on March 17 at 8:00 AM. The guideline harvest level (GHL) was 12,869 tons. There were no announced openings during the season. Test setting was conducted to locate concentrations schools with high quality sac roe; however, herring that were of acceptable average size and roe content for markets were not available in volumes necessary to hold fishery openings. Test sets revealed that a large proportion of the herring in 2019 were of small length and low weight, indicating a large recruitment of herring.

Seymour Canal

There was no commercial fishery in the Seymour Canal area during the 2018–2019 season, because no stock assessment survey or forecast was conducted due to budget cuts.

West Behm Canal

There was no commercial fishery in the West Behm Canal area during the 2018–2019 season, because no stock assessment survey or forecast was conducted due to budget cuts.

Hobart Bay-Port Houghton

There was no commercial fishery in the Hobart Bay–Port Houghton area during the 2018–2019 season, because no stock assessment survey or forecast was conducted due to budget cuts.

Kah Shakes–Cat Island

There was no commercial fishery in the Kah Shakes–Cat Island area during the 2018–2019 season. A stock assessment survey was conducted; however, results suggested that the biomass would be forecast below threshold.

Winter Bait Fisheries

During the 2018–2019 season, the only winter food and bait fishery was in the Craig area. All other winter bait areas were closed due to lack of surveys and forecasts.

Craig

The fishery was opened in the Craig area on October 18, 2018 and was closed by regulation on February 28, 2019. The bait allocation was 2,344 tons, which was by regulation 60% of the total GHL of 3,906 tons. A total of 995 tons of herring were harvested.

Ernest Sound

There was no commercial fishery in Ernest Sound during the 2018–2019 season due to budget cuts preventing survey and forecast.

Tenakee Inlet

There was no commercial fishery in Tenakee Inlet during the 2018–19 season due to budget cuts preventing survey and forecast.

Spawn-on-Kelp Pound Fisheries

In the spawn-on-kelp (SOK) fisheries, *closed-pound fishing* involves capturing sexually mature herring and releasing them into a net impoundment in which kelp is suspended. The herring are released from the pound after they spawn on the kelp and the kelp with eggs is then sold. *Open-pound fishing* involves suspending kelp from a floating frame structure in an area where herring are spawning. The herring are not impounded but instead they naturally spawn on the suspended kelp. The kelp blades with eggs are removed from the water then sold. In the Southeast Alaska herring SOK fisheries, a closed or an open pound may be operated by one or more Commercial Fisheries Entry Commission (CFEC) permit holders (Coonradt et al. 2017).

These fisheries present unique challenges to fishery management, primarily because herring are released alive after spawning in pounds, which makes determining herring usage and mortality difficult to estimate. Attempts have been made to estimate the amount of herring placed into pounds by brailing and weighing herring from pounds instead of releasing after spawning; however, these were largely unsuccessful due to low sample size of pounds and uncertainty about herring losses (e.g., to sea lion or eagle predation) prior to brailing. Estimates of herring use in SOK pounds have been completed in Prince William Sound (PWS) by measuring egg deposition on kelp and pound webbing, egg retention within herring, and herring fecundity to back calculate the number of herring (Morstad and Baker 1995; Morstad et al. 1992). These studies found that approximately 12.5 tons of herring are used for each 1 ton of spawn-on-kelp product. However, because mean pound size in PWS fisheries is substantially larger than those used in Southeast Alaskan fisheries, this ratio may not be directly comparable. Nevertheless, because no studies have been conducted in Southeast Alaska, this conversion is used to approximate herring usage for Southeast Alaska pound fisheries, particularly when reporting estimates over time, to ensure consistency. Other estimates of the amount of herring in pounds have also been used, which are based on observations of fishery managers during fisheries. These estimates have ranged from 10 to 20 tons of herring per closed pound structure and have been used as inputs to stock assessment models. To estimate herring dead loss from pounds, a mortality rate of 75% of herring that are placed into pounds is assumed.

The only area open to the commercial harvest of SOK during the 2018–2019 season was Craig. The other SOK areas in the region, Hoonah Sound, Ernest Sound, and Tenakee Inlet, were not opened during the 2018–2019 season because surveys and forecasts were not conducted.

Craig

A total of 73 closed pounds were actively fished, by a total of 140 permit holders. Of the 73 closed pounds, there were 1 single, 61 double, and 3 triple-permit pounds. No open pounds were fished. Total harvest was 202 tons of spawn on kelp.

Hoonah Sound

There was no commercial fishery in Hoonah Sound during the 2018–2019 season due to budget cuts preventing survey and forecast.

Ernest Sound

There was no commercial fishery in Ernest Sound during the 2018–2019 season due to budget cuts preventing survey and forecast.

Tenakee Inlet

There was no commercial fishery in Tenakee Inlet during the 2018–2019 season due to budget cuts preventing survey and forecast.

Bait Pound (Fresh Bait and Tray Pack) Fisheries

During the 2018–2019 season, no herring were harvested for fresh bait pounds or tray-pack in Southeast Alaska.

Test Fisheries

There was no herring test fishery harvest in Southeast Alaska during the 2018–2019.

DISCUSSION

Spawn Deposition

The combined observed spawning biomass estimated in 2019 for Sitka Sound and Craig, as determined from spawn deposition data only, was 164,604. This is more than double the 78,839 tons observed for these stocks in 2018. A survey was also conducted for the Kah Shakes–Cat Island (Revilla Channel) stock, which resulted in an estimate of an additional 4,910 tons. The Sitka Sound and Craig stocks typically account for about 80% of the spawning biomass in Southeast Alaska. Sitka Sound observed spawning biomass increased by 131% in 2019 relative to 2018, and Craig increased by 99%. Although the error surrounding biomass estimates was not calculated, it is assumed that the magnitudes of these changes were large enough that they reflect actual and 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 73.

Spawn deposition estimates for 2019 suggest that combined herring spawning biomass in Southeast Alaska is at a high level relative to the period 1980–2019, and possibly at the highest level during this reference period. This is despite only surveying three stocks in 2019, because Sitka Sound and Craig historically have comprised a large proportion of the region's biomass. The 2019 combined estimate of all three surveyed areas of 169,514 tons is 167% of the mean regional spawning biomass (1980–2018), which is an underestimate for the region because so many areas were not surveyed in 2019.

After a period of building since about the late 1990s and peaking during 2008–2011, herring spawning biomass in Southeast Alaska began a period of decline, particularly for spawning stocks located in inside waters. Coincident with the decline were reductions to state budgets, which has prevented annual stock assessment surveys for most herring stocks in the region since 2016. Stock assessment surveys have continued uninterrupted for only the two largest stocks, Sitka Sound and Craig, and so conclusions cannot be made about broader herring biomass trends throughout the region. Limited aerial surveys have continued at most areas, which provides some information about stock levels; however, miles of shoreline do not necessarily provide an accurate depiction of spawning biomass. Nonetheless, based on spawn mileage alone, herring stocks in the region other than Sitka and Craig appear to remain at a relatively low level. This continued pattern suggests that outer coastal stocks are faring far better than those located in inside waters, which are less exposed to open ocean influence. It is unknown why this pattern persists.

Although changes in estimated spawning biomass over the past year are probably due to actual changes in the herring population, it must be acknowledged that they 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 very large increases and consistency observed between Sitka Sound and Craig suggest that estimate error was probably a minor factor affecting biomass estimates.

Estimates of observed 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, such as 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 hindcast 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.

Age Composition

Age compositions of all spawning populations in 2019 were dominated by age-3 herring, clearly indicating a large recruitment pulse (Figure 74). The proportion of age-3 herring was very high for all stocks sampled in the region, but the phenomenon extended beyond Southeast Alaska. Extremely high proportions of age-3 herring were also reported in Kodiak (97%) and Prince William Sound (84 %), indicating that the successful recruitment was a Gulf of Alaska-wide event. Broad-scale large recruitments have been observed in the past when Sitka Sound and Prince William Sound displayed very similar recruitment patterns (Carls and Rice 2007); however, the remarkable similarity from Kodiak to southern Southeast Alaska is indicative of a very uncommon event.

The specific mechanism that caused this recruitment spike over such a large scale is uncertain, but it is very likely linked to a common pattern in ocean temperature. This cohort was hatched in spring 2016, which was coincident with the tail end of the "blob", an unusually warm water mass that circulated through the northern Pacific Ocean (Gentemann et al. 2017). Although speculation, it is possible that elevated sea temperatures from the blob helped produce marine conditions favorable to larval and juvenile herring survival in 2016, ultimately leading to a large recruitment three years later when those fish first entered the spawning population.

The very high proportions of mature age-3 herring observed in 2019 increases the likelihood that herring populations could increase as this cohort matures. This is especially true because of the high spawning biomass in 2019. However, increasing mature biomass is not a foregone conclusion, because it is possible that survival rates could decline, or recruitment may decline in coming years, which could negate increases expected from this maturing young cohort.

For herring stocks sampled in 2019, estimates of age composition in 2019 continued to follow patterns that are generally expected from tracking previous cohorts; that is, 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 36–44). These patterns lend support to the assumption that the method of aging scales from 2019 samples was consistent with those methods used in prior years, which has been a concern in prior years (see Hebert 2012a and 2012b).

Historical patterns of age composition, and particularly proportions of age-3 herring, over time are also evident among stock groups within the region, suggesting that similar marine conditions may be present among certain areas within the region (Figure 45). 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 broad areas within the region where the mean proportion of age-3 herring is similar. For stocks south of latitude 56 degrees (i.e., those in the lower half of the region: Craig, West Behm Canal, Ernest Sound, and Kah Shakes), the mean proportion of age-3 herring is relatively high (range of 24–33%), 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 14–19%). The strength of the 2019 age-3 pulse apparently overrode the usual pattern seen among stocks on separate sides of the latitudinal split, further indicating that the common influence seen across the Gulf of Alaska was exceptional.

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. It is beyond the scope of this report to further explore whether 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.

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REFERENCES CITED

Carlile, D. W. 1998a. Estimation and evaluation of a harvest threshold for management of the Sitka herring sac roe fishery based on a percentage of average unfished biomass. Alaska Department of Fish and Game, Division of Commercial Fisheries Regional Information Report 1J98-18, Juneau.

Carlile, D. W. 1998b. Estimation and evaluation of a harvest threshold for management of the Tenakee Inlet herring bait fishery based on a percentage of average unfished biomass. Alaska Department of Fish and Game, Division of Commercial Fisheries Regional Information Report 1J98-21, Juneau.

Carlile, D. W. 2003. Estimation and evaluation of a harvest threshold for a W. Behm Canal herring fishery based on a percentage of average unfished biomass. Alaska Department of Fish and Game, Division of Commercial Fisheries Regional Information Report 1J03-02, Juneau.

Carlile, D. W., R. L. Larson, and T. A. Minicucci. 1996. Stock assessments of Southeast Alaska herring in 1994 and forecasts for 1995 abundance. Alaska Department of Fish and Game, Division of Commercial Fisheries Regional Information Report 1J96-05, Juneau.

Carls, M. G., and S. D. Rice. 2007. Prince William Sound herring: An updated synthesis of population declines and lack of recovery. Exxon Valdez Oil Spill Restoration Project 050794 Final Report, Chapter 3.

Cobb, J. N. 1905. The commercial fisheries of Alaska in 1905. Bureau of Fisheries Document No. 603.

Coonradt, E., D. Harris, T. Thynes, and S. Walker. 2017. 2017 Southeast Alaska herring spawn-on-kelp pound fishery management plan. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 1J17-01, Douglas.

Doubleday, W. G. 1985. Managing herring fisheries under uncertainty. Canadian Journal of Fisheries and Aquatic Sciences 42:245–257.

Gentemann, C. L., M. R. Fewing, and M. Garcia-Reyes. 2017. Satellite sea surface temperatures along the West Coast of the United States during the 2014–2016 northeast Pacific marine heat wave. Geophysical Research Letters 44:312–319.

Grice, D. G, and N. J. Wilimovsky. 1957. Herring spawning survey of Alaska with particular reference to Southeastern Alaska. Marine Fisheries Investigations Operations Report–1957. Department of the Interior, United States Fish and Wildlife Service, Bureau of Commercial Fisheries, Alaska Region.

Haegele, C. W. 1993a. Seabird predation of Pacific herring, Clupea pallasi, spawn in British Columbia. Canadian Field-Naturalist 107:73–82.

Haegele, C. W. 1993b. Epibenthic invertebrate predation of Pacific herring, Clupea pallasi, spawn in British Columbia. Canadian Field-Naturalist 107:83–91.

Hebert, K. 2012a. Southeast Alaska 2011 herring stock assessment surveys. Alaska Department of Fish and Game, Fishery Data Series No. 12-53, Anchorage.

Hebert, K. 2012b. Southeast Alaska 2010 herring stock assessment surveys. Alaska Department of Fish and Game, Fishery Data Series No. 12-46, Anchorage.

Hebert, K. 2006. Dive Safety Manual. Alaska Department of Fish and Game, Special Publication No. 06-39, Anchorage.

Jessen, R. J. 1978. Statistical survey techniques. John Wiley & Sons. New York.

Jones, E. L., T. J. Quinn, and B. W. Van Alen. 1998. Observer accuracy and precision in aerial and foot survey counts of pink salmon in a Southeast Alaska stream. North American Journal of Fisheries Management 18:832–846.

Li, M., Stein, M., Wang, M., Shelton, A., Pfister, C., and K. Wilder. 2011. A method for unbiased estimation of population along curvy margins. Environmetrics 22:330–339.

Morstad, S., and T. T. Baker. 1995. Pacific herring pound spawn-on-kelp fishery in Prince William Sound, Alaska, 1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A95-21, Anchorage.

REFERENCES CITED (Continued)

Morstad, S., T. T. Baker, and J. A. Brady. 1992. Pacific herring pound spawn-on-kelp fishery in Prince William Sound, Alaska, 1990. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A92-02, Anchorage, AK.

Nash, R. D. M., A. H. Valencia, and A. J. Geffen. 2006. The origin of Fulton's condition factor – setting the record straight. Fisheries 31:236–238.

Rounsefell, G. A., and E. H. Dahlgren. 1935. Races of herring, *Clupea pallasii* in Southeastern Alaska. Bulletin of the Bureau of Fisheries, Vo. XLVIII, Bulletin No. 17.

Schweigert, J., and C. Haegele. 2001. Estimates of egg loss in Pacific herring spawning beds and its impact on stock assessments. Proceedings of the International Herring Symposium. University of Alaska Sea Grant, AK-SG-01-04, Fairbanks.

Schweigert, J. F., C. W. Haegele, and M. Stocker. 1985. Optimizing sampling design for herring spawn surveys in the Strait of Georgia, B.C. Canadian Journal of Fisheries and Aquatic Sciences 42:1806–1814.

Thompson, S. K. 1987. Sample size for estimating multinomial proportions. American Statistician. 41:42–46.

Zheng, J., F. Funk, G. Kruse, and R. Fagan. 1993. Evaluation of threshold management strategies for Pacific herring in Alaska. Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations, Alaska Sea Grant College Program, Report No. 93-02.

TABLES AND FIGURES

Table 1.–Historical dates of herring spawn deposition surveys in Southeast Alaska.

Year	Sitka Sound	Craig	Ernest Sound	WBC	Revilla Channel	Hobart	Seymour	Tenakee	Hoonah Sound	Lynn Canal
1976	5/1–6	–	–	–	4/13–24	–	–	–	–	–
1977	4/26–28	–	–	–	4/13–19	–	–	–	–	–
1978	4/18–21	–	–	–	4/10–11	–	5/14–16	–	–	5/2–4
1979	–	–	–	–	4/9–12	–	–	–	–	–
1980	–	–	–	–	4/7–11	–	5/15–16	–	–	5/13–15
1981	4/10–11	–	–	–	4/1–4	–	5/14–15	–	5/4	–
1982	4/13–22	–	–	–	4/4–18	–	5/24–25	–	–	–
1983	4/13–17, 4/29	–	–	–	4/5–11	–	5/9–11	–	–	5/6
1984	4/10–17	–	–	–	4/10–15	–	5/4	5/5–7	5/8	5/4
1985	*	*	*	*	*	*	*	*	*	*
1986	*	*	*	*	*	*	*	*	*	*
1987	*	*	*	*	*	*	*	*	*	*
1988	4/15–20	3/24–25	–	–	4/8–12	–	5/5–7	5/10–11	–	5/14
1989	4/10–16	4/7–9	–	–	–	–	5/17–19	5/10–12	4/18–19	–
1990	4/15–18	4/14	–	–	3/29–4/12	–	5/7–10	5/5–6	5/20–23	–
1991	4/25–27	*	*	*	*	*	*	*	*	*
1992	4/23–26	3/30, 4/18–21	5/2	–	4/14–17	5/10–11	5/9–10	–	5/5	–
1993	4/10–13	4/8	4/29–30	4/25–26	4/22–24	5/5	5/10–11	5/7–8	5/6	–
1994	4/8–11	4/18–19	5/6	5/4–5	4/15–17	5/7–8	5/12, 19	–	4/29–30	–
1995	4/7–10	4/6	5/2–3	–	4/20–22	5/4–6	5/23–24	–	4/27–28	–
1996	3/29, 4/2–4, 4/23–24	4/17–18	5/1	4/21	4/19–20	5/10	5/16, 29	5/15–16	5/12–13	–
1997	4/7–9	4/22–23	–	4/29–5/1	4/16–17	5/9	5/12–13	5/10–11	5/6–8	–
1998	4/1–3	4/12–14	4/22–23	4/20, 4/22–23	4/9	4/29–30	5/2, 8–9	5/5–7	5/4–5	–
1999	4/7–9	4/10, 20	–	4/16–17	4/14–15	4/4–5	5/11–12	5/7–8	5/9	–
2000	4/4–6	4/13–14	4/25	4/17–18	4/16–17	5/11	5/12–13	5/3–4, 6	5/7	–
2001	4/9–10	4/18–19	4/24	4/21–22	4/20	5/11–12	5/21–22	5/8–9	5/6–7	–
2002	4/8–11	4/16–18	4/21	4/19–20	–	5/10–11	5/30–31	5/3–4, 6	5/7	–
2003	4/8–11, 4/22	4/13–14	4/27	4/24–26	–	5/8–9	5/10	5/7	5/5–6	–
2004	4/15–19	4/8–9	4/11, 21	4/19–20	–	5/9–10	5/11–12	5/7–8	5/5	5/13
2005	4/9–12	4/17–19	5/4	4/21	–	5/9–10	5/10–11	5/7	5/5–6	5/18
2006	4/7–8	4/10–11	4/14–15	4/29	–	5/7	5/10	5/8	5/4–5	5/26
2007	4/13–16, 4/24	4/18–19	4/24–25	4/23, 5/4	–	5/22	5/21	5/5	5/7	5/25
2008	4/10–14	4/15–16	5/2–3	4/18	–	5/13	5/16	5/10	5/7–8	5/21
2009	4/18–20	4/15–16	4/23	4/21–22	–	5/14–15	5/13–14	5/8–9	5/6–7	5/11–12
2010	4/16–19	4/14–15	4/22	4/20	–	5/5–6	5/7–8	5/11	5/9–10	5/12–13
2011	4/18–20	4/14–15	4/24	4/23	–	5/8–9	5/9–10		5/5–6	–
2012	4/13–16	4/21–22	4/24	4/23	–	5/5	5/12–13	5/8	5/7	5/10–11
2013	4/8–12, 5/2–5	4/14–15	4/17	4/16	–	5/8	5/13–14	5/11	5/12	5/10
2014	4/7–11, 4/24–26	4/13	4/22	4/15	–	5/1	5/10	5/7	5/8	5/9
2015	4/10–13, 5/6–7	4/8	4/21–22	–	4/6	5/5	5/11	5/9	5/6	5/10
2016	4/1–3, 4/20–21	4/8–9	4/26–27	–	–	–	5/8	–	–	5/7
2017	4/12–14, 4/28	4/7–8	–	–	–	–	5/15	–	–	–
2018	4/8–11, 4/24–25	4/13–14	–	–	–	–	–	–	–	–

Note: En dashes represent years without surveys and asterisks represent years where surveys were completed but records of dates are missing.

Table 2.–Transect sampling rates used for 2019 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	5.0	3.5	3.5
Hoonah Sound	2.9	1.0	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 3.–Fecundity relationships used for estimating 2019 herring spawning biomass for stocks in Southeast Alaska.

Sampling year	Stock sampled	Fecundity equation	Stocks to which fecundity equation is applied
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 4.–Dates of 2019 herring spawn deposition surveys conducted in Southeast Alaska.

Survey area	Survey leg	Survey dates
Kah Shakes–Cat Island	I	April 6
West Behm Canal	NA	No Survey
Craig	I	April 9–10
Sitka Sound	I	April 12–15
Ernest Sound	NA	No Survey
Hobart Bay–Port Houghton	NA	No Survey
Hoonah Sound	NA	No Survey
Tenakee Inlet	NA	No Survey
Lynn Canal	NA	No Survey
Seymour Canal	NA	No Survey

Note: Survey leg "I" is the first survey leg. Normally there are two or three survey legs, but this year there was only one. NA means there was no survey.

Table 5.–Summary of herring egg estimates (in thousands) by transect for 2018 spawn deposition surveys conducted in Southeast Alaska. Frame counts are the number of quadrats estimated along each transect.

	Craig		Sitka Sound 1st survey		Sitka Sound 2nd survey	
Transect Number	Egg estimate	Frame count	Egg estimate	Frame count	Egg estimate	Frame count
1	1,023	30	1,867	70	151	18
2	1,285	33	1,070	26	96	2
3	414	15	8,736	82	0	1
4	13	4	1,505	27	3	2
5	1,386	36	1,753	27	0	2
6	748	5	674	34	149	9
7	495	9	15,725	77	315	30
8	448	13	9,566	97	1,289	16
9	222	11	10,027	188	147	8
10	305	8	8,188	44	594	22
11	4,166	14	19,070	87	455	24
12	433	6	534	16	476	6
13	635	10	2,341	20	364	12
14	605	9	4,009	33	84	5
15	3,069	25	235	7	320	11
16	760	13	1,906	47	0	1
17	244	27	1,186	31	0	1
18	6,454	43	392	17	13	6
19	4,456	21	0	1	133	6
20	275	17	0	1	133	4
21	126	3	3,086	51	246	7
22	137	3	2,624	17	0	1
23	0	1	555	12	406	9
24	163	5	503	18	0	1
25	331	13	10	3	–	–
26	792	9	0	1	–	–
27	676	11	560	9	–	–
28	8,116	31	568	22	–	–
29	178	7	173	4	–	–
30	2,383	14	247	12	–	–
31	652	7	593	18	–	–
32	593	14	1,264	8	–	–
33	324	5	402	8	–	–
34	254	6	0	1	–	–
35	30	2	412	6	–	–
36	–	–	494	11	–	–
37	–	–	93	3	–	–
38	–	–	149	11	–	–
39	–	–	2,609	27	–	–
40	–	–	1,096	14	–	–
41	–	–	1,576	17	–	–
42	–	–	185	9	–	–
Average	1,205	14	2,523	29	224	9

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

Table 6.–Summary of results of herring spawn deposition surveys in Southeast Alaska for 2018.

Spawning Stock	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	35	69	17.3	2,197,001	878,963	2.146	91.0	18,073	237,445,829	23,830
Sitka Sound (total)[a]	66	94	33.1	5,540,258	692,405	4.262	108.4	18,525	460,161,406	55,009
Sitka Sound (1st)	42	145	14.7	3,934,574	873,024	3.817	–	–	–	–
Sitka Sound (2nd)	24	43	14.2	1,117,682	263,370	0.327	–	–	–	–
2nd spawn that overlapped 1st[b]	–	–	2.0	157,420	263,370	0.046	–	–	–	–
post survey spawn[c]	–	–	4.2	330,582	197,528	0.073	–	–	–	–
Seymour Canal[d]	–	–	1.4	–	–	–	–	–	–	–
Ernest Sound[d]	–	–	3.5	–	–	–	–	–	–	–
Hobart/Houghton[d]	–	–	1.6	–	–	–	–	–	–	–
Hoonah Sound[d,e]	–	–	0.0	–	–	–	–	–	–	–
Kah Shakes–Cat Island[d]	–	–	1.2	–	–	–	–	–	–	–
Lynn Canal[d]	–	–	1.9	–	–	–	–	–	–	–
Tenakee Inlet[d]	–	–	1.4	–	–	–	–	–	–	–
West Behm Canal[d]	–	–	2.3	–	–	–	–	–	–	–

Note: En 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.

[a] Value for total miles of spawn depicts cumulative mileage; the value used for stock assessment was 35.1 nmi, which includes spawn mileage used for 1st and 2nd surveys, 2.0 nmi of overlapping spawn between the two surveys, and 4.2 nmi of spawn that was observed after surveys were complete.

[b] Not surveyed, but average transect length and average egg density from second survey were applied to estimate spawn area and egg deposition.

[c] Not surveyed, but average transect length and 75% of egg density from second survey were applied to estimate spawn area and egg deposition. Egg density estimate was a judgement based on relative intensity of spawn determined from aerial surveys.

[d] No spawn deposition survey conducted due either to lack of funding or low observed mileage in traditional spawning areas.

[e] Very infrequent aerial surveys conducted, so spawning may have been present but not observed.

Table 7.–Correction coefficients used for herring spawn deposition estimates in Southeast Alaska in 2018.

	Estimator[a]							
Kelp type	A	B	C	D	E	F	G	Average
Eelgrass	0.96	1.08	0.91	0.94	0.97	1.02	0.98	0.98
n =	27	22	28	28	28	28	28	27
Fucus	1.23	1.10	0.89	1.37	1.02	0.79	1.54	1.14
n =	30	22	28	29	29	29	29	28
Fir kelp	0.60	0.93	0.78	0.81	0.77	0.76	0.97	0.80
n =	28	23	25	26	26	26	26	26
Hair kelp	1.33	1.13	0.97	0.82	0.94	0.87	1.00	1.01
n =	29	25	28	29	29	29	28	28
Large brown kelp[b]	0.79	0.76	0.67	1.44	0.91	0.73	1.50	0.97
n =	25	21	24	25	25	25	25	24
Average[c]	0.98	1.00	0.84	1.07	0.92	0.84	1.20	0.98

[a] Estimator identity is withheld to prevent results from biasing estimates in future years.

[b] Values are 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 2018–19.

	Commercial Fishery			Survey	Test Fishery	
Stock	Herring gillnet	Pound	Purse seine	Cast net	Purse seine	Total
Craig	–	530	528	530	–	1,588
Ernest Sound	–	–	–	522	–	522
Hobart/Houghton	–	–	–	–	–	–
Hoonah Sound	–	–	–	–	–	–
Lynn Canal	–	–	–	–	–	–
Seymour Canal	–	–	–	528	–	528
Sitka Sound	–	–	–	1,125	–	1,125
Tenakee Inlet	–	–	–	–	–	–
West Behm Canal	–	–	–	–	–	–
Revilla Channel	–	–	–	532	–	532
Yakutat	–	–	–	–	–	–
Total	–	530	528	3,237	–	4,295

Note: En dashes indicate that no samples were collected in 2018–19, either due to lack of funding or observed spawning.

Table 9.–Summary herring samples aged for Southeast Alaska stocks in 2018–19.

	Commercial fishery			Survey	Test fishery	
Stock	Herring gillnet	Pound	Purse seine	Cast net	Purse seine	Total
Craig	–	530	527	529	–	1,586
Ernest Sound	–	–	–	520	–	520
Hobart/Houghton	–	–	–	–	–	–
Hoonah Sound	–	–	–	–	–	–
Lynn Canal	–	–	–	–	–	–
Seymour Canal	–	–	–	527	–	527
Sitka Sound	–	–	–	1,124	–	1,124
Tenakee Inlet	–	–	–	–	–	–
West Behm Canal	–	–	–	–	–	–
Revilla Channel	–	–	–	530	–	530
Yakutat	–	–	–	–	–	–
Total	–	530	527	3,230	–	4,287

Note: En dashes indicate that no samples were collected in 2018–19, either due to lack of funding or observed spawning.

Table 10.–Summary of age, weight, and length for the Sitka Sound herring stock in 2018–19.

		Age category						
Gear type/season	Parameter	3	4	5	6	7	8+	Total
survey cast net–spring (full sample)	number of fish	857	90	67	13	92	5	1,124
	percent age composition	76%	8%	6%	1%	8%	0%	100%
	average weight (g)	65.3	82.3	99.5	108.1	122.1	136.3	102.3
	standard dev. of weight (g)	13.1	16.1	19.4	10.1	21.6	39.6	20.0
	average length (mm)	174	187	197	206	211	217	199
	standard dev. of length (mm)	9.6	10.5	10.7	7.2	9.7	12.5	10.0
commercial purse seine–spring	number of fish							
	percent age composition							
	average weight (g)	NO SAMPLES OBTAINED						
	standard dev. of weight (g)							
	average length (mm)							
	standard dev. of length (mm)							
test fishery purse seine–winter	number of fish							
	percent age composition							
	average weight (g)	NO SAMPLES OBTAINED						
	standard dev. of weight (g)							
	average length (mm)							
	standard dev. of length (mm)							

Table 11.–Summary of age, weight, and length for the Craig herring stock in 2018–19.

		Age category						
Gear type/season	Parameter	3	4	5	6	7	8+	Total
survey cast net–spring	number of fish	429	29	31	16	21	3	529
	percent age composition	81%	5%	6%	3%	4%	1%	100%
	average weight (g)	57.5	72.4	87.5	92.3	103.7	116.4	88.3
	standard dev. of weight (g)	14.2	15.6	16.5	20.4	10.8	23.8	16.9
	average length (mm)	165	178	190	196	203	212	191
	standard dev. of length (mm)	11.7	10.4	7.6	9.2	6.1	8.1	8.9
commercial pound–spring	number of fish	449	40	22	12	6	1	530
	percent age composition	85%	8%	4%	2%	1%	0.2%	100%
	average weight (g)	64.2	81.3	98.8	109.6	123.8	136.5	102.4
	standard dev. of weight (g)	15.5	15.9	17.5	17.3	20.9	–	17.4
	average length (mm)	165	178	192	197	204	218	192
	standard dev. of length (mm)	11.6	9.8	8.0	8.8	6.5	–	8.9
commercial purse seine–winter	number of fish	274	48	84	51	51	19	527
	percent age composition	52%	9%	16%	10%	10%	4%	100%
	average weight (g)	62.9	78.3	97.6	106.7	121.1	128.5	99.2
	standard dev. of weight (g)	17.0	22.5	14.4	18.7	18.2	18.7	18.2
	average length (mm)	163	173	186	192	200	206	187
	standard dev. of length (mm)	14.1	14.7	10.0	12.1	9.2	9.9	11.7

Note: En dashes mean value cannot be calculated due to sample size limitations.

Table 12.–Summary of age, weight, and length for the Hobart Bay–Port Houghton herring stock in 2018–19.

		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 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 13.–Summary of age, weight, and length for the Ernest Sound herring stock in 2018-19.

		Age category						
Gear type/season	Parameter	3	4	5	6	7	8+	Total
survey cast net–spring	number of fish	NO FISHERY						
	percent age composition							
	average weight (g)							
	standard dev. of weight (g)							
	average length (mm)							
	std. dev. 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 14.–Summary of age, weight, and length for the Hoonah Sound herring stock in 2018–19.

		Age category						Tota l
Gear type/season	Parameter	3	4	5	6	7	8+	
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 pound–spring	number of fish							
	percent age composition							
	average weight (g)	NO FISHERY						
	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 2018–19.

		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 pound–spring	number of fish							
	percent age composition							
	average weight (g)	NO FISHERY						
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							
commercial seine–winter	number of fish							
	percent age composition							
	average weight (g)	NO FISHERY						
	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 2018–19.

		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 FISHERY						
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							
commercial gillnet–spring	number of fish							
	percent age composition							
	average weight (g)	NO FISHERY						
	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 2018–19.

		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)[a]	NO SAMPLES OBTAINED						
	standard dev. of weight (g)							
	average length (mm)							
	standard dev. of length (mm)							
commercial gillnet–spring	number of fish							
	percent age composition							
	average weight (g)	NO FISHERY						
	standard dev. of weight (g)							
	average length (mm)							
	variance of length (mm)							

Table 18.–Summary of age, weight, and length for the Lynn Canal herring stock in 2018–19.

		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)							
	std. dev. of length (mm)							

Table 19.–Summary of age, weight, and length for the Revilla Channel herring stock in 2018–19.

		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 2018–19.

		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 21.–Proportion of mature age-3 herring (cast net, 1988–2019), latitude, and mean sea surface 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 (°C)	Mean minimum annual sea temperature (°C)	Mean maximum annual sea temperature (°C)
Kah Shakes	55.0300	27%	33%	8.6	5.9	14.7
Craig	55.4770	20%	24%	9.3	3.5	16.6
WBC	55.4846	26%	31%	9.0	4.9	15.0
Ernest Sound	55.8307	31%	33%	–	–	–
Sitka	57.0079	11%	19%	8.7	4.2	15.7
Hobart Bay	57.4308	7%	14%	7.1	3.1	15.2
Seymour Canal	57.5923	12%	16%	6.8	2.4	14.2
Hoonah Sound	57.6001	7%	16%	8.0	1.0	18.0
Tenakee Inlet	57.7381	11%	15%	7.8	1.0	17.8
Lynn Canal	58.6402	12%	14%	7.2	2.6	15.4

Note: En dashes mean there is no temperature data available at this site.

Table 22.–Summary of Southeast Alaska herring target levels for the 2018–19 season.

Area	Minimum spawning biomass threshold (tons)	Forecast (tons)	Target Exploitation Rate (%)	Guideline harvest level (tons)[a]
Craig	5,000	22,810	17.1	3,906
Ernest Sound	2,500	–	0.0	–
Hobart Bay–Port Houghton	2,000	–	0.0	–
Hoonah Sound[b]	2,000	–	0.0	–
Seymour Canal	3,000	–	0.0	–
Sitka Sound	25,000	64,343	20.0	12,869
Tenakee Inlet	3,000	–	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 the 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 in 2016 from 1,000 tons to 2,000 tons to align with the minimum threshold applied to all other stocks in Southeast Alaska.

Table 23.–Summary of commercial herring harvest during the 2018–19 season.

Fishery	Gear	Area	District	Opening[a]	Closing[b]	Harvest (tons)[c]
Winter food and bait	Purse seine	Craig	3/4	18 Oct 2018	28 Feb 2019	995
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		–
Subtotal						995
Sac roe	Purse seine	Sitka Sound	13	No Openings Announced		–
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		–
Subtotal						–
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 2019	5 Apr 2019	202
Subtotal						202
Test fishery-bait	Purse seine	Sitka	13	No Fishery		–

[a] For spawn-on-kelp fisheries, represents when seining was opened.

[b] For spawn-on-kelp fisheries, represents end of removing spawn on kelp from pounds; for purse seine fisheries represents date of last opening.

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

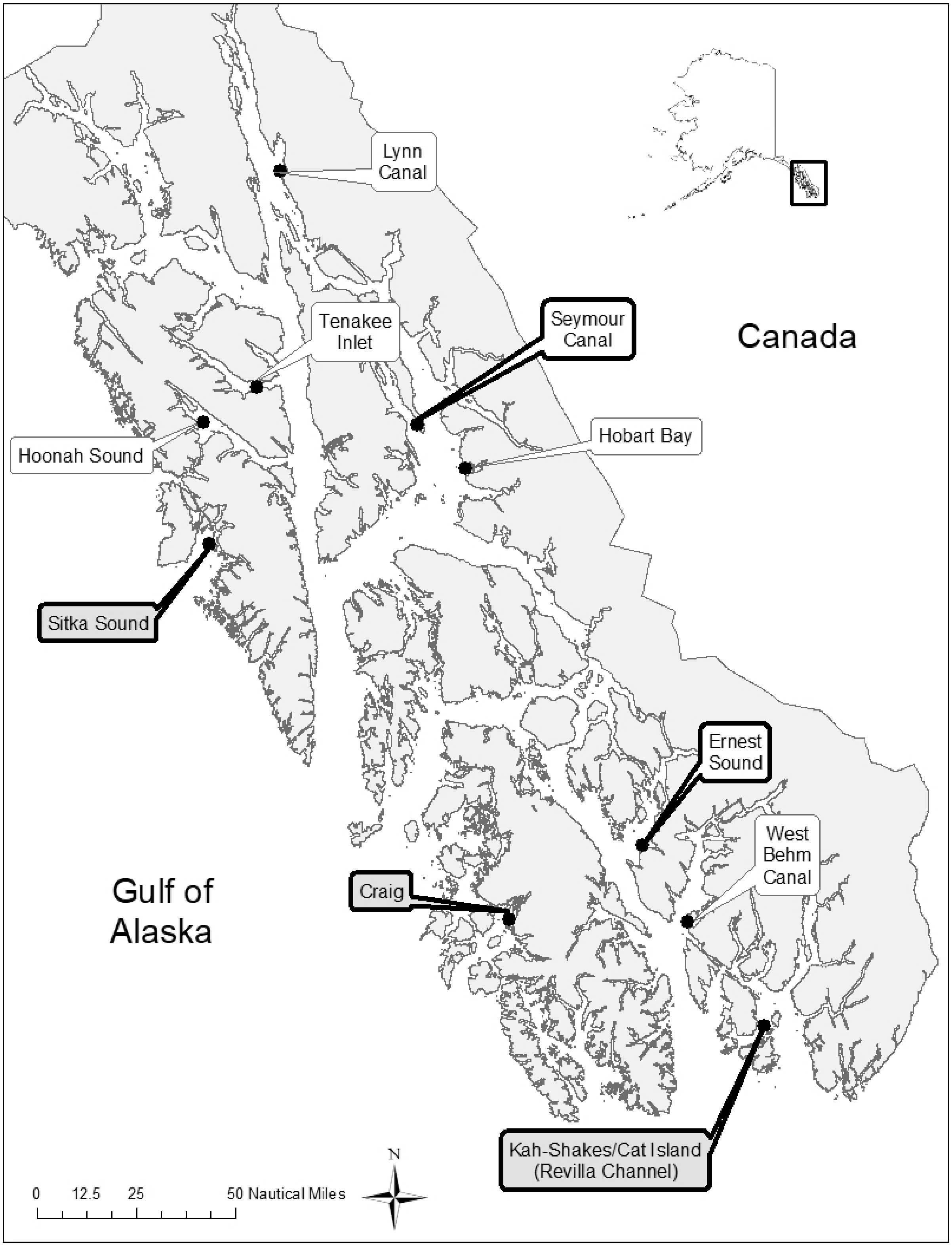

Figure 1.–Locations of major herring spawning areas in Southeast Alaska. Labels with shading and heavy outline indicate areas where spawn deposition surveys and age-size sampling were conducted during the 2019 spawning season; labels with only heavy outline indicate only age-size sampling of herring was completed during the 2018–19 fishery or spawning seasons.

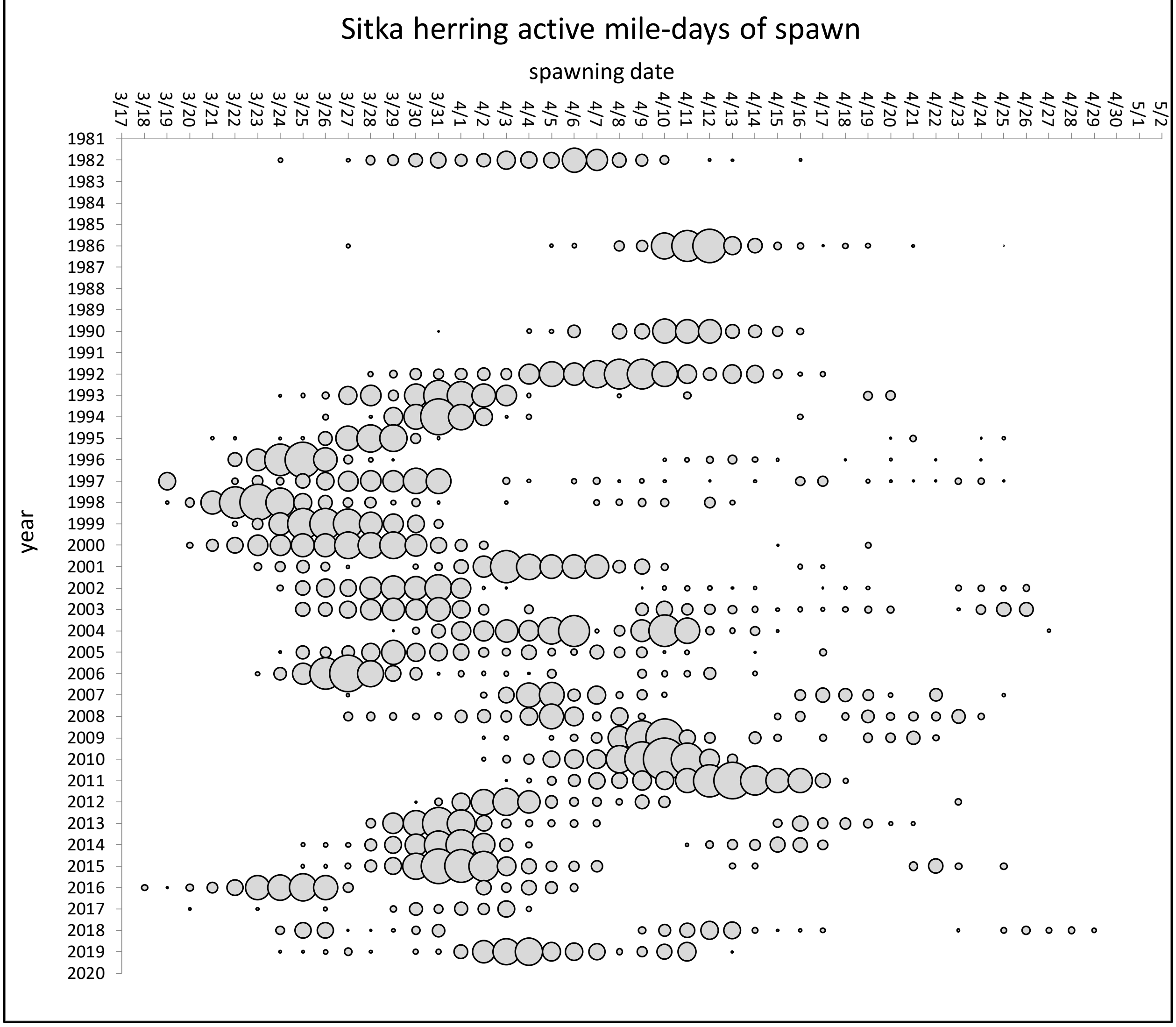

Figure 2.–Historical dates of active spawn observed for the Sitka Sound herring stock. The size of circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of 48 nautical miles of spawn and the smallest circles represent "spot spawns", which here have been given an arbitrary value of 0.1 nautical mile. For years with blanks, data could not be located.

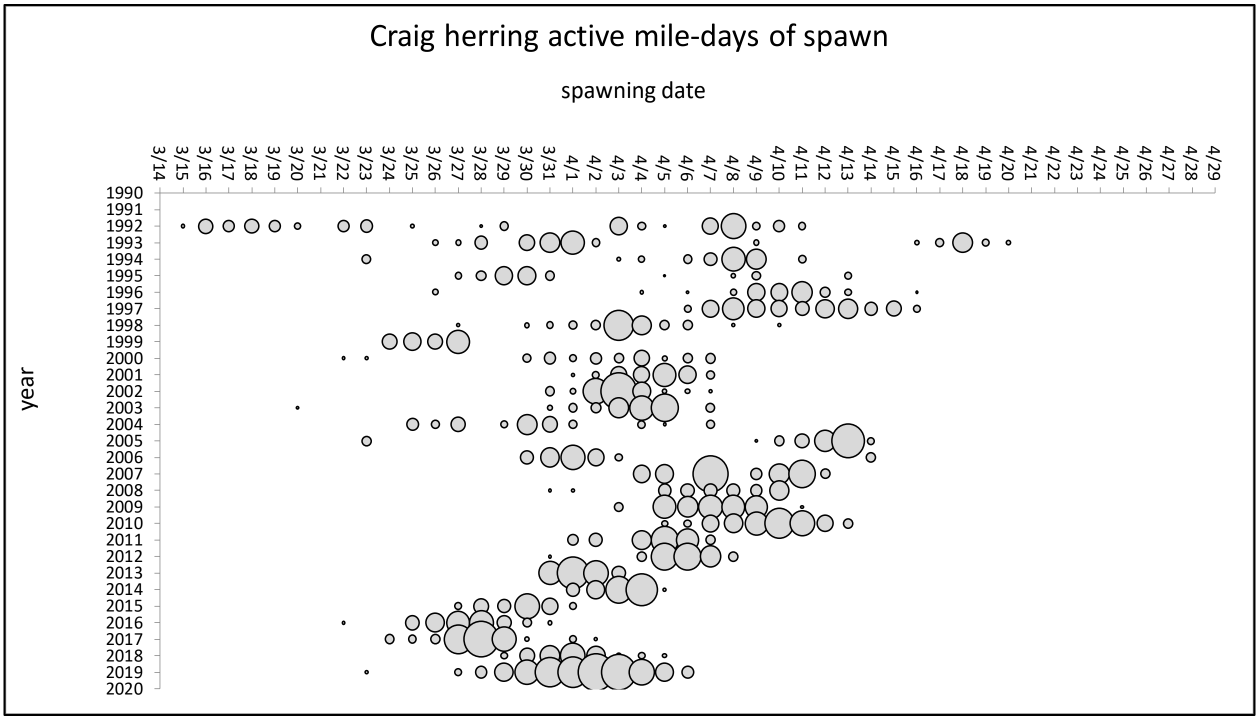

Figure 3.–Historical dates of active spawn observed for the Craig herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of 15 nautical miles of spawn and the smallest circles represent "spot spawns", which here have been given an arbitrary value of 0.1 nautical mile. Black circles represent days of active spawn, but for which no estimates of daily mileage are available.

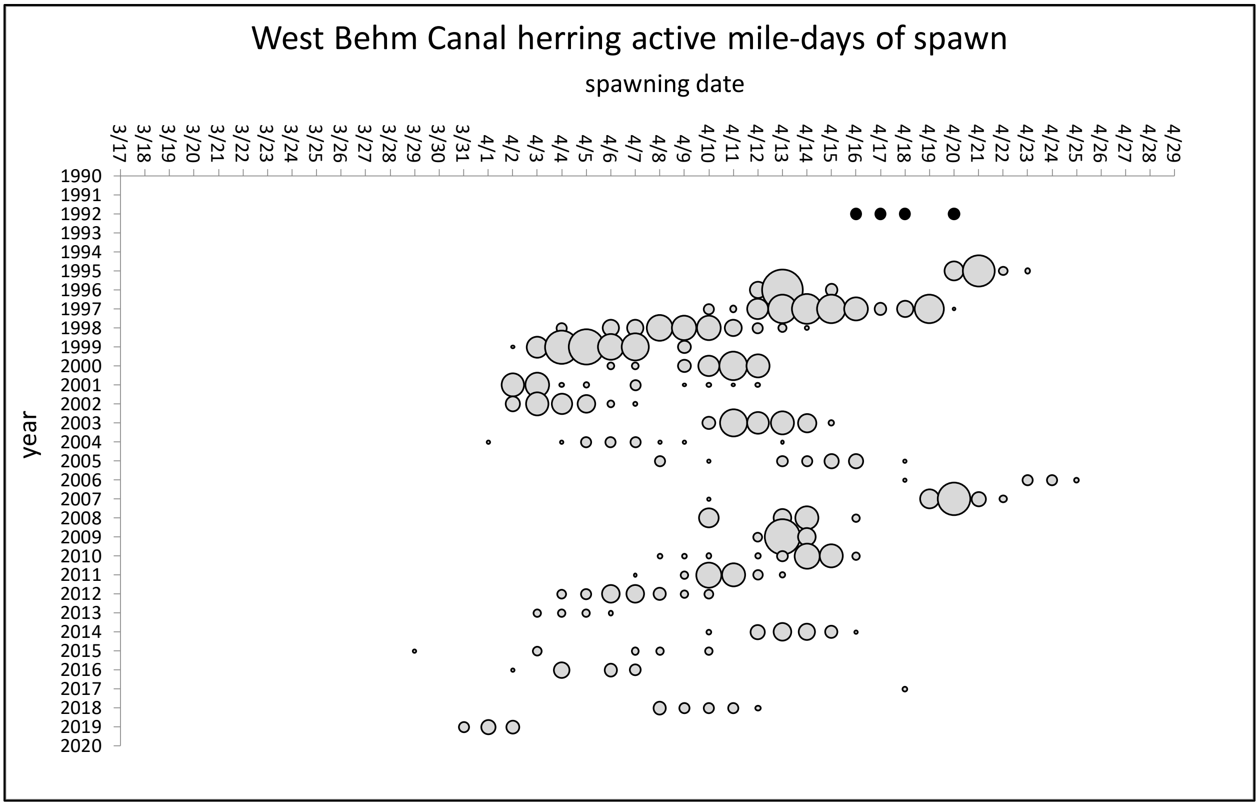

Figure 4.–Historical dates of active spawn observed for the West Behm Canal herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of 12 nautical miles of spawn and the smallest circles represent "spot spawns", which here have been given an arbitrary value of 0.1 nautical mile. Black circles represent days of active spawn, but for which no estimates of daily mileage are available. For years with blanks, data could not be located.

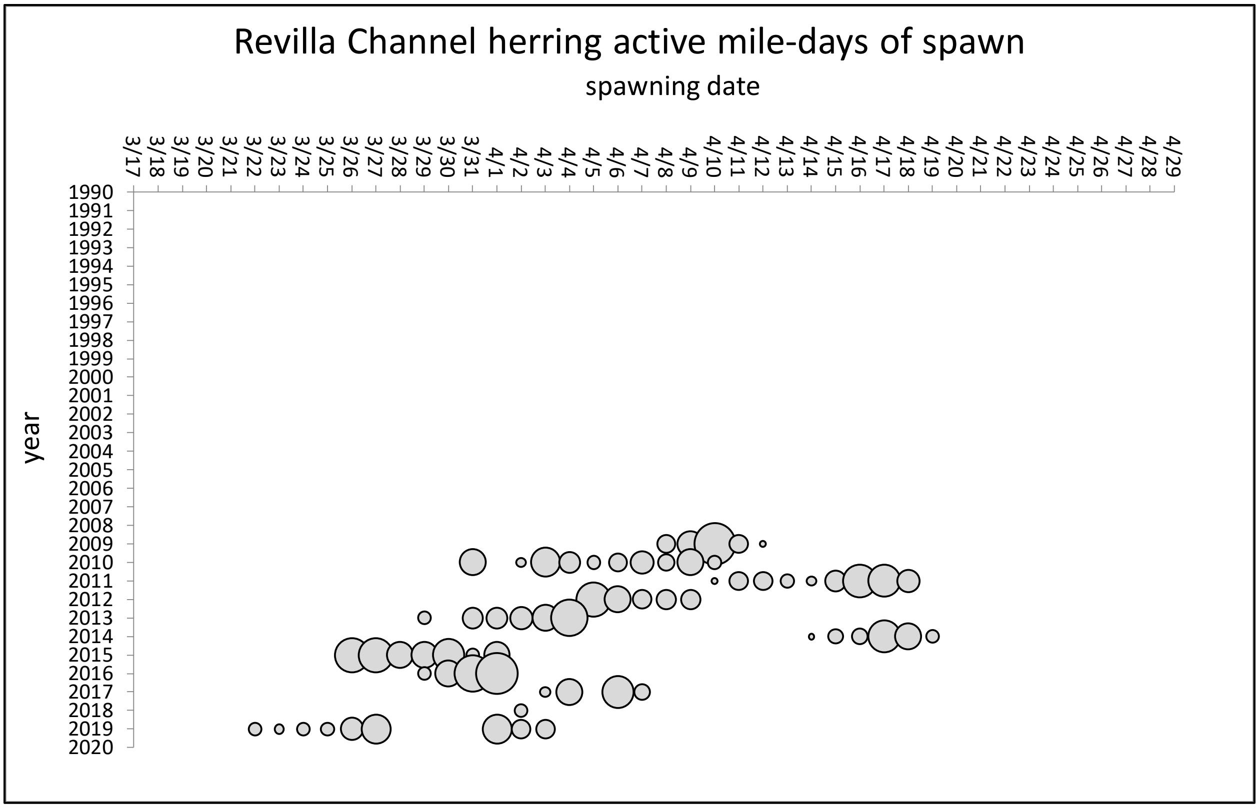

Figure 5.–Historical dates of active spawn observed for the Revilla Channel herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of 5 nautical miles of spawn and the smallest circles represent "spot spawns", which here have been given an arbitrary value of 0.1 nautical mile. For years with blanks, data could not be located or is not yet summarized.

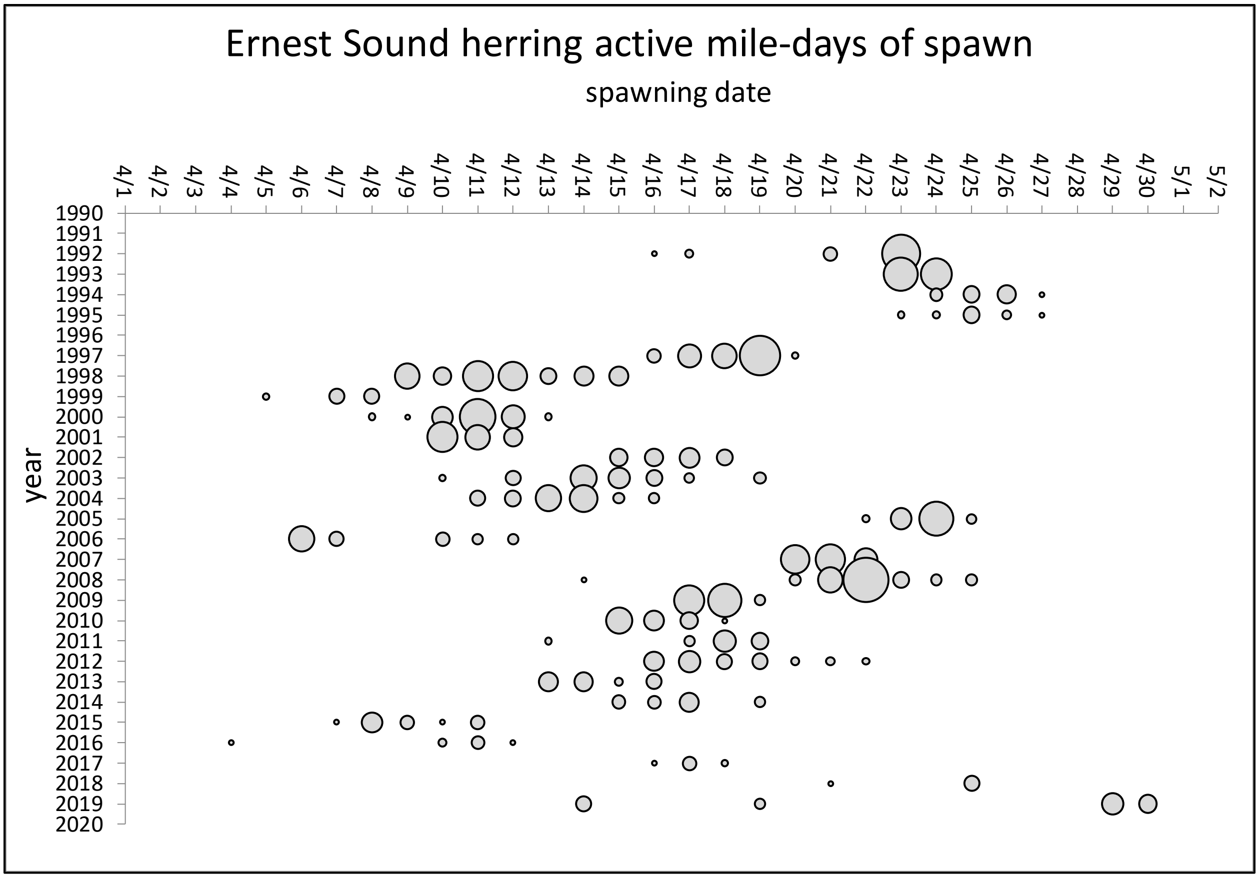

Figure 6.–Historical dates of active spawn observed for the Ernest Sound herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 9 nautical miles of spawn and the smallest circles represent “spot spawns”, which here have been given an arbitrary value of 0.1 nautical mile.

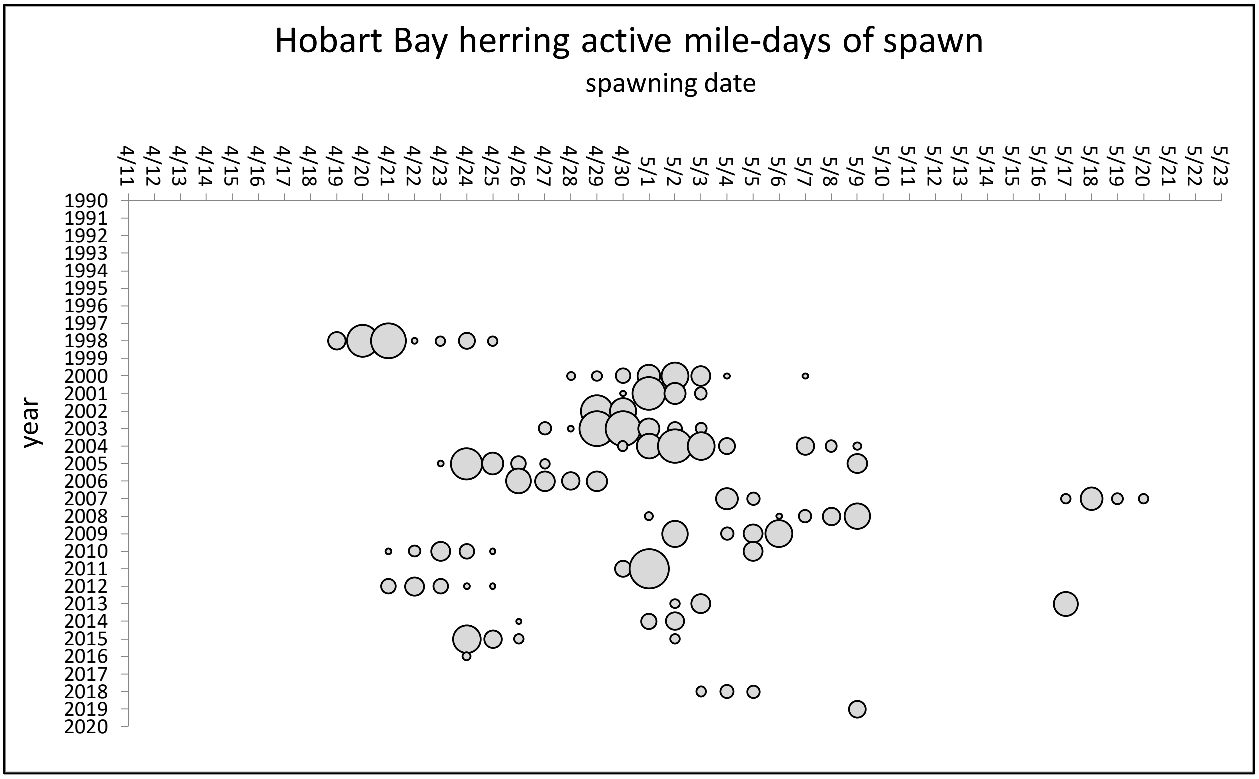

Figure 7.–Historical dates of active spawn observed for the Hobart Bay herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 6 nautical miles of spawn and the smallest circles represent “spot spawns”, which here have been given an arbitrary value of 0.1 nautical mile. For years with blanks, data could not be located.

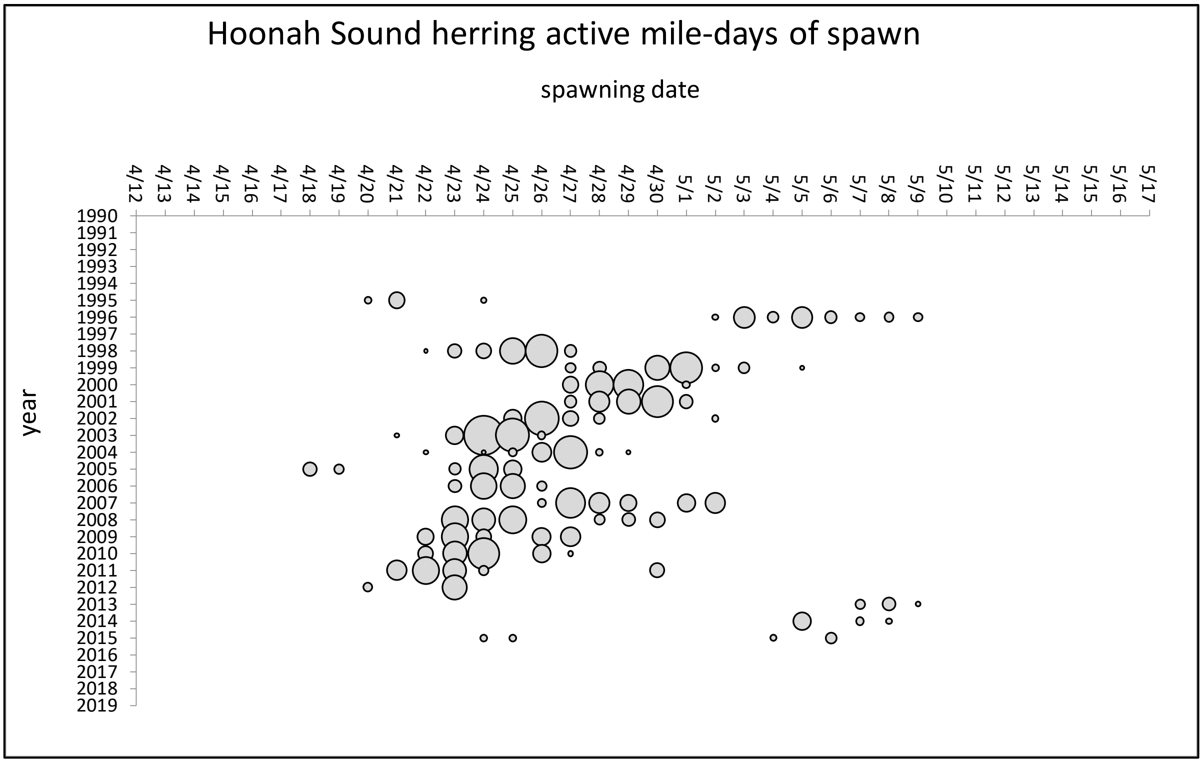

Figure 8.–Historical dates of active spawn observed for the Hoonah Sound herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 12 nautical miles of spawn and the smallest circles represent “spot spawns”, which here have been given an arbitrary value of 0.1 nautical mile. For years with blanks, data could not be located.

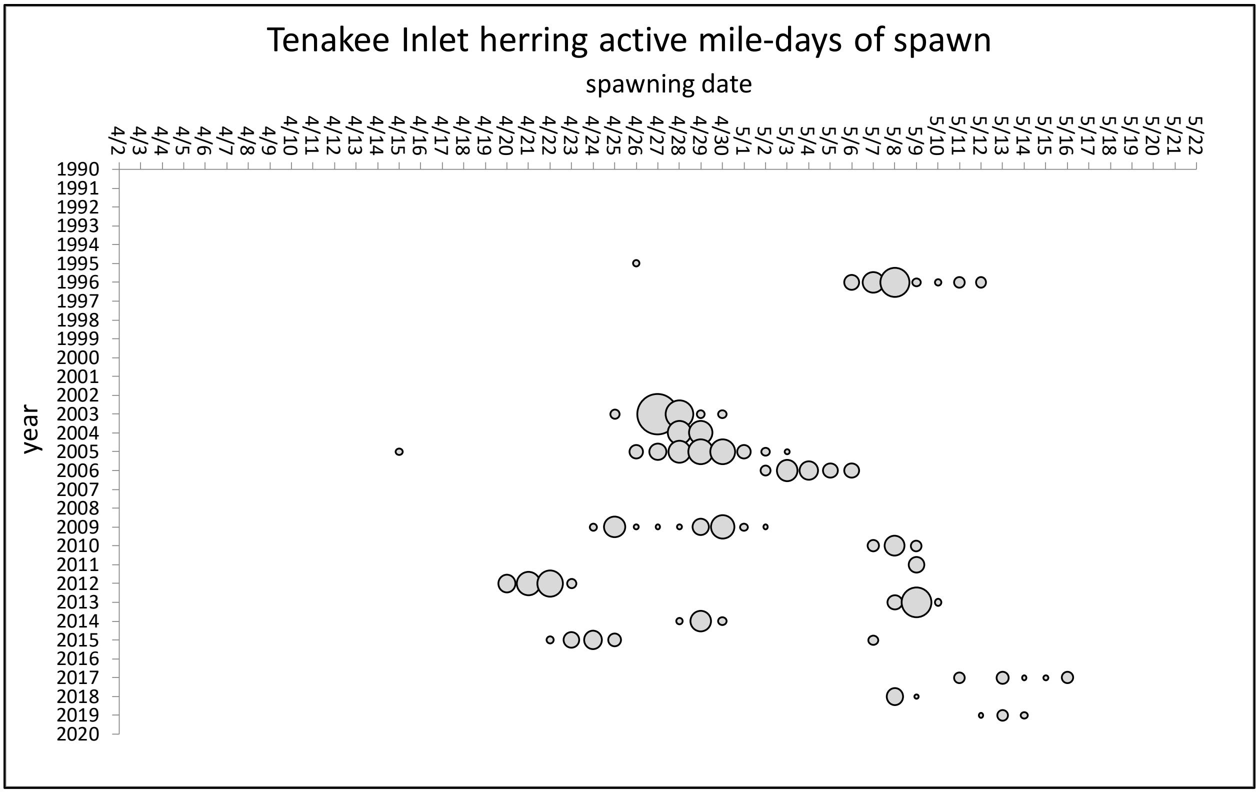

Figure 9.–Historical dates of active spawn observed for the Tenakee Inlet herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 8 nautical miles of spawn and the smallest circles represent "spot spawns", which here have been given an arbitrary value of 0.1 nautical mile. For years with blanks, data could not be located.

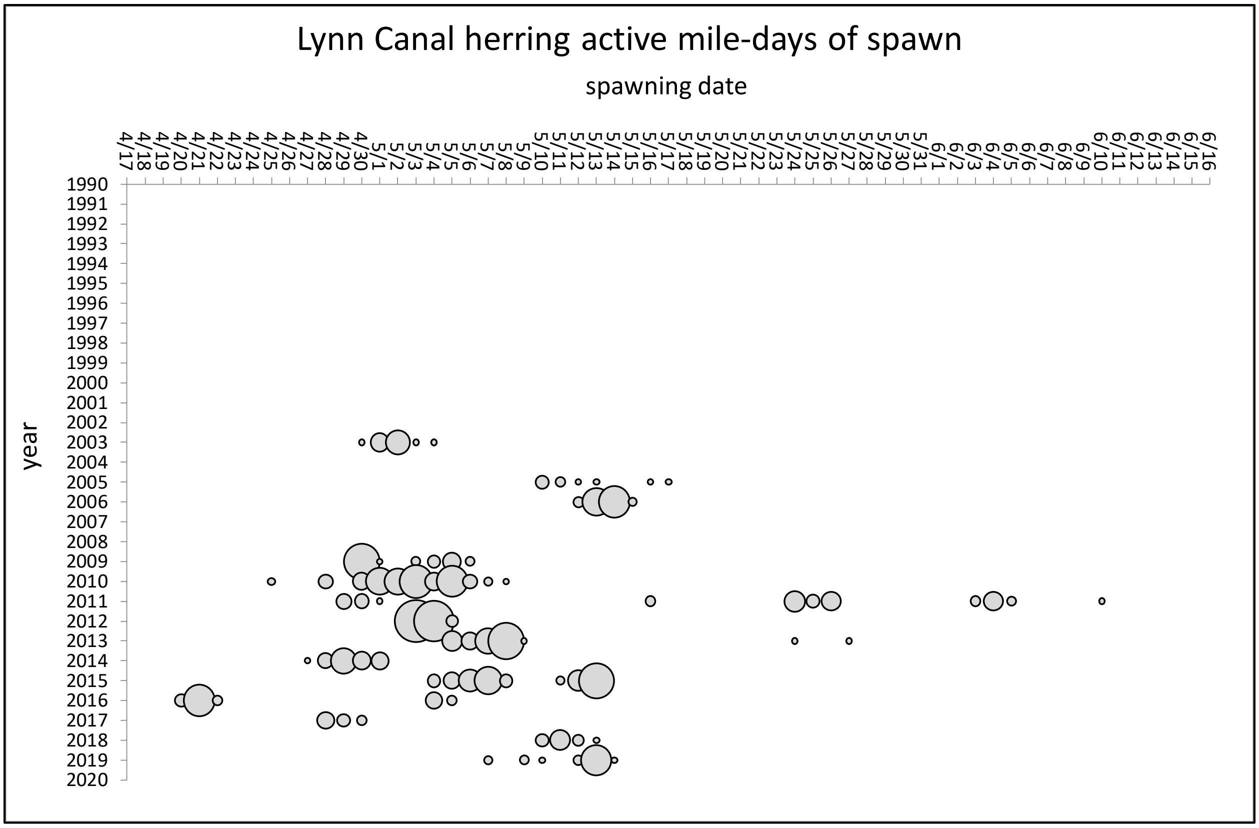

Figure 10.–Historical dates of active spawn observed for the Lynn Canal herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 5 nautical miles of spawn and the smallest circles represent "spot spawns", which here have been given an arbitrary value of 0.1 nautical mile. For years with blanks, data could not be located or is not yet summarized.

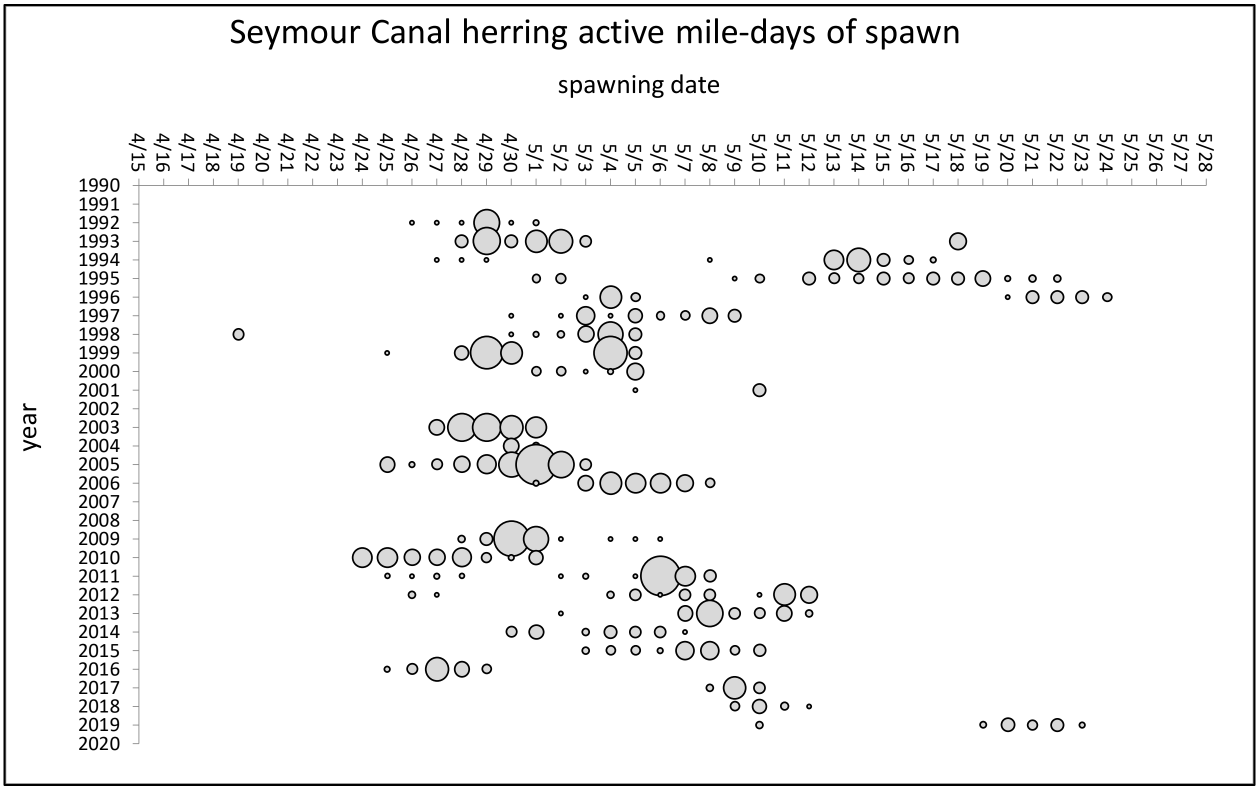

Figure 11.–Historical dates of active spawn observed for the Seymour Canal herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 10 nautical miles of spawn and the smallest circles represent "spot spawns", which here have been given an arbitrary value of 0.1 nautical mile. For years with blanks, data could not be located.

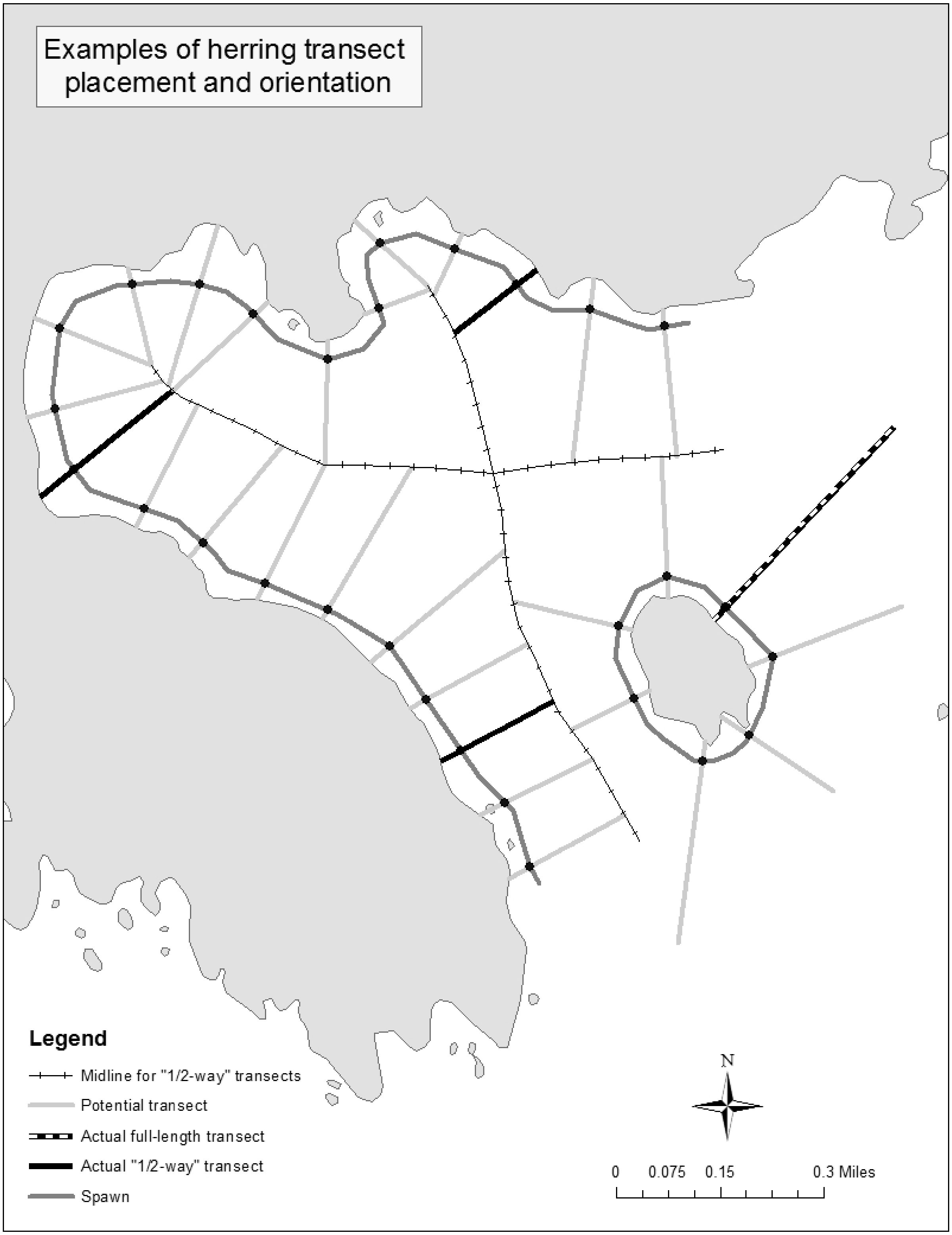

Figure 12.–Example of hypothetical herring transect placement and orientation, representing points at which transects should be halted to prevent over sampling.

Stock	9-Mar	10-Mar	11-Mar	12-Mar	13-Mar	14-Mar	15-Mar	16-Mar	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	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
Craig									ns	0.0	ns	ns	ns	ns	0.1	0.0	0.0	0.0	0.5	1.5	3.9	6.6	9.8	10.8	14.8	14.1	7.1	3.6	1.6	ns									
Sitka Sound			0.0	0.0	ns	ns	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.5	1.6	0.2	0.0	0.7	0.8	5.1	14.2	18.7	21.0	9.2	8.7	7.8	0.9	2.8	6.1	9.0	0.0	0.1	ns		
West Behm Canal																					0.0	ns	1.0	2.0	1.5	0.0	ns	ns	ns	ns	ns	0.0	ns						
Revilla Channel									ns	0.0	ns	ns	ns	0.5	0.2	0.5	0.5	1.5	2.5	0.0	0.0	ns	ns	2.5	1.0	1.0	0.0	ns											
Ernest Sound																												0.0	ns	ns	ns	ns	0.0	ns	ns	0.0	1.0	0.0	0.0
Hobart/Houghton																																						ns	0.0
Seymour Canal																																						ns	0.0
Tenakee Inlet																																						ns	0.0
Lynn Canal																																						ns	0.0

continued	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	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
Hoonah Sound	ns	1.0	ns	ns	ns	ns	ns	ns	1.0	ns	ns	ns	1.0	ns																									
Ernest Sound	ns	ns	0.5	0.0	ns	0.0	ns	0.0	ns	0.0	ns	ns	2.0	1.4	0.0	0.0	ns																						
Hobart/Houghton	ns	ns	ns	ns	ns	ns	ns	0.0	ns	0.0	ns	ns	0.0	0.0	0.0	ns	0.0	ns	ns	ns	ns	ns	ns	0.9	0.0	ns													
Seymour Canal	ns	ns	0.0	ns	ns	ns	0.0	ns	ns	ns	ns	0.0	0.0	0.0	0.0	0.0	0.0	ns	0.0	ns	0.0	ns	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.1	0.6	1.0	0.2	ns	
Tenakee Inlet	ns	ns	0.0	ns	ns	ns	0.0	ns	ns	0.0	ns	0.0	ns	ns	0.0	ns	ns	ns	ns	ns	0.0	ns	ns	ns	ns	0.1	0.5	0.2	0.0	ns									
Lynn Canal	ns	ns	0.0	ns	ns	ns	0.0	ns	ns	ns	ns	0.0	ns	0.0	ns	0.0	ns	ns	0.0	ns	0.2	0.0	0.3	0.0	ns	0.3	2.8	0.2	0.0	ns	ns	ns	ns	0.0	ns				
Yakutat	No aerial surveys completed in 2018																																						
Haines	No aerial surveys completed in 2018																																						

Figure 13.–Spawn timing of herring stocks in Southeast Alaska during spring 2019. Values indicate daily measurements of nautical miles of active spawn recorded during aerial surveys. Shaded area depicts dates when cast-net samples were taken. Boxed areas indicate duration of spawning (first to last dates of observed spawn). Dates with no survey are depicted by “ns”.

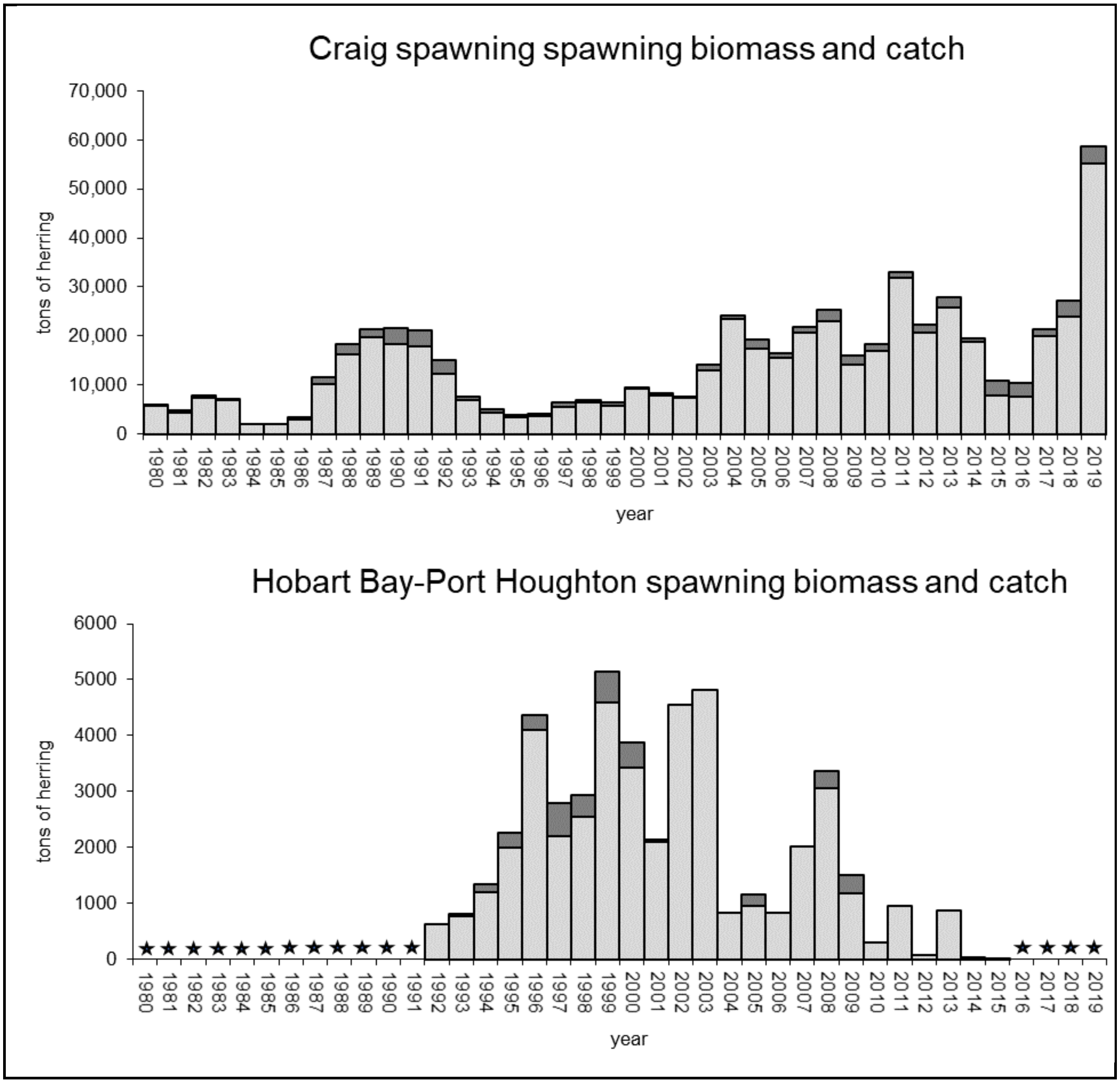

Figure 14.–Observed herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys, and catch (dark gray bars) for stocks in the Craig and Hobart Bay–Port Houghton areas, during 1980–2019. Stars represent years when spawn deposition surveys were not conducted.

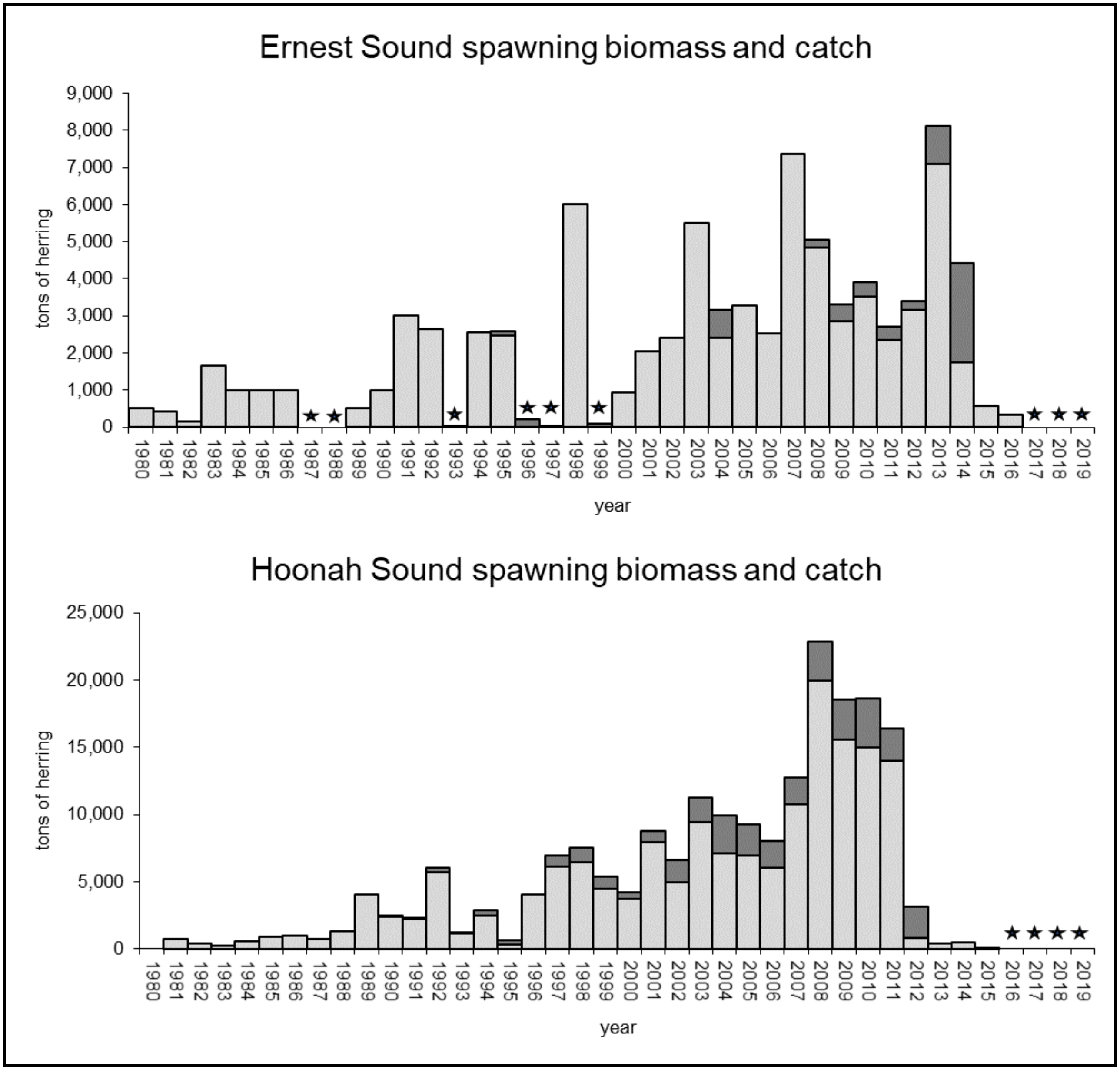

Figure 15.–Observed herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys or hydroacoustic surveys, and catch (dark gray bars) for stocks in the Ernest Sound and Hoonah Sound areas, during 1980–2019. Stars represent years when spawn deposition surveys were not conducted.

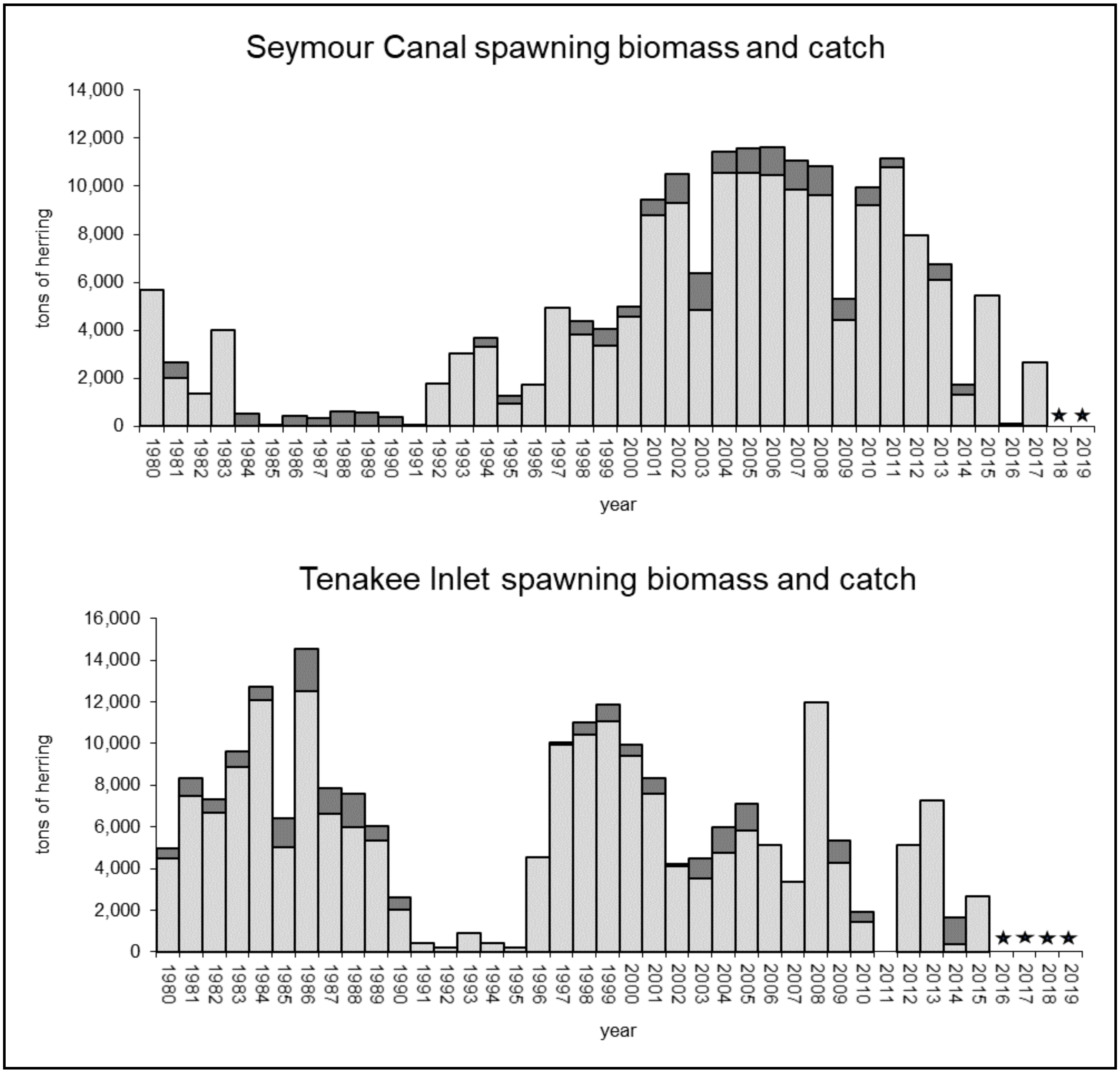

Figure 16.–Observed herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys or hydroacoustic surveys, and catch (dark gray bars) for stocks in the Seymour Canal and Tenakee Inlet areas, during 1980–2019. Stars represent years when spawn deposition surveys were not conducted.

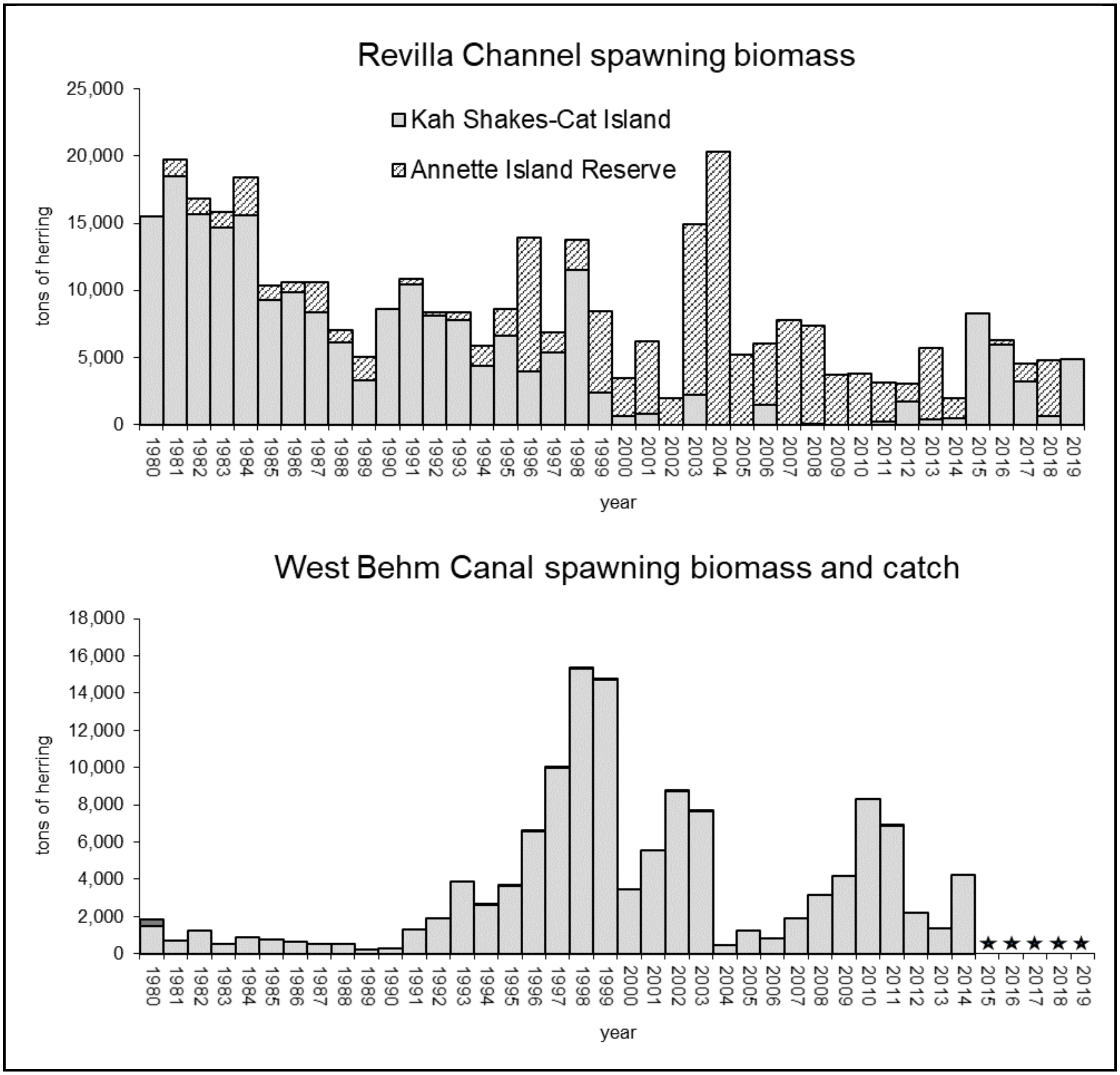

Figure 17.–Observed herring post-fishery spawning biomass, based on spawn deposition surveys or hydroacoustic surveys for stocks in the West Behm Canal and Revilla Channel (Kah Shakes–Cat Island–Annette Island) areas, during 1980–2019. Annette Island spawning biomass estimates between 1981 and 2016 were 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. Stars represent years when spawn deposition surveys were not conducted.

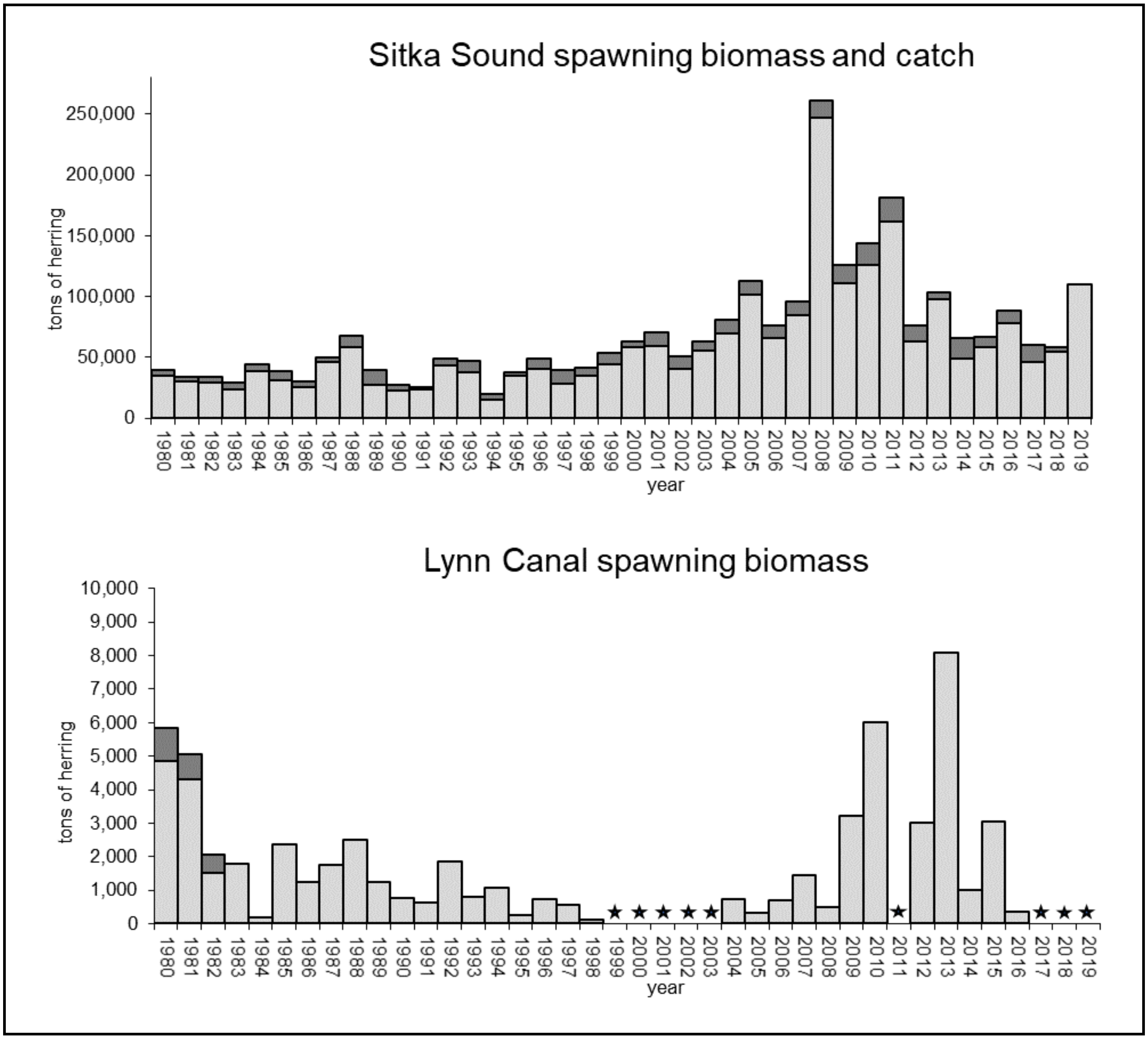

Figure 18.–Observed herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys, and catch (dark gray bars) for stock in the Sitka Sound and Lynn Canal areas, during 1980–2019. Estimates of spawning biomass for Lynn Canal prior to 2004 were made using a variety of methods (e.g., hydroacoustics or visual estimates of spawn density converted to biomass), and results should be viewed as approximations. Stars represent years when spawn deposition surveys were not conducted.

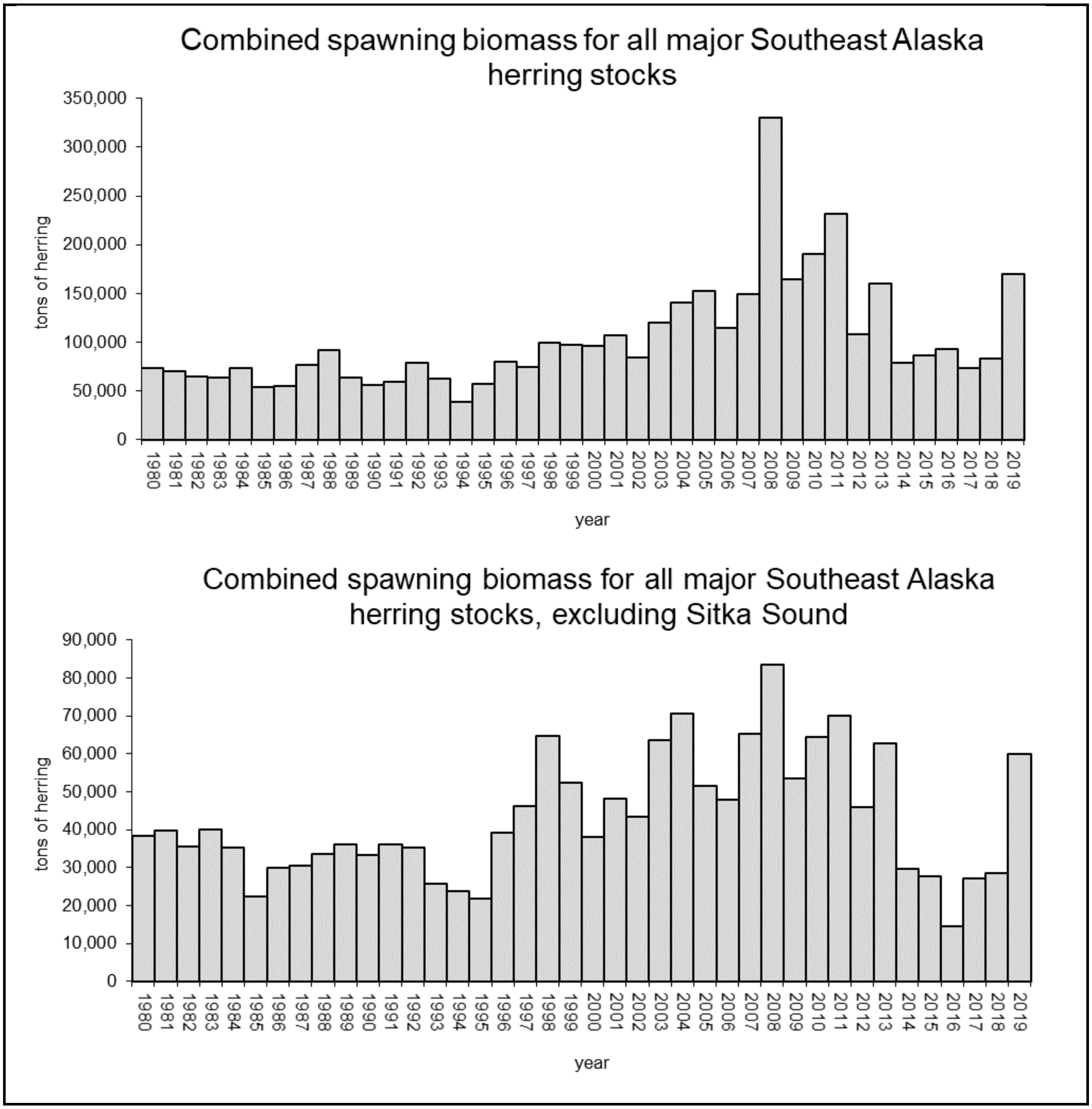

Figure 19.–Combined observed herring post-fishery spawning biomass, based on spawn deposition surveys or hydroacoustic surveys, for major herring stocks in Southeast Alaska, during 1980–2019. Recent years represent an underestimate of regional total biomass, because of the ten major spawning areas that have been historically monitored, the following number of areas were surveyed in recent years: 2016, 6 areas; 2017, 7 areas; 2018, 2 areas; and 2019, 3 areas.

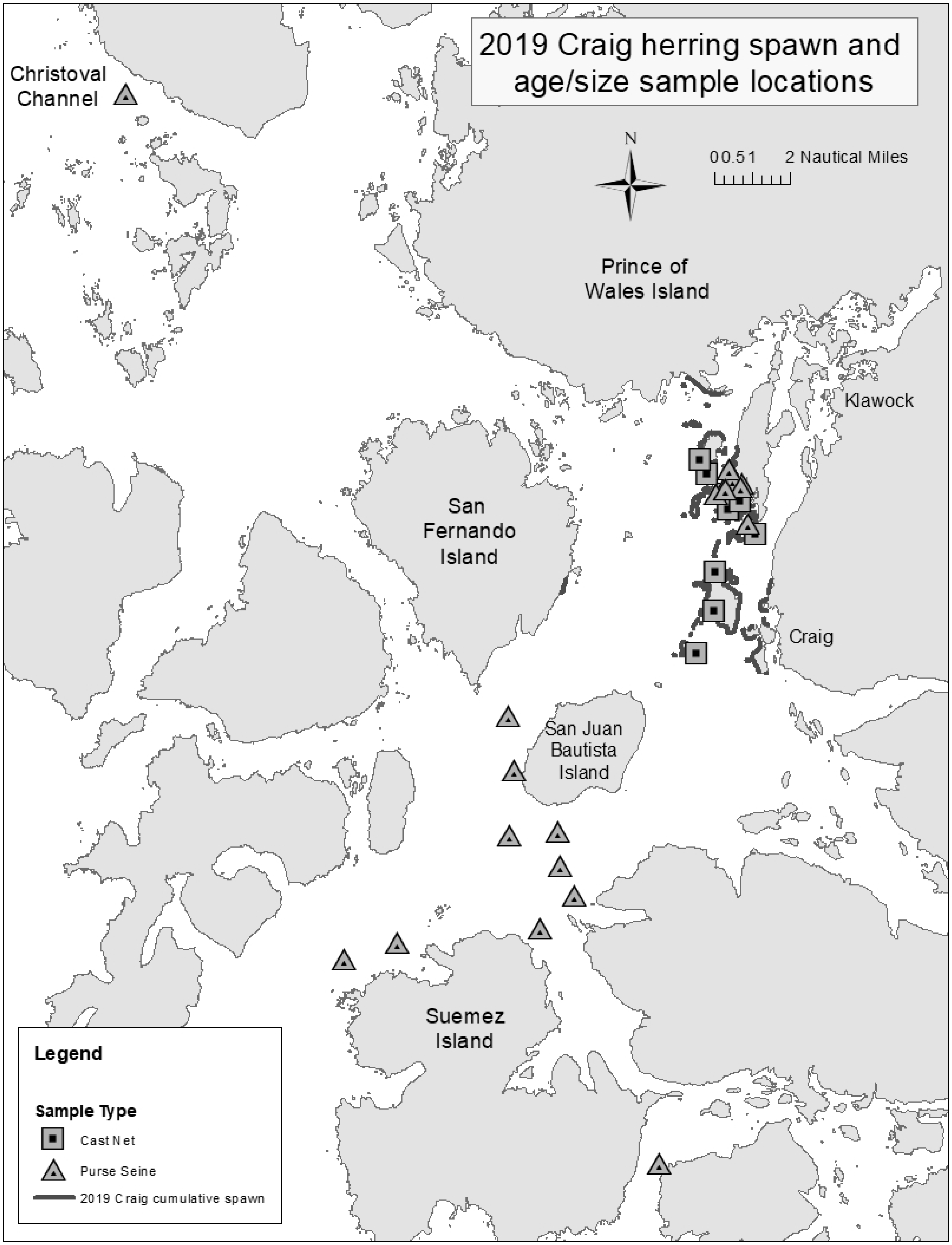

Figure 20.–Locations of herring samples collected for estimates of age and size for the Craig herring stock for the 2018–19 season. Cumulative herring spawn denoted by thick gray line along shoreline.

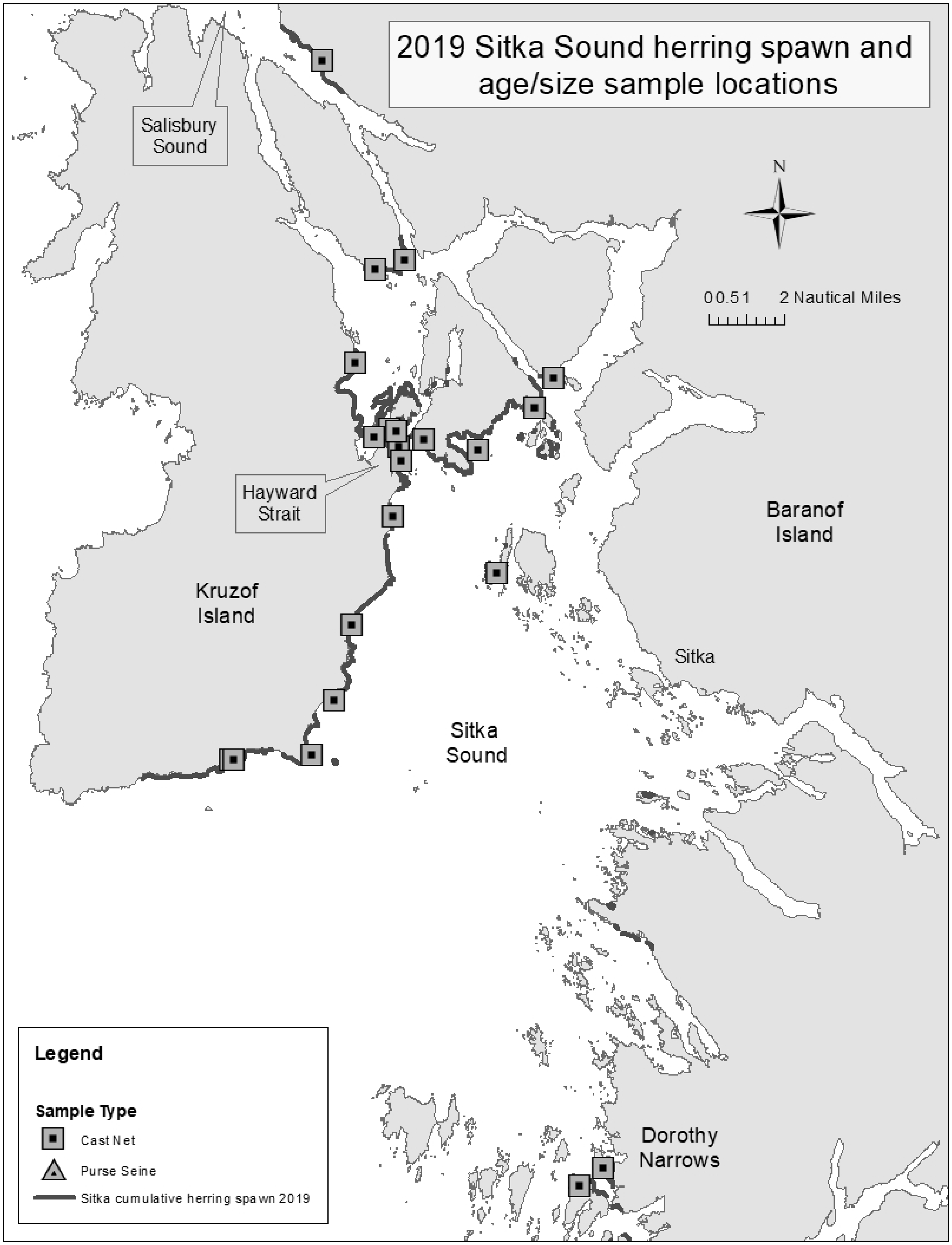

Figure 21.–Locations of herring samples collected for estimates of age and size for the Sitka Sound herring stock for the 2018–19 season. Cumulative herring spawn denoted by thick gray line along shoreline.

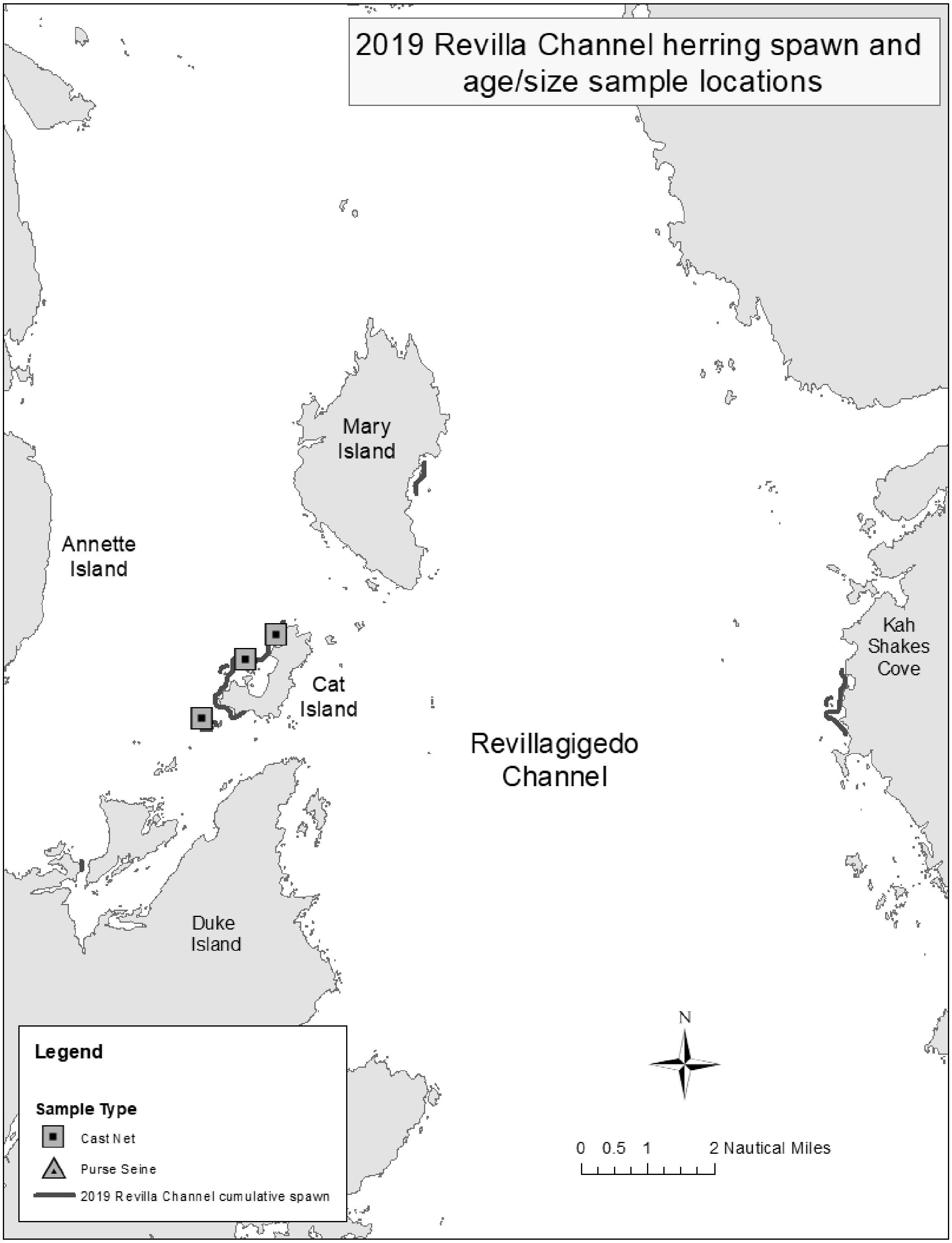

Figure 22.–Locations of herring samples collected for estimates of age and size for the Revilla Channel herring stock for the 2018–19 season. Cumulative herring spawn denoted by thick gray line along shoreline.

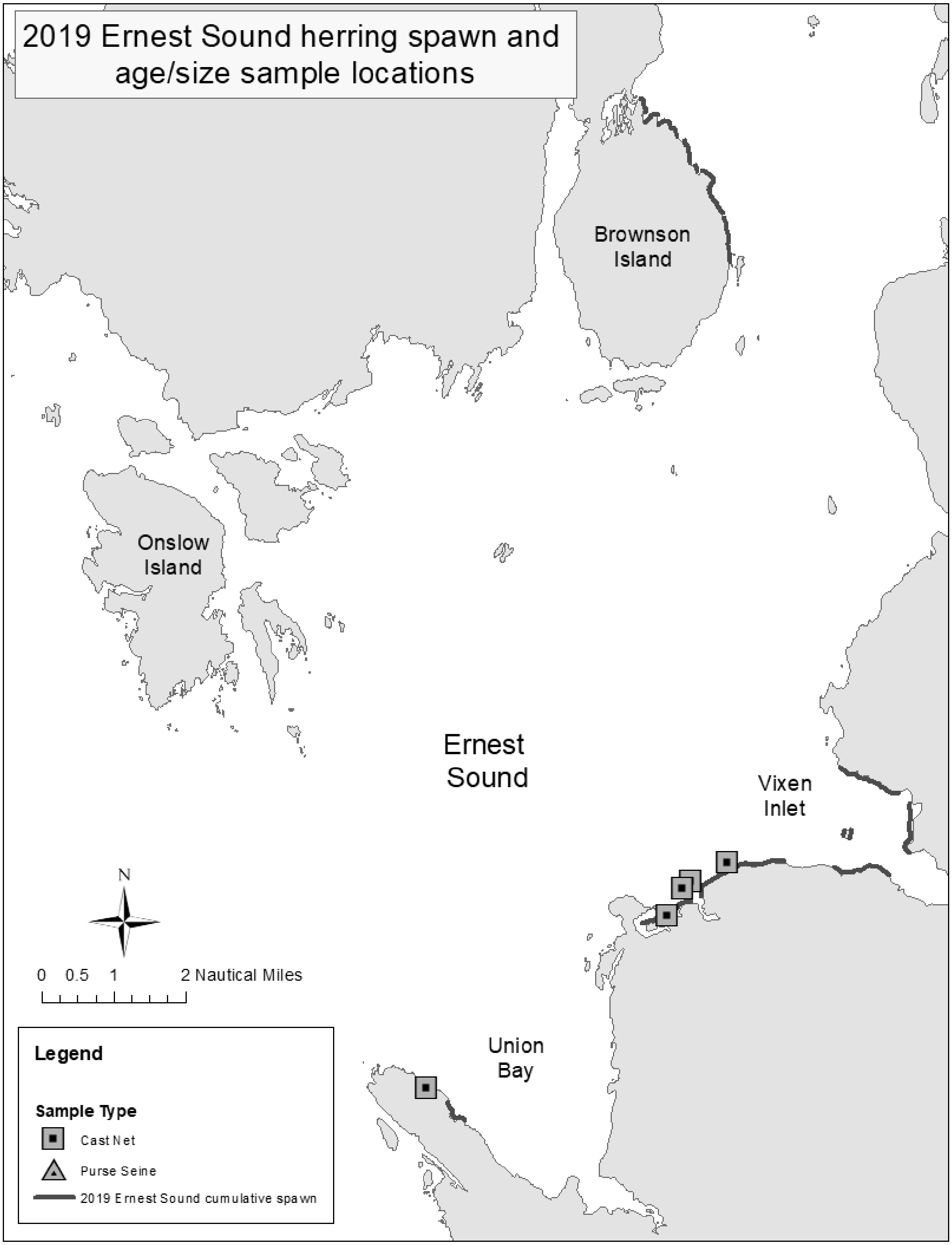

Figure 23.–Locations of herring samples collected for estimates of age and size for the Ernest Sound herring stock for the 2018–19 season. Cumulative herring spawn denoted by thick gray line along shoreline.

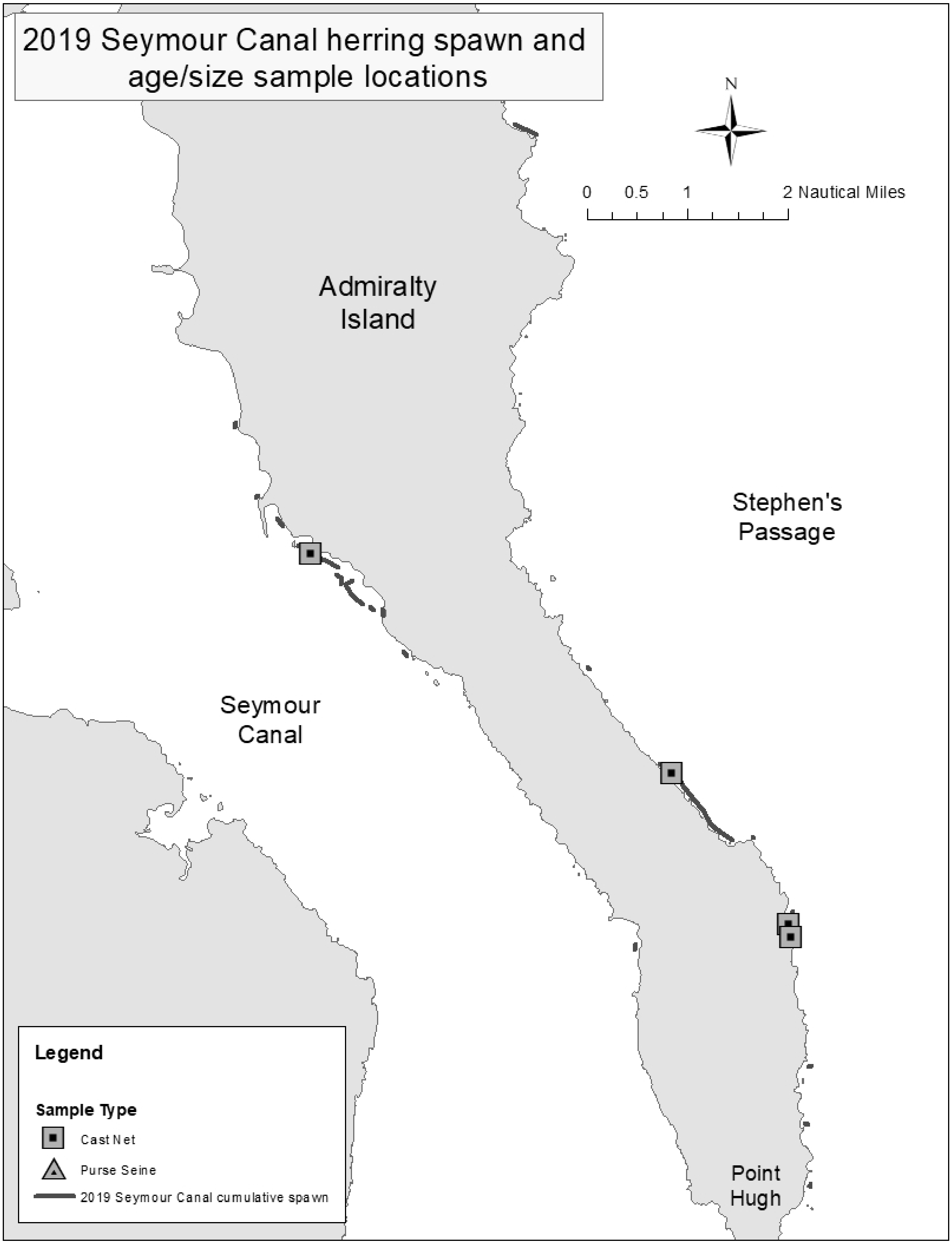

Figure 24.–Locations of herring samples collected for estimates of age and size for the Seymour Canal herring stock for the 2018–19 season. Cumulative herring spawn denoted by thick gray line along shoreline.

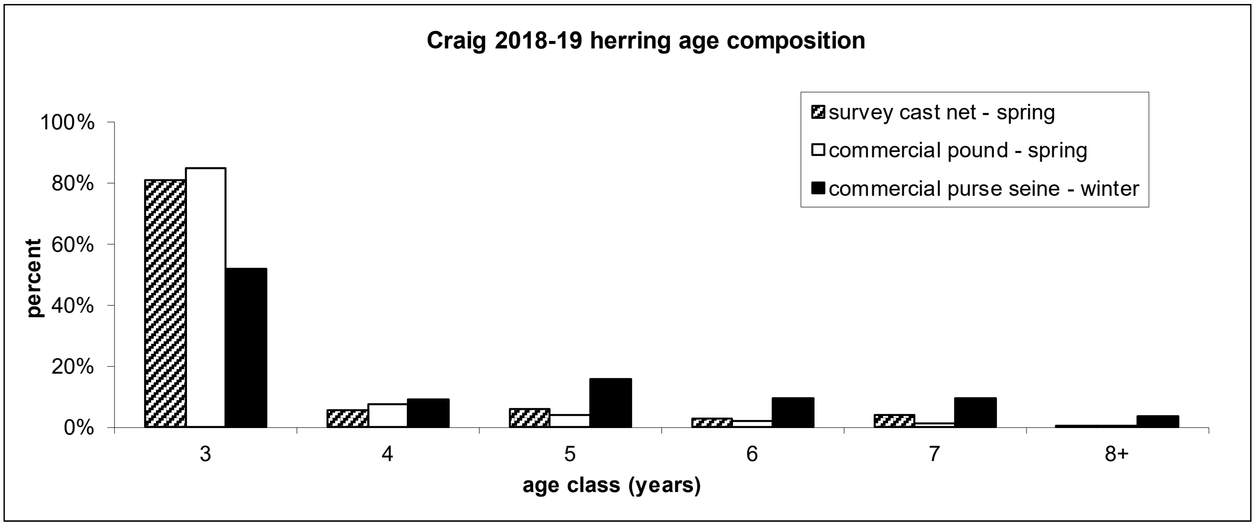

Figure 25.–Observed age composition for Craig herring stock in 2018–19.

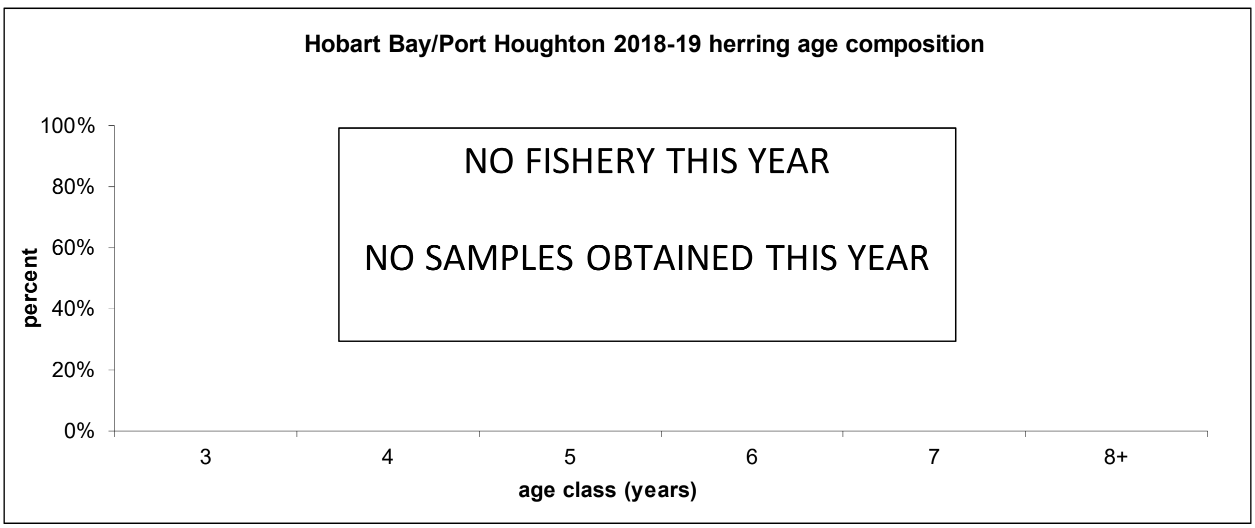

Figure 26.–Observed age composition for Hobart Bay–Port Houghton herring stock in 2018–19. No samples were attempted or obtained in 2018–19.

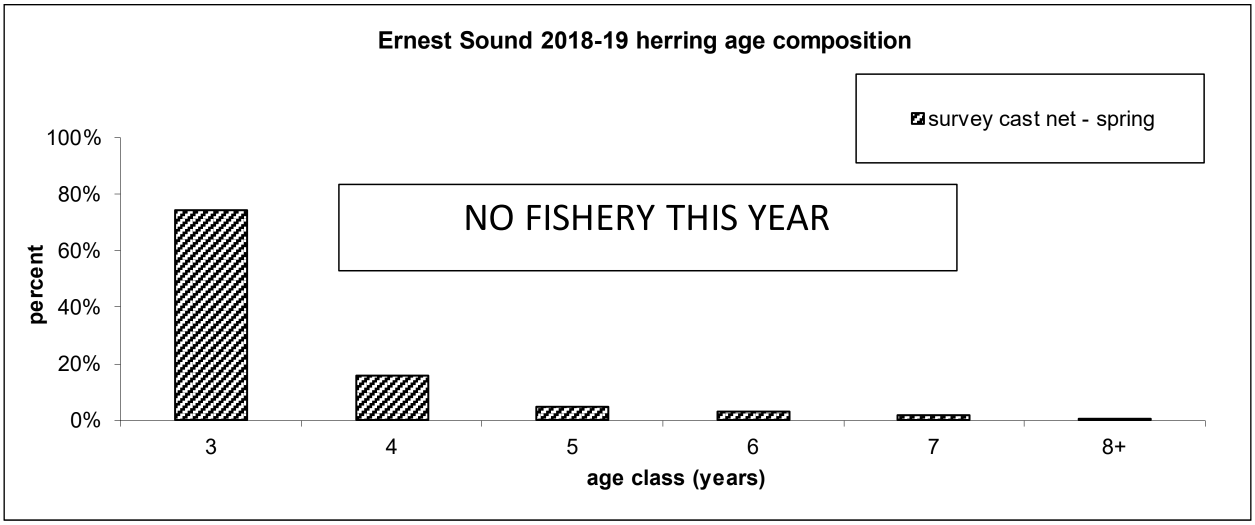

Figure 27.–Observed age composition for Ernest Sound herring stock in 2018–19.

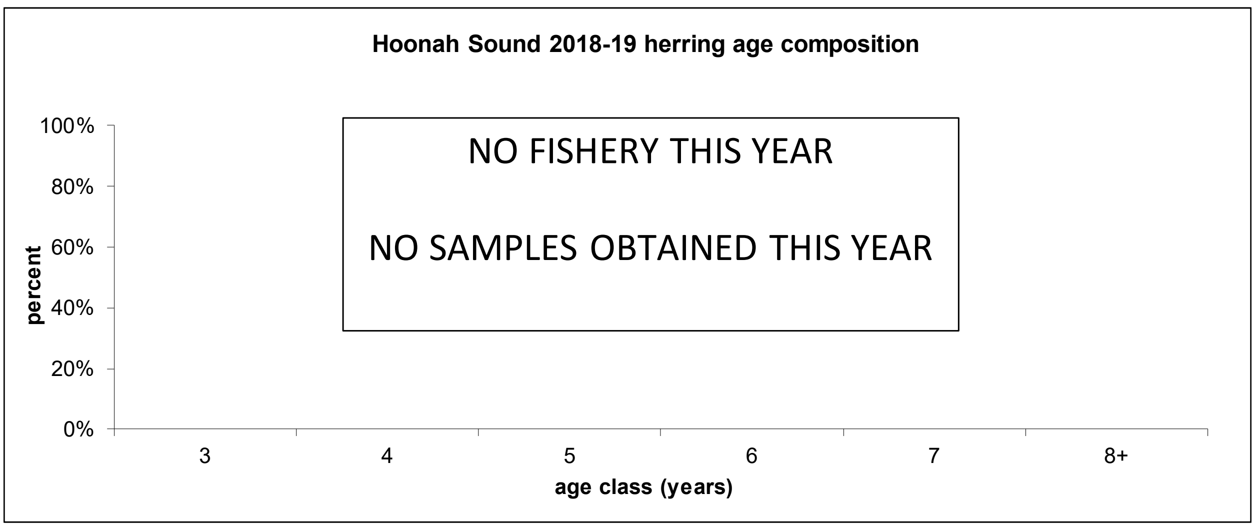

Figure 28.–Observed age composition for Hoonah Sound herring stock in 2018–19. No samples were attempted or obtained in 2018–19.

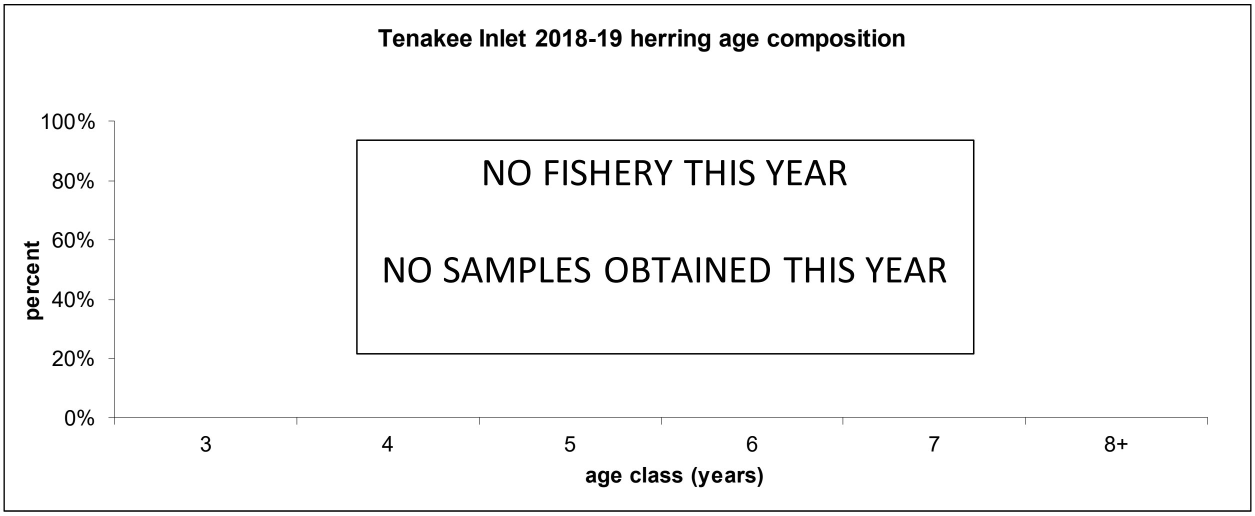

Figure 29.–Observed age composition for Tenakee Inlet herring stock in 2018–19. No samples were attempted or obtained in 2018–19.

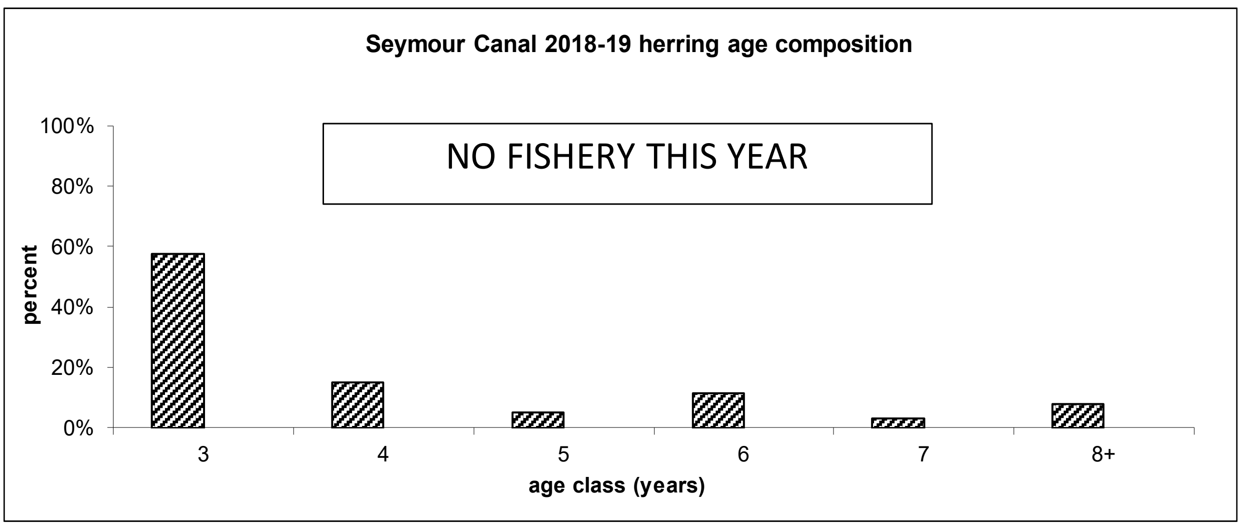

Figure 30.–Observed age composition for Seymour Canal herring stock in 2018–19. No samples were attempted or obtained in 2018–19.

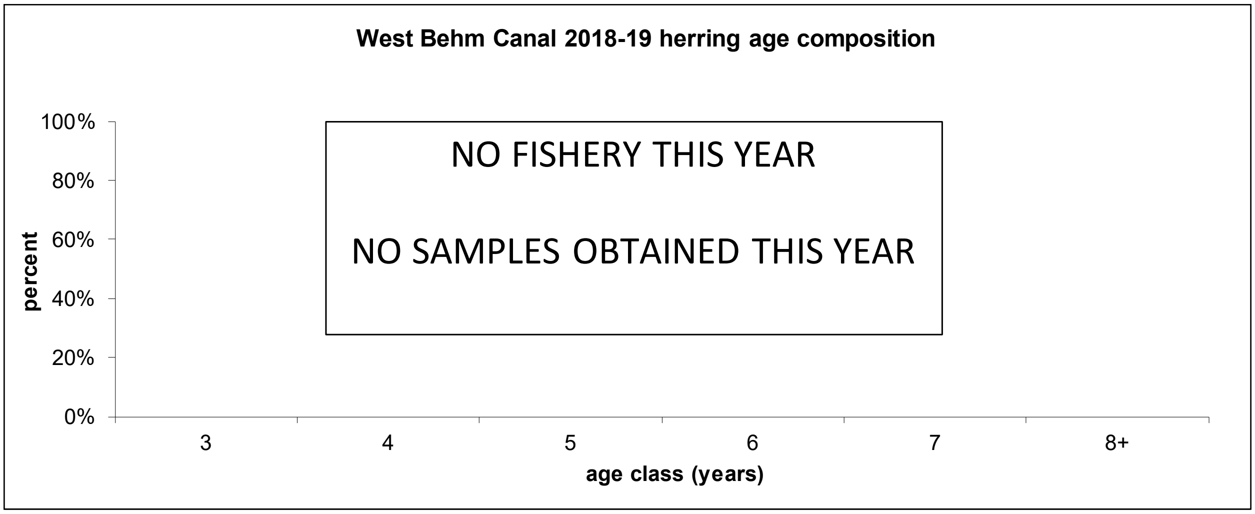

Figure 31.–Observed age composition for West Behm Canal herring stock in 2018–19. No samples were attempted or obtained in 2018–19.

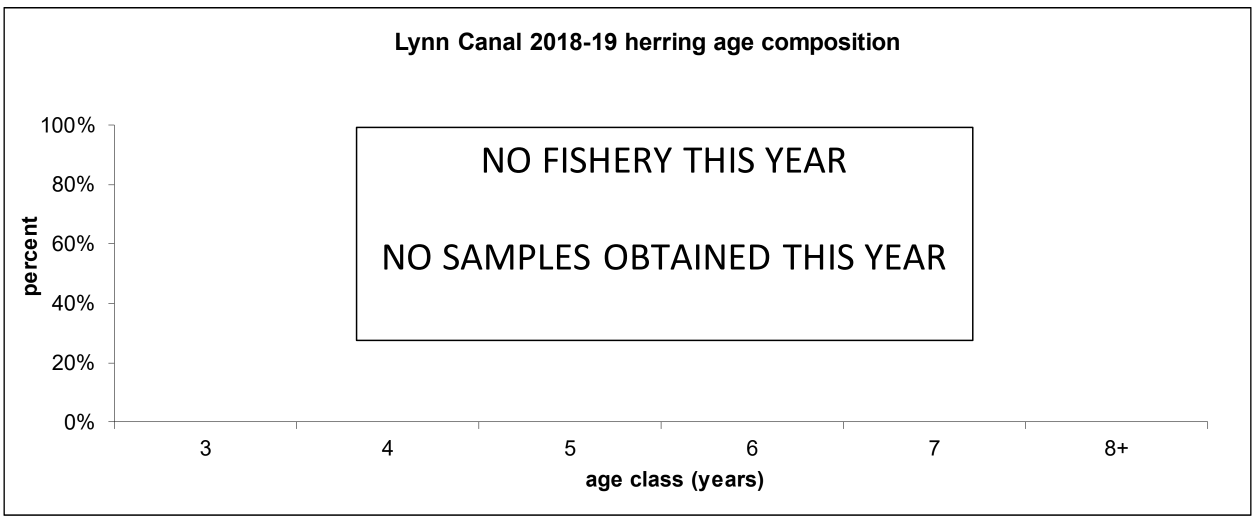

Figure 32.–Observed age composition for Lynn Canal herring stock in 2018–19. No samples were attempted or obtained in 2018–19.

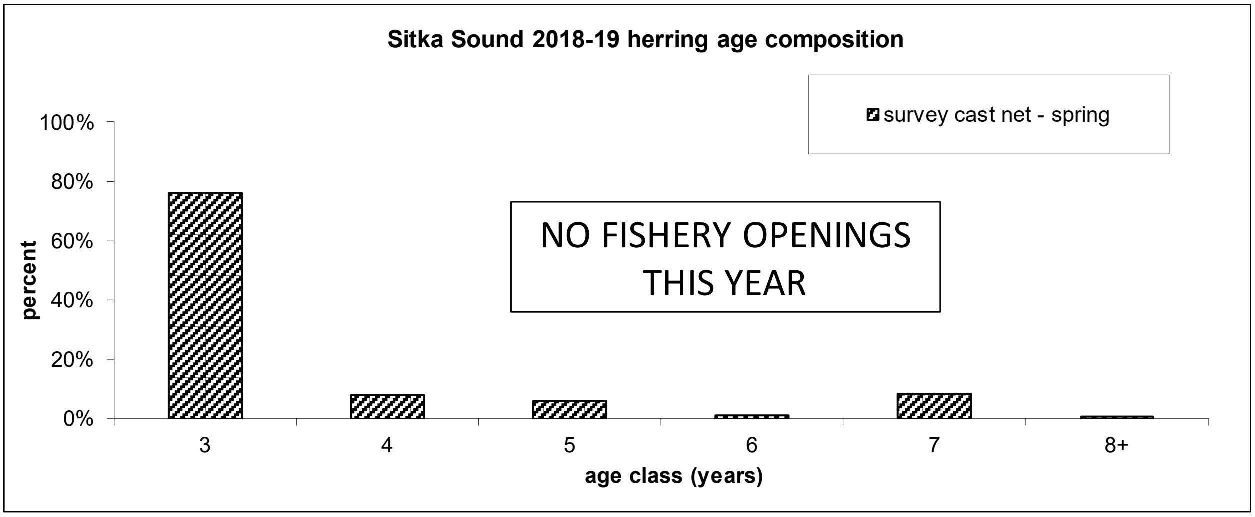

Figure 33.–Observed age composition for Sitka Sound herring stock in 2018–19. No commercial samples obtained in 2018–19 due to no fishery openings announced.

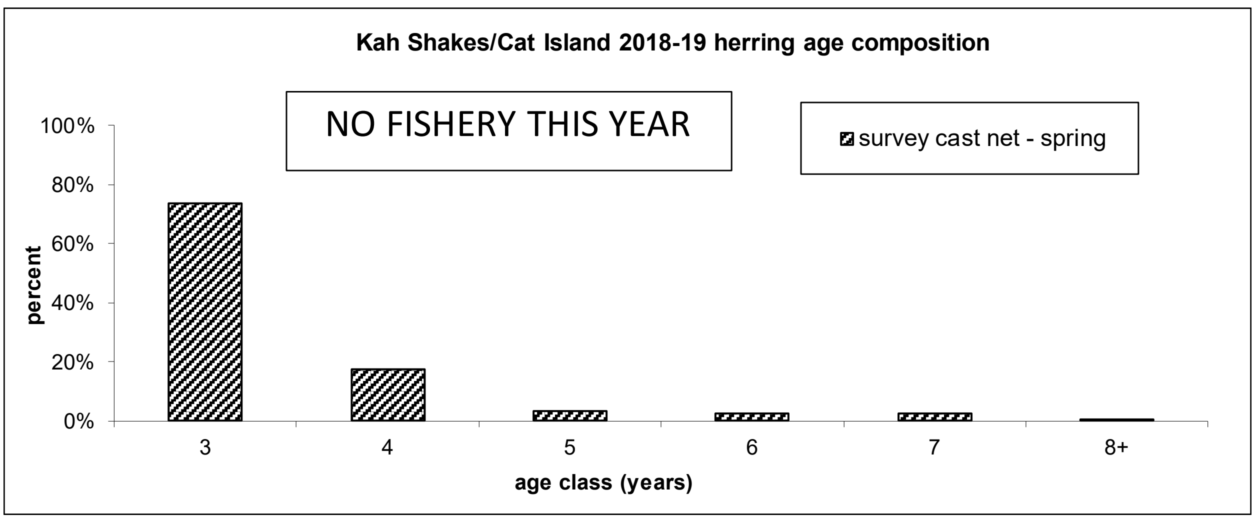

Figure 34.–Observed age composition for Revilla Channel herring stock (state waters only) in 2018–19. No samples were attempted or obtained in 2018–19.

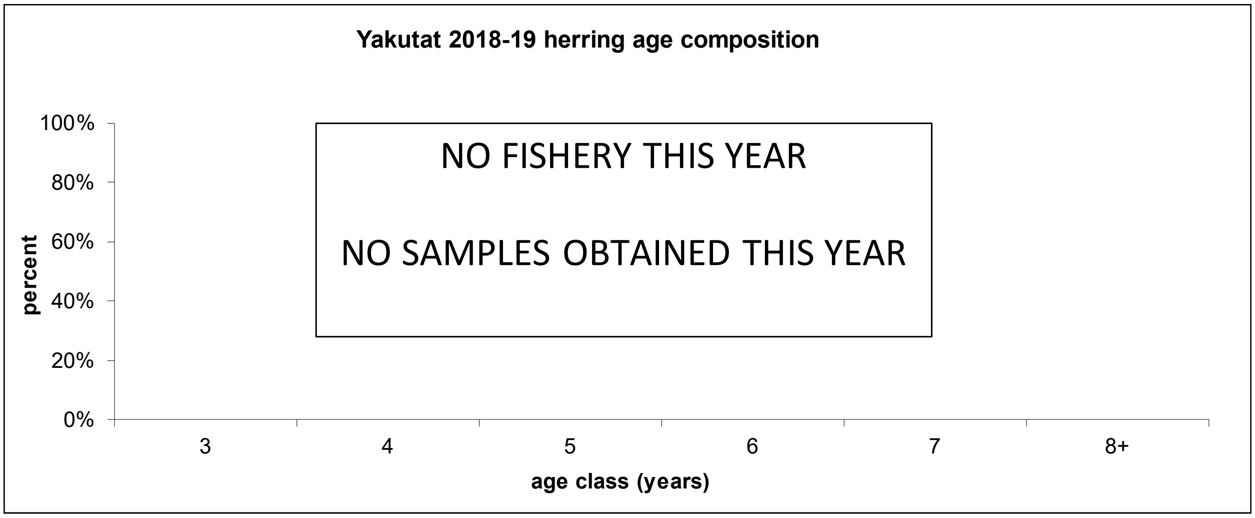

Figure 35.–Observed age composition for Yakutat Bay herring stock in 2018–19. No samples were attempted or obtained in 2018–19.

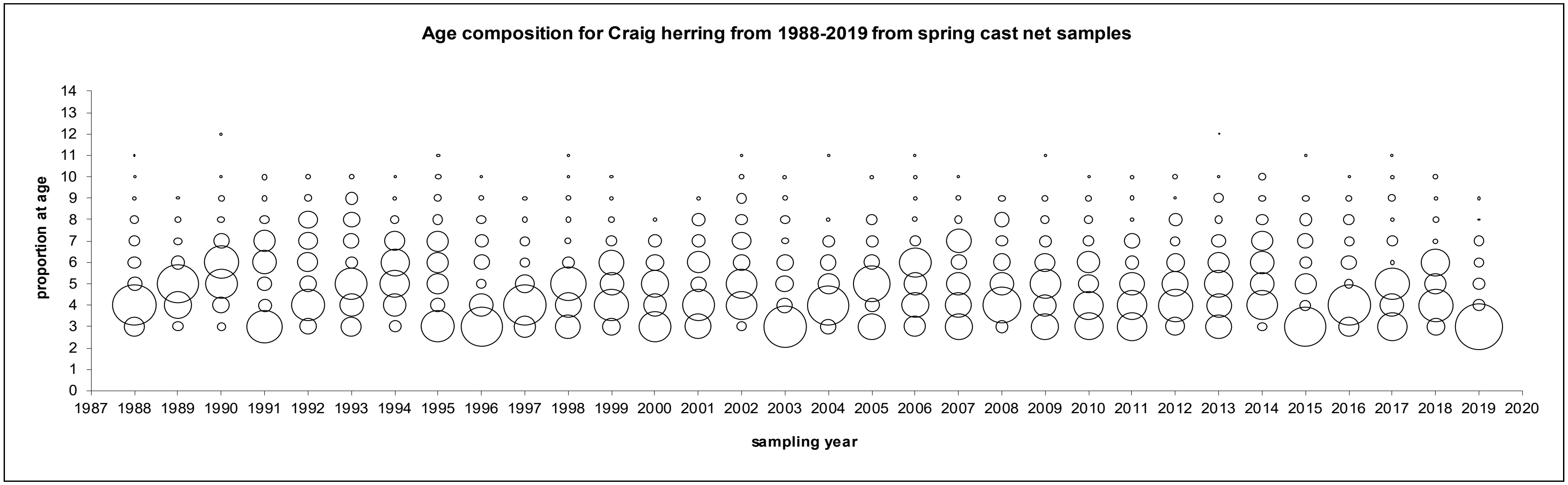

Figure 36.–Observed age compositions from sampling data for the Craig herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli. For reference, the largest circle represents 81%.

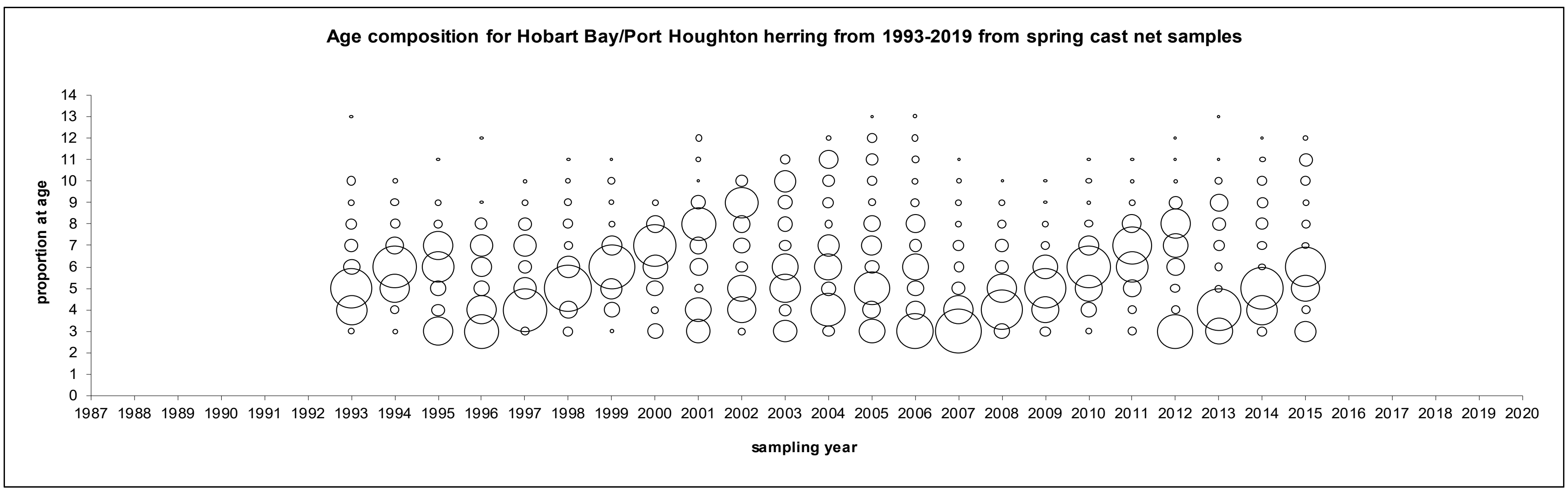

Figure 37.–Observed age compositions from sampling data for the Hobart Bay–Port Houghton herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli. For reference, the largest circle represents 67%.

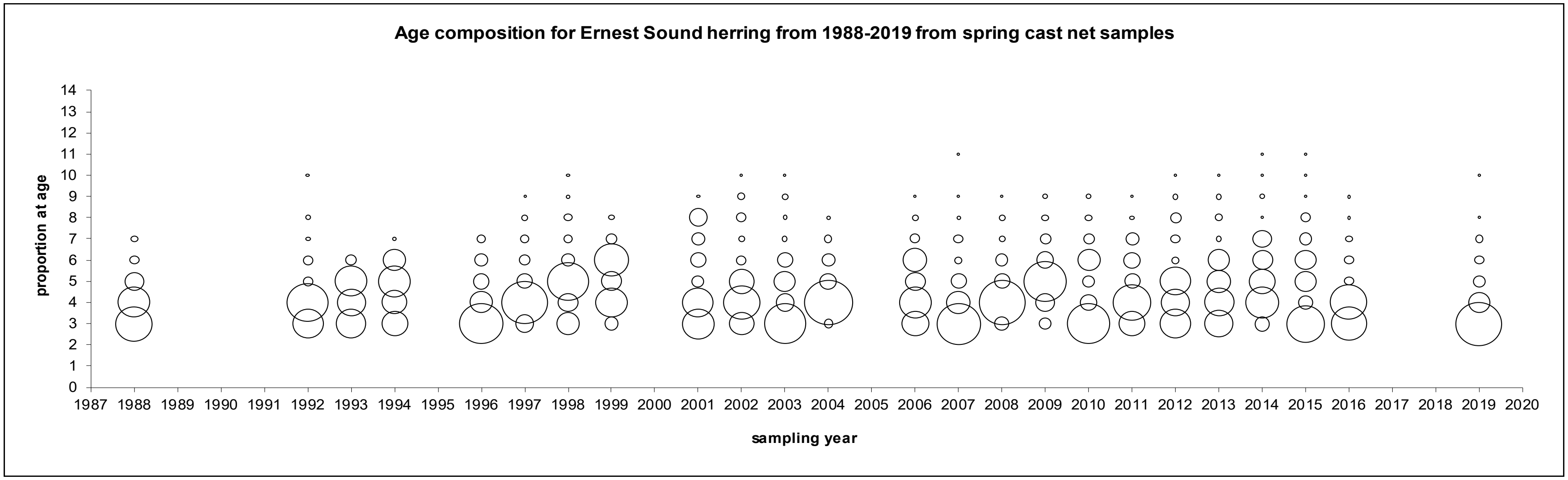

Figure 38.–Observed age compositions from sampling data for the Ernest Sound herring stock. For reference, the largest circle represents 80%.

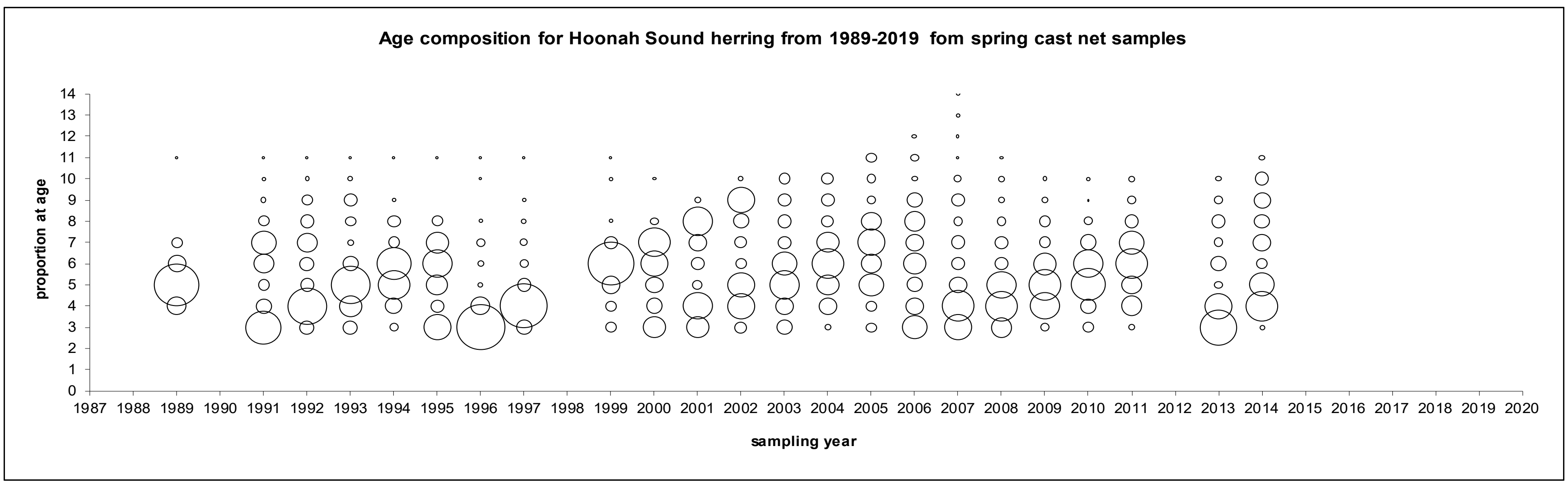

Figure 39.–Observed age compositions from sampling data for the Hoonah Sound herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli. For reference, the largest circle represents 82%.

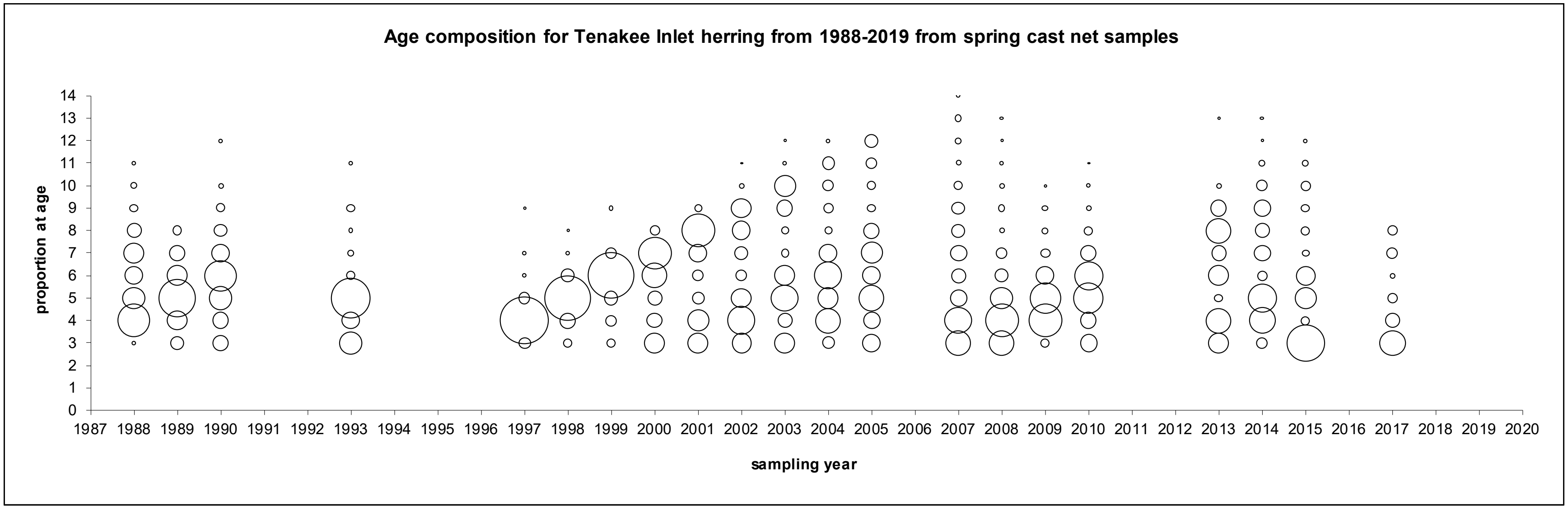

Figure 40.–Observed age compositions from sampling data for the Tenakee Inlet herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli. For reference, the largest circle represents 88%.

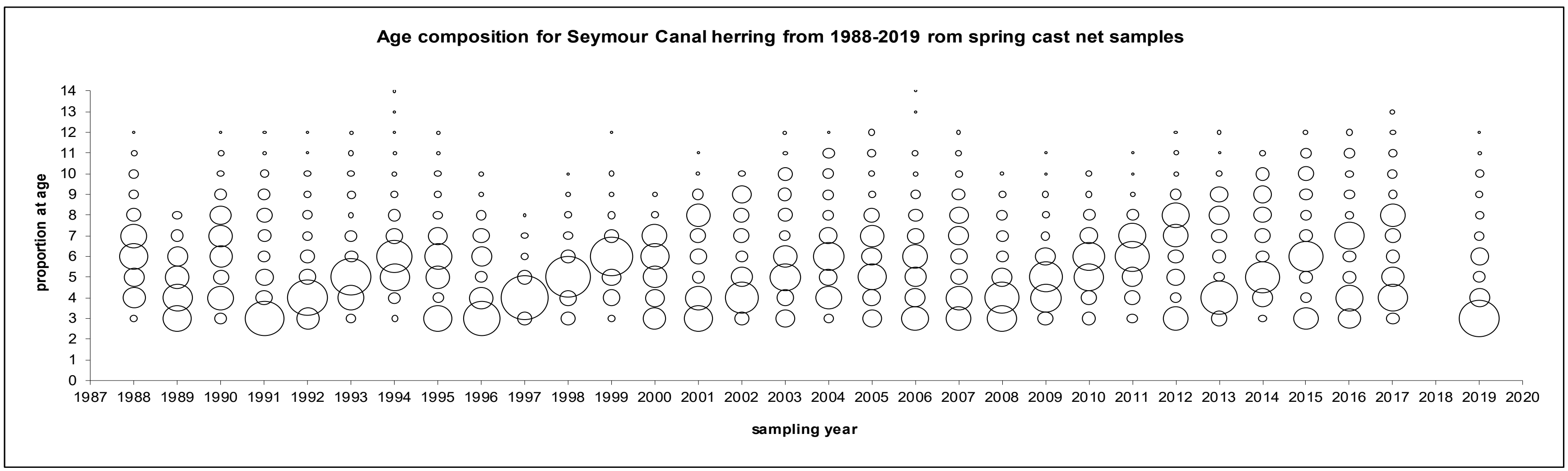

Figure 41.–Observed age compositions from sampling data for the Seymour Canal herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli. For reference, the largest circle represents 81%.

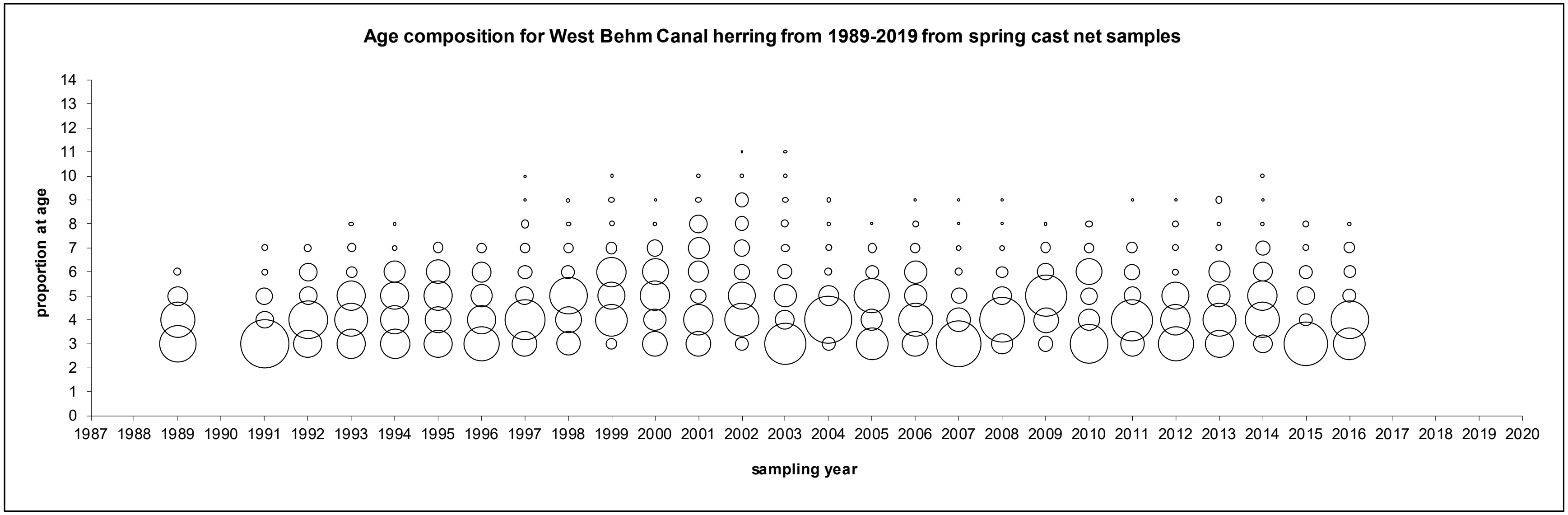

Figure 42.–Observed age compositions from sampling data for the West Behm Canal herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli. For reference, the largest circle represents 76%.

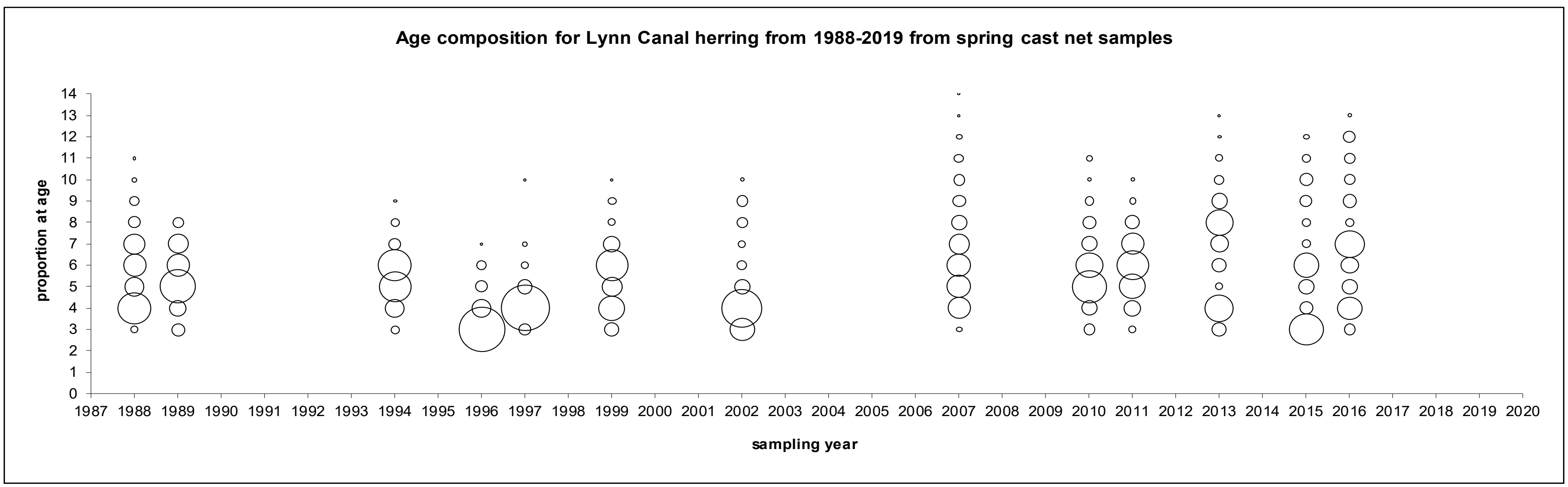

Figure 43.–Observed age compositions from sampling data for the Lynn Canal herring stock. For reference, the largest circle represents 79%.

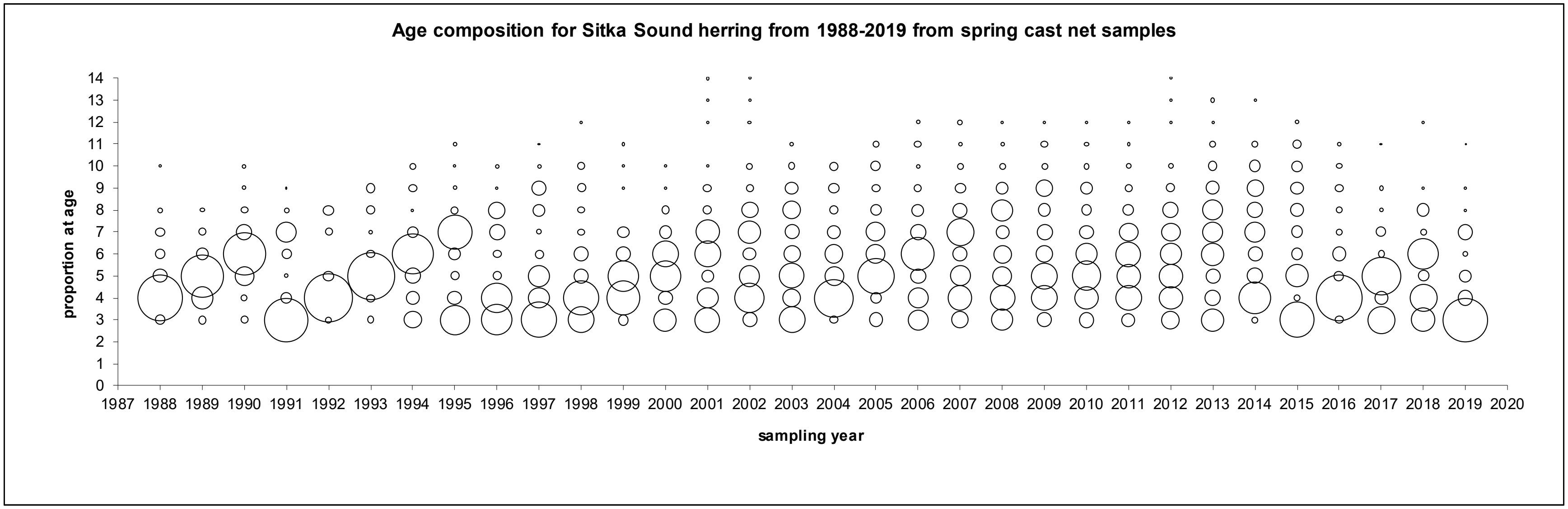

Figure 44.–Observed age compositions from sampling data for the Sitka Sound herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli. For reference, the largest circle represents 89%.

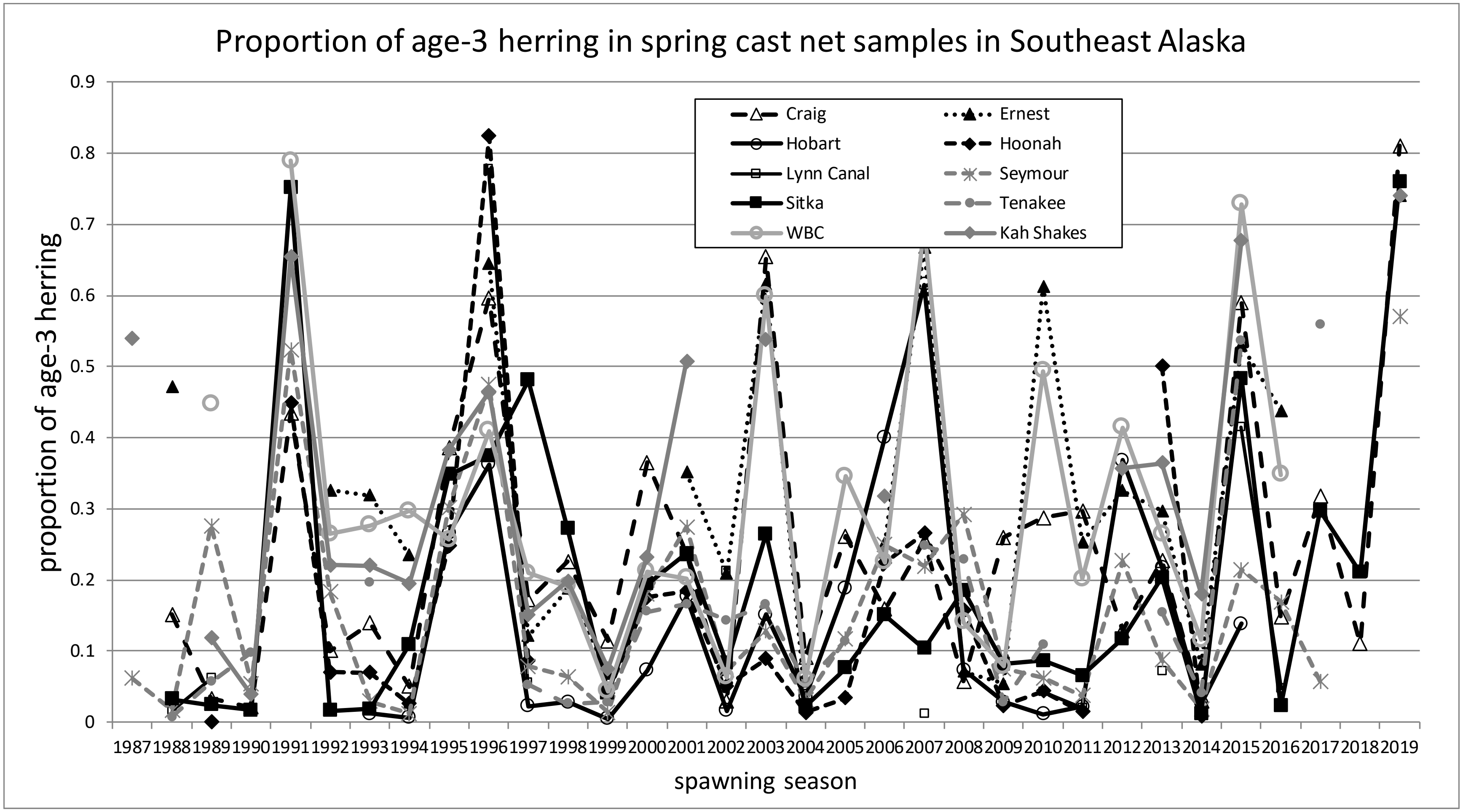

Figure 45.–Proportions of observed age-3 herring in spring cast nest samples of spawning populations for stocks in Southeast Alaska.

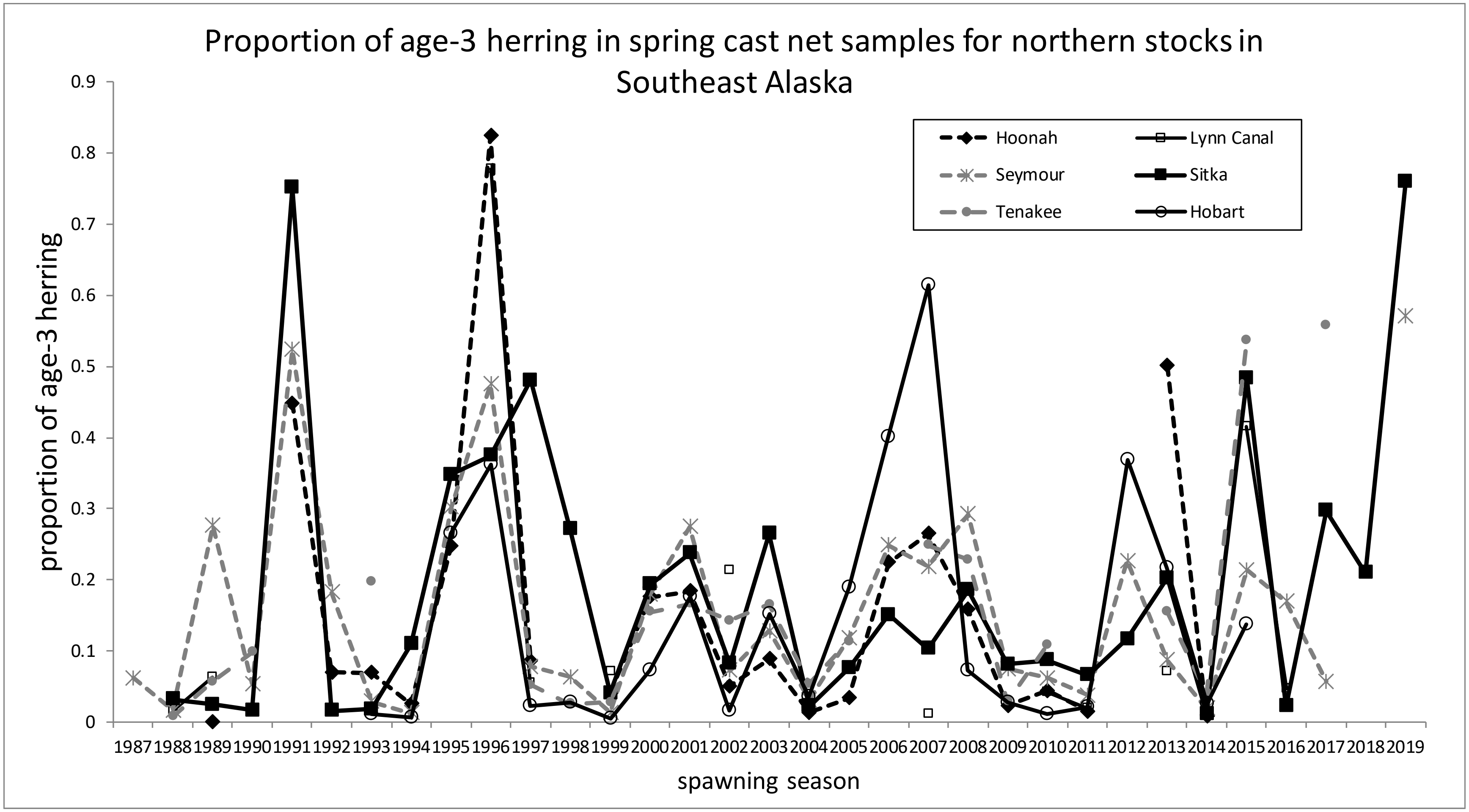

Figure 46.–Proportions of observed age-3 herring in spring cast nest samples of spawning populations for northern stocks in Southeast Alaska.

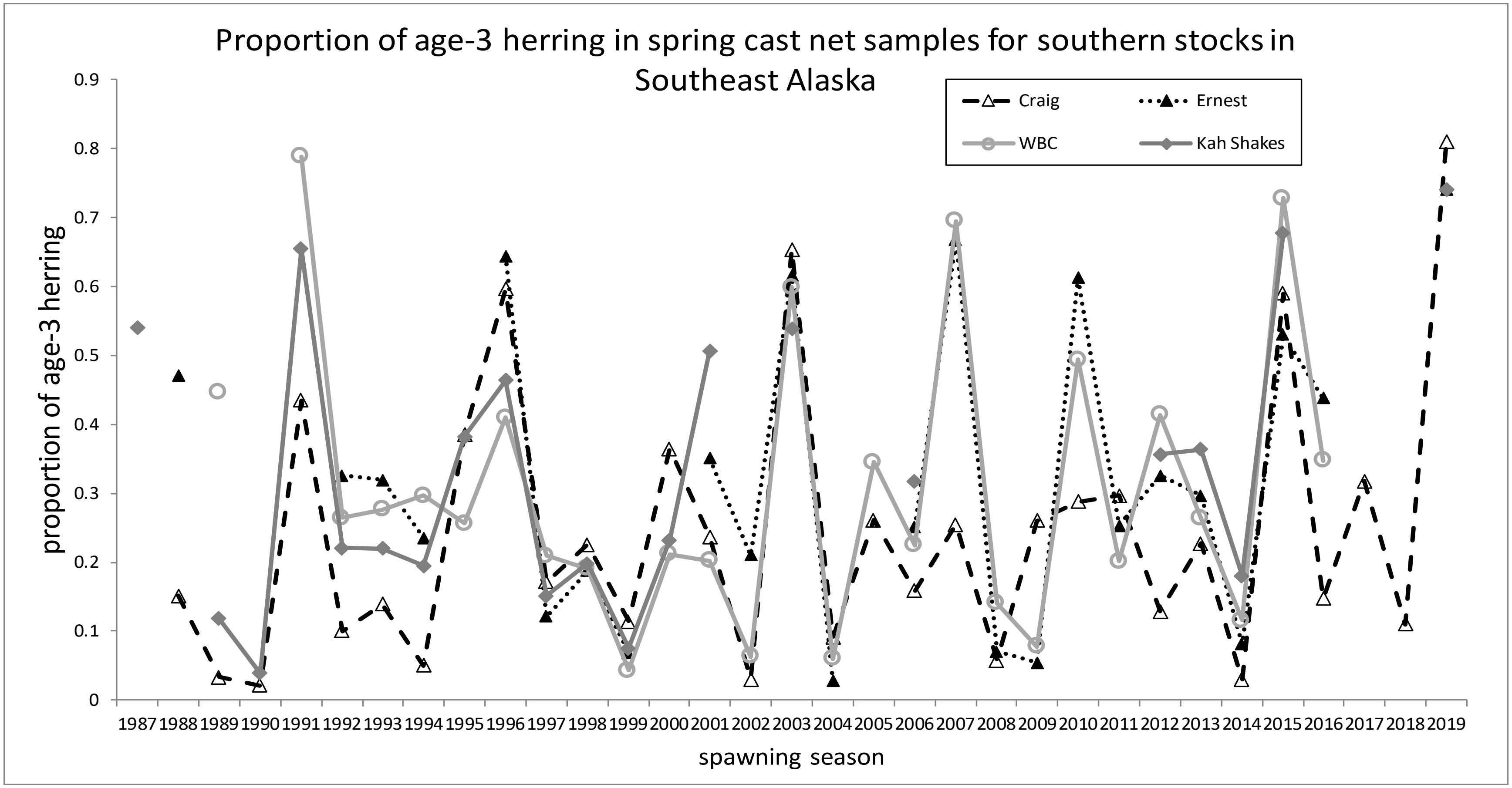

Figure 47.–Proportions of observed age-3 herring in spring cast nest samples of spawning populations for southern stocks in Southeast Alaska.

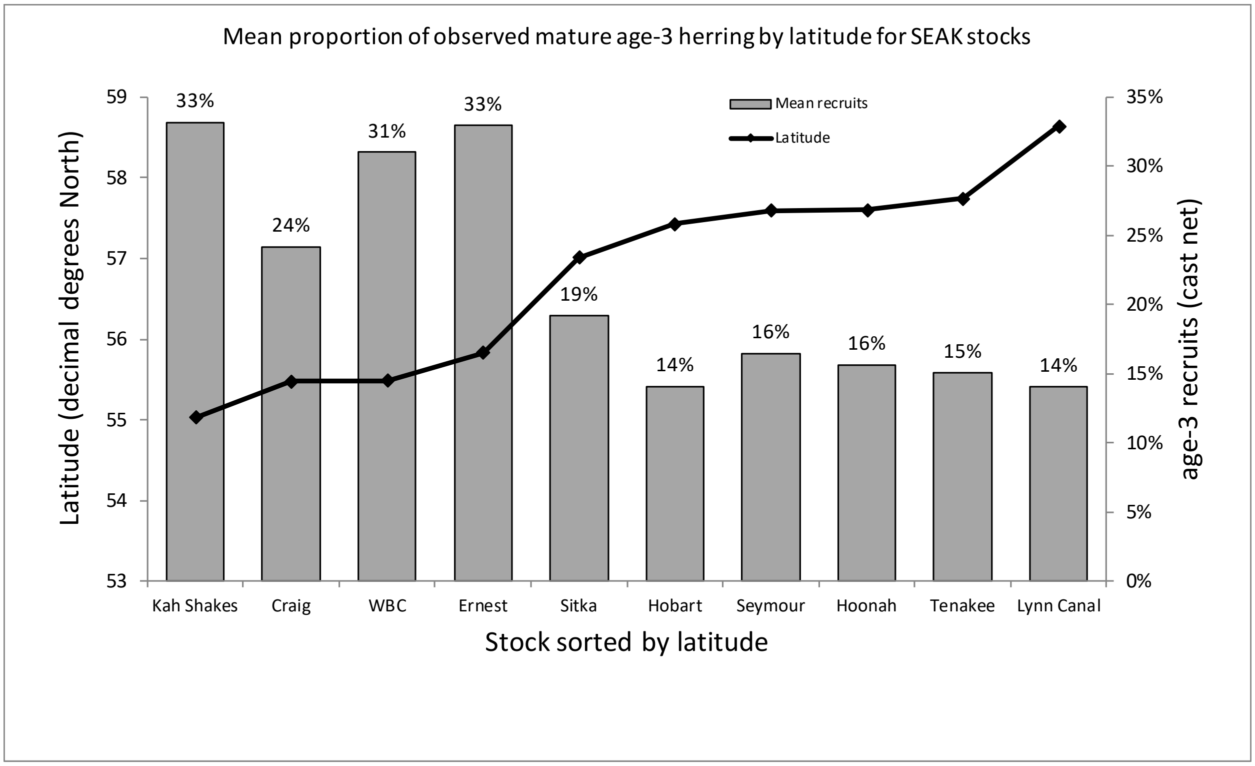

Figure 48.–Mean proportion of observed age-3 herring in spring cast nest samples (1988–2019) and latitude of spawning populations for stocks in Southeast Alaska.

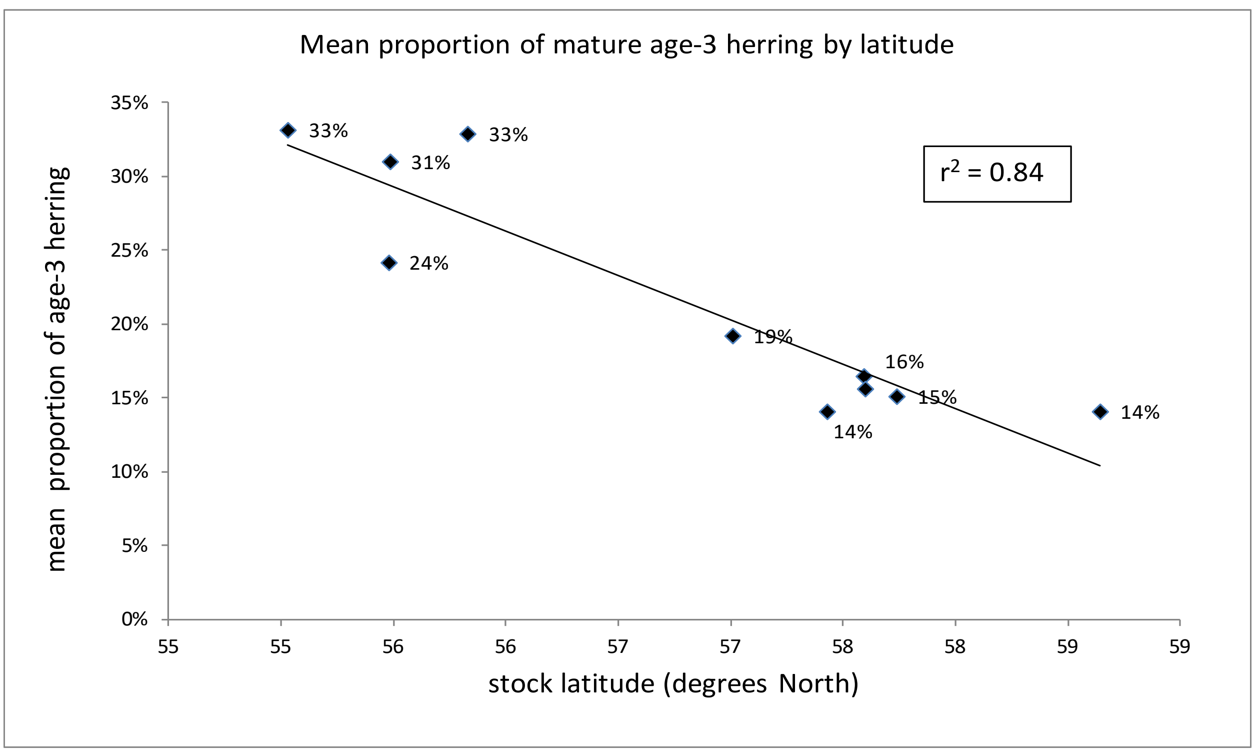

Figure 49.–Relationship between mean proportion of observed age-3 herring in spring cast nest samples and stock latitude of spawning stocks in Southeast Alaska.

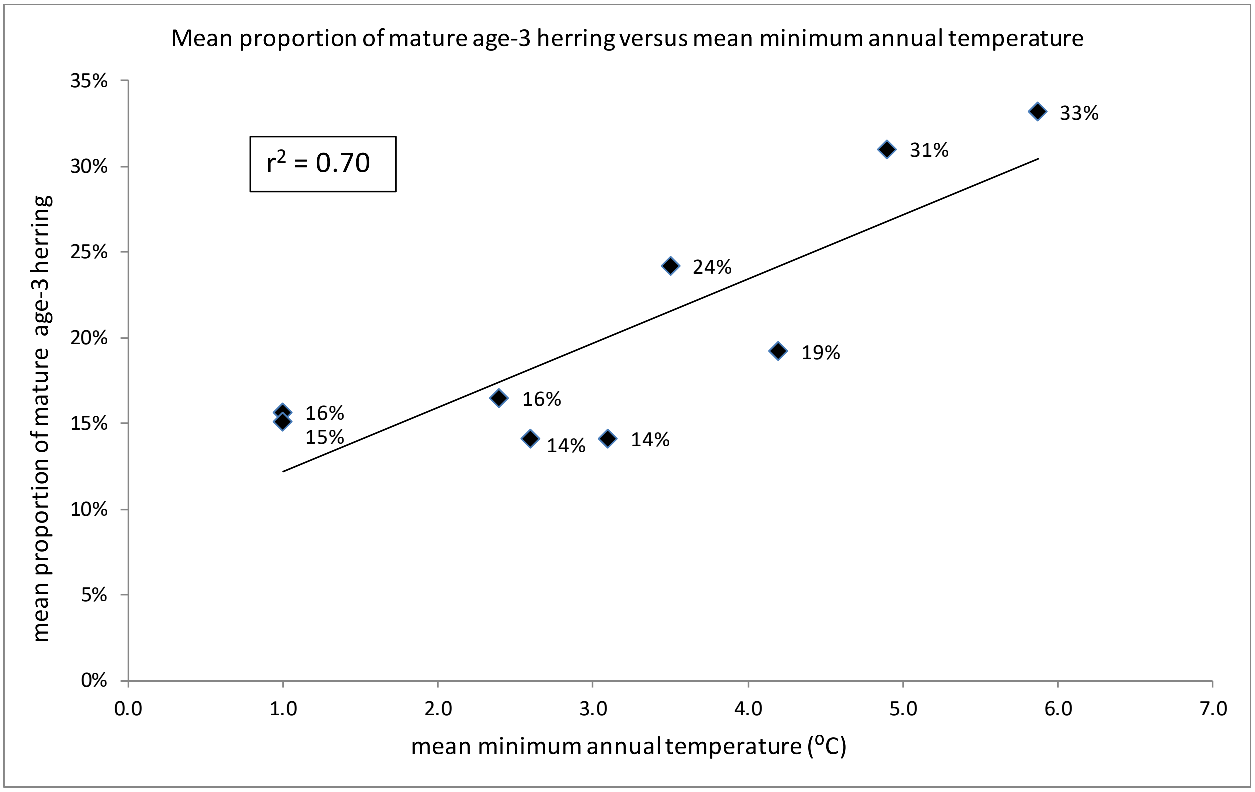

Figure 50.–Mean proportion of age-3 herring in spring cast nest samples versus mean minimum annual sea water temperature at location of spawning stocks in Southeast Alaska.

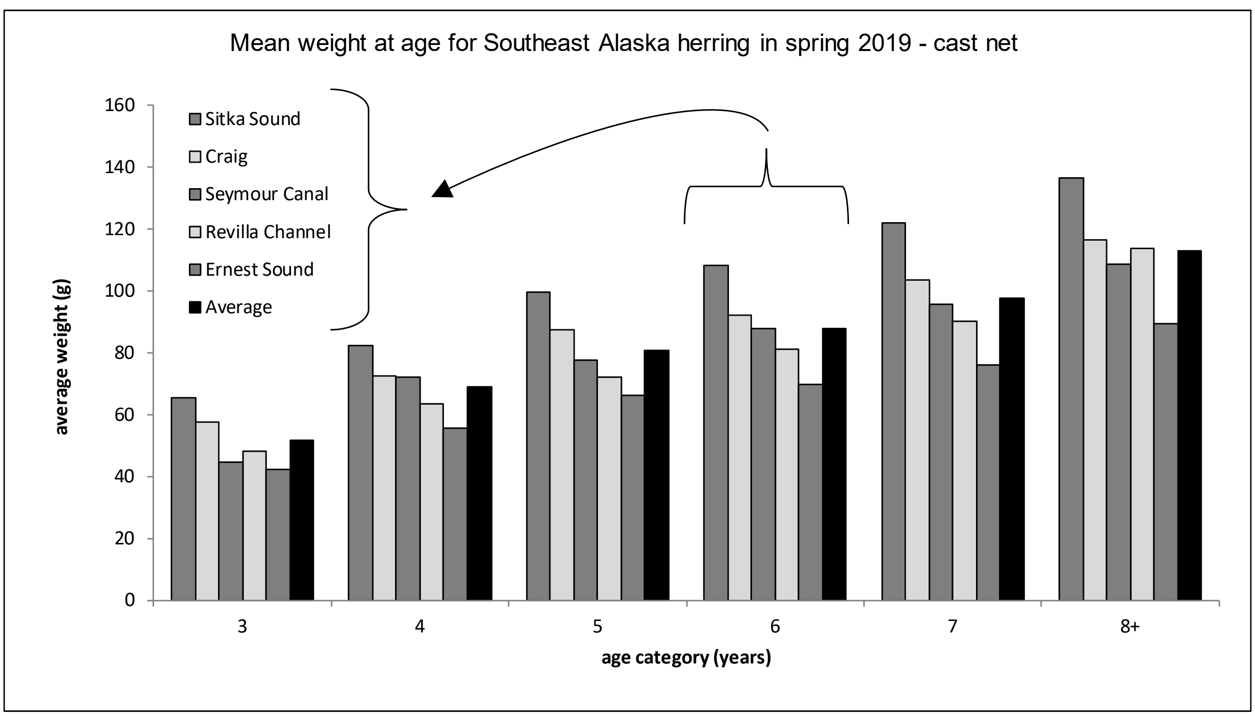

Figure 51.–Mean observed weight-at-age for Southeast Alaska herring stocks surveyed in spring 2019, sorted by age-6.

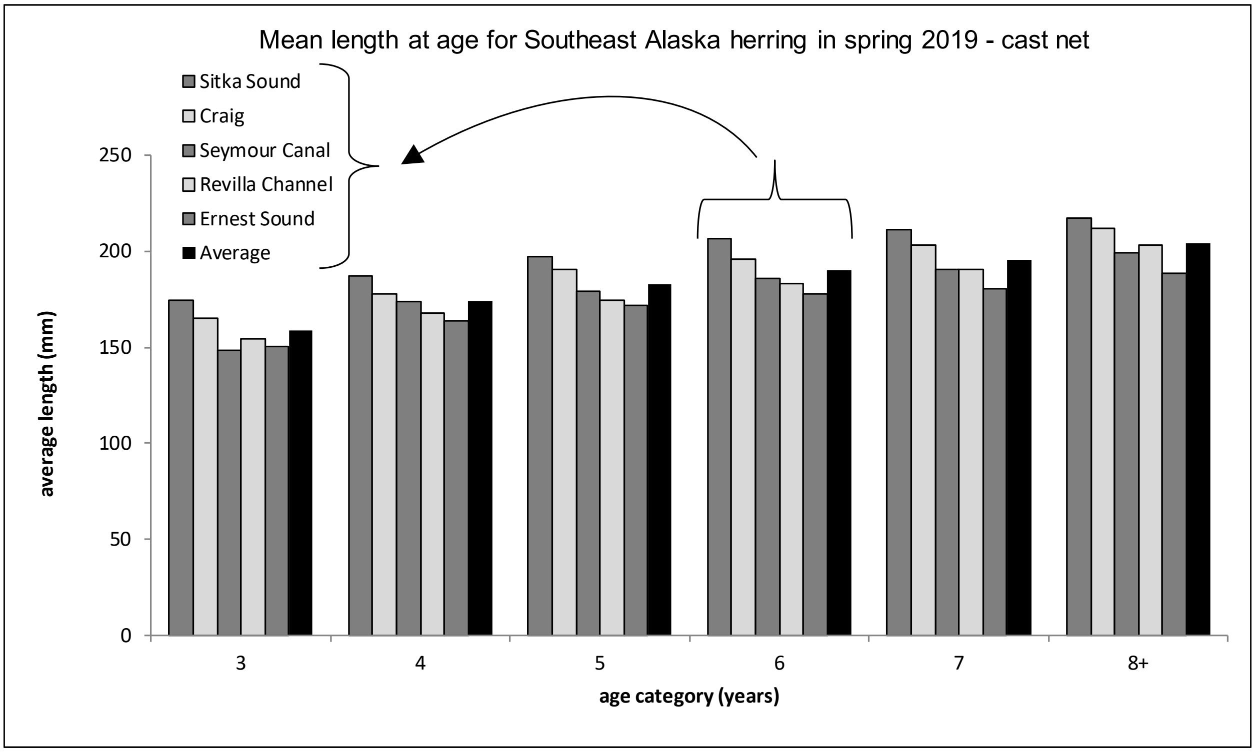

Figure 52.–Mean observed length-at-age for Southeast Alaska herring stocks surveyed in spring 2019, sorted by age-6.

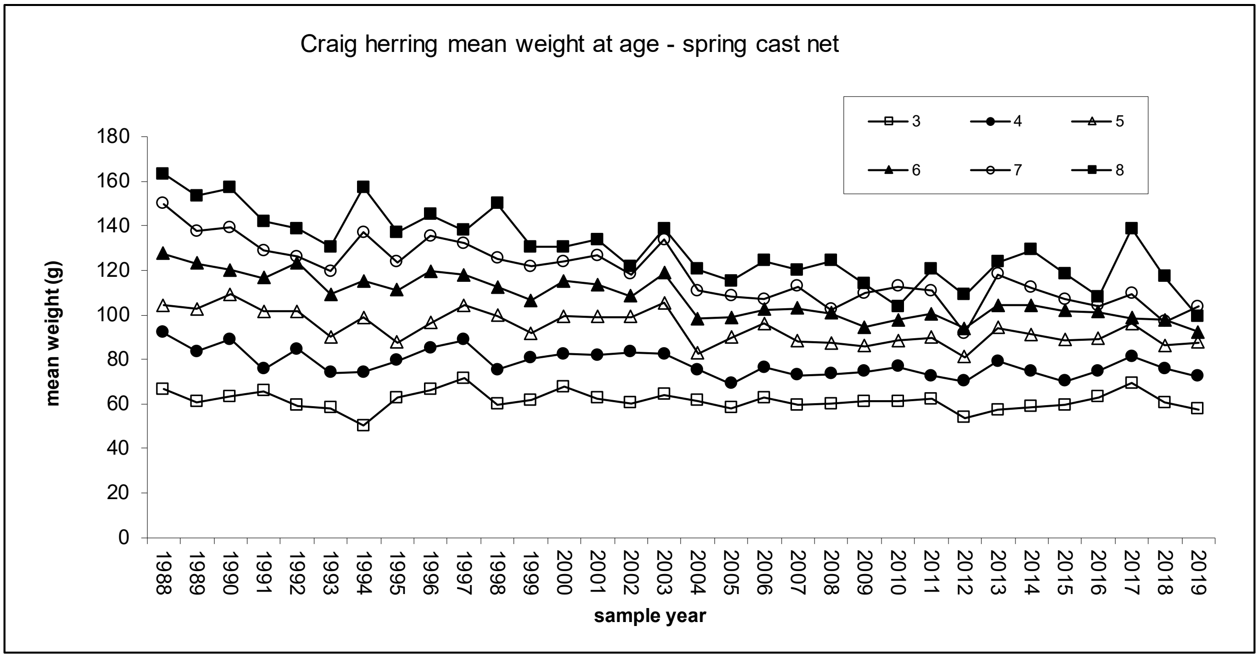

Figure 53.–Mean observed weight-at-age of the Craig herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

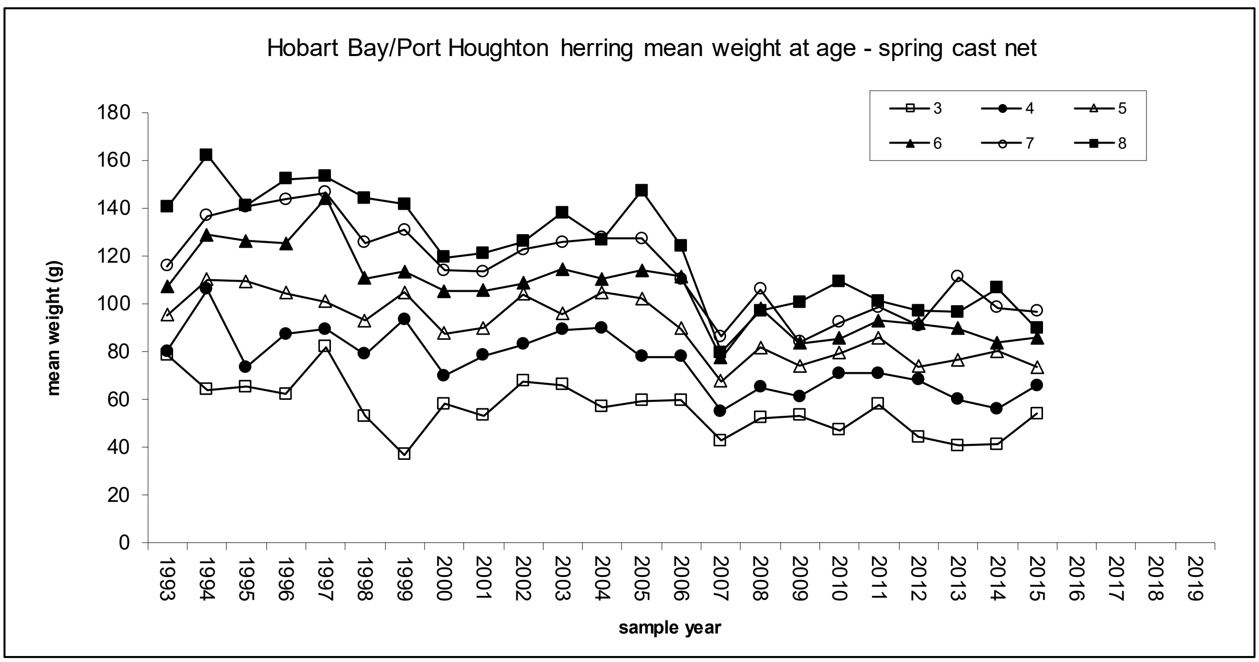

Figure 54.–Mean observed weight-at-age of the Hobart Bay–Port Houghton herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

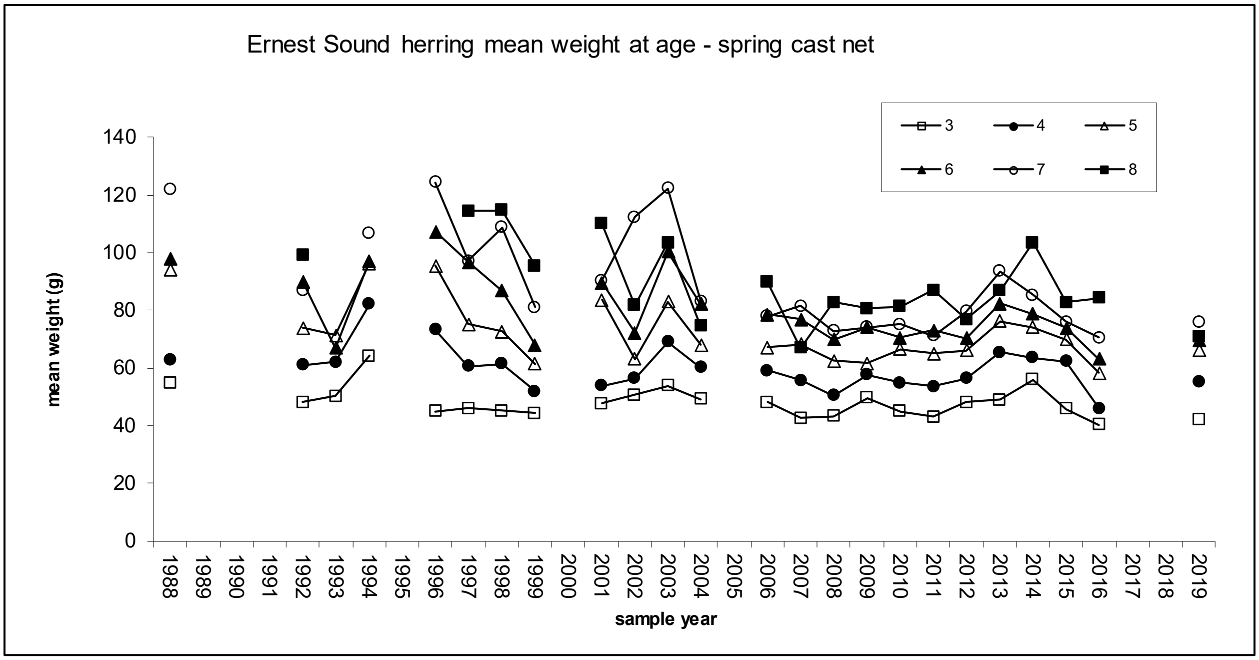

Figure 55.–Mean observed weight-at-age for the Ernest Sound herring spawning population.

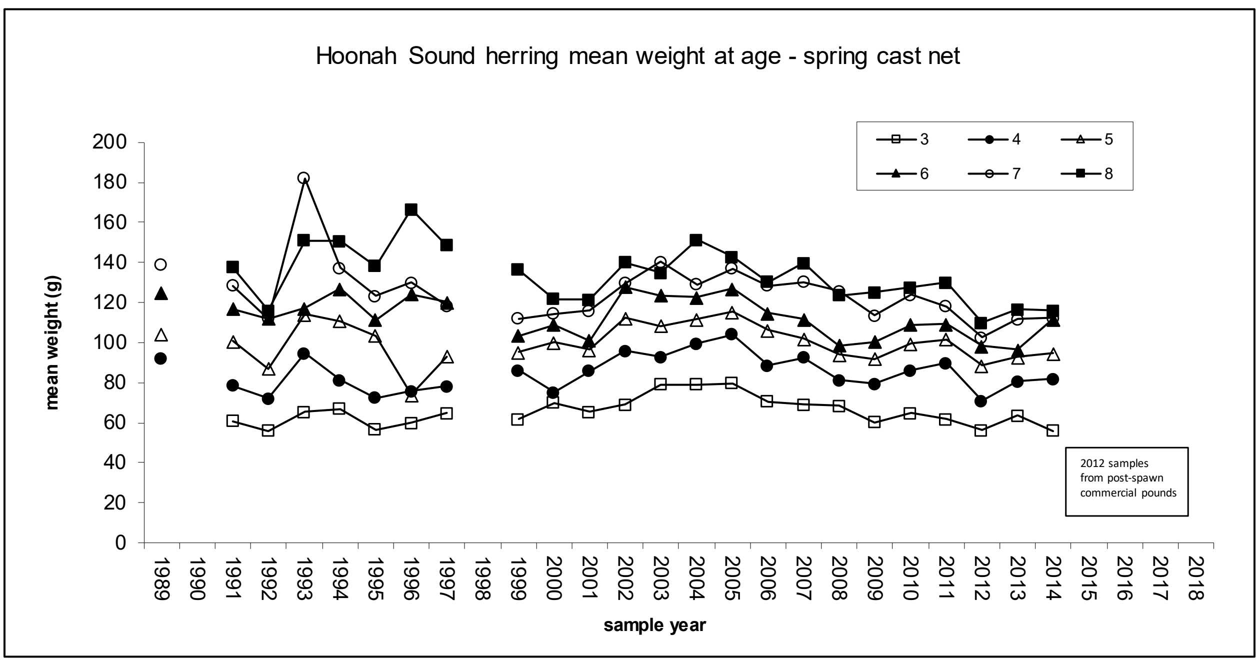

Figure 56.–Mean observed weight-at-age for the Hoonah Sound herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

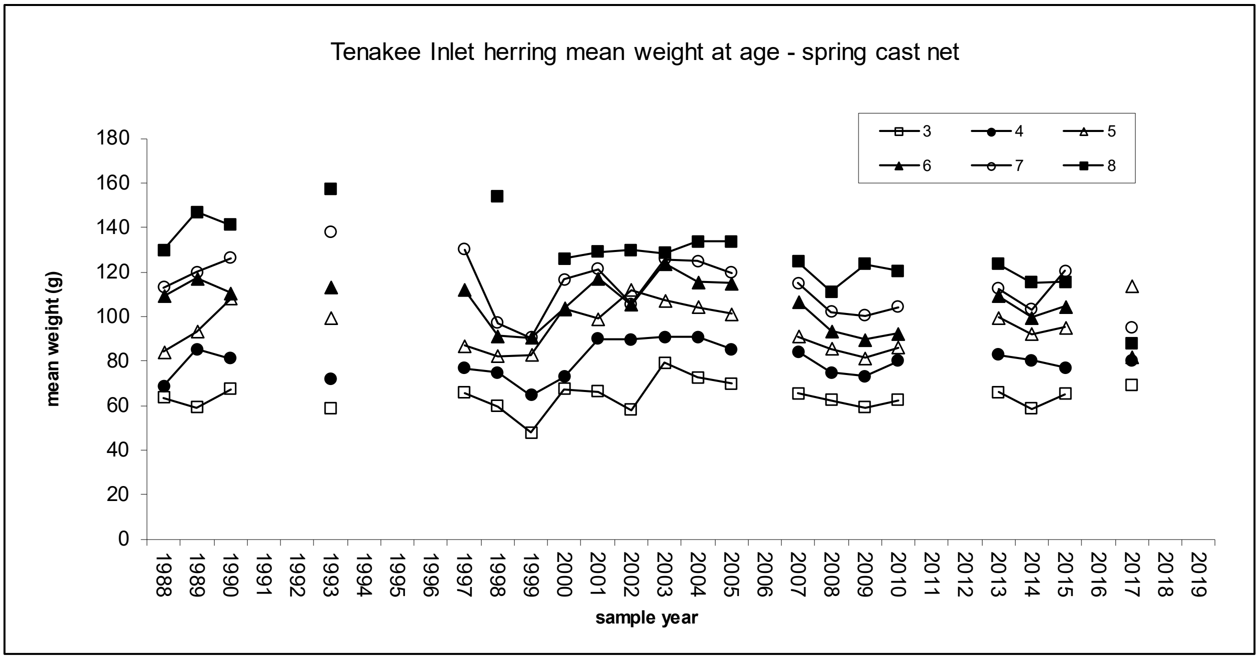

Figure 57.–Mean observed weight-at-age for the Tenakee Inlet herring stock. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

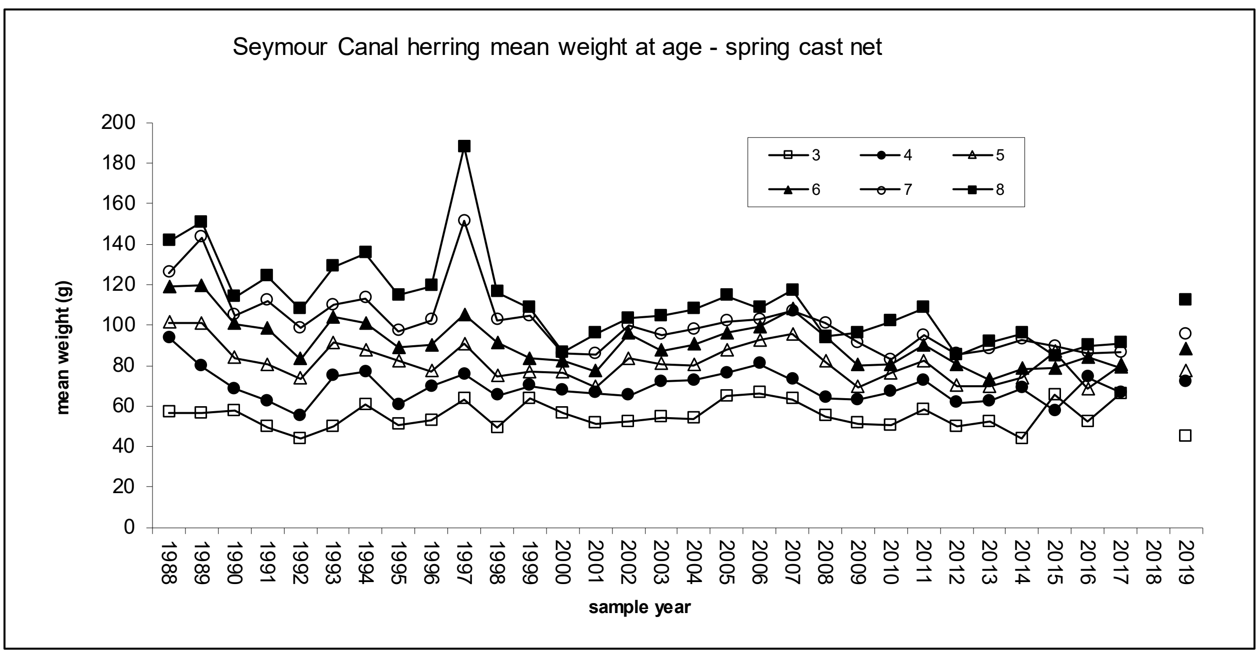

Figure 58.–Mean observed weight-at-age for the Seymour Canal herring stock. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

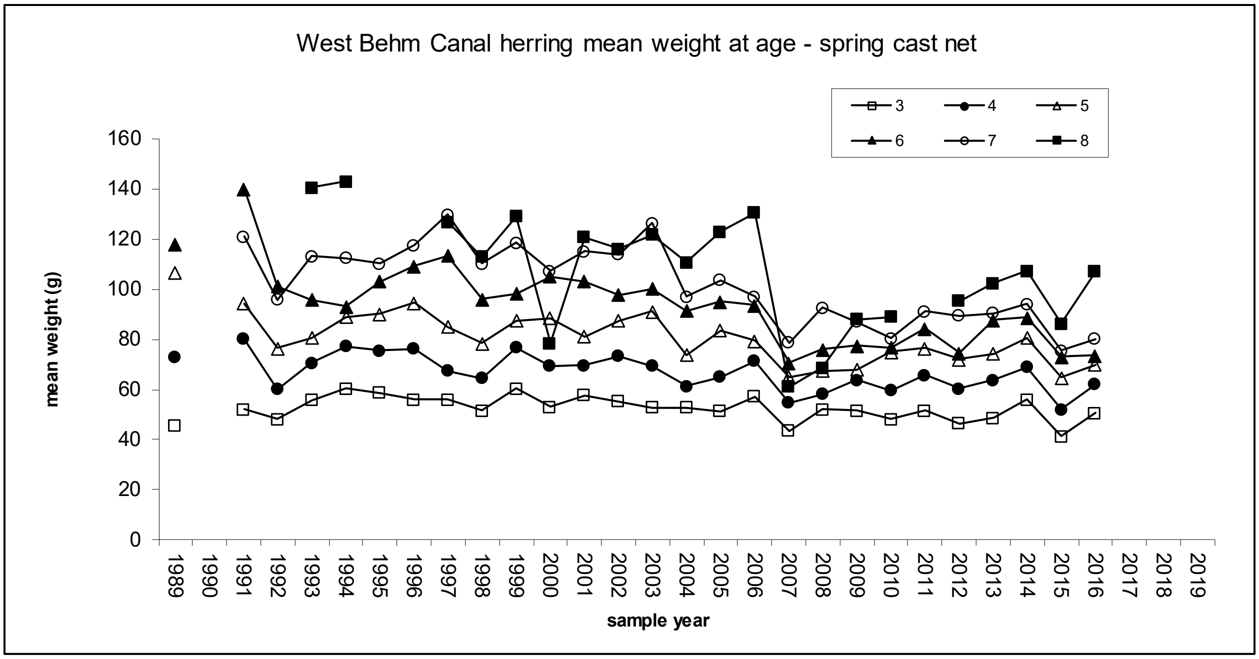

Figure 59.–Mean observed weight-at-age for the West Behm Canal herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli. 2015 weights are likely biased low due to required additional sample handling that resulted in loss of weight.

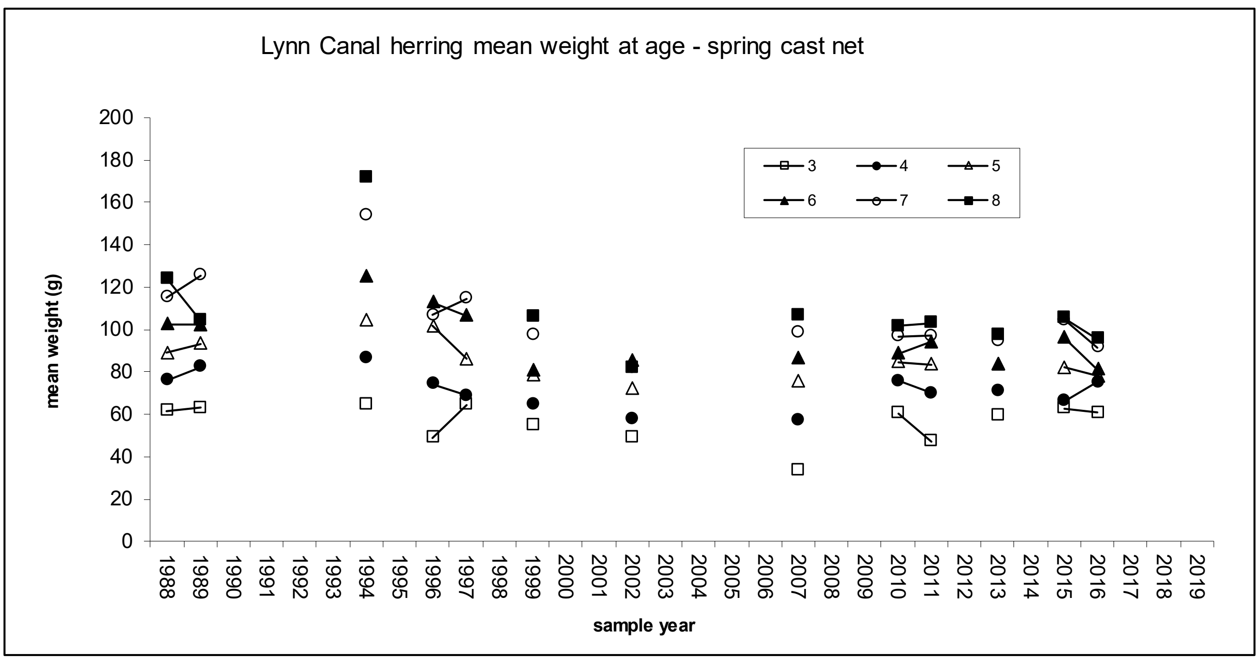

Figure 60.–Mean observed weight-at-age for the Lynn Canal herring spawning population.

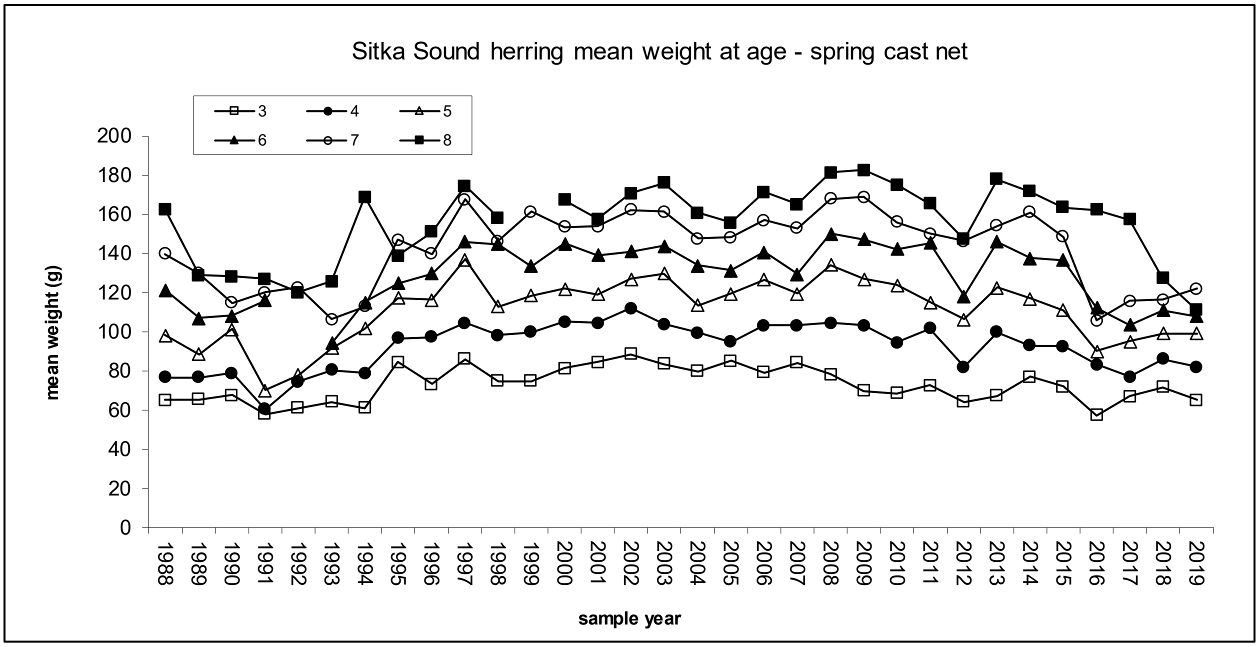

Figure 61.–Mean observed weight-at-age for the Sitka Sound herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

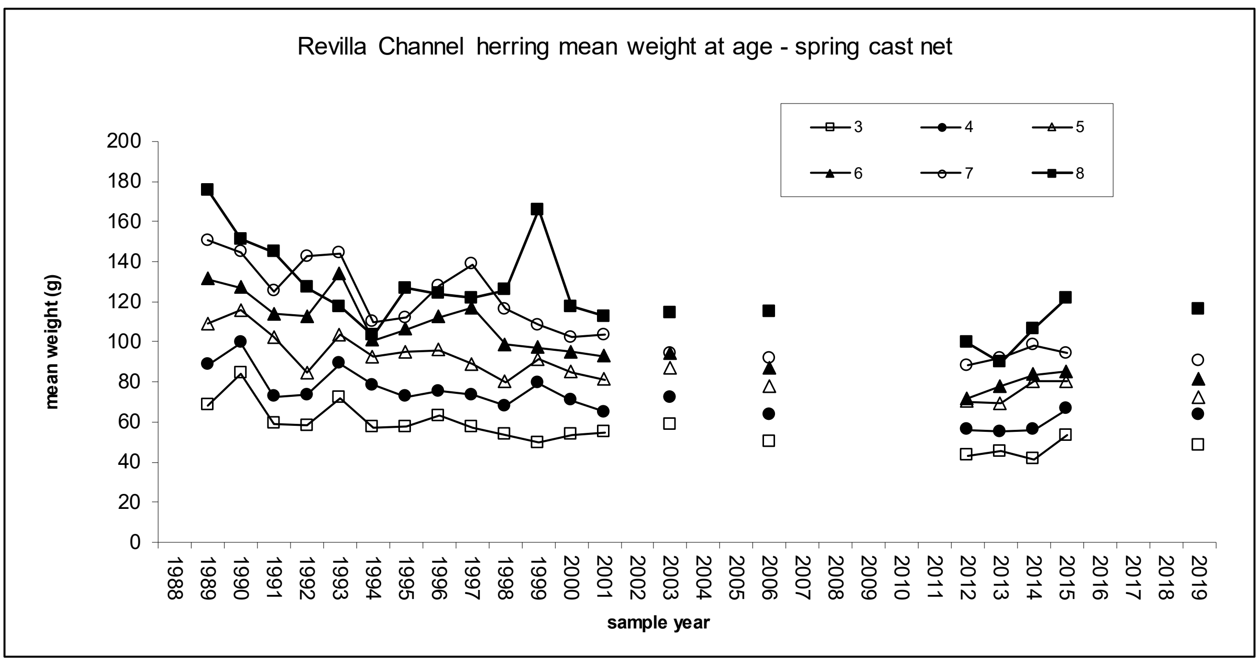

Figure 62.–Mean observed weight-at-age for the Revilla Channel herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

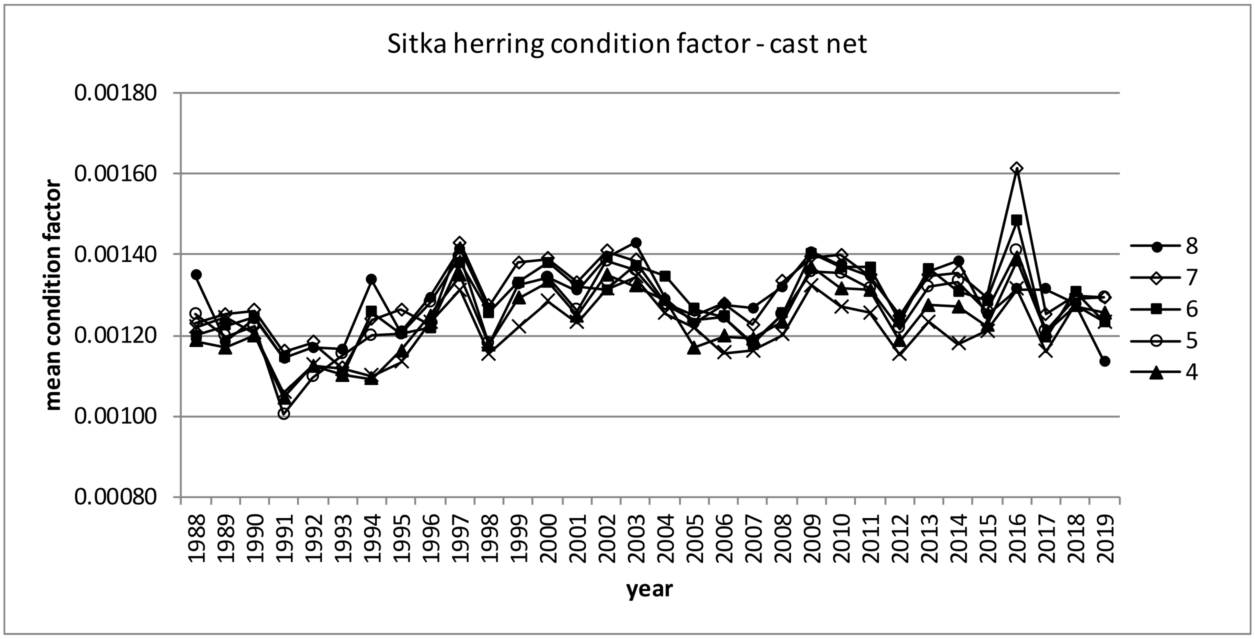

Figure 63.–Mean condition factors of age-3 through age-8 herring for the Sitka Sound spawning population, based on spring cast net samples taken during active spawning. 2016 values may be biased high due to length measurements that were likely underestimated.

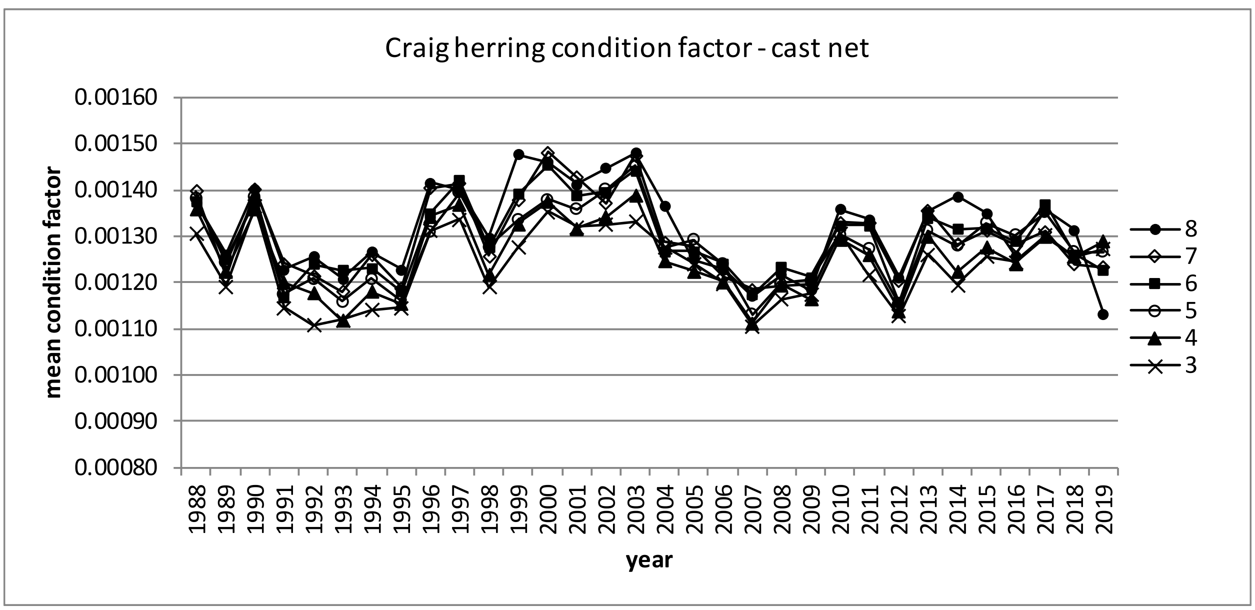

Figure 64.–Mean condition factors of age-3 through age-8 herring for the Craig spawning population, based on spring cast net samples taken during active spawning.

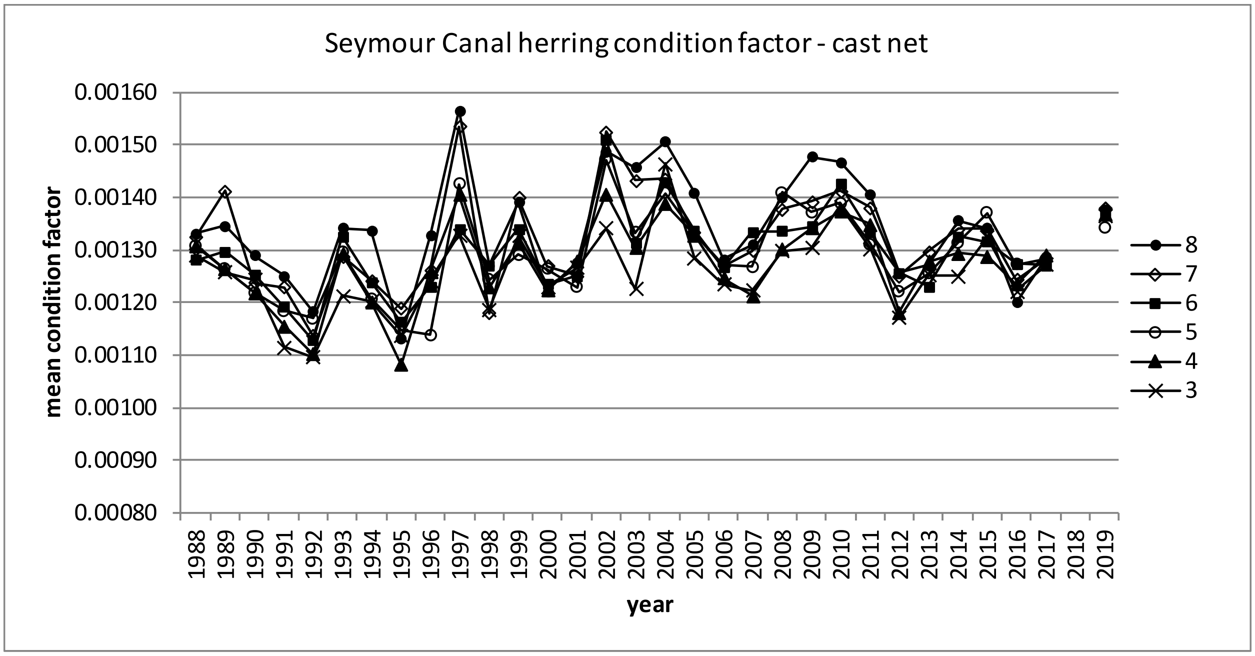

Figure 65.–Mean condition factors of age-3 through age-8 herring for the Seymour Canal spawning population, based on spring cast net samples taken during active spawning.

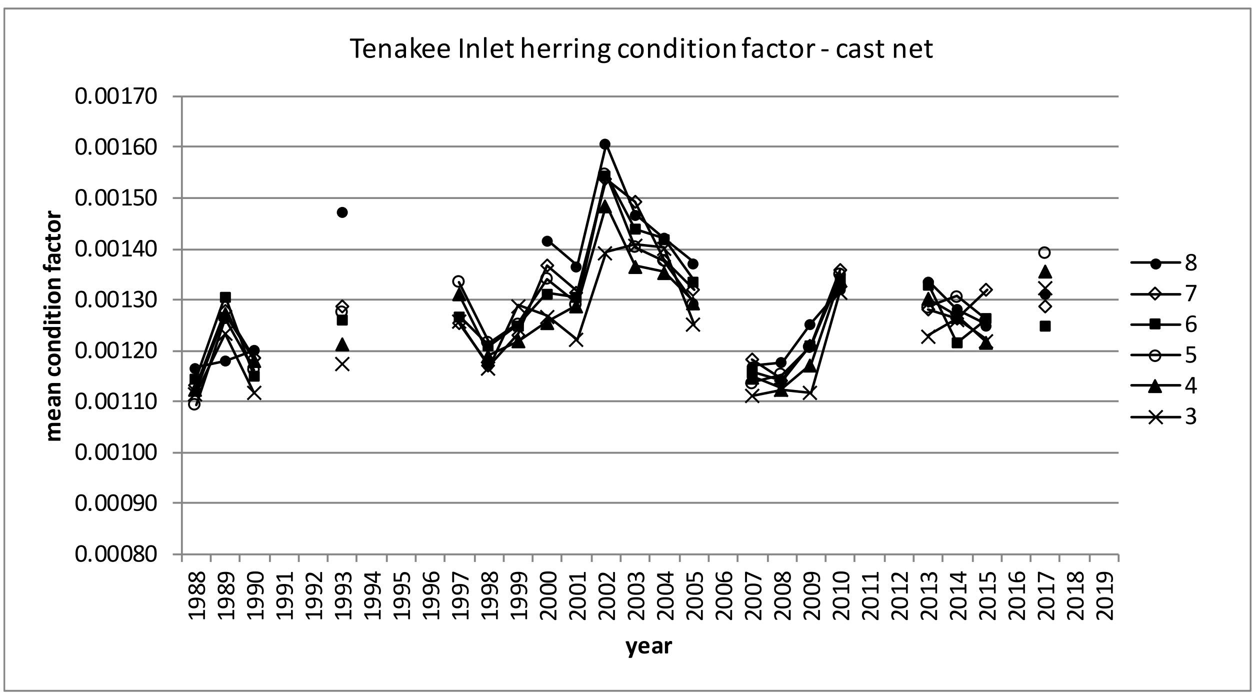

Figure 66.–Mean condition factors of age-3 through age-8 herring for the Tenakee Inlet spawning population, based on spring cast net samples taken during active spawning.

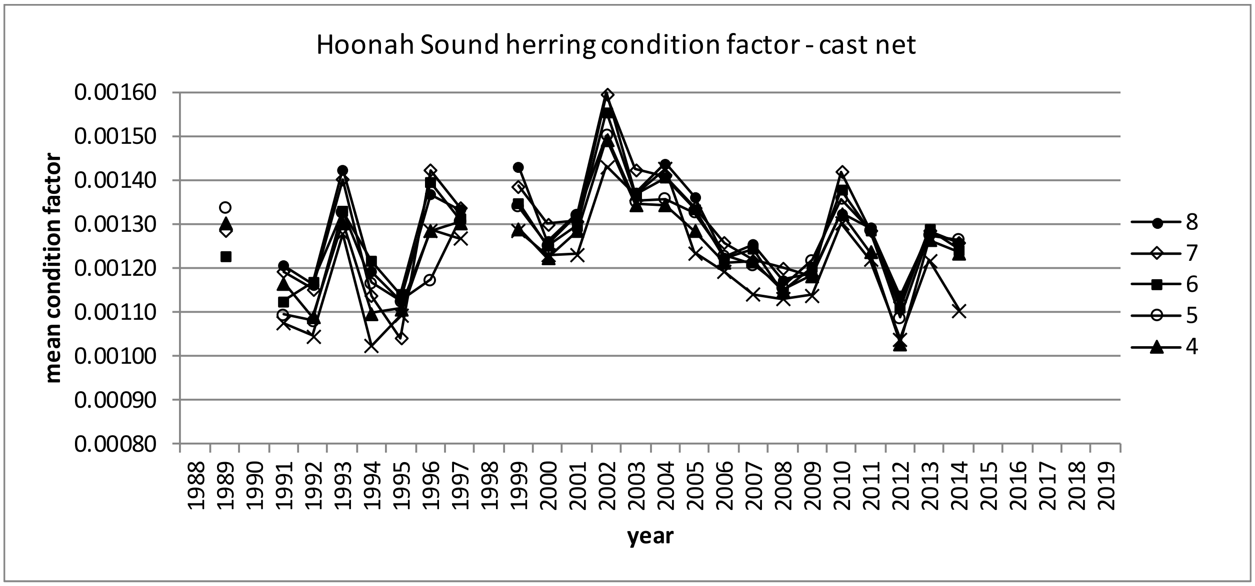

Figure 67.–Mean condition factors of age-3 through age-8 herring for the Hoonah Sound spawning population, based on spring cast net samples taken during active spawning.

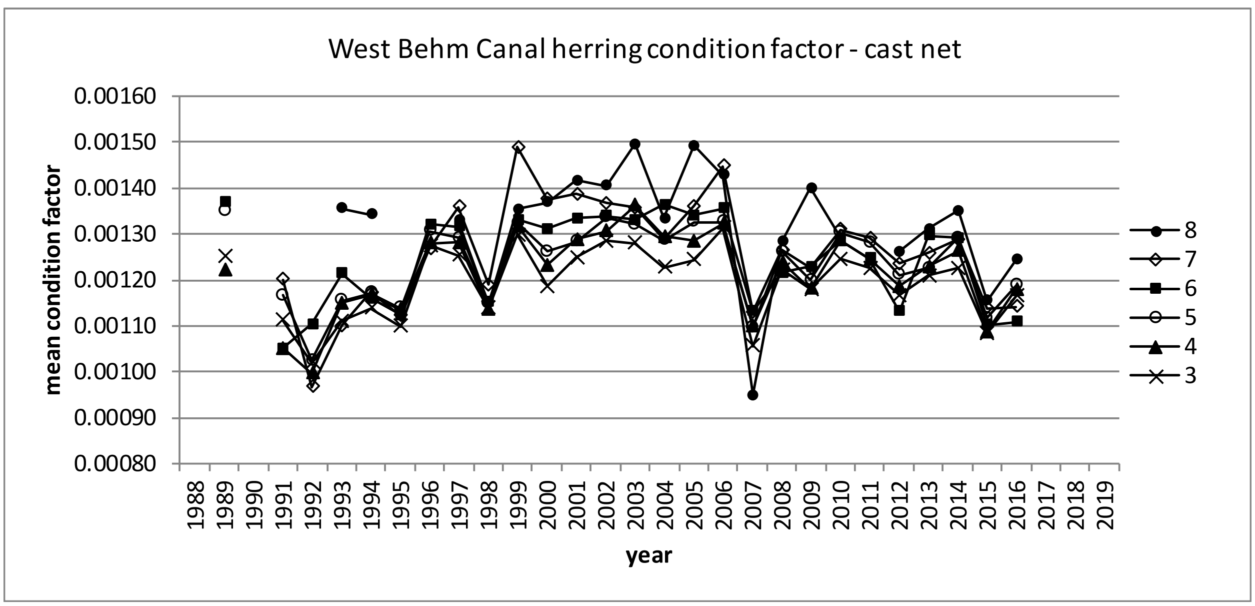

Figure 68.–Mean condition factors of age-3 through age-8 herring for the West Behm Canal spawning population, based on spring cast net samples taken during active spawning. 2015 condition factors are probably biased low due to required additional sample handling that resulted in loss of weight.

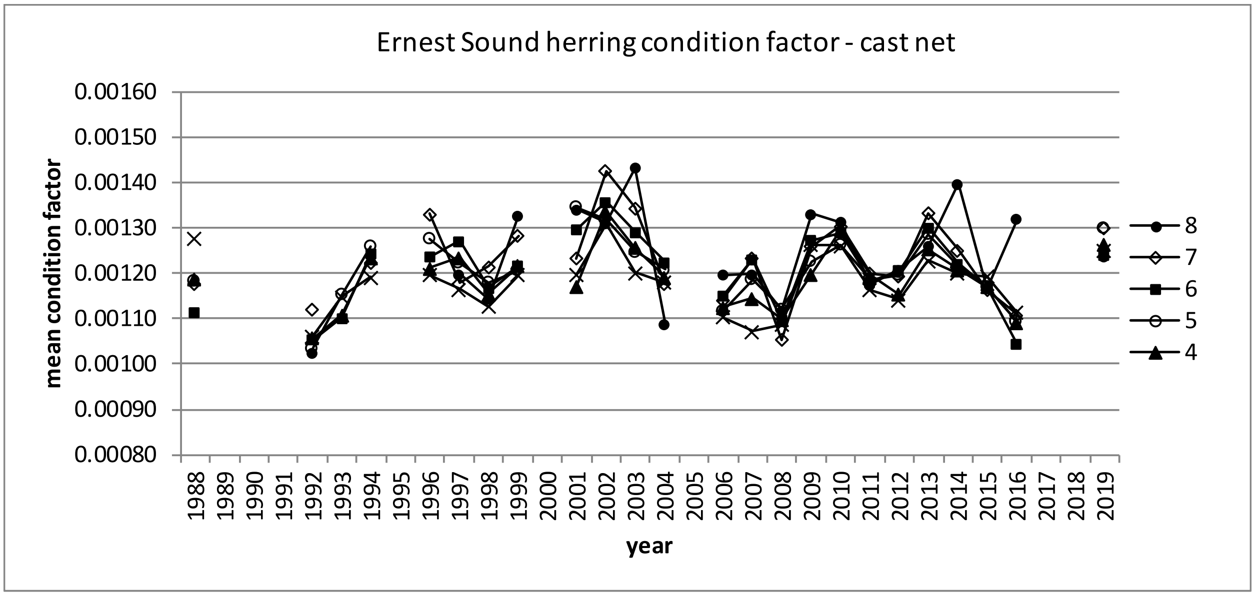

Figure 69.–Mean condition factors of age-3 through age-8 herring for the Ernest Sound spawning population, based on spring cast net samples taken during active spawning.

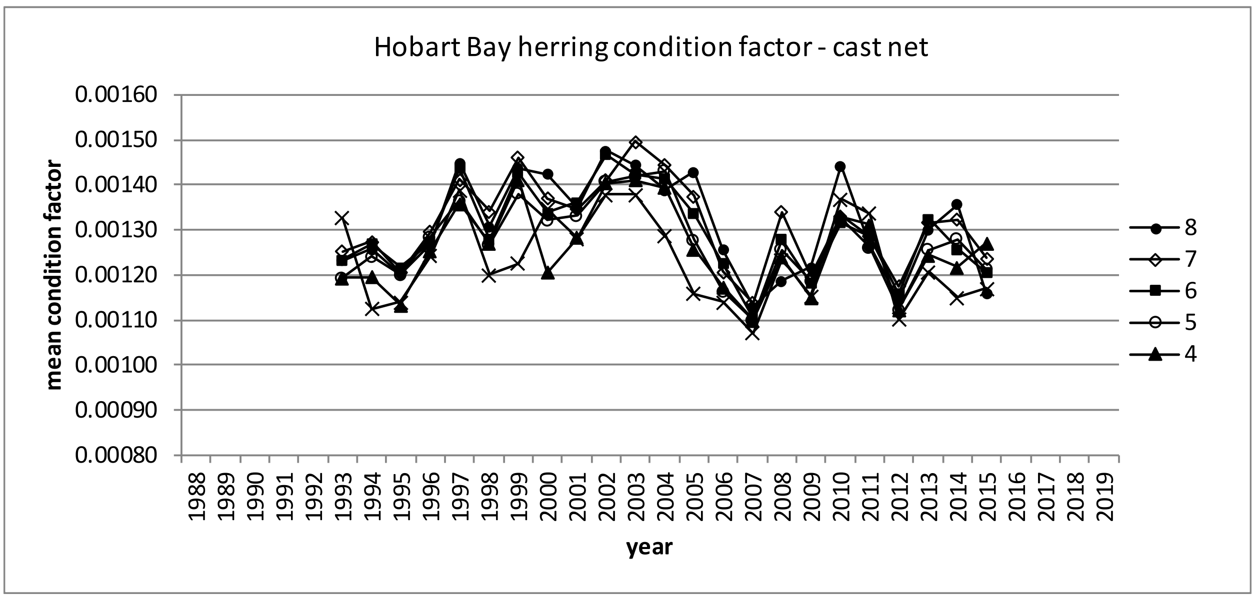

Figure 70.–Mean condition factors of age-3 through age-8 herring for the Hobart Bay spawning population, based on spring cast net samples taken during active spawning.

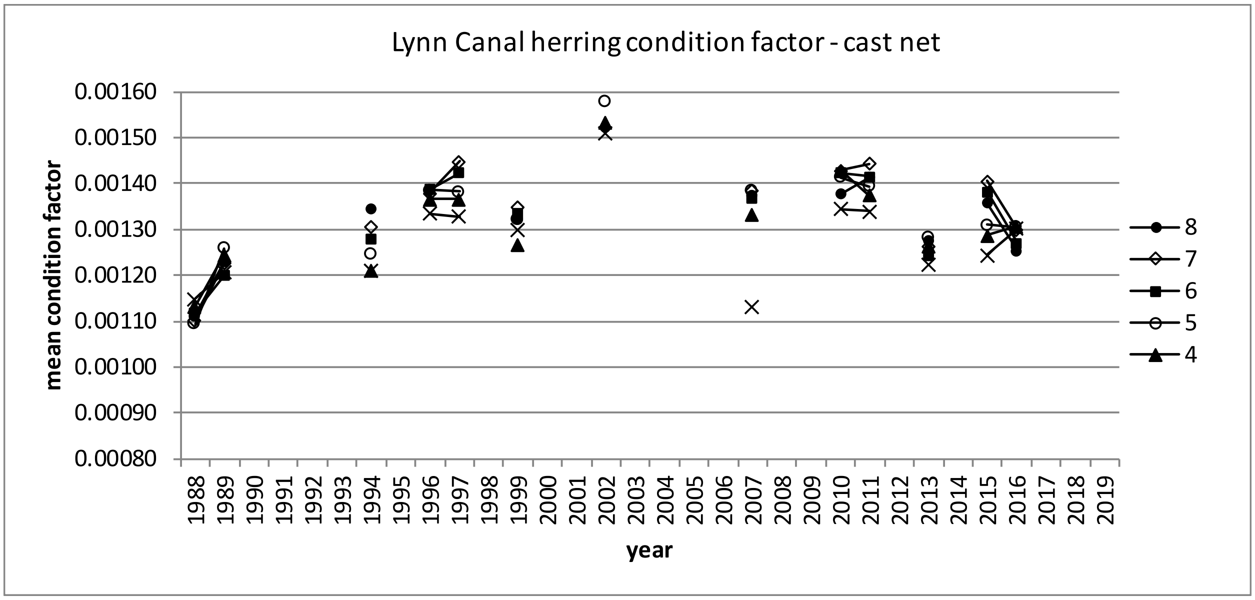

Figure 71.–Mean condition factors of age-3 through age-8 herring for the Lynn Canal spawning population, based on spring cast net samples taken during active spawning.

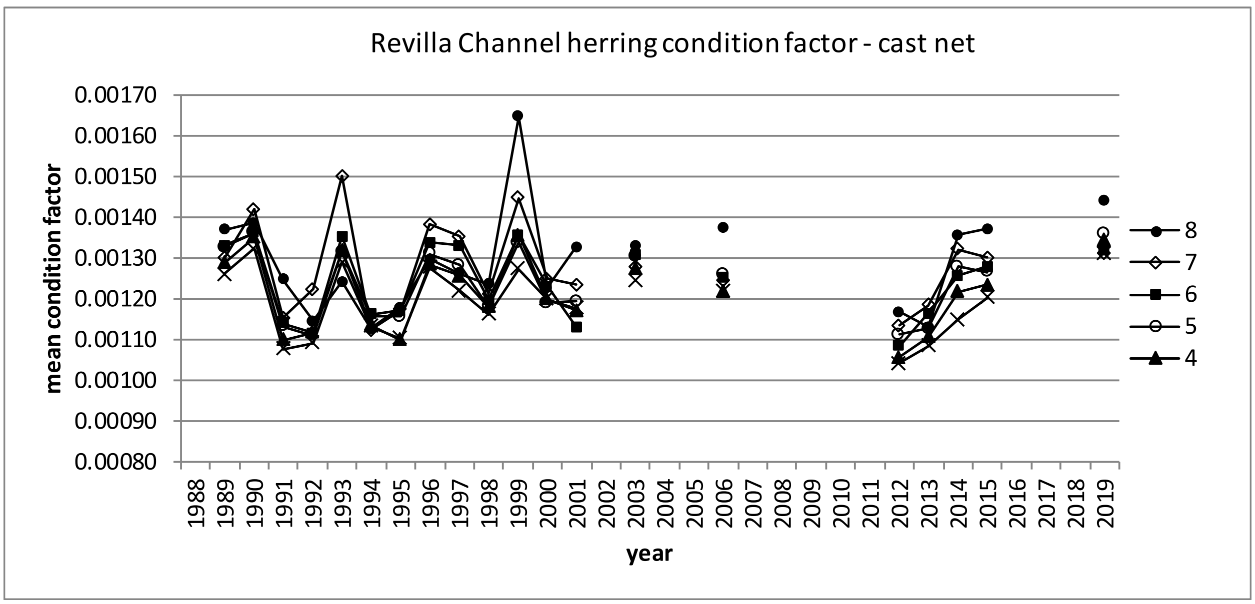

Figure 72.–Mean condition factors of age-3 through age-8 herring for the Revilla Channel spawning population, based on spring cast net samples taken during active spawning.

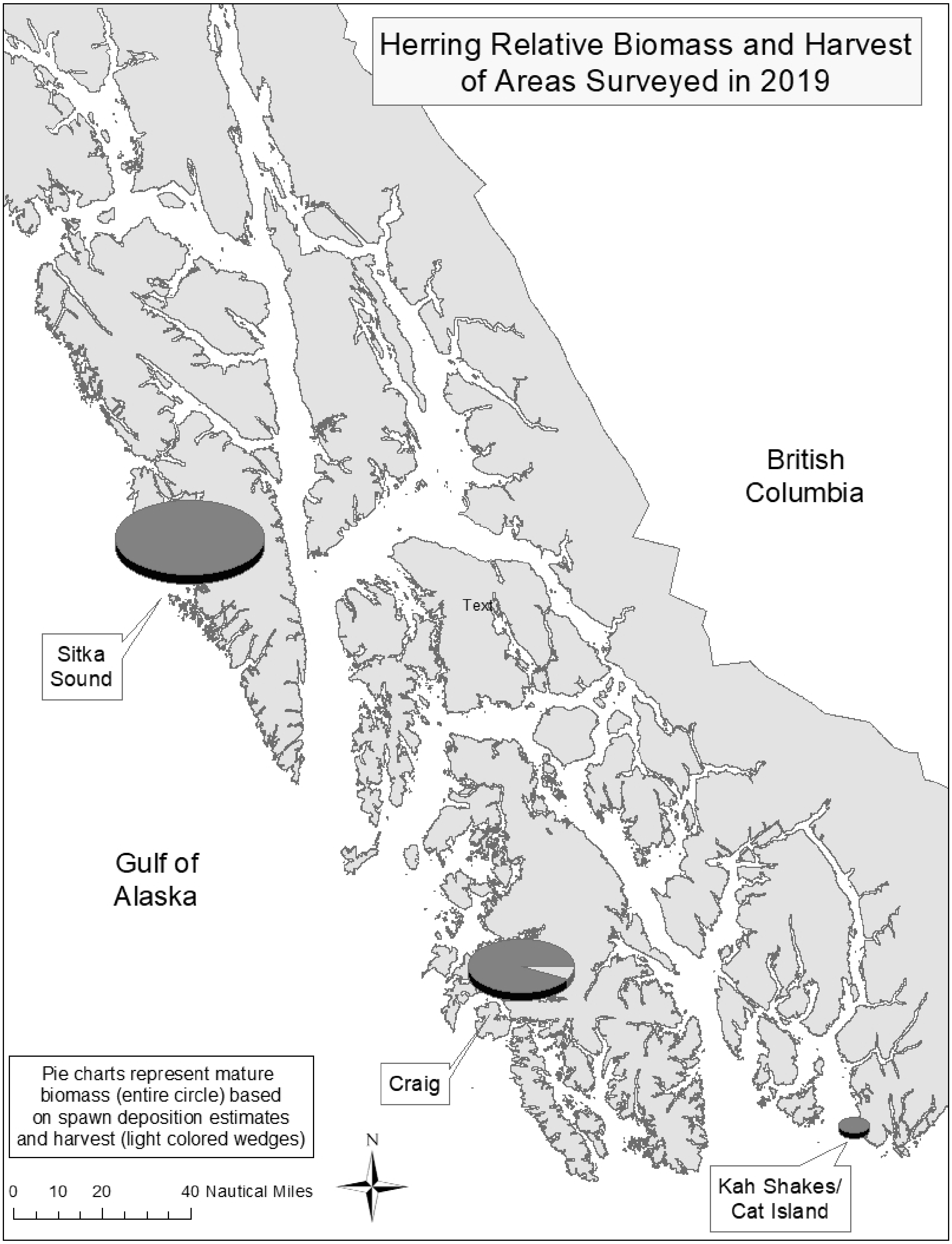

Figure 73.–Relative magnitude of observed herring spawning stock biomass and harvest levels in Southeast Alaska, based on biomass estimates converted from spawn deposition estimates. White wedges are intended to provide an approximate depiction of relative harvest but do not represent actual exploitation rate.

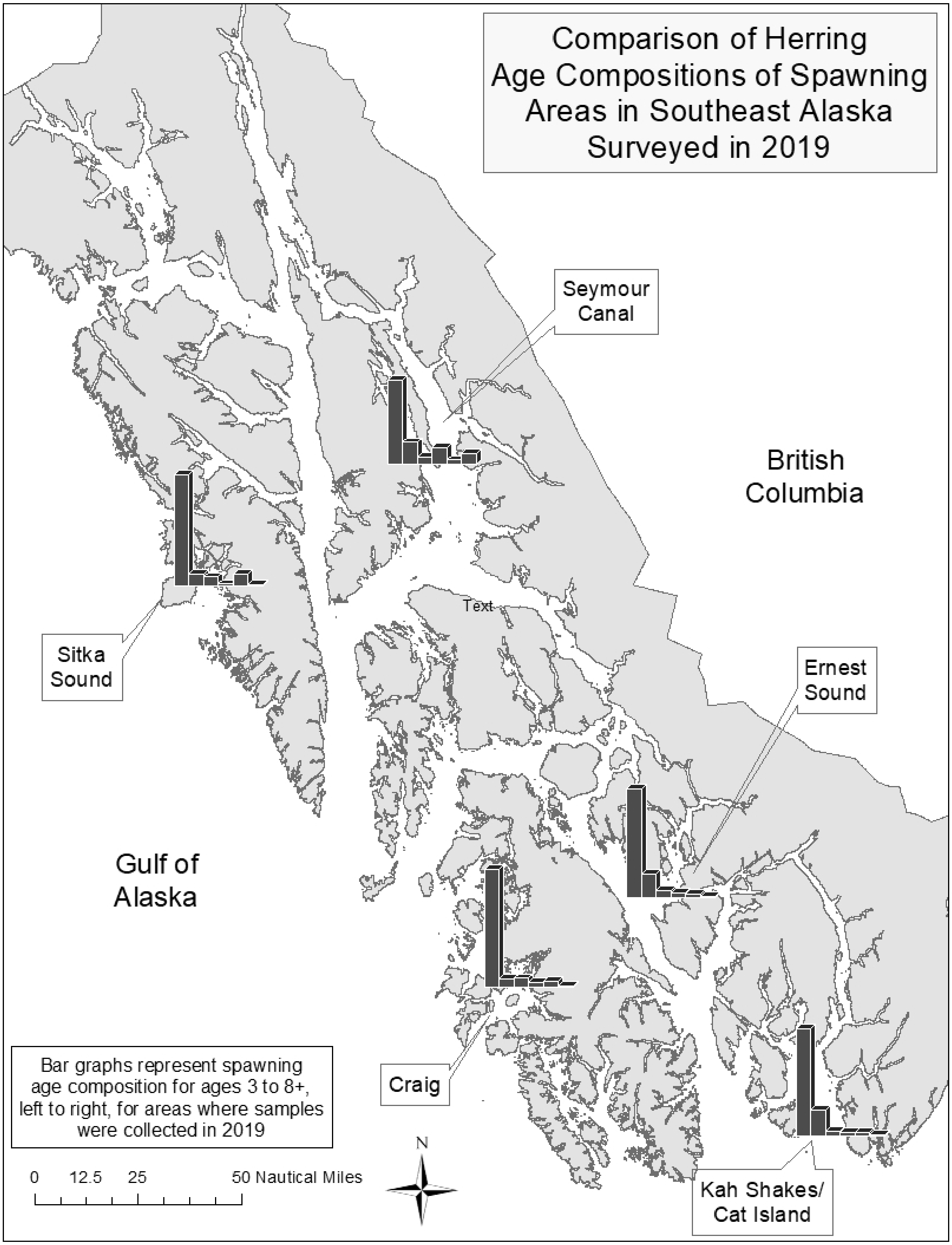

Figure 74.–Regional comparison of observed age compositions of herring spawning stocks in Southeast Alaska that were sampled with cast nets in 2019. For reference, the highest value for age-3 (first bar in graphs) was 81%.

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/leafy 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* spp.
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 2019.

Craig	Survey notes
March 18, 2019	Herring and predator activity in the Craig area.
March 23, 2019	Spot spawn on Wadleigh Island. Herring and predator activity in the Craig area.
March 24, 2019	Herring and predator activity in the Craig area.
March 25, 2019	Herring and predator activity in the Craig area.
March 26, 2019	Herring and predator activity in the Craig area.
March 27, 2019	0.5 nmi spawn on Fish Egg Island.
March 28, 2019	1.5 nmi of spawn on Fish Egg, Wadleigh, and Alberto islands.
March 29, 2019	3.9 nmi of spawn on Fish Egg, Wadleigh, and Alberto islands.
March 30, 2019	6.6 nmi of spawn on Fish Egg, Wadleigh, Abbess, and Alberto islands.
March 31, 2019	9.8 nmi of spawn on Fish Egg, Wadleigh, Abbess, Clam and Alberto islands.
April 01, 2019	10.8 nmi of spawn on Fish Egg, Wadleigh, Abbess, Clam and Alberto islands.
April 02, 2019	14.8 nmi of spawn on Fish Egg, Wadleigh, Abbess, Clam and Alberto islands.
April 03, 2019	14.1 nmi of spawn on Fish Egg, Wadleigh, Abbess, Clam and Alberto islands.
April 04, 2019	7.1 nmi of spawn on Fish Egg, Abbess, Ballenas, and outer Alberto islands.
April 05, 2019	3.6 nmi of spawn on Fish Egg, Abbess, Ballenas, and outer Alberto islands.
April 06, 2019	1.6 nmi of spawn on Fish Egg, Abbess, and Ballenas islands. Spawn in upper Shiniku Inlet, and Fern Point.
April 07–08, 2019	Weather prevented surveys.

West Behm	Survey notes
March 29, 2019	Little activity observed.
March 31, 2019	1 nmi of spawn in Tongass Narrows and Cleveland Peninsula.
April 01, 2019	2 nmi of spawn in Tongass Narrows, Cleveland Peninsula and near Dall Head.
April 02, 2019	1.5 nmi of spawn on Indian Point, Cleveland Peninsula and near Dall Head.
April 03, 2019	Predator activity observed on Cleveland Peninsula.
April 09, 2019	Little activity observed.

Revilla Channel	Survey notes
March 18, 2019	Little activity observed.
March 22, 2019	0.5 nmi of spawn in Cat Island.
March 23, 2019	0.25 nmi of spawn in Cat Island.
March 24, 2019	0.5 nmi of spawn in Cat Island.
March 25, 2019	0.5 nmi of spawn in Cat Island.
March 26, 2019	1.5 nmi of spawn in Cat Island.
March 27, 2018	2.5 nmi of spawn in Cat Island.
March 28, 2019	Little activity observed.
March 29, 2019	Little activity observed.
April 01, 2019	2.5 nmi of spawn in Mary Island, Annette Island and the Revilla Shore.
April 02, 2019	1 nmi of spawn in Mary Island, and Annette Island.
April 03, 2019	1 nmi of spawn in Mary Island, and Annette Island.
April 04, 2019	Little activity observed.

Appendix C2.–Aerial and skiff herring spawn surveys by date, in Sitka Sound and Hoonah Sound (Sitka Management Area), Southeast Alaska in 2019.

March 11: Coonradt. Sonar survey with industry vessel of north Sitka Sound showed small schools of herring starting north of Old Sitka Rocks and ending near Lisianski Point. The deep water between Bieli Rock, Inner Point, and Hayward Strait contained most of the herring observed on the survey with a school stretching the width of the southern and nearly the length of the eastern portion of the trench. That school was approximately 20–30 fathoms in depth and topping out around 50 fathoms.

March 12: 0830–0930. Dupuis/Coonradt. Today's aerial survey covered Sitka Sound north of Crawfish Inlet and south of Hayward Strait. No herring or herring spawn was observed. The highest concentration of herring predators was seen between Bieli Rock, Inner Point, and Hayward Strait. Numerous whales were seen working in deeper waters west of Bieli Rock and approximately 280 sea lions in several large groups holding off the rock piles. Four whales and a small group of sealions were observed off Lisianski Point. South of Sitka, 4 whales were observed in Eastern Channel. Herring predator numbers observed today are low for timing, however, weather is likely a factor in observed numbers.

March 14: No aerial survey.

- 3:00 p.m. F/V *Hukilau*; Promisila Bay; 250 ton set; 9.0% mature roe, 2.7% immature roe; 109 gram average weight; 48.9% female.

March 15: 0800–0900. Dupuis. Today's aerial survey covered Sitka Sound from Cape Burunof to Hayward Strait. No herring or herring spawn was observed. The highest concentration of herring predators was seen between Bieli Rock, Inner Point, and Hayward Strait. Numerous whales were seen working in deeper waters west of Bieli Rock and approximately 300 sea lions in several large groups holding off the rock piles. 2 whales and a small group of sealions were observed in Western Channel from Signal Island to Battery Island. South of Sitka, 2 whales were observed in Eastern Channel.

News release issued at 9:30 a.m. to put the fishery on 2-hour notice beginning 10 a.m. on Sunday, March 17.

March 16: 0800–0845. Dupuis. Today's aerial survey covered Sitka Sound from Cape Burunof to Hayward Strait. Weather was poor with southeast winds to 25 knots and rain. No herring or herring spawn was observed. Weather conditions were poor for spotting whales from the air. The highest concentration of herring predators was seen between Bieli Rock, Inner Point, and Hayward Strait. Approximately 400 sea lions were observed holding off the rock piles in several large groups. South of Sitka, 2 whales were observed in Eastern Channel.

2-hour notice meeting occurred at 1:30 p.m. at the Westmark Hotel.

March 17: 0815–0900. Dupuis. Today's aerial survey covered Sitka Sound from Cape Burunof to Hayward Strait. Weather was poor with southeast winds to 30 knots and rain showers. No herring or herring spawn was observed. Weather conditions were poor for spotting whales from the air. The highest concentration of herring predators was seen between Bieli Rock, Inner Point, and Hayward Strait. Approximately 400 sea lions were observed holding off the rock piles in several large groups.

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Two successful test sets were made today the results are as follows:

- 9:35 a.m. F/V *Perseverance*; Eastern Bay; 100 ton set; 3.4% mature roe, 6.3% immature roe; 82 gram average weight; 49.3% female.
- 9:45 a.m. F/V *Infinate Legacy*; Siginaka Islands; 75 ton set; 1.8% mature roe, 6.8% immature roe; 67 gram average weight; 45.9% female.

R/V *Kestrel* arrived in Sitka at 0800. The vessel survey conducted by the R/V *Kestrel* of north Sitka Sound showed several large schools of herring in shallower waters off the shorelines of eastern Kruzof Island north of Inner Point, in Eastern Bay, and around the Siginaka Islands. When the large body of fish was located along the Kruzof Island shoreline between Inner Point and Mountain Point tight to the beach none of the industry boats left on the grounds had a shallow net and both were unwilling to take the chance of tearing their net so no test sample was taken from this biomass. Limited jig sampling suggested these fish may be of a slightly larger size than the fish found by the Siginakas and in Eastern Bay.

March 18: 0800–0900. Coonradt. Today's aerial survey covered Sitka Sound from Cape Burunof to Hayward Strait. Weather was poor with southeast winds to 30 knots. No herring or herring spawn was observed. Weather conditions were poor for spotting whales from the air. The highest concentration of herring predators was seen between Bieli Rock, Inner Point, and Hayward Strait. Approximately 400 sea lions were observed holding off the rock piles in several large groups.

The vessel survey conducted by the R/V *Kestrel* of north Sitka Sound showed multiple schools of herring in southern Krestof Sound. Three successful test sets were made today, the results are as follows:

- 9:30 a.m. F/V *Infinite Legacy*; Southern Krestof; 150 ton set; 11.1% mature roe, 0.5% immature roe; 100 gram average weight; 50.7% female.
- 9:45 a.m. F/V *Emily Nichole*; Double Island; 2 ton set; 11.9% mature roe, 0.5% immature roe; 106 gram average weight; 50.2% female.
- 11:00 a.m. F/V *Infinite Legacy*; Mills Island; 150 ton set; 10.2% mature roe, 0.93% immature roe; 96 gram average weight; 46.8% female.

March 19: 0815–0945. Dupuis. Today's aerial survey covered Sitka Sound from Cape Burunof to Krestof Sound. Weather was good with southeast winds to 10 knots and clear skies. Herring schools were observed close to the shore from Silver Point to Deep Inlet. No herring spawn was observed. The highest concentration of herring predators was seen South and West of Vitskari Rocks where numerous whales were seen working in deeper water. Approximately 300 sea lions were observed holding off the rock piles in several large groups between Bieli Rock and Inner Point.

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The vessel survey conducted by the R/V *Kestrel* of north Sitka Sound showed multiple schools of herring along the Kruzof Island shoreline and a large biomass of fish in the deeper waters near Vitskari Rocks. It appears that the large mass of fish is still in deeper waters in central Sitka Sound. Assessment activity shifted to the south mid-morning following pilot reports of fish from Redoubt Bay to Silver Bay. South of Sitka, multiple schools of fish were identified between Silver Point and the head of Deep Inlet and from Entry Point to Indian River. Schools were also seen in the islands south of the airport. There was a fishable mass in Deep Inlet but test sets showed small fish with low roe content. Industry pilots also reported visible schools of herring in the Redoubt Bay area. Four successful test sets were made today, the results are as follows:

- 10:45 a.m. F/V *Ace*; Silver Point; 100 ton set; 7.5% mature roe, 2.4% immature roe; 85 gram average weight; 46.5% female.
- 11:30 a.m. F/V *Infinite Legacy*; Deep Inlet; 200 ton set; 9.9% mature roe, 0.7% immature roe; 104 gram average weight; 47.1% female.
- 12:00 p.m. F/V *Chelsea Dawn*; Deep Inlet; 100 ton set; 10.7% mature roe, 1.2% immature roe; 96 gram average weight; 51.6% female.

March 20: 0730–0900. Coonradt. Today's aerial survey covered Sitka Sound from Windy Pass to Krestof Sound. Weather was good with southeast winds 15 to 20 knots and overcast skies. Herring schools were observed in Deep Inlet. No herring spawn was observed. The highest concentration of herring predators appeared to shift toward Inner Point and Hayward Strait. Whales were seen working the shallower waters of the Kruzof Island shoreline between Inner Point and Hayward Strait. Sealions were scattered between Inner Point, Bieli Rock, and Hayward Strait.

The vessel survey conducted by the R/V *Kestrel* of north Sitka Sound showed schools of herring from the harbor entrance to Middle Island. Multiple schools were located along the Kruzof Island shoreline from Inner Point to Kamenoi Point and in Krestof Sound near Mud Bay. A large biomass of fish was identified in Hayward Strait. Schools of herring were also found in Promisla Bay. Three successful test sets were made today, the results are as follows:

- 9:30 a.m. F/V *Ace*; Point Brown; 75 ton set; 8.5% mature roe, 0.9% immature roe; 88 gram average weight; 42.7% female.
- 11:15 a.m. F/V *Ace*; Inner Point; 100 ton set; 7.5% mature roe, 1.7% immature roe; 83 gram average weight; 39.9% female.
- 11:20 p.m. F/V *Defiant*; Mud Bay; 300 ton set; 8.9% mature roe, 0.3% immature roe; 109 gram average weight; 39.3% female.

March 21: 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Redoubt Bay to Salisbury Sound. Weather was good with calm winds and overcast skies. Herring schools were observed in Deep Inlet, Redoubt Bay, near Middle Island, and in the Magoun Islands. No herring spawn was observed. The highest concentration of herring predators was between Fred's Creek and Kamenoi Point, near the Magoun Islands, and in outer Redoubt Bay. Whales were seen working the shallower waters of the Kruzof Island shoreline between Inner Point and Hayward Strait. Sealions were scattered between Inner Point, Bieli Rock, and Hayward Strait.

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The vessel survey conducted by the R/V *Kestrel* of north Sitka Sound showed scattered schools of herring from the harbor entrance to Middle Island. Multiple schools were located along the Kruzof Island shoreline from Fred's Creek to Kamenoi Point and in Katlian Bay near Cedar Cove. Industry vessels and pilots reported numerous schools of herring from Povorotni Point to Kanga Bay and near the Magoun Islands. Four successful test sets were made today, the results are as follows:

- 10:30 a.m. F/V *Chelsea Dawn*; Pirates Cove; 300 ton set; 10.2% mature roe, 0.5% immature roe; 97 gram average weight; 47.7% female.
- 11:00 a.m. F/V *Emily Nichole*; Katlian Bay; 200 ton set; 10.1% mature roe, 0.5% immature roe; 101 gram average weight; 44.1% female.
- 1:15 p.m. F/V *Ace*; Redoubt Bay; 200 ton set; 6.4% mature roe, 0.9% immature roe; 86 gram average weight; 32.7% female.

March 22: 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Redoubt Bay to Krestof Sound, including Nawasina Sound and Katlian Bay. Weather was good with 15 knot winds and overcast skies. Herring schools were observed in Deep Inlet, Redoubt Bay, near Middle Island, in the Magoun Islands, and in Katlian Bay. No herring spawn was observed. The highest concentration of herring predators was between Fred's Creek and Kamenoi Point, near the Magoun Islands, and in outer Redoubt Bay.

The vessel survey conducted by the R/V *Kestrel* of north Sitka Sound showed scattered schools of herring in Krestof Sound near the Magoun Islands. Numerous large schools of herring were found in the deeper waters North and West of Bieli Rocks. Industry vessels reported numerous schools of herring from Indian River to Deep Inlet. One successful test set was made today, the results are as follows:

- 12:00 p.m. F/V *El Dorado*; N. Bieli Rocks; 200 ton set; 7.8% mature roe, 1.63% immature roe; 83 gram average weight; 40.8% female.

March 23: 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Windy Pass to Salisbury Sound. Weather was marginal with 20-knot winds, low clouds, and rain. Herring schools were observed in Aleutkina Bay, Kanga Bay, near Middle Island, in the Magoun Islands, and in Dorothy Narrows. No herring spawn was observed. The highest concentration of herring predators was between Inner Point and Kamenoi Point, the Magoun Islands, Middle Island, and North of Bieli Rocks. Several whales were observed working in deeper waters North of Bieli Rocks.

The vessel survey conducted by the R/V *Kestrel* of north Sitka Sound showed numerous large schools of herring in the deeper waters North and West of Bieli Rocks and scattered schools from Middle Island to the harbor entrance. No test sets were made today as the fleet stood down from test setting until further notice.

March 24: 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Windy Pass to Krestof Sound. Weather was good with 10-knot winds and clear skies. Herring schools were observed in Kanga Bay, Katlian Bay, in the Magoun Islands, and in Dorothy Narrows. A spot spawn was observed in Krestof Sound on the southern end of Partofshikof Island. The highest concentrations of herring predators were found between Inner Point and Kamenoi Point, the

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Magoun Islands, Dorothy Narrows, and north of Bieli Rocks. Several whales were observed working in deeper waters north of Bieli Rocks and south of Vitskari Rocks.

The vessel survey conducted by the R/V *Kestrel* of north Sitka Sound showed numerous large schools of herring in the deeper waters north and west of Bieli Rocks and south of Vitskari Rocks. No test sets were made today.

March 25: 0800–0930. Dupuis/Coltharp. Today's aerial survey covered Sitka Sound from Windy Pass to Krestof Sound. Weather was good with 10-knot winds and clear skies. Herring schools were observed in Kanga Bay, in the Magoun Islands, and among the islands to the south of the airport. A spot spawn was again observed in Krestof Sound on the southern end of Partofshikof Island. The highest concentrations of herring predators were found between Inner Point and Kamenoi Point, Redoubt Bay, and north of Bieli Rocks. Several whales were observed working in deeper waters north of Bieli Rocks and east of Vitskari Rocks.

The vessel survey conducted by the R/V *Kestrel* of Sitka Sound showed numerous large schools of herring in the deeper waters north and west of Bieli Rocks and east of Vitskari Rocks. Schools of herring were also located in Redoubt and Kanga bays. No test sets were made today.

March 26: 0800–0930. Dupuis/Coltharp. Today's aerial survey covered Sitka Sound from Windy Passage to St. John Baptist Bay. Weather was good with 10-knot winds and clear skies. Herring schools were observed in Kanga Bay, north Krestof Sound, and in Olga and Neva straits. Spot spawn was again observed in Krestof Sound on the southern end of Partofshikof Island. Spot spawn was observed by industry pilots in Redoubt Bay. The highest concentrations of herring predators were found in Krestof Sound and Windy Passage. Several whales were observed working in deeper waters north of Bieli Rocks and east of Vitskari Rocks.

The vessel survey conducted by the R/V *Kestrel* of Sitka Sound showed scattered schools near St. John Baptist Bay, in Krestof Sound, and east of Middle Island.

March 27: 0800–1130. Dupuis/Coltharp. Today's aerial survey covered Sitka Sound from Crawfish Inlet to St. John Baptist Bay. Weather was good with 10-knot winds and clear skies. Herring schools were observed in the Magoun Islands, Kanga Bay, West Crawfish Inlet, Cedar Pass, and Crawfish Inlet. Spawn was again observed in Krestof Sound on the southern end of Partofshikof Island and in lower Neva Strait. Spot spawn was observed north of Povorotni Point. The highest concentrations of herring predators were found in Krestof Sound and Windy Passage.

The vessel survey conducted by the R/V *Kestrel* of Sitka Sound showed numerous schools in Windy Passage, Cedar Pass, and Crawfish Inlet. One successful test set was made today, the results are as follows:

- 11:30; Crawfish Inlet; 75-ton set; 10.7% mature roe, 0.7% immature roe; 91-gram average weight; 49.4% female.

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<u>March 28:</u> 0800–0930. Dupuis/Coltharp. Today's aerial survey covered Sitka Sound from Crawfish Inlet to St. John the Baptist Bay. Weather was good with calm winds and clear skies. Herring schools were observed in the Magoun Islands, Kanga Bay, Windy Pass, West Crawfish Inlet, Cedar Pass, and Crawfish Inlet. The only active spawn observed today was a spot spawn north of Povorotni Point. Cumulative spawn to date is 1.6 nautical miles. The highest concentrations of herring predators were found in Krestof Sound, west of Shoals Point and in Windy Passage. The R/V *Kestrel* departed Sitka Sound today, March 28.

<u>March 29:</u> 0800–0930. Coonradt. Today's aerial survey covered Sitka Sound from Crawfish Inlet to Whitestone Narrows. Weather was good with calm winds and overcast skies. Herring schools were observed in Whitestone Narrows. No active spawn was observed today. The highest concentrations of herring predators were found in Krestof Sound and in Windy Passage.

<u>March 30:</u> 0800–0930. Dupuis/Russel. Today's aerial survey covered Sitka Sound from Crawfish Inlet to Salisbury Sound. Weather was good with calm winds and partly overcast skies. Herring schools were observed in Salisbury Sound, Neva Strait, Krestof Sound and in Kanga Bay. Today 0.7 nmi active spawn was observed east of Lava Island along south Kruzof Island. Cumulative spawn to date is 2.4 nmi. The highest concentrations of herring predators wesre found in Krestof Sound, Neva Strait and around Vitskari Rocks. Smaller concentrations of herring predators were observed in Windy Passage and Kanga/Redoubt Bays and in Salisbury Sound.

<u>March 31:</u> 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Crawfish Inlet to Salisbury Sound. Weather was good with calm winds and clear skies. Herring schools were observed in Neva Strait and Krestof Sound. Today 0.8 nautical miles of active herring spawn was observed east of Lava Island along south Kruzof Island. The highest concentrations of herring predators were found in Krestof Sound, Neva Strait, and Olga Strait. Smaller concentrations of herring predators were observed in Windy Passage and Salisbury Sound.

<u>April 01:</u> 0800–0930. Dupuis/Coonradt. Today's aerial survey covered Sitka Sound from Windy Pass to Salisbury Sound. Weather was good with calm winds and clear skies. Herring schools were observed in Neva Strait and Krestof Sound. Today 5.1 nautical miles of active herring spawn was observed along Kruzof Island. To date 6.8 nmi of cumulative spawn has been mapped. The highest concentrations of herring predators were found along south Kruzof Island, in Krestof Sound and Neva Strait.

<u>April 02:</u> 0800–0930. Coonradt. Today's aerial survey covered Sitka Sound from Windy Pass to Salisbury Sound. Weather was good with calm winds and clear skies. Herring schools were observed along the Kruzof Island shoreline and in Krestof Sound. Today 14.2 nautical miles of active herring spawn was observed along Kruzof Island and in the Magoun Islands. To date 15.9 nmi of cumulative spawn has been mapped. The highest concentrations of herring predators were found along Kruzof Island, in Hayward Strait and Neva Strait.

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April 03: 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Cape Burunof to Salisbury Sound. Weather was good with calm winds and clear skies. No herring schools were observed. Today 18.7 nautical miles of active herring spawn was observed along Kruzof Island, in the Magoun Islands, and Kresta Point. To date approximately 21.4 nmi of cumulative spawn has been mapped. The highest concentrations of herring predators were found along Kruzof Island, in the Magoun Islands, and Neva Strait.

April 04: 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Cape Burunof to Krestof Sound. Weather was good with calm winds and overcast skies. Today 21.0 nautical miles of active herring spawn was observed along Kruzof Island, in the Magoun Islands, and Promisula Bay. To date approximately 26.6 nmi of cumulative spawn has been mapped. The highest concentrations of herring predators were found along Kruzof Island, in the Magoun Islands, and Krestof Sound.

April 05: 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Windy Passage to Salisbury Sound. Weather was good with 20-knot winds and overcast skies. Today approximately 9.2 nautical miles of active herring spawn was observed along Kruzof Island, in the Magoun Islands, Promisula Bay, Eastern Bay, and Gagarin Island. Smaller areas of herring spawn were observed along Long Island and in Redoubt Bay. To date approximately 31.7 nmi of cumulative herring spawn has been mapped. The highest concentrations of herring predators were again found near St. Lazaria Island, in the Magoun Islands, and Krestof Sound.

April 06: 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Windy Passage to Salisbury Sound. Weather was poor with southeast 35 knot winds and mostly sunny skies. Today approximately 8.3 nautical miles of active herring spawn was observed along Kruzof Island, in the Magoun Islands, Promisla Bay, Eastern Bay, and Gagarin Island. Smaller areas of herring spawn were observed along Long Island and in Redoubt Bay. To date approximately 33.6 nmi of cumulative herring spawn has been mapped.

Additionally, a survey covering Hoonah Sound from Broad Island to the North Arm was conducted. No herring, herring spawn, or herring predators were seen.

April 07: 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Windy Passage to Salisbury Sound. Weather was poor with southeast 35 knot winds and overcast skies. Today approximately 7.3 nautical miles of active herring spawn was observed along the Siginaka Islands, Promisula Bay, Eastern Bay, Olga Strait and Redoubt Bay. Smaller areas of herring spawn were observed along Kruzof Island north of Inner Point, Long Island and the Magoun Islands and Gagarin Island. To date approximately 37.1 nmi of cumulative herring spawn has been mapped.

April 08: 0800–0930. Dupuis. Today's aerial survey covered Sitka Sound from Windy Passage to Krestof Sound. Weather was poor with southeast 25 knot winds, low overcast skies, and rain. Today approximately 0.9 nautical miles of active herring spawn was observed along the Siginaka Islands, Eastern Bay, and Redoubt Bay. A skiff survey mapped an additional 4.8 nmi of herring spawn in Sitka Sound. To date approximately 41.9 nmi of cumulative herring spawn has been mapped.

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April 09: **0800–0930.** Jensen. Today's aerial survey covered Sitka Sound from Windy Passage to Salisbury Sound. Weather was poor with southeast 20-knot winds, low overcast skies, and rain. Today approximately 2.8 nautical miles of active herring spawn was observed along the Siginaka Islands, Dorothy Narrows, Golf Island, Redoubt Bay, and near Kane Island in Salisbury Sound. A skiff survey mapped an additional 1.2 nmi of herring spawn in Sitka Sound. To date approximately 45.6 nmi of cumulative herring spawn has been mapped.

April 10: **0800–0930.** Jensen. Today's aerial survey covered Sitka Sound from Crawfish Inlet to Salisbury Sound. Weather was good with calm winds, mostly clear overcast skies. Today approximately 6.1 nautical miles of active herring spawn was observed along the Second Narrows, Dorothy Narrows, Windy Pass and in Salisbury Sound. To date approximately 50.1 nmi of cumulative herring spawn has been mapped.

April 11: **0800–0930.** Jensen. Today's aerial survey covered Sitka Sound from Crawfish Inlet to Salisbury Sound. Weather was good with calm winds and clear skies. Today approximately 9.0 nautical miles of active herring spawn was observed along the Second Narrows, Dorothy Narrows, Windy Pass and in Salisbury Sound. To date approximately 53.3 nmi of cumulative herring spawn has been mapped.

April 18: **0800–0930.** Dupuis. Today's aerial survey covered Hoonah Sound from Broad Island to the North Arm. Weather conditions were not great for spotting predators as there were stiff winds and rough seas. No herring or herring spawn were observed. 3 whales were seen; one in the South Arm, one by the Vixen Islands, and one south of Emmons Island.

April 25: **0800–0930.** Jensen. Today's aerial survey covered Hoonah Sound from Broad Island to the North Arm. Weather conditions were good. One whale and zero sea lions were observed. No herring or herring spawn were observed.

April 29: **0800–0930.** Dupuis. Today's aerial survey covered Hoonah Sound from Broad Island to the North Arm. Weather conditions were good. One whale and two sea lions were observed. No herring or herring spawn were observed.

Appendix C3.–Aerial and skiff herring spawn surveys by date, at Bradfield Canal, Ernest Sound, Ship Island, Zimovia Strait and Eastern Passage, Bear Creek, Hobart Bay, and other areas within Petersburg-Wrangell Management Area in Southeast Alaska, 2019.

Bradfield Canal

Not Surveyed in 2019

3/20 Industry pilot reported approximately 5 nmi of active spawn around Duck Point.

Vixen Inlet/ Union Bay/Emerald Bay

Total miles of spawn: ~5.6 nmi

Spawning dates: 4/19 and 4/29–4/30, possibly a day earlier

Peak spawning: 4/29

4/5 No herring spawn or schools observed, 20 sea lions, no birds.

4/10 No herring spawn or schools observed, 16 sea lions, very few birds.

4/13 No herring spawn or schools observed, 21 sea lions, very few birds.

4/14 No herring spawn or schools, 31 sea lions, few birds, one whale.

4/15 Two herring schools, no herring spawn, 16 sea lions, very few birds.

4/16 No herring spawn or schools observed, 11 sea lions, very few birds.

4/19 0.5 nmi of active spawn in Union, couple schools in Vixen, 27 sea lions, few birds.

4/20 No herring spawn or schools observed, 49 sea lions, very few birds, one whale.

4/22 No herring spawn or schools observed, 38 sea lions, few birds.

4/24 No herring spawn or schools observed, 62 sea lions, no birds in Vixen.

4/26 No herring spawn or schools observed, 24 sea lions, very few birds in Vixen.

4/29 2.0 nmi of active spawn in Vixen, couple schools in Vixen, 32 sea lions, 200 gulls.

4/30 1.4 nmi active, 0.5 nmi drift in Vixen, 4 schools in Vixen, 29 sea lions, 1,000 scoters.

5/1 No herring spawn or schools observed, 38 sea lions, 1,000 scoters, 1,000 gulls.

5/2 No herring spawn or schools observed, 7 sea lions, 2,500 scoters, 1,000 gulls.

Onslow/Stone/Brownson Island/Canoe Pass

Total miles of spawn: 2.6 nmi

Spawning dates: 4/14

Peak spawning: 4/14

4/5 No herring spawn or schools observed, no sea lions or birds.

4/10 No herring spawn or schools observed, no sea lions or birds.

4/13 Several herring schools observed on Brownson Is., 5 sea lions, few birds.

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4/14 1.0 nmi of active spawn on Brownson Is., several schools, 4 sea lions, no birds.

4/15 No herring spawn or schools observed, no sea lions or birds.

4/16 No herring spawn or schools observed, 3 sea lions, no birds.

4/19 No herring spawn or schools observed, one sea lion, 500 gulls.

4/20 No herring spawn or schools observed, no sea lions or birds.

4/22 No herring spawn or schools observed, no sea lions, 200 scoters, few gulls.

4/24 No herring spawn or schools observed, no sea lions, 800 scoters, few gulls.

4/26 No herring spawn or schools observed, two sea lions, 1,500 scoters, 700 gulls.

4/29 No herring spawn or schools observed, no sea lions, 1,000 scoters.

5/1 No herring spawn or schools observed, no sea lions, few birds.

5/2 No herring spawn or schools observed, no sea lions, no birds.

Zimovia St. and Eastern Passage

Total miles of spawn: 0.0 nmi

4/5 Herring spot spawn near Pats Landing

4/10 No herring spawn or schools observed, 100 scoters.

4/13 No herring spawn, several schools, 1,500 scoters.

4/14 No herring spawn, several schools, 2,000 scoters.

4/15 No herring spawn or schools observed, 2,000 scoters.

4/16 No herring spawn or schools observed, 2,200 scoters.

4/19 No herring spawn or schools observed, very few birds.

4/22 No herring spawn or schools observed, very few birds.

4/24 No herring spawn or schools observed, very few birds.

Bear Creek

Not Surveyed in 2019

5/1 Industry pilot reported a spot spawn at the mouth of Bear Creek with supporting photographs.

Farragut Bay

Total miles of spawn: ~2.6 nmi

Spawning dates: 5/10–5/11

Peak spawning: 5/10

4/16 No herring spawn or schools observed, one sea lion.

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4/24 No herring spawn or schools observed, three sea lions.

4/26 No active spawn, sea lions, or birds.

4/29 No herring spawn or schools observed, 12 sea lions.

4/30 No herring spawn or schools observed, 28 sea lions.

5/1 No herring spawn or schools observed, seven sea lions.

5/3 No herring spawn or schools observed, 12 sea lions.

5/10 ~1.75 nmi active spawn, one sea lion

5/11 ~0.8 nmi active spawn, one sea lion

Hobart Bay

Total miles of spawn: ~0.9 nmi

Spawning dates: 5/10

Peak spawning: 5/10

4/16 No herring spawn or schools observed, five sea lions.

4/24 No herring spawn or schools observed, 24 sea lions, one whale.

4/26 No herring spawn or schools observed, 34 sea lions, one whale.

4/29 No herring spawn observed, three schools, seven sea lions.

4/30 No herring spawn or schools observed. 12 sea lions, 200 scoters.

5/1 No herring spawn or schools observed, no sea lions.

5/3 No herring spawn or schools observed, ten sea lions.

5/10 ~0.9 nmi active spawn, 30 sea lions, 300 scoters.

5/11 No herring spawn or schools observed, seven sea lions, 500 scoters.

Port Houghton

Total miles of spawn: unknown

Spawning dates: unknown, likely sometime between 5/3 and 5/10

Peak spawning: unknown

4/16 No herring spawn or schools observed, five sea lions.

4/24 No herring spawn or schools observed, eight sea lions.

4/26 No herring spawn or schools observed, ten sea lions.

4/29 No herring spawn or schools observed, 14 sea lions.

4/30 No herring spawn or schools observed. 19 sea lions.

5/1 No herring spawn or schools observed, ten sea lions.

-continued-

5/3 No herring spawn observed, one school, five sea lions.

5/10 No herring spawn or schools observed, two sea lions, 300 scoters.

5/11 No herring spawn or schools observed, four sea lions, one whale, 1,000 scoters.

Sunset Cove/Windham Bay

4/16 No herring spawn or schools observed, 15 sea lions.

4/24 No herring spawn or schools observed, 30 sea lions.

4/26 No herring spawn or schools observed, three sea lions.

4/29 No herring spawn observed, three schools, seven sea lions.

4/30 No herring spawn or schools observed. 15 sea lions.

5/1 No herring spawn or schools observed, no sea lions.

5/3 No herring spawn or schools observed, eight sea lions.

5/10 No herring spawn or schools observed, no sea lions.

5/11 No herring spawn or schools observed, no sea lions.

Gambier Bay/Pybus Bay

Not surveyed in 2019.

Port Camden

Not surveyed in 2019.

Tebenkof Bay

Not surveyed in 2019

Appendix C4.–Aerial and skiff herring spawn surveys by date, in Juneau Management Area, in Southeast Alaska, 2019.

Seymour Canal

Number of times surveyed: 25

Total miles of spawn: 3.0

Spawning dates: 5/10, 5/19–5/23

Peak spawn: 5/19–5/23

4/16: No herring or herring spawn; 80 SL, 3 W. Good vis.

4/19: No herring or herring spawn; 69 SL 3 W. Good vis.

4/23: No herring or herring spawn; 55SL 11 W. Good vis.

4/28: Schools of herring by Dogleg, no herring spawn; 104 SL 4 W. Excellent vis.

4/29: Schools of herring Cloverleaf Rocks to Dogleg, no herring spawn; 75 SL 10 W. Excellent vis.

4/30: Schools of herring by Pt Hugh Light, no herring spawn; 60 SL 2 W. Good vis.

5/1: Schools by Pt Hugh and n. of Dogleg, no herring spawn; 84 SL, 7 W. Excellent vis.

5/2: Schools by Dogleg and lining the beach to the north, no herring spawn; 63 SL 11 W. Good vis.

5/3: One school of herring at Dogleg, no herring spawn; 90 SL, 5 W. Good vis.

5/5: Small school at Sorethumb, one N of Pt Hugh, no herring spawn; 61 SL, 3 W. Fair vis.

5/7: No herring or herring spawn; 63 SL, 6 W. Good vis.

5/9: Schools south of Dorn Island, no herring spawn. 25 SL, 8 W. Excellent vis.

5/10: Schools between Cloverleaf Rks and Pt Hugh, and by Shortfinger Bay, 3 spot spawns between Cloverleaf Rks and Pt Hugh. 70 SL, 2 W. Good vis.

5/11: Schools between Cloverleaf Rks and Pt Hugh, and Twin Islands; 78 SL, 11W. Good vis.

5/12: Schools between Pt Hugh and Pt Hugh Light; 60 SL, 7W. Good vis.

5/13: Schools on Stephens Passage opposite Twin Islands and by Pt Hugh; 31 SL, 0W. Excellent vis.

5/14: Schools at Pt Hugh Light, Pt Hugh, and between Blackjack and Sorethumb Cove; 42 SL, 1W. Good vis.

5/15: Schools at Pt Hugh, Rockgarden and Sorethumb; 8 SL, 6W. Excellent vis.

5/16: Schools at Pt Hugh, between Twin Islands and #9 rock, and from Dorn Is to Wining Cove; 40 SL, 3W. Good vis.

5/17: School at Pt Hugh, between Swimming Pool and Sorethumb; 9 SL, 4 W. Good vis.

-continued-

5/19: Schools north of the Stephens Passage nipple, by Cloverleaf Rocks and S of Sorefinger. 0.25 nmi Active spawn in the Rock Garden; 14 SL, 0W. Good Vis.

5/20: Spot spawn N of Midway Point and 1.0 nmi active spawn in Rockgarden. School at Dogleg and among the spawn; 28 SL and 2 W. Good vis.

5/21: 0.2 nmi spawn on Stephens Passage, 0.4 nmi by Rockgarden, no schools of herring and few predators.

5/22: 1.0 nmi spawn on Stephens Passage, spots spawns near Sorethumb, Blackjack and Winning coves. Schools of herring by Pt Hugh light, few predators.

5/23: 0.2 nmi spawn by Pt Hugh light, spot spawns on either side of Sorefinger cove. No schools of herring, few sea lions and 3 whale.

Tenakee Inlet

Number of times surveyed: 11

Total miles of spawn: 0.5

Spawning dates: 5/12–5/14

Peak spawn: 5/13

4/16: No herring or herring spawn; 250 SL, 2 W. Good vis.

4/19: No herring or herring spawn; 14 SL. Fair vis.

4/23: No herring or herring spawn; 6 SL, 6 orca. Fair vis.

4/26: Small school of herring on Corner Pt.; 2 SL.

4/28: No herring or herring spawn; 12 SL. Excellent vis.

5/1: Small school at Cannery Pt; 12 SL. Excellent vis.

5/7: No herring or herring spawn; 8 SL, 0W. Good to Excellent vis.

5/12: light spawn near W end of pounding area with associated school: 17 SL, 1 W. Excellent vis.

5/13: 0.5 nmi light spawn near W end of pounding area, spot spawn at S Passage Point, one school near Trap Bay; 6 SL, 0W. Excellent vis.

5/14: Schools by LTF and W end of pounding area, spot spawns associated with each; 1 SL. Excellent vis.

5/15: No herring, herring spawn or predators.

Lynn Canal

Number of times surveyed: 16

Total miles of spawn: 3.9

Spawning dates: 5/7, 5/9–5/14

-continued-

Peak spawn: 5/13

4/16: One school of herring in Auke Bay, no herring spawn; 98 SL, 0 W. Good vis.

4/19: One school of herring in Auke Bay, no herring spawn; 116 SL 1 W. Good vis.

4/23: No herring or herring spawn; 4 SL 0 W. Good vis.

4/28: Herring schools in Auke Bay, Bridget Cove, Berners Bay and N of Pt St Mary no herring spawn; 29 SL 1 W. Excellent vis.

4/30: Herring schools in Tee Harbor and Auke Bay, no herring spawn; 12 SL 2 W. Good to fair vis.

5/2: Herring schools in N Bridget Cove by Cascade Pt and in Echo Cove, no herring spawn; 5 SL 3 W. Good vis.

5/5: No herring or herring spawn; 2 SL, 5 W. Fair vis – foggy.

5/7: Active spot spawns at Pt St Mary, a school to the north. 3 SL, 0W. good to excellent vis.

5/8: No herring, herring spawn or predators, gulls and scoters on yesterday's spawn; good to fair vis.

5/9: 0.25 nmi active spawn at Pt St Mary, several small schools on the beach 4–5 nmi to the north; 2 SL 5 W. Excellent vis.

5/10: Herring schools in Auke Bay, by Lena Point, and N of Tee Harbor, and N of Pt St Mary. Spot spawn at Pt St Mary; 6 SL, 4 W. Good vis.

5/12: 0.3 nmi active spawn in three spots at Pt St Mary and to the north, school in Camping Cove; 3 SL 1 W. Fair vis.

5/13: 2.8 nmi active spawn; 1.1 nmi from Pt Bridget S, the rest 5–6 nmi N of Pt St Mary; 0SL 1 W. Excellent vis.

5/14: small active spawn 5–6 nmi N of Pt St Mary, several schools in Bridget Cove and Auke Bay; 15 SL, 0W. Excellent to good vis.

5/15: schools by Tee Harbor, no herring spawn; 42 SL, 2W. Good vis.

5/20: surveyed to Tee Harbor; no herring, herring spawn or predators; good vis.

<u>Port Frederick</u>

Number of times surveyed: 9

Total miles of spawn observed: 0

4/16: No herring or herring spawn; 1 SL. Good vis.

4/19: No herring or herring spawn; 1 W. Good vis.

4/23: No herring or herring spawn; no predators. Good vis.

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

-continued-

5/7: Schools outside Hoonah Harbor, no herring spawn or predators; excellent vis.

5/12: Numerous schools from the Narrows to Burnt Point, no herring spawn; 1W. Excellent vis.

5/13: Schools by Hoonah and the Narrows, no herring spawn; 3 SL, 1W. Excellent vis.

5/14: Schools by Hoonah and the Narrows, no herring spawn; 2W. Excellent vis.

5/15: Schools by Hoonah, Burnt Point and the Narrows, no herring spawn or predators. Good vis.

Oliver Inlet and Stephens Passage

Number of times surveyed: 25

Spawning dates: 5/12–5/15

Peak Spawn: 5/13

Total miles of spawn: 4.8

4/16: No herring or herring spawn; no predators. Excellent vis.

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

4/23: No herring or herring spawn; no predators. Excellent vis.

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

4/29: Several herring schools outside Inlet, no spawn. 3 W. Excellent vis.

4/30: No herring or herring spawn; no predators. Excellent vis.

5/1: Many schools of herring from sandspit to head of inlet, no herring spawn; no predators. Excellent vis.

5/2: Many schools of herring inside inlet, no spawn. No predators. Good vis.

5/3: Several schools of herring inside inlet, no spawn. No predators. Good vis.

5/5: Several schools of herring inside inlet, no spawn. No predators. Good vis.

5/7: One school of herring inside inlet, no spawn or predators. Terrible vis.

5/9: No herring or herring spawn; no predators. Excellent vis.

5/10: Many schools of herring on the beach from Point Young to Green Cove and inside Oliver Inlet. No spawn, 1 W. Good vis.

5/11: Schools from Point young to Stink Creek, no spawn or predators. Good vis.

5/12: Two spot spawns, one in mouth of Stink Creek another to the east. Schools of fish near Pt Young and lining the beach towards Oliver Inlet. No predators, excellent vis.

5/13: 3.3 nmi of active spawn from Stink Creek to Oliver Inlet, schools at the mouth of Oliver inlet. 3 W and excellent vis.

-continued-

5/14: 1.6 nmi active spawn in the 5 nmi of shore west of Oliver, schools lining the mouth of Oliver and on either side of Green Cove, one school near head of inlet. No predators and good to excellent vis.

5/15: 0.9 nmi active spawn at mouth of Oliver Inlet and in mouth of creek west of Stink Creek, schools by Green Cove and west of Stink Creek. No predators, good vis.

5/16: No herring or herring spawn; no predators. Fair vis

5/17: Schools by Point Young no herring spawn; no predators.

5/19: No herring or herring spawn; no predators. Good vis.

5/20: No herring or herring spawn; no predators. Good vis.

5/21: No herring or herring spawn; no predators.

5/22: No herring or herring spawn; no predators.

5/23: No herring or herring spawn; no predators.

Taku Harbor

4/30: No herring or herring spawn. No predators. Good vis.

Freshwater Bay

5/1: a few schools outside Kennel Creek, no herring spawn. No predators. Excellent vis.

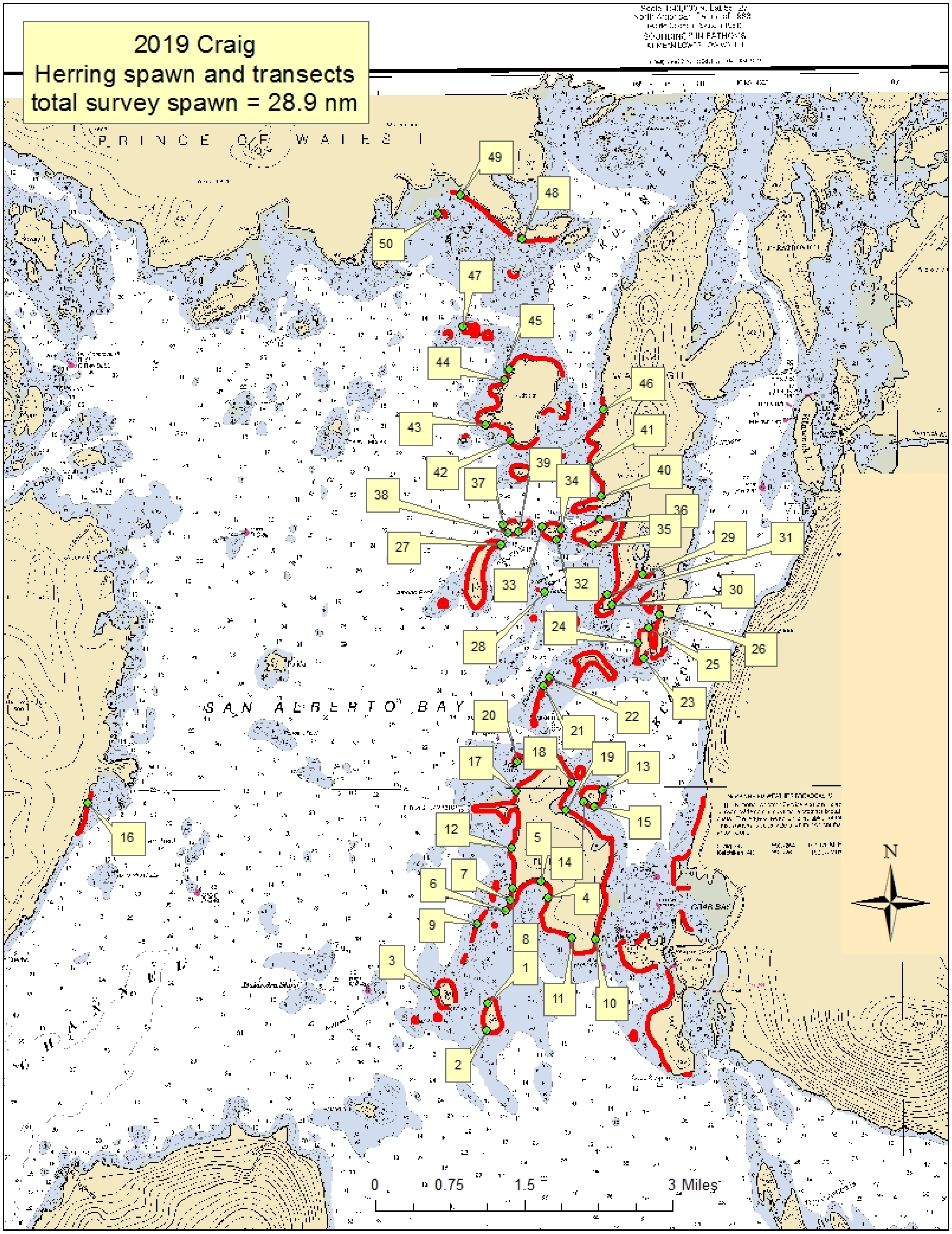
Appendix C5.–Aerial and skiff herring spawn surveys by date, in the Yakutat Management Area, in Southeast Alaska, 2019.

Yakutat Bay

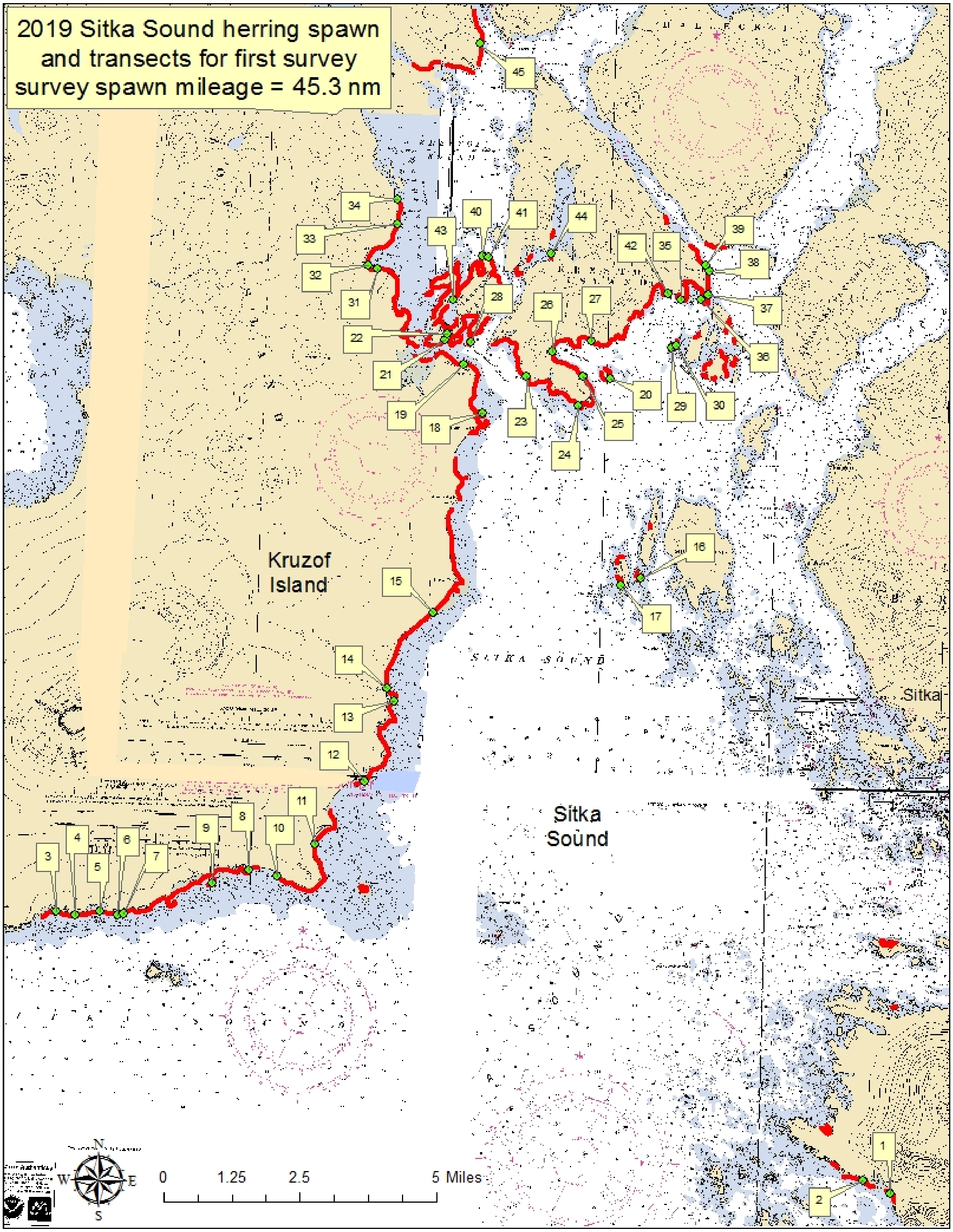
There were no aerial survey flights conducted in 2019. Total miles of spawn for the season are unknown.

APPENDIX D: SPAWN AND SPAWN DEPOSITION SURVEY TRANSECT LOCATIONS

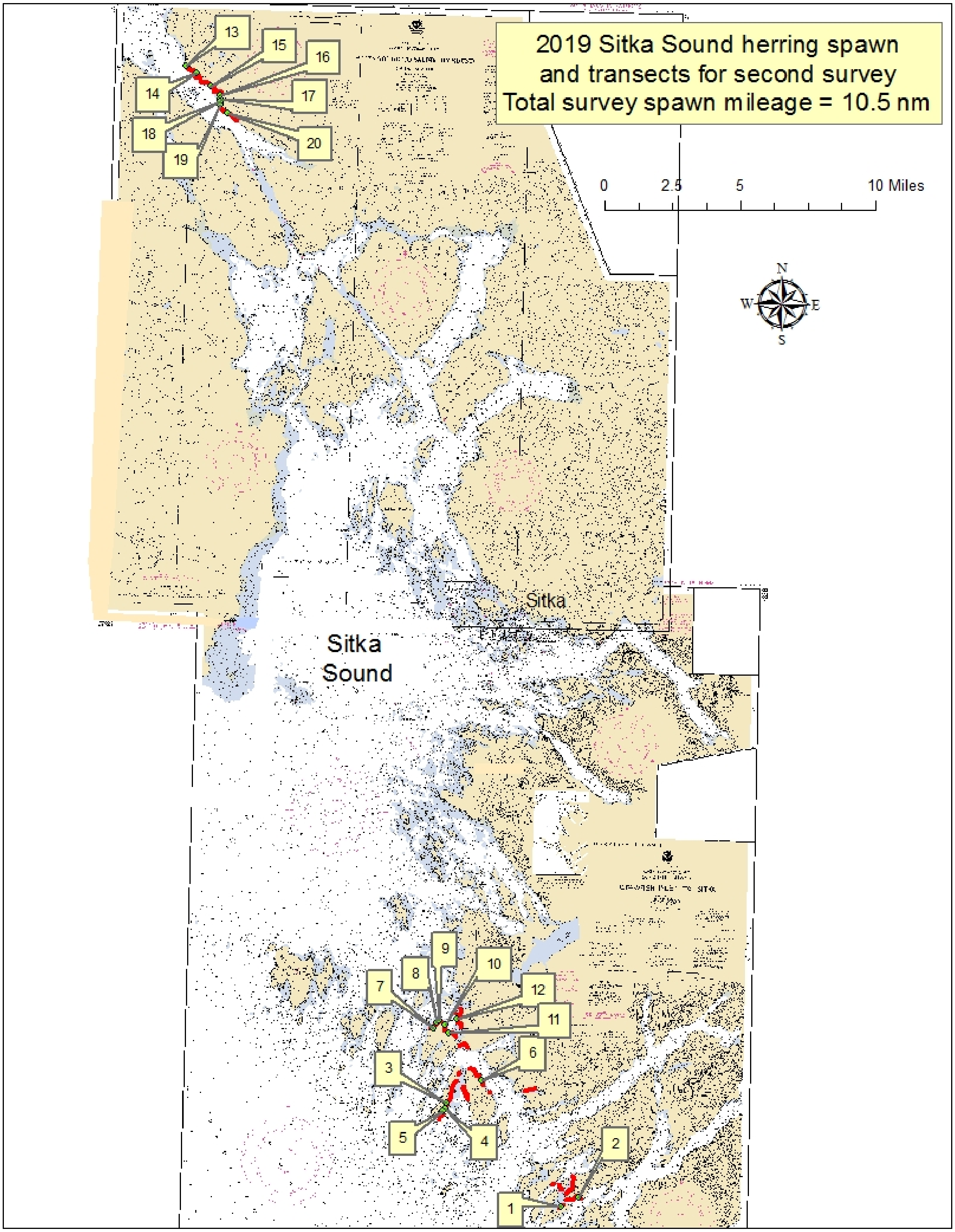
Appendix D1.–Spawn (heavy red or gray line) and spawn deposition survey transect locations (numbered labels) for the Craig herring stock in 2019. Spawn mileage up to date of dive survey.



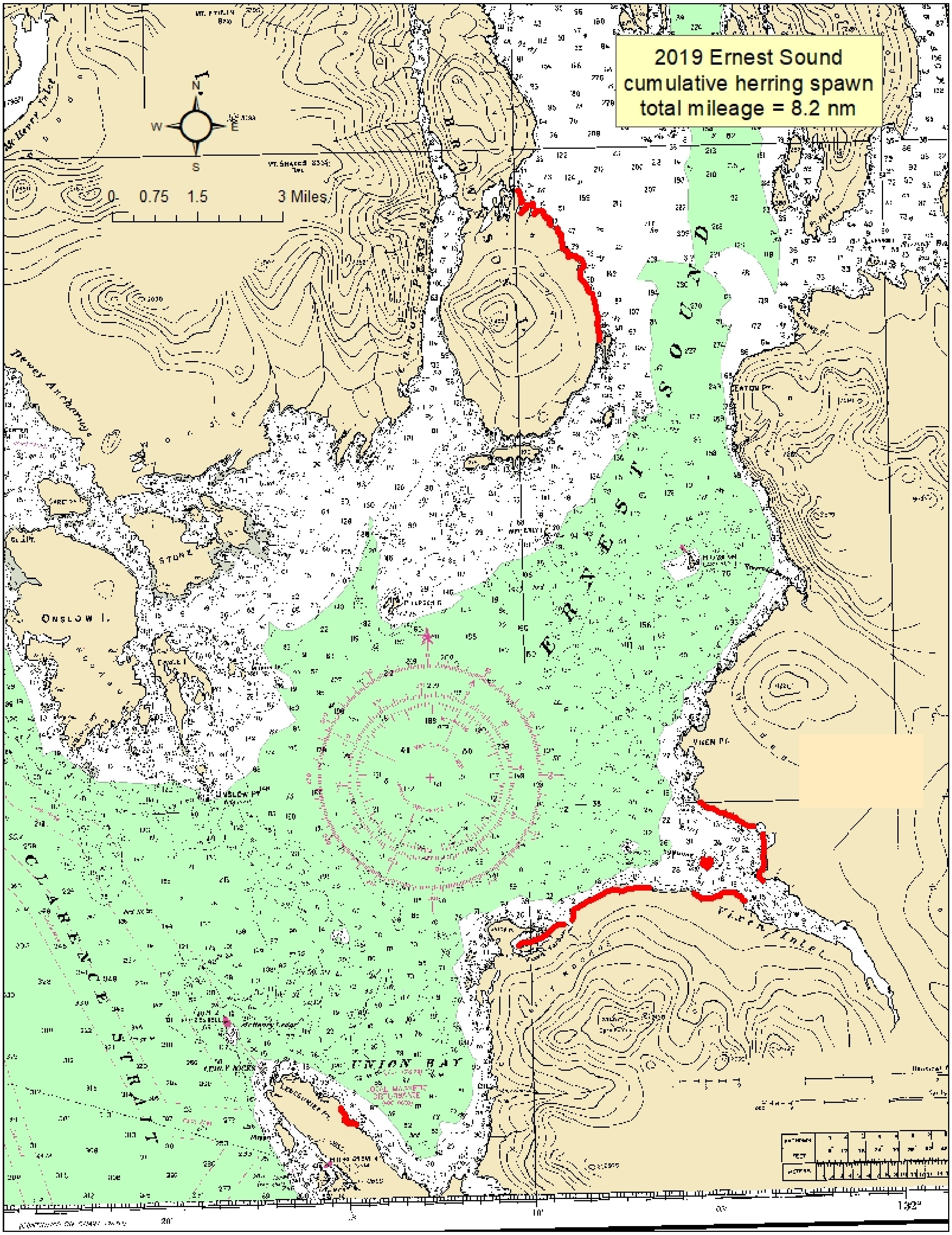
Appendix D2.–Spawn (heavy red or gray line) and spawn deposition survey transect locations (numbered labels) for the Sitka Sound herring stock first survey in 2019.



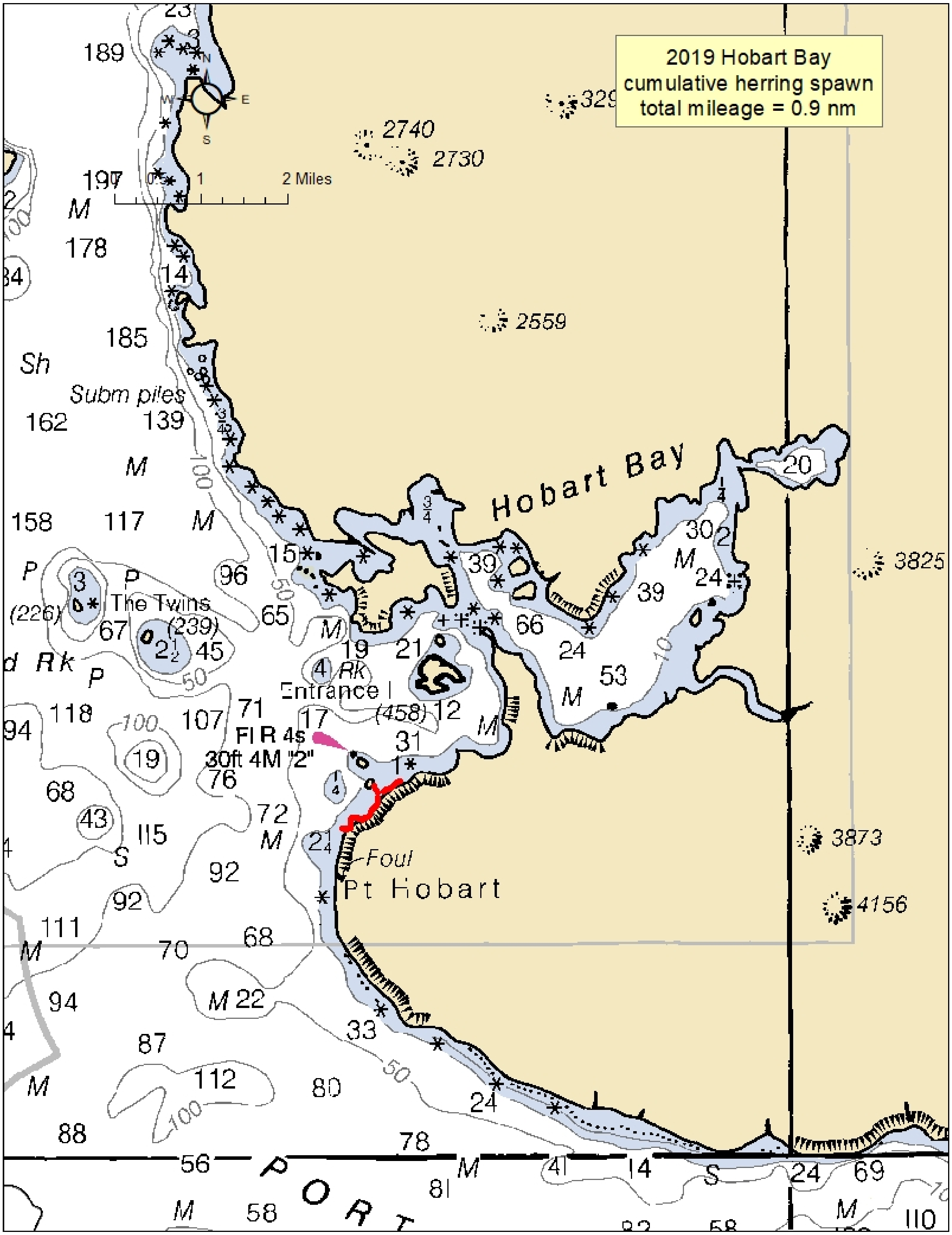
Appendix D3.–Spawn (heavy red or gray line) and spawn deposition survey transect locations (numbered labels) for the Sitka Sound herring stock second survey in 2019.



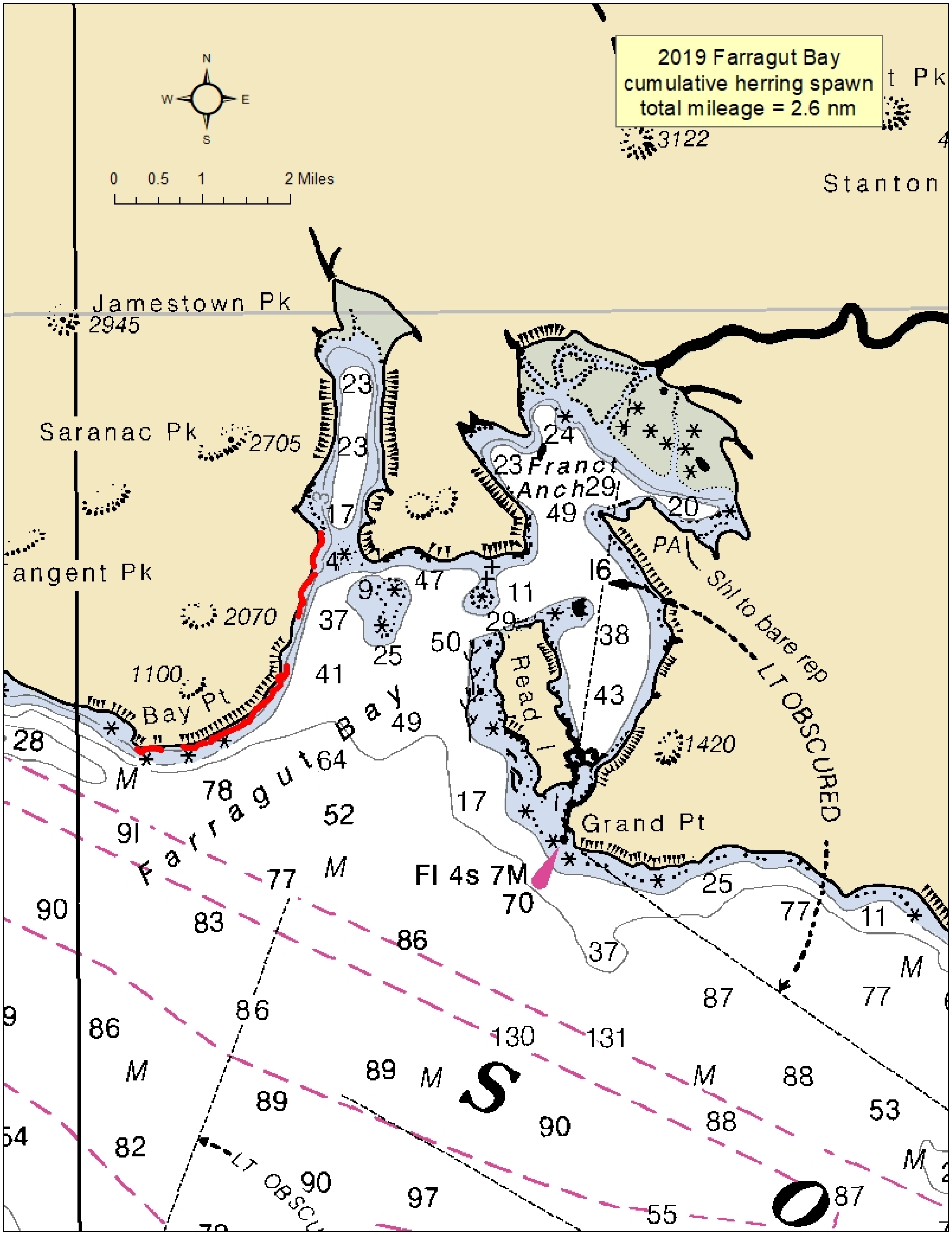
Appendix D4.–Spawn (heavy red or gray line) for the Ernest Sound herring stock in 2019.



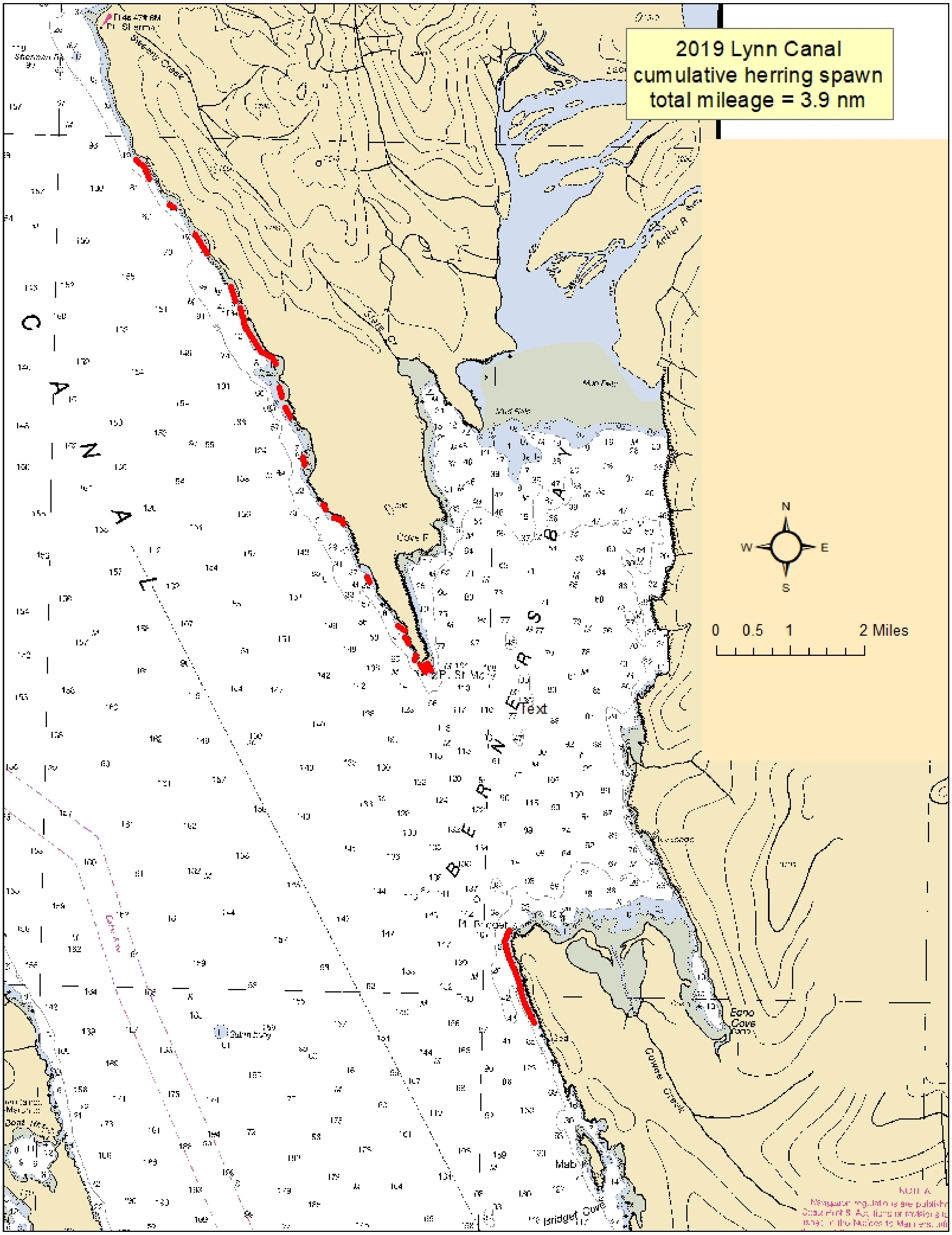
Appendix D5.–Spawn (heavy red or gray line) for the Hobart Bay–Port Houghton herring stock in 2019.



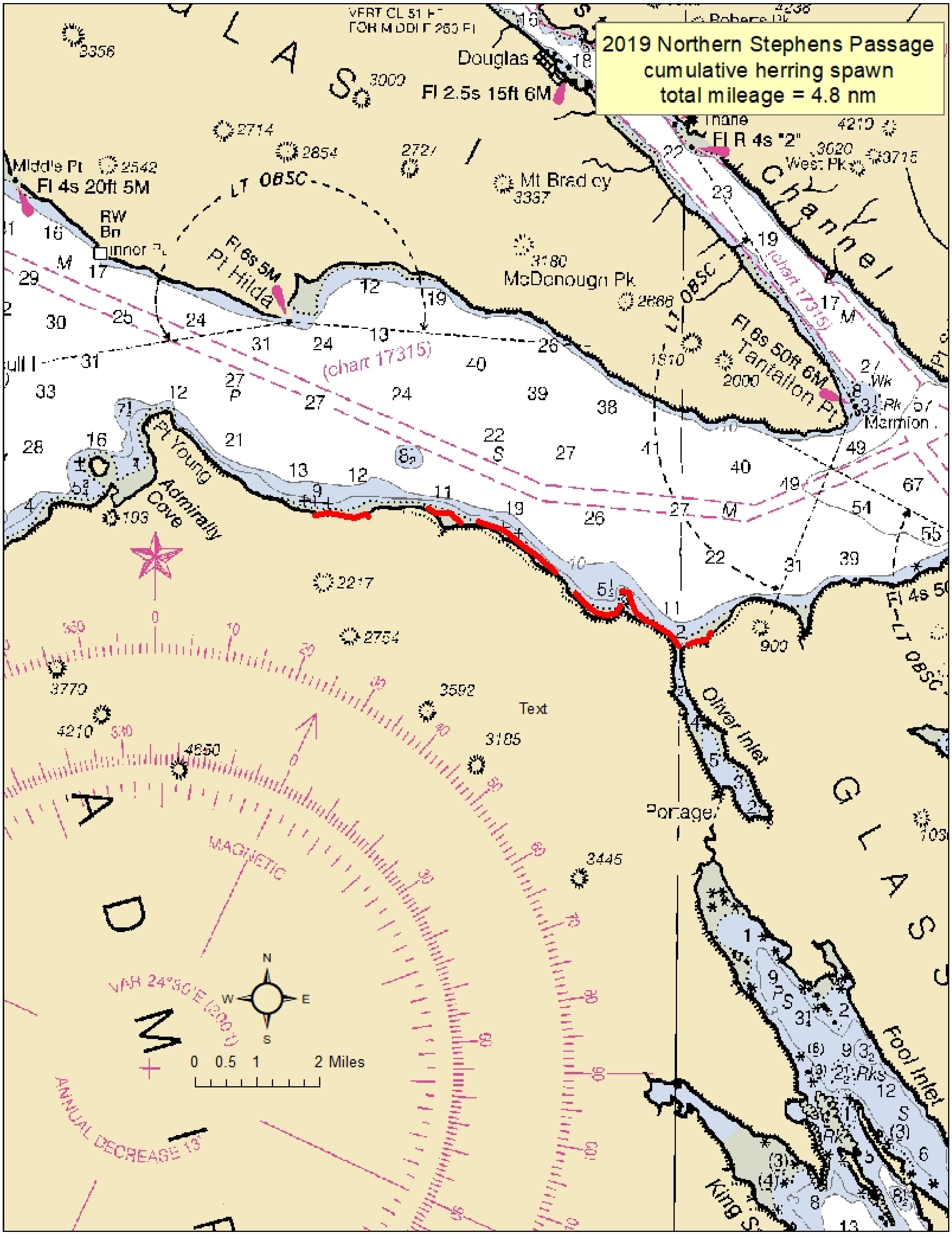
Appendix D6.–Spawn (heavy red or gray line) for the Farragut Bay herring stock in 2019.



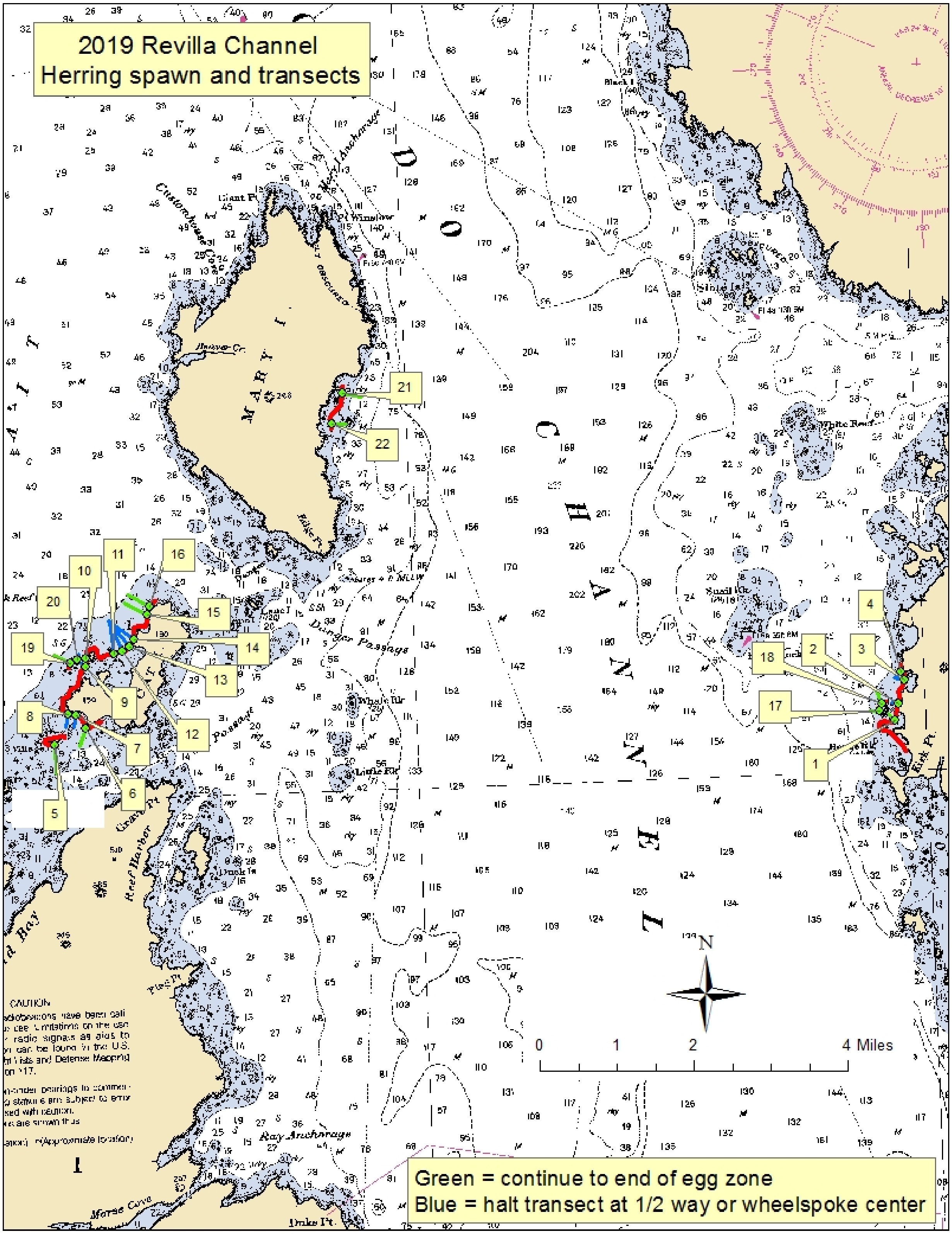
Appendix D7.–Spawn (heavy red or gray line) for the Lynn Canal herring stock in 2019.



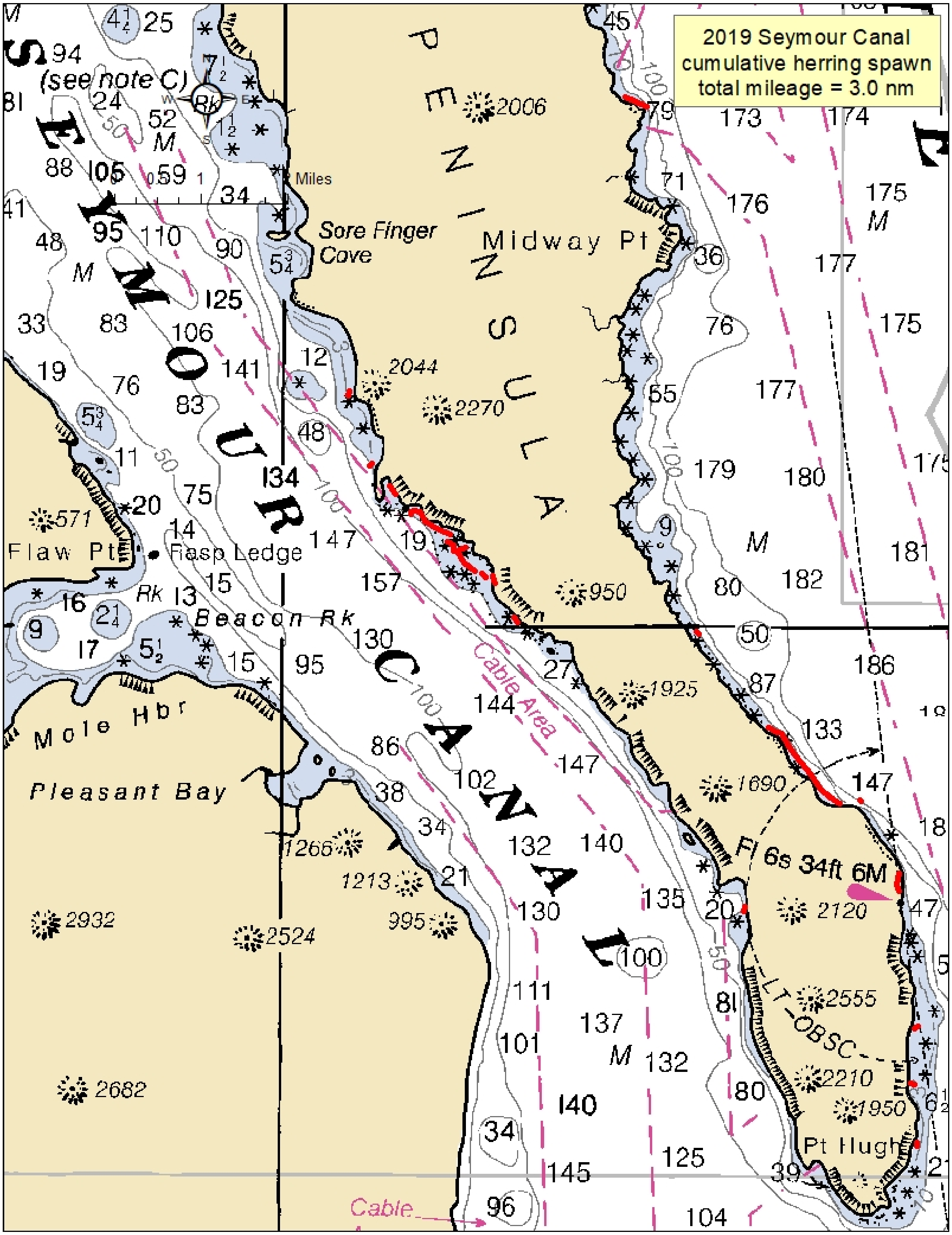
Appendix D8.–Spawn (heavy red or gray line) for the Northern Lynn Canal area in 2019.



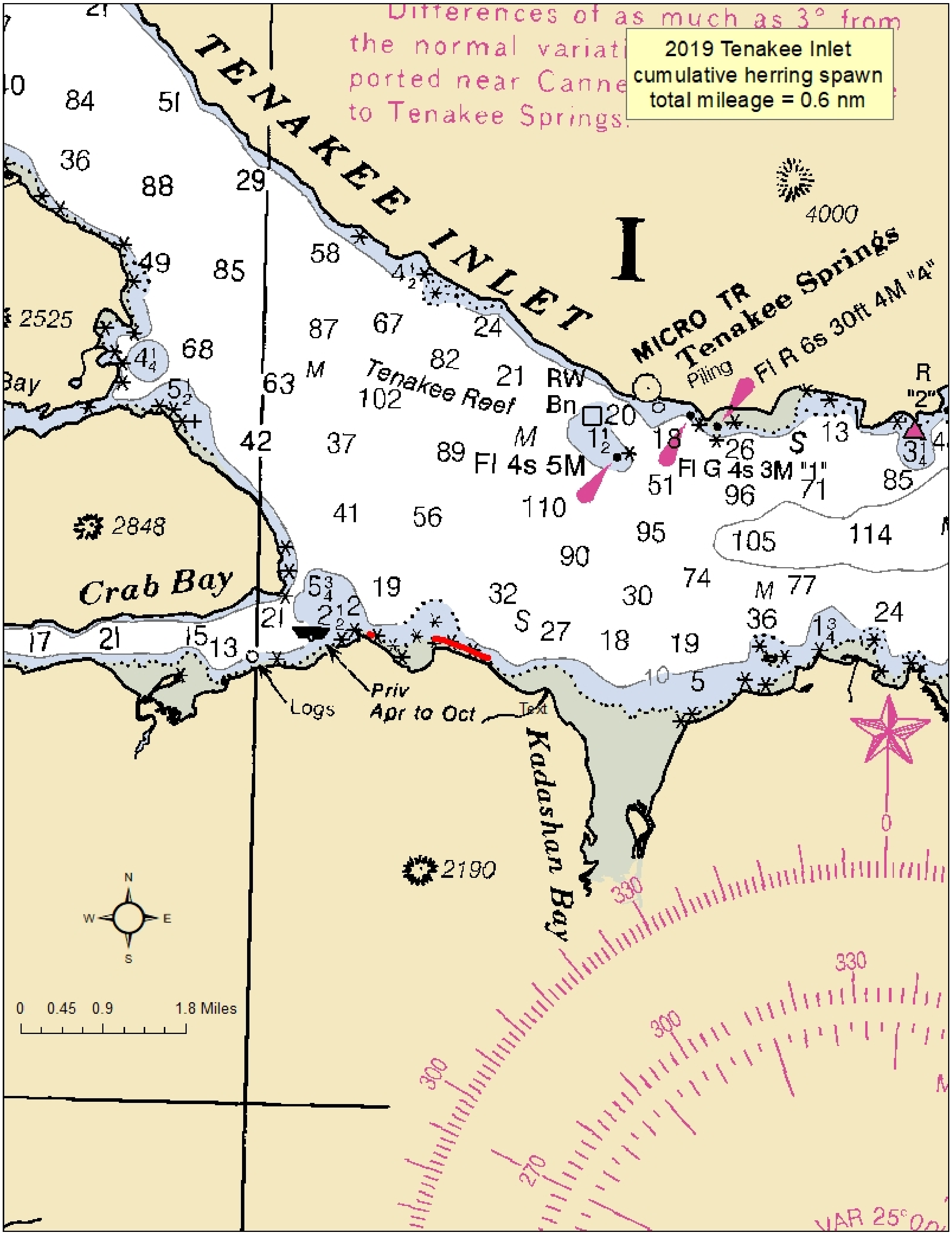
Appendix D9.–Spawn (heavy red or gray line) and spawn deposition survey transect locations (numbered labels) for the Revilla Channel (state waters only) herring stock in 2019.



Appendix D10.–Spawn (heavy red or gray line) for the Seymour Canal herring stock in 2019.



Appendix D11.–Spawn (heavy red or gray line) for the Tenakee Inlet herring stock in 2019.



Appendix D12.–Spawn (heavy red or gray line) for the West Behm Canal herring stock in 2019.