

Fishery Data Series No. 15-35

Abundance, Age, Sex, and Size Statistics for Pacific Herring in Togiak District of Bristol Bay, 2014

by

Gregory B. Buck

October 2015

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



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Weights and measures (metric)		General		Mathematics, statistics	
centimeter	cm	Alaska Administrative Code		all standard mathematical signs, symbols and abbreviations	
deciliter	dL		AAC		
gram	g	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	alternate hypothesis	H _A
hectare	ha			base of natural logarithm	e
kilogram	kg	all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.	catch per unit effort	CPUE
kilometer	km			coefficient of variation	CV
liter	L	at	@	common test statistics	(F, t, χ^2 , etc.)
meter	m	compass directions:		confidence interval	CI
milliliter	mL	east	E	correlation coefficient (multiple)	R
millimeter	mm	north	N	correlation coefficient (simple)	r
Weights and measures (English)		south	S	covariance	cov
cubic feet per second	ft ³ /s	west	W	degree (angular)	°
foot	ft	copyright	©	degrees of freedom	df
gallon	gal	corporate suffixes:		expected value	E
inch	in	Company	Co.	greater than	>
mile	mi	Corporation	Corp.	greater than or equal to	≥
nautical mile	nmi	Incorporated	Inc.	harvest per unit effort	HPUE
ounce	oz	Limited	Ltd.	less than	<
pound	lb	District of Columbia	D.C.	less than or equal to	≤
quart	qt	et alii (and others)	et al.	logarithm (natural)	ln
yard	yd	et cetera (and so forth)	etc.	logarithm (base 10)	log
Time and temperature		exempli gratia		logarithm (specify base)	log ₂ , etc.
day	d	(for example)	e.g.	minute (angular)	'
degrees Celsius	°C	Federal Information Code	FIC	not significant	NS
degrees Fahrenheit	°F	id est (that is)	i.e.	null hypothesis	H ₀
degrees kelvin	K	latitude or longitude	lat or long	percent	%
hour	h	monetary symbols		probability	P
minute	min	(U.S.)	\$, ¢	probability of a type I error (rejection of the null hypothesis when true)	α
second	s	months (tables and figures): first three letters	Jan,...,Dec	probability of a type II error (acceptance of the null hypothesis when false)	β
Physics and chemistry		registered trademark	®	second (angular)	"
all atomic symbols		trademark	™	standard deviation	SD
alternating current	AC	United States (adjective)	U.S.	standard error	SE
ampere	A	United States of America (noun)	USA	variance	
calorie	cal	U.S.C.	United States Code	population	Var
direct current	DC			sample	var
hertz	Hz	U.S. state	use two-letter abbreviations (e.g., AK, WA)		
horsepower	hp				
hydrogen ion activity (negative log of)	pH				
parts per million	ppm				
parts per thousand	ppt, ‰				
volts	V				
watts	W				

FISHERY DATA SERIES NO. 15-35

**ABUNDANCE, AGE, SEX, AND SIZE STATISTICS FOR PACIFIC
HERRING IN TOGIAK DISTRICT OF BRISTOL BAY, 2014**

by

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ABSTRACT

The Pacific herring *Clupea pallasii* total population in the Togiak District of Bristol Bay was monitored for abundance/biomass and sampled for age, size, and sex composition in 2014. 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. Herring were sampled from commercial purse seine and gillnet harvests. The 2014 run biomass was estimated at 203,267 tons (184,403 tonnes). Total commercial harvest was 27,205 tons (25,560 tons from the sac roe fisheries with 19,544 tons harvested by purse seine and 6,016 tons by gillnet, and 1,645 tons harvested by the Dutch Harbor food and bait fishery). The preseason allowable exploitation rate is 20% by regulation, and the final exploitation rate was estimated at 13%. A total of 4,670 herring were sampled for age, sex, length, weight, and sexual maturity information between 30 April and 7 May 2014. Ages ranged from 3 to 16 years, with purse seine harvest dominated by age-7 (26%), and -8 (27%) fish, whereas gillnet harvest was dominated by age-7 (22%), and -8 (35%) fish. Mean length and weight of herring from the purse seine fishery samples were 279 mm and 358 g, whereas fish sampled from the gillnet fishery averaged 289 mm and 394 g.

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

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 is managed as a single spawning population as established in the *Bristol Bay Herring Management Plan* (5 AAC 27.865). 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 tons¹ (1,361 tonnes²) 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 a gear allocation target of 30% reserved for the gillnet fleet and 70% for the purse seine fleet (Sands 2009).

The primary commercial fishery targeting this stock occurs in the 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 km²; Figure 1). This fishery occurs as fish move inshore prior to spawning and targets the ripened ovaries (sac roe) of female herring prior to spawning. Biomass estimates of this spawning aggregation have been conducted annually using aerial surveys since 1978. The largest was 239,022 tons (216,839 tonnes) in 1979 and has averaged 145,963 tons (130,948 tonnes) between 1994 and 2013 (McBride et al. 1981; McBride and Whitmore 1981; Fried et al. 1982a, 1982b, 1983a, 1983b, and 1984; Lebida et al. 1985a, 1985b; Lebida 1987; Sandone and Brannian 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; and Buck 2010a, 2010b, 2012, 2013a, 2013b, 2014; Table 1).

Commercial harvest 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 United States (U.S.) waters prompted increased interest in the Togiak

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.

fishery by U.S. fishermen. The 10-year mean sac roe harvest is presently 21,236 tons (19,265 tonnes; Table 1). During this period, the harvest ranged from a high of 30,315 tons (27,502 tonnes) in 1994 to a low of 17,021 tons (15,441 tonnes) in 2012. In addition to the sac roe fishery, wild spawn-on-kelp has historically been harvested as well, either by hand or rake. First documented in 1967, this fishery has been intermittent in recent years because of low demand, and it did not occur in 1997, 1998, 2000, 2001, and from 2004 to the present (Table 1).

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 2007; Figure 2). 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. Spawning occurs throughout the Togiak fishing district, particularly in areas where eelgrass and rockweed are present, and occurs from late April through early June. After spawning, the fish continue their clockwise migration along the Alaska Peninsula to feeding areas near Unimak Pass. 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).

After leaving Togiak District, fish from this stock are susceptible to one other directed fishery during their postspawn 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 1,455 tons (1,320 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 fishermen 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).

OBJECTIVES

The specific objectives for assessing Togiak herring were to

- 1) estimate the biomass of herring within Togiak District;
- 2) document the commercial harvest (including deadloss 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 spawning population, 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

Biomass within Togiak District in 2014 was estimated using fixed-wing aerial surveys (Lebida and Whitmore 1985). Surveys were flown daily at low tide within the constraints of aircraft availability and weather. 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, and run biomass was the sum of all daily biomass estimates judged to be composed of fish not accounted for in any other survey plus all harvest 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)³ completed by buyers for each commercial delivery were the primary source for documenting harvest. Fish ticket information included date of harvest, gear type, biomass (tons), and location by management 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

ADF&G sampling crews attempted to sample the commercial catch for age composition from each management section during every commercial fishing period (usually consisting of a single 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, location, and harvest date. Attempts were made to collect samples from multiple vessels and/or processors to ensure the broadest distribution of samples. Samples collected from each gear type were used to characterize the harvest of each gear type, but 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, they removed 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 (~10×) magnification using a microfiche reader or dissecting microscope. Age was estimated by counting the compressed annuli formation at the end of winter prior to spawning (Shaboneev 1965; Lebida 1986).

In addition to age, standard length (tip of snout to the hypural plate) of each fish was measured to the nearest millimeter. Individual herring were weighed to the nearest 0.5 g and determined sex and maturity for each herring by visually examining the gonads. Maturity was rated using an

³ Statewide electronic fish ticket database [Internet]. 1985-. Juneau, AK: Alaska Department of Fish and Game, Division of Commercial Fisheries. [URL not available as some information is confidential]. Hereafter referred to as fish tickets.

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% ($\delta = 0.05$) of the true population age proportions 90% of the time (Thompson 1987). A sample size of 400 fish provides this level of precision and accuracy. Sampling crews 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 stepwise process until the minimum sample size was achieved. This process resulted in 4 sampling groups for the purse seine harvest and 3 for gillnet harvest (Table 2; Figures 4 and 5).

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

$$\bar{W}_a = \frac{\sum_{i=1}^{n_a} W_{ai}}{n_a}, \quad (1)$$

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

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

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

$$N_a = \frac{B_a}{\bar{W}_a}. \quad (3)$$

The spawning escapement biomass (E_{tot}) for all ages (a) is the difference between the total spawning biomass at age (B_a) and the combined purse seine and gillnet harvests at age (C_a):

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

An age-structured analysis (ASA) model (Funk and Rowell 1995) was used to forecast the 2014 run (Appendix D). This model uses the total run biomass estimate from aerial surveys as well as the age composition and weight at age estimated from harvest sampling as inputs. The model hind casts pre-recruitment age classes for each year ($< \text{age-5}$) to achieve the best fit with the data. The most recent biomass estimate included in the 2014 forecast model occurred in 2013.

EXPLOITATION RATE

The exploitation rate (U) is estimated as

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

where

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

B = run biomass.

RESULTS

BIOMASS

Aerial surveys began on 22 April, and herring were first spotted on 24 April during a survey that documented 4,554 tons. Biomass increased through 2 May when surveyed biomass peaked at 99,219 tons but was still 96,860 tons on 16 May, 2 days after fishing had ended (Table 3). Spawning was concentrated in the center of Togiak District (Figures 3 and 6). Spawn occurred for 92 statute miles (148 km) along the Togiak District coastline, with approximately 80% of the total spawn surveyed between 28 April and 1 May (Table 3).

The 2014 biomass estimate was the sum of aerial survey estimates conducted on 2 May and 16 May and all harvest occurring prior to the 2 May survey. The survey on 2 May recorded the largest biomass of the season, and by 16 May the fishery had ceased. We assume that fish present on 16 May arrived on the spawning grounds after 2 May, that no fish present during the 2 May survey were still present on the spawning grounds during the 16 May survey, and that the amount of fish arriving after the 2 May survey and harvested prior to 16 May was a negligible percentage of the total available.

Aerial survey conditions ranged from fair to excellent throughout the season, with good to fair conditions during the peak inseason survey (Table 3). Run biomass was estimated at 203,267 tons (184,403 tonnes) by combining the peak inseason biomass estimate of 2 May with the biomass estimate 16 May and all harvest that occurred prior to the peak biomass survey (Table 4).

HARVEST

Commercial openings between 27 April and 14 May produced a total harvest of 25,560 tons (23,188 tonnes) within Togiak District in 2014 (Table 4). Historically, this fishery commences around 7 May; however, there is annual 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 5). This temporal variation is thought to be largely a function of the spring ice breakup and related water temperatures in the eastern Bering Sea (Tojo et al. 2007). In 2014, fishing opened on 27 April and ended on 14 May, making for a relatively early and long 18-day fishing season. Fishing was open continuously from 27 April through 14 May for both gear types. The total commercial harvest in the Togiak District sac roe fishery of 25,560 tons represents 120% of the 10-year average and 116% of the 20-year average (Table 1). Catches from Hagemeister Section accounted for the largest percentage (31%) of the total commercial harvest, followed by Kulukak (24%), Pyrite Point (23%), and Nunavachak (22%). All other sections had <1% of the harvest (Table 4; Figure 7).

Roe percentages ranged from 13.4% for herring harvested by gillnet in Kulukak Section on 11 May and Kulukak Section on 27 May to 8.1% for herring harvested by purse seine in Hagemeister Section on 30 April (Table 4).

Purse Seine

The Togiak purse seine fishery opened at 6:00 PM on April 27. ADF&G initially opened the purse seine fishery for 76 hours. Commercial quality fish were available late on 29 April, when 1,646 tons of herring were harvested by the purse seine fleet. Herring continued to be of marketable quality for the remainder of the purse seine fishery, and ADF&G extended the fishery on 30 April for 48 hours, again on 2 May for 72 hours, and finally on 5 May until further notice. Excellent weather prevailed throughout the season and the purse seine fleet steadily harvested the quota at a pace of about 1,700 tons per day for the first 10 days of the fishery. Day 11 was somewhat slower with only 546 tons harvested, but the harvest increased to over 1,000 tons for each of the next 2 days. On 11 May, all but one company completed its purse seine fishing operations for the season. The last company finished operations on 13 May and the fishery was closed the next day. The final harvest was 19,544 tons of herring, equal to 100.1% of the purse seine quota. Purse seine participation was documented at 17 vessels, down from 26 in 2013. A total of 40% of the harvest occurred in Hagemeister Section (Table 4). Purse seine harvests averaged 1,420 tons per fishing day.

Roe accounted for 9.7% (by weight) of the commercial purse seine fishery and ranged from 8.1% in Hagemeister Section on 30 April to 11.6% in Pyrite Point on 3 May (Table 4). The total average roe percentage (9.7%) for purse seine herring was 0.3% higher than the most recent 10-year and 20-year average (Table 6).

Gillnet

The Togiak gillnet fishery opened at 6:00 PM April 27 until further notice, with no prior test fishing. In 2014, five companies participated in the Togiak sac roe gillnet fishery, a decrease from 6 in 2013. Fishermen participation was significantly lower at 24 vessels than 2013 (37 vessels). Although the season opened on April 27, the first day that more than 3 companies purchased fish was April 30. The combined harvest from April 29 and April 30 was 1,891 tons of herring. Harvest continued at a somewhat erratic rate for the entire season. The best single day

catch was 30 April with 916 tons of herring harvested, and the slowest day was 9 May with only 95 tons harvested. The last company finished operations on May 13 and the fishery was closed the next day. The total gillnet harvest was 6,016 tons of herring, representing 72% of the quota. A total of 99.8% of the harvest occurred in Kulukak Section (Table 4). Purse seine harvests averaged 334 tons per fishing day.

Roe accounted for 11.9% (by weight) of the commercial gillnet fishery and ranged from 9.4% on 1 and 2 May in Kulukak Section, to a high of 13.4% on 11 May in Kulukak Section (Table 4). The total average roe percentage (weighted) for gillnet harvested herring in 2013 was 0.9% above the 10-year average and 0.7% above the 20-year average (Table 6).

Spawn on Kelp

There was no commercial harvest for spawn on kelp in 2014 because there were no registered buyers (Table 1). This fishery last occurred in 2003.

AGE, SIZE, AND SEX COMPOSITION

A total of 3,780 samples collected from the commercial purse seine fishery (all sections) produced 3,234 readable scales of the 3,965 total readable scales from all gear types (Table 5; Appendices B1–B4). A total of 1,510 samples collected between 2 May and 5 May in Hagemester Section produced 1,326 (33%) of the total readable scales (Appendices B1 and B4). A total of 880 samples were collected from purse seine catches between 30 April and 1 May in Nunavachak Section produced 716 (18%) of the total readable scales (Appendices B2 and B4).

A total of 890 herring sampled from the commercial gillnet fishery between 1 May and 7 May produced 731 (18%) of the total readable scales (Table 5; Appendices C1). All gillnet samples were collected from the Kulukak Section. Standard sampling protocol accounted for the typical percentage of non-readable scales and was designed to meet the sample size goal of readable scales.

Total Run

The age composition of the 106,407 tons that represent peak biomass and harvest up to that point in the run were characterized using purse seine samples groups 1 and 2 (Table 2). The age composition of the 96,860 tons estimated during the 16 May survey were characterized using purse seine sample groups 3 and 4. These 2 biomass estimates by age class were summed to produce the total run age composition and biomass.

Age classes composing more than 10% of the run either in abundance or run biomass were age-6, -7, -8 and -9 fish, which composed 10%, 24%, 28%, and 19% (respectively) of the run by weight and 11%, 25%, 27%, and 17% by number (Table 7; Figure 8; Appendix A1). The mean lengths were slightly below historical means for fish older than age-6 (Figure 9), and mean weight at age was higher than historical means for fish younger than age-9 (Figure 10).

Typically, the Bristol Bay–Alaska Peninsula herring spawning biomass experiences a shift towards younger age classes as the season progresses. This did not occur in 2014, with age classes remaining relatively stable throughout the run.

Commercial Harvest

Abundant age classes (> 10% of the harvest in abundance or harvest biomass) were age-6, -7, -8, and -9 fish, which composed 10%, 23%, 29%, and 19% (respectively) of the harvest by weight

and 11%, 25%, 28%, and 18% by number (Table 7; Appendix A1). The gillnet harvest was only slightly older than those in the purse seine harvest (Table 7 and Figure 11).

The average length and weight of fish harvested in the commercial purse seine fishery was 279 mm and 358 g, whereas the average length and weight of fish in the commercial gillnet fishery was 289 mm and 394 g (Table 8). Samples collected from commercial purse seine and gillnet harvests were 47% male and 53% female, varying in composition by time ($\chi^2 = 17.8$, $P = 0.013$) and location ($\chi^2 = 23.5$, $P < 0.01$; Appendix B4 and C1).

Purse Seine

Samples were collected from the commercial purse seine harvest between 30 April and 7 May from Hagemeister and Nunavachak Sections (Appendices B1–B3). Abundant age classes (>10% of the harvest in abundance or harvest biomass) were age-6, -7, -8 and -9 fish, which composed 10%, 24%, 27%, and 19% (respectively) of the harvest by weight and 11%, 26%, 27%, and 17% by number (Table 7; Appendix A2). Samples from the 2014 purse seine harvest had a mean length of 279 mm and mean weight of 358 g (Table 8), were 49% male, and varied by harvest date ($\chi^2 = 19.2$, $P < 0.01$) but not location ($\chi^2 = 2.5$, $P = 0.28$; Appendix B1–B3).

Gillnet

Samples were collected from the commercial gillnet harvest between 1 May and 7 May from the Kulukak Section (Appendix C1). Abundant age classes (>10% of the harvest in abundance or harvest biomass) were age-6, -7, -8, and -9 fish, which composed 10%, 21%, 36%, and 18% (respectively) of the harvest by weight and 11%, 22%, 35%, and 18% by number (Table 7; Appendix A3). Samples from the 2014 gillnet harvest had a mean length of 289 mm and mean weight of 394 g (Table 8). Herring sampled from the gillnet harvest were 39% male and varied by harvest date ($\chi^2 = 10.0$, $P = 0.02$) and were all sampled from the Kulukak Section (Appendix C3).

EXPLOITATION RATE

The 2014 exploitation of this stock was estimated at 13% by dividing the combined Togiak District commercial sac roe harvest of 25,560 tons and the Dutch Harbor food and bait harvest of 1,645 tons by the total run biomass estimate of 203,267 tons (Table 1).

DISCUSSION

The purpose of this assessment was to estimate total run biomass; spawning escapement; and age, size (weight and length), and sex composition of the Bristol Bay–Alaska Peninsula herring stock that spawn or are harvested in Togiak District. A sampling crew located in King Salmon processed samples from this fishery collected from processors throughout the district. This strategy provides managers with inseason age composition estimates in a timely and cost-effective manner.

The estimated 2014 total run biomass of 203,267 tons (Objective 1) was 133% higher than the most recent 10-year average and 139% of the most recent 20-year average (Table 1; Appendix A1). Herring were first observed on a survey conducted 24 April, and spawning activity was first detected on 28 April (Table 3).

The total Togiak sac roe commercial harvest (Objective 2) of 25,560 tons was approximately 120% and 116% of the 10- and 20-year average respectively (Table 1). The commercial fishery

started 13 days earlier than the 10-year average, opening on 27 April, which is the second earliest opening date on record. The earliest that this fishery has opened is 25 April, which occurred in 1980 and 2002. The average roe percent was above average for both gillnet and purse seine harvest.

Over the last decade or so, changes in agency and industry management (processor co-ops) as well as global market conditions have driven several trends in this fishery. Beginning around the turn of the century, fishing seasons have become longer and daily fishing effort has declined. At 18 days, the 2014 fishery was 2 days longer than the recent 10-year average with effort at or slightly below average for both gear types (Table 6). These trends allow purse seine fishermen to inspect their catches more closely and harvest only the most valuable fish, although this holding and inspecting of fish has the potential to produce more dead loss.

The commercial purse seine harvest of 25,560 tons was 120% of the 10-year average and 116% of the 20-year average, and the commercial gillnet harvest of 6,016 tons was 106% of the 10-year average and 102% of the 20-year average (Table 6).

The number of readable scales (3,965) collected from the 2014 commercial fishery was 70% of the 5-year average of readable scales (Table 5). This below average sampling effort was due to a change in the sampling of this fishery. Prior to 2014, this fishery was sampled by a crew that was based at the Togiak Fisheries International (TFI) plant in Togiak and sampled largely from the floating processors. In 2014, this fishery was sampled by a crew based in King Salmon sampling processors in that area. This sampling effort was sufficient to characterize the Togiak District spawning biomass.

Age-8 fish dominated the total run and the harvest in 2014 (Objective 3), accounting for 29% of the total biomass harvested and 28% of all herring harvested (Table 7). The age composition of the 2014 run was steady over time.

A major problem with estimating recruitment in any given year is the lack of postseason sampling necessary to detect younger fish. The 2014 season was longer and earlier than other recent years. Personnel and budget constraints precluded any sampling of fish caught after 7 May, and no postseason survey or sampling was conducted. This makes the detection of younger recruit age classes, such as age-4 and age-5, difficult because they generally spawn later than older fish. Although age-4 and -5 herring were present at low levels, they were well below the elevated levels seen during the last significant recruitment event experienced by this biomass that occurred in 2008 and 2009 (Figure 12). This population typically experiences a large recruitment event every 8 to 10 years.

The total exploitation rate (Objective 4) in Togiak District was 13% (Table 1), which was below the recent 10- and 20-year average, largely due to the fact that the 2014 forecast called for 157,000 tons (Appendix D) while the actual run was 203,000 tons.

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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, 1994–2014.

Year	Togiak		Spawn on kelp			Dutch Harbor	
	Total run biomass (tons)	Sac roe harvest (tons)	Harvest (lb)	Harvest (tons)	Herring equivalent (tons)	Food and bait harvest (tons)	Exploitation rate
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 ^b	34 ^b	260 ^b	2,014	16.1%
2003	126,213 ^a	21,663				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%
2012	167,738	17,021				1,807	11.2%
2013	169,020	27,610				1,764	17.4%
2014	203,267	25,560				1,645	13.4%
2004–2013							
Average	153,379	21,236	NA	NA	NA	1,455	14.8%
1994–2013							
Average	145,963	22,110	306,631	153	1,179	1,803	16.7%

Note: Blank cells indicate no fishery occurred that year.

Sources: Jones et al. 2012; Bernard 2011; ADF&G fish tickets.

^a Total biomass estimate based on preseason forecast; 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 and harvest (including deadloss) by gear type, Togiak District, 2014.

Gear	Sample group	Harvest (tons)	Sample size	Dates	Fishing sections
Purse seine	1	2,674	381	4/29–4/30	NUN
Purse seine	2	4,179	907	4/29–5/2	TOG,NUN,HAG, PYR
Purse seine	3 ^a	4,937	1,150	5/3–5/6	TOG,NUN,HAG, PYR
Purse seine	4	6,499	796	5/6–5/11	TOG,HAG,PYR,CPN
Gill net	1	3,438	338	4/29–5/4	KUK,NUN
Gill net	2	819	191	5/5–5/6	KUK
Gill net	3	1,760	202	5/7–5/11	KUK

Note: Age composition of samples in each sampling group was applied to harvest in same sampling group. Fishing section abbreviations: NUN: Nunavachak; TOG: Togiak; HAG: Hagemeister; PYR: Pyrite Point; CPN: Cape Newenham; KUK: Kulukak.

^a Nunavachak harvest from May 10 and May 11 was included in this sample group.

Table 3.–Aerial survey estimates (tons) of herring by index area, Togiak District, 2014.

Date	Start time	Survey rating ^b	Spawn (statute miles)	Estimated biomass by index area ^a											Daily total
				NUS	KUK	MET	NVK	UGL	TOG	TNG	MTG	OSK	PYR	HAG	
22 Apr	9:00	4.0													0
24 Apr	10:30	1.0												4,554	4,554
27 Apr	10:00	2.7		4,438	13,780	628		228	15,743	2,468					37,285
28 Apr	11:30	1.4	21.9	4,177	29,068	8,353	2,120	11,070	17,388	3,210	8,283	1,023			84,692
29 Apr ^c	10:00	4.5	16.7												NA ^c
30 Apr	10:00	2.7	17.5		23,233	2,160	1,032	1,827	16,060	13,527	7,407	2,206		1,572	69,024
1 May	10:00	3.5	16.6	682	4,628	774	1,077	3,863	11,937	1,417	3,481			849	28,708
2 May	10:00	2.5	6.4	4	34,110	2,537	4,081	4,780	40,865	9,138	1,219	1,250	1,235		99,219
4 May	10:00	2.5	0.4		23,738	5,320	365	354	43,393	619	653	12		18	74,472
7 May	10:00	2.5	2.3		10,380	1,473	109	405	31,322	86	45	317	235		44,372
12 May	10:00	1.0	7.3	24,085	3,360	28	49	170	34,497	561	172	1,252			64,174
16 May	10:00	1.3	1.8	17,586	28,449	2,222	100	1,820	46,662	10	11				96,860
23 May	10:00	1.8	0.7	4,801	10,541	11,586	990	36	36,174	7,524	334				71,986
Peak biomass estimate															99,219

Note: Blank cells represent no biomass observed.

^a Index area abbreviations: NUS: Nushagak Peninsula; KUK: Kulukak; MET: Metervik; NVK: Nunavachak; UGL: Ungalikthluk/Togiak; TOG: Togiak; TNG: Tongue Pt.; MTG: Matogak; OSK: Osviak; PYR: Pyrite Point; HAG: Hagemeister.

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

^c Spawning survey only.

Table 4.–Commercial herring harvest (tons) and roe (%) by fishing section and gear type, Togiak District, Bristol Bay, 2014.

Date	Duration (hours)	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																
4/29	76:00	1			1,184.7	9.7			461.4	8.6					1,646.1	9.4
4/30	24:00	2			1,489.7	9.6			399.2	8.1					1,888.9	9.3
5/1	24:00	3			971.3	9.7	117.1	9.0	1,016.4	9.5					2,104.8	9.6
5/2	24:00	4			148.6	10.4			960.1	10.3	105.0	9.1			1,213.8	10.2
5/3	24:00	5							1,004.1	9.7	181.5	11.6			1,185.6	10.0
5/4	24:00	6			155.1	9.9			1,260.0	9.5	305.3	10.0			1,720.3	9.6
5/5	24:00	7			156.3	10.7			378.7	10.1	1,228.9	10.2			1,763.9	10.3
5/6	24:00	8			267.2	10.7			326.3	9.2	729.1	9.9			1,322.6	9.9
5/7	24:00	9							314.2	9.2	1,752.0	9.9			2,066.2	9.8
5/8	24:00	10							535.2	10.0	1,047.1	10.1	75.9	9.6	1,658.2	10.0
5/9	24:00	11							304.7	10.4	241.3	11.2			546.1	10.7
5/10	24:00	12			959.4	9.6			102.0	8.5	93.8	11.0	17.3	10.1	1,172.4	9.6
5/11	72:00	13			294.5	9.2	65.4	9.1	766.4	8.5	128.4	8.6			1,254.7	8.7
Subtotal ^{1a}	412:00				5,626.8	9.7	182.5	9.0	7,828.7	9.5	5,812.4	10.1	93.1	9.7	19,543.5	9.7
Gillnet																
4/29	76:00	1	245.1	10.8											245.1	10.8
4/30	24:00	2	916.0	11.6											916.0	11.6
5/1	24:00	3	828.2	11.1	7.0	9.4									835.2	11.1
5/2	24:00	4	601.7	11.6	7.0	9.4									608.7	11.6
5/3	24:00	5	376.1	10.7											376.1	10.7
5/4	24:00	6	456.7	11.6											456.7	11.6
5/5	24:00	7	359.6	12.1											359.6	12.1
5/6	24:00	8	459.0	12.2											459.0	12.2
5/7	24:00	9	348.9	12.1											348.9	12.1
5/8	24:00	10	104.8	11.9											104.8	11.9
5/9	24:00	11	94.5	11.6											94.5	11.6
5/10	24:00	12	458.5	12.6											458.5	12.6
5/11	72:00	13	752.9	13.4											752.9	13.4
Subtotal ^{1a}	412:00		6,002.1	11.9	14.0	9.4									6,016.1	11.9

-continued-

Table 4.–Page 2 of 2.

Date	Duration (hours)	Period	Kulukak		Nunavachak		Togiak		Hagemeister		Pyrite Point		Cape Newenham		Total	
			Tons	Roe %	Tons	Roe %	Tons	Roe %	Tons	Roe %	Tons	Roe %	Tons	Roe %	Tons	Roe % ^a
							Combined									
4/29		1	245.1	10.8	1,184.7	9.7			461.4	8.6					1,891.2	9.6
4/30		2	916.0	11.6	1,489.7	9.6			399.2	8.1					2,805.0	10.0
5/1		3	828.2	11.1	978.3	9.7	117.1	9.0	1,016.4	9.5					2,940.1	10.0
5/2		4	601.7	11.6	155.6	10.3			960.1	10.3	105.0	9.1			1,822.5	10.7
5/3		5	376.1	10.7					1,004.1	9.7	181.5	11.6			1,561.7	10.2
5/4		6	456.7	11.6	155.1	9.9			1,260.0	9.5	305.3	10.0			2,177.0	10.0
5/5		7	359.6	12.1	156.3	10.7			378.7	10.1	1,228.9	10.2			2,123.5	10.6
5/6		8	459.0	12.2	267.2	10.7			326.3	9.2	729.1	9.9			1,781.6	10.5
5/7		9	348.9	12.1					314.2	9.2	1,752.0	9.9			2,415.1	10.2
5/8			104.8	11.9					535.2	10.0	1,047.1	10.1	75.9	9.6	1,763.0	10.1
5/9			94.5	11.6					304.7	10.4	241.3	11.2			640.6	10.9
5/10			458.5	12.6	959.4	9.6			102.0	8.5	93.8	11.0	17.3	10.1	1,630.8	10.5
5/11			752.9	13.4	294.5	9.2	65.4	9.1	766.4	8.5	128.4	8.6			2,007.7	10.5
Total and Mean			6,002.1	11.9	5,640.8	9.7	182.5	9.0	7,828.8	9.5	5,812.4	10.1	93.1	9.7	25,559.6	10.2

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

^a Weighted roe percentage used with this formula: (tons × roe % + tons × roe % +) / total tons.

Table 5.–Number of herring samples for which age estimations were made by gear type, Togiak District, 2014.

Gear type	Readable	Missing & unreadable	Total	Percent unreadable
Commercial purse seine	3,234	546	3,780	14.4
Commercial gillnet	731	159	890	17.9
Total	3,965	705	4,670	15.1

Table 6.–Sac roe herring industry participation, fishing effort and harvest, Togiak District, 1994–2014.

Year	Buyers	Daily capacity ^a	Fishery dates			Gillnet				
			Start	Close	Days	Effort ^b	Duration (hours)	Harvest ^c	CPUE	Roe %
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
2012	4	1,970	5/14	6/5	23	18	534	4,027	0.4	12.1
2013	6	2,775	5/11	5/27	17	37	534	8,244	0.4	10.9
2014	6	2,600	4/27	5/14	18	24	412	6,016	0.6	11.9
2004-2013	6	2,169	5/9	5/24	16	36	348	5,665	0.6	11.0
1994-2013	10	2,573	5/7	5/18	12	118	205	5,881	0.6	11.2

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Table 6.–Page 2 of 2.

Year	Purse seine					Total harvest ^c
	Effort ^b	Duration (hours)	Harvest ^c	CPUE	Roe %	
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	9.3 ^d	17,049
2003	35	110	15,158	3.9	8.9 ^d	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
2012	16	328	12,994	2.5	9.4	17,021
2013	26	328	19,366	2.3	9.0	27,610
2014	17	412	19,544	2.8	9.7	25,560
2004-2013	25	223	15,570	3.4	9.4	21,236
1994-2013	85	124	16,230	8.6	9.4	22,110

Note: Blank cells represent no data. CPUE is catch per unit effort. CPUE defined as harvest divided by effort times duration.

^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.

^d Lower than inseason assessment due to more stringent postseason market scrutiny.

Table 7.—Herring harvest and biomass estimates by age and gear type, Togiak District, 2014.

Purse seine					Gillnet					Total harvest				
Age	Biomass (tons)	%	Herring (x1000)	%	Age	Biomass (tons)	%	Herring (x1000)	%	Age	Biomass (tons)	%	Herring (x1000)	%
3	4	0.0	23	0.0	3	16	0.3	42	0.3	3	20	0.1	64	0.1
4	132	0.7	512	1.0	4	14	0.2	45	0.3	4	146	0.6	557	0.9
5	909	4.7	3,377	6.8	5	185	3.1	485	3.5	5	1,094	4.3	3,862	6.1
6	1,899	9.7	5,620	11.3	6	595	9.9	1,463	10.6	6	2,494	9.8	7,083	11.1
7	4,612	23.6	12,751	25.5	7	1,249	20.8	2,970	21.6	7	5,861	22.9	15,722	24.7
8	5,358	27.4	13,285	26.6	8	2,136	35.5	4,819	35.0	8	7,494	29.3	18,104	28.4
9	3,670	18.8	8,688	17.4	9	1,103	18.3	2,510	18.2	9	4,773	18.7	11,198	17.6
10	1,555	8.0	3,203	6.4	10	466	7.7	971	7.0	10	2,020	7.9	4,174	6.6
11	791	4.0	1,428	2.9	11	193	3.2	362	2.6	11	984	3.8	1,790	2.8
12	291	1.5	514	1.0	12	36	0.6	68	0.5	12	327	1.3	582	0.9
13	201	1.0	335	0.7	13	24	0.4	43	0.3	13	224	0.9	378	0.6
14	41	0.2	66	0.1	14	0	0.0	0	0.0	14	41	0.2	66	0.1
15	53	0.3	79	0.2	15	0	0.0	0	0.0	15	53	0.2	79	0.1
16	27	0.1	42	0.1	16	0	0.0	0	0.0	16	27	0.1	42	0.1
Total	19,544	100	49,924	100	Total	6,016	100	13,777	100	Total	25,560	100	63,701	100

Biomass peak (2 May)					Biomass postseason (16 May)					Total run biomass				
Age	Biomass (tons)	%	Herring (x1000)	%	Age	Biomass (tons)	%	Herring (x1000)	%	Age	Biomass (tons)	%	Herring (x1000)	%
3	0	0.0	0	0.0	3	25	0.0	129	0.1	3	25	0.0	129	0.0
4	987	0.9	3,641	1.4	4	468	0.5	1,929	0.8	4	1,456	0.7	5,569	1.1
5	4,728	4.4	16,181	6.2	5	4,011	4.1	15,430	6.2	5	8,739	4.3	31,611	6.2
6	10,545	9.9	29,530	11.3	6	9,030	9.3	27,131	10.8	6	19,575	9.6	56,661	11.1
7	25,580	24.0	67,150	25.8	7	22,179	22.9	62,620	25.0	7	47,759	23.5	129,770	25.4
8	29,032	27.3	70,184	26.9	8	27,003	27.9	67,763	27.1	8	56,036	27.6	137,947	27.0
9	18,526	17.4	42,677	16.4	9	19,339	20.0	46,290	18.5	9	37,865	18.6	88,967	17.4
10	8,525	8.0	16,990	6.5	10	8,132	8.4	16,973	6.8	10	16,657	8.2	33,963	6.6
11	5,517	5.2	9,304	3.6	11	3,192	3.3	6,043	2.4	11	8,709	4.3	15,347	3.0
12	1,422	1.3	2,427	0.9	12	1,577	1.6	2,829	1.1	12	2,999	1.5	5,256	1.0
13	645	0.6	1,011	0.4	13	1,314	1.4	2,186	0.9	13	1,959	1.0	3,197	0.6
14	373	0.4	607	0.2	14	159	0.2	257	0.1	14	532	0.3	864	0.2
15	393	0.4	607	0.2	15	266	0.3	386	0.2	15	659	0.3	993	0.2
16	134	0.1	202	0.1	16	164	0.2	257	0.1	16	298	0.1	459	0.1
Total	106,407	100	260,510	100	Total	96,860	100	250,222	100	Total	203,267	100	510,733	100

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Table 7.–Page 2 of 2.

Age	Escapement			
	Biomass (tons)	%	Herring (x1000)	%
3	5	0.0	64	0.0
4	1,310	0.7	5,012	1.1
5	7,645	4.3	27,748	6.2
6	17,081	9.6	49,578	11.1
7	41,898	23.6	114,048	25.5
8	48,542	27.3	119,843	26.8
9	33,092	18.6	77,769	17.4
10	14,637	8.2	29,789	6.7
11	7,725	4.3	13,558	3.0
12	2,672	1.5	4,674	1.0
13	1,735	1.0	2,819	0.6
14	491	0.3	798	0.2
15	606	0.3	913	0.2
16	270	0.2	417	0.1
Total	177,707	100	447,032	100

Table 8.–Mean length (mm), weight (g), and standard deviation (SD) by age for herring of the commercial harvest by gear type, Togiak District, 2014.

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
3	1	235	NA	177	NA	3	2	276	2.1	343	7.8
4	33	249	17.6	234	44.7	4	2	270	8.5	286	29.0
5	200	251	17.8	248	61.1	5	24	276	16.3	344	61.8
6	357	269	17.4	311	67.0	6	74	282	12.7	367	55.2
7	819	274	15.3	330	65.4	7	154	285	13.8	379	58.2
8	874	282	12.6	366	59.4	8	259	290	12.5	399	51.1
9	571	285	12.7	383	65.1	9	140	290	11.8	395	50.3
10	216	297	18.3	443	95.3	10	52	298	16.0	430	68.7
11	93	308	16.6	508	92.4	11	18	306	15.0	485	71.6
12	34	309	17.6	515	96.7	12	3	309	7.8	490	59.8
13	22	321	12.7	553	70.5	13	3	325	5.2	524	95.4
14	5	317	12.1	447	255.4	14	NA	NA	NA	NA	NA
15	6	335	16.2	607	77.8	15	NA	NA	NA	NA	NA
16	3	327	10.4	585	29.8	16	NA	NA	NA	NA	NA
Average		279		358				289		394	
Total	3,234						731				

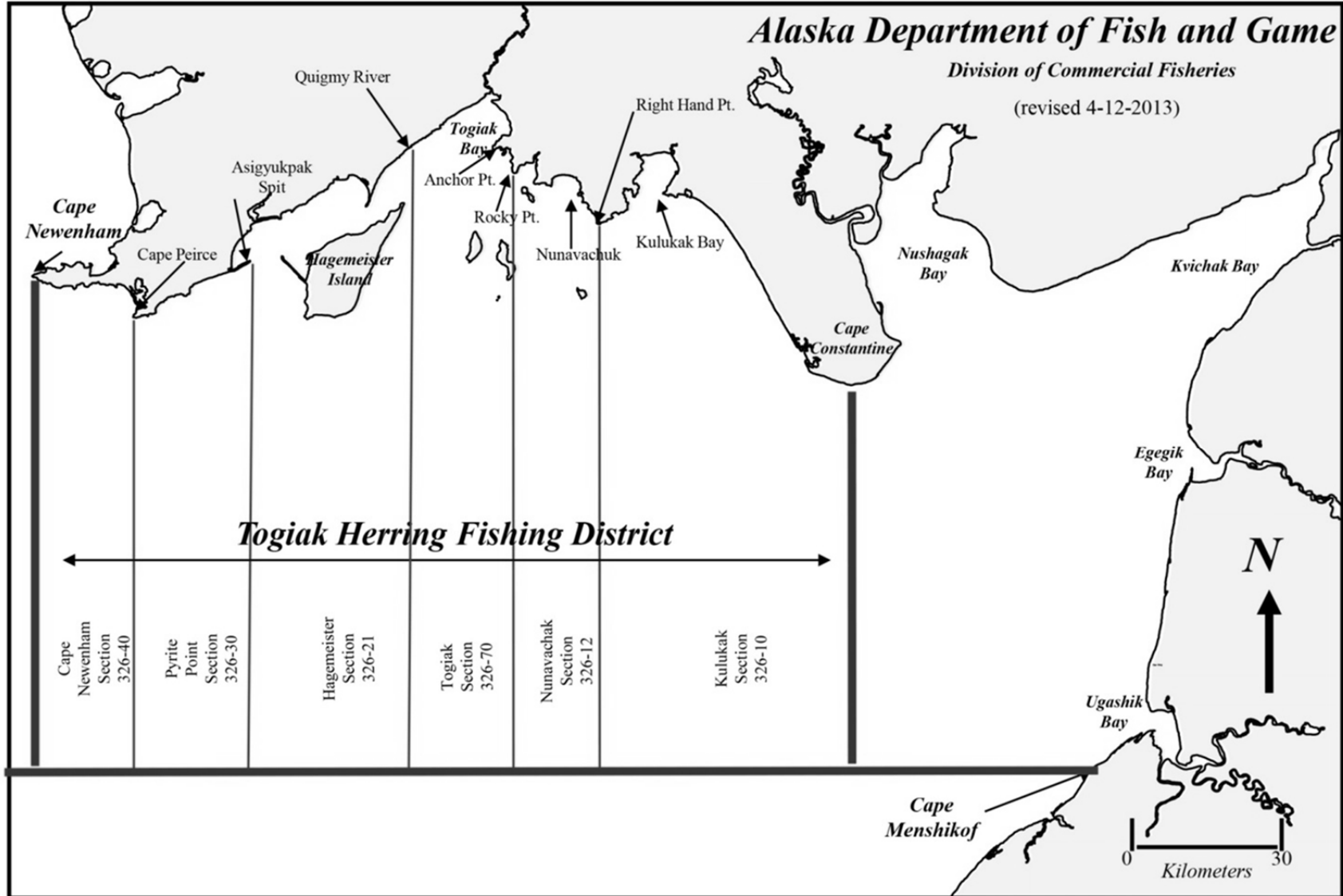


Figure 1.—Map of Togiak District herring management sections, Bristol Bay.

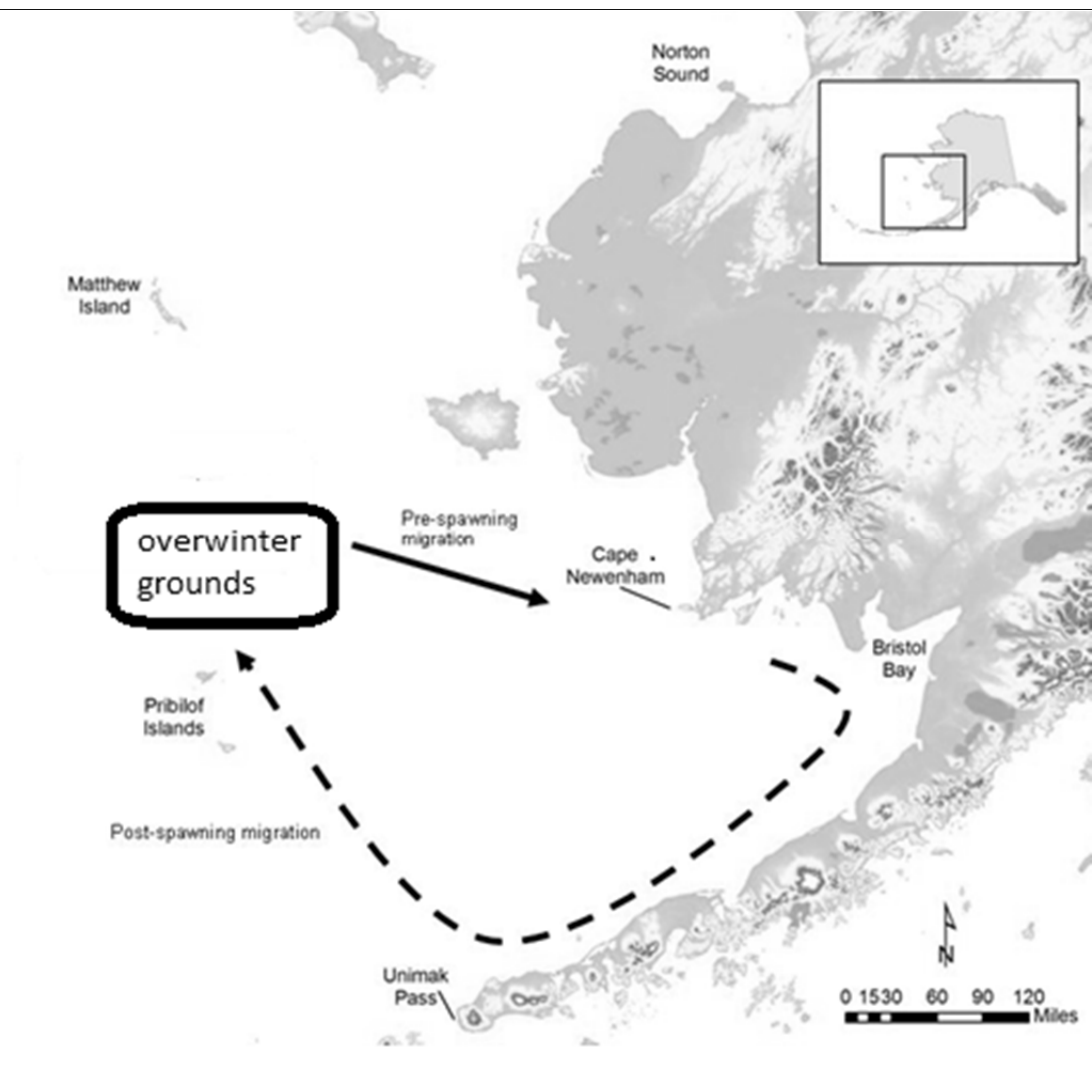


Figure 2.—Southeastern Bering Sea herring migration.

Source: Tojo et al. 2007.

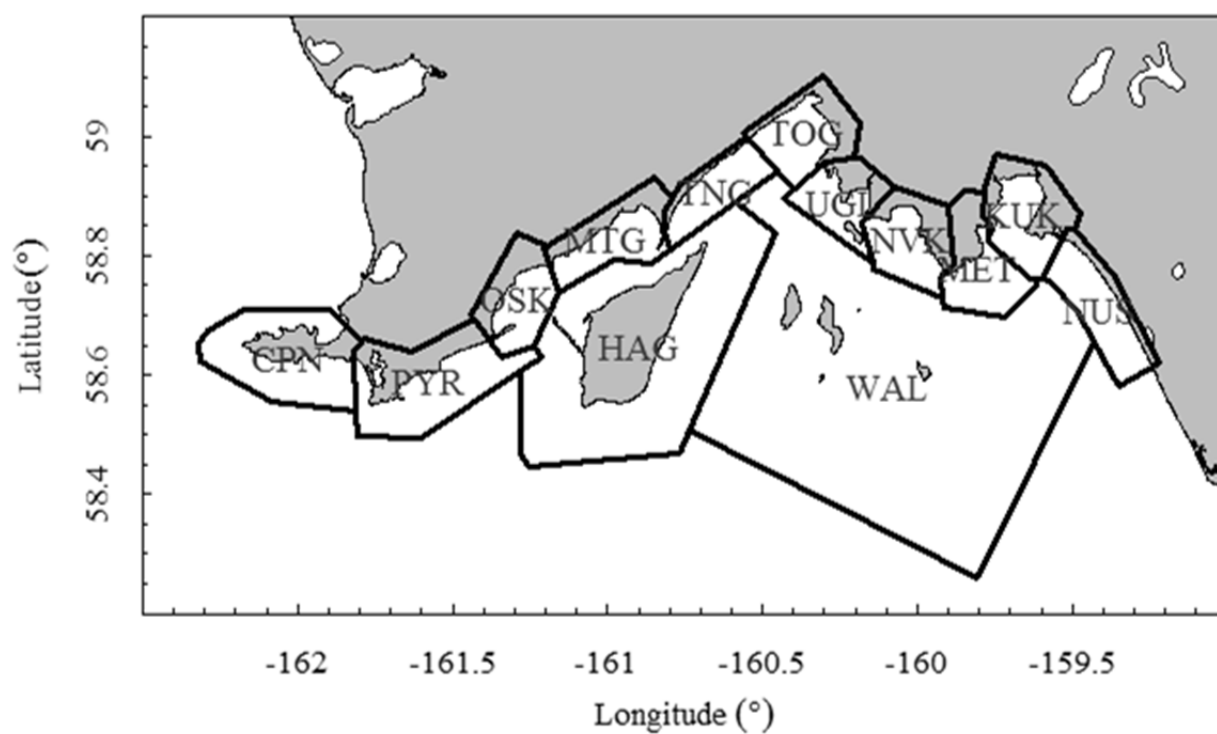


Figure 3.—Togiak herring aerial survey sections, Bristol Bay.

Note: Survey sections abbreviated as 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.

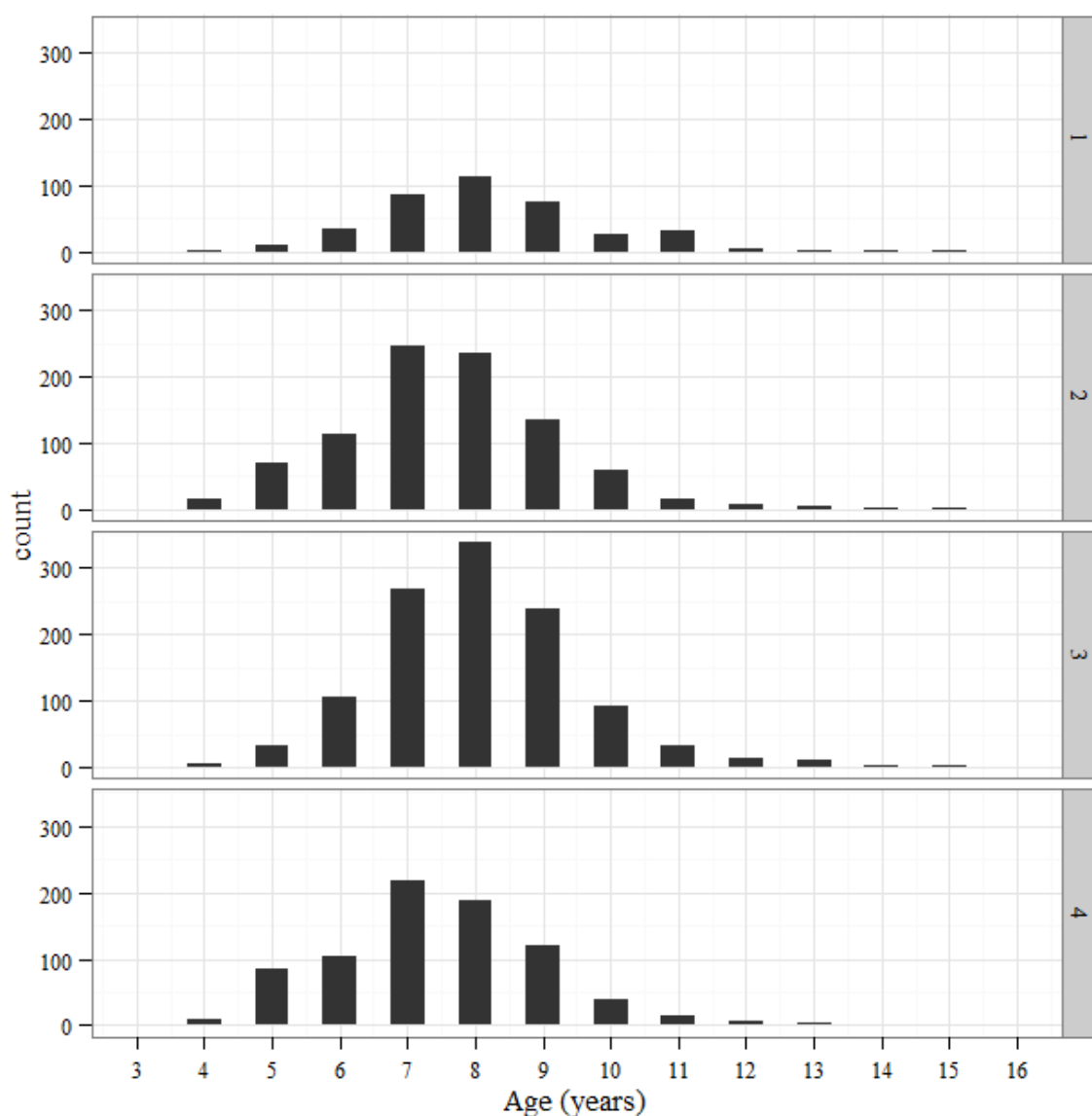


Figure 4.—Age composition of purse seine sample groups, Togiak District, 2014.

Note: Sample Group 1 = Nunavachak (April 29–30); Sample Group 2 = Togiak, Nunavachak, Hagemeister, and Pyrite Point (April 29–May 2); Sample Group 3 = Togiak, Nunavachak, Hagemeister, and Pyrite Point (May 3–6); Sample Group 4 = Togiak, Hagemeister, Pyrite Point, and Cape Newenham (May 6–11).

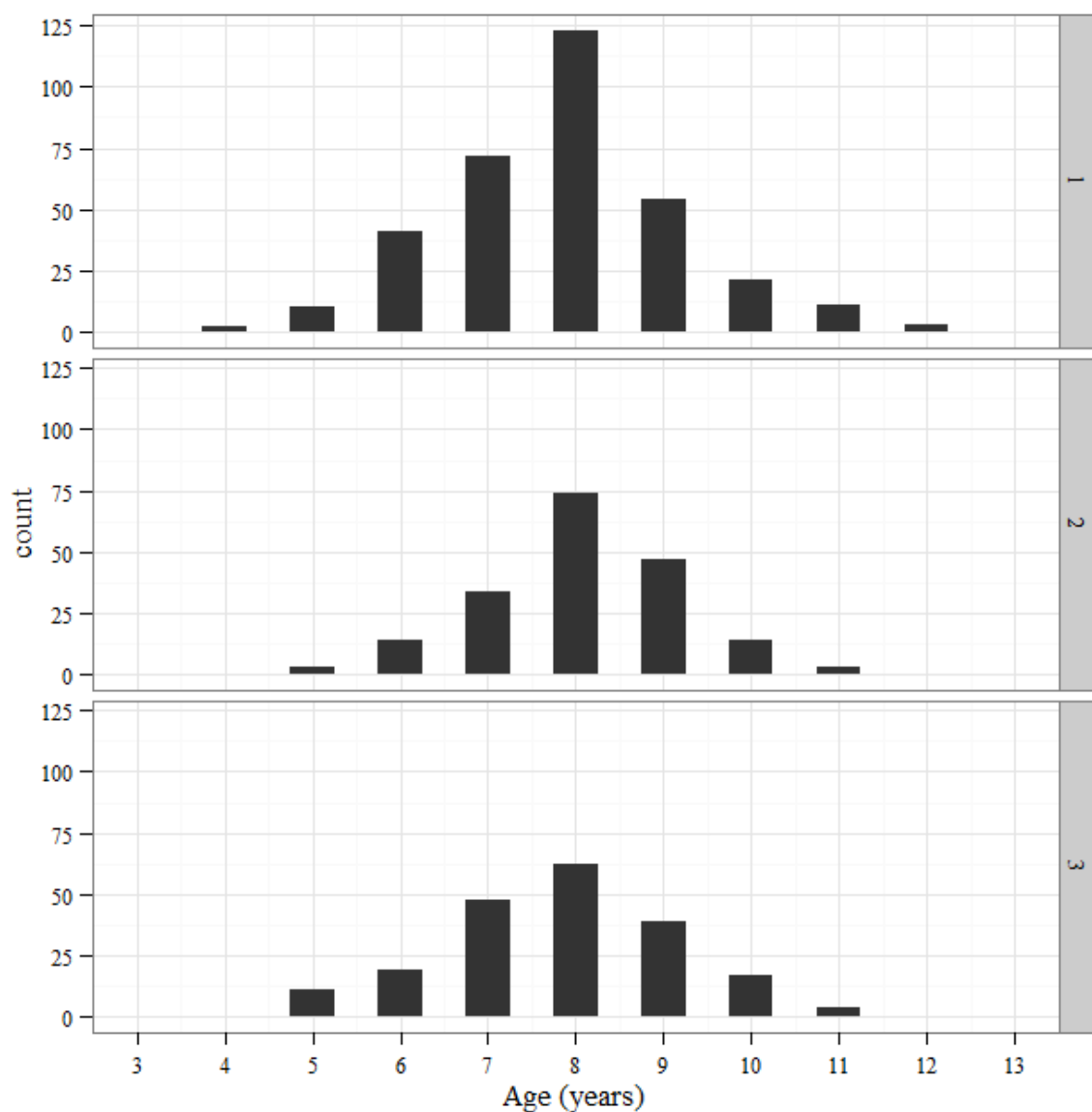


Figure 5.—Age composition of gillnet sample groups, Togiak District, 2014.

Note: Sample Group 1 = Nunavachak (April 29–30); Sample Group 2 = Togiak, Nunavachak, Hagemeister, and Pyrite Point (April 29–May 2); Sample Group 3 = Togiak, Nunavachak, Hagemeister, and Pyrite Point (May 3–6).

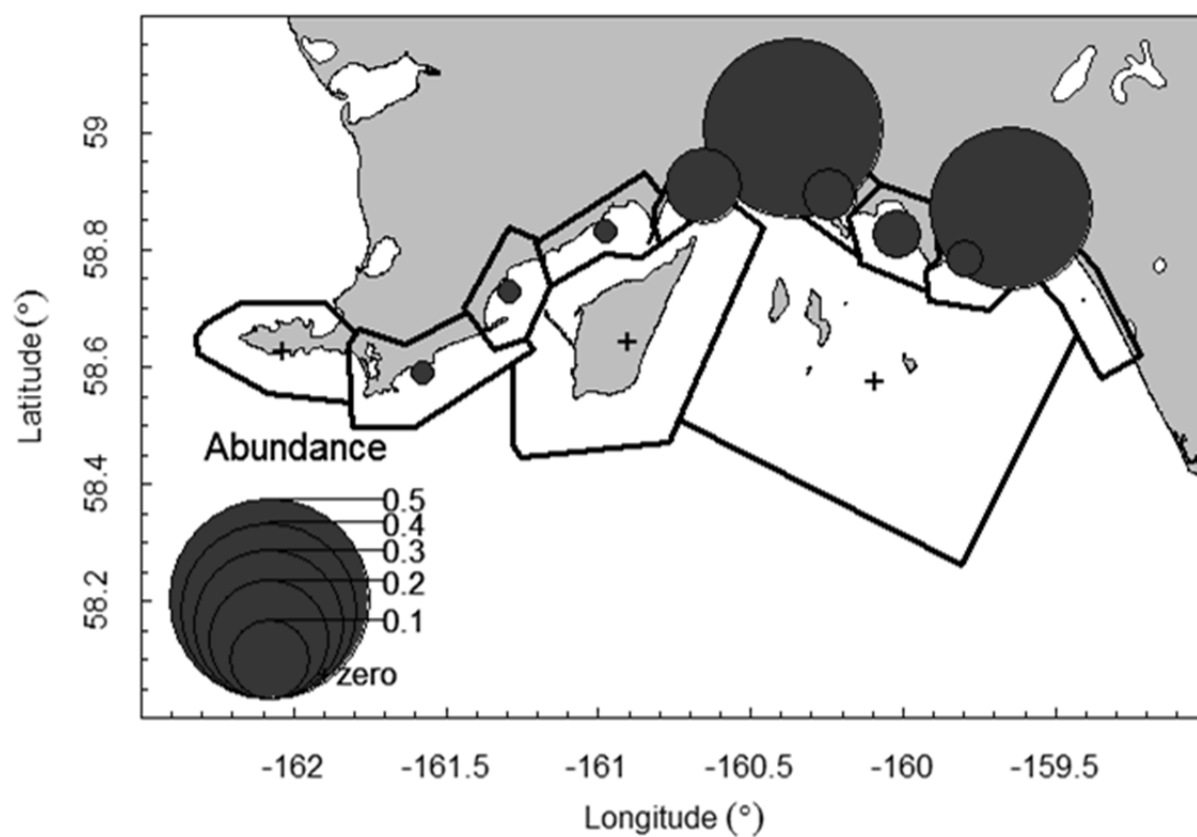


Figure 6.—Proportion of biomass estimated in each survey section during the peak biomass survey on May 2, 2014.

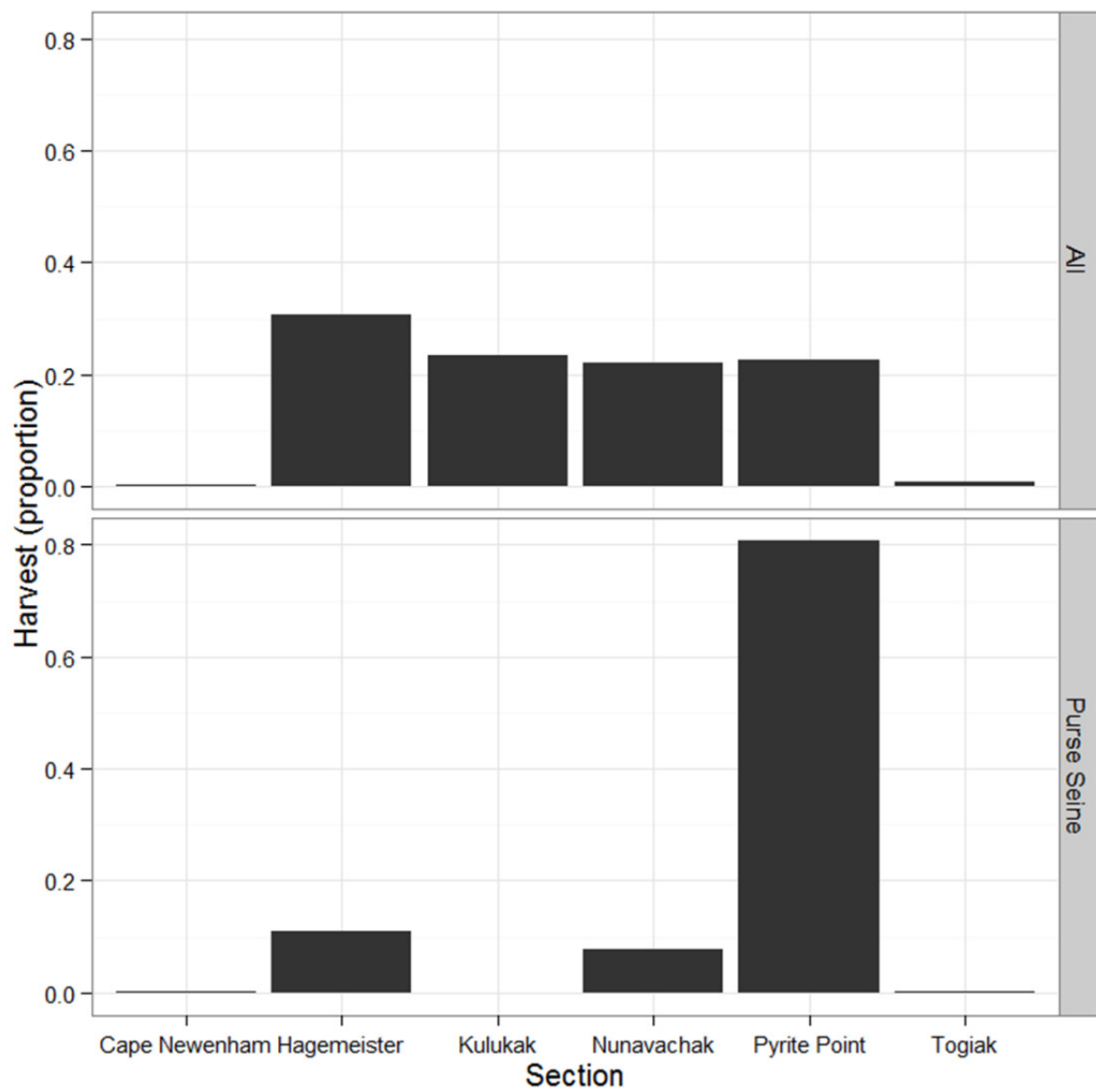


Figure 7.—Commercial herring harvest by reporting section for all gear types (top) and for purse seine only (bottom), Togiak District, 2014.

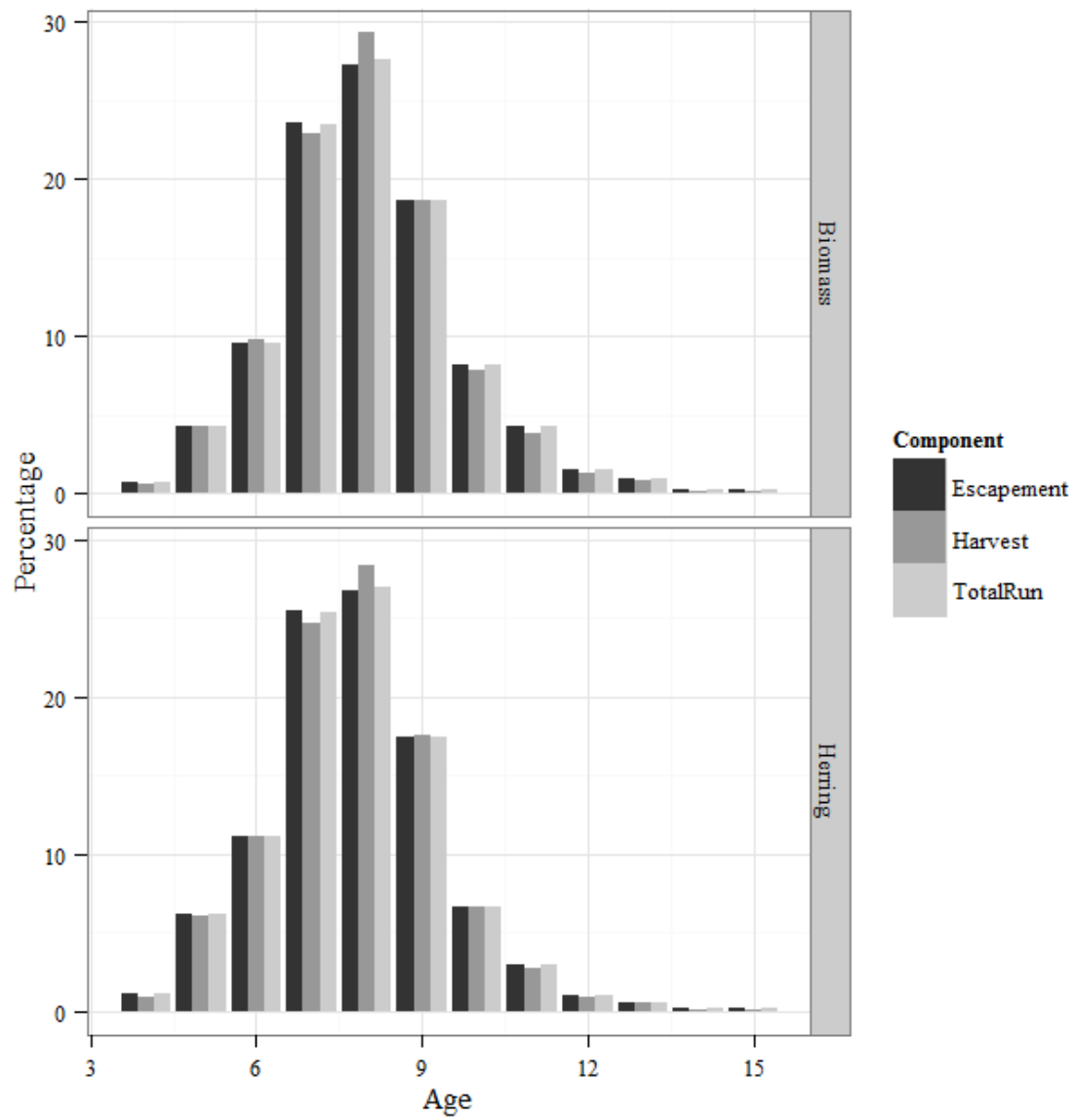


Figure 8.—Age composition of total run, escapement, and harvest by biomass (top) and numbers of fish (bottom), Togiak District, 2014.

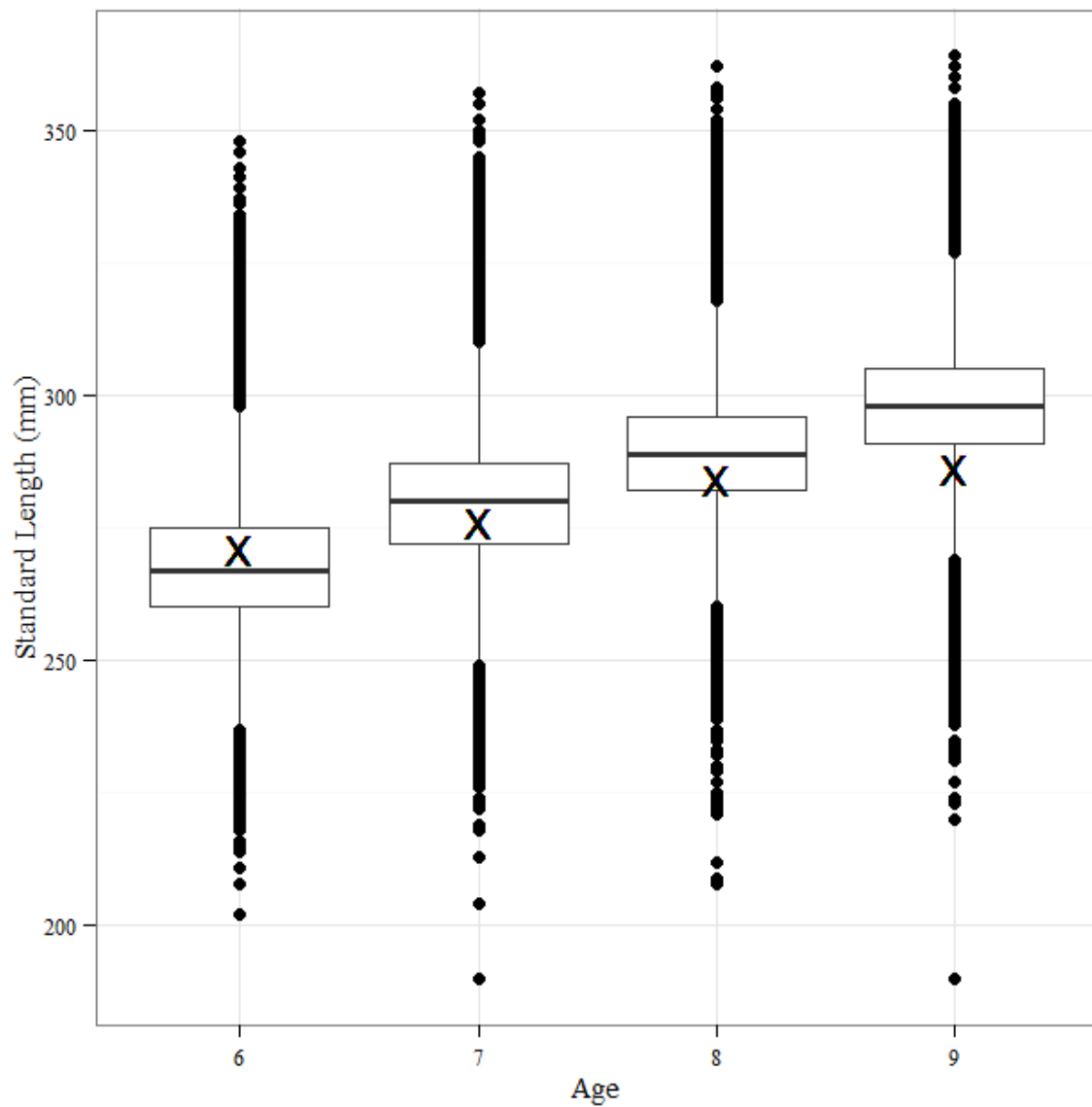


Figure 9.—Average length (denoted as X) for major age classes of herring observed (>10% by numbers or biomass) in 2014 with distribution (box and whisker plot) of historical observations (1981–present).

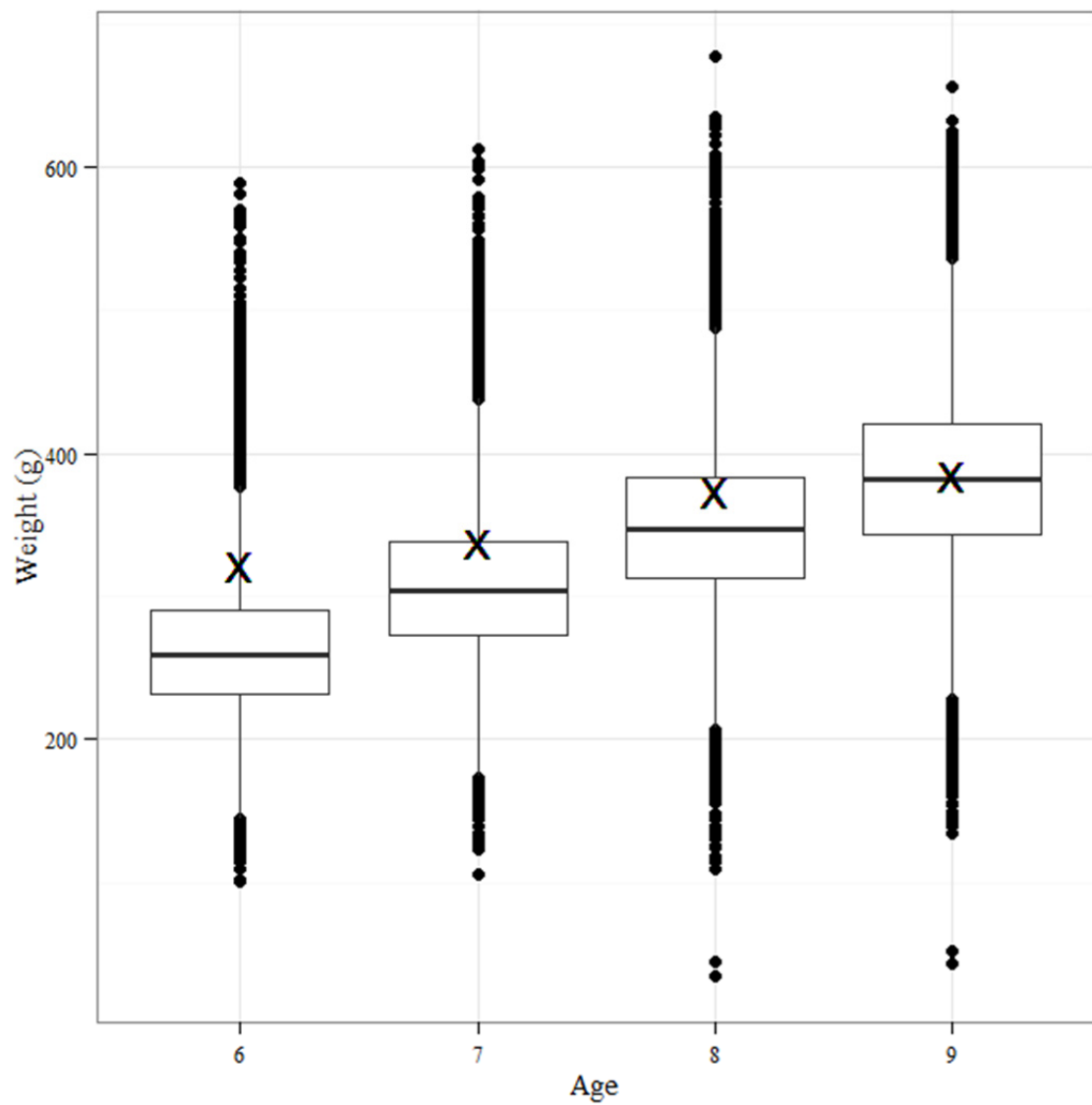


Figure 10.—Average weight (denoted as X) for major age classes of herring observed (>10% by numbers or biomass) in 2014 with distribution (box and whisker plot) of historical observations (1981–present).

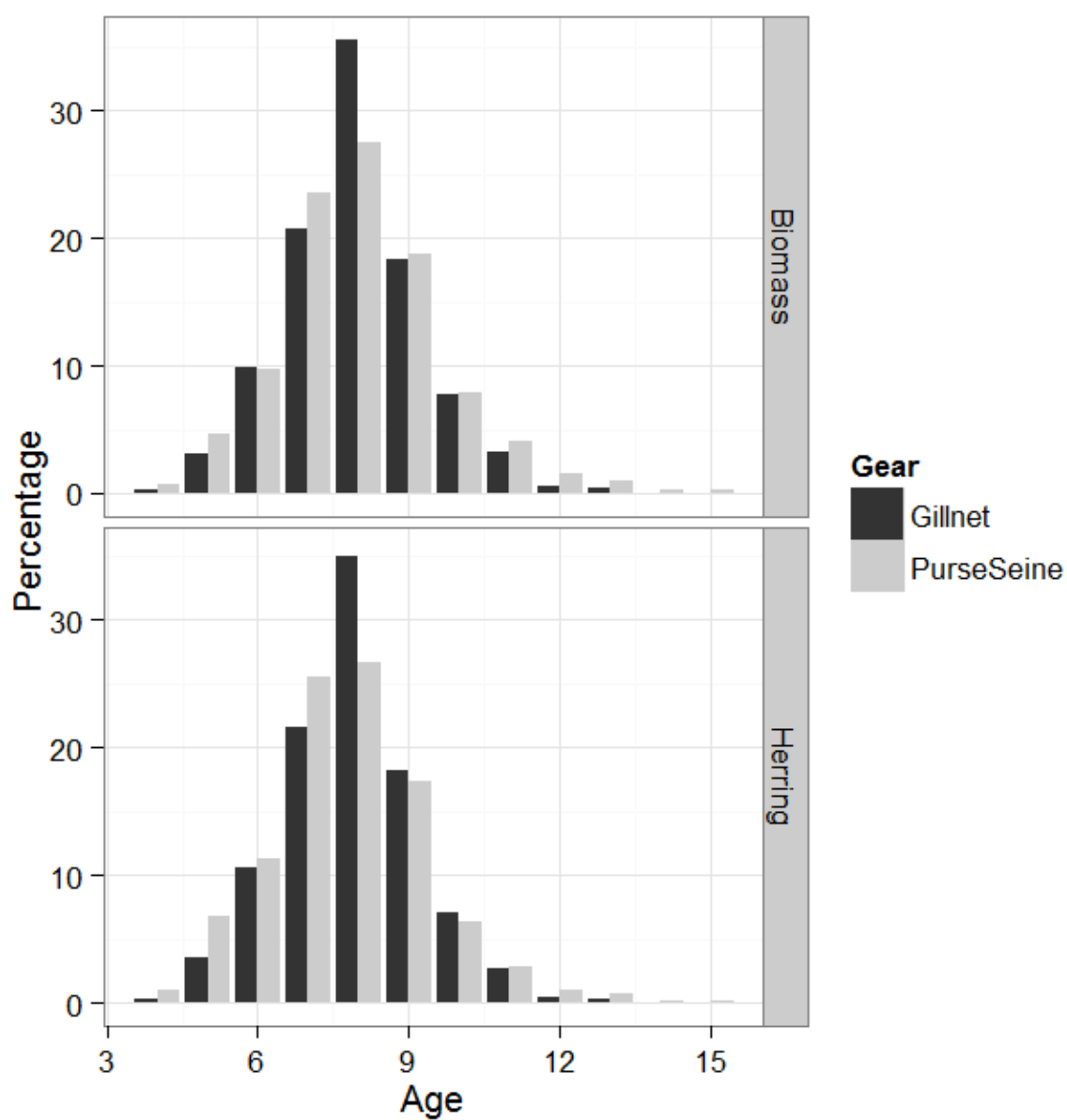


Figure 11.—Percentage composition of the commercial herring harvest by gear type, by biomass, and by numbers of fish, Togiak District, 2014.

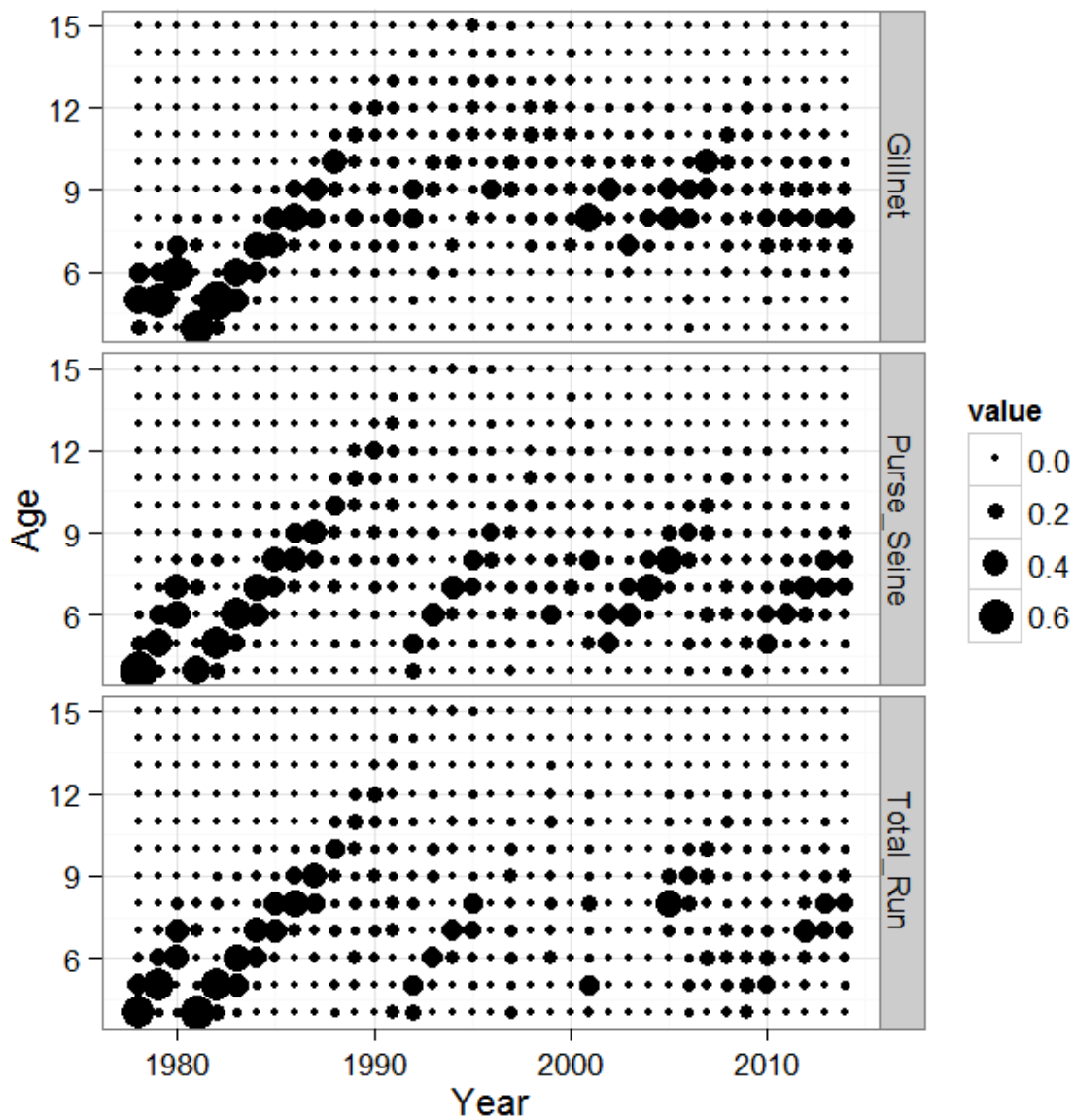


Figure 12.—Relative age class contribution (proportion) of herring in gillnet (top panel), purse seine (middle panel) and total run (bottom panel), Togiak District, Bristol Bay, 1977–2014.

Note: Age composition of total run not estimated in 1996, 1998, 2000, 2002–2004 and 2011.

**APPENDIX A:
ESTIMATED AGE COMPOSITION OF HERRING IN THE
TOGLIAK DISTRICT**

Appendix A1.–Estimated age composition of the Togiak herring run by aerial survey date, Togiak District, 2014.

Survey date 5/2/14				Survey date 1/0/00			
Index section(s): NUN,TOG,HAG,PYR				Index section(s): NUN,TOG,HAG,PYR			
Survey biomass (tons): 106,407				Survey biomass (tons): 96,860			
Age	No.	Percent by No.	Numbers (x1,000)	Age	No.	Percent by No.	Numbers (x1,000)
3	0	0.0	0	3	1	0.1	129
4	18	1.4	3,641	4	15	0.8	1,929
5	80	6.2	16,181	5	120	6.2	15,430
6	146	11.3	29,530	6	211	10.8	27,131
7	332	25.8	67,150	7	487	25.0	62,620
8	347	26.9	70,184	8	527	27.1	67,763
9	211	16.4	42,677	9	360	18.5	46,290
10	84	6.5	16,990	10	132	6.8	16,973
11	46	3.6	9,304	11	47	2.4	6,043
12	12	0.9	2,427	12	22	1.1	2,829
13	5	0.4	1,011	13	17	0.9	2,186
14	3	0.2	607	14	2	0.1	257
15	3	0.2	607	15	3	0.2	386
16	1	0.1	202	16	2	0.1	257
Total	1,288	100.0	260,510	Total	1946	100.0	250,222
Age	Weight (total g)	Percent by Wt.	Biomass (tons)	Age	Weight (total g)	Percent by Wt.	Biomass (tons)
3	0	0.0	0	3	177	0.0	25
4	4,428	0.9	987	4	3,304	0.5	468
5	21,207	4.4	4,728	5	28,297	4.1	4,011
6	47,297	9.9	10,545	6	63,708	9.3	9,030
7	114,732	24.0	25,580	7	156,483	22.9	22,179
8	130,219	27.3	29,032	8	190,518	27.9	27,003
9	83,095	17.4	18,526	9	136,445	20.0	19,339
10	38,237	8.0	8,525	10	57,376	8.4	8,132
11	24,744	5.2	5,517	11	22,521	3.3	3,192
12	6,379	1.3	1,422	12	11,123	1.6	1,577
13	2,893	0.6	645	13	9,272	1.4	1,314
14	1,674	0.4	373	14	1,120	0.2	159
15	1,763	0.4	393	15	1,879	0.3	266
16	600	0.1	134	16	1,156	0.2	164
Total	477,267	100.0	106,407	Total	683,379	100.0	96,860

Note: Sections refers to the following subdistricts within the Togiak District: TOG = Togiak, NUN = Nunavachak, HAG = Hagemester, PYR = Pyrite Point.

Appendix A2.–Estimated age composition of herring in the commercial purse seine harvest by sample group, date and fishing section(s), Togiak District, 2014.

Sample group 1				Sample group 2			
Sample date(s) 4/30				Sample date(s) 5/1-5/2			
Section(s): NUN				Section(s): NUN/HAG			
Harvest biomass (tons): 2,674				Harvest biomass (tons): 4,179			
Age	No.	Percent by No.	Numbers (x1,000)	Age	No.	Percent by No.	Numbers (x1,000)
3	0	0.0	0	3	0	0.0	0
4	2	0.5	31	4	16	1.8	188
5	10	2.6	157	5	70	7.7	821
6	33	8.7	519	6	113	12.5	1,326
7	85	22.3	1,336	7	247	27.2	2,899
8	112	29.4	1,761	8	235	25.9	2,758
9	75	19.7	1,179	9	136	15.0	1,596
10	25	6.6	393	10	59	6.5	692
11	31	8.1	487	11	15	1.7	176
12	4	1.0	63	12	8	0.9	94
13	1	0.3	16	13	4	0.4	47
14	1	0.3	16	14	2	0.2	23
15	1	0.3	16	15	2	0.2	23
16	1	0.3	16	16	0	0.0	0
Total	381	100	5,989	Total	907	100	10,644
Age	Weight (total g)	Percent by Wt.	Biomass (tons)	Age	Weight (total g)	Percent by Wt.	Biomass (tons)
1	0	0.0	0	1	0	0.0	0
2	0	0.0	0	2	0	0.0	0
3	0	0.0	0	3	0	0.0	0
4	687	0.4	12	4	3,741	1.2	48
5	3,127	2.0	54	5	18,080	5.6	234
6	11,283	7.3	196	6	36,014	11.1	466
7	31,219	20.2	541	7	83,578	25.9	1,081
8	43,702	28.3	757	8	86,524	26.8	1,119
9	30,840	20.0	534	9	52,289	16.2	676
10	11,795	7.6	204	10	26,442	8.2	342
11	16,924	11.0	293	11	7,820	2.4	101
12	2,305	1.5	40	12	4,074	1.3	53
13	605	0.4	10	13	2,288	0.7	30
14	605	0.4	10	14	1,116	0.3	14
15	650	0.4	11	15	1,113	0.3	14
16	600	0.4	10	16	0	0.0	0
Total	154,342	100.0	2,674	Total	323,079	100	4,179

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Sample group 3				Sample group 4			
Sample date(s) 5/3-5/5				Sample date(s) 5/6-5/7			
Section(s): HAG/PYR				Section(s): PYR			
Harvest biomass (tons): 6,191				Harvest biomass (tons): 6,499			
Age	No.	Percent by No.	Numbers (x1,000)	Age	No.	Percent by No.	Numbers (x1,000)
3	0	0.0	0	3	1	0.1	23
4	5	0.4	66	4	10	1.3	226
5	34	3.0	451	5	86	10.8	1,947
6	107	9.3	1,421	6	104	13.1	2,354
7	268	23.3	3,559	7	219	27.5	4,958
8	338	29.4	4,488	8	189	23.7	4,279
9	239	20.8	3,174	9	121	15.2	2,739
10	93	8.1	1,235	10	39	4.9	883
11	32	2.8	425	11	15	1.9	340
12	15	1.3	199	12	7	0.9	158
13	12	1.0	159	13	5	0.6	113
14	2	0.2	27	14	0	0.0	0
15	3	0.3	40	15	0	0.0	0
16	2	0.2	27	16	0	0.0	0
Total	1150	100	15,271	Total	796	100	18,020
Age	Weight (total g)	Percent by Wt.	Biomass (tons)	Age	Weight (total g)	Percent by Wt.	Biomass (tons)
1	0	0.0	0	1	0	0.0	0
2	0	0.0	0	2	0	0.0	0
3	0	0.0	0	3	177	0.1	4
4	1,087	0.3	16	4	2,217	0.9	55
5	8,215	1.9	120	5	20,082	7.7	501
6	34,124	8.1	499	6	29,584	11.4	738
7	88,704	21.0	1,298	7	67,779	26.0	1,691
8	123,335	29.2	1,805	8	67,183	25.8	1,677
9	91,626	21.7	1,341	9	44,819	17.2	1,118
10	41,056	9.7	601	10	16,320	6.3	407
11	16,067	3.8	235	11	6,454	2.5	161
12	7,720	1.8	113	12	3,403	1.3	85
13	6,852	1.6	100	13	2,420	0.9	60
14	1,120	0.3	16	14	0	0.0	0
15	1,879	0.4	28	15	0	0.0	0
16	1,156	0.3	17	16	0	0.0	0
Total	422,941	100	6,191	Total	260,438	100	6,499

Note: Sections refers to the following subdistricts within the Togiak District: NUN = Nunavachak, HAG = Hagemeister, and PYR = Pyrite Point.

Appendix A3.–Estimated age composition of herring in the commercial gillnet harvest by sample group, date and fishing section(s), Togiak District, 2014.

Sample group	1			Sample group	2		
Sample date(s)	5/1/-5/3			Sample date(s)	5/5		
Section(s):	KUK			Section(s):	KUK		
Harvest biomass (tons):	3,438			Harvest biomass (tons):	819		
		Percent	Numbers			Percent	Numbers
Age	No.	by No.	(x1,000)	Age	No.	by No.	(x1,000)
3	0	0.0	0	3	0	0.0	0
4	2	0.6	45	4	0	0.0	0
5	10	3.0	225	5	3	1.6	31
6	41	12.1	923	6	14	7.3	143
7	72	21.3	1,621	7	34	17.8	347
8	123	36.4	2,770	8	74	38.7	755
9	54	16.0	1,216	9	47	24.6	480
10	21	6.2	473	10	14	7.3	143
11	11	3.3	248	11	3	1.6	31
12	3	0.9	68	12	0	0.0	0
13	1	0.3	23	13	2	1.0	20
Total	338	100.0	7,611	Total	191	100.0	1,949
		Percent Weighted by				Percent Weighted by	
Age	Weight	Weight	Biomass	Age	Weight	Weight	Biomass
3	0	0.0	0	3	0	0.0	0
4	571	0.4	14	4	0	0.0	0
5	3,675	2.7	91	5	1,011	1.4	11
6	15,574	11.2	387	6	4,931	6.8	55
7	29,109	21.0	723	7	12,446	17.1	140
8	50,610	36.5	1,256	8	28,356	39.0	319
9	21,776	15.7	540	9	17,673	24.3	199
10	9,791	7.1	243	10	5,685	7.8	64
11	5,497	4.0	136	11	1,520	2.1	17
12	1,470	1.1	36	12	0	0.0	0
13	434	0.3	11	13	1,138	1.6	13
Total	138,507	100.0	3,438	Total	72,760	100.0	819

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Sample group	3		
Sample date(s)	5/7		
Section(s):	KUK		
Harvest biomass (tons):	1,760		
Age	No.	Percent by No.	Numbers (x1,000)
3	2	1.0	42
4	0	0.0	0
5	11	5.4	230
6	19	9.4	397
7	48	23.8	1,002
8	62	30.7	1,294
9	39	19.3	814
10	17	8.4	355
11	4	2.0	83
12	0	0.0	0
13	0	0.0	0
Total	202	100.0	4,216
Age	Weight	Percent Weighted by	
		Weight	Biomass
3	685	0.9	16
4	0	0.0	0
5	3,563	4.7	82
6	6,649	8.7	153
7	16,791	22.0	386
8	24,367	31.9	561
9	15,807	20.7	364
10	6,900	9.0	159
11	1,715	2.2	39
12	0	0.0	0
13	0	0.0	0
Total	76,477	100.0	1,760

Note: Sections refers to the following subdistricts within the Togiak District: KUK = Kulukak.

APPENDIX B:
AGE, SEX, AND SIZE COMPOSITION OF HERRING
CAUGHT BY COMMERCIAL PURSE SEINE

Appendix B1.—Age, sex, and size composition of herring caught by commercial purse seine, Hagemeister Section.

Sample dates	Age	Sex (number)				% of Total	SE	Weight		Number weighed	Length		Number measured
		Male	Female	Unk.	Total			Mean (g)	SD		Mean (mm)	SD	
5/2	4	3	4	0	7	1.2	0.5	213	31.1	7	239	10.4	7
	5	20	27	3	50	8.7	1.2	246	59.7	50	250	17.3	50
	6	46	33	0	79	13.8	1.4	315	74.2	79	269	18.9	79
	7	66	79	4	149	26.0	1.8	332	66.0	149	275	16.7	149
	8	67	77	0	144	25.2	1.8	367	59.1	144	281	12.1	144
	9	34	53	1	88	15.4	1.5	376	63.5	88	284	14.7	88
	10	11	25	0	36	6.3	1.0	440	94.9	36	295	17.0	36
	11	2	10	0	12	2.1	0.6	525	119.3	12	304	23.9	12
	12	0	3	0	3	0.5	0.3	548	78.3	3	315	13.0	3
	13	1	1	0	2	0.3	0.2	503	3.5	2	319	15.6	2
	14	1	0	0	1	0.2	0.2	578	NA	1	319	NA	1
	15	0	1	0	1	0.2	0.2	600	NA	1	328	NA	1
Sample total		251	313	8	572	100.0		350	88.2	572	277	20.2	572
5/3	4	3	0	0	3	0.8	0.4	200	11.6	3	239	5.5	3
	5	10	5	0	15	3.8	1.0	229	52.7	15	249	18.3	15
	6	22	19	0	41	10.4	1.5	323	75.1	41	272	19.3	41
	7	55	31	0	86	21.9	2.1	329	61.3	86	276	14.9	86
	8	55	68	1	124	31.6	2.3	365	55.9	124	282	12.6	124
	9	32	39	1	72	18.3	2.0	386	58.5	72	287	11.2	72
	10	12	20	1	33	8.4	1.4	443	88.4	33	298	17.8	33
	11	3	7	0	10	2.5	0.8	555	88.8	10	315	13.4	10
	12	1	4	0	5	1.3	0.6	573	48.4	5	318	7.7	5
	13	0	2	0	2	0.5	0.4	559	53.7	2	328	6.4	2
	14	1	1	0	2	0.5	0.4	560	100.4	2	326	11.3	2
Sample total		194	196	3	393	100.0		366	88.3	393	282	19.1	393

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Sample dates	Age	Sex (number)				% of Total	SE	Weight		Number weighed	Length		Number measured
		Male	Female	Unk.	Total			Mean (g)	SD		Mean (mm)	SD	
5/5	4	0	1	0	1	0.3	0.3	281		1	263	NA	1
	5	5	2	0	7	1.9	0.7	234	49.4	7	249	14.3	7
	6	16	16	0	32	8.9	1.5	323	51.2	32	272	11.3	32
	7	44	34	2	80	22.2	2.2	331	52.1	80	275	12.8	80
	8	39	49	0	88	24.4	2.3	357	46.3	88	281	11.1	88
	9	46	45	2	93	25.8	2.3	380	57.8	93	286	11.5	93
	10	11	25	0	36	10.0	1.6	438	85.4	36	297	15.5	36
	11	5	8	1	14	3.9	1.0	478	87.0	14	304	14.3	14
	12	3	3	0	6	1.7	0.7	467	110.1	6	302	21.0	6
	13	2	2	0	4	1.1	0.6	560	45.9	4	324	3.2	4
Sample total		171	185	5	361	100.0		368	76.5	361	283	16.3	361
Samples combined		616	694	16	1,326			360	86	1,326	280	19	1,326

Appendix B2.—Age, sex, and size composition of herring caught by commercial purse seine, Nunavachak Section.

Sample dates	Sex (number)						SE	Weight		Number weighed	Length		
	Age	Male	Female	Unk.	Total	% of Total		Mean (g)	SD		Mean (mm)	SD	Number measured
4/30	4	1	1	0	2	0.5	0.4	344	3.5	2	281	11.3	2
	5	7	3	0	10	2.6	0.8	313	61.2	10	269	17.0	10
	6	18	15	0	33	8.7	1.4	342	51.9	33	275	10.5	33
	7	31	50	4	85	22.3	2.1	367	53.5	82	278	11.4	85
	8	53	57	2	112	29.4	2.3	390	57.4	111	284	12.8	112
	9	31	41	3	75	19.7	2.0	411	61.8	73	286	12.1	75
	10	13	12	0	25	6.6	1.3	472	118.6	25	302	22.1	25
	11	8	23	0	31	8.1	1.4	546	62.5	31	313	11.0	31
	12	2	2	0	4	1.0	0.5	576	99.4	4	321	9.1	4
	13	1	0	0	1	0.3	0.3	605	NA	1	330	NA	1
	14	0	0	1	1	0.3	0.3	NA	NA	0	301	NA	1
	15	1	0	0	1	0.3	0.3	650	NA	1	334	NA	1
	16	1	0	0	1	0.3	0.3	600	NA	1	332	NA	1
Sample total		167	204	10	381	100.0		405	87.0	374	286	17.4	381
5/1	4	7	2	0	9	2.7	0.9	250	44.3	9	263	17.3	9
	5	12	8	0	20	6.0	1.3	289	71.5	20	262	18.7	20
	6	25	9	0	34	10.1	1.7	327	69.8	34	276	17.8	34
	7	52	43	3	98	29.3	2.5	349	57.6	98	280	14.0	98
	8	49	40	2	91	27.2	2.4	370	54.3	90	287	13.6	91
	9	26	22	0	48	14.3	1.9	399	69.9	48	291	13.3	48
	10	10	13	0	23	6.9	1.4	461	109.3	23	302	19.6	23
	11	1	2	0	3	0.9	0.5	509	24.0	3	315	13.7	3
	12	3	2	0	5	1.5	0.7	486	93.0	5	304	13.0	5
	13	1	1	0	2	0.6	0.4	642	19.1	2	329	3.5	2
	14	0	1	0	1	0.3	0.3	538	NA	1	311	NA	1
	15	1	0	0	1	0.3	0.3	513	NA	1	330	NA	1
Sample total		187	143	5	335	100.0		367	83.2	334	284	18.3	335
Samples combined		354	347	15	716			387	87.2	708	285	17.9	716

Appendix B3.–Age, sex, and size composition of herring caught by commercial purse seine, all sections.

Sample dates	Age	Sex (number)					SE	Weight		Number weighed	Length		Number measured
		Male	Female	Unk.	Total	% of Total		Mean (g)	SD		Mean (mm)	SD	
4/30	4	1	1	0	2	0.5	0.4	344	3.5	2	281	11.3	2
	5	7	3	0	10	2.6	0.8	313	61.2	10	269	17.0	10
	6	18	15	0	33	8.7	1.4	342	51.9	33	275	10.5	33
	7	31	50	4	85	22.3	2.1	367	53.5	82	278	11.4	85
	8	53	57	2	112	29.4	2.3	390	57.4	111	284	12.8	112
	9	31	41	3	75	19.7	2.0	411	61.8	73	286	12.1	75
	10	13	12	0	25	6.6	1.3	472	118.6	25	302	22.1	25
	11	8	23	0	31	8.1	1.4	546	62.5	31	313	11.0	31
	12	2	2	0	4	1.0	0.5	576	99.4	4	321	9.1	4
	13	1	0	0	1	0.3	0.3	605	NA	1	330	NA	1
	14	0	0	1	1	0.3	0.3	NA	NA	0	301	NA	1
	15	1	0	0	1	0.3	0.3	650	NA	1	334	NA	1
	16	1	0	0	1	0.3	0.3	600	NA	1	332	NA	1
Sample total		167	204	10	381	100.0		405	87.0	374	286	17.4	381
5/1	4	7	2	0	9	2.7	0.9	250	44.3	9	263	17.3	9
	5	12	8	0	20	6.0	1.3	289	71.5	20	262	18.7	20
	6	25	9	0	34	10.1	1.7	327	69.8	34	276	17.8	34
	7	52	43	3	98	29.3	2.5	349	57.6	98	280	14.0	98
	8	49	40	2	91	27.2	2.4	370	54.3	90	287	13.6	91
	9	26	22	0	48	14.3	1.9	399	69.9	48	291	13.3	48
	10	10	13	0	23	6.9	1.4	461	109.3	23	302	19.6	23
	11	1	2	0	3	0.9	0.5	509	24.0	3	315	13.7	3
	12	3	2	0	5	1.5	0.7	486	93.0	5	304	13.0	5
	13	1	1	0	2	0.6	0.4	642	19.1	2	329	3.5	2
	14	0	1	0	1	0.3	0.3	538	NA	1	311	NA	1
	15	1	0	0	1	0.3	0.3	513	NA	1	330	NA	1
Sample total		187	143	5	335	100.0		367	83.2	334	284	18.3	335

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Sample dates	Age	Sex (number)						SE	Weight		Length		
		Male	Female	Unk.	Total	% of Total	Mean (g)		SD	Number weighed	Mean (mm)	SD	Number measured
5/2	4	3	4	0	7	1.2	0.5	213	31.1	7	239	10.4	7
	5	20	27	3	50	8.7	1.2	246	59.7	50	250	17.3	50
	6	46	33	0	79	13.8	1.4	315	74.2	79	269	18.9	79
	7	66	79	4	149	26.0	1.8	332	66.0	149	275	16.7	149
	8	67	77	0	144	25.2	1.8	367	59.1	144	281	12.1	144
	9	34	53	1	88	15.4	1.5	376	63.5	88	284	14.7	88
	10	11	25	0	36	6.3	1.0	440	94.9	36	295	17.0	36
	11	2	10	0	12	2.1	0.6	525	119.3	12	304	23.9	12
	12	0	3	0	3	0.5	0.3	548	78.3	3	315	13.0	3
	13	1	1	0	2	0.3	0.2	503	3.5	2	319	15.6	2
	14	1	0	0	1	0.2	0.2	578	NA	1	319	NA	1
	15	0	1	0	1	0.2	0.2	600	NA	1	328	NA	1
Sample total		251	313	8	572	100.0		350	88.2	572	277	20.2	572
5/3	4	3	0	0	3	0.8	0.4	200	11.6	3	239	5.5	3
	5	10	5	0	15	3.8	1.0	229	52.7	15	249	18.3	15
	6	22	19	0	41	10.4	1.5	323	75.1	41	272	19.3	41
	7	55	31	0	86	21.9	2.1	329	61.3	86	276	14.9	86
	8	55	68	1	124	31.6	2.3	365	55.9	124	282	12.6	124
	9	32	39	1	72	18.3	2.0	386	58.5	72	287	11.2	72
	10	12	20	1	33	8.4	1.4	443	88.4	33	298	17.8	33
	11	3	7	0	10	2.5	0.8	555	88.8	10	315	13.4	10
	12	1	4	0	5	1.3	0.6	573	48.4	5	318	7.7	5
	13	0	2	0	2	0.5	0.4	559	53.7	2	328	6.4	2
	14	1	1	0	2	0.5	0.4	560	100.4	2	326	11.3	2
Sample total		194	196	3	393	100.0		366	88.3	393	282	19.1	393

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Sample dates	Age	Sex (number)				% of Total	SE	Mean (g)	SD	Weight	Length		
		Male	Female	Unk.	Total					Number weighed	Mean (mm)	SD	Number measured
5/4	4	1	0	0	1	0.3	0.3	205	NA	1	239	NA	1
	5	5	6	1	12	3.0	0.9	261	60.0	12	257	20.6	12
	6	17	17	0	34	8.6	1.4	310	69.5	34	269	18.4	34
	7	53	49	0	102	25.8	2.2	333	63.6	102	276	15.5	102
	8	56	67	3	126	31.8	2.3	370	52.5	126	283	11.5	126
	9	29	45	0	74	18.7	2.0	384	51.6	74	285	11.5	74
	10	7	16	1	24	6.1	1.2	444	82.8	24	297	17.5	24
	11	4	4	0	8	2.0	0.7	478	87.9	8	312	17.4	8
	12	2	2	0	4	1.0	0.5	513	65.3	4	310	17.3	4
	13	1	5	0	6	1.5	0.6	583	57.7	6	325	13.2	6
	15	0	3	0	3	0.8	0.4	626	96.0	3	339	24.5	3
	16	1	1	0	2	0.5	0.4	578	38.2	2	325	13.4	2
Sample total		176	215	5	396	100.0		369	82.9	396	282	18.7	396
5/5	4	0	1	0	1	0.3	0.3	281	NA	1	263	NA	1
	5	5	2	0	7	1.9	0.7	234	49.4	7	249	14.3	7
	6	16	16	0	32	8.9	1.5	323	51.2	32	272	11.3	32
	7	44	34	2	80	22.2	2.2	331	52.1	80	275	12.8	80
	8	39	49	0	88	24.4	2.3	357	46.3	88	281	11.1	88
	9	46	45	2	93	25.8	2.3	380	57.8	93	286	11.5	93
	10	11	25	0	36	10.0	1.6	438	85.4	36	297	15.5	36
	11	5	8	1	14	3.9	1.0	478	87.0	14	304	14.3	14
	12	3	3	0	6	1.7	0.7	467	110.1	6	302	21.0	6
	13	2	2	0	4	1.1	0.6	560	45.9	4	324	3.2	4
Sample total		171	185	5	361	100.0		368	76.5	361	283	16.3	361

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Sample dates	Age	Sex (number)				% of Total	SE	Weight		Number weighed	Length		Number measured
		Male	Female	Unk.	Total			Mean (g)	SD		Mean (mm)	SD	
5/6	4	3	3	0	6	1.7	0.7	227	24.4	6	243	7.9	6
	5	22	14	0	36	10.4	1.6	242	57.8	36	249	18.1	36
	6	16	20	0	36	10.4	1.6	292	59.5	36	263	15.9	36
	7	45	44	1	90	25.9	2.4	318	58.9	90	270	14.9	90
	8	47	45	1	93	26.8	2.4	362	58.1	93	280	12.2	93
	9	27	29	0	56	16.1	2.0	375	54.1	56	283	12.8	56
	10	9	8	0	17	4.9	1.2	386	76.1	17	285	16.2	17
	11	3	3	0	6	1.7	0.7	424	73.5	6	294	10.6	6
	12	0	3	0	3	0.9	0.5	404	128.7	3	288	33.7	3
	13	2	2	0	4	1.2	0.6	472	87.2	4	311	19.6	4
Sample total		174	171	2	347	100.0		335	76.2	347	273	18.8	347
5/7	3	1	0	0	1	0.2	0.2	177	NA	1	235	NA	1
	4	2	2	0	4	0.9	0.4	214	22.5	4	237	11.0	4
	5	29	21	0	50	11.1	1.5	227	49.4	50	245	13.6	50
	6	40	27	1	68	15.1	1.7	280	55.0	68	262	16.9	68
	7	64	64	1	129	28.7	2.1	304	61.1	129	267	15.7	129
	8	52	44	0	96	21.4	1.9	349	61.6	96	276	13.0	96
	9	31	34	0	65	14.5	1.7	367	63.9	65	282	13.5	65
	10	7	15	0	22	4.9	1.0	443	96.9	22	296	19.2	22
	11	6	3	0	9	2.0	0.7	434	99.4	9	293	18.7	9
	12	1	3	0	4	0.9	0.4	548	86.0	4	314	11.6	4
	13	0	1	0	1	0.2	0.2	531	NA	1	305	NA	1
Sample total		233	214	2	449	100.0		321	85.6	449	270	20.3	449
Samples combined		1,553	1,641	40	3,234			359	87.2	3,226	279	19.6	3,234

**APPENDIX C:
AGE, SEX, AND SIZE COMPOSITION OF HERRING
CAUGHT BY COMMERCIAL GILLNET**

Appendix C1.–Age, sex, and size composition of herring caught by commercial gillnet, Kulukak Section.

Sample dates	Age	Sex (number)				% of Total	SE	Weight		Number weighed	Length		Number measured
		Male	Female	Unk.	Total			Mean (g)	SD		Mean (mm)	Sd	
5/1	5	3	2	0	5	2.9	1.3	365	70.2	5	279	18.9	5
	6	8	9	0	17	9.8	2.3	399	48.2	17	285	11.2	17
	7	20	18	0	38	22.0	3.2	433	49.3	38	293	13.2	38
	8	27	39	2	68	39.3	3.7	424	50.9	68	291	11.8	68
	9	14	12	0	26	15.0	2.7	408	43.0	26	290	9.6	26
	10	5	7	0	12	6.9	1.9	489	84.9	12	310	19.1	12
	11	2	3	0	5	2.9	1.3	525	61.3	5	309	5.7	5
	12	2	0	0	2	1.2	0.8	507	74.2	2	307	9.2	2
Sample total		81	90	2	173	100.0		428	59.9	173	293	13.9	173
5/3	4	0	1	1	2	1.2	0.9	286	29.0	2	270	8.5	2
	5	1	4	0	5	3.0	1.3	370	61.4	5	281	12.6	5
	6	9	15	0	24	14.5	2.8	366	36.9	24	283	9.3	24
	7	14	20	0	34	20.6	3.2	372	47.4	34	284	11.4	34
	8	20	35	0	55	33.3	3.7	396	49.0	55	288	13.0	55
	9	14	12	2	28	17.0	2.9	399	51.7	28	289	13.1	28
	10	5	3	1	9	5.5	1.8	436	52.3	9	299	9.0	9
	11	3	3	0	6	3.6	1.5	479	62.5	6	308	11.7	6
	12	0	1	0	1	0.6	0.6	457	NA	1	314	NA	1
	13	0	0	1	1	0.6	0.6	434	NA	1	322	NA	1
Sample total		66	94	5	165	100.0		391	54.7	165	288	13.4	165

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Appendix C1.–Page 2 of 2.

Sample dates	Age	Sex (number)				% of Total	SE	Weight		Number weighed	Length		Number measured
		Male	Female	Unk.	Total			Mean (g)	SD		Mean (mm)	Sd	
5/5	5	2	1	0	3	1.6	0.9	337	18.1	3	286	7.0	3
	6	4	10	0	14	7.3	1.9	352	64.5	14	283	16.0	14
	7	17	17	0	34	17.8	2.8	366	44.8	34	289	11.0	34
	8	20	54	0	74	38.7	3.5	383	39.0	74	294	11.2	74
	9	13	34	0	47	24.6	3.1	376	50.8	47	292	13.0	47
	10	3	11	0	14	7.3	1.9	406	46.2	14	297	12.3	14
	11	1	2	0	3	1.6	0.9	507	78.8	3	311	25.0	3
	13	0	2	0	2	1.0	0.7	569	77.8	2	327	6.4	2
Sample total		60	131	0	191	100.0		381	53.8	191	292	13.2	191
5/7	3	1	1	0	2	1.0	0.7	343	7.8	2	276	2.1	2
	5	4	7	0	11	5.4	1.6	324	65.0	11	269	17.1	11
	6	6	13	0	19	9.4	2.1	350	63.9	19	276	14.1	19
	7	20	28	0	48	23.8	3.0	350	52.5	48	277	13.2	48
	8	29	33	0	62	30.7	3.3	393	56.7	62	286	12.7	62
	9	12	27	0	39	19.3	2.8	405	48.5	39	288	10.7	39
	10	4	13	0	17	8.4	2.0	406	57.3	17	291	15.5	17
	11	1	3	0	4	2.0	1.0	429	77.4	4	295	19.6	4
Sample total		77	125	0	202	100.0		379	61.3	202	283	14.4	202
Samples combined		284	440	7	731			394	60.7	731	289	14.3	731

APPENDIX D:
TOGIAK HERRING BIOMASS FORECAST

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



Cora Campbell, Commissioner
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Anchorage Regional Office
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Anchorage, AK 99518
Date Issued: October 9, 2013
Time: 1:00 p.m.

2014 TOGIAC HERRING FORECAST

The 2014 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 (Bristol Bay Herring Management Plan 5 AAC 27.865):

Harvest Allocation of the 2014 Forecasted Pacific Herring Run Biomass, Togiak District, Bristol Bay

	Biomass (Short Tons)	Harvest (Short Tons)
Forecasted Biomass	157,448	
Total Allowable Harvest (20% exploitation rate)		31,490
Togiak Spawn-on-Kelp Fishery (Fixed Allocation)		1,500
Remaining Allowable Harvest		29,990
Dutch Harbor Food/Bait Allocation (7.0% of the remaining allocation)		2,099
Remaining Allowable Harvest for Togiak District Sac Roe Fishery:		27,890
Purse Seine Allocation 70.0%		19,523
Gill Net Allocation 30.0%		8,367

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2014 TOGIAC HERRING FORECAST SUMMARY

The Pacific herring spawning biomass in the Togiak District was estimated at 169,020 tons in 2013 and is forecast to be 157,448 tons in 2014 (Figure 1). Age 9–11 herring are expected to comprise 48.2% of the biomass in 2014 (Figure 2). The remainder of the run is expected to be comprised of herring ages 4–6 (10.7%), ages 7–8 (35.5%) and ages 12+ (5.6%) by weight. The forecasted individual average weight of herring in the harvest biomass is 372 g.

A run biomass of 157,448 tons would be ~103% of the recent 10-year average. A biomass of this size has the potential to produce an overall harvest of 31,490 tons in all fisheries and 27,890 tons in the Togiak sac roe fisheries (purse seine and gillnet). A harvest of this size in the Togiak sac roe fisheries would be ~131% of the recent 10-year average harvest.

An age-structured analysis (ASA) model is used to forecast the Togiak herring population. This model utilizes catch and age composition data as well as total run biomass estimates. Currently, the ASA model integrates data from purse seine fishery age compositions (1978–2013), total run age compositions (1978–1995, 1997, 1999, 2001, 2005–2010, 2012 and 2013), and aerial survey biomass estimates (1981, 1983, 1992–1994, 1997, 1999–2001, 2005–2010, 2012 and 2013). Samples from non-selective gear (commercial purse seine) are used to assess age composition of the total run biomass when a total run biomass is estimated. Commercial purse seine catch samples from 2013 ranged from age-4 to age-15. The average weight of age-4 herring for 2013 is estimated as the most recent four-year average while simple linear regression models of historical trends are used to forecast average weights of remaining age classes.

A temporal change in age composition from older to younger herring typically occurs during this fishery. However, the 2013 inshore spawning biomass age composition was fairly stable and consisted largely of age-8 herring. This age class accounted for 30% of the total commercial purse seine harvest and 29% of the total harvest by weight.

The biomass of the Togiak herring spawning population has been estimated with aerial surveys since the late 1970s, concurrent with development of the sac-roë fishery. Estimating the peak inshore biomass is a necessary precondition for estimating total run biomass. Surveys were flown between 28 April and 29 May 2013 with peak biomass observed on 13 May. Most of the biomass surveyed occurred in the center of Togiak Bay with smaller concentrations to the east and smaller still out to the west (Figure 3).

Herring become visible to our sampling effort when they recruit into the fishery; a process that we believe begins around age-4 and is fully complete by age-9. Large recruitments in this population generally occur every eight to ten years. The last large recruitment event experienced by Togiak herring saw relatively large numbers of age-4 herring entering the fishery in 2008 and 2009. It should be noted that measuring contributions of younger age classes is difficult because these fish are not fully recruited (available) in the harvest and often arrive on the spawning grounds near the end of the fishery.

There is always uncertainty in forecasting the Togiak District herring biomass. The forecasted mean percent error (MPE) has been relatively stable at ~20% for years with reliable total run biomass estimates (Figure 1). The historical forecast accuracy or mean absolute percent error (MAPE) between 1993 and 2013 using the ASA model has been 18%. Using this historical forecast error, the forecast range for 2014 is between 128,824 tons and 186,072 tons. We consider this population to be healthy and sustainable.

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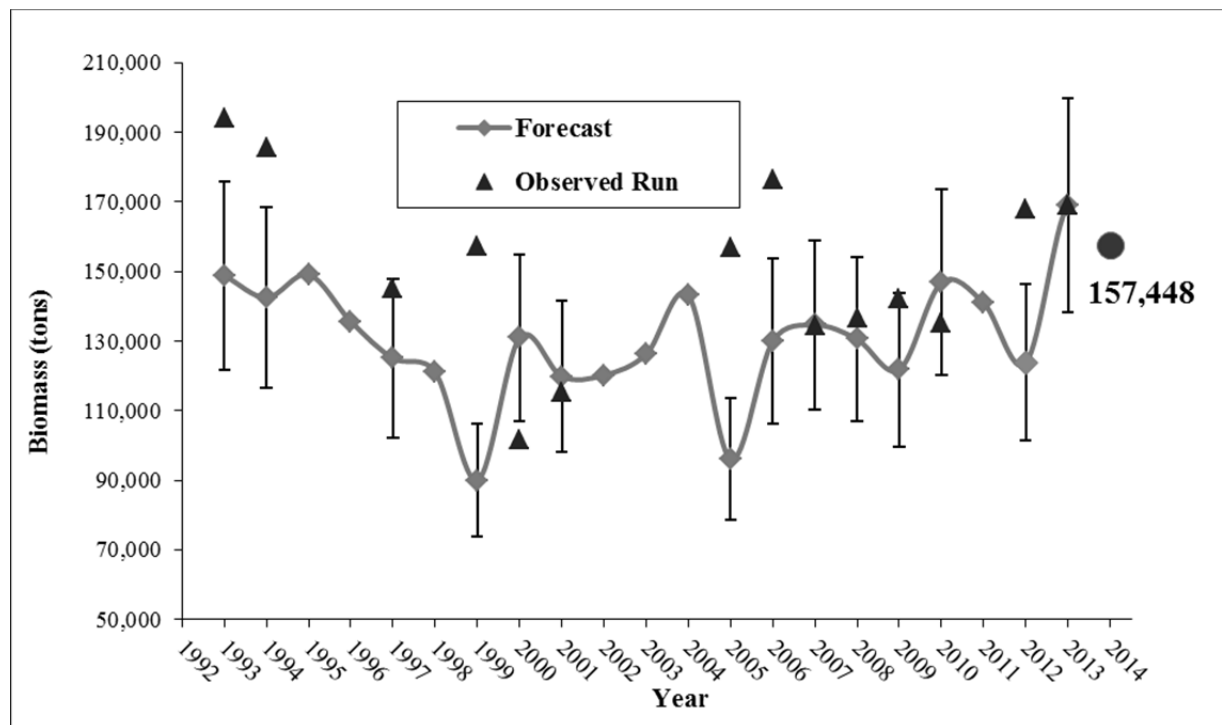


Figure 1.—Annual observed Togiak herring total run biomass estimates and preseason forecasts based on the ASA model. Mean absolute percent error (MAPE) of 20% around the forecast is also shown for years with a reliable total run biomass estimate.

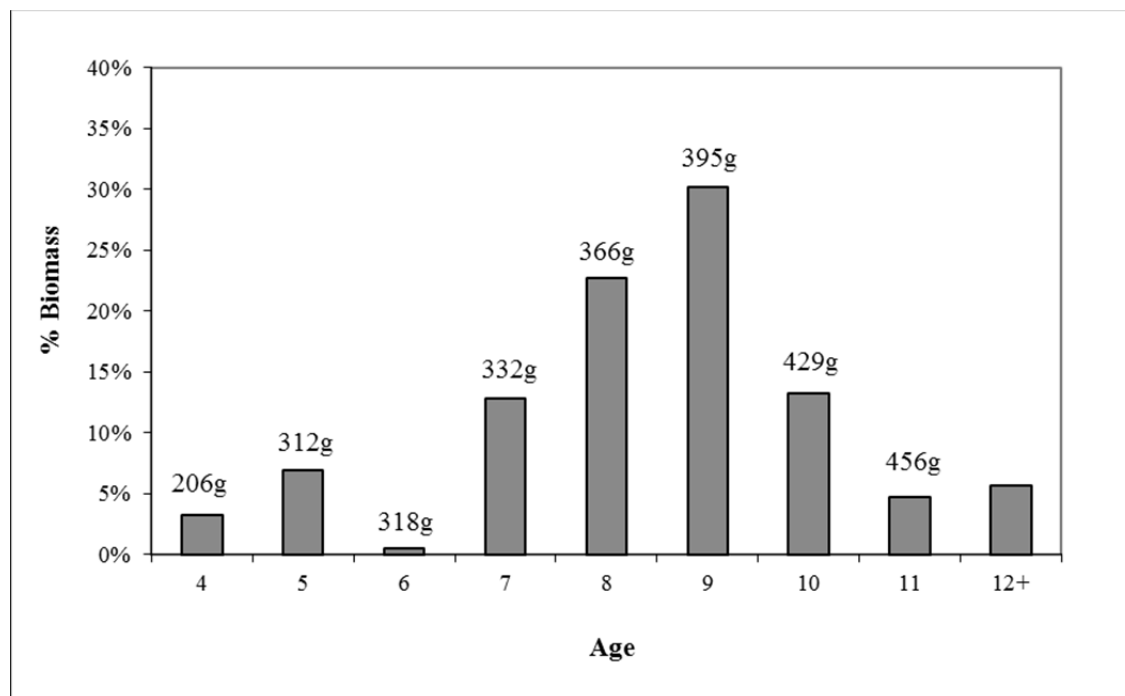


Figure 2.—Forecasted age composition and average weight (grams) for the 2014 Togiak herring return.

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