Regional Operational Plan CF.1J.2019.11

Operational Plan: Southeast Alaska Herring Stock Assessment Surveys and Sampling, 2019

by

Kyle Hebert

September 2019

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

REGIONAL OPERATIONAL PLAN CF.1J.2019.11

OPERATIONAL PLAN: SOUTHEAST ALASKA HERRING STOCK ASSESSMENT SURVEYS AND SAMPLING, 2019

by
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Alaska Department of Fish and Game
Division of Commercial Fisheries

September 2019

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SIGNATURE PAGE

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Plan Type:	Category II

Approval

Title	Name	Signature	Date
Project leader			
Biometrician			
Research Coordinator			

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PURPOSE

The primary purpose of this project is to collect the data necessary for conducting stock assessments and forecasts of herring spawning populations in Southeast Alaska, with the ultimate goal of setting appropriate guideline harvest levels. To conduct stock assessments using the established methods, it is critical to obtain estimates of egg deposition (i.e. "spawn deposition") within each spawning area, estimates of age composition of the spawning population, and estimates of age composition of harvested herring. This information, along with estimates of fecundity relationships and amount harvested are direct inputs for models used to forecast the biomass and age composition of herring spawning populations in the ensuing year.

OBJECTIVES

1. Estimate total spawn deposition (total number of herring eggs), for each major herring spawning area, to provide input for both the age-structured assessment (ASA) and biomass accounting models.
2. Estimate age compositions of mature (spawning) herring for each major spawning area, by using cast nets to collect a minimum of 525 herring per spawning area.
3. Estimate age compositions of commercial catch for each commercial herring fishery, by collecting a minimum of 525 herring per gear type used for each stock.
4. Estimate mean weight at age and mean length at age for herring within each spawning area, and for herring in commercial catch for each fishery. The same fish sampled for age composition estimates are used to estimate mean weight at age.
5. Periodically, estimates of fecundity are made, which are used with spawn deposition estimates to determine absolute abundance of herring populations. Typically, an estimate of the fecundity-to-weight relationship is made for one or more of the four herring spawning areas where ASA models are used (Sitka, Craig, Revillagigedo Channel, and Seymour Canal) by sampling female herring distributed among ten 20-g weight classes. Fecundity sampling will not be conducted 2019.

BACKGROUND

In 1971 the Alaska Department of Fish and Game (ADF&G) instituted a herring research program to evaluate Pacific herring stocks in Southeast Alaska. Visual estimates, hydroacoustic surveys, and spawn deposition surveys using scuba diving have been used to assess stocks, particularly in areas judged to support significant herring populations. This Project Operational Plan (POP) describes the data required for assessing the abundance and condition of herring populations in Southeast Alaska and the methods and rationale for collecting those data. Data generated during these stock assessment programs are used directly in the management of all commercial herring fisheries conducted in Southeast Alaska.

Data described in this POP are used as input into two different stock assessment models to determine abundance and forecast future abundance of herring populations. These models include an ASA model and a biomass accounting model.

Historically biomass estimates and abundance forecasts of mature herring in Southeast Alaska were either developed from hydroacoustic surveys or the product of estimates of egg density and area of spawn deposition (called "spawn deposition" method). Presently the ASA model is used for herring populations for which there exist adequately long (i.e. > 10 years) or appropriate time-series of stock assessment data and the biomass accounting model is used for all other populations. The two methods are not mutually exclusive. Spawn deposition data is an important element of ASA and biomass accounting models. A primary difference between the two models is the amount of data needed to conduct the respective analyses. Spawn deposition is estimated using only the most recent spawn deposition data, and no specific age composition or weight data, to yield an estimate of current biomass. A standard number of eggs per ton (based on data specific for that area, when available, or the closest area when not available) of herring is applied to the total egg estimate to compute spawning escapement. In contrast, the ASA uses a time series of age compositions and weights-at-age in conjunction with spawn deposition to estimate biomass. Biomass accounting is based on spawn deposition estimates adjusted for natural mortality, age-specific growth, and recruitment. Beginning in 1993 ASA, with auxiliary information, has been used to estimate the abundance of herring for up to five major Southeast Alaskan herring fishery populations: for the 1994 season in Sitka, Seymour Canal, Revillagigedo Channel (Kah Shakes/Cat Island), and Craig/Klawock, with Tenakee Inlet added for the 2000 season. These five potential commercial harvest areas or spawning populations have a sufficiently long time series of data to permit the use of ASA for estimating historical and forecasting future biomass. Other areas, which may support significant herring fisheries but lack time-series data suitable for ASA, are candidates for biomass accounting. This approach began in 1996 and biomass accounting forecasts have been made for West Behm Canal, Ernest Sound, Hobart Bay/Port Houghton, and Hoonah Sound.

The principal outputs from all models are forecasts of mature herring biomass for the ensuing year. These forecasts are compared to stock-specific threshold biomass levels to determine whether a fishery will be allowed in a particular area. This biomass forecast is coupled with the appropriate exploitation rate to determine the commercial fishing guideline harvest level.

METHODS

STUDY SITE

Surveys or sampling may be conducted at any of the several major herring spawning areas throughout Southeast Alaska (Figure 1). Spawning events may be expected in most years at each of these areas; however, in some years spawning may not occur at some areas, or the amount of spawn deposition may be so low that a survey or sampling is not warranted or is impossible. In some years, the magnitude of spawning may be high in areas that are typically considered minor spawning areas, which are not show in Figure 1, and occasionally surveys or sampling will be conducted in these areas.

Due to serious declines in state general funds in recent years, the region’s herring stock assessment program was scaled back starting in fiscal year (FY) 2016, and data collection became focused on Sitka Sound and Craig. Prior to this, spawn deposition and age-size data were collected annually for most major herring stocks. However, small amounts of unexpected funding became available in 2016, allowing additional dive surveys in Seymour Canal, Ernest Sound, and Lynn Canal, and again in 2017 allowing a survey in Seymour Canal. In FY 2019 the legislature approved an increment of $81k in general funds to partially replace the herring funding lost in FY 2016. About $100k of $175k was cut from the herring research budget in FY 16, which affected spawn deposition surveys and age-size sample processing at the lab. An additional sum was cut from management budgets, which eliminated funds to manage fisheries and reduced the frequency of aerial survey flights to map spawn mileage. The return of $81k in

FY 19 is expected to allow some increase to aerial surveys, spawn deposition surveys, and age-size data collection on a case-by-case basis but is not sufficient funding to return to completing stock assessment surveys of all major stocks in the region. Results of aerial surveys will be monitored through the spawning season and after consultation between research and management staff a determination will be made as to whether spawn deposition surveys should be conducted, or age-size data should be processed.

Dive Operations

An ADF&G research vessel (e.g. *R/V Kestrel*) will be on site during spawn deposition surveys of each area and serve as the support vessel and base for all dive operations. The only exceptions anticipated are the possible use of skiffs for day trips 1) near Ketchikan for the Kah-Shakes/Cat Island spawning area, or 2) for secondary spawn surveys in Sitka Sound if necessary. The *R/V Kestrel* will accommodate all members of the dive team (usually six divers) in addition to vessel officers (usually three Boat Officers) for extended periods. Typically, the support vessel remains in a location central to dive activity throughout the survey.

Actual diving will be conducted from 19-foot outboard powered aluminum skiffs. Three-person dive teams will be assigned to each skiff. All dives will be conducted in pairs, with the third team member remaining in the skiff to monitor surface traffic and provide support and assistance to the dive team. Team members will rotate diving/tending responsibilities. Equipment required for dive surveys, such as scuba gear and sampling/data collection equipment, is assembled on-board the support vessel to reduce unnecessary trips between support vessel and dive site. While conducting surveys teams may be separated from the support vessel by as much as five nautical miles, although actual distances will be kept at a minimum and are usually within one mile. All dive operations will be done in compliance with the department's current Dive Safety Manual (Hebert 2012). All dives are limited to a maximum of 21 m (70 fsw) because deeper dives severely limit total bottom times for scuba divers and pose safety risks when done repetitively over several days.

Spawn Deposition

Aerial Surveys

Beginning in mid-to-late March, the historical start of herring spawning in some areas, fixed-wing aerial surveys will be conducted in locations where spawning is anticipated. Flights will be coordinated within each management area by the local Area Management Biologists.

During aerial surveys ADF&G personnel indicate on a chart the shoreline where active spawning occurs. Additionally, indications of herring schools, presence of recent or old milt, presence and numbers of seabirds and marine mammals, and other information relevant to herring spawning is noted. On occasion the aircraft will land to collect herring samples for estimates of age, weight, and length, using a cast net. Aerial surveys will continue until active spawning is no longer observed in an area.

Upon completion of an aerial survey notes will be transcribed and presented, with charts indicating spawn activity, to the herring research biologist. Spawn data from charts will be transferred to ArcGIS ™ to calculate final spawn mileage estimates and help to determine position of transects used for spawn deposition dive surveys.

Transect Location

Once the desired number of transects per nautical mile of spawn is determined, transect location is decided through a process of measuring the distance of shoreline that received spawn and then randomly selecting locations. The final mileage is obtained using ArcGIS ™ software.

Shoreline measurement and transect placement can be subjective and depend 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 distance but may not be appropriate for instances when spawn deposition does not closely follow the shoreline. In such situations, less resolution is used for measurements and transects are placed perpendicular to a "theoretical" shoreline so they intersect the spawn in a meaningful way. Conversely, spawn may closely follow a convoluted shoreline, requiring finer resolution of measurements, and transects are placed perpendicular to the actual shoreline contingent upon physical features such as depth, bottom slope, and distance to the opposite shore. For example, a steep sloped shore with a narrow band of spawn habitat (e.g. Sitka) requires much finer shoreline mapping as opposed to an area with broad shallow waters (e.g. Cat Island) interspersed with rocks and reefs at some distance from shore.

The product of the total measured shoreline and the estimated optimal number of transects per nautical mile (Table 1) determines the minimum number of transects to be surveyed in an area. Total measured shoreline that received spawn is divided into tenths of a nautical mile and each of these segments becomes a candidate for transect location.

The location of transects to be surveyed are then selected from these segments using a random number generator. Possible transect points are 0.10 nmi apart and the target number of transects are randomly chosen from these potential points.

Transects are conducted perpendicular to the spawn as depicted by the spawn line on charts produces from aerial surveys. The orientation of the transect may not necessarily be perpendicular to the shoreline, so it is important to review the spawn charts prior to conducting dives. Transects may be truncated prior to the end of the egg zone if transects are deemed to be in the direction of an opposing shoreline that received spawn or if in a cove where potential transects would be expected to converge at a central point. In these cases, the end point of the transect should be determined prior to the dive, divers should be informed of the potential for call-up and the expected depth of call-up, and the tender should call up the divers at the pre-determined point using the diver recall bell. See Figures 2 and 3 for depiction and examples of these types of transects.

Sampling Design

A two-stage sampling design, similar to that of Schweigert et al. (1985), is used to estimate the density of herring eggs at selected spawning locations in Southeast Alaska. The field sampling procedure entails two-person scuba teams swimming along transects and recording visual estimates of the number of eggs within a 0.10 m^2 square sampling frame placed on the bottom at fixed distances along the transects.

The specific approach is as follows: diver 1 holds a 0.10 m^2 sampling quadrate (frame) with an attached compass. Diver 2 holds an underwater writing slate with an attached diving computer for depth and dive time at depth, along with an attached data sheet for recording distance covered, depth, bottom type, percent vegetative cover, most prevalent vegetation type, number of herring eggs observed, and other comments. Diver 1 sets a compass course perpendicular to the mapped spawn zone. The course may often be roughly perpendicular to the shore; however, depending on where the spawning occurred and how the spawn was mapped, it may not be perpendicular to the shore. Starting at a point above the spawn zone, which may be on land or in the water, estimator walks or swims along the pre-determined course, and places the sampling frame every five meters. Estimators walk or swim until they first encounter eggs before placing the frame. To determine the distance in meters into the leading edge of the egg zone to place the first frame, the transect number is used, such that the second digit equates to the number of meters (or first digit for single digit transects). For example, on transect #3 the estimator would place the frame three meters into the leading edge of egg zone; on transect #14 the estimator would start 4 meters in; on transect #26 the estimator would start one meter in as 6 resumes the sequence of 1 to 5.

After the first frame, the distance is measured using a 5-meter line tied to the sampling frame. Divers stop every 5 meters. If eggs are not present the estimate is entered as "0". When eggs are present, diver 1 visually estimates the number of eggs observed within the entire water column defined by the frame. Often the frame cannot be placed on the bottom without displacing eggs and vegetation and must be held in mid-water column. This may require estimating numbers of eggs both above and below the frame as they occur on the substrate. Diver 1, using hand signals, indicates his estimate to diver 2 to record. Diver 2 also records depth, distance covered, bottom type, percent vegetative cover, vegetative type, and any additional observations on a standardized form (Figure 4). Vegetative type will be coded using a key that groups various algae and marine and intertidal plants species into categories (Appendix A). Similarly, bottom type will be coded according to Appendix B. Since frames are spaced equidistant along transects, the number of frames is also used to compute individual transect length.

In the situation where eggs are observed along a transect and then are not present further along the transect, but the water is still shallow enough that eggs may be deeper, then estimates may halt until divers encounter more eggs deeper. The estimator would indicate to the recorder to swim without placing the frame and then estimate and keep track of the meters swam. If eggs are encountered further along the transect, then the estimator places the frame at the next 5-meter interval as counted from the previous egg zone and resumes 5-meter intervals. If no further eggs are encountered, then recorder simply notes the distance swam and ending depth.

Upon completion of a survey dive all data will be entered into a database on-board the supporting research vessel. When possible, the collector of the data will complete data entry.

Diver Calibration

Since visual estimates, rather than complete counts of eggs within the sampling frames are recorded, measurement error occurs. To minimize the influence of this measurement error on final estimates of total egg deposition diver-substrate-specific correction coefficients (c_h) are used to adjust estimates of eggs. Correction coefficients are estimated by double sampling (Jessen 1978) frames independent of those estimates obtained along regular spawn deposition transects. This involves visually estimating the number of eggs within a sampling frame and then collecting all the eggs within the frame for later more precise estimation in the laboratory.

Transect frames will be simulated by laying out numerous frames along a convenient, pre-selected site. Frames will be identical to those used for regular transects and will be attached to a lead line at intervals of approximately three meters (Figure 5). Lines will include about 20 frames and will be positioned along a depth contour that minimizes diving difficulty and interference with samples (i.e. shallow, low current, etc.). Samples of the five major algal types with herring eggs will be collected and one algal type will be placed within each sampling frame. Algal types (often referred to as "kelp types") and their abbreviations include eelgrass (ELG), hair kelp (HIR), rock weed or *Fucus* (FUC), fir kelp (FIR) and large brown kelp (LBK). Kelp types refer to kelp shapes more than accurately naming the variety of algae or grass. For example, "eelgrass" may include both eelgrass and surf grass, and large brown kelp may include any variety of wide bladed brown kelps such as in genera *Laminaria* or *Agarum*, or others. An attempt will be made to create egg-kelp bundles of various sizes and densities that may be encountered along actual survey transects. One bundle will be secured to each calibration frame, so it cannot drift away. Additionally, a mesh bag will be secured to each frame, into which estimators will place waterproof tags that identify themselves, the date, the sample number, and their estimate (see examples in Figure 6). Divers will proceed along the line of transects one at a time and make estimates of total eggs within each frame, spending no more time at each frame than would be spent estimating a regular transect frame, which should be about twenty seconds.

After all divers have made estimates, designated divers will be assigned to collect all egg-kelp bundles located within each frame and carefully place the samples in collection bags. Eggs that are attached to rocks and other uncollectable substrates remaining within the frame are not part of the estimate. All samples will be preserved in a 100% salt brine solution until laboratory analysis. A detailed description of the processing and counting of collected eggs in the laboratory is provided in Blankenbeckler (1987). In addition to diver estimates when conditions permit (e.g. proper substrate, visibility) samples will be photographed prior to estimates and collection. A photographic record may allow for later comparison of diver to lab estimates. Photographs may also provide a venue for future training both in herring egg estimation and kelp identification.

Given the visual estimates and actual counts of eggs, the diver-specific correction factors are estimated as:

$$c_{ih} = \frac{\bar{r}_{hk}}{\bar{v}_{hk}} \qquad (1)$$

where c_{ih} is the estimated correction factor for diver *h*, v_{hk} is the mean visual estimate of egg numbers for diver *h, and* $\bar{r}_{hk}$ is the mean laboratory count of egg numbers for diver *h.*

Estimates of Total Egg Deposition

For each spawning area, *i*, total egg deposition is estimated as:

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

where t_i is the estimated total deposition of eggs for spawning area *i*, a_i is the estimated total area (m^2) on which eggs have been deposited at spawning area *i*, and $\bar{d}_i$ is the estimated mean density of eggs (eggs/m^2) at spawning area *i*.

The total area on which eggs have been deposited is estimated as:

$$a_i = l_i w_i, \qquad (3)$$

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

The mean density of eggs/m² at area i ($\bar{d}_i$) is estimated as:

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

where v_{hij} is the visual estimate of egg numbers by diver *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 diver *h* on kelp type *k*, and m_{hi} is the number of quadrates visually estimated by diver *h* at area *i*. Divers visually estimate egg density within 0.1 m quadrates. Multiplying by 10 expands the mean density from a 0.1 m² to a 1.0 m².

Sample Size

The statistical objective of spawn deposition sampling is to estimate herring egg densities (per quadrate) so the lower bound of the one-sided 90% confidence interval is within 30% of the mean density (see Table 1). This will also achieve the objective of estimating the total spawn deposition at a particular location with the specified precision. A one-sided confidence interval is used because we are concerned more with avoiding overestimating, rather than avoiding underestimating the densities of spawn deposition. Since spawn deposition surveys are conducted as two-stage sampling, target precision can be achieved by changing the number of transects per nautical mile of shore and/or by changing the number of quadrates within transects per nautical mile of shore. Sampling optimization, which accounts for both the costs and variances specific to sampling, could be used to obtain optimum estimates of egg density given constraints on precision and cost. This approach would necessitate some flexibility in varying both the transect density (i.e. number of transects per nautical mile of shore) and quadrate density (i.e. number of quadrates per meters of transect) at the various spawning areas. Since a length of line is now used to measure inter-quadrate distances, it would be practical to optimize the spawn deposition sampling by varying not only the number of transects per nautical mile, but also the number of quadrates per transect specific to each spawning area. But to simplify the sampling and reduce chances of error a standard quadrate spacing of one quadrate every 5 m of transect will be maintained. This standardization simplifies estimation of desired sample.

The desirable number of transects is estimated as:

$$n = \frac{\left(S_b^2 - \frac{S_2^2}{\bar{M}} + \frac{S_2^2}{\bar{m}} \right)}{\left(\frac{x\bar{d}}{t_\alpha} \right)^2 + \frac{S_b^2}{N}}, \quad (5)$$

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,
$\bar{M}$	=	estimated mean width of spawn,

$\overline{m}$	=	estimated mean number of 0.1 m quadrates per transect,
x	=	specified precision, expressed as a proportion (i.e. 0.3 = 30%),
$\overline{d}$	=	overall estimated mean egg density,
t_a	=	critical t value for a one-sided, 90% confidence interval,
N	=	estimated total number of transects possible within the spawning area.

These preliminary estimates may be obtained from the prior year's spawn deposition surveys, or may be obtained from preliminary sampling from the current years' sampling and updated as the current years' survey proceeds (Table 1). The latter approach is preferred but current available resources preclude obtaining sample size estimates from recent data; sample sizes calculated from 2000 data will be used in 2019 and future years until the analysis is updated. From a practical standpoint, the number of transects located in an area (per survey) will generally be set as a minimum of 20 and a maximum of 50, unless surveys are conducted on very low mileage of spawn or with other unusual circumstances that require fewer or more transects.

FECUNDITY

Fecundity sampling is not planned for 2019. However, during years when there is an opportunity for herring fecundity sampling, the following protocol will be followed:

Sampling Design

Estimates of fecundity are used with spawn deposition estimates to determine absolute abundance of herring populations. Sufficient samples of female herring, distributed among 20-g weight classes will be collected to promote estimates of fecundity-at-weight. In 1995, 1996, 1998, and 2005 fecundity-at-weight estimates were obtained for the four major herring spawning areas: Sitka (1995, 1996, 1998, 2005), Craig, Kah Shakes/Cat Island (1996), and Seymour Canal (1996). Sampling will be conducted so that regression estimates of fecundity as a function of weight can be obtained.

Herring samples must be obtained as close to spawning as possible though sampling should not occur during spawning (to prevent sampling of partially spent females). Sample timing is crucial to provide real time estimates of potential egg deposition. Sampling procedures may occur in conjunction with herring sampling prior to the sac roe fishery using purse seines; samples from multiple locations are preferred.

Sample Size

In Southeast Alaska weights of mature herring may range from approximately 40g for an age-3 fish to over 200g for an age-10 fish. Given this range of weights and the need to sample for a possible nonlinear relationship, sampling will be conducted evenly across this weight range. Sampling will be conducted by selecting a minimum of 10 reproductively mature female herring from each of the following 20g weight categories: <80, 80-99, 100-119, 120-139, 140-159, 160-179, 180-199, 200-219, ≥220 grams. This will yield a minimum of 90 herring to define the fecundity relationship. This total sample size is dictated largely by limitations on the number of fish that can reasonably be processed given available resources. This sample size is also consistent with previous fecundity sample sizes. All herring collected for potential fecundity sampling will be individually bagged to prevent cross contamination and to make it readily apparent if a herring is losing eggs.

Ovary Removal

Appropriate size females will be selected and weighted to the nearest gram. The standard length (tip of snout to posterior margin of the hypural plate) of each fish will be measured to the nearest millimeter. Using a sharp dissecting knife or scissors, a shallow incision will be made from the vent to the gill cage, exposing the skeins.

Fecundity Estimate

The skein will be carefully removed and eggs separated from the membrane (removing as much membrane and “non-skein” tissue as possible without losing or breaking any eggs). The skein’s weight will be recorded to the nearest 0.01 gram. The skein/eggs will then be placed into a suitable container or on weight paper. Three skein sub samples will be weighted to the nearest 0.01 gram. The number of eggs in each sub sample will be counted. Each sub sample should contain approximately 300 - 500 eggs. All weights and counts will be recorded and identified with that fish’s total weight and length. There is still some concern about counting eggs and herring egg “stickiness”. If eggs are too sticky to accurately count, they may be boiled or washed in either a brine or KOH solution prior to counting. Other reagents and methods may be investigated as needed. As sub sample weight has already been obtained, the wash procedure will not alter the sub sample weight though care must be taken to avoid loss or destruction of eggs in the sub sample. This procedure is designed to avoid using caustic preservatives and reagents such as Gilson’s solution.

Data Collected

When completed, the data collected shall include:

Spawning Stock (e.g. Sitka Sound)

Collection Date, Sample Date

Location (e.g. Old Sitka Rocks)

Gear (e.g. purse seine)

length (mm)

weight (grams)

sub samples weights (x3)

sub samples counts (x3)

sampler (technician(s) completing project).

A separate data sheet can be used for each weight category to more easily keep track of the number of herring sampled in each category.

Data will be entered into a spreadsheet but preferably, if available, into the department’s herring database. Once entered average number of eggs per gram will be calculated and extrapolated to estimate the number of eggs for the individual herring.

Catch Age Composition

Sampling Design

Samples from all fisheries will be stored in plastic bags (large garbage bag) in 5-gallon buckets and shipped to the ADF&G Mark, Age and Tag Laboratory in Juneau (henceforth "the lab") for processing at the earliest convenience. Information with each sample will include: date of set, descriptive location of set, coordinates of the set, name of vessel making the set, name of person collecting the sample, commercial gear used in making the set and if available, the approximate tonnage of harvest from the set. Samples will be collected from all commercial fisheries conducted during the year. Labels will be included (Figure 7) both inside the plastic bag and outside the plastic bag within each bucket, and the lid of each bucket shall be labeled with at least the species, stock name, date, and sample type.

Sac-roe fishery

Samples should be collected from at least three different vessels participating in each commercial fishery opening. Vessels targeted for sampling should be determined to have caught relatively large sets within the opening to get a sample that is representative of the body of fish available to the fishery. Apportioning samples among vessels and positions within fishery area is intended to promote more representative estimates of age composition. In the case of purse seine sac-roe fisheries, samples may be collected from a vessel while fish are being pumped aboard a tender. A 5-gallon bucket of herring from each sampled vessel/tender should be obtained to ensure enough fish, and then samples may be packaged in plastic garbage bags as smaller quantities (e.g. half a bucket) to ensure adequate sampling across vessels and openings to achieve the sample size goal.

Spawn-on-kelp fishery

Sample collection should be dispersed throughout fishing grounds if possible and samples should be taken directly from purse seines or tow pounds as they are filled. Collection of samples is done in similar fashion to the sac-roe fishery, but typically a dip net must be used to collect herring because fish are not pumped to a tender. Samples should not be taken from spawn-on-kelp pounds unless there is no opportunity to sample immediately after fish are captured in seine.

Winter food and bait fishery

Samples should be taken from fishing vessels when possible. Fishing vessels are provided 5-gallon buckets and sampling forms and are required to provide a sample from each deliver unless otherwise directed. Sampling from tenders at the processing plants may be required for the winter bait fishery but is not preferred due to scale loss.

Sample Size

Based on multinomial sampling theory (Thompson, 1987), a sample size of 511 ages is sufficient to assure age composition estimates that deviate no more than 5% (absolute basis) from the true value, 90% of the time. A target sample size of 525 fish are collected to ensure samples to replace unusable scales due to scale regeneration or other issues.

MATURE AGE COMPOSITION

Sample Size

The sampling goal is 525 fish for each spawning stock. It is a goal to sample over several different dates and/or sites within the general spawning locale prior to or during the onset of the major spawning event.

Sampling Design

Samples are collected to estimate age composition of the spawning population. Cast nets are used in shallow water to collect samples during or just prior to spawning events. Sample collection should be dispersed across spawning area and across the duration of spawning throughout the season to obtain a representative sample of the entire spawning population. Samples will be labeled in the same was as described for commercial fishery age/size samples.

Cast net samples should be taken and/or processed at the lab in proportion to the spawning herring biomass. This may be done by collecting and bagging numerous samples in small quantities, such as half of a 5-gallon bucket, and then later selecting samples to send to the lab that are most proportionally representative. Spawning areas should be targeted for cast net samples based on significance of length of spawn along the shoreline and intensity of spawn so that more samples are taken in areas of greater spawn length and intensity. Typically, the areas and days of highest spawn mileage are obvious and are of highest priority for sampling.

Decisions about which samples to send to the lab are made after the spawning season has ended so there is a complete picture of how spawning progressed. Instructions should be given from the management staff to the lab staff about how to further select herring during lab processing to ensure that lab staff know how many herring to select from each bucket to reach the sample goal. Instructions should provide guidance to lab staff, such as whether to sub-sample evenly across all buckets or to process all herring within each bucket or apply another sub-sampling technique. If samples are taken on the spawning grounds such that each bucket should carry equal weight, then lab staff should be instructed to sample evenly across buckets. However, if some buckets already and intentionally include more herring than others and are believed to be in proportion to herring biomass, then lab staff should be instructed to process all herring in each bucket. However, using the latter approach may make it more difficult to precisely target the sample goal in the field. Research and biometric staff should be included in plans for processing aging samples and consulted with if questions arise about how best to sample or process samples so that they are proportional to and representative of the spawning biomass.

AGE-SPECIFIC WEIGHT AND LENGTH

Sampling Design

The sampling design to estimate age-specific weight and length is dictated by the design used to estimate mature and catch age compositions, since the same fish are used for estimating age, weight, and length.

Sample Size

The precision of the estimates of mean weights and lengths at age will vary depending upon age composition of populations, as will the numbers of herring within the various age classes among the 525 ages sampled. In addition, precision will vary depending upon inherent variability in weights among fish within the various age classes.

SCHEDULE AND DELIVERABLES

SCHEDULES

Spawn deposition surveys will be conducted from approximately the first week of April through mid-May, depending on actual herring spawn timing. A goal is to begin dive surveys about 10 days after the first substantial spawn of the spawning event, which is typically between 1 nm and 5 nm depending on the stock size. Egg calibration samples collected during spawn deposition surveys will be shipped to the lab in Juneau about mid-April. Collection of age and size samples will occur during spawning events from late-March through May, and during commercial fisheries, which may occur from October through mid-May. Age/size samples will be shipped to the lab in Juneau after sampling is complete for each stock, which for spring samples may be by mid-April. Processing of herring and herring egg samples by laboratory staff is expected to be complete by the end of June. Data preparation and preliminary analysis is expected to be completed by the end of September and forecast modeling will be conducted during fall/winter. Typically, the Craig forecast is finalized by the end of September to provide the recommended GHL to management staff in time to announce the food and bait fishery, which opens by regulation on October 1st. The Sitka Sound forecast is usually finalized sometime in December. A timetable of events is presented in Figure 8.

DATA ENTRY / DATABASE AND SOFTWARE REQUIREMENTS

All spawn deposition data will be entered into the “portable ZANDER” data entry form (i.e Integrated Fisheries Database or “IFDB”), and ideally by a designated dive team member within the same day of data collection to maximize recall of dives. All divers will be involved in data entry to facilitate better understanding of the need to fill out survey forms correctly, completely and clearly. Upon completion of the cruise, data will be uploaded to the IFDB master database either directly or remotely by computer database staff in Juneau.

OTHER NECESSARY RESOURCES

The *R/V Kestrel*, based in Petersburg, will be used as the support research vessel and base dive platform for herring spawn deposition survey cruises. This is a live-aboard 105-foot vessel capable of accommodating up to nine divers in addition to three vessel officers. It is equipped with compressors for on-board filling of scuba tanks with air or Nitrox. A 36% Nitrox breathing mixture will be used for all dives to enhance safety by reducing the nitrogen absorption from repetitive dives and repetitive dive days. All diving will adhere to guidelines and procedures outlined in the department’s Dive Safety Manual (Hebert 2012) and emergency response to dive accidents will follow the current dive safety plan, a copy of which will reside in an easily accessible location in the wheelhouse.

Two 19-foot aluminum skiffs that have been enhanced for diving purposes will accompany the support research vessel and all diving will be conducted directly from these skiffs. Each skiff will be outfitted with first aid equipment and emergency oxygen kits.

Samples for age and size of spawning populations (cast net samples) and commercial catch (fishery sample) will be collected from skiffs provided by area offices, or in the case of Sitka Sound, may be collected using skiffs supported by the R/V Kestrel. Area management staff will be primarily responsible for collecting age and size samples, in consultation with research and biometric staff as needed.

DELIVERABLES

Survey results are summarized in Microsoft Excel spreadsheet tables and figures that are provided to biometric staff by July/August to begin review and stock assessment. Tables include summaries for spawn deposition results, calibration factors, age/length/weight data, and catch, which are primarily used to check and review data and results before inputting data into other computer analysis packages such as R and AD Model Builder to conduct stock assessments. Stock assessments and forecasts are provided to area management biologists in the form of extended memo and email with supporting Excel spreadsheets between late September and January. A report of the stock assessment survey results will be published annually in the ADF&G Fishery Data Series (example Hebert 2018).

RESPONSIBILITIES OF KEY POSITIONS

Kyle Hebert, Herring/Dive Research Project/Program Leader, Fishery Biologist IV. Oversight of all aspects of the project and vessel operation, including planning, budgeting, sample design, field work, personnel; analyzes data and reports project results; conducts stock assessment/forecast for areas where biomass accounting used for forecast; participates in dive surveys.

Jeff Meucci, Dive Research Project, Fish and Wildlife Technician V. Assists with operational planning, oversees dive operations and safety as dive master, lead for medical issues, maintenance of skiffs and dive gear/equipment, data entry, participates in dive surveys.

Sherri Dressel, Statewide herring, Fisheries Scientist I. Assists with/recommends survey design; overall scientific review; conducts stock assessment and forecast for Sitka Sound; participates in dive surveys

Sara Miller, Statewide salmon/herring, Biometrician II. Assists with/recommends survey design; overall scientific review; conducts stock assessment and forecast for Craig area and other areas where age-structured assessment model used other than Sitka Sound.

Jane Sullivan, Statewide groundfish/herring, Biometrician II. Assists with/recommends survey design; overall scientific review.

Detlef Buettner, Mark, Tag, and Age Laboratory Supervisor, Fishery Biologist III. Directs and participates in processing of herring samples for age and size.

Area and Assistant Management Biologists for Sitka, Ketchikan, Petersburg-Wrangell and Juneau areas, Fishery Biologist III or II. May participate in dive surveys, conduct aerial spawn surveys, AWL sample collection; provides guidance on local level as needed.

Joselito Skeek, Captain of *R/V Kestrel*, Boat Officer IV. Command of dive research vessel and overall responsibility of vessel operations, safety and conduct aboard the vessel.

Erik Larson, Chief Engineer of *R/V Kestrel*, Boat Officer III. Operation and maintenance of engine room, safety systems, davits/cranes and hydraulic deck gear, assists with operation of vessel, operates dive cylinder air/Nitrox compressor.

Vacant, Deck Mate and Cook of *R/V Kestrel*, Boat Officer I. Galley operations/cook, operation of davits/cranes, assists engineer and captain as needed.

Lowell Fair, Regional Supervisor, Region I. Provides overall guidance as needed.

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TABLES

Table 1.–Transect sampling rate for herring stock assessment surveys. 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.

Area	Estimated target transects per nautical mile of spawn			
	Based on 1994 analysis	Based on 1997 analysis	Based on 2000 analysis	Average
Sitka	0.2	0.6	.03	0.4
West Behm Canal	–	0.4	1.7	1.1
Seymore Canal	2.8	2.4	1.2	2.1
Craig	0.8	3.1	1.3	1.7
Hobart/Houghton	4.5	1.7	3.6	3.3
Ernest Sound	1.9	5.0	3.5	3.5
Hoonah Sound	2.9	1.0	0.7	1.5
Tenakee Inlet	5.1	1.2	1.6	2.6
Average	2.6	1.9	1.7	2.1

FIGURES

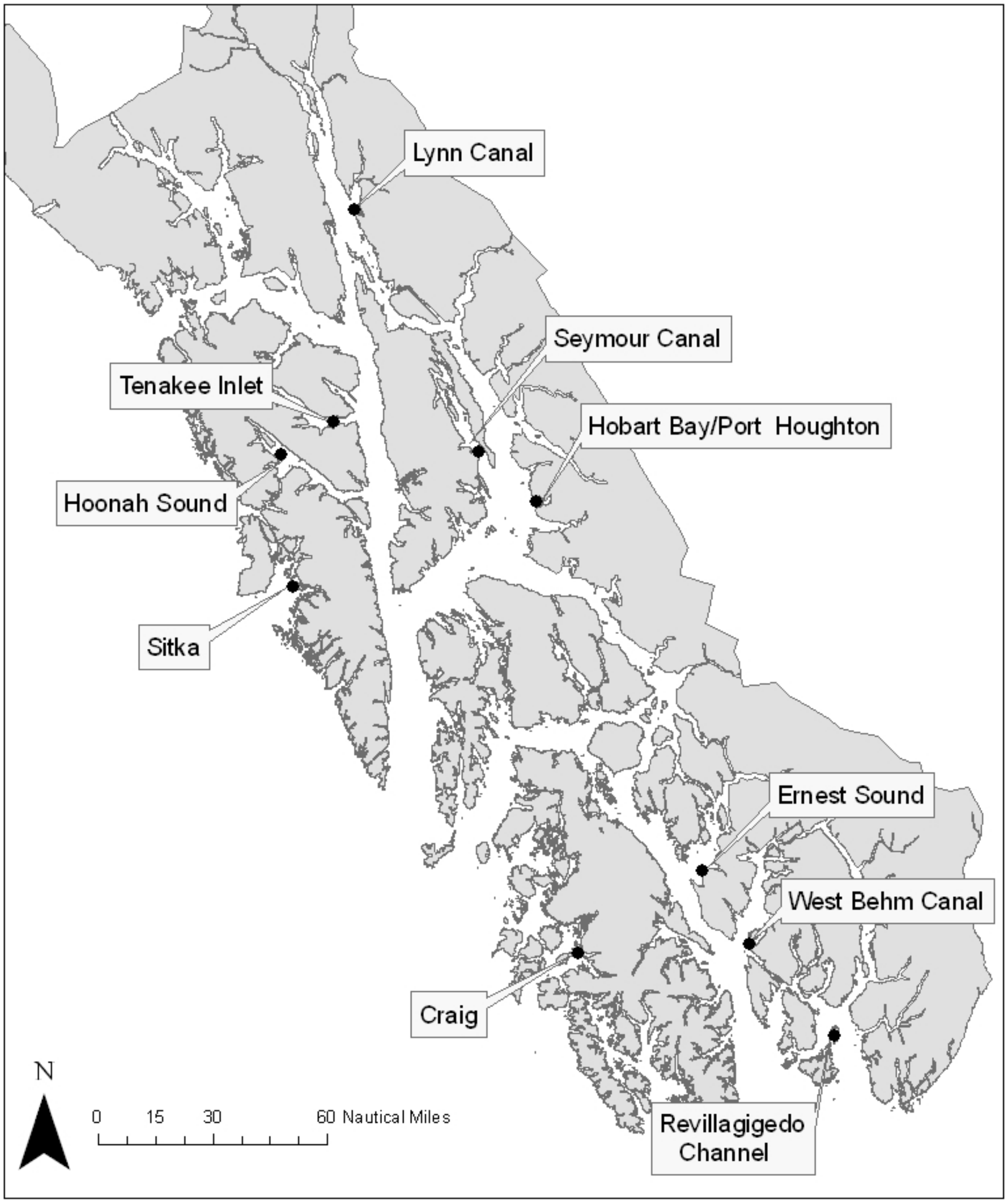

Figure 1.–Locations of major herring stocks in Southeast Alaska where stock assessment surveys or sampling may occur in 2019.

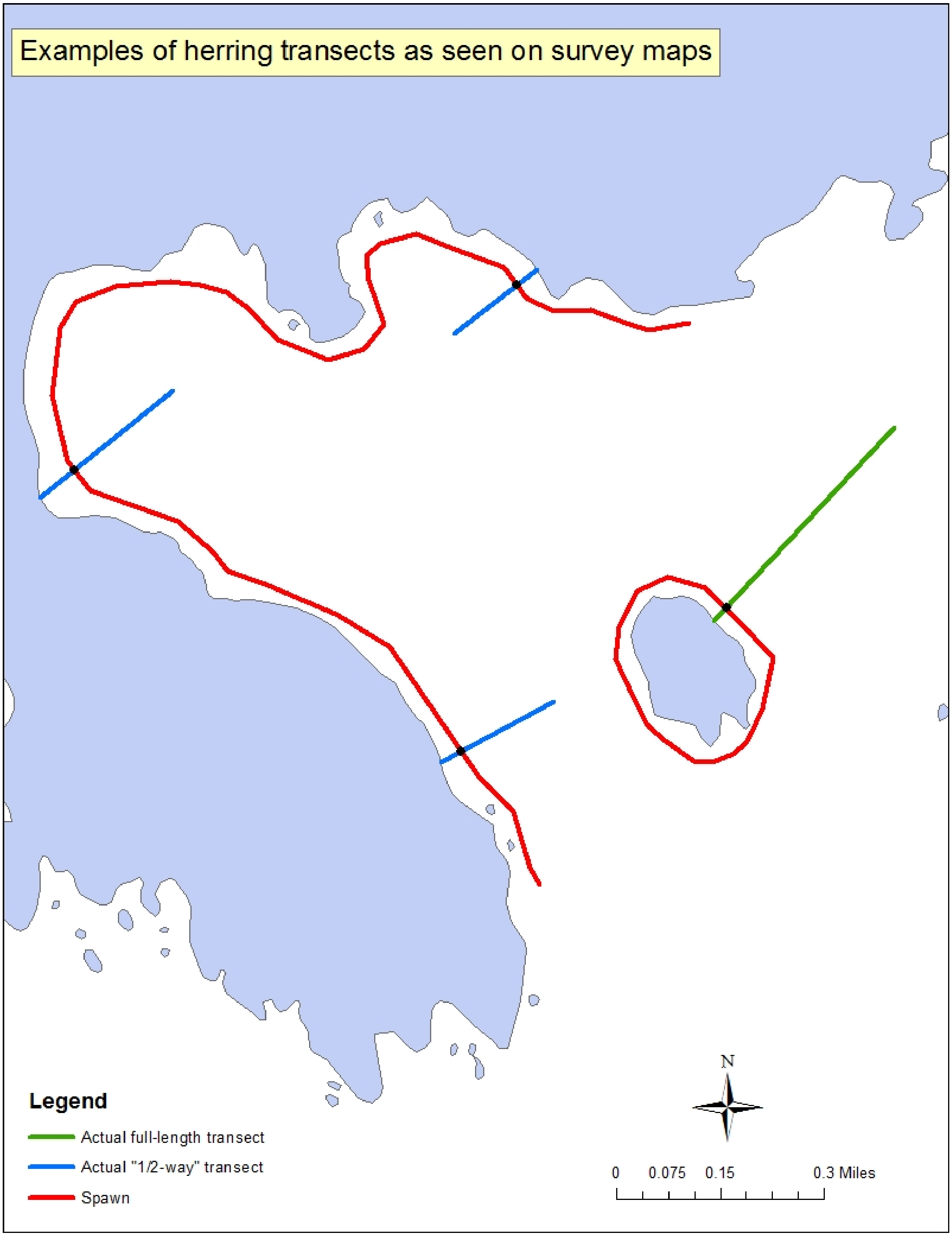

Figure 2.–Depiction of theoretical herring transect layout as seen in field survey charts.

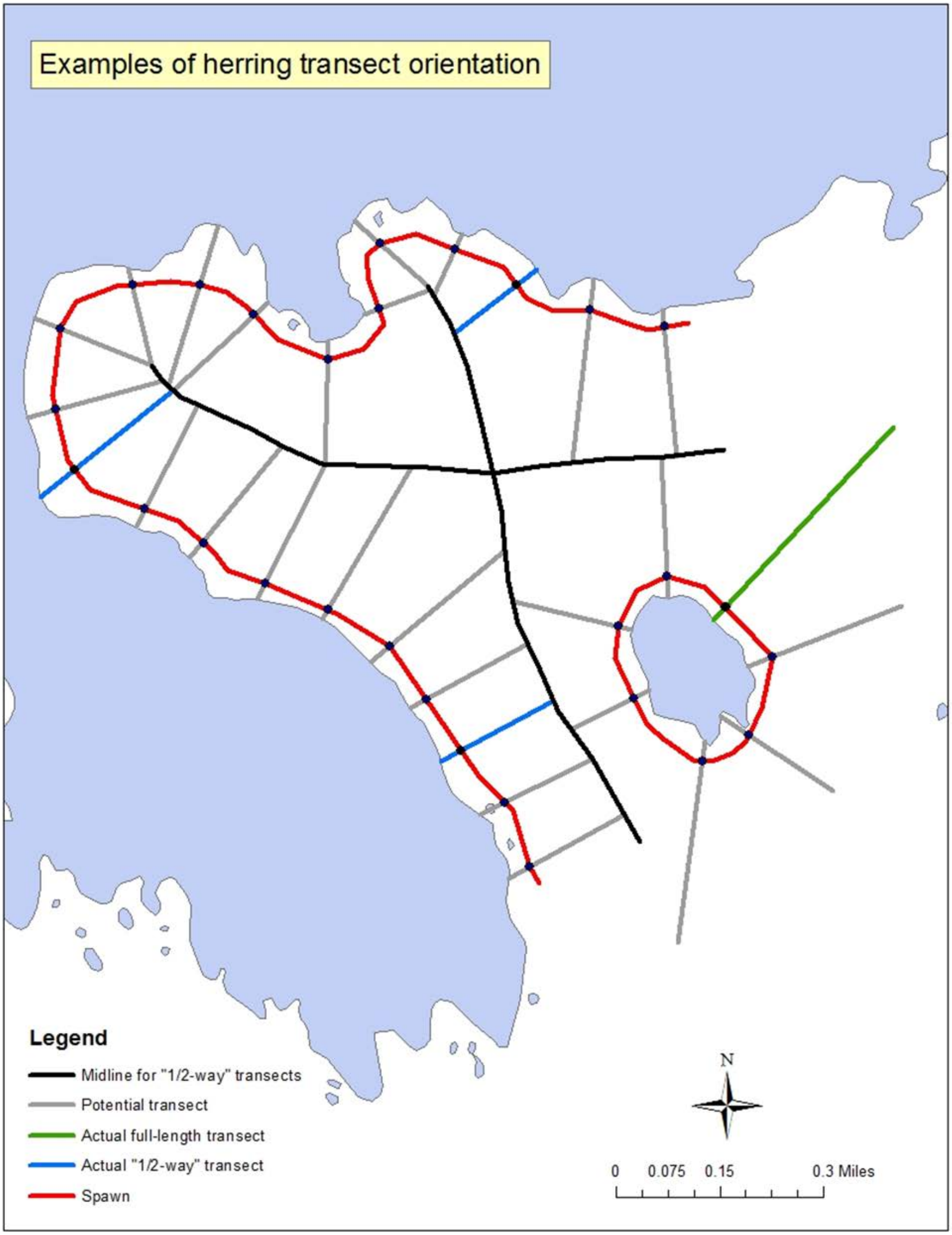

Figure 3.–Depiction of how to visualize survey grounds to conduct transects using the correct orientation and length.

HERRING SPAWN DEPOSITION

AREA: Sitka Sound	ESTIMATOR: RSC	TIME IN: 1020	DIVER 1: FFE
DATE: 4/2/19			
TRANSECT #: 23		TIME OUT: 1151	QUADRAT DISTANCE: 5 m
LAT. & LONG.: 57.1552 / -135.4442			TIDE CORRECTION: -2

	DEPTH (ft)	BOTTOM TYPE	% VEG. COVER	VEG. TYPE	TOTAL # EGGS	NOTES		DEPTH (ft)	BOTTOM TYPE	% VEG. COVER	VEG. TYPE	TOTAL # EGGS	NOTES
1	-3	RCK	100	ELG	5		21						
2	-2	CBL	50	FUC	25		22						
3	-1	GVL	25	FIR	10		23						
4	0	SND	75	ELG	100		24						
5	3	SND	100	RED	20		25						
6	6	CBL	50	LAM	50		26						
7	8	BLD	10	HIR	120	loose	27						
8	10	BLD	5	AGM	10		28						
9	12	BLD	50	AGM	150	on rock	29						
10	15	RCK	100	LAM	200		30						
11	16	RCK	100	LAM	20		31						
12	17	RCK	50	LAM	0		32						
13	18	BLD	50	LAM	0	swam 30m	33						
14	24	GVL	100	MAC	500	HMAC	34						
15	26	GVL	100	MAC	1,000	VMAC	35						
16	32	CBL	50	LAM	10		36						
17	35	CBL	25	HIR	0		37						
18		swam	30m	to	45 fsw		38						
19		no	eggs	seen			39						
20							40						

Figure 4.–Example of data recorded on standardize form used for herring egg deposition transects.

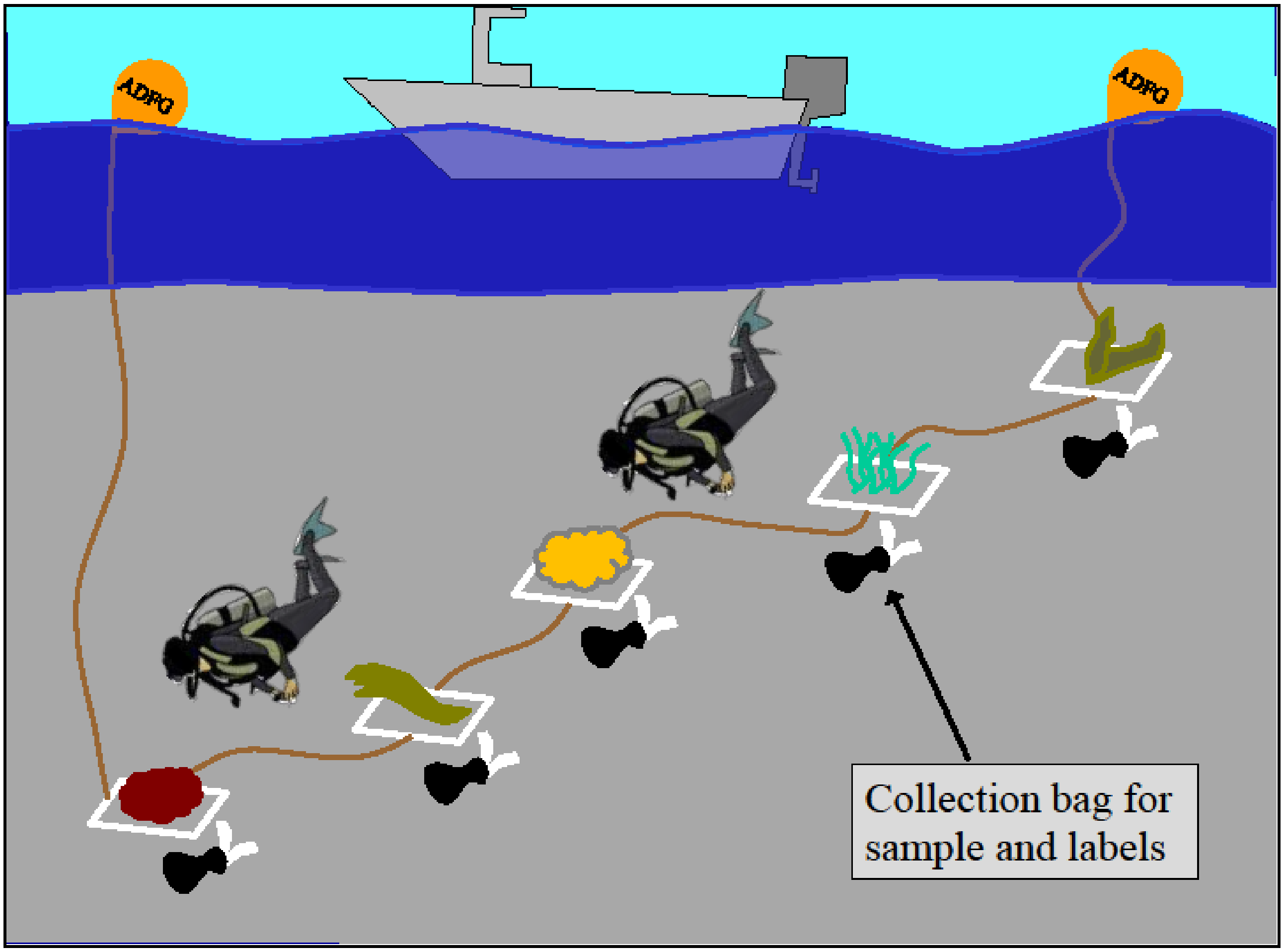

Figure 5.–Depiction of sampling lines used for herring egg calibration estimation for several classes of algae/egg spawning substrate.

Date	Sample No.	Initials (3)	Veg Type	Estimate
4/1/19	3	RSC	ELG	200k

Date	Sample No.	Initials (3)	Veg Type	Estimate
4/1/19	4	RSC	LBK	75k

Date	Sample No.	Initials (3)	Veg Type	Estimate
4/1/19	5	RSC	FIR	300k

Date	Sample No.	Initials (3)	Veg Type	Estimate
4/2/19	6	RSC	HIR	150k

Date	Sample No.	Initials (3)	Veg Type	Estimate
4/2/19	7	RSC	FUC	55k

Figure 6.–Examples data recorded in several data tags used for herring egg calibration sampling.

Herring AWL Forms

Vessel Name:____________________

Sampled By:____________________ **ADF&G #:**________________

Date Sampled:_______________

Spawning Stock:____________________________

Statistical Area:______________

Specific Area Fished:_________________________________

Lat/Lon (decimal degrees):___________________________________

Gear: 01 Seine 07 Trawl Castnet 21 Pound 34 Gillnet

Harvest Code : 11 Traditional 43 Test Fishery
(Circle one)

Code: 43 sac roe 44 food/bait 45 eggs on kelp unsalted 46 eggs on kelp salted
(Circle one)

Fishery Status: Pre______In______Post_______

Figure 7.–Label used for identifying herring age/size samples.

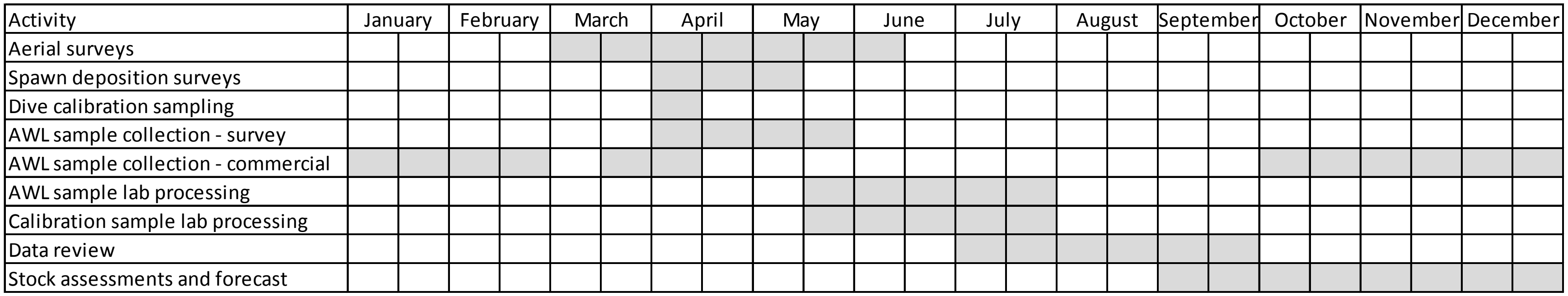

Figure 8.–Timetable of events for herring stock assessment surveys and sampling.