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Assessment of Weathervane Scallops near Kayak Island, Alaska, 2002

by

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Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

FISHERY DATA SERIES NO. 13-46

ASSESSMENT AND HARVEST RECOMMENDATIONS FOR WEATHERVANE SCALLOPS NEAR KAYAK ISLAND, ALASKA, 2002

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ABSTRACT

The Alaska Department of Fish and Game (ADF&G) conducted an area-swept dredge survey for weathervane scallops in 2 scallop beds (East Bed and West Bed) near Kayak Island, Alaska during May 2002. This survey continued a time series extending to 1996 that has been used by ADF&G to monitor stock status and establish harvest guidelines of weathervane scallops in the Prince William Sound Management Area. In recent years, this has been a biennial survey used to set the fishery harvest level for 2 successive fishing seasons. .A total of 20 successful tows occurred in the East Bed and 22 successful tows occurred in the West Bed. Estimated 2002 weathervane scallop population biomass and 95% confidence interval was 257,492 ±117,176 kg (567,667 ±258,326 lb) in the East Bed and 1,023,892 ±547,594 kg (2,257,272 ±1,207,226 lb) in the West Bed. This was a substantial decrease relative to recent surveys, particularly for the East Bed where the 2002 biomass estimate for the East Bed represented a decline of 86% from 2000 and 70% from 1998. However, the 2002 survey indicated that scallop population abundance and biomass at Kayak Island is sufficient to support a commercial fishery. Although subsequent analysis of the vessel logs and discussion with the survey crew suggested systematic errors in survey gear deployment occurred during the survey, a true decline in stock abundance cannot be ruled out. As a risk-averse approach, it was recommended that the fishery guideline harvest level (GHL) for 2003 and 2004 be set at the GHL applied in 1998 and 1999 of 2,722 kg (6,000 lb) of meats for the East Bed and 6,350 kg (14,000 lb) of meats for the West Bed. Aspects such as scallop size, age, sex, and maturity composition and survey bycatch of crab and fish are discussed.

Key words: weathervane scallop *Patinopecten caurinus*, assessment, dredge, Kayak Island, Alaska, size, age, guideline harvest level

INTRODUCTION

The weathervane scallop *Patinopecten caurinus* inhabits coastal waters of Alaska from Dixon Entrance to Kodiak and into the Bering Sea (Kaiser 1986; Shirley and Kruse 1995). The Alaska Department of Fish and Game (ADF&G) and the National Marine Fisheries Service cooperatively manage commercial fisheries for weathervane scallops of Alaska in the Southeast, Yakutat, Prince William Sound, Cook Inlet, Kodiak, and Bering Sea Management Areas.

The fishery for weathervane scallops in Registration Area E, the Prince William Sound Management Area, developed in 1992 (Table 1; Figure 1). In that year, 4 vessels harvested 94,727 kg (208,836 lb) of shucked scallop meats (Berceli et al. 2003). The following year the Alaska Board of Fisheries established a guideline harvest range of 0–22,680 kg (0–50,000 lb) of shucked scallop meats. The 1993 fishery harvested 28,607 kg (63,068 lb). In 1994, the Board of Fisheries defined the fishing season as 15 January to 15 February, unless closed prior to that date by emergency order.

Following the 1995 fishery closure, a vessel neither licensed by the State of Alaska, nor registered with ADF&G, harvested weathervane scallops from federal waters near Kayak Island. The additional harvest was estimated to total 27,216 kg (60,000 lb) of shucked scallop meats, which, in itself, exceeded the upper limit of the Area E guideline harvest range (Berceli and Brannian 2000). This fishing activity identified a previously undetected regulatory problem, and National Marine Fisheries Service subsequently closed all federal waters off Alaska to scallop fishing. Because of the unanticipated harvest of weathervane scallops in 1995, the Area E scallop fishery remained closed in 1996 and did not reopen until 1997 following an amendment of the federal management plan (Kruse et al. 2005).

Due to the greater than anticipated 1995 harvest, ADF&G initiated dredge surveys of the weathervane scallop bed east of Kayak Island in 1995 to evaluate the stock and harvest levels

(Charles Trowbridge, Commercial Fisheries Biologist, ADF&G, Homer; personal communication). Given ADF&G budget and survey time constraints, a biennial survey of Kayak Island scallops was established beginning in 1996 (Bechtol and Bue 1998; Bechtol 2003a, 2003b). Although the survey design has remained consistent among years, ADF&G expanded the area surveyed in 1998 to include both the East Bed and the West Bed (Table 1).

OBJECTIVES

Specific objectives of the 2002 Kayak Island survey were to:

1. Estimate biomass, abundance, age and size composition, and sexual maturity of weathervane scallops in this population.
2. Estimate shucked scallop meat recovery.
3. Provide guideline harvest levels (GHL) for the East and West beds near Kayak Island.
4. Determine relative bycatch of king and Tanner crabs and other incidentally caught species.

This report documents methods and results of the 2002 survey of weathervane scallops at Kayak Island and the rationale used to set the GHL for the commercial fisheries in 2002 and 2003.

GENERAL BIOLOGY

Weathervane scallops exhibit a patchy distribution extending from Point Reyes, California to the Pribilof Islands, Alaska (Foster 1991). Scallops occur from intertidal depths to 300 m (Foster 1991), but in Alaska waters are more commonly found at depths of 37–229 m (20–125 fathoms) on a variety of substrates, including mud, clay, silt, sand, and pebble (Hennick 1973; Barnhart and Rosenkranz 2000). Scallop aggregations, or "beds," are typically elongated or elliptical in shape with an orientation, often north-south, in the direction of mean current flow (Kruse et al. 2000).

Scallops are mostly dioecious, with males distinguished by white testes and females by red-orange ovaries (Hennick 1970). Gonads reach full maturity in mid-December to late January, and remain "ripe" until spawning. Broadcast spawning of spermatozoa and eggs typically occurs over a period of 3–4 days from May to July. Fertilized eggs settle to the substrate and hatch into larvae after several days. After several more days, the larvae assume a pelagic existence, known as a veliger that uses velium, or cilia, to swim and feed (Mottett 1979). After approximately 3 weeks, veligers settle to the substrate where they attach with byssal threads. After developing a foot, the scallops may move across the substrate or attach. After 4–8 weeks, the nearly transparent juveniles develop an ability to swim, and after a few months, shell pigmentation develops at a shell height of approximately 10–15 mm (0.5 inch). These juveniles feed on microscopic plankton. Weathervane scallops in Alaska become sexually mature at around age 3 or a shell height of approximately 76 mm (3 inch; Hennick 1973). Kruse (1994) reviewed several methods for calculating instantaneous natural mortality in weathervane scallops and found mortality ranged from 4% to 25% with a median estimate of 15%. An age-structured model for weathervane scallops in Kamishak Bay, Alaska estimated mortality to be 14% (Bechtol 2000).

Adult weathervane scallops are bivalves that lie on the right, or bottom, valve. The right valve is convex and the left, or top, valve is flat to convex (Keen and Coan 1974). Scallops are the only

bivalve in Alaska capable of swimming, with propulsion achieved by rapid ejection of water from the shell interior. Formal studies on the swimming capabilities of weathervane scallops are limited. Older, larger scallops are thought to be less adept at swimming than juveniles due to a greater body mass relative to the water discharge capacity (Gould 1971). In comparison, the giant scallop *Placopecten magellanicus* makes repetitive swims, but the frequency and distance covered decreases with each swim; the scallop's adductor muscle may require several hours to return to a pre-swimming physiological condition (Thompson et al. 1980). Movement is likely important to scallop spawning success. Stokesbury and Himmelman (1993) suggested spawning success was increased for the giant scallop by a clumped distribution, with small-scale aggregations, on the magnitude of centimeters, maintained by swimming. In addition, mobility allows scallops to return to an optimum habitat or evade predators (Stokesbury and Himmelman 1996).

STUDY AREA

The study area is located approximately at Cape St. Elias (144°20' W long, 59°47' N lat) on the southern end of Kayak Island in the Gulf of Alaska (Figure 2). This area is subject to severe weather conditions and large ocean swells. Coastal currents primarily run westerly as part of a counter-clockwise gyre in the northern Gulf of Alaska, and maximum tidal exchanges are typically less than 5 m (15 ft). Bottom substrate in the study area is primarily sand and pebbles with some rock and mud; rocky reefs are present near Cape St. Elias. Mud and glacial sediments are common in the nearshore marine waters as outfall from glacial rivers located east of Kayak Island. Depth contours in this area generally have a southwest to northeast orientation, approximately parallel to the Kayak Island shoreline. Bottom depths in the scallop beds gradually slope from approximately 55 m (30 fathoms) in the northwest to over 110 m (60 fathoms) in the southeast.

METHODS

VESSEL AND GEAR

ADF&G research vessel *Pandalus* surveyed the Kayak Island scallop beds during 11–15 May 2002 (Table 2). The *Pandalus* has an overall length of 20 m (66 ft), a displacement of 100 mt, and is powered by a 365 hp diesel engine. Survey staff in 2002 included 3 biologists and 3 vessel crew.

The survey was conducted with a 2.4 m (8 ft) dredge having a ring bag consisting of 10.2 cm (4.0 inch) inside diameter rings. To facilitate retention of small scallops, the ring bag was fitted with a 3.8 cm (1.5 inch) mesh liner; scallop catchability with this dredge was assumed to be 1.0, such that all scallops larger than the liner stretch mesh were retained. The liner was used in the first 37 tows and was removed for last 5 tows, which were replicate tows in the West Bed. Dredge weight was approximately 816 kg (1,800 lb).

SAMPLE DESIGN

The 2002 weathervane scallop survey was conducted east and west of Kayak Island, with the initial sample area based on previous survey results and commercial fishery data (Bechtol 2003a, 2003b; Figure 2). Sampling stations were defined by overlaying a checker-board grid of 1,852 m (1.0 nmi) squares over a chart of the study area. A systematic design was used in which every other station was designated for sampling after the primary sampling unit (light or dark squares)

was randomly selected to give an equal probability of selecting either set of grid cells. The vessel skipper, in coordination with the project leader, determined the specific tow location within each sample station. The dredge was towed for a distance of approximately 1,852 m (1.0 nmi) within the sample station.

To define the scallop bed margin, stations were added diagonally, maintaining the checker-board pattern, when catches along the edge of the initial sampled stations catch exceeded a threshold level of 9.1 kg (20 lb). The edge of a scallop bed was considered defined when catch in a given station was below the threshold amount. Only data from stations where the catch was at least as large as the threshold, with the mesh liner installed, were used for biomass and abundance estimates

For animal populations with individuals that are randomly distributed, a single systematic sample provides good variance estimates. Because weathervane scallops have a patchy distribution and are not uniformly clustered within beds, a systematic sample tends to overestimate the population variance (Thompson 1992). However, similar to previous surveys (Bechtol and Bue 1998; Bechtol 2003a, 2003b), we decided to forego precision about the variance estimate in order to equally distribute sampling effort across the survey area and better define weathervane scallop bed boundaries.

DATA COLLECTION

The vessel skipper recorded the following information for each tow:

1. sequential tow number;
2. alphanumeric station code;
3. date;
4. start and stop locations (lat. and long.);
5. tow compass heading;
6. average vessel speed;
7. tow start and stop times;
8. distance towed;
9. maximum and minimum depths;
10. sea conditions;
11. scope used (ratio of tow cable length to bottom depth)
12. gear performance.

Upon completion of each tow, the catch was washed clean of mud and separated into weathervane scallops, weathervane scallop shells, fish species, Tanner crab, other bycatch species, and debris. Tanner crab were weighed in aggregate then sampled to determine carapace width, shell condition, and sex. Fish were weighed in aggregate, and then enumerated by major species group. Debris, assorted invertebrates, and any remaining bycatch were weighed and their relative contribution by volume visually estimated (e.g., 60% starfish and 40% rocks).

Weathervane Scallop Sampling

Total live weight and abundance of weathervane scallops, including broken shells with attached viscera, were recorded. Weathervane scallop shells and shell fragments without attached viscera were weighed and discarded. Empty weathervane scallop shells (hereafter referred to as “cluckers” or “clappers”), with both valves connected by an intact hinge ligament, were retained, cleaned, measured for shell height, aged, labeled, and bagged for archival.

Twenty weathervane scallops were randomly selected, weighed, and shucked aboard the vessel. The scallop meats (i.e., the large adductor muscle, referred to as the “quick” by the fishing industry) were placed into a container, and the dorsal shells were cleaned, labeled, measured, aged, and placed in storage for later age determination. Several non-random samples of

immature weathervane scallops from each tow were also shucked, cleaned, measured, aged, and stored for representative size-at-age data. Shell heights of all weathervane scallops remaining from a tow were captured with an electronic measuring board to construct height frequency distributions.

Fresh weathervane scallop meat recovery was estimated each day from whole weight of the twenty scallops sampled from each tow and the weight of their shucked meats. Mean fresh meat recovery was estimated as pooled meat weight divided by pooled whole scallop weight.

DATA ANALYSIS

For each tow, weathervane scallop age and size composition data were pooled within beds to determine population age and size compositions. Shell height-at-age, L_t, was modeled for aged scallops only with a von Bertalanffy growth equation (Ricker 1975), using the Microsoft Excel[1] Solver utility to minimize sums of squares, by

$$L_t = L_\infty (1 - e^{-K(t-t_0)}), \quad (1)$$

where:

L_∞ is the theoretical mean maximum size,

K is the constant relative rate of growth,

t is age (time) in years, and

t_0 is the age of theoretical zero size.

All retained scallop shells were re-aged in the laboratory by a second reader. Discrepancies in ages were resolved through re-aging and agreement between readers. Because the observation of scallops in spawning condition indicated the spawning season was still in progress, no scallops were assigned the age of "0" and all unaged scallops 35 mm or smaller in shell height were assigned as age 1. Based on height-at-age data pooled between the East Bed and the West Bed for aged scallop shells, ages were assigned to all unaged shell heights in proportion to the aged shells in either 5 or 10 mm size classes, depending upon sample size within the size classes. Age composition within a bed was estimated as the sum of observed and assigned scallop ages. Prior to summing within a bed, scallop size and age data were standardized to counts per nautical mile and adjusted for scallops that were counted but neither aged nor measured. Thus, all captured scallops were used in the analysis.

The weathervane scallop population estimate derived from the 2002 Kayak Island survey was based on area-swept calculations (Gunderson 1993), similar to estimates for previous weathervane scallop surveys in southcentral Alaska (Hammarstrom and Merritt 1985; Bechtol and Bue 1998; Bechtol and Gustafson 2002). Mean catch per nautical mile ($\bar{c}$), its variance (s^2), and 95% confidence interval (*CI*) within a bed were calculated by

[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

$$\bar{c} = \frac{\sum_{i=1}^{n} \frac{c_i}{l_i}}{n}, \tag{2}$$

and

$$s^2 = \frac{1}{n-1} \sum_{i=1}^{n} \left(\frac{c_i}{l_i} - \bar{c} \right)^2, \tag{3}$$

$$CI = \pm t_{95\%,\ n-1 d.f.} \frac{s}{\sqrt{n}}, \tag{4}$$

where:

c_i is the catch of a species, either as abundance or weight, in sample tow *i*,

l_i is the distance towed in nautical miles for sample tow *i*, and

n is the number of stations sampled.

The population estimate (*P*) was calculated by expanding $\bar{c}$ over the surveyed area as

$$P = \left(\frac{6{,}076}{8} \right) N \bar{c} \tag{5}$$

where:

6,076 is the length in feet of a nautical mile,

8 is the width of the dredge in feet, and

N, the number of squares within a defined bed, is 2*n*, or twice the number of stations actually sampled within the defined bed.

Variance of the surveyed population was estimated by (N. Gove, ADF&G, Anchorage, personal communication).

$$Var\left(\bar{C}\right) = \left(1 - \frac{8}{6{,}076} \right) \frac{s^2}{n}, \tag{6}$$

$$Var\left(P\right) = \left(N \frac{6{,}076}{8} \right)^2 Var(\bar{C}). \tag{7}$$

The GHLs were calculated independently as shucked scallop meats for the East Bed and West Bed using estimated scallop population biomass, estimated meat recovery, and target harvest rate.

RESULTS

During the 2002 survey of weathervane scallop beds located near Kayak Island, a total of 42 successful tows were completed, including 20 tows in the East Bed and 22 tows in the West Bed (Table 2; Figure 3). Tow duration among all survey tows lasted 13–17 minutes at vessel speeds of 7,038–7,778 m/h (3.8–4.2 nmi/h). Tow depths ranged from 53 to 119 m (29 to 65 fathoms), and scope on individual tows was between 3.7:1 and 5.3:1.

EAST BED CATCHES

The 20 successful tows in the weathervane scallop bed east of Kayak Island retained a total catch of 322.2 kg (710.3 lb) of organisms and debris (Table 3). Tow depth ranged from 62 to 97 m (34 to 53 fathom). Individual tow catches ranged from 2.4 to 58.4 kg (5.3 to 128.7 lb). Debris comprised 116.4 kg (256.5 lb), or 36%, of the total catch, and ranged from 0 to 93% of the catch weight from individual tows.

Weathervane Scallops

Scallop Catches

Weathervane scallops were caught in all of the 20 tows in the East Bed (Table 3; Figure 4). The total weathervane scallop catch was 190.1 kg (419.2 lb), comprising 59% of the aggregate catch. Catches in individual tows ranged from 0.1 to 40.4 kg/nmi (0.3 to 89.1 lb/nmi), and averaged 9.5 kg/nmi (21.0 lb/nmi). Catch abundance among all stations ranged from 1 to 161.4 scallops/nmi, totaled 769.9 scallops, and averaged 38.5 scallops/nmi (Table 4).

Scallop Biomass and Abundance

Based on a scallop catch threshold of 9.1 kg/nmi (20 lb/nmi), the East Bed was represented by 9 tows (Table 5; Figures 4 and 5). Within the defined bed, mean catch and the 95% confidence interval was 18.8 ±8.6 kg/nmi (41.5 ±18.9 lb/nmi; 8 d.f. (degrees of freedom)). Assuming a balanced survey design, the East Bed was calculated to encompass 18 nmi^2. The area-swept population biomass estimate was 257,492 ±117,176 kg (567,667 ±258,326 lb). Mean catch abundance with 95% confidence interval within the East Bed was 74.3 ±35.3 scallops/nmi, and scallop population abundance within the defined bed was 1,015,428 ± 482,628 scallops (8 d.f.). Mean weight of individual scallops was 254 g (0.56 lb) within the East Bed.

Size and Age

A total of 699 weathervane scallop shells was measured from the East Bed (Table 6). Shell heights ranged from 21 to 161 mm (0.8 to 6.3 inch). Evaluated within size classes after standardizing for tow distance and extrapolating for counted but unmeasured shells (total n = 770), the most abundant shell height was 136–140 mm (5.4–5.5 inch), representing 24% of the sampled population (Table 6; Figure 6). One major grouping, from 111 to 155 mm (4.4 to 6.1 inch), comprised 90% of the East Bed population. Scallops ≤l00 mm in height accounted for 8% of total scallop abundance.

A sample of 327 weathervane scallops from the East Bed yielded ages ranging from 1 to 19 (Table 7). Based on size-at-age data extrapolated to the shell height composition (Figure 7) in the East Bed (n=697), the dominant cohort was age 14, representing 23% of the sampled population (Table 7; Figure 8). Four age classes, encompassing ages 12–15, comprised 73% of the sampled population. Weathervane scallops age-11 and younger comprised 25% of the

population. Among younger scallops, cohort abundance was relatively strong for age-2 scallops, comprising 5% of the East Bed population abundance.

Sex and Maturity

Of the 285 weathervane scallops from the East Bed visually examined for sex and spawning status, 118 (41%) were determined to be male, 158 (55%) were female, and 9 (3%) could not be classified (Table 8). From the pool of 276 scallops for which sex was determined, 111 (94%) of the males and 136 (86%) of the females were in spawning condition. In the East Bed, spawning scallops were observed in males as young as age 3 and females as young as age 2.

Tanner Crab

Although adult Tanner crab were not caught during the 2002 survey, juvenile Tanner crab were caught in 18 tows, or 90% of all completed tows in the East Bed (Tables 3 and 4; Figure 9). Standardized Tanner crab catches totaled 305 g (0.7 lb) and 94.5 animals. Mean catch abundance of juvenile Tanner crab among all tows was 4.7 crab/nmi. Male and female Tanner crab carapace width ranged from 10 to 33 mm (0.4 to 1.3 inch), with 12 mm (0.5 inch) being the most abundant size (Figure 10). Male crabs comprised 44% of the catch.

Fishes

Fishes were caught in 10 tows, or 50% of all completed tows in the East Bed (Table 4). The total fish catch was 5.0 kg (11.0 lb; Table 3). Fish catches from individual tows ranged from 0.0 to 3.6 kg (0 to 7.9 lb), and mean fish catch was 0.3 kg/nmi (0.6 lb/nmi). Dover sole was the most abundant species captured in the East Bed (Table 9).

WEST BED CATCHES

For the 22 successful tows in the weathervane scallop bed west of Kayak Island, the dredge retained a total of 994.7 kg (2,192.9 lb) of organisms and debris (Table 3). Individual tow catches ranged from 2.2 to 170.3 kg (4.8 to 375.5 lb). Debris comprised 126.0 kg (277.8 lb), or 13%, of the total catch, and ranged from 9 to 95% of the catch weight from individual tows. Tow depth ranged from 53 to 119 m (29 to 65 fathom).

Weathervane Scallops

Scallop Catches

Weathervane scallops were caught in 21 (95%) of the 22 tows in the West Bed (Table 3; Figure 4). Total weathervane scallop catch was 798.7 kg (1,760.8 lb), comprising 80.3% of the aggregate catch. Catches in individual tows ranged from 0.0 to 140.0 kg/nmi (0.0 to 308.7 lb/nmi; Figure 5). Catch abundance among stations ranged from 0.0 to 574 scallops/nmi, totaled 3,492 scallops, and averaged 158.7 scallops/nmi (Table 4).

Scallop Biomass and Abundance

Based on the threshold of 9.1 kg/nmi (20 lb/nmi) of scallops, 13 tows were within the defined West Bed (Table 5; Figure 4). Mean catch and 95% confidence interval within the West Bed was 51.9 ±18.3 kg/nmi (114.3 ±40.4 lb/nmi; 12 d.f.). Based on a balanced survey design, the West Bed was calculated to encompass 26 nmi. The area-swept population biomass estimate was 1,023,892 ±547,594 kg (2,257,272 ±1,207,226 lb) of whole scallops. Mean catch abundance with 95% confidence interval within the West Bed was 214.1 +110.8 scallops/nmi,

and population abundance within the defined bed was 4,228,734 ±2,185,884 scallops. Mean weight of individual scallops was 242 g (0.53 lb) within the West Bed.

Size and Age

A total of 3,168 weathervane scallop shells was measured from the West Bed (Table 6; Figure 6). Shell heights for all measured weathervane scallops ranged from 22 to 156 mm (0.9 to 6.1 inch). After extrapolating for unmeasured scallops (total n = 3,491), the most abundant shell height, evaluated as 5 mm size classes, was 126–130 mm, representing 28.5% of the sampled scallops. One major grouping, from 111 to 145 mm (4.4 to 5.7 inch), comprised 96% of the West Bed population. Small weathervane scallops, l00 mm or less, accounted for less than 1% of total scallop abundance.

A total of 312 weathervane scallops was aged from the West Bed (Table 7). Ages ranged from 1 to 19. Based on size-at-age data extrapolated to shell height composition for the West Bed (total n = 3,168), the dominant cohort was age 13 representing 20% of the sampled population (Table 7; Figure 8). Ages 10–14 comprised 80% of the sampled population and scallops age 9 and younger comprised 15% of the population. Cohort strength was generally weak for ages younger than 8 or older than 15.

Sex and Maturity

Of the 305 weathervane scallops from the West Bed that were visually examined for sex and spawning status, 147 (48.2%) were determined to be male, 145 (47.5%) were female, and 13 (4.3%) could not be classified (Table 8). From the pool of 292 scallops for which sex was determined, 142 (97%) of the males and 133 (92%) of the females were in spawning condition. In the West Bed, spawning gonads were observed in age-5 and older males and females.

Tanner Crab

Adult Tanner crab were not caught during the 2002 survey. However, juvenile Tanner crab were caught in 14 tows, or 64% of all completed tows in the West Bed (Table 3; Figure 9). Tanner crab catch totaled 534 g (1.2 lb) and 168.4 animals (Tables 3 and 4). Average catch abundance of juvenile Tanner crab among tows was 7.7 crab/nmi (Table 4). Tanner crab carapace width ranged from 9 to 45 mm (0.3 to 1.8 inch) with 12 mm (0.5 inch) being the most abundant size (Figure 10). Male crab comprised 55% of the catch.

Fishes

Fishes were caught in 15 (68%) of the completed tows in the West Bed (Table 3). Total fish catch was 24.0 kg (52.8 lb). Fish catches from individual tows ranged from 0 to 5.4 kg/nmi (0 to 11.9 lb/nmi), and mean fish catch was 1.1 kg/nmi (2.4 lb/nmi). The greatest fish catch of 5 kg/nmi (12 lb/nmi) occurred in tow 02005 at station J32 on the western edge of the West Bed (Figure 11). Flatfishes of the family *Pleuronectidae*, particularly rex sole and Dover sole, were the most abundant fishes caught in the West Bed (Table 9).

GROWTH

A von Bertalanffy curve was fit to scallop shell height-at-age data from the East (n=327) and West Beds (n=312) near Kayak Island (Figure 7). The weathervane scallop population from the 2002 survey indicated asymptotic growth, with the first 4 years of life having the fastest growth, decreasing rapidly to approximately 1 mm annually after age 13.

Clucker Composition

A total of 36 cluckers, 13 from the East Bed and 23 from the West Bed, was sampled during the 2002 Kayak Island survey. Accurate shell heights were available for all 36 cluckers and showed that the most abundant size class was 126–130 mm (5.0–5.1 inch) for data pooled among beds (Figure 12). Age-12 was the most abundant clucker cohort.

Scallop Meat Recovery

Mean daily meat recovery for all survey samples, weighted by the whole scallop weight sampled daily, was 7.17% (n=4 daily samples). The range of meat recovery among the daily samples was 6.82–7.40% (Table 10).

DISCUSSION

Extensive scallop harvests near Kayak Island have only occurred since 1992, with the initial GHL based on area-swept estimates calculated inseason from commercial catch data (Berceli et al. 2003). Biological implications for the Kayak Island scallop population resulting from the unanticipated harvest in 1995 by a vessel operating outside of the existing management structure remain unknown. Estimated 2002 weathervane scallop population biomass was 257,492 ±117,176 kg (567,667 ±258,326 lb) in the East Bed and 1,203,892 ±547,594 kg (2,257,272 ±1,207,226 lb) in the West Bed. This was a substantial and unanticipated decrease in estimated scallop biomass for each bed relative to the previous survey in 2000 when the East Bed population biomass was 1,845,000 ±416,000 kg (4,067,000 ±917,000 lb) and West Bed population biomass was 2,843,000 ±1,699,000 kg (6,268,000 ±3,746,000 lb; Table 11). In particular, estimated biomass in the East Bed had steadily increased from 1996 to 2000 due largely to improved sampling gear and greater survey expertise, but the 2002 biomass estimate for the East Bed represented an 86% decrease from 2000 and a 70% decrease from 1998. However, such a drastic decrease in estimated biomass in only a few years reveals some of the survey uncertainty. Unreported (i.e., illegal) fishing effort could certainly have occurred, but is thought unlikely because statewide scallop harvests in recent years have generally fallen well short of statewide harvest guidelines, probably due to market considerations (J. Barnhart, ADF&G, Kodiak, personal communication). Another possibility for decreased biomass might be a “die-off” of a large component of the weathervane scallop populations. A die-off is believed to have occurred in the Kamishak Bay bed in Cook Inlet, as indicated by cluckers comprising up to 30% of total (cluckers plus live scallops) scallop abundance in fishery catches (Bechtol et al. 2009). However, only 36 cluckers, representing less than 1% of total catch abundance, were measured from the 2002 Kayak Island survey.

Subsequent analysis of vessel logs and discussion with the survey crew suggested systematic errors occurred during the 2002 Kayak Island survey. At the end of the 2000 survey, the survey crew was concerned that the catches were substantially lower than in the 2000 survey. The survey crew determined the dredge liner was slightly smaller than the dredge opening, potentially reducing catch rates. As a test, 5 additional dredge tows were made without the liner. Replicate tows in station H36, H34, and G35 yielded smaller weathervane scallop biomass catches, which was expected since the liner would retain more scallops. However, biomass was less and abundance greater in the replicate tow at station I35, and the replicate tow at station I33 had 6 times the biomass and 9 times the abundance of the original tow. Thus, the replicate tows without the liner were inconclusive. Analysis of the scope (length of wire/maximum depth)

showed that mean scope for the 2002 East Bed was 4.3, compared to 3.7 in 1996, 3.5 in 1998, 3.6 in 2000. West Bed means scope was 4.1 in 2002, compared to 3.5 in 1998 and 2000 (Table 11). Therefore, the scope is suspect.

Available age and size composition data has substantial utility for a more formal stock assessment model, such as an age-structured model (Bechtol 2000). A more formal model could inform factors such as gear-specific catchability and age-specific selectivity. In the absence of a developed model, these factors are treated as unity. A recent comparison between video and dredge estimates of scallop biomass in a limited number (n=5) of survey stations at Kayak Island suggested that mean dredge catchability slightly exceeds 80% (Bechtol et al. 2009). However, additional comparisons are needed to determine how catchability and selectivity vary with aspects such as substrate type, scallop density, current, and water surface conditions.

The Kayak Island scallop survey is conducted biennially, with the 2002 assessment used to set the fishery GHLs for 2002 and 2003. Defining a standardized boundary for the Kayak Island scallop bed is a high survey priority, and 2002 is the fifth survey of the East Bed and the third survey of the West Bed. We recognize the actual scallop distribution extends beyond the "defined" scallop beds near Kayak Island (Figure 4). However, the use of a threshold catch rate on individual tows to define the scallop beds acknowledges that the scallop fishery will focus on areas of higher aggregation. Having bed-specific GHLs provides a conservative approach to long-term yield by protecting against localized depletion within individual scallop beds. The uncertainty in establishing an appropriate harvest rate for each bed at Kayak Island results, to some extent, from: (1) reduced recruitment observed at Kayak Island relative to some other scallop beds in the northern Gulf of Alaska (Bechtol and Gustafson 2002; Bechtol et al. 2003); (2) the limited harvest history for these beds (Berceli et al. 2003); and (3) a dramatic increase from 1998 to 2000 and a dramatic decrease from 2000 to 2002 in survey biomass estimates (Bechtol 2003a, 2003b).

We do not understand the processes affecting recruitment, or how various aggregations within the surveyed bed contribute to reproductive success of the scallop population, as a whole, near Kayak Island. Despite using the same gear type and a similar survey design, little sustained recruitment was observed at Kayak Island, particularly at the West Bed (Figure 13). There has been a consistent presence of age-1 scallops in the East Bed surveys (Figures 8 and 13). Although a relatively low representation of younger scallops would be expected in the dredge survey due to gear selectivity, scallops younger than age 5 are much less evident in the West Bed than in the East Bed. Still, recruitment in the defined scallop beds at Kayak Island differs sharply from that of the Kamishak Bay population in Cook Inlet where over half of the sampled population was younger than age 7, and age-3 and age-4 cohorts were abundant (Bechtol and Gustafson 2002). The lack of recruitment at Kayak Island has persisted since at least 1996 (Bechtol and Bue 1998; Bechtol 2003), suggesting a conservative approach should be taken in setting the Kayak GHL, particularly for the West Bed.

The ultimate determination of an appropriate harvest rate, and the corresponding GHL, should be based on available biological data, tempered by harvest experiences within a particular bed or harvest histories in comparable beds in other areas. Traditional fisheries approaches suggest that fishing mortality should be set at something less than natural mortality (Restrepo et al. 1998). Kruse (1994), when examining several methods for calculating instantaneous natural mortality in weathervane scallops, estimated M ranged from 0.04 to 0.25, with a median estimate of 15%. An age-structured model for scallops in Kamishak Bay estimated mortality to be 14% (Bechtol

2000). Mortality in Kayak Island scallops is likely similar and applied fishing mortality should similarly be less than natural mortality.

Recommended 2003 and 2003 Guideline Harvest Levels

The maximum guideline harvest range allowed under regulation 5 AAC 38.221 is 0–22,680 kg (0–50,000 lb) of shucked meats. Based on the moderately distinct geographic separation between the major scallop aggregations in the East Bed and West Bed, it was recommended that each bed continue to be given individual harvest levels that reflect the underlying population biomass.

The GHLs of 9,000 lb of meats for the East Bed and 21,000 lb of meats for the West Bed in 1999 and 2000 incorporated the greater survey biomass estimated by the 2000 survey while compensating some for the lack of recruitment by keeping overall harvest well below potential natural mortality of 14–15%. Given the dramatic decrease in the 2002 survey biomass following several surveys of increasing biomass, it is more likely that the pessimistic biomass estimates for the 2002 survey result from systematic survey errors caused by gear deployment issues, specifically an excessive amount of scope on the survey dredge. However, because the 2000 survey was the largest on record; fishery performance data in 2000 and 2001 did not indicate significant resource problems; a population decline in two years to the level suggested by the survey seems unlikely; but the possibility of some stock decline in 2002 cannot be ruled out; it is recommended that the 2002 and 2003 GHL be set at the level applied following the 1998 survey and before the dramatic increase observed in 2000. This approach would result in GHLS of 6,000 lb of meats for the East Bed and 14,000 lb of meats for the West Bed. This approach will buffer against a 2002 survey anomaly and also provide stability to the fishery. However, to protect this resource and provide for sustained annual yield, it will be important to continue to monitor this population using information from fishery sampling and fishery-independent surveys. If this evaluation of the 2002 Kayak Island survey results proves unwarranted, and there is actually a substantial stock decline, fishery performance should provide an indication to managers during the 2002–2003 fishing season such that corrective action may be taken during that season and in advance of the 2003–2004 season.

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TABLES

Table 1.–Commercial guideline harvest level, season length, effort, and harvest for the weathervane scallop fishery in the Prince William Sound Management Area, 1992–2002.

Year	GHL[a] (meat lb)	Season (hours)	Number of Vessels	Harvest (meat lb)	Comments
1992	64,000	NA	4	208,836	
1993	50,000	67	7	63,068	
1994	Fishery rescheduled to 1995.				Season start date changed.
1995	50,000	390	2	108,000	60,000 lb illegal harvest.
1996	Closed due to 1995 overharvest.			0	
1997	17,200	141	1	18,000	
1998					
East Bed	6,000	26	2	6,210	First year of split GHL.
West Bed	14,000	78	2	13,440	
1999					
East Bed	6,000	54	2	[b]	
West Bed	14,000	84	2	[b]	
2000					
East Bed	9,000	744	3	9,998	
West Bed	21,000	783	3	21,268	
2001					
East Bed	9,000		1	[b]	
West Bed	21,000		1	[b]	
2002					
East Bed	6,000		2	[b]	
West Bed	14,000		2	[b]	

[a] GHL = guideline harvest level; separate GHLs first established for East and West beds in 1998.

[b] Confidential data.

Table 2.–Vessel log of dredge tows made during the weathervane scallop survey near Kayak Island, Alaska, 2002.

East Bed

Tow number	Station	Date	Tow Start Lat (°N)	Tow Start Long (°W)	Course (True)	Speed (nmi/h)	Start time	Duration (minutes)	Distance (nmi)	Depth (fathoms) Min	Depth (fathoms) Max	Scope (fathoms)
East Bed Stations												
02018	J08	5/13	59.77	144.36	050	4.08	08:19	15	1.02	45.6	48.7	215
02019	H08	5/13	59.80	144.34	312	4.00	09:07	15	1.00	35.8	40.1	190
02020	H06	5/13	59.81	144.41	225	4.04	09:47	15	1.01	33.6	36.1	165
02021	J06	5/13	59.78	144.40	227	4.10	10:31	15	1.01	45.3	49.3	215
02022	J04	5/13	59.77	144.47	312	4.00	11:17	15	1.00	42.7	49.3	215
02023	F14	5/13	59.85	144.16	134	3.98	13:07	15	0.98	37.6	41.0	165
02024	H14	5/13	59.82	144.14	225	4.08	13:55	15	1.02	46.2	47.9	215
02025	H12	5/13	59.80	144.20	316	4.05	14:38	15	1.03	42.6	46.4	215
02026	F12	5/13	59.84	144.20	315	4.12	15:23	15	1.03	35.2	38.6	165
02027	F10	5/13	59.85	144.27	224	3.9	16:07	17	1.10	33.5	35.1	165
02028	H10	5/13	59.81	144.30	131	4.04	16:49	15	1.01	39.7	43.4	190
02029	J10	5/13	59.78	144.27	224	4.14	17:33	15	1.00	49.2	52.2	215
02030	I05	5/14	59.80	144.47	132	4.08	10:10	15	1.02	35.0	42.2	165
02031	I07	5/14	59.80	144.40	136	4.08	10:56	15	1.02	39.1	44.1	190
02032	G09	5/14	59.83	144.33	132	4.03	12:00	15	1.03	34.5	38.5	165
02033	I15	5/14	59.79	144.11	321	4.04	13:27	15	1.01	49.7	53.2	215
02034	G15	5/14	59.82	144.11	320	4.00	14:13	15	1.00	42.2	45.8	190
02035	G13	5/14	59.83	144.19	141	3.98	15:42	16	1.03	41.3	44.3	190
02036	I13	5/14	59.79	144.18	321	3.92	16:33	15	.98	47.9	51.5	215
02037	G11	5/14	59.82	144.24	321	4.20	17:16	15	1.01	36.7	40.7	165

-continued-

Table 2.–Page 2 of 2.

West Bed

Tow number	Station	Date	Tow Start Lat (°N)	Tow Start Long (°W)	Course (True)	Speed (nmi/h)	Start time	Duration (minutes)	Distance (nmi)	Depth (fathoms) Min	Depth (fathoms) Max	Scope (fathoms)
West Bed Stations												
02001	H34	5/11	59.82	144.77	229	4.20	11:39	15	1.05	40.6	42.8	165
02002	H36	5/11	59.82	144.70	226	4.06	12:39	16	1.05	33.8	35.1	140
02003	J36	5/11	59.78	144.70	228	4.08	13:42	15	1.02	29.4	30.2	140
02004	J34	5/11	59.78	144.77	227	4.00	14:29	15	1.00	34.1	34.5	140
02005	J32	5/11	59.78	144.84	226	4.04	15:19	15	1.01	52.1	61.0	240
02006	L34	5/11	59.75	144.77	228	4.04	16:21	15	1.01	34.5	39.7	165
02007	L32	5/11	59.74	144.87	072	3.86	17:23	16	1.03	40.8	49.3	215
02008	N32	5/11	59.70	144.87	064	3.82	08:20	16	1.02	50.2	58.1	240
02009	M31	5/12	59.73	144.87	230	4.00	09:11	15	1.00	53.2	58.2	215
02010	K31	5/12	59.76	144.89	055	3.92	10:14	15	0.98	58.8	64.6	260
02011	K33	5/12	59.76	144.83	062	3.90	11:40	16	1.01	34.7	38.4	165
02012	M33	5/12	59.72	144.83	058	4.04	13:32	15	1.01	43.1	46.0	190
02013	M35	5/12	59.73	144.77	068	3.80	14:50	16	1.02	41.5	43.8	165
02014	K35	5/12	59.75	144.76	054	3.91	15:43	16	1.01	30.5	33.3	140
02015	I33	5/12	59.79	144.83	064	3.91	16:39	16	1.01	41.6	52.0	215
02016	I35	5/12	59.79	144.77	071	3.90	17:28	16	1.00	33.3	34.3	140
02017	G35	5/12	59.82	144.77	073	4.00	18:24	15	1.00	37.2	41.6	165
02038	H36	5/15	59.81	144.71	229	4.08	15:47	15	1.02	35.2	34.0	165
02039	I35	5/15	59.79	144.74	250	4.15	16:23	13	0.90	35.2	34.7	165
02040	I33	5/15	59.80	144.80	245	4.00	17:12	15	1.00	53.2	42.1	215
02041	H34	5/15	59.81	144.78	231	3.93	18:49	15	0.95	46.2	41.0	190
02042	G35	5/15	59.82	144.76	039	4.08	19:38	15	1.02	43.1	40.1	190

Table 3.–Catch weight by station and catch category during a weathervane scallop survey near Kayak Island, Alaska, 2002.

East Bed

Station	Whole Scallops	Scallop shells	Tanner Crab	Fishes	Debris/ Other	Total Catch
	Pounds per nautical mile					
J08	17.6	1.0	<0.1	0.8	5.9	25.3
H08	24.0	1.0	<0.1	<0.1	6.0	31.1
H06	0.3	0.0	<0.1	0.0	5.0	5.3
J06	22.2	0.5	<0.1	0.1	7.9	30.7
J04	24.0	0.5	<0.1	0.0	6.0	30.5
F14	8.2	1.0	<0.1	<0.1	4.1	13.3
H14	17.6	1.0	<0.1	<0.1	2.0	20.6
H12	21.4	0.0	<0.1	7.9	5.8	35.1
F12	9.7	1.9	<0.1	0.0	15.5	27.2
F10	0.2	1.8	0.0	0.6	3.6	6.2
H10	27.7	1.0	<0.1	0.0	13.9	42.6
J10	6.0	2.0	0.0	0.0	0.0	8.0
I05	3.9	3.9	0.4	1.3	37.3	46.8
I07	49.0	0.3	<0.1	0.2	21.6	71.2
G09	3.9	1.0	<0.1	0.0	5.8	10.7
I15	13.9	0.0	<0.1	0.0	21.8	35.7
G15	44.0	0.0	<0.1	0.1	12.0	56.1
G13	5.8	1.9	<0.1	0.0	1.9	9.7
I13	30.6	2.0	<0.1	0.0	42.9	75.5
G11	89.1	2.0	<0.1	0.0	37.6	128.7
Total	419.2	22.9	0.7	11.0	256.5	710.3
Mean	21.0	1.1	0.0	0.6	12.8	35.5
Percent	59%	3%	<1%	2%	36%	100%
Frequency	100%	80%	90%	50%	90%	100%

-continued-

Table 3.–Page 2 of 2.

West Bed

Station	Whole Scallops	Scallop Shells	Tanner Crabs	Fishes	Debris/ Other	Total Catch
	Pounds per nautical mile					
H34	32.4	2.9	0.2	1.0	11.4	47.9
H36	28.6	7.6	0.1	0.9	17.1	54.4
J36	15.7	1.0	0.0	10.5	2.0	29.1
J34	74.0	0.0	0.1	0.7	8.0	82.7
J32	65.3	1.0	0.0	11.9	0.0	78.2
L34	79.2	7.9	0.1	4.7	23.8	115.7
L32	308.7	48.5	0.0	2.7	15.5	375.5
N32	17.6	0.0	0.0	1.1	13.7	32.5
M31	144.0	1.0	0.1	6.0	12.0	163.1
K31	0.9	0.0	0.0	6.1	32.7	39.7
K33	180.2	11.9	0.1	3.3	21.8	217.2
M33	184.2	1.0	0.0	1.6	21.8	208.6
M35	0.0	0.6	0.2	1.2	35.3	37.4
K35	42.1	0.7	0.0	0.0	16.2	59.0
I33	21.8	5.0	0.0	0.0	9.9	36.6
I35	188.0	4.0	0.0	0.1	20.0	212.1
G35	22.0	1.0	0.1	1.2	10.0	34.4
H36[a]	3.9	1.0	0.0	0.0	0.0	4.9
I35[a]	173.3	2.2	0.0	0.0	6.7	182.2
I33[a]	144.0	1.0	0.0	0.0	0.0	145.0
H34[a]	21.1	1.1	0.0	0.0	0.0	22.1
G35[a]	13.7	1.0	0.0	0.0	0.0	14.7
Total	1,760.8	100.4	1.2	52.8	277.8	2,192.9
Mean	80.0	4.6	0.1	2.4	12.6	99.7
Percent	80%	5%	<1%	2%	13%	100%
Frequency	95%	86%	64%	73%	77%	100%

[a] Replicate tow with the dredge liner removed.

Table 4.–Catch abundance by catch category during a weathervane scallop survey near Kayak Island, 2002.

East Bed

Station	Weathervane Scallops	Tanner Crabs	Fishes	Total
	Animals per nautical mile			
J08	30.4	1.0	2.0	33.3
H08	37.0	1.0	1.0	39.0
H06	1.0	5.9	0.0	6.9
J06	39.6	1.0	1.0	41.6
J04	44.0	2.0	0.0	46.0
F14	18.4	1.0	1.0	20.4
H14	30.4	1.0	1.0	32.4
H12	43.7	3.9	2.9	50.5
F12	20.4	1.0	0.0	21.4
F10	1.8	0.0	0.9	2.7
H10	40.6	2.0	0.0	42.6
J10	12.0	0.0	0.0	12.0
I05	14.7	54.9	3.9	73.5
I07	82.4	5.9	3.9	92.2
G09	8.7	2.9	0.0	11.7
I15	29.7	2.0	0.0	31.7
G15	89.0	2.0	1.0	92.0
G13	9.7	1.0	0.0	10.7
I13	55.1	4.1	0.0	59.2
G11	161.4	2.0	0.0	163.4
Total	769.9	94.5	18.6	883.0
Mean	38.5	4.7	0.9	44.2
Percent	87%	11%	2%	100%
Frequency	100%	90%	50%	100%

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Table 4.–Page 2 of 2.

West Bed				
Station	Whole Scallops	Tanner Crabs	Fishes	Total
	Animals per nautical mile			
H34	87.6	32.4	4.8	124.8
H36	66.7	18.1	17.1	101.9
J36	34.3	1.0	35.3	70.6
J34	157.0	9.0	4.0	170.0
J32	118.8	1.0	2.0	121.8
L34	134.7	9.9	9.9	154.5
L32	573.8	4.9	5.8	584.5
N32	39.2	0.0	3.9	43.1
M31	261.0	20.0	17.0	298.0
K31	4.1	1.0	1.0	6.1
K33	356.4	10.9	5.9	373.3
M33	323.8	0.0	6.9	330.7
M35	0.0	34.3	14.7	49.0
K35	74.3	4.0	1.0	79.2
I33	41.6	0.0	0.0	41.6
I35	318.0	4.0	2.0	324.0
G35	53.0	18.0	0.0	71.0
H36[a]	10.8	0.0	0.0	10.8
I35[a]	376.7	0.0	0.0	376.7
I33[a]	371.0	0.0	0.0	371.0
H34[a]	51.6	0.0	0.0	51.6
G35[a]	37.3	0.0	0.0	37.3
Total	3,491.5	168.4	131.4	3,791.3
Mean	158.7	7.7	6.0	172.3
Percent	92%	4%	4%	100%
Frequency	95%	64%	68%	100%

[a] Replicate tow with the dredge liner removed.

Table 5.–Weathervane scallop population biomass, abundance, and potential harvest levels for the East Bed and West Bed at Kayak Island, 2002.

East Bed			West Bed		
Station	Biomass (lb/nmi)	Abundance (scallops/nmi)	Station	Biomass (lb/nmi)	Abundance (scallops/nmi)
G11	101.6	184.0	L32	357.1	663.6
G15	51.5	104.2	K13	209.3	413.9
I07	50.2	84.4	I35	196.0	331.6
H08	30.6	47.2	M33	192.4	338.2
I13	30.6	55.1	M31	157.9	286.2
H10	29.9	43.8	L34	79.2	134.7
H12	27.5	56.2	J34	74.0	157.0
J04	26.4	48.4	J32	65.9	119.8
J06	25.4	45.3	K35	45.1	79.6
			H34	32.4	87.6
			H36	28.6	66.7
			G35	25.9	62.4
			I33	22.3	42.6
Mean Catch	41.5	74.3	Mean Catch	114.3	214.1
Variance	605.1	2,112.1	Variance	10,247.5	33,593.3

	Biomass (lb)	Abundance (scallops)		Biomass (lb)	Abundance (scallops)
Population [a]	567,667	1,015,428	Population [a]	2,257,272	4,228,734
Est. Meats [b]	40,678		Est. Meats [b]	161,752	

	Potential Meat Harvest			Potential Meat Harvest	
Harvest Rate	(lbs)	(kg)	Harvest Rate	(lbs)	(kg)
3%	1,220	554	3%	4,853	2,201
4%	1,627	738	4%	6,470	2,935
5%	2,034	923	5%	8,088	3,669
6%	2,441	1,107	6%	9,705	4,402
7%	2,847	1,292	7%	11,323	5,136
8%	3,254	1,476	8%	12,940	5,870
9%	3,661	1,661	9%	14,558	6,603
10%	4,068	1,845	10%	16,175	7,337

[a] The population estimate uses a survey design that samples half of the stations in a defined bed.

[b] Based on an estimated meat recovery of 7.17%.

Table 6.–Size frequency distribution of weathervane scallops captured during a survey of East Bed and West Bed stations near Kayak Island, 2002.

East Bed

Shell heights range (mm)	Station											
	J08	H08	H06	J06	J04	F14	H14	H12	F12	F10	H10	J10
	Number of shell heights measured from tow											
	31	29	1	35	40	11	29	35	21	2	38	9
	Number of extrapolated shell heights											
>25	0	0	0	1	0	0	0	1	0	0	0	0
26–30	0	0	0	0	0	0	0	0	0	0	0	0
31–35	0	0	0	0	0	0	0	0	0	0	0	0
46–40	0	0	0	0	0	0	0	0	0	0	0	0
41–45	0	0	0	0	0	0	0	0	0	0	0	0
46–50	0	0	0	0	0	0	0	0	0	0	0	0
51–55	0	0	0	0	0	0	0	0	0	0	0	0
56–60	0	0	0	0	0	0	1	1	0	0	0	0
51–65	1	0	0	0	0	0	0	1	1	0	0	0
66–70	0	0	0	1	0	0	0	0	0	0	0	0
71–75	0	0	0	0	0	0	0	0	3	0	0	0
76–80	1	0	0	0	0	0	0	0	1	1	0	0
81–85	0	0	0	0	3	0	0	0	0	0	0	0
86–90	0	0	0	0	1	0	0	0	0	0	0	0
91–95	0	0	0	0	0	0	0	0	0	0	0	0
96–100	0	0	0	0	0	0	0	0	0	0	0	0
101–105	0	1	0	0	0	0	0	0	0	1	0	0
106–110	0	0	0	0	3	0	0	0	0	0	0	0
111–115	0	0	0	0	2	0	0	0	0	0	0	0
116–120	0	5	0	0	2	3	0	0	0	0	0	1
121–125	1	3	0	0	0	2	2	1	1	0	0	0
126–130	6	1	0	0	2	0	3	2	0	0	3	0
131–135	6	6	0	5	10	0	5	15	1	0	4	5
136–140	11	8	1	18	7	3	9	15	4	0	12	3
141–145	4	8	0	9	8	2	6	4	7	0	15	1
146–150	1	3	0	5	4	7	3	0	3	0	6	1
151–155	0	3	0	1	1	0	0	1	0	0	0	0
156–160	0	0	0	0	0	2	0	1	0	0	0	0
161–165	0	0	0	0	0	0	0	0	0	0	0	0
Total	30	37	1	40	44	18	30	44	20	2	41	12
Percent	3.8	4.6	0.1	4.9	5.4	2.3	3.8	5.4	2.5	0.2	5.0	1.5

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Table 6.–Page 2 of 4.

East Bed (continued)

	Station									
	I05	I07	G09	I15	G15	G13	I13	G11	Total	Percent
	Number of shell heights measured from tow									
Shell heights	15	82	9	30	76	9	54	143	699	
range (mm)	Number of extrapolated shell heights									
>25	0	0	0	0	0	0	0	0	2	0.3
26–30	0	0	0	0	0	0	0	1	1	0.1
31–35	0	0	0	0	1	0	0	0	1	0.2
46–40	0	0	0	0	0	0	0	0	40	5.2
41–45	0	0	0	0	0	0	1	0	1	0.1
46–50	0	0	0	1	0	0	0	0	1	0.1
51–55	0	0	0	0	2	0	0	1	3	0.5
56–60	0	0	0	1	5	0	0	0	8	1.0
51–65	0	2	0	1	1	0	0	0	7	1.0
66–70	1	2	0	1	1	0	0	0	6	0.8
71–75	3	1	0	1	0	0	0	0	8	1.0
76–80	1	0	1	0	0	0	0	0	5	0.6
81–85	0	3	0	1	1	1	0	0	10	1.2
86–90	0	3	0	0	0	0	0	0	4	0.5
91–95	0	0	0	0	2	0	0	1	3	0.5
96–100	1	0	0	0	0	0	0	0	1	0.1
101–105	0	0	0	0	0	0	0	0	2	0.3
106–110	0	0	0	0	0	0	0	1	4	0.6
111–115	4	3	0	0	0	1	0	1	11	1.5
116–120	3	5	0	0	0	0	0	2	22	2.9
121–125	1	1	0	4	2	0	4	1	23	3.0
126–130	1	3	1	10	6	0	6	5	50	6.4
131–135	0	7	2	6	19	2	16	20	130	16.9
136–140	0	14	3	1	21	2	18	37	187	24.3
141–145	0	19	1	1	15	3	6	52	161	20.9
146–150	0	11	1	1	8	0	3	32	89	11.5
151–155	0	7	0	1	1	0	0	7	22	2.9
156–160	0	1	0	0	1	0	0	0	5	0.7
161–165	0	0	0	0	1	0	0	0	1	0.2
Total	15	82	9	30	89	10	55	161	770	100
Percent	1.8	10.2	1.1	3.7	11.0	1.2	6.8	19.9	100	

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Table 6.–Page 3 of 4.

West Bed												
	Station											
Shell heights range (mm)	H34	H36	J36	J32	J35	L34	L32	N32	M31	K31	K33	M33
	Number of shell heights measured from tow											
	92	70	35	157	119	136	511	40	238	4	310	313
	Number of extrapolated shell heights											
>25	0	0	0	0	0	0	0	0	0	0	0	0
26–30	0	0	0	0	0	0	0	0	0	0	0	0
31–35	0	0	0	0	0	0	0	0	0	0	0	0
46–40	0	0	0	0	0	0	0	0	0	0	0	0
41–45	0	1	1	0	0	0	0	0	0	0	0	0
46–50	0	0	1	0	0	0	0	0	0	0	0	0
51–55	1	1	0	0	0	0	0	0	0	0	0	0
56–60	1	0	0	0	0	0	0	0	0	0	0	0
51–65	0	0	0	0	0	0	0	0	0	0	0	0
66–70	0	0	0	0	0	0	0	0	0	0	1	0
71–75	0	1	0	0	0	0	0	0	1	0	0	0
76–80	1	1	0	0	0	0	0	2	0	0	1	0
81–85	0	0	0	0	0	0	0	0	0	0	0	0
86–90	0	0	0	0	0	0	0	1	0	0	1	0
91–95	0	1	0	0	0	1	0	0	0	0	0	0
96–100	0	0	0	0	0	0	0	0	0	0	0	0
101–105	9	2	1	1	1	0	0	0	0	0	1	0
106–110	1	2	0	0	0	1	1	0	1	0	17	1
111–115	9	8	0	14	1	2	9	0	5	0	33	8
116–120	14	12	5	18	3	6	35	2	15	0	39	30
121–125	25	18	6	25	20	11	58	7	42	0	44	69
126–130	16	13	9	33	30	49	183	8	93	1	80	124
131–135	10	7	7	42	27	29	135	14	58	1	71	55
136–140	1	0	4	17	25	24	89	6	32	1	51	28
141–145	0	0	1	4	10	11	47	0	8	1	11	7
146–150	0	0	0	2	1	2	13	0	4	0	3	1
151–155	0	0	0	1	0	0	3	0	1	0	1	0
156–160	0	0	0	0	1	0	0	0	0	0	0	0
161–165	0	0	0	0	0	0	0	0	0	0	0	0
Total	88	67	34	157	119	135	574	39	261	4	356	324
Percent	2.5	1.9	1.0	4.4	3.4	3.8	16.2	1.1	7.4	0.1	10.1	9.2

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Table 6.–Page 4 of 4.

West Bed (continued)											
	Station										
	K15	I33	I35	G35	H36[a]	I35[a]	I33[a]	H34[a]	G35[a]	Total	Percent
	Number of shell heights measured										
Shell heights range (mm)	70	41	305	45	11	298	303	39	31	3,168	
	Number of extrapolated shell heights										
>25	0	0	0	2	0	0	0	0	0	2	0.1
26–30	0	0	0	0	0	0	0	0	0	0	0.0
31–35	0	0	0	2	0	0	0	0	0	2	0.1
46–40	0	0	0	1	0	0	0	0	0	1	0.0
41–45	0	0	0	0	0	0	0	0	0	2	0.1
46–50	0	0	0	0	0	0	0	0	0	1	0.0
51–55	0	0	0	0	0	0	0	0	0	2	0.1
56–60	0	0	0	0	0	0	0	0	0	1	0.0
51–65	0	0	0	0	0	0	0	0	0	0	0.0
66–70	0	0	0	0	0	0	0	0	0	1	0.0
71–75	0	0	0	0	0	0	0	0	0	2	0.1
76–80	0	0	0	0	0	0	0	0	0	5	0.1
81–85	0	0	0	0	0	0	0	0	0	0	0.0
86–90	0	0	0	0	0	0	0	0	0	2	0.1
91–95	0	0	0	1	0	0	0	0	0	3	0.1
96–100	0	0	0	1	0	0	0	0	0	1	0.0
101–105	0	0	1	1	0	0	0	0	0	17	0.5
106–110	0	0	5	2	0	4	0	1	2	39	1.1
111–115	0	0	13	8	2	11	2	1	6	133	3.8
116–120	5	2	15	16	1	23	7	8	14	272	7.8
121–125	11	5	59	11	4	70	29	5	6	524	15.0
126–130	25	12	106	2	2	106	81	13	6	994	28.5
131–135	20	13	66	4	2	119	144	16	2	841	24.1
136–140	12	5	39	0	0	33	72	5	0	442	12.7
141–145	1	2	14	0	0	10	26	0	0	153	4.4
146–150	0	2	1	0	0	1	6	1	0	39	1.1
151–155	0	0	0	0	0	0	2	0	0	9	0.3
156–160	0	0	0	0	0	0	0	0	0	1	0.0
161–165	0	0	0	0	0	0	0	0	0	0	0.0
Total	74	42	318	53	11	377	371	52	37	3,491	100
Percent	2.1	1.2	9.0	1.5	0.3	10.7	10.5	1.5	1.1	100	

[a] Replicate tow with dredge liner removed.

Table 7.–Age composition of weathervane scallops by station based on size-at-age extrapolations from ADF&G Kayak Island survey data, 2002.

East Bed		Scallop Age Class (years)																			
	Aged	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
Station	n	Extrapolated Abundance by Age Class																			
J08	19	0	2	0	0	0	0	0	0	0	5	5	3	4	7	5	0	0	0	0	31
H08	18	0	0	0	0	1	1	0	0	0	3	1	3	4	8	7	0	0	1	0	29
H06	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
J06	22	1	0	1	0	0	0	0	0	0	1	3	8	9	7	5	0	0	0	0	35
J04	20	0	0	2	2	2	3	1	2	0	1	1	3	11	9	3	0	0	0	0	40
F14	11	0	0	0	0	2	1	0	0	0	0	0	2	2	3	0	1	0	0	0	11
H14	20	0	1	0	0	0	0	0	0	2	2	2	7	11	3	1	0	0	0	0	29
H12	2	1	2	0	0	0	0	0	0	0	2	5	5	10	4	5	0	0	0	1	35
F12	21	0	5	0	0	1	0	0	0	0	0	0	6	3	4	2	0	0	0	0	21
F10	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
H10	20	0	0	0	0	0	0	0	0	0	0	2	9	9	14	4	0	0	0	0	38
J10	9	0	0	0	0	0	0	0	0	0	2	3	3	0	1	0	0	0	0	0	9
I05	15	0	4	1	2	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	15
I07	31	0	4	2	5	3	1	0	1	0	2	3	6	20	15	15	3	0	2	0	82
G09	8	0	1	0	0	0	0	0	0	0	0	1	2	2	3	0	0	0	0	0	9
I15	26	0	4	2	0	0	0	0	0	0	5	5	6	5	2	1	0	0	0	0	30
G15	31	1	8	2	0	1	0	0	0	0	2	3	12	10	26	7	1	1	1	1	76
G13	9	0	0	0	2	0	0	0	0	1	1	1	1	2	0	1	0	0	0	0	9
I13	21	0	1	0	0	0	0	0	0	0	7	5	16	10	13	2	0	0	0	0	54
G11	22	1	1	0	1	2	0	0	2	0	0	3	30	14	42	42	4	1	0	0	143
Total	327	4	34	10	12	19	7	1	6	3	33	43	123	126	161	100	9	2	4	2	697
Percent		0.6	4.9	1.4	1.7	2.7	1.0	0.1	0.9	0.4	4.7	6.2	17.6	18.1	23.1	14.3	1.3	0.3	0.6	0.3	100

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Table 7.–Page 2 of 2.

West Bed		Scallop Age Class (years)																			
	Aged	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
Station	n	Extrapolated Abundance by Age Class																			
H34	20	0	3	0	2	14	6	5	7	3	12	16	12	7	3	2	0	0	0	0	92
H36	21	1	3	0	2	11	2	6	5	0	12	12	10	4	2	0	0	0	0	0	70
J36	21	1	1	0	0	1	0	3	0	1	0	9	6	5	5	3	0	0	0	0	35
J34	20	0	0	0	3	17	1	4	16	10	10	33	28	21	11	3	0	0	0	0	157
J32	19	0	0	0	0	3	1	0	3	8	7	24	23	29	18	2	0	1	0	0	119
L34	19	0	0	0	1	2	0	3	5	3	16	25	24	31	23	3	0		0	0	136
L32	20	0	0	0	1	7	0	11	9	17	47	128	103	112	58	15	1	2	0	0	511
N32	19	0	0	3	0	0	0	0	3	1	5	13	4	6	5		0	0	0	0	40
M31	20	0	0	1	0	5	1	3	3	17	22	50	44	44	39	9	0	0	0	0	238
K31	4	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0	4
K33	20	0	1	2	5	27	12	9	8	25	24	58	51	50	26	11	1	0	0	0	310
M33	20	0	0	0	1	6	0	6	10	16	64	86	53	32	33	6	0	0	0	0	313
M35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K35	19	0	0	0	0	0	0	0	0	3	5	19	18	14	10	1	0	0	0	0	70
I33	19	0	0	0	0	0	0	0	1	0	2	6	10	12	8	0	1	0	0	1	41
I35	26	0	0	0	2	9	2	3	15	4	37	55	52	76	36	13	0	1	0	0	305
G35	25	5	0	0	0	7	0	1	4	2	3	7	12	1	2	0	1	0	0	0	45
H36[a]	0	0	0	0	0	2	0	0	1	0	4	0	0	4	0	0	0	0	0	0	11
I35[a]	0	0	0	0	1	7	2	5	8	0	47	25	71	74	36	21	1	0	0	0	298
I33[a]	0	0	0	0	0	2	0	0	4	0	23	13	72	83	57	38	7	4	0	0	303
H34[a]	0	0	0	0	0	1	1	0	0	0	5	4	6	8	6	2	6	0	0	0	39
G35[a]	0	0	0	0	1	3	0	4	2	0	8	3	2	6	0	0	2	0	0	0	31
Total	312	7	8	6	19	124	28	63	105	111	353	588	601	619	378	129	20	8	0	1	3,168
Percent		0.2	0.3	0.2	0.6	3.9	0.9	2.0	3.3	3.5	11.1	18.6	19.0	19.5	11.9	4.1	0.6	0.3	0.0	0.0	100

[a] Replicate tow with dredge liner removed.

Table 8.–Sex composition and maturity of weathervane scallops sampled from a dredge survey near Kayak Island, Alaska, 2002.

	Sex (number of scallops)				
East Bed	Unknown	Male	Female	Total	Percent
Maturity					
Spawning	0	111	136	247	86.7%
Nonspawning	9	7	22	38	13.3%
Total	9	118	158	285	100.0%
Percent	3.2%	41.4%	55.4%	100.0%	

	Sex (number of scallops)				
West Bed	Unknown	Male	Female	Total	Percent
Maturity					
Spawning	0	142	133	275	90.2%
Nonspawning	13	5	12	30	9.8%
Total	13	147	145	305	100.0%
Percent	4.3%	48.2%	47.5%	100.0%	

Table 9.–Fish catch by area during the Kayak Island scallop survey, 2002.

Common Name	Scientific name	East	West	Total
Arrowtooth Flounder	*Atheresthes stomias*	1	0	1
Eelpout	Family Zoarcidae	4	14	18
Greenling	*Hexagrammos* sp	1	0	1
Rex Sole	*Glyptocephalus zachirus*	4	53	57
Walleye Pollock	*Theragra chalcogramma*	0	1	1
Wrymouth	Family Cryptacanthodidae	4	1	5
Flathead Sole	*Hippoglossoides elassodon*	0	5	5
Dover Sole	*Microstomus pacificus*	6	43	49
Sculpin	Family Cottidae	0	2	2
Skate	Genera *Raja* and *Bathyraja*	0	1	1
Sturgeon Poacher	Family Agonidae	0	2	2
Total		20	122	142

Table 10.–Whole weight, meat weight, and average meat recovery of weathervane scallops sampled from a dredge survey near Kayak Island, Alaska, 2002.

Date	Number of Scallops	Weight (kg)		Percent Recovery
		Whole	Meat	
5/11/2002	139	34	2.4	7.03%
5/12/2002	167	35	2.6	7.40%
5/13/2002	180	47	3.5	7.34%
5/14/2002	129	34	2.4	6.82%
Total	615	151	10.8	7.17% [a]

[a] Total mean recovery calculated as daily recovery weighted by daily whole scallop weight.

Table 11.–Estimates of weathervane scallop CPUE, biomass, abundance, and scope within defined bed areas during ADF&G surveys near Kayak Island, 1996–2002.

Year	Defined bed (nmi^2)	Stations sampled	CPUE (kg/nmi)	CPUE (lb/nmi)	Population Biomass (mt)	Population Biomass (1,000 lb)	Population Biomass CV (%)	Population Abundance (million)	Population Abundance CV (%)	Mean scope
East Bed										
1996	82	41	15.9	30.0	988 ±235	2,177 ±518		4.4 ±1.3		3.7
1998	42	21	27.2	60.0	868 ±256	1,914 ±563	14.1	3.4 ±1.2	17.6	3.5
2000	50	25	48.6	107.1	1,845 ±416	4,067 ±917	10.9	7.8 ±1.6	9.7	3.6
2002	18	9	18.8	41.5	257 ±117	568 ±258	19.7	1.0 ±0.5	20.6	4.3
Average	48	24	27.6	60.9	990 ±256	2,182 ±	14.9	4.13 ±1.1	16.0	
West Bed										
1996	No Svy									
1998	26	13	53.8	118.5	1,062 ±576	2,341 ±1,269	24.9	4.3 ±1.4	14.7	3.5
2000	32	16	117.0	257.9	2,843 ±1,699	6,268 ±3,746	28.0	14.5 ±7.2	23.1	3.5
2002	26	13	51.9	114.3	1,024 ±548	2,257 ±1,207	24.5	4.2 ±2.2	23.7	4.1
Average	28.0	14.0	74.2	163.6	1,643 ±941	3,622 ±	25.8	7.7 ±3.6	20.5	

Note: All sampled stations were used for the 1996 estimate. After 1996, the scallop bed was defined to include only those stations where scallop catch exceeded 9.8 kg/nm (20lb/nmi), and only stations in the defined bed were used for calculation of catch per unit of effort (CPUE), biomass, and abundance.

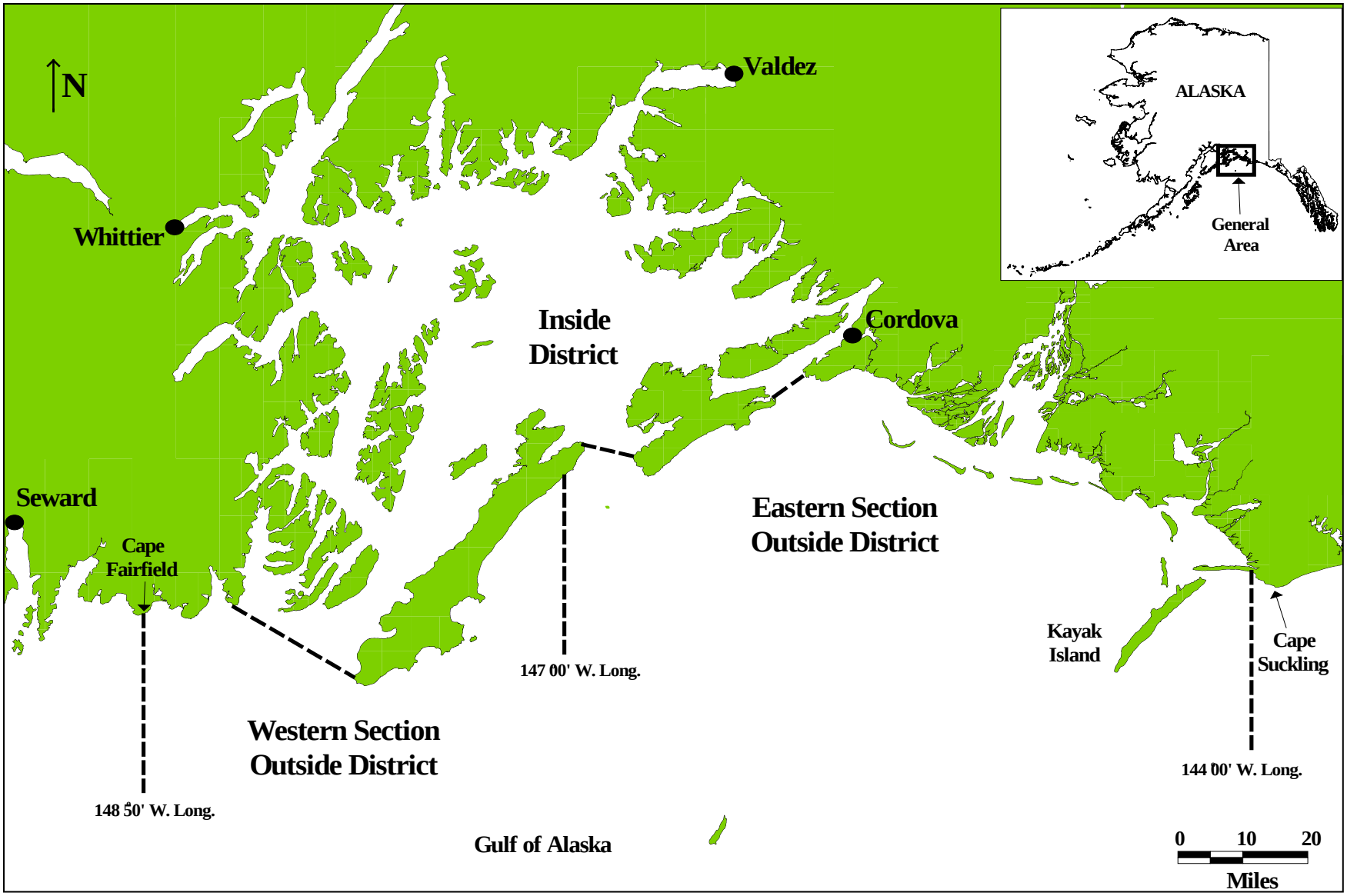

Figure 1.–Location of Kayak Island within the Eastern Section of the Outside District in the Prince William Sound Management Area.

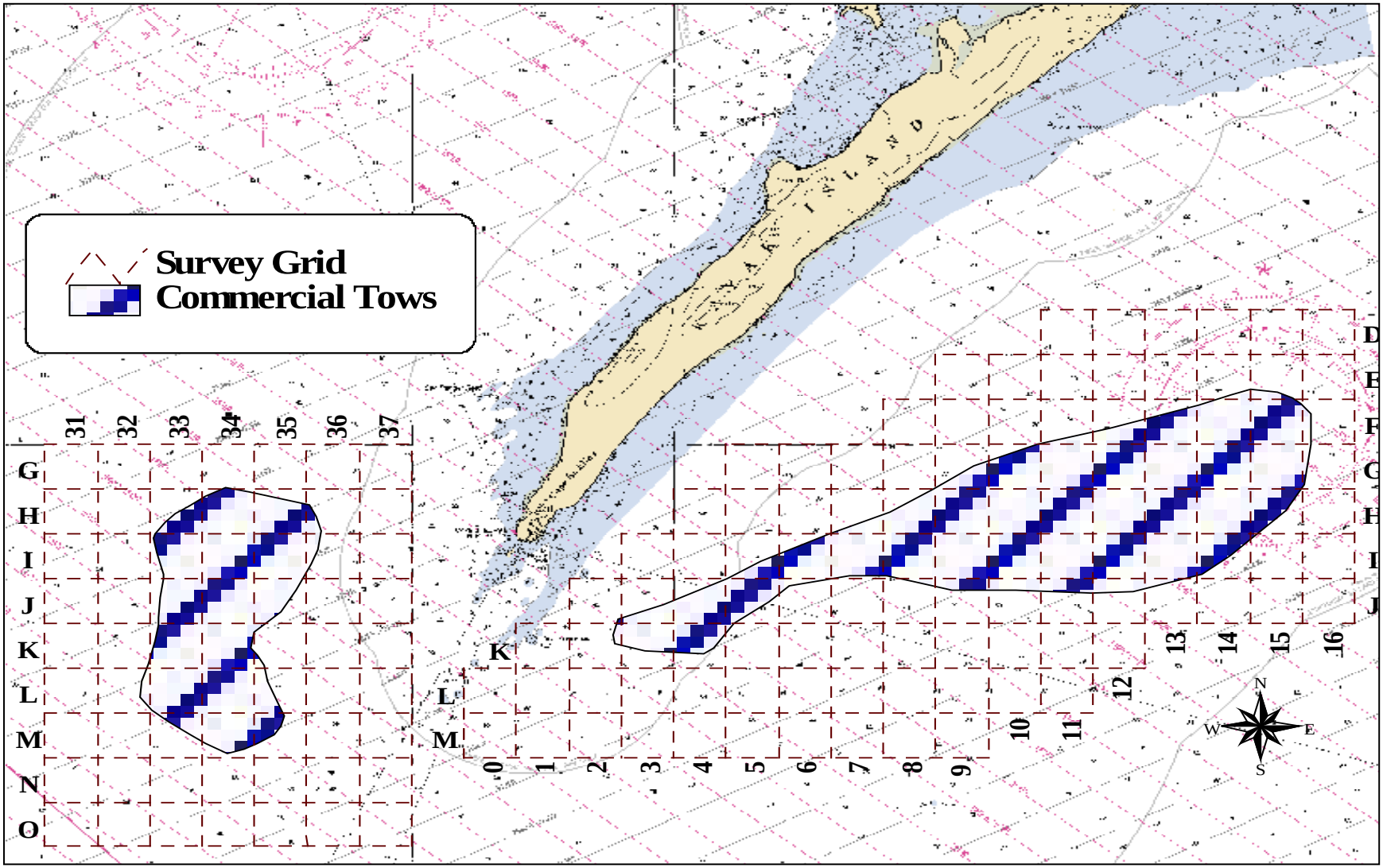

Figure 2.–General survey area showing 95% bounds of the commercial fishery tows (hatched pattern) and the preliminary survey grid.

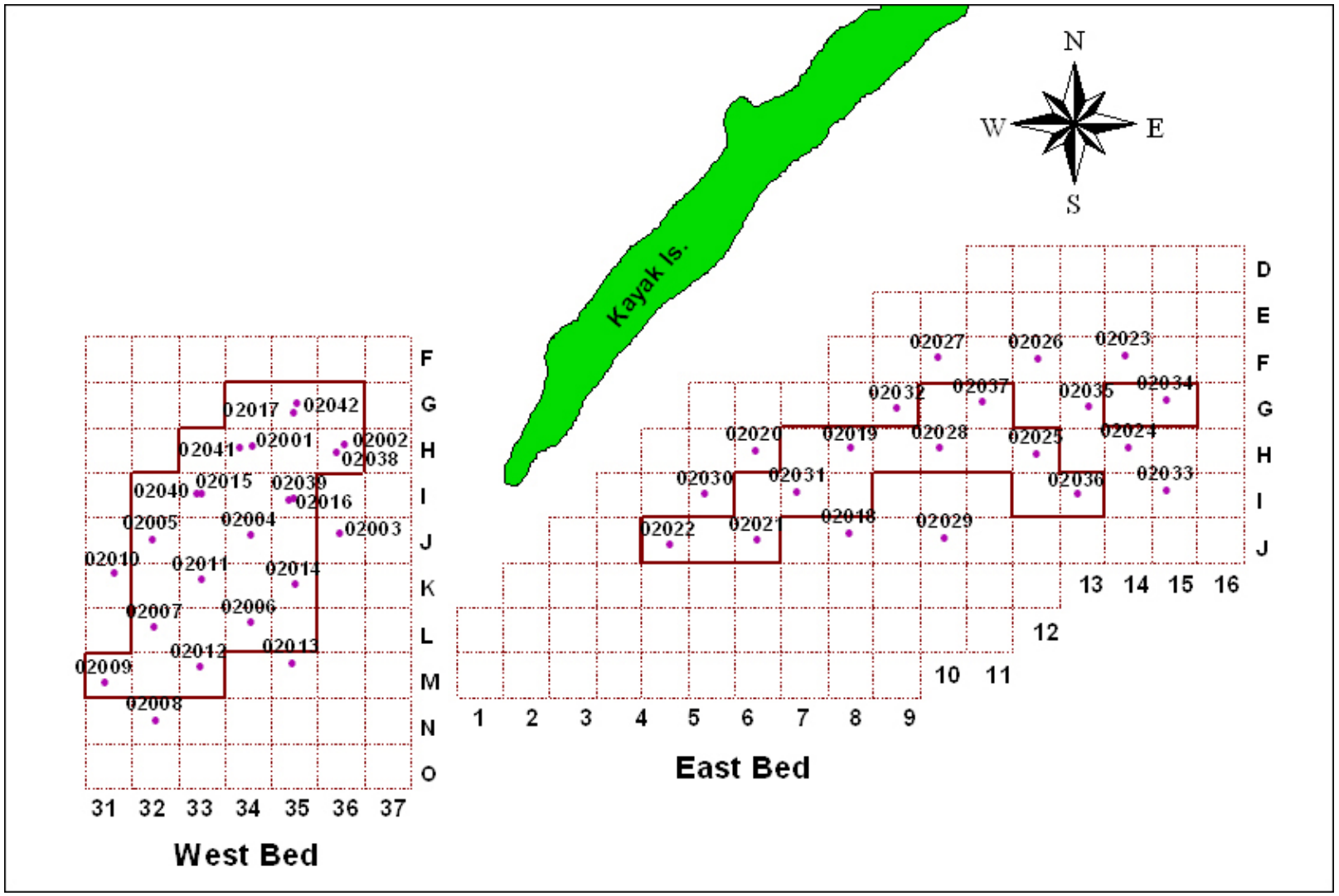

Figure 3.–Midpoints of dredge tows, identified by tow number, across the survey grid for the ADF&G weathervane scallop survey near Kayak Island, Alaska, 2002.

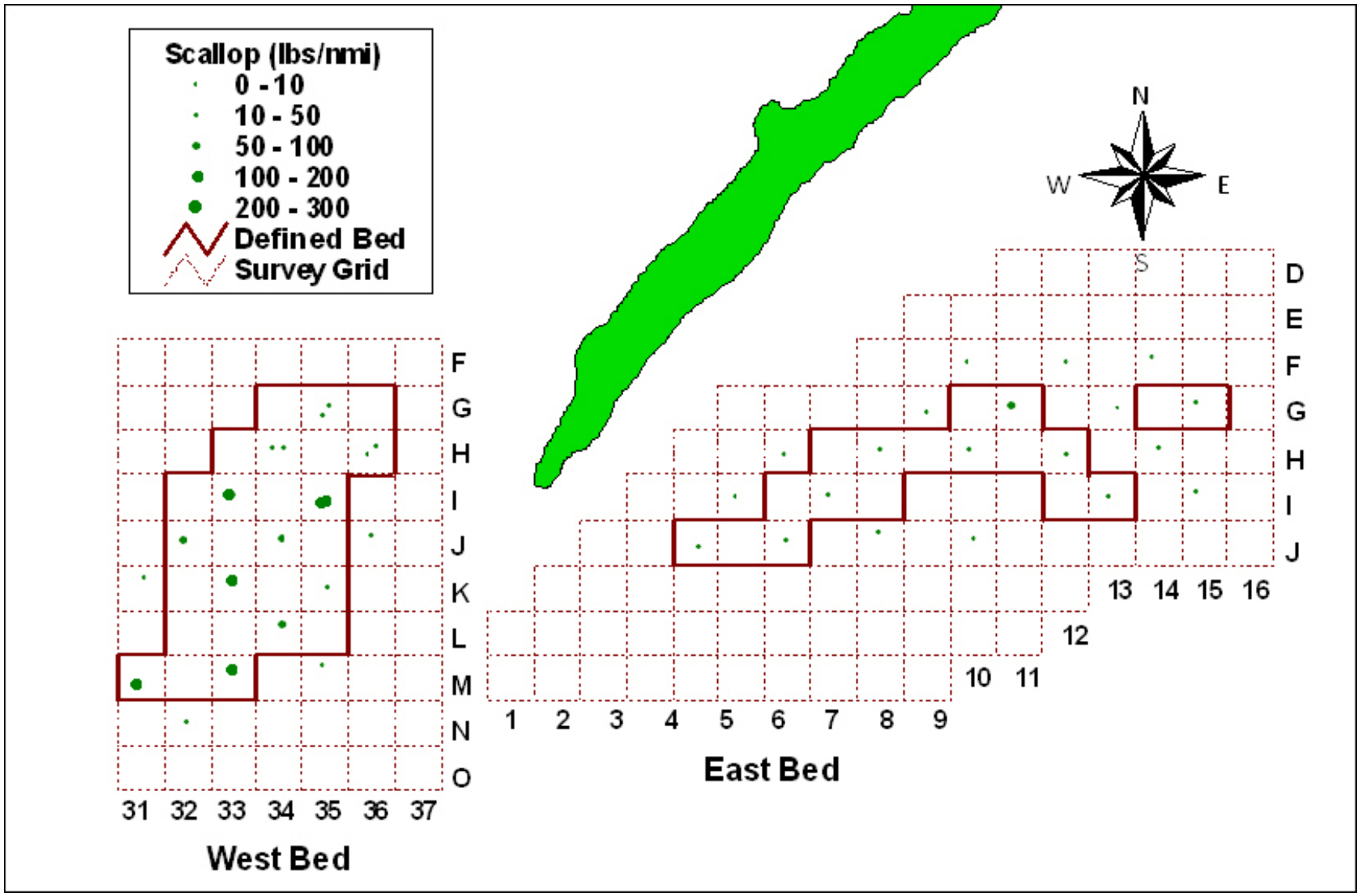

Figure 4.–Weathervane scallop catch weight by survey tow from the ADF&G dredge survey near Kayak Island, Alaska, 2002.

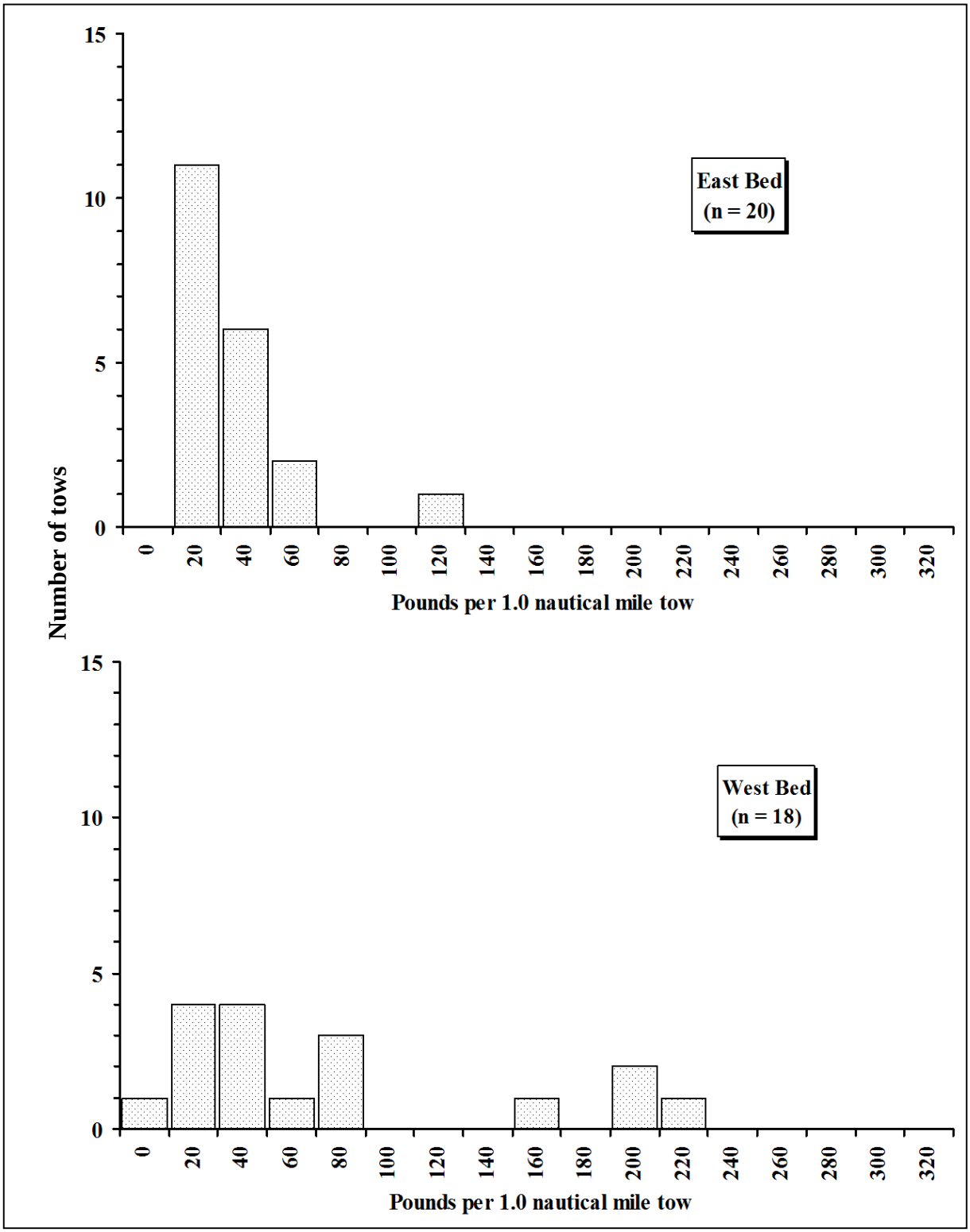

Figure 5.–Frequency distributions of weathervane scallop tow catch weights of during the ADF&G dredge survey near Kayak Island, Alaska, 2002.

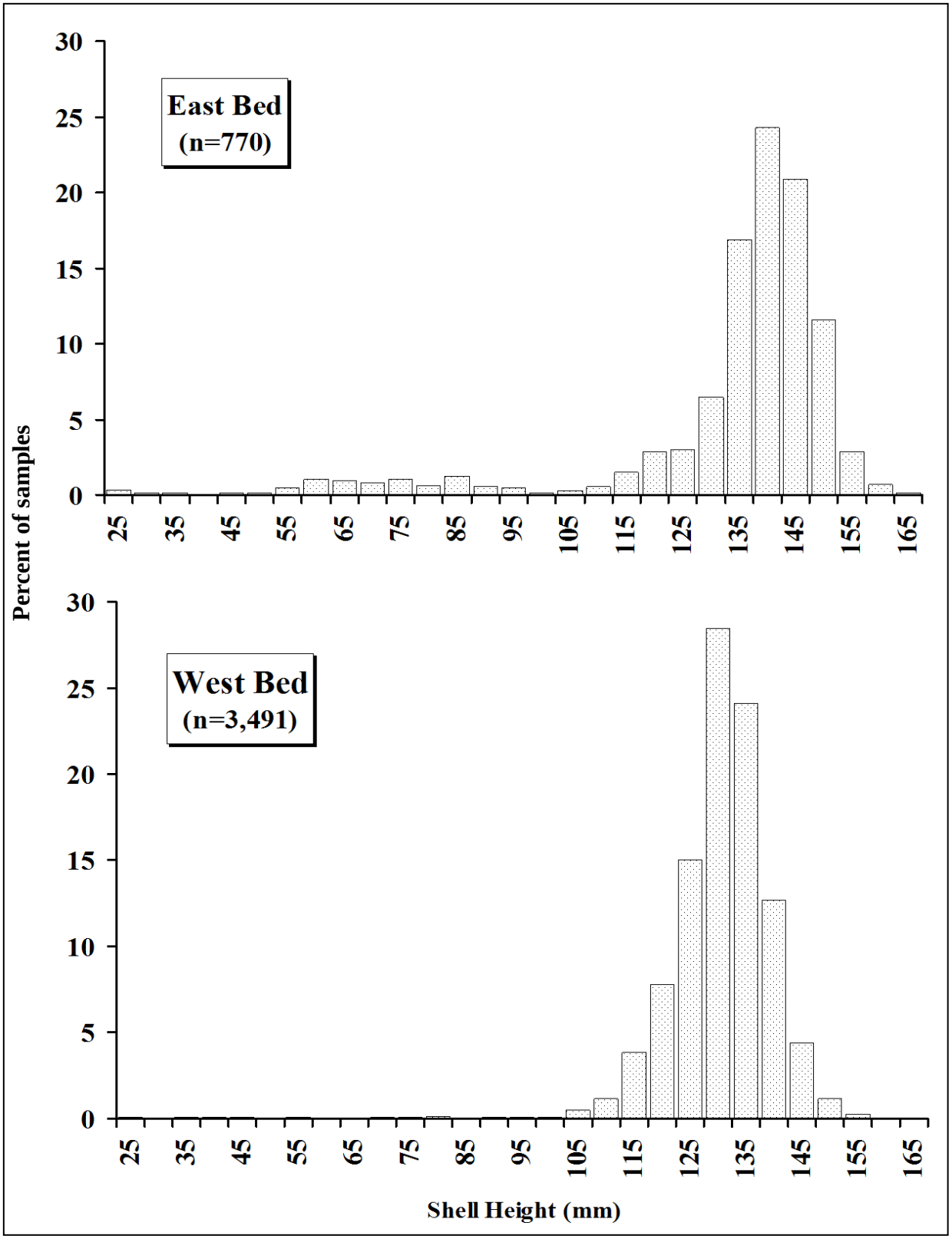

Figure 6.–Shell height compositions of weathervane scallops caught in the ADF&G dredge survey near Kayak Island, Alaska, 2002.

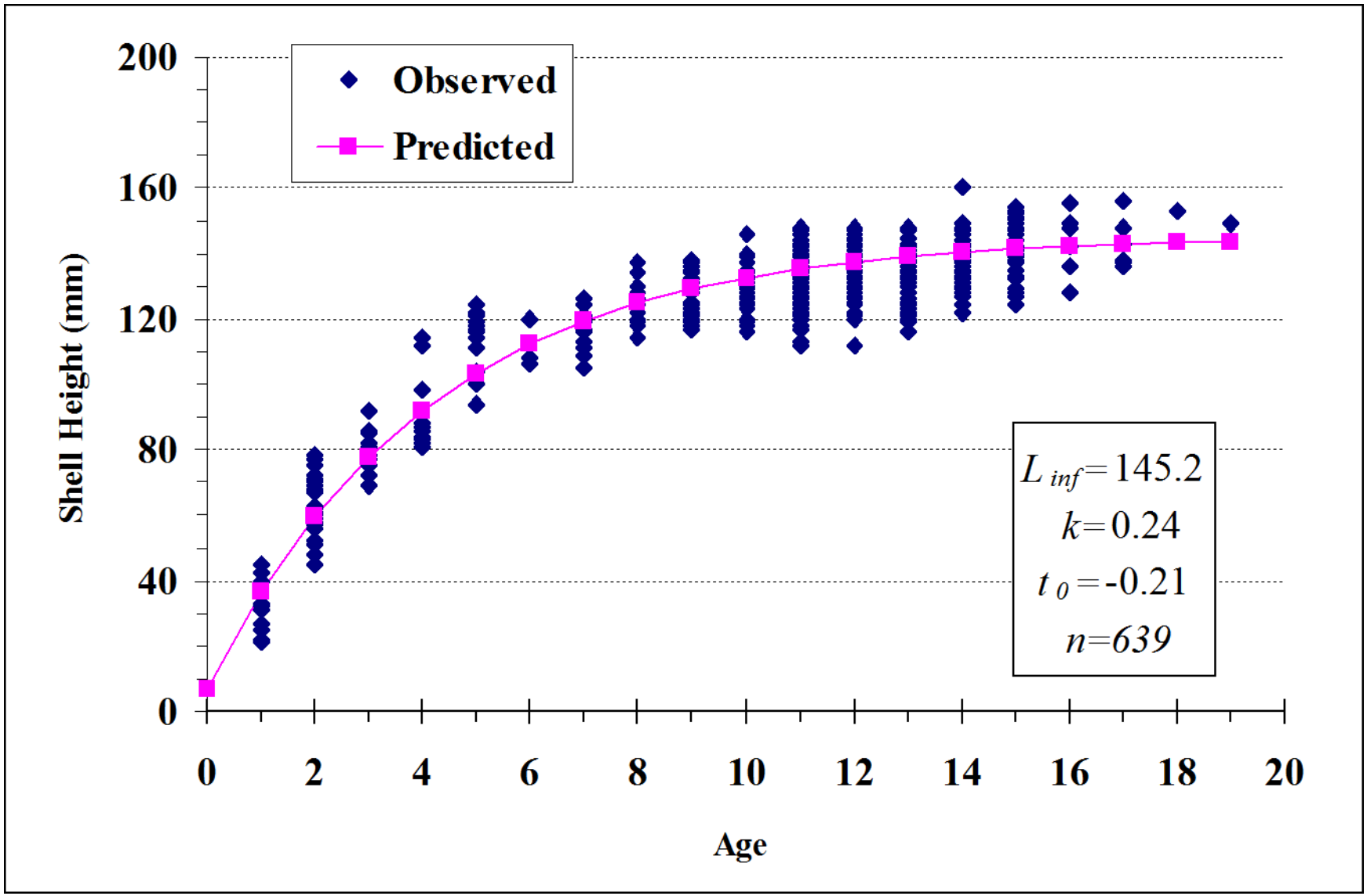

Figure 7.–Von Bertalanffy growth curve showing shell height-at-age for weathervane scallops in the ADF&G survey near Kayak Island, 2002.

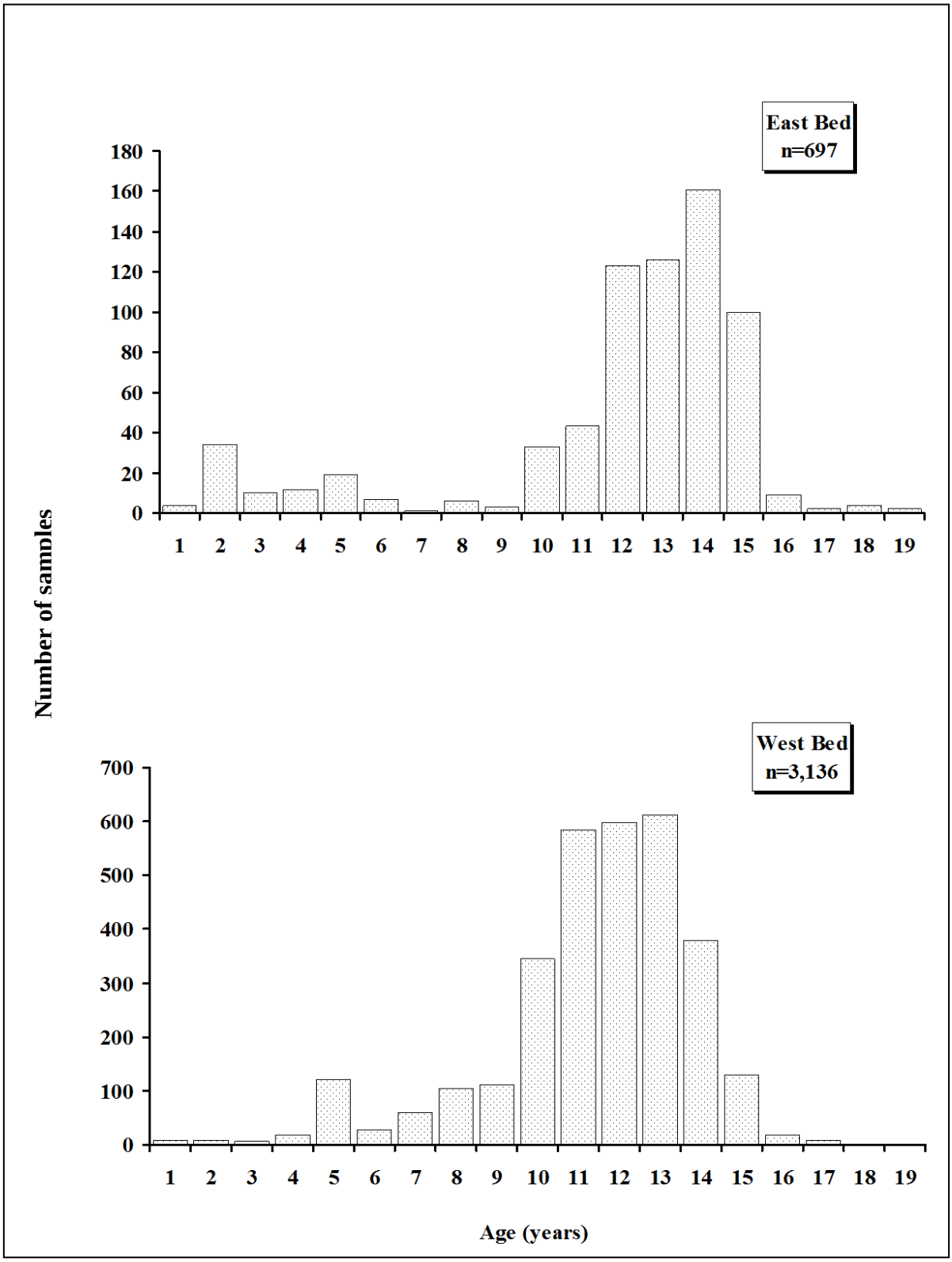

Figure 8.–Age compositions of weathervane scallops in the ADF&G survey near Kayak Island, Alaska, 2002.

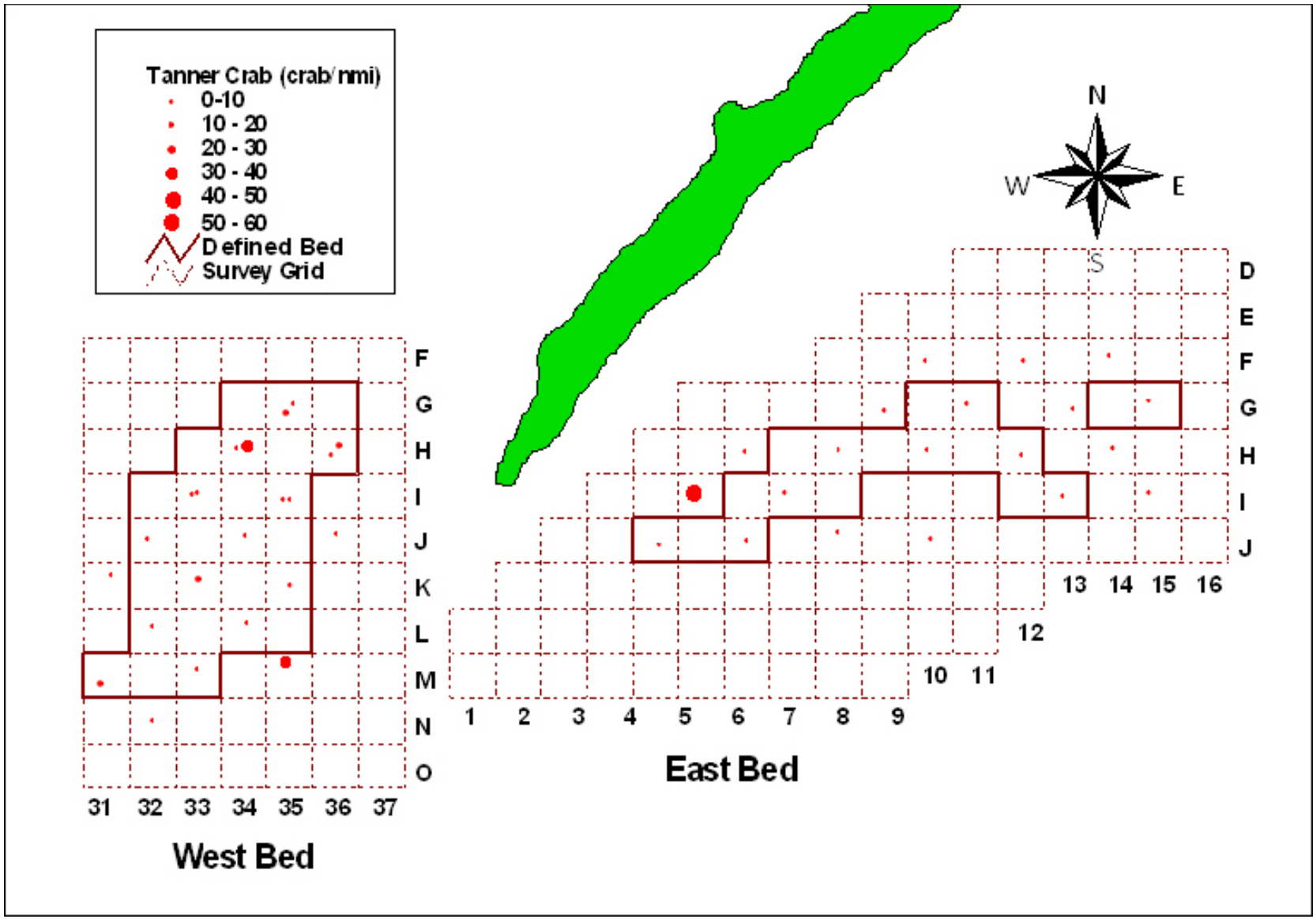

Figure 9.–Tanner crab catches during the ADF&G weathervane scallop survey near Kayak Island, 2002.

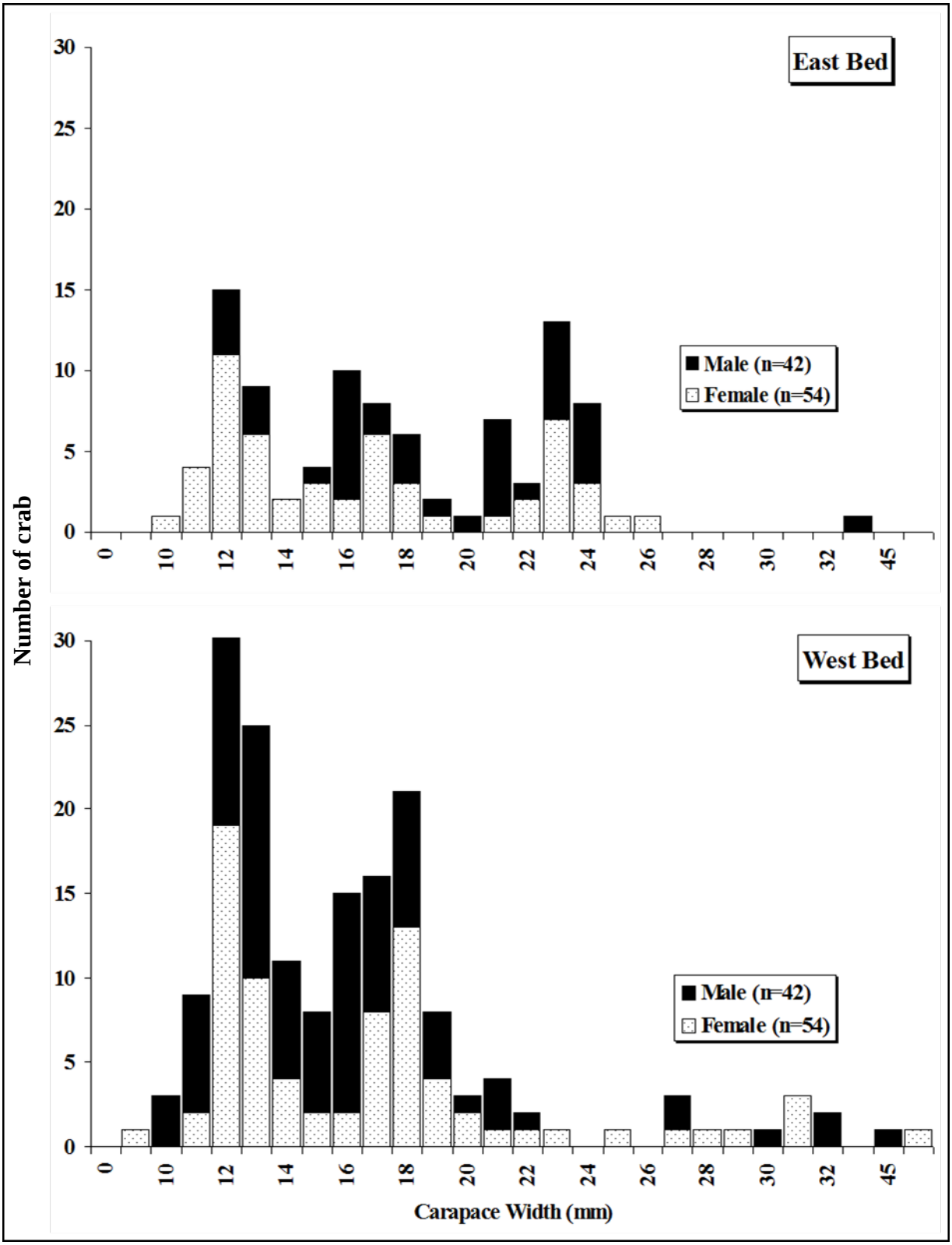

Figure 10.–Carapace width of Tanner crab caught in the ADF&G scallop survey near Kayak Island, 2002.

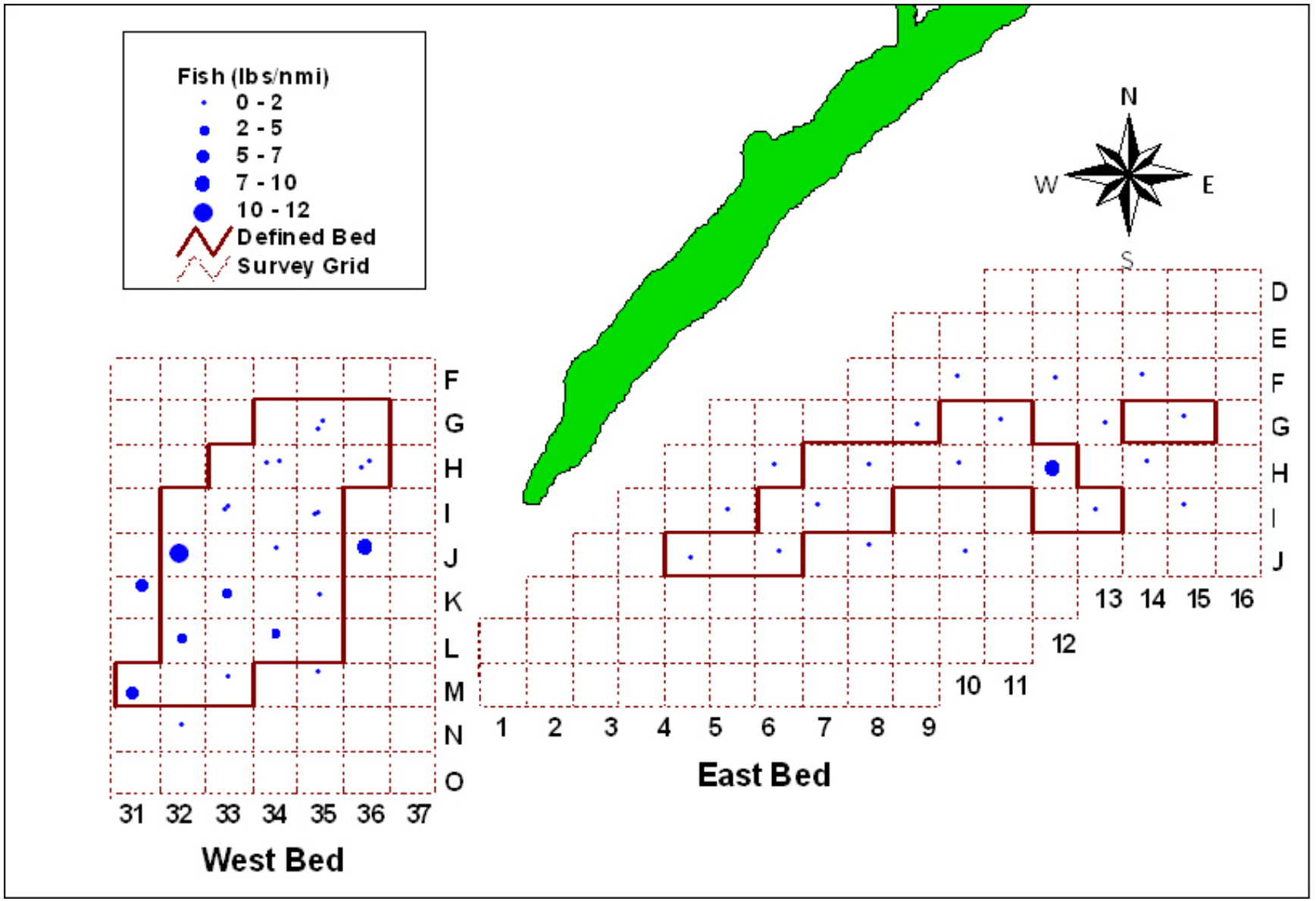

Figure 11.–Fish catches during the ADF&G weathervane scallop survey near Kayak Island, 2002.

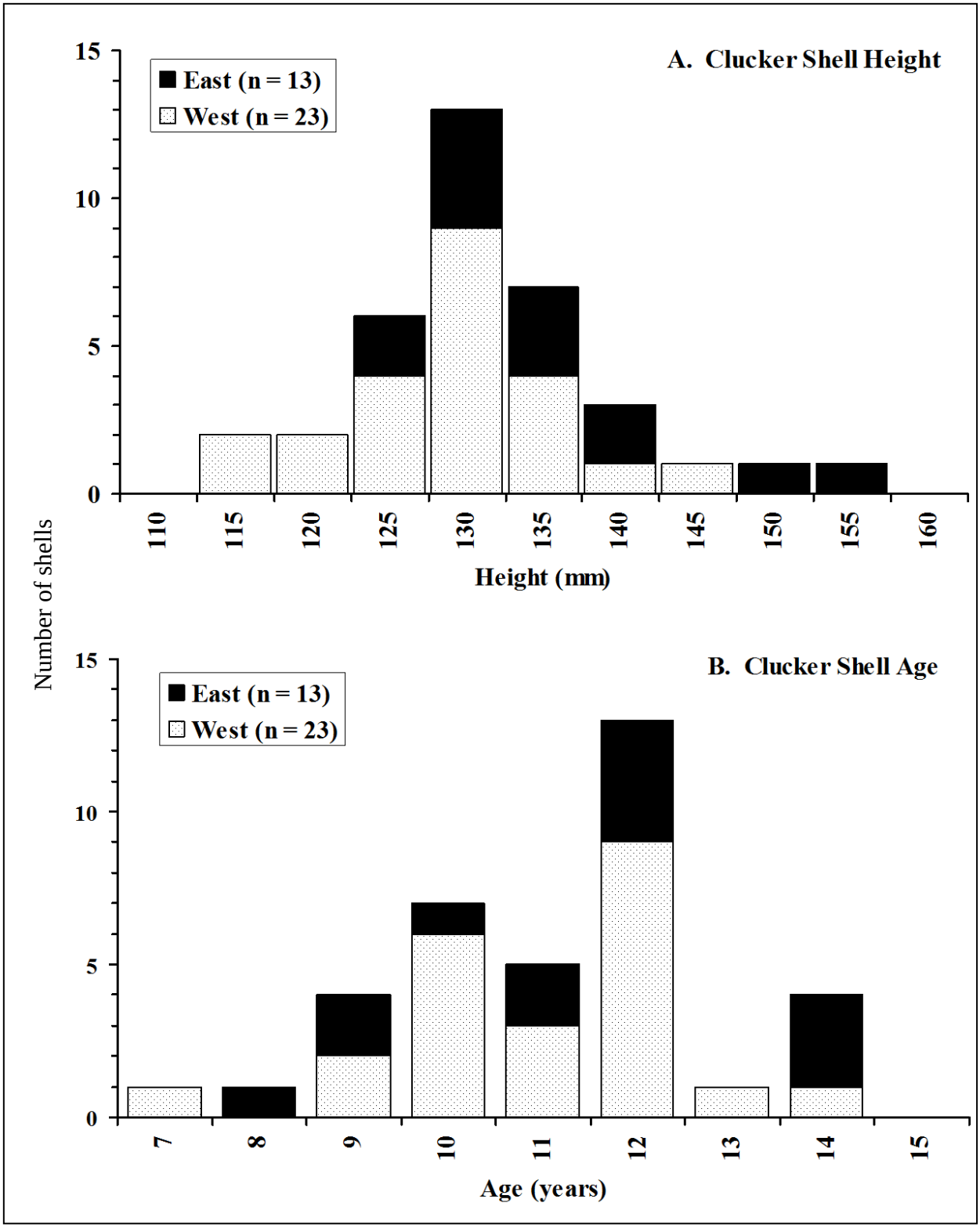

Figure 12.–Shell height (A) and age (B) composition of scallop cluckers sampled in the ADF&G scallop survey near Kayak Island, 2002.

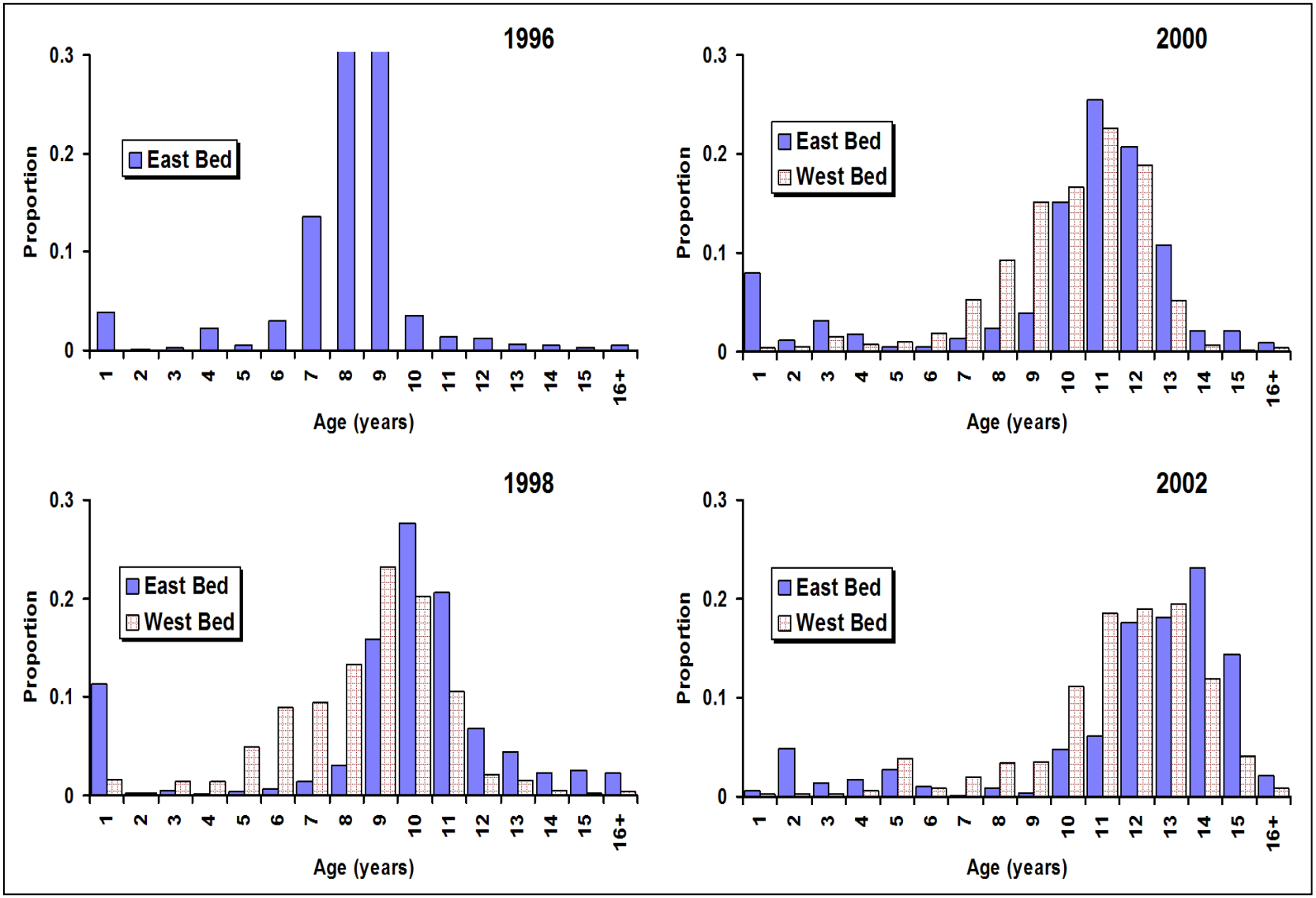

Figure 13.–Weathervane scallop age compositions from ADF&G surveys near Kayak Island, 1996–2002.