Regional Information Report No. 1J07-01

Berners Bay Herring Research for 2005 and 2006

by

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and

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March 2007

Alaska Department of Fish and Game **Division of Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

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

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Lynn Canal aerial and skiff surveys were used to document herring spawn locations in 2005 and 2006. Spawn deposition dive surveys were used to estimate spawning biomass. Results of these surveys indicate the Lynn Canal herring spawning population remains below threshold. As a result, commercial herring fisheries were not opened in Lynn Canal in 2005 or 2006 and will not be opened in 2007. The 2005 and 2006 herring spawn occurred mostly outside of Berners Bay, unlike the 1999–2004 spawn that occurred along the eastern shore of Berners Bay.

Key words: Lynn Canal, Berners Bay, herring, Southeast Alaska, stock assessment

INTRODUCTION

Prior to 1983 the Lynn Canal herring stock was one of the larger stocks in Southeast Alaska supporting several commercial fisheries including a sac roe fishery, bait pound fishery, and a winter food and bait fishery. This stock declined in 1982 and has remained at low levels. The reason for the decline is not clear, however potential contributing factors include: over fishing, habitat degradation or disturbance in Auke Bay, water pollution, geographic shifting of spawning aggregations, and population growth of major predators such as sea lions. If the long-term decline was solely the result of over fishing, it is expected that this stock should have recovered during the 20-year period since commercial exploitation has ceased. In other areas in Southeast Alaska, such as Hoonah Sound, herring stocks have grown from low levels to relatively high levels over a span of a few years.

The established spawning biomass threshold level for this stock is 5,000 tons. This means that before a herring fishery may be considered for the Lynn Canal spawning stock, a forecast of spawning biomass must meet or exceed 5,000 tons. Based on shoreline miles of spawn, it is estimated that the stock biomass has varied between 100 and 2,500 tons over the last 20 years. No commercial harvest has occurred in the Juneau area since the 1981–82 season.

From 1953 to 1981 Lynn Canal herring spawned from Auke Bay to Point Sherman including Berners Bay and Cascade Point. The documented spawn for the Lynn Canal herring stock during this period ranged from 6 to 28 nmi, averaging approximately 12 nmi. While significant spawning occurred in the vicinity of Auke Bay prior to 1981, there has been very limited spawning in Auke Bay in recent years. Recently, spawning activity for the entire Lynn Canal herring stock is centered between Bridget Cove and the east shoreline of Berners Bay. Since 1982 the documented spawn has ranged from 0.5 to 9 nautical miles, averaging only 3.7 nautical miles. ADF&G records since 1971 document herring spawn between Echo Cove and the Berners Bay flats in most years, with few exceptions. The consistent herring spawn along this shoreline for the last 20 years is indicative of its importance to this stock. Pacific herring have been documented to spawn at Cascade Point as early as April 18 and as late as May 24.

Because Cascade Point and adjacent areas of Berners Bay are within primary spawning grounds for the depressed Lynn Canal herring stock, development of a marine facility here could have an impact on this herring resource. Increased disturbance from vessel traffic, transient lighting, increased turbidity and sedimentation, and increased petroleum hydrocarbons in the water from oil or gas spills are all concerns. Additionally, because herring spawn on inter tidal and sub tidal kelp, the project may directly affect spawning success if it reduces kelp abundance or variety.

The Alaska Department of Fish and Game conducts aerial, skiff, and scuba dive surveys to monitor the Lynn Canal spawning stock. Aerial and skiff surveys have been conduced since

1970 to identify the dates and extent (miles of spawn along shoreline) of herring spawn. A 2004 dive survey provided the first estimate of spawning biomass escapement by the department for the Lynn Canal area since a 1984 dive survey and a 1992 hydroacoustic estimate. Using dive surveys, the department estimates the total number of herring eggs in the Lynn Canal spawning grounds and converts this to an estimate of spawning population biomass through use of a fecundity relationship and weight-at-age data. Monitoring of the Lynn Canal spawning stock through aerial, skiff, and spawn deposition scuba dive surveys continued in 2005 and 2006 as reported here.

MATERIALS AND METHODS

A series of aerial and skiff surveys are used to record spawning activities during the spring spawning period to document spawn timing and estimate the nautical miles of beach that received herring spawn. During the spring of 2005, all aerial surveys were flown in a Piper PA-18 Supercub aircraft on floats with a department contracted pilot. In 2005 there were 14 aerial surveys and one skiff survey conducted for the Lynn Canal area between April 22 and May 27 (Appendix A). During the spring of 2006, all aerial surveys were flown in a Cubcrafters CC-18 supercub aircraft on floats with a department contracted pilot. In 2006 there were 13 aerial surveys conducted for the Lynn Canal area between April 11 and May 16 (Appendix B).

As in 2004, scuba dive surveys were used in 2005 and 2006 to estimate the total number of herring eggs in the Lynn Canal spawning grounds. Scuba dive line transect surveys were used to estimate egg densities along shoreline segments identified with herring spawn from aerial and skiff surveys. Two-person SCUBA teams swam along line transects and recorded visual estimates of the number of eggs within a 0.10 m^2 sampling quadrat placed on the bottom at 5 m intervals along the transects. Depth, substrate, and vegetation type were recorded along with the visual estimate of egg abundance at each 5 m interval. Because the quadrats (i.e. samples) were spaced equidistant along transects, the record of the number of quadrats along a transect was also used to compute transect length.

Starting points for dive transects were located randomly along the shore in areas where aerial or skiff surveys indicated probable spawn deposition. Transects were oriented perpendicular to the shoreline. Transects extended from intertidal to either a maximum of 15 m (50 fsw) of depth or until no further egg deposition was observed. Transects extended above the waterline as far as egg deposition occurred. Dives were limited to 15 m because deeper dives severely limit total bottom time for SCUBA divers and pose safety risks when conducted repetitively over several days. Normally, little if any herring egg deposition occurs deeper than 15 m.

Since visual estimates rather than actual counts of eggs within the sampling quadrat are recorded, measurement error occurs. To minimize the influence of measurement error on final estimates of total egg deposition, diver-specific correction coefficients are used to adjust estimates of egg density. Correction coefficients are calculated by visually estimating the number of eggs within a sampling quadrat and then collecting all of the eggs within the quadrat for later enumeration. To collect the eggs, divers either remove them from the substrate (e.g. rock) or collect the vegetation (e.g., kelp) for later removal of the eggs. Correction samples were collected from several southeast Alaska spawning areas in 2005 and 2006 but not from Lynn Canal. Collected samples were combined and used to adjust all southeast Alaskan herring stock estimates, including Lynn Canal. Detailed procedures for determining egg densities from collected samples are discussed in the 1993 Annual Report, RIR IJ93-19.

Total egg deposition for a Lynn Canal (t) is estimated as:

$$t = a\,\overline{d} \tag{1}$$

where a is the estimated total area (m^2) on which eggs have been deposited and $\overline{d}$ is the estimated mean density of eggs (eggs/m^2). The total area on which eggs have been deposited (a) is estimated as:

where *l* is the total meters of shoreline receiving spawn (determined from aerial and skiff

$$a = l\overline{w} \tag{2}$$

surveys) and $\overline{w}$ is the mean length of transects in meters. The mean density of eggs/m^2 ($\overline{d}$) is estimated as:

$$\overline{d} = 10 \cdot \left[\frac{\sum_h \sum_j \sum_k v_{hjk}\, c_{hk}}{\sum_h m_h} \right] \tag{3}$$

where v_{hj} is the visual estimate of egg numbers by diver h, quadrat 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_h is the number of quadrats visually estimated by diver h. Divers visually estimate egg density within 0.1 m^2 quadrats. Multiplying by 10 expands the mean density from a 0.1 m^2 to a 1.0 m^2 unit basis. Diver-specific, kelp-specific correction factors (c_{hk}) are estimated as:

$$c_k = \frac{\bar{r}_{hk}}{\bar{v}_{hk}} \tag{4}$$

where $\bar{v}_{hk}$ is the mean visual estimate of egg numbers for diver *h* on kelp type *k* and $\bar{r}_{hk}$ is the mean laboratory count of egg samples collected from quadrats visually estimated by diver *h* on kelp type *k.*

The total number of eggs per spawning area is a key element used in estimating herring spawning biomass. The Lynn Canal estimate of spawning biomass (tons) is calculated using the total number of eggs estimated in the Lynn Canal spawning grounds, weight-at-age from Lynn Canal age, weight and length (AWL) sampling, and a linear weight-to-fecundity relationship

estimated with 1996 data from fecundity sampling in Seymour Canal. The weight-to-fecundity relationship was estimated as:

$$f(g) = -1573.3 + 222.4 \cdot g \tag{5}$$

where *f(g)* is the fecundity (total number of eggs deposited) of a fish of weight *g*. The total biomass (b) was estimated for Lynn Canal as:

$$b = \frac{\left[\frac{\left(\frac{t}{L}\right) * 2}{f(\overline{w})}\right] \cdot \overline{w}}{907180} \tag{6}$$

where *t* is the total egg deposition for Lynn Canal, $\overline{w}$ is the mean weight of all Lynn Canal AWL samples, *L* is the egg loss correction factor (0.9) that accounts for an estimated 10% egg mortality between the time eggs are deposited and spawn deposition surveys are conducted, and $f(\overline{w})$ is the fecundity of a fish of weight $\overline{w}$.

RESULTS AND DISCUSSION

Aerial surveys documented a total of 1.4 nmi of spawn in Berners Bay in 2005 (Figure 1, Appendix A). Aerial surveys documented a total of 3.9 nmi of spawn in Berners Bay in 2006 (Figure 2, Appendix B). In Berners Bay all 2006 spawning was documented west of Cowee Creek. In Lynn Canal no 2006 spawn was observed south of Bridget Cove. Figure 3 documents herring spawn recorded in the Berners Bay area from 1999 through 2004 where the majority of the spawning occurred on the eastern shore of Berners Bay. In 2005 and 2006 no spawn was documented along the eastern Berners Bay shore but was observed along the Point Bridget shoreline and in Lynn Canal.

The 2004, 2005, and 2006 dive surveys were the first biomass estimates completed by the department in the Lynn Canal area since a 1984 dive survey and a 1992 hydroacoustic estimate. Estimates in years without dive or hydroacoustic surveys have been approximated based on observed nautical miles of shoreline and average historical biomass per linear nautical mile. In 2005, the spawn deposition survey was conducted on May 18 with the completion of seven[1] randomly selected transects. The average transect length was 54 meters with an average density of 190,692 eggs per square meter. The estimated 2005 spawning biomass was 318 tons (Table 1). In 2006, the spawn deposition dive survey was conducted on May 26 with the completion of eight randomly placed transects. The average transect length was 58 m with an average density of 141,408 eggs per square meter. The estimated 2006 spawning biomass was 712 tons (Table 1). The 2006 spawning biomass estimate was similar to the 719 ton herring spawning escapement estimate for 2004.

[1] A total of eight transects were placed but transect #3 was not surveyed due to increasing weather conditions and concerns for diver safety.

The Lynn Canal spawning stock is currently below the 5,000 ton threshold and will likely remain closed to commercial harvest in the foreseeable future. In the future, and as resources permit, the department intends to document herring spawning locations in the Juneau area with aerial and skiff surveys and to conduct dive assessment surveys in Lynn Canal and Berners Bay.

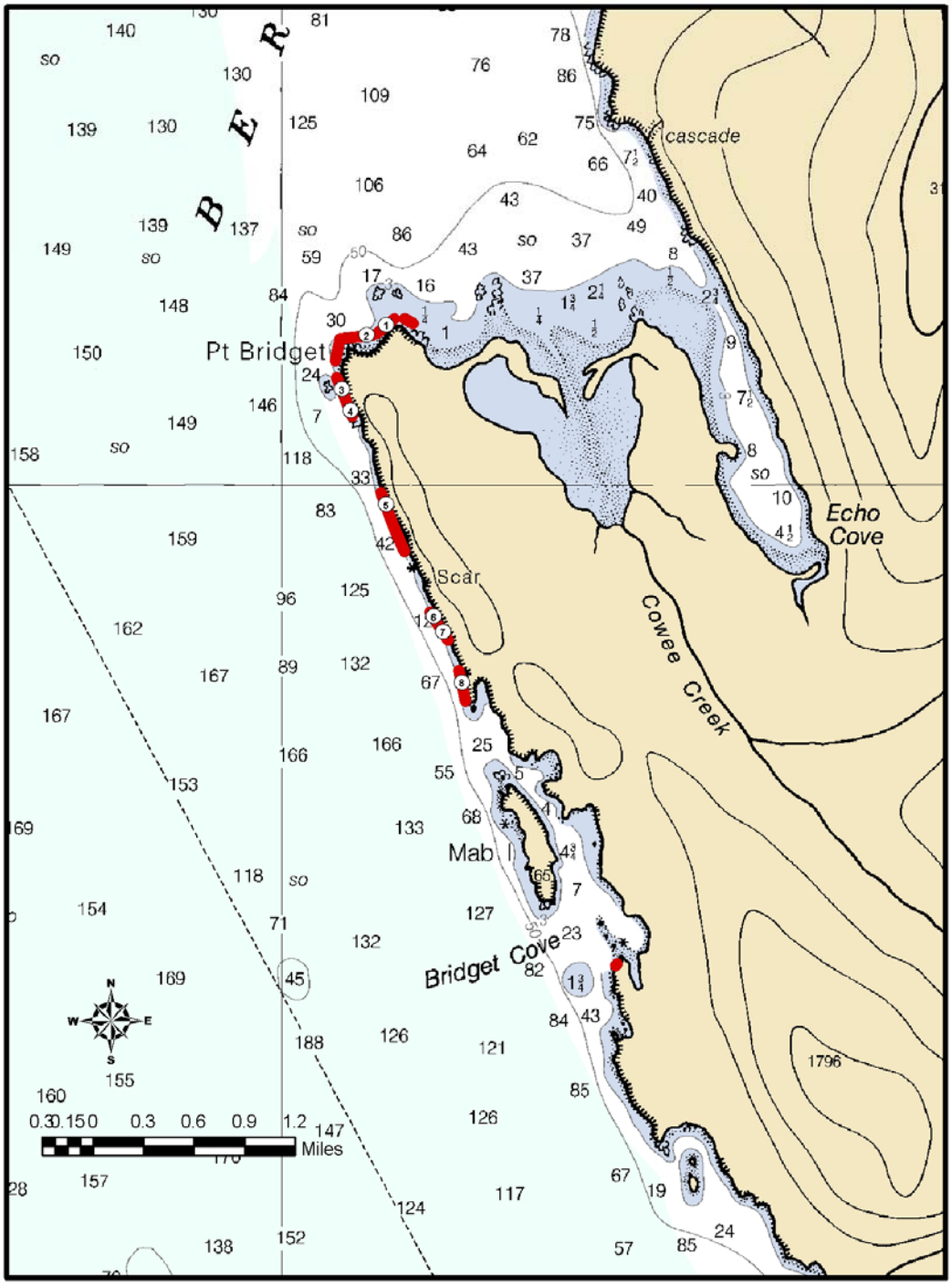

Figure 1.–Berners Bay 2005 herring spawn shoreline (broad, dark line parallel to shore) and transect locations (numbers 1–8).

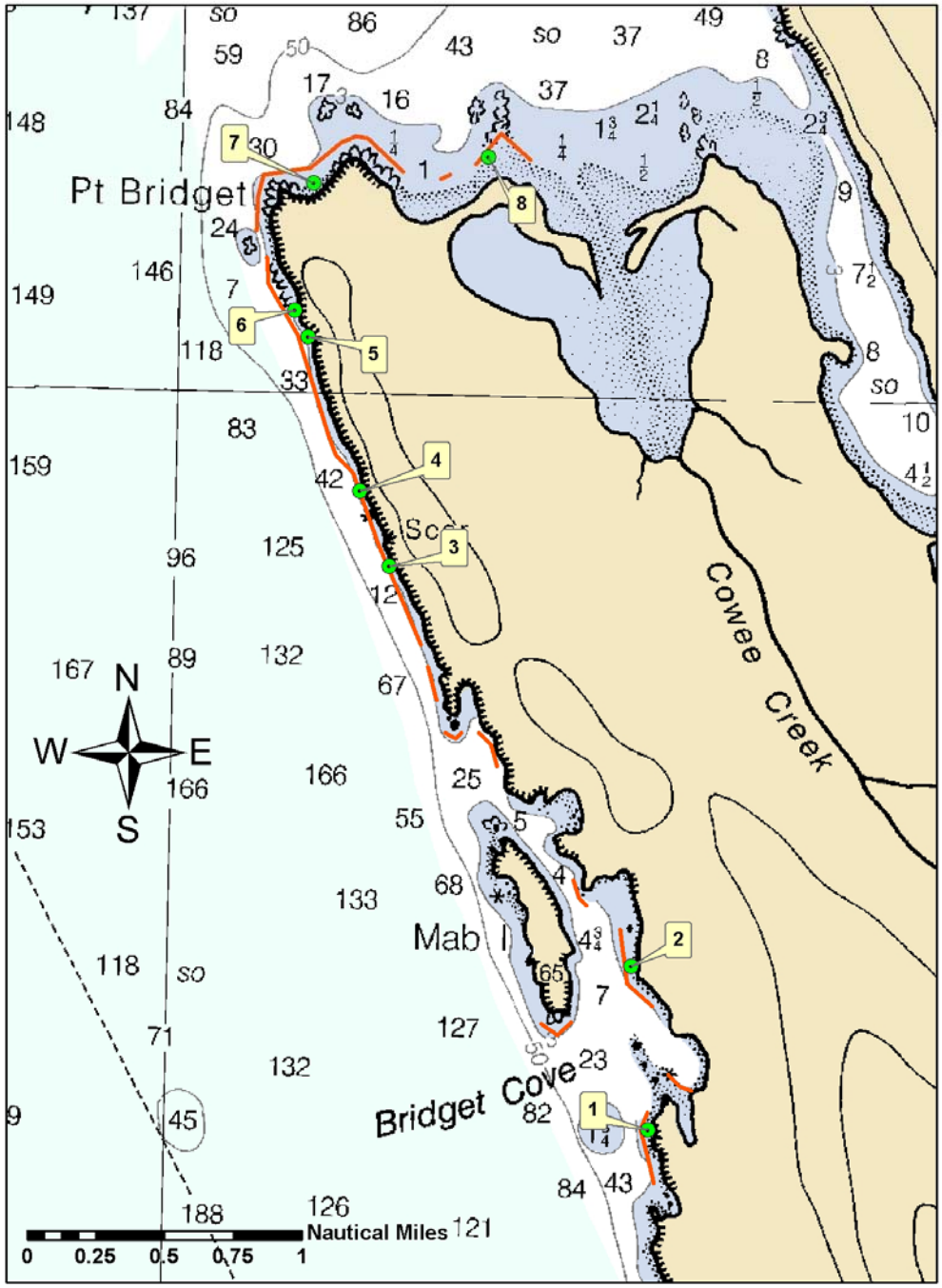

Figure 2.–Berners Bay and Lynn Canal 2006 herring spawn shoreline (broad, dark line parallel to shore) and transect locations (numbers 1–8).

Figure 3.–Berners Bay and Lynn Canal 1999–2004 herring spawn.

Table 1.–Historic Lynn Canal commercial harvest and nautical miles of spawn.

Season	Total quota (tons)	Total Harvest (tons)	Pound catch (tons)	Seine catch (tons)	Gillnet catch (tons)	Date of first spawn	Major spawning dates	Nautical miles of spawn	Spawning biomass
1952–53								8.2	
1953–54								9.4	
1954–55								12.2	
1955–56								10.0	
1956–57								28.1	
1957–58								24.1	
1958–59								10.8	
1959–60		156	156			5/1	5/1–5/15	12.9	
1960–61		22	22						
1961–62		354	354						
1962–63		101	101						
1963–64		195	195						
1964–65		200	200						
1965–66		109	109						
1966–67		100	100						
1967–68		475	475						
1968–69		600	0	600					
1969–70	750	240	240				5/2–5/4	11.5	
1970–71	750	654	654						
1971–72	950	524	431	93		5/2	5/6–10	8.5	
1972–73	950	350	49	301			4/25	10.6	
1973–74	620	396	73	319	4		4/27	13.2	
1974–75	620	644	88	556	2		5/5	10.9	
1975–76	870	631	74	433	124		4/27	15.9	
1976–77	995	926	0	709	217		5/3	9.7	
1977–78	820	966	0	603	363		4/24	8.0	
1978–79	120	7	11	0			4/18	5.7	
1979–80	720	976	0	976			5/8	9.8	
1980–81	845	777	2	775			4/30	9.2	
1981–82	400	551	0	551			spotty	2.5	
1982–83							5/1	6.0	
1983–84							4/24	2.6	
1984–85							4/29	5.1	
1985–86							5/2	5.0	
1986–87							5/4	2.5	
1987–88							4/30–5/3	7.0	
1988–89							24-Apr	5.0	
1989–90							26-Apr	3.0	
1990–91							4/30–5/4	2.5	
1991–92							27-Apr	4.0	
1992–93							5/4–5/6	3.2	
1993–94							4/27–5/8	4.3	

-continued-

Table 1–continued (page 2 of 2)

Season	Total quota (tons)	Total Harvest (tons)	Pound catch (tons)	Seine catch (tons)	Gillnet catch (tons)	Date of first spawn	Major spawning dates	Nautical miles of spawn	Spawning biomass
1994–95							5/10–5/24	0.95	
1995–96						4/29	5/1	2.9	
1996–97						5/1	5/5	2.2	
1997–98						5/13		0.49	
1998–99								6.0	
1999–00						5/4	5/10–5/10	3.3	
2000–01						5/5	5/5–5/6	4.0	
2001–02						5/29	5/29	3.0	
2002–03						4/30	4/30 – 5/2	2.2	
2003–04						5/4	5/4 – 5/9	5.1	719
2004–05						5/10	5/11 – 5/12	1.4	318
2005–06						5/12	5/13 – 5/14	3.9	712

APPENDIX

Appendix A.–Lynn Canal and Berners Bay 2005 Herring Survey Flight Log.

Total miles of spawn: 1.4

Spawning dates: 5/10–5/17

Peak spawning: 5/11–5/12

4/22 No spawn or herring observed. No evidence of eulachon up the Berners and Lace. 15 sea lions, w/ 5 in Berners Bay

5/3 No spawn observed. Fair sized school in Bridget Cove, no predators.

5/5 No spawn observed. Many schools, Auke Bay, Indian Cove, Lena Cove, Tee Harbor, Bridget Cove, Pt Bridget and along east BB. Few predators.

5/7 No spawn observed. More schools in same places, with herring lining the beach along the east shore of BB. Few predators.

5/9 No spawn observed. Additional schools in Fritz Cove, lining beach near Outer Point. Few predators, no sea lions at Benjamin Is. Many birds between Echo Cove and Pt. Bridget - possible spawn yesterday?

5/10 ~0.5 nm spawn at Pt Bridget. Numerous small schools, Auke Bay, Tee Harbor, Bridget Cove and Berners Bay. 80-100 sea lions, one whale.

5/11 Scattered spot spawns from Bridget Cove to Pt. Bridget. Small schools in Smugglers Cove, Indian Cove, Tee Harbor, Sunshine Cove, Echo Cove.

5/12 40 yards active spawn at Bridget Cove, two light spots S of and one at Pt. Bridget. Small schools in Auke and Berners Bay. Few predators.

5/13 Very light spawn S of Pt Bridget. Small schools Fritz Cove, Auke Bay, Auke Nu, Auke Rec, Tee Harbor, Good sized school inside Mab Island

5/16 Spot spawns on W Mab Is. Large schools in Auke Bay, Auke Nu, and Tee Harbor. 50 harbor seal at Slate Point, otherwise few predators.

5/17 Skiff survey. Very small spot spawn E Mab Is. No spawn observed on entire E coast of BB

5/23 No spawn observed. Herring lining the beach at Auke Cape, good schools in N Tee Harbor, small schools in Berners Bay. 70 sea lions on Benjamin Is.

5/24 No spawn observed. Good school on beach near Cascade Pt. Small schools in Auke Bay, Pt Louisa, Lena Cove, Tee Harbor. Sea lions hauled out at Benjamin Is.

5/27 No spawn observed. Schools in Auke Bay, Indian Cove, Tee Harbor. Few predators.

Appendix B.–Lynn Canal and Berners Bay 2006 Herring Survey Flight Log.

Total miles of spawn: 3.9

Spawning dates: 5/12–5/15

Peak spawning: 5/13–5/14

4/11: 6 sea lions between Pt Bridget and the flats, gulls and scattered eagles as though some eulachon may have been in the area – nothing obvious. Many sea lions at Benjamin Is.

4/18: Quiet, very few predators – 18 sea lions in Berners Bay. A good sea lion show at Benjamin Is, with two orcas in stealth mode approaching.

4/21: Lynn Canal was very quiet, with one small school of herring observed in the Auke Bay area. Very few predators were observed along the shoreline between Auke Bay and Mab Island. Berners Bay was very quiet as well with a half dozen sea lion observed spread out in singles and pairs. One whale was observed in the southeast portion of the bay. No herring were observed.

4/25: The Lynn Canal shoreline was very quiet, with only a couple of sea lions observed near Pt. Lena and Mab Island. More than 100 sea lions were observed at the Benjamin Island haulout. Large concentrations of scoters were observed near Eagle River and Mab Island. Berners Bay was quiet with very few sea lions and no whales observed. No herring or herring spawn was observed.

4/28: No herring, spawn, or predators, except a good show at Benjamin Is. on the Lynn Canal shore. A few sea lions near Pt Bridget and Cascade Point, 10 seal ions actively feeding near the head of the bay. Many dead eulachon observed on the flats. Many birds and eagles feeding on the Lace and Antler Rivers.

5/3: No herring or spawn. Only about 30 sea lions at the Benjamin Is haulout. Two whales at Pt Bridget. Many seal feeding at the mouth of Berners River. Lots of eagles and seabirds about 5 miles up Lace River, and about 2 miles up Antler River.

5/7: No spawn, small school off Pt Louisa. 250 sea lions at Benjamin, and 2 in Berners Bay

5/10: No spawn, one school in the Auke Bay ferry terminal area. Approximately 200 sea lions observed at Benjamin Is. 33 sea lion and 2 whales observed from Mab Is to Point Bridget.

5/12: 0.33 miles of active spawn observed between Bridget Cove and Cowee Creek. Three whales and 20-30 sea lions in the Mab Is Bridget Cove area.

5/13: 2.4 miles active spawn observed in the Pt Bridget area between Mab Is and Cowee Creek. Schools staging in Bridget Cove. A large school observed in Tee Harbor.

5/14: 3 miles of active spawn observed in same area. More intense in the Mab Is area. Herring in N Tee Harbor broken into four schools

5/15: Two spots S Bridget and Mab Island. Benjamin haulout half full of sea lions. Schools in shallow in N Tee Harbor.

5/16: No herring or spawn observed.

5/22: No herring or spawn observed.