Fishery Data Series No. 19-12

# Southeast Alaska 2018 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

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

| **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, $\chi^2$, 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. 19-12*

# SOUTHEAST ALASKA 2018 HERRING STOCK ASSESSMENT SURVEYS


by
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# ABSTRACT

Pacific herring, *Clupea pallasii*, are important prey for many marine species found in Southeast Alaska and are also harvested in fisheries for commercial bait, commercial sac roe, commercial spawn-on-kelp, subsistence spawn-on-branches, subsistence spawn-on-kelp, personal use, and research/cost-recovery purposes. The Southeast Alaska Herring Management plan (5 AAC 27.190(3)) requires the Alaska Department of Fish and Game to assess the abundance of mature herring for each stock before allowing commercial harvest. Included here are results of stock assessment surveys completed primarily during 2018, including summaries of herring spawn deposition surveys and age-weight-length sampling, which are the principle model inputs used to forecast herring abundance. In 2018 spawn deposition surveys were conducted only for Sitka Sound and Craig stocks. Spawn deposition surveys were not conducted in several other traditionally major spawning areas in 2018, due to lack of funding resulting from cuts to state budgets, although aerial surveys of spawning were continued on a limited basis. The shoreline in state waters where spawn was documented during aerial surveys in 2018, combined for all areas, was 63.7 nautical miles. In 2018, post-fishery spawn deposition biomass estimates, combined for both surveyed stocks, totaled 78,839 tons.

During the 2017–2018 season, a commercial winter bait fishery was opened in Craig with a guideline harvest level of 1,387 tons. A commercial purse seine sac-roe fishery was opened in Sitka Sound with a guideline harvest level of 11,128 tons. A commercial spawn-on-kelp fishery was open in Craig, with an allocation of 1,602 tons of herring. There were no commercial gillnet fisheries opened in 2018. No commercial fisheries were opened in Seymour Canal, Ernest Sound, Hobart Bay-Port Houghton, Hoonah Sound, Tenakee Inlet, West Behm Canal, Kah Shakes/Cat Island, or Lynn Canal. Herring harvested commercially during the 2017–2018 season totaled 3,636 tons, not including herring pounded for spawn-on-kelp fisheries.



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


# INTRODUCTION

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

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

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

Since 1993, and when data has allowed, the ASA model has been used to estimate and forecast the abundance of herring for four major Southeast Alaska herring stocks: Sitka, Seymour Canal, Revillagigedo Channel (also called "Revilla Channel," which refers to the greater Kah Shakes/Cat Island and Annette Island spawning areas), and Craig. The ASA model was used for Tenakee Inlet beginning in 2000. For these five potential commercial harvest areas or spawning populations, the time series of data has been 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 2017 through spring 2018 and to provide historical perspective by presenting general trends in Southeast Alaska herring populations.

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

# METHODS AND PROCEDURES

## AERIAL AND SKIFF SURVEYS

A combination of aerial and skiff surveys 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, generally indicating presence of herring, 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 containing the cumulative shoreline that received spawn during the duration of the spawning event was used as the basis for targeting and designing the spawn deposition dive surveys.

## SPAWN DEPOSITION SURVEYS

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

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

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 but was not. 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 is eliminated without additional corrections (Li et al. 2011). A theoretical example of a spawn line along the shore, and how the layout of potential transects are considered for these instances, is presented in Figure 12.

Although the same procedure and patterns of drawing spawn were followed as in past years, the process requires that judgment be used based on knowledge and experience of the local spawning areas. The intent of drawing a smoothed spawn line is to produce a survey area that is oriented along the spawn and is such that transects laid perpendicularly to the spawn line will sample egg density throughout the entire width of the spawn, without biasing the estimate. A second objective of measuring the spawn observed along shorelines is to obtain an estimate of spawn length, which factors into the estimate of overall spawn area, and is discussed more below. 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 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. 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:

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

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%); |
| $\bar{d}$ | = | overall estimated mean egg density; |
| $t_a$ | = | critical t value for a one-sided, 90% confidence interval; and |
| $N$ | = | estimated total number of transects possible within the spawning area. |

## Field Sampling

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

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

## VISUAL ESTIMATE CORRECTION

Since visual estimates rather than actual counts of eggs within the sampling frame are recorded, measurement error occurs. To minimize bias and the influence of measurement error on estimates of egg deposition within each frame, estimator-specific correction coefficients were applied to adjust egg estimates either up or down depending on an 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 with 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 density within vegetation type. Vegetation categories included eelgrass (ELG), fir kelp (FIR), leafy brown kelp (LBK), rockweed (FUC), and hair kelp (HIR) (see Appendix A.1 for species within each category). Samples were transported to the ADF&G Mark, Tag and Age Laboratory 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 laboratory estimates to an estimator's visual estimates. To reduce potential of highly variable correction coefficients, minimum sample size guidelines were used. Data from the 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/kelp-specific correction coefficients were applied to egg estimates when the appropriate kelp type matched. For example, the "large/leafy brown kelp" correction coefficient was applied when kelp types that fit that description were encountered, and the "eelgrass" correction coefficient was applied when eelgrass was encountered. When loose eggs or eggs adhering to bare rock were encountered within the frame, an estimator-specific correction coefficient based on the average of all estimator/kelp-specific correction coefficients was applied.

## ESTIMATES OF TOTAL EGG DEPOSITION

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

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

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

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

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

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

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

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

## SPAWNING BIOMASS ESTIMATION

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

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

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

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

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

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

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

### Condition Factor

Condition factor (CF) was calculated to provide a general indication of overall condition of fish based on body proportion. Condition factor was based on the method described in Nash et al. (2006) and was estimated as follows003A

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

where

$w$ = whole body wet weight in grams; and
$l$ = standard length in millimeters.

### Sea Temperature

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

## COMMERCIAL FISHERIES

During the 2017–2018 season, only three commercial herring fisheries were conducted in Southeast Alaska, from two spawning areas: Sitka Sound and Craig. Products resulting from these fisheries included food and bait, sac roe, and spawn on kelp. Threshold biomass levels have been established for each commercially exploited stock in Southeast Alaska, which are intended to reduce the risk of sharp declines in abundance due to recruitment failure, and to maintain adequate herring abundance for predators. Commercial harvest of herring is not permitted unless the forecast of mature herring meets or exceeds the threshold. For Sitka Sound and West Behm Canal, threshold levels were based on 25% of estimated average unfished biomass as determined through simulation models (Carlile 1998a, 2003). In the case of Sitka Sound, the threshold was subsequently increased by the Board of Fisheries on two occasions (1997 and 2009) to provide additional protection to the stock and to help alleviate concerns over adequate subsistence opportunities to harvest the resource. For the Tenakee Inlet stock, 25% of the average unfished biomass was estimated; however, because the value was lower than the existing threshold of 3,000 tons, the existing threshold was retained (Carlile 1998b). For all other stocks in Southeast Alaska, thresholds were established after considering estimates of abundance, historical knowledge of stock size and distribution, and manageability of minimum quotas. Threshold levels during the 2017–2018 season ranged from 2,000 tons (Hoonah Sound and Hobart Bay) to 25,000 tons (Sitka Sound).

### Management Strategy

The following management plan was in place for the 2017–2018 Southeast Alaska commercial herring fisheries. It was adopted by the Alaska Board of Fisheries at its January 1994 meeting.

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

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

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

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

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

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

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

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

# RESULTS

## AERIAL AND SKIFF SURVEYS

Aerial and skiff surveys of herring activity, herring spawn, and marine mammal/bird activity were conducted at major stock locations beginning on March 9, 2018, in Sitka Sound and ending on May 15, 2018, in Lynn Canal. Notes of activity related to herring or herring spawning were recorded in logs, which are presented in Appendix C. Surveys or observations were conducted by staff in each area office (Ketchikan, Petersburg, Sitka, Juneau, Haines, Yakutat) and covered major 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. Aerial surveys were conducted in several minor spawning areas, but no spawn deposition surveys were completed in these areas due to the low level of spawning, or in the case of some areas (e.g., Bradfield Canal), because surveys conducted in previous years revealed that only a narrow band of spawning habitat exists resulting in relatively low egg deposition (see Appendix C). ADF&G also completed aerial surveys of Annette Island Reserve while en route to other spawning areas located in state waters.

## SPAWN DEPOSITION SURVEYS

During spring 2018, spawn deposition surveys were conducted only in Sitka Sound and Craig. The first survey of Sitka Sound began on April 8, the survey of Craig began on April 13, and the second survey of Sitka Sound began on April 24 (Table 4). Survey site locations, 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 2018, spawn deposition surveys were not conducted in Seymour Canal, Tenakee Inlet, Lynn Canal, Hoonah Sound, West Behm Canal, Revilla Channel, Ernest Sound, or Hobart Bay/Port Houghton, although limited aerial surveys were conducted in these areas.

Total herring spawning biomass, combined for both surveyed areas, was similar in 2018 to that observed in 2017. A summary of the 2018 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 2018 spawning stock abundance to prior years, estimates of historical spawning biomass are presented in Figures 14–19.

The total documented spawn for major spawning areas in state waters where aerial surveys were conducted in Southeast Alaska in 2018 was 63.7 nmi (Table 6). 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).

### Visual Estimate Correction

Minimum sample size guidelines (at least 3 samples per kelp type for the most recent 3 years) were met using data from 2016 through 2018 for all (7 of 7) estimators. Correction coefficients applied to 2018 spawn deposition visual estimates ranged from 0.56 to 1.54 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 a non-linear relationship for others caused by a tendency to underestimate when egg numbers in sample frames are high. A similar non-linear pattern has been observed for aerial estimates of salmon in streams (see Jones et al. 1998), although correction coefficients were calculated as a straight ratio of known to estimated values. For herring egg correction coefficients presented here, values were calculated as an overall ratio of values summed across the entire range of lab-estimated and visually estimated values, which was considered to adequately correct visual estimates, although values may be biased low due to the non-linear relationship.

## AGE AND SIZE

A combined total of 2,637 herring were sampled from all stocks and gear types (cast net, purse seine, and pound) during the 2017–2018 season. Of those, 2,601 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. Samples of the spawning population 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 (Figure 13).

Samples were also obtained from all commercial fisheries that were conducted in 2017–2018. Fisheries sampled included Craig winter bait, Craig spawn on kelp, and Sitka sac roe. Samples were obtained opportunistically from vessels or tenders, during or shortly after the fishery openings. Sample locations during fisheries are shown in Figures 20 and 21.

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 two stocks in the region due to reduced budgets in 2018: Sitka Sound and Craig. Samples were not obtained from Ernest Sound, Seymour Canal, Tenakee Inlet, Lynn Canal, Hoonah Sound, Hobart Bay/Port Houghton, West Behm Canal, or Revilla Channel due to reduced budgets. Frequency distributions of herring ages from sampled spawning areas are presented in Tables 10–20 and Figures 22–32.

In Sitka Sound, age composition samples were obtained in typical fashion, roughly proportional to spawn mileage; however, after processing of samples was completed at the laboratory and the target sample size was attained, it was apparent that individual cast net samples were not collected in proportion to the spawning biomass. Additionally, it was clear from individual samples that the proportions of age classes were substantially different between the herring that spawned earlier and later in the season. The 14.7 nmi of spawn from the first spawn event were roughly similar to the 16.2 nmi from the second spawn event. Miles of spawn was used as a proxy for the proportion of the population that spawned during each event when deciding how many cast net samples to take. As a result, 5 buckets were taken from the first spawn event and 7 from the second. The lab sampled proportionately among buckets resulting in 219 fish from the first spawn event and 308 from the second.

Because the first spawn event was on Kruzof Island, however, miles of spawn was not a good indicator of the proportion of the population that spawned during each event. The area and estimated number of eggs from the first spawn event (3.9 million sq m, 3.817 trillion eggs) was much higher than that of the second spawn event (1.3 million sq m, 0.373 trillion eggs). The first spawn event represented 76% of the combined area and 91% of the combined eggs (post-survey spawn not included).

Therefore, an alternative age composition was calculated *post hoc* by subsampling the herring from the second spawn event to get closer to the proportion of eggs estimated from each spawn event, which is presented in Table 15 and Figure 30. As few herring as possible were randomly subsampled from the second spawn event, while maintaining an overall sample size of at least $n = 300$. This resulted in a ratio of samples between spawning events (72:28) that approximated the spawning area of each event (76:24). This minimum sample size was chosen, so that all age class proportions would be within 0.05 of the true population proportions with 80% probability per Thompson 1987.

Observed age distributions for Sitka Sound and Craig areas had some similarities but were not closely aligned. For both areas, age-3 through age-6 herring dominated the distribution. Age-7 and age-8+ herring totaled less than 8% combined for each area. In both areas ages 4 and 6 were prominent, with age 5 notably lower in proportion. Similar age distributions in Craig and Sitka Sound are not unusual and 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 33-42.

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 43). When northern and southern stocks are viewed separately, the synchronized pattern is even more apparent within each group (Figures 44 and 45). 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 two areas in 2018, and it appears that age-3 proportions for Sitka were similar to those in 2017 and for Craig were lower than 2017.

The relationship between the latitude of spawning stocks and the proportion of mature age-3 herring continues to be relatively strong (Table 21, Figure 46). 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 $r^2 = 0.81$ (Figure 47). There is also a moderate correlation between the mean proportion of age-3 mature herring and the mean minimum annual sea temperature ($r^2 = 0.66$) (Figure 48). Although there is no linear correlation between the mean proportion of age-3 herring and the mean maximum annual sea temperature, graphic display reveals a possible curvilinear relationship (dome-shaped), suggesting the possibility of an optimal temperature for recruitment of mature age-3 herring, around 16.5º C (Figure 49).

## Size at Age

Based on cast net samples in 2018, there is a clear distinction between mean weight at age for Sitka Sound and Craig spawning herring (Figure 50). The divergence between Sitka Sound herring weight at age and other stocks in the region generally increases greatly with age, as Sitka Sound herring attain a substantially higher average weight by age 8 and typically by age 6.

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 Craig herring, the only other stock sampled in 2018 (Figure 51).

Trends in weight at age over time are variable among stocks (Figures 52–61). 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 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 index the physical dimensions of herring (i.e., weight-to-length ratio) over time, to roughly gauge herring health (Figures 62–71). Data obtained from cast net samples during active spawn events were used to calculate condition factors. Weight estimates derived from samples taking from actively spawning herring probably produce lower average values that contain more variability than would be expected from pre-spawning fish sampled during the commercial fishery; however, the overall trends in condition factor are expected to be the same. Other benefits of using data from cast net samples are that they provide a more complete and consistent time series and bias is expected to be lower than for fishery-dependent data that may be influenced by targeting larger fish.

Mean condition factors of herring from most stocks on Southeast Alaska follow the same general pattern over the last two decades: relatively low in the early 1990s, peaking in the early 2000s, followed by a decline until about 2007. Starting in 2008, condition factors for most stocks increased sharply, peaking in 2010 and then declined sharply to 2012. The condition factors calculated for 2018 are not notably different from those observed in 2017.

### Sitka Sound Winter Test Fishery

A test fishery was prosecuted in Sitka Sound during the winter of 2017-18; however, no samples were collected for estimating size or age.

## 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. 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 2018 was for the Sitka Sound area. There were no sac roe fisheries announced for Seymour Canal, West Behm Canal, Hobart Bay–Port Houghton, Kah Shakes–Cat Island, or Lynn Canal areas because spawning biomass was estimated to be below threshold.

#### *Sitka Sound*

The sac roe fishery was placed on two-hour notice on March 20 at 7:00 AM. The GHL was 11,128 tons. This season the fishery was conducted as a controlled (non-competitive) fishery. There were two days when openings were held during the 2018 fishery. The first opening was on March 25 from 1:00 PM until 6:00 PM in the northern part of Sitka Sound, Promisla Bay, and along the Kruzof Island shoreline. Estimated harvest was approximately 2,500 tons during the first opening. The second opening occurred on March 26 starting from 11:30 AM until 4:00 PM in the waters of northwest Sitka Sound and Hayward Strait. Approximately 400 tons were harvested during the second opening. There were no other openings announced and the fishery was announced closed for the season on April 3 at 11:00 AM.

The total harvest for the season was 2,926 tons, which fell short the GHL of 11,128 tons by 8,202 tons. The remaining GHL was not harvested because test sets that were conducted did not yield herring of sufficient market quality (e.g., size and % roe content) to warrant additional openings.

#### *Seymour Canal*

There was no commercial fishery in the Seymour Canal area during the 2017–2018 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 2017–2018 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 2017–2018 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 2017–2018 season, because no stock assessment survey or forecast was conducted due to budget cuts.

#### *Lynn Canal*

There was no commercial fishery in the Lynn Canal area during the 2017–2018 season, because no stock assessment survey or forecast was conducted due to budget cuts.

### Winter Bait Fisheries

During the 2017–2018 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, 2017, and was closed by regulation on February 28, 2018. The bait allocation was 1,387 tons, which was by regulation 60% of the total GHL of 2,312 tons. A total of 710 tons of herring were harvested.

#### *Ernest Sound*

There was no commercial fishery in Ernest Sound during the 2017–18 season due to budget cuts preventing survey and forecast.

#### *Tenakee Inlet*

There was no commercial fishery in Tenakee Inlet during the 2017–18 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 are allowed to 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 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 2017–2018 season was Craig. The other SOK areas in the region, Hoonah Sound, Ernest Sound, and Tenakee Inlet, were not opened during the 2017–2018 season because surveys and forecasts were not conducted.

#### *Craig*

A total of 66 closed pounds were actively fished, by a total of 132 permit holders. Of the 66 closed pounds, there were 5 single, 56 double, and 5 triple-permit pounds. No open pounds were fished. Total harvest was 205 tons of spawn on kelp.

#### *Hoonah Sound*

There was no commercial fishery in Hoonah Sound during the 2017–18 season due to budget cuts preventing survey and forecast.

#### *Ernest Sound*

There was no commercial fishery in Ernest Sound during the 2017–18 season due to budget cuts preventing survey and forecast.

#### *Tenakee Inlet*

There was no commercial fishery in Tenakee Inlet during the 2017–18 season due to budget cuts preventing survey and forecast.

### Bait Pound (Fresh Bait and Tray Pack) Fisheries

During the 2017–2018 season, no herring were harvested for fresh bait pounds or tray-pack in Southeast Alaska.

## Test Fisheries

The sole herring test fishery conducted in Southeast Alaska during the 2017–2018 season was in Sitka Sound, for bait, using purse seine gear to harvest. The fishery took place between October 25, 2017 and March 11, 2018. A total of 54 tons of herring were harvested.

# DISCUSSION

## Spawn Deposition

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 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 it appears that herring stocks in the region other than Sitka and Craig are at a relatively low level.

The combined observed spawning biomass estimated in 2018 for Sitka Sound and Craig, as determined from spawn deposition data only, was 78,839 tons. These two stocks typically account for about 80% of the spawning biomass in Southeast Alaska. Sitka Sound observed spawning biomass increased by 19% between 2017 and 2018, and Craig increased by 20%. Although the error surrounding biomass estimates was not calculated, it is assumed that the magnitudes of these changes were large enough that they probably 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 71.

Although changes in estimated spawning biomass over the past year may be 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.

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.

Spawn deposition estimates for 2018 suggest that combined herring spawning biomass in Southeast Alaska is at a moderate level relative to the period 1980–2017. This despite only surveying two stocks in 2018, because Sitka Sound and Craig historically have comprised a large proportion of the region's biomass. The 2018 combined estimate of surveyed areas of 78,839 tons is about 77% of the mean spawning biomass (1980-2017), which is an underestimate for the region because so many areas were not surveyed in 2018. However, when spawning areas other than Sitka Sound and Craig are considered separately, based on spawn mileage alone, most areas appear to remain at a low or very low level.

## Age Composition

For Sitka Sound and Craig, estimates of age composition in 2018 continued to follow patterns that are generally expected; 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 33–42). These patterns lend support to the assumption that the method of aging scales from 2018 samples was consistent with those methods used in prior years, which has been a concern in prior years (see Hebert 2012a and 2012b).

The observed proportions of mature age-3 herring in 2018 were variable but relatively high for Sitka and relatively low for Craig compared to proportions observed in 2017. The relatively high proportions of mature age-3 herring observed in 2017 and 2018 for Sitka Sound offers some insight to future biomass levels, increasing the likelihood that the populations could increase as this cohort matures. 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 these maturing young cohorts.

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

Historical patterns of age composition, and particularly proportions of age-3 herring, over time are also evident among stock groups within the region, which suggest that similar marine conditions may be present among certain areas within the region (Figure 72). 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 22–31%), but for stocks at 57 degrees and northward (Sitka, Hobart Bay, Seymour Canal, Hoonah Sound, Tenakee Inlet, and Lynn Canal) the proportions are relatively low (range of 14–18%). Although only one stock from each area was sampled, the latitudinal split continues to be supported by age compositions observed in 2018. In 2018 the rough similarity of age composition between Sitka Sound and Craig suggest that despite these stocks being on separate sides of the latitudinal split, there may also be a common influence from the outer coastal marine environment that these two areas share.

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

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.

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, AK.

Morstad, S., T.T. Baker, 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.

Oxman, D. S., and D. Buettner. *In prep*. Southeast Alaska Pacific herring *Clupea pallasi* age, weight, length and sex sampling. Alaska Department of Fish and Game.

# REFERENCES CITED (Continued)

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.

# TABLES AND FIGURES

Table 1.–Historical dates of herring spawn deposition surveys in Southeast Alaska. Dashes represent years without surveys and asterisks represent years where surveys were completed but records of dates are missing.

| 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 | – | – | – | – | – | – | – | – |

Table 2.–Transect sampling rates used for 2018 herring spawn deposition surveys.

| Area | Estimated target transects per nautical mile of spawn[a] | | | |
|---|---|---|---|---|
| | Based on 1994 analysis | Based on 1997 analysis | Based on 2000 analysis | Average |
| Sitka | 0.2 | 0.6 | 0.3 | 0.4 |
| West Behm Canal | — | 0.4 | 1.7 | 1.1 |
| Seymour Canal | 2.8 | 2.4 | 1.2 | 2.1 |
| Craig | 0.8 | 3.1 | 1.3 | 1.7 |
| Hobart/Houghton | 4.5 | 1.7 | 3.6 | 3.3 |
| Ernest Sound | 1.9 | 5 | 3.5 | 3.5 |
| Hoonah Sound | 2.9 | 1 | 0.7 | 1.5 |
| Tenakee Inlet | 5.1 | 1.2 | 1.6 | 2.6 |
| Average | 2.6 | 1.9 | 1.7 | 2.1 |

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

Table 3.–Fecundity relationships used for estimating 2018 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 2018 herring spawn deposition surveys conducted in Southeast Alaska.

| Survey area | Survey Leg | Survey Dates |
|---|---|---|
| Kah Shakes/Cat Island | NA | No Survey |
| West Behm Canal | NA | No Survey |
| Craig | I | April 13–14 |
| Sitka Sound | I, II | April 8–11, 24–25 |
| 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 |

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:* Em 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[de] | -- | -- | 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 | -- | -- | -- | -- | -- | -- | -- |

[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.

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

Table 7.–Correction coefficients used for herring spawn deposition estimates in Southeast Alaska in 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 2017–18.

| | Commercial Fishery | | | Survey | Test Fishery | |
|---|---|---|---|---|---|---|
| Stock | Herring gillnet | Pound | Purse seine | Cast net | Purse seine | Total |
| Craig | – | 525 | 530 | 530 | – | 1,585 |
| Ernest Sound | – | – | – | – | – | – |
| Hobart/Houghton | – | – | – | – | – | – |
| Hoonah Sound | – | – | – | – | – | – |
| Lynn Canal | – | – | – | – | – | – |
| Seymour Canal | – | – | – | – | – | – |
| Sitka Sound | – | – | 524 | 528 | – | 1,052 |
| Tenakee Inlet | – | – | – | – | – | – |
| West Behm Canal | – | – | – | – | – | – |
| Revilla Channel | – | – | – | – | – | – |
| Yakutat | – | – | – | – | – | – |
| Total | – | 525 | 1,054 | 1,058 | – | 2,637 |

*Note:* Em dashes indicate that no samples were collected in 2017–18, either due to lack of funding or observed spawning.

Table 9.–Summary herring samples aged for Southeast Alaska stocks in 2017–18.

| | Commercial Fishery | | | Survey | Test Fishery | |
|---|---|---|---|---|---|---|
| Stock | Herring gillnet | Pound | Purse seine | Cast net | Purse seine | Total |
| Craig | – | 519 | 527 | 525 | – | 1,571 |
| Ernest Sound | – | – | – | – | – | – |
| Hobart/Houghton | – | – | – | – | – | – |
| Hoonah Sound | – | – | – | – | – | – |
| Lynn Canal | – | – | – | – | – | – |
| Seymour Canal | – | – | – | – | – | – |
| Sitka Sound | – | – | 518 | 512 | – | 1,030 |
| Tenakee Inlet | – | – | – | – | – | – |
| West Behm Canal | – | – | – | – | – | – |
| Revilla Channel | – | – | – | – | – | – |
| Yakutat | – | – | – | – | – | – |
| Total | – | 519 | 1,045 | 1,037 | – | 2,601 |

*Note:* Em dashes indicate that no samples were collected in 2017–18, either due to lack of funding or observed spawning.

Table 10.–Summary of age, weight, and length for the Sitka Sound herring stock in 2017–18.

| Gear type/season | Age category | 3 | 4 | 5 | 6 | 7 | 8+ | Total |
|---|---|---|---|---|---|---|---|---|
| survey cast net - spring (full sample) | number of fish | 175 | 148 | 19 | 144 | 7 | 19 | 512 |
| | percent age composition | 34% | 29% | 4% | 28% | 1% | 4% | 100% |
| | average weight (g) | 71.8 | 86.4 | 99.3 | 111.2 | 116.4 | 132.2 | 102.9 |
| | standard dev. of weight (g) | 10.9 | 14.7 | 17.2 | 18.1 | 16.2 | 29.3 | 17.7 |
| | average length (mm) | 178 | 189 | 197 | 204 | 208 | 218 | 199 |
| | standard dev. of length (mm) | 6.9 | 8.2 | 9.4 | 9.1 | 11.5 | 11.9 | 9.5 |
| survey cast net - spring (sub-sample) | number of fish | 65 | 91 | 14 | 110 | 5 | 18 | 303 |
| | percent age composition | 21% | 30% | 5% | 36% | 2% | 6% | 100% |
| commercial purse seine - spring | number of fish | 113 | 145 | 23 | 218 | 5 | 14 | 518 |
| | percent age composition | 22% | 28% | 4% | 42% | 1% | 3% | 100% |
| | average weight (g) | 80.5 | 95.9 | 100.8 | 126.8 | 151.4 | 155.2 | 118.4 |
| | standard dev. of weight (g) | 11.9 | 16.0 | 20.1 | 18.0 | 20.5 | 30.6 | 19.5 |
| | average length (mm) | 180 | 190 | 194 | 206 | 217 | 225 | 202 |
| | standard dev. of length (mm) | 7.3 | 8.7 | 10.0 | 8.1 | 6.5 | 13.8 | 9.1 |
| test fishery purse seine - winter | number of fish | | | | | | | |
| | percent age composition | | | | | | | |
| | average weight (g) | | | | | | | |
| | standard dev. of weight (g) | | | | | | | |
| | average length (mm) | | | | NO SAMPLES OBTAINED | | | |
| | standard dev. of length (mm) | | | | | | | |

* Sub-sampling done to correct for undersampling the early spawn, when a much larger proportion of the population spawned.

Table 11.–Summary of age, weight, and length for the Craig herring stock in 2017–18.

| Gear type/season | Age category | 3 | 4 | 5 | 6 | 7 | 8+ | Total |
|---|---|---|---|---|---|---|---|---|
| survey cast net - spring | number of fish | 59 | 217 | 87 | 147 | 4 | 11 | 525 |
| | percent age composition | 11% | 41% | 17% | 28% | 1% | 2% | 100% |
| | average weight (g) | 60.7 | 75.9 | 86.1 | 97.6 | 97.0 | 121.7 | 89.8 |
| | standard dev. of weight (g) | 9.7 | 12.8 | 14.2 | 16.1 | 17.1 | 16.6 | 14.4 |
| | average length (mm) | 169 | 182 | 189 | 198 | 199 | 209 | 191 |
| | standard dev. of length (mm) | 7.5 | 9.3 | 8.3 | 8.4 | 8.3 | 7.0 | 8.1 |
| commercial pound - spring | number of fish | 98 | 219 | 76 | 98 | 10 | 18 | 519 |
| | percent age composition | 19% | 42% | 15% | 19% | 2% | 3% | 100% |
| | average weight (g) | 61.0 | 83.4 | 94.3 | 108.6 | 115.6 | 134.6 | 99.6 |
| | standard dev. of weight (g) | 9.2 | 14.7 | 16.1 | 18.2 | 11.4 | 19.8 | 14.9 |
| | average length (mm) | 166 | 182 | 191 | 198 | 202 | 212 | 192 |
| | standard dev. of length (mm) | 7.7 | 9.8 | 10.1 | 9.3 | 3.9 | 7.8 | 8.1 |
| commercial purse seine - winter | number of fish | 58 | 219 | 80 | 138 | 10 | 22 | 527 |
| | percent age composition | 11% | 42% | 15% | 26% | 2% | 4% | 100% |
| | average weight (g) | 66.1 | 84.9 | 98.4 | 110.1 | 111.2 | 125.4 | 99.3 |
| | standard dev. of weight (g) | 10.2 | 12.6 | 15.2 | 17.1 | 15.3 | 19.5 | 15.0 |
| | average length (mm) | 167 | 182 | 191 | 196 | 199 | 205 | 190 |
| | standard dev. of length (mm) | 8.2 | 8.6 | 9.8 | 9.3 | 11.9 | 10.4 | 9.7 |

Table 12.–Summary of age, weight, and length for the Hobart Bay/Port Houghton herring stock in 2017–18.

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

Table 13.–Summary of age, weight, and length for the Ernest Sound herring stock in 2017–18.

| Gear type/season | Parameter | Age Category 3 | 4 | 5 | 6 | 7 | 8+ | Total |
|---|---|---|---|---|---|---|---|---|
| survey cast net–spring | number of fish | | | | | | | |
| | percent age composition | | | | | | | |
| | average weight (g) | | | | | | | |
| | standard dev. of weight (g) | NO SAMPLES OBTAINED | | | | | | |
| | average length (mm) | | | | | | | |
| | std. dev. of length (mm) | | | | | | | |
| commercial pound–spring | number of fish | | | | | | | |
| | percent age composition | | | | | | | |
| | average weight (g) | | | | | | | |
| | standard dev. of weight (g) | NO FISHERY | | | | | | |
| | 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 14.–Summary of age, weight, and length for the Hoonah Sound herring stock in 2017–18.

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

Table 15.–Summary of age, weight, and length for the Tenakee Inlet herring stock in 2017–18.

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

Table 16.–Summary of age, weight, and length for the Seymour Canal herring stock in 2017–18.

| Gear type/season | Parameter | Age category | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | 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 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 2017–18.

| Gear type/season | Parameter | Age category | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 | 8+ | |
| survey cast net–spring | number of fish | | | | | | | |
| | percent age composition | | | | | | | |
| | average weight (g)[a] | | | | | | | |
| | standard dev. of weight (g) | | | NO SAMPLES OBTAINED | | | | |
| | average length (mm) | | | | | | | |
| | std. 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 2017–18.

| Gear type/season | Parameter | Age category | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | 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) | | | | | | | |
| | std. dev. of length (mm) | | | | | | | |

Table 19.–Summary of age, weight, and length for the Revilla Channel herring stock in 2017–18.

| | | 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 2017–18.

| | | 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, 1988–2018), 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 | 23% | 31% | 8.6 | 5.9 | 14.7 |
| Craig | 55.4770 | 17% | 22% | 9.0 | 4.7 | 14.1 |
| WBC | 55.4846 | 26% | 31% | 8.8 | 5.3 | 14.3 |
| Ernest Sound | 55.8307 | 30% | 31% | — | — | — |
| Sitka | 57.0079 | 11% | 18% | 8.6 | 4.9 | 13.8 |
| Hobart Bay | 57.4308 | 7% | 14% | 7.1 | 3.9 | 12.9 |
| Seymour Canal | 57.5923 | 10% | 15% | 6.7 | 3.0 | 13.3 |
| Hoonah Sound | 57.6001 | 7% | 16% | 7.9 | 2.0 | 15.0 |
| Tenakee Inlet | 57.7381 | 11% | 15% | 7.8 | 1.9 | 15.0 |
| Lynn Canal | 58.6402 | 10% | 14% | 7.1 | 2.6 | 15.4 |

Table 22.–Summary of Southeast Alaska herring target levels for the 2017–18 season.

| Area | Minimum spawning biomass threshold (tons) | Forecast (tons) | Target Exploitation Rate (%) | Guideline harvest level (tons)[a] |
|---|---|---|---|---|
| Craig | 5,000 | 16,039 | 14.4 | 2,312 |
| 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 | 55,637 | 20.0 | 11,128 |
| 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 bring into line with the minimum threshold applied to all other stocks in Southeast Alaska.

Table 23.–Summary of commercial herring harvest during the 2017–18 season.

| Fishery | Gear | Area | District | Opening[a] | Closing[b] | Harvest (tons)[c] |
|---|---|---|---|---|---|---|
| Winter food and bait | Purse seine | Craig | 3/4 | 18-Oct-17 | 28-Feb-18 | 710 |
| Winter food and bait | Purse seine | Tenakee Inlet | 12 | Not Open | | – |
| Winter food and bait | Purse seine | Ernest Sound | 7 | Not Open | | – |
| Winter food and bait | Purse seine | Hobart Bay | 10 | Not Open | | – |
| Sub-total | | | | | | 710 |
| Sac roe | Purse seine | Sitka Sound | 13 | 25-Mar-18 | 3-Apr-18 | 2,926 |
| Sac roe | Purse seine | Lynn Canal | 11 | Not Open | | – |
| Sac roe | Gillnet | Seymour Canal | 11 | Not Open | | – |
| Sac roe | Gillnet | Hobart Bay | 10 | Not Open | | – |
| Sac roe | Gillnet | Kah Shakes | 1 | Not Open | | – |
| Sac roe | Gillnet | West Behm Canal | 1 | Not Open | | – |
| Sub-total | | | | | | 2,926 |
| 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-18 | 2-Apr-18 | 205 |
| Sub-total | | | | | | 205 |
| Test fishery-bait | Purse seine | Sitka | 13 | 25-Oct-17 | 11-Mar-18 | 54 |

[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.

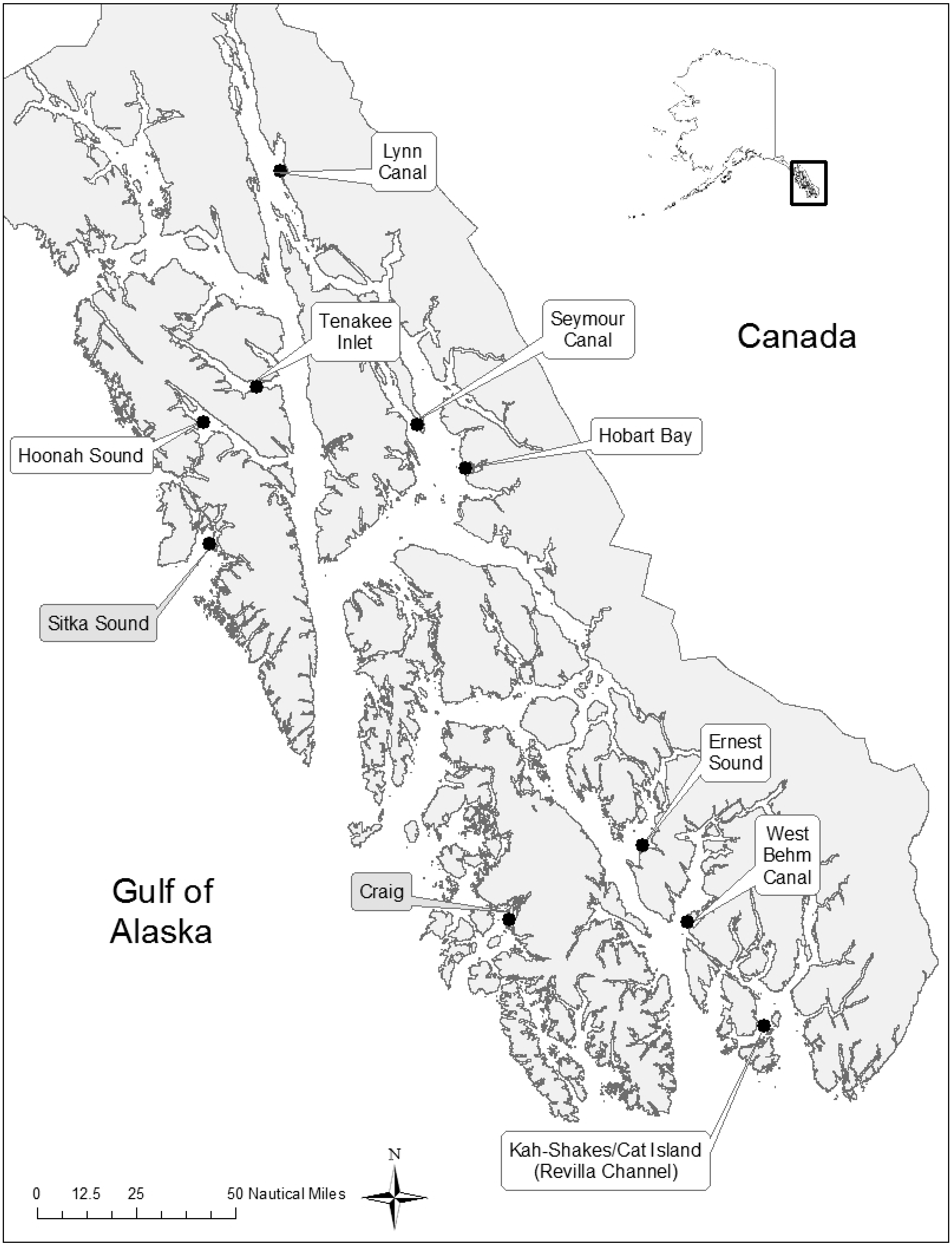



Figure 1.–Locations of major herring spawning areas in Southeast Alaska. Labels with shading indicate areas where spawn deposition surveys were conducted during the 2018 spawning season, and age-size sampling of herring was completed during the 2017–18 fishery or spawning seasons.

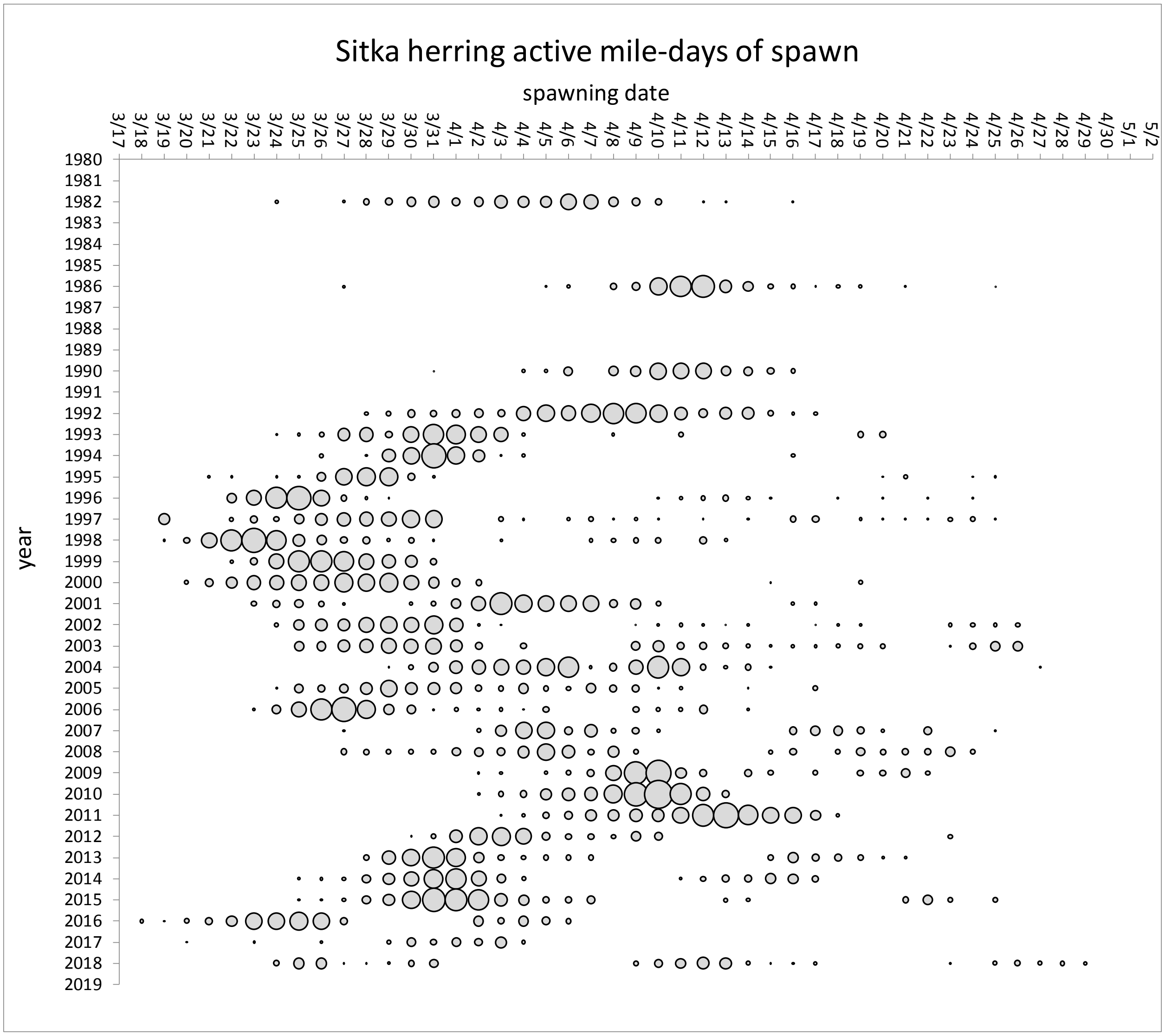



Figure 2.–Historical dates of active spawn observed for the Sitka Sound herring stock. The size of circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of 48 nautical miles of spawn and the smallest 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.

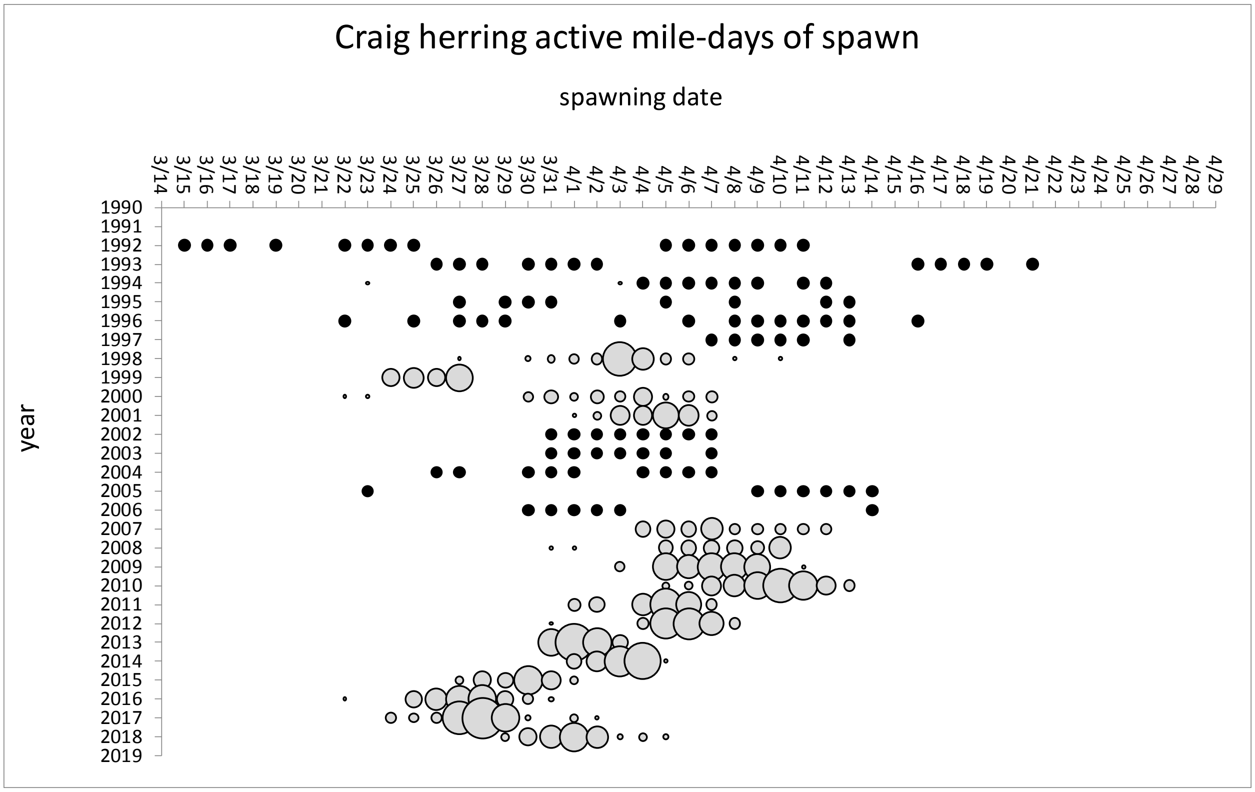



Figure 3.–Historical dates of active spawn observed for the Craig herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of 14 nautical miles of spawn and the smallest 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.

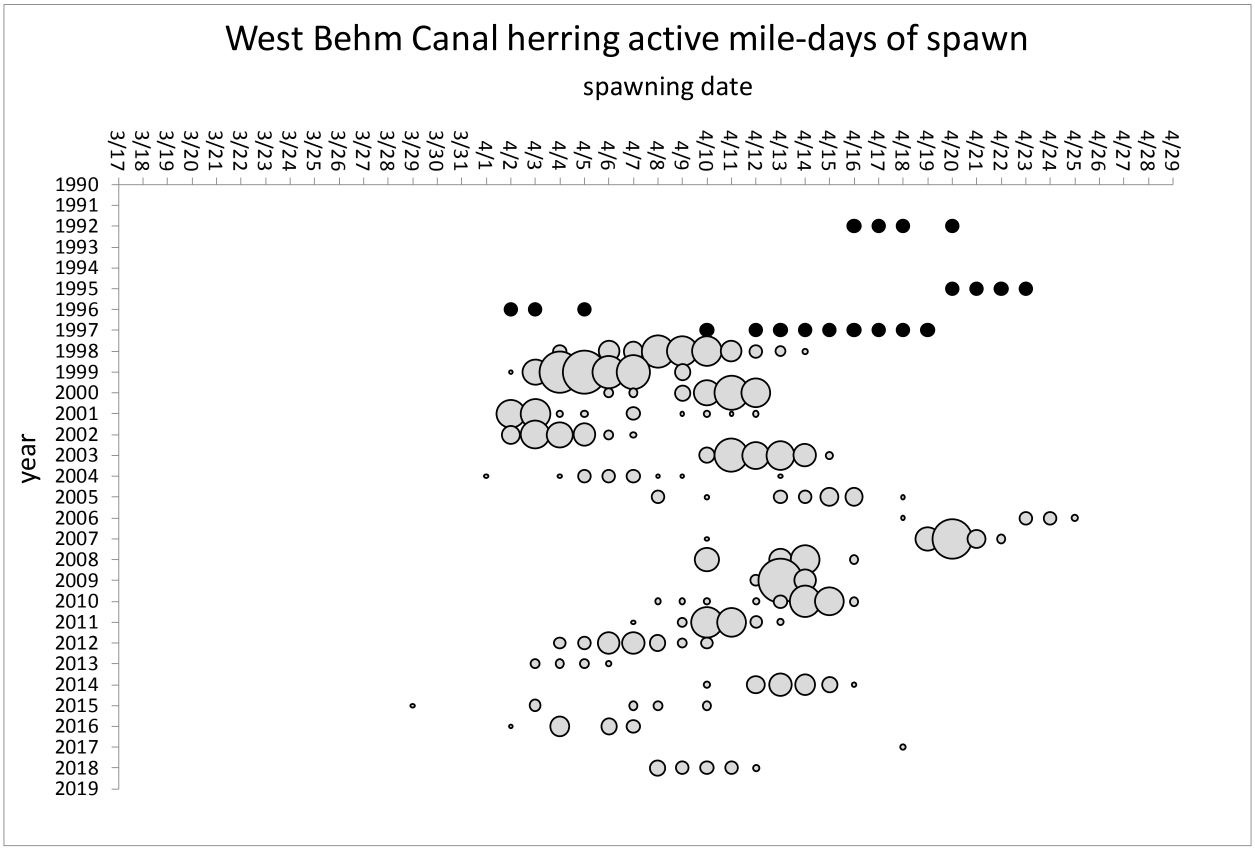



Figure 4.–Historical dates of active spawn observed for the West Behm Canal herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of 12 nautical miles of spawn 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.

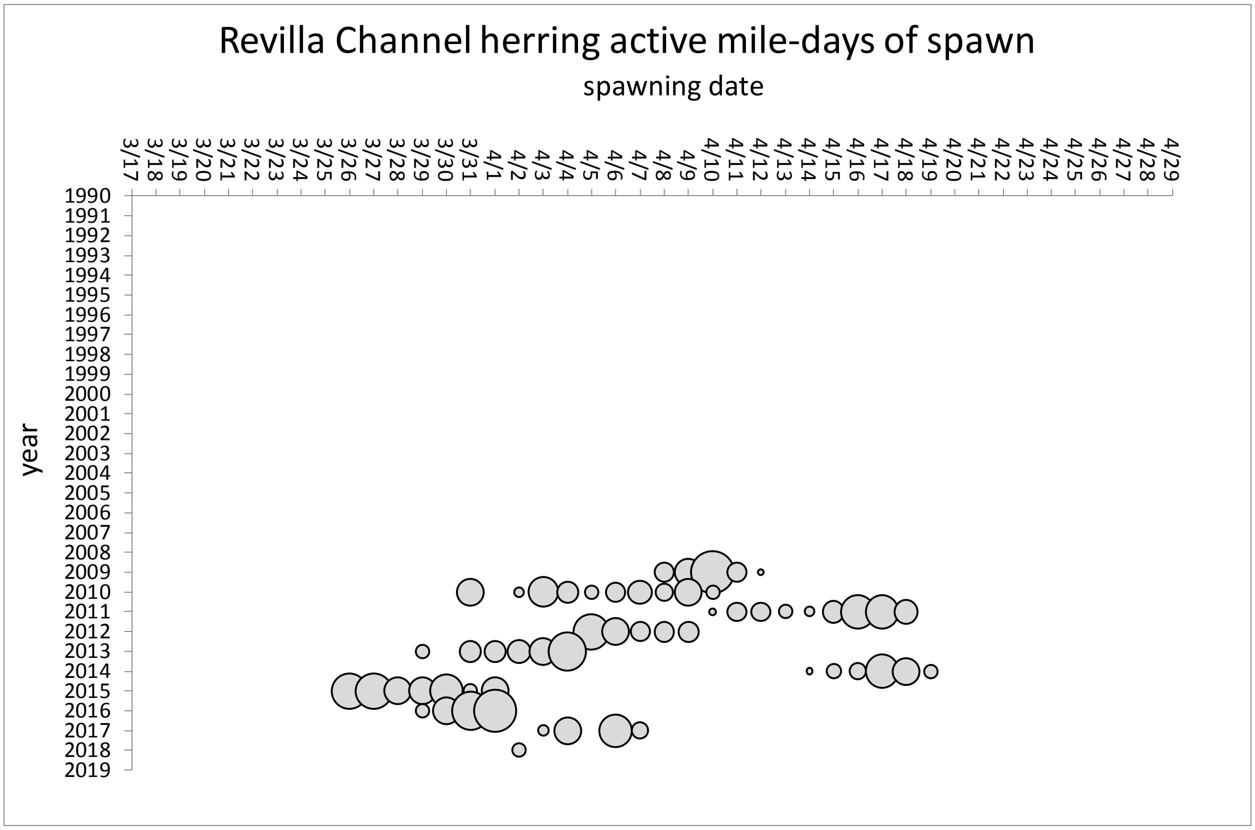



Figure 5.–Historical dates of active spawn observed for the Revilla Channel herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of 5 nautical miles of spawn and 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.

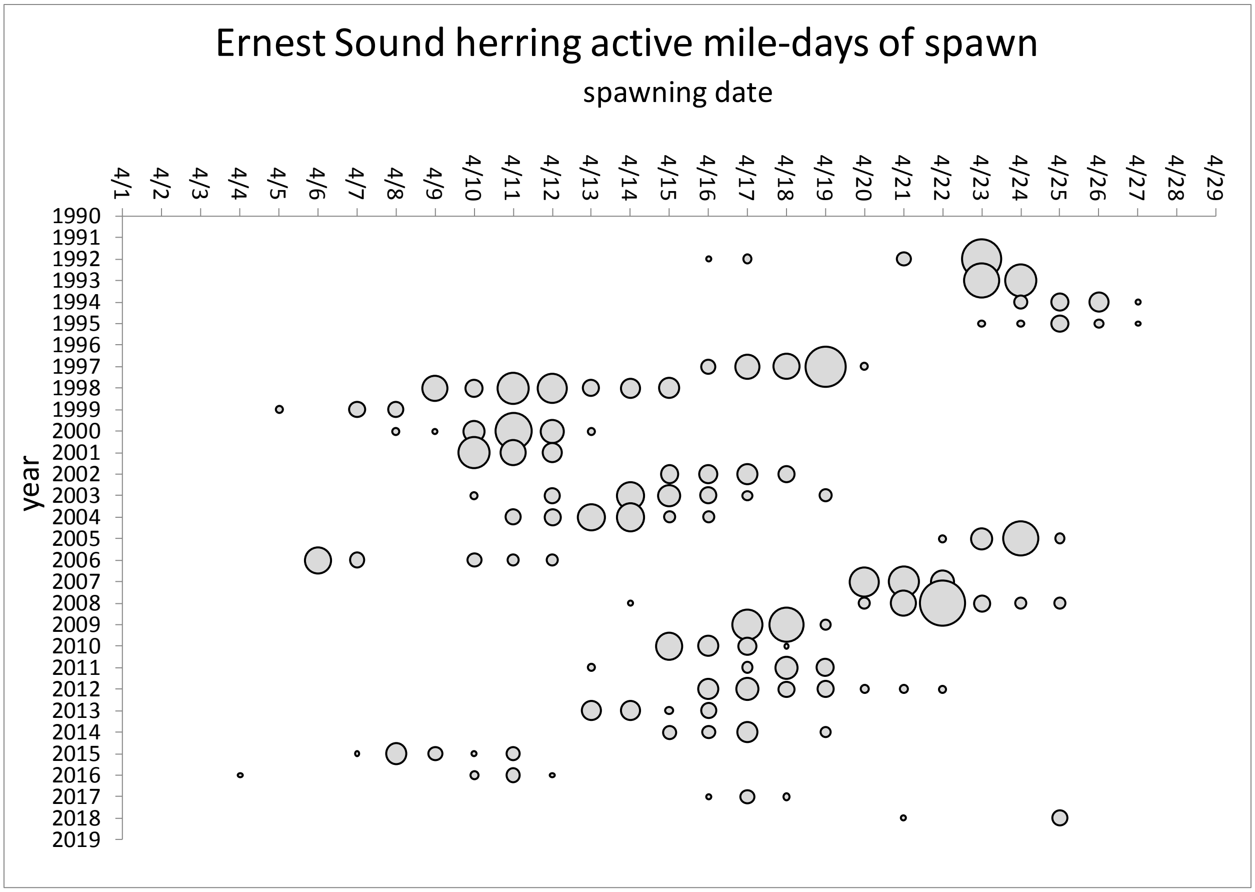



Figure 6.–Historical dates of active spawn observed for the Ernest Sound herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 9 nautical miles of spawn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

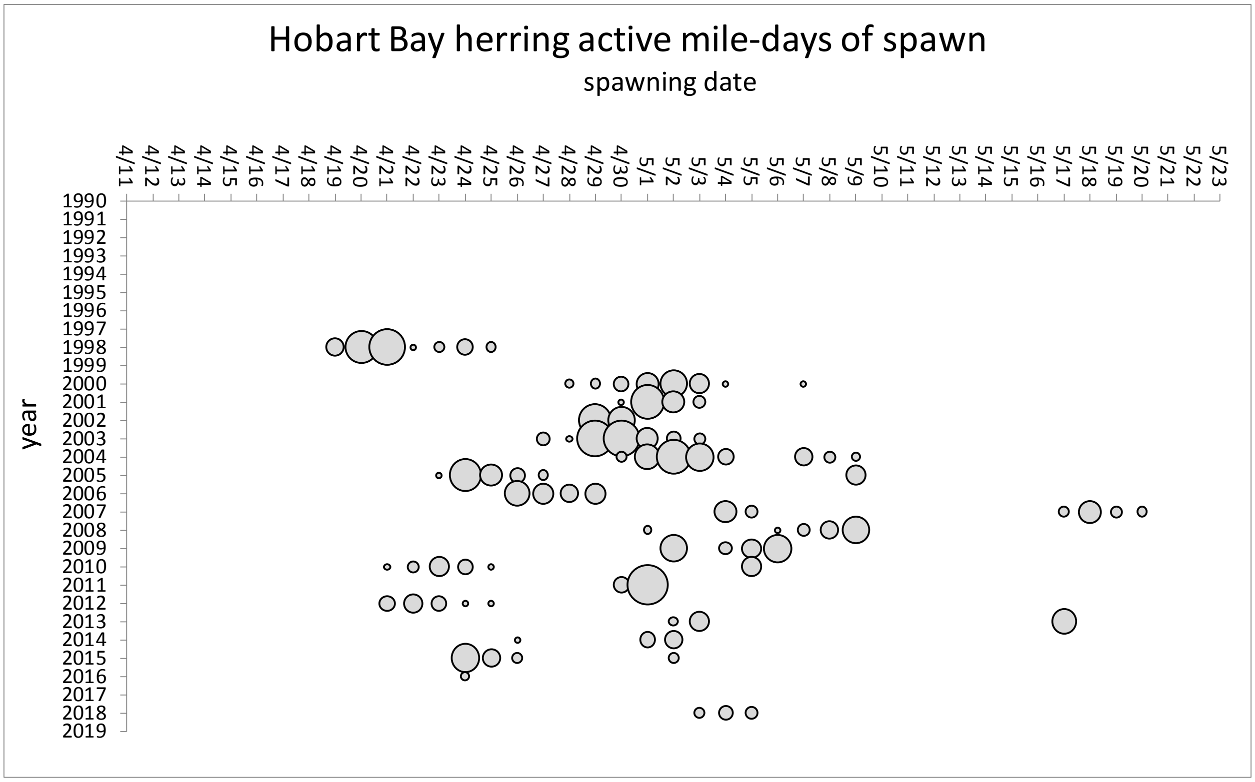



Figure 7.–Historical dates of active spawn observed for the Hobart Bay herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 6 nautical miles of spawn 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.

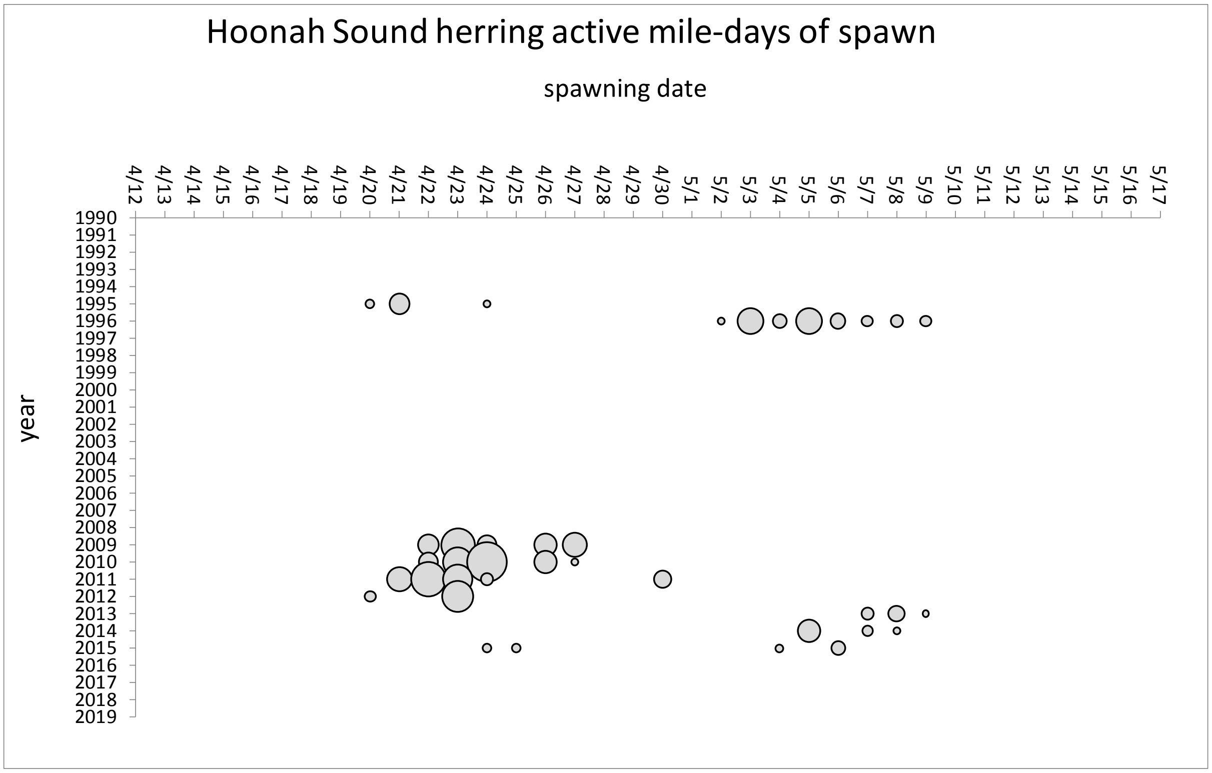



Figure 8.–Historical dates of active spawn observed for the Hoonah Sound herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 8 nautical miles of spawn 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.

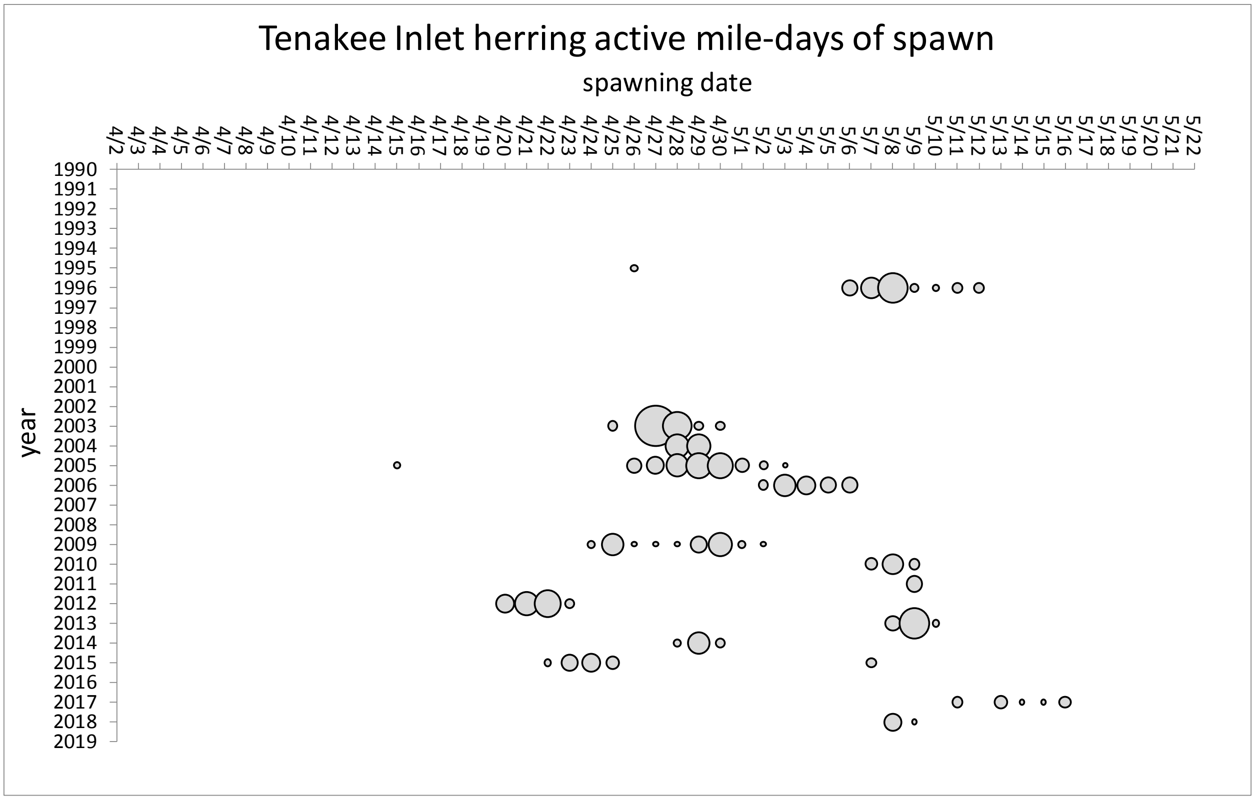



Figure 9.–Historical dates of active spawn observed for the Tenakee Inlet herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 8 nautical miles of spawn 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.

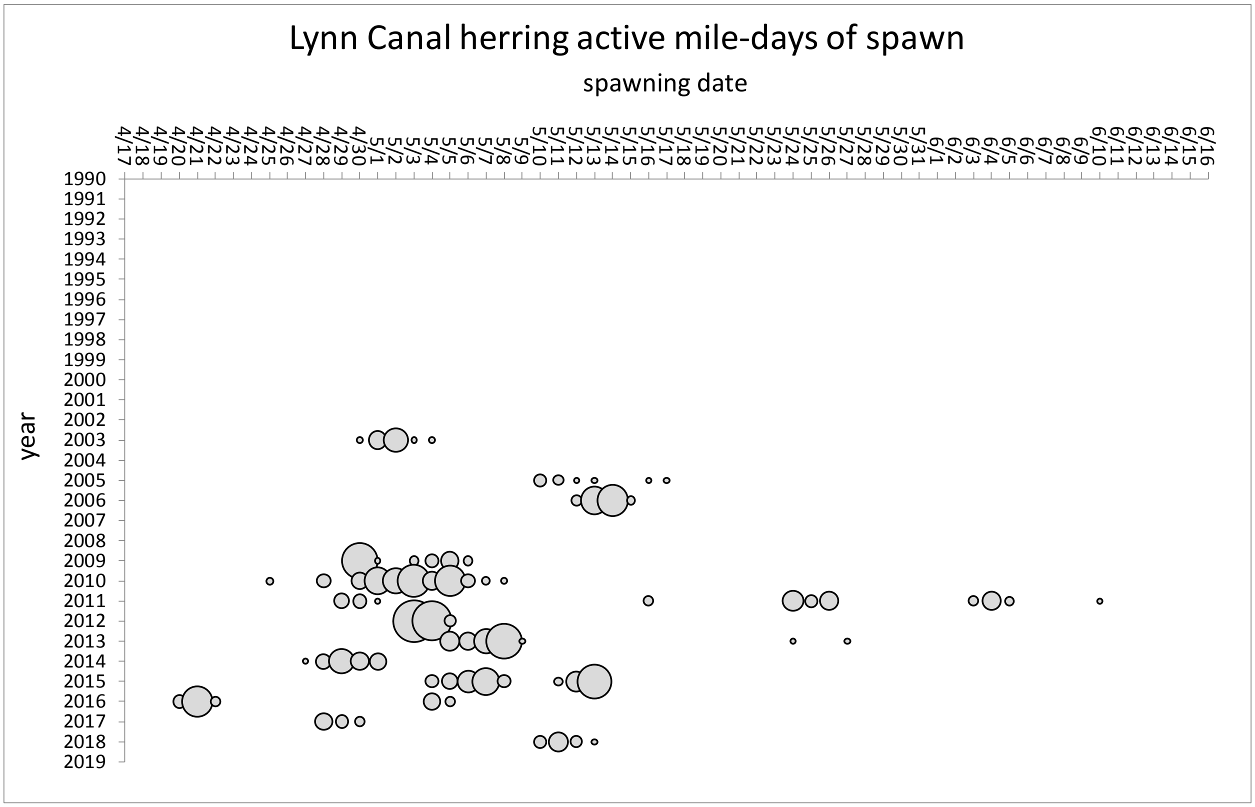



Figure 10.–Historical dates of active spawn observed for the Lynn Canal herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 5 nautical miles of spawn 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.

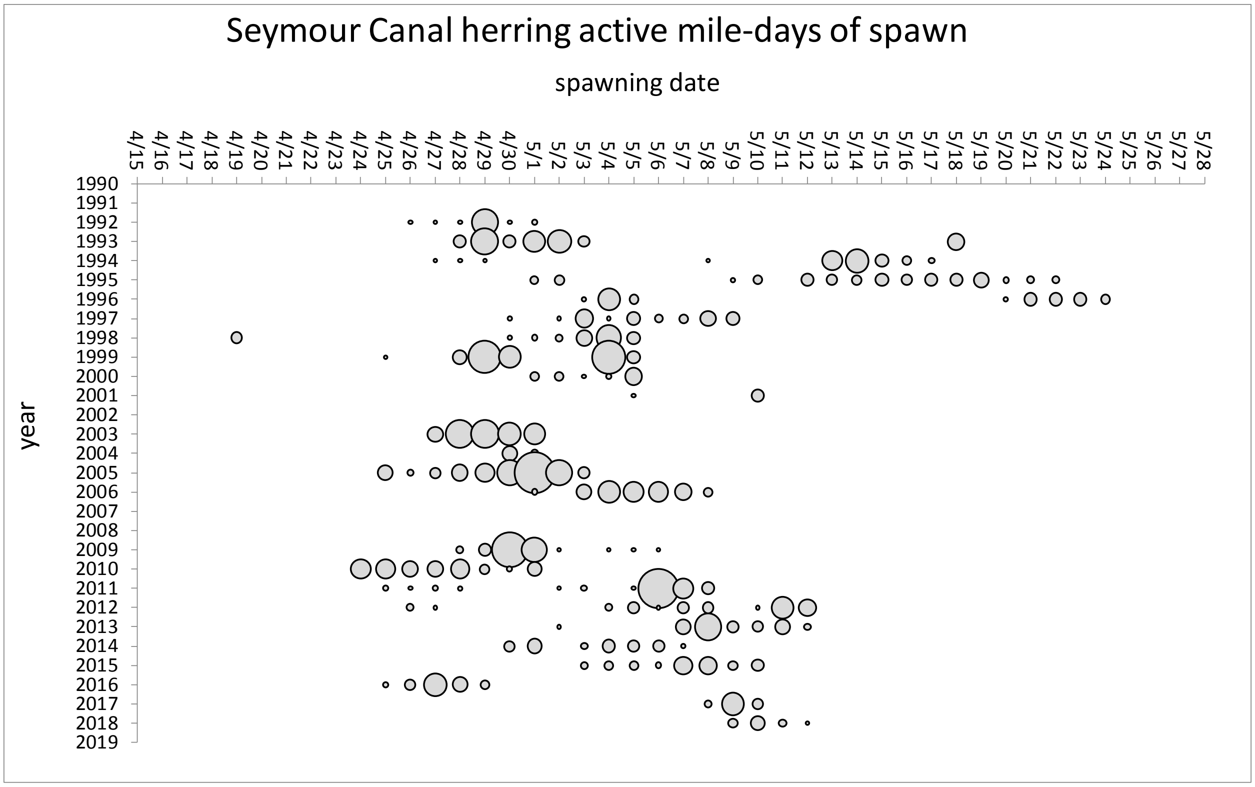



Figure 11.–Historical dates of active spawn observed for the Seymour Canal herring stock. The size of gray circles represents the total mileage of active spawn observed on each day, relative to all other days of spawn. For reference, the largest circle represents a day of about 10 nautical miles of spawn 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.

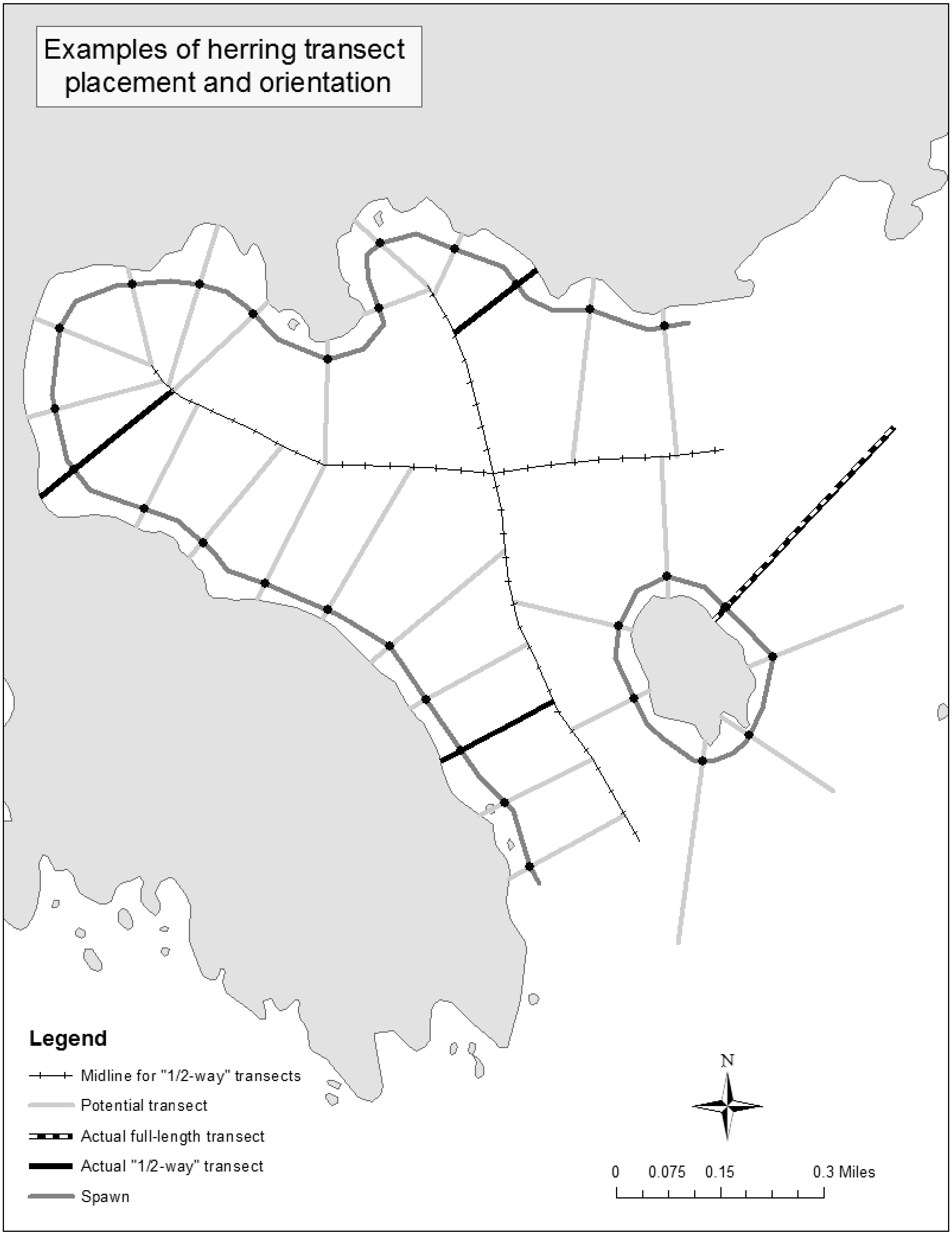



Figure 12.–Example of hypothetical herring transect placement and orientation, representing points at which transects should be halted to prevent over sampling.

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Craig | | | | | | | ns | 0.0 | ns | ns | ns | 0.0 | ns | ns | ns | 0.0 | ns | ns | 0.0 | ns | 0.5 | 2.5 | 4.5 |
| Sitka Sound | 0.0 | ns | ns | 0.0 | 0.0 | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 | 7.0 | 7.0 | 0.1 | 0.1 | 0.3 | 2.0 | 4.2 |
| West Behm Canal | | | | | | | | | | | | | | | | | | | | | | | ns |
| Revilla Channel | | | | | | | | | | | | | | ns | 0.0 | ns | ns | ns | 0.0 | ns | ns | 0.0 | ns |
| Ernest Sound | | | | | | | | | | | | | | | | | | | | | | | |

| Stock | 1-Apr | 2-Apr | 3-Apr | 4-Apr | 5-Apr | 6-Apr | 7-Apr | 8-Apr | 9-Apr | 10-Apr | 11-Apr | 12-Apr | 13-Apr | 14-Apr | 15-Apr | 16-Apr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Craig | 7.0 | 4.0 | 0.3 | 0.5 | 0.2 | ns | ns | | | | | | | | | |
| Sitka Sound | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 | 3.7 | 5.8 | 8.3 | 7.7 | 1.0 | 0.1 | 0.2 |
| West Behm Canal | 0.0 | ns | ns | ns | ns | ns | ns | 1.5 | 1.0 | 1.0 | 1.0 | 0.3 | 0.0 | ns | | |
| Revilla Channel | ns | 0.5 | 0.0 | ns | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns | | | | |
| Ernest Sound | | | | | | | | | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sitka Sound | 0.6 | ns | ns | 0.0 | ns | ns | 0.2 | ns | 0.9 | 1.8 | 1.0 | 1.1 | 0.6 | 0.0 | ns | | | | |
| Ernest Sound | 0.0 | 0.0 | ns | 0.0 | 0.1 | 0.0 | ns | ns | 1.0 | 0.0 | 0.0 | 0.0 | ns | ns | 0.0 | ns | | | |
| Hobart/Houghton | | | | | | | ns | 0.0 | ns | ns | 0.0 | ns | ns | ns | ns | ns | 0.3 | 0.6 | 0.5 |
| Tenakee Inlet | 0.0 | ns | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns |
| Seymour Canal | 0.0 | ns | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns |
| Lynn Canal | 0.0 | ns | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns |
| Hoonah Sound | ns | ns | ns | 0.0 | ns | ns | 0.0 | ns | ns | ns | ns | ns | ns | ns | ns | | | | |
| Yakutat | No aerial surveys completed in 2018 | | | | | | | | | | | | | | | | | | |
| Haines | No aerial surveys completed in 2018 | | | | | | | | | | | | | | | | | | |

| continued | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sitka Sound | | | | | | | | | | | | | | | | | | | | |
| Ernest Sound | | | | | | | | | | | | | | | | | | | | |
| Hobart/Houghton | 0.0 | ns | | | | | | | | | | | | | | | | | | |
| Tenakee Inlet | ns | 0.0 | 1.3 | 0.1 | 0.0 | ns | | | | | | | | | | | | | | |
| Seymour Canal | ns | 0.0 | 0.0 | 0.5 | 1.2 | 0.4 | 0.1 | 0.0 | ns | | | | | | | | | | | |
| Lynn Canal | ns | 0.0 | 0.0 | ns | 0.1 | 0.1 | 0.6 | ns | 0.2 | 0.5 | ns | | | | | | | | | |
| Hoonah Sound | | | | | | | | | | | | | | | | | | | | |
| Yakutat | | | | | | | | | | | | | | | | | | | | |
| Haines | | | | | | | | | | | | | | | | | | | | |

Figure 13.–Spawn timing of herring stocks in Southeast Alaska during spring 2018. Values indicate daily measurements of nautical miles of active spawn recorded during aerial surveys. Shaded area depict dates when cast-net samples were taken. Boxed areas indicate duration of spawning (first to last dates of observed spawn).

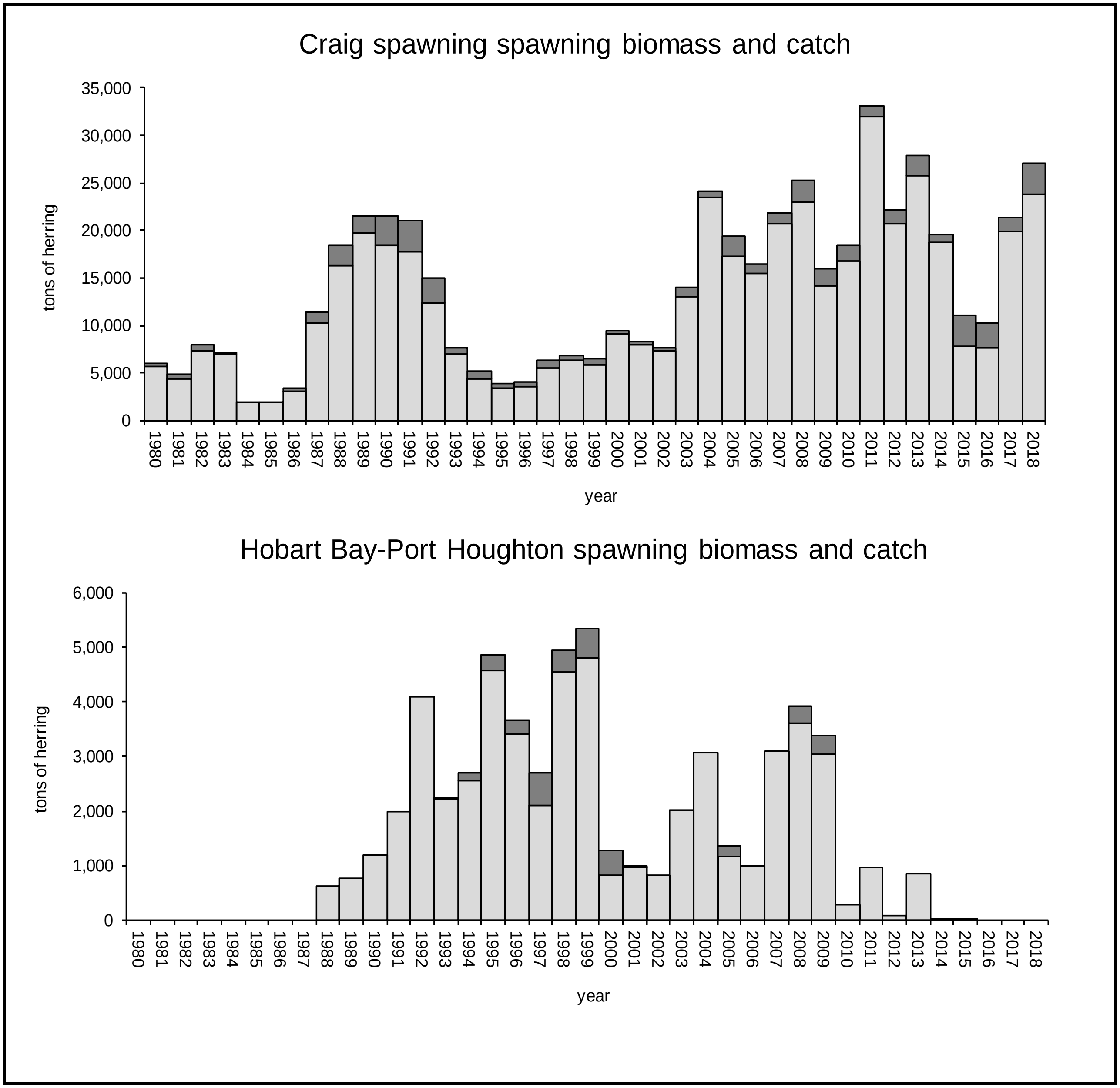



Figure 14.–Observed herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys, and catch (dark gray bars) for stocks in the Craig and Hobart Bay-Port Houghton areas, during 1980–2018. Spawn deposition surveys were not conducted in Hobart Bay-Port Houghton during 2016-2018.

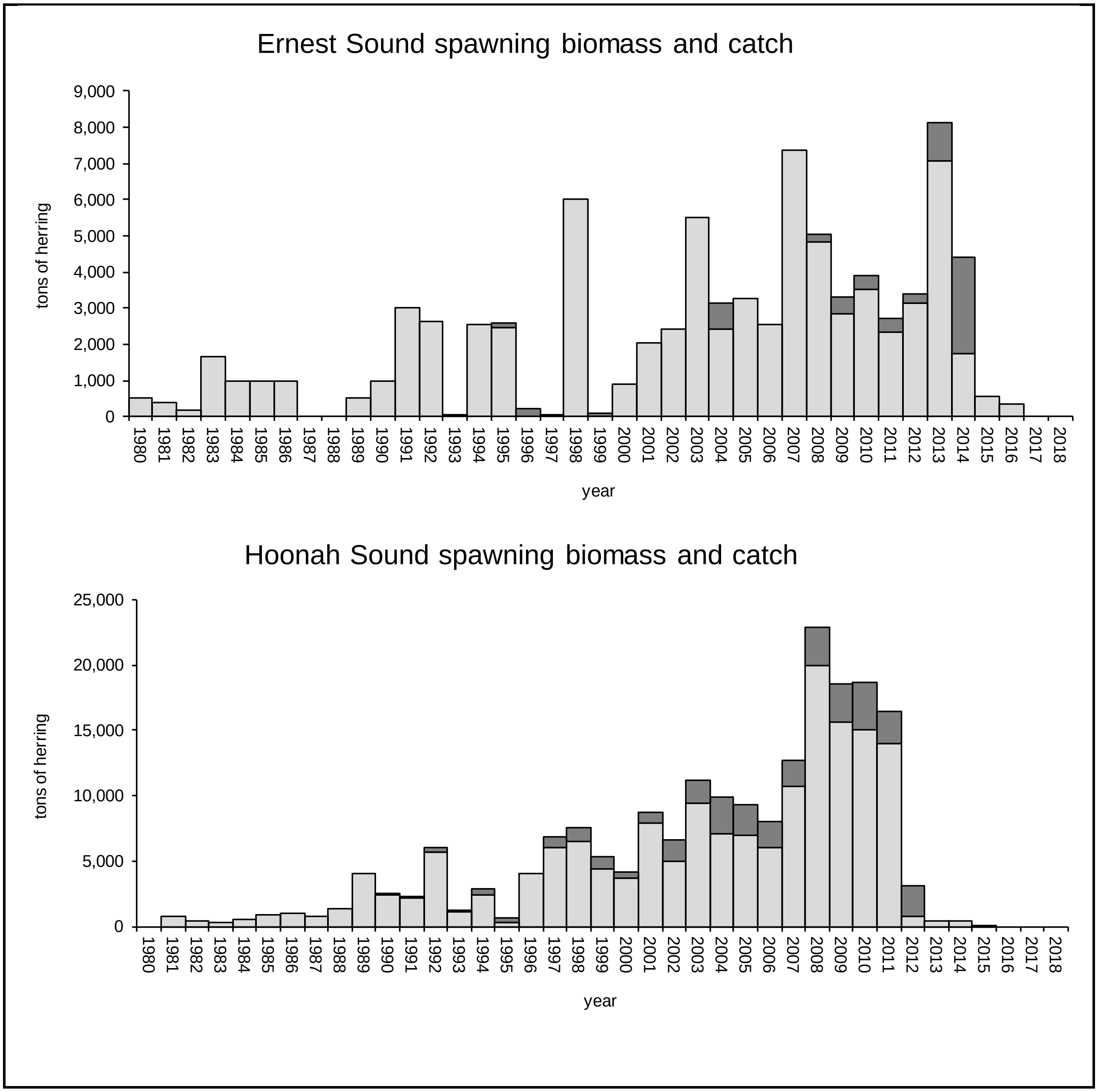



Figure 15.–Observed herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys or hydroacoustic surveys, and catch (dark gray bars) for stocks in the Ernest Sound and Hoonah Sound areas, during 1980–2018. No spawn deposition surveys were conducted in Ernest Sound in 2017 or 2018 or in Hoonah Sound in 2016-2018.

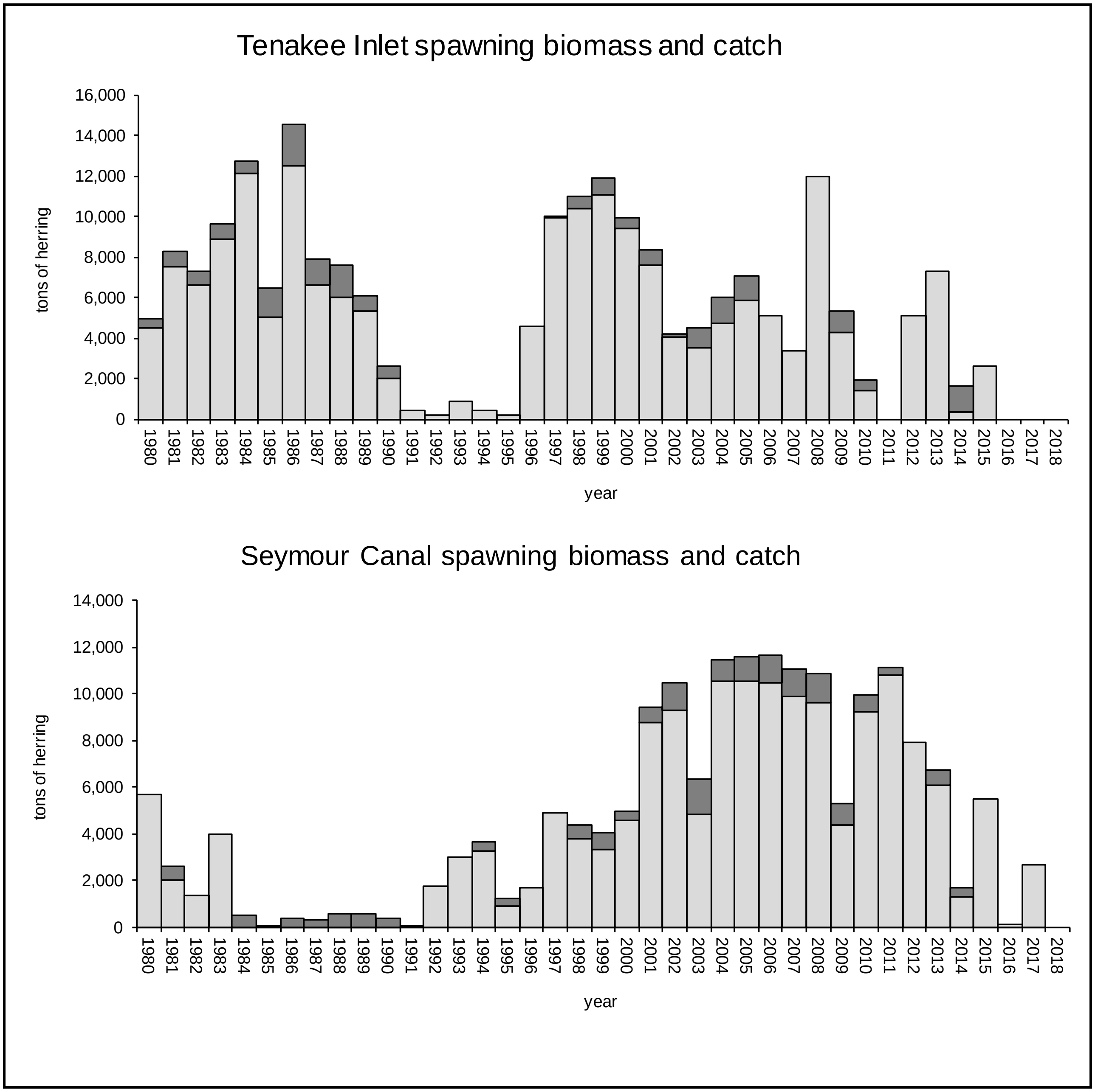



Figure 16.–Observed herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys or hydroacoustic surveys, and catch (dark gray bars) for stocks in the Tenakee Inlet and Seymour Canal areas, during 1980–2018. Spawn deposition surveys were not conducted in Tenakee Inlet during 2016-2018 or in Seymour Canal in 2018.

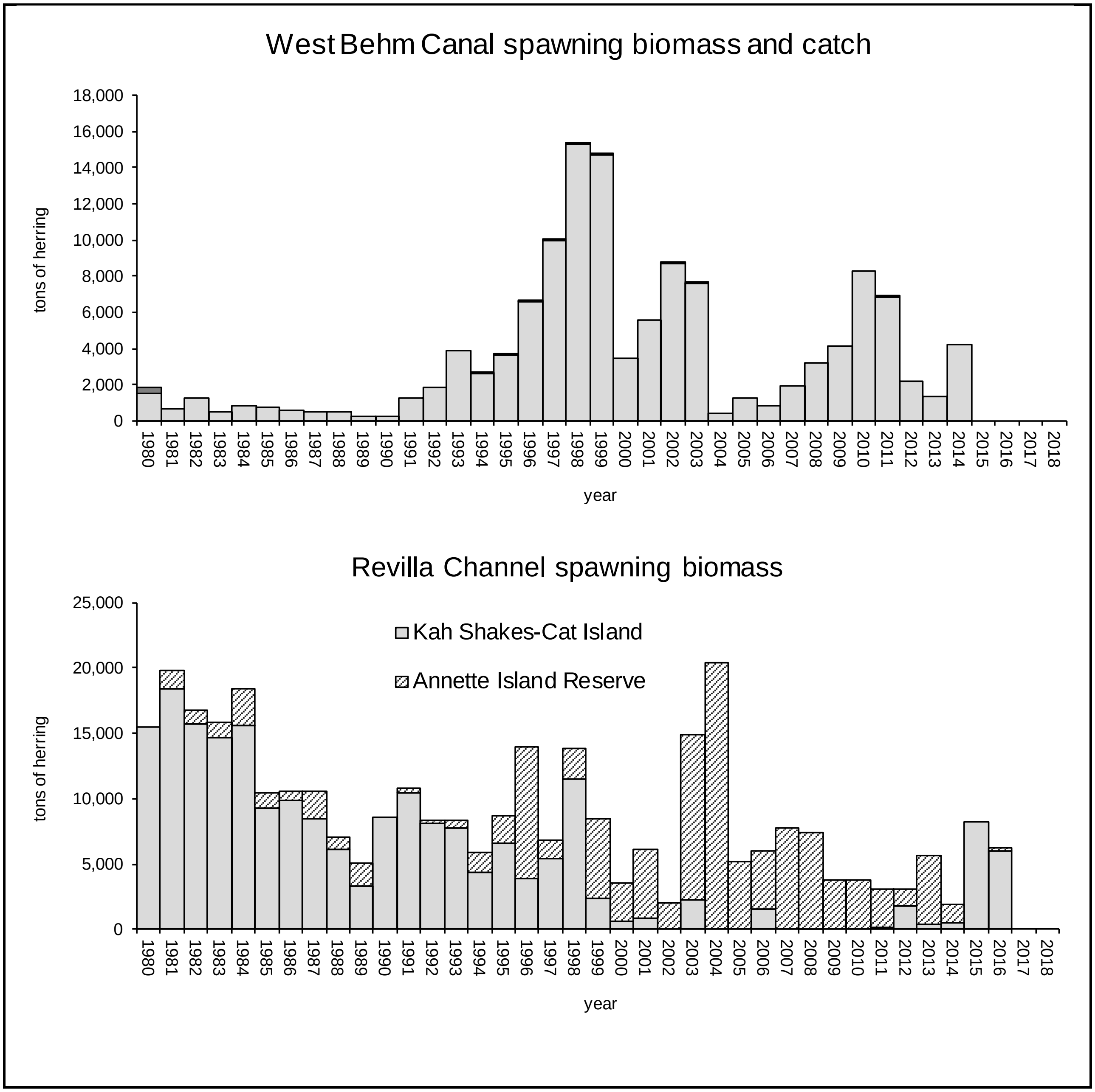



Figure 17.–Observed herring post-fishery spawning biomass, based on spawn deposition surveys or hydroacoustic surveys for stocks in the West Behm Canal and Revilla Channel (Kah Shakes–Cat Island–Annette Island) areas, during 1980–2018. Annette Island spawning biomass estimates between 1981 and 2016 were 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. Spawn deposition surveys were not conducted in West Behm Canal during 2015–2018 or at Kah Shakes/Cat Island during 2017-2018.

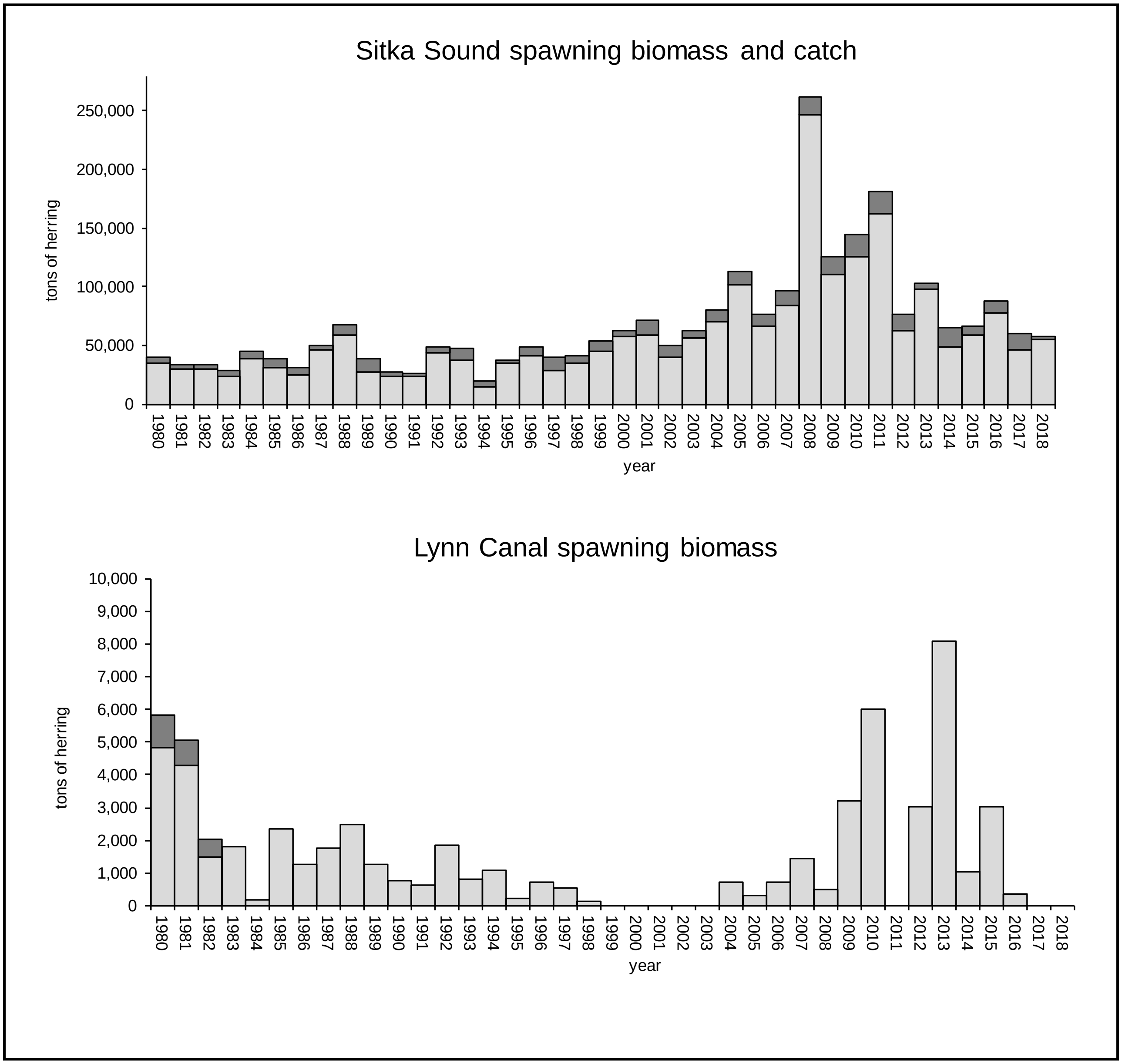



Figure 18.–Observed herring post-fishery spawning biomass (light gray bars), based on spawn deposition surveys, and catch (dark gray bars) for stock in the Sitka Sound and Lynn Canal areas, during 1980–2018. Estimates of spawning biomass for Lynn Canal prior to 2004 were made using a variety of methods (e.g., hydroacoustics or visual estimates of spawn density converted to biomass), and results should be viewed as approximations. Spawn deposition surveys were not conducted in Lynn Canal in 2017 or 2018.

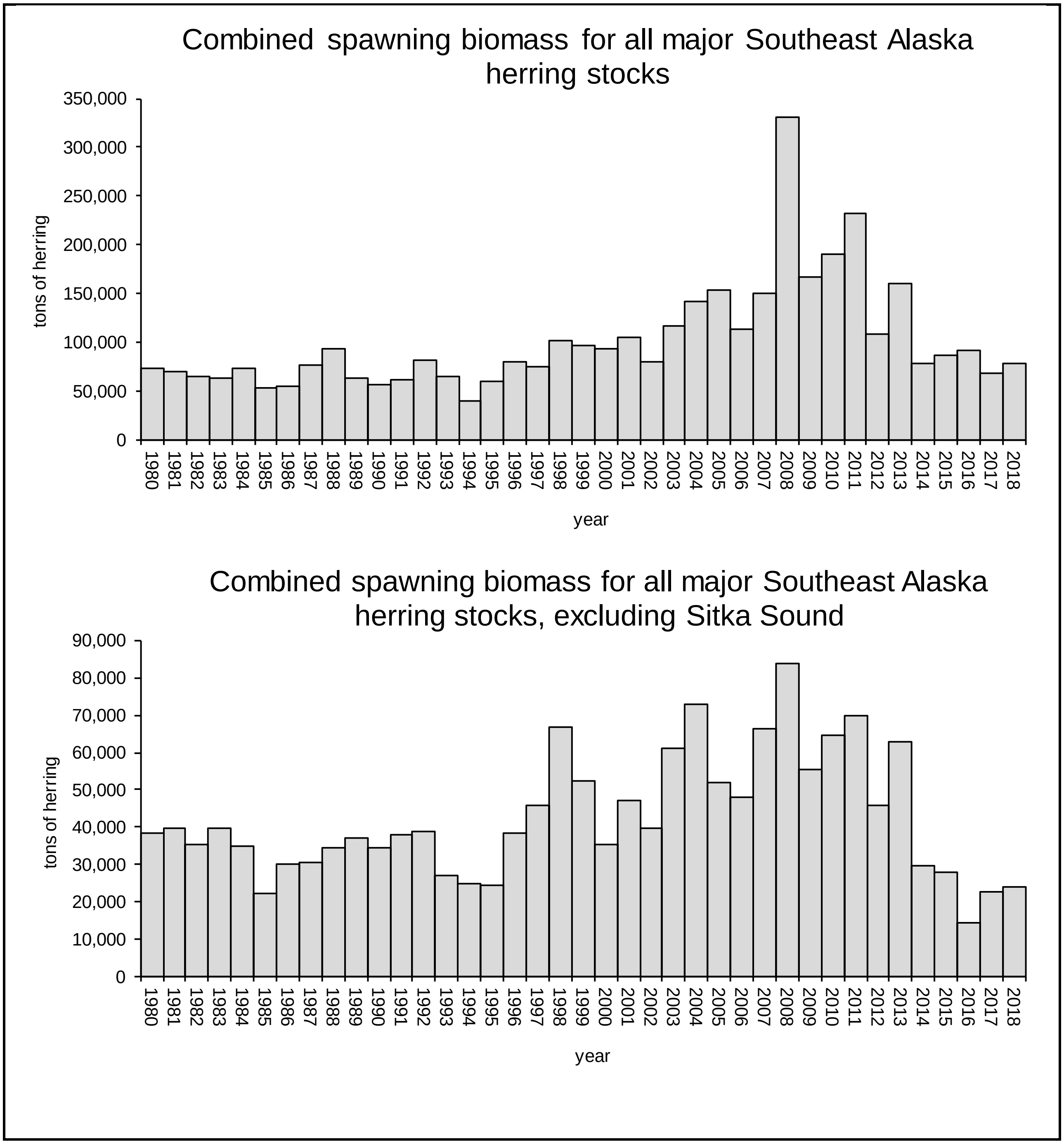



Figure 19.–Combined observed herring post-fishery spawning biomass, based on spawn deposition surveys or hydroacoustic surveys, for major herring stocks in Southeast Alaska, during 1980–2018. Spawn deposition surveys were conducted in six of ten major spawning areas in 2016, in seven of ten major spawning areas in 2017, and in two of ten major spawning areas in 2018.

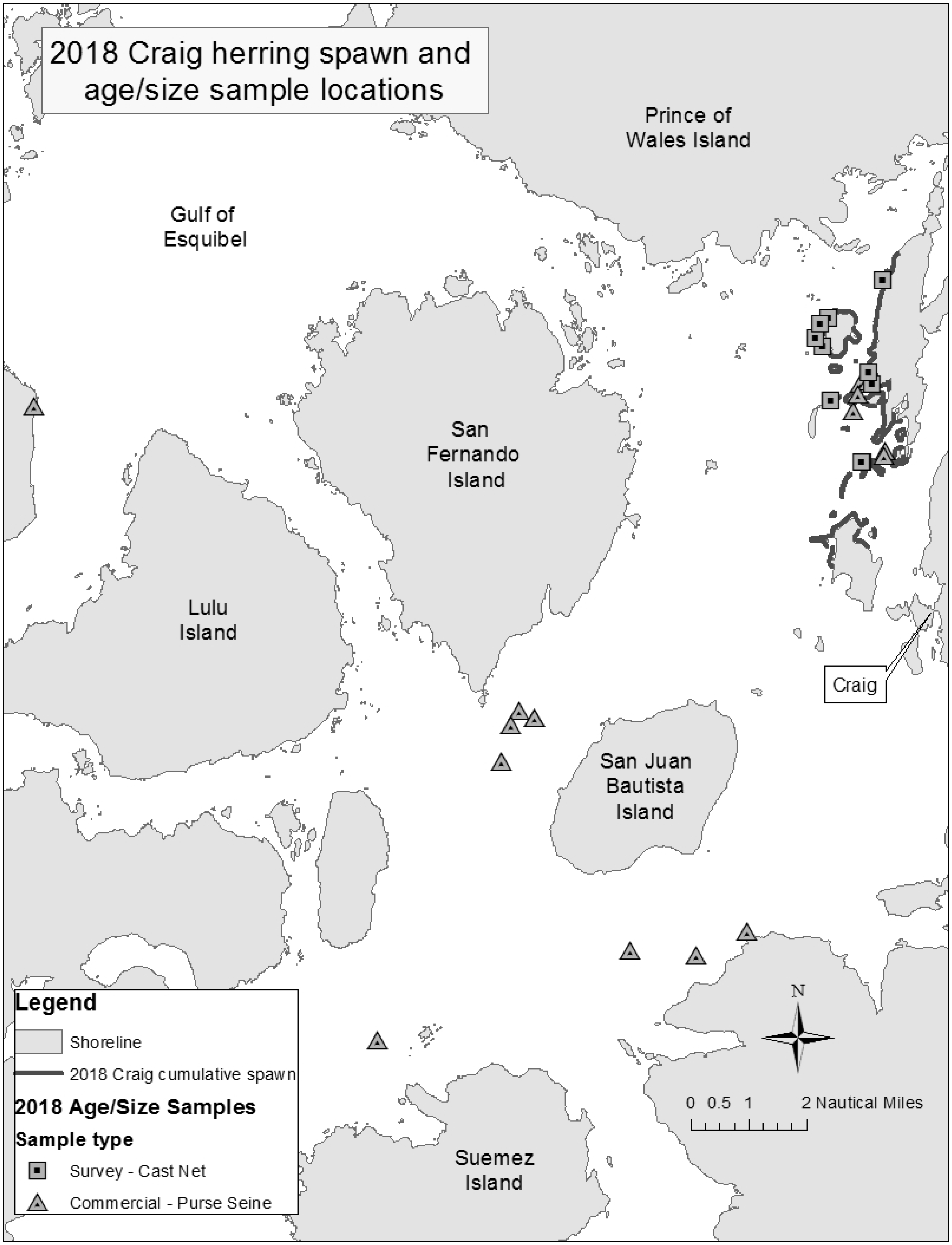



Figure 20.–Locations of herring samples collected for estimates of age and size for the Craig herring stock for the 2017-2018 season. Cumulative herring spawn denoted by thick gray line along shoreline.

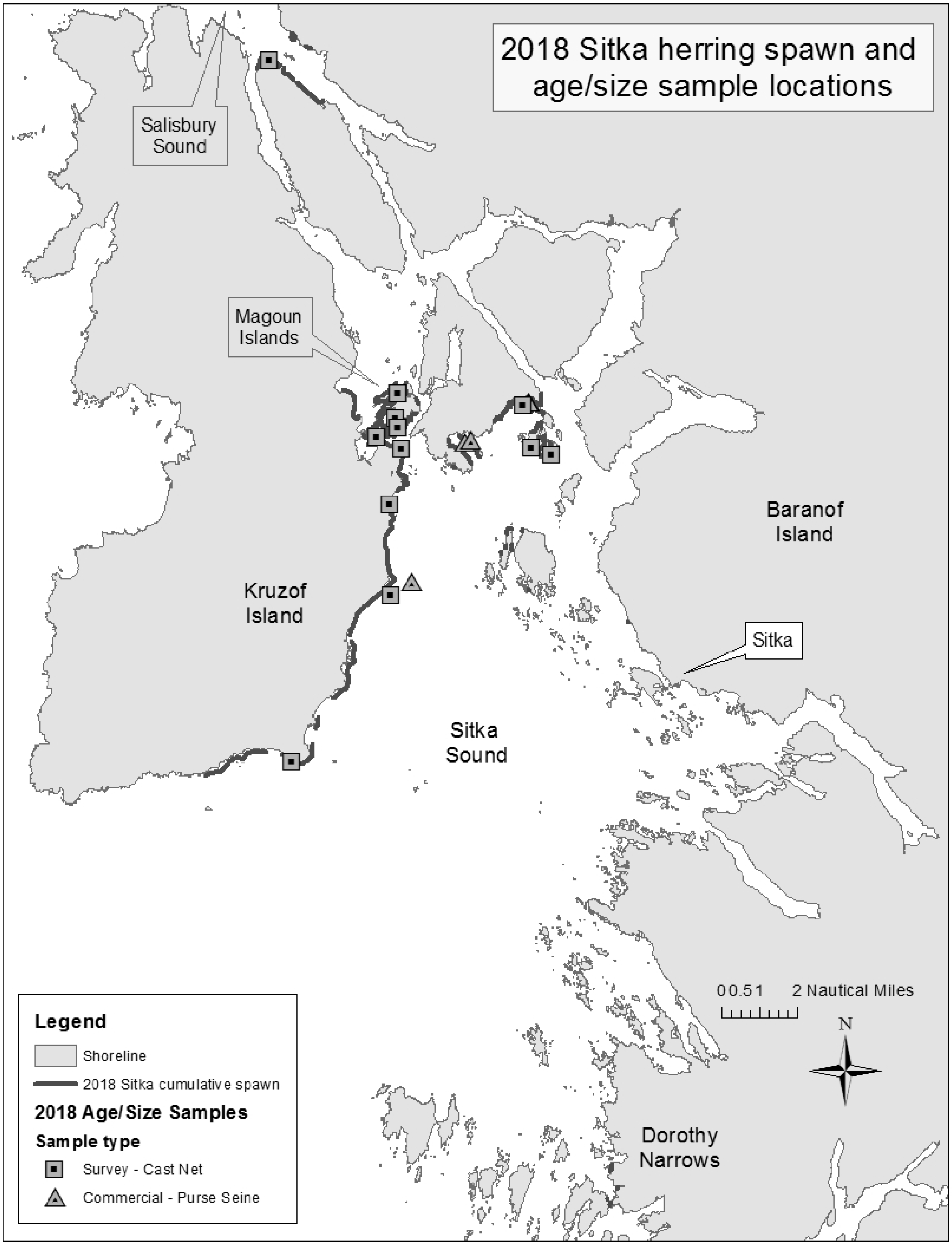



Figure 21.–Locations of herring samples collected for estimates of age and size for the Sitka Sound herring stock for the 2017-18 season. Cumulative herring spawn denoted by thick gray line along shoreline.

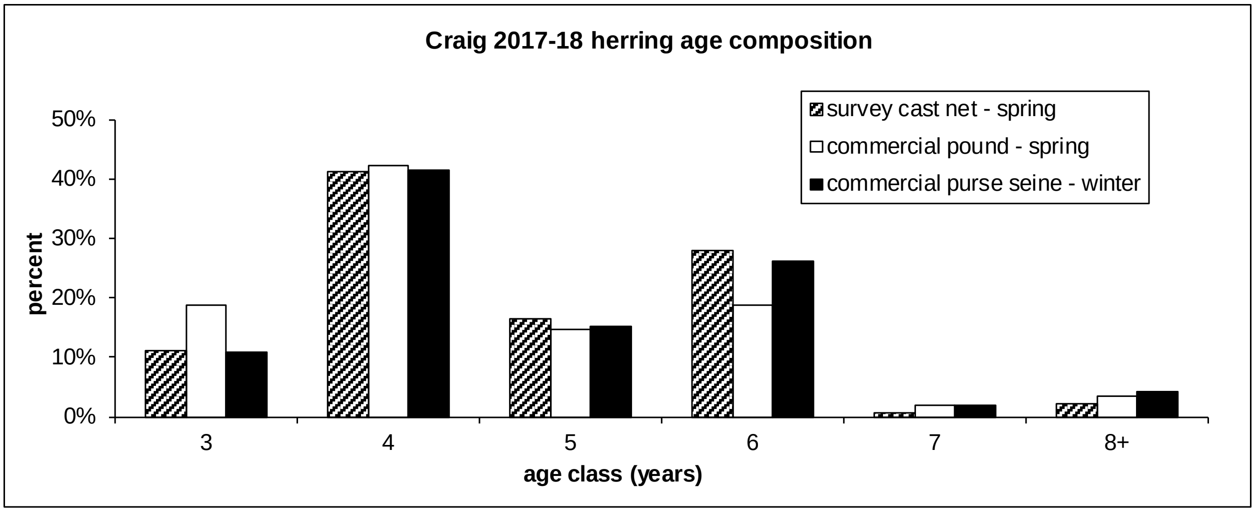



Figure 22.–Observed age composition for Craig herring stock in 2017–18.

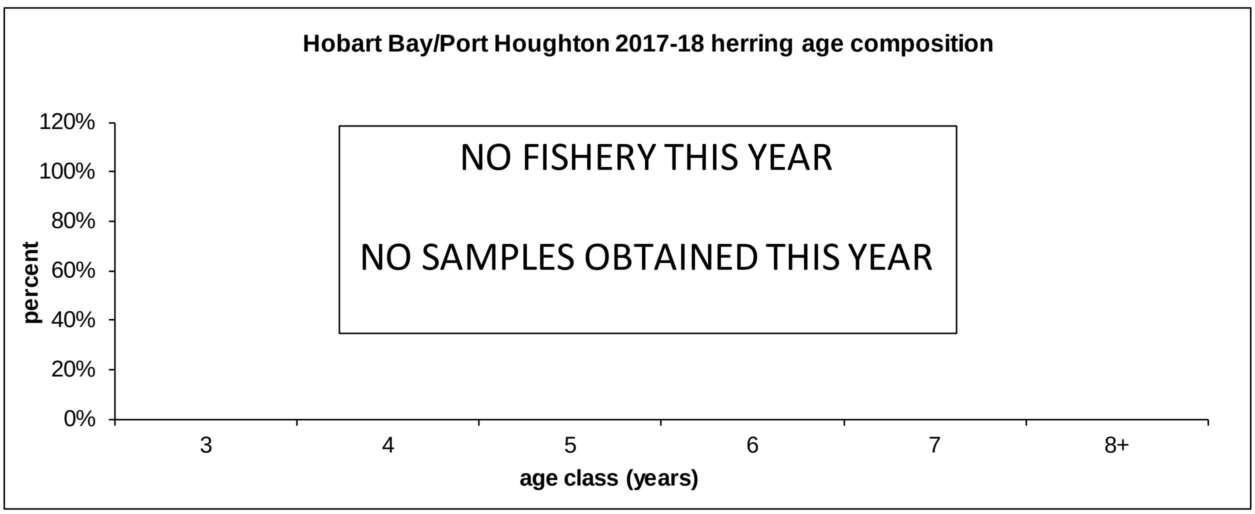



Figure 23.–Observed age composition for Hobart Bay/Port Houghton herring stock in 2017–18. No samples were attempted or obtained in 2017–18.

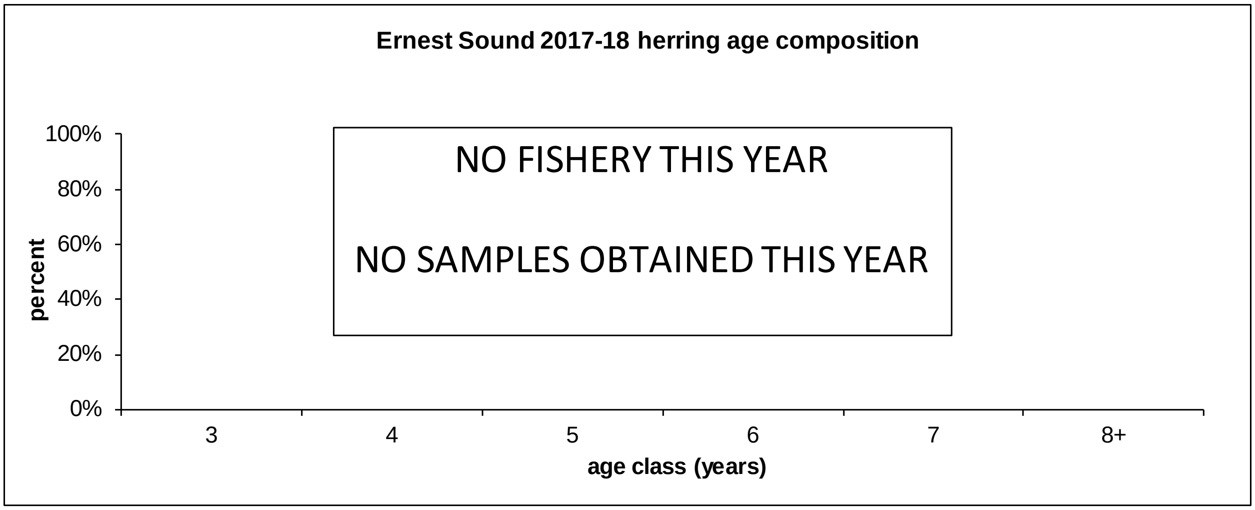



Figure 24.–Observed age composition for Ernest Sound herring stock in 2017–18. No samples were attempted or obtained in 2017–18.

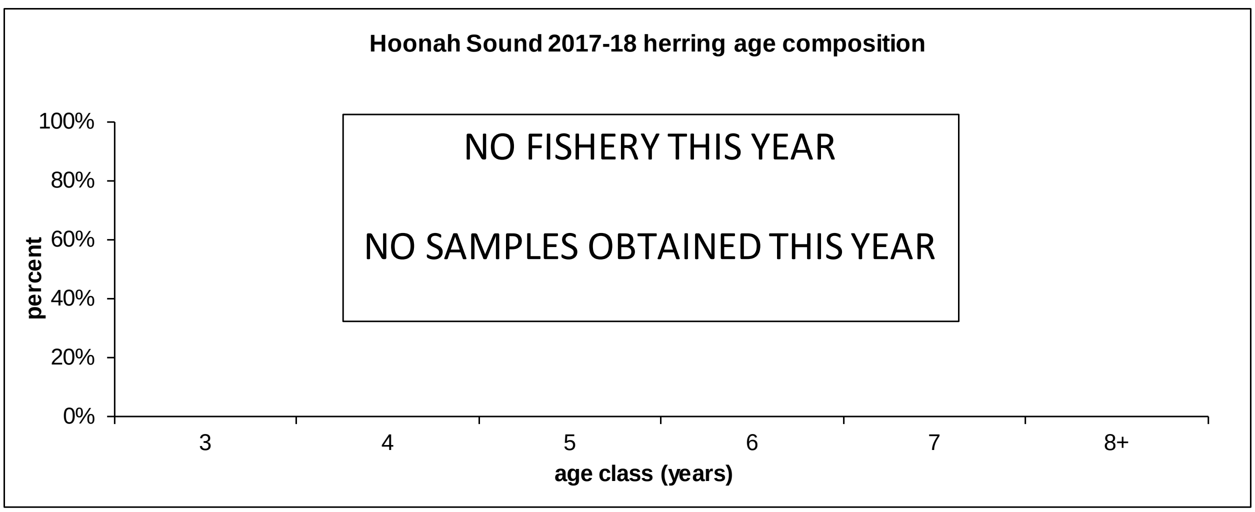



Figure 25.–Observed age composition for Hoonah Sound herring stock in 2017–18. No samples were attempted or obtained in 2017–18.

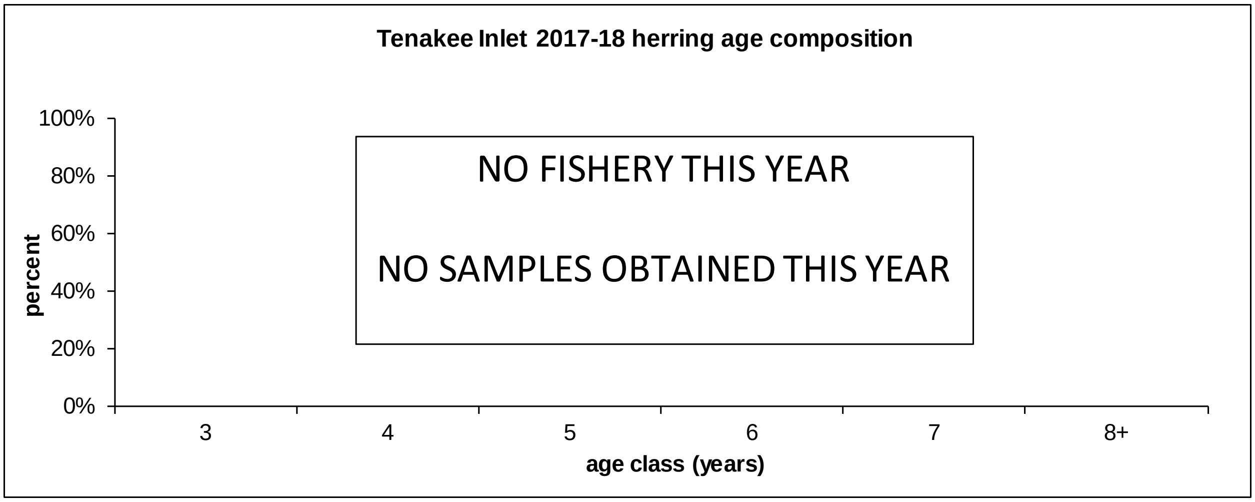



Figure 26.–Observed age composition for Tenakee Inlet herring stock in 2017–18. No samples were attempted or obtained in 2017-18.

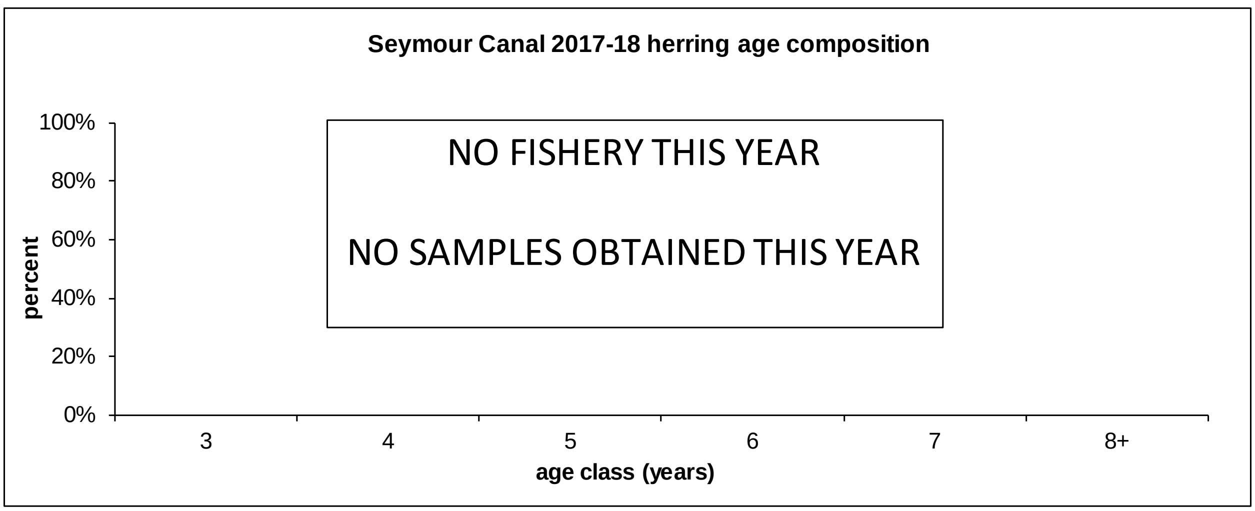



Figure 27.–Observed age composition for Seymour Canal herring stock in 2017–18. No samples were attempted or obtained in 2017–18.

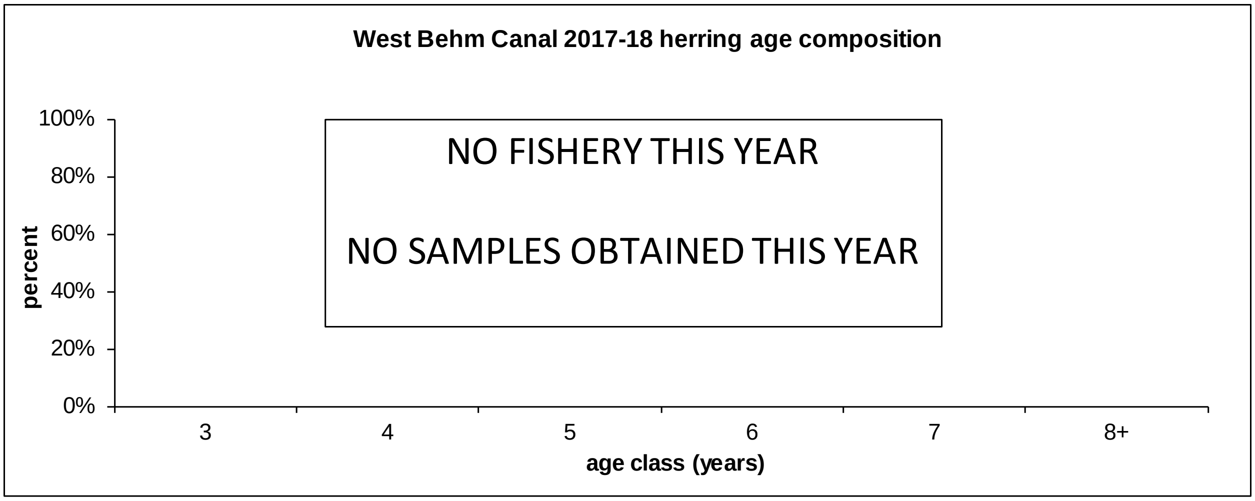



Figure 28.–Observed age composition for West Behm Canal herring stock in 2017–18. No samples were attempted or obtained in 2017–18.

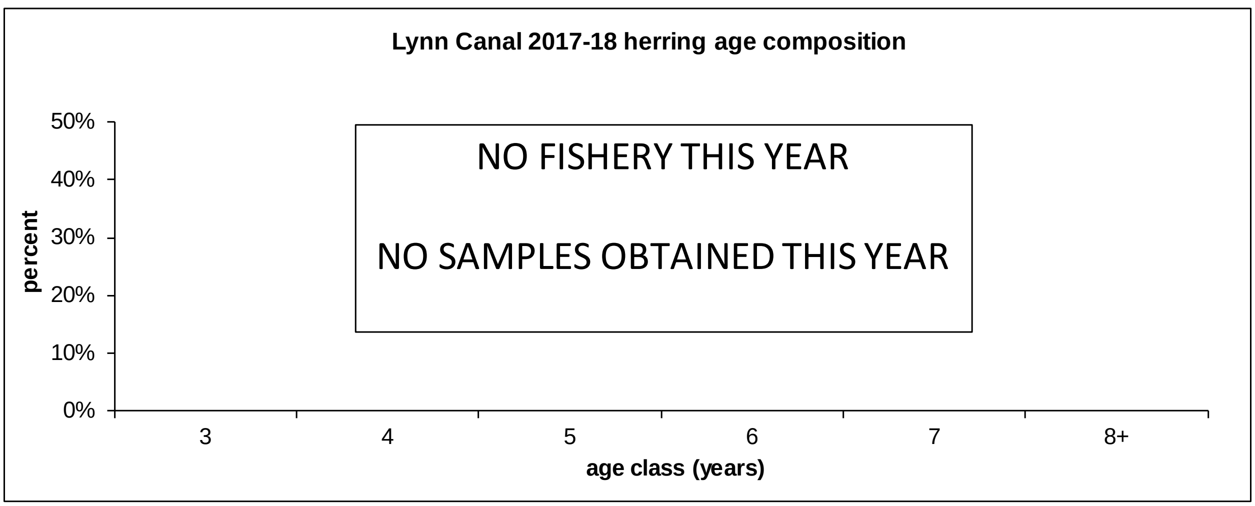



Figure 29.–Observed age composition for Lynn Canal herring stock in 2017–18. No samples were attempted or obtained in 2017–18.

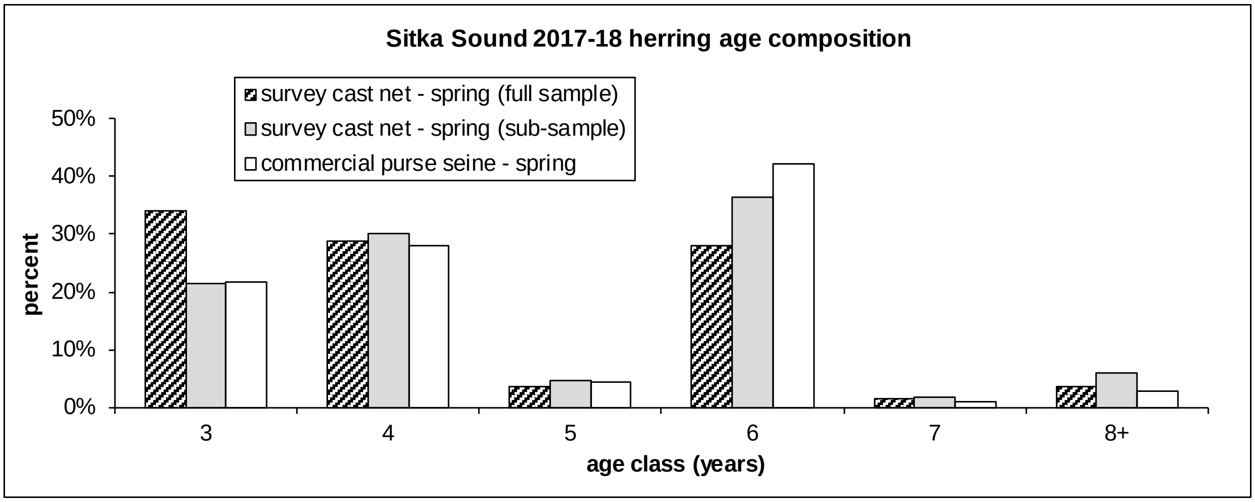



Figure 30.–Observed age composition for Sitka Sound herring stock in 2017–18. Cast net full sample represents results using all herring obtained in samples, whereas cast net sub-sample represents results where herring were fully obtained from samples from the first spawn event, but were sub-sampled from samples from the second spawn event to account for the much high spawning biomass in the first spawn event compared to the second, and the much different age compositions between the two spawning events.

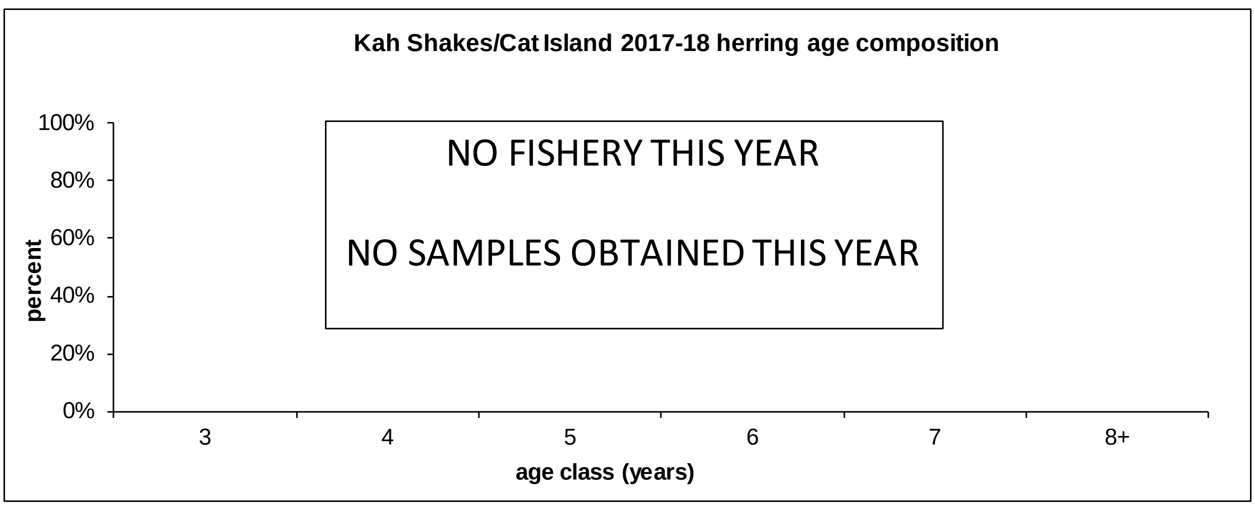



Figure 31.–Observed age composition for Revilla Channel herring stock (state waters only) in 2017–18. No samples were attempted or obtained in 2017–18.

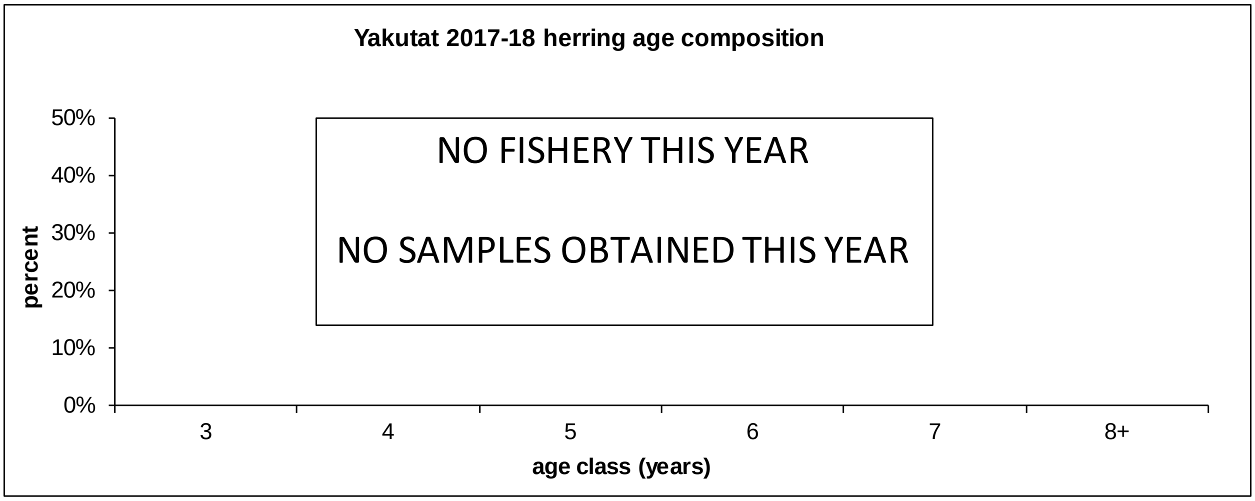



Figure 32.–Observed age composition for Yakutat Bay herring stock in 2017–18. No samples were attempted or obtained in 2017–18.

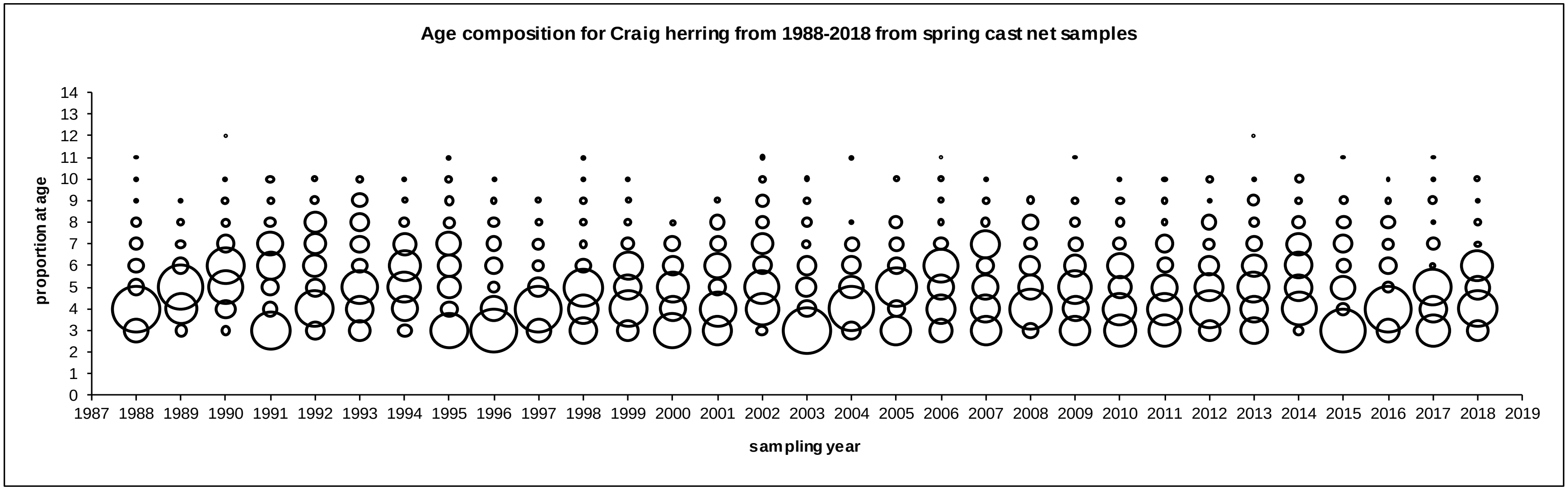



Figure 33.–Observed age compositions from sampling data for the Craig herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

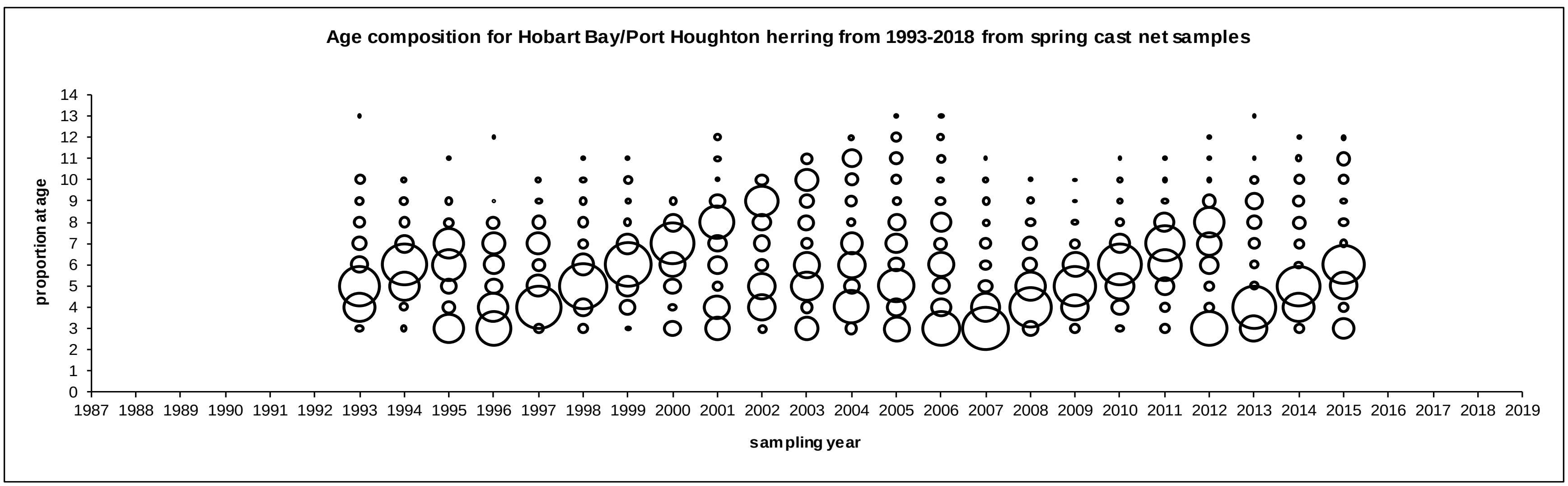



Figure 34.–Observed age compositions from sampling data for the Hobart Bay/Port Houghton herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

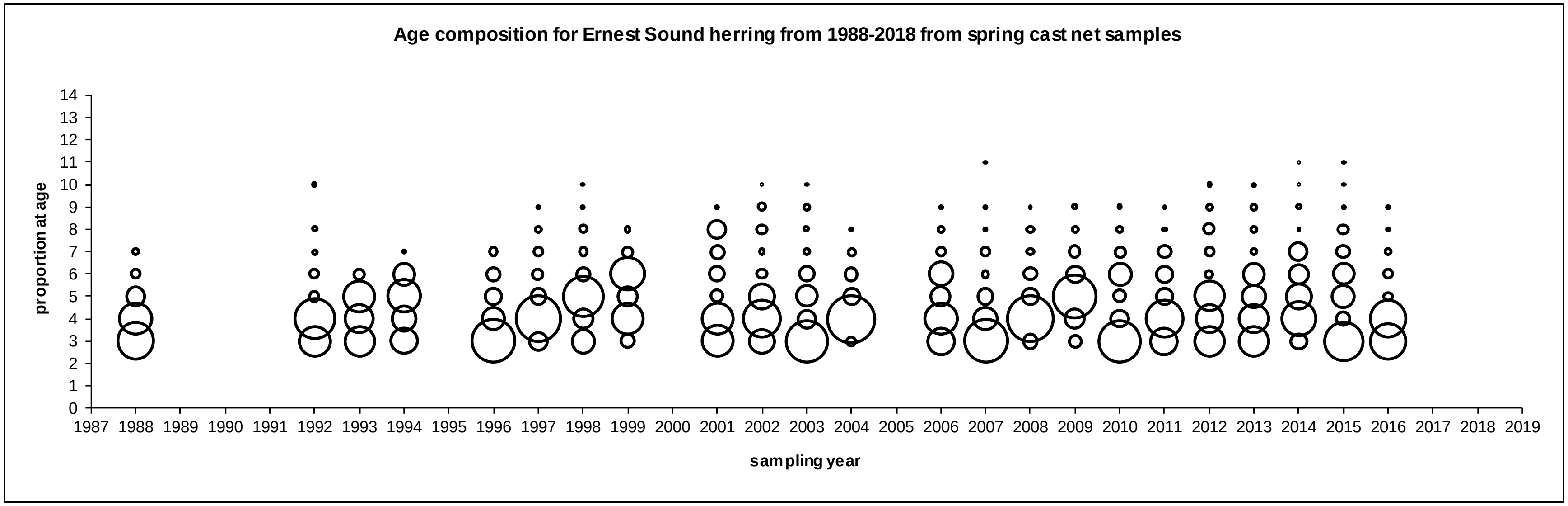



Figure 35.–Observed age compositions from sampling data for the Ernest Sound herring stock.

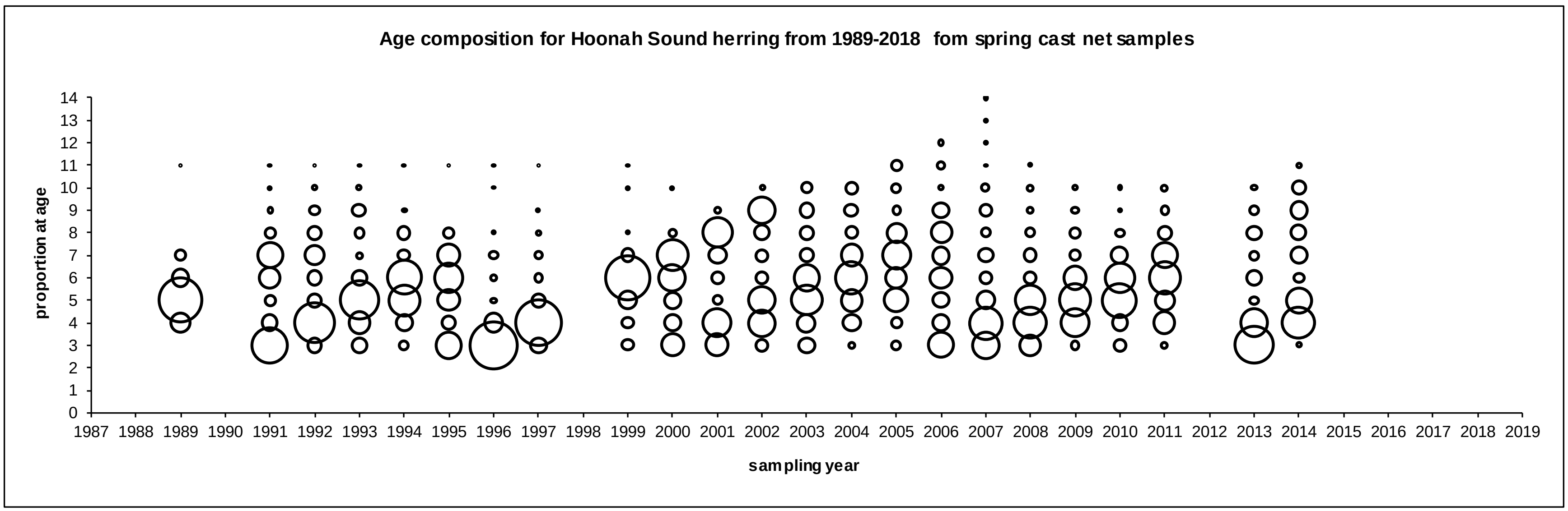



Figure 36.–Observed age compositions from sampling data for the Hoonah Sound herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

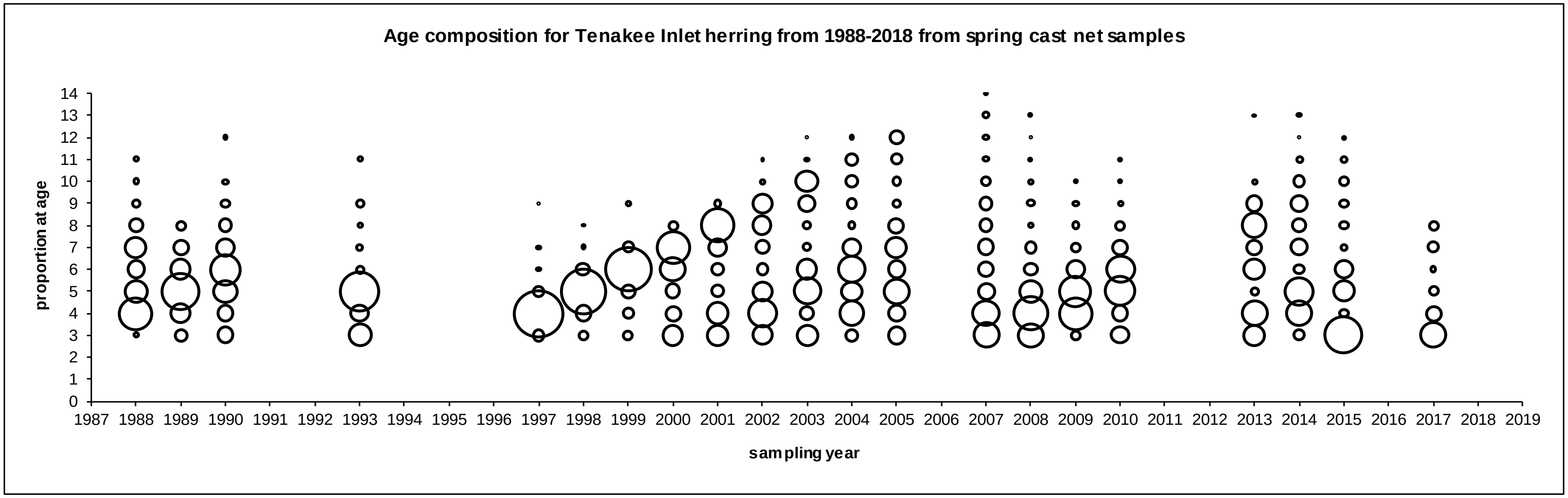



Figure 37.–Observed age compositions from sampling data for the Tenakee Inlet herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

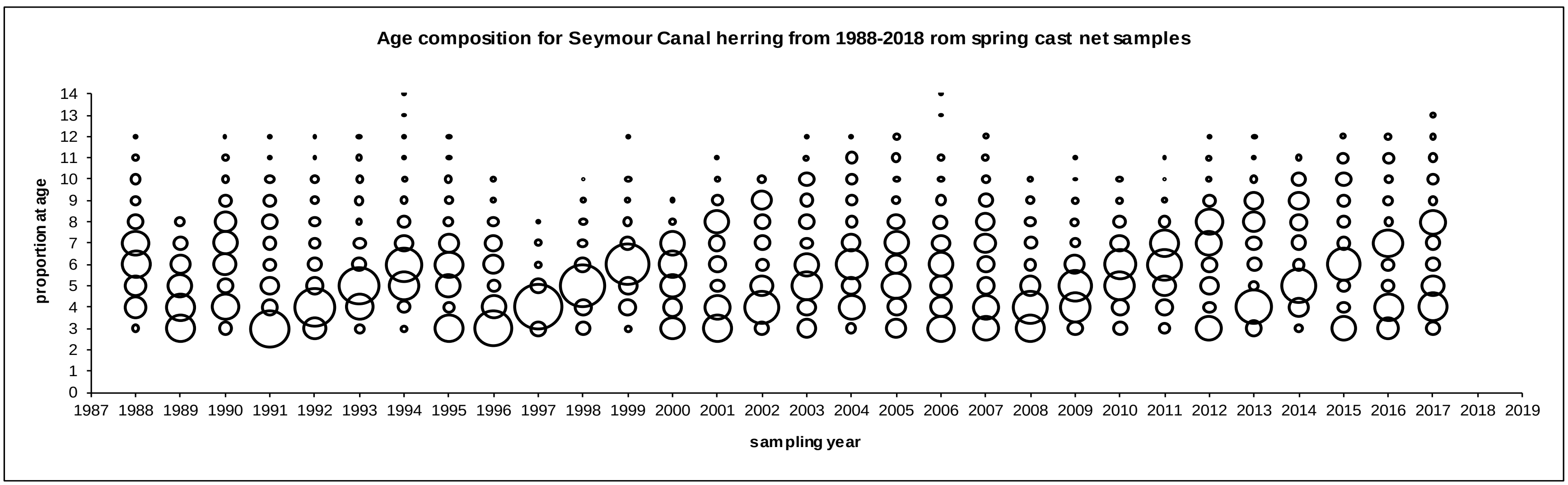



Figure 38.–Observed age compositions from sampling data for the Seymour Canal herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

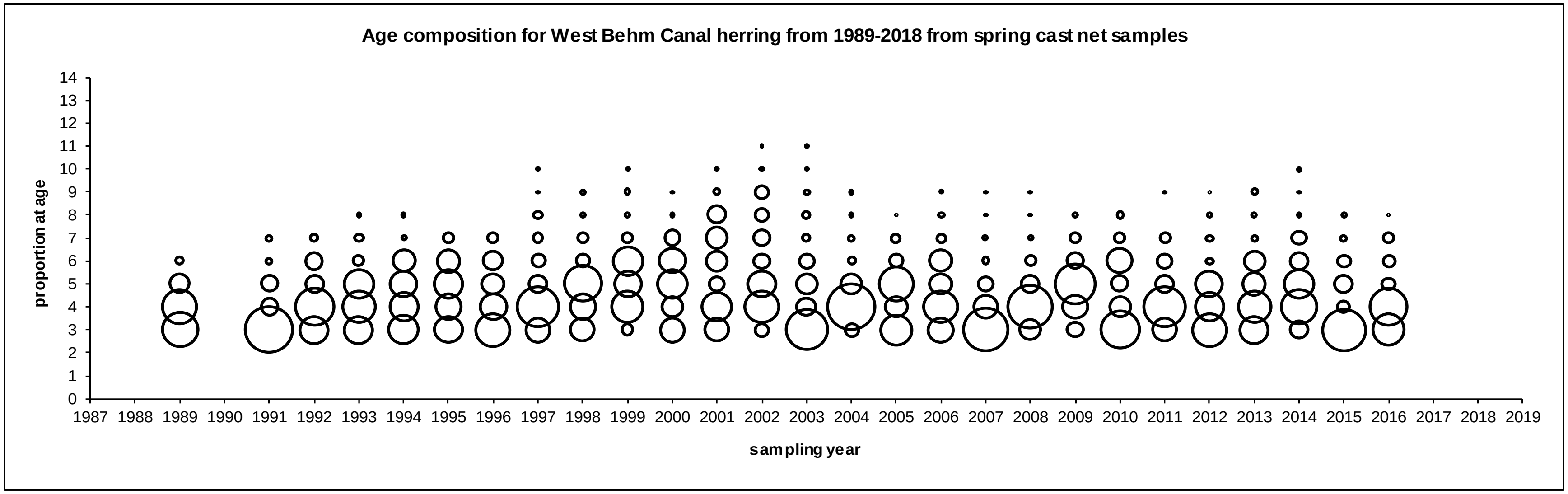



Figure 39.–Observed age compositions from sampling data for the West Behm Canal herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

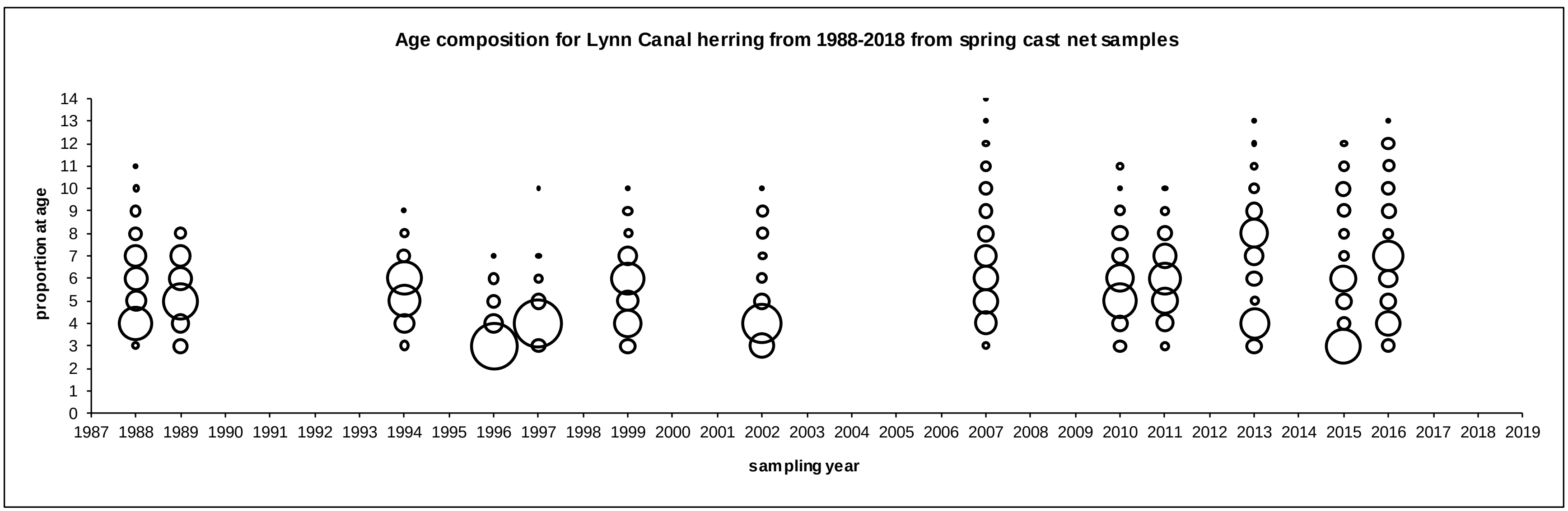



Figure 40.–Observed age compositions from sampling data for the Lynn Canal herring stock.

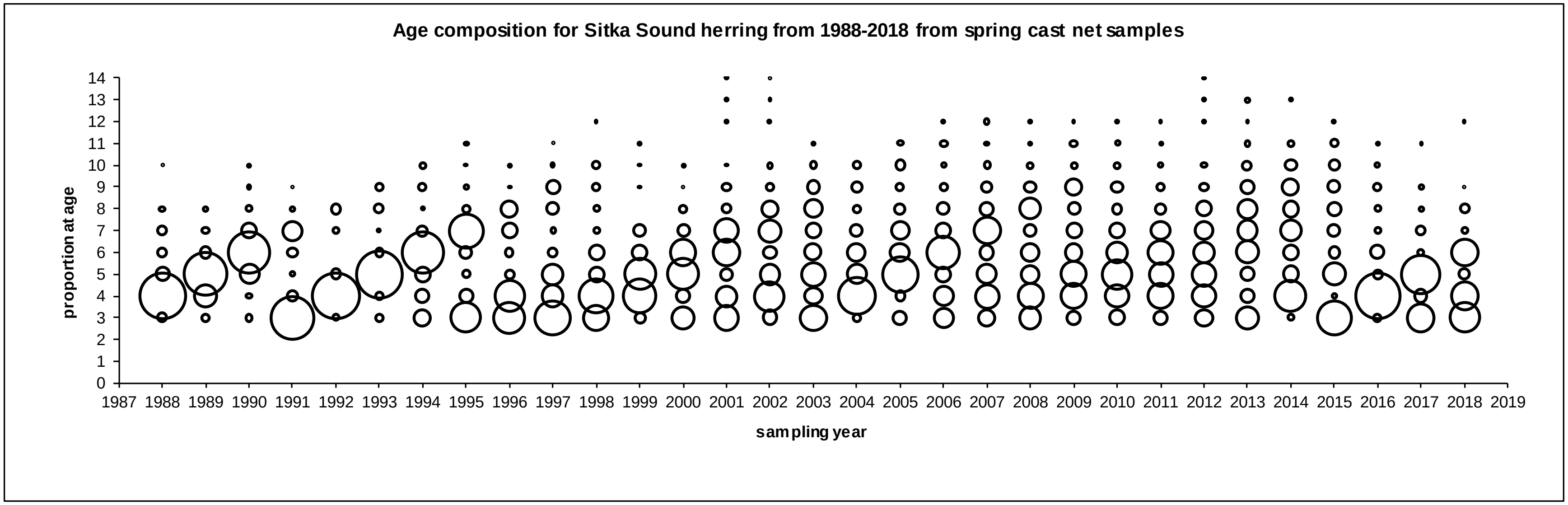



Figure 41.–Observed age compositions from sampling data for the Sitka Sound herring stock. Ages presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

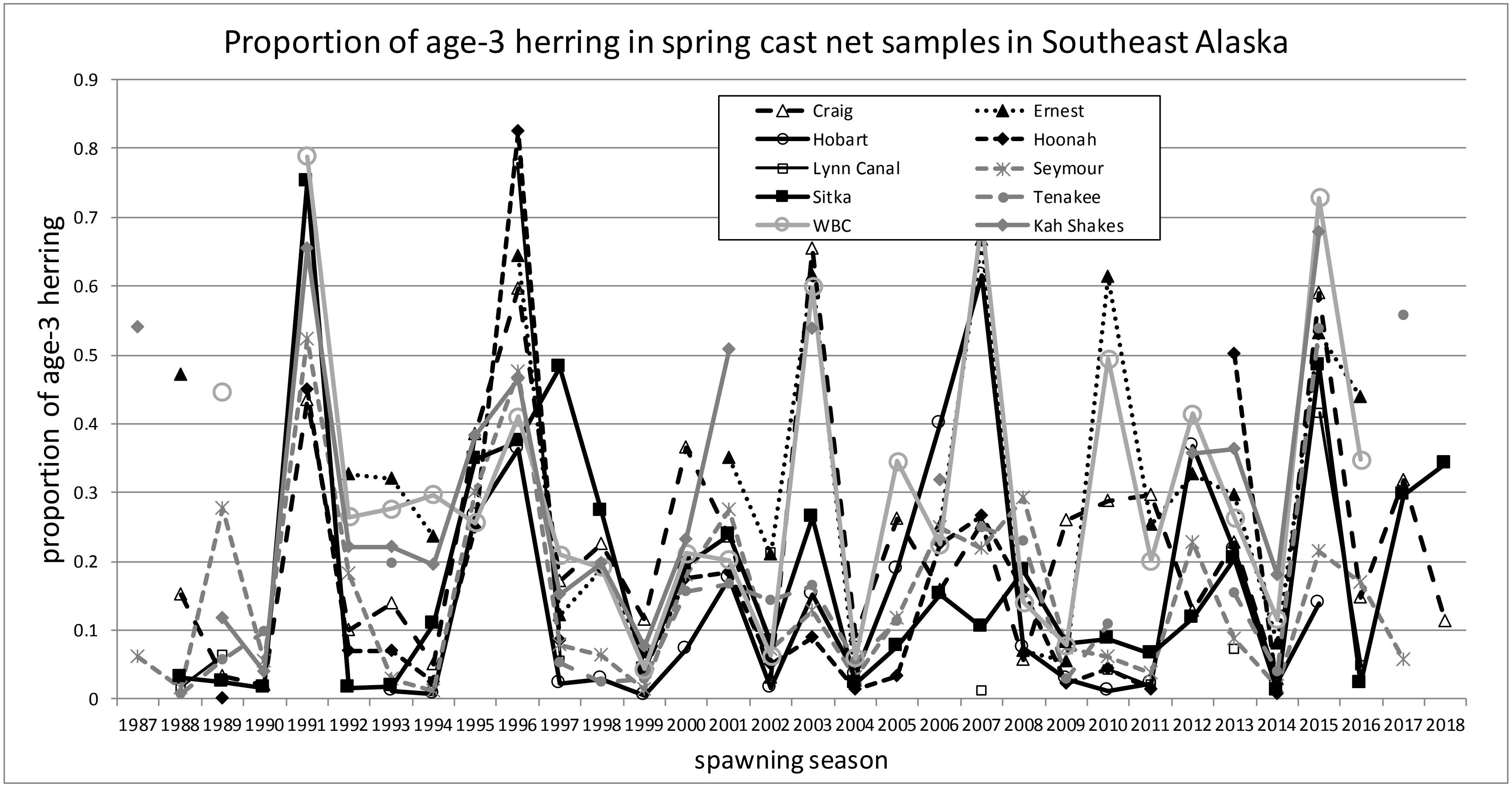



Figure 42.–Proportions of observed age-3 herring in spring cast nest samples of spawning populations for stocks in Southeast Alaska.

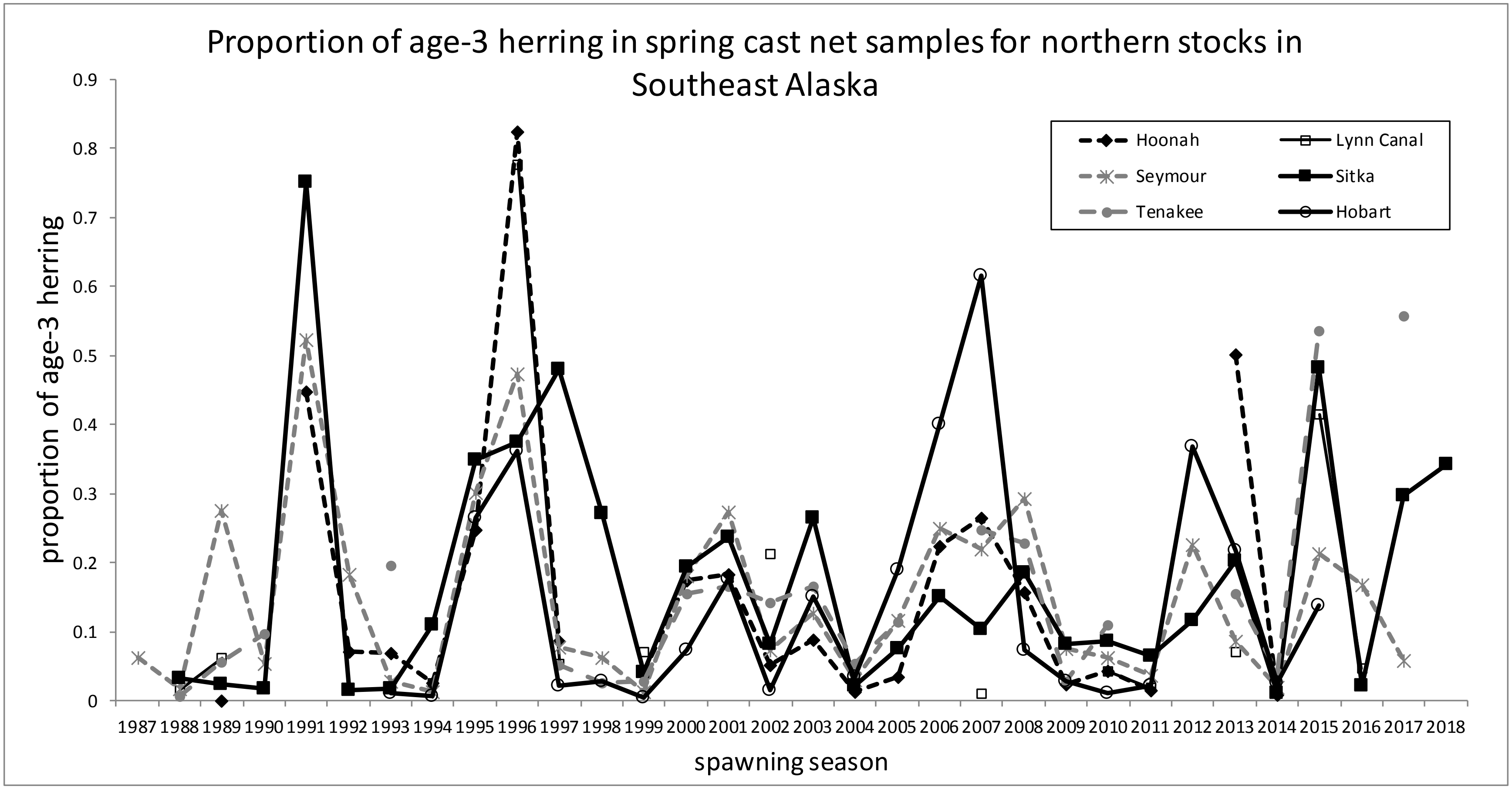



Figure 43.–Proportions of observed age-3 herring in spring cast nest samples of spawning populations for northern stocks in Southeast Alaska.

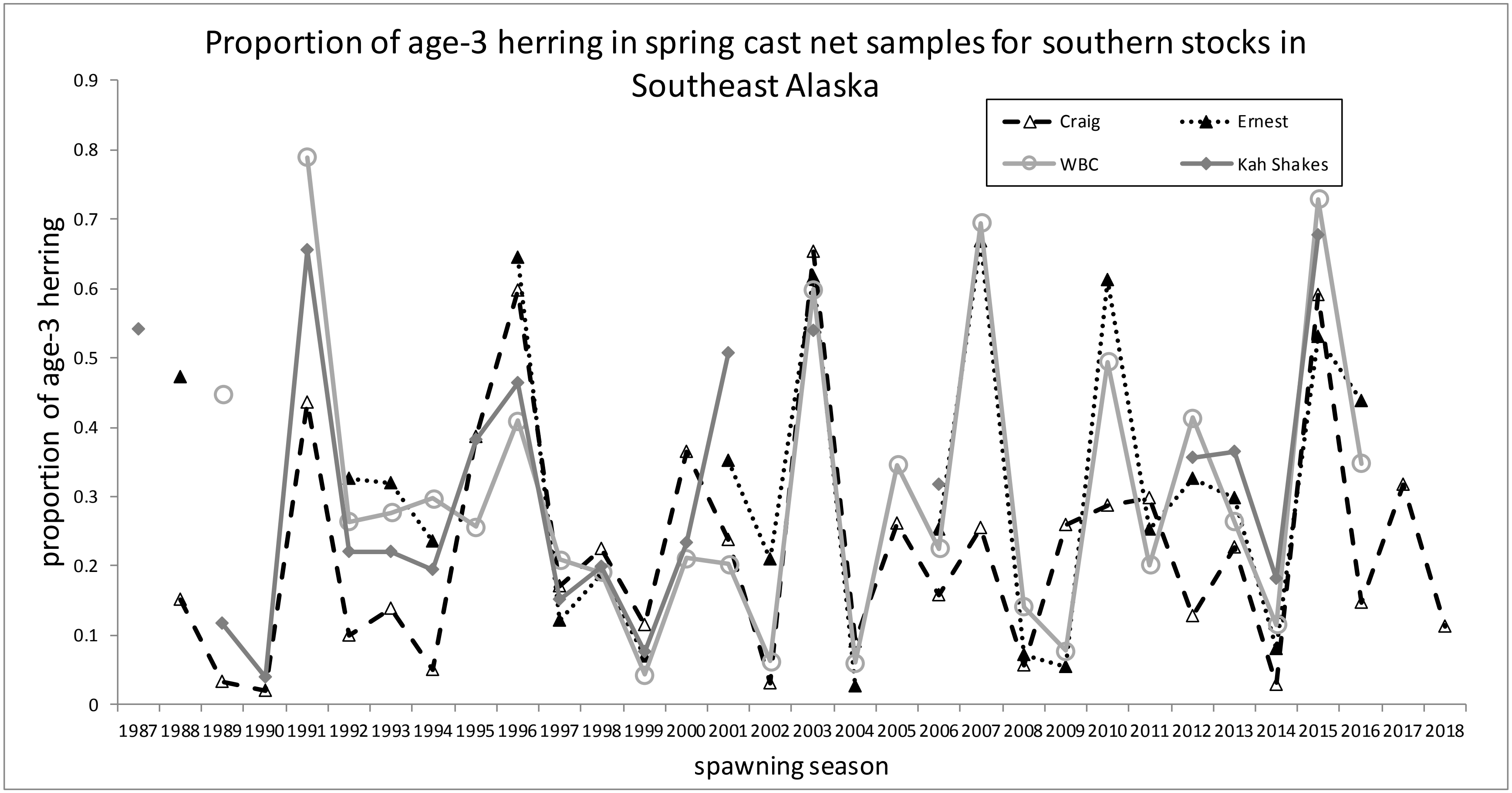



Figure 44.–Proportions of observed age-3 herring in spring cast nest samples of spawning populations for southern stocks in Southeast Alaska.

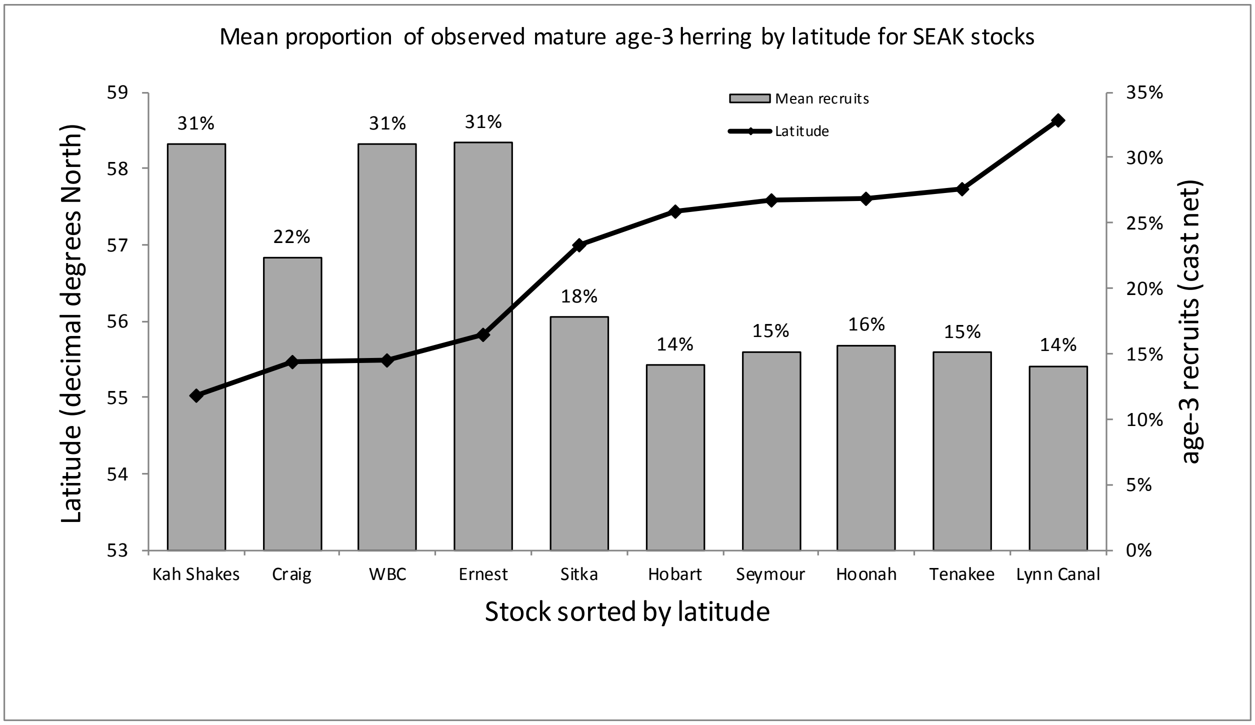



Figure 45.–Mean proportion of observed age-3 herring in spring cast nest samples (1988–2018) and latitude of spawning populations for stocks in Southeast Alaska.

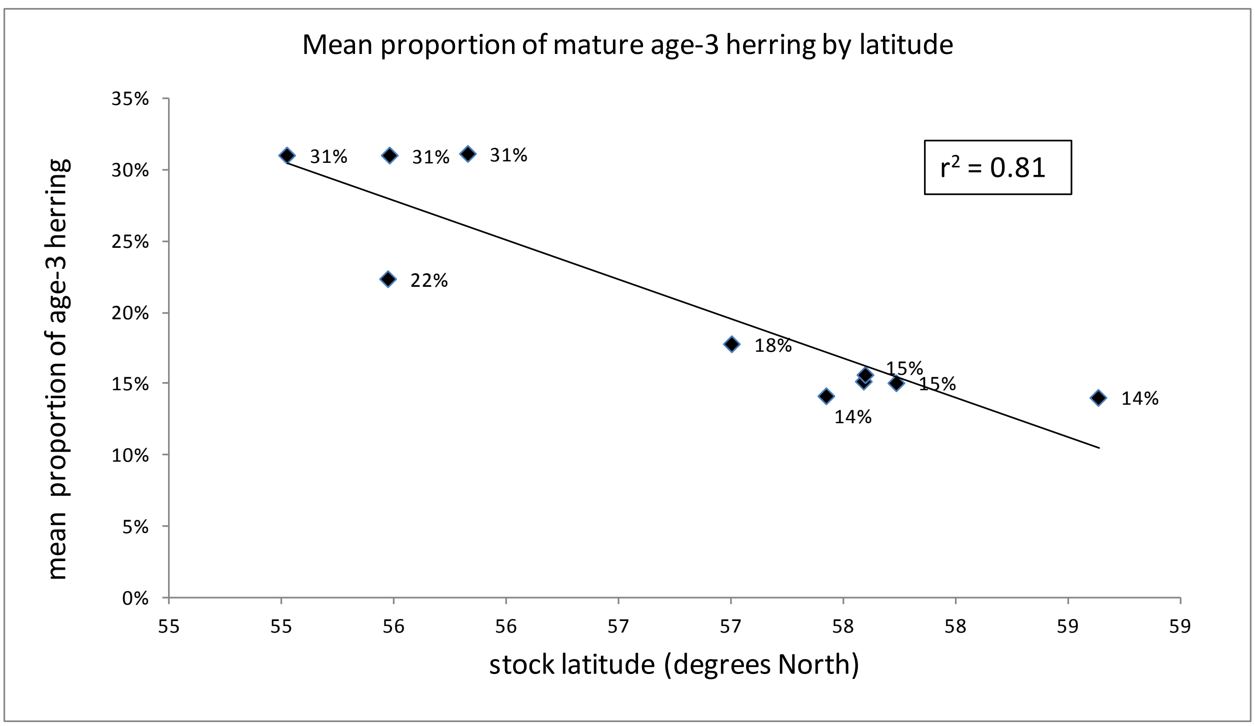



Figure 46.–Relationship between mean proportion of observed age-3 herring in spring cast nest samples and stock latitude of spawning stocks in Southeast Alaska.

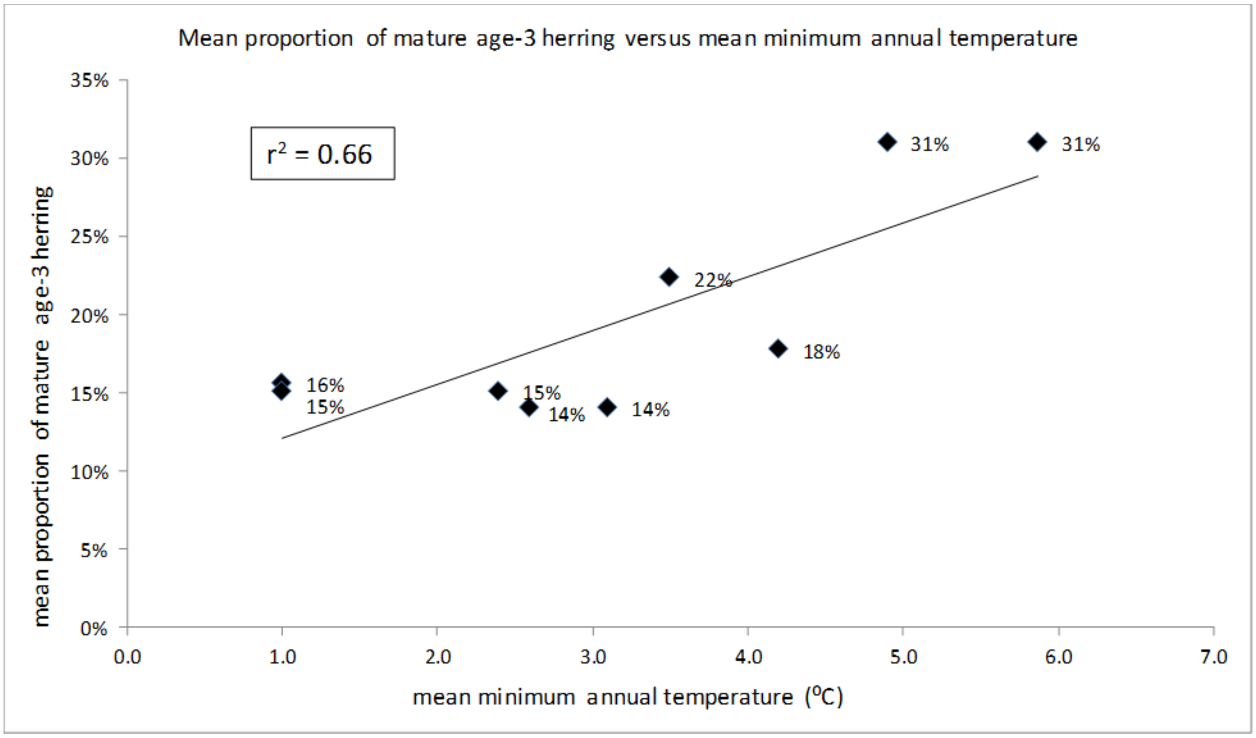



Figure 47.–Mean proportion of age-3 herring in spring cast nest samples versus mean minimum annual sea water temperature at location of spawning stocks in Southeast Alaska.

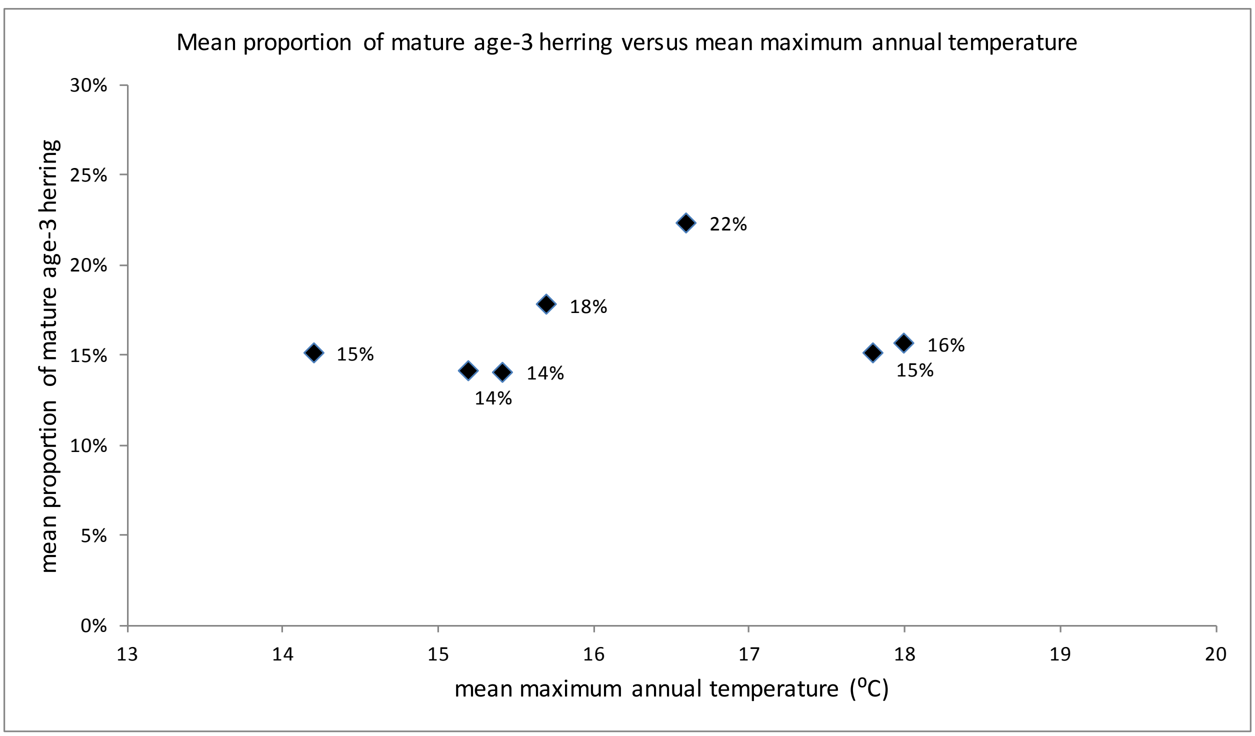



Figure 48.–Mean proportion of age-3 herring in spring cast nest samples versus mean maximum annual sea water temperature at location of spawning stocks in Southeast Alaska.

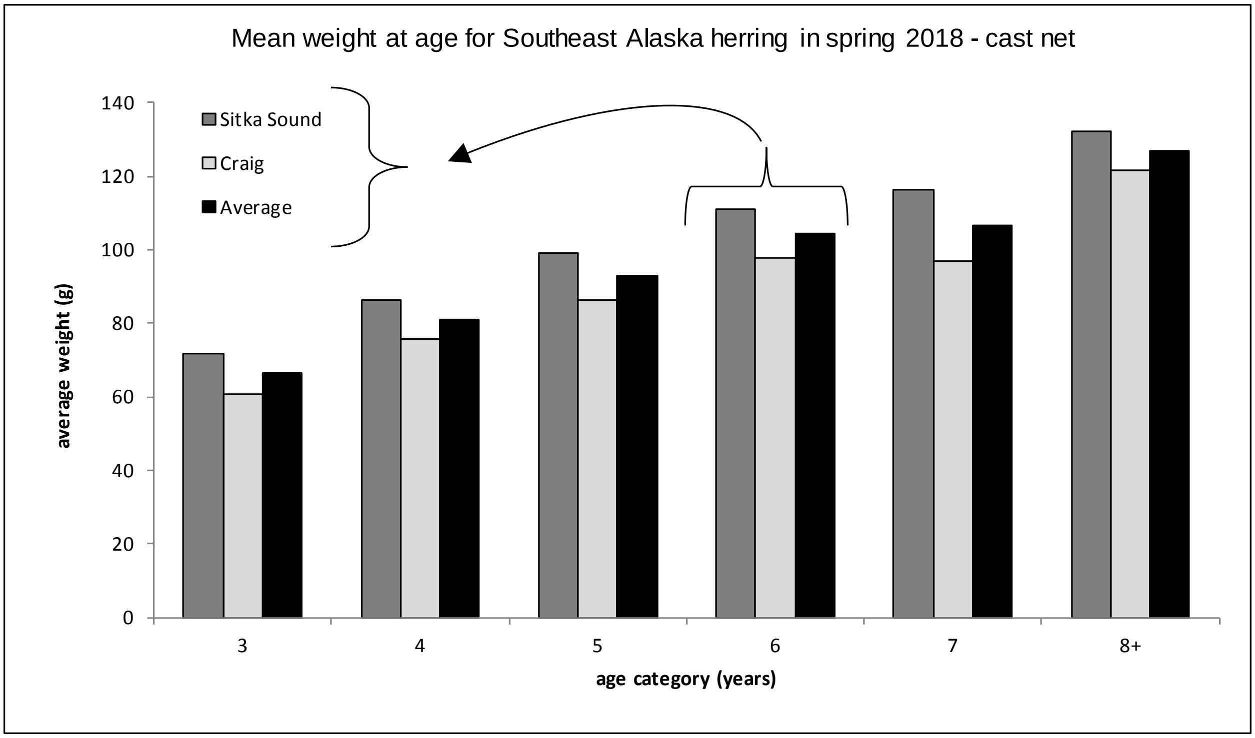



Figure 48.–Mean observed weight-at-age for Southeast Alaska herring stocks surveyed in spring 2018, sorted by age-6.

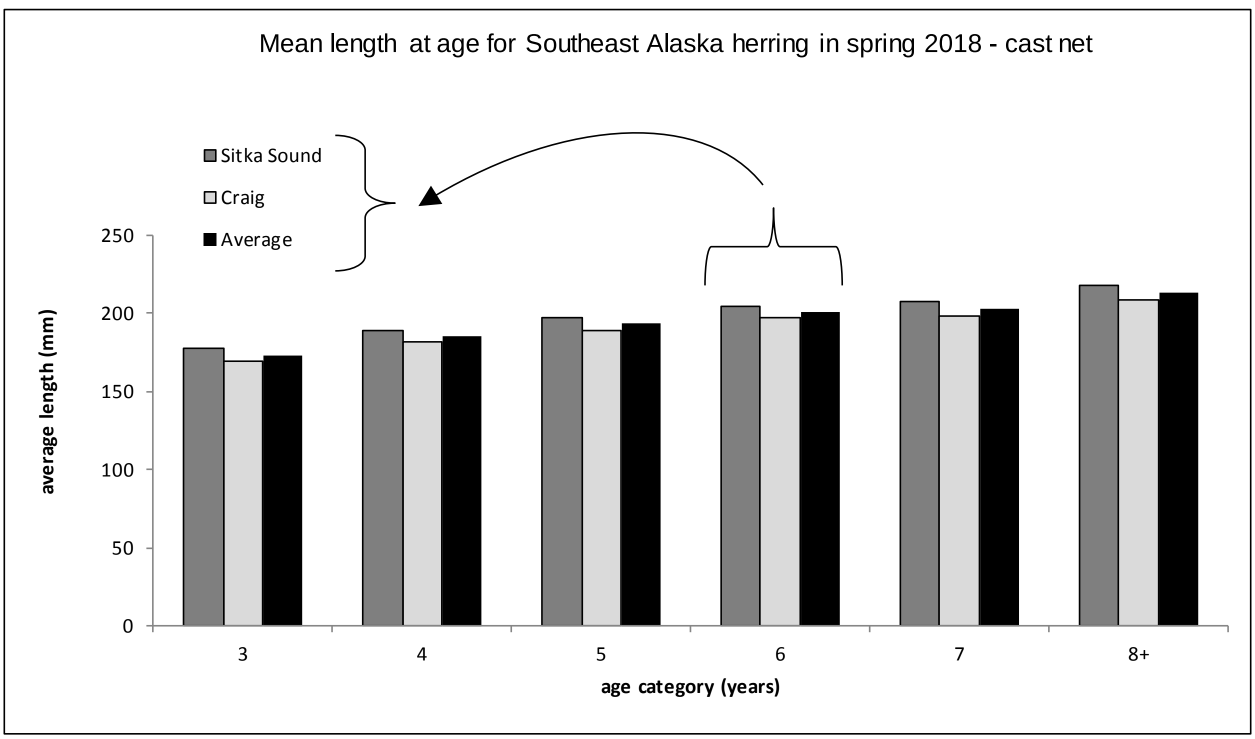



Figure 50.–Mean observed length at age for Southeast Alaska herring stocks surveyed in spring 2018, sorted by age-6.

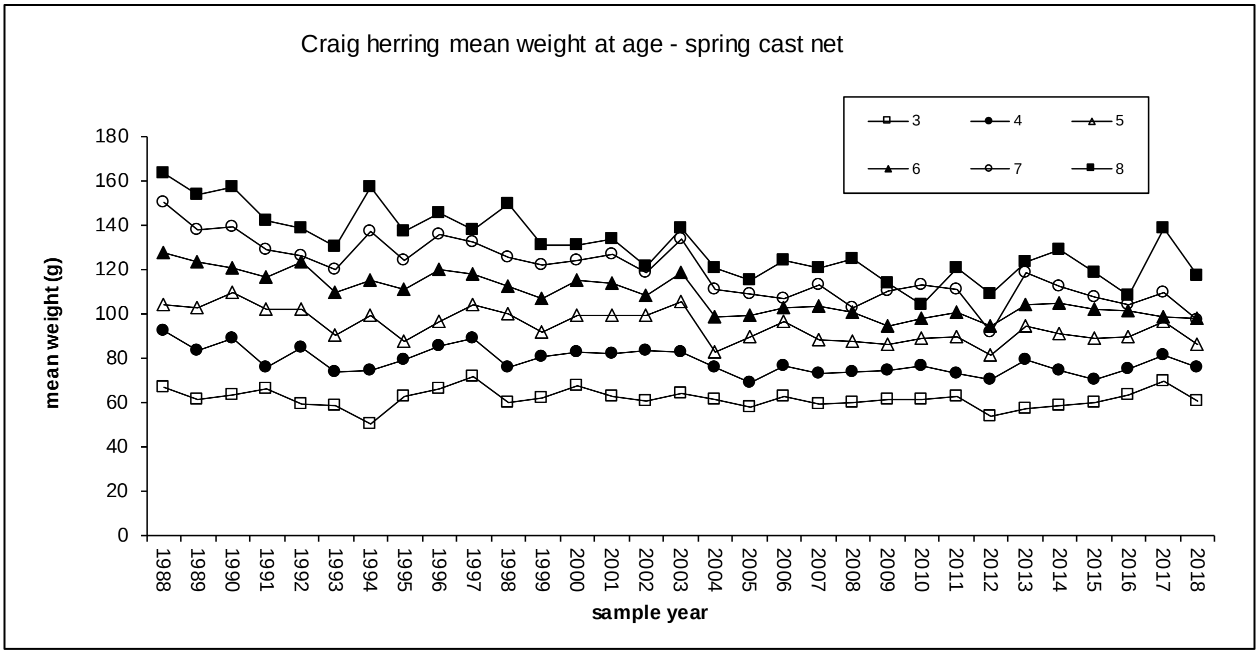



Figure 49.–Mean observed weight-at-age of the Craig herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

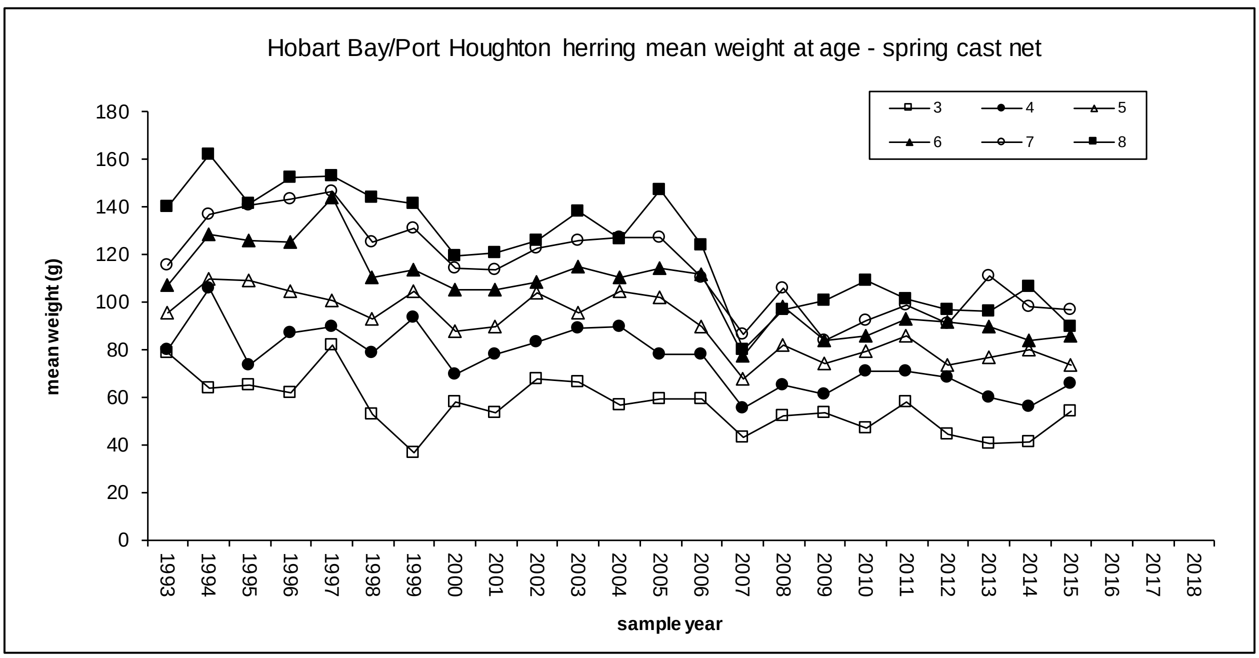



Figure 52.–Mean observed weight at age of the Hobart Bay/Port Houghton herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

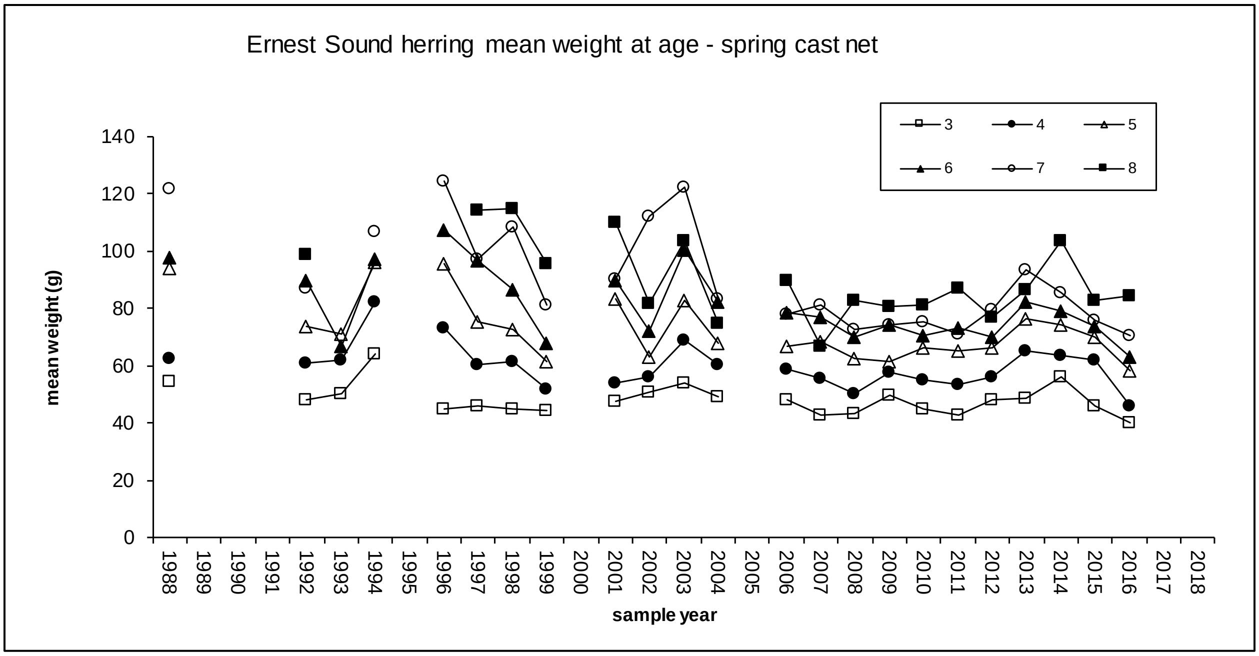



Figure 53.–Mean observed weight at age for the Ernest Sound herring spawning population.

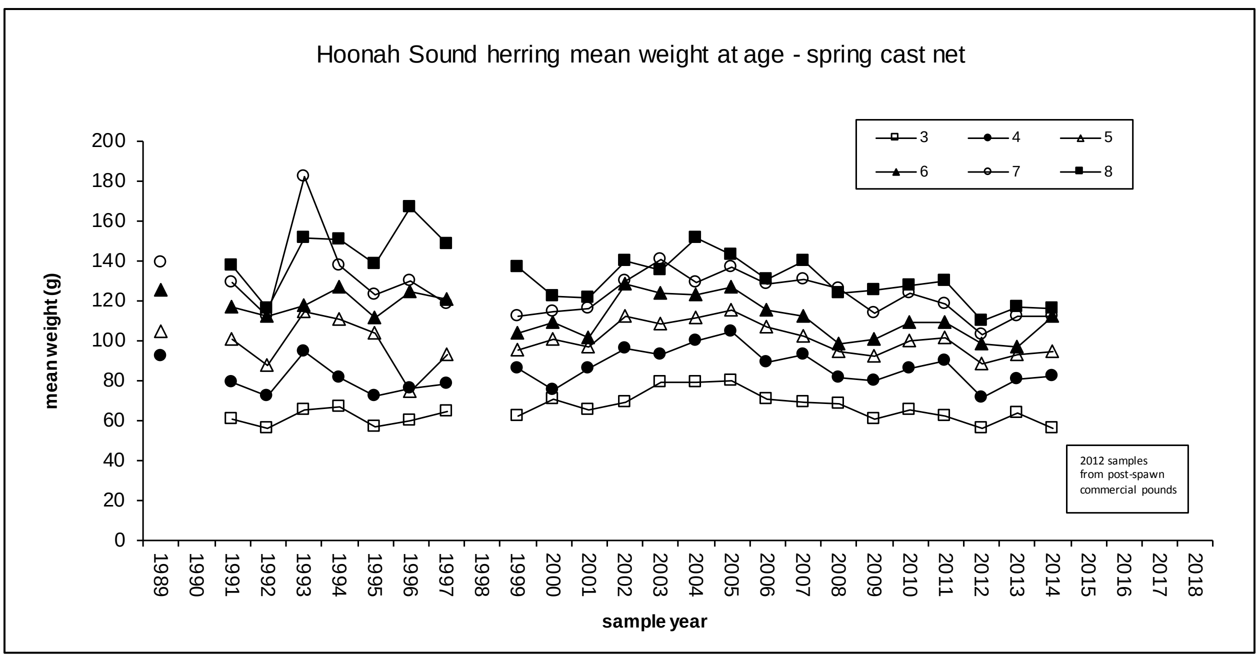



Figure 54.–Mean observed weight at age for the Hoonah Sound herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

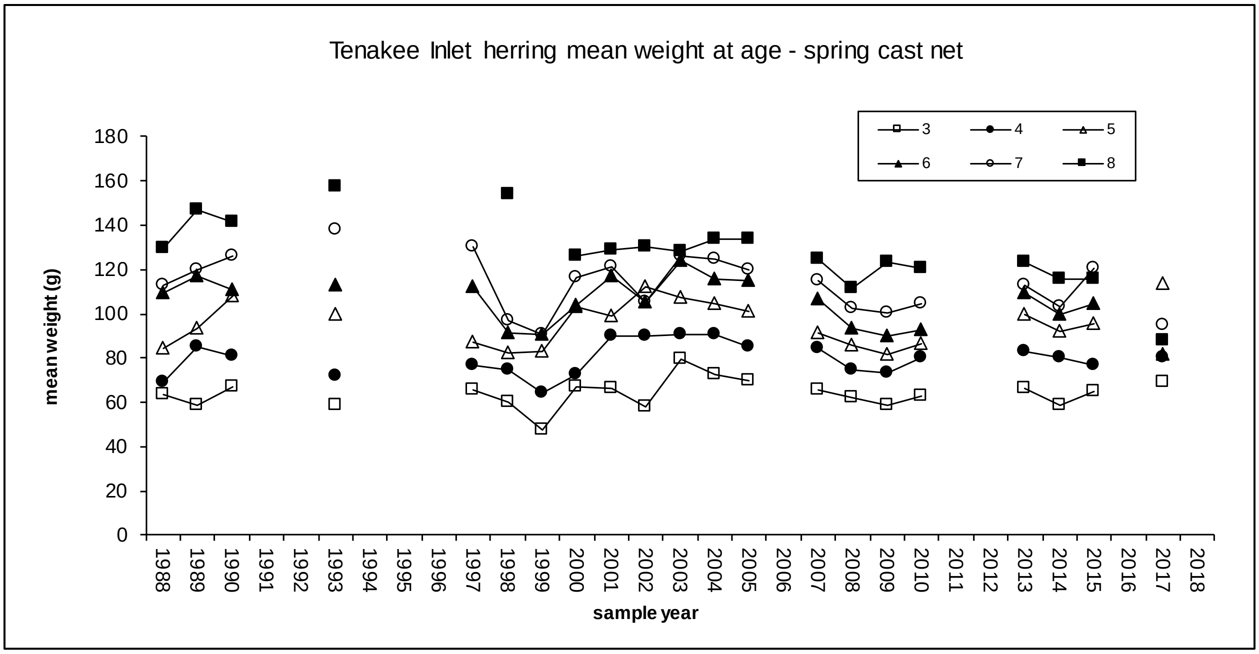



Figure 55.–Mean observed weight at age for the Tenakee Inlet herring stock. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

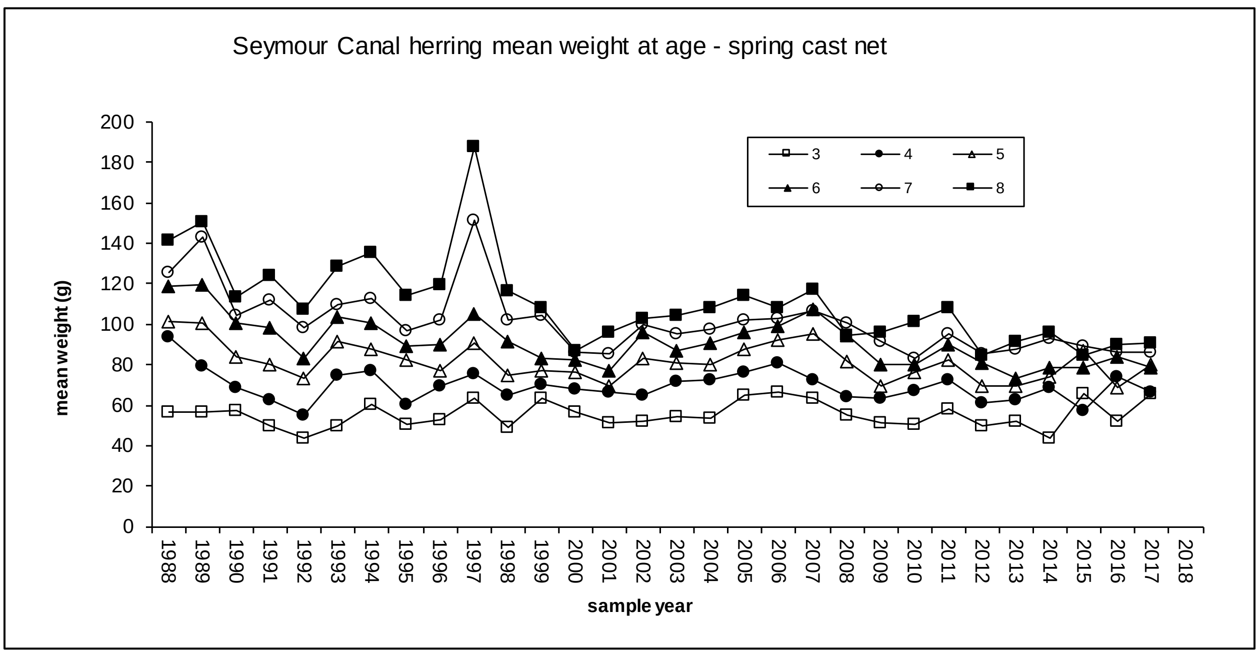



Figure 56.–Mean observed weight at age for the Seymour Canal herring stock. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

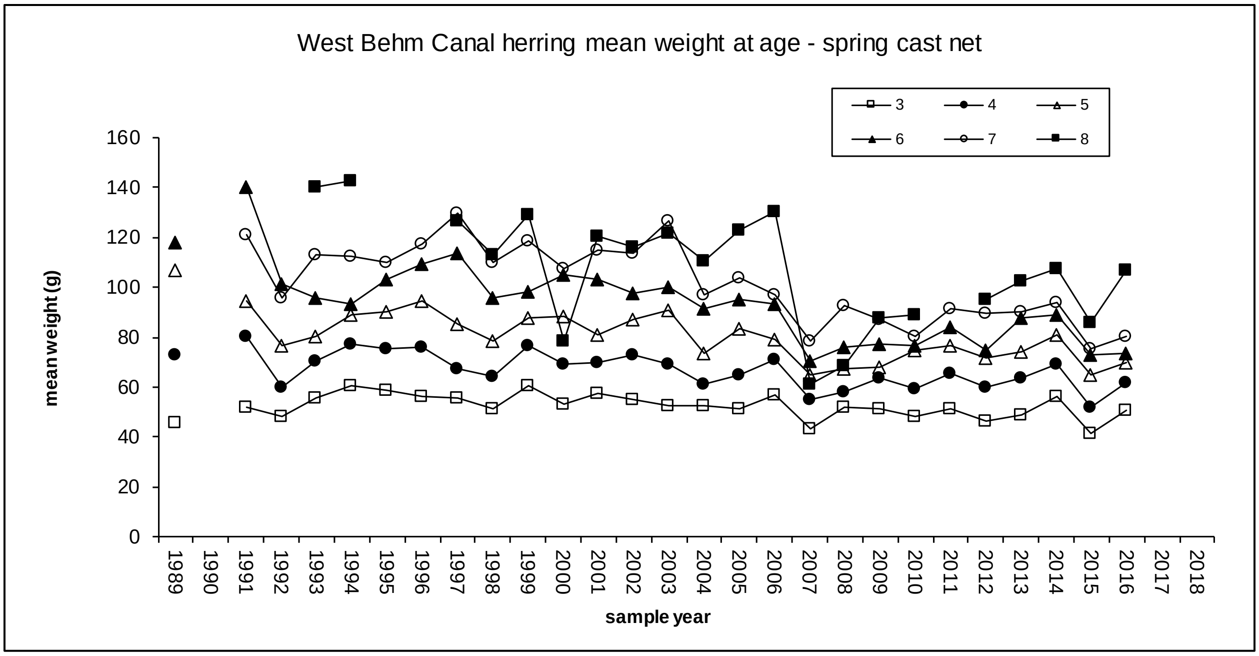



Figure 57.–Mean observed weight at age for the West Behm Canal herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli. 2015 weights are likely biased low due to required additional sample handling that resulted in loss of weight.

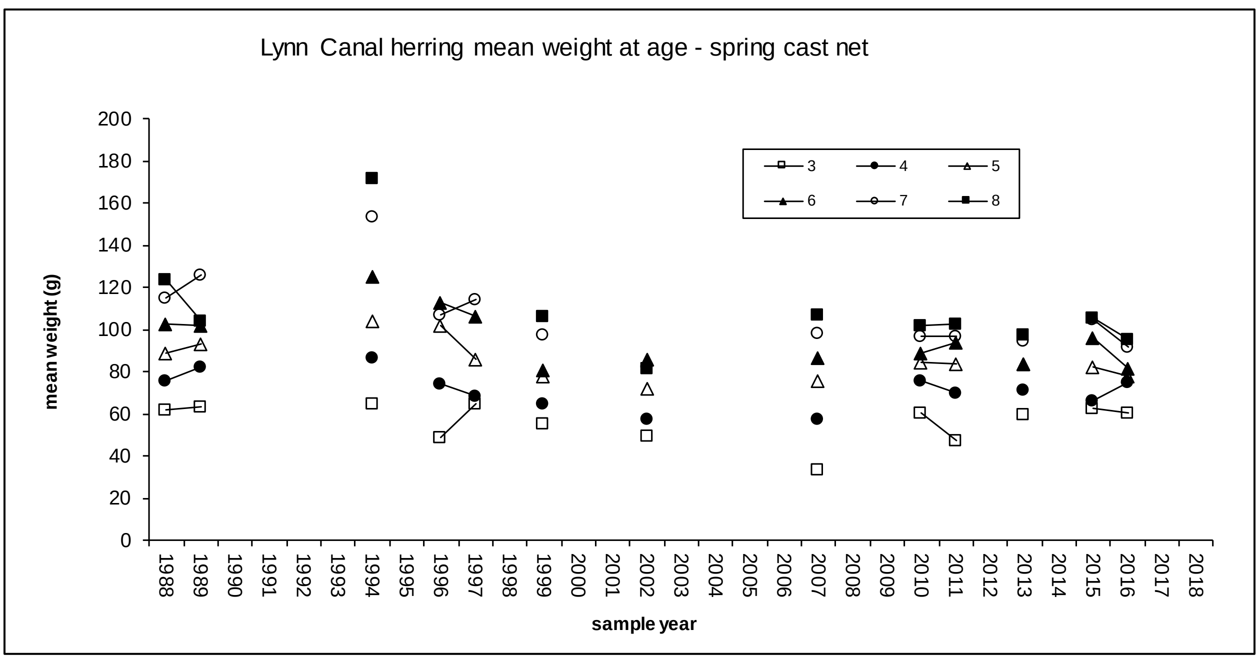



Figure 58.–Mean observed weight at age for the Lynn Canal herring spawning population.

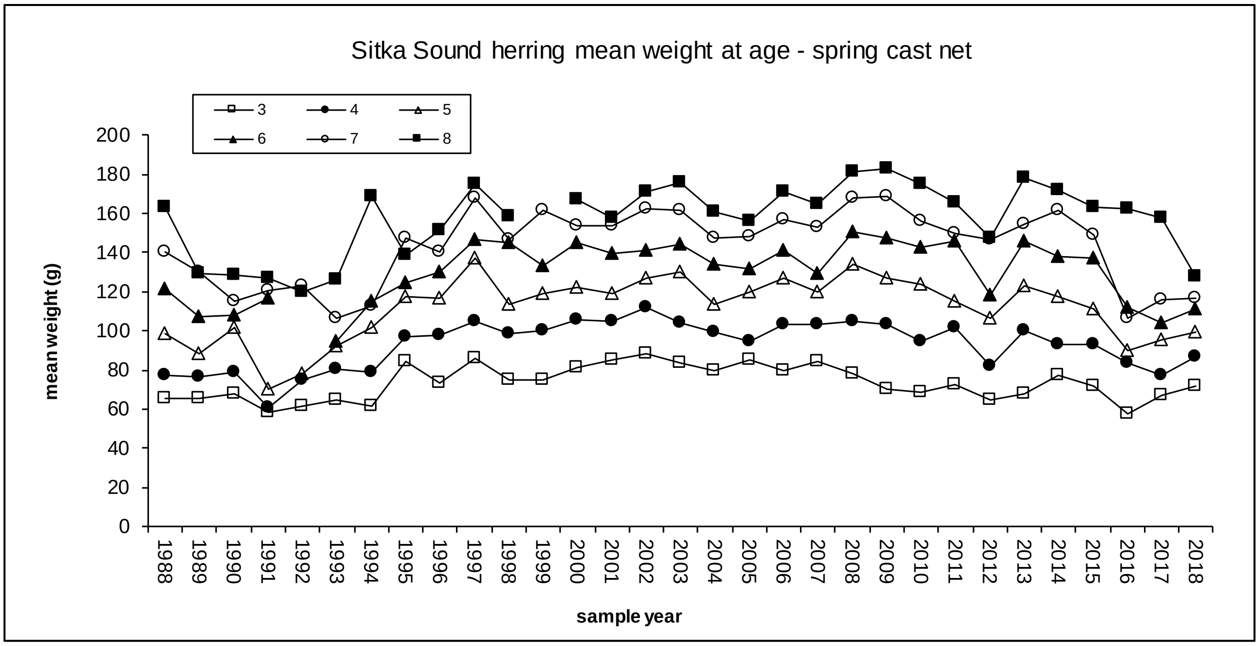



Figure 50.–Mean observed weight at age for the Sitka Sound herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

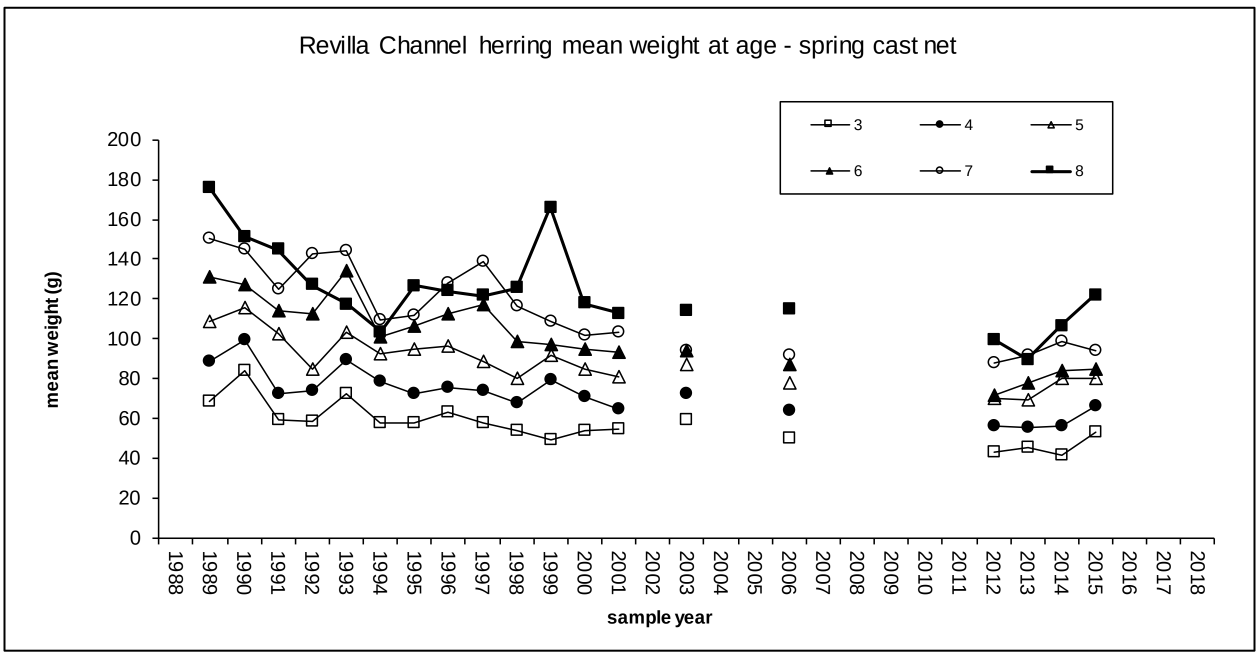



Figure 51.–Mean observed weight at age for the Revilla Channel herring spawning population. Weights presented for 2000 may be biased slightly high due to misinterpretation of scale annuli.

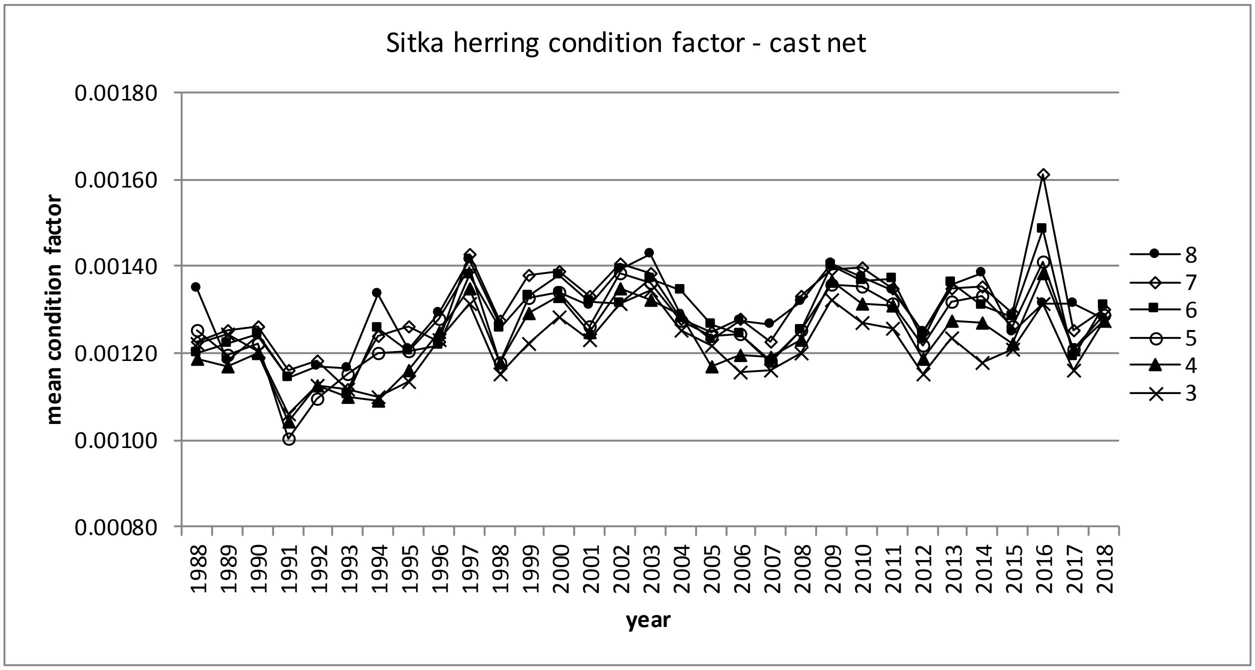



Figure 52.–Mean condition factors of age-3 through age-8 herring for the Sitka Sound spawning population, based on spring cast net samples taken during active spawning. 2016 values may be biased high due to length measurements that were likely underestimated.

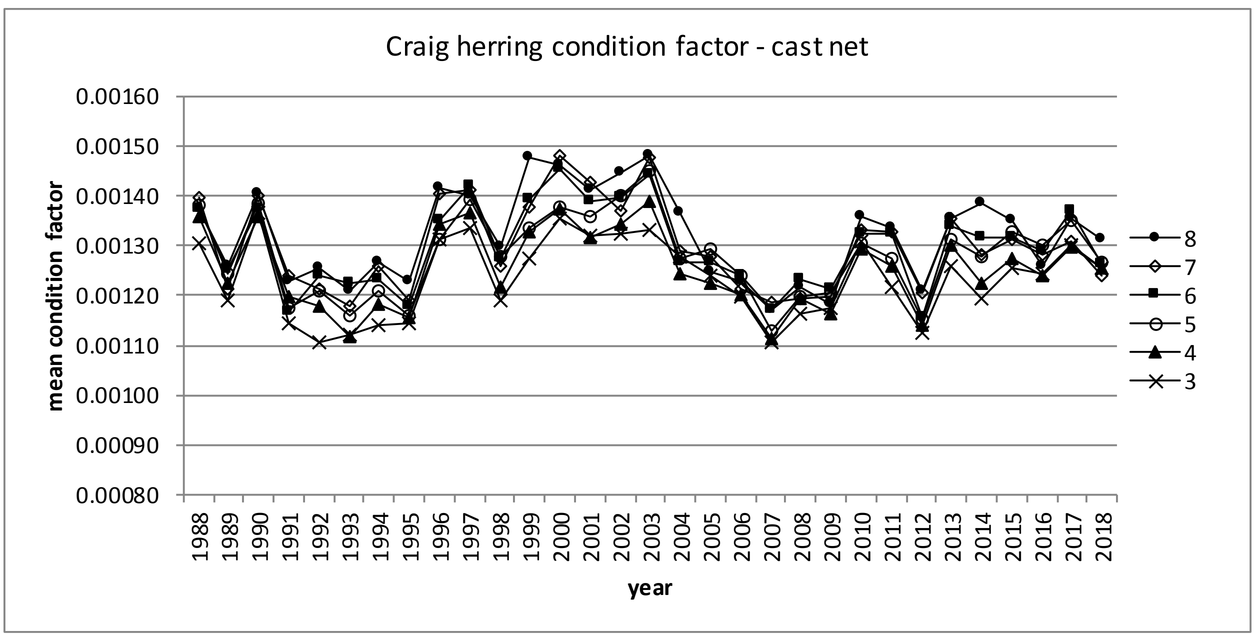



Figure 53.–Mean condition factors of age-3 through age-8 herring for the Craig spawning population, based on spring cast net samples taken during active spawning.

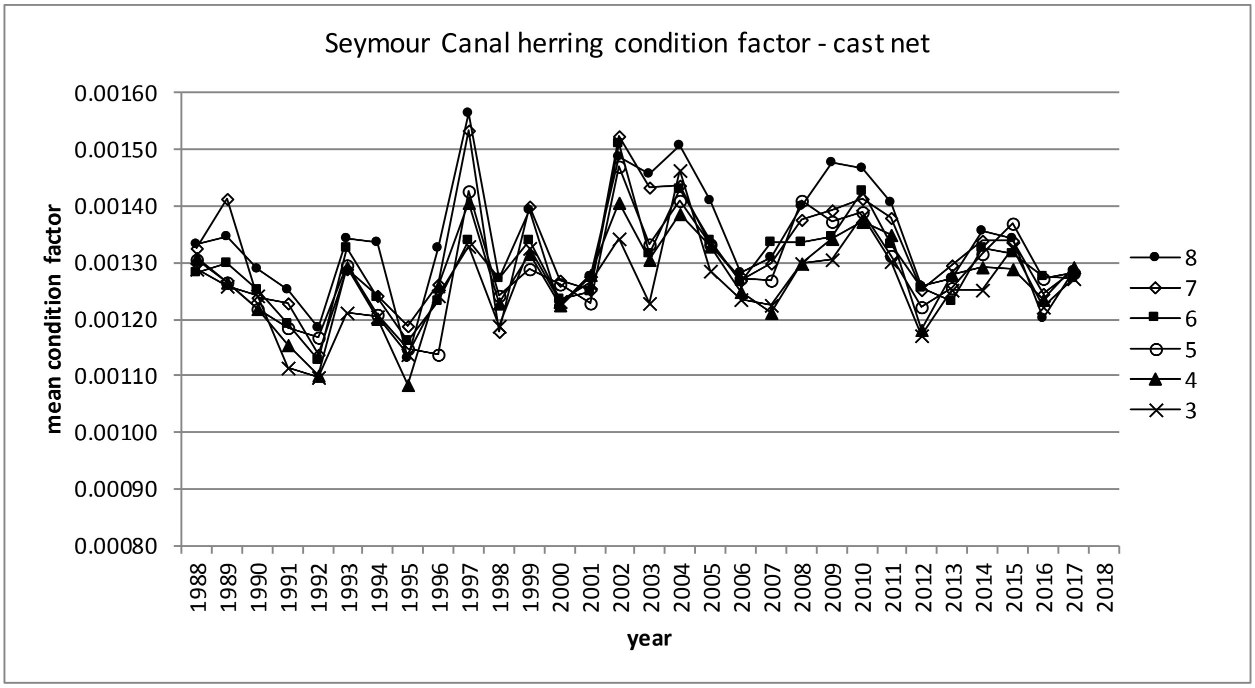



Figure 54.–Mean condition factors of age-3 through age-8 herring for the Seymour Canal spawning population, based on spring cast net samples taken during active spawning.

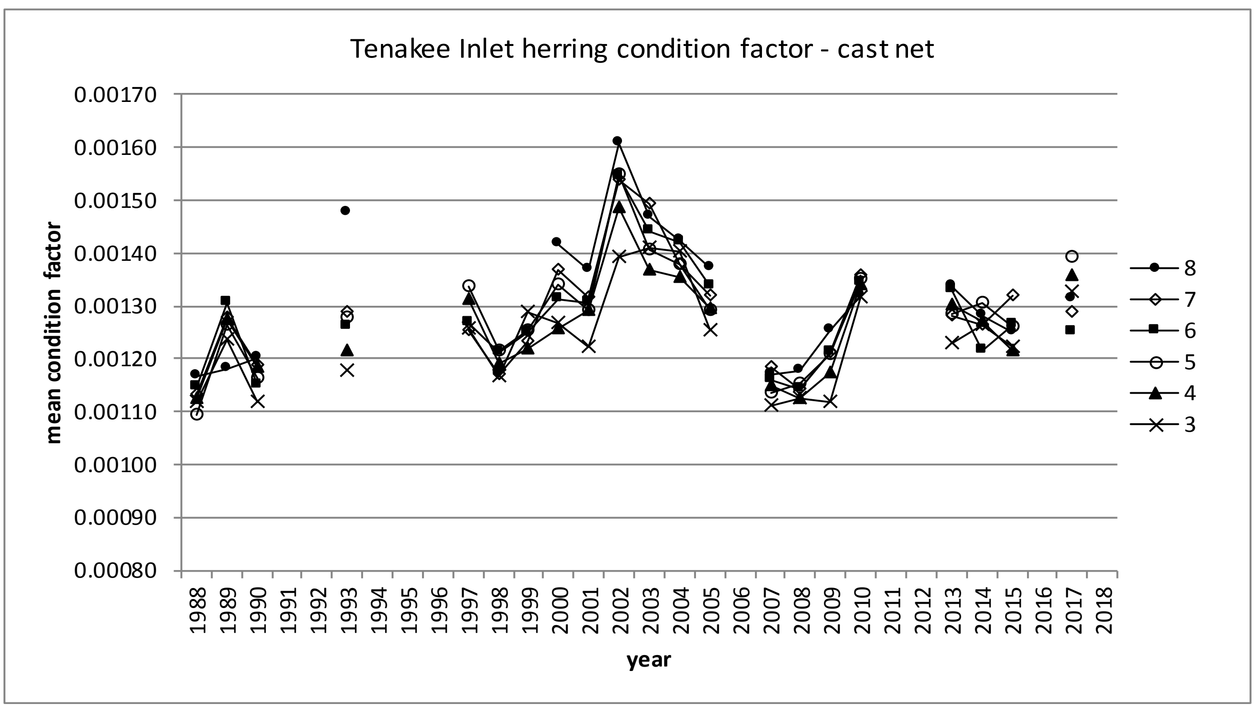



Figure 55.–Mean condition factors of age-3 through age-8 herring for the Tenakee Inlet spawning population, based on spring cast net samples taken during active spawning.

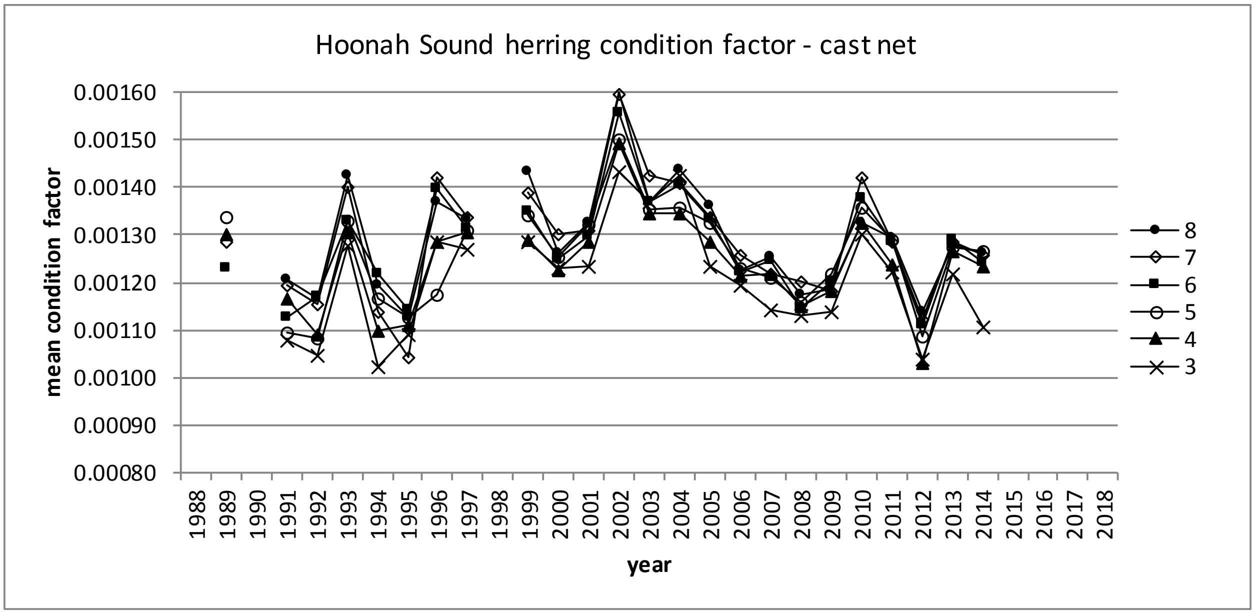



Figure 56.–Mean condition factors of age-3 through age-8 herring for the Hoonah Sound spawning population, based on spring cast net samples taken during active spawning.

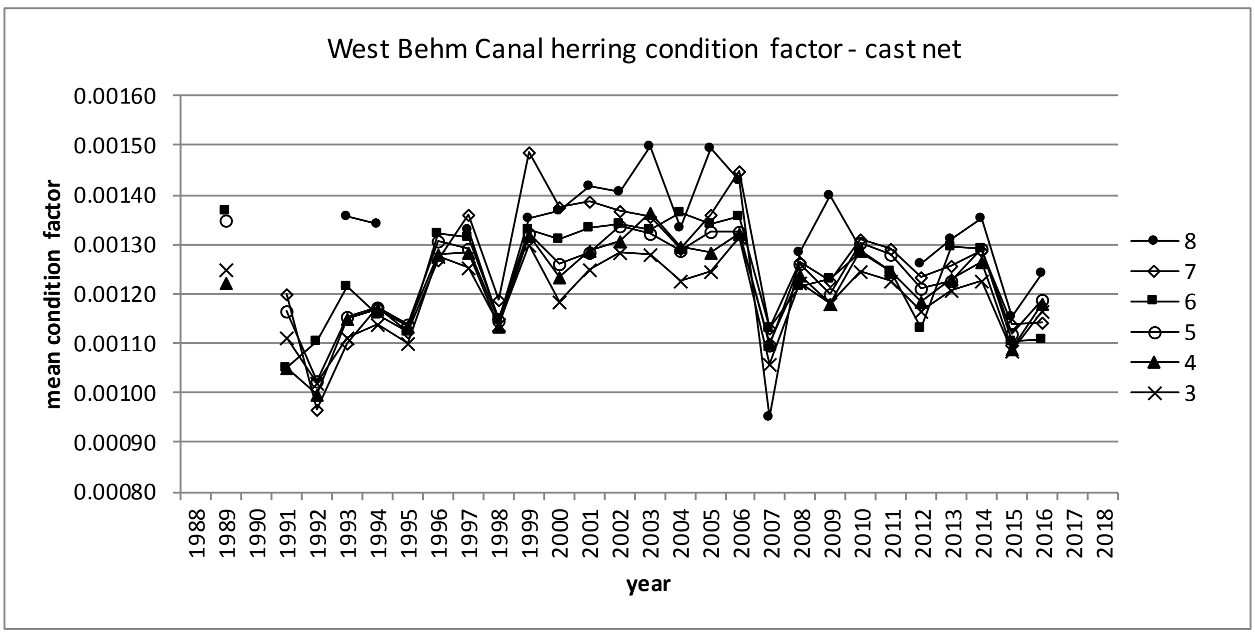



Figure 57.–Mean condition factors of age-3 through age-8 herring for the West Behm Canal spawning population, based on spring cast net samples taken during active spawning. 2015 condition factors are probably biased low due to required additional sample handling that resulted in loss of weight.

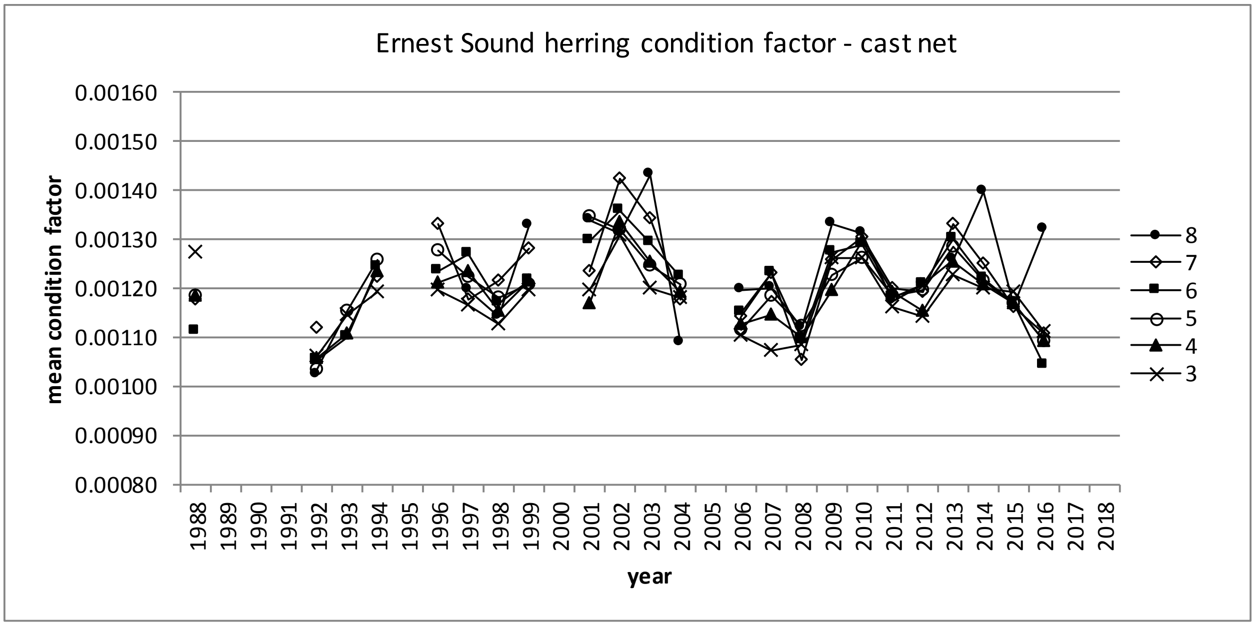



Figure 58.–Mean condition factors of age-3 through age-8 herring for the Ernest Sound spawning population, based on spring cast net samples taken during active spawning.

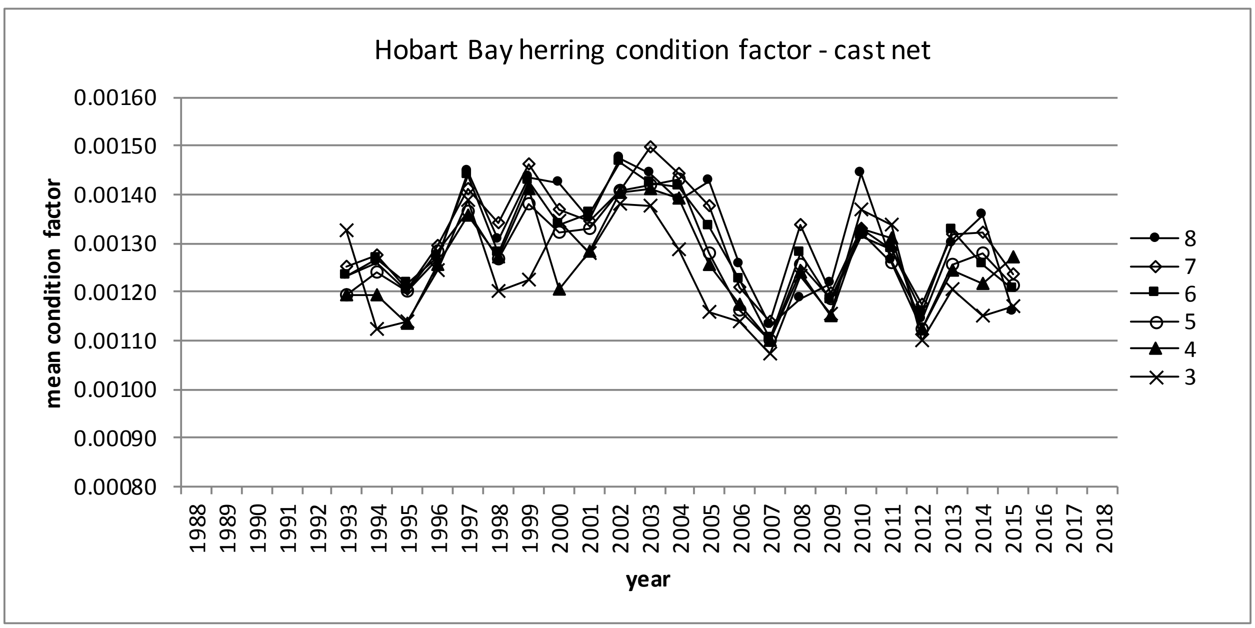



Figure 59.–Mean condition factors of age-3 through age-8 herring for the Hobart Bay spawning population, based on spring cast net samples taken during active spawning.

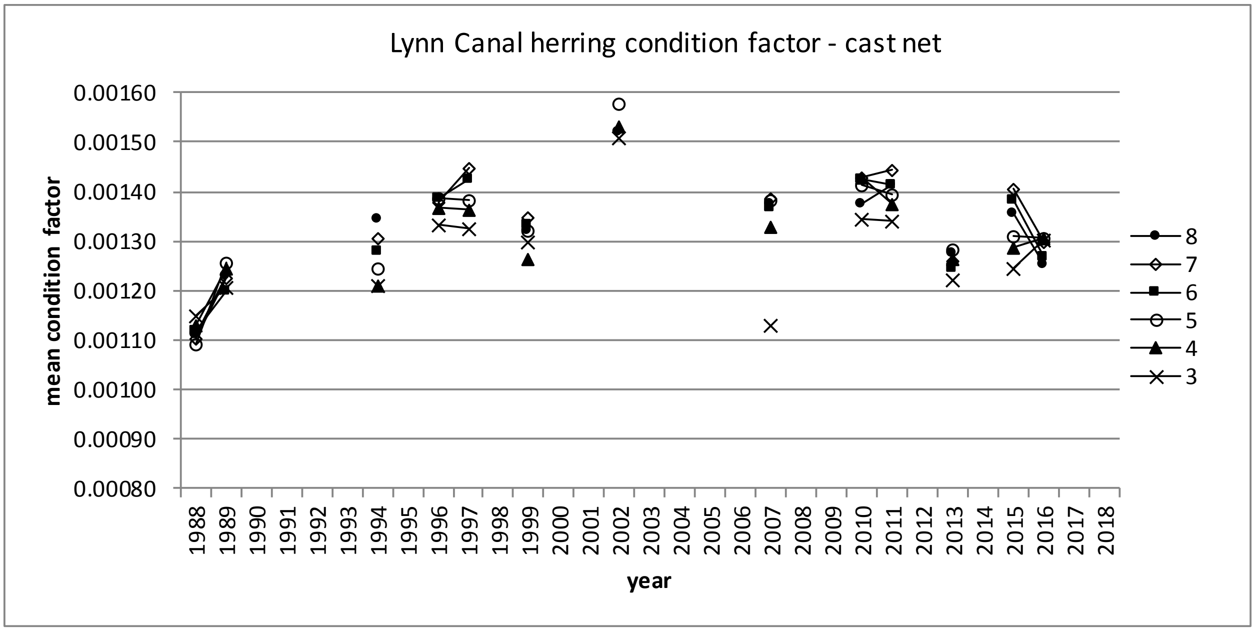



Figure 60.–Mean condition factors of age-3 through age-8 herring for the Lynn Canal spawning population, based on spring cast net samples taken during active spawning.

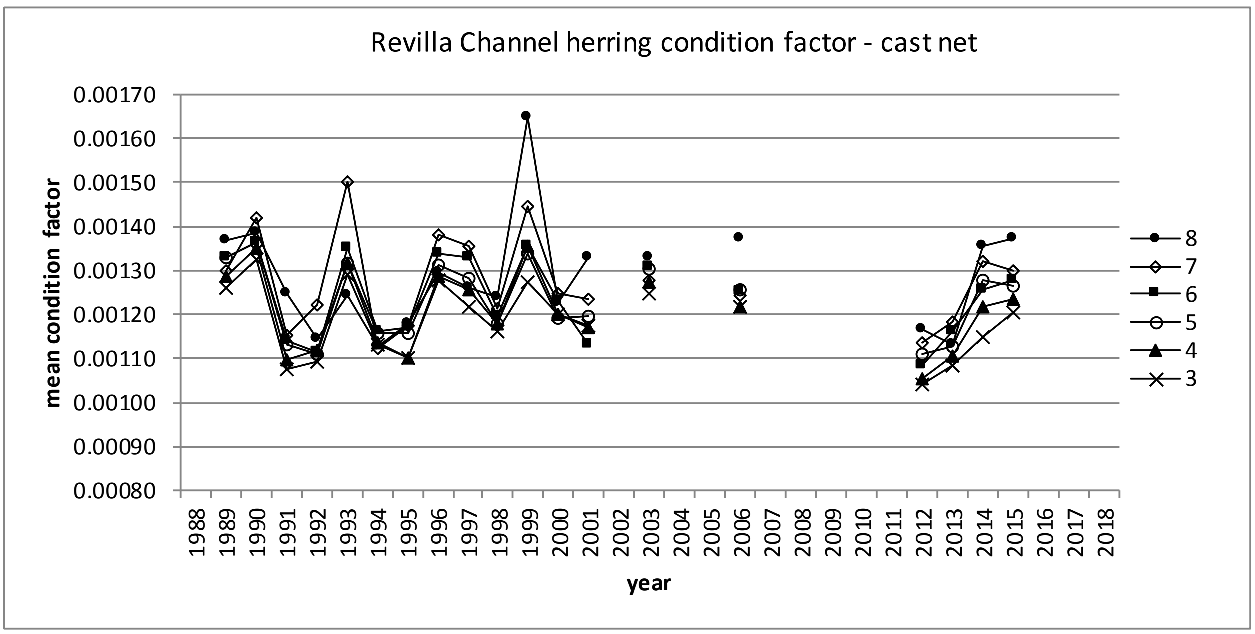



Figure 61.–Mean condition factors of age-3 through age-8 herring for the Revilla Channel spawning population, based on spring cast net samples taken during active spawning.

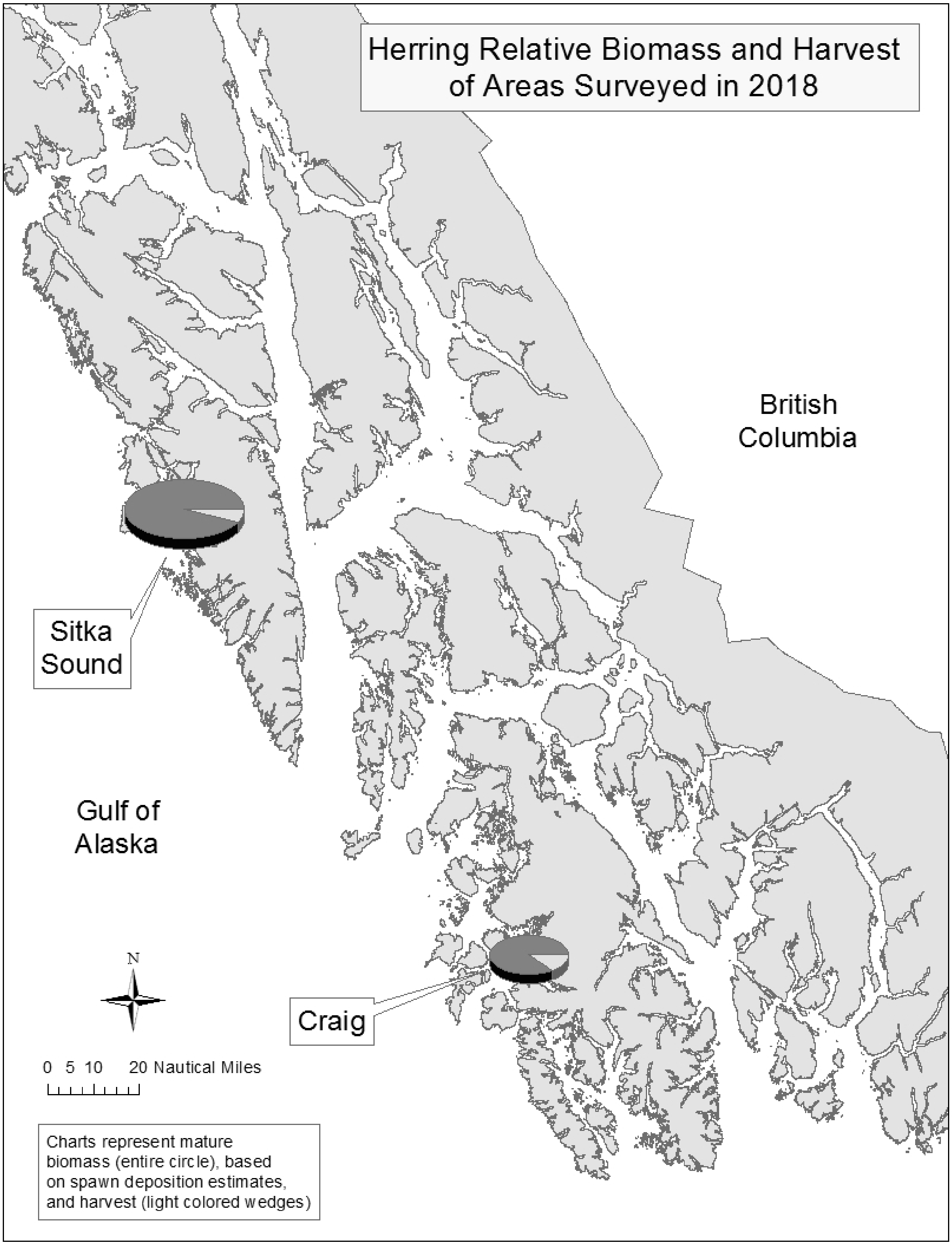



Figure 62.–Relative magnitude of observed herring spawning stock biomass and harvest levels in Southeast Alaska, based on biomass estimates converted from spawn deposition estimates. White wedges are intended to provide an approximate depiction of relative harvest but do not represent actual exploitation rate.

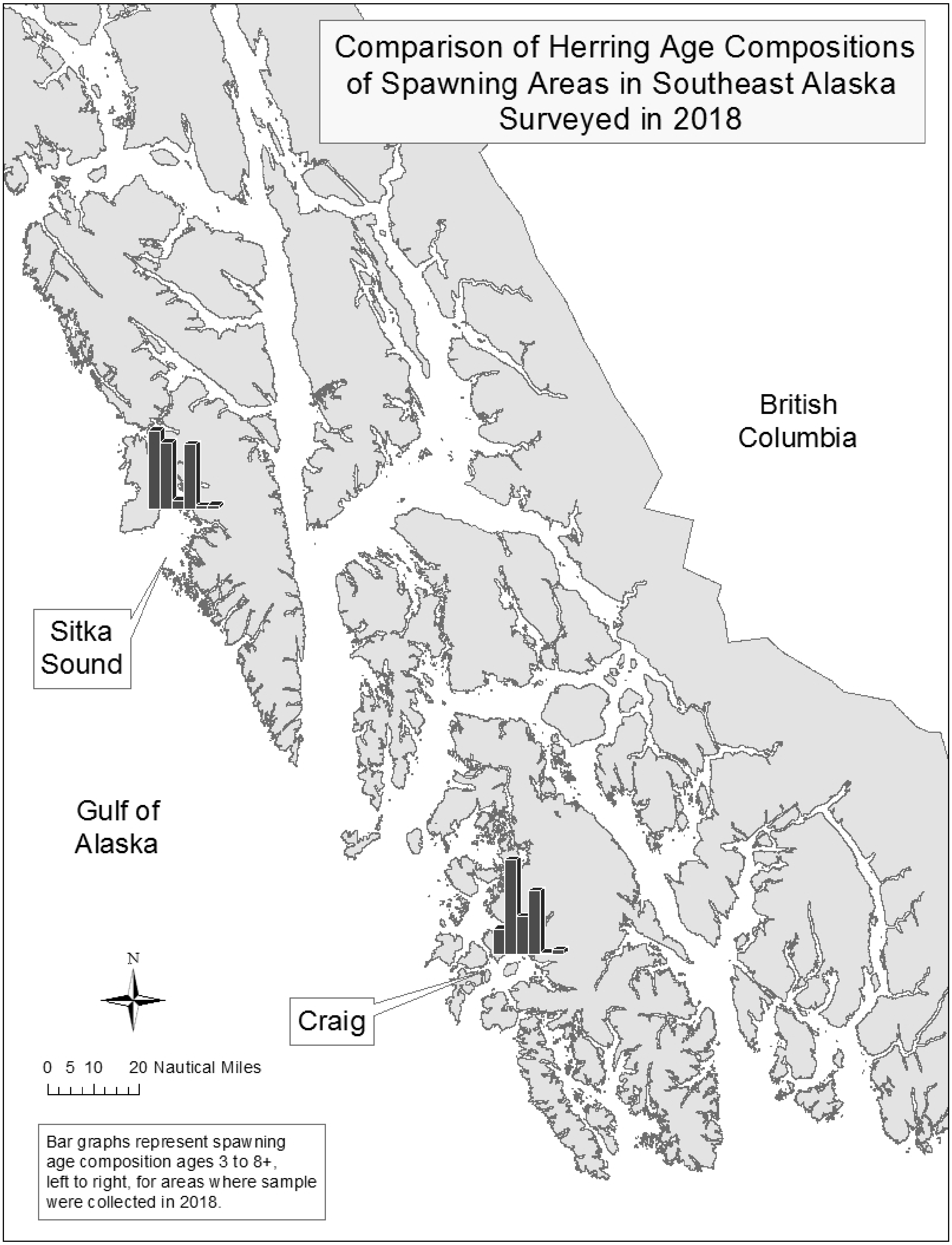



Figure 63.–Regional comparison of observed age compositions of herring spawning stocks in Southeast Alaska that were sampled with cast nets in 2018.

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

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

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

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

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

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

# APPENDIX C: SPAWN SURVEYS BY DATE

Appendix C1.–Aerial and skiff herring spawn surveys by date, in Revilla Channel, Craig, and West Behm Canal (Ketchikan Management Area), Southeast Alaska in 2018.

| **Craig** | |
|---|---|
| March 16, 2018 | Limited herring and predator activity in the Craig Area. |
| March 20, 2018 | No Spawn. Predators in the Craig Area. |
| March 24, 2018 | No Spawn. Predators in the Craig Area. |
| March 27, 2018 | No Spawn. Herring and predators around Clam and Wadleigh Islands. |
| March 29, 2018 | **0.5 nmi. spawn on SW Wadleigh Island and Abbess Island.** |
| March 30, 2018 | **2.5 nmi. spawn on SW Wadleigh Island and Abbess Island.** |
| March 31, 2018 | **4.5 nmi. spawn on Wadleigh Island and Abbess Island.** |
| April 1, 2018 | **7 nmi. spawn on Wadleigh, Clam, Abbess, Fish Egg Islands.** |
| April 2, 2018 | **4 nmi. spawn on Wadleigh, Clam, Abbess, Fish Egg Islands.** |
| April 3, 2018 | **0.25 nmi. spawn on Northeast Fish Egg Island.** |
| April 4, 2018 | **0.5 nmi. spawn on Fish Egg Island.** |
| April 5, 2018 | **0.2 nmi. spawn on Fish Egg Island.** |

| **Revilla Channel** | |
|---|---|
| March 23, 2018 | No Spawn. Limited predator activity. |
| March 27, 2018 | No Spawn. Limited predator activity. |
| March 30, 2018 | No Spawn. Limited predator activity. |
| April 2, 2018 | 0.5 nmi spawn on Mary Island. |
| April 3, 2018 | No spawn observed |
| April 5, 2018 | No spawn. Limited predator activity. |
| April 8, 2018 | No spawn observed. |
| April 11, 2018 | No spawn observed. |

| **West Behm** | |
|---|---|
| April 1, 2018 | No significant activity observed |
| April 8, 2018 | **1.5 nmi of herring spawn on Cleveland Peninsula**. |
| April 9, 2018 | **1 nmi of herring spawn on Cleveland Peninsula**. |
| April 10, 2018 | **1 nmi of herring spawn on Cleveland Peninsula**. |
| April 11, 2018 | **1 nmi of herring spawn on Cleveland Peninsula**. |
| April 12, 2018 | **0.25 nmi of herring spawn on Cleveland Peninsula.** |
| April 13, 2018 | No Spawn observed |

Appendix C2.–Aerial and skiff herring spawn surveys by date, in Sitka Sound and Hoonah Sound (Sitka Management Area), Southeast Alaska in 2018.

**March 09: 1145–1245.** Dupuis/Coonradt. Today's aerial survey covered Sitka Sound north of Cape Burunof, including Krestof Sound. 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 270 sea lions in several large groups holding off the rock piles. South of Sitka, no herring predators were observed. Herring predator numbers observed today are low for timing, however, weather is likely a factor in observed numbers.

**March 12: 0800–0900**. Dupuis/Coonradt. Today's aerial survey covered Sitka Sound north of Cape Burunof, including Krestof and Salisbury sounds. No herring or herring spawn was observed. The highest concentration of herring predators was seen between Bieli Rock and north Crow Island. Numerous whales were seen working in deeper waters north of Bieli Rock and approximately 400 sea lions in several large groups holding off the rock piles. South of Sitka, no herring predators were observed.

**March 13: 1200–1300**. Dupuis/Jensen. Today's aerial survey covered Sitka Sound from West Crawfish Inlet to the Magoun Islands. South of Sitka, several hundred sea lions and a few whales were seen near the rocks south of Biorka Island. The highest concentration of herring predators was observed between Bieli Rock and north Crow Island. Numerous whales were seen working in deeper waters north of Bieli Rock and approximately 400 sea lions in several large groups holding off the rock piles. South of Sitka, no herring predators were observed.

**March 15: 0800–0900**. Dupuis/Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Hayward Strait. Weather during today's flight was glorious with east winds at 5-knots and overcast skies. No herring or herring spawn was observed. The highest concentration of herring predators was still north of Bieli Rock. Numerous whales were seen working in deeper waters north of Bieli Rock and approximately 300 sea lions in several large groups were observed in open water near the whales. A brief boat survey conducted by the department located several whales and sea lions feeding on smaller schools of herring in the shallower waters near the eastern shore of Kruzof Island. Additionally, a test boat located a large biomass of herring north of Bieli Rock this morning, but the fish were too deep to make a successful set.

**March 16: 0800–0900**. Coonradt/Gray. Today's aerial survey covered Sitka Sound from Cape Burunof to Krestof Sound. Weather during today's flight was good with south winds at 5–10 knots and clear skies. No herring spawn was observed. One school of herring was observed in Hayward Strait west of Guide Island. The highest concentration of herring predators was still north of Bieli Rock, where numerous whales were seen working in deeper waters and approximately 400 sea lions in several large groups were observed in open water near the whales. Three test fishing boats located a large biomass of herring north of Bieli Rock this morning, but the herring remained too deep to make a successful set.

**March 17: 0800–0900.** Coonradt. Today's aerial survey covered Sitka Sound from Biorka Island to Krestof Sound. Weather during today's flight was good with south winds at 5–10 knots and overcast skies. No herring or herring spawn was observed on today's flight. The highest concentration of herring predators has moved over to the Kruzof Island shoreline between Inner Point and Hayward Strait, where numerous whales were seen working the edge of the deeper waters and several large groups of sea lions were observed in open water near the whales. Predators remain in the Bieli Rock area but not in concentrations observed in previous flights. The sea lion haul-out near Biorka Island still had approximately 250 sea lions, suggesting some herring are still in the deeper waters outside of Sitka Sound. No test fish vessels were available for today, so no samples were taken.

**March 18:** **0800–0900**. Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Hayward Strait. Weather during today's flight was good with south winds at 10 knots and overcast skies. No herring spawn was observed on today's flight. Several large herring schools were observed in Crow Pass spanning its entire length. The highest concentration of herring predators has moved to the Crow Pass/Bieli Rock area, where numerous whales were seen feeding on the herring schools observed in the area and several large groups of sea lions were observed near the whales. Predators remain in the Inner Point/Mountain Point area but not in concentrations observed in yesterday's flights. Two test fish vessels were available for today, however no samples were taken.

The Alaska Department of Fish and Game announced today that the Sitka Sound sac roe herring fishery will be on 2-hour notice effective 7:00 a.m., Tuesday, March 20, 2018.

- Jig sample: Crow Pass 4/5 5-gallon bucket. 8.7% mature roe; 135 grams.

**March 19:** **0900–1000**. Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Hayward Strait. Weather during today's flight was poor with south winds at 15–20 knots and overcast skies with rain and low layers. No herring spawn was observed on today's flight. One smaller herring school was observed in south Crow Pass. The highest concentration of herring predators was concentrated around the Crow Island/Bieli Rock area, where numerous whales were seen feeding on the herring and several large groups of sea lions were observed near the whales. Predators remain in the Inner Point area, and whales have moved into the eastern Middle Island area. One test fish vessel was available for today, however no samples were taken.

**March 20:** **0800–0900**. Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Hayward Strait. Weather during today's flight was poor with south winds at 20–25 knots and overcast skies with snow squalls. No herring spawn was observed on today's flight. The highest concentration of herring predators was observed northwest of Bieli Rock. Numerous whales were observed in deeper waters northwest of Bieli Rock to Guide Island. Large groups of sea lions were seen off Inner Point, Bieli Rock, and north Crow Island. The vessel survey conducted by the R/V Kestrel showed a large biomass of herring in the deeper waters northwest of Bieli Rock and several smaller schools northeast of Middle Island and east of the Siginaka Islands. While the fish tended to remain deep, several moderately sized schools broke off and were located in shallower water near Guide Island before returning to deeper waters. Several test fishing vessels were available for today, however no samples were taken.

**March 21:** **0800–0900.** Dupuis/Pawluk. Today's aerial survey covered Sitka Sound from Eastern Channel to Hayward Strait. Weather during today's flight was good with northeast winds at 10 knots and partly cloudy skies. No herring or herring spawn was observed on today's flight. The highest concentration of herring predators was observed northwest of Bieli Rock. Numerous whales were observed in deeper waters northwest of Bieli Rock to Guide Island. Large groups of sea lions were seen off Inner Point, Bieli Rock, and north Crow Island. Several whales were also observed between Middle Island and Halibut Point. The vessel survey conducted by the R/V Kestrel showed a large biomass of herring in the deeper waters northwest of Bieli Rock with several smaller school's northeast of Middle Island. Another large school of herring was observed east of Middle Island as far north as the Siginaka Islands. Several test fishing vessels were available for today, however no samples were taken.

**March 22:** **0800–0900.** Dupuis/Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Hayward Strait. Weather during today's flight was poor with northeast winds at 30 knots and partly cloudy skies. No herring or herring spawn was observed on today's flight. The highest concentration of herring predators was observed northwest of Bieli Rock. Numerous whales were observed in deeper waters northwest of Bieli Rock to Guide Island. Large groups of sea lions were seen off Inner Point, Bieli Rock, and north Crow Island.

**March 23:** **0800–0900**. Coonradt/Fair. Today's aerial survey covered Sitka Sound from West Crawfish Inlet to Krestof Sound. Weather during today's flight was good with northeast winds at 10 knots and partly cloudy skies. No herring or herring spawn was observed on today's flight. The highest concentration of herring predators was observed northwest of Bieli Rock. Numerous whales were observed in deeper waters northwest of Bieli Rock to Guide Island. Large groups of sea lions were seen off Inner Point, Bieli Rock, and north Crow Island. The vessel survey conducted by the R/V Kestrel showed a large biomass of herring in the deeper waters northwest of Bieli Rock. Later in the day fish moved into shallower water near Guide Island and Kresta Point. Three successful test sets were made today.

- 12:30 p.m. F/V Invincible; Guide Island; 25 ton set; 8.7% mature roe, 1.6% immature roe; 112 gram average weight; 44.0% female.
- 1:30 p.m. F/V Anduril; Guide Island; 5 ton set; 15.4% mature roe, 0.3% immature roe; 134 gram average weight; 64.3% female.
- 2:30 p.m. F/V Chelsea Dawn; Kresta Point; 75 ton set; 10.6% mature roe, 2.5% immature roe; 98 gram average weight; 58.4% female.

**March 24:** **0800–0900**. Today's aerial survey covered Sitka Sound from Eastern Channel to Krestof Sound. Weather during today's flight was good with calm wind and clear skies. Several large schools of herring were observed around Shoals Point and approximately 1.9 nm of herring spawn was observed near Fred's Creek. The highest concentration of herring predators was observed near the Kruzof Island shoreline north of Shoals Point continuing into Eastern Bay. The large concentrations of whales working the deeper waters north of Bieli Rock have dispersed to the shorelines of eastern Kruzof and eastern Krestof islands. The vessel survey conducted by the R/V Kestrel showed a large biomass of herring in shallower waters off the shorelines of eastern Kruzof and eastern Krestof islands. Four successful test sets were made today; however, results of the test sets did not warrant prosecuting a fishery. **Total spawn was 1.9 nmi**.

- 9:00 a.m. *F/V Anduril*; Promisila Bay; 200 ton set; 9.7% mature roe, 0.8% immature roe; 129 gram average weight; 45.0% female.
- 10:00 a.m. *F/V Perseverance*; Inner Point; 100 ton set; 8.3% mature roe, 1.3% immature roe; 100 gram average weight; 40% female.
- 11:00 a.m. *F/V Invincible*; Shoals Point; 20 ton set; 8.8% mature roe, 1.0% immature roe; 119 gram average; 40% female.
- 1:00 p.m. *F/V Sea Prince*; Promisila Bay; 25 ton set; 14.0% mature roe, 1.0% immature roe; 123 gram average weight; 63.3% female.

**<u>March 25:</u> 0800–0900.** Today's aerial survey covered Sitka Sound from Eastern Channel to Krestof Sound. Weather during today's flight was good with calm wind and high overcast. Some small schools of herring were observed near the Siginaka Islands and approximately 7.0 nm of herring spawn was observed on Kruzof Island. The highest concentration of herring predators was observed near the Kruzof Island shoreline from Lava Island to Shoals Point continuing north to Inner point, and in. The large concentrations of whales working the deeper waters north of Bieli Rock have dispersed to the shorelines of eastern Kruzof Island and Eastern/Promisila Bay. The vessel survey conducted by the R/V Kestrel and radio hails from commercial fishing vessels showed a large biomass of herring in shallower waters off the shorelines of eastern Kruzof Island and Eastern/Promisila Bay. Several test sets were conducted early in the day. **Total spawn was 7.0 nmi**.

- 9:30 a.m. *F/V Harvester*; Eastern Bay; 100 ton set; 12.1% mature roe, 0.8% immature roe; 125 gram average weight; 52.3% female.
- 9:45 a.m. *F/V Invincible*; Mountain Point; 50 ton set; 10.3% mature roe, 0.0% immature roe; 117 gram average weight; 45.7% female.
- 9:45 a.m. *F/V Perseverance*; Mountain Point; 300 ton set; 11.67% mature roe, 0.4% immature roe; 120 gram average weight; 58.8% female.

The fishery was opened from 1:00 p.m. until 6:00 p.m.; the estimated harvest from this period was approximately 2,500 tons.

**<u>March 26:</u> 0800–0900**. Dupuis. Today's aerial survey covered Sitka Sound from Eastern Channel to Krestof Sound. Weather during today's flight was poor with low ceiling and snow. Approximately 7.0 nm of herring spawn was observed on the Kruzof Island shoreline from Shoals Point to Inner Point. Herring predators were widely distributed throughout the area with the highest concentration being in Eastern and Promisila bays. The vessel survey conducted by the R/V Kestrel and radio hails from commercial fishing vessels showed several schools of herring in shallower waters off the shorelines of Eastern/Promisila Bay. **Total spawn was 7.0 nmi.**

- 9:15 a.m. *F/V Invincible*; Promisila Bay; 125 ton set; Sample 1) 11.0% mature roe, 125 gram average weight; Sample 2) 12.1% mature roe, 114 gram average weight; Sample 3) 13.6% mature roe, 125 gram average weight; sampled on the grounds by Icicle.

The fishery was opened from 11:30 a.m. until 4:00 p.m.; the estimated harvest from this period was approximately 400 tons.

**<u>March 27</u>: 0800–0900**. Dupuis/Jensen. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. Weather during today's flight was poor with low ceiling and snow. Small schools of herring were observed in Eastern Bay and a small amount of spawn was located in Eastern Bay. Herring predators were widely distributed throughout the area with no large concentration identified. The vessel survey conducted by the R/V Kestrel focused on the area south of Sitka and within waters closed to commercial fishing. Several large schools were located off of Makhnati Island and Indian River. Additionally, several large schools were located east of Middle Island and East of the Kasiana Islands. **Total spawn was 0.04 nmi.**

**<u>March 28</u>: 0800–0900**. Dupuis/Gray. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. Weather during today's flight was good with overcast skies and 10 knot winds. A small amount of spawn was located in Eastern Bay. Herring predators were widely distributed throughout the area with concentrations of whales and sealions observed in St. John Baptist Bay and Hayward Strait. The vessel survey conducted by the R/V Kestrel identified several large schools in Hayward Strait. Several test sets were conducted but did not yield herring of sufficient quality to warrant a fishery. **Total spawn was 0.04 nmi.**

- 10:30 a.m. *F/V Harvester*; Hayward Strait; 5 ton set; 5.03% mature roe, 5.07% immature roe; 88 gram average weight; 46.8% female.
- 12:00 p.m. *F/V Anduril*; Mountain Point; Sample 1) 5.0% mature roe, 4.5% immature roe, 93 gram average weight; Sample 2) 5.0% mature roe, 3.2% immature roe, 86 gram average weight; Sample 3) 6.0% mature roe, 4.5% immature roe, 82 gram average weight; sampled on the grounds.
- 2:00 p.m. *F/V Hukilau*; Hayward Strait; Sample 1) 6.0% mature roe, 3.2% immature roe, 104 gram average weight; Sample 2) 6.8% mature roe, 2.4% immature roe, 105 gram average weight, 7.9% mature roe, 2.6% immature roe, 105 gram average weight; sampled on the grounds.

**March 29: 0800–0900**. Dupuis. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. Weather during today's flight was good with overcast skies and 10 knot winds. A small amount of spawn was located in Eastern Bay. Herring predators were widely distributed throughout the area. The vessel survey conducted by the R/V Kestrel identified several large schools in St. John Baptist Bay. Several test sets were conducted but did not yield herring of sufficient quality to warrant a fishery. **Total spawn was 0.3 nmi.**

- 8:00 a.m. *F/V Chelsea Dawn*; St. John Baptist Bay; 75 ton set; 6.4% mature roe, 2.9% immature roe; 87 gram average weight; 42.9% female.
- 9:30 a.m. *F/V Emily Nichole*; St. Joh Baptist Bay; 75 ton set; 7.1% mature roe, 2.1% immature roe; 85 gram average weight; 39.38% female.

R/V Kestrel departed Sitka. Met with processors to discuss future of 2018 fishery. Agreed to keep assessing with test vessel and aerial surveys.

**March 30: 0800–0900.** Dupuis. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. Weather during today's flight was good with clear skies and 10 knot winds. Approximately 2 nm of spawn was located in Eastern Bay and the Siginaka Islands. Herring predators were widely distributed throughout the area. The vessel survey conducted by industry vessels located several schools of herring in southern Olga Strait. Several test sets were conducted but did not yield herring of sufficient quality to warrant a fishery. **Total spawn was 2.0 nmi.**

- 1:30 p.m. *F/V Valkyrie*; Eastern Point; 10 ton set; 8.5% mature roe, 1.23% immature roe; 104 gram average size; 43.75% female.
- 1:50 p.m. *F/V Anduril*; Eastern Point; 5 ton set; 7.9% mature roe, 1.5% immature roe; 84 gram average weight; 32.8% female.

**March 31: 0930–1045**. Coonradt. Today's aerial survey covered Sitka Sound from Cape Burunof to Salisbury Sound. Weather was clear with NE winds 15–25 knots. Active spawn was observed near Inner Point, Eastern Bay, and the Siginaka Islands. **Total spawn was 4.2 nmi**.

**April 1: 08:00–09:00.** Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. No spawn observed.

**April 2:** **08:00–09:00.** Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. No spawn observed.

**April 3:** **08:00-09:00.** Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. No spawn observed. Fishery closed.

**April 4:** **0800–0900**. Dupuis. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. No spawn observed.

**April 5:** **08:00–09:00.** Jensen. No active spawn observed. Skiff survey conducted in the Siginaka Islands. **Added 1.8 nmi of spawn.**

**April 6:** 08:00–09:00. Coonradt. No spawn observed.

**April 7:** 08:00–09:00. Coonradt. No spawn observed.

**April 8:** 08:00–09:00. Coonradt. No spawn observed.

**April 9:** **0800–0900**. Coonradt. Today's aerial survey covered Sitka Sound from Cape Burunof to Krestof Sound. Weather was overcast with SE winds at 15 knots. Active spawn was observed on the Kruzof Island shoreline north of Inner Point. **Total spawn was 1.4 nmi.**

**April 10:** **0800–0900.** Coonradt. Today's aerial survey covered Sitka Sound from Cape Burunof to Dry Pass. Weather was overcast with SE winds 15–25 knots. Active spawn was observed on the Kruzof Island shoreline from Inner Point to Point Brown. **Total spawn was 3.7 nmi.**

**April 11:** **1300–1400**. Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. Weather was clear with SE winds 10–15 knots. Active spawn was observed on the Kruzof Island shoreline from Inner Point to Point Brown and in the southern Magoun Islands. **Total spawn was 5.8 nmi.**

**April 12:** **1300–1345**. Coonradt. Today's aerial survey covered Sitka Sound from Makhnati Island to Mud Bay. Weather was overcast with SE winds 20–25 knots. Active spawn was observed on the Kruzof Island shoreline from Inner Point to Point Brown, in the Magoun Islands, and Crow Island. **Total spawn was 8.3 nmi.**

**April 13:** **1000–1100**. Jensen. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. Active spawn was observed on the Kruzof Island shoreline in Krestof Sound, in the Magoun Islands, on Crow Island, and on Middle Island. **Total spawn was 7.7 nmi.**

**April 14:** **0800–0900**. Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. Weather was clear and calm. Active spawn was observed in the Magoun Islands, on Crow Island, and on Middle Island. **Total spawn was 1.0 nmi.**

**April 15:** **1300–1400**. Jensen. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. Weather was clear with SE winds 15–20 knots. Active spawn was observed in the Magoun Islands. **Total spawn was 0.1 nmi.**

**April 16:** **1300–1400**. Dupuis. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. Weather was clear with light winds. Active spawn was observed near Fred's Creek and Sandy Beach. **Total spawn was 0.2 nmi.**

**April 17:** **1300–1400**. Dupuis. Today's aerial survey covered Sitka Sound from Dorothy Narrows to Salisbury Sound. Weather was clear with SE winds 15–20 knots. Active spawn was observed in Dorothy Narrows, Crow Island, and Middle Island. **Total spawn was 0.6 nmi.**

**<u>April 18:</u>** No flight due to weather.

**<u>April 19:</u>** No flight due to weather.

**<u>April 20:</u> 1300–1500**. Dupuis. Today's aerial survey covered Sitka Sound from Dorothy Narrows to Hoonah Sound. Weather was foggy and rainy with calm winds. No active spawn was observed. Skiff survey conducted. **<u>Added</u> 1.5 nmi of spawn.**

No spawn or herring observed in Hoonah Sound.

**<u>April 21:</u>** No flight.

**<u>April 22:</u>** No flight.

**<u>April 23:</u> 1400–1600**. Dupuis. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound, including Hoonah Sound. Weather was overcast with fog and calm winds. Active spawn was observed near Hayward Point. **Total spawn was 0.2 nmi.** No herring spawn or herring predators were seen in Hoonah Sound.

**<u>April 24:</u>** No flight was scheduled for today.

**<u>April 25:</u> 0830–0930**. Dupuis. Today's aerial survey covered Sitka Sound from Makhnati Island to Salisbury Sound. Weather was overcast with SE winds to 10 knots. Active spawn was observed near Hayward Point and in Promisila Bay. **Total spawn was 0.9 nmi.**

**<u>April 26:</u> 1000–1100**. Dupuis/Coonradt. Today's aerial survey covered Sitka Sound from Makhnati Island to Salisbury Sound. Weather was overcast with calm winds. Active spawn was observed near Hayward Point and Marine Cove. **Total spawn was 1.8 nmi.**

Additionally, we received a report from a fisherman who was in Hoonah Sound from 4/25 to 4/26. He observed some small schools of herring, no herring predators, and no herring spawn within Hoonah Sound.

**<u>April 27:</u> 0800–0900**. Dupuis. Today's aerial survey covered Sitka Sound from Makhnati Island to Salisbury Sound. Active spawn was observed near Gilmer Cove and Promisila Bay. **Total spawn was 1.0 nmi.**

**<u>April 28:</u>** Dupuis. **0800–0900**. Today's aerial survey covered Sitka Sound from Makhnati Island to Salisbury Sound. Weather was clear with light winds. Active spawn was observed near Promisila Bay. **Total spawn was 1.1 nmi.**

**<u>April 29:</u> 0800–0900.** Coonradt. Today's aerial survey covered Sitka Sound from Eastern Channel to Salisbury Sound. Weather was overcast and calm. Active spawn was observed near Promisila Bay. **Total spawn was 0.6 nmi.**

**<u>April 30:</u> 0930–00945**. Dupuis. Today's aerial survey covered Sitka Sound from Makhnati the Magoun Islands. Weather was poor with very low ceilings. Flight was turned around in the Magoun Islands due to poor visibility. No spawn was observed. Last flight of 2018.

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, 2018.

# BRADFIELD CANAL

Not Surveyed in 2018.

# VIXEN INLET/ UNION BAY/EMERALD BAY

Total miles of spawn: ~3.5 nm

Spawning dates: 4/25, possibly a day or two earlier

Peak spawning: 4/25

4/9 No herring spawn or schools observed, 16 sea lions, no birds.

4/12 One herring school, no herring spawn, 24 sea lions, very few birds.

4/15 No herring spawn or schools observed, 37 sea lions, very few birds.

4/17 One spot spawn, no herring schools, 74 sea lions, 1,000 scoters, one whale.

4/18 Three herring schools, no herring spawn, 36 sea lions, 2,000 scoters.

4/20 No herring spawn or schools observed, 19 sea lions, very few birds.

4/21 One spot spawn, one school of herring, 32 sea lions, 1,500 scoters.

4/22 No herring spawn or schools observed, 36 sea lions, 2,000 scoters, 500 gulls.

4/25 **1.0 nm of active spawn**, nine herring schools, 26 sea lions, 1,000's of scoters.

4/26 Three areas of older milt, two schools of herring, 62 sea lions, 1,000's of scoters.

4/27 No herring spawn or schools observed, 28 sea lions, 1,000's of scoters and gulls.

4/28 No herring spawn or schools observed, 6 sea lions, 1,000's of scoters and gulls.

5/1 3.5nm egg deposition by skiff survey.

# ONSLOW/STONE/BROWNSON ISLAND/CANOE PASS

Total miles of spawn: 0.0 nm

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

4/17 One area of old milt, no herring schools observed, no sea lions, 100 scoters.

4/18 One area of old milt, no herring schools observed, no sea lions or birds.

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

4/21 No herring activity, no eggs observed on beach of earlier activity during skiff survey.

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

4/25 No herring spawn or schools observed, no sea lions or birds.

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

4/27 No herring spawn or schools observed, no sea lions or birds.

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

## ZIMOVIA ST. AND EASTERN PASSAGE

Total miles of spawn: 0.0 nm

4/9 No herring spawn or schools observed, no sea lions or birds.

4/12 No herring spawn or schools observed, 700 scoters on sandy deltas

4/17 No herring spawn or schools observed, 1,500 scoters on sandy deltas.

4/18 No herring spawn or schools observed, 1,000 scoters on sandy deltas.

4/20 No herring spawn or schools observed, very few birds.

4/21 One school of herring, no sea lions or birds.

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

4/25 One school of herring, 1,500 scoters on sandy deltas.

4/26 No herring spawn or schools observed, very few birds.

4/27 No herring spawn or schools observed.

4/28 No herring spawn or schools observed.

## BEAR CREEK

Not Surveyed in 2018.

## FARRAGUT BAY

Total miles of spawn: ~0.4 nm

Spawning dates: 4/26

Peak spawning: 4/26

4/24 No herring spawn or schools observed, 22 sea lions.

4/26 **~ 0.25 miles of active spawn reported with supporting photographs by industry pilot.**

4/27 No active spawn, 1 herring school, 23 sea lions, 6,000 scoters.

5/3 No herring spawn or schools observed, 7 sea lions.

5/4 No herring spawn or schools observed.

5/5 No herring spawn or schools observed, 500 scoters.

5/6 No herring spawn or schools observed, 14 sea lions.

## HOBART BAY

Total miles of spawn: ~0.4 nm

Spawning dates: 5/3

Peak spawning: 5/3

4/24 No herring spawn or schools observed, 21 sea lions, 6,000 scoters.

4/27 No herring spawn or schools observed, 37 sea lions, 1,100 scoters.

5/3 **~0.1 nm active spawn,** 6 sea lions, 1 whale, 1,000 scoters.

5/4 No herring spawn or schools observed, 200 scoters.

5/5 No herring spawn or schools observed.

5/6 No herring spawn or schools observed. 2 sea lions, 1 whale, 1,000 scoters.

## PORT HOUGHTON

Total miles of spawn: ~3.6 nm

Spawning dates: 5/3–5/5

Peak spawning: 5/4

4/24 No herring spawn or schools observed, 7 sea lions, 200 scoters.

4/27 No herring spawn or schools observed, 15 sea lions, 400 scoters.

5/3 ~**0.2 nm active spawn, 2 schools of herring,** 10 sea lions, 2 whales, 300 gulls.

5/4 ~**0.6 nm active spawn, 2 schools of herring,** 30 sea lions, 300 gulls.

5/5 **~0.5 nm active spawn, 1 school of herring,** 68 sea lions, 3,000 scoters, 500 gulls.

5/6 No herring spawn or schools observed, 39 sea lions, 3,500 scoters, 700 gulls.

## SUNSET COVE/WINDHAM BAY

4/24 No herring spawn or schools observed, 5 sea lions.

4/27 No herring spawn or schools observed, 1 sea lion.

5/3 No herring spawn or schools observed, 40 sea lions, 300 scoters.

5/4 No herring spawn or schools observed.

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

5/6 No herring spawn or schools observed, 1 sea lion, 1,000 scoters.

## GAMBIER BAY/PYBUS BAY

Not Surveyed in 2018.

## PORT CAMDEN

Not Surveyed in 2018.

## TEBENKOF BAY

Not Surveyed in 2018.

Appendix C4.–Aerial and skiff herring spawn surveys by date, in Juneau Management Area, in Southeast Alaska, 2018.

**Seymour Canal**

Number of times surveyed: 13

Total miles of spawn: 1.4

Spawning dates: 5/9–5/12

Peak spawn: 5/10

4/17: No herring or herring spawn; 52 SL most at Pt Hugh and up Stephens Passage; 12 orca. Excellent vis.

4/21: No herring or herring spawn; 65 SL similar distribution; 8 whales; reported biomass S of Blackjack Cove. Good vis.

4/24: No herring or herring spawn; 32 SL similar w/ distribution; good visibility.

4/27: No herring or herring spawn; 32 SL similar distribution; 3 whales widely spaced good vis.

4/30: No herring or herring spawn; 66 SL, 55 at Pt Hugh, 6 whales also at Pt Hugh. Good vis.

5/3: No herring or herring spawn; 89 SL, 6 whales. Good vis.

5/7: No herring or herring spawn; 139 SL and 10 whales. Excellent vis.

5/8: Numerous herring schools on beach on Stephens Passage side of lower Glass Peninsula; 116 SL and 5 whales. Good vis.

5/9: Spawn at Point Hugh, a few schools of herring nearby. 80 SL, 1 whale. Good vis.

5/10: 1.2 nm active spawn between Cloverleaf Rocks and Point Hugh. Few predators fair to good vis.

5/11: 0.36 nm active spawn between Cloverleaf Rocks and Pt Hugh. 3 whales, good vis.

5/12: trace of spawn at Cloverleaf Rocks, schools on the beach between Pt Hugh and blackjack.

5/14: No herring or herring spawn, very few predators.

**Tenakee Inlet**

Number of times surveyed: 10

Total miles of spawn: 1.4

Spawning dates: 5/7-5/9

Peak spawn: 5/8

4/17: No herring or herring spawn; 14 SL all in Chatham; no whales. Excellent vis.

4/21: No herring or herring spawn; 43 SL most between Saltery and Corner Pt. ~100 at Cannery Pt haulout. No whales. Good vis.

4/24: No herring or herring spawn; 34 SL, most by Crab Bay, ~100 at Cannery Pt haulout. Excellent vis.

4/27: No herring or herring spawn; 4 scattered single sealions along southern shore with ~100 at Cannery Pt. Excellent vis.

4/30: No herring or herring spawn; 9 scattered sealions Corner Pt, Crab Bay and Saltery Cove still over 100 at Cannery Pt. Good vis.

5/3: No herring or herring spawn; 2 SL with ~100 at Cannery Pt haulout.

5/7: Herring schools on Kadashan flats, about **0.25 nmi light spawn** by Rudy Creek. Few predators ~100 SL at Cannery Pt. Excellent vis.

5/8: Observed about **0.75 nmi light spawn** by Rudy Creek and in pounding area. Few Predators, ~100 SL at Cannery Pt.

5/9: Observed about **0.2 of light and trace spawn** on either side of Crab Bay entrance. Few Predators, ~100 SL at Cannery Pt. Excellent vis

5/10: One small school on Corner Point. Few predators ~100 SL at Cannery Pt. Excellent vis.

**<u>Lynn Canal</u>**

Number of times surveyed: 14

Total miles of spawn: 1.9

Spawning dates: 5/10-5/12; 5/14, 5/15

Peak spawn: 5/12

4/17: No herring or herring spawn; 49 SL, 30 scattered in Berners Bay. Benjamin Island near full (300+ animals). No whales. No eulachon activity

4/21: No herring or herring spawn; 118 SL, 87 in Berners Bay, mostly along southern beach. Benjamin Is half full. One whale.

4/24: No herring or herring spawn; 54 SL, most along southern side of Berners Bay. Benjamin half full again. Very quiet along road system.

4/27: No herring or herring spawn; 28 SL scattered, one whale at Pt St Mary. No birds or seals at Berners Bay river mouths. Good vis.

4/30: No herring or herring spawn; 36 SL 2 whales. All but 3 SL near Point Bridget. Good vis.

5/3: No herring or herring spawn; 43 SL plus 200 in Slate Cove, 2 whales. Good vis.

5/7: Herring schools in Bridget Cove; 59 SL, 5 whales. Good vis

5/8: Herring schools in Auke Bay, Auke Rec, Eagle River, Sunshine Cove, Bridget Cove and north of Pt St Mary. No herring spawn. 18 SL and 3 whales. Good to excellent vis.

5/10: Large body of herring on the beach west of Cowee Creek with spot spawn in center, 0.6 nm of active spawn N of Pt St Mary. Good vis

5/11: Spot spawn west of Cowee Creek. Schools of herring on S shore and Pt Bridget. Fair to poor vis.

5/12: 0.6 nm spawn on reefs W of Cowee Creek, school on beach in front of Blue Mussel Cabin.

5/14: Spot spawns just N of Pt Bridget, no herring. 70 SL by Pt Bridget.

5/15: 0.5 nm spawn west of Cowee Creek and in N Bridget Cove. Schools in Bridget Cove, 12 sealions by Bridget Cove spawn.

5/16: No spawn, 2 small schools in S Bridget Cove, few predators.

**Port Frederick**

Number of times surveyed: 8

Total miles of spawn observed: 0

4/17: No herring or herring spawn; one SL and one whale.

4/21: No herring or herring spawn; no predators.

4/24: No herring or herring spawn; no predators.

4/27: No herring or herring spawn; 5 SL N of Cannery Point, 7 whales – 6 together in middle of bay off Hoonah

4/30: No herring or herring spawn; 5 SL N of Cannery Point, 1 whale, offshore south of Hoonah

5/3: No herring or herring spawn; 1 whale observed between Hoonah and Cannery Point – reports of people catching herring in Hoonah.

5/7: No herring or herring spawn; no predators.

5/9: No herring or herring spawn; few predators.

**Oliver Inlet and Stephens Passage**

Number of times surveyed: 12

Total miles of spawn: 1.1

4/17: No herring or herring spawn; no predators.

4/21: No herring or herring spawn; no predators.

4/24: No herring or herring spawn; no predators.

4/24: No herring or herring spawn; no predators.

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

5/3: No herring or herring spawn; no predators.

5/7:  No herring or herring spawn; no predators.

5/9:  .9 nm spawn by Stink Creek, herring school near Oliver Inlet; few predators.

5/10: .5 nm spawn by Stink Creek, 150 yds south of Outer Point.

5/11: No herring or herring spawn; no predators.

5/12: No herring or herring spawn; no predators.

5/14: No herring or herring spawn; no predators.

**Taku Harbor**

5/8:  No herring or herring spawn; no predators.

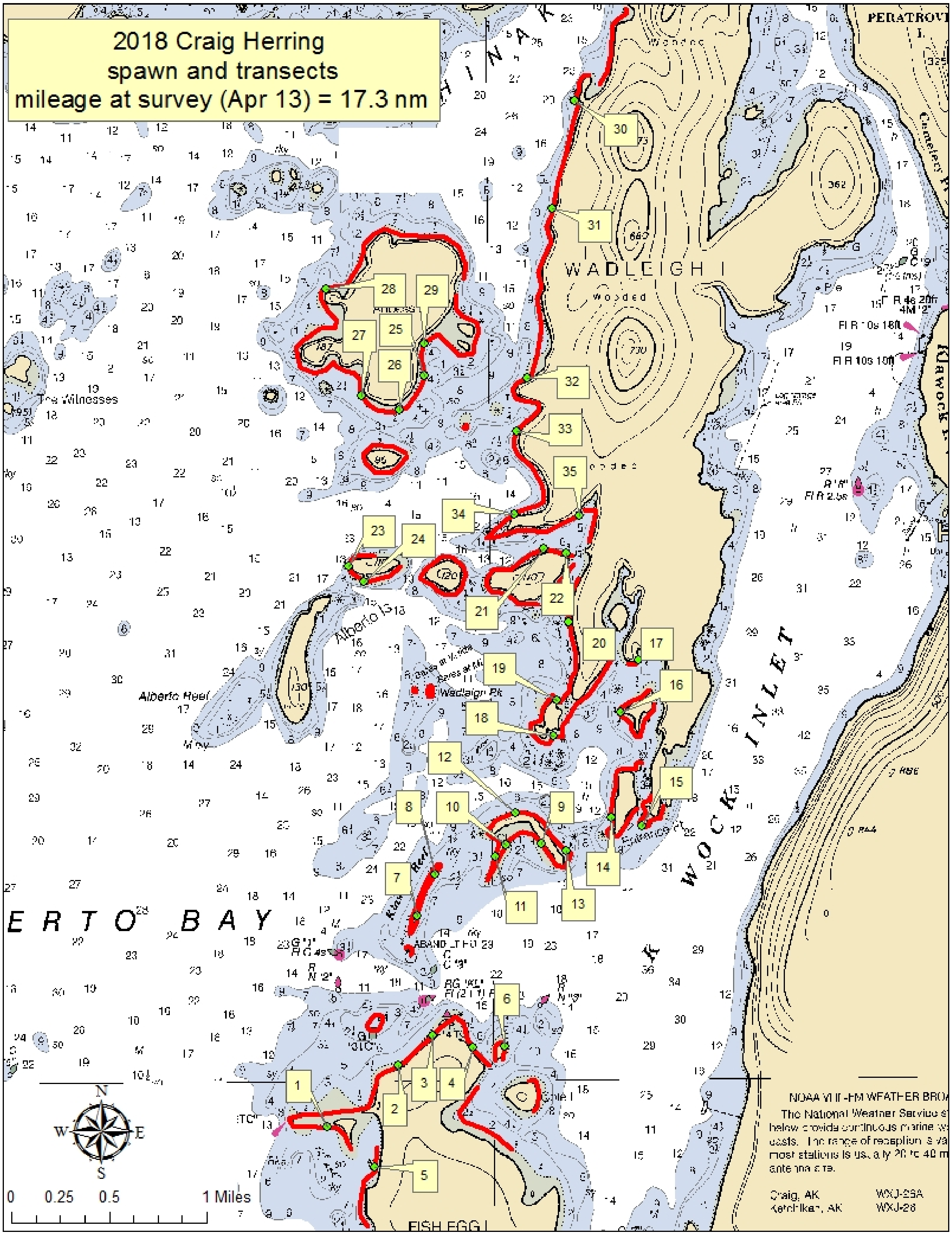
Appendix C5.–Aerial and skiff herring spawn surveys by date, in the Yakutat Management Area, in Southeast Alaska, 2018.

**Yakutat Bay**

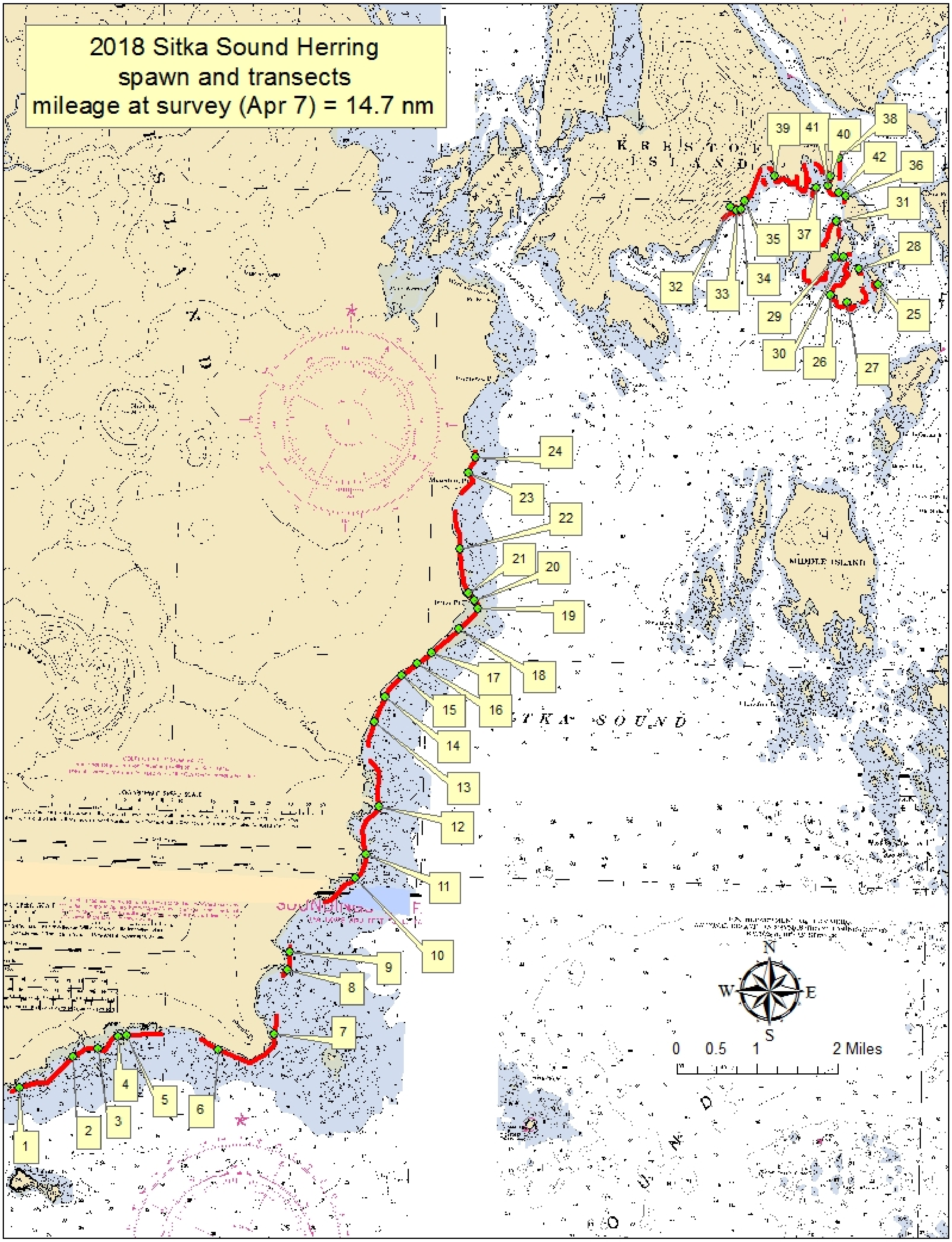
There were no aerial survey flights conducted in 2018. Total miles of spawn for the season are unknown.

# APPENDIX D: SPAWN AND SPAWN DEPOSITION SURVEY TRANSECT LOCATIONS

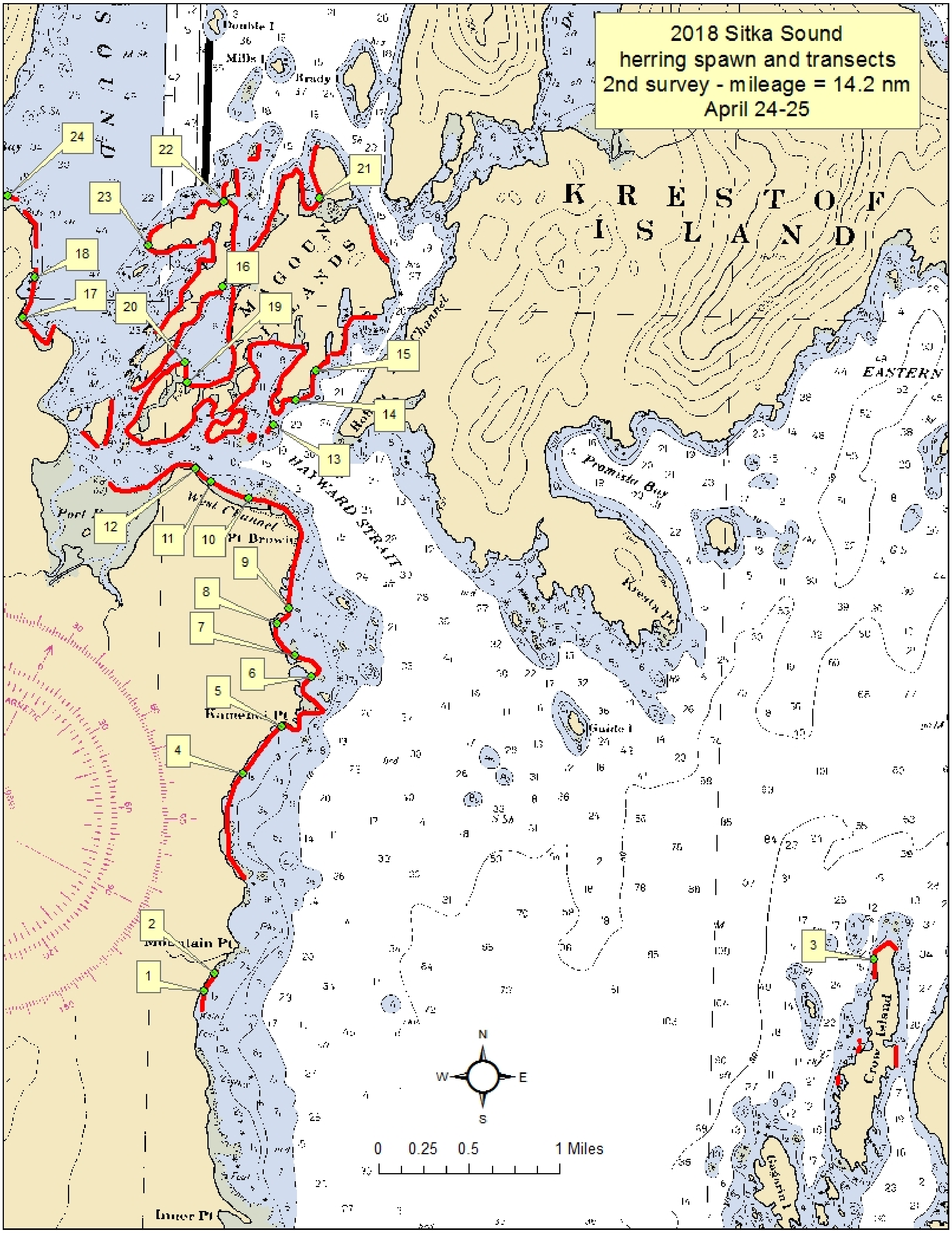
Appendix D1.–Spawn (heavy gray line) and spawn deposition survey transect locations (numbered labels) for the Craig herring stock in 2018. Spawn mileage up to date of dive survey.



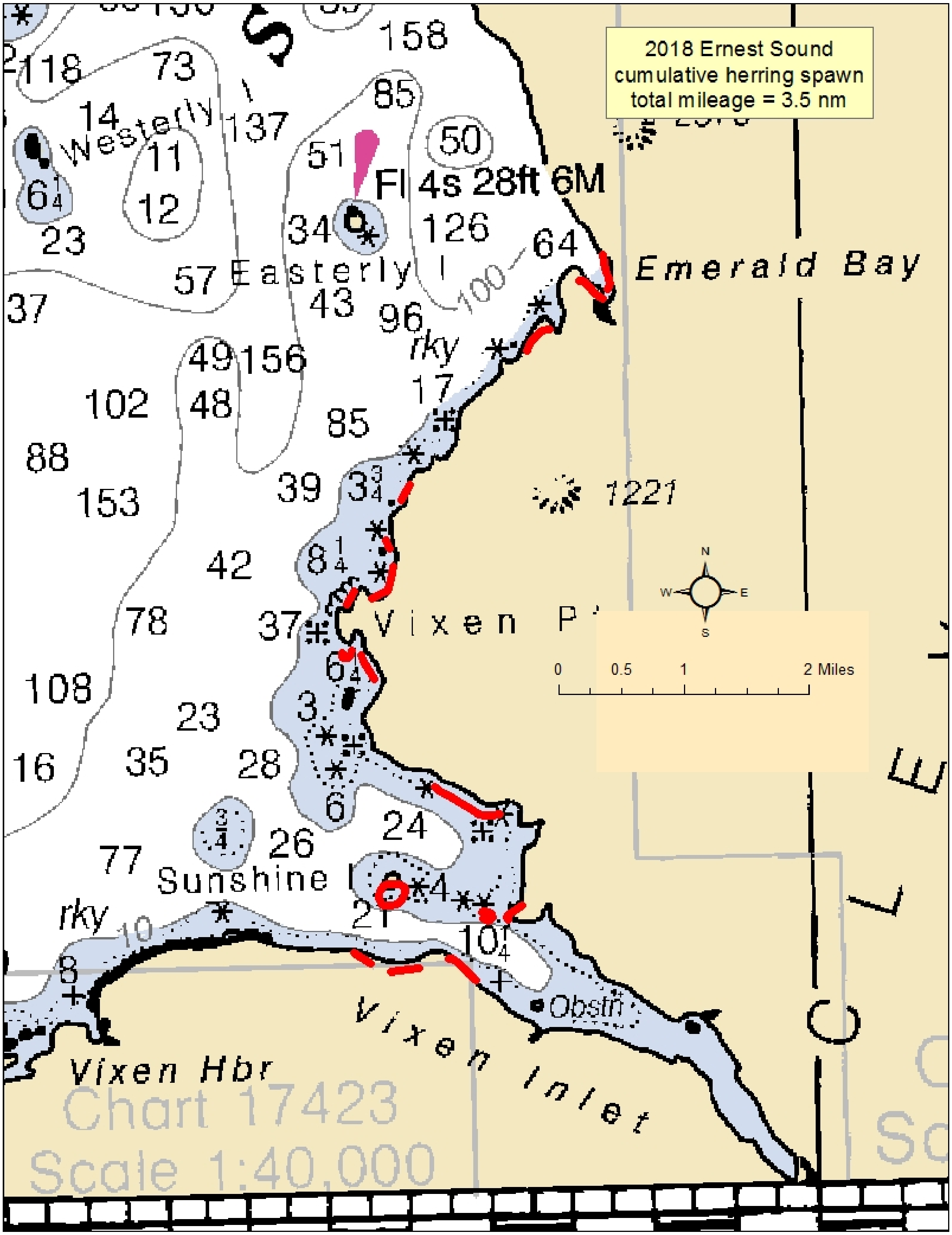
Appendix D2.–Spawn (heavy gray line) and spawn deposition survey transect locations (numbered labels) for the Sitka Sound herring stock first survey in 2018.



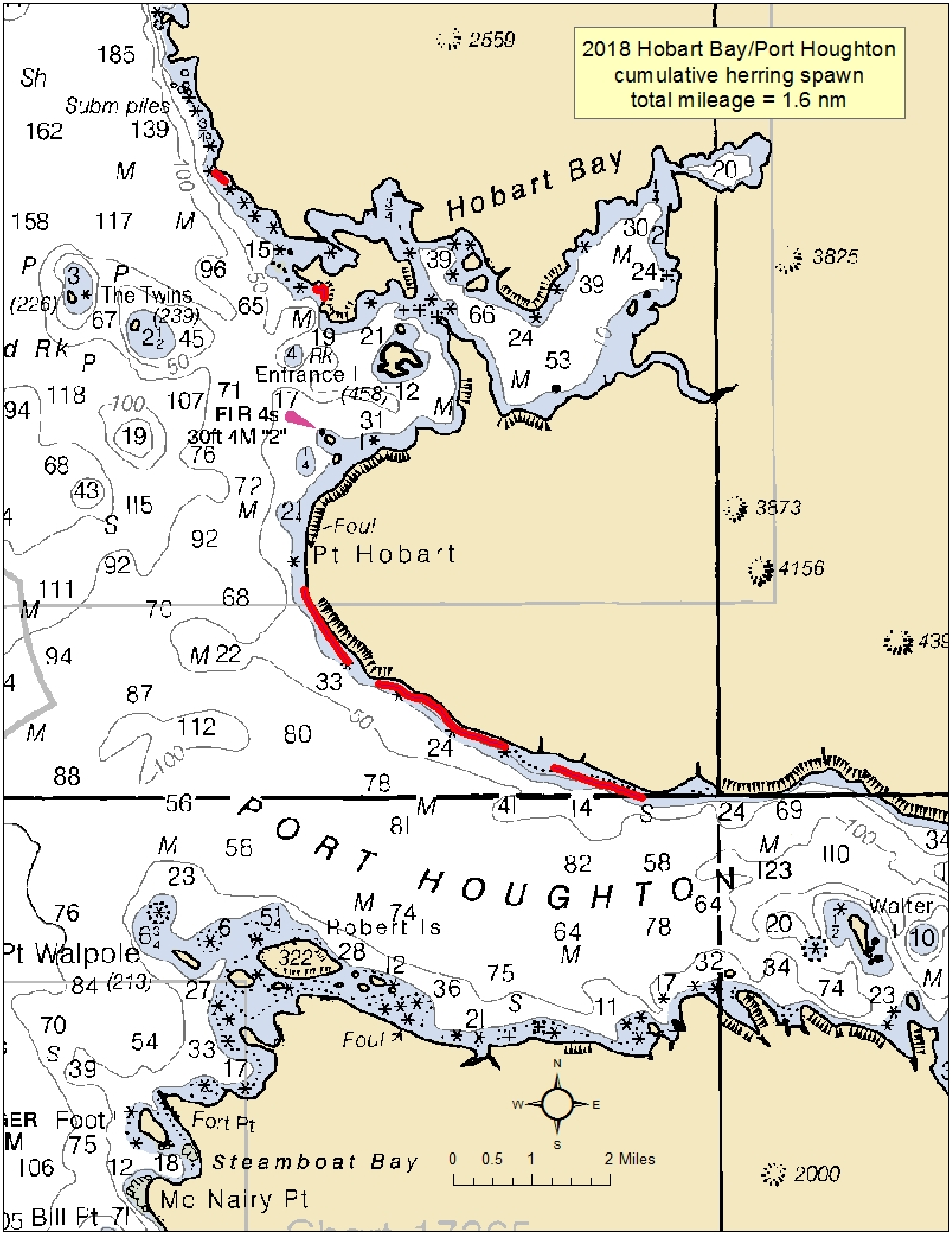
Appendix D3.–Spawn (heavy gray line) and spawn deposition survey transect locations (numbered labels) for the Sitka Sound herring stock second survey in 2018.



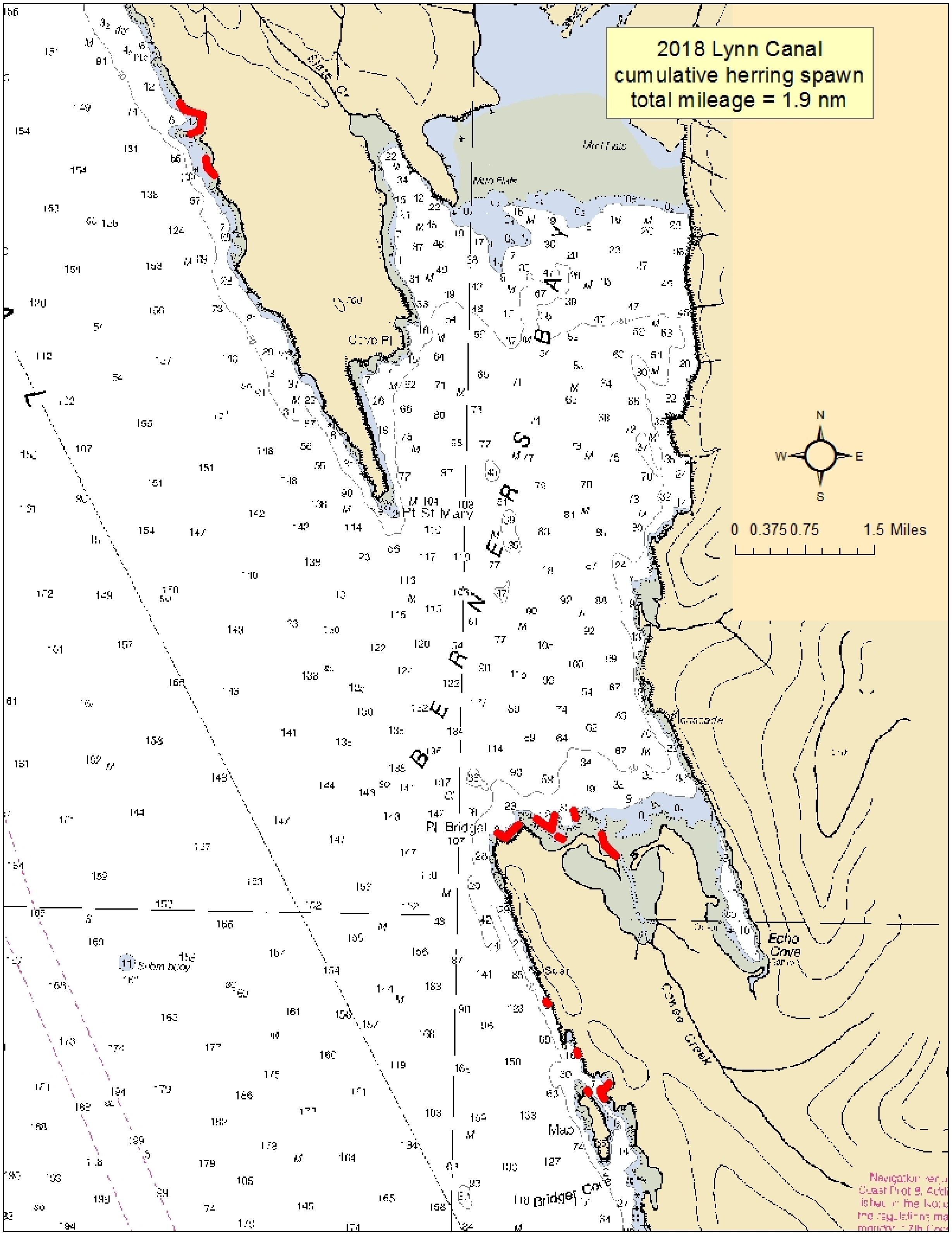
Appendix D4.–Spawn (heavy gray line) for the Ernest Sound herring stock in 2018.



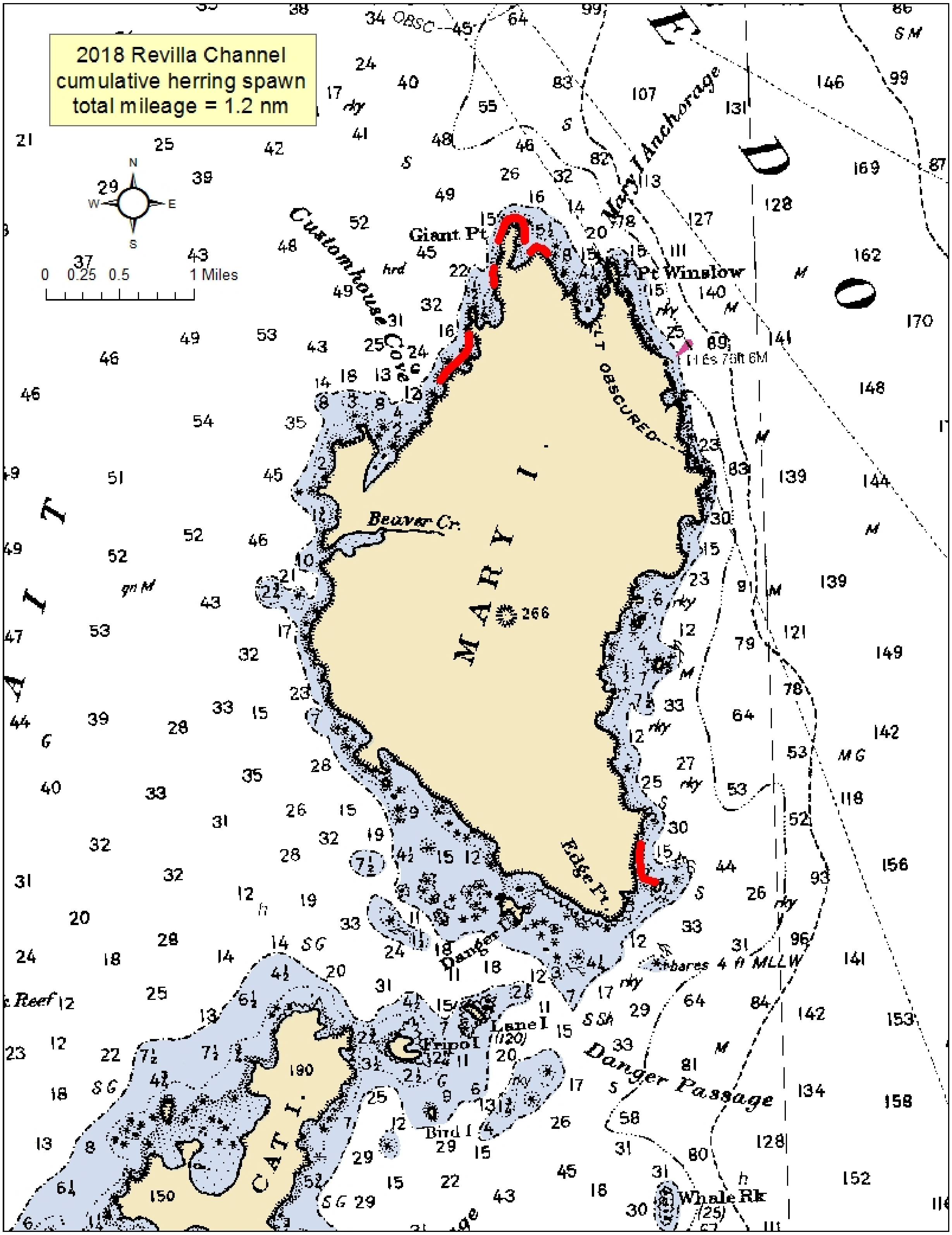
Appendix D5.–Spawn (heavy gray line) for the Hobart Bay/Port Houghton herring stock in 2018.



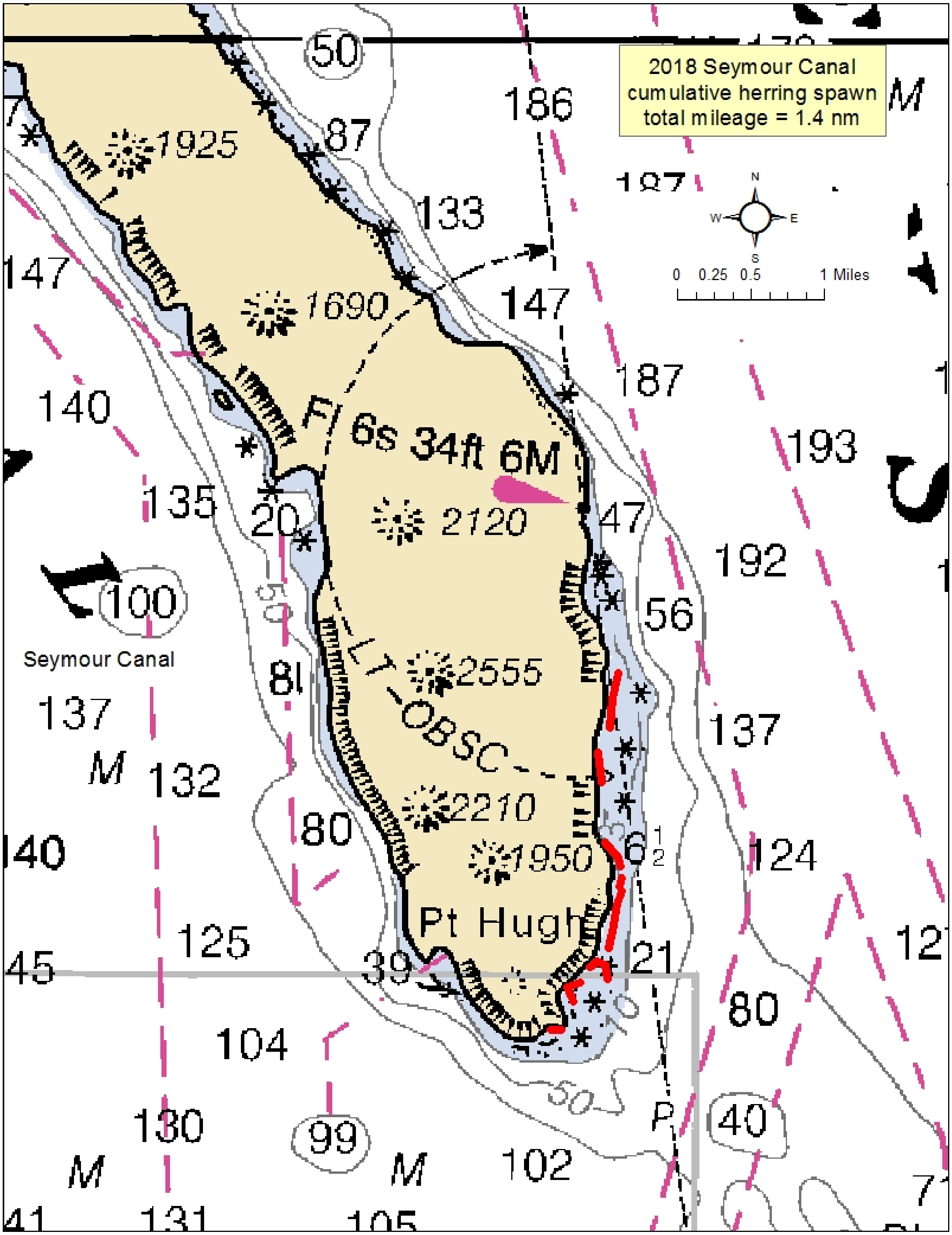
Appendix D6.–Spawn (heavy gray line) for the Lynn Canal herring stock in 2018.



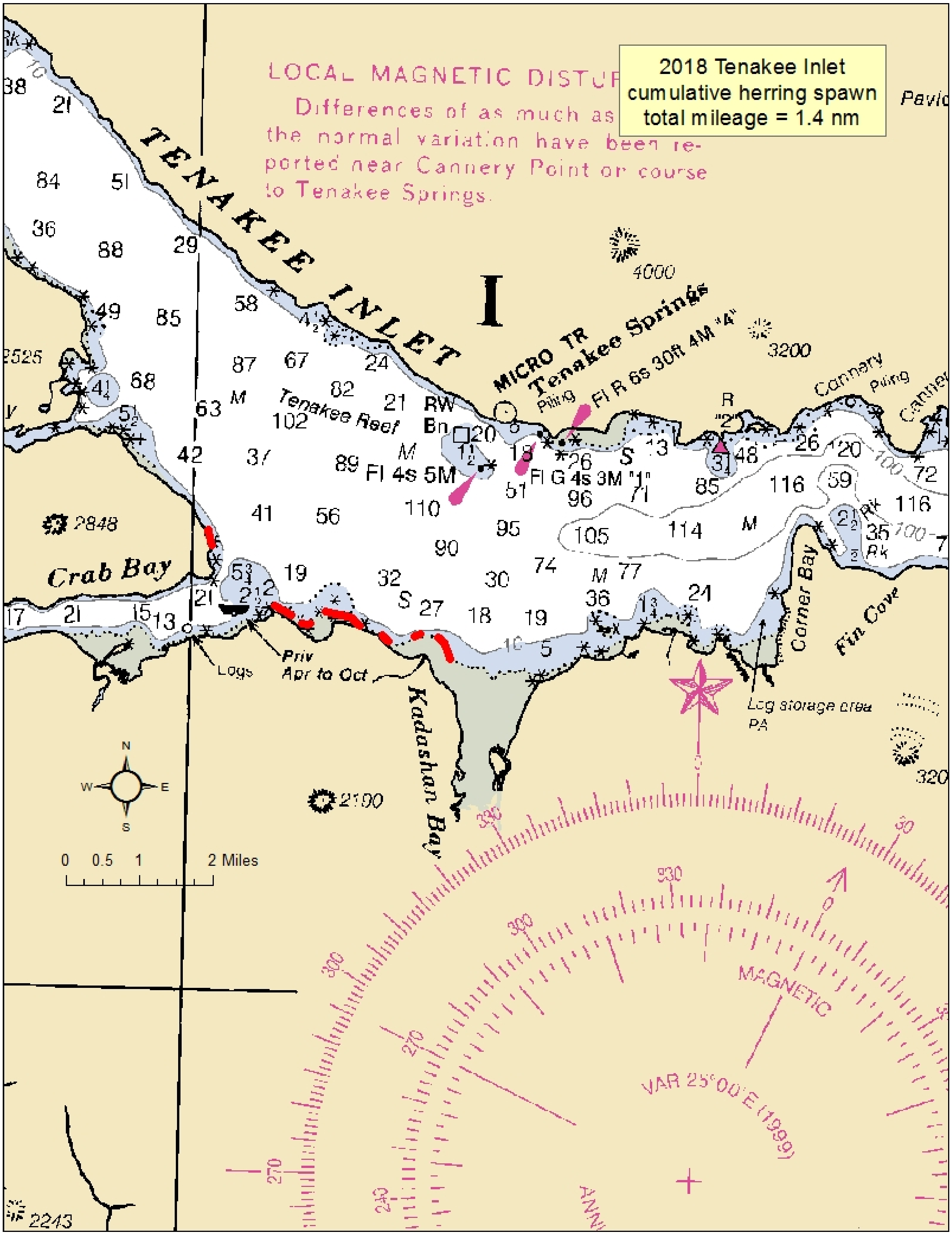
Appendix D7.–Spawn (heavy gray line) for the Revilla Channel herring stock in 2018.



Appendix D8.–Spawn (heavy gray line) for the Seymour Canal herring stock in 2018.



Appendix D9.–Spawn (heavy gray line) for the Tenakee Inlet herring stock in 2018.



Appendix D10.–Spawn (heavy gray line) for the West Behm Canal herring stock in 2018.