Abundance, Age, Sex, and Size Statistics for Pacific Herring in the Togiak District of Bristol Bay, 2011

by

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Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations

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

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ABUNDANCE, AGE, SEX, AND SIZE STATISTICS FOR PACIFIC HERRING IN THE TOGIAK DISTRICT OF BRISTOL BAY, 2011

by

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ABSTRACT

The Pacific herring *Clupea pallasii* total run in Togiak District of Bristol Bay was monitored for abundance/biomass and sampled for age, size, and sex composition in 2011. Abundance was estimated from aerial surveys with chartered aircraft. Commercial harvest was measured through landing reports filed by commercial fish processors to the Alaska Department of Fish and Game. Samples were collected from commercial purse seine and gillnet harvests at the processors. The 2011 run biomass was not estimated because aerial surveys were insufficient to estimate peak biomass. Instead, total run biomass for 2011 was assumed to be equal to its preseason forecasted biomass of 140,860 tons (127,787 tonnes). Total commercial harvest was 24,672 tons (22,877 tons from the sac roe fisheries with 16,970 tons harvested by purse seine and 5,907 tons by gillnet and 1,795 tons harvested by the Dutch Harbor food and bait fishery). Final exploitation rate was estimated at 18%. A total of 6,620 herring were sampled for age, sex, length, weight, and sexual maturity information between 10 May and 21 May 2011. The 2011 inshore herring ages ranged from 4 to 16 years, with purse seine harvest dominated by age 6 (32%), 7 (23%), and 8 (14%), while gillnet fish were dominated by age 7 (16%), 8 (24%) and 9 (20%). Mean length and weight of herring from the purse seine fishery samples were 289 mm and 333 grams, while fish sampled from the gillnet fishery averaged 312 mm and 425 grams.

Key words: Pacific herring, *Clupea pallasii*, sac roe, abundance, spawning biomass, commercial herring fishery, Bristol Bay, Togiak District, age, length, weight, sex, Dutch Harbor, food and bait

INTRODUCTION

Commercially exploited quantities (or stocks) of Pacific herring *Clupea pallasii* are found along the coast of Alaska from its southern boundary at Dixon Entrance to Norton Sound (Woodby et al. 2005). One of the most important of these exploited stocks is the Bristol Bay-Alaska Peninsula stock. The Bristol Bay-Alaska Peninsula herring stock has been managed as a single spawning population with a total allowable exploitation rate of 20% established by the *Bristol Bay Herring Management Plan*, 5 AAC 27.865.

Each spring, herring from the Bristol Bay-Alaska Peninsula stock migrate from their overwinter habitat north of the Pribilof Islands to spawning locations along the eastern Bering Sea coast, primarily in the Togiak region east of Cape Newenham (Tojo et al. 2007; Figure 1). The shoreline in this region is characterized by a wide intertidal zone and shallow bays with diurnal tidal ranges up to 4.6 m (Selkregg 1976). The primary marine vegetation consists of ribbon kelp *Laminaria* spp., rockweed *Fucus* spp., and eelgrass *Zostera* spp. Rockweed is the most visible species of aquatic vegetation because it grows on cobble substrate in intertidal areas and upon rocky outcroppings. Herring spawn throughout the fishing district, particularly in areas where eelgrass and rockweed are present.

Herring spawn within Togiak District from late April through early June. After spawning, herring continue their clockwise migration along the Alaska Peninsula to feeding areas near Unalaska Island. In August and September, these fish move north to overwintering grounds north of the Pribilof Islands (Shaboneev 1965; Rumyantsev and Darda 1970; Wespestad and Barton 1981; Funk 1990; Figure 1).

The commercial fishery for herring in Togiak District occurs as the fish move inshore at or near their time of spawning. The target of this harvest is the ripened ovaries, or egg skeins, referred to as sac roe. This product is primarily marketed in Japan. Commercial harvest of herring for sac roe was first documented in Togiak District in 1968. Passage of the Fisheries Conservation and Management Act in 1976 and the resulting inability of Japanese fishermen to harvest sac roe from U.S. waters prompted increased interest in the Togiak fishery by U.S. fishermen. The 20-

year mean sac roe harvest is presently 21,672 tons[1] (19,661 tonnes[2]; Table 1). During this period, the harvest has ranged from a high of 30,315 tons (27,502 tonnes) in 1994 to a low of 14,970 tons (13,581 tonnes) in 1991. Gillnets and purse seines are used to capture herring in the sac roe fishery.

The herring fishery in Togiak District, which consists of all state waters between the longitude at the tip of Cape Constantine and the tip of Cape Newenham and extending south to the latitude of Cape Menshikof (approximately 4,116 km[2]) occurs on the largest discrete spawning biomass of Pacific herring in Alaska waters (Figure 2). Biomass estimates of this spawning aggregation have been conducted using aerial surveys since 1978. The largest estimated annual biomass was 239,022 tons[1] (216,839 tonnes[2]) in 1979, and averaged 141,774 tons (128,614 tonnes) from 2001 through 2010 (Table 1).

Currently this fishery is managed under the *Bristol Bay Herring Management Plan* (5 AAC 27.865; Sands 2009). This plan, originally adopted in 1980, sets a maximum 20% exploitation rate of the available spawning biomass as the management target. Of this potential harvest, a fixed allocation of 1,500 tons (1,361 tonnes) is set aside for a spawn-on-kelp harvest in Togiak District and 7% of the remaining available biomass for a food and bait fishery operated out of Dutch Harbor. Remaining available biomass is reserved for the Togiak sac roe fishery with an allocation target of 30% gillnet and 70% purse seine.

Wild spawn-on-kelp product has been historically harvested either by hand or by rake. This harvest, first documented in 1967, has been intermittent in recent years because of low demand, with no fishery occurring during the 1997, 1998, 2000, and 2001 seasons, as well as from 2004 to the present (Table 1).

After leaving Togiak District, herring are susceptible to one other directed fishery during their post-spawn migration. This is a food and bait fishery occurring mid- to late-summer around Unalaska Island with boats operating out of Dutch Harbor. Harvests in this fishery began in 1929 and peaked at 3,006 tons (2,727 tonnes) in 1932 (Jackson 2008). The fishery declined and ended by 1938 because of poor market demand. This fishery was renewed in 1981 whereupon harvest quickly peaked in 1984 at 3,578 tons (3,246 tonnes) and has since trended down with the most recent 10-year average at 1,497 tons (1,358 tonnes; Table 1).

In addition to the managed harvest, Togiak herring occur as bycatch in fisheries targeting groundfish in the southeastern Bering Sea. Foreign vessels first developed this fishery but domestic fishers have recently been more dominant. These fisheries occur in areas that include the migratory route of feeding herring (Rowell et al. 1991). In the Bering Sea and Aleutian Islands Management Area, a 1% cap of available (forecasted) herring biomass has been established for this fishery (NPFMC 2009).

Stock assessments of the Togiak herring population began in 1976 and have been conducted annually since 1978 (McBride et al. 1981; McBride and Whitmore 1981; Fried et al. 1982a, 1982b, 1983a, 1983b, 1984; Lebida et al. 1985a, 1985b; Lebida 1987; Sandone and Brannian

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[1] The Alaska Board of Fisheries requires that inseason catch and aerial survey biomass estimates be calculated and reported in short tons. The English short ton = 2,000 lb or 907.2 kg.

[2] The metric tonne (1,000 kg or 2,205 lbs) = tons/1.1023

1988; Lebida and Sandone 1990; Rowell et al. 1991; Rowell 1995, 2002a, 2002b; West 2002; West et al. 2003; Schwanke 2003a, 2003b; Brazil 2007a, 2007b, 2007c; Brazil et al. 2009; Buck 2010a, 2010b, 2012).

OBJECTIVES

The specific objectives for assessing Togiak herring each year were to

1) estimate the run biomass of spawning herring within Togiak District;

2) document the commercial harvest (including dead loss and test fishing) of herring within Togiak District by time period (date), gear type, and district subsection;

3) characterize the age composition as well as length and weight at age of the run, harvest (by gear type), and escapement; and

4) estimate the total exploitation rate of herring in Togiak District and the Dutch Harbor food and bait fishery.

METHODS

BIOMASS

Run biomass of herring within Togiak District was estimated following aerial survey procedures outlined by Lebida and Whitmore (1985). Surveys were flown daily at low tide, weather permitting. The district was divided into 13 aerial survey sections (Figure 3). Daily biomass estimates were made by summing survey section estimates. Peak inseason biomass was the maximum daily estimate during the fishing season, whereas run biomass was the sum of all daily biomass estimates judged to be composed of fish not accounted for in any other survey plus any harvests that occurred prior to the first usable daily biomass estimate. In a typical fishing season, this will be the peak biomass estimate combined with an immediate postseason estimate combined with all pre-peak harvest.

HARVEST

Fish tickets (sales receipts) completed by buyers for each commercial delivery of herring were the primary source for documenting harvest. Fish ticket information included date of harvest, gear type, biomass (tons), and location by section. Estimates of waste and or discarded herring observed during aerial surveys or reported by fishermen or processors were added to the fish ticket database and counted as harvest when calculating exploitation rates.

AGE, SIZE, AND SEX COMPOSITION

We attempted to sample the commercial catch for age composition from each management section during every commercial fishing period (usually by day). Sampling staff collected samples at the close of each commercial fishing period from processors, tenders, or individual fishing vessels and labeled them by gear type, processor, and section. Attempts were made to collect samples from multiple vessels and or processors to ensure samples came from a maximum number of herring schools. Samples collected from each gear type were used to characterize the harvest of each gear type, while only fish captured by purse seine gear were used to characterize aerial survey biomass estimates because purse seines are less size-selective than gillnets.

To determine age, samplers removed a scale from the preferred left side of each fish approximately 2.5 cm behind the operculum and 2.5 cm below the lateral line for later interpretation. If scales were absent from this preferred area, a scale from the right side of the fish in the same location or any other area where readable scales were present. Removed scales were dipped in a 10% mucilage solution, mounted sculptured side up on glass slides, and read by annuli interpretation at low (~10x) magnification using a microfiche reader. Age was estimated by counting the compressed annuli formation at the end of winter prior to spawning (Shaboneev 1965). Because samples were collected during the spawning migration, the outer edge of the scale was considered an annulus.

In addition to age, standard length (tip of snout to the hypural plate) of each fish was measured to the nearest millimeter. We weighed each herring to the nearest 0.5 g and determined sex and maturity for each herring by visually examining the gonads. We rated maturity using an abbreviated version of the 8-scale guideline outlined in Barton and Steinhoff (1980), combining categories as green (not ready to spawn), ripe (ready to spawn), or spent (already spawned).

Adequate sample sizes ensured that age composition estimates for a multinomial population resulted in a solution whereby each age category would simultaneously fall within 5% (δ =0.05) of the true population age proportions 90% of the time (Thompson 1987). A sample size of 400 herring provides this level of precision and accuracy. We attempted to collect this amount daily from each section where commercial purse seine fishing occurred and every other day where gillnet fishing occurred.

Harvest sample group assignment was accomplished by considering the earliest samples and sequentially adding samples from subsequent days and or adjacent fishing sections if they did not differ significantly (χ^2, P<0.05) or if additional samples were needed in a step-wise process until the minimum sample size was achieved. This process resulted in six sampling groups for the purse seine harvest (Table 2, Figure 4) and 5 for gillnet harvest (Figure 5).

Age composition and related information was calculated by matching sampling groups with corresponding harvest and aerial survey biomass estimates. The mean weight-at-age, $\overline{W}_a$, for herring for each gear-time-area stratum is estimated as

$$\overline{W}_a = \frac{\sum_{i=1}^{n_a} W_{ai}}{n_a} \tag{1}$$

where:

W_{ai} = the individual weight of herring in sample n of age a and

n_a = the number of herring in the sample of age a.

The mean length-at-age is calculated by substituting the individual length, L_{ai}, of herring for the individual weight, W_{ai}. Biomass by age, B_a, is estimated as

$$B_a = \left[\frac{n_a \overline{W}_a}{\sum_{a=1}^{\max_a} (n_a \overline{W}_a)} \right] B \qquad (2)$$

where:

B_a = the biomass for age a,

n_a = the number of herring in the sample of age a, and

B = aerial survey or harvest biomass estimate.

The estimated run biomass is calculated by summing B_a for all ages. This can also be converted to numbers of fish for each age class, N_a, as

$$N_a = \frac{B_a}{\overline{W}_a} \qquad (3)$$

The sum across all age classes of the difference between the run biomass at age B_a and the combined purse seine and gillnet harvests at age C_a which is defined as the escapement biomass, E_{tot}:

$$E_{tot} = \sum_{a=1}^{\max} (B_a - C_a) \qquad (4)$$

An age-structured analysis (ASA) model (Funk and Rowell 1995) was used to forecast the 2011 herring run (Appendix C). The latest biomass estimate included in the 2011 forecast model was for 2010.

EXPLOITATION RATE

The exploitation rate, U, is estimated as

$$U = \frac{C}{B} \qquad (5)$$

where:

C = total Togiak sac roe harvest and Dutch Harbor food and bait harvest, and

B = run biomass.

RESULTS

BIOMASS

Aerial surveys in Togiak District began on 27 April (Table 3). Observers first spotted herring on 6 May during a survey that documented 20,979 tons (19,032 tonnes). Herring biomass increased steadily through 12 May to a peak inseason biomass of 56,763 tons (51,495 tonnes), then fell to 4,646 tons (4,215 tonnes) on the final survey conducted on 26 May. Herring concentrated their spawning biomass in the center of Togiak District (Figures 3 and 6).

Aerial survey conditions ranged from poor to excellent throughout the season, with good conditions during the peak inseason survey (Table 3). The relatively low peak biomass estimate, combined with the fact that no survey was flown two days prior to that date and only one survey occurring in poor to fair conditions occurred in the four days after the peak biomass survey, leads us to believe that we did not fully estimate peak spawning biomass. Therefore, we did not attempt to estimate the total run biomass for 2011 and instead used the 2011 forecast as a proxy (Table 1).

Spawn occurred for 49 miles (79 km) along the coastlines in Togiak District in 2011, with half of it observed during the 13 May survey (Table 3). This distance represents 138% of the 10-year average and 101% of the 20-year average (Table 4).

HARVEST

Commercial openings between 8 and 23 May produced a total harvest of 22,877 tons (20,754 tonnes) within Togiak District (Table 5) in 2011. Historically, this fishery commences around 6 May; however, there is a fair bit of temporal variation, with fishing commencing as early as 25 April (in 2003) and as late as 16 May (in 2008 and 2009) within the last 10 years (Table 6). This temporal variation is largely a function of the spring ice break-up and related water temperatures in the eastern Bering Sea. In 2011, with the eastern Bering Sea experiencing warmer than usual sea surface temperatures, Alaska Dept. of Fish & Game (ADF&G) forecasted the first harvest on 30 April. Fishing opened on 8 May and ended on 31 May, making for a relatively long 24 day fishing season. Fishing with purse seine gear was initially open from Togiak Reef west to Cape Newenham and from Anchor Point to Right Hand Point, while gillnet gear was allowed from Right Hand Point east to Egg Island. Adjustments limiting the open purse seine area east of Togiak Bay were made on 13 and 16 May. On 20 May, the gillnet area was extended to the west of Right Hand Point and purse seine fishing was closed (Figure 7).

The total commercial harvest in the Togiak District sac roe fishery of 22,877 tons (20,754 tonnes) represents 111% of the 10-year average and 106% of the 20-year average (Table 1). Catches from Hagemeister Section accounted for the largest percentage (64%) of the total commercial harvest, followed by Kulukak (25%), Pyrite Point (7%), Cape Newenham (2%), Nunavachak (2%) and Togiak (1%) sections (Table 5, Figure 8).

Roe percentages ranged from 12.4% for herring harvested by gillnet in Kulukak Section on 22 May to 8.0% for herring harvested by purse seine in Pyrite Point Section on 17 May (Table 5).

Purse Seine

There were nine commercial purse seine openings totaling 270 hours in Togiak District between 8 May and 19 May, harvesting a total of 16,970 tons (15,395 tonnes) during 2011 (Table 5). The

first opening that closed on 12 May experienced an 838 ton (760 tonnes) purse seine harvest concentrated in Hagemeister Section. Purse seine harvests peaked on 12 May with 5,041 tons (4,573 tonnes) and ended on 19 May with a harvest of 1,380 tons (1,252 tonnes). A total of 86% of the harvest occurred in Hagemeister Section. No dead loss was reported or observed in 2011. Purse seine harvests averaged 1,886 tons (1,711 tonnes) per fishing period and excluding the initial 76 h opening, the commercial purse seine fleet harvested 2,017 tons (1,830 tonnes) per day.

Roe accounted for 9.6% (by weight) of the commercial purse seine fishery and ranged from 8.0% in Pyrite Point Section on 17 May to 10.0% in the same location on 12 May (Table 5). The total average roe percentage (weighted) for purse seine herring was 103% of the 10-year and 101% of the 20-year average (Table 6).

Gillnet

Thirteen commercial gillnet openings totaling 601 hours were held between 8 May and 23 May, harvesting a total of 5,907 tons (5,359 tonnes); 96% from Kulukak Section and the remainder from Nunavachak Section. The first commercial harvest took 85 tons (77 tonnes). Harvest peaked on 16 May with a landing of 969 tons (1,438 tonnes) and ended with an 8 day period lasting from 23 May through the end of the month with a harvest of 1,065 tons (966 tonnes) (Table 5). Gillnet harvests averaged 454 tons (412 tonnes) per fishing period and excluding the initial 76 h opening and the final 192 h opening, the commercial gillnet fleet harvested 433 tons (393 tonnes) per day.

Roe accounted for 12.1% (by weight) of the commercial gillnet fishery. Roe percentages ranged from a low of 10.1% on 8 May in Kulukak Section, to a high of 12.9% on 16 May in the same section (Table 5). The total average roe percentage (weighted) for gillnet harvested in 2011 was 113% of the 10-year and 112% of the 20-year average (Table 6).

Spawn on Kelp

There was no commercial harvest for a spawn-on-kelp fishery in 2011, as there were no registered buyers (Table 1). This fishery last occurred in 2003.

AGE, SIZE, AND SEX COMPOSITION

A total of 4,760 samples collected from the commercial purse seine fishery (all sections) produced 4,120 readable scales (Table 7, Appendices B1–B3 and B5). A total of 3,970 samples were collected between 8 and 19 May in Hagemeister Section, producing 3,426 (62%) of the total readable scales (Appendices B1 and B5). A total of 390 samples were collected from catches on 12 May in Nunavachak Section, producing 357 (6%) of the total readable scales (Appendices B2 and B5). A total of 400 samples were collected from catches on 8 May in Togiak Section producing 337 (6%) of the total readable scales (Appendices B3 and B5).

A total of 1,860 herring were sampled from the commercial gillnet fishery between 8 and 19 May from Kulukak Section, producing 1,434 (26%) of the total readable scales (Table 7, Appendix B4).

Sampling protocol accounted for the typical percentage of readable scales and was designed to meet the sampling size goals with readable scales.

Total Run

No age composition estimate was generated for the total run biomass in 2011 since there was not a total run biomass estimate.

Commercial Harvest

Abundant age classes (>10% of the harvest in abundance or harvest biomass) were age-6, -7, -8 and -9 fish, which comprised 20%, 21%, 18% and 15% (respectively) of the harvest by weight and 29%, 22%, 16% and 12% by number (Table 8; Appendix A1). Herring in the gillnet harvest were markedly older than those in the purse seine harvest (Figures 9, 10, and 11).

The average length and weight of herring harvested in the commercial fishery was 296 mm and 360 g. Samples collected from commercial purse seine and gillnet harvests were 47% male and 53% female, varying in composition by time and location (χ^2=18.2, P=1.9e^{-5}).

Purse Seine

Herring samples were collected from commercial purse seine openings between 8 and 19 May from Hagemeister Section, and from Nunavachak Section on 8 May and Togiak Section on 12 May (Appendices B1, B2, B3, and B5).

Herring sampled from the purse seine fishery ranged from age 4 to 16 (Table 8). Age-6, -7, -8, and -9 fish comprised 25%, 22%, 16%, and 13% of the commercial purse seine harvest by weight and 32%, 23%, 14%, and 11% by number (Table 8).

Herring sampled from the 2011 purse seine harvest had a mean length of 289 mm and mean weight of 333 g (Table 9), and were 49% male and 51% female, varying in composition by time and location (χ^2=2.7, P=0.103).

Gillnet

Herring sampled from the gillnet fishery ranged from age 4 to 16 (Table 8), with age-7, -8, -9, and -10 fish representing 18%, 25%, 22% and 12% of the commercial gillnet harvest by weight and 16%, 24%, 20% and 14% by number (Table 8, Appendices A2 and B4).

Herring sampled from the 2011 gillnet harvest had a mean length of 312 mm and mean weight of 425 g (Table 9). Herring sampled from the gillnet harvest were 44% male and 56% female, varying in composition by time (χ^2=291.8, P~1).

EXPLOITATION RATE

We estimated a total exploitation rate of 18% by dividing the combined Togiak District commercial sac roe harvest of 22,877 tons (20,754 tonnes) and the Dutch Harbor food and bait harvest of 1,795 tons (1,628 tonnes) by the forecasted total run biomass of 140,860 tons (127,787 tonnes) (Table 1).

DISCUSSION

The purpose of this report was to estimate total run biomass, spawning escapement, and age, size (weight and length), and sex composition of herring in Togiak District. A sampling crew located at the North Pacific Seafoods plant in Togiak processed fishery samples from processors throughout the district. This strategy provided managers with inseason age composition estimates in a timely and cost-effective manner.

We were unable to make an estimate of the 2011 total run biomass (Objective 1) based on aerial surveys and used the forecasted total run instead (Table 1, Appendix C1). In total, surveyors observed 49 linear miles (79 km) of spawning herring, more than the long-term averages. Herring spawning activity was first observed during the 12 May survey at 13 miles (21 km); the largest distance of spawn occurred the following day at 25 miles (40 km; Table 3).

The total commercial harvest (Objective 2) of 22,877 tons (20,754 tonnes) was greater than the long-term averages (Table 6). The commercial fishery started on 8 May, one day later than the average starting date over the last 20 years (Table 6). The average roe percent was 10.2% for all harvested herring (Table 5).

At 24 days, the 2011 Togiak District herring fishery was twice as long as the most recent 10-year average and 13 days longer than the 20-year average (Table 6). Fishing effort, defined as the peak vessel count during aerial surveys, was down for both gillnet and purse seiners over 2010 (Table 6). Effort for gillnet gear was 47% of the 10-year average and 68% for purse seine gear. This continued low effort was probably the result of depressed market conditions as well as fishing and processor co-ops, which first appeared in 2001 and focus on quality over quantity of harvest. This practice allows the purse seine fishermen to inspect their catches more closely, and harvest only the most valuable fish.

The commercial purse seine harvest of 16,970 tons (tonnes) of herring was 114% of the 10-year average and 105% of the 20-year average (Table 6). The average roe percentage of 9.6% was slightly greater than the long-term averages. The commercial gillnet harvest of 5,907 tons (tonnes) was 104% of the 10-year average and 106% of the 20-year average while the average roe percentage of 12.1% was more than the long-term averages.

Our sampling effort in 2011 was 81% of our effort in 2010. The number of readable scales (5,554) collected from the 2010 commercial fishery was 106% of readable scales collected on average since 2000 (Schwanke 2003a, 2003b; West et al. 2003; Brazil 2007a, 2007b, 2007c; Brazil et al. 2009; Buck 2010a, 2010b, 2011). This sampling effort was sufficient to characterize the Togiak District herring spawning biomass.

While we can make no age composition estimate for the total run or escapement (Objective 3), the 2011 Togiak herring harvest was composed of 62% (by biomass) and 71% (by number) of age 8 or younger fish (Table 8).

Age-6, -7, -8, and -9 herring were abundant in the commercial purse seine biomass, accounting for 25%, 22%, 16%, and 13% of the harvest respectively (Table 8). Age-7, -8, -9, and -10 herring accounting for 18%, 25%, 22%, and 12% of the gillnet harvest biomass, respectively (Table 8). Age-6, -7, -8, and -9 herring in 2011 tended to be slightly longer and heavier than the historical trend (Figures 12 and 13).

A major problem with estimating recruitment in any given year is the lack of postseason sampling necessary to detect younger fish. In 2011, the lateness of the season and budget constraints precluded any sampling of fish caught after 19 May and no postseason survey was conducted. The younger recruit age classes, age-4 and age-5 herring, generally spawn later than older fish and are typically underrepresented when late-season sampling is curtailed. Nevertheless, age-4 and -5 herring were present at low levels, although not at the elevated levels seen in 2008 and 2009, suggesting that the strong recruitment event observed over the past few

years may be over (Table 8, Figure 11, Appendix C1). Togiak herring typically experience large recruitment events every 8–10 years.

The total exploitation rate (Objective 4) of herring in Togiak District was 18% (Table 1), which was lower than the management target exploitation rate of 20%, but higher than the 16% and 17% average exploitation rates over the last 10 to 20 years.

ACKNOWLEDGEMENTS

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TABLES AND FIGURES

Table 1.–Historical total run biomass and commercial harvests (tons) of herring returning to Togiak District, Bristol Bay, 1991–2011.

| | Togiak | | Spawn-on-Kelp | | | Dutch Harbor | |
| | Total Run Biomass (tons) | Sac Roe Harvest (tons) | Harvest (lbs) | Harvest (tons) | Herring Equivalent (tons) | Food and Bait Harvest (tons) | Exploitation Rate |
Year							
1991	83,229	14,970	348,357	174	1,310	1,325	21.2%
1992	156,957	25,808	363,600	182	1,482	1,982	18.6%
1993	193,847	17,956	383,000	192	1,481	2,824	11.5%
1994	185,412	30,315	308,400	154	1,134	3,349	18.8%
1995	149,093[a]	26,732	281,600	141	996	1,705	19.7%
1996	135,585[a]	24,871	455,800	228	1,899	2,279	21.4%
1997	144,887	23,813				1,950	17.8%
1998	121,000[a]	22,776				1,994	20.5%
1999	157,028	19,878	419,563	210	1,605	2,437	15.2%
2000	130,904[a]	20,421				2,014	17.1%
2001	115,155	22,330				2,437	21.5%
2002	120,196[a]	17,049	67,793	34	260	2,014	16.1%
2003	126,213[a]	21,663	[b]	[b]	[b]	1,332	18.2%
2004	143,124[a]	18,868				1,038	13.9%
2005	163,737	20,912				1,159	13.5%
2006	179,580	23,953				952	13.9%
2007	143,827	17,132				1,248	12.8%
2008	136,839	20,523				1,536	16.1%
2009	142,154	17,107				1,310	13.0%
2010	146,913	26,355				1,941	19.3%
2011	140,860[a]	22,877				1,795	17.5%
2001-2010 Average	141,774	20,589	67,793	34	260	1,497	15.8%
1991-2010 Average	143,784	21,672	328,514	164	1,271	1,841	17.0%

Note: Blank cells indicate no fishery occurred that year.

Sources: Salomone et al. 2011; Bernard 2011; ADF&G fish tickets.

[a] Total biomass estimate based on preseason forecast because inseason biomass could not be estimated due to poor aerial survey conditions during the season.

[b] Data confidential under Alaska Statute 16.05.815.

Table 2.–Herring samples with purse seine harvest and associated sampling groups. Togiak District, 2011.

Date	Available Samples					Purse Seine Harvest (tons)					Sample Group				
	NUN	TOG	HAG	PYP	CPN	NUN	TOG	HAG	PYP	CPN	NUN	TOG	HAG	PYP	CPN
8 May		337	451			42	104	692			1	1	1		
12 May	357		263			68		4,544	430		2		2	2	
13 May			297				110	1,256				3	3		
14 May			337					155					3		
15 May			607					505					4		
16 May			438					3,242					5		
17 May			328					1,638	314				6	6	
18 May			349					1,930	344	217			6	6	6
19 May			356					648	418	314			6	6	6

Note: Fishing section abbreviations: NUN=Nunavachak, TOG=Togiak, HAG=Hagemeister, PYP=Pyrite Point, CPN=Cape Newenham.

Table 3.–Aerial survey estimates (tons) of herring by index area, Togiak District, 2011.

Date	Start Time	Survey Rating [b]	Spawn (miles)	Estimated Biomass by Index Area [a]													Daily Total
				NUS	KUK	MET	NVK	UGL	TOG	TNG	MTG	OSK	PYR	CPN	HAG	WAL	
27 Apr	10:30	3.2															0
3 May	14:00	1.2															0
6 May	11:00	2.0							34	2,209					16,391	2,345	20,979
8 May	12:30	4.0						266	32,735	15					1,041		34,057
12 May	10:00	2.0	12.9	891	3,517	20,778	9,272	2,571	5,497	693	10,213	2,971			360		56,763
13 May	15:00	3.5	24.8														c
16 May	15:00	3.5	0.5	201			287	670	13,317		511						14,986
19 May	09:00	3.3	7.0	49	3		1,057	1,549	27,365	286		24	11	30			30,374
26 May	13:00	4.0	3.9			9	300	450	3,888								4,646
Total linear miles of spawn			49.1									Peak biomass estimate					56,763

Note: Blank cells represent nothing observed. Total Togiak herring biomass was estimated at 142,133 (tons). This was the sum of 16 May and 24 May surveys.

[a] Index areas: NUS - Nushagak Peninsula; KUK - Kulukak; MET - Metervik; NVK - Nunavachak; UGL - Ungalikthluk/Togiak; TOG - Togiak; TNG - Tongue Pt.; MTG - Matogak; HAG - Hagemeister; OSK - Osviak; PYR - Pyrite Point; CPN - Cape Newenham; WAL – Walrus Islands.

[b] Average survey rating for all sections surveyed: 1= Excellent, 2 = Good, 3 = Fair, 4 = Poor, 5 = Unsatisfactory.

[c] Partial survey due to poor weather conditions.

Table 4.–Aerial survey estimates of herring spawn deposition, Togiak District, 1991–2011.

Year	Spawn Estimates	
	Observations	Miles
1991	90	69.5
1992	160	96.9
1993	76	53.4
1994	80	71.9
1995	70	58.7
1996	99	72.9
1997	79	59.1
1998	42	33.0
1999	33	56.0
2000	71	46.0
2001	100	57.0
2002	79	32.0
2003	182	94.7
2004	47	36.4
2005	106	27.6
2006	66	17.8
2007	43	18.9
2008	38	48.6
2009	32	15.3
2010	9	8.4
2011	43	49.1
2001–2010 Average	70.2	35.7
1991–2010 Average	75.1	48.7

Table 5.–Commercial herring harvest (tons) and roe (%) by fishing section and gear type, Togiak District, Bristol Bay, 2011.

Date	Duration	Period	Kulukak		Nunavachak		Togiak		Hagemeister		Pyrite Point		Cape Newenham		Total	
			Tons	Roe %	Tons	Roe %	Tons	Roe %	Tons	Roe %	Tons	Roe %	Tons	Roe %	Tons	Roe %
Purse Seine																
8 May	78:00	1			42.0	9.9	103.8	[a]	692.0	9.8					837.8	9.8
12 May	24:00	2			67.5	10.8			4,544.0	10.0	429.6	10.0			5,041.1	10.0
13 May	24:00	3					110.2	8.8	1,255.5	9.8					1,365.7	9.7
14 May	24:00	4							155.4	9.8					155.4	9.8
15 May	24:00	5							505.0	9.7					505.0	9.7
16 May	24:00	6							3,241.8	9.0					3,241.8	9.0
17 May	24:00	7							1,638.4	9.9	313.6	8.0			1,952.0	9.6
18 May	24:00	8							1,929.6	9.9	343.8	8.6	217.4	9.4	2,490.8	9.7
19 May	24:00	9							648.1	9.2	418.4	9.0	313.8	8.8	1,380.3	9.0
Subtotal	270:00				109.5	10.5	214.0	8.8	14,609.8	9.7	1,505.4	9.0	531.2	9.0	16,969.9	9.6
Gillnet																
8 May	78:00	1	84.6	10.1											84.6	10.1
12 May	24:00	2	407.7	11.1											407.7	11.1
13 May	24:00	3	635.1	12.0											635.1	12.0
14 May	24:00	4	53.8	11.7											53.8	11.7
15 May	24:00	5	11.0	10.8											11.0	10.8
16 May	24:00	6	969.2	12.9											969.2	12.9
17 May	24:00	7	637.3	12.3											637.3	12.3
18 May	24:00	8	700.9	11.7											700.9	11.7
19 May	24:00	9	473.0	11.3											473.0	11.3
20 May	24:00	10	31.9	11.1	55.3	11.2									87.2	11.2
21 May	13:00	11	228.7	11.4	135.6	11.4									364.3	11.4
22 May	24:00	12	393.7	12.3	24.2	12.4									417.9	12.3
23 May	192:00	13	1,014.9	12.8	50.3	12.1									1,065.2	12.8
Subtotal	601:00		5,641.8	12.1	265.4	11.6									5,907.2	12.1

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Table 5.–Page 2 of 2.

Date	Duration	Period	Kulukak Tons	Roe %	Nunavachak Tons	Roe %	Togiak Tons	Roe %	Hagemeister Tons	Roe %	Pyrite Point Tons	Roe %	Cape Newenham Tons	Roe %	Total Tons	Roe %
Combined																
8 May			84.6	10.1	42.0	9.9	103.8	[a]	692.0	9.8					922.4	8.7
12 May			407.7	11.1	67.5	10.8			4,544.0	10.0	429.6	10.0			5,448.8	10.1
13 May			635.1	12.0			110.2	8.8	1,255.5	9.8					2,000.8	10.4
14 May			53.8	11.7					155.4	9.8					209.2	10.3
15 May			11.0	10.8					505.0	9.7					516.0	9.7
16 May			969.2	12.9					3,241.8	9.0					4,211.0	9.9
17 May			637.3	12.3					1,638.4	9.9	313.6	8.0			2,589.3	10.3
18 May			700.9	11.7					1,929.6	9.9	343.8	8.6	217.4	9.4	2,974.3	10.9
19 May			473.0	11.3					648.1	9.2	418.4	9.0	313.8	8.8	1,539.5	11.6
20 May			31.9	11.1	55.3	11.2									87.2	11.2
21 May			228.7	11.4	135.6	11.4									364.3	11.4
22 May			393.7	12.3	24.2	12.4									417.9	12.3
23 May			1,014.9	12.8	50.3	12.1									1,065.2	12.8
Total			5,641.8	12.1	374.9	11.3	214.0	8.8	14,609.8	9.7	1,505.4	9.0	531.2	9.0	22,877.1	10.2

Note: Blank cells represent no data due to area closures or no fishing.

[a] Food/bait harvest.

Table 6.–Sac roe herring industry participation, fishing effort and harvest, Togiak District, 1991–2011.

			Fishery Dates			Gillnet				
Year	Buyers	Daily Capacity[a]	Start	Close	Days	Effort[b]	Duration (hours)	Harvest[c]	CPUE	Roe %
1991	16	3,350	5/10	5/17	8	170	14	3,182	1.3	8.5
1992	18	3,700	5/20	5/27	8	274	26	5,030	0.7	8.8
1993	12	2,500	4/27	5/12	16	75	145	3,564	0.3	10.1
1994	16	3,300	5/11	5/20	10	146	76	7,462	0.7	12.0
1995	22	4,350	5/7	5/15	9	250	34	6,995	0.8	12.0
1996	19	4,850	5/5	5/8	4	461	18	6,863	0.8	11.1
1997	18	4,200	5/2	5/6	5	336	24	5,164	0.6	11.8
1998	15	2,475	4/29	5/10	12	152	46	5,952	0.9	12.5
1999	12	2,400	5/18	5/26	9	171	28	4,858	1.0	11.5
2000	12	2,100	5/6	5/14	9	227	67	5,464	0.4	10.6
2001	11	2,255	5/6	5/13	8	96	84	6,481	0.8	10.6
2002	8	1,920	5/3	5/13	11	82	102	5,216	0.6	10.9
2003	7	1,920	4/25	5/7	13	75	142	6,505	0.6	10.9
2004	6	2,150	4/29	5/9	11	54	162	4,980	0.6	10.4
2005	8	2,330	4/30	5/8	9	56	149	5,841	0.7	11.2
2006	7	2,060	5/12	5/21	10	49	144	7,132	1.0	10.8
2007	5	1,420	5/10	5/25	16	25	366	4,012	0.4	11.2
2008	7	1,950	5/16	5/31	16	27	312	4,832	0.6	11.4
2009	6	2,015	5/16	5/29	14	32	338	4,140	0.4	9.7
2010	6	2,603	5/11	5/27	17	35	338	7,540	0.6	10.1
2011	6	2,413	5/8	5/31	24	25	601	5,907	0.4	12.1
2001-2010 Average	7	2,062	5/6	5/18	13	53	214	5,668	0.6	10.7
1991-2010 Average	12	2,692	5/7	5/16	11	140	131	5,561	0.7	10.8

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Table 6.–Page 2 of 2.

Year	Purse Seine					Total Harvest[c]
	Effort[b]	Duration (hours)	Harvest[c]	CPUE	Roe %	
1991	200	3	11,788	19.6	10.0	14,970
1992	301	0	20,778	230.1	9.2	25,808
1993	140	34	14,392	3.0	9.6	17,956
1994	240	5	22,853	20.7	9.4	30,315
1995	254	12	19,737	6.4	10.1	26,732
1996	268	2	18,008	27.8	9.0	24,871
1997	231	6	18,649	12.6	9.4	23,813
1998	123	17	16,824	8.3	9.6	22,776
1999	96	5	15,020	33.3	9.2	19,878
2000	90	16	14,957	10.6	10.1	20,421
2001	64	26	15,849	9.5	9.2	22,330
2002	37	58	11,833	5.6	9.3d	17,049
2003	35	110	15,158	3.9	8.9d	21,663
2004	31	78	13,888	5.7	9.5	18,868
2005	33	83	15,071	5.5	9.6	20,912
2006	28	113	16,821	5.3	9.2	23,953
2007	21	244	13,120	2.6	10.0	17,132
2008	28	292	15,691	1.9	8.4	20,523
2009	21	226	12,967	2.7	9.2	17,107
2010	26	266	18,816	2.7	9.7	26,355
2011	22	270	16,970	2.9	9.6	22,877
2000-2009 Average	32	150	14,921	4.6	9.4	20,589
1990-2009 Average	113	80	16,111	20.9	9.5	21,672

Note: Blank cells represent no data.

[a] Number of tons per day based on companies registered.

[b] Peak aerial survey count of fishing vessels.

[c] Harvest total includes dead loss and test fish harvest.

Table 7.–Number of herring samples for which age estimations were made by gear type, Togiak District, 2011.

Gear Type	Readable	Missing & Unreadable	Total	Percent unreadable
Commercial Purse Seine	4,120	640	4,760	13.4
Commercial Gillnet	1,434	426	1,860	22.9
Total	5,554	1,066	6,620	16.1

Table 8.–Herring harvest (biomass) by age and gear type, Togiak District, 2011.

	Purse Seine					Gillnet					Total Harvest			
Age	Biomass ST	%	Herring (x1000)	%	Age	Biomass ST	%	Herring (x1000)	%	Age	Biomass ST	%	Herring (x1000)	%
4	14	0.1	61	0.1	4	1	0.0	9	0.1	4	16	0.1	71	0.1
5	685	4.0	2,636	5.7	5	22	0.4	57	0.7	5	707	3.1	2,692	5.0
6	4,293	25.3	14,994	32.4	6	353	6.0	433	5.7	6	4,647	20.3	15,427	28.6
7	3,675	21.7	10,720	23.2	7	1,076	18.2	1,221	16.0	7	4,750	20.8	11,941	22.1
8	2,657	15.7	6,536	14.1	8	1,494	25.3	1,862	24.4	8	4,151	18.1	8,398	15.6
9	2,239	13.2	4,862	10.5	9	1,277	21.6	1,557	20.4	9	3,516	15.4	6,420	11.9
10	1,195	7.0	2,437	5.3	10	689	11.7	1,030	13.5	10	1,883	8.2	3,467	6.4
11	982	5.8	1,834	4.0	11	419	7.1	686	9.0	11	1,401	6.1	2,520	4.7
12	621	3.7	1,113	2.4	12	361	6.1	501	6.6	12	982	4.3	1,615	3.0
13	463	2.7	837	1.8	13	158	2.7	193	2.5	13	620	2.7	1,030	1.9
14	125	0.7	224	0.5	14	48	0.8	59	0.8	14	173	0.8	283	0.5
15	5	0.0	9	0.0	15	7	0.1	11	0.1	15	12	0.1	20	0.0
16	16	0.1	25	0.1	16	2	0.0	5	0.1	16	18	0.1	30	0.1
Total	16,970	100.0	46,289	100.0	Total	5,907	100.0	7,625	100.0	Total	22,877	100.0	53,914	100.0

Table 9.–Mean length (mm), weight (g), and standard deviation by age for herring of the commercial harvest by gear type, Togiak District, 2011.

		Purse Seine						Gillnet			
Age	Sample (n)	Mean Length (mm)	SD	Mean Weight (g)	SD	Age	Sample (n)	Mean Length (mm)	SD	Mean Weight (g)	SD
4	7	260	20.3	203	42.2	4	2	247	3.5	148	12.0
5	243	264	13.4	237	42.2	5	14	299	22.5	382	91.1
6	1293	271	14.0	261	48.3	6	89	296	15.5	359	69.3
7	974	285	15.6	313	59.5	7	238	303	13.4	384	49.3
8	599	298	14.9	369	64.9	8	353	308	11.5	406	48.1
9	431	309	16.0	416	75.2	9	289	314	11.9	432	52.6
10	229	315	14.1	445	72.3	10	186	320	14.1	455	65.3
11	154	322	16.1	477	79.7	11	121	324	10.0	477	53.9
12	95	327	11.7	506	65.8	12	90	329	10.9	493	60.2
13	72	327	13.3	505	80.1	13	35	328	9.2	491	45.3
14	19	333	8.5	497	44.9	14	13	334	11.3	514	68.9
15	2	340	1.4	522	25.5	15	1	339	NA	538	NA
16	2	341	2.8	563	23.3	16	3	334	8.4	506	46.7
Average		289	23.7	333	98.4			312	15.8	425	68.0
Total	4,120						1,434				
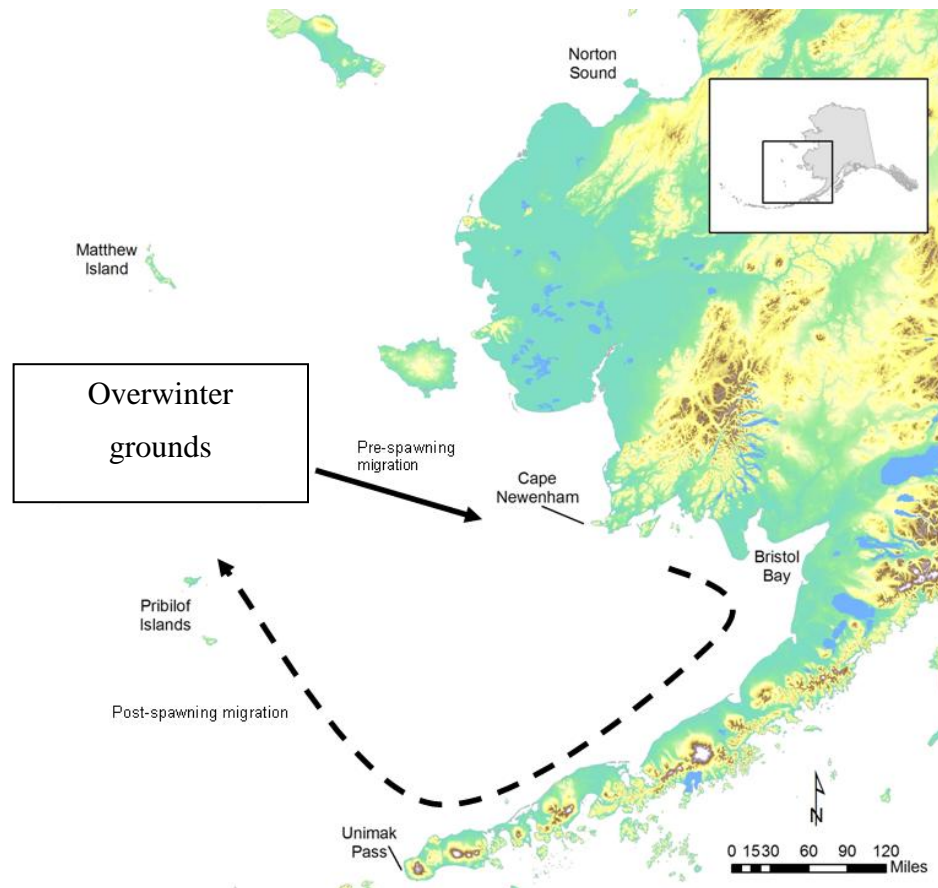
Source: Adapted from Tojo et al. 2007.

Figure 1.–Southeastern Bering Sea herring migration.
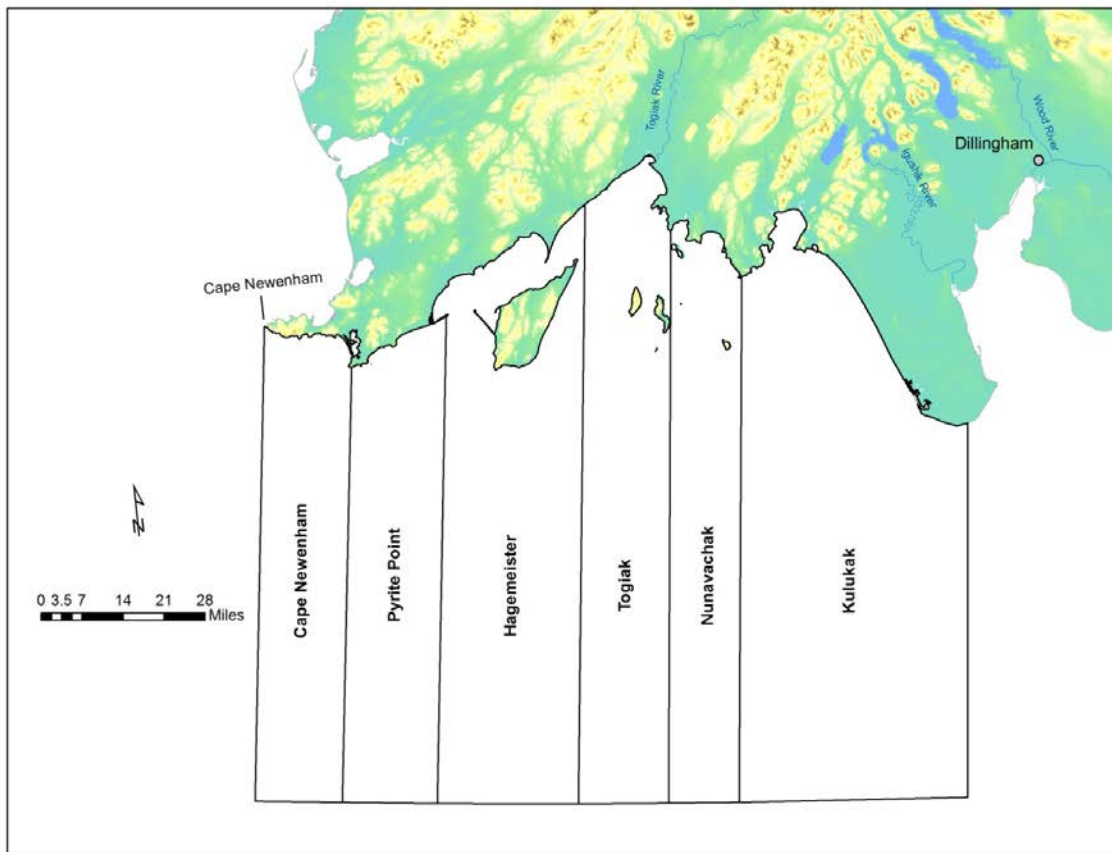
Figure 2.–Map of Togiak District herring management sections, Bristol Bay.
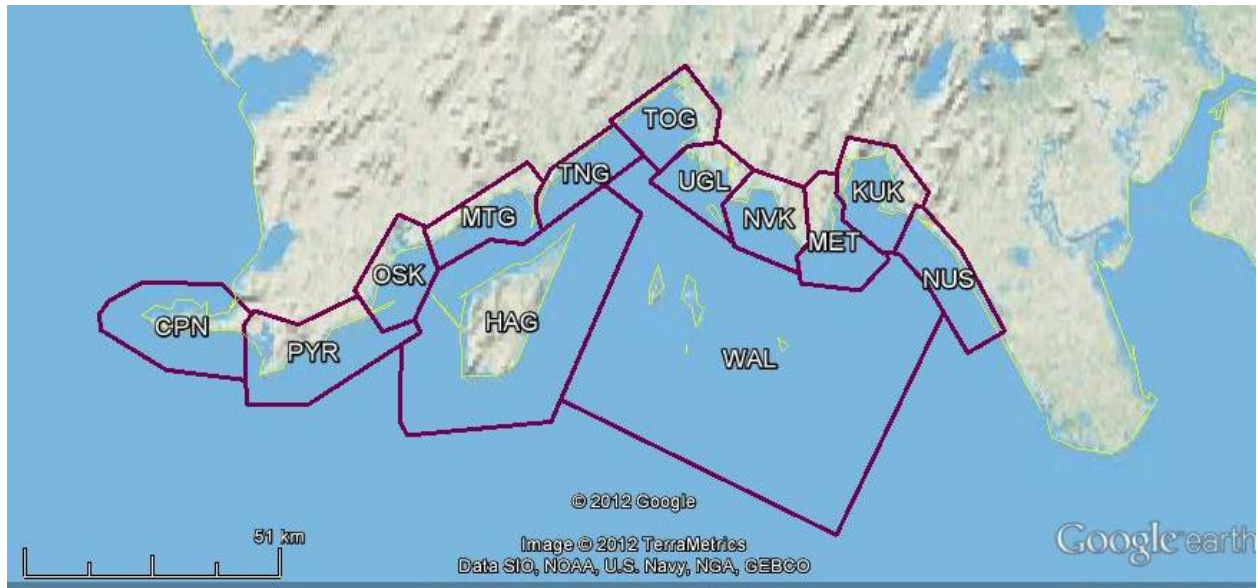
Note: NUS - Nushagak Peninsula; KUK - Kulukak; MET - Metervik; NVK - Nunavachak; UGL - Ungalikthluk/Togiak; TOG - Togiak; TNG - Tongue Pt; MTG - Matogak; OSK - Osvisak; PYR - Pyrite Point; CPN - Cape Newenham; HAG - Hagemeister; WAL - Walrus Islands.

Figure 3.–Togiak herring aerial survey sections, Bristol Bay.
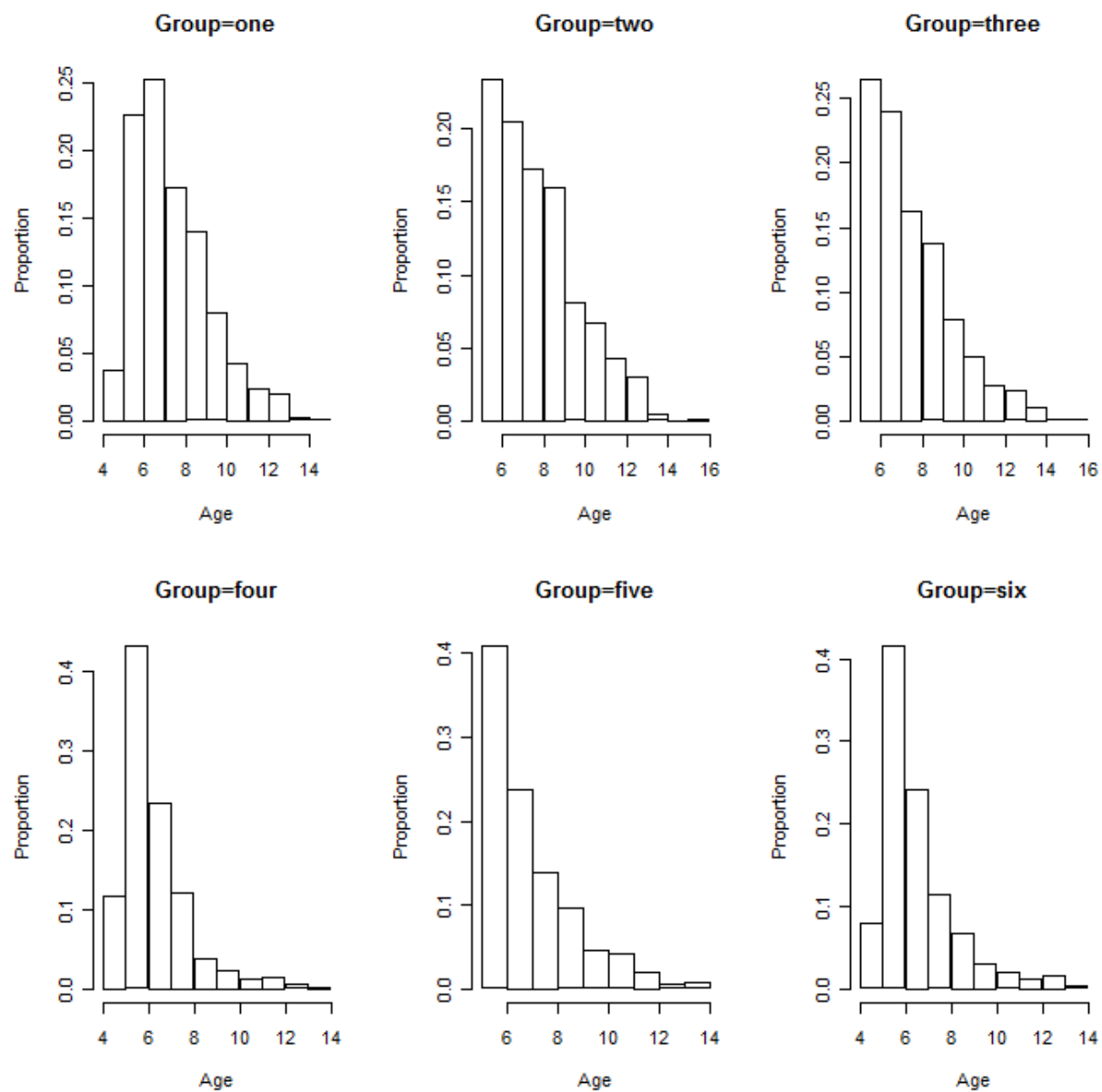
Figure 4.–Age composition of purse seine sample groups, Togiak District, 2011.
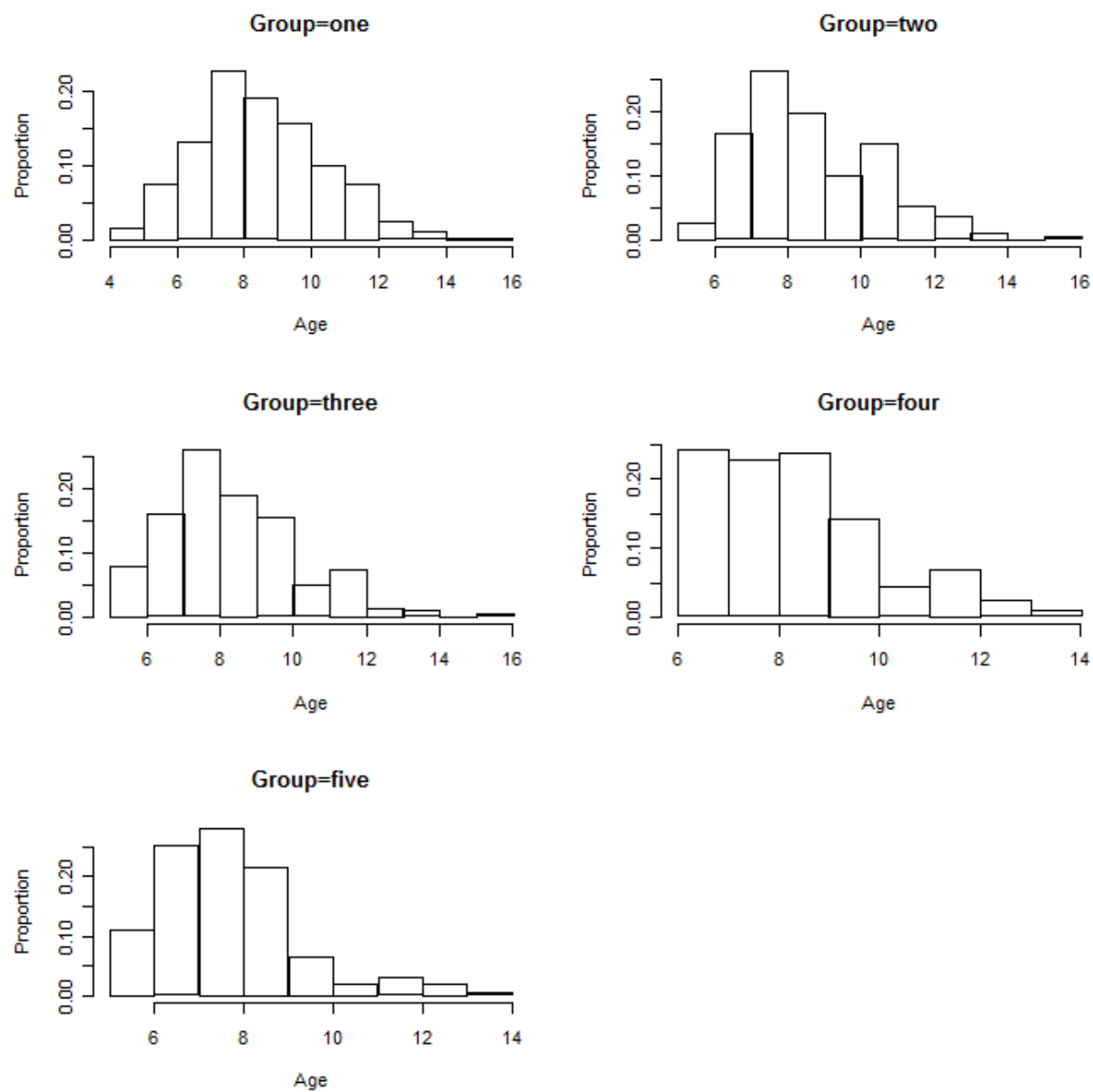
Figure 5.–Age composition of gillnet sample groups, Togiak District, 2011.
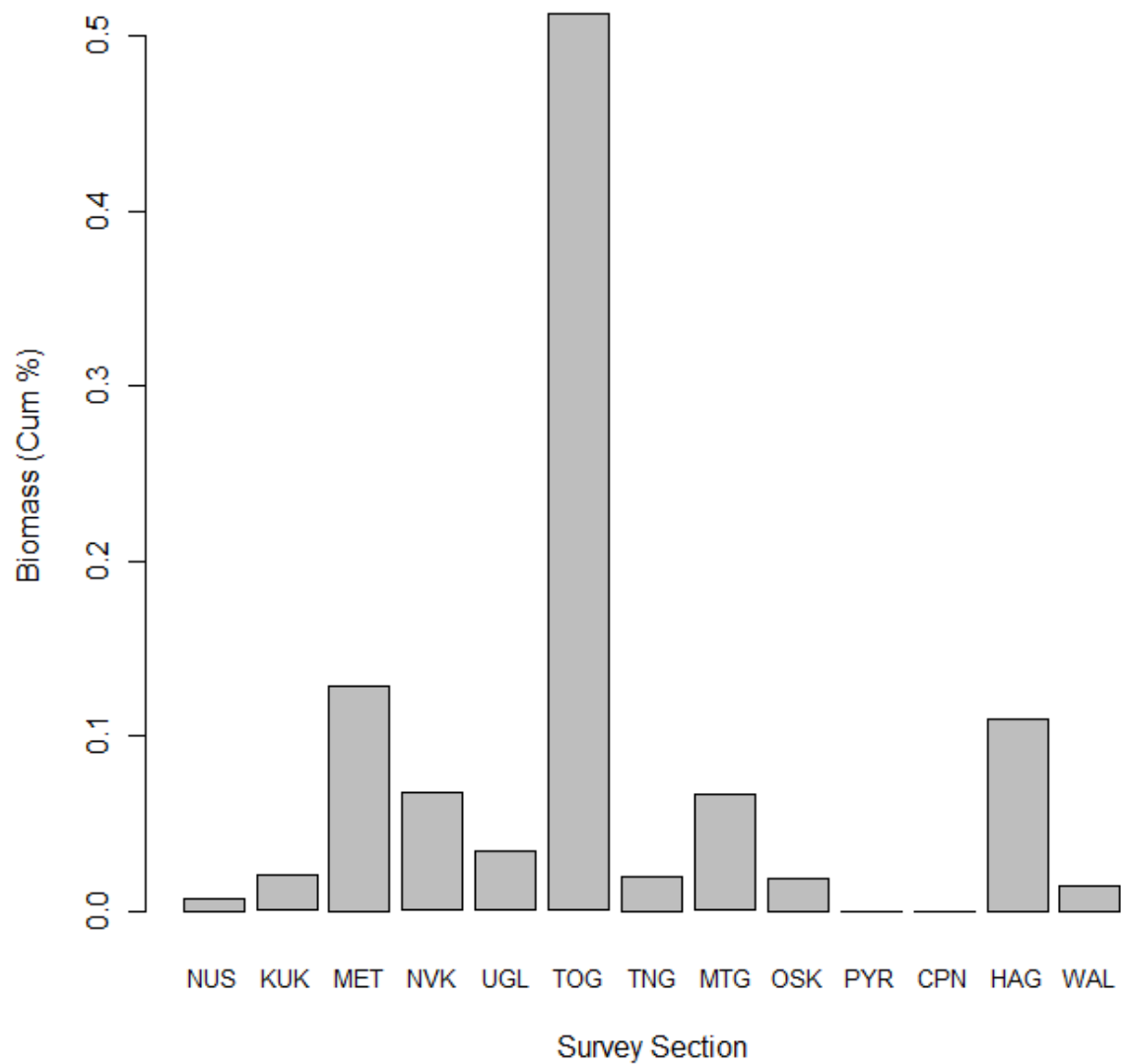
Note: NUS - Nushagak Peninsula; KUK - Kulukak; MET - Metervik; NVK - Nunavachak; UGL - Ungalikthluk/Togiak; TOG - Togiak; TNG - Tongue Pt; MTG - Matogak; OSK - Osvisak; PYR - Pyrite Point; CPN - Cape Newenham; HAG - Hagemeister; WAL - Walrus Islands.

Figure 6.–Cumulative tons of herring estimated in each aerial survey section during all aerial surveys, Togiak District, 2011.
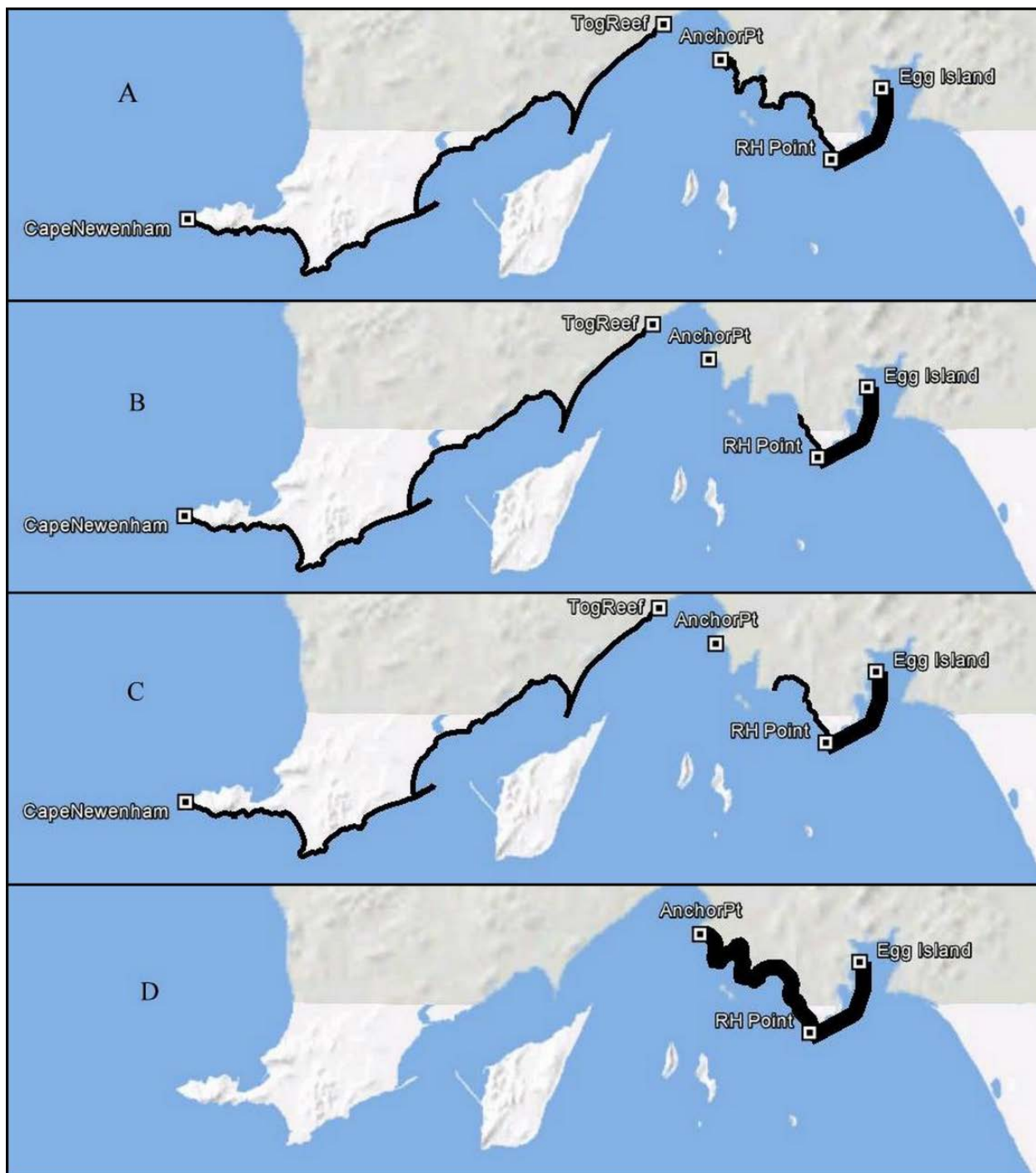
Note: Top panel (A) shows areas open to gillnet (thick black outline) and purse seine (thin black outline). Panels B, C and D show areas open effective 12:00 13 May, 12:00 16 May and 01:00 20 May respectively.

Figure 7.–Commercial herring harvest areas opened by gear type, Togiak District, 2011.

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All Gear Types
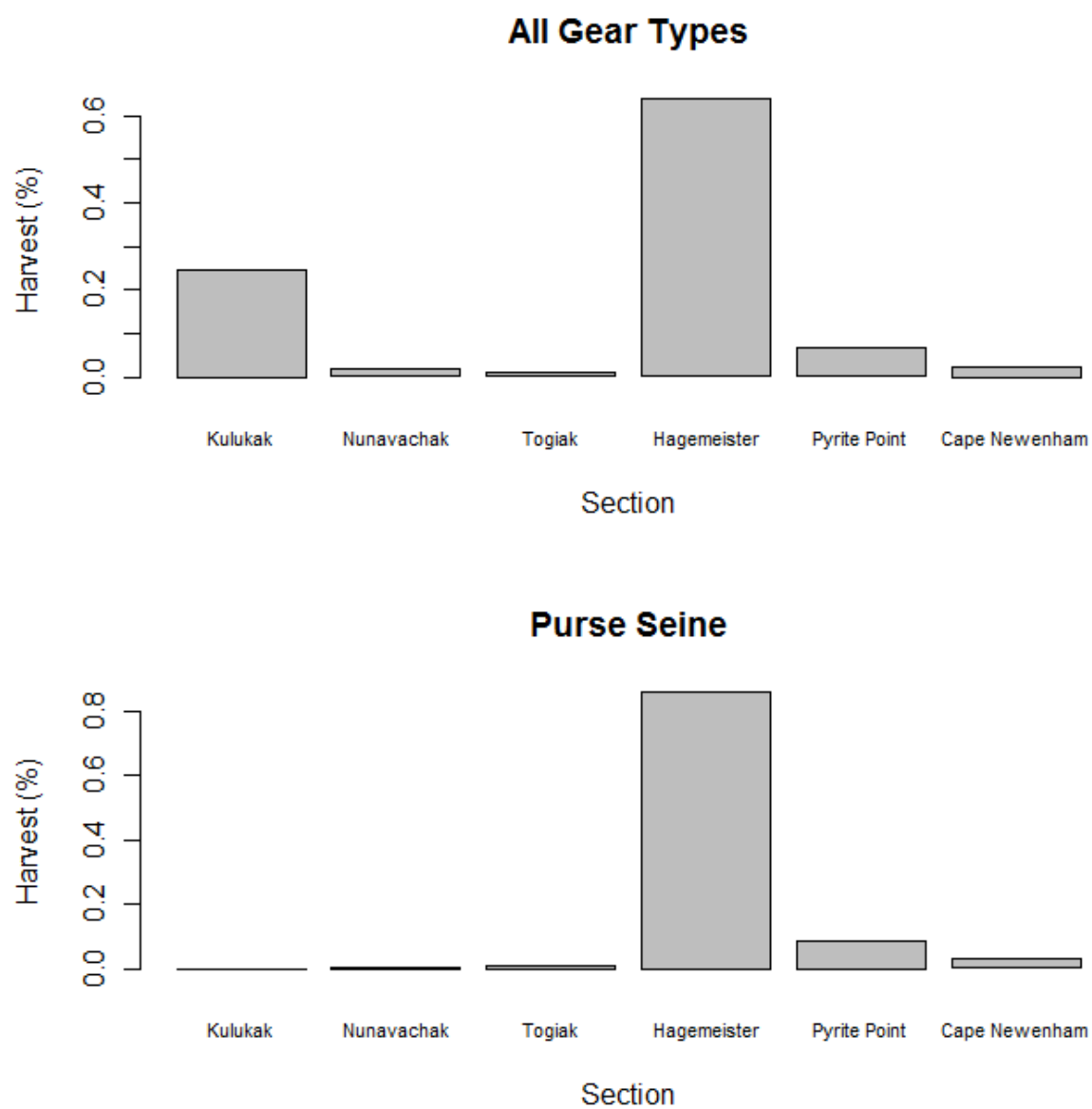
Purse Seine

Figure 8.–Commercial herring harvest by reporting section for all gear types (top) and for purse seine only (bottom), Togiak District, 2011.
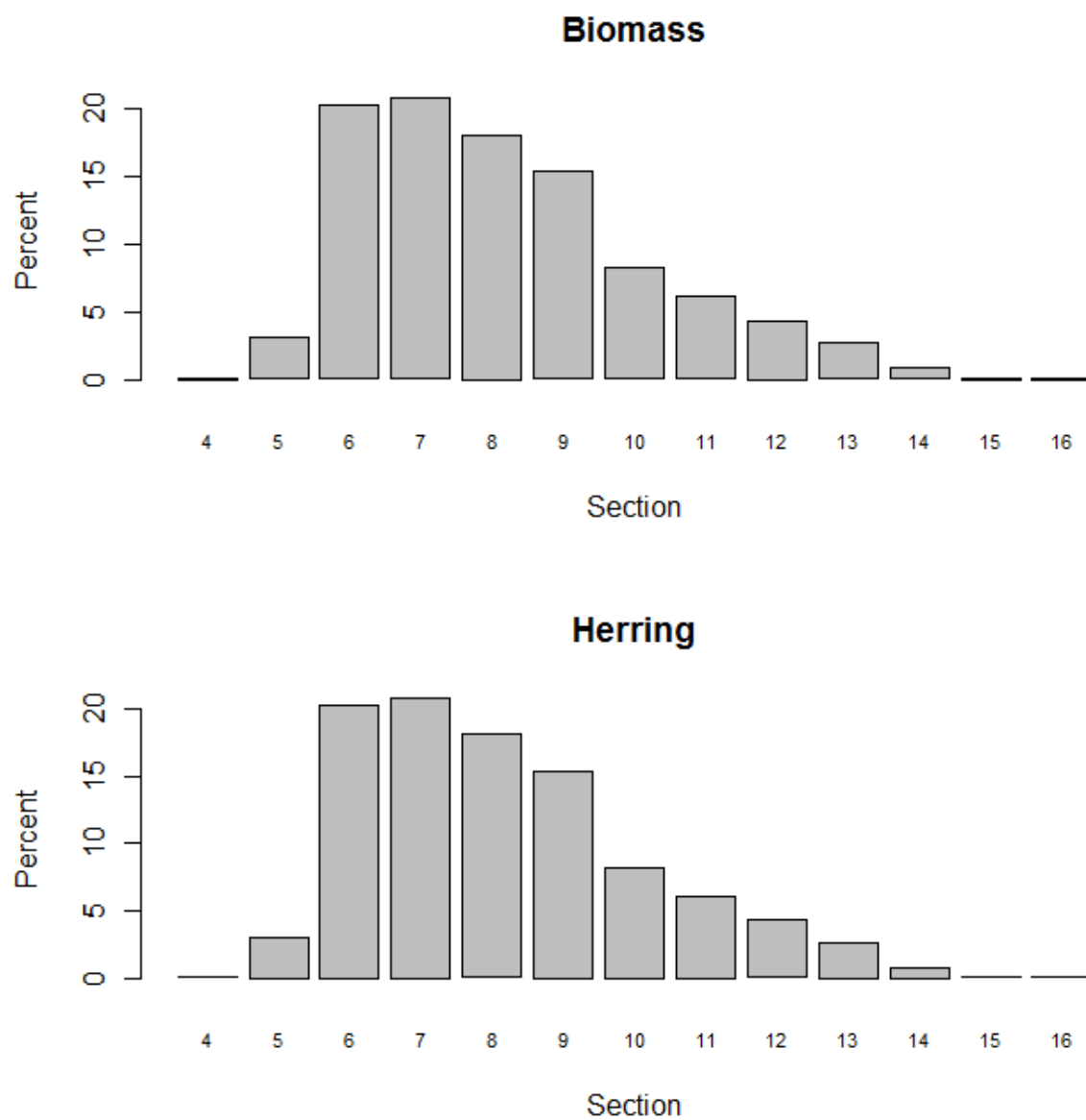
Biomass

Herring

Figure 9.–Age composition of harvest by biomass (top) and numbers of fish (bottom), Togiak District, 2011.
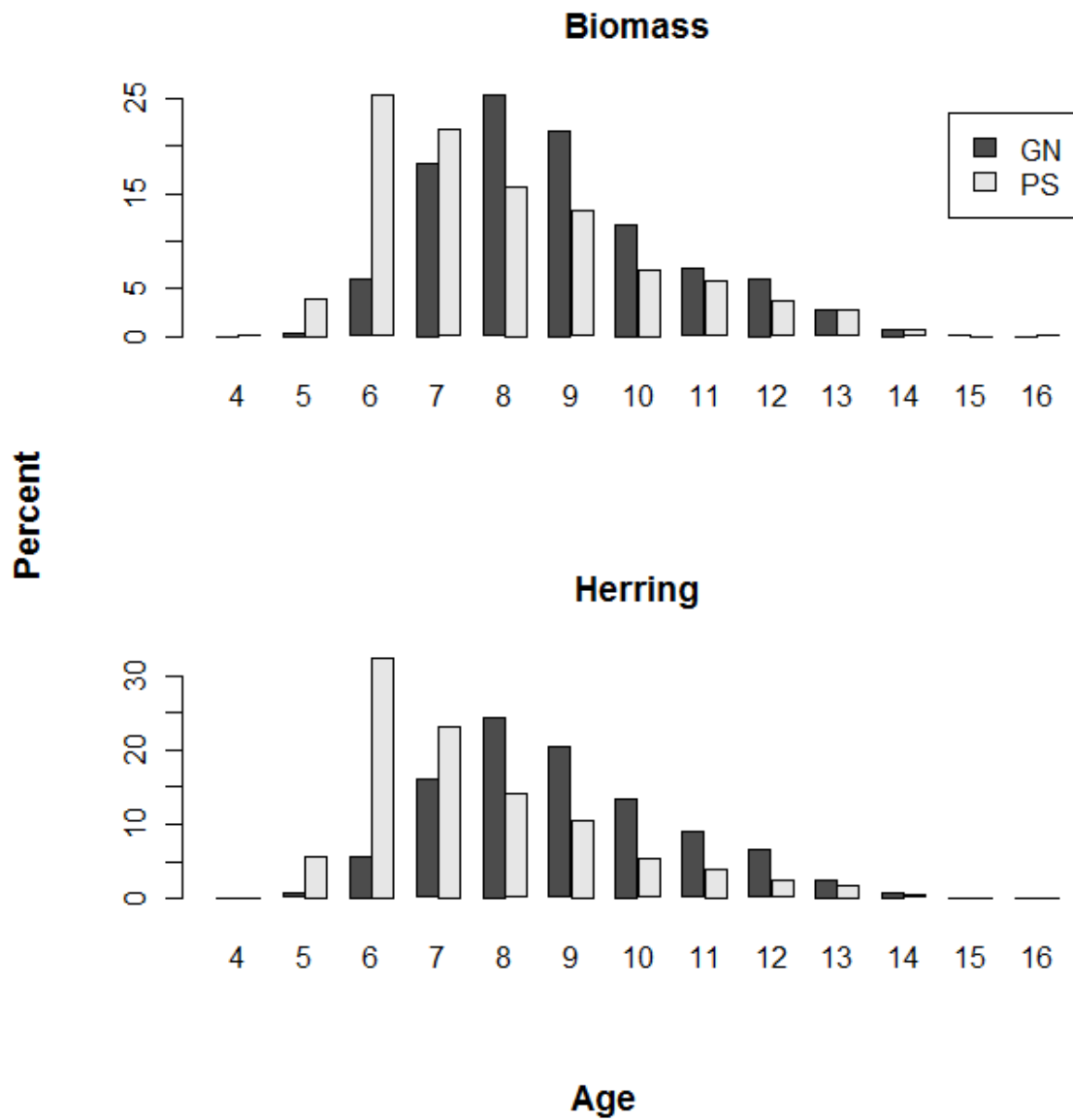
Note: PS = Purse Seine and GN = Gillnet.

Figure 10.–Percentage composition of the commercial herring harvest by gear type by biomass (top) and by numbers of fish (bottom), Togiak District, 2011.
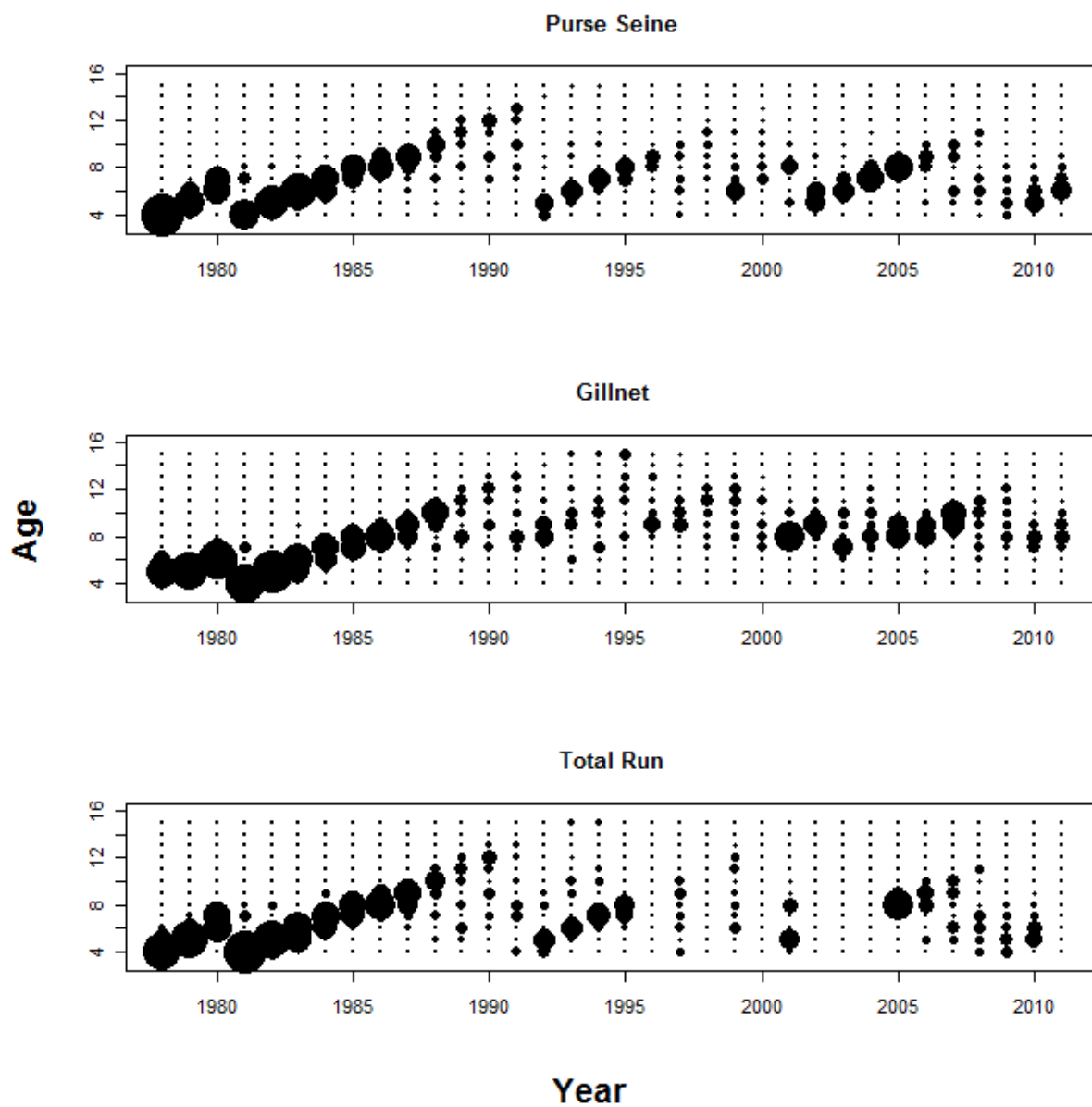
Figure 11.–Relative age class contribution of herring in the purse seine harvest, gillnet harvest and total run, Togiak District, Bristol Bay, 1977–2011.
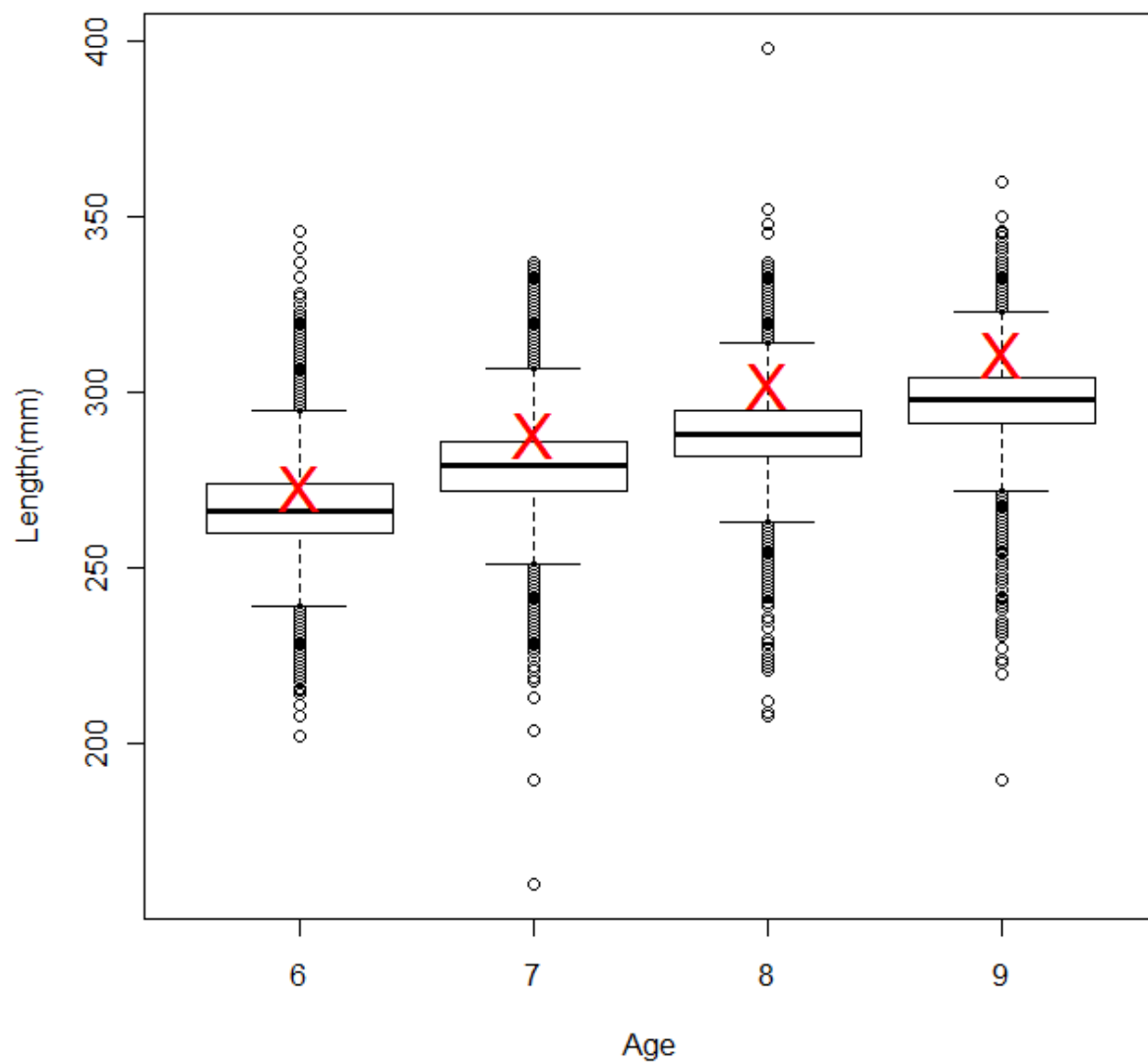
Figure 12.–Average length (denoted as "X") of herring observed in 2011 age-6 through age-9 and distribution (box plot) of historical observations (1981–present).
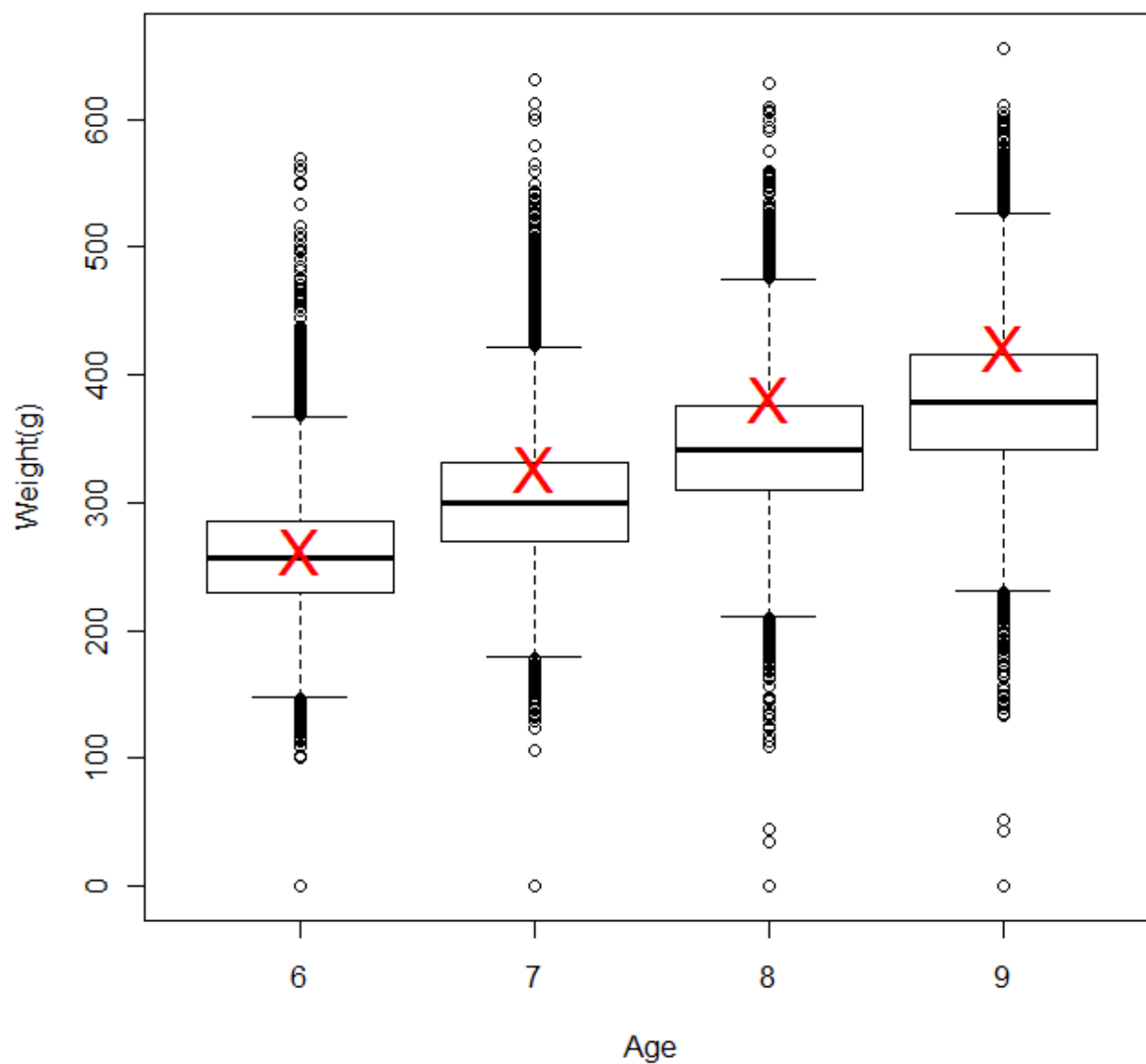
Figure 13.–Average weight (denoted as "X") of herring observed in 2011 age-6 through age-9 and distribution (box plot) of historical observations (1981–present).

APPENDIX A

Appendix A1.–Estimated age composition of herring in the commercial purse seine harvest by sample group, date and fishing section(s) Togiak District, 2011.

Sample Group			1	Sample Group			2
Sample Date(s)			8 May	Sample Date(s)			12 May
Section(s):			NUN/TOG/HAG	Section(s):			NUN/HAG/PP
Harvest Biomass:			838	Harvest Biomass:			5,041
Age	No.	Percent by No.	Numbers (x1,000)	Age	No.	Percent by No.	Numbers (x1,000)
4	1	0.1	3	4	0	0.0	0
5	29	3.7	75	5	13	2.1	248
6	178	22.6	460	6	132	21.3	2,517
7	199	25.3	515	7	127	20.5	2,421
8	136	17.3	352	8	107	17.3	2,040
9	110	14.0	285	9	99	16.0	1,888
10	63	8.0	163	10	50	8.1	953
11	34	4.3	88	11	42	6.8	801
12	19	2.4	49	12	27	4.4	515
13	16	2.0	41	13	19	3.1	362
14	2	0.3	5	14	3	0.5	57
15	1	0.1	3	15	0	0.0	0
16	0	0.0	0	16	1	0.2	19
Total	788	100	2,038	Total	620	100	11,821
Age	Weight (total g)	Percent by Wt.	Biomass (tons)	Age	Weight (total g)	Percent by Wt.	Biomass (tons)
4	177	0.1	1	4	0	0.0	0
5	7,652	2.6	22	5	3,431	1.4	72
6	50,334	17.1	144	6	37,274	15.5	783
7	67,516	23.0	192	7	42,375	17.7	891
8	52,951	18.0	151	8	43,034	17.9	904
9	48,980	16.7	140	9	43,838	18.3	921
10	29,174	9.9	83	10	22,933	9.6	482
11	16,826	5.7	48	11	20,887	8.7	439
12	10,182	3.5	29	12	13,937	5.8	293
13	8,488	2.9	24	13	9,986	4.2	210
14	1,034	0.4	3	14	1,588	0.7	33
15	540	0.2	2	15	0	0.0	0
16	0	0.0	0	16	579	0.2	12
Total	293,854	100.0	838	Total	239,862	100	5,041

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Sample Group			3	Sample Group			4
Sample Date(s)			13-14 May	Sample Date(s)			15 May
Section(s):			TOG/HAG	Section(s):			HAG
Harvest Biomass:			1,521	Harvest Biomass:			505

Age	No.	Percent by No.	Numbers (x1,000)	Age	No.	Percent by No.	Numbers (x1,000)
4	0	0.0	0	4	3	0.5	8
5	24	3.8	152	5	68	11.2	182
6	144	22.7	913	6	262	43.2	702
7	152	24.0	963	7	142	23.4	381
8	103	16.2	653	8	74	12.2	198
9	87	13.7	551	9	23	3.8	62
10	50	7.9	317	10	14	2.3	38
11	32	5.0	203	11	8	1.3	21
12	18	2.8	114	12	9	1.5	24
13	15	2.4	95	13	3	0.5	8
14	7	1.1	44	14	1	0.2	3
15	1	0.2	6	15	0	0.0	0
16	1	0.2	6	16	0	0.0	0
Total	634	100	4,018	Total	607	100	1,627

Age	Weight (total g)	Percent by Wt.	Biomass (tons)	Age	Weight (total g)	Percent by Wt.	Biomass (tons)
4	0	0.0	0	4	605	0.4	2
5	5,917	2.7	41	5	15,265	8.9	45
6	38,941	17.9	272	6	64,565	37.8	191
7	47,134	21.6	329	7	41,574	24.3	123
8	36,351	16.7	254	8	25,679	15.0	76
9	33,280	15.3	232	9	8,228	4.8	24
10	21,442	9.8	150	10	5,747	3.4	17
11	13,957	6.4	97	11	3,309	1.9	10
12	8,999	4.1	63	12	4,024	2.4	12
13	7,342	3.4	51	13	1,540	0.9	5
14	3,336	1.5	23	14	417	0.2	1
15	504	0.2	4	15	0	0.0	0
16	546	0.3	4	16	0	0.0	0
Total	217,749	100	1,521	Total	170,953	100	505

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Sample Group			5	Sample Group			6
Sample Date(s)			16 May	Sample Date(s)			17-19 May
Section(s):			HAG	Section(s):			HAG/PP/CPN
Harvest Biomass:			3,242	Harvest Biomass:			5,823
Age	No.	Percent by No.	Numbers (x1,000)	Age	No.	Percent by No.	Numbers (x1,000)
4	0	0.0	0	4	3	0.3	51
5	31	7.1	660	5	78	7.6	1,319
6	148	33.8	3,150	6	429	41.5	7,253
7	104	23.7	2,213	7	250	24.2	4,226
8	61	13.9	1,298	8	118	11.4	1,995
9	42	9.6	894	9	70	6.8	1,183
10	20	4.6	426	10	32	3.1	541
11	18	4.1	383	11	20	1.9	338
12	9	2.1	192	12	13	1.3	220
13	2	0.5	43	13	17	1.6	287
14	3	0.7	64	14	3	0.3	51
Total	438	100	9,322	Total	1,033	100	17,463
Age	Weight (total g)	Percent by Wt.	Biomass (tons)	Age	Weight (total g)	Percent by Wt.	Biomass (tons)
4	0	0.0	0	4	639	0.2	12
5	6,878	5.0	161	5	18,431	5.9	343
6	37,830	27.4	887	6	108,196	34.6	2,016
7	31,886	23.1	748	7	74,675	23.9	1,392
8	20,979	15.2	492	8	41,840	13.4	780
9	16,860	12.2	396	9	28,226	9.0	526
10	8,203	5.9	192	10	14,503	4.6	270
11	8,729	6.3	205	11	9,796	3.1	183
12	4,468	3.2	105	12	6,428	2.1	120
13	900	0.7	21	13	8,132	2.6	152
14	1,453	1.1	34	14	1,615	0.5	30
Total	138,186	100	3,242	Total	312,481	100	5,823

Note: Sections refers to the following subdistricts within the Togiak District: TOG=Togiak, NUN=Nunavachak, HAG=Hagemeister, KUL=Kulukak, PYP=Pyrite Point and CPN=Cape Newenham.

Appendix A2.–Estimated age composition of herring in the commercial gillnet harvest by sample group, date and fishing section(s), Togiak District, 2011.

Sample Group			1	Sample Group			2
Sample Date(s)			8-14 May	Sample Date(s)			16 May
Section(s):			KUL/NUN	Section(s):			KUL/NUN
Harvest Biomass:			1,181	Harvest Biomass:			980
Age	No.	Percent by No.	Numbers (x1,000)	Age	No.	Percent by No.	Numbers (x1,000)
4	2	0.4	9	4	0	0.0	0
5	6	1.1	28	5	1	0.3	7
6	39	7.4	180	6	7	2.3	47
7	68	13.0	313	7	51	16.5	339
8	118	22.5	544	8	81	26.2	539
9	99	18.9	456	9	61	19.7	406
10	82	15.6	378	10	31	10.0	206
11	52	9.9	240	11	46	14.9	306
12	39	7.4	180	12	16	5.2	106
13	12	2.3	55	13	11	3.6	73
14	5	1.0	23	14	3	1.0	20
15	1	0.2	5	15	1	0.3	7
16	1	0.2	5	16	0	0.0	0
Total	524	100.0	2,416	Total	309	100.0	2,055
Age	Weight (total g)	Percent by Wt.	Biomass (tons)	Age	Weight (total g)	Percent by Wt.	Biomass (tons)
4	295	0.1	1	4	0	0.0	0
5	2,229	1.0	11	5	425	0.3	3
6	14,406	6.2	73	6	2,932	2.2	21
7	27,107	11.7	138	7	19,886	14.9	146
8	50,248	21.6	255	8	32,755	24.5	240
9	44,470	19.1	226	9	27,058	20.2	198
10	38,444	16.5	195	10	13,732	10.3	101
11	25,506	11.0	130	11	21,515	16.1	158
12	19,817	8.5	101	12	7,849	5.9	58
13	6,245	2.7	32	13	5,468	4.1	40
14	2,683	1.2	14	14	1,524	1.1	11
15	538	0.2	3	15	547	0.4	4
16	455	0.2	2	16	0	0.0	0
Total	232,443	100.0	1,181	Total	133,691	100.0	980

Note: Sections refers to the following subdistricts within the Togiak District: TOG=Togiak, NUN=Nunavachak, HAG=Hagemeister, KUL=Kulukak, PYP=Pyrite Point and CPN=Cape Newenham.

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Sample Group			3	Sample Group			4
Sample Date(s)			17 May	Sample Date(s)			18 May
Section(s):			KUL/NUN	Section(s):			KUL/NUN
Harvest Biomass:			637	Harvest Biomass:			701
Age	No.	Percent by No.	Numbers (x1,000)	Age	No.	Percent by No.	Numbers (x1,000)
5	3	1.5	18	5	0	0.0	0
6	13	6.5	96	6	12	5.9	92
7	32	16.0	234	7	37	18.3	285
8	52	26.0	369	8	46	22.8	354
9	38	19.0	283	9	48	23.8	369
10	31	15.5	210	10	29	14.4	223
11	10	5.0	67	11	9	4.5	69
12	15	7.5	101	12	14	6.9	108
13	3	1.5	23	13	5	2.5	38
14	2	1.0	0	14	2	1.0	15
15	0	0.0	0	15	0	0.0	0
16	1	0.5	0	16	0	0.0	0
Total	200	100.0	1,401	Total	202	100.0	1,553
Age	Weight (total g)	Percent by Wt.	Biomass (tons)	Age	Weight (total g)	Percent by Wt.	Biomass (tons)
5	1,013	1.2	8	5	0	0.0	0
6	4,812	5.6	36	6	4,021	4.9	34
7	12,816	15.0	95	7	13,736	16.6	116
8	21,888	25.6	163	8	17,947	21.7	152
9	17,625	20.6	131	9	19,777	23.9	168
10	14,378	16.8	107	10	12,701	15.4	108
11	4,588	5.4	34	11	4,376	5.3	37
12	6,890	8.1	51	12	6,927	8.4	59
13	1,533	1.8	11	13	2,229	2.7	19
14	0	0.0	0	14	970	1.2	8
15	0	0.0	0	15	0	0.0	0
16	0	0.0	0	16	0	0.0	0
Total	85,543	100.0	637	Total	82,684	100.0	701

Sample Group	5
Sample Date(s)	19-23 May
Section(s):	KUL/NUN
Harvest Biomass:	2,408

Age	No.	Percent by No.	Numbers (x1,000)
5	4	2.0	0
6	18	9.0	494
7	50	25.1	1,406
8	56	28.1	1,620
9	43	21.6	1,241
10	13	6.5	390
11	4	2.0	134
12	6	3.0	175
13	4	2.0	108
14	1	0.5	29
Total	199	100.0	5,596

Age	Weight (total g)	Percent by Wt.	Biomass (tons)
5	0	0.0	0
6	6,031	7.8	189
7	18,562	24.1	580
8	21,849	28.4	683
9	17,717	23.0	554
10	5,694	7.4	178
11	1,945	2.5	61
12	2,969	3.9	93
13	1,783	2.3	56
14	485	0.6	15
Total	77,034	100.0	2,408

APPENDIX B

Appendix B1.–Age, sex and size composition of herring caught by commercial purse seine, Hagemeister Section, 8 and 12–19 May, 2011.

Sample Dates	Age	Sex (number)				% of Total	SE	Weight			Length		
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
8 May	5	11	12	0	23	5.1	1.0	264	55.1	23	268	15.1	23
	6	58	62	0	120	26.6	2.1	288	51.6	120	277	13.2	120
	7	53	55	0	108	23.9	2.0	341	59.5	108	290	15.0	108
	8	34	34	0	68	15.1	1.7	391	69.0	68	301	14.8	68
	9	29	22	0	51	11.3	1.5	454	77.1	51	314	17.3	51
	10	20	17	0	37	8.2	1.3	460	65.1	37	314	12.8	37
	11	12	13	0	25	5.5	1.1	502	74.2	25	324	16.7	25
	12	3	5	0	8	1.8	0.6	557	42.7	8	332	6.4	8
	13	3	5	0	8	1.8	0.6	533	84.0	8	329	14.2	8
	14	1	1	0	2	0.4	0.3	517	25.5	2	328	14.1	2
	15	1	0	0	1	0.2	0.2	540	NA	1	341	NA	1
Sample Total		225	226	0	451	100.0		370	100.8	451	295	22.9	451
12 May	5	2	5	0	7	2.7	1.0	265	28.3	7	275	8.6	7
	6	33	31	0	64	24.3	2.7	276	57.2	64	274	15.1	64
	7	27	27	0	54	20.5	2.5	326	57.6	54	287	15.7	54
	8	18	25	0	43	16.3	2.3	388	51.1	43	301	11.7	43
	9	21	21	0	42	16.0	2.3	441	67.0	42	312	13.6	42
	10	10	7	0	17	6.5	1.5	449	77.1	17	312	12.1	17
	11	8	11	0	19	7.2	1.6	503	48.4	19	323	9.3	19
	12	4	8	0	12	4.6	1.3	497	82.9	12	323	14.7	12
	13	2	2	0	4	1.5	0.8	524	59.1	4	328	9.4	4
	14	0	1	0	1	0.4	0.4	547	NA	1	337	NA	1
Sample Total		125	138	0	263	100.0		373	100.4	263	297	22.4	263

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Sample Dates	Age	Sex (number)				% of Total	SE	Weight			Length		
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
13 May	5	6	5	0	11	3.7	1.1	241	42.5	11	266	11.9	11
	6	27	19	8	54	18.2	2.2	284	75.4	54	281	19.3	54
	7	31	24	4	59	19.9	2.3	330	76.1	59	292	18.3	59
	8	22	24	4	50	16.8	2.2	368	72.6	50	301	16.0	50
	9	21	23	1	45	15.2	2.1	399	78.7	45	309	18.0	45
	10	12	17	2	31	10.4	1.8	428	77.8	31	314	17.4	31
	11	7	12	1	20	6.7	1.5	425	102.3	20	315	22.3	20
	12	2	5	0	7	2.4	0.9	533	51.9	7	332	7.3	7
	13	3	8	1	12	4.0	1.1	478	94.4	12	328	14.5	12
	14	4	2	0	6	2.0	0.8	484	35.7	6	336	6.0	6
	15	1	0	0	1	0.3	0.3	504	NA	1	339	NA	1
	16	1	0	0	1	0.3	0.3	546	NA	1	339	NA	1
Sample Total		137	139	21	297	100.0		367	101.1	297	300	23.8	297
14 May	5	6	7	0	13	3.9	1.1	251	49.8	13	269	15.3	13
	6	46	43	1	90	26.7	2.4	263	54.8	90	273	15.4	90
	7	47	46	0	93	27.6	2.4	298	53.5	93	283	15.4	93
	8	26	26	1	53	15.7	2.0	339	56.9	53	294	14.6	53
	9	24	18	0	42	12.5	1.8	365	77.3	42	303	19.1	42
	10	10	9	0	19	5.6	1.3	430	53.3	19	319	10.5	19
	11	5	7	0	12	3.6	1.0	455	88.4	12	322	14.1	12
	12	5	6	0	11	3.3	1.0	479	67.8	11	328	10.9	11
	13	0	3	0	3	0.9	0.5	534	52.8	3	340	8.7	3
	14	1	0	0	1	0.3	0.3	434	NA	1	327	NA	1
Sample Total		170	165	2	337	100.0		323	87.0	337	289	22.8	337

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Sample Dates	Age	Sex (number)				% of Total	SE	Weight			Length		
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
15 May	4	1	2	0	3	0.5	0.3	202	44.7	3	260	24.6	3
	5	31	35	2	68	11.2	1.3	224	35.1	68	260	12.1	68
	6	125	137	0	262	43.2	2.0	246	44.3	262	267	15.3	262
	7	75	66	1	142	23.4	1.7	293	52.2	142	281	17.3	142
	8	40	34	0	74	12.2	1.3	347	57.5	74	294	15.9	74
	9	16	7	0	23	3.8	0.8	358	67.9	23	298	19.4	23
	10	9	5	0	14	2.3	0.6	411	93.9	14	318	23.7	14
	11	4	4	0	8	1.3	0.5	414	90.0	8	312	25.8	8
	12	5	4	0	9	1.5	0.5	447	71.2	9	316	11.4	9
	13	2	1	0	3	0.5	0.3	513	91.9	3	332	8.1	3
	14	1	0	0	1	0.2	0.2	417	NA	1	325	NA	1
Sample Total		309	295	3	607	100.0		282	74.8	607	277	22.1	607
16 May	5	17	14	0	31	7.1	1.2	222	36.8	31	265	12.8	31
	6	69	79	0	148	33.8	2.3	256	45.4	148	273	12.3	148
	7	49	55	0	104	23.7	2.0	307	57.4	104	288	14.2	104
	8	26	35	0	61	13.9	1.7	344	59.0	61	297	14.6	61
	9	19	22	1	42	9.6	1.4	401	80.1	42	312	17.7	42
	10	11	9	0	20	4.6	1.0	410	66.2	20	315	16.6	20
	11	11	7	0	18	4.1	0.9	485	86.2	18	328	9.0	18
	12	4	5	0	9	2.1	0.7	496	55.7	9	323	18.2	9
	13	2	0	0	2	0.5	0.3	450	5.7	2	330	2.1	2
	14	1	2	0	3	0.7	0.4	484	39.2	3	337	15.5	3
Sample Total		209	228	1	438	100.0		315	91.7	438	289	22.7	438

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Sample Dates	Age	Sex (number) Male	Female	Unk.	Total	% of Total	SE	Weight Mean (g)	SD	Number Weighed	Length Mean (mm)	SD	Number Measured
17 May	4	0	1	0	1	0.3	0.3	267	NA	1	277	NA	1
	5	12	18	0	30	9.1	1.6	239	46.8	30	266	14.0	30
	6	61	73	0	134	40.9	2.7	247	31.5	134	268	9.4	134
	7	26	42	1	69	21.0	2.3	307	50.1	69	285	14.0	69
	8	23	20	1	44	13.4	1.9	359	62.9	44	298	14.5	44
	9	10	9	2	21	6.4	1.4	402	72.8	21	310	18.1	21
	10	5	6	0	11	3.4	1.0	419	66.7	11	313	10.5	11
	11	2	3	3	8	2.4	0.9	476	58.5	8	331	13.5	8
	12	3	1	0	4	1.2	0.6	485	72.1	4	332	3.3	4
	13	3	1	1	5	1.5	0.7	477	32.7	5	332	7.4	5
	14	0	1	0	1	0.3	0.3	526	NA	1	332	NA	1
Sample Total		145	175	8	328	100.0		303	84.5	328	283	22.5	328
18 May	4	1	0	0	1	0.3	0.3	160	NA	1	231	NA	1
	5	7	5	0	12	3.4	1.0	222	23.7	12	255	14.0	12
	6	84	66	0	150	43.0	2.7	252	31.9	150	268	11.3	150
	7	49	53	0	102	29.2	2.4	293	44.4	102	279	13.9	102
	8	19	15	0	34	9.7	1.6	336	64.2	34	289	18.4	34
	9	8	14	0	22	6.3	1.3	397	68.0	22	308	13.6	22
	10	1	8	0	9	2.6	0.8	477	36.2	9	317	9.1	9
	11	2	4	0	6	1.7	0.7	478	53.5	6	322	7.8	6
	12	3	3	0	6	1.7	0.7	505	54.8	6	332	6.5	6
	13	3	2	0	5	1.4	0.6	482	39.4	5	318	13.6	5
	14	2	0	0	2	0.6	0.4	545	67.2	2	336	10.6	2
Sample Total		179	170	0	349	100.0		299	82.1	349	280	21.5	349

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Sample Dates	Age	Sex (number)				% of Total	SE	Weight			Length		
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
19 May	4	1	0	0	1	0.3	0.3	212	NA	1	260	NA	1
	5	15	21	0	36	10.1	1.6	239	37.9	36	264	11.8	36
	6	76	69	0	145	40.7	2.6	257	36.7	145	269	10.6	145
	7	43	36	0	79	22.2	2.2	299	59.8	79	279	14.5	79
	8	23	17	0	40	11.2	1.7	366	62.7	40	297	14.4	40
	9	11	16	0	27	7.6	1.4	409	62.1	27	306	13.5	27
	10	5	7	0	12	3.4	1.0	467	56.1	12	318	7.5	12
	11	3	3	0	6	1.7	0.7	521	25.4	6	334	10.8	6
	12	2	1	0	3	0.8	0.5	487	61.9	3	334	23.1	3
	13	3	4	0	7	2.0	0.7	477	117.6	7	321	25.9	7
Sample Total		182	174	0	356	100.0		306	88.0	356	281	21.8	356
Samples Combined		1,681	1,710	35	3,426			322	95.2	3,426	287	23.8	3,426

Appendix B2.–Age, sex and size composition of herring caught by commercial purse seine, Nunavachak Section, 18 May, 2011.

| Sample Dates | Age | Sex (number) | | | | % of Total | SE | Weight | | | Length | | |
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
8 May	5	3	3	0	6	1.7	0.7	263	24.5	6	271	7.4	6
	6	34	34	0	68	19.0	2.1	288	49.5	68	276	12.9	68
	7	31	42	0	73	20.4	2.1	339	52.9	73	289	13.8	73
	8	37	27	0	64	17.9	2.0	412	59.9	64	304	12.6	64
	9	20	37	0	57	16.0	1.9	444	51.7	57	312	10.4	57
	10	21	12	0	33	9.2	1.5	464	56.9	33	316	11.0	33
	11	9	14	0	23	6.4	1.3	492	78.6	23	320	17.5	23
	12	7	8	0	15	4.2	1.1	532	56.5	15	331	6.2	15
	13	9	6	0	15	4.2	1.1	526	65.8	15	325	9.5	15
	14	2	0	0	2	0.6	0.4	521	7.8	2	328	1.4	2
	15	0	0	0	0	0.0	0.0	NA	NA	0	NA	NA	0
	16	0	1	0	1	0.3	0.3	579	NA	1	343	NA	1
Sample Total		170	184	0	357	100.0		397	96.6	357	301	21.2	357

Appendix B3.–Age, sex and size composition of herring caught by commercial purse seine, Togiak Section, 10 May, 2011.

| Sample Dates | Age | Sex (number) | | | | % of Total | SE | Weight | | | Length | | |
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
10 May	4	1	0	0	1	0.3	0.3	177	NA	1	272	NA	1
	5	2	4	0	6	1.8	0.7	265	47.0	6	271	15.6	6
	6	29	29	0	58	17.2	2.1	273	56.7	58	274	17.0	58
	7	43	48	0	91	27.0	2.4	337	62.8	91	287	13.3	91
	8	30	38	0	68	20.2	2.2	388	51.6	68	299	11.8	68
	9	28	31	0	59	17.5	2.1	438	61.4	59	308	12.3	59
	10	11	15	0	26	7.7	1.5	467	91.8	26	315	16.3	26
	11	7	2	0	9	2.7	0.9	476	40.7	9	321	9.0	9
	12	6	5	0	11	3.3	1.0	521	51.6	11	327	9.0	11
	13	3	5	0	8	2.4	0.8	528	101.9	8	328	9.1	8
Sample Total		160	177	0	337	100.0		376	96.0	337	296	20.6	337

Appendix B4.–Age, sex and size composition of herring caught by commercial gillnet, Kulukak Section, 8, 12, 13 and 16–19 May, 2011.

Sample Dates	Age	Male	Female	Unk.	Total	% of Total	SE	Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
		Sex (number)						Weight			Length		
8 May	6	5	3	0	8	6.2	2.1	377	50.9	8	297	10.7	8
	7	9	8	0	17	13.1	3.0	410	45.5	17	306	12.5	17
	8	8	21	0	29	22.3	3.7	427	45.9	29	311	9.3	29
	9	19	16	0	35	26.9	3.9	447	48.8	35	312	12.6	35
	10	11	10	0	21	16.2	3.2	480	57.5	21	323	10.7	21
	11	4	4	0	8	6.2	2.1	488	30.1	8	323	10.4	8
	12	3	7	0	10	7.7	2.3	507	58.9	10	330	9.7	10
	13	0	2	0	2	1.5	1.1	536	43.1	2	329	6.4	2
Sample Total		59	71	0	130	100.0		447	59.6	130	314	13.8	130
12 May	4	0	0	2	2	0.7	0.5	148	12.0	2	247	3.5	2
	5	1	3	0	4	1.4	0.7	311	115.7	4	277	25.1	4
	6	11	14	0	25	8.7	1.7	354	79.6	25	295	20.4	25
	7	24	18	0	42	14.5	2.1	394	78.2	42	304	18.6	42
	8	29	35	0	64	22.1	2.4	426	49.5	64	311	12.4	64
	9	15	29	0	44	15.2	2.1	453	51.1	44	317	12.7	44
	10	15	32	0	47	16.3	2.2	460	59.1	47	320	14.9	47
	11	15	17	0	32	11.1	1.8	485	58.0	32	322	10.3	32
	12	8	10	0	18	6.2	1.4	515	52.7	18	331	11.0	18
	13	3	3	0	6	2.1	0.8	503	49.8	6	328	9.7	6
	14	1	3	0	4	1.4	0.7	546	84.4	4	335	15.8	4
	16	0	1	0	1	0.3	0.3	455	NA	1	324	NA	1
Sample Total		122	165	2	289	100.0		437	79.9	289	313	18.7	289

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Sample Dates	Age	Sex (number) Male	Female	Unk.	Total	% of Total	SE	Weight Mean (g)	SD	Number Weighed	Length Mean (mm)	SD	Number Measured
13 May	5	1	1	0	2	1.9	1.3	492	80.6	2	321	11.3	2
	6	3	3	0	6	5.7	2.3	422	41.1	6	312	7.5	6
	7	5	4	0	9	8.6	2.7	399	23.9	9	302	4.1	9
	8	6	19	0	25	23.8	4.2	424	39.0	25	308	9.4	25
	9	6	14	0	20	19.0	3.9	444	43.5	20	315	9.4	20
	10	7	7	0	14	13.3	3.3	481	40.2	14	327	9.5	14
	11	5	7	0	12	11.4	3.1	507	46.7	12	330	11.5	12
	12	4	7	0	11	10.5	3.0	498	58.9	11	324	14.1	11
	13	2	2	0	4	3.8	1.9	539	43.4	4	334	7.4	4
	14	0	1	0	1	1.0	1.0	498	NA	1	329	NA	1
	15	1	0	0	1	1.0	1.0	538	NA	1	339	NA	1
Sample Total		40	65	0	105	100.0		458	57.1	105	318	13.5	105
16 May	5	1	0	0	1	0.3	0.3	425	NA	1	305	NA	1
	6	1	6	0	7	2.3	0.8	419	80.6	7	307	16.3	7
	7	21	30	0	51	16.5	2.1	390	40.3	51	305	14.2	51
	8	29	51	1	81	26.2	2.5	404	44.9	81	309	10.6	81
	9	24	37	0	61	19.7	2.3	444	49.8	61	317	11.0	61
	10	11	19	1	31	10.0	1.7	443	68.2	31	318	12.9	31
	11	19	27	0	46	14.9	2.0	468	49.3	46	323	7.9	46
	12	7	9	0	16	5.2	1.3	491	42.9	16	329	9.7	16
	13	5	6	0	11	3.6	1.1	497	33.6	11	329	10.1	11
	14	2	1	0	3	1.0	0.6	508	87.7	3	333	11.7	3
	16	1	0	0	1	0.3	0.3	547	NA	1	338	NA	1
Sample Total		121	186	2	309	100.0		433	59.5	309	315	13.6	309

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Sample Dates	Age	Sex (number)				% of Total	SE	Weight			Length		
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
17 May	5	2	1	0	3	1.5	0.9	373	57.8	3	303	14.6	3
	6	4	9	0	13	6.5	1.7	338	40.2	13	292	8.1	13
	7	12	20	0	32	16.0	2.6	370	35.4	32	299	11.6	32
	8	24	28	0	52	26.0	3.1	401	55.5	52	308	14.0	52
	9	17	21	0	38	19.0	2.8	421	45.1	38	312	10.4	38
	10	15	16	0	31	15.5	2.6	464	77.9	31	324	13.8	31
	11	6	4	0	10	5.0	1.5	464	47.0	10	328	10.4	10
	12	7	8	0	15	7.5	1.9	459	56.9	15	327	10.8	15
	13	1	2	0	3	1.5	0.9	459	37.3	3	328	7.1	3
	14	1	1	0	2	1.0	0.7	511	11.3	2	336	5.7	2
	16	0	1	0	1	0.5	0.5	515	NA	1	339	NA	1
Sample Total		89	111	0	200	100.0		415	66.0	200	312	16.1	200
18 May	6	6	6	0	12	5.9	1.7	335	54.5	12	293	13.6	12
	7	13	24	0	37	18.3	2.7	371	47.2	37	300	12.6	37
	8	18	28	0	46	22.8	3.0	390	38.2	46	305	9.5	46
	9	21	27	0	48	23.8	3.0	412	56.4	48	312	12.5	48
	10	16	11	2	29	14.4	2.5	438	53.5	29	317	11.7	29
	11	4	5	0	9	4.5	1.5	486	69.3	9	328	9.0	9
	12	8	6	0	14	6.9	1.8	495	61.4	14	329	8.9	14
	13	5	0	0	5	2.5	1.1	446	36.1	5	317	7.7	5
	14	1	1	0	2	1.0	0.7	485	113.1	2	329	13.4	2
Sample Total		92	108	2	202	100.0		409	65.0	202	310	14.8	202

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Sample Dates	Age	Sex (number)				% of Total	SE	Weight			Length		
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
19 May	5	3	1	0	4	2.0	1.0	392	51.0	4	305	17.5	4
	6	4	14	0	18	9.0	2.0	346	70.8	18	291	12.2	18
	7	23	27	0	50	25.1	3.1	374	32.7	50	302	10.0	50
	8	29	27	0	56	28.1	3.2	382	40.6	56	304	11.4	56
	9	17	26	0	43	21.6	2.9	405	49.1	43	312	12.6	43
	10	7	6	0	13	6.5	1.8	414	80.3	13	311	21.8	13
	11	3	1	0	4	2.0	1.0	410	53.0	4	310	13.0	4
	12	2	4	0	6	3.0	1.2	482	107.5	6	337	13.1	6
	13	3	1	0	4	2.0	1.0	467	15.9	4	329	5.2	4
	14	0	1	0	1	0.5	0.5	482	NA	1	348	NA	1
Sample Total		91	108	0	199	100.0		390	56.6	199	306	15.2	199
Samples Combined		614	814	6	1,434			425	68.0	1,434	312	15.8	1,434

Appendix B5.–Age, sex and size composition of herring caught by commercial purse seine, all sections, 8 and 12–19 May, 2011.

Sample Dates	Age	Sex (number)				% of Total	SE	Weight			Length		
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
8 May	4	1	0	0	1	0.1	0.1	177	NA	1	272	NA	1
	5	13	16	0	29	3.7	0.7	264	52.7	29	268	15.0	29
	6	87	91	0	178	22.6	1.5	283	53.6	178	276	14.5	178
	7	96	103	0	199	25.3	1.5	339	60.9	199	288	14.2	199
	8	64	72	0	136	17.3	1.3	389	60.7	136	300	13.4	136
	9	57	53	0	110	14.0	1.2	445	69.2	110	311	15.1	110
	10	31	32	0	63	8.0	1.0	463	76.7	63	315	14.3	63
	11	19	15	0	34	4.3	0.7	495	67.3	34	323	15.0	34
	12	9	10	0	19	2.4	0.5	536	50.2	19	329	8.2	19
	13	6	10	0	16	2.0	0.5	531	90.2	16	328	11.5	16
	14	1	1	0	2	0.3	0.2	517	25.5	2	328	14.1	2
	15	1	0	0	1	0.1	0.1	540	NA	1	341	NA	1
Sample Total		385	403	0	788	100.0		373	98.8	788	295	21.9	788
12 May	5	5	8	0	13	2.1	0.6	264	25.5	13	273	8.0	13
	6	67	65	0	132	21.3	1.6	282	53.5	132	275	14.0	132
	7	58	69	0	127	20.5	1.6	334	55.1	127	288	14.6	127
	8	55	52	0	107	17.3	1.5	402	57.4	107	303	12.3	107
	9	41	58	0	99	16.0	1.5	443	58.4	99	312	11.8	99
	10	31	19	0	50	8.1	1.1	459	64.1	50	315	11.4	50
	11	17	25	0	42	6.8	1.0	497	66.2	42	322	14.3	42
	12	11	16	0	27	4.4	0.8	516	70.3	27	327	11.3	27
	13	11	8	0	19	3.1	0.7	526	62.8	19	325	9.3	19
	14	2	1	0	3	0.5	0.3	529	16.3	3	331	5.3	3
	16	0	1	0	1	0.2	0.2	579	NA	1	343	NA	1
Sample Total		298	322	0	620	100.0		387	98.8	620	299	21.8	620

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| Sample Dates | Age | Sex (number) | | | | % of Total | SE | Weight | | | Length | | |
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
13 May	5	6	5	0	11	3.7	1.1	241	42.5	11	266	11.9	11
	6	27	19	8	54	18.2	2.2	284	75.4	54	281	19.3	54
	7	31	24	4	59	19.9	2.3	330	76.1	59	292	18.3	59
	8	22	24	4	50	16.8	2.2	368	72.6	50	301	16.0	50
	9	21	23	1	45	15.2	2.1	399	78.7	45	309	18.0	45
	10	12	17	2	31	10.4	1.8	428	77.8	31	314	17.4	31
	11	7	12	1	20	6.7	1.5	425	102.3	20	315	22.3	20
	12	2	5	0	7	2.4	0.9	533	51.9	7	332	7.3	7
	13	3	8	1	12	4.0	1.1	478	94.4	12	328	14.5	12
	14	4	2	0	6	2.0	0.8	484	35.7	6	336	6.0	6
	15	1	0	0	1	0.3	0.3	504	NA	1	339	NA	1
	16	1	0	0	1	0.3	0.3	546	NA	1	339	NA	1
Sample Total		137	139	21	297	100.0		367	101.1	297	300	23.8	297
14 May	5	6	7	0	13	3.9	1.1	251	49.8	13	269	15.3	13
	6	46	43	1	90	26.7	2.4	263	54.8	90	273	15.4	90
	7	47	46	0	93	27.6	2.4	298	53.5	93	283	15.4	93
	8	26	26	1	53	15.7	2.0	339	56.9	53	294	14.6	53
	9	24	18	0	42	12.5	1.8	365	77.3	42	303	19.1	42
	10	10	9	0	19	5.6	1.3	430	53.3	19	319	10.5	19
	11	5	7	0	12	3.6	1.0	455	88.4	12	322	14.1	12
	12	5	6	0	11	3.3	1.0	479	67.8	11	328	10.9	11
	13	0	3	0	3	0.9	0.5	534	52.8	3	340	8.7	3
	14	1	0	0	1	0.3	0.3	434	NA	1	327	NA	1
Sample Total		170	165	2	337	100.0		323	87.0	337	289	22.8	337

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Sample Dates	Age	Sex (number)				% of Total	SE	Weight			Length		
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
15 May	4	1	2	0	3	0.5	0.3	202	44.7	3	260	24.6	3
	5	31	35	2	68	11.2	1.3	224	35.1	68	260	12.1	68
	6	125	137	0	262	43.2	2.0	246	44.3	262	267	15.3	262
	7	75	66	1	142	23.4	1.7	293	52.2	142	281	17.3	142
	8	40	34	0	74	12.2	1.3	347	57.5	74	294	15.9	74
	9	16	7	0	23	3.8	0.8	358	67.9	23	298	19.4	23
	10	9	5	0	14	2.3	0.6	411	93.9	14	318	23.7	14
	11	4	4	0	8	1.3	0.5	414	90.0	8	312	25.8	8
	12	5	4	0	9	1.5	0.5	447	71.2	9	316	11.4	9
	13	2	1	0	3	0.5	0.3	513	91.9	3	332	8.1	3
	14	1	0	0	1	0.2	0.2	417	NA	1	325	NA	1
Sample Total		309	295	3	607	100.0		282	74.8	607	277	22.1	607
16 May	5	17	14	0	31	7.1	1.2	222	36.8	31	265	12.8	31
	6	69	79	0	148	33.8	2.3	256	45.4	148	273	12.3	148
	7	49	55	0	104	23.7	2.0	307	57.4	104	288	14.2	104
	8	26	35	0	61	13.9	1.7	344	59.0	61	297	14.6	61
	9	19	22	1	42	9.6	1.4	401	80.1	42	312	17.7	42
	10	11	9	0	20	4.6	1.0	410	66.2	20	315	16.6	20
	11	11	7	0	18	4.1	0.9	485	86.2	18	328	9.0	18
	12	4	5	0	9	2.1	0.7	496	55.7	9	323	18.2	9
	13	2	0	0	2	0.5	0.3	450	5.7	2	330	2.1	2
	14	1	2	0	3	0.7	0.4	484	39.2	3	337	15.5	3
Sample Total		209	228	1	438	100.0		315	91.7	438	289	22.7	438

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Sample Dates	Age	Sex (number)				% of Total	SE	Weight			Length		
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
17 May	4	0	1	0	1	0.3	0.3	267	NA	1	277	NA	1
	5	12	18	0	30	9.1	1.6	239	46.8	30	266	14.0	30
	6	61	73	0	134	40.9	2.7	247	31.5	134	268	9.4	134
	7	26	42	1	69	21.0	2.3	307	50.1	69	285	14.0	69
	8	23	20	1	44	13.4	1.9	359	62.9	44	298	14.5	44
	9	10	9	2	21	6.4	1.4	402	72.8	21	310	18.1	21
	10	5	6	0	11	3.4	1.0	419	66.7	11	313	10.5	11
	11	2	3	3	8	2.4	0.9	476	58.5	8	331	13.5	8
	12	3	1	0	4	1.2	0.6	485	72.1	4	332	3.3	4
	13	3	1	1	5	1.5	0.7	477	32.7	5	332	7.4	5
	14	0	1	0	1	0.3	0.3	526	NA	1	332	NA	1
Sample Total		145	175	8	328	100.0		303	84.5	328	283	22.4	328
18 May	4	1	0	0	1	0.3	0.3	160	NA	1	231	NA	1
	5	7	5	0	12	3.4	1.0	222	23.7	12	255	14.0	12
	6	84	66	0	150	43.0	2.7	252	31.9	150	268	11.3	150
	7	49	53	0	102	29.2	2.4	293	44.4	102	279	13.9	102
	8	19	15	0	34	9.7	1.6	336	64.2	34	289	18.4	34
	9	8	14	0	22	6.3	1.3	397	68.0	22	308	13.6	22
	10	1	8	0	9	2.6	0.8	477	36.2	9	317	9.1	9
	11	2	4	0	6	1.7	0.7	478	53.5	6	322	7.8	6
	12	3	3	0	6	1.7	0.7	505	54.8	6	332	6.5	6
	13	3	2	0	5	1.4	0.6	482	39.4	5	318	13.6	5
	14	2	0	0	2	0.6	0.4	545	67.2	2	336	10.6	2
Sample Total		179	170	0	349	100.0		299	82.1	349	280	21.5	349

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Sample Dates	Age	Sex (number)				% of Total	SE	Weight			Length		
		Male	Female	Unk.	Total			Mean (g)	SD	Number Weighed	Mean (mm)	SD	Number Measured
19 May	4	1	0	0	1	0.3	0.3	212	NA	1	260	NA	1
	5	15	21	0	36	10.1	1.6	239	37.9	36	264	11.8	36
	6	76	69	0	145	40.7	2.6	257	36.7	145	269	10.6	145
	7	43	36	0	79	22.2	2.2	299	59.8	79	279	14.5	79
	8	23	17	0	40	11.2	1.7	366	62.7	40	297	14.4	40
	9	11	16	0	27	7.6	1.4	409	62.1	27	306	13.5	27
	10	5	7	0	12	3.4	1.0	467	56.1	12	318	7.5	12
	11	3	3	0	6	1.7	0.7	521	25.4	6	334	10.8	6
	12	2	1	0	3	0.8	0.5	487	61.9	3	334	23.1	3
	13	3	4	0	7	2.0	0.7	477	117.6	7	321	25.9	7
Sample Total		182	174	0	356	100.0		306	88.0	356	281	21.8	356
Samples Combined		2,014	2,071	35	4,120			333	98.4	4,120	289	23.7	4,120

APPENDIX C

Appendix C1.–2011 Togiak Herring Forecast.

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF COMMERCIAL FISHERIES
NEWS RELEASE

Denby S. Lloyd, Commissioner

John R. Hilsinger, Director

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Greg Buck & Fred West, Asst. Area Research Biologists	333 Raspberry Road
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Phone: (907) 267-2355	Date Issued: November 12, 2011
Fax: (907) 267-2442	Time: 1:00 p.m.

2011 TOGIAK HERRING FORECAST

The 2011 Togiak herring forecast and harvest allocation are listed below for the Togiak District sac roe and spawn-on-kelp fishery, and the Dutch Harbor food and bait fishery, given a maximum 20% exploitation rate of the projected run biomass:

Harvest Allocation of the 2011 Forecasted Pacific Herring Run Biomass, Togiak District, Bristol Bay

	Biomass	Harvest
	(Short Tons)	(Short Tons)
Forecasted Biomass for 2011	140,860	
Total Allowable Harvest (20% exploitation rate)		28,172
Togiak Spawn-on-Kelp Fishery (Fixed Allocation)		1,500
Remaining Allowable Harvest		26,672
Dutch Harbor Food/Bait Allocation (7.0% of the remaining allocation)		1,867
Remaining Allowable Harvest for Togiak District Sac Roe Fishery:		24,805
Purse Seine Allocation 70.0%		17,364
Gill Net Allocation 30.0%		7,442

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2011 TOGIAK HERRING FORECAST SUMMARY

The Pacific herring population is forecasted to be 140,860 tons in Togiak District during 2011 (Figure 1). Younger herring (ages 4–6), returning from the 2005 through 2007 year classes, are expected to comprise 38.2% of the biomass in 2011 (Figure 2). The remainder of the population biomass will be comprised of herring ages 7–8 (32.8%), ages 9–11 (20.2%) and ages 12+ (8.8%). The forecasted individual average weight of herring in the harvest biomass is 340 g.

A run biomass of 140,860 tons would be ~1% less than the recent 10-year average observed biomass of 142,319 tons. A biomass of this size would potentially produce an overall harvest of 28,172 tons in all fisheries and 24,805 tons in the Togiak sac roe fisheries (purse seine and gillnet). A harvest of this size in the Togiak sac roe fisheries would be ~17% more than the recent 10-year average harvest of 20,589 tons.

We use an age-structured analysis (ASA) model to forecast the Togiak herring population that incorporates catch and age composition data as well as total run biomass estimates. The ASA model integrates data from purse seine fishery age compositions (1978–2010), total run age compositions (1978–1995, 1997, 1999, 2001, and 2005–2010), and aerial survey biomass estimates (1981, 1983, 1992–1994, 1997, 1999-2001, and 2005–2010). The model estimates were generated by comparing them to observed data. Samples from non-selective gear (commercial purse seine) were used to assess age composition of the total run biomass. Commercial purse seine catch samples ranged from age 3 to age 17. Age-4 herring average weight for 2011 was predicted using the recent four-year average while simple linear regression models were used to forecast average weight of age-5 through age-15 herring based on their weight the previous year.

A temporal change in age composition from older to younger herring typically occurs during this fishery. However, the 2010 inshore spawning biomass consisted largely of younger herring age 5–8 with a few discrete pulses of older fish. Herring between age 5 and age 8 (inclusive) made up 51.4% of the total commercial purse seine harvest, 45.2% of the total harvest, 37.8% of the total run and 47.8% of the escapement by weight.

Large recruitments in this population are typical every eight to ten years. During the last few years, one of these recruitment events appears to have been underway. However, the contribution of age-4 fish to the total run dropped to less than 5% in 2010 from the 10-20% observed in 2008 and 2009. This may be a signal that this period of high recruitment is complete. However, it should be noted that measuring contributions of younger age classes to the spawning biomass is difficult as they typically do not show up until late in the fishery and the department no longer conducts post-fishery sampling as was typical during the 1980s.

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The biomass of the Togiak herring spawning population has been estimated with aerial surveys since the late 1970s, concurrent with development of the sac-roe fishery. Total run biomass for 2010 was estimated to be 135,214 tons. This was the sum of the peak biomass observed on the aerial survey conducted 18 May (98,290 tons) and postseason survey conducted 2 June (36,924 tons). The time between these surveys leads us to believe that a near complete turnover of herring on the spawning grounds had occurred between these surveys. Herring were first observed in the district on 10 May, when approximately 2,371 tons were documented, mostly around Hagemeister Island and between Anchor Point and Right Hand Point. The biomass steadily increased through 18 May before declining, with herring most heavily concentrated in Togiak Bay throughout the season (Figure 3).

There is always uncertainty in forecasting the Togiak District herring biomass and predicting the 2011 run is no different. Although the ASA model has had a tendency to under-forecast since its inception in 1993, it over-forecast the 2010 run (146,775 tons forecast and 135,214 tons observed). The mean percent error (MPE) has been -19.7% for years with reliable total run biomass estimates (Figure 1). The accuracy or mean absolute percent error (MAPE) of the ASA model is currently running at 19%. The forecast range for 2011 is from 114,067 tons to 167,653 tons based on a MAPE of 20%. We consider this population to be healthy and sustainable.

Greg Buck, Fred West and Tim Baker
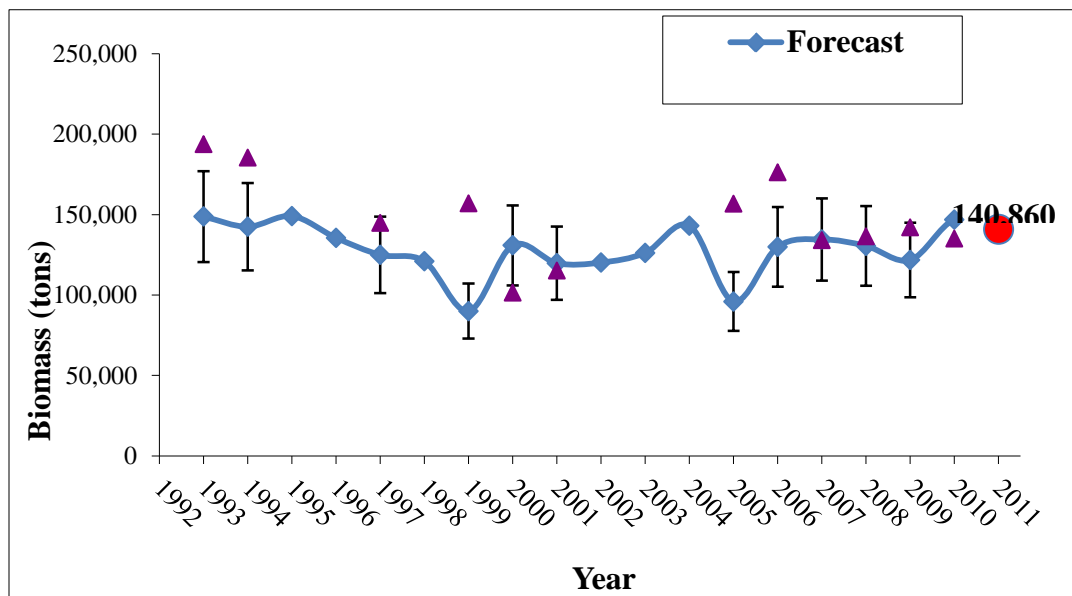
Bristol Bay Fishery Research Staff

Anchorage

Figure 1.-Annual observed Togiak herring total run biomass estimates and preseason forecasts based on the ASA model. Mean absolute percent error (MAPE) of 25% around the forecast is also shown for years with a reliable total run biomass estimate.
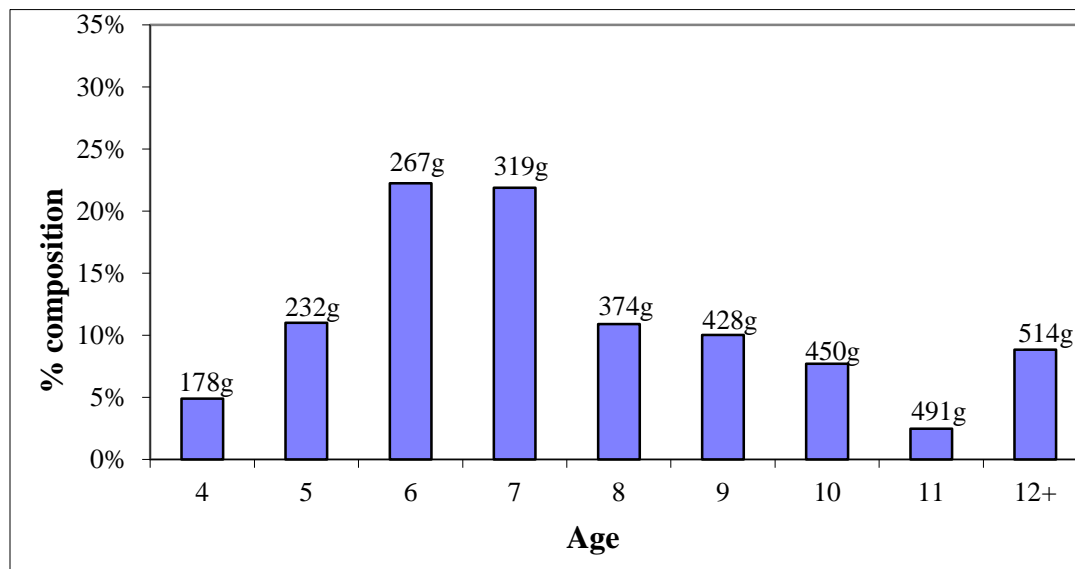

Figure 2.-Forecasted age composition by weight for the 2011 Togiak herring return. Forecasted average weight (grams) shown for each age category.
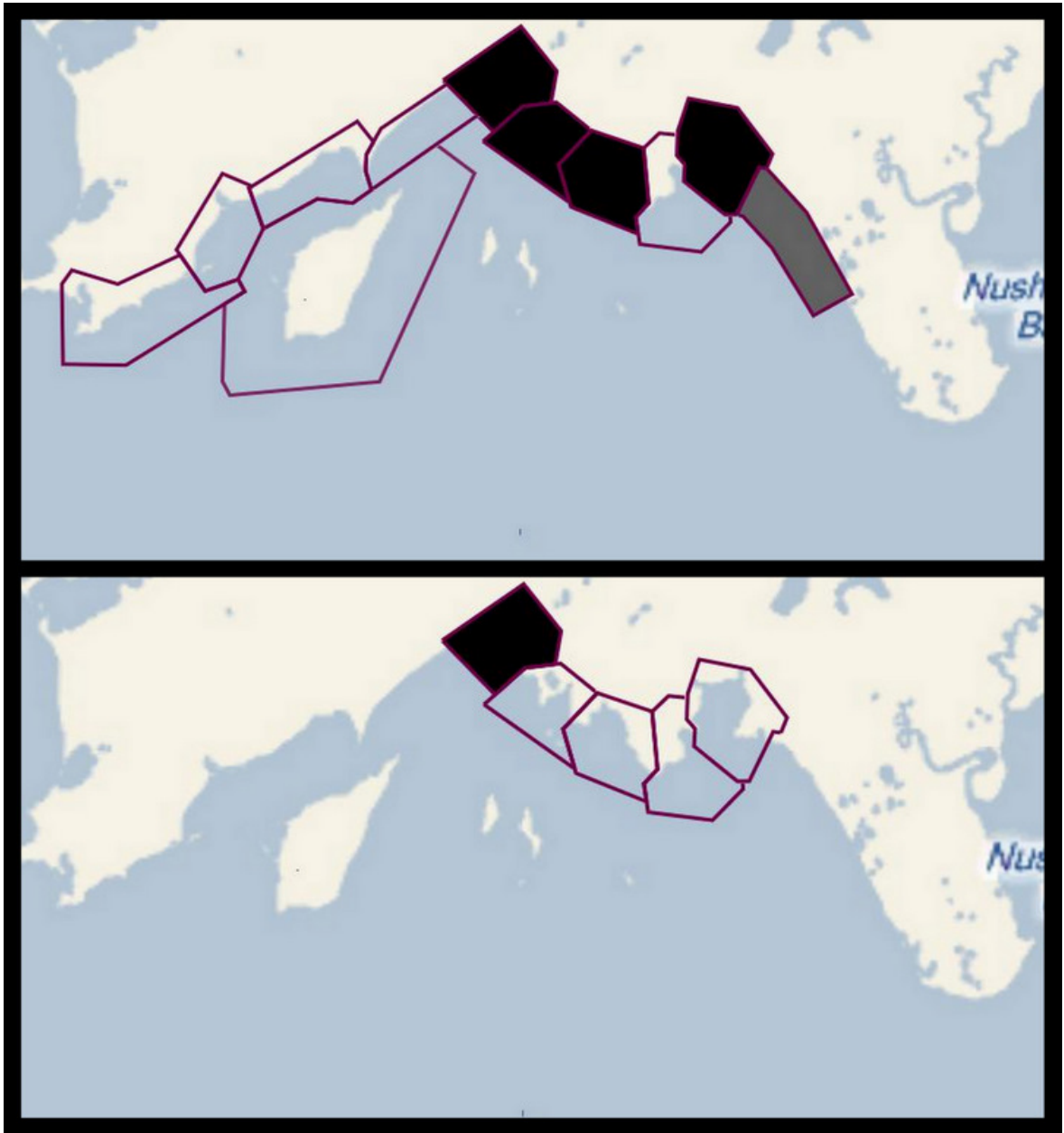
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Figure 3.-Herring spawning distribution observed during aerial surveys conducted on 18 May 2010 (top) and 2 June 2010 (bottom). Aerial survey sections with measurable biomass are outlined while sections with biomass >5,000 tons are shaded grey and sections with biomass >10,000 tons are shaded black.