Fishery Data Series No. 09-24

A Survey of Weathervane Scallops in Kamishak Bay, 2003

by

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May 2009

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)

Measures (fisheries)

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

Mathematics, statistics

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

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ABSTRACT

During 3–11 June 2003, the Alaska Department of Fish and Game conducted an area-swept survey of the weathervane scallops *Patinopecten caurinus* located in Kamishak Bay, Lower Cook Inlet, Alaska. A total of 62 successful tows (31 in the North bed, and 31 in the South bed), each 1.0 nautical mile (nmi) in length and representing a unique station, were made with the survey dredge. Aggregate weight of material retained by the survey dredge from the North bed totaled 4,773 kg (10,523 lb), and from the South bed totaled 5,908 kg (13,026 lb), and catch weights of individual tows ranged from 69 to 327 kg (152 to 720 lb) in the North bed, and 31 to 387 kg (68 to 854 lb) in the South bed. Debris, primarily mud and gravel, accounted for 3,380 kg (7,453 lb), or 71% of the aggregate survey catch in the North bed, and 4,077 kg (8,989 lb), or 69% in the South bed. Aggregate scallop catch among North bed tows was 811 kg (1,788 lb) and among South bed tows was 1,660 kg (3,660 lb). Scallop catches rates ranged from 0 to 83 kg/nmi (0 to 184 lb/nmi) in the North, and from 0 to 210 kg/nmi (0 to 464 lb/nmi) in the South. Total catch abundance was 1,863 individual scallops in the North, and 4,961 in the South; catch rates among tows ranged from 1 to 177 scallops/nmi in the North, and 0 to 622 scallops/nmi in the South. Mean catch abundance in the North bed was 60 scallops/nmi, and 160 scallops/nmi in the South.

The survey used a random-systematic design in which alternate stations were sampled and the edges of the Kamishak Bay scallop beds were adaptively expanded stations where catch was ≥ 9.1 kg/nmi (20.0 lb/nmi). Mean scallop catch and 95% confidence interval (95% CI) was 39.3 ±8.5 kg/nmi (86.6 ±18.7 lb/nmi) in the North bed and 74.4 ±22.1 kg/nmi (164.1 ±48.8 lb/nmi) in the South bed. Based on an estimate of the North bed encompassing 40 nmi^2, the scallop population biomass was 1,193 ±257 metric tons (2.6 ±0.6 million lb). The South bed was estimated to encompass 44 nmi^2, with a scallop population biomass of 2,487 ±738 metric tons (5.5 ±1.6 million lb). Estimated population abundance and 95% CI was 2.7 ±0.6 million scallops in the North bed and 4.6 ±0.6 million scallops in the South bed. Based on estimated population biomass and a mean meat recovery rate of 6.78%, harvesting the population at the maximum regulatory allowance of 20,000 lb was recommended in 2003. This would result in an instantaneous harvest rate of 3.63%, substantially below estimated natural mortality. Additional information is provided on estimated scallop growth rates and depth distribution. Geographic distribution and catch rates of other species, including Tanner crab, red king crab, and fishes, are also presented.

Keywords: weathervane scallop, assessment, dredge, Kamishak Bay, Cook Inlet, Alaska

INTRODUCTION

The commercial fishery for weathervane scallops *Patinopecten caurinus* in Kamishak Bay, Alaska dates to 1983 when the Alaska Board of Fisheries (BOF) directed the Alaska Department of Fish and Game (ADF&G) to allow restricted exploratory scallop fishing (Kimker 1994). Fisheries in 1983 and 1984 had limited participation, partly due to the following restrictions:

- Gear was limited to a 1.8 m (6 ft) wide dredge with a minimum ring size of 10.2 cm (4.0 inch), inside diameter.
- Only one unit of gear may be deployed at a time.
- A logbook must be maintained while fishing and submitted after fishing.
- Vessel operators must check-in with the Homer office before and after each trip.
- An observer must be taken on the vessel if requested by the department.

These were more restrictive measures than for other scallop fisheries off Alaska (Shirley and Kruse 1995). Based on a 1984 ADF&G survey (Hammarstrom and Merritt 1985) and preliminary fisheries catch data, the Alaska Board of Fisheries in 1985 adopted a guideline harvest range (GHR) of 4.5–9.1 metric tons (mt; 10,000–20,000 lb) of shucked scallop meats and a 15 August to 31 October fishing season.

Annual harvest increased from 1.1 mt (2,346 lb) of shucked meats in 1983 to 7.0 mt (15,364 lb) in 1986, and corresponding catch per unit of effort (CPUE) increased from 9.8–16.4 kg (21.5–36.2 lb) of shucked meats/h (Table 1). However, initial fishing in 1987 yielded an unexpectedly low CPUE of 6.8 kg (15.1 lb) of shucked meats/h, and the fishery was closed with a catch of only 163.3 kg (360 lb) of shucked meats (Kimker 1994). Anecdotal information suggested the Kamishak Bay scallop bed was illegally fished between the 1986 and 1987 seasons (Kimker 1996b). Although fishing was allowed during the 1988–1992 seasons, no vessels fished because ADF&G lacked fishery-independent assessments and could not guarantee that the fishery would remain open for more than a single delivery.

In 1993, ADF&G acted to protect dwindling crab resources in the area by setting bycatch limits in the scallop fishery at 0.5% of the estimated populations of king or Tanner crabs. Subsequent harvests of shucked meats of were 9.1 mt (20,115 lb) in 1993 and 9.3 mt (20,431 lb) in 1994 (Table 1). In the spring of 1995, the National Marine Fisheries Service closed federal waters off Alaska to scallop fishing following the identification of a regulatory problem. Existing regulations has allowed unrestricted fishing by vessels not registered with the state of Alaska (National Marine Fisheries Service, News Release Nos. 95–20, 95–61, and 95–91, Juneau, AK). Because the Kamishak Bay scallop bed is located in federal waters, no fishing occurred in 1995 (Kimker 1996b). Amended federal regulations allowed commercial fishing to resume in 1996.

Weathervane scallops in Kamishak Bay were initially surveyed in 1984 (Hammarstrom and Merritt 1985). Fishery catch rates increased from 1983 to 1996, and catch rates in 1993 and 1994 were some of the highest since the fishery began (Table 1). Because the fishery was closed in 1995 following seasons of high catch rates in 1993 and 1994, the scallop fleet requested the harvest allowance be raised for 1996. However, observed CPUE increases in recent years may have been a function of increased fishing power rather than increased scallop abundance. Due to changes in fishing technology, considering CPUE changes from 1984 to present as an accurate index of population abundance may have overestimated the true population in recent years.

Based on changes in fishery performance, coupled with the absence of recent stock abundance data for Kamishak Bay scallops, a fishery-independent survey was needed. ADF&G, with industry support, reinitiated a scallop survey of the Kamishak Bay scallop bed in 1996 (Bechtol and Gustafson 2000). Intending to conduct biennial surveys, a follow-up survey in 1998 was only marginally successful due to loss of the primary survey dredge. Therefore, another survey with a new dredge was conducted in 1999; this survey has since been conducted biennially (Trowbridge and Bechtol 2003). This report documents methods used to conduct the 2003 weathervane scallop survey in the Kamishak Bay District, and the recommendations for subsequent commercial fishery harvest levels.

SURVEY OBJECTIVES

1. Determine the abundance, age, height, and sexual maturity of weathervane scallops caught by a 2.4 m (8.0 ft) dredge with 10.2 cm (4.0 in) inside diameter rings and a 3.8 cm (1.5 in) liner.
2. Estimate scallop meat recovery.
3. Determine the relative catch of king and Tanner crab and other non-scallop species.
4. Calculate a guideline harvest level (GHL) based on the current estimated population size.
5. Evaluate changes in scallop distribution and density since previous surveys.

STUDY AREA

Although weathervane scallops are found throughout the Kamishak Bay District, the fished component of the population is aggregated in limited areas, or scallop beds, located east and southeast of Augustine Island (Figure 1). The commercial scallop fishery has historically occurred in the bed located immediately east of Augustine Island, herein referred to as the North bed. However, department trawl surveys have also observed substantial aggregations in an area located southeast of the North bed (Bechtol 2001; Figure 1). The 2003 Kamishak Bay scallop survey was the first formal assessment of scallop abundance and biomass in this new scallop bed, herein referred to as the South bed. Whereas previous surveys focused on the North bed, this study also surveyed the South bed (Hammarstrom and Merritt 1985; Bechtol and Gustafson 2000, 2002; Bechtol et al. 2003). The Kamishak Bay scallop beds occur on relatively flat or gradually sloping bottom ranging from 30 to 90 m (20 to 50 fathoms) in depth with mud or sand substrate interspersed with shale outcroppings.

METHODS

VESSEL AND GEAR

The state research vessel *Pandalus* conducted the 2003 Kamishak Bay survey. The *Pandalus* has an overall length of 20.2 m (66.0 ft), a displacement of 157 mt (173.6 tons), and a 365 hp diesel main engine. Survey staff included 3 biologists and 3 vessel crewmembers. Vessel tow speed was approximately 7,420 m/h (4.0 nautical miles per hour; up to 4.0 nmi/h), with a tow duration of approximately 15 min, and an average cable scope (ratio of tow cable to bottom depth) of about 3.1:1. Dredge setting, tow, and retrieval occurred from about 0800 hours to 1700 hours each day.

Although a consistent dredge design has been used for all Kamishak Bay scallop surveys, a heavier dredge has generally been used since the 1984 survey (Bechtol and Gustafson 2002). The dredge is 2.4 m (8.0 ft) in width and the retainer bag was fitted with a 3.8 cm (1.5 in) mesh liner to facilitate retention of small scallops.

Weathervane scallop catchability in the dredge was assumed equal to 1.0, such that all scallops larger than the liner stretch mesh were retained (Bechtol 2000). An age-structured model for the Kamishak Bay scallop stock treated gear selectivity as a logistic function with selectivity increasing with scallop age to an asymptotic value of approximately 1.0 for scallop heights that are selected by the commercial fishery (Bechtol 2000). However, this model estimate is likely biased low because of the strong influence that the biomass estimate from the dredge survey has in tuning the model performance. In fact, recent video sled analysis suggested that catchability might be approximately 0.86 (Gregg Rosenkranz, ADF&G, Kodiak, personal communication). Thus, biomass estimates from the dredge survey are likely conservative, but by an unknown amount. Nonetheless, the ADF&G survey gear is adequate and sufficiently consistent to assess population biomass and abundance in order to provide for sustainable yield.

STUDY DESIGN

Sample Area

The preliminary sample area for the 2003 survey of the North bed was based on results of previous surveys. The 1984 survey encompassed a 56 nmi^2 (1.0 nmi = 1,855 m = 6,076 ft) study area, divided into 1 nmi^2 grids, and sampled a total of 47 stations (Hammarstrom and Merritt 1985). Based on scallop catches during department trawl surveys for king and Tanner crab, we now believe the Kamishak Bay scallop bed covers a larger area than was sampled in 1984 (Kimker 1996a; Bechtol et al. 2003). The 1996 survey involved 26 tows that encompassed a 52 nmi^2 study area in the North bed (Bechtol and Gustafson 2000). Due to the loss of the survey dredge during the 1998 survey, a follow-up survey was conducted in 1999; the 1999 survey resulted in 45 successful tows and a defined North bed of 58 nmi^2 (Bechtol and Gustafson 2002). Although the South bed had not previously been assessed for scallop densities, a preliminary grid of approximately 110 survey stations was delineated.

Survey Design

To allow greater survey coverage and identification of the scallop distribution, a systematic survey design was used with an adaptation for delineating the edge of the scallop beds. Sample stations were defined by overlaying a checker-board grid of 1.0 nmi squares over the study areas (Figure 2). For each bed, a systematic design with 2 primary units was used in which alternate stations were identified for potential sampling. The primary sample unit, either light or dark squares, was randomly selected to give an equal probability of selecting either unit. For the 2003 survey, the light square unit was selected for possible sampling. The vessel skipper, in cooperation with the project leader, determined the specific tow location within each sample station (light square). The dredge was towed for a distance of approximately 1,855 m (1.0 nmi) in the direction of the prevailing current within the sample station. Under the adaptive portion of this design, adjacent stations (the next light squares diagonally) were added if the tow catch in a station exceeded 9.1 kg (20.0 lb) of whole scallops. Thus, the 9.1 kg catch level, which was approximately 5% of the highest station catch observed during the 1996 survey (Bechtol and Gustafson 2000), was used to define the bed margin within a sampling unit. The systematic pattern of sampling alternate survey stations was preserved when expanding survey area margins.

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 1987). However, we decided to forego precision about the variance estimate in order to equally distribute sampling effort across the survey area and better define the weathervane scallop bed boundary.

Data Collection

During each tow, the vessel captain recorded the following:

1. sequential tow identification number;
2. alphanumeric station code;
3. date;
4. tow start and stop location (latitude and longitude);
5. true tow course heading;
6. vessel speed;
7. tow start and stop time;
8. distance towed;
9. maximum and minimum depth;
10. sea conditions;
11. amount of cable deployed (scope); and
12. gear performance.

Upon completion of each tow, the catch was washed clean of mud and then separated into weathervane scallops, weathervane scallop shells, fishes, crab, and other bycatch, including debris. Commercially important crab species were examined to determine carapace width, shell age, and sex and then discarded. Of particular interest were red king crab (*Paralithodes camtschaticus*) and Tanner crab (*Chionoecetes bairdi*). Fish were weighed, enumerated by major species group, and discarded. Debris, assorted invertebrates, and any remaining bycatch were weighed and their relative contribution visually estimated (e.g., 60% starfish and 40% rocks).

Weathervane Scallop Sampling

Total live weight and numbers 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 with both valves connected by an intact ligament (referred to as cluckers), were cleaned, measured (shell height), aged, labeled, and retained for archival purposes.

Twenty randomly selected weathervane scallops from each tow were weighed and shucked aboard the vessel. Their meats were placed into a container, and their dorsal shells were cleaned, labeled, measured, aged, and placed in storage for later age assessment. A sample size of at least 600 scallops was desired to estimate age proportions p_i from a population of k age groups simultaneously within a distance d (0.05) of their true population proportions π_i , 90% of the time (1-α), and providing a conservative buffer for unreadable shells (Thompson 1987). Non-random samples of immature weathervane scallops from each tow were also shucked, cleaned, measured, aged, and stored for representative age verification. When possible, shell heights of all weathervane scallops remaining from a tow were captured with an electronic measuring board to construct height frequency distributions. For large catches, only a portion of the scallop catch was measured and the remaining scallops were counted and weighed before being discarded. For analysis, height classes were comprised of 10 mm increments (i.e., the 30 mm height class included scallops from 30 to 39 mm).

Fresh weathervane scallop meat recovery was estimated each day from whole weight of the approximately 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 weathervane scallop weight.

Random samples of approximately 10% of the aged scallops were re-aged by a second reader, or by a second reading by the primary reader, to examine between-reader and within-reader differences. Although data are not reported here, there was good agreement both within and between readings. For shells in which ages differed between readings, multiple readers examined the shell to reach concurrence on the age. If concurrence was not reached, the sample was discarded.

DATA ANALYSIS

Weathervane scallop age and height composition data were pooled within each tow. Age and height data, weighted by within-tow sample size, were pooled among all successful tows to estimate population age and height compositions. Shell height-at-age, L_t was modeled with the following von Bertalanffy growth equations (Ricker 1975):

$$L_t = L_\infty (1 - e^{-k(t-t_0)}) \tag{1}$$

Where:

k = is the constant relative rate of growth,

t = is age (time) in years,

t_0 = is the age of theoretical zero length, and

L_∞ = is the theoretical mean maximum length.

The Microsoft Excel[1] Solver utility was used to minimize sums of squares while adjusting the constant growth rate, t_0, and theoretical mean maximum height in the above equation. For subsequent analysis of height composition, shell heights were rounded to the nearest 10 mm.

The weathervane scallop population estimate derived from the Kamishak Bay surveys was based on area-swept calculations (Sokal and Rolf 1969; Gunderson 1993), similar to estimates for previous weathervane scallop surveys in southcentral Alaska (Hammarstrom and Merritt 1985; Bechtol and Gustafson 2000, 2002; Bechtol et al. 2003). Mean catch per nautical mile ($\bar{c}$) and its variance (s^2) within a sampling unit were estimated by:

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

and

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

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

Where:

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

d_i = is the distance towed in nautical miles for sample tow i, and

n = is the number of stations sampled.

An estimate of the population abundance or biomass (P) was calculated by expanding $\bar{c}$ over the surveyed area as

$$P = \left(\frac{6{,}076}{8}\right)N\bar{c}, \quad (4)$$

Where:

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

8 is the width of the dredge in feet, and

N is number of possible survey stations within the survey area.

Variance of the surveyed population was estimated by

$$Var(P) = N^2\left(\frac{N-n}{N}\right)\left(\frac{6{,}076}{8}\right)^2\frac{s^2}{n}, \quad (5)$$

For these estimates, calculations for weathervane scallops were applied to the scallop bed as defined by the adaptive survey design. For other species, calculations were based on the surveyed area, including all survey tows, in order to use more of the available data. Calculations maintained a balanced survey design such that the total number of possible survey stations was twice the number of stations actually sampled; i.e., each sampled station was matched to an unsampled station.

The confidence interval was constructed as

$$P \pm t_{(0.975;n-1)}\sqrt{Var(\ P)}, \quad (6)$$

Note that standardized population or bed estimates may differ slightly from actual catch values (e.g., the number of shell heights measured differs from the standardized catch abundances) because of: (1) rounding differences; (2) the aspect that some shells may be aged but heights not measured or visa versa; and (3) survey catches are standardized for tow distance.

Age Composition

To extrapolate the observed subsample age composition to the total population, and to account for potential bias in selection of aged scallops, an age-at-height matrix was developed using data from the aged scallops pooled between beds. Scallops with shell heights smaller than 35 mm were assumed to be age one based on the height of the first annulus observed in older scallops. For larger scallops, shell age was either: (1) the estimated age based on visually observed growth patterns; or (2) the assigned age based on the scallop height composition observed in a given 10 mm or 15 mm height stratum of the age-at-height matrix. Preliminary comparisons between growth patterns detected visually and with stable isotope analysis showed good correlation (J. Barnhart, ADF&G, Kodiak, personal communication).

2003 SURVEY RESULTS

A total of 62 successful tows (31 in the North bed, and 31 in the South bed), each 1.0 nmi in length and representing a single station, were made with the survey dredge (Table 2). Aggregate weight of material retained by the survey dredge from the North bed totaled 4,773 kg (10,523 lb), and from the South bed totaled 5,908 kg (13,026 lb). Catch weight of individual tows ranged from 69 to 327 kg (153 to 720 lb) in the North bed, and 31 to 387 kg (68 to 854 lb) in the South bed (Table 3).

NORTH BED

Weathervane Scallops

Scallop Catches

Weathervane scallops were caught in all North bed tows (n=31; Table 3; Figure 3). Aggregate scallop catch among tows was 811 kg (1,788 lb), or 17.0% of the weight of all material retained by the dredge. Standardized catches of live scallops per 1.0 nmi tow ranged from 0 to 83.6 kg (0 to 184 lb), with a mean catch of 26.2 kg/nmi (57.7 lb/nmi). A standardized total of 1,863 individual scallops were caught during the 2003 survey (Table 4). Catch abundance in the North bed ranged from 1 to 177 scallops/nmi with a mean catch of 60.1 scallops/nmi. Greatest scallop catch abundance occurred in tow 03507 (station E03), which yielded 10.3% of total scallop catch weight and 9.5% of total North bed scallop abundance.

Scallop shells contributed 53.4 kg (117.8 lb) to total North bed catches. The survey dredge retained scallop shells from 87% (n=31) of the stations (Table 3).

Height, Age, and Growth

A total of 1,874 shell heights were measured. Heights ranged from 32 to 194 mm (1.2 to 7.6 in). After standardizing scallop abundance for survey tow length, the effective number of shell heights was 1,863 (Table 5; Figure 4). The most abundant height class was the 160–169 mm (6.3–6.7 in) height class, representing 28% of the sampled population.

A total of 518 scallop shells were aged from the North bed (Table 6). Scallops ages ranged from age-1 to -20 (Figure 4). Height-at-age from the 2003 survey indicated asymptotic growth for the Kamishak Bay scallop population, with the greatest annual growth in height during the first 5 years of life (Figure 5). Predicted annual growth in height decreased to less than 10% per year after about age-6. Use of an age-at-height matrix of available shell heights, standardized for tow length, resulted in an effective sample size of 1,863 ages (Table 6). Age composition data indicated 50% of the surveyed population abundance was younger than age-9. Age-8 was the most abundant cohort (13.4% of the estimated population), and ages seven to 14 comprised 62% of the North bed population (Table 6; Figure 4).

Sexual Maturity

Of the 525 weathervane scallops visually examined for sex and spawning status, 259 (49%) were classified as male, 196 (37%) as female, and 70 (13%) could not be classified (Table 7). From the pool of 455 scallops for which sex was determined, 95% of the males and 99% of the females were in spawning condition.

Weathervane Scallop Population Estimate

A balanced survey design was used to obtain the weathervane scallop population estimate, with one-half of the stations in the estimate being sampled. Based on the stations sampled in 2003, the Kamishak Bay District North bed was defined to encompass 40 nmi^2. Mean catch rate and 95% confidence interval in 2003 for the North bed was 39.3 ±8.5 kg/nmi (86.6 ± 18.7 lb/nmi). Multiplying the North bed area by mean scallop catch rate and converting linear tow distance to an area swept calculation yielded a weathervane scallop population biomass estimate and 95% confidence interval of 1,193 ±257 metric tons (2.6 ±0.6 million lb). Estimated population abundance was 2.7 ±0.6 (95% CI) million scallops within the defined North bed.

Tanner Crab

A standardized total of 4,099 Tanner crab, with an aggregate weight of 433 kg (954 lb), were caught in 30 stations (97%) in the North bed (Tables 3 and 4). Tanner crab catch rates ranged from 0.0 to 41.1 kg/nmi (0.0 to 90.6 lb/nmi) and 0 to 422 crab/nmi, with the greatest catch from tow 03517 in station G07 (Figure 6).

King Crab

A standardized total of 9 red king crab with an aggregate weight of 26 kg (57 lb), were caught by the survey (Tables 3 and 4). King crab were caught in 29% (*n*=8) of the North bed stations (Figure 7).

Miscellaneous Fish

Fish species were caught in all (*n*=31) survey tows in the North bed. Catch biomass of fish ranged from <0.1 to 14.4 kg/nmi (0.1 to 31.8 lb/nmi) with the greatest catch, 21% of the total North bed fish catch, from tow 03526 (station C07; Table 3; Figure 8). Standardized catch abundance ranged from 2 to 14 fish/nmi (Table 4). Arrowtooth flounder *Atheresthes stomias* was the most abundant species, comprising 28% of all fish catches and yielding a mean catch of 1.0 fish/nmi among all tows (Table 8). Catches of fish as a species group occurred across a wide depth range (Figure 9).

SOUTH BED

Weathervane Scallops

Scallop Catches

Weathervane scallops were caught in 94% (*n*=29 tows) of the South bed tows (Table 3; Figure 3). Aggregate scallop catch among these tows was 1,660 kg (3,660 lb), or 28% of all material retained by the dredge. Standardized catches of live scallops ranged from 0.0 to 210.5 kg/nmi (0.0 to 464.0 lb/nmi). A total of 4,961 scallops were caught during the 2003 survey (Table 4). Catch abundance in the South bed ranged from 0.0 to 662.0 scallops/nmi, with a mean catch of 160 scallops/nmi. Greatest scallop catch abundance occurred in tow 03531 (station M17), which yielded 12.7% of total scallop catch weight and 13.3% of total South bed scallop abundance.

Scallop shells contributed 18 kg (39 lb) to total South bed catches. The survey dredge retained scallop shells from 71% (*n*=22) of the stations (Table 3).

Height, Age, and Growth

A total of 3,388 shell heights were measured (Table 5). Heights ranged from 11 to 196 mm (0.4 to 7.7 in). After standardizing scallop abundance for survey tow length and unmeasured scallops, the effective number of shell heights was 4,961 (Table 5). The most abundant height class was the 160–169 mm (6.3–6.7 in) height class, representing 37% of the sampled population (Figure 4).

A total of 552 scallop shells were aged from the South bed. Scallops ages ranged from age-1 to 20 (Table 6; Figure 4). Age-at-height from the 2003 survey indicated asymptotic growth for the Kamishak Bay scallop population (Figure 5). The greatest annual growth in height occurred during the first 5 years of life. Predicted annual growth in height decreased to less than 10% per year after about age-11. Use of an age-at-height matrix on shell height counts, standardized for tow length, resulted in an effective sample size of 4,961 ages. Age composition data indicated 46% of the surveyed population abundance was younger than age-9. Age-2 was the most abundant cohort (11.4% of the estimated population), and ages 7 to 14 comprised 44% of the South bed population (Figure 4).

Sexual Maturity

Of the 551 weathervane scallops for which sex and spawning status were visually examined, 243 (44%) were classified as male, 204 (37%) as females, and 104 (19%) could not be classified (Table 7). From the pool of 447 scallops for which sex was determined, 97% of the males and 97% of the females were in spawning condition.

Weathervane Scallop Population Estimate

A balanced survey design was used to obtain the weathervane scallop population estimate, with one-half of the stations in the estimate being sampled. Based on stations sampled during the 2003 survey, the defined South bed encompassed 44 nmi^2. Mean catch rate and 95% confidence interval in 2003 for the South bed 74.4 ±22.1 kg/nmi (164.1 ±48.8 lb/nmi). Extrapolating the mean scallop catch rate to an area swept calculation yielded a weathervane scallop population biomass estimate and 95% confidence interval of 2,487 ±739 metric tons (5.5 ±1.6 million lb). The estimated population abundance was 4.6 ±0.6 (95% CI) million scallops within the defined South bed.

Tanner Crab

A standardized total of 874 Tanner crab, with an aggregate weight of 78 kg (171 lb), was caught in 28 stations (90%) in the South bed (Tables 3 and 4). Tanner crab catch rates ranged from 0 to 13 kg/nmi (0 to 28 lb/nmi) and 0 to 122 crab/nmi, with the greatest catch from tow 03532 in station K17 (Figure 6).

King Crab

No red king crab were caught in any of the South bed stations (Figure 7).

Miscellaneous Fish

Fish species were caught in all (n=31) survey tows in the South bed. Catch biomass of fish ranged from 0.1 to 11.7 kg/nmi (0.1 to 25.7 lb/nmi) with the greatest catch, accounting for 16% of the total South bed fish catch, from tow 03532 (station K17; Table 3; Figure 8). Standardized catch abundance ranged from one to 15 fish/nmi (Table 4). Arrowtooth flounder was the most abundant species caught, comprising 38% of all fish catches and yielding a mean catch of one fish/nmi among all tows (Table 8). Catches of fish as a species group occurred across a wide depth range (Figure 9).

RECOMMENDED WEATHERVANE SCALLOP HARVEST

Meat Recovery

Aggregate whole weight of scallops selected randomly for meat recovery was 907 kg (2,000 lb), and aggregate meat weight was 60.9 kg (134 lb) for 7 sampled survey days (Table 9). Mean meat recovery, weighted by whole daily sample weight, was 6.78%.

Harvest Guideline

Assuming a mean meat recovery rate of 6.78%, the estimated population biomass of 3,680 mt (8.1 million lb) between both beds equates to 249,650 kg (550,378 lb) of scallop meats. Harvesting the population at the maximum regulatory allowance of 9,072 kg (20,000 lb) of meats would result in an instantaneous harvest rate of 3.63%. This harvest rate is well below the instantaneous natural mortality of 14% estimated by a previous age-structured model for the Kamishak population (Bechtol 2000*)* and should readily provide for sustained yield. Therefore, the maximum harvest level of 20,000 lb of meats was recommended for the 2003 weathervane scallop fishery in Kamishak Bay. Because the Kamishak Bay scallop beds are surveyed biennially, this harvest guideline would also be applied for the 2004 fishery.

DISCUSSION

The time series of weathervane scallop surveys in the Kamishak Bay District extends to 1984, although the frequency and geographic coverage of surveys has varied somewhat among years (Table 10). A total of 62 tows were made in the 2003 survey; 20 tows were within the defined North bed, 22 tows were within the defined South bed, and the remaining tows were outside of the scallop beds. The beds were described as having tows where standardized scallop catch was equal or greater than 9.1 kg/nmi (20 lb/nmi). Under an assumption that survey dredge catchability equals 1.0, the point estimate and 95% confidence interval for weathervane scallops in was 1,193 ±257 metric tons (2.6 ±0.6 million lb) within the defined North bed in 2003, and of 2,487 ±738 metric

tons (5.5 ±1.6 million lb) within the defined South bed. Estimated population abundances were 2.7 ±0.6 million scallops in the North bed, and 4.6 ±0.6 million scallops in the South bed.

The processes affecting weathervane scallop recruitment and natural mortality, including the contribution of localized beds or aggregations to the reproductive success of the Kamishak Bay population, are poorly understood. For long-lived species, a broad age distribution is important for providing resilience to the population (Leaman and Beamish 1984; Berkeley et al. 2004). The greater prevalence of older scallops in the previously unfished South bed may indicate the lack of fishing pressure on this bed, or conversely, the effect of greater long-term fishing pressure on the North bed (Figure 4B). However, the time series of age composition data generally appears to exhibit continued and steady recruitment for the population (Figure 11). For the 2003 survey, more than half of the Kamishak Bay population was age-9 or younger, well past the age of recruitment to the fishery, indicating environmental conditions have been sufficient for stable reproduction and recruitment in recent years (Figure 11). Although strong cohorts may be seen progressing through age classes across multiple years, a broad distribution of ages has supported the population. We note that scallops younger than age-3 tend to be more prominent in the surveys than in the commercial fisheries, probably due to the use of a liner to retain smaller scallops in the survey gear (Figures 4 and 11). However, fishery and survey age compositions should become more similar as scallops grow and fully recruit to the fishery, after which, cohort abundance should decline as mortality increases. Commercial fishery and survey age data suggest mortality increases rapidly around age-13, as evidenced by declines in cohort abundance after this age. But, the drastic change in age distribution patterns in the 2003 survey and fishery is disconcerting in indicating an apparent and unexpected reduction in the abundance of scallops between 4 to 9 years of age (Figure 11). Although excessive or illegal fishing offers a potential explanation for this reduction, biologists also noted an unusual increase in cluckers, suggesting an unexpected "die-off" of a component of the population between the 2002 fishery and the 2003 survey (ADF&G unpublished data). Cluckers are thought to represent scallop losses through natural mortality. Naidu (1988) showed that increased clucker abundances in areas fished heavily for the Icelandic scallop (*Chlamys icelandica*) resulted from indirect fishing mortality associated with encounters with the fishing gear. We similarly noted that cluckers were more prevalent in the North bed than the South bed during the 2003 survey (Figure 10). Thus, although indirect fishing mortality could be responsible for increased clucker abundance in Kamishak Bay, changes in fishing practices that would account for such mortality are not obvious. Another plausible cause is an increase in epibiotics. For example, shell parasites are commonly observed in the Kamishak Bay shell population, and tend to exhibit greater densities on older/larger scallops, but parasite loads have not been formally analyzed. Still, the prevalence of scallop epibiotics is an issue of concern and may play a significant role in both mortality and how the fishery is managed in the coming years (ADF&G unpublished data).

An aspect of weathervane scallop management is to minimize the bycatch of non-target species, particularly Tanner and king crabs. Populations of these crab species are insufficient to support fisheries in the Kamishak Bay District (Bechtol et al. 2002). However, dredge catches of Tanner crab, particularly juveniles, during the scallop survey may someday be used to improve crab assessment by providing data to supplement ADF&G bottom trawl survey information. The scallop dredge appears to catch a greater abundance of smaller Tanner crab cohorts than is observed in ADF&G trawl surveys to assess crab (ADF&G unpublished data), and the trawl survey has long been recognized as having low selectivity for Tanner crab smaller than 92 mm

carapace width (Kimker 1996a; Bechtol 2001; Bechtol and Gustafson 2002). Although the red king crab population remains well below historical levels, catches by the scallop dredge survey may prove to be a useful index of red king crab abundance and distribution (Table 4; Figures 7 and 9). The scallop fishery typically avoids areas of significant crab aggregations because of bycatch restrictions that could potentially curtail the fishery (Trowbridge and Bechtol 2003). The largest catch rates for weathervane scallops in the 2003 survey occurred at depths of 55–92 m (30–50 fathoms; Figure 9). Although the depth distributions of Tanner crab and red king crab overlap that of weathervane scallops, the geographic distributions of these species show less overlap (Figure 9).

The maximum scallop age of 20 years observed in the 2001 and 2003 surveys was slightly less than the age 24 maximum observed in the 1996 and 1999 surveys. Under the empirical approach of Hoenig (1983), natural mortality rates for the Kamishak Bay population can be approximated as M=0.19, corresponding to an annual mortality rate of 17%, for a maximum observed age of 24 years. This agrees well with estimates of 4–22% obtained by Kruse (1994) for *P. caurinus* and the median estimate of 15% reported by Kruse (1994) using a maximum scallop age of 28 years as reported by Hennick (1973). Preliminary efforts at an age structured model for the Kamishak Bay scallop stock suggested that instantaneous fishing mortality has historically been less than 5% (Bechtol 2000). Although fishing effort has not occurred every year since the fishery's inception in 1983 (Trowbridge and Bechtol 2003), the fishery appears to have been sustained under this constant harvest strategy.

This weathervane scallop harvest in Kamishak Bay occurs entirely with commercial dredges; scallop catches by recreational harvesters or other commercial other gears are negligible (Trowbridge and Bechtol 2003). Because the Kamishak Bay scallop bed is surveyed biennially, a harvest determination based on the 2003 survey will apply to commercial fisheries in 2003 and 2004. Management for the regulatory maximum allowable harvest of 20,000 lb of scallop meats will represent a harvest rate of 3.63% of the 2003 standing stock. Under an approach that fishing mortality should not exceed natural mortality, management in 2003 and 2004 for the maximum regulatory allowable harvest in Kamishak Bay should present a conservative approach to the scallop fishery. However, it is again recognized that additional population aspects may affect fishery performance. In particular, an excess of cluckers that reflect mortality factors, may result in adjustments to harvest guidelines or to fishing areas.

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TABLES AND FIGURES

Table 1.–Weathervane scallop harvests from the Kamishak Bay District, Cook Inlet Management Area, 1983–2003.

Year	Number of vessels	Catch (lb) of shucked meats	CPUE (lb/hour)
1983	1	2,346	21.5
1984	3	6,305	25.4
1985 [a]	1	11,810	39.5
1986	3	15,364	36.2
1987 [b]	2	360	15.1
1988	0	No Effort	
1989	0	No Effort	
1990	0	No Effort	
1991	0	No Effort	
1992	0	No Effort	
1993	3	20,115	38.1
1994	4	20,431	44.6
1995c	0	No Effort	
1996	5	28,228	52.9
1997	3	20,336	50.9
1998	1	Confidential	
1999	3	20,315	60.8
2000	3	20,516	74.6
2001	2	Confidential	
2002	3	8,591	26.9
2003	2	Confidential	

[a] Season and harvest guideline set by regulation.

[b] Season closed by EO on August 21, 1987 due to low CPUE.

[c] Only state waters opened.

Table 2.–Vessel log of dredge tows made during a weathervane scallop survey in the Kamishak Bay District, 2003.

North Bed

Tow number	Station	Date	Tow start		Course	Speed (nautical	Duration	Distance (nautical	Tow depth (fathoms)		Scope
			Latitude (°N)	Longitude (°W)	(°True)	miles/h)	(minutes)	miles)	Minimum	Maximum	(fathoms)
03501	B 10	6/4	59.292	153.208	012	4.0	15	1.00	26.9	27.6	95
03502	D 06	6/4	59.357	153.143	031	4.0	15	1.01	24.7	25.2	87
03503	G 05	6/4	59.373	153.045	032	4.0	15	1.00	25.3	26.7	80
03504	C 03	6/4	59.408	153.175	045	4.0	15	1.00	21.4	22.2	66
03505	F 02	6/4	59.425	153.066	036	4.0	15	1.01	23.1	23.3	69
03506	G 03	6/4	59.409	153.035	047	4.0	15	1.01	25.3	25.8	75
03507	E 03	6/4	59.425	153.076	235	4.0	15	1.02	24.2	24.4	75
03508	D 02	6/4	59.427	153.112	315	4.0	15	1.01	22.0	23.4	75
03509	D 04	6/4	59.409	153.139	145	4.0	15	1.00	24.0	25.1	75
03510	B 08	6/5	59.324	153.211	038	4.0	15	1.01	27.2	27.4	81
03511	D 08	6/5	59.325	153.140	029	4.0	15	1.00	26.9	27.6	83
03512	F 08	6/5	59.327	153.074	031	4.0	15	1.00	29.1	29.7	90
03513	E 09	6/5	59.325	153.108	144	4.1	15	1.03	29.1	30.3	90
03514	D 10	6/5	59.308	153.142	145	4.0	15	1.00	29.9	31.4	91
03515	C 09	6/6	59.321	153.175	135	4.0	15	1.00	28.2	29.2	85
03516	E 07	6/6	59.342	153.078	315	4.0	15	1.00	27.3	29.1	87
03517	G 07	6/6	59.342	153.011	308	4.0	15	1.06	29.1	31.3	94
03518	H 06	6/6	59.360	152.979	332	4.0	15	1.02	29.3	30.8	93
03519	H 04	6/6	59.392	153.008	018	4.0	15	0.99	26.3	27.0	85
03520	F 04	6/6	59.405	153.075	138	4.0	15	1.00	24.2	25.4	75
03521	F 06	6/6	59.373	153.043	221	4.0	15	1.00	26.8	27.0	81

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Table 2.–Page 2 of 3.

Tow number	Station	Date	Tow start		Course	Speed (nautical miles/h)	Duration (minutes)	Distance (nautical miles)	Tow depth (fathoms)		Scope (fathoms)
			Latitude (°N)	Longitude (°W)	(°True)				Minimum	Maximum	
03522	E 05	6/6	59.375	153.08	318	4.0	15	1.01	24.3	25.6	79
03523	C 05	6/6	59.3748	153.144	312	4.0	15	1.00	23.6	24.6	75
03524	B 04	6/6	59.3918	153.208	42	4.0	15	1.00	22.4	23.9	75
03525	B 06	6/6	59.3595	153.178	344	4.0	15	1.00	24.1	26.4	81
03526	C 07	6/6	59.3572	153.168	158	4.0	15	1.00	26.4	26.7	80
03527	C 11	6/7	59.2903	153.172	141	4.0	15	0.99	29.7	31	91
03536	E 11	6/9	59.281	153.077	304	4.0	15	1.00	29.7	32.5	98
03537	F 10	6/9	59.297	153.043	303	4.0	15	1.00	26.8	32.6	100
03538	G 09	6/9	59.3133	153.011	304	3.9	16	1.04	31.5	33.5	100
03539	H 08	6/9	59.3277	152.143	305	4.0	15	1.01	31.8	32.9	100
South Bed											
03528	K 13	6/7	59.2535	152.897	137	4.0	15	1.01	50.9	57	160
03529	J 14	6/7	59.2402	152.92	203	4.0	15	1.00	52	54.5	175
03530	L 14	6/7	59.2252	152.851	311	4.0	15	1.00	58.3	64.2	192
03531	M 17	6/7	59.1757	152.839	044	4.0	15	1.00	71.9	73.3	225
03532	K 17	6/7	59.176	152.906	045	4.0	15	1.01	72.1	72.6	225
03533	L 18	6/7	59.1595	152.873	047	4.0	15	1.00	74.2	76	225
03534	N 18	6/7	59.1598	152.806	040	4.0	15	1.00	74	75.4	225
03535	N 16	6/7	59.1947	152.803	038	4.0	15	1.00	67.9	71.3	225
03540	J 12	6/9	59.2607	152.91	298	4.0	15	1.01	44	49.3	150
03541	I 13	6/9	59.2442	152.944	298	4.0	15	1.00	39.7	47.6	150
03542	I 15	6/9	59.2113	152.951	309	4.0	15	1.00	44.8	54.6	175

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Table 2.–Page 3 of 3.

Tow number	Station	Date	Tow start		Course	Speed (nautical	Duration	Distance (nautical	Tow depth (fathoms)		Scope
			Latitude (°N)	Longitude (°W)	(°True)	miles/h)	(minutes)	miles)	Minimum	Maximum	(fathoms)
03543	H 14	6/10	59.2415	153.007	134	4.0	15	1.00	38.6	43.2	125
03544	H 16	6/10	59.2075	153.006	134	4.0	15	1.00	44.2	53.4	156
03545	J 16	6/10	59.1953	152.936	042	4.0	15	1.00	65	66	200
03546	K 15	6/10	59.2105	152.904	045	4.0	15	1.00	64.5	65.3	200
03547	L 16	6/10	59.1945	152.869	043	4.0	15	1.01	70.2	72.9	225
03548	L 12	6/10	59.2742	152.844	225	4.0	15	1.01	49.2	50.9	150
03549	M 13	6/10	59.2563	152.838	136	4.0	15	0.99	53.8	58.6	175
03550	M 15	6/10	59.2225	152.813	226	4.0	15	1.00	65.2	68.5	200
03551	N 14	6/10	59.2272	152.803	048	4.0	15	1.01	62.4	64.2	200
03552	O 15	6/10	59.2227	152.771	131	4.0	15	1.07	64.4	66.3	200
03553	O 17	6/10	59.1885	152.746	230	4.0	15	1.00	71.5	72.7	225
03554	O 19	6/10	59.1553	152.748	224	4.0	15	1.00	78.9	79.2	250
03555	M 19	6/11	59.157	152.84	135	4.0	15	1.00	76.7	78.4	250
03556	J 18	6/11	59.1733	152.913	232	4.0	15	1.00	73.5	73.7	225
03557	K 19	6/11	59.1562	152.903	135	4.0	15	1.00	77.4	78.9	235
03558	I 19	6/11	59.157	152.971	118	4.0	15	1.00	70.1	75.6	225
03559	I 17	6/11	59.1773	152.972	041	4.0	15	1.01	63	64.1	200
03560	H 18	6/11	59.1712	153.005	118	4.0	15	1.00	57.3	66.9	195
03561	N 12	6/11	59.2598	152.803	047	4.0	15	1.00	56.1	57.3	170
03562	O 13	6/11	59.2563	152.773	135	4.0	15	1.05	58.3	59.2	180

Table 3.–Standardized catch weight during the 2003 Kamishak Bay District scallop survey.

North Bed Tow number	Station	Pounds per nautical mile: Whole scallops	Scallop shells	Tanner crab	King crab	Fish	Debris/ Other	Total catch
03501	B 10	0.8	1.0	28.0	0.0	1.0	218.0	248.8
03502	D 06	85.1	2.0	1.0	0.0	2.0	136.6	226.7
03503	G 05	96.0	4.0	36.0	0.0	6.0	46.0	188.0
03504	C 03	128.0	12.0	0.2	0.0	6.0	560.0	706.2
03505	F 02	81.2	0.0	0.3	0.0	13.9	413.9	509.2
03506	G 03	87.1	1.4	13.9	0.4	0.7	69.3	172.9
03507	E 03	184.3	2.0	2.4	0.0	1.3	111.8	301.7
03508	D 02	5.9	2.0	0.4	7.9	4.0	372.3	392.4
03509	D 04	140.0	12.0	2.2	0.0	10.0	280.0	444.2
03510	B 08	19.8	7.9	1.5	0.0	1.5	532.7	563.5
03511	D 08	54.0	2.0	54.0	0.0	1.0	62.0	173.0
03512	F 08	38.0	2.0	62.0	0.0	2.6	62.0	166.6
03513	E 09	58.3	1.1	73.8	0.0	6.6	69.9	209.6
03514	D 10	80.0	2.0	70.0	12.0	6.0	58.0	228.0
03515	C 09	76.0	6.0	62.0	8.0	4.0	72.0	228.0
03516	E 07	84.0	2.0	62.0	12.0	1.6	64.0	225.6
03517	G 07	32.1	0.9	90.6	0.0	0.1	120.8	244.5
03518	H 06	1.1	0.0	64.7	0.0	0.9	174.5	241.2
03519	H 04	24.2	0.0	70.7	1.0	1.2	66.7	163.9
03520	F 04	126.0	10.0	0.0	0.0	6.3	74.0	216.3
03521	F 06	124.0	4.0	40.0	0.0	5.8	78.0	251.8
03522	E 05	108.9	7.9	4.0	5.9	0.7	71.3	198.7
03523	C 05	68.0	6.0	<0.1	10.0	1.2	378.0	463.3
03524	B 04	12.0	16.0	0.0	0.0	5.0	476.0	509.0
03525	B 06	0.8	1.2	<0.1	0.0	18.7	678.0	698.8
03526	C 07	56.0	8.0	2.0	0.0	31.8	316.0	413.8
03527	C 11	2.0	2.0	80.8	0.0	5.0	62.6	152.5
03536	E 11	0.1	0.4	14.0	0.0	5.3	566.0	585.8
03537	F 10	10.0	1.1	24.0	0.0	0.6	684.0	719.7
03538	G 09	3.8	0.0	46.2	0.0	1.1	305.8	356.8
03539	H 08	0.3	0.9	47.5	0.0	0.1	273.3	322.1
Total	*n*=31	1,788.0	117.8	954.2	57.3	151.9	7,453.3	10,522.5
Mean		57.7	3.8	30.8	1.8	4.9	240.4	339.4
Percent		17.0%	1.1%	9.1%	0.5%	1.4%	70.8%	100.0%

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Table 3.–Page 2 of 2.

South Bed Tow number	Station	Pounds per nautical mile: Whole scallops	Scallop shells	Tanner crab	King crab	Fish	Debris/ Other	Total catch
03528	K 13	164.4	0.0	19.8	0.0	1.4	344.6	530.1
03529	J 14	124.0	4.0	4.0	0.0	2.6	414.0	548.6
03530	L 14	104.0	0.4	4.0	0.0	0.3	254.0	362.7
03531	M 17	464.0	1.1	0.1	0.0	6.6	160.0	631.8
03532	K 17	105.0	1.1	17.8	0.0	25.7	37.6	187.2
03533	L 18	48.0	0.3	8.0	0.0	4.0	40.0	100.3
03534	N 18	134.0	0.0	0.1	0.0	3.9	334.0	472.0
03535	N 16	204.0	0.9	0.1	0.0	2.2	358.0	565.1
03540	J 12	15.8	0.9	4.0	0.0	0.3	405.9	426.9
03541	I 13	16.0	1.3	12.0	0.0	6.0	516.0	551.3
03542	I 15	222.0	6.0	2.0	0.0	2.2	314.0	546.2
03543	H 14	0.0	0.0	0.3	0.0	0.2	344.0	344.6
03544	H 16	14.0	1.5	0.8	0.0	4.0	344.0	364.3
03545	J 16	128.0	4.0	2.0	0.0	1.0	140.0	275.0
03546	K 15	234.0	4.0	<0.1	0.0	0.4	174.0	412.5
03547	L 16	251.5	2.0	0.5	0.0	10.4	29.7	294.1
03548	L 12	1.5	0.0	1.6	0.0	2.0	338.6	343.7
03549	M 13	113.1	0.0	24.2	0.0	0.2	319.2	456.8
03550	M 15	372.0	0.0	<0.1	0.0	6.0	208.0	586.0
03551	N 14	170.3	1.1	0.0	0.0	0.1	356.4	527.9
03552	O 15	43.0	0.3	0.0	0.0	3.7	529.0	576.0
03553	O 17	58.0	0.1	0.1	0.0	1.3	794.0	853.6
03554	O 19	0.0	0.1	0.7	0.0	20.0	318.0	338.7
03555	M 19	72.0	1.0	0.7	0.0	20.0	68.0	161.7
03556	J 18	216.0	2.0	22.0	0.0	4.4	60.0	304.4
03557	K 19	0.4	0.0	28.0	0.0	8.0	32.0	68.4
03558	I 19	52.0	2.2	18.0	0.0	1.7	48.0	121.9
03559	I 17	259.4	3.1	0.3	0.0	23.8	259.4	546.0
03560	H 18	71.0	2.0	0.2	0.0	1.4	228.0	302.7
03561	N 12	2.0	0.0	0.0	0.0	1.2	480.0	483.2
03562	O 13	0.5	0.0	<0.1	0.0	0.3	741.0	741.8
Total	*n*=31	3,660.0	39.4	171.4	0.0	165.5	8,989.4	13,025.6
Mean		118.1	1.3	5.5	0.0	5.3	290.0	420.2
Percent		28.1%	0.3%	1.3%	0.0%	1.3%	69.0%	100.0%

Table 4.–Standardized catch abundance during the 2003 Kamishak Bay District scallop survey.

North Bed Tow number	Station	Animals per nautical mile: Whole scallops	Tanner crab	King crab	Fish	Total Catch
03501	B 10	17.0	119.0	0.0	6.0	142.0
03502	D 06	75.2	11.9	0.0	5.9	93.1
03503	G 05	98.0	168.0	0.0	8.0	274.0
03504	C 03	110.0	18.0	0.0	7.0	135.0
03505	F 02	90.1	3.0	0.0	9.9	103.0
03506	G 03	75.2	63.4	1.0	4.0	143.6
03507	E 03	177.5	14.7	0.0	6.9	199.0
03508	D 02	6.9	12.9	1.0	13.9	34.7
03509	D 04	116.0	13.0	0.0	13.0	142.0
03510	B 08	22.8	19.8	0.0	6.9	49.5
03511	D 08	68.0	248.0	0.0	12.0	328.0
03512	F 08	41.0	293.0	0.0	11.0	345.0
03513	E 09	68.0	335.0	0.0	4.9	407.8
03514	D 10	96.0	288.0	1.0	9.0	394.0
03515	C 09	104.0	258.0	2.0	6.0	370.0
03516	E 07	95.0	258.0	1.0	9.0	363.0
03517	G 07	31.1	421.7	0.0	4.7	457.5
03518	H 06	2.9	269.6	0.0	2.9	275.5
03519	H 04	25.3	292.9	1.0	6.1	325.3
03520	F 04	110.0	13.0	0.0	6.0	129.0
03521	F 06	117.0	144.0	0.0	14.0	275.0
03522	E 05	105.0	7.9	1.0	10.9	124.8
03523	C 05	83.0	11.0	1.0	12.0	107.0
03524	B 04	15.0	0.0	0.0	11.0	26.0
03525	B 06	3.0	2.0	0.0	8.0	13.0
03526	C 07	70.0	17.0	0.0	13.0	100.0
03527	C 11	14.1	258.6	0.0	7.1	279.8
03536	E 11	1.0	49.0	0.0	7.0	57.0
03537	F 10	13.0	90.0	0.0	2.0	105.0
03538	G 09	7.7	193.3	0.0	7.7	208.7
03539	H 08	4.0	205.0	0.0	2.0	210.9
Total	*n*=31	1,862.8	4,098.5	9.0	247.7	6,217.9
Mean		60.1	132.2	0.3	8.0	200.6
Percent		30.0%	65.9%	0.1%	4.0%	100.0%

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Table 4.–Page 2 of 2.

South Bed Tow number	Station	Animals per nautical mile: Whole scallops	Tanner crab	King crab	Fish	Total Catch
03528	K 13	145.5	54.5	0.0	8.9	208.9
03529	J 14	125.0	16.0	0.0	4.0	145.0
03530	L 14	122.0	16.0	0.0	5.0	143.0
03531	M 17	662.0	16.0	0.0	4.0	682.0
03532	K 17	198.0	121.8	0.0	5.9	325.7
03533	L 18	118.0	61.0	0.0	4.0	183.0
03534	N 18	194.0	33.0	0.0	7.0	234.0
03535	N 16	173.0	12.0	0.0	10.0	195.0
03540	J 12	10.9	10.9	0.0	3.0	24.8
03541	I 13	15.0	25.0	0.0	3.0	43.0
03542	I 15	218.0	4.0	0.0	5.0	227.0
03543	H 14	0.0	1.0	0.0	1.0	2.0
03544	H 16	44.0	2.0	0.0	3.0	49.0
03545	J 16	182.0	2.0	0.0	6.0	190.0
03546	K 15	292.0	1.0	0.0	2.0	295.0
03547	L 16	391.1	108.9	0.0	7.9	507.9
03548	L 12	2.0	4.0	0.0	12.9	18.8
03549	M 13	87.9	36.4	0.0	2.0	126.3
03550	M 15	437.0	1.0	0.0	4.0	442.0
03551	N 14	192.1	0.0	0.0	2.0	194.1
03552	O 15	50.5	0.0	0.0	2.8	53.3
03553	O 17	93.0	19.0	0.0	4.0	116.0
03554	O 19	0.0	94.0	0.0	15.0	109.0
03555	M 19	136.0	64.0	0.0	8.0	208.0
03556	J 18	334.0	67.0	0.0	5.0	406.0
03557	K 19	8.0	90.0	0.0	3.0	101.0
03558	I 19	127.0	0.0	0.0	6.0	133.0
03559	I 17	465.3	2.0	0.0	4.0	471.3
03560	H 18	130.0	11.0	0.0	7.0	148.0
03561	N 12	7.0	0.0	0.0	4.0	11.0
03562	O 13	1.0	1.0	0.0	1.9	3.8
Total	*n*=31	4,961.2	874.3	0.0	161.3	5,996.8
Mean		160.0	28.2	0.0	5.2	193.4
Percent		82.7%	14.6%	0.0%	2.7%	100.0%

Table 5.–Height distribution of weathervane scallops captured during a dredge survey in the Kamishak Bay District, 2003.

		Number of Scallops (scallops per nautical mile) Shell Height Class (mm)																		
North Bed Tow ID	Actual number measured	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	Grand Total
3501	17		2	5	8			2												17
3502	76		1	6				1			1		1	5	31	19	9	2		75
3503	98										3	2	11	28	30	20	4			98
3504	110		1	7	1	1	8	2		3	3	4	2	2	18	35	21	2		110
3505	91		1			2	9	3	1	5	8	8	4	10	21	15	4			90
3506	76		1				2	3				1	2	13	24	20	6	4		75
3507	181						2	1		1	6		8	21	66	65	6	3		177
3508	7										1	2		1		1	1	1		7
3509	116		1	3			4	2		1	4	2	2	11	35	28	20	3		116
3510	23			1	1	1	3	3							1	3	8	2		23
3511	68		4	12			3			3	2	2		2	16	21	3			68
3512	41			1				1	1		2	1		2	9	18	6			41
3513	70						4	2	5		2	3		11	17	16	9	1		68
3514	96			2		2	5	7	1	1	1	4	5	12	31	20	5			96
3515	104		3	7	3	2	2	7	2			2	2	5	24	34	9	2		104
3516	95			4	2		1					1	1	11	30	36	7	2		95
3517	33						1	1	1					1	5	15	7	1		31
3518	3			1	1										1					3
3519	25						1						1	1	10	8	3	1		25
3520	110		1				1	1	1	3	3	6	13	17	37	24	3			110
3521	117										2	1	9	26	49	27	3			117
3522	106						1		1	1		2	4	15	37	37	8			105
3523	83			6	1		12	3	1	1		3	2	1	10	26	14	2	1	83
3524	15					1	1	1		2		1			2	7				15
3525	3					1	1								1					3
3526	70		1	5			7	3	1	2	3	1	2	3	8	18	12	4		70
3527	14		1	4	3	1	1	1	1						1		1			14
3536	1						1													1
3537	13				1			1						1	8	1	1			13
3538	8				2				2				1		3					8
3539	4				1	1			1		1									4
Grand Total	1,874		17	64	24	12	70	45	19	23	42	46	70	198	523	512	169	30	1	1,863

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Table 5.–Page 2 of 2.

South Bed Tow ID	Actual number measured	Number of Scallops (scallops per nautical mile) Shell Height Class (mm) 30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	Grand Total
3528	147	0	0	1	1	0	1	7	8	1	3	0	10	5	2	35	48	22	3	146
3529	125	0	0	9	0	0	3	6	9	0	2	0	2	5	5	15	41	26	2	125
3530	122	0	1	1	0	0	11	5	8	1	2	5	2	4	9	33	35	5	0	122
3531	179	4	15	0	4	4	15	0	4	0	7	30	122	170	192	78	18	0	0	662
3532	200	3	17	3	7	13	8	1	1	1	2	4	22	58	47	10	2	0	0	198
3533	118	2	22	1	8	18	6	0	1	1	4	2	9	24	20	0	0	0	0	118
3534	194	1	7	0	1	4	1	0	1	4	6	3	11	27	66	50	12	0	0	194
3535	173	0	4	5	0	3	4	0	0	1	3	12	14	36	36	39	15	1	0	173
3540	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	4	2	11
3541	15	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	5	5	0	15
3542	171	0	0	3	0	0	4	3	11	4	8	11	11	1	8	56	70	22	6	218
3544	44	0	0	4	3	1	1	7	12	0	1	1	5	5	1	0	1	2	0	44
3545	182	0	7	5	0	6	23	1	4	5	3	4	8	19	42	41	12	2	0	182
3546	173	2	2	5	0	0	19	0	2	10	8	17	10	25	69	86	37	0	0	292
3547	205	6	17	8	6	23	8	0	2	0	10	15	57	124	97	13	6	0	0	391
3548	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	2
3549	87	0	1	1	0	0	1	1	2	0	0	0	7	1	4	6	25	30	8	88
3550	180	0	7	15	0	5	41	15	12	2	5	22	19	27	85	119	51	10	2	437
3551	115	0	2	8	0	0	0	8	7	2	3	7	7	2	10	22	75	38	2	192
3552	54	0	0	0	0	0	2	1	3	0	1	1	3	4	4	16	13	3	1	50
3553	93	0	4	4	0	6	10	2	1	0	4	4	6	8	14	17	12	1	0	93
3555	136	3	22	3	2	11	1	0	0	0	3	5	10	40	30	6	0	0	0	136
3556	201	0	0	0	8	13	3	0	5	5	2	7	61	150	78	2	0	0	0	334
3557	8	0	1	0	2	4	0	0	0	1	0	0	0	0	0	0	0	0	0	8
3558	127	4	21	0	8	24	9	2	0	1	1	2	9	24	18	4	0	0	0	127
3559	188	0	0	10	2	5	62	17	7	25	17	22	50	64	67	79	32	5	0	465
3560	130	0	10	13	0	1	10	3	4	9	5	14	5	13	13	22	8	0	0	130
3561	7	0	0	0	0	0	0	1	0	0	1	0	4	0	0	1	0	0	0	7
3562	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Grand Total	3388	41	227	151	77	196	458	134	157	120	174	371	1,004	1,669	1,858	1,353	795	229	33	4,961

Table 6.–Age distribution of weathervane scallops caught in a dredge survey in the Kamishak Bay District, 2003.

		Scallop Age Class (years)																				
North	Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Tow ID	Aged	Standardized Number of Scallops (scallops per nautical mile)																				
3501	17	15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
3502	18	7	1	0	1	8	9	3	15	9	4	2	5	0	6	1	4	1	0	0	0	75
3503	19	0	1	3	8	16	13	5	6	18	2	5	12	4	2	0	1	1	1	0	0	98
3504	19	9	11	4	7	2	2	4	3	13	4	4	13	6	13	3	7	3	2	0	0	110
3505	20	1	15	12	12	4	7	4	11	10	0	5	5	1	1	1	1	0	0	0	1	90
3506	20	1	5	0	2	4	8	5	20	9	1	2	3	3	7	2	2	2	0	0	0	75
3507	20	0	3	2	7	4	18	8	34	30	3	16	18	16	16	2	1	1	0	0	0	177
3508	6	0	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	1	0	0	7
3509	21	4	6	2	5	0	3	8	18	10	6	8	11	11	11	4	6	3	0	0	0	116
3510	22	2	7	0	0	0	0	0	1	0	0	2	2	0	1	0	3	2	1	1	1	23
3511	21	16	3	4	2	0	0	6	7	8	5	0	1	7	6	1	1	0	1	0	0	68
3512	20	1	2	3	0	0	2	4	7	4	4	4	1	2	4	0	2	1	0	0	0	41
3513	20	0	11	2	3	0	3	4	12	6	5	1	2	10	7	1	1	1	1	0	0	68
3514	22	2	15	2	5	1	2	14	11	7	9	4	4	11	6	0	1	2	0	0	0	96
3515	30	13	13	0	3	1	1	9	10	11	9	5	3	9	4	6	3	3	1	0	0	104
3516	23	6	1	1	0	1	1	14	14	7	10	2	3	13	4	11	2	3	1	1	0	95
3517	19	0	3	0	0	1	1	3	3	5	3	2	2	2	1	4	2	1	0	0	0	31
3518	3	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
3519	20	0	1	0	0	2	0	6	7	4	0	1	0	0	1	1	0	1	0	1	0	25
3520	20	1	3	5	10	11	3	20	13	8	15	2	1	9	2	4	1	2	0	0	0	110
3521	21	0	0	1	3	9	4	17	25	16	12	3	1	11	3	6	1	5	0	0	0	117
3522	20	0	2	1	4	2	3	10	16	10	14	6	6	10	11	5	2	3	1	0	0	105
3523	20	7	16	1	4	0	2	2	4	3	6	8	3	3	12	3	1	7	0	1	0	83
3524	14	0	3	2	1	0	0	0	2	0	3	0	1	1	1	1	0	0	0	0	0	15
3525	3	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3

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Table 6.–Page 2 of 3.

North	Number	Scallop Age Class (years)																			Total
Tow ID	Aged	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
		Standardized Number of Scallops (scallops per nautical mile)																			
3526	21	6	11	4	2	3	0	1	6	0	8	2	3	1	9	3	2	5	0	4	0	70
3527	14	8	4	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	14
3536	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3537	13	1	1	0	0	0	0	3	3	3	2	0	0	0	0	0	0	0	0	0	0	13
3538	8	2	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	8
3539	4	1	2	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	4
Total	518	105	145	52	81	69	82	150	250	193	125	84	100	130	127	59	44	47	10	8	2	1,863
Percent		5.6	7.8	2.8	4.3	3.7	4.4	8.1	13.4	10.3	6.7	4.5	5.4	7.0	6.8	3.1	2.3	2.5	0.5	0.4	0.1	100.0
South																						
Tow ID																						
3528	20	2	16	4	0	8	2	2	4	4	10	3	10	11	26	13	13	12	6	1	0	146
3529	24	9	18	2	1	2	0	0	2	6	7	2	2	10	21	9	10	13	5	3	3	125
3530	25	2	24	2	7	2	0	4	6	6	5	6	8	3	11	6	9	11	6	2	2	122
3531	26	22	22	4	44	33	37	100	118	30	67	44	7	11	70	15	18	11	7	0	0	662
3532	24	27	25	2	10	11	4	21	23	20	13	2	4	4	24	4	3	2	1	0	0	198
3533	27	27	31	2	4	4	4	4	6	8	8	1	2	1	2	9	1	3	1	0	0	118
3534	21	9	5	6	8	6	4	7	34	24	22	12	6	7	12	11	12	6	3	0	0	194

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Table 6.–Page 3 of 3.

South Tow ID[d]	Number Aged	Scallop Age Class (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
		Standardized Number of Scallops (scallops per nautical mile)																				
3535	22	9	7	2	17	10	9	9	13	20	8	18	3	2	3	23	9	5	2	3	1	173
3540	11	0	0	0	0	0	0	0	1	0	1	1	1	0	1	3	2	1	0	0	0	11
3541	15	0	3	0	0	1	0	0	0	0	1	1	1	3	2	1	2	0	0	0	0	15
3542	20	3	18	8	13	4	9	0	1	4	9	17	25	9	20	27	17	20	6	6	3	218
3544	21	7	21	0	4	5	0	2	0	0	0	1	0	1	1	2	0	0	0	0	0	44
3545	22	12	33	7	6	2	4	4	7	23	15	14	16	3	3	17	7	9	0	0	0	182
3546	24	8	20	12	22	5	2	12	17	30	19	22	24	7	14	27	22	12	19	0	0	292
3547	21	31	38	4	29	11	19	15	48	50	2	53	11	6	8	34	19	2	11	0	0	391
3548	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
3549	20	2	4	0	2	2	1	2	1	3	2	4	1	3	15	10	14	12	2	5	2	88
3550	21	22	73	5	29	5	5	7	27	19	24	27	27	27	29	29	27	24	24	2	5	437
3551	22	10	15	0	8	5	2	3	3	5	5	5	13	13	17	27	13	25	10	5	7	192
3552	21	0	6	0	3	2	2	1	3	3	1	3	3	2	5	7	7	3	2	0	0	50
3553	21	8	19	0	8	1	3	4	4	5	2	6	0	4	2	5	7	4	6	1	4	93
3555	21	29	13	1	9	3	4	1	18	7	3	11	1	7	5	14	6	3	0	0	1	136
3556	19	3	27	5	23	23	15	7	52	20	13	32	2	2	15	25	65	2	5	0	0	334
3557	8	1	6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
3558	21	30	38	0	6	3	1	0	6	4	4	11	4	2	1	2	8	6	1	0	0	127
3559	22	10	72	40	62	37	17	2	20	7	5	15	40	7	15	2	47	22	15	7	22	465
3560	23	23	13	11	23	1	4	1	1	9	3	1	8	2	8	3	7	5	3	2	2	130
3561	7	0	1	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7
3562	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	552	306	568	115	345	187	147	208	416	307	248	311	219	146	329	326	344	213	136	38	51	4,961
Percent		6.2	11.4	2.3	7.0	3.8	3.0	4.2	8.4	6.2	5.0	6.3	4.4	3.0	6.6	6.6	6.9	4.3	2.7	0.8	1.0	100.0

Table 7.–Sex composition and maturity of weathervane scallops sampled from a dredge survey of the Kamishak Bay District, 2003.

	Sex (number of scallops)				
North Bed	Unknown	Male	Female	Total	Percent
Maturity					
Nonspawning	70	12	1	83	15.8%
Spawning	0	247	195	442	84.2%
Total	70	259	196	525	100.0%
Percent	13.3%	49.3%	37.3%	100.0%	
South Bed					
Maturity					
Nonspawning	104	8	7	119	21.6%
Spawning	0	235	197	432	78.4%
Total	104	243	204	551	100.0%
Percent	18.9%	44.1%	37.0%	100.0%	

Table 8.–Fish catch abundance during the Kamishak Bay District scallop survey, 2003.

Common Name	Scientific name	North	South	Total
Arrowtooth flounder	*Atheresthes stomias*	32	33	65
Butter sole	*Isopsetta isolepis*	28	17	45
Eelpout	Family Zoarcidae	1	0	1
English sole	*Parophrys vetulus*	0	1	1
Pacific cod	*Gadus macrocephalus*	15	13	28
Ronquil	Family Bathymasteridae	6	0	6
Sculpin	Family Cottidae	7	4	11
Searcher	Family Bathymasteridae	4	0	4
Snailfish	Family Liparidae	3	1	4
Starsnout	Family Agonidae	10	19	29
Sturgeon poacher	*Podothecus accipenserinus*	7	0	7
Total		113	88	201

Table 9.–Meat recovery during a weathervane scallop survey in the Kamishak Bay District, 2003.

	Number of	Weight (kg)		Percent
Date	scallops	Whole	Meat	recovery
6/4/2003	148	148	9.0	6.11%
6/5/2003	103	96	5.3	5.56%
6/6/2003	197	202	13.0	6.44%
6/7/2003	219	146	10.2	6.99%
6/9/2003	67	68	5.4	7.88%
6/10/2003	191	172	12.5	7.24%
6/11/2003	114	75	5.5	7.29%
Total	1,039	907	60.9	6.78%

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

Table 10.–Summary of weathervane scallop surveys in Kamishak Bay, 1984–2003.

Year	Defined bed (nmi^2)	Stations sampled	Survey CPUE (kg/nmi)	Population biomass (mt)	Population abundance	Meat recovery
1984	56	47	21.9	940	2.0 million	10.10%
			No Surveys - 1985–1995			
1996	52	26	63.0	2,485	3.2 million	8.50%
1997			No Survey			
1998	58	14	63.6	2,803	8.0 million	7.09%
1999	58	28	99.6	4,236	11.5 million	6.55%
2000			No Survey			
2001	52	25	92.1	3,637	8.0 million	6.37%
2002			No Survey			
2003						
North	40	31	39.3	1,193	2.7 million	6.78%
South	44	31	74.4	2,487	4.6 million	6.78%

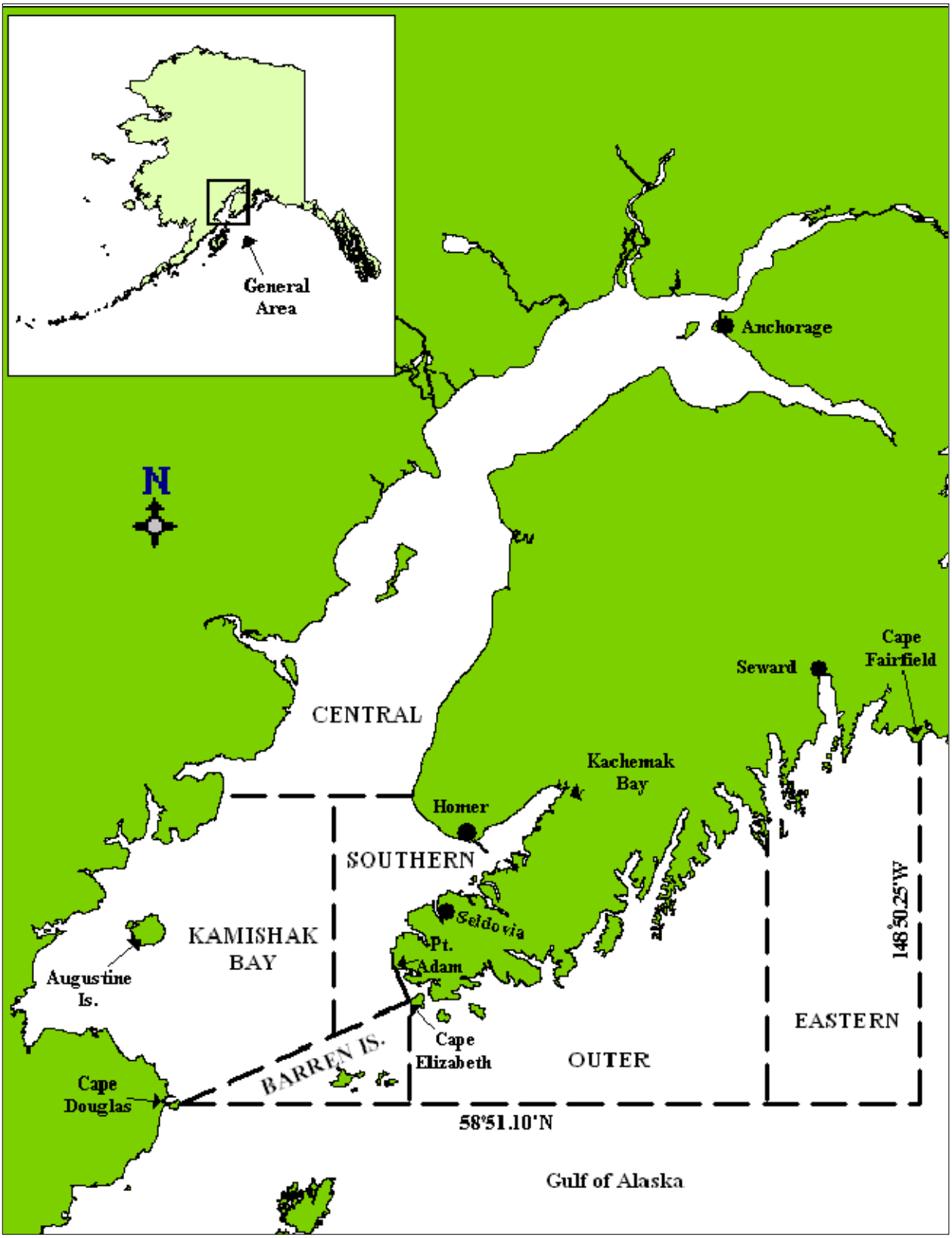


Figure 1.–Commercial shellfish fishing districts of the Cook Inlet Management Area.

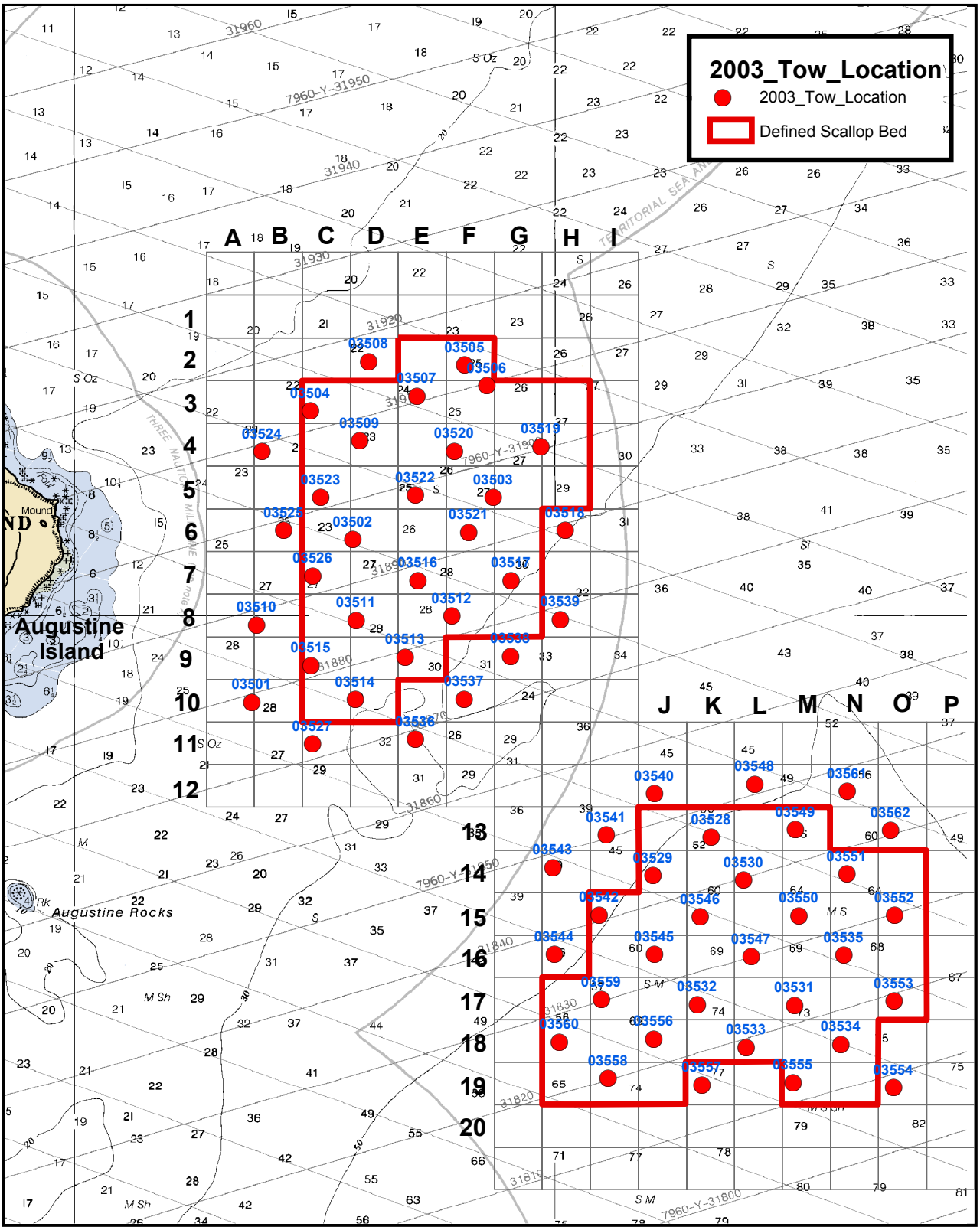


Figure 2.–Mid-points of dredge tows within the general survey grid of 1.0 nmi^2 for the 2003 Kamishak Bay scallop survey.

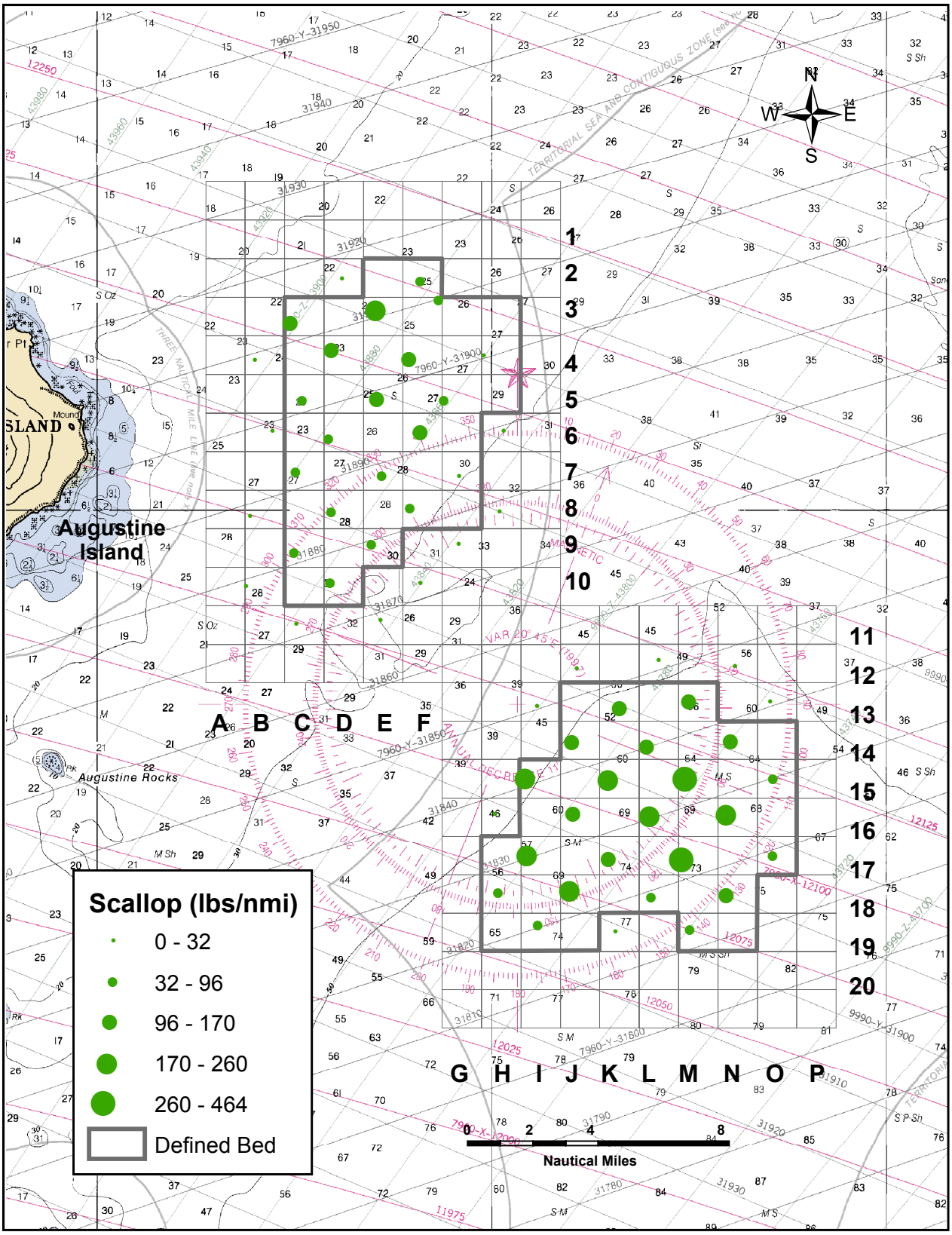
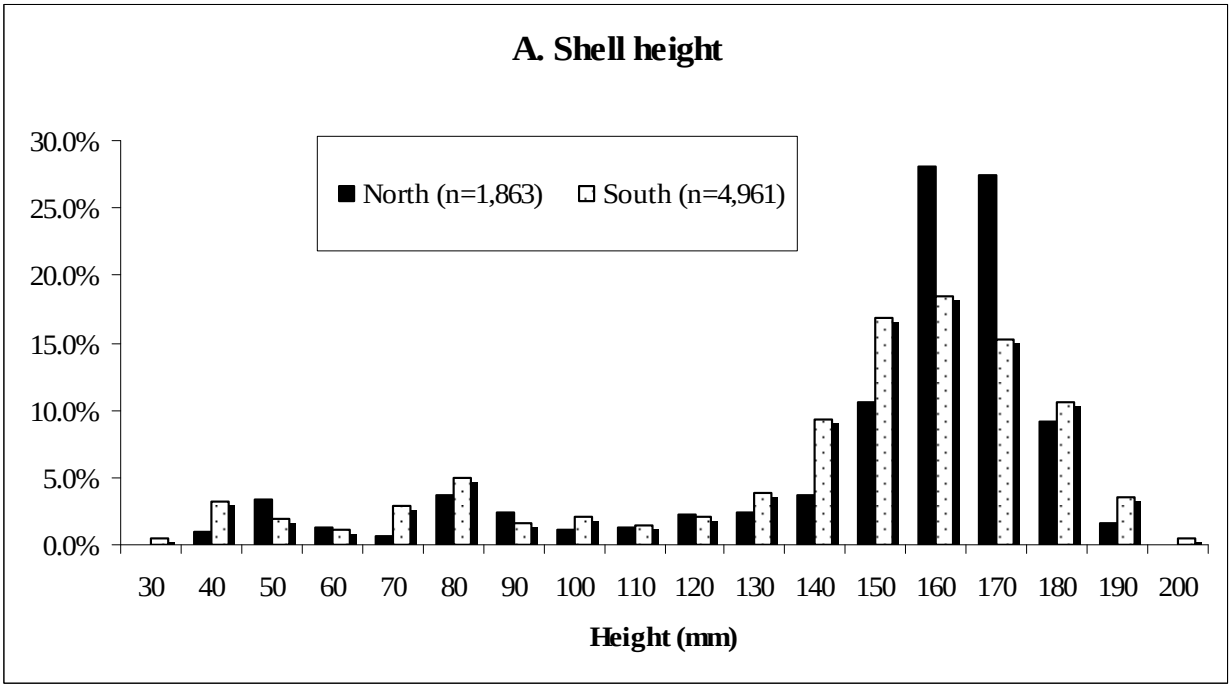


Figure 3.–Distribution of weathervane scallops during a scallop survey in the Kamishak Bay District, 2003.



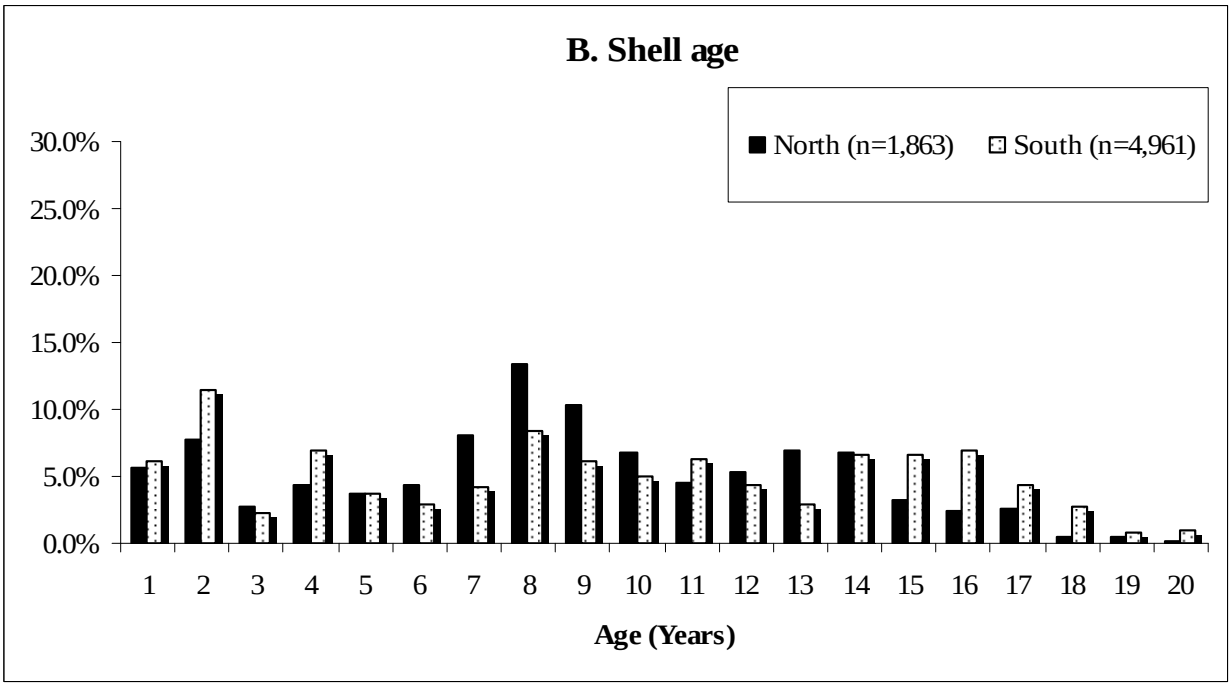


Figure 4.–Shell height (A) and age (B) distribution of weathervane scallops caught during a dredge survey of the Kamishak Bay District, 2003.

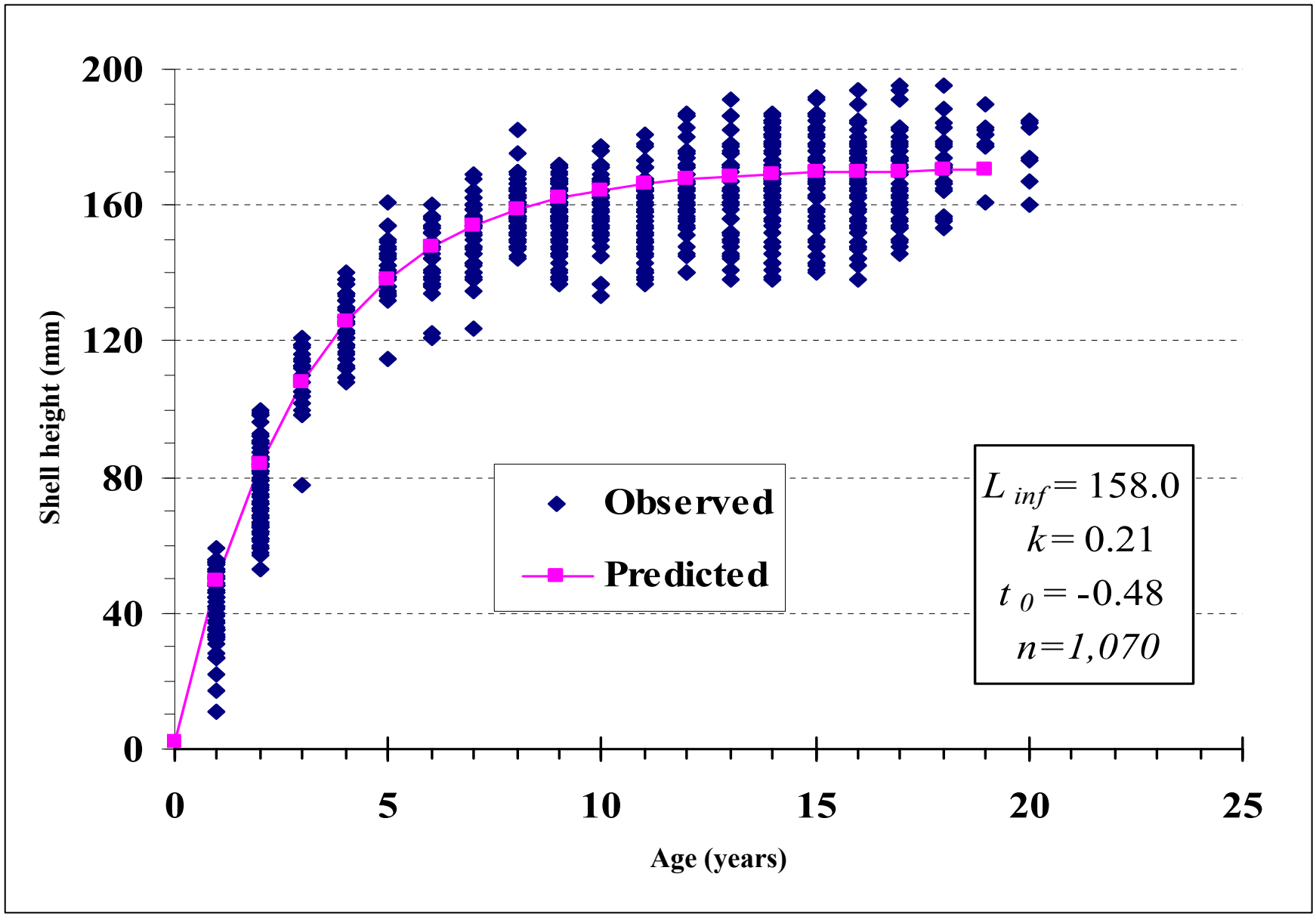


Figure 5.–Von Bertalanffy growth curve for weathervane scallops caught during a dredge survey of the Kamishak Bay District, 2003.

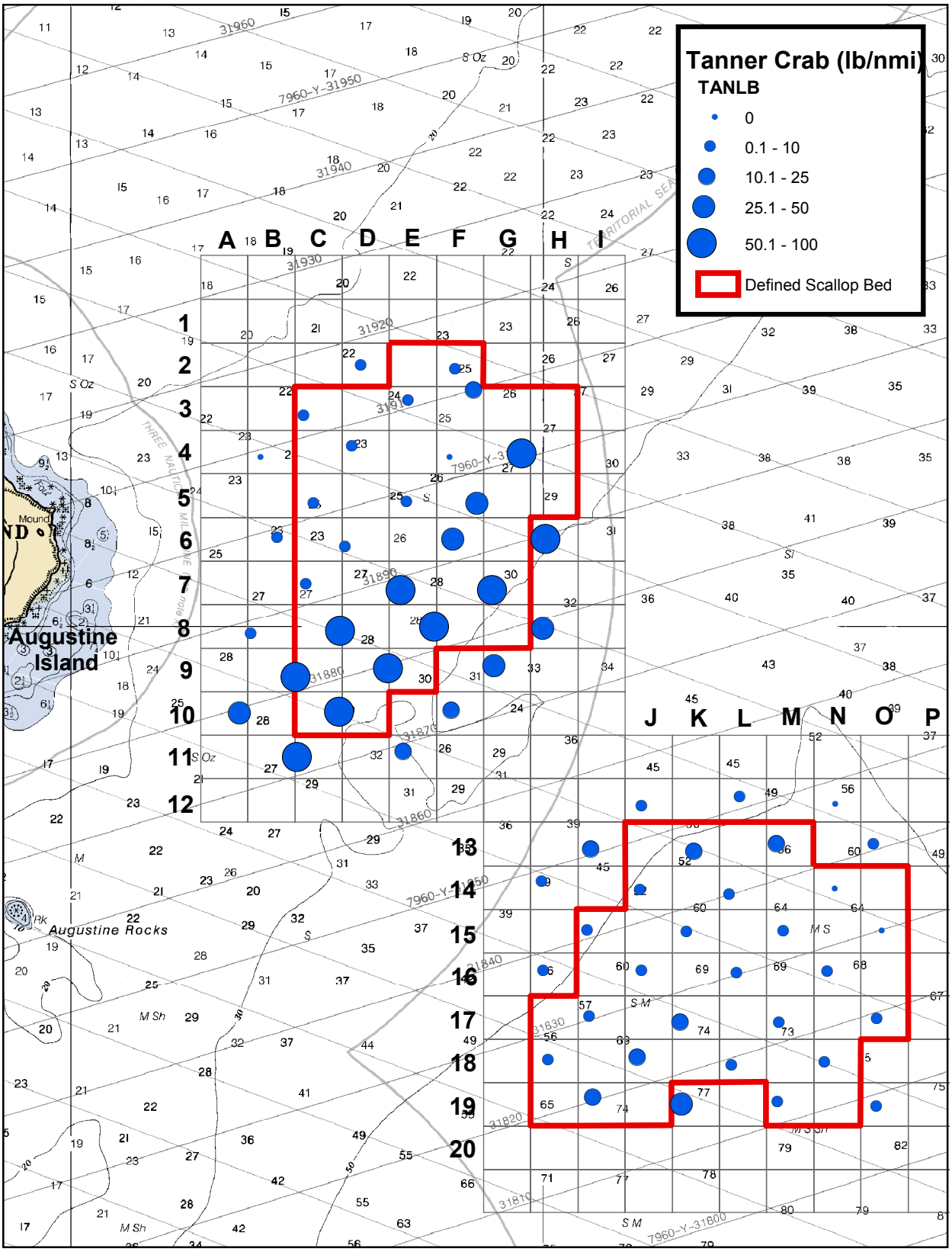


Figure 6.–Distribution of Tanner crab during a scallop survey in the Kamishak Bay District, 2003.

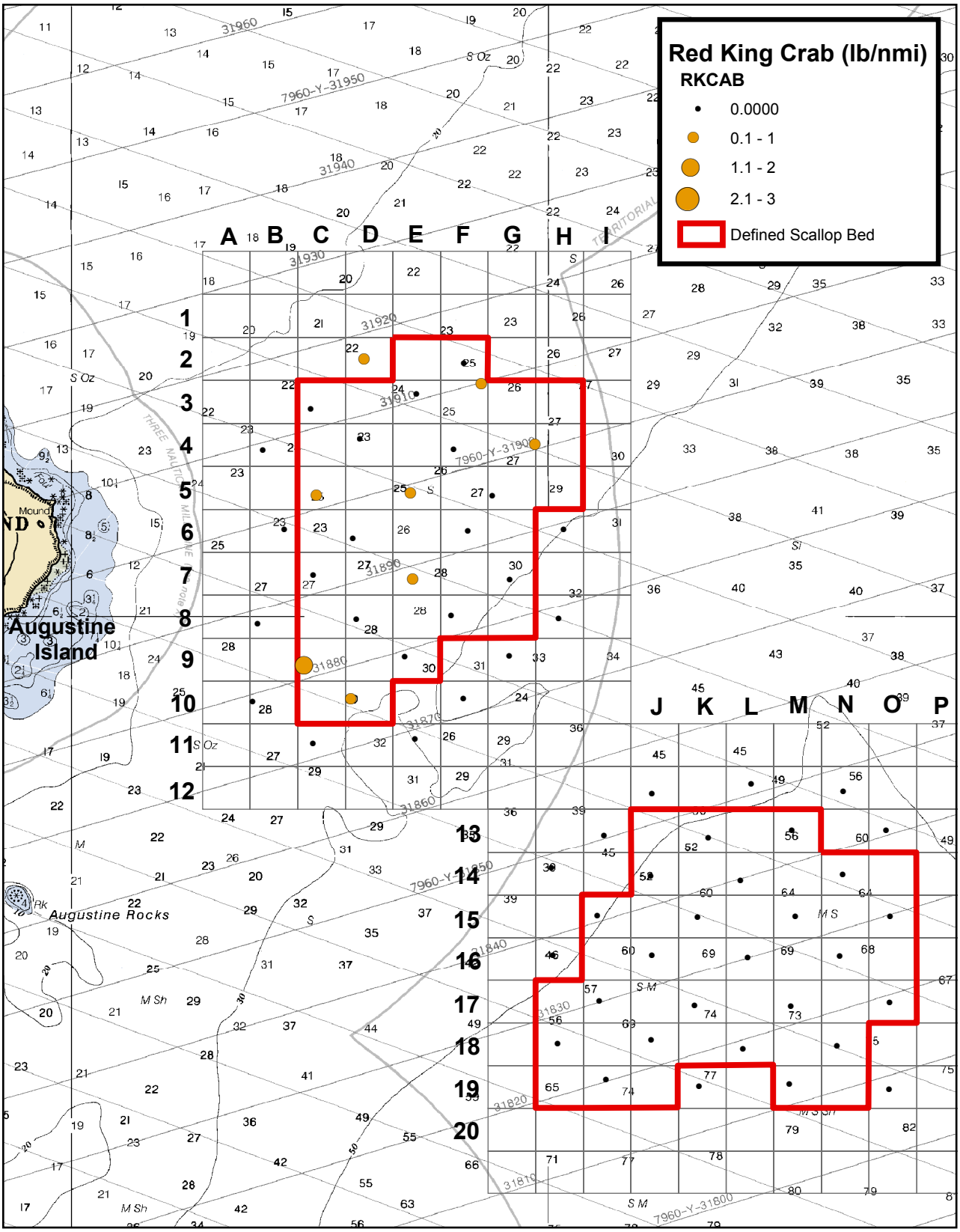


Figure 7.–Distribution of red king crab during a scallop survey in the Kamishak Bay District, 2003.

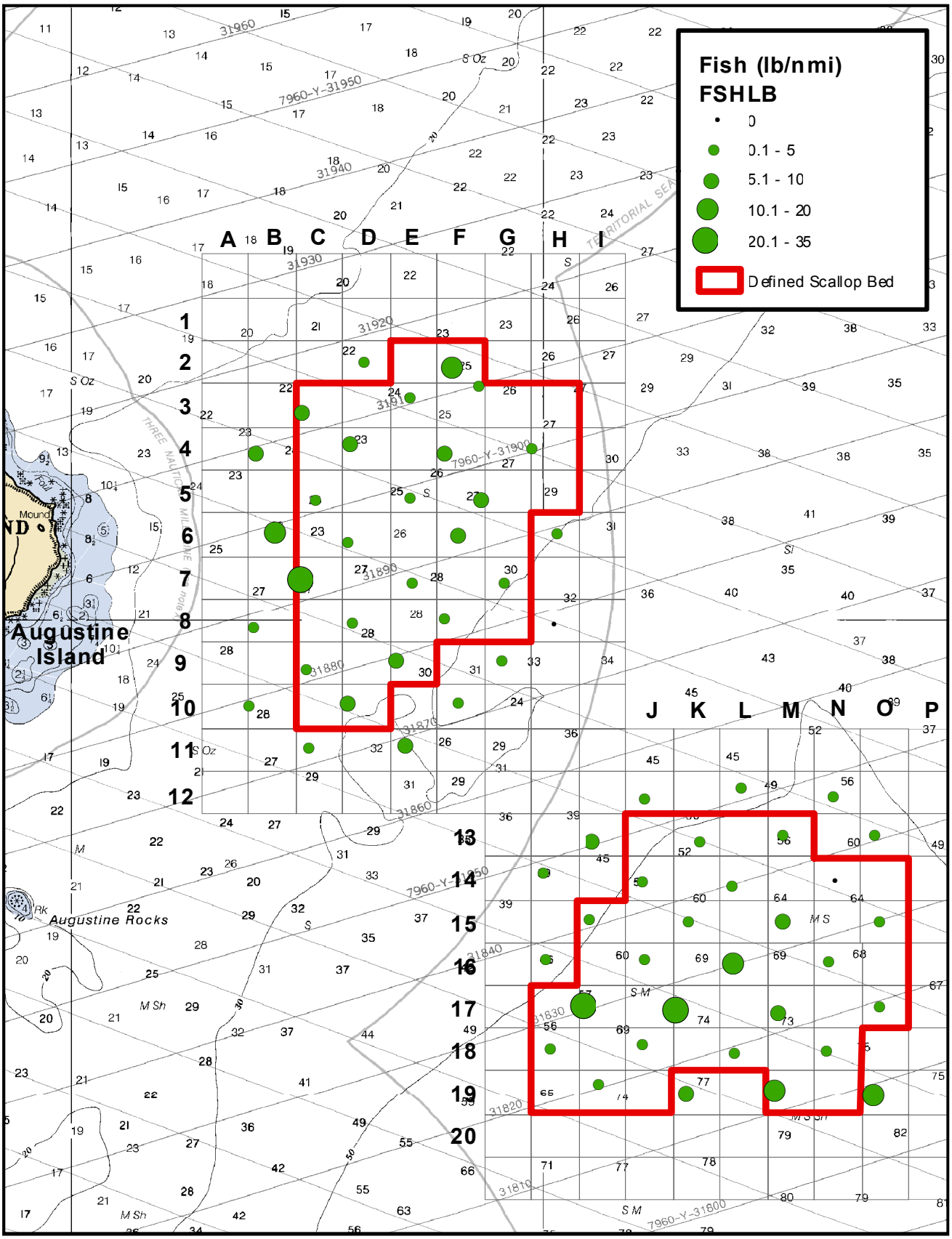


Figure 8.–Distribution of fish catches during a scallop survey in the Kamishak Bay District, 2003.

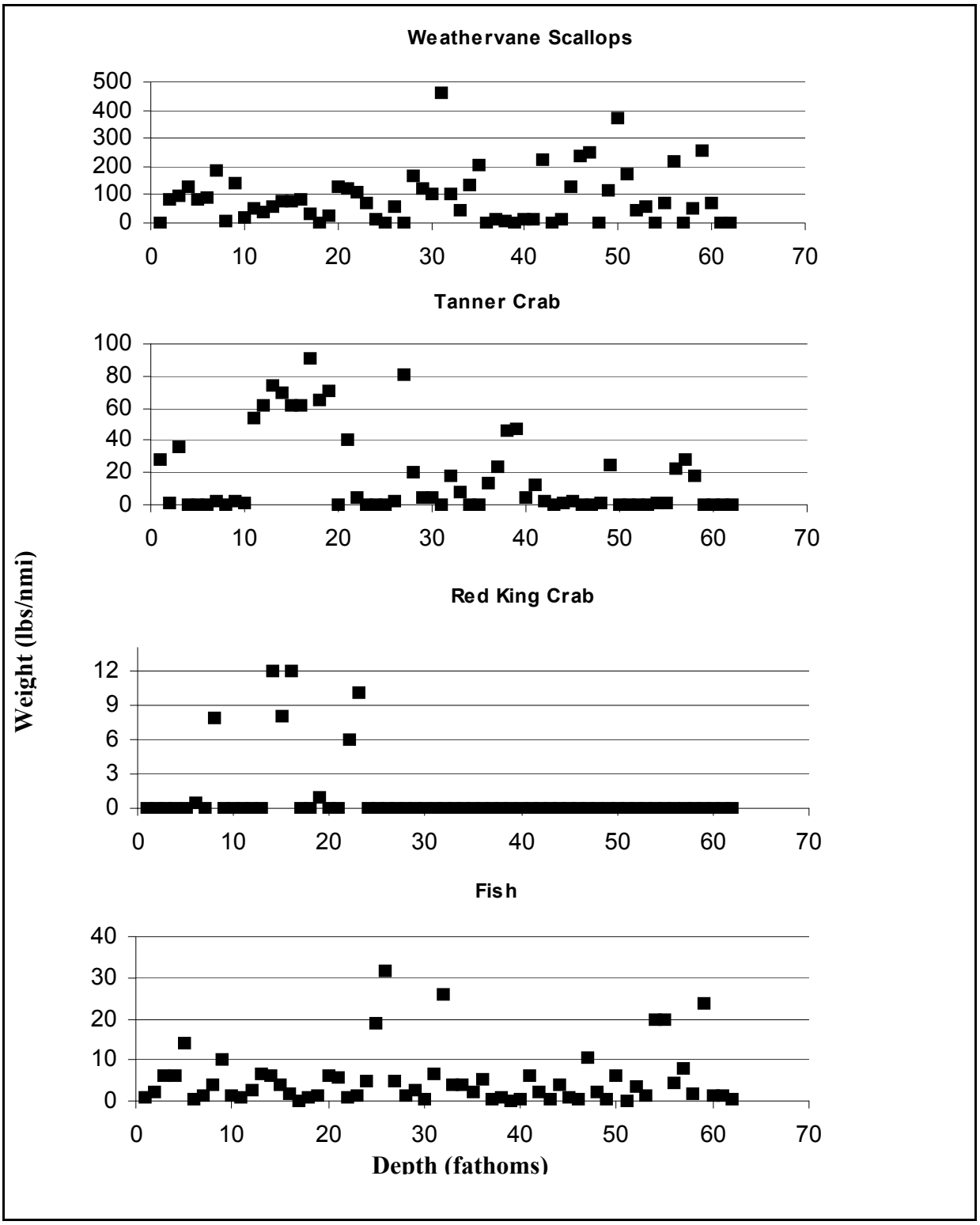


Figure 9.–Distribution of catches by depth for scallops, Tanner crab, red king crab, and fish in the 2003 Kamishak Bay scallop survey.

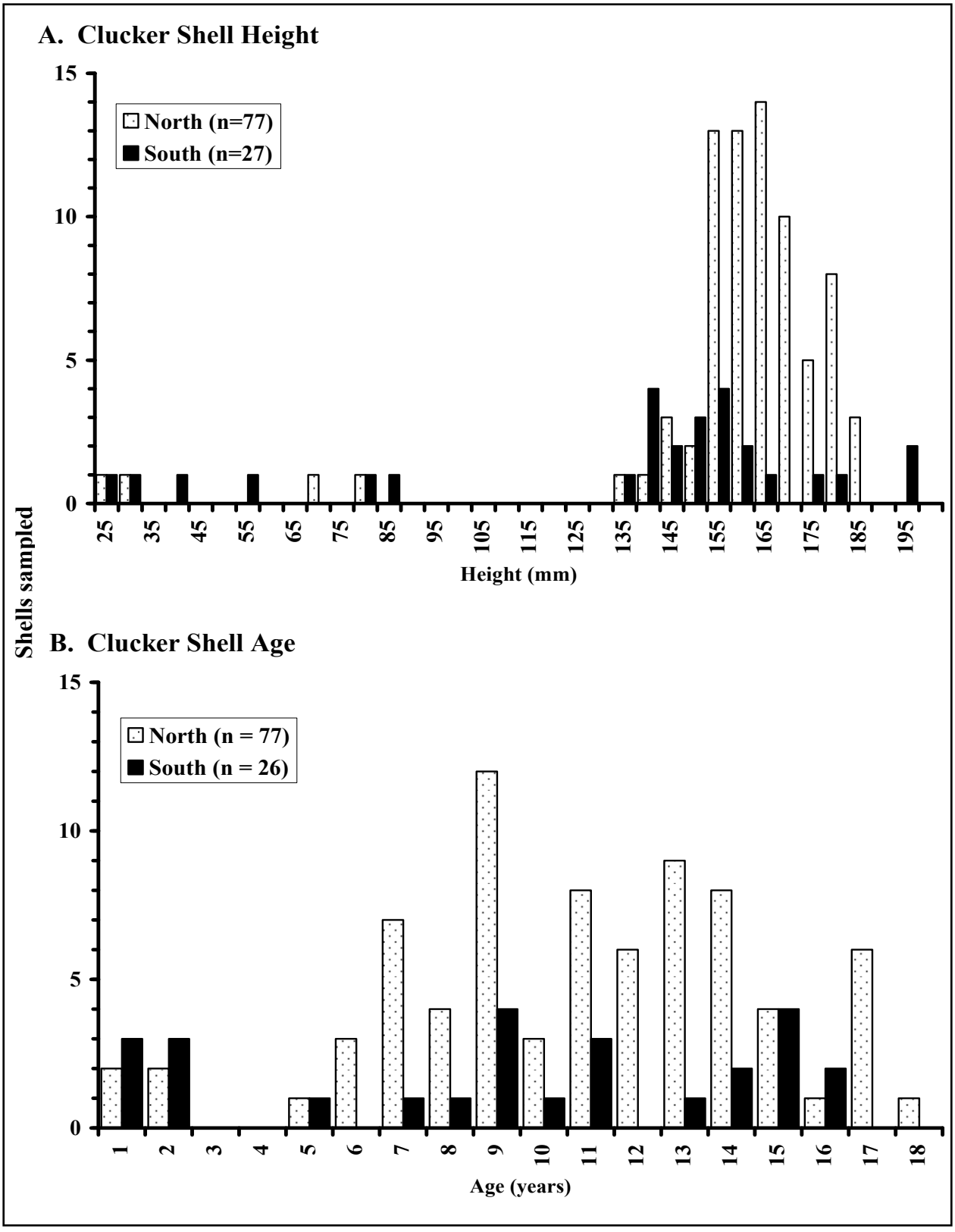


Figure 10.–Clucker shell height (A) and age (B) distribution of weathervane scallops caught during a dredge survey of the Kamishak Bay District, 2003.

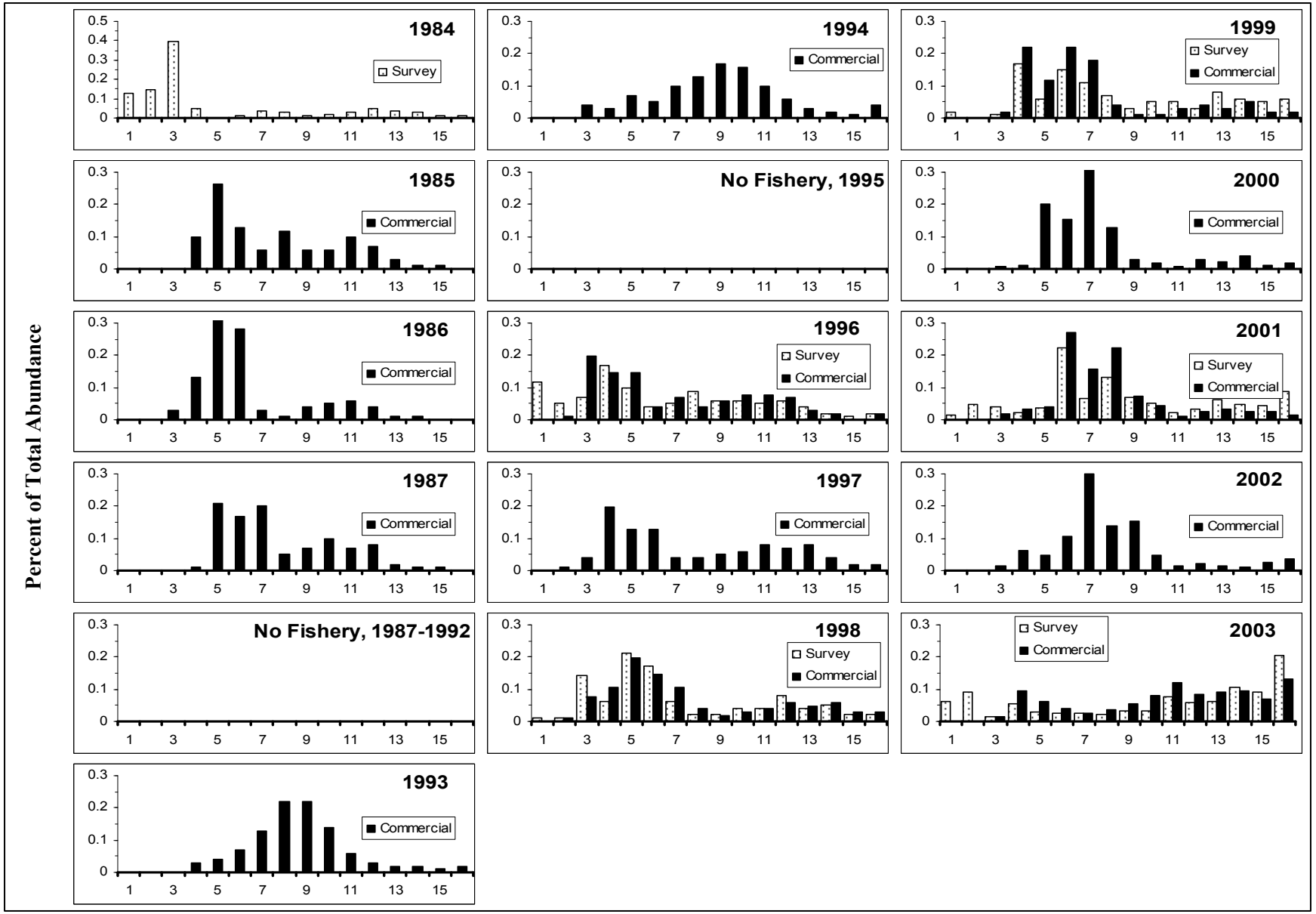


Figure 11.–Age composition of weathervane scallops from Kamishak Bay trawl survey and commercial harvests, 1984–2003.