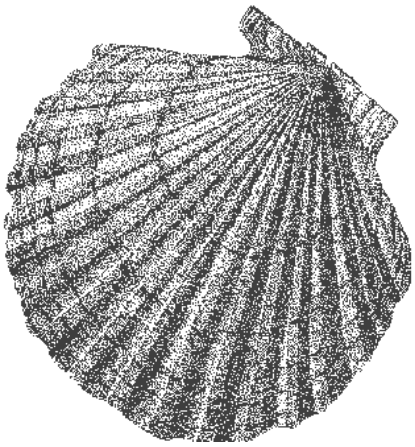
A SURVEY OF WEATHERVANE SCALLOPS IN KAMISHAK BAY, ALASKA, 1998 AND 1999

by

William R. Bechtol
and
Richard L. Gustafson



Regional Information Report No. 2A02-21

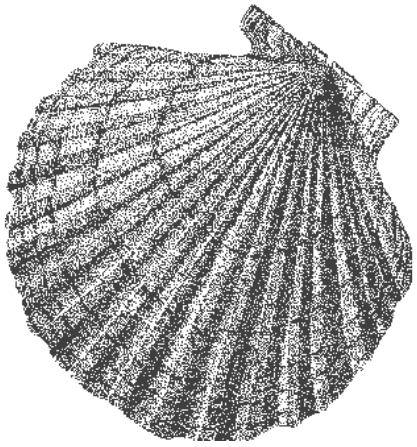
Alaska Department of Fish and Game
Division of Commercial Fisheries
333 Raspberry Road
Anchorage, AK 99518-1599

May 2002

A SURVEY OF WEATHERVANE SCALLOPS IN KAMISHAK BAY, ALASKA, 1998 AND 1999

by

William R. Bechtol
and
Richard L. Gustafson



Regional Information Report No. 2A02-21

Alaska Department of Fish and Game
Division of Commercial Fisheries
333 Raspberry Road
Anchorage, AK 99518-1599

May 2002

AUTHORS

William R. Bechtol is the Research Project Leader for Region II groundfish and shellfish for the Alaska Department of Fish and Game, Division of Commercial Fisheries, 3298 Douglas Street, Homer, AK 99603-7942.

Richard Gustafson is a Fisheries Biologist for Region II shellfish for the Alaska Department of Fish and Game, Division of Commercial Fisheries, 3298 Douglas Street, Homer, AK 99603-7942

ACKNOWLEDGMENTS

Among all survey legs, the crew aboard the research vessel *Pandalus* included skipper Paul Desjardin, deckhands Rick Gustin and Tom Sigurdsson, biologists Charlie Trowbridge, Richard Gustafson, and William Bechtol in 1998, and skipper Mark Hottmann, deckhands Rick Gustin and Brad Harris, and biologists Brian Bue, Jeff Barhnart, Richard Gustafson, Sharon Delsack, and William Bechtol was in 1999. Richard Gustafson was responsible for most of the gear preparation, including assembly, maintenance, and repair of the scallop dredge, and also is responsible for ageing of scallop shells. Karla Granath assisted in ageing of scallops. Tim Baker provided technical input to the final format of this report. Mark Kandianis and the Kodiak Fish Company provided the initial survey dredge and Scott McEntire and Craig Rose of the Resource Assessment and Conservation Engineering Division, National Marine Fisheries Service, provided suggestions on the use of the underwater video camera. Partial funding for some of the analysis in this report was provided by a grant-cooperative agreement from the National Oceanic and Atmospheric Administration (NOAA). The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its subagencies.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

During 7-9 May and 1 July 1998, the Alaska Department of Fish and Game conducted an area-swept survey of the weathervane scallop *Patinopecten caurinus* bed located in Kamishak Bay, Alaska survey of weathervane scallops in Kamishak Bay. A total of 17 successful tows, each 1.0 nautical mile (nmi) in length, were made with the survey dredge. Due to the loss of the primary survey dredge during the first survey leg, three tows were repeated during the second survey leg, resulting in 14 unique survey stations sampled. Aggregate weight of material retained by the survey dredge totaled 1,839 kg (4,054 lb), and catch weights of individual tows ranged from 3 to 224 kg (7 to 538 lb). Debris, primarily mud and gravel, accounted for 650 kg (1,432 lb), or 35% of the aggregate survey catch including replicates, although debris contribution to individual tows ranged from 8.5 to 99.3%. Aggregate scallop catch among all tows was 1,111 kg (2,450 lb). Scallop catches rates ranged from 0 to 197 kg/nmi (0 to 434 lb/nmi) and declined dramatically at the edge of the bed. Mean scallop catch and 95% confidence interval for unique stations was 63.6 ±35.8 kg/nmi (140.3 ±78.9 lb/nmi). Based on as estimation of the scallop bed encompassing 58 nmi^2, the scallop population biomass was 2,803 ±1,577 metric tons (6.2 ±3.5 million lb). A total of 3,119 individual scallops were caught; catch abundance among tows ranged from 0 to 560 scallops/nmi. With a mean catch among unique stations of 180.8 ±105.3 (95% C.I.) scallops/tow, estimated population abundance was 8.0 ±4.6 (95% C.I.) million scallops. Based on estimated population biomass and a mean meat recovery rate of 7.09%, harvesting the population at the maximum regulatory allowance of 20,000 lb was recommended in 1998 as this would result in an instantaneous harvest rate of 4.6%, substantially below estimated natural mortality.

A second area-swept survey was conducted during the 22-27 May 1999 resulted in 45 successful tows of the survey dredge. Aggregate weight of material retained by dredge was 8,836 kg (19,481 lb); catch weights of individual tows ranged from 16 to 544 kg (35 to 1,200 lb). Aggregate scallop catch among all tows was 2,820 kg (6,218 lb), and scallop catch rates ranged from 0 to 281 kg/nmi (0 to 618 lb/nmi) with a mean catch rate of 99.6 ±21.0 kg/nmi (219.6 ±58.7 lb/nmi) within the defined bed. Estimated weathervane scallop population biomass was 4,236 ±1,132 metric tons (9.3 ±2.5 million lb). A total of 7,429 individual scallops were caught during the 1999 survey (Table 8). Scallop catch abundances ranged from 0 to 804 scallops/nmi. Mean catch abundance within the defined bed was 260.9 ±72.6 (95% C.I.) scallops/tow and estimated population abundance was 11.5 ±3.2 (95% C.I.) million scallops 260.8 ±72.6 scallops/nmi. Based on the estimated population biomass and mean meat recovery rate of 6.55%, harvesting at the maximum regulatory level of 20,000 lb would result in an instantaneous harvest rate of 3.3%.

Additional information is provided on estimated scallop growth rates and depth distribution. Survey bycatch, including Tanner crab, king crab, and fish, is also discussed.

INTRODUCTION

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

1. Gear was limited to a 1.8-m (6-ft) wide dredge with a minimum ring size of 10.2 cm (4 in), inside diameter.
2. Only one unit of gear could be deployed at a time.
3. A logbook must be maintained while fishing and submitted after fishing.
4. Vessels must check-in with the Homer office before and after each trip.
5. An observer must be taken on the vessel if requested by the department.

These measures were more restrictive than measures 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 level (GHL) 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*a*). Anecdotal information indicated the Kamishak Bay scallop bed was illegally fished between the 1986 and 1987 seasons (Kimker 1996*b*). Although fishing was allowed during the 1988-1992 seasons, no vessels fished because ADF&G, lacking fishery-independent assessments, could not guarantee that the fishery would remain open long enough to allow more than a single delivery.

In 1993, ADF&G acted to protect dwindling crab resources by setting bycatch limits in the scallop fishery at 0.5% of the estimated populations of king or Tanner crabs. The 1993 harvest yielded 9.1 mt (20,115 lb) of shucked meats from 15 deliveries by three vessels, while the 1994 harvest yielded 9.3 mt (20,431 lb) of shucked meats from 11 deliveries by four vessels. 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 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 largely located in federal waters, no fishing occurred in 1995 (Kimker 1996*b*). 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 between 1983 and 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, and catch rates were high in 1993 and 1994, the scallop fleet requested the GHL be raised for 1996. However, observed CPUE increases may have been a function of increased fishing power rather than increased scallop abundance. Due to changes in fishing technology, application of recent CPUE values to the 1984 relationship between CPUE and population abundance may overestimate the true population. In addition, age frequencies of weathervane scallops in commercial catches from Kamishak Bay have often been multimodal with a primary peak in abundance for 5- to 7-year-old scallops and a secondary peak for age-11 to -13 scallops (Bechtol 2000*a*). However, the 1993 and 1994 fisheries showed unimodal age distributions with a dominant age-8 cohort in 1993 becoming dominant age-9 scallops in 1994.

Based on changes in fishery performance, coupled with the absence of recent stock abundance data for Kamishak Bay scallops data, 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 a biennial survey, 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 report documents methods used to conduct the 1998 and 1999 weathervane scallop surveys in Kamishak Bay and the recommendations for the subsequent commercial fishery harvest levels.

Survey Objectives

1. Determine the abundance, age, size, and sexual maturity of weathervane scallops caught by a 2.4-m (8-ft) dredge with 10.2-cm (4-in) inside diameter rings and a 3.8-cm (1.5-in) liner.

2. Estimate meat recovery group.

3. Determine the relative bycatch of king and Tanner crabs and other non-scallop species.

4. Calculate a GHR based on the current estimated population size, and evaluate changes in scallop distribution and density since previous surveys.

5. Estimate scallop catchability in the 2.4-m (8-ft) dredge using a video camera.

Study area

Although weathervane scallops are found throughout the Kamishak Bay District, the fished component of the population is aggregated in a limited area, or scallop bed, located east of Augustine Island (Figure 1). This study, as well as previous surveys, focused on this aggregation

(Hammarstrom and Merritt 1985; Bechtol and Gustafson 2000). The scallop bed occurs on flat or gradually sloping bottom ranging from 30 to 90 m (20 to 50 fathoms) in depth with muddy or sand substrate interspersed with shale outcroppings.

METHODS

Vessel and Gear

The state research vessel *Pandalus* conducted the survey. The *Pandalus* has an overall length of 20.2 m (66 ft), a displacement of 100 mt, and is powered by a 365 hp diesel engine. Survey staff included 3-4 biologist and 3 vessel crewmembers. Vessel tow speed was approximately 7,421 m/h (4.0 nautical miles per hour; 4.0 nmi/h), with a tow duration of approximately 15 min, and the cable scope (ratio of tow cable to bottom depth) was about 4:1. Dredge setting, tow, and retrieval occurred from about 0800 hours to 1700 hours each day.

Several different dredges have been used for ADF&G surveys. All dredges are 2.4-m (8-ft) in width. To capture small scallops, the retainer bags were fitted with a 3.8-cm (1.5-in) mesh liner. These dredges will be identified as follows:

Dredge A – This dredge was used for the 1984 survey and also on 1 July 1998. The retainer bag consists of 7.6-cm (3-in) inside diameter rings.

Dredge B - In a cooperative effort between ADF&G and the fishing industry, Dredge B was provided by Kodiak Fish Company and used in the 1996 survey and during 7-9 May 1998 until being lost due to being hung up in some bottom structure. Dredge B was similar to Dredge A, but was constructed of heavier steel and also equipped with a heavier sweep chain and a retainer bag with larger 10.2-cm (4-in) inside diameter rings.

Dredge C – Following loss of the survey dredge in the previous year, Dredge C was purchased by ADF&G and used in the 1998 survey. Materials and design were similar to Dredge B.

Weathervane scallop catchability with all dredges was assumed equal to 1.0 such that all scallops larger than the liner stretch mesh were retained (Hammarstrom and Merritt 1985; Bechtol 2000*a*; Bechtol and Gustafson 2000). However, a paired-tow study using Dredge A and a 4.6-m (15-ft) commercial dredge off Kayak Island, Alaska in 1995 indicated that catchability, measured as mean catch per meter of dredge width, was less for Dredge A than for the commercial dredge (Charles Trowbridge, ADF&G, Homer, AK, unpublished data). An age-structured model for the Kamishak Bay scallop stock suggested that survey dredge selectivity increases with scallop size, but selectivity

was approximately 1.0 for scallop sizes that are selected by the commercial fishery (Bechtol 2000*a*). Thus, ADF&G survey gear is adequate to allow estimation of biomass and abundance of the underlying population.

To examine scallop catchability by the dredge, a battery-powered underwater video camera was periodically attached to the dredge tow wire approximately 2 m in front of the dredge. The camera was aimed toward the mouth of the dredge in front of the cutting bar. Videotaped dredge tows were later reviewed on a 36-inch video screen at the ADF&G Homer office. The objective was to estimate the proportion of scallops observed in the path of the dredge to the abundance of scallops retained and counted on the vessel deck. Analyses of these data will be provided in a future report.

Study Design

Sample Area

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 crabs, we believed the Kamishak Bay scallop bed now covers a larger area than was sampled in 1984 (Kimker 1994*b*, 1996*a;* Bechtol 1998, 2000*b*, 2000*c*). The 1996 survey involved 26 tows that encompassed a 52-nmi^2 study area (Bechtol and Gustafson 2000).

Survey Design

To allow greater survey coverage and identification of the scallop bed distribution, an adaptive, systematic survey design was used beginning in 1996. Sample stations were defined by overlaying a grid of 1.0-nmi squares over the study areas (Figure 2). A systematic design with two primary units was used in which alternate stations were identified for potential sampling. The primary sample unit was randomly selected, so there was equal probability of selecting either unit. The vessel skipper, in cooperation with the project leader, determined the specific tow location within each sample station. The dredge was towed for a distance of approximately 1.0 nmi in the direction of the prevailing current within the sample station. Under the adaptive design, stations were added in the 1996, 1998, and 1999 surveys if the tow catch in an adjacent station exceeded 9.1 kg (20 lb) of whole scallops, which was approximately 5% of the highest station catch observed during the 1996 survey (Bechtol and Gustafson 2000). Thus, the 9.1-kg catch level was used to define the bed margin within an area. 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. tow compass 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, fish, crab, and other bycatch, including debris. Commercially important crab species were examined to determine carapace width, shell age, and sex, and discarded. 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.

Ten adult weathervane scallops were randomly selected from each tow, placed intact into a plastic bag, and frozen. These were taken back to the ADF&G Homer laboratory to examine the relationship between recovered meat (i.e. the large adductor muscle, referred to as the “quick” by the fishing industry) and age class. Twenty randomly selected weathervane scallops 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 verification. A sample size of at least 600 scallops was desired to achieve a predetermined precision in the estimated age class proportions (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.

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.

Frozen weathervane scallop meat recovery was estimated from samples returned to the ADF&G Homer laboratory. These samples were thawed and shucked, and the empty shell was cleaned, measured for height, and aged. Meat recovery from these frozen samples will be reported in a future document.

Random samples of approximately 10% of the aged scallops were re-aged by two readers to examine between-reader and within-reader variance. Although data are not reported here, there was good agreement both within and between readers.

Data Analysis

For each tow, weathervane scallop age and size composition data were pooled for both fresh and frozen samples and results applied to all weathervane scallops captured in that tow. Age and size data, weighted by within-tow sample size, were pooled among all successful tows to estimate population age and size compositions. Shell height-at-age, L_t was modeled with the following von Bertalanffy growth equations (Ricker 1975):

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

where

K_l is the constant relative rate of growth in length,
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 Solver utility was used to minimize sums of squares while adjusting the constant growth rate, t_0, and theoretical mean maximum size in the above equation.

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). Mean catch per nautical mile ($\bar{c}$) and it's variance (s^2) were calculated by

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

and

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

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

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

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

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

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 exactly twice the number of stations actually sampled; i.e., each sampled station was matched with an unsampled station.

The confidence interval was constructed as

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

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-size matrix was developed using data pooled from both the 1998 and 1999 aged scallops. It was assumed that growth was relatively stable across the Kamishak Bay scallop population in the years immediately preceding the 1998 and 1999 surveys. Because so few scallops smaller than legal size were measured for shell height, and even fewer were aged, shell heights smaller than 35 mm were assumed to be age-0 scallops 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 observed age composition of scallops in a given 5-mm or 10-mm size strata of the age-at-size matrix.

1998 SURVEY RESULTS

A total of 10 successful tows, each 1.0 nmi in length, were made with Dredge B during the 7-9 May 1998 survey of weathervane scallops in Kamishak Bay (Appendix A; Figure 3). However, during a tow on 9 May, the dredge became entangled with the substrate and was lost; the survey vessel returned to Homer. The survey vessel returned to the Kamishak Bay with Dredge A and concluded 6 tows on 1 July 1998 (Appendix A; Figure 3). To evaluate catchability between dredges, tows were replicated between May and July at three stations. Vessel time availability and weather prevented more extensive comparisons and the data from the three replicated tows was deemed insufficient to draw conclusions regarding differences in catchability between the two dredges.

For the 17 successful tows including replicates, the aggregate weight of material retained by the survey dredge totaled 1,839 kg (4,054 lb; Table 2). Catch weights of individual tows ranged from 3 to 224 kg (7 to 538 lb). Debris, primarily mud and gravel, accounted for 650 kg (1,432 lb), or 35% of the aggregate survey catch including replicates, although debris contribution to individual tows ranged from 8.5 to 99.3%. The surveyed water depths ranged from 35-60 m (19-33 fathoms).

Weathervane Scallops

Scallop Catches

Weathervane scallops were caught in 88% (n=15 tows) of the survey tows (Table 2). Aggregate scallop catch among all tows was 1,111 kg (2,450 lb), or 60% of the weight of all material retained by the dredge. Standardized catches of live scallops per 1.0-nmi tow ranged from 0 to 197 kg (0 to 434 lb). Scallop catch dropped dramatically at the edge of the bed (Figure 4). A

total of 3,119 individual scallops were caught during the 1998 survey (Table 3). Catch abundance ranged from 0 to 560 scallops/nmi with a mean catch of 183.5 scallops/nmi. Greatest scallop catch occurred in tow 98010 (station E04), which yielded 17.8% of total scallop catch weight and 18.0% of total survey scallop abundance.

Scallop shells contributed 8 kg (17 lb) to total survey catch. The survey dredge retained scallop shells from 60% (n=15) of the stations.

Size, Age, and Growth

A total of 2,770 shell heights were measured (Table 4; Figure 5). Heights ranged from 22-192 mm (0.9-7.6 in). After dividing catch of replicate tows in half, the effective number of shell heights was 2,531. Weighting of individual tow size distribution by total tow catch abundance indicated the most abundant size class was the 131-140-mm (5.2-5.5-in) size category, representing 19.5% of the sampled population. Shell heights were well represented in the 101-170-mm (4.0-6.7-in) size ranges, comprising 87.5% of the total population.

Ages from 323 scallops ranged from age 1 to age 21 (Table 5). Size-at-age, pooled from the 1998 and 1999 surveys samples, indicated asymptotic growth for the Kamishak Bay scallop population (Figure 6). The greatest annual growth in height occurred during the first five years of life. Annual height growth rates decreased rapidly to less than 1% per year after about age 10. After using an age-at-size matrix to proportionally assign ages to unaged scallop heights, weighted age composition data indicated 52% of the surveyed population abundance was younger than age 6 (Figure 5). Age 3 was the most abundant cohort (21%), although age-4, -5, and -6 scallops also each comprised over 10% of total population abundance.

Aggregate whole weight of scallops selected randomly for meat recovery was 80.7 kg (178 lb), and aggregate meat weight was 5.7 kg (13 lb) for three sampled survey days (Table 6). Mean meat recovery, weighted by daily catch weight, was 7.09%.

Weathervane Scallop Population Estimate

Due to insufficient data to calculate catchability from video observations, the estimate of the weathervane scallop population was based on an assumption of catchability equal to 1.0. Population estimation also applied a balanced survey design such that the number of sampled stations represented one half of the available stations. The 1998 survey was truncated and only sampled 14 unique stations, but, in combination with previous surveys, did expand the identified scallop bed to 58 nmi^2. After averaging replicate tows, mean catch rate and 95% confidence interval for unique stations in 1998 was 63.6 ±35.8 kg/nmi (140.3 ±78.9 lb/nmi). Multiplying the bed area by mean scallop catch rate and converting the linear tow distance to an area swept calculation yielded a weathervane scallop population biomass estimate and 95% confidence interval of 2,803 ±1,577 metric tons (6.2 ±3.5 million lb). Based on a mean scallop catch

abundance of 180.8 ±105.3 (95% C.I.) scallops/tow, estimated population abundance was 8.0 ±4.6 (95% C.I.) million scallops.

Recommended Weathervane Scallop Harvest Guideline

The maximum allowable harvest level allowed under regulation is 20,000 lb of scallop meats. Assuming a mean meat recovery rate of 7.09%, the estimated population biomass of 6.2 million lb equates to 438,290 lb of scallop meats. Harvesting the population at the maximum allowable harvest level of 20,000 lb would result in an instantaneous harvest rate of 4.6%. This harvest rate is well below estimated natural mortality and should readily provide for sustained yield (Bechtol 2000*a*). Therefore, the maximum harvest level of 20,000 lb of meats was recommended for the 1998 weathervane scallop fishery.

Tanner Crab

A total of 13.5 kg (31 lb) of Tanner crab was caught from all except one station (n=18) in the 1998 Kamishak Bay survey (Table 2). Catch rates of adult Tanner crab ranged from 0-4 kg/nmi (0-8 lb/nmi), with the greatest catch from tow 98004 in station B01. The survey caught 374 Tanner crab, resulting in a mean weight of less than 0.04 kg (0.08 lb; Table 3). Mean catch abundance for Tanner crab was 25.2 ±15.2 (95% C.I.) crab/nmi, extrapolation of this catch rate resulted in a population estimate of 1.1 million crab in the 58 nmi^2 survey area.

King Crab

A total of 19 king crab, totaling 28 kg (62 lb), was caught by the survey (Tables 2 and 3), yielding a mean king crab catch weight of 2.0 ±1.8 kg/nmi (4.4 ±4.0 lb/nmi). King crab were caught in only 35% (n=5) of the survey stations. Tow 98007 in station G04 yielded the most king crab (n=8).

Miscellaneous Fish

Fish species were caught in 94% of the survey tows (n=16) and in all of the unique survey stations (n=14), totaling 28 kg (63 lb), or 1.5%, of the total survey catch (Table 2).

1999 SURVEY RESULTS

A total of 45 successful tows were made with Dredge C during the 22-27 May 1999 survey of weathervane scallops in Kamishak Bay (Appendix B; Figure 7). Data from an additional five tows were discarded and the tow repeated. During all rejected tows, the survey dredge flipped upside down and became ineffective. Tow distance for successful tows ranged from 0.76 to 1.10 nmi, with most approximately 1.0 nmi in length. Surveyed water depths ranged from 20 to 37 m (37 to 69 fathoms). For the 45 successful tows including replicates, the aggregate weight of material retained by the survey dredge totaled 8,836 kg (19,481 lb; Table 7). Catch weights of individual tows ranged from 16 to 544 kg (35 to 1,200 lb) and averaged 196 kg (434 lb). Debris, primarily mud and gravel, accounted for 5,629 kg (12,409 lb), or 64% of the aggregate survey catch, although debris contribution to individual tows ranged from 6.6 to 99.9%. Station E03 fell within the systematic grid pattern but was not sampled in 1999 due to the loss of gear in that station during the 1998 survey.

Weathervane Scallops

Scallop Catches

Weathervane scallops were caught in 89% (n=40 tows) of the successful survey tows (Table 7). Aggregate scallop catch among all tows was 2,820 kg (6,218 lb), or 32% of the weight of all material retained by the dredge. Catches of live scallops per 1.0-nmi tow ranged from 0 to 281 kg (0 to 618 lb), with the highest catch rate from tow 99022 in station F05 (Figure 8). Based on the threshold definition of 9.1 kb/nmi (20 lb/nmi), the scallop bed was estimated to encompass 58 nmi^2, including the unsampled station E03. Scallop catch dropped dramatically at the edge of the bed (Figure 8). A total of 7,429 individual scallops were caught during the 1999 survey, standardized to a per nautical mile catch of 7,415 (Table 8). Catch abundance, standardized to a 1.0-nmi tow, ranged from 0 to 804 scallops/nmi; mean catch was 260.8 ±72.6 scallops/nmi. Greatest scallop catch occurred in tow 99022 (station F05), which yielded 10.0% of aggregate scallop catch weight and 10.8% of total survey scallop abundance.

Scallop shells contributed another 49 kg (108 lb). The survey dredge retained scallop shells from 69% (n=31) of the stations.

Size, Age, and Growth

A total of 7,424 shell heights were obtained (Table 9). After being standardized for tow distance, the effective number of shell heights was 7,415. Heights ranged from 18-198 mm (0.7-7.8 in). Weighting of individual tow distribution by total tow catch abundance indicated the most abundant size class was the 141-150-mm (5.6-5.9-in) size category, representing 19.3% of the

sampled population (Figure 9). Shell heights were well represented in the 121-170-mm (4.8-6.7-in) size ranges, comprising 78% of the total population.

Ages from 565 scallops ranged from age 0 to age 24, although no age-22 or -23 scallops were observed (Table 10). After using an age-at-size matrix to proportionally assign ages to unaged scallop heights, weighted age composition data indicated 51% of the surveyed population abundance was younger than age 7 (Figure 9). Age 4 was the most abundant cohort (17%), although age-4, -5, and -6 scallops each comprised over 10% of total population abundance.

For 883 scallops for which sex was visually determined during the 1999 survey, 52% were male and 48% were female. The remaining examined scallops were either sexually immature or were in a pre- or post-spawning condition. Gonad maturity was in a ripe, spawning-condition in 98% of the males and 97% of the females for which sex was visually determined.

Aggregate whole weight of scallops selected randomly for meat recovery was 239 kg (528 lb), and aggregate meat weight was 15.7 kg (34.6 lb) for five sampled survey days (Table 6). Daily meat recovery ranged from 6.31 to 7.08% and mean meat recovery was 6.54% among days.

Weathervane Scallop Population Estimate

For the 1999 survey, dredge catchability was assumed to equal 1.0. Population estimation applied a balanced survey design such that the number of sampled stations represented one half of the available stations. Scallop catch biomass within the defined bed ranged from 0 to 280 kg/nmi (0 to 618 lb/nmi; Table 7). Mean catch rate and 95% confidence interval among all successful tows in 1999 was 62.7 ±21.6 kg/nmi (138.2 ±37.6 lb/nmi). However, restricting the analysis to stations yielding catches greater than 20 lb/nmi resulted in a mean catch rate of 99.6 ±21.0 kg/nmi (219.6 ±58.7 lb/nmi) for the 28 tows within the defined survey bed (Table 7). Multiplying the bed area of 58 nmi^2 by mean scallop catch rate and converting the linear tow distance to an area swept calculation yielded a weathervane scallop population biomass estimate and 95% confidence interval of 4,236 ±1,132 metric tons (9.3 ±2.5 million lb). Mean catch abundance among all successful tows was 164.8 ±57.8 (95% C.I.) scallops/tow the data to tows within the defined bed (Table 8). However, restriction of data to tows within the defined bed resulted in a mean catch abundance of 260.9 ±72.6 (95% C.I.) scallops/tow and an estimated population abundance of 11.5 ±3.2 (95% C.I.) million scallops.

Recommended Weathervane Scallop Harvest Guideline

The maximum harvest level allowed under regulation is 20,000 lb of scallop meats. Assuming a mean meat recovery rate of 6.55%, the estimated population biomass of 9.3 million lb equates to 611,175 lb of scallop meats. Harvesting the population at the maximum level of 20,000 lb would result in an instantaneous harvest rate of 3.3%. This harvest rate is well below the natural mortality rate and should readily provide for sustained yield (Bechtol 2000*a*). Therefore, the

maximum harvest rate of 20,000 lb of meats was recommended for the 1999 weathervane scallop fishery.

Tanner Crab

A total of 23.3 kg (51 lb) of Tanner crab was caught in the 1999 Kamishak Bay survey (Table 7). Tanner crab were caught in 93% (n=42) of the surveyed stations. Catch rates of Tanner crab ranged from 0 to 3.5 kg (0 to 7.6 lb) per 1.0 nmi, with the greatest catch from tow 99019 in station E02 (Figure 10). Survey catch abundance totaled 907 Tanner crab, comprised of 465 male (51%) and 442 female (49%) crab (Table 8). Male carapace width ranged from 7 to 145 mm and female carapace width ranged from 7 to 178 mm (Figure 11). The most abundant 5-mm size class was 11- to 15-mm crab, comprising 37% of male and 39% of female crab abundances. Based on a mean catch rate of 20.1 crab/tow, and assuming a balanced survey design with a total of 90 stations represented by the survey, the Tanner crab population was estimated to total 1.4 million male and female crab in the surveyed area.

King Crab

A standardized total of 115 king crab, with an aggregate weight of 197 kg (434 lb), was caught by the survey (Tables 7 and 8). King crab were caught in only 51% (n=23) of the survey stations (Figure 12). Tow 99025 in station D01 yielded the most king crab (n=33 crab; 136 lb). Aggregate king crab catch abundance was comprised of 43% male crab and 57% female crab. Mean king crab weight between sexes was 4.4 kg (9.7 lb). Male carapace length ranged from 123 to 178 mm and female carapace length ranged from 122 to 166 mm (Figure 13). The most abundant 5-mm size class was 161 to 165 mm for male crab (21% of all males) and 136 to 140 mm for female crab (29% of all females).

Miscellaneous Fish

Fish species were caught in all survey tows and catch biomass totaled 118 kg (260 lb; Table 7). Mean catch rates ranged from 0.1 to 14.6 kg/nmi (0.1 to 32.1 lb/nmi). Catch abundance totaled 689 fish (Table 8).

DISCUSSION

Under an assumption that survey dredge catchability equals 1.0, the point estimate and 95% confidence interval for weathervane scallops in Kachemak Bay was 2,803 ±1,577 metric tons (6.2 ±3.5 million lb) in 1998 and 4,236 ±1,132 metric tons (9.3 ±2.0 million lb) in 1999. Estimated population abundance was 8.0 ±4.6 million scallops in 1998 and 11.4 ±3.2 million scallops in 1999. The scallop bed was better defined in 1999 compared to 1998. Among other effects, this allowed mean scallop catch rates in 1999 to be calculated only from stations exceeding the threshold level of 20 lb/nmi and not from all available tows, as was the case in 1998. As a result, mean scallop catch rates were substantially larger in the 1999 survey compared to the 1998 survey and estimates scallop biomass and abundance was greater in 1999.

We do not understand the processes affecting recruitment, or how various aggregations within the surveyed bed contribute to the reproductive success of the weathervane scallop population in Kamishak Bay. More than half of the Kamishak Bay population was age 7 or younger, indicating environmental conditions have been sufficient for stable reproduction and recruitment in recent years (Figures 5 and 9). The time series of commercial age composition data also appears to exhibit continued and steady recruitment for this scallop bed (Figure 14). Commercial fishery age data suggests mortality increased rapidly around ages 8-10, as evidenced by declines in cohort abundance at around these ages. However, the relatively strong cohorts in ages 9-12 observed in the 1996 fishery can be seen progressing to ages 12-15 in the 1999 fishery. In addition, the age-4-6 scallop cohorts tend to be more prominent in the surveys than in the commercial fisheries, probably due to the influence of younger age classes on the overall age composition for the survey as a result of a liner in the survey gear (Figures 5, 9, and 14).

One aspect of the weathervane scallop management approach includes minimizing the bycatch of Tanner and king crabs. Populations of both of these species are not sufficient to support commercial crab 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 crab data from ADF&G bottom trawl surveys. 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 (Tables 2 and 7), and the trawl survey has long been recognized as having low selectivity for Tanner crab smaller than 92 mm carapace width (Kimker 1994*b*, 1996*a*; Bechtol 1998, 2000*b*, 2000*c*; Bechtol et al. 2002). Although the king crab population remains well below historical levels, catches by the scallop dredge also provided an indication that limited king crab recruitment may be occurring (Table 7). The fishery typically avoids areas of significant crab aggregations because of bycatch restrictions that could potentially curtail the fishery (Trowbridge et al. 2000). The largest catch rates for weathervane scallops tended to occur in depths of 24-31 fathoms (Figure 15). Tanner crab tended to be more prominent at less than 27 fathoms, whereas king crab, although rarely occurring in great abundance, tended to be caught at depths less than 30 fathoms.

The Kachemak Bay fishery for weathervane scallops is annually managed for a guideline harvest range of no more than 106 metric tons (20,000 lb) of meats. Preliminary efforts at a structured

model for the Kamishak Bay scallop stock suggested that instantaneous fishing mortality has historically been less than 5% (Bechtol 2000*a*). Although fishing effort has not occurred every year since the fishery's inception in 1983 (Kimker 1994*a* , Trowbridge et al. 2000), the fishery appears to be sustainable under this constant harvest strategy.

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 the 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). Management for the regulatory maximum allowable harvest of 20,000 lb of scallop meats in the 1998 and 1999 fisheries would represent a harvest rate of less than 5% of the standing stock. Under an approach that fishing mortality should not exceed natural mortality, fishery management in 1998 and 1999 for the maximum regulatory allowable harvest in Kamishak Bay should present a conservative approach that continues to provide for long-term sustainability to the scallop population.

LITERATURE CITED

Bechtol, W.R. 1998. A bottom trawl survey for crabs in the Southern, Kamishak, and Barren Islands Districts of the Cook Inlet Management Area, 20-23 June and 17-20 August 1996. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report No. 2A98-04, Anchorage.

Bechtol, W.R. 2000*a*. Preliminary evaluation of multiple data sources in an age-structured model for weathervane scallops in Kamishak Bay, Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A00-03, Anchorage.

Bechtol, W.R. 2000*b*. A bottom trawl survey for crabs and groundfish in the Southern, Kamishak, and Barren Islands Districts of the Cook Inlet Management Area, 8-12 June and 26 June – 1 July 1997. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A00-21, Anchorage.

Bechtol, W.R. 2000*c*. A bottom trawl survey for crabs and groundfish in the Southern, Kamishak, and Barren Islands Districts of the Cook Inlet Management Area, 16-30 June and 13-20 August 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A00-24, Anchorage.

Bechtol, W.R., and R. Gustafson. 2000. Abundance and biomass of weathervane scallops in Kamishak Bay, Alaska, 1996. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A99-14, Anchorage.

Bechtol, W.R., Trowbridge, C., and N. Szarzi. 2002. Tanner and king crabs in the Cook Inlet Management Area: stock status and harvest strategies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A02-07, Anchorage.

Gunderson, D.R. 1993. Surveys of fish resources. John Wiley & Sons, Inc., New York. 248 p.

Hammarstrom, L.F., and M.F. Merritt. 1985. A survey of Pacific weathervane scallops (*Pecten caurinus*) in Kamishak Bay, Alaska. Alaska Department of Fish and Game, Informational Leaflet No. 252, Juneau.

Hennick, D.P. 1973. Sea scallop *Patinopecten caurinus* investigations in Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Completion Report 5-23-R, Juneau.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 83:898-903.

Kimker, A 1994*a*. Cook Inlet Area Annual Shellfish Management report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2A94-01, Anchorage.

Kimker, A 1994b. A bottom trawl survey for crabs in the Southern, Kamishak, and Barren Islands Districts of the Cook Inlet Management Area, June 12-July 6, 1994. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2A94-33, Anchorage.

Kimker, A 1996*a*. A bottom trawl survey for crabs in the Southern, Kamishak, and Barren Islands Districts of the Cook Inlet Management Area, June 18-July 10, 1995. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report No. 2A96-24, Anchorage.

Kimker, A 1996*b*. Cook Inlet Area: annual shellfish management report, 1995-1996. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2A96-30, Anchorage.

Kruse, G.H. 1994. Fishery management plan for commercial scallop fisheries in Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Draft Special Publication 5, Juneau.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Journal of Fisheries Research Board of Canada, Bulletin 191.

Shirley, S.M., and G.H. Kruse. 1995. Development of the fishery for weathervane scallops *Patinopecten caurinus* (Gould 1850) in Alaska. Journal of Shellfish Research 14:71-78.

Sokal, R.R., and F.J. Rohlf. 1969. Biometry. W.H. Freeman and Company, San Francisco.

Trowbridge, C., N. Szarzi, and W.R. Bechtol. 2000. Review of commercial, sport, and personal use fisheries for miscellaneous shellfish in Lower Cook Inlet: Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A00-13, Anchorage.

Table 1. Weathervane scallop harvests from the Kamishak District, Cook Inlet Management District during 1983 to 1999.

Year	Number of vessels	Catch (lb) of shucked meats	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		No Effort	
1989		No Effort	
1990		No Effort	
1991		No Effort	
1992		No Effort	
1993	3	20,115	38.1
1994	4	20,431	44.6
1995[c/]	0	0	
1996	5	20,228	52.9
1997	3	20,336	50.9
1998	1	Confidential	49.1
1999	3	20,250	60.8

[a/] Season and harvest guideline set by regulation.
[b/] Season closed by E.O. on August 21,1987, one week after opening , due to low CPUE.
[c/] Only state waters opened.

Table 2. Catch weight composition during the 1998 Kamishak Bay scallop survey.

Tow Number[a/]	Station	Pounds per 1.0 nautical mile tow: Scallops (whole)	Scallop shells	Tanner Crab	King Crab	Misc. Fish	Debris	Total Catch
				Dredge B[b/]				
98001	H09	0.1	0.5	0.0	0.0	0.5	26.0	27.1
98002	F09	276.0	2.0	0.0	0.0	0.0	46.0	324.0
98003	D09	388.0	2.0	4.0	0.0	0.1	46.0	440.1
98004	B01	16.0	0.0	8.0	0.0	22.0	220.0	266.0
98005	E02	50.0	0.2	2.0	0.0	2.0	80.0	134.2
98006	G02	44.0	0.0	1.0	8.0	2.0	38.0	93.0
98007	G04	404.0	0.1	2.0	22.0	4.0	40.0	472.1
98008	H03	104.0	0.1	4.0	12.0	4.0	30.0	154.1
98009	F03	240.0	0.2	2.0	18.0	4.0	74.0	338.2
98010	E04	434.0	4.0	6.0	2.0	4.0	88.0	538.0
98011	D03	Dredge B Lost						
				Dredge A[b/]				
98012	B11	2.0	0.1	0.1	0.0	1.0	74.0	77.2
98013	D11	158.0	2.0	0.1	0.0	0.1	44.0	204.2
98014	F11	0.0	0.1	0.0	0.0	3.0	430.0	433.1
98015	H09	0.0	0.1	0.1	0.0	1.0	6.0	7.2
98016	F09	276.0	1.0	0.1	0.0	6.0	32.0	315.1
98017	D09	32.0	4.0	0.1	0.0	8.0	14.0	58.1
98018	B09	26.0	0.2	1.0	0.0	1.0	144.0	172.2
Total	n = 17	2,450.1	16.6	30.5	62.0	62.7	1432.0	4,053.9
				Survey Summary Data[c/]				
Average	n = 14	140.3	0.8	2.0	4.4	3.9	96.2	247.7
Variance		22,697.3	1.7	5.9	57.3	29.1	12,160.6	24,468.0
95% C.I.		78.9	0.7	1.3	4.0	2.8	57.8	81.9
Population Biomass		6,179,883	37,129	89,203	195,083	172,743	4,238,336	
95% C.I.		3,476,372	29,712	56,092	174,731	124,375	2,544,588	

[a/] Tows 98015, 98016, and 98017 represented replicate tows with the newer dredge.
[b/] Dredge B lost during tow 99011; see text for dredge descriptions.
[c/] Summary data calculated by averaging and treating tow replicates as single stations; population estimates calculated by extrapolating mean catch rates to the 58 stations assumed to encompass the scallop bed.

Table 3. Catch abundance during the 1998 Kamishak Bay scallop survey.

Tow Number[a/]	Animals per 1.0 nautical mile tow			
	Scallops	Tanner Crab	King Crab	Fish
		Dredge B[b/]		
98001	1	0	0	4
98002	343	0	0	0
98003	486	13	0	4
98004	17	99	0	17
98005	63	77	0	10
98006	49	19	1	8
98007	532	8	8	8
98008	102	8	2	8
98009	400	22	6	4
98010	561	9	2	4
98011		Dredge B Lost		
		Dredge A[b/]		
98012	4	33	0	9
98013	183	27	0	10
98014	0	0	0	18
98015	0	3	0	4
98016	306	1	0	4
98017	41	26	0	9
98018	31	29	0	2
Total	3,119	374	19	123
		Survey Summary Data[c/]		
Average	163.5	25.8	1.4	8.2
Variance	40,718.9	832.3	6.4	22.3
95% C.I.	105.7	15.1	1.3	2.5
Est. Population	7,202,339	1,135,887	59,784	361,848
95% C.I.	4,656,259	665,715	58,380	109,052

[a/] Tows 98015, 98016, and 98017 represented replicate tows with the newer dredge.
[b/] Dredge A lost during tow 99011; see text for dredge descriptions.
[c/] Summary data calculated by averaging and treating tow replicates as single stations; population estimates calculated by extrapolating mean catch rates to the 58 stations assumed to encompass the scallop bed.

Table 4. Shell height distribution of weathervane scallops captured during a dredge survey in Kamishak Bay, 1998.

	Shell Height (mm)																			Sample	Total
Tow	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	n	Catch
98001	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
98002	0	0	0	0	0	0	1	0	2	3	29	35	55	42	77	57	33	9	0	343	343
98003	0	0	0	0	1	0	1	4	1	7	40	32	120	71	120	61	26	2	0	486	486
98004	0	0	0	0	0	0	0	0	0	0	1	0	0	1	4	7	1	1	0	15	17
98005	0	0	0	1	0	0	2	2	1	9	12	4	8	9	6	9	1	0	0	64	64
98006	0	0	0	0	0	1	0	1	1	13	6	3	1	2	5	8	7	1	0	49	49
98007	0	0	2	3	0	0	7	12	5	65	50	29	103	52	34	45	10	0	0	417	532
98008	0	0	0	0	1	1	0	0	2	6	11	2	6	2	8	37	25	1	0	102	102
98009	0	0	3	9	3	0	12	5	12	84	106	20	61	26	13	24	19	3	0	400	400
98010	0	0	0	3	0	1	0	4	7	41	46	28	91	25	38	29	12	3	0	328	560
98011																					
98012	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	4	4
98013	0	0	0	0	1	0	0	0	0	0	4	15	23	30	34	46	26	3	1	183	183
98014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98016	0	0	0	0	0	0	0	1	1	2	9	30	31	79	77	50	23	3	0	306	306
98017	0	1	0	0	1	0	0	1	0	0	1	2	1	14	7	7	6	0	0	41	41
98018	0	0	0	0	0	0	0	0	0	0	2	2	3	4	4	8	6	2	0	31	31
Total	0	1	5	16	8	3	23	30	33	230	317	202	504	358	428	388	195	28	1	2,770	3,119
Effective[a/]	0.0	0.5	5.0	16.0	6.5	3.0	22.0	27.0	31.0	224.0	277.5	152.5	400.5	255.0	287.5	300.5	151.0	21.0	1.0	2,181.5	2,530.5
Percent	0.0%	0.0%	0.2%	0.7%	0.3%	0.1%	0.9%	1.3%	1.5%	10.7 %	12.8 %	7.1%	19.5 %	11.3 %	12.8 %	13.2 %	6.4%	0.9%	0.0%		100.0%

[a/] To compensate for replicate tows among 98001, 98002, 98003, 98015, 98016, and 98017, catches were halved before totaling and estimating percentages.

Table 5. Age composition of weathervane scallops caught in a survey of Kamishak Bay, 1998.

	Age Class (years)																									Tow
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Catch
Tow	Catch Abundance Composition of Scallops																									
98001	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
98002	0	0	2	23	54	32	53	41	15	6	14	17	14	23	15	16	8	2	3	2	0	1	0	0	2	343
98003	0	1	6	32	60	68	88	67	35	15	16	17	12	30	17	5	9	1	4	2	1	0	0	0	0	486
98004	0	0	0	1	0	0	1	0	0	0	1	2	4	3	1	1	1	0	0	0	0	0	0	0	0	17
98005	0	1	5	17	8	6	5	7	2	2	1	3	0	2	4	1	0	0	0	0	0	0	0	0	0	64
98006	0	0	3	18	4	1	2	0	0	2	2	2	3	2	2	5	2	1	0	0	0	0	0	0	0	49
98007	0	5	22	10	67	58	57	18	14	10	7	11	10	20	9	3	1	1	1	1	0	0	0	0	0	532
98008	0	2	0	18	3	6	3	0	1	2	4	5	6	19	7	14	5	4	3	0	0	0	0	0	0	102
98009	0	15	22	17	62	34	23	15	4	1	6	2	6	12	10	8	4	1	3	0	0	0	0	0	0	400
98010	0	4	5	83	62	54	28	20	12	8	5	7	8	11	10	8	0	2	0	0	1	0	0	0	0	560
98011																										0
98012	0	0	1	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
98013	0	1	0	4	18	15	29	16	11	4	7	11	14	17	10	16	4	2	2	1	0	1	0	0	0	183
98014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98016	0	0	2	7	40	24	61	45	23	10	18	9	19	14	13	12	7	1	1	0	0	0	0	0	0	306
98017	1	1	1	1	2	2	8	5	4	1	6	1	1	0	3	2	1	1	0	0	0	0	0	0	0	41
98018	0	0	0	3	1	4	2	1	2	1	0	2	2	2	4	4	2	0	0	1	0	0	0	0	0	31
Total	0.5	33.7	73.1	536.	365.	297.	290.	176.	96.8	54.4	65.6	75.3	84.9	135.	90.7	84.1	31.9	15.2	13.3	5.3	2.2	1.5	0.0	0.0	1.0	2530.5
Percent	0.0	1.3	2.9	21.	14.	11.	11.	7.0	3.8	2.2	2.6	3.0	3.4	5.3	3.6	3.3	1.3	0.6	0.5	0.2	0.1	0.1	0.0	0.0	0.0	100.0

[a/] Tow catch may exceed catch abundance composition if some scallops were not included in estimated aged specimens.

Table 6. Meat recovery from a weathervane scallop survey in Kamishak Bay, 1998 and 1999.

1998 Survey

Date	Scallop Weight (pounds)	Meat Weight (pounds)	Meat Recovery
5/7/1998	34	2.4	0.069853
5/9/1998	108	7.5	0.069444
7/1/1998	36	2.7	0.076365
Total	178	13.0	0.070922

1999 Survey

Date	Scallop Weight (pounds)	Meat Weight (pounds)	Meat Recovery
5/22/1999	54	3.5	0.065321
5/23/1999	112	7.5	0.066925
5/24/1999	162	10.4	0.063906
5/25/1999	126	7.9	0.063059
5/27/1999	74	5.2	0.070756
Total	528	34.6	0.065449

Table 7. Catch weight composition during the 1999 Kamishak Bay scallop survey.

Tow Number[a/]	Station	Pounds per 1.0 nautical mile tow: Scallops (whole)	Scallop shells	Tanner Crab	King Crab	Misc. Fish	Debris	Total Catch
99001	I02	0.0	0.0	1.0	9.5	0.5	137.1	148.1
99002	I04	6.0	0.0	0.1	0.0	2.0	42.0	50.1
99003	G08	194.4	1.9	0.1	3.7	1.9	24.3	226.3
99004	G06	164.0	1.0	2.0	0.0	0.1	28.0	195.1
99005	G04	231.4	5.9	2.0	2.0	7.8	66.7	315.7
99006	A08	0.0	0.0	1.8	0.0	1.4	1,078.2	1,081.4
99007	C08	178.0	2.0	0.3	14.0	5.0	254.0	453.3
99008	E08	252.0	6.0	0.1	30.0	1.0	50.0	339.1
99009	E10	96.0	6.0	0.1	0.0	10.0	170.0	282.1
99010	E12	1.0	0.1	0.1	0.0	1.0	318.0	320.2
99011	C12	0.2	0.0	0.1	0.0	1.0	130.0	131.3
99012	C10	230.0	0.5	0.3	8.0	6.0	116.0	360.8
99013	E06	512.0	6.0	2.0	6.0	10.0	84.0	620.0
99014	C06	120.0	3.8	0.1	0.0	7.6	721.9	853.4
99015	A02	18.9	3.8	1.9	3.8	1.9	700.0	730.2
99016	C04	166.7	7.8	1.0	3.9	1.0	323.5	503.9
99017	C02	47.4	5.3	5.3	0.0	5.3	394.7	457.9
99018	E04	258.0	6.0	2.0	80.0	6.0	90.0	442.0
99019	E02	135.2	1.0	7.6	5.7	15.2	150.5	315.2
99020	G02	33.0	0.0	0.5	0.0	1.9	191.3	226.7
99021	H03	32.7	0.0	3.8	0.0	13.5	46.2	96.2
99022	F05	618.4	6.1	0.2	12.2	6.1	67.3	710.4
99023	H05	7.8	0.0	1.0	7.8	11.8	23.5	52.0
99024	D05	438.0	4.0	0.5	5.0	14.0	186.0	647.5
99025	D01	24.0	0.0	4.0	136.0	1.5	74.0	239.5
99026	F03	243.8	1.9	5.7	11.4	1.9	53.3	318.1
99027	F01	11.3	0.0	0.9	11.3	32.1	283.0	338.7
99028	B03	64.0	6.0	0.1	6.0	7.0	392.0	475.1
99029	B05	98.1	7.5	0.1	13.2	0.9	420.8	540.7
99030	H07	3.8	0.4	0.1	0.0	1.9	28.6	34.8
99031	F07	464.6	0.0	2.1	0.0	6.3	33.3	506.3
99032	D07	365.7	3.8	0.1	24.8	7.6	62.9	464.9
99033	F09	177.1	1.0	0.1	0.0	0.5	45.8	224.6
99034	A04	8.0	4.0	0.1	12.0	0.1	484.0	508.2
99035	B11	3.0	0.2	0.1	0.0	4.0	222.0	229.3

Table 7. (page 2 of 2)

Tow Number[a/]	Station	Pounds per 1.0 nautical mile tow: Scallops (whole)	Scallop shells	Tanner Crab	King Crab	Misc. Fish	Debris	Total Catch
99036	B09	144.0	5.0	0.1	8.0	6.0	204.0	367.1
99037	A10	2.0	0.1	2.0	0.0	3.9	415.7	423.6
99038	B07	82.0	1.0	1.5	0.0	16.0	1,014.0	1,114.5
99039	A06	0.0	0.0	0.3	0.0	12.0	1,188.0	1,200.3
99040	D11	379.2	2.1	0.1	0.0	10.4	47.9	439.7
99041	F11	0.0	0.2	0.0	0.0	0.5	952.0	952.7
99042	H11	0.0	0.0	0.0	0.0	0.9	218.9	219.8
99043	G10	8.0	0.0	0.0	0.0	8.0	778.0	794.0
99044	H09	0.2	0.0	0.1	0.0	4.0	42.0	46.3
99045	D09	398.0	8.0	0.1	20.0	2.0	56.0	484.1
Total	n = 45	6,217.8	108.4	51.4	434.4	259.5	12,409.4	19,480.9
		Survey Summary Data[a/]						
Average		219.6	2.4	1.1	9.7	5.8	275.8	432.9
Variance		25107.3	7.3	2.9	545.4	36.4	98,029.5	82,504.2
95% C.I.		58.7	0.8	0.5	6.8	1.8	91.5	83.9
Population Biomass		9,338,171	164,631	78,047	659,913	394,226		
95% C.I.		2,496,228	53,981	34,113	466,390	120,444		

[a/] Weathervane scallop summary data was calculated using only tows in which catch biomass exceeded 20 lb/nmi (see text). Summary data for other species included all tows.

Table 8. Catch abundance during the 1999 Kamishak Bay scallop survey.

Tow Number	Scallops	Tanner Crab	King Crab	Fish
	Animals per 1.0 nautical mile tow			
99001	0.0	3.8	1.0	17.1
99002	5.0	5.0	0.0	26.0
99003	196.3	11.2	0.9	27.1
99004	217.0	23.0	0.0	4.0
99005	274.5	24.5	1.0	25.5
99006	0.0	24.5	0.0	9.1
99007	227.0	105.0	2.0	14.0
99008	343.0	36.0	5.0	41.0
99009	134.0	6.0	0.0	17.0
99010	16.0	6.0	0.0	26.0
99011	11.0	41.0	0.0	17.0
99012	301.0	65.0	1.0	6.0
99013	611.0	14.0	1.0	16.0
99014	119.0	8.6	0.0	4.8
99015	15.1	20.8	0.9	1.9
99016	152.0	18.6	2.0	9.8
99017	43.4	21.1	2.6	13.2
99018	310.0	2.0	21.0	11.0
99019	176.2	49.5	1.0	41.0
99020	33.0	2.9	0.0	1.9
99021	20.2	2.9	0.0	19.2
99022	804.1	48.0	3.1	35.7
99023	7.8	10.8	22.5	7.8
99024	469.0	11.0	1.0	38.0
99025	22.0	58.0	33.0	24.0
99026	396.2	31.4	1.9	13.3
99027	18.9	9.4	0.9	29.2
99028	64.0	16.0	1.0	20.0
99029	81.1	25.5	2.8	15.1
99030	4.8	5.7	0.0	11.4
99031	495.8	20.8	0.0	34.4
99032	393.3	8.6	3.8	9.5
99033	204.2	7.3	0.0	20.8
99034	6.0	18.0	1.0	4.0
99035	15.0	18.0	0.0	7.0
99036	216.0	41.0	1.0	11.0
99037	2.0	30.4	0.0	8.8
99038	71.0	8.0	0.0	7.0
99039	0.0	11.0	0.0	9.0
99040	432.3	8.3	0.0	11.5

Table 8. (page 2 of 2)

Tow Number	Scallops	Tanner Crab	King Crab	Fish
	Animals per 1.0 nautical mile tow			
99041	0.0	0.0	0.0	4.0
99042	0.0	0.0	0.0	0.9
99043	7.0	0.0	0.0	7.0
99044	1.0	2.0	0.0	4.0
99045	499.0	26.0	3.0	7.0
Total	7,415.2	906.6	114.5	689.2
	Survey Summary Data [a/]			
Mean	260.9	20.1	2.5	15.3
Variance	38,448.9	421.8	41.9	120.4
95% C.I.	72.6	6.0	1.9	3.2
Est. Population	11,493,571	1,377,157	173,855	1,046,862
95% C.I.	3,199,382	410,157	129,258	219,173

[a/] Weathervane scallop summary data was calculated using only tows where catch biomass exceeded 20 lb/nmi (see text). Summary data for other species included all tows.

Table 9. Shell height distribution of weathervane scallops captured during a dredge survey in Kamishak Bay, 1999.

Tow	Shell Height (mm) 20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	Total
	Number of Scallops																			
99001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99002	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	1	0	1	0	5
99003	0	0	0	1	2	0	1	0	1	0	2	8	17	39	53	33	29	8	2	196
99004	0	0	2	2	8	3	1	7	1	3	8	32	22	55	48	12	10	3	0	217
99005	0	0	0	3	8	1	5	4	3	3	9	32	56	36	44	26	31	12	1	275
99006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99007	0	0	0	0	1	0	0	0	0	0	2	12	10	19	46	82	42	12	1	227
99008	0	0	0	0	1	0	1	0	3	4	11	45	47	66	81	54	27	2	1	343
99009	0	0	1	0	0	4	0	1	0	1	3	22	29	28	21	16	6	1	0	133
99010	0	0	0	0	9	2	0	1	1	1	2	0	0	0	0	0	0	0	0	16
99011	1	0	0	0	7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	11
99012	0	0	0	1	0	3	0	1	3	2	9	23	50	65	73	42	24	5	0	301
99013	0	0	0	4	16	2	5	6	5	9	27	59	90	111	118	94	56	8	1	611
99014	0	0	0	0	0	1	0	0	0	1	4	8	11	23	22	21	21	8	0	119
99015	0	0	0	0	0	0	0	0	0	0	0	0	2	4	2	4	4	0	0	15
99016	0	0	0	0	0	0	0	1	0	0	0	4	5	13	28	48	45	8	0	152
99017	0	0	0	0	0	0	0	0	0	0	1	1	0	4	9	21	4	3	0	43
99018	0	0	1	2	2	2	3	2	1	4	12	65	52	73	45	21	22	3	0	310
99019	0	0	1	2	1	2	2	6	4	9	15	38	25	29	23	10	9	2	0	176
99020	0	0	0	0	2	0	0	2	0	2	0	8	4	2	3	5	9	0	0	36
99021	0	0	0	0	1	0	1	0	0	0	0	5	1	2	2	3	5	1	0	20
99022	0	0	6	21	44	5	6	23	4	12	29	96	110	207	134	53	39	9	0	799
99023	0	0	0	0	0	0	0	0	0	0	0	2	1	1	1	1	1	1	0	8
99024	0	0	0	2	3	0	5	1	3	8	22	65	74	72	69	58	64	22	1	469
99025	0	0	0	0	0	0	0	0	0	0	0	1	0	5	5	3	5	2	0	21
99026	0	0	8	22	20	2	16	15	3	15	21	118	59	41	10	26	18	2	0	396
99027	0	0	0	0	0	0	0	0	0	1	2	5	3	5	2	1	1	0	0	19
99028	0	0	0	0	0	0	0	0	0	1	1	1	2	9	16	27	7	0	0	64
99029	0	0	0	0	0	0	0	0	0	0	1	1	2	8	10	25	27	6	0	81
99030	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	0	0	0	4

Table 9. (page 2 of 2)

Tow	Shell Height (mm) 20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	Total
	Number of Scallops																			
99031	0	0	0	1	3	1	1	4	1	4	13	48	92	120	115	62	29	2	0	496
99032	0	0	0	0	1	0	0	0	0	5	12	68	37	80	80	79	28	4	0	393
99033	0	0	0	0	0	0	0	0	0	1	5	23	22	47	54	32	19	1	0	204
99034	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	1	0	0	0	6
99035	0	0	0	2	2	0	0	0	0	0	1	2	5	2	1	0	0	0	0	15
99036	0	0	0	0	0	0	0	0	0	1	0	24	30	39	49	43	27	3	0	216
99037	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	2
99038	0	0	0	0	0	0	0	0	0	0	0	3	3	14	8	21	12	10	0	71
99039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99040	0	0	0	0	1	0	0	0	1	1	5	33	55	99	82	99	50	5	0	432
99041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99043	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	2	2	0	0	7
99044	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
99045	0	0	0	1	2	0	0	3	3	3	12	69	88	111	101	74	28	4	0	499
Total	1	0	19	64	136	31	48	77	37	91	229	922	1,008	1,431	1,360	1,102	701	147	7	7,410
Percent	<0.1	0.0	0.3	0.9	1.8	0.4	0.6	1.0	0.5	1.2	3.1	12.4	13.6	19.3	18.4	14.9	9.5	2.0	0.1	100.0

Table 10. Age composition of weathervane scallops caught in a survey of Kamishak Bay, 1999.

	Age Class (years)																									Tow
Tow	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
	Number of Scallops																									
99001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99002	0	2	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	5
99003	0	3	1	5	17	22	38	15	4	19	15	8	12	22	10	8	3	5	0	1	0	1	0	0	1	210
99004	0	15	8	11	35	31	40	25	5	4	8	7	9	9	4	3	1	1	0	0	0	0	0	0	1	217
99005	0	12	11	10	52	41	35	24	3	3	7	14	16	11	19	8	8	1	5	0	0	0	0	0	0	280
99006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99007	0	1	0	1	17	8	21	15	15	4	10	12	35	24	13	30	13	3	4	0	0	0	0	0	0	343
99008	0	1	4	11	63	36	53	47	19	12	20	8	15	30	3	12	6	1	1	1	0	0	0	0	0	133
99009	0	5	1	3	29	13	35	11	7	1	10	1	5	5	2	1	1	0	2	0	1	0	0	0	0	16
99010	0	11	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
99011	1	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	301
99012	0	4	2	9	39	30	62	50	11	11	19	7	12	21	7	9	3	0	4	1	0	0	0	0	1	611
99013	0	22	16	30	85	80	75	55	41	1	26	47	13	49	33	21	10	1	2	2	0	1	0	0	0	125
99014	0	1	0	4	14	12	14	5	15	3	2	5	6	16	4	9	10	1	2	2	0	0	0	0	0	16
99015	0	0	0	0	0	1	3	2	0	0	1	3	1	2	0	0	2	1	0	0	0	0	0	0	0	343
99016	0	0	1	0	6	7	5	7	3	9	1	14	12	33	17	20	14	4	1	0	0	1	0	0	0	155
99017	0	0	0	1	0	2	1	3	2	0	1	2	6	7	5	2	1	0	0	0	0	0	0	0	0	33
99018	0	7	6	14	77	47	46	29	13	9	6	7	6	7	8	10	11	4	3	0	0	0	0	0	0	310
99019	0	5	11	25	49	22	22	8	6	5	1	4	7	10	1	3	4	2	0	0	0	0	0	0	0	185
99020	0	2	2	1	13	0	0	2	1	0	1	0	2	0	3	5	4	1	0	0	0	0	0	0	0	37
99021	0	1	1	0	5	2	1	1	0	0	0	1	0	3	2	1	2	1	0	0	0	0	0	0	0	21
99022	0	75	32	35	11	11	16	63	28	10	13	8	30	32	21	15	14	14	8	0	0	0	0	0	0	783
99023	0	0	0	0	2	1	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0	8
99024	0	5	7	27	95	33	75	37	23	4	12	8	13	25	26	17	20	7	15	14	1	2	0	0	3	469
99025	0	0	0	1	0	1	2	2	2	1	1	1	1	3	1	1	1	1	0	0	1	1	0	0	0	21
99026	0	53	36	27	15	45	28	15	6	2	3	2	4	14	10	11	1	0	1	1	0	1	0	0	1	416
99027	0	0	0	3	6	0	5	2	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	20
99028	0	0	0	2	1	2	4	10	4	5	3	3	5	11	8	5	1	0	0	0	0	0	0	0	0	64

Table 10. (page 2 of 2)

	Age Class (years)																									Tow
Tow	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
	Number of Scallops																									
99029	0	0	0	0	2	2	7	9	3	1	1	2	0	22	19	10	5	3	0	0	0	0	0	0	0	86
99030	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4
99031	0	5	5	12	74	49	88	99	26	16	17	17	0	16	33	11	2	3	2	1	0	0			0	476
99032	0	1	0	13	70	37	54	53	32	9	28	25	15	11	38	20	4	1	1	0	1	0			0	413
99033	0	0	0	4	28	15	27	36	19	4	11	7	6	16	13	9	1	0	0	0	0	0			0	196
99034	0	0	0	0	0	2	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0			0	6
99035	0	4	0	0	3	4	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0			0	15
99036	0	0	0	3	32	19	38	21	20	5	9	10	10	9	12	21	3	1	3	0	0	0			0	216
99037	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0			0	2
99038	0	0	0	0	5	1	8	4	6	0	4	4	7	3	6	14	4	2	1	2	0	0			0	71
99040	0	1	1	5	40	37	67	35	40	19	22	32	25	23	19	30	12	2	5	0	0	0			0	415
99041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99043	0	0	0	0	0	1	1	0	0	1	0	0	0	0	3	0	0	1	0	0	0	0			0	7
99044	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
99045	0	3	6	12	10	67	63	28	40	25	28	26	29	27	10	15	6	3	3	4	1	0	0	0	0	499
Total	1	249	154	272	1228	781	1090	71	396	183	282	288	302	464	352	322	167	66	64	29	5	8	0.0	0.0	8	7,424
Percent	<0.1	3.4	2.1	3.7	16.5	10.5	14.7	9.6	5.3	2.5	3.8	3.9	4.1	6.3	4.7	4.3	2.2	0.9	0.9	0.4	0.1	0.1	0.0	0.0	0.1	100.0

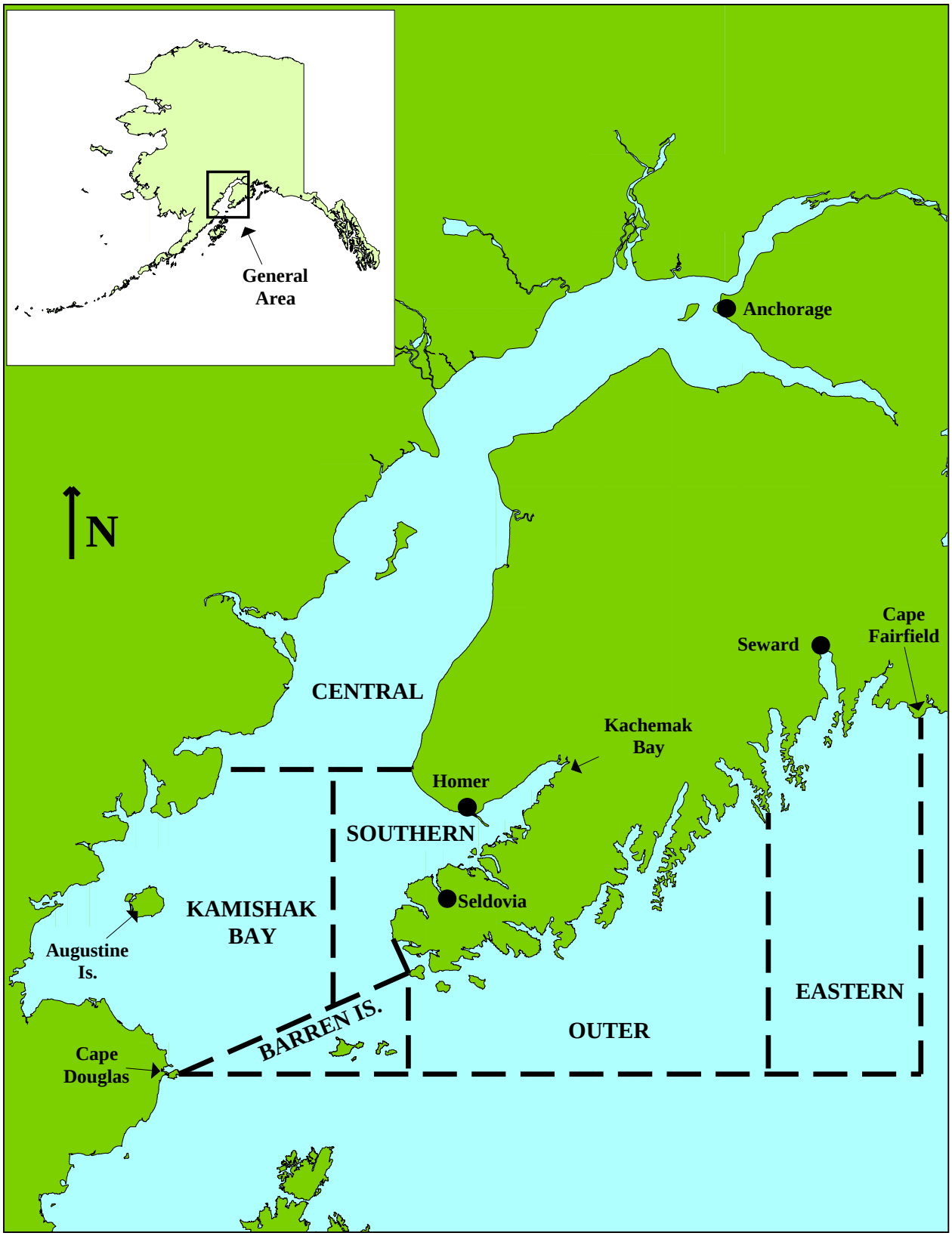


Figure 1. Commercial shellfish fishing districts of the Cook Inlet Management Area.

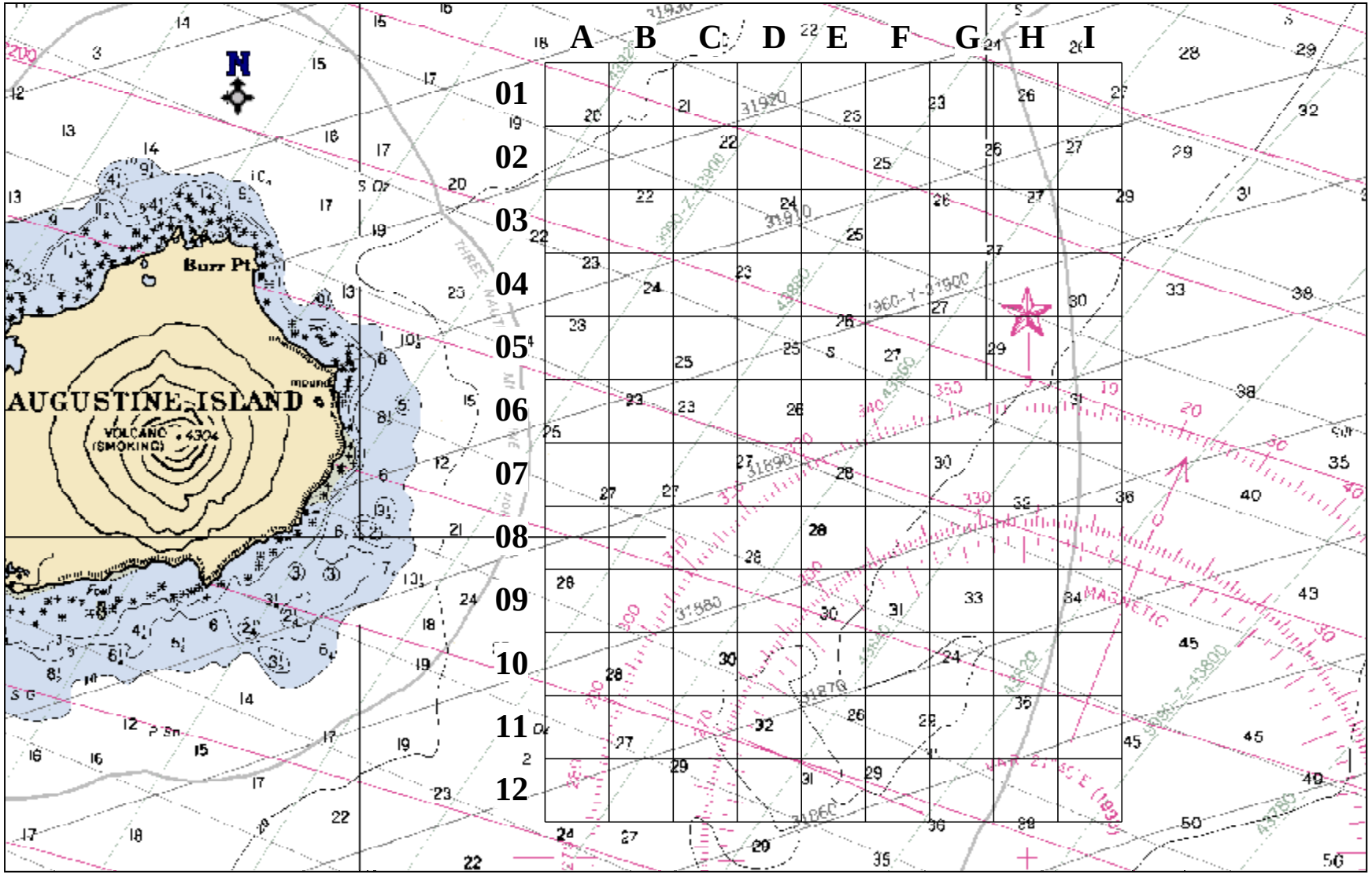


Figure 2. General survey grid of 1.0 nmi^2 showing potential sample stations (depth in fathoms) for a scallop survey in Kamishak Bay, 1998 and 1999.

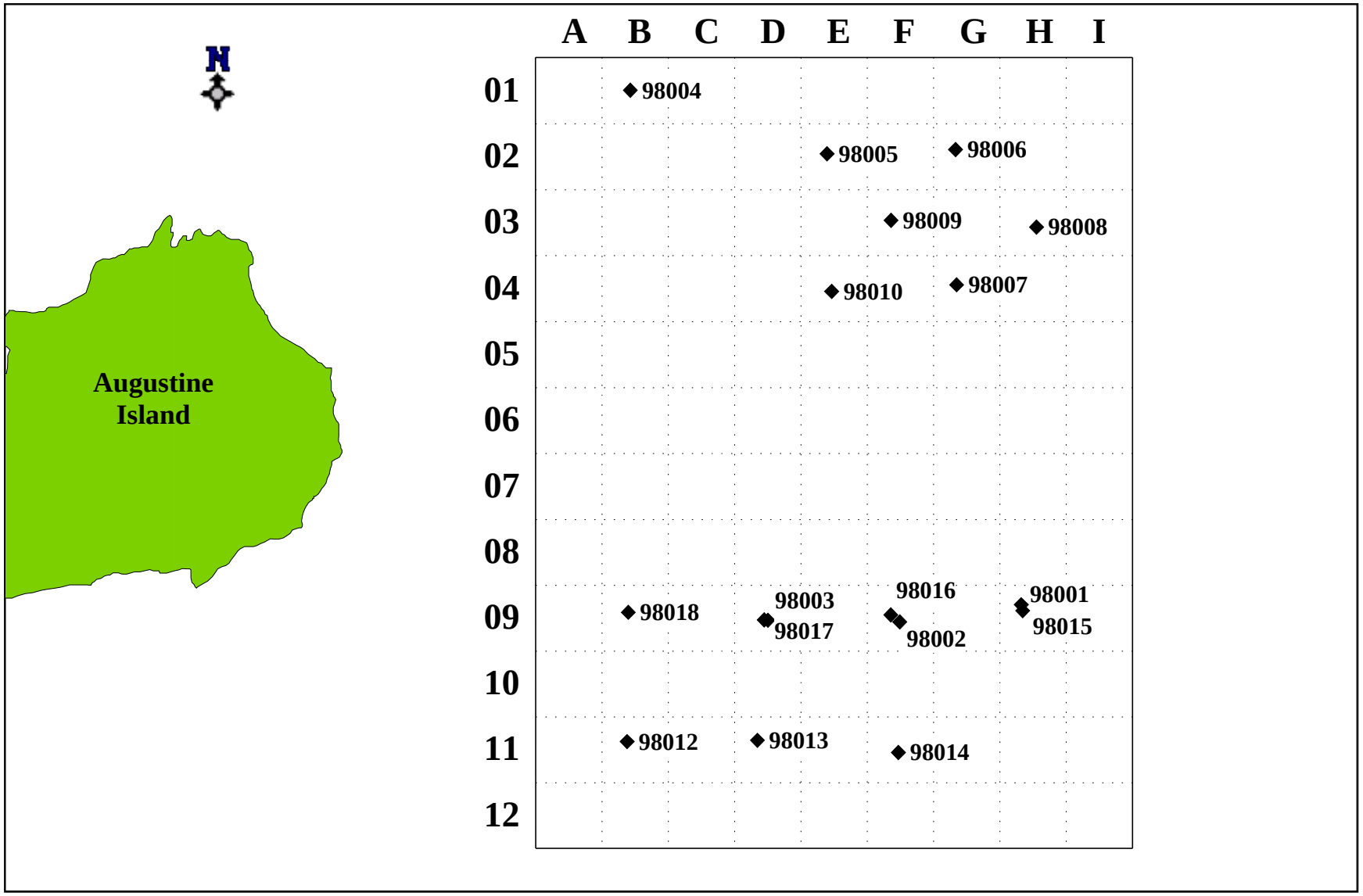


Figure 3. Midpoints of successful tows made during a dredge survey for weathervane scallops in Kamishak Bay, 1998.

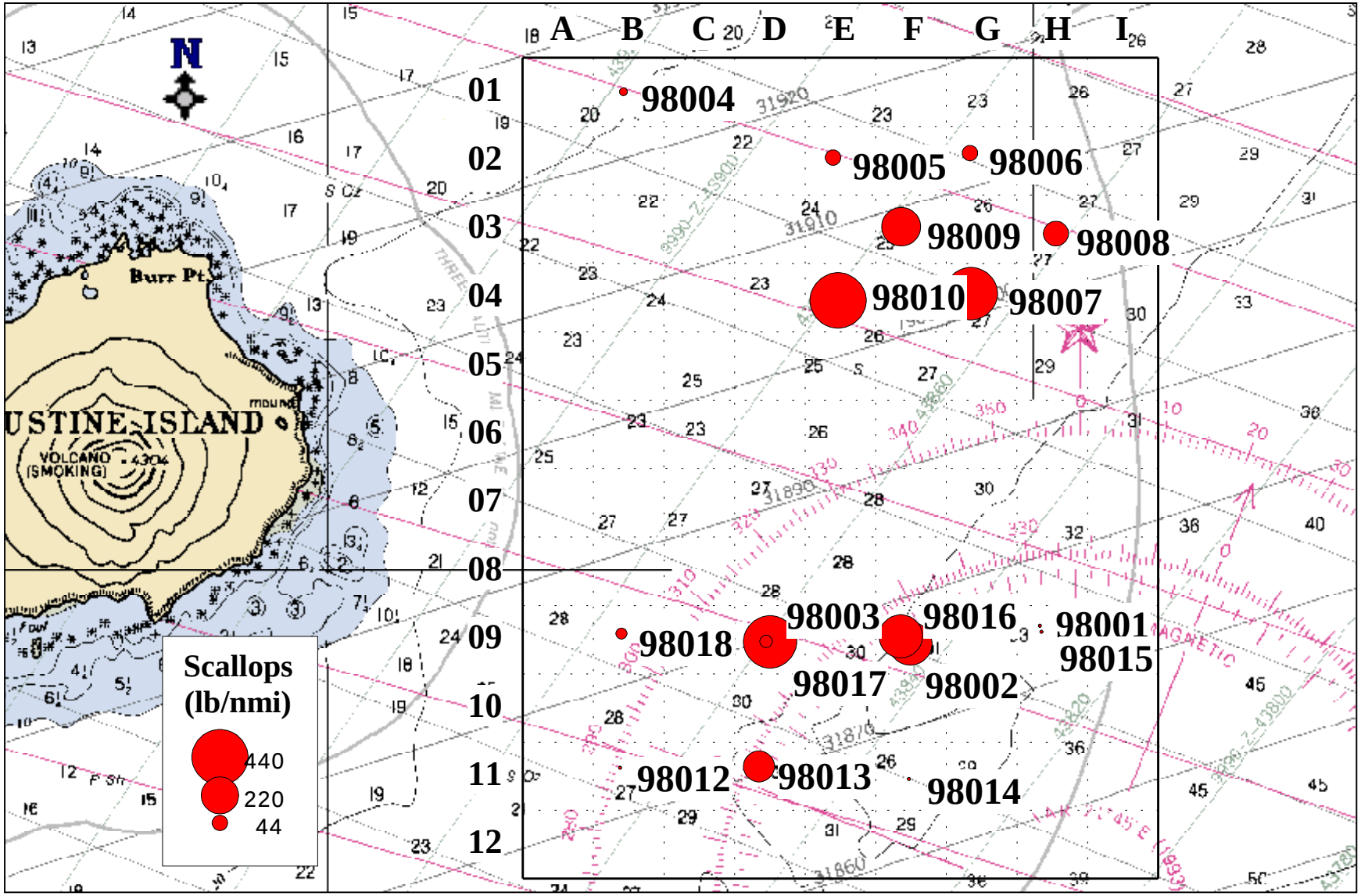


Figure 4. Distribution of weathervane scallop catches during a dredge survey of Kamishak Bay, 1998.

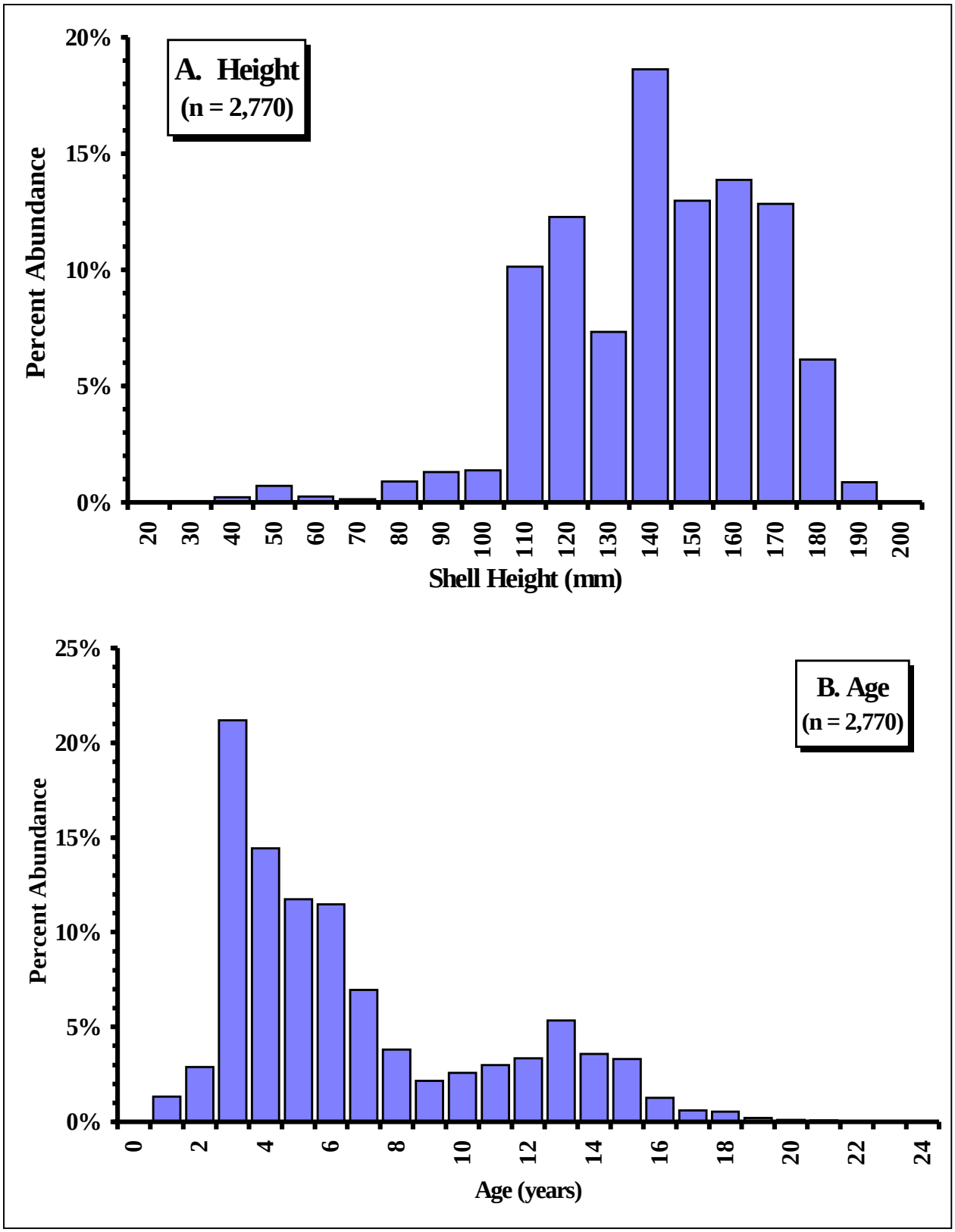


Figure 5. Shell height (A) and age (B) distribution of weathervane scallops caught during a dredge survey of Kamishak Bay, 1998.

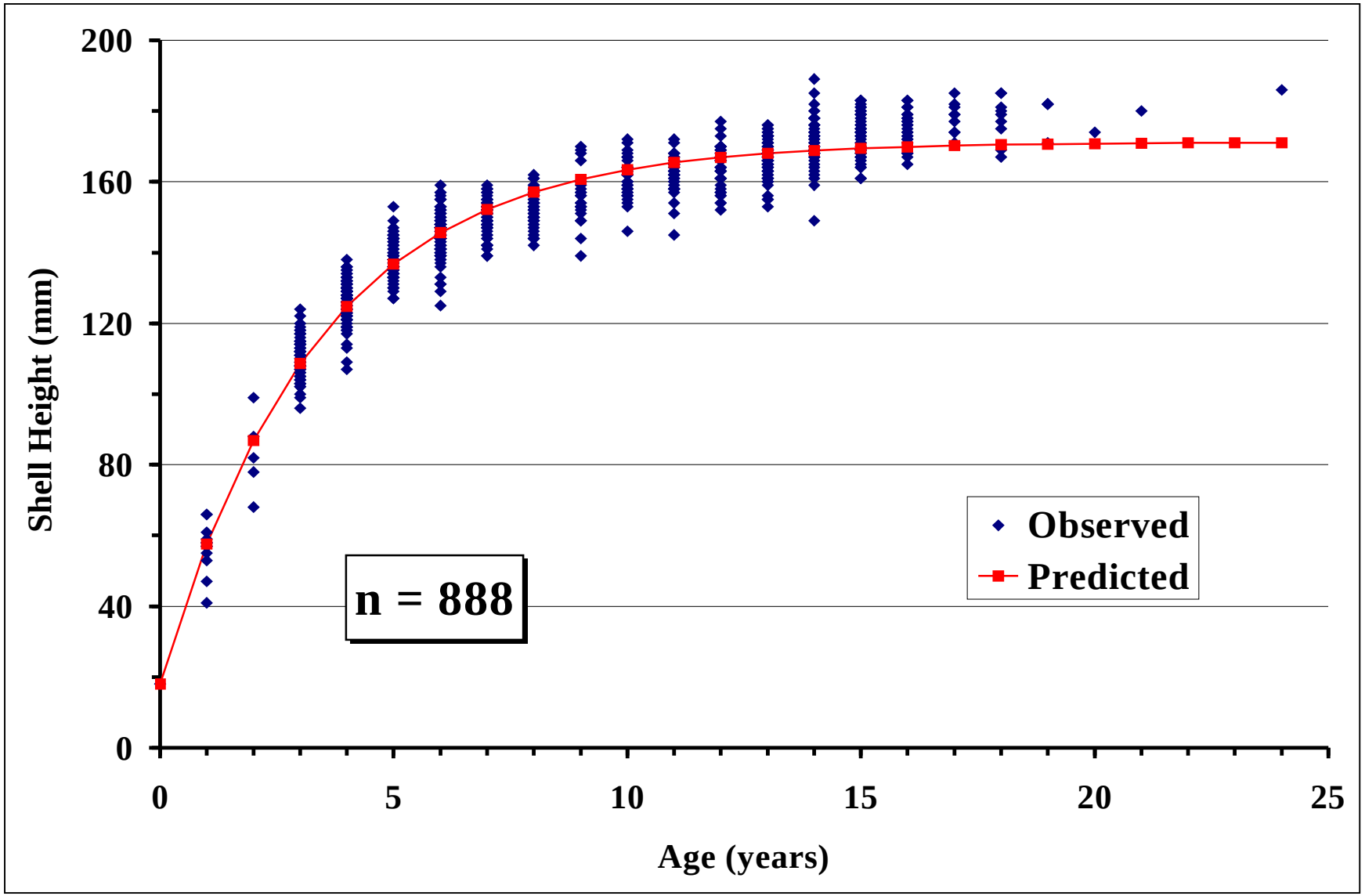


Figure 6. Height-at-age for weathervane scallops caught during dredge surveys of Kamishak Bay, 1998 and 1999.

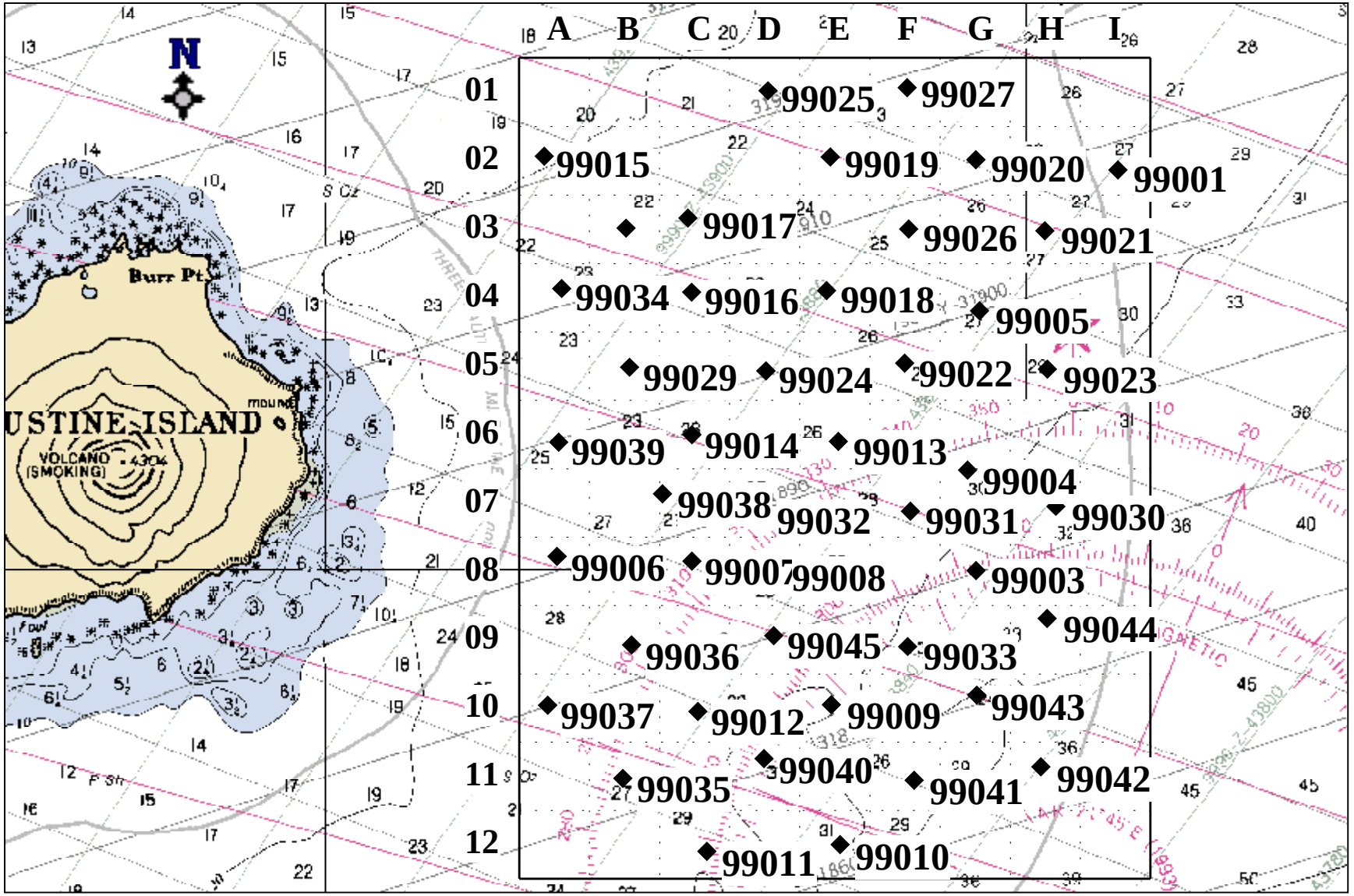


Figure 7. Midpoints of successful tows made during a dredge survey for weathervane scallops in Kamishak Bay, 1999.

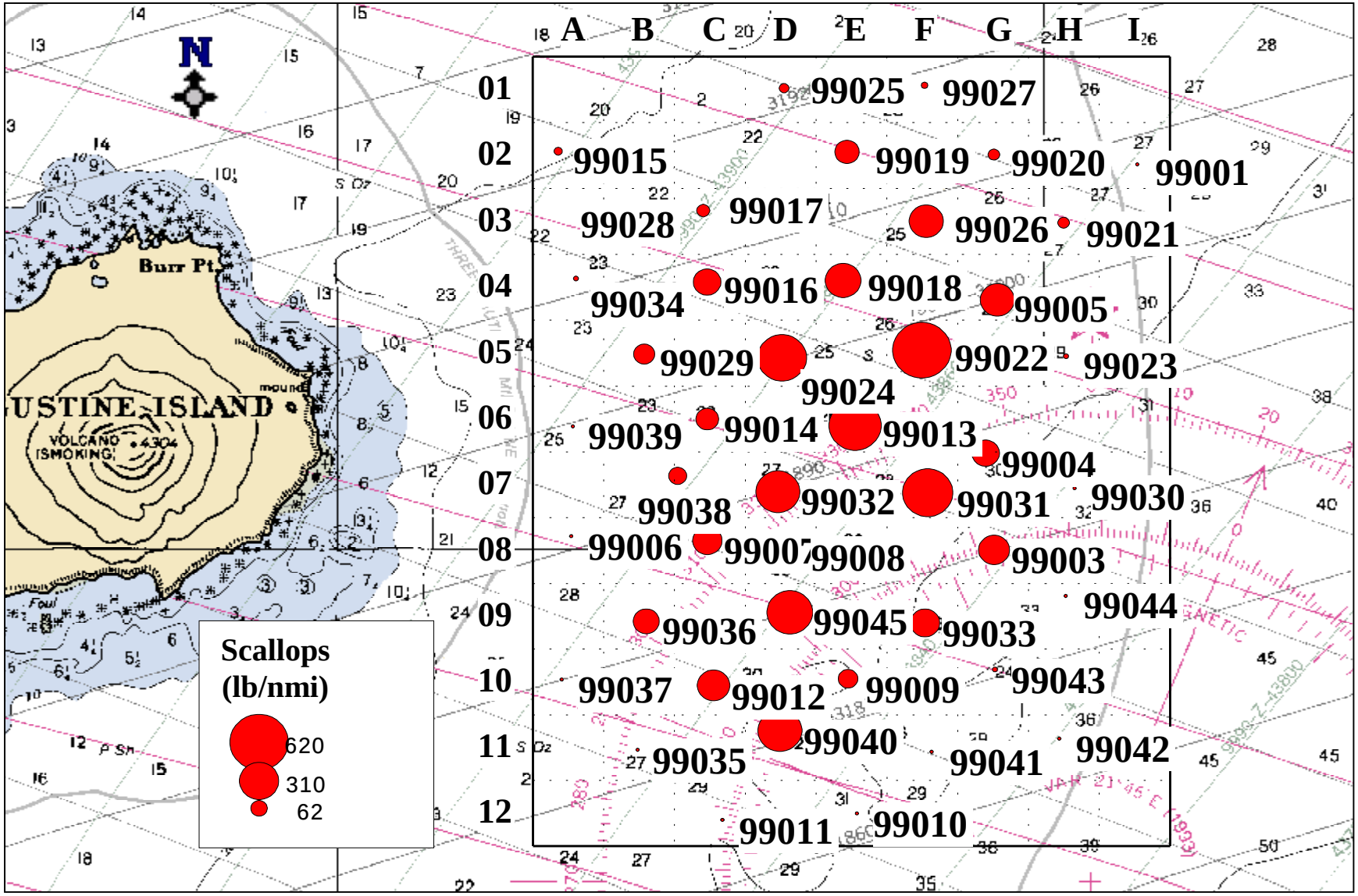


Figure 8. Distribution of weathervane scallop catches during a dredge survey of Kamishak Bay, 1999.

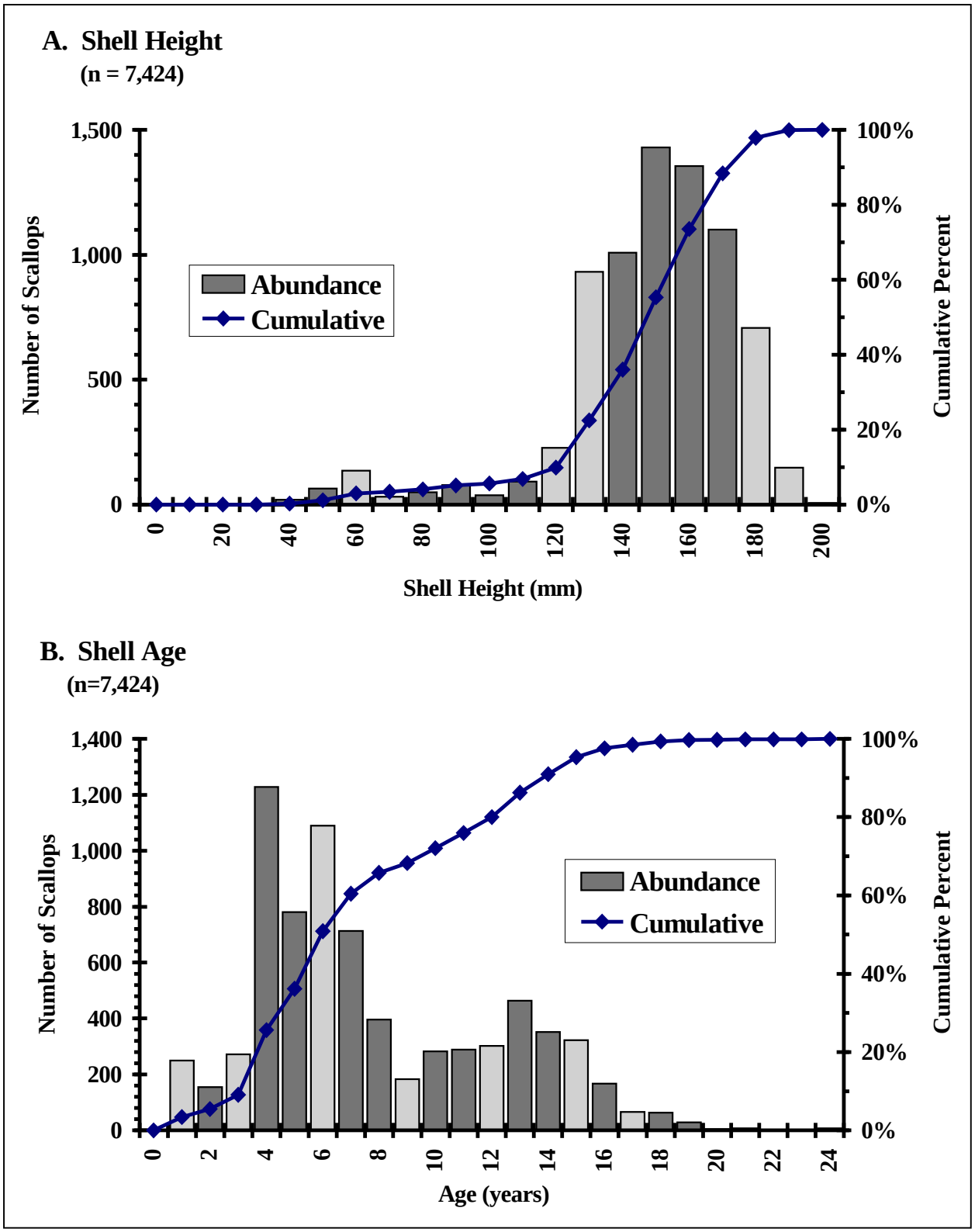


Figure 9. Shell height (A) and age (B) for weathervane scallops caught during a dredge survey of Kamishak Bay, 1999.

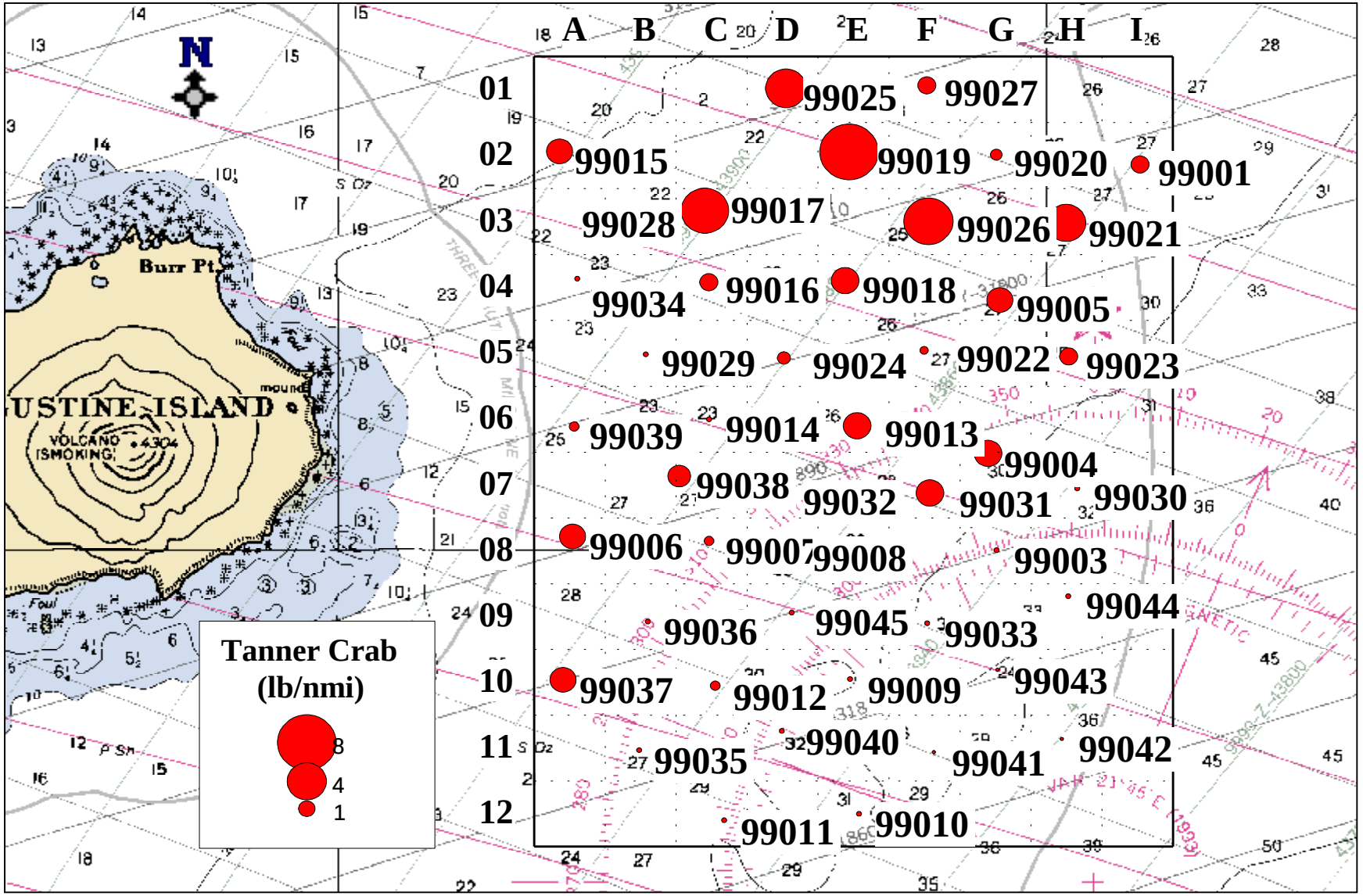


Figure 10. Distribution of Tanner crab catches during a scallop dredge survey in Kamishak Bay, 1999.

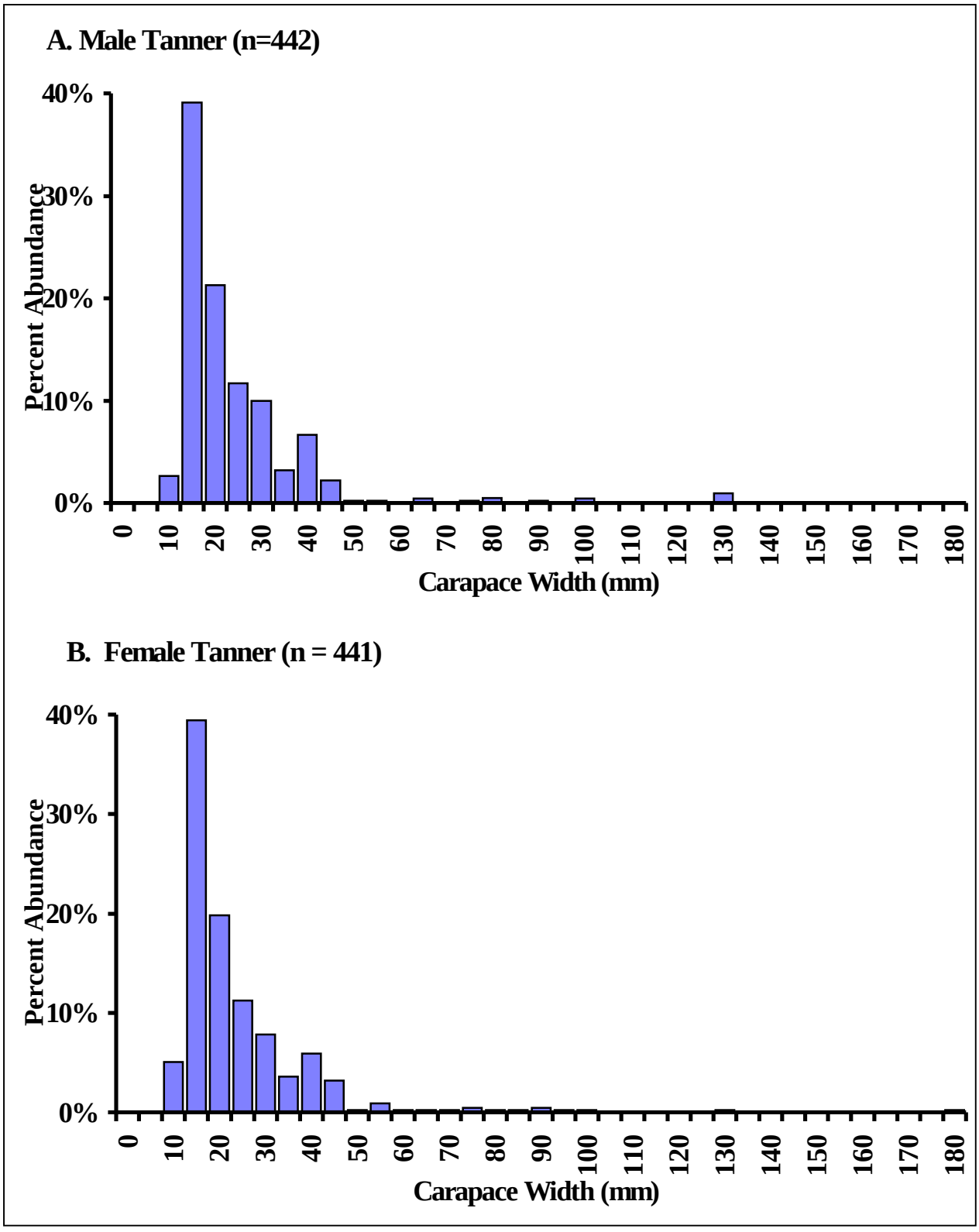


Figure 11. Carapace width of male (A) and female (B) Tanner crab caught in the Kamishak Bay scallop survey, 1999.

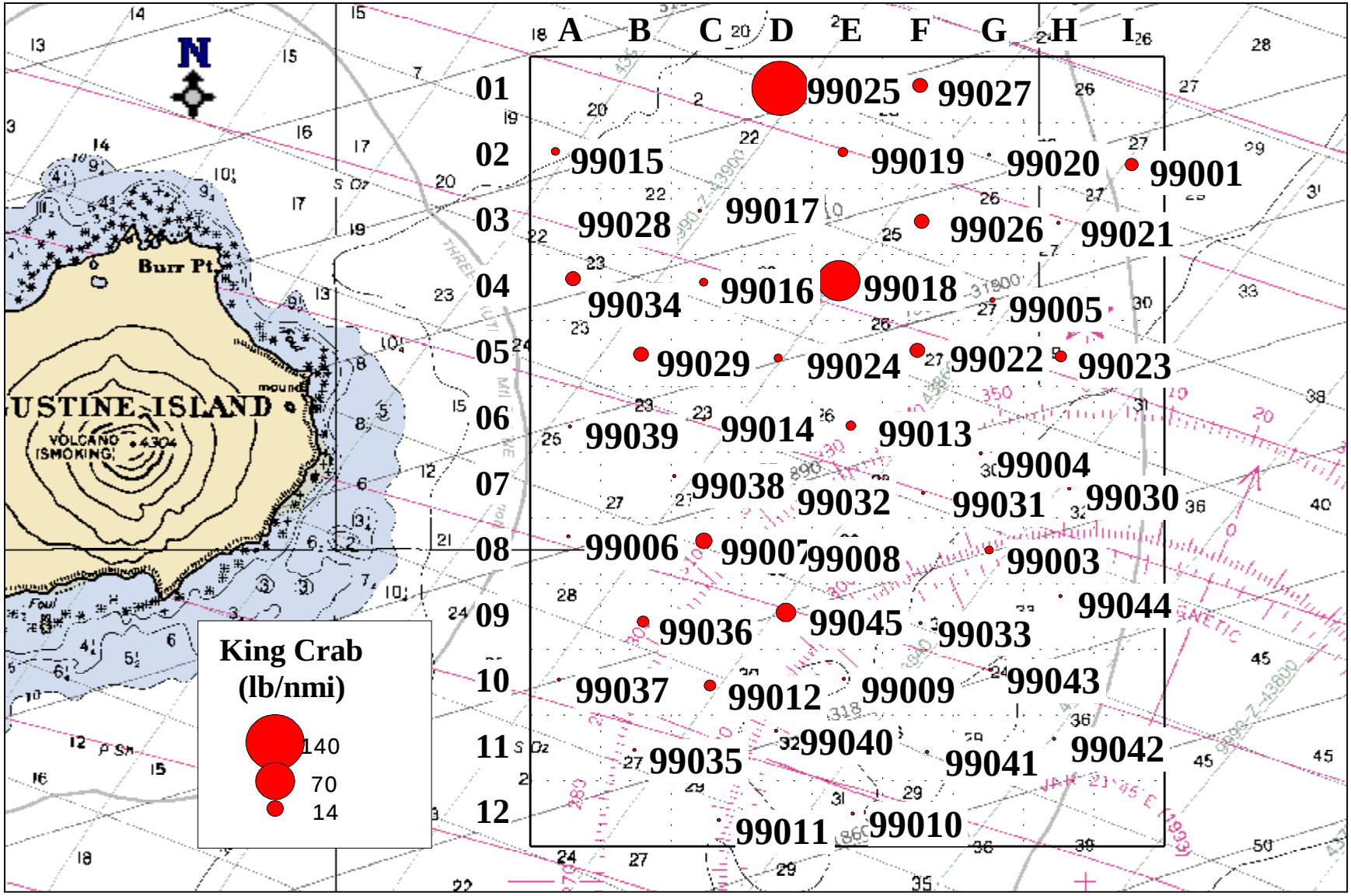


Figure 12. Distribution of red king crab catches during a scallop dredge survey in Kamishak Bay, 1999.

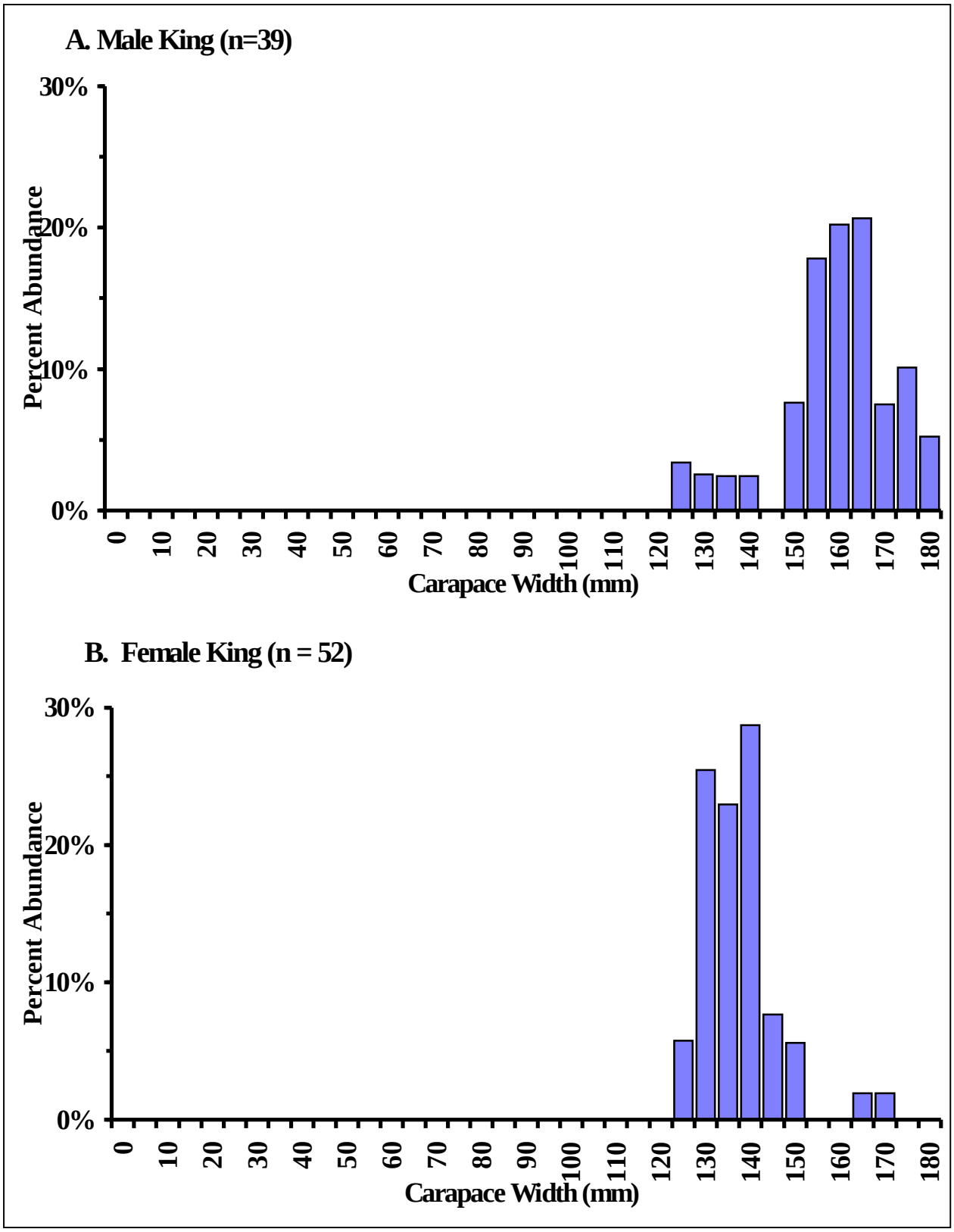


Figure 13. Carapace length of male (A) and female (B) red king crab caught in the Kamishak Bay scallop survey, 1999.

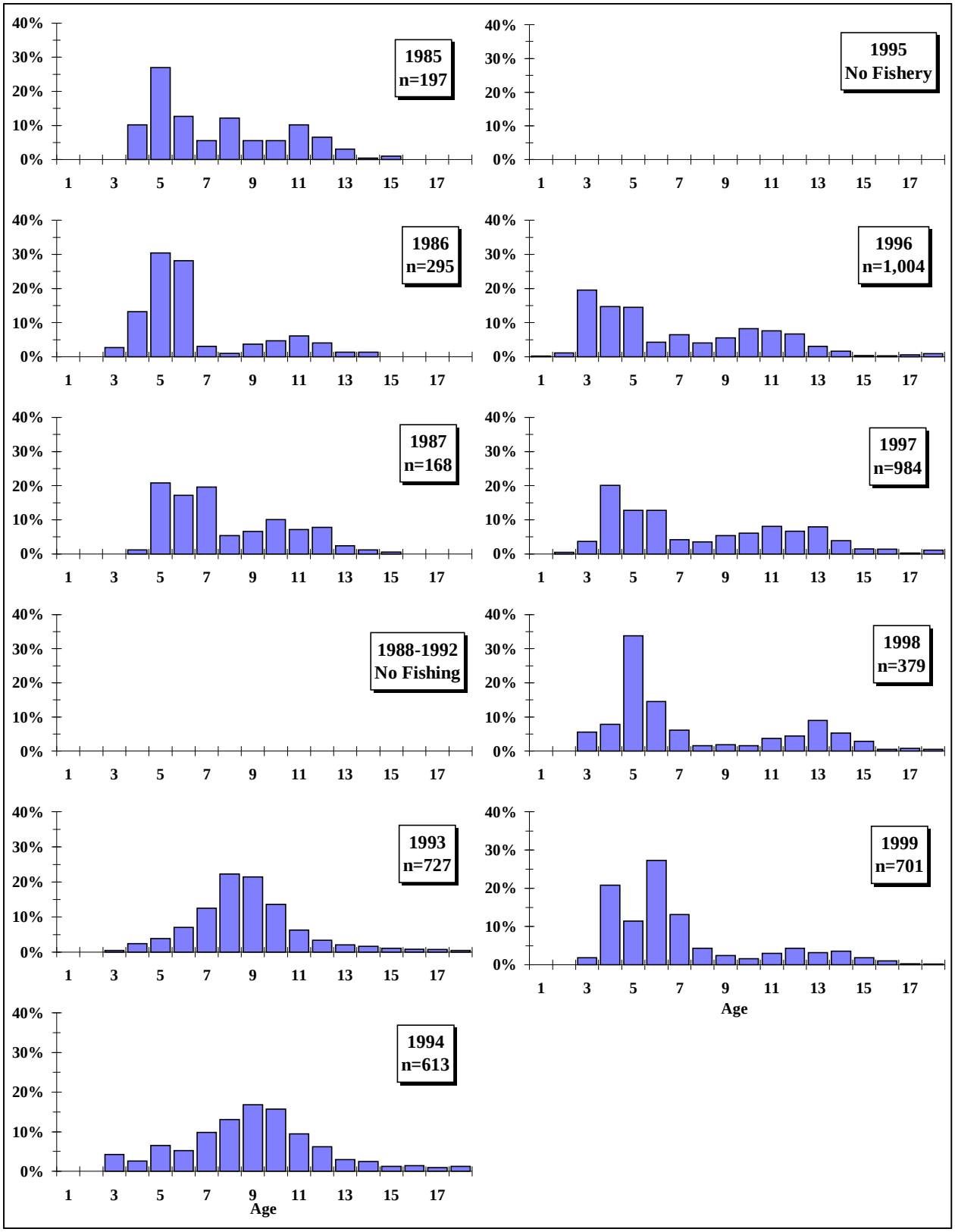


Figure 14. Age composition of weathervane scallops caught in Kamishak Bay by commercial fisheries during 1985-1999.

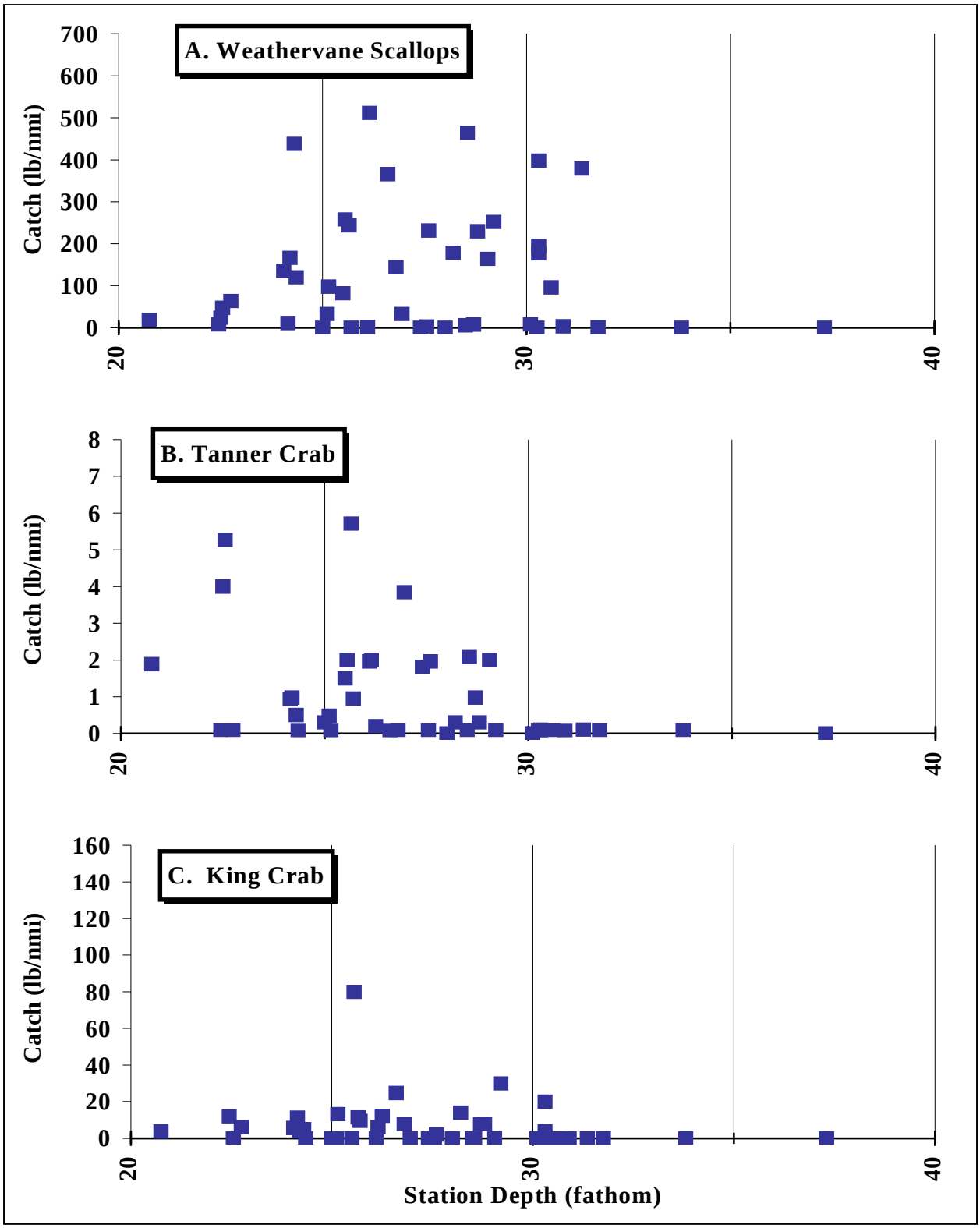


Figure 15. Distribution of weathervane scallops, Tanner crab, and king crab relative to depth in the Kamishak Bay scallop survey, 1999.

Appendix A. Tow data for dredge sets during the 1998 Kamishak Bay scallop survey.

Tow	Square	Date	Time	Start Location Lat. (°N)	Start Location Long. (°W)	Course (°True)	Speed (kt)	Duration (min)	Distance (nmi)	Scope (fathom)	Depth (fathom) Min.	Depth (fathom) Max.	Remarks
						Dredge B[a/]							
98001	H09	5/7	15:26	59.31	152.99	275°	4.0	:17	1.0	200	32	33	
98002	F09	5/7	16:32	59.32	153.07	132°	4.0	:16	1.0	125	29	31	
98003	D09	5/7	17:50	59.31	153.11	285°	4.0	:16	1.0	125	27	29	
98004	B01	5/9	10:43	59.46	153.21	120°	4.0	:15	1.0	75	19	20	
98005	E02	5/9	11:30	59.44	153.11	120°	4.0	:16	1.0	100	23	24	
98006	G02	5/9	12:22	59.44	153.04	120°	4.0	:15	1.0	100	24	26	
98007	G04	5/9	13:08	59.41	153.04	120°	4.0	:15	1.0	100	26	28	
98008	H03	5/9	14:06	59.42	153.00	120°	4.0	:15	1.0	100	27	29	
98009	F03	5/9	15:04	59.42	153.07	125°	4.0	:15	1.0	100	25	26	
98010	E04	5/9	15:59	59.41	153.11	120°	4.2	:14	1.0	100	25	26	
98011	E03	5/9	16:49	59.41	153.11	284°	4.0			100	24		Dredge Lost
						Dredge A[a/]							
98012	B11	7/1/98	9:57	59.29	153.21	120°	4.0	:15	1.0	100	27	28	
98013	D11	7/1/98	10:53	59.29	153.14	115°	4.0	:16	1.0	110	30	32	
98014	F11	7/1/98	11:50	59.29	153.07	110°	4.0	:15	1.0	100	28	29	
98015	H09	7/1/98	12:39	59.31	152.98	285°	4.0	:16	1.0	112	31	32	
98016	F09	7/1/98	13:15	59.32	153.07	110°	4.0	:15	1.0	105	28	30	
98017	D09	7/1/98	13:49	59.31	153.11	285°	4.0	:15	1.0	100	27	28	
98018	B09	7/1/98	14:29	59.32	153.21	110°	4.0	:15	1.0	100	26	27	

[a/] Dredge B lost during tow 99011; see text for dredge descriptions.

Appendix B. Tow data for dredge sets during the 1999 Kamishak Bay scallop survey.

Tow	Square	Date	Time	Start Location		Course	Speed	Duration	Distance	Scope	Depth (fathom)		Remarks
				Lat. (°N)	Long. (°W)	(°True)	(kt)	(min)	(nmi)	(fathom)	Min.	Max.	
99001	I02	5/22	14:45	59.44	152.97	112	5.0	:12	1.00	100	26	27	Dredge Flipped
" ":	" ":	5/22	15:26	59.44	152.97	102	4.0	:15	1.00	100	25	27	Dredge Flipped
" ":	" ":	5/22	15:55	59.43	152.94	288	4.0	:16	1.05	100	25	26	Repeated tow
99002	I04	5/22	16:46	59.40	152.95	294	4.0	:16	1.00	125	27	29.8	
99003	G08	5/22	17:50	59.33	153.02	292	3.9	:15	1.07	125	29.6	31	
99004	G06	5/22	18:56	59.36	153.02	283	4.0	:15	1.00	125	28.1	30	
99005	G04	5/22	19:28	59.39	153.01	284	3.9	:16	1.02	125	26.3	28.9	
99006	A08	5/23	8:47	59.33	153.21	289	4.0	:15	1.10	125	25.9	28.8	Dredge Flipped
" ":	" ":	5/23	9:19	59.34	153.24	123	3.7	:18	1.10	100	25.6	29.2	Repeated Tow
99007	C08	5/23	10:10	59.34	153.17	125	3.8	:16	1.00	125	28	28.4	Lg. rock in dredge
99008	E08	5/23	10:59	59.34	153.17	116	4.0	:15	1.00	125	28.6	29.8	
99009	E10	5/23	11:54	59.31	153.10	116	4.0	:15	1.00	125	29.2	32	
99010	E12	5/23	12:39	59.26	153.08	303	3.8	:16	1.00	125	31.4	32.1	Jarred at 0.84 nmi
99011	C12	5/23	13:28	59.26	153.14	310	4.0	:15	1.00	125	30	31	
99012	C10	5/23	14:07	59.29	153.14	295	4.0	:15	1.00	125	28	30	Dredge Flipped
" ":	" ":	5/23	14:45	59.29	153.15	292	4.0	:15	1.00	125	28	30	Repeated Tow
99013	E06	5/23	15:37	59.36	153.08	292	4.0	:15	1.00	115	25	27	
99014	C06	5/23	16:47	59.37	153.17	133	4.0	:15	1.05	100	24	25	
99015	A02	5/24	9:58	59.44	153.24	134	4.2	:15	1.06	80	20	22	Test camera housing
99016	C04	5/24	10:38	59.41	153.17	135	4.1	:15	1.02	100	24	25	
99017	C02	5/24	11:32	59.41	153.17	132	4.0	:12	0.76	100	22	23	Dredge hung on
99018	E04	5/24	12:11	59.41	153.11	137	4.0	:15	1.00	100	25	26	Start of ebb
99019	E02	5/24	13:24	59.43	153.08	312	4.2	:15	1.05	100	24	25	First camera tow
99020	G02	5/24	14:19	59.43	153.01	314	4.1	:15	1.03	110	24	26	Many sea pens
99021	H03	5/24	15:18	59.41	152.98	312	4.2	:15	1.04	115	26	28	Camera on wire
99022	F05	5/24	16.26	59.38	153.05	309	3.9	:15	0.98	110	26	27	Camera on wire
99023	H05	5/24	17.07	59.38	152.98	307	4.0	:16	1.02	125	28	30	
99024	D05	5/24	17.57	59.38	153.11	314	3.9	:16	1.00	100	24	25	Camera on wire
99025	D01	5/25	10:36	59.46	153.13	144	4.0	:15	1.00	110	22	23	Irregular bottom

Appendix B. (p. 2 of 2)

Tow	Square	Date	Time	Start Location Lat. (°N)	Start Location Long. (°W)	Course (°True)	Speed (kt)	Duration (min)	Distance (nmi)	Scope (fathom)	Depth (fathom) Min.	Depth (fathom) Max.	Remarks
99026	F03	5/25	11:22	59.42	153.07	138	4.2	:15	1.05	110	25	26	Still flooding
99027	F01	5/25	12:22	59.46	153.07	143	4.2	:15	1.06	100	23	25	Camera on wire
99028	B03	5/25	14:01	59.42	153.20	136	4.0	:15	1.00	100	22	23	SeaPlot prob, Cam.
99029	B05	5/25	14:47	59.38	153.18	312	4.2	:15	1.06	100	25	25	Ebbing
99030	H07	5/25	16:09	59.34	152.98	315	4.0	:15	1.00	115	26	28	Dredge flipped
"	":	"	": 5/25	16:42	59.36	153.00	132	4.2	:15	1.05	125	30	32	w/ebb; hard bottom
99031	F07	5/25	17:27	59.34	153.04	316	3.8	:15	0.96	125	28	29	
99032	D07	5/25	18:09	59.34	153.11	314	4.2	:15	1.05	115	26	27	
99033	F09	5/25	19:08	59.31	153.05	315	3.8	:15	0.96	125	30	31	
99034	A04	5/26	8:56	59.41	153.23	120	4.3	:14	1.00	100	21	24	3'-5- swell WNW
99035	B11	5/27	6:28	59.28	153.18	315	4.0	:15	1.00	125	27	28	Tow into 1 kt ebb
99036	B09	5/27	7:07	59.31	153.18	315	4.3	:14	1.00	120	27	27	
99037	A10	5/27	7:56	59.29	153.21	303	4.1	:15	1.02	120	26	27	Rocks; 2-3' swell
99038	B07	5/27	8:52	59.34	153.17	315	4.6	:13	1.00	110	25	27	Start of flood
99039	A06	5/27	9:30	59.36	153.21	314	4.0	:15	1.00	100	25	26	
99040	D11	5/27	10:34	59.29	153.14	99	3.8	:15	0.96	125	31	32	Swell to 5'
99041	F11	5/27	11:15	59.29	153.07	99	3.8	:16	1.00	125	27	29	Marginal seas
99042	H11	5/27	11:55	59.28	153.01	46	4.0	:16	1.06	150	37	37	
99043	G10	5/27	12:44	59.31	153.04	122	4.0	:15	1.00	125	28	33	Swell moderating
99044	H09	5/27	13:24	59.32	153.01	90	4.0	:15	1.00	125	33	35	
99045	D09	5/27	14:32	59.32	153.13	118	4.0	:15	1.00	132	30	31	Increased swell