Technical Paper No. 408

The Subsistence Harvest of Pacific Herring Spawn in Sitka Sound, Alaska, 2014

by

Lauren A. Sill

and

Terri Lemons

February 2015

Alaska Department of Fish and Game Division of Subsistence

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the reports by the Division of Subsistence. 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.)	$, ¢
mnths (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	two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

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

TECHNICAL PAPER NO. 408

THE SUBSISTENCE HARVEST OF PACIFIC HERRING SPAWN IN SITKA SOUND, ALASKA, 2014

by

Lauren A. Sill,
Alaska Department of Fish and Game Division of Subsistence, Douglas

and

Terri Lemons
Alaska Department of Fish and Game Division of Subsistence, Anchorage

Alaska Department of Fish and Game
Division of Subsistence
PO Box 110024
Juneau, AK 99811

February 2015

The Division of Subsistence Technical Paper series was established in 1979 and represents the most complete collection of information about customary and traditional uses of fish and wildlife resources in Alaska. The papers cover all regions of the state. Some papers were written in response to specific fish and game management issues. Others provide detailed, basic information on the subsistence uses of particular communities which pertain to a large number of scientific and policy questions.

Technical Paper series reports are available through the Alaska Resources Library and Information Services (ARLIS), the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications. This publication has undergone editorial and professional review.

Lauren A. Sill
Alaska Department of Fish and Game Division of Subsistence
PO Box 110024, Juneau, AK 99811-0024, USA

and
Terri Lemons
Alaska Department of Fish and Game Division of Subsistence
333 Raspberry Road, Anchorage, AK 99518-1565, USA

This document should be cited as:
Sill, L.A. and T. Lemons. 2015. The Subsistence Harvest of Pacific Herring Spawn in Sitka Sound, Alaska, 2014. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 408, Juneau.

The Alaska Department of Fish and Game (ADF&G) administers all programs and activities free from discrimination based on race, color, national origin, age, sex, religion, marital status, pregnancy, parenthood, or disability. The department administers all programs and activities in compliance with Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act (ADA) of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972.
If you believe you have been discriminated against in any program, activity, or facility please write:
ADF&G ADA Coordinator, P.O. Box 115526, Juneau, AK, 99811-5526
U.S. Fish and Wildlife Service, 4401 N. Fairfax Drive, MS 2042, Arlington, VA, 22203
Office of Equal Opportunity, U.S. Department of the Interior, 1849 C Street NW, MS 5230, Washington DC 20240
The department's ADA Coordinator can be reached via phone at the following numbers:
(VOICE) 907-465-6077, (Statewide Telecommunication Device for the Deaf) 1-800-478-3648, (Juneau TDD) 907-465-3646, or (FAX) 907-465-6078
For information on alternative formats and questions on this publication, please contact:
ADF&G Division of Subsistence at http://www.adfg.alaska.gov/index.cfm?adfg=contacts.main.

TABLE OF CONTENTS

Page

LIST OF TABLES ..... **ii**

LIST OF FIGURES ..... **ii**

LIST OF APPENDICES ..... **ii**

ABSTRACT ..... **iii**

1. INTRODUCTION **1**

Project Objectives 2

Methods 2

Survey Plan and Implementation 3

Development of the Household Survey List 3

The Survey Instrument 3

Survey Implementation 4

Update of the 2014 Conversion Factors 4

Data Analysis 6

Dissemination of Survey Results 7

2. 2014 RESULTS **9**

Conversion Factors 15

Harvest Locations 15

3. DISCUSSION **17**

Changes in Use of Herring Spawn 21

Conversion Factors 22

Location of Harvests 22

Spawn-on-Kelp Fishery 23

4. CONCLUSION **24**

ACKNOWLEDGEMENTS **25**

REFERENCES CITED **26**

LIST OF TABLES

Table **Page**

1.–Estimated subsistence harvest of herring spawn in Sitka Sound, 1983, 1987, 1996, 2002–2014. 8
2.–Subsistence harvest and use of herring spawn by community of residence, Sitka area, 2014. 11
3.–Distribution of subsistence herring spawn harvest, Sitka area, 2014. 13
4.–Conversion factors for 2010–2014. 15
5.–Reported locations of subsistence herring spawn harvest, Sitka Sound, 2014. 16

LIST OF FIGURES

Figure **Page**

1.–Distribution of subsistence herring spawn harvest by substrate, Sitka area, 2014. 12
2.–Household perception of herring spawn harvest and use compared to previous years, Sitka area, 2014. 12
3.–Percentage of total Sitka Sound subsistence harvested herring spawn that was shared, 2014. 13
4.–Reported reasons households did not attempt to harvest herring spawn, Sitka area, 2014. 14
5.–Reasons given for why household harvests were different, either less or more, in 2014 than in recent years, Sitka Sound harvesters, 2014. 14
6.–Reported harvest locations, 2014. 16
7.–Total pounds usable weight of herring spawn harvested, number of harvesting households, and amount reasonably necessary for subsistence (ANS) of herring spawn on all substrates in Sitka Sound, 2002–2014. 18
8.–Estimated mature biomass of Pacific herring in Sitka Sound, 1964–2014. 19
9.–Percentage of households using, receiving, giving, and harvesting herring eggs, 2012. 22

LIST OF APPENDICES

Appendix **Page**

A: Map of Area of Sitka Sound Closed to Commercial Herring Sac Roe Fishing 27

B: Sitka Sound Subsistence Herring Egg Harvest Survey, 2014 29

C: 2014 Code Book 34

ABSTRACT

The subsistence fishery for the spawn of Pacific herring *Clupea pallasii* in Sitka Sound was historically, and remains, important to Alaska residents. Alaska Department of Fish and Game (ADF&G) Division of Subsistence research on this contemporary subsistence fishery reveals that harvesting herring spawn is a specialized activity in which a relatively small number of Southeast Alaska residents harvest and distribute herring spawn widely. Annual subsistence harvest monitoring surveys began in 2002 in response to concerns from subsistence harvesters that the commercial sac roe herring fishery was negatively impacting subsistence harvesting success. This report presents the results of the 13th annual harvest survey conducted in Sitka and neighboring communities in 2014. The survey generated data used to calculate estimates of the subsistence harvest of herring spawn on various substrates, including hemlock branches, kelp, and other seaweed in Sitka Sound. An estimated total of 154,412 lb of herring spawn was harvested in 2014. More than 90% of the harvest was shared with other households within Sitka as well as other communities in the state and beyond.

Key words: Pacific herring, *Clupea pallasii*, herring spawn, subsistence fishing, harvest estimate, subsistence, Sitka, Sitka Tribe of Alaska

1. INTRODUCTION

The spawn of Pacific herring *Clupea pallasii*, generally known as "herring eggs," is a traditional food of great cultural importance for indigenous coastal communities throughout the Pacific Northwest and Southeast Alaska. Although herring spawn is consumed throughout this region, only a small number of people have the time, equipment, skills, and knowledge required to harvest it. This report presents findings of the 13th annual harvest assessment, which occurred in the spring of 2014, designed to document subsistence harvests of herring spawn in Sitka Sound (see Holen et al. 2011; Sill and Lemons 2012, 2014a–b for discussion of the previous study years).

Herring return annually to Sitka Sound in numbers that are not seen elsewhere in Southeast Alaska. The sheer abundance of herring and herring spawn, and the length of the spawning period, has set Sitka Sound apart from other areas in Alaska and the Pacific Northwest (Schroeder and Kookesh 1990). Herring harvesters have taken advantage of this unique harvest opportunity during both historical and contemporary periods (Schroeder and Kookesh 1990). In the 19th century, Sitka was a center for Tlingit from all over Southeast Alaska to harvest herring and herring spawn (Emmons 1991; Pierce 1972). In the 1860s, herring were so numerous around Sitka in February and March that the water became milky from eggs and milt and it was easy to catch herring with a rake (Tikhmenev 1978). Herring spawn was traditionally exchanged for specialized foods, such as eulachon *Thaleichthys pacificus* oil and dried eulachon, berries, dried seaweed, and mountain goat *Oreamnos americanus* meat. It was also traded for raw materials and handicrafts. Recently, herring eggs from Sitka Sound have been documented as being shared throughout Southeast Alaska and beyond to as far north as Barrow and Point Hope and as far south as Seattle (Sill and Lemons 2012).

The primary method of the contemporary harvest is to submerge branches of the Western hemlock *Tsuga heterophylla* in salt waters just outside the intertidal zone before spawning takes place. Herring spawn is also collected on other substrates such as *Macrocystis* kelp, hair seaweed *Desmarestia* spp., and rockweed *Fucus* spp. (Schroeder and Kookesh 1990). The herring deposit their eggs on the branches of the hemlock or other substrate that are then removed from the water. Historically, herring spawn was consumed either fresh or air-dried, or was packed in salt for later use and distribution. As freezers became more common in households in the 1940s and 1950s, freezing became the preferred method of preserving herring spawn.

At its February 1989 meeting, the Alaska Board of Fisheries (BOF) made a positive customary and traditional use determination for the harvest of herring spawn in Sitka Sound. In September 2001, the Sitka Tribe of Alaska (STA) met with representatives from the Alaska Department of Fish and Game (ADF&G) to discuss tribal members' difficulty in meeting their subsistence needs for herring spawn in Sitka Sound during the spring 2001 season. They cited the intensive commercial harvest of herring in the sac roe fishery in the Middle, Crow, and Kasiana islands areas as affecting the subsistence users' ability to successfully harvest herring spawn on hemlock branches.

At the January 2002 BOF meeting, STA submitted an unsuccessful proposal requesting recognition of the geographically and historically important areas used for the subsistence herring spawn harvest. During this meeting the BOF also considered, but did not adopt, a permit program for the subsistence fishery. As a consequence of these proposals, the BOF requested that the ADF&G Division of Subsistence work with STA to develop a harvest monitoring program based on in-person harvest surveys. The BOF also made a determination that the amount reasonably necessary for subsistence[1] (ANS) was between 105,000 and 158,000 lb of herring spawn harvested from Section 13A and that portion of Section 13B that is north of the latitude of Aspid Cape (5 AAC 01.716 (b)). This finding was based upon the best harvest estimates of ADF&G, including results from a 1996 household harvest survey and a 1989 harvest estimate. At its 2009

1. Pursuant to Alaska Statute 16.05.258, the Alaska Board of Fisheries and the Alaska Board of Game are charged with identifying the fish stocks and game populations that are customarily and traditionally taken or used for subsistence, and with determining the amount of the harvestable portion that is reasonably necessary for subsistence uses.

meeting, the BOF revised the ANS to 136,000–227,000 lb, based on the mean estimated harvest from 2002–2008, as determined through the annual herring spawn harvest survey conducted by ADF&G and STA (Holen et al. 2011). In the Sitka Sound area, state regulations allow the subsistence harvest of herring and herring spawn in sections 13A and 13B north of Aspid Cape on Baranof Island (5 AAC 01.716 (a) (7)) as well as the limited noncommercial exchange of subsistence-harvested herring spawn on kelp for customary trade (5 AAC 01.717). In 2012, STA submitted a proposal to close to commercial fishing an area of Sitka Sound that has historically been used for the subsistence harvest of herring spawn. A compromise version of the proposal was adopted by the BOF, resulting in approximately 10 square miles of Sitka Sound being closed to the commercial herring sac roe fishery (see Appendix A).

Monitoring the subsistence harvest of herring spawn in Sitka Sound is an ongoing project. ADF&G participation in the annual harvest monitoring program is partially supported by a reimbursable services agreement (RSA) from the Division of Commercial Fisheries to the Division of Subsistence as well as by the Division of Subsistence general funds. STA provides its own funding for the project, except for the harvest survey component of the research, which is supported by a cooperative agreement with ADF&G. STA and ADF&G collaborate on survey design and data collection. ADF&G provides technical consultation and, when possible, field survey and interviewing support for the project and STA provides ADF&G with completed surveys.

This report complements the Sitka Sound subsistence herring spawn harvest monitoring discussions found in previously published reports that are part of the ADF&G Division of Subsistence Technical Paper series (Brock and Turek 2007; Holen et al. 2011; Sill and Lemons 2012, 2014a–b).

PROJECT OBJECTIVES

The goal of the harvest monitoring program is to annually document the subsistence harvest of herring spawn through household surveys with all harvesters who participate in the fishery in Sitka Sound. The objectives of the project in 2014 were to:

1. Conduct in-person interviews with household members in Sitka and surrounding communities who were identified as likely harvesters of herring spawn from Sitka Sound for subsistence;
2. Produce estimates of the total pounds of herring spawn harvested on hemlock branches, giant kelp *Macrocystis pyrifera*, hair seaweed *Desmarestia spp*., and "other" substrates; and
3. Identify locations where herring spawn were harvested.

METHODS

Estimates of the subsistence herring spawn harvest in Sitka Sound have been produced for 2002–2014 by systematically identifying and surveying households that harvest herring spawn. This annual project is guided by the research principles outlined in the *Alaska Federation of Natives Guidelines for Research*[2] and by the National Science Foundation, Office of Polar Programs in its *Principles for the Conduct of Research in the Arctic*[3], as well as the Alaska confidentiality statute (AS 16.05.815). These principles stress community approval of research designs, informed consent, anonymity of study participants, community review of draft study findings, and the provision of study findings to each study community upon completion of the research.

2. Alaska Federation of Natives. 2013. *Alaska Federation of Natives Guidelines for Research*. Alaska Native Knowledge Network. Accessed February 25, 2014. http://www.ankn.uaf.edu/IKS/afnguide.html
3. National Science Foundation Interagency Social Science Task Force. 2012. *Principles for the Conduct of Research in the Arctic*. Accessed February 25, 2014. http://www.nsf.gov/od/opp/arctic/conduct.jsp

Survey Plan and Implementation

STA and ADF&G met in February and March prior to the start of the 2014 subsistence herring spawn harvest to review the survey instrument, the methods for compiling the household list, and the methods for creating and validating conversion factors. The methods outlined in this section are a collaborative effort between ADF&G and STA. Division staff participated in the beginning of the herring spawn harvest in Sitka during March and April 2014 and collaborated with STA staff in updating the weight conversion factors. STA staff conducted most of the household surveys; ADF&G staff were present in Sitka at the beginning of the survey effort and assisted with approximately one-half of the household surveys during this time.

Development of the Household Survey List

To meet Objective 1, STA updated the list of known and likely harvesters for the 2014 season. Using the 2013 household list as a starting point, new harvesters were added and non-harvesters were removed, following the methods discussed below and in more detail in Holen et al. (2011). Outreach by STA and a chain referral method were employed to expand the list. Harvesting is a highly visible activity; therefore it was assumed that active harvesters would be aware of other harvesters. Based on the knowledge of active harvesters identified through STA outreach efforts, additional potential harvesting households were added to the household list. The household list also included households from other communities who harvested herring spawn in Sitka Sound as identified through STA outreach efforts and knowledge of the surveyors and STA staff.

For this annual survey program, once added to the household list, an identified household remains on the list unless 1 of 3 situations occurs:

1. If the household is surveyed for 3 consecutive years and has not attempted to harvest within that time, it is removed, even if the household answers in the affirmative as to whether they plan to harvest in the future; or
2. If a household is unable to be contacted for 3 consecutive years, it is removed from the list; or
3. If the household identifies that it no longer plans to harvest, it is removed from the list.

Once removed from the list, the household identification (ID) number is retired. Prior to the beginning of the 2014 herring spawn event, staff from STA and ADF&G reviewed the household master list to ensure these parameters were satisfied.

The Survey Instrument

Objectives 2 and 3 were addressed through the use of a household survey. The survey instrument was designed to collect information about:

1. Whether respondents harvested, attempted to harvest, used, received, or gave away herring spawn.
2. The amount of herring spawn harvested.
3. The kind of substrate used.
4. Whether respondents harvested on their own or in collaboration with other households.
5. The amount of herring spawn respondents kept for their own use, gave away locally, or shipped out of Sitka, and the communities with which they shared the harvest.
6. The location of respondents' harvests.
7. Survey respondents' qualitative assessments of the study year's herring spawn harvest.

8. Survey respondents' qualitative descriptions of their participation in the harvest.

There were no substantive changes to the survey instrument from the 2013 survey. The question "How many households do you typically harvest for?" was added. A copy of the 2014 instrument can be found in Appendix B. Harvest location information was collected through 2 methods. One method was for the respondent to simply pick among standard generalized locations offered on the survey (see Appendix B). The other method was using an application designed on the ArcGIS Runtime SDK for iOS platform; basically a mapping data collection application for the iPad.[4] The point, polygon, or line was drawn on a U.S. Geological Survey topographic relief map downloaded on the iPad. The iPad allowed the user to zoom in and out to the appropriate scale, and the ability to document harvesting activities wherever they occurred. Once a feature was accepted, an attribute box was filled out by the researcher that noted the species harvested, amount, method of access to the resources, and month of harvest. The data were uploaded via Wi-Fi to a server. Once data collection was complete the data were downloaded into an ArcGIS file geodatabase. The application was developed by HDR, Inc. The use of the iPad software during this study year was a test to see if this method could be useful during these harvest assessments. Based on this year's experience, future survey efforts will likely include more digital mapping efforts.

Survey Implementation

Using the 2013 household list as a base, STA created a list of 99 potential harvesting households for 2014. An interview was attempted for each household on the list; 60 households were successfully interviewed, 39 households were unable to be contacted. ADF&G Subsistence Resource Specialist Rosalie Grant and STA Fisheries Biologist Jessica Gill conducted the surveys in April, May, and June 2014 directly after both herring spawn events. After the final survey effort was finished, completed surveys were sent to ADF&G for coding and analysis. Completed surveys were given a code (see Appendix C for code book) based on user status: 1) individual harvester, 2) non-harvester, or 3) community-harvest boat. The latter code encompasses boats, such as STA's traditional foods boat or the Southeast Alaska Herring Conservation Alliance-sponsored vessel, that harvest herring for community-wide distribution in Sitka or another Southeast community. These community boats are considered a "household" for the purposes of this report, and are part of the 60 households interviewed. As will be seen in the data analysis section, they are treated slightly differently during analysis. For survey methods, the skipper or owner of the boat is surveyed about the entire harvest brought in by that boat. Crew on board who take home any of the boat's harvest are not considered harvesting households but as receivers of herring spawn.

Update of the 2014 Conversion Factors

Prior to beginning the household survey, conversion factors to estimate the weight of herring spawn in common storage containers were created following the methods established in 2010. On March 28 and 29, 2014, division staff worked with STA to process 2,096 lb of their herring spawn on hemlock branches harvest to create conversion factors. This was the first harvest of the season for STA and was conducted using a boat owned and operated by STA. Prior to the beginning of the spawn, STA staff set hemlock branches in Sitka Sound. The locations of the sets were determined by STA staff based on active spawning conditions, their knowledge of herring spawn events, and their experience with the harvest.

Based on the plan devised by STA and ADF&G, the following steps were taken to measure weights in the field in 2014.

1. STA staff, accompanied by ADF&G researchers, checked all herring sets and pulled those that were ready.

4. Product names are given because they are established standards for the State of Alaska or for scientific completeness; they do not constitute product endorsement.

2. Once the boat returned to the harbor after pulling a set, STA staff used a hanging scale connected to a hydraulic hoist attached to the dock to weigh the branches and remove them from the boat. While still on the deck of the boat, some of the branches were placed in a plastic fish tote of the type commonly used in commercial fisheries. Once full, the tote was lifted off the boat and weighed. Some branches were not placed in totes; these branches were tied up with rope, then weighed and removed from the boat. During 2014 activities, the scale broke after weighing approximately 1/3 of the harvest in this manner. A replacement scale was unreadable at the distance it had to be read. Weights were taken instead by using a smaller scale after the branches were transported to the sorting facility. Branches were weighed prior to being processed; the processed branches were weighed again at the end, as was all the material that was discarded during processing using the smaller scale at the STA facility.
3. STA staff loaded the branches into a pickup truck for transfer to the processing site located in front of the STA Resources Protection Department office. The method of processing spawn depended on how the final product was to be stored. For storage in boxes or grocery bags, processors used pruning shears to remove the larger branches and the poorly covered branches. For storage in gallon-sized bags, the more rigid branches were discarded, leaving only the softer branches and needles that would not tear the bags.
4. The processed spawn was placed in containers identified by STA as common containers used to store, move, and ship herring spawn. The container types reflected the units harvesters might be familiar with and able to report rather than having to estimate total pounds harvested for the survey. STA and division researchers identified 25 lb and 50 lb wetlock boxes—a type of waxed cardboard box commonly used for shipping seafood—as well as plastic zip-top gallon-sized bags as the most common container types for herring spawn on hemlock branches and on kelp.
    a. Each wetlock box from a herring set was placed in a plastic tote and weighed from a hanging scale. The gross weight of each tote was recorded by hand (weight of the plastic tote plus the weight of the wetlock box plus the weight of the spawn).
    b. Weights were taken for each box of processed spawn in order to understand variability between boxes. An average weight of each type of box was established. The net weights of all boxes of spawn coming from the original unprocessed set were compared to understand the difference between the unprocessed and processed spawn.
5. A few wetlock boxes from each set were taken into the STA offices and further processed for gallon-sized zip-top plastic bags. Weights of filled bags were measured by a desktop analog scale and recorded by hand.
    a. The weights of all zip-top bags coming from one wetlock box of spawn were compared to the weight of the wetlock box to understand the effect of additional processing.
    b. The weights of the bags were also taken independently for the purpose of developing an average weight of a bag filled with processed spawn.
    c. During the processing, some of the plastic bags did not get filled to the 100% mark. These bags were included in the total weight calculations, but not included in mean bag weight calculations.

In all, 20 sets of branches were placed by STA staff in herring spawning areas and 7 of these sets were harvested for a total STA harvest of 3,364 lb of herring spawn in 2014. The first 3 sets were weighed and processed for the conversion factor. The other 4 sets were harvested at a later date and not used in the conversion factor update.

DATA ANALYSIS

ADF&G Information Management staff analyzed the data from the 2014 survey to produce estimates of the total harvest of herring spawn on all substrates. For 2014, the surveys were coded for data entry by ADF&G staff in Douglas using the conversion factors that were determined as described above. ADF&G staff also created codes for responses given to assessment questions (see Appendix C for 2014 code book). Responses were coded following standardized conventions used by ADF&G. ADF&G Information Management staff in Anchorage set up database structures within a Microsoft SQL Server database. The database structures included rules, constraints, and referential integrity to ensure that data were entered completely and accurately. Data entry screens were developed in Microsoft Access and made available on a secure network. Daily incremental backups of the database occurred, and transaction logs were backed up hourly. Full backups of the database occurred twice weekly. This ensured that no more than 1 hour of data entry would be lost in the unlikely event of a catastrophic failure. All survey data were entered twice and reviewed so as to minimize data entry errors.

Once data were entered and quality-control checked using standardized procedures employed by ADF&G Information Management staff, the information was processed using the Statistical Package for the Social Sciences (SPSS), Version 21. Initial processing included performing standardized logic checks of the data, which are often needed in complex datasets where rules, constraints, and referential integrity do not capture all the possible inconsistencies that may appear.

Data analysis also included review of raw data frequencies, cross tabulations, table generation, estimation of population parameters, and calculation of confidence intervals for the estimates. Missing information was dealt with in a manner appropriate to each situation, following such standardized practices as minimal value substitution or the use of an average response for similarly-characterized households (mean replacement). Typically, missing data are an uncommon, randomly-occurring phenomenon in ADF&G household surveys. In unusual cases, where a substantial amount of survey information is missing, the household survey is treated as a "non-response" and not included in community estimates. All adjustments were documented.

ADF&G applied the weighted means method (Cochran 1977) to generate harvest estimates for herring spawn from an interviewed sample of households drawn from a list of households known to harvest herring spawn in Sitka during the study year. In cases where a household was known to be an active harvester during one year, but the harvest was unknown that year, the mean household harvest of that year was used as an estimate of that household's actual harvest. Information Management staff used the following formula to generate these estimates:

$$H = N\left(\frac{\sum x}{n}\right) \tag{1}$$

Where

H = Total estimated harvest,

N = Total number of households identified,

n = Number of sampled households, and

x = household's reported harvest.

In this approach, the mean of the estimate remains the same as the sampled mean so percentages derived from sampled households can be applied to the entire household list. The principal assumption is that the group of households from the household list of likely harvesters that were unable to be surveyed in 2014 has (on average) the same harvest and use patterns as the households that were successfully contacted. Since the mean is the primary statistic used to develop the estimates, Information Management staff produced a 95% confidence interval (CI), represented as a percentage, to measure the relative precision of

the mean. The CI can also be applied to the total estimated harvest to obtain a likely upper and lower range for the estimate. The following formula was applied to create the CI percentage:

$$CI\% = \frac{t_{\propto/2} \times \frac{s}{\sqrt{n}} \times \sqrt{1 - \frac{n}{N}}}{\bar{x}} \tag{2}$$

Where

s = sample standard deviation,

n = sampled households,

N = total households identified,

$t_{\alpha/2}$ = student's t statistic for alpha level ($\alpha = 0.05$) with n–1 degrees of freedom, and

$\bar{x}$ = mean harvest.

A small CI percentage indicates low variance in household harvest amounts and that the actual mean is very close to the sampled mean. A larger CI percentage would indicate that there is a larger variance between household harvest amounts and an increased likelihood that the actual mean differs, possibly substantially, from the sampled harvest mean. Confidence intervals for household surveys conducted in 1987 and 1996 as well as data from the annual monitoring program are presented in Table 1. Confidence intervals are not available for the 1983 harvest estimates (Table 1).

DISSEMINATION OF SURVEY RESULTS

Each year the data are presented at the Southeast Alaska sac roe herring preseason meeting held in Sitka in February. In addition, results are presented at a preseason meeting held by STA, although this meeting was not held in 2014. The written report is reviewed within ADF&G as well as by the Southeast Alaska Herring Conservation Alliance and STA. The final report, once published, is available on the ADF&G website. Hard copies are distributed to STA.

Table 1.–Estimated subsistence harvest of herring spawn in Sitka Sound, 1983, 1987, 1996, 2002–2014.

		Percentages based on surveyed households				Estimated values					
Year	Total number of surveyed households	Percentage of households attempting to harvest	Percentage of households harvesting	Percentage of harvesting households giving away herring spawn	Percentage of harvesting households receiving herring spawn	Estimated number of households attempting to harvest	Estimated number of households harvesting	Estimated harvest, all substrates, pounds	95% confidence interval (± %)	Range: low	Range: high
For the following 3 years, the data pertain to the entire population of Sitka, based on a random sample.											
1983	139	n/a	24.0%	n/a	n/a	n/a	586	42,000[a]	n/a	n/a	n/a
1987	296	n/a	9.0%	n/a	n/a	n/a	261	20,494[a]	91%	1,755	39,235
1996	150	16.0%	15.0%	n/a	20.0%	476	464	127,174	72%	35,131	219,217
For the following 13 years, the data pertain to only those Sitka households identified as potential participants in the subsistence herring spawn fishery.											
2002	86	n/a	71.0%	95.0%	40.0%	n/a	77	151,717	23%	116,701	186,734
2003	118	72.0%	71.0%	88.0%	30.0%	117	116	278,799	19%	225,704	331,895
2004	144	61.0%	60.0%	93.0%	17.0%	120	118	381,226	18%	312,224	450,229
2005	159	61.0%	52.0%	82.0%	13.0%	111	95	79,064	9%	72,272	85,856
2006	127	58.0%	55.0%	91.0%	27.0%	93	88	219,356	20%	176,484	262,228
2007	126	55.0%	48.0%	89.0%	43.0%	92	81	87,211	22%	67,702	106,720
2008	128	45.0%	41.0%	73.0%	52.0%	59	54	71,936	6%	67,764	76,108
2009	150	48.0%	48.0%	89.0%	79.0%	91	91	213,712	9%	193,623	233,801
2010	132	30.0%	30.0%	85.0%	12.5%	40	40	154,620	10%	139,872	169,367
2011	109	38.5%	35.4%	94.0%	35.0%	57	53	83,443	5%	79,719	87,166
2012	75	45.0%	43.2%	84.0%	88.0%	50	47	115,799	12%	102,332	129,265
2013	59	64.4%	62.7%	86.1%	27.7%	52	50	78,090	10%	70,075	86,106
2014	60	68.3%	67.8%	87.5%	31.7%	68	68	154,412	13%	135,054	173,769

Sources CSIS; Brock and Turek (2007); Sitka Tribe of Alaska household surveys, as summarized in Gmelch and Gmelch (1985).

Note "n/a" = data were not collected during the study year.

a. Harvest estimates for 1983 and 1987 are likely low due to the small size of the random sample, which might have failed to include high harvesting households that specialize in harvesting herring spawn.

2. 2014 RESULTS

All 3 project objectives were satisfied in 2014. Sixty of 99 households identified as potential harvesters of herring spawn were interviewed, including the STA boat, a boat sponsored by the Southeast Herring Conservation Alliance (SHCA), and 4 other community harvester boats. As reported in Table 1, an estimated 68 households attempted to harvest herring spawn and all were successful. This represents an increase in the number of estimated households that attempted to harvest or harvested in comparison to 2013.

The second objective of the project was to estimate the total subsistence harvest of herring spawn in Sitka Sound during 2014. Table 2 presents the total estimated harvest (154,412 lb) of herring spawn by harvester type and substrate for all of Sitka Sound. As has been seen in prior years of study, the vast majority of harvesters were Sitka residents, but approximately 70% of the herring spawn was harvested by the community harvester boats (including the STA and SHCA boats). These are boats that come to Sitka Sound and harvest large quantities of spawn for general distribution within Sitka or the boats' home communities. In 2014, these boats came from, at a minimum, Hoonah, Angoon, Kake, and Metlakatla; an additional boat was sponsored by SHCA and the STA Traditional Foods program also harvested for the community. Regardless of who harvested the spawn, by far the most commonly used substrate for the harvest was hemlock branches (Figure 1). Ninety-seven percent (150,020 lb) of estimated harvests occurred on hemlock branches, while 3% was herring spawn-on-kelp (3,562 lb) or spawn harvested on hair seaweed (831 lb) (Figure 1; Table 3). The 2014 spawn-on-kelp harvest amount was similar to what has been documented in years past. In addition to reporting harvest amounts by substrate, respondents were also asked if their use was the same as, less than, or more than their use in recent years. A similar question asked specifically about the harvest of herring eggs, not just the use of them. Almost one-half of the respondents reported using about the same amount of herring eggs as recent years. Nearly one-half of all respondents additionally reported harvesting more or the same amount of herring spawn in 2014 than in previous years (Figure 2).

The majority of the 2014 harvest was shared with the community of Sitka and beyond; this is a documented characteristic of the harvest common to every year of the project. Of the surveyed households that harvested herring spawn in 2014, 88% shared at least some of their harvest (Table 1). Because this survey only attempted to interview harvesters of herring spawn, it is not possible to obtain data for overall community use and sharing of herring spawn. However, some survey respondents who did not harvest any eggs still shared the eggs they received from others. Of the total estimated amount of herring spawn that was harvested, only 6% was kept for use by the harvesting household; the remainder was given away (Figure 3; Table 3). Of the 94% of the harvest that was shared with others, one-half remained within Sitka while the other one-half was shipped outside of Sitka (Figure 3). Spawn on hemlock branches composed most of the harvest, by weight (80%), kept for the harvester's personal use, but that is largely a factor of the overall higher harvest amounts of spawn harvested on branches. The majority of the spawn-on-branches harvest was shared, with only about 5% kept for personal use (Table 3). In contrast, 48% of all the spawn on kelp harvested was kept for personal use; the rest was shared (Table 3). In 2014, herring spawn from Sitka Sound was shared with residents of the following communities in addition to Sitka: Anchorage, Angoon, Barrow, Craig, Dillingham, Haines, Hoonah, Hydaburg, Juneau, Kake, Kasaan, Ketchikan, Klawock, Kodiak, Metlakatla, Nome, Savoonga, and Yakutat, as well as communities outside of Alaska including locations in Washington, California, and Florida. In addition, as noted above, boats from Angoon, Hoonah, Kake, and Metlakatla traveled to Sitka Sound to harvest herring spawn for those communities' residents.

Not all potential harvesters contacted for this survey attempted to harvest herring spawn in 2014. The most common reason given for not attempting to harvest in 2014 was that the respondent was "working during the harvest." Conflicts with a work schedule have consistently been one of the most common reasons given for not participating in the harvest. Other reasons given were "received from friends or

family" and "not ready" (Figure 4). When asked for a qualitative assessment of the harvest in 2014, of the 54 households who answered this question, one-half shared that they felt the resource availability was different (either more or less) this year than in years past. Among this one-half of respondents, the availability of the resource and the quality of the eggs were the most common observed differences with years past (Figure 5).

Table 2.–Subsistence harvest and use of herring spawn by community of residence, Sitka area, 2014.

Resource	Percentage of households					Estimated pounds harvested	Confidence interval		
	Used	Attempted	Harvested	Gave	Received	Total	CI %	Low	High
Sitka Households (n=55)									
Herring spawn on hemlock branches	59.3%	46.3%	46.3%	38.9%	20.4%	36,944	9%	33,772	40,116
Herring spawn on kelp	40.7%	37.0%	35.2%	27.8%	5.6%	3,463	6%	3,244	3,681
Herring spawn on hair seaweed	25.9%	24.1%	24.1%	13.0%	0.0%	580	10%	522	638
Subtotal, herring spawn, all types	72.2%	64.8%	64.8%	55.6%	24.1%	40,986	8%	37,775	44,197
Community Harvester Boats (n=5)									
Herring spawn on hemlock branches	100.0%	100.0%	100.0%	100.0%	0.0%	109,156	3%	105,409	112,903
Herring spawn on kelp	20.0%	20.0%	20.0%	20.0%	0.0%	36	8%	33	39
Herring spawn on hair seaweed	20.0%	20.0%	20.0%	20.0%	0.0%	240	8%	220	260
Subtotal, herring spawn, all types	100.0%	100.0%	100.0%	100.0%	0.0%	109,431	3%	105,682	113,181
Sitka Tribe of Alaska (n=1)									
Herring spawn on hemlock branches	100.0%	100.0%	100.0%	100.0%	0.0%	3,920	0%	3,920	3,920
Herring spawn on kelp	100.0%	100.0%	100.0%	100.0%	0.0%	64	0%	64	64
Herring spawn on hair seaweed	100.0%	100.0%	100.0%	100.0%	0.0%	10	0%	10	10
Subtotal, herring spawn, all types	100.0%	100.0%	100.0%	100.0%	0.0%	3,994	0%	3,994	3,994
Total	**75.0%**	**68.3%**	**68.3%**	**60.0%**	**21.7%**	**154,412**	**13%**	**135,054**	**173,769**

Source Sitka Tribe of Alaska and ADF&G Division of Subsistence household surveys, 2014.

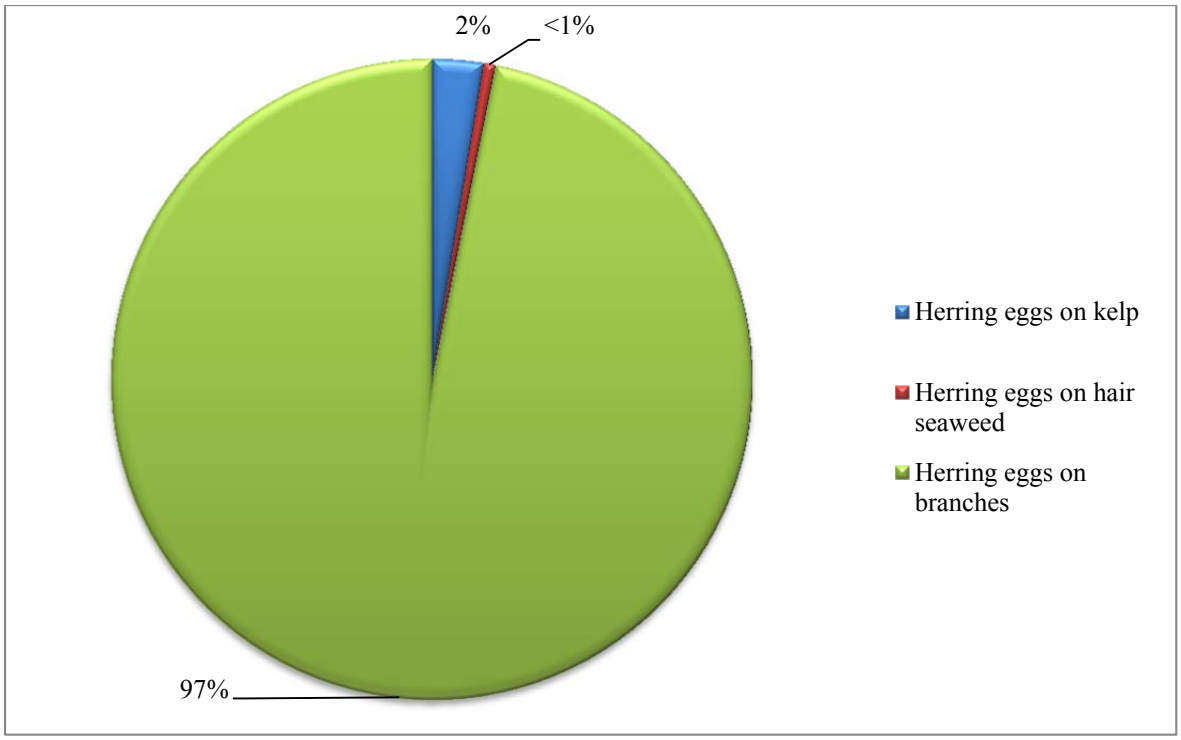


Figure 1.–Distribution of subsistence herring spawn harvest by substrate, Sitka area, 2014.

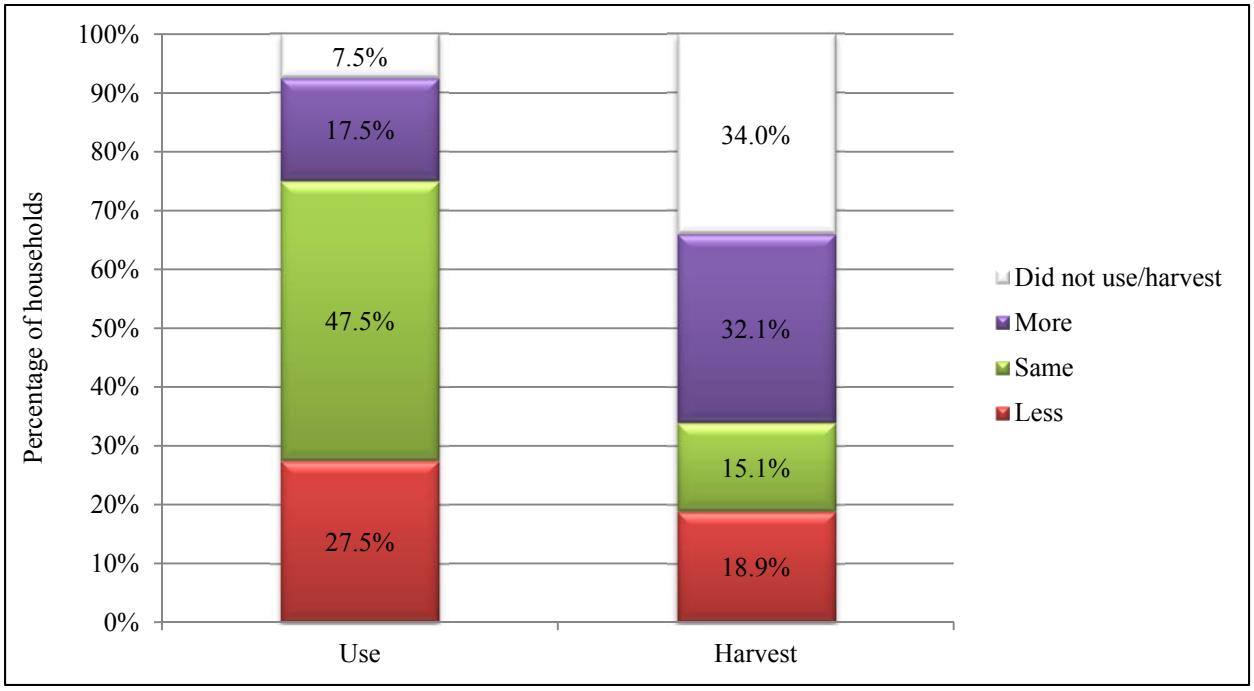


Figure 2.–Household perception of herring spawn harvest and use compared to previous years, Sitka area, 2014.

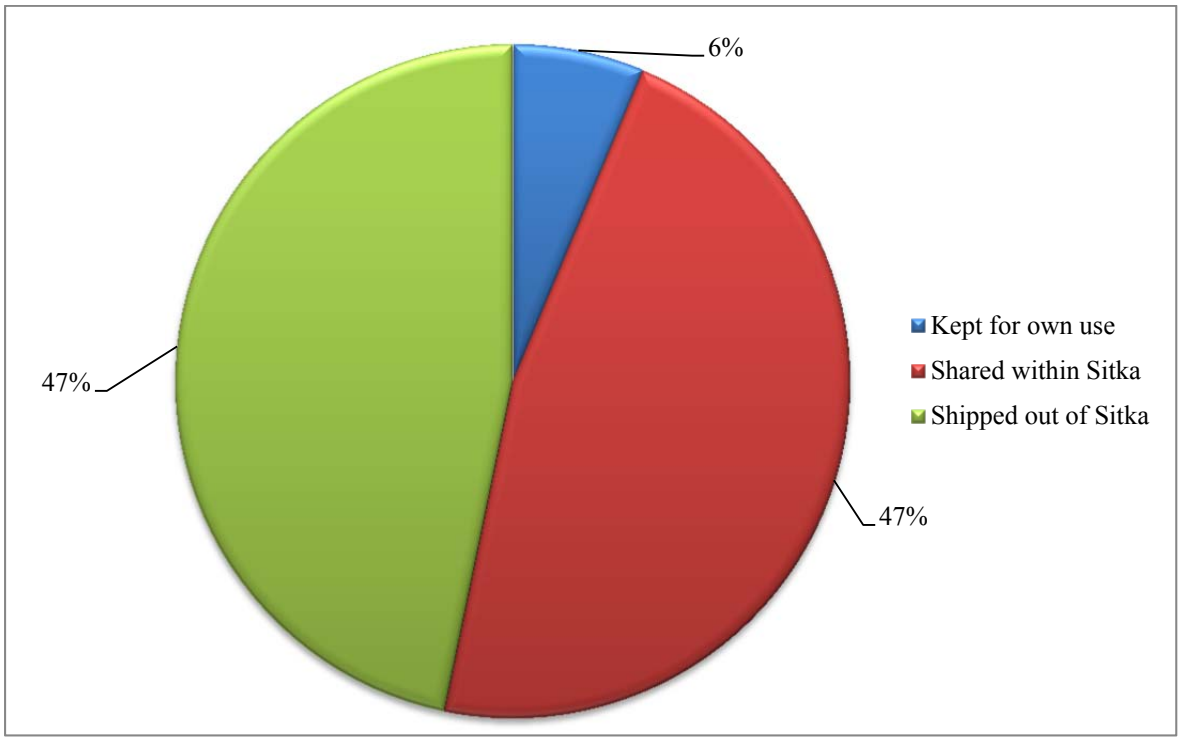


Figure 3.–Percentage of total Sitka Sound subsistence harvested herring spawn that was shared, 2014.

Table 3.–Distribution of subsistence herring spawn harvest, Sitka area, 2014.

	Estimated harvest						
	Kept for own use		Shared within Sitka		Shared outside of Sitka		
Resource	Pounds	Percentage of total harvest	Pounds	Percentage	Pounds	Percentage	Total pounds
Herring spawn on kelp	1,716	48.2%	1,439	40.4%	407	11.4%	3,562
Herring spawn, hair seaweed	233	28.0%	350	42.2%	247	29.7%	830
Herring spawn on hemlock branches	7,841	5.2%	70,677	47.1%	71,502	47.7%	150,020
Herring spawn, all types	9,789	6.3%	72,467	46.9%	72,156	46.7%	154,412

Sources Sitka Tribe of Alaska and ADF&G Division of Subsistence household surveys, 2014.

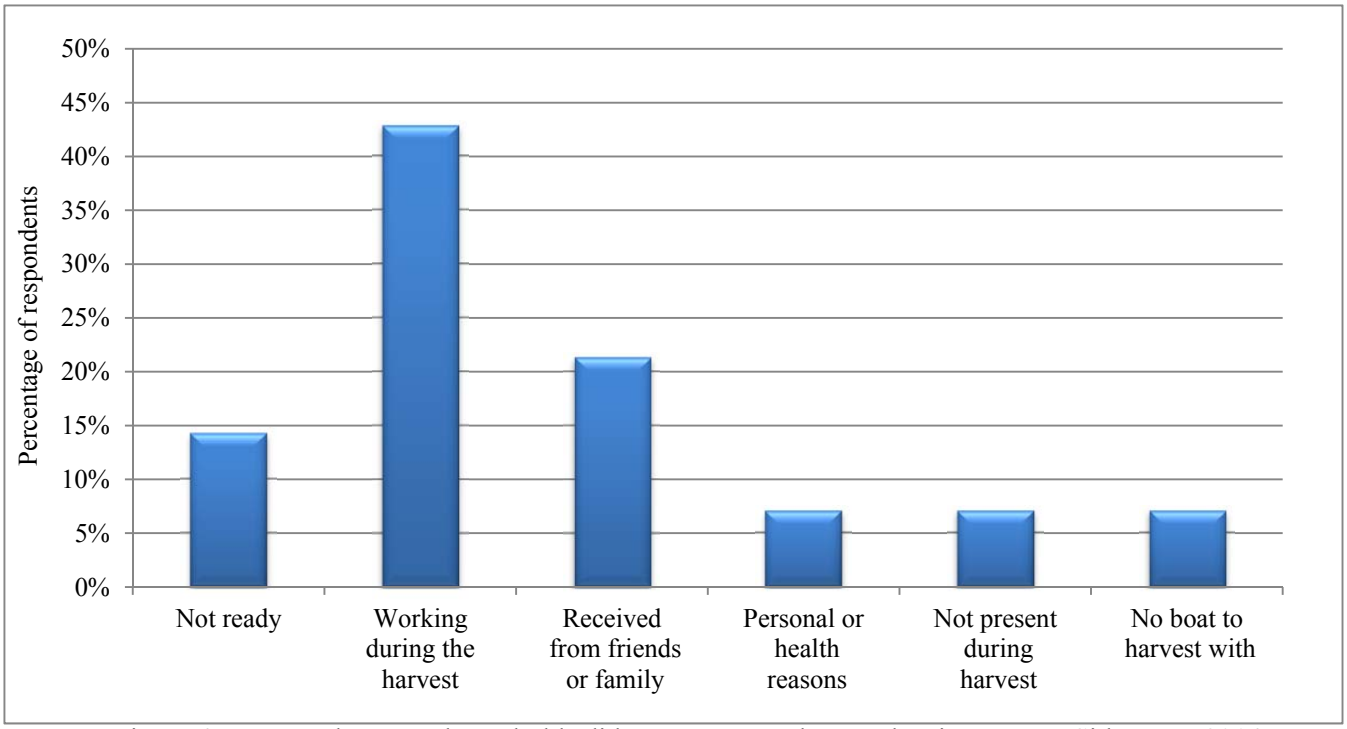


Figure 4.–Reported reasons households did not attempt to harvest herring spawn, Sitka area, 2014.

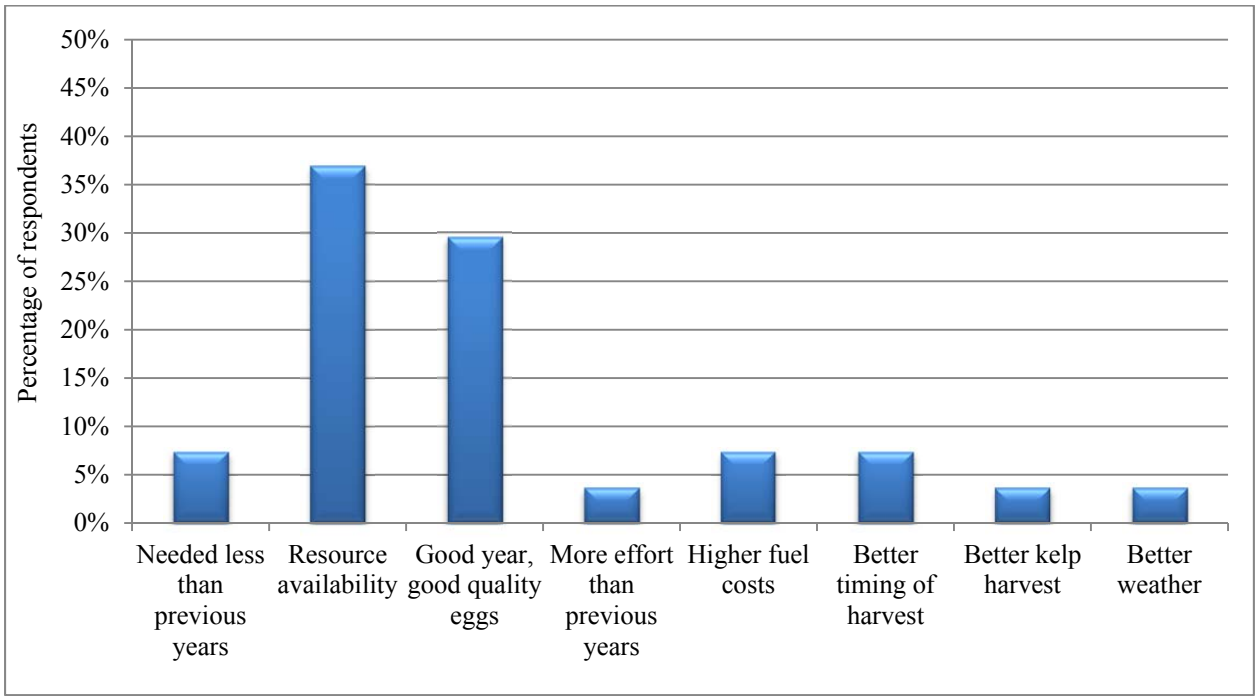


Figure 5.–Reasons given for why household harvests were different, either less or more, in 2014 than in recent years, Sitka Sound harvesters, 2014.

CONVERSION FACTORS

Researchers found that there was a slight decrease in weight between primarily processed (from tote to wetlock box) and secondarily processed (from box to bag) weights due to the removal of branches during processing. This decrease has been factored into the conversion formula for 2014 (Table 4). Conversion factors were not calculated prior to 2010. In 2014 STA staff decided that quart-sized bags were not going to be weighed for the purposes of this survey since they are rarely used by the community to distribute herring eggs.

Table 4.–Conversion factors for 2010–2014.

	Estimated average weight (pounds)				
Container type, spawn on branches	2014	2013	2012	2011	2010
Sea Pro[a] large (50 lb) wetlock box	48.91 lb	53.0 lb	59.10 lb	53.27 lb	57.78 lb
Sea-Pro[a] small (25 lb) wetlock box	24.68 lb	22.8 lb	28.50 lb	24.88 lb	25.50 lb
Ziploc[a] gallon bag	4.12 lb	3.94 lb	4.43 lb	3.87 lb	4.07 lb
Ziploc[a] quart bag	n/a	1.35 lb	1.38 lb	1.46 lb	1.42 lb
Container type, spawn on kelp					
Ziploc[a] gallon bag	n/a	n/a	3.65 lb	n/a	n/a
5-lb bucket	n/a	n/a	23.94 lb	n/a	n/a
Sea-Pro[a] small (25 lb) wetlock box	n/a	16.7 lb	n/a	n/a	n/a

Sources Sitka Tribe of Alaska and ADF&G Division of Subsistence household surveys, 2014; Holen et al. (2011); and Sill and Lemons (2012).

Note "n/a" indicates conversion factors were not calculated for these years.

a. Product names are given because they are established standards for the State of Alaska, and for scientific completeness; they do not constitute an endorsement.

HARVEST LOCATIONS

The final project objective was to document where the herring spawn harvest took place. The aggregate locations of harvests by all survey respondents are shown in Figure 6. The majority of the harvests occurred in the core area of Sitka Sound. As can be seen more readily in Table 5, the most important location in 2014 was South Middle Island (32% of harvesting households used location) followed by the Kasiana islands group (22%) and Crow/Gagarin islands (19%). These harvest locations are similar to 2013, when the majority of harvesters set in the Kasiana islands, Crow/Gagarin islands, and North Middle Island (Sill and Lemons 2014b). While 12% of households used North Middle Island, South Middle Island was more heavily used in 2014 (Table 5).

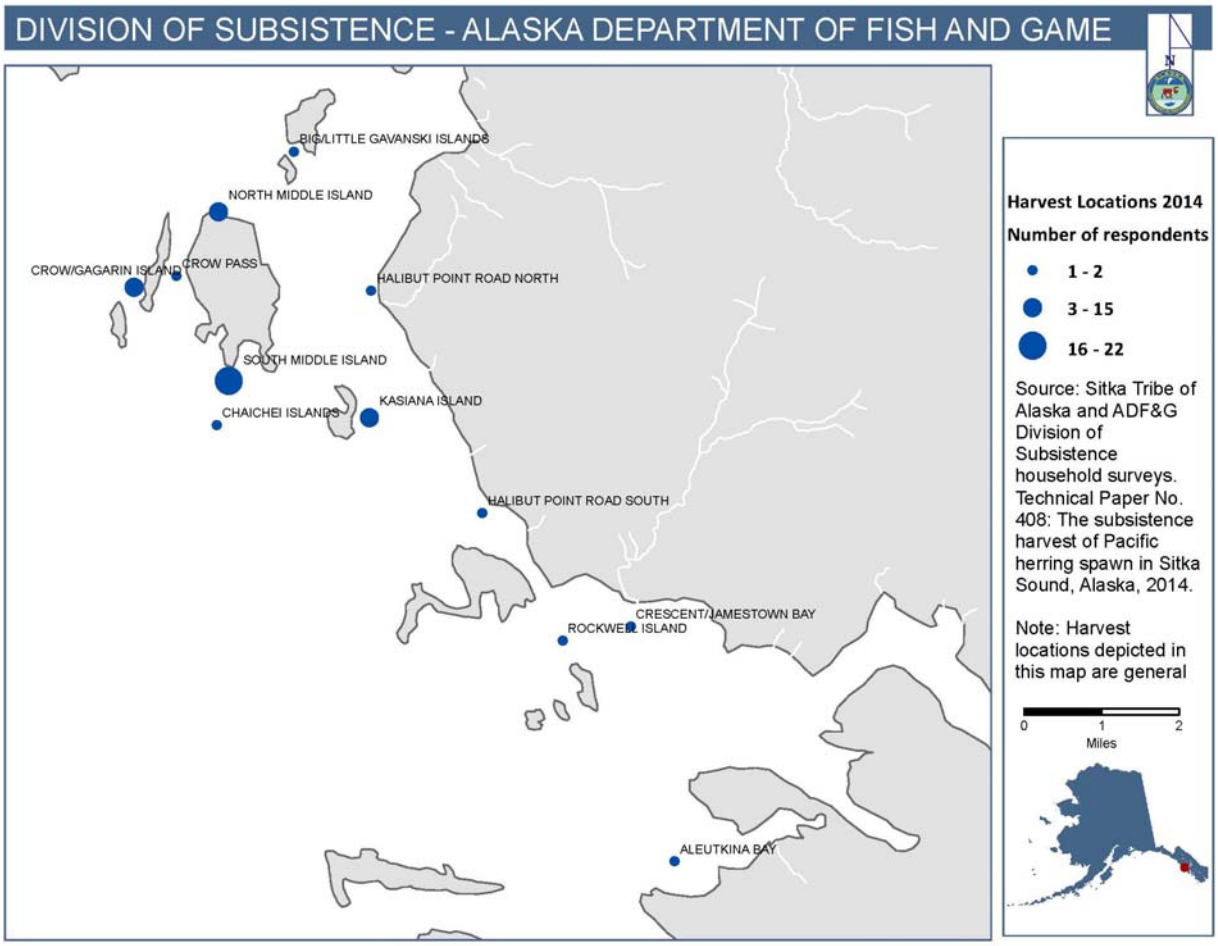


Figure 6.–Reported harvest locations, 2014.

Table 5.–Reported locations of subsistence herring spawn harvest, Sitka Sound, 2014.

Location	Reported households using each location	Percentage of harvesting households using each location
South Middle Island	22	32.4%
Kasiana Islands Group	15	22.1%
Crow/Gagarin Islands	13	19.1%
North Middle Island	8	11.8%
Other	6	8.8%
Big/Little Gavanski Islands	2	2.9%
Halibut Point Road North	2	2.9%

Source Sitka Tribe of Alaska and ADF&G Division of Subsistence household surveys, 2014.

3. DISCUSSION

After several years in which the total subsistence harvest from Sitka Sound was less than the amount set as the lower bound of the range of the ANS, the 2014 harvest exceeded this threshold (Figure 7). In part, the higher harvest is likely due to the increased number of harvesters in 2014 than in the previous 4 years, but it is also likely that the timing, quality, and dispersion of herring spawn contributed to the increased harvest amount. The overall amount of the subsistence herring egg harvest depends not only upon people making the effort to harvest herring spawn, but also on the opportunity for the harvest of quality spawn. Social, cultural, economic, and ecological factors all affect these 2 key components—participation and opportunity.

Year-to-year household participation varies, with some years showing greater participation than others. Over the first years of the survey, participation rates displayed a general decrease (Table 1). Since a low point in 2010 of 40 harvesters, participation rates appear to be increasing again with a high of 68 households in 2014. Participation in the herring spawn harvest is impacted by a harvester's other commitments—to work, to travel, to family—as well as economic considerations such as the price of gas or maintenance of a boat or engine. Individual households being able and choosing to participate in the harvest is only one factor influencing subsistence harvest success of the community. Certainly the level of participation or effort will affect the total harvest in any given year; however, effort does not explain the high variability seen in the annual harvest data. There is little correlation seen between the number of harvesting households and the total harvest for a given year over the course of this survey project (Figure 7). For example, years with fewer households participating, such as 2010 (40 households), had a much higher harvest (by 85% or more) than years with higher participation, such as 2011 and 2013 (57 and 52 participating households, respectively).

The other relevant factor in successful harvests to be considered can be termed "opportunity." The opportunity to harvest is influenced by both socio-cultural and ecological factors. The ecological side is the spatial component of the harvest and the variation in where, when, and how spawn is deposited. In short, there needs to be herring spawn available to harvest. As can be seen Figure 8, the amount of herring that return to Sitka Sound annually has been variable, but has decreased yearly since 2009. While the number of herring that return to spawn to Sitka Sound may contribute to the overall success of the subsistence harvest, there appears to be little correlation between the size of the herring stock and the subsistence harvest. Since 2009, subsistence harvests have been variable and the large increase in 2014 corresponds with the smallest return of herring seen since 2003. Another contributing factor is the dispersion of herring spawn. A consistent spawn of some duration in locations suitable to set branches is necessary. During in-depth interviews with herring harvesters, at public meetings, and in casual conversation, researchers have repeatedly heard about spawning events that lasted for weeks when the respondents were younger or during their parents' lifetimes. Although ADF&G spawning deposition records for Sitka Sound do not show a trend of decreasing length of spawning events, respondents have stated that more recent spawning events in the areas most heavily used by subsistence harvesters have lasted a much shorter length of time, with less shoreline having multi-day deposition of spawn.[5] About 3 days of spawn in an area is commonly cited by harvesters as the minimum amount necessary for quality egg deposition and a good harvest. It has been found that mean spawning days in subsistence use areas of Sitka Sound can be a reasonably good predictor of harvest success (for a further discussion of the relationship between harvest success and multi-day spawning events see both Sill and Lemons [2014a]

5. While subsistence harvesters have shared with researchers that the length of the herring spawn has decreased in their lifetimes or their parents', the spawn records kept by ADF&G over the past 50 years do not support this conclusion. Shewmake (Shewmake 2013) illustrates that the length of spawn deposition since 2000 can be highly variable, especially when looking at the deposition of all of Sitka Sound versus just subsistence use areas or the preferred subsistence use areas. The discrepancies between ADF&G data and respondents' recollections may be due to the different geographical scales at which information is processed. ADF&G records spawn deposition throughout Sitka Sound and surrounding water bodies. Harvesters record spawning information usually from much smaller, discrete areas within Sitka Sound that they experience firsthand.

and a thesis by James Shewmake [2013]). Similar to 2013, the 2014 spawn occurred during 2 distinct events. The first spawn began on March 25 and ended on April 4, lasting 11 days. The second spawn, a smaller event, began on April 11 and ended on April 18. There was good spawn deposition during the first event in the traditionally used locations, especially Kasiana and Middle islands, which is where the majority of the subsistence harvests came from. Together, the 2 events covered approximately 49.6 nautical miles of shoreline with spawn. This compares to the recent 10-year average of 60.0 nm and is less than the spawn coverage in 2013. The overall number of miles of herring spawn is not as useful a metric as where the spawn is when analyzing the success of the subsistence harvest, because the harvests occur in very localized areas.

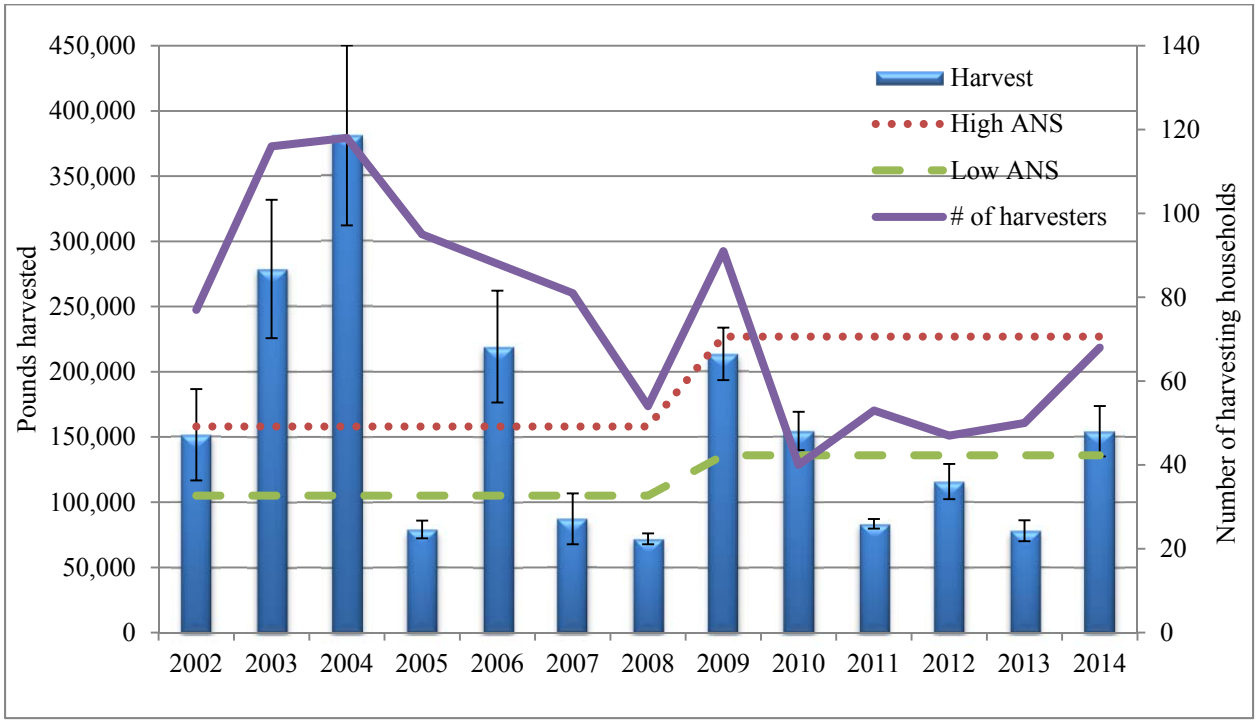


Figure 7.–Total pounds usable weight of herring spawn harvested, number of harvesting households, and amount reasonably necessary for subsistence (ANS) of herring spawn on all substrates in Sitka Sound, 2002–2014.

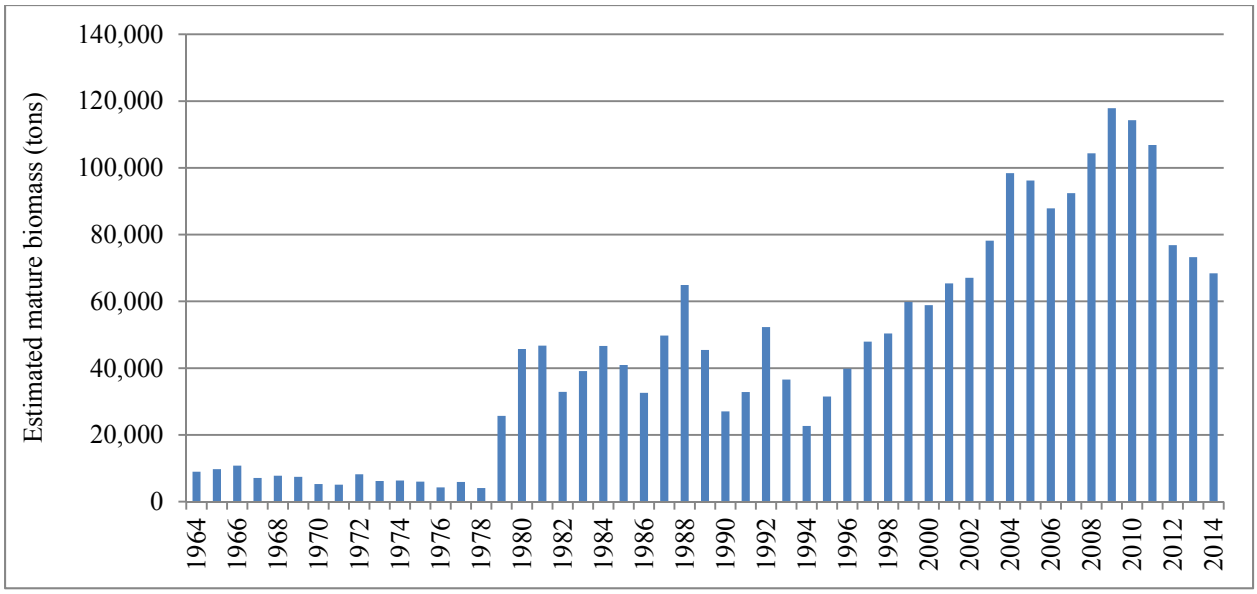


Figure 8.–Estimated mature biomass of Pacific herring in Sitka Sound, 1964–2014.

The socio-cultural aspects of opportunity are separate from the ecological. Assuming there is sufficient herring spawn in locations accessible and suitable for herring egg harvest, to be a successful harvester requires, at the most basic level, that an individual can be physically present on the spawning grounds with the time available to prepare hemlock branches, set them, and, in some cases, guard them against theft. Harvesters note that branches should not soak for more than 3 days or they become soft and the needles start to disintegrate, leading to a poor deposition on the branches, so branches need to go in the water shortly before or right as the spawn is occurring. After the herring have spawned on the branches, individuals need the time and equipment to haul in their sets, process the eggs, and preserve them. In 2014, as in previous years, the most common reason given (by 43% of the responding households in 2014) for why the household did not participate in the fishery was "work" (Figure 4). The perceived shorter available spawning period harvesters have spoken of at preferred harvest locations may be exacerbating this issue. Harvesters do not necessarily have the ability to take time off of work with little notice in order to capitalize on the spawn event. When the spawn lasts less than a week, the harvester does not have the flexibility to accommodate work schedules and other commitments. The 2014 spawning event of more than a week, including weekend days, may have made this less of a problem for the 2014 harvest. During the last 30 years, the spawn has begun as early as March 19 and as late as April 28. Some harvesters can predict fairly accurately when the spawn is going to happen as the time gets closer, but there is no real predictability to allow for much prior planning. Successful harvests often require a lot of time spent on the water, watching the herring for signs that spawning is imminent.

Bringing the 2 factors together—participation and opportunity—Shewmake (2013) investigated harvest success in terms of participation and opportunity. By graphing the relationship between household days in subsistence areas[6] (defined as the number of participating households multiplied by mean spawn days) and the total pounds of eggs harvested, he found that the relationship explained much of the variability in the total harvest at a statistically significant level ($p<0.001$). Declining participation is a factor, but declining opportunity is an equally valid factor when looking at overall harvest success in a season. The

6. Shewmake (2013) defined subsistence areas through a participant mapping exercise. Areas that had historically been used for herring spawn harvests by key informants were identified and digitized. Additionally, the 19 areas identified on the annual harvest survey were included in the areas designated "subsistence areas."

contemporary subsistence herring roe on substrate fishery is not a particularly resilient system in that its capacity to buffer perturbations (such as interannual changes in where there is herring spawn deposition) is relatively low. There are comparatively few locations within Sitka Sound that are suitable for the harvest of herring eggs. As the deposition of herring eggs in Sitka Sound varies over time, in terms of length of deposition and area of deposition, this contributes to the variable success of the harvesters.

These metrics provide a feasible way to assess the subsistence fishery. Commercial fisheries often look at metrics such as catch per unit effort (CPUE) when analyzing the performance of a fishery, but this metric is a difficult one in subsistence fisheries, particularly fisheries such as for herring eggs. Defining a unit of effort, while possible, would be very difficult to measure. Using number of participants as the unit of effort discounts the important role of sharing and the specialized nature of the herring egg harvest. Using vessels as the unit of effort would obscure households that participate in the harvest jointly. The most accurate unit of effort would be of the fishing gear, but what constitutes a set varies among harvesters. Some sets are an entire tree, some are multiple trees or branches tied together, and others are simply submerged branches. Because of the uncertain nature of the herring spawn, sets are made widely throughout likely spawning areas, and not all of the sets will be placed in areas that receive good deposition of spawn. Sets that receive little spawn are likely left in the water. If a harvester makes particularly good sets and harvests all that is needed for the household's use as well as for sharing, the harvester may decide to leave sets in the water that have good deposition, simply because more eggs are not needed. Capturing this level of detail and annual variation would be difficult and burdensome on respondents and is unlikely to provide greater insight into the success of any year's overall harvest. Shewmake's metrics using household days in subsistence areas (which takes into account mean spawn days) and total harvest utilize information that is already collected and provide the best approach to analyzing the herring egg harvest.

The responses given to the question of respondents' use and harvest of herring eggs as compared to previous years differed substantially from the responses given in 2013. In that year, most respondents noted that their use and their harvest were the same as or less than previous years (Sill and Lemons 2014b). In contrast, in 2014 the majority of respondents said their use was the same, but that their harvest was more than in previous years. Although this question has only been asked for 2 years, so far the responses appear to support the idea that a harvester's immediate needs are met first during a harvest while the remainder of the harvest, however large or small, is shared. For many years, the survey instrument included a question as to whether the respondent met their needs for herring eggs. Researchers and respondents felt this question did not accurately reflect reality as the definition of "needs" was not clear, and the timeframe in which the question was asked was not appropriate. While a respondent may feel that the needs of his household were met, at the time of the survey (directly following the harvest) he may not know how much additional demand there may be to supply eggs to other households. Occasionally, events will occur later in the year for which herring eggs are needed but may not be available. Respondents seemed better equipped to answer the question about needs in the year following the harvest.

These questions of harvest versus use lead directly to a discussion of the importance of sharing in subsistence economies generally, but in particular with a resource such as herring eggs, which require specialized knowledge to successfully harvest. Regardless of how good or poor the harvest, this survey program has shown that 80%–90% of harvesting households share their harvest; in 2014, 88% of such households shared (Table 1). Also, similarly to previous years, much of the herring spawn-on-kelp harvest was retained for personal use while the herring eggs harvested on hemlock branches were most often shared within or outside of Sitka. By weight, an equal amount of herring eggs were shared within Sitka and distributed outside of Sitka. By substrate, herring eggs on branches were shared equally within and outside of Sitka, while herring spawn on kelp and on hair seaweed were skewed toward distribution within Sitka. The community boats, which harvested almost two-thirds of the total harvest in 2014, likely

drive these percentages. The community boats tend to harvest mostly eggs on branches and their harvests are almost entirely shared with households either in Sitka or the boats' home communities.

However widely herring spawn is shared and whatever the changes in the harvest amount, the overall harvest and sharing patterns have not changed much since 2010. These statistics, in part, speak to the skill and knowledge necessary to successfully harvest herring spawn. The pattern of a small number of households harvesting a unique resource and then distributing the resource is common in Alaska's subsistence economies (Wolfe et al. 2010). These "super-households" have the time, ability, knowledge, and equipment necessary to successfully harvest subsistence resources that are then shared throughout the community. If ecological changes have occurred in the Sitka Sound herring population, such as shorter spawn events or less predictable herring behavior, these skills and knowledge become even more important because there is little time and limited resources for experimentation and adaptation. Some of the changes experienced in the subsistence herring egg harvest may be also be the result of demographic changes within the subsistence harvester group. Over the past decade, a number of elder high harvesters have passed on. Some of these harvesters were also involved in the commercial fishery so they had the equipment, as well as the time and the knowledge, to participate fully. These individuals were responsible for large-scale distribution of herring eggs within Sitka Sound, as well as to outlying communities to a lesser extent. With their passing, it is not clear that younger entrants to either the subsistence or commercial fisheries are rising to take their places within the community. Some of the activities of the former high harvesters have been taken up in a more formal manner by community harvester boats and industry-sponsored boats.

CHANGES IN USE OF HERRING SPAWN

One of the limitations of this research project is that only herring egg harvesters are targeted. While that method allows for the collection of much useful information about the harvest of herring eggs, it does not allow for analysis of the wider use of herring eggs. The study had been able to document a decrease in the participation of the subsistence herring egg harvest, but there is little data available to speak to changes in overall use of the resource, either within Sitka or in other Southeast communities, or overall participation in the processing of herring eggs. In 2013, several comprehensive studies were conducted in Southeast communities for the study year of 2012. The use of herring eggs was documented in Hydaburg, Hoonah, Haines, and Angoon; Whale Pass was surveyed, but no herring eggs were used in 2012.[7] The percentage of households using herring eggs on hemlock branches ranged from 15% in Haines to 77% in Hydaburg, while the percentage of households harvesting eggs on hemlock branches ranged from 0% to 23% (Figure 9). The rates of sharing in these communities were high, both in terms of percentages of households that received herring eggs, but also of those that gave them. The majority of respondents indicated that the eggs they used or harvested came from Sitka, with the exception of Hydaburg, which also showed a lot of harvest and use of eggs from the Craig/Klawock area. In this limited sample of communities of Southeast, the use of herring eggs from Sitka Sound remains high, and patterns of sharing remain evident and of importance. While the harvest monitoring survey tracks participation in the harvest of herring eggs, there is currently no information to show how many households are involved in the processing, distribution, or receipt of herring eggs. The survey has shown that herring eggs continue to be widely shared and used throughout the state, but a broader survey looking specifically at the use and receipt of herring eggs from the general populace would be necessary to fully discuss changes in the use of herring eggs over time.

7. Alaska Department of Fish and Game. *In prep*. "The Harvest and Use of Wild Resources in Haines, Hoonah, Angoon, Whale Pass, and Hydaburg, Alaska, 2012." Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 399.

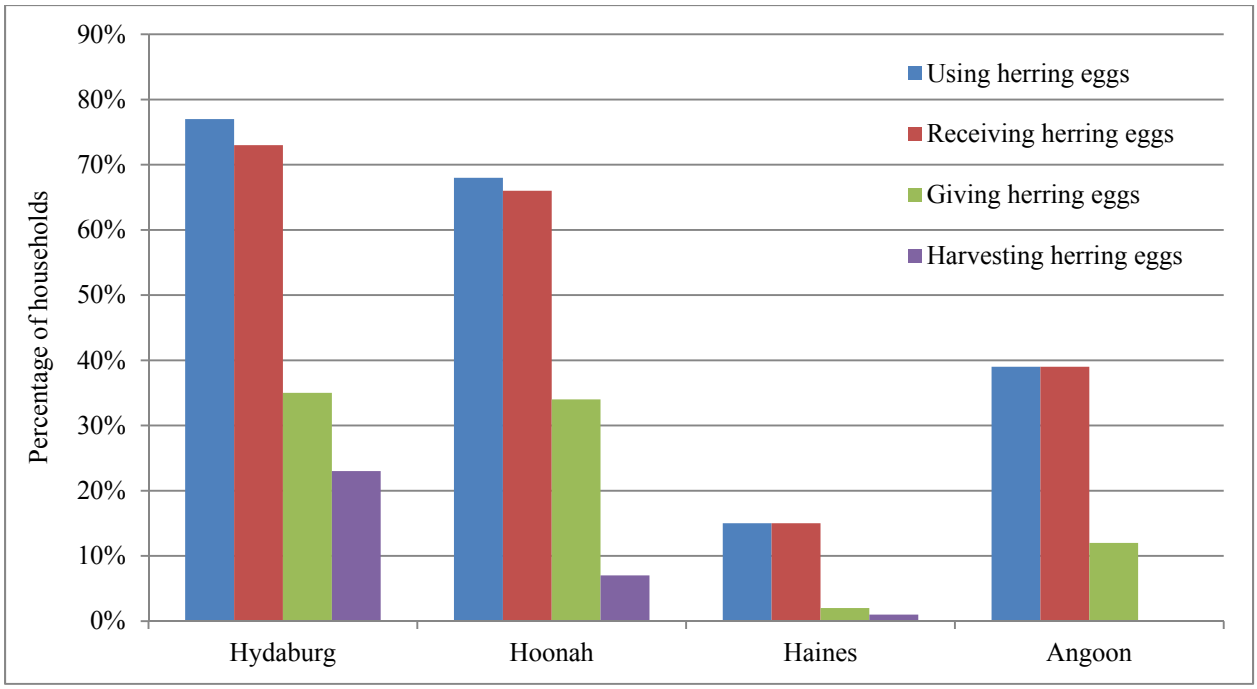


Figure 9.–Percentage of households using, receiving, giving, and harvesting herring eggs, 2012.

CONVERSION FACTORS

Creating annual conversion factors is useful for 2 reasons.

1. Annual conversion factor summaries give researchers a more accurate estimate of herring egg harvests because individuals often report their harvest in number of boxes/bags, rather than total pounds harvested. With an average weight determined for storage containers for that year, researchers can convert the entire reported harvest into pounds with greater accuracy.
2. The other aspect of conversion factors is their potential insight into the effect of egg density on the success of the overall harvest. From Shewmake's (2013) work, it can be seen that the number of consecutive spawning days is important to overall success. More spawning days should lead to thicker egg deposition and heavier branches. One way the project can potentially investigate egg density is through the creation of annual conversion factors.

Assuming that the herring spawn processors are relatively consistent in how they process branches for packing containers during the conversion factor updates, the average weight of a wetlock box should vary annually with spawn density—less in years with low density and more in high-density years. However, other factors such as sea water content of the set may also be affecting the weights of the processed spawn. Until more work is done to identify other factors potentially affecting the weight of wetlock boxes of processed spawn, year-to-year variations in conversion factors cannot be taken as an accurate indicator of herring spawn densities.

LOCATION OF HARVESTS

The final aspect of the subsistence herring harvest that the project attempts to understand is the location of harvests. While the question concerning harvest locations has not been on the survey every year, from the years when this information was sought it is clear that there is a core area most harvesters use, but there is also year-to-year variability in all the locations used for the harvest. There are a number of reasons for this pattern. Within limits, harvesters will go where the herring are spawning. Herring do not have site

fidelity like salmon; therefore, where they spawn each year can change. Harvesters look for areas they feel are most likely to produce high-quality spawn based on factors such as geography, substrate, and protection from wind and waves. Some harvesters do not have access to a boat, so they need to harvest in locations accessible by the road system, regardless of where the herring are spawning. Skiffs and other small boats are commonly used by herring harvesters and wind and rough seas can make harvesting dangerous; therefore, protected areas are sought. Protected areas are also favored for their likelihood of high-quality spawn since ocean surge can stir up sand on the seafloor, thus degrading the quality of the herring spawn harvest. As Sitka has developed, and concerns for water quality have grown, harvesters have also tried to ensure that the area they harvest from is not negatively impacted by development. ADF&G documents the nautical miles of herring spawn observed in all of Sitka Sound each year. Because of the limitations in where quality subsistence harvests can occur, looking at the overall nautical miles of herring spawn in Sitka Sound does not give an accurate picture of the opportunity available to harvesters. A harvester's assessment of the length of the spawn and quality of the season is localized to areas that are accessible to that harvester and therefore may not be the same as the documented duration or total coverage of the spawn.

SPAWN-ON-KELP FISHERY

In addition to further investigating the role of spawn deposition on weight conversion measurements, another aspect of the herring spawn fishery that researchers will continue to explore is the spawn-on-kelp fishery. While surveys are attempted with all harvesters of herring spawn, regardless of the substrate, herring spawn on branches accounts for the majority of the harvest and has therefore received the most attention. Often, the amounts of spawn on kelp documented by the survey have been less than that recorded on the permits (a permit is necessary to harvest spawn-on-kelp in Sitka Sound; the amount of spawn a household may harvest is not limited through this system since multiple permits may be obtained). Beginning in 2012 and continuing through 2014, researchers concentrated additional effort on identifying and contacting spawn-on-kelp harvesters. The harvest survey in 2014 estimated 3,562 lb of spawn-on-kelp harvested (Table 3), while the preliminary permit data show a harvest of 2,042 lb.[8] In part, the discrepancy in total could be explained through the expansion of survey data, whereas permit data are unexpanded. However, there may be other sources of difference between the 2 estimates, such as different participation rates in the survey process versus permit reporting compliance, that will be explored in future studies.

8. Preliminary data released by the Alaska Department of Fish and Game Division of Commercial Fisheries to the Division of Subsistence.

4. CONCLUSION

Although participation in the subsistence harvest of herring spawn from Sitka Sound has dropped since the early 2000s, participation has stabilized and shown a slight increase since 2010 and the harvest remains an important cultural activity for Southeast Alaska residents. Overall harvest amounts are influenced by the number of harvesters participating, but also by the opportunity for quality spawn in accessible locations. The herring spawn harvest continues to be shared extensively throughout Sitka, Southeast Alaska, and beyond. Concern for the resource due to the possible impact of the commercial sac roe herring harvesting activities is a consistent theme heard from harvesters. Future years of this project will continue to investigate the spawn-on-kelp harvest and comparisons with permit data for that fishery. In addition, the variations in spawn density and identifying accurate ways to track and correlate density with the harvest will be explored. Finally, a broader effort to look at overall use of herring eggs, not just the harvest effort, and changes over time, is needed but is beyond the scope of this project.

ACKNOWLEDGEMENTS

The ADF&G Division of Subsistence would like to thank the staff of the Sitka Tribe of Alaska for their hard work and dedication to this project; in particular we thank Jeff Feldpausch and Jessica Gill. The survey would not have been possible without their leadership and cooperation. We would like to thank the Sitka Tribe of Alaska Tribal Council and Herring Committee members for their dedication and support of the project. Within the Division of Commercial Fisheries, we appreciate the assistance and review of this project provided by Dave Gordon and Eric Coonradt. Input into the final draft of the report was gratefully received from Steve Reifenstuhl with Northern Southeast Regional Aquaculture Association and Jessica Gill with STA. There are many subsistence harvesters and commercial fishers who contributed to the success of this project by taking the time to speak to researchers and we would like to take this opportunity to thank them as well.

REFERENCES CITED

Brock, M. and M.F. Turek

2007. *Sitka Sound subsistence herring roe fishery, 2002, 2003, and 2006.* Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 327: Juneau. http://www.adfg.alaska.gov/techpap/tp327.pdf

Cochran, W.G.

1977. *Sampling techniques*, 3rd edition. John Wiley & Sons: New York.

Gmelch, G. and S.B. Gmelch

1985. *Resource use in a small Alaskan city–Sitka.* Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 90: Juneau. http://www.adfg.alaska.gov/techpap/tp090.pdf

Holen, D., J. Stariwat, T. Lemons, V. Ciccone, and M.F. Turek

2011. *The subsistence harvest of herring spawn in Sitka, Alaska, 2002-2010*. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 343: Anchorage. http://www.adfg.alaska.gov/techpap/TP%20343.pdf

Pierce, R.A.

1972. *Alaskan shipping, 1867–1878: arrivals and departures at the Port of Sitka*, Materials for the study of Alaskan history. Limestone Press: Kingston, Ontario.

Schroeder, R.F. and M. Kookesh

1990. *The subsistence harvest of herring eggs in Sitka Sound, 1989.* Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 173. http://www.adfg.alaska.gov/techpap/tp173.pdf

Shewmake, J.W.I

2013. *Spatial resilience and the incorporation of traditional ecological knowledge in mapping Sitka herring.* master's thesis. University of Alaska Fairbanks: Fairbanks.

Sill, L.A. and T. Lemons

2012. *The subsistence harvest of herring spawn in Sitka Sound, Alaska, 2011*. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 369: Juneau. http://www.adfg.alaska.gov/techpap/TP%20369.pdf

2014a. *The subsistence harvest of Pacific herring spawn in Sitka Sound, Alaska, 2012*. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 392: Juneau. http://www.adfg.alaska.gov/techpap/TP392.pdf

2014b. *The subsistence harvest of Pacific herring spawn in Sitka Sound, Alaska, 2013*. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 401: Juneau. http://www.adfg.alaska.gov/techpap/TP401.pdf

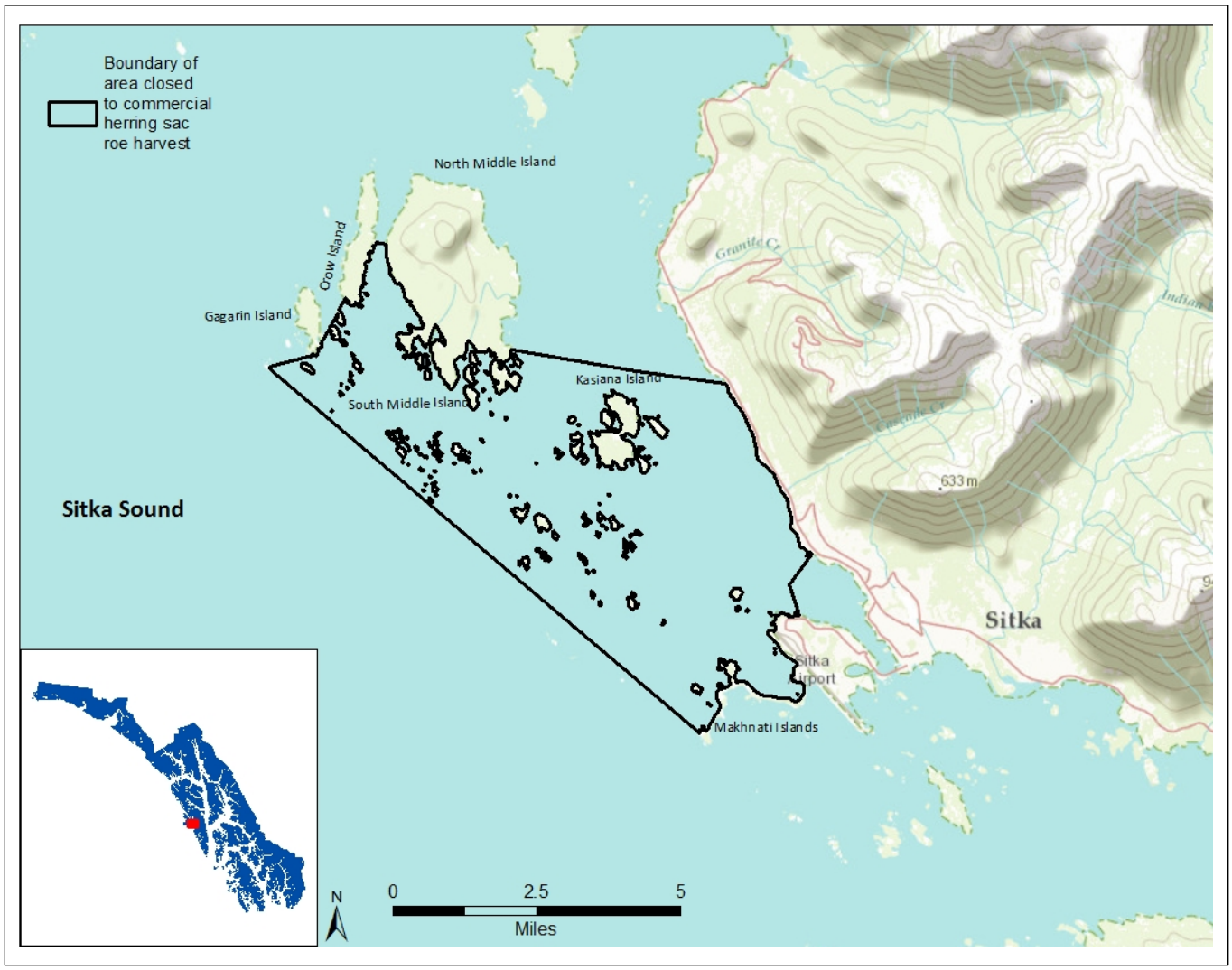
Tikhmenev, P.A.

1978. *A history of the Russian-American Company*. University of Washington Press: Seattle.

Wolfe, R.J., C.L. Scott, W.E. Simeone, C.J. Utermohle, and M.C. Pete

2010. *The "super-household" in Alaska Native subsistence economies*. Final Report to the National Science Foundation, Project ARC 0352611.

APPENDIX A: MAP OF AREA OF SITKA SOUND CLOSED TO COMMERCIAL HERRING SAC ROE FISHING


Boundary of area closed to commercial herring sac roe harvest
North Middle Island
Crow Island
Gagarin Island
Kasiana Island
South Middle Island
Sitka Sound
Granite Cr
633 m
Sitka
Sitka Airport
Makhnati Islands
N
0
2.5
5
Miles

APPENDIX B: SITKA SOUND SUBSISTENCE HERRING EGG HARVEST SURVEY, 2014

HERRING EGG SUBSISTENCE HARVEST SURVEY
SITKA, ALASKA
2014

This survey is used to estimate subsistence harvests of herring eggs from Sitka Sound and to describe community subsistence economies. We will publish a summary report which will be available to all households in your community. We share this information with the Sitka Tribe of Alaska, the Alaska Department of Fish and Game, the U.S. Fish and Wildlife Service and the National Park Service. We work with the Federal Regional Advisory Councils and with local Fish and Game Advisory Committees to better manage subsistence, and to implement federal and state subsistence priorities.

This project is guided by the research principles adopted by the Alaska Federation of Natives in 1993. We will NOT identify your household. We will NOT use this information for enforcement. Participation in this survey is voluntary. Even if you agree to be surveyed, you may stop at any time.

HOUSEHOLD ID:		
COMMUNITY ID:	Sitka	313
INTERVIEWER:		
INTERVIEW DATE:		
	DATA CODED BY:	
	DATA ENTERED BY:	
	SUPERVISOR:	

COOPERATING ORGANIZATIONS

RESOURCE PROTECTION DEPARTMENT
SITKA TRIBE OF ALASKA
429 KATLIAN STREET
SITKA, AK 99835

907-747-7168

DIVISION OF SUBSISTENCE
ALASKA DEPT OF FISH & GAME
802 3RD STREET
JUNEAU, AK 99801

907-465-3617

HARVESTS: HERRING EGGS

HOUSEHOLD ID

How many people lived in your household in 2014?..... _____

Is anyone in the household enrolled in a tribe?..... Y N

If YES, which one?..... _____

Do members of your household USUALLY harvest HERRING EGGS for subsistence?..... Y N

In 2014...

...Did members of your household TRY TO HARVEST herring eggs?..... Y N

If NO... why not? _____

If the household tried to harvest herring eggs in 2014 fill out the rest of this page. Otherwise go to 'Assessment' section on the next page.

Please estimate how many herring eggs ALL MEMBERS OF YOUR HOUSEHOLD HARVESTED for subsistence use this year. INCLUDE herring eggs you gave away, ate fresh, lost to spoilage, or got by helping others. If fishing with others, report ONLY YOUR SHARE of the catch.

	IN 2014 DID MEMBERS OF YOUR HH...				IN 2014, HOW MANY (_____) DID YOUR HOUSEHOLD HARVEST...?		
	...USE _____?	...RECEIVE _____	...GIVE _____	...TRY TO HARVEST _____?	...FOR PERSONAL USE	...TO GIVE AWAY IN SITKA	...TO SHIP OUT OF SITKA
	(circle)				*(amount used for each purpose)*		
Herring eggs on hemlock branches	Y N	Y N	Y N	Y N			
120310000							
Herring eggs on kelp	Y N	Y N	Y N	Y N			
120306000							
Herring eggs on hair seaweed (né)	Y N	Y N	Y N	Y N			
120308000							

These columns should include all the herring eggs harvested by members of this household in 2014.

If you shared with others, how many households did you share with?

NUMBER OF HOUSEHOLDS	COMMUNITY	

How many households do you typically harvest for?..... _____

What size vessel(s) did you use to harvest herring eggs in 2014?..... _____

HARVESTS: HERRING EGGS

HOUSEHOLD ID

ASSESSMENT: HERRING EGGS

In 2014...

Did your household use LESS, the SAME, or MORE herring eggs than in recent years?..... X L S M

If LESS or MORE, why was there a change?

_____

_____

_____

Did your household get enough herring eggs?.....Y N

How do you feel your 2014 HARVEST was compared to other years?..... X L S M

If LESS or MORE, why was your harvest different?

_____

_____

_____

If you HARVESTED LESS herring eggs in 2014, what was the last year you remember having a good harvest? _____

Do you harvest with other households?.....Y N

COMMENTS

DO YOU HAVE ANY QUESTIONS, COMMENTS, OR CONCERNS ABOUT THE 2014 SUBSISTENCE HERRING EGG HARVEST?

_____

_____

_____

_____

_____

_____

_____

_____

OTHER FISH: 06 SITKA: 313

HARVESTS:

HOUSEHOLD ID

Where did you harvest your herring eggs in 2014 - set branches, harvest seaweed, macrocystis kelp?

	Location	Date	# of sets made	# of sets harvested	Quality (coverage, thickness)	Soak time	Comments
1	Kasiana Islands Group						
2	North Middle Island						
3	South Middle Island						
4	Crow/Gagarin islands						
5	Big/Little Gavanski islands						
6	Siginaka Islands						
7	North Japonski/Whiting Harbor						
8	South Japonski/Mermaid Cove						
9	Causeway Islands						
10	South Halibut Point Road						
11	North Halibut Point Road						
12	Eastern/Promisla Bay						
13	Magoons/Hayward						
14	Katlian Bay						
15	Apple/Parker Group						
16	Crescent/Jamestown Bay						
17	Other:						

LOCATION

SITKA: 313

APPENDIX C: 2014 CODE BOOK

Subsistence Herring Egg Harvest Survey 2014

Herring Spawn User Status	Code
Individual Harvester	1
Non-Harvester	2
Community boat	3

Page 1: Harvests

If enrolled in a tribe, which one?	
Sitka Tribe of Alaska	1
Organized Village of Kake	2
Metlakatla Indian Community	3
Hoonah Indian Association	4
Hydaburg Cooperative Association	5
Native Village of Savoonga	6
Angoon Community Association	7

If household did not try to harvest herring eggs in 2014, why not?	Code
Harvester - no response necessary	Blank
Refused	-7
Missing (blank, but should not be & the reason is not clear)	-8
Unknown to respondent	-9
Not ready	1
Working during the harvest/no time	2
Received from friends/family	3
Personal or health issues	4
Not present during the harvest	5
Transportation/no boat	6

What size vessel did you use to harvest herring eggs?	Code
less than 20 feet	1
20-24 feet	2
over 24 foot pleasure cruiser	3
commercial vessel	4
other	5
No boat – harvested from shore	6

Page 2: Assessments

If less or more USE, why?	Code
Non-harvester - no response necessary	Blank
Refused	-7
Missing (blank, but should not be & the reason is not clear)	-8
Unknown to respondent	-9
Resource availability	1
Needed less	2
No time/working	3
Better than last year	4
Needed more	5
Equipment	7
Personal reasons	8

More effort	9

If less or more HARVEST, why?

Non-harvester - no response necessary	Blank
Refused	-7
Missing (blank, but should not be & the reason is not clear)	-8
Unknown to respondent	-9
Needed less	1
Resource availability	2
Good year/good quality eggs	3
More effort	4
No time/work	5
Fuel costs	6
Good timing	7
Good kelp harvest	8
Good weather	9

5. Do you have any additional comments about the 2014 subsistence herring egg harvest?	Code
Spawn was short	1
Concerned about the future of the resource	2
Concerned about the effect of the commercial fishery on the resource	3
Spawn is less predictable in timing and location	4
Longer spawn	5
Good quality eggs/good spawn	6
Theft of branches an issue	7
Good kelp harvest	8
Concerned about industry harvesting subsistence eggs	9
Concern about hatchery fish	10