Weathervane Scallops *Patinopecten caurinus* near Kayak Island, Alaska, 1996

by

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and

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ABSTRACT

During the 5-9 August 1996, the Alaska Department of Fish and Game conducted an area-swept survey of the weathervane scallop *Patinopecten caurinus* bed located southeast of Kayak Island, Alaska. A total of forty-three 1,855-m (1.0-nautical mile) tows were completed using a systematic sample design and a 2.4-m (8-ft) wide dredge with 10.2-cm (4-inch) rings and a 3.8-cm (1.5-inch) liner. Three age classes, encompassing ages 7-9, comprised 81.9% of the sampled population. Age-6 and younger weathervane scallops comprised only 10.0% of the population, and age-10 and older weathervane scallops comprised 8.1% of the surveyed population. Few weathervane scallops younger than age 2 were caught during the survey. Catches in individual tows ranged from 0.5-257 kg (1-566 lb). Mean catch was 26.7 kg (58.9 lb) per nautical mile, and median catch was 11 kg (24 lb) per nautical mile. Mean weight of individual scallops ranged from 136-349 g (0.30-0.77 lb) within tows, and was 227 g (0.50 lb) among tows. Distribution of catches was skewed with 41 tows having catches ≤ 85 kg (188 lb) and two tows having catches >240 kg (529 lb). The two stations with catches > 240 kg accounted for 44% of total weathervane scallop biomass and 47% of total weathervane scallop abundance during the survey. As a result, we also post-stratified data to evaluate the effect on population and harvest estimates. Estimates of a potential guideline harvest level (GHL) for the 1997 commercial fishery, calculated as 10% of each of four area-swept population estimates, ranged from 5,498-13,498 kg (12,096-29,695 lb) of shucked meats. All GHL estimates were within the regulatory guideline harvest range of 0-22,727 kg (0-50,000 lb) of shucked meats. However, we were concerned with a lack of recruitment and the location of the two stations in the higher density stratum being located in high relief habitat not readily utilized by the commercial fishing fleet. These concerns led us to use a population estimate based on post-stratified data that excluded the stratum with the largest mean catch (550 lb per nautical mile). Using mean catch of 16 kg (35 lb) per nautical mile from the remaining stratum resulted in a population estimate of 989,767 kg (2,177,487 lb) and a recommended 1997 GHL of 98,977 kg (217,749 lb) of whole weathervane scallops or 7,849 kg (17,268 lb) of shucked meats. To protect this resource and provide for sustained annual yield, it will be important to continue to monitor this population using information from fishery sampling and fishery-independent surveys.

INTRODUCTION

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

A fishery for weathervane scallops in Registration Area E, the Prince William Sound Management Area, developed in 1992 (Figure 1). In that year, four vessels harvested 94,925 kg (208,836 lb) of shucked scallop meats. The following year the Alaska Board of Fisheries established a guideline harvest range (GHR) of 0-22,727 kg (0-50,000 lb) of shucked scallop meats for Area E. Subsequent fisheries yielded harvests of 28,667 kg (63,068 lb) in 1993 and 21,954 kg (48,300 lb) in 1995. In 1994 the Alaska Board of Fisheries defined the fishing season as opening 15 January and closing 15 February, unless closed prior to that date by Emergency Order.

Following the 1995 fishery, a vessel not licensed or registered with ADF&G harvested weathervane scallops from federal waters off Kayak Island. The harvest was estimated to total 27,273 kg (60,000 lb) of shucked scallop meats, which in itself exceeded the upper limit of the Area E guideline harvest range (Charles Trowbridge, ADF&G, Homer, Alaska, personal communication). This fishing activity occurred due to a previously undetected regulatory problem, and NMFS subsequently closed all federal waters off Alaska to scallop fishing (NMFS, News Releases 95-20, 95-61, and 95-91, Juneau, Alaska). Due to the unanticipated large harvest of weathervane scallops in 1995 prior to the federal closure, ADF&G did not open the Area E scallop fishery in1996.

In August 1995, ADF&G conducted their first dredge survey of the Kayak Island weathervane scallop bed to assess the stock and examine effects of the greater than anticipated 1995 harvest (Charles Trowbridge, ADF&G, Homer, Alaska, unpublished data). In 1996, to address industry concerns about dredge performance during the 1995 survey, ADF&G surveyed the weathervane scallop bed with a new dredge. Survey designs in 1995 and 1996 were similar. Specific objectives of the 1996 Kayak Island survey were to:

1. Estimate biomass, abundance, age and size composition, and sexual maturity of weathervane scallops in this population.

2. Estimate shucked scallop meat recovery.

3. Provide a guideline harvest level for this weathervane scallop population.

4. Determine relative bycatch of king and Tanner crabs as well as other species.

Based on the results of the 1996 survey, ADF&G set a 1997 guideline harvest level (GHL) of 98,977 kg (217,749 lb) of whole weathervane scallops or 17,268 lb (7,849 kg) of shucked scallop

meats. This report documents methods used to conduct the 1996 Kayak Island weathervane scallop survey and the rationale used to set the 1997 GHL for the commercial fishery.

STUDY AREA

The study area is centered at approximately 144°20' W longitude, 59°47' N latitude in the Gulf of Alaska southeast of Kayak Island (Figure 1). This area is subject to severe weather conditions and large ocean swells. Coastal currents primarily run westerly as part of a counter-clockwise gyre, and maximum tidal exchanges are typically less than 5 m (15 ft). Bottom substrate in the study area is primarily gravel with some rock and mud; rocky reefs are present along the northwest near Cape St. Elias. Depth contours run from southwest to northeast, approximately parallel to the Kayak Island shoreline. Bottom depths gradually slope from approximately 55 m (30 fathoms) in the northwest to over 110 m (60 fathoms) in the southeast.

METHODS

Vessel and Gear

The state research vessel *Pandalus* conducted the survey during 5-9 August 1996. 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 4 biologist and 3 vessel crewmembers.

The first survey in 1995 was conducted with a 2.4-m (8-ft) dredge having a retainer bag consisting of 7.6-cm (3-inch) inside diameter rings. To capture small scallops, the retainer bag was fitted with a 3.8-cm (1.5-inch) mesh liner. We assumed that weathervane scallop catchability with this dredge was 1.0, such that all scallops larger than the liner stretch mesh were retained. However, data from paired tow study using two different sized dredges off Kayak Island in 1995 suggested that this assumption may not have been true (Charles Trowbridge, ADF&G, Homer, unpublished data). Average catch per meter of width was less for the 2.4-m dredge than for a 4.6-m (15-ft) commercial dredge.

In a cooperative effort between ADF&G and the fishing industry, the 1996 Kayak Island survey used a dredge provided by Kodiak Fish Company. This dredge had the same 2.4-m width as was used for the 1995 survey and was also fitted with a 3.8-cm mesh liner to retain small weathervane scallops. The new dredge was equipped with a heavier sweep chain and a retainer bag with larger 10.2-cm (4-inch) inside diameter rings. Vessel tow speed was approximately

7,421 m/h (4.0 nautical miles per h) and the cable scope (ratio of cable to bottom depth) was about 4:1.

Sample Design

The 1996 weathervane scallop survey was conducted southeast of Kayak Island, in the same general area as 1995 survey, and in an area targeted by the 1993 and 1995 commercial fisheries (Charles Trowbridge, ADF&G, Homer, personal communication). Sampling stations were defined by overlaying a grid of 1,855-m (1.0-nautical mile; 6,076-ft) squares over the study area (Figure 2). During both years, a systematic design with two primary units was used in which every other station was sampled. 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 1,855 m (1.0 nautical mile) within the sample station.

For the first survey in 1995, the area to be sampled was based on commercial fishery information, and 53 potential sampling stations were initially identified. To better delineate the scallop bed, additional stations were added during the survey when catches along the edge of the initial sample area were large. A strict definition of a large catch had not been determined prior to the 1995 survey. Selection of additional stations preserved the systematic survey pattern for the sampled area. While this approach extended the previously known range of the weathervane scallop bed, available vessel time did not allow all bed margins to be identified.

The 1996 survey again used a systematic design with two primary units and incorporated 1995 survey results (Figure 2). The preliminary 1996 survey area contained 82 potential sampling stations and was larger than the initial 1995 survey area. The primary sample unit was again randomly selected, and additional stations were added along the survey area margins when weathervane scallop catches were large. A large catch was defined as exceeding 8.9 kg (20 lb) for a 1,855-m (1.0-nautical mile) tow, a value which was 8% of the largest station catch obtained during the 1995 survey. 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 1992). However, we decided to forego precision about the variance estimate in order to equally distribute sampling effort across the survey area and better define weathervane scallop bed boundaries.

Data Collection

The vessel skipper recorded the following information for each tow:

1. sequential tow identification number,
2. alphanumeric station code,
3. date,
4. start and stop location (latitude and longitude),
5. tow compass heading,
6. average vessel speed,
7. tow start and stop time,
8. distance towed,
9. maximum and minimum depth,
10. sea conditions,
11. scope used, 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 retained, cleaned, measured (shell height), aged, labeled, and bagged 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. 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 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 at room temperature overnight. Scallops were then individually weighed and shucked. The shucked meat was weighed, and the empty shell was cleaned, measured for height, and aged.

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 a von Bertalanffy growth equation (Ricker 1979), using the Microsoft Excel Solver utility to minimize sums of squares, by

$$L_t = L_\infty (1 - e^{-a(t-t_0)})^{1/b} \quad , \tag{1}$$

where

a is the constant relative rate of growth,
b is the incremental rate of growth,
t is age (time) in years,
t_0 is the age of theoretical zero size, and
L_∞ is the theoretical mean maximum size.

The weathervane scallop population estimate derived from the 1996 Kayak Island survey was based on area-swept calculations (Gunderson 1993), similar to estimates for previous weathervane scallop surveys in southcentral Alaska (Hammarstrom and Merritt 1985; Charles Trowbridge, ADF&G, Homer, Alaska, personal communication). Mean catch per nautical mile ($\bar{c}$) and it's variance (s^2) were calculated by

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

and

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

where

c_i is the catch of a species, either as abundance or weight, in sample tow i,
l_i is the distance towed in nautical miles for sample tow i, and
n is the number of stations sampled.

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

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

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 grids within the survey area.

Variance of the surveyed population was estimated by

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

Median catch per nautical mile was also determined and used to provide another estimate of the population.

Finally, survey data were post-stratified to estimate the population because distribution of weathervane scallop catches among stations was very skewed (see Results). A weighted estimate of mean catch per nautical mile $(\bar{c}_w)$ was calculated by

$$\bar{c}_w = \frac{1}{N}\sum_{h=1}^{2} N_h \bar{c}_h \quad , \tag{6}$$

where

N_h is the number of possible survey grids, and
$\bar{c}_h$ is mean catch per nautical mile for strata h.

The post-stratified population estimate (P_T) was then calculated by

$$P_T = \left(\frac{6076}{8}\right) N\,\bar{c}_w \quad , \tag{7}$$

with variance (Sokal and Rohlf 1969; Thompson 1992) estimated by

$$Var(P_T) \approx \frac{N-n}{Nn} \sum_{h=1}^{2} \left(\frac{N_h}{N} s_h^2 \right) + \frac{N-n}{n^2(N-1)} \sum_{h=1}^{2} \left(\frac{N-N_h}{N} s_h^2 \right) \quad , \qquad (8)$$

where

s_h^2 is the variance about the mean catch per nautical mile for strata h.

The confidence interval was constructed as

$$P_T \pm t_{(0.975;n-1)} \sqrt{Var(P_T)} \quad . \qquad (9)$$

Because weathervane scallops are relatively long lived and contribute to harvests and spawning over several years, we calculated potential GHL's as 10% of each population estimate.

RESULTS

Survey Catches

During the 5-9 August 1996 survey of the weathervane scallop bed located southeast of Kayak Island, a total of forty-three 1,855-m (1.0-nautical mile) tows were completed (Figure 3; Table 1). Tows lasted 14-18 minutes at vessel speeds ranging from 6,493-8,349 m/h (3.5-4.5 nautical miles per h). Survey tow depths ranged from 57-130 m (31-72 fathoms). An additional tow (number 96234) was aborted after only 0.1 nautical mile when the dredge hung-up on the ocean bottom. No attempt was made to repeat this aborted tow because the bottom profile at this station was very uneven.

For the 43 completed tows, the dredge retained a total of 2,850 kg (6,284 lb) of organisms and debris (Table 2). Individual tow catches ranged from 16-275 kg (36-605 lb). Debris comprised 2,850 kg (3,476 lb), or 55%, of the total catch, and ranged from 0-99% of the catch weight from individual tows.

Weathervane Scallops

Scallop Catches

Weathervane scallops were caught in all 43 tows (Figure 4). The total weathervane scallop catch was 1,149 kg (2,534 lb), comprising 40% of the aggregate catch. Catches in individual tows ranged from 0.5-257 kg (1-566 lb). Mean catch was 26.7 kg (58.9 lb) per nautical mile (Table 2). Median catch was (11 kg (24 lb), with first and third quartile catches of 5 kg (11 lb) and 25 kg

(55 lb), respectively. Mean weight of individuals ranged from 136-349 g (0.30-0.77 lb) within tows, and was 227 g (0.50 lb) for all tows combined (Table 3).

Distribution of catches for the 43 tows was skewed: 41 tows had catches ≤ 85kg (188 lb; range: 1-188 lb), while two tow catches exceeded 240 kg (Figure 5; Table 2). The two stations with catches > 240 kg (534 lb in tow 96201 and 566 lb in tow 96202) accounted for 44% of the total weathervane scallop biomass and 47% of the total weathervane scallop abundance during the survey (Table 3). Except for the two stations with catches > 240 kg, weathervane scallops were most abundant in the central portion of the sampled area, which lay within the 62-92 m (34-50 fathom) depth contours running parallel to the Kayak Island coastline (Figure 4). Because of the skewed catch distribution within the survey area, catch data were post-stratified to evaluate the effect on the population estimate (see Weathervane Scallop Population Estimates).

Size, Age, and Growth

A total of 2,891 weathervane scallop shells were measured (Table 4). We attempted to measure shell heights for all weathervane scallops caught, but subsampled scallops from tows 96201 and 96202 due to the large catches. Shell heights for all weathervane scallops measured ranged from 24-167 mm (0.9-6.6 inch). Weighted size composition indicated the dominant size class to be 121-130 mm (4.8-5.1 inch), representing 32.5% of the sampled population (Figure 6; Table 4). Three size categories, encompassing 111-140 mm shell heights, comprised 81.9% of the surveyed population. Small weathervane scallops, 100 mm or less, were absent from 83% of the tows. Small weathervane scallops accounted for at least 10% of total scallop abundance in only six of 35 tows yielding catches of at least 10 live weathervane scallops.

A total of 1,030 weathervane scallops were aged. Weathervane scallops ranged from age 0+ (young-of-the-year) to age 19. Weighted composition data indicated the dominant cohort was age 9, representing 36.5% of the sampled population (Figure 7; Table 4). Three age classes, encompassing ages 7-9, comprised 81.9% of the sampled population. Age-6 and younger weathervane scallops comprised only 10.0% of the population, and age-10 and older weathervane scallops comprising 8.1% of the surveyed population. Few newly recruited weathervane scallops, ages 1 and 0+, were caught during the survey. All new recruits were encountered in the western portion of the weathervane scallop bed (Figure 3), in tows 96202 (134 age 1), 96203 (41 age1), 96217 (8 age 1), 96244 (5 age 1), 96206 (2 age 1; 5 age 0+), 96205 (1 age 0+), 96221(1 age 0+), and 96233 (1 age 0+).

A von Bertalanffy curve fit Kayak Island weathervane scallop shell height-at-age data well (Figure 8). Few individuals were measured for age classes younger than 4 and older than 14. Growth rate was greatest during the first four years of life, particularly between ages 1 and 2, and decreased rapidly after age 10.

Sex and Maturity

Of the 392 weathervane scallops examined for sex, 169 (43.1%) were males, 181 (46.2%) were females, and 42 (10.7%) could not be classified (Table 6). Only 2 weathervane scallops (0.5%),

both males, were in spawning condition, while 257 (91.1%) were mature but not ripe, and 33 (8.4%) were immature.

Meat Recovery

Mean daily meat recovery for all survey samples was 7.9% ±0.76 % (95% confidence interval; n=5 daily samples). The range of meat recovery among the daily samples was 7.2-8.7% (Table 7).

Tanner Crab

Adult Tanner crab were not caught during the 1996 survey. However, juvenile Tanner crab were caught in all completed tows except number 96208 (Table 2). The total juvenile Tanner crab catch was estimated to be ≤ 5 kg (11 lb). Juvenile Tanner crab catches in individual tows were usually ≤ 227 g (0.5 lb).

Fishes

Fishes were caught in 40 (93%) of the completed tows (Table 2). The total fish catch was 114 kg (251 lb). Fish catches from individual tows ranged from 0-7 kg (0-16 lb), and mean fish catch was 2.6 kg (5.8 lb). Most fishes captured were either flatfish of the family Pleuronectidae or skates of the genera *Raja* and *Bathyraja*. The most abundant flatfishes were flathead sole *Hippolossoides elassodon*, Dover sole *Microstomus pacificus*, and rex sole *Glyptocepahlus zachirus*. Fish catches were greatest in the northwest, shallower, portion of the weathervane scallop bed (Figure 9).

Weathervane Scallop Population and Available Harvest Estimates

Although we originally planned to treat survey data as a single systematic sample when estimating weathervane scallop biomass and abundance, the skewed distribution of catches (Figure 5; Table 3), along with observations on bottom relief within sampled areas, led us to also post-stratify our data. The four area-swept population estimates ranged from 694,526-1,705,021 kg (1,531,152-3,758,889 lb; Table 8). The smallest and largest estimates were obtained by treating survey catch data as a single systematic sample. The median catch produced the smallest of the four area-swept estimates, while the mean catch produced the largest one. Post-stratified data using mean catches for both strata, one stratum with catches > 240 kg per nautical mile and the other with catches ≤ 85 kg (188 lb) per nautical mile, produced a population estimate of 1,366,659 kg (3,012,937 lb). Post-stratified data using the mean catch from only one stratum, the one with catches ≤ 188 lb per nautical mile, produced a population estimate of 987,702 kg (2,177,487 lb). Converting estimated biomass into numbers of individual scallops, using the 227

g (0.50 lb) mean size of sampled individuals, produced population abundance estimates ranging from 3,062,304-7,517,778 weathervane scallops.

Estimates of the potential GHL for the 1997 commercial fishery, calculated as 10% of each of the four area-swept population estimates and applying the 7.9% mean meat recovery, ranged from 5,487-13,470 kg (12,096-29,695 lb) of shucked meats (Table 8).

Recommended 1997 Guideline Harvest Level

All four GHL estimates were within the regulatory guideline harvest range of 0-22,727 kg (0-50,000 lb) of shucked meats (regulation 5 AAC 38.221). However, we remained concerned with: (1) a lack of scallops younger than age 2 recruiting into the population; (2) young scallops primarily occurring on the western portion of the surveyed bed; (3) a dominance of age-8 and -9 weathervane scallops indicating that good recruitment events may be infrequent; (4) the substantial influence of catches from only two survey stations on the total population estimates; and (5) impacts of the unanticipated harvest in 1995. Additionally, weathervane scallops from the area represented by the two survey stations with largest catches were not thought to be readily used by the commercial fishery based on the high relief substrate and a lack of commercial effort in this area in past years (Jeffrey Barnhart, ADF&G, Kodiak, Alaska, personal communication).

Although weathervane scallop distributions were generally similar between the 1995 and 1996 surveys (Figure 10), our concerns led us to use a population estimate based on a post-stratified sample which excluded the stratum with the largest mean catch (550 lb per nautical mile). Using mean catch from the remaining stratum (35 lb per nautical mile) resulted in a population estimate of 987,702 kg (2,177,487 lb) and a recommended 1997 GHL of 98,770 kg (217,749 lb) of whole weathervane scallops or 7,833 kg (17,268 lb) of shucked meats Table 8).

DISCUSSION

We do not understand the processes affecting recruitment, or how various aggregations within the surveyed bed contribute to reproductive success of the population near Kayak Island. The domination of the Kayak Island population by three age classes contrasts sharply with that of the Kamishak Bay population in Cook Inlet where over 50% of the sampled population was younger than age 7 and age-3 and age-4 cohorts were abundant (William Bechtol, ADF&G, unpublished data). The apparent lack of new recruits into the Kayak Island population, as well as the lack of a large recruitment event over the last 7 years, suggests we should be conservative in setting a GHL for this area. Although annual natural mortality rates of weathervane scallops tend to be relatively low, ranging from 4% to 20% (Kruse 1994), lack of recruitment into the Kayak Island

population indicates harvests will continue to decline over the next few years. In considering options in recommending a 1997 GHL, we recognized that unharvested portions of the Kayak Island population would be available in future seasons to serve as brood stock as well as to provide some future harvest potential. To protect this resource and provide for sustained annual yield, it will be important to continue to monitor this population using information from fishery sampling and fishery-independent surveys.

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Table 1. Vessel log of dredge tows made during a weathervane scallop survey near Kayak Island, Alaska. 1996.

Tow Number	Station	Date	Tow Start Coordinates. Latitude	Longitude	Course Made Good	Speed (nautical Miles/h)	Duration (minutes)	Distance (nautical miles)	Tow Depth (fathoms) Minimum	Maximum	Scope (fathoms)
96201	K2	08/05	59°45.92'	144°32.22'	202°	4.3	17	1.0	47	53	175
96202	J3	08/05	59°46.91'	144°30.20'	190°	4.3	17	1.0	39	45	150
96203	I4	08/05	59°47.96'	144°28.04'	188°	4.3	15	1.0	34	38	125
96204	H5	08/05	59°48.94'	144°26.22'	185°	4.4	16	1.0	31	33	125
96205	H7	08/05	59°48.03'	144°24.07'	030°	4.3	18	1.0	36	38	150
96206	G8	08/05	59°49.85'	144°20.10'	185°	4.4	17	1.0	33	35	125
96207	F9	08/05	59°50.07'	144°19.74'	020°	4.0	17	1.0	33	31	125
96208	E10	08/05	59°51.10'	144°17.72'	025°	4.3	17	1.0	31	30	125
96209	E12	08/05	59°50.97'	144°12.99'	025°	4.0	18	1.0	33	34	125
96210	D13	08/05	59 °52.83'	144°10.07'	190°	4.2	18	1.0	31	33	125
96211	D15	08/06	59 °52.86'	144°06.25'	185°	4.3	18	1.0	33	35	125
96212	E16	08/06	59 °51.90'	144°04.25'	185°	4.1	18	1.0	38	39	140
96213	F15	08/06	59 °50.88'	144°06.25'	185°	4.1	18	1.0	40	41	150
96214	G14	08/06	59 °49.89'	144°08.18'	185°	4.1	18	1.0	42	43	150
96215	H15	08/06	59 °48.98'	144°06.09'	185°	4.1	18	1.0	46	48	175
96216	I14	08/06	59°47.93'	144°08.10'	185°	4.1	18	1.0	49	51	175
96217	L1	08/07	59°43.89'	144°36.29'	025°	4.1	18	1.0	56	58	225
96218	L3	08/07	59°44.01'	144°31.88'	020°	4.5	18	1.0	59	65	250
96219	K4	08/07	59°44.98'	144°29.85'	020°	4.4	18	1.0	51	57	225
96220	J5	08/07	59°46.00'	144°29.71'	018°	4.2	18	1.0	45	50	200
96221	M2	08/08	59°43.78'	144°32.12'	200°	4.0	15	1.0	68	71	250
96222	L5	08/08	59°44.99'	144°26.07'	200°	3.5	18	1.0	58	62	225
96223	K6	08/08	59°45.07'	144°25.73'	018°	3.8	17	1.0	51	56	225
96224	J7	08/08	59°46.15'	144°24.00'	020°	3.8	16	1.0	47	51	200
96225	I8	08/08	59°46.93'	144°21.92'	018°	4.0	15	1.0	42	45	175

- Continued -

Table 1. (page 2 of 2)

Tow Number	Station	Date	Tow Start Coordinates. Latitude	Longitude	Course Made Good	Speed (nautical miles/h)	Duration (minutes)	Distance (nautical miles)	Tow Depth (fathoms) Minimum	Maximum	Scope (fathoms)
96226	H9	08/08	59°47.95'	144°19.85'	018°	4.0	15	1.0	39	41	150
96227	G10	08/08	59°49.00'	144°17.75'	018°	4.0	15	1.0	36	38	150
96228	F11	08/08	59°49.97'	144°15.83'	018°	4.0	16	1.0	34	35	125
96229	E14	08/08	59°11.01'	144°09.71'	020°	4.0	14	1.0	35	36	125
96230	F13	08/08	59°50.86'	144°10.22'	200°	4.0	15	1.0	36	38	125
96231	G12	08/08	59°49.92'	144°12.15'	200°	4.0	15	1.0	38	40	150
96232	H11	08/08	59°48.93'	144°14.26'	200°	4.0	15	1.0	40	43	150
96233	I6	08/08	59°47.84'	144°24.24'	195°	4.0	15	1.0	40	43	150
96234	I2	08/08	59°47.75'	144°32.10'	200°	-	02	0.1	-	-	-
96235	I10	08/09	59°47.88'	144°16.19'	190°	4.0	15	1.0	44	46	175
96236	J9	08/09	59°46.91'	144°18.32'	195°	4.0	15	1.0	47	51	175
96237	K8	08/09	59°45.85'	144°21.92'	195°	4.0	15	1.0	52	56	200
96238	L7	08/09	59°44.93'	144°22.26'	195°	4.0	15	1.0	57	62	225
96239	L9	08/09	59°44.04'	144°19.85'	025°	4.0	15	1.0	59	61	225
96240	K10	08/09	59°45.04'	144°17.74'	022°	4.0	16	1.0	54	57	225
96241	J11	08/09	59°46.02'	144°15.88'	020°	4.0	14	1.0	50	52	200
96242	I12	08/09	59°47.06'	144°13.85'	025°	4.0	15	1.0	47	49	200
96243	H13	08/09	59°48.03'	144°11.80'	025°	4.0	14	1.0	44	45	175
96244	M0	08/09	59°43.75'	144°36.44'	195°	4.0	15	1.0	59	62	225

Table 2. Catch weight (pounds) per nautical mile tow during a weathervane scallop survey near Kayak Island, Alaska, 1996.

Tow Number	Whole Scallops	Scallop Shells	Tanner Crabs	Fishes	Debris	Total Catch
96201	534	1	1.0	4	28	568
96202	566	0	0.5	12	26	605
96203	61	0	0.5	0	0	62
96204	1	0	0.5	8	34	44
96205	12	0	0.5	12	40	65
96206	7	0	0.5	10	60	78
96207	2	0	0.1	16	74	92
96208	1	0	0.0	4	134	139
96209	32	0	0.1	4	178	214
96210	5	0	0.1	8	128	141
96211	6	1	0.5	16	64	88
96212	20	0	0.1	6	117	143
96213	14	0	0.1	6	166	186
96214	4	0	0.1	10	214	228
96215	18	1	0.1	4	162	185
96216	14	1	0.1	1	124	140
96217	24	1	0.1	1	12	38
96218	26	0	0.2	1	70	97
96219	36	1	0.5	8	64	110
96220	90	0	0.5	2	44	137
96221	20	0	0.5	8	54	83
96222	18	1	0.1	2	15	36
96223	34	0	0.5	2	56	93
96224	48	0	0.5	2	68	119
96225	74	0	0.1	6	48	128
96226	50	0	0.1	8	72	130
96227	64	1	0.1	14	70	149
96228	40	0	0.1	2	86	128
96229	38	1	0.1	10	54	103
96230	60	0	0.1	6	22	88
96231	82	0	0.1	6	36	124
96232	98	0	0.1	6	20	124
96233	20	0	0.5	8	60	89
96234		Aborted Tow – No Catch Data				
96235	188	0	0.5	6	26	221
96236	104	0	0.5	8	26	139
96237	30	0	0.1	8	154	192
96238	10	1	0.1	4	88	103
96239	2	0	0.1	2	140	144
96240	1	0	0.1	1	128	130
96241	2	0	0.1	0	146	148
96242	18	1	0.1	1	144	164
96243	36	1	0.1	0	184	221
96244	24	1	0.5	8	40	74
Total	2,534	13	11	251	3,476	6,284
Mean	58.9	0.3	0.3	5.8	80.8	146.1

Table 3. Weathervane scallop catch weight, abundance and mean weight during a dredge survey near Kayak Island survey, Alaska,1996.

	Catch Weight		Catch Abundance		Mean
Tow	Weight (lb)	Percent of Total	Number	Percent of Total	Weight (lb)
96201	534	21.1	1,218	24.1	0.44
96202	566	22.3	1,175	23.3	0.48
96203	61	2.4	141	2.8	0.43
96204	1	0.0	3	0.1	0.33
96205	12	0.5	23	0.5	0.52
96206	7	0.3	18	0.4	0.39
96207	2	0.1	3	0.1	0.67
96208	1	0.0	3	0.1	0.33
96209	32	1.3	44	0.9	0.73
96210	5	0.2	7	0.1	0.71
96211	6	0.2	8	0.2	0.75
96212	20	0.8	33	0.7	0.61
96213	14	0.6	24	0.5	0.58
96214	4	0.2	7	0.1	0.57
96215	18	0.7	39	0.8	0.46
96216	14	0.6	28	0.6	0.50
96217	24	0.9	62	1.2	0.39
96218	26	1.0	50	1.0	0.52
96219	36	1.4	53	1.0	0.68
96220	90	3.6	148	2.9	0.61
96221	20	0.8	37	0.7	0.54
96222	18	0.7	34	0.7	0.53
96223	34	1.3	54	1.1	0.63
96224	48	1.9	72	1.4	0.67
96225	74	2.9	139	2.8	0.53
96226	50	2.0	100	2.0	0.50
96227	64	2.5	111	2.2	0.58
96228	40	1.6	69	1.4	0.58
96229	38	1.5	59	1.2	0.64
96230	60	2.4	106	2.1	0.57
96231	82	3.2	154	3.1	0.53
96232	98	3.9	197	3.9	0.50
96233	20	0.8	34	0.7	0.59
96234	Aborted Tow - No Catch Data				
96235	188	7.4	354	7.0	0.53
96236	104	4.1	192	3.8	0.54
96237	30	1.2	48	1.0	0.63
96238	10	0.4	13	0.3	0.77
96239	2	0.1	3	0.1	0.67
96240	1	0.0	1	0.0	0.50
96241	2	0.1	6	0.1	0.33
96242	18	0.7	35	0.7	0.51
96243	36	1.4	64	1.3	0.56
96244	24	0.9	79	1.6	0.30
Total	2,534	100.0	5,049	100.0	0.50

Table 4. Size frequency distribution of weathervane scallops captured during a dredge survey near Kayak Island, Alaska, 1996.

	Scallop Abundance																
	Scallop Shell Height (mm) [a]															Total	Sample
Tow	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	Catch	Size
96201	12	-	-	-	-	-	-	24	61	784	301	24	12	-	-	1,218	101
96202	17	9	9	9	-	-	9	43	70	505	453	35	17	-	-	1,175	135
96203	-	4	9	-	-	-	1	6	20	8	38	41	12	2	-	141	141
96204	-	-	-	-	-	-	1	1	-	-	1	-	-	-	-	3	3
96205	1	-	-	-	-	-	-	3	3	2	4	4	6	-	-	23	23
96206	-	4	3	-	-	-	-	-	2	1	1	5	2	-	-	18	18
96207	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	3	3
96208	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	3	3
96209	-	-	-	-	-	-	-	-	-	-	10	19	15	-	-	44	44
96210	-	-	-	-	-	-	-	-	-	-	1	4	2	-	-	7	7
96211	-	-	-	-	-	-	-	-	-	-	-	2	5	1	-	8	8
96212	-	-	-	-	-	-	-	-	-	2	7	15	9	-	-	33	33
96213	-	-	-	-	-	-	-	-	-	-	9	13	2	-	-	24	24
96214	-	-	-	-	-	-	-	-	-	-	1	5	-	1	-	7	7
96215	-	-	-	-	-	-	-	1	8	21	9	-	-	-	-	39	39
96216	-	-	-	-	-	-	-	-	-	6	19	2	1	-	-	28	28
96217	-	-	-	3	2	-	-	1	16	18	19	3	-	-	-	62	62
96218	-	-	-	-	-	-	2	3	1	3	10	14	10	6	1	50	50
96219	-	-	-	-	-	-	-	-	-	1	3	20	16	11	2	53	53
96220	-	-	-	-	-	-	1	-	-	-	22	63	41	20	1	148	148
96221	2	-	-	-	-	-	2	1	2	2	4	12	9	3	-	37	37
96222	-	-	-	-	-	-	1	-	2	-	7	7	7	7	3	34	34
96223	-	-	-	-	-	-	-	-	1	3	6	15	14	12	3	54	54
96224	-	-	-	-	-	-	-	-	-	-	16	30	17	8	1	72	72
96225	-	-	-	-	-	-	-	-	-	4	67	48	15	5	-	139	139

-continued-

Table 4. (page 2 of 2)

	Scallop Abundance																
	Scallop Shell Height (mm) [a]															Total	Sample
Tow	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	Catch	Size
96226	-	-	-	-	-	-	-	-	-	-	50	40	9	1	-	100	100
96227	-	-	-	-	-	-	-	1	2	2	46	49	8	2	1	111	111
96228	-	-	-	-	-	-	-	-	1	2	25	33	8	-	-	69	69
96229	-	-	-	-	-	-	-	-	-	2	21	28	8	-	-	59	59
96230	-	-	-	-	-	-	-	-	-	2	23	64	17	-	-	106	106
96231	-	-	-	-	-	-	-	-	-	5	65	72	11	1	-	154	154
96232	-	-	-	-	-	-	-	-	-	6	78	96	16	1	-	197	197
96233	-	1	-	-	2	-	1	-	-	-	6	12	11	1	-	34	34
96235	-	-	-	-	-	-	-	-	-	8	168	148	20	8	2	354	354
96236	-	-	-	-	-	-	-	1	-	9	77	77	12	14	2	192	192
96237	-	-	-	-	-	-	1	1	-	2	10	19	4	10	1	48	48
96238	-	-	-	-	-	-	1	-	2	-	1	2	4	3	-	13	13
96239	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-	3	3
96240	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	1
96241	-	-	-	-	-	-	-	-	-	-	-	2	1	3	-	6	6
96242	-	-	-	-	-	-	-	-	-	3	18	12	-	1	1	35	35
96243	-	-	-	-	-	-	-	-	-	4	31	22	3	3	1	64	64
96244	2	8	6	7	3	-	-	2	10	24	11	5	1	-	-	79	79
Total	34	26	27	19	7	-	21	88	201	1,429	1,641	1065	348	124	19	5,049	2,891
Percent	0.7	0.5	0.5	0.4	0.1	0.0	0.4	1.7	4.0	28.3	32.5	21.1	6.9	2.5	0.4	100.0	

[a] Shell height designates upper limit of category (e.g. 30 is upper limit of 21-30 mm category); a dash (-) indicates no scallop heights were measured within a size interval.

Table 5. Age distribution of weathervane scallops captured during a dredge survey near Kayak Island, Alaska, 1996.

	Scallop Abundance																					
	Scallop Age Class (years) [a]																				Total	Sample
Tow	0+	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Catch	Size
96201	-	-	-	-	-	-	39	118	432	590	39	-	-	-	-	-	-	-	-	-	1,218	31
96202	-	134	-	-	67	-	34	201	403	336	-	-	-	-	-	-	-	-	-	-	1,175	35
96203	-	41	-	3	19	-	6	19	31	13	3	6	-	-	-	-	-	-	-	-	141	45
96204	-	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3
96205	1	-	1	1	3	2	-	1	5	3	3	3	-	-	-	-	-	-	-	-	23	23
96206	5	2	-	-	1	2	-	1	2	3	1	-	1	-	-	-	-	-	-	-	18	18
96207	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	3	3
96208	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	3	3
96209	-	-	-	-	-	-	1	4	15	15	9	-	-	-	-	-	-	-	-	-	44	30
96210	-	-	-	-	-	-	-	-	3	3	1	-	-	-	-	-	-	-	-	-	7	7
96211	-	-	-	-	-	-	-	-	1	2	1	4	-	-	-	-	-	-	-	-	8	8
96212	-	-	-	-	-	-	1	2	11	17	1	1	-	-	-	-	-	-	-	-	33	30
96213	-	-	-	-	-	-	1	3	8	12	-	-	-	-	-	-	-	-	-	-	24	26
96214	-	-	-	-	-	-	-	1	1	3	1	-	-	-	-	-	1	-	-	-	7	7
96215	-	-	-	-	1	-	1	7	20	9	1	-	-	-	-	-	-	-	-	-	39	30
96216	-	-	-	-	-	-	2	4	10	10	-	-	-	1	-	-	-	-	-	-	28	27
96217	-	8	-	-	11	4	11	15	9	4	-	-	-	-	-	-	-	-	-	-	62	33
96218	-	-	-	2	-	-	2	3	8	15	8	5	5	2	-	-	-	-	-	-	50	30
96219	-	-	-	-	-	-	-	9	5	7	7	12	5	2	-	2	2	-	2	-	53	30
96220	-	-	-	-	-	-	-	5	30	49	35	10	20	-	-	-	-	-	-	-	148	30
96221	1	-	-	1	1	-	-	1	7	14	1	2	5	-	2	-	-	-	-	-	37	30
96222	-	-	-	-	1	-	2	2	5	7	5	2	2	2	1	-	-	-	1	2	34	29
96223	-	-	-	-	4	-	4	-	13	4	7	7	4	2	2	4	4	2	-	-	54	30
96224	-	-	-	-	-	-	-	5	22	19	7	2	2	10	5	-	-	-	-	-	72	30
96225	-	-	-	-	-	-	-	27	49	54	-	4	-	4	-	-	-	-	-	-	139	31

- continued -

Table 5. (page 2 of 2)

	Scallop Abundance																					
	Scallop Age Class (years) [a]																				Total	Sample
Tow	0+	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Catch	Size
96225	-	-	-	-	-	-	-	27	49	54	-	4	-	4	-	-	-	-	-	-	139	31
96226	-	-	-	-	-	-	-	17	43	33	3	3	-	-	-	-	-	-	-	-	100	30
96227	-	-	-	-	-	-	7	18	29	47	7	-	-	-	4	-	-	-	-	-	111	31
96228	-	-	-	-	-	-	2	7	25	21	12	2	-	-	-	-	-	-	-	-	69	30
96229	-	-	-	-	-	-	4	8	31	14	2	-	-	-	-	-	-	-	-	-	59	30
96230	-	-	-	-	-	-	7	11	49	28	7	4	-	-	-	-	-	-	-	-	106	30
96231	-	-	-	-	-	-	-	26	56	67	5	-	-	-	-	-	-	-	-	-	154	30
96232	-	-	-	-	-	-	7	46	79	66	-	-	-	-	-	-	-	-	-	-	197	30
96233	1	-	1	1	-	-	-	6	5	11	7	1	-	-	-	1	-	-	-	-	34	30
96235	-	-	-	-	-	-	-	53	89	212	-	-	-	-	-	-	-	-	-	-	354	20
96236	-	-	-	-	-	-	-	32	51	83	-	-	13	-	6	-	-	6	-	-	192	30
96237	-	-	2	-	-	-	-	5	10	16	3	-	2	5	5	-	2	-	-	-	48	30
96238	-	-	1	1	1	-	-	-	2	1	-	-	2	3	-	1	-	-	-	-	13	12
96239	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	3	3
96240	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1
96241	-	-	-	-	-	-	-	1	-	1	-	1	2	-	-	-	-	1	-	-	6	6
96242	-	-	-	-	-	-	-	4	15	13	-	-	1	-	-	1	-	-	-	1	35	30
96243	-	-	-	-	-	-	-	9	9	39	-	-	2	-	-	2	2	-	-	-	64	28
96244	-	5	-	3	5	16	16	11	21	3	-	-	-	-	-	-	-	-	-	-	79	30
Total	8	190	7	13	115	24	149	682	1,609	1,844	177	72	66	31	25	12	10	9	3	4	5,049	1,030
	Percent																					
By Age	0.2	3.8	0.1	0.3	2.3	0.5	2.9	13.5	31.9	36.5	3.5	1.4	1.3	0.6	0.5	0.2	0.2	0.2	0.1	0.1		
Cumulative	0.2	3.9	4.1	4.3	6.6	7.1	10.0	23.5	55.4	91.9	95.4	96.8	98.1	98.8	99.2	99.5	99.7	99.9	99.9	100.0		

[a] Dash (-) indicates no scallops were observed within the age class.

Table 6. Sex composition and maturity of weathervane scallops sampled from a dredge survey near Kayak Ialand, Alaska, 1996.

	Sex (number of scallops)				
Maturity	Unknown	Male	Female	Total	Percent
Immature	33			33	8.4%
Mature	9	167	181	357	91.1%
Spawning		2		2	0.5%
Total	42	169	181	392	100.0%
Percent	10.7%	43.1%	46.2%	100.0%	

Table 7. Whole weight, meat weight, and average meat recovery of weathervane scallops sampled from a dredge survey near Kayak Island, Alaska, 1996.

	Weight (kg)		Average
Date	Whole	Meat	Recovery
8/5/96	22.1	1.93	0.087
8/6/96	17.0	1.42	0.084
8/7/96	19.2	1.55	0.081
8/8/96	74.2	5.33	0.072
8/9/96	30.1	2.21	0.073
Total	123.5	9.08	0.079

Table 8. Population biomass and harvest values based on four different area-swept estimators from a dredge survey of weathervane scallops near Kayak Island, Alaska, 1996.

Area-Swept Estimator	Catch per nautical mile (lb)	Population Estimate (lb)	95% Confidence Limits of Population Estimate		Potential Harvest of 10% of Population Estimate	
			Lower (lb)	Upper (lb)	Total Weight (lb)	Shucked Meats (lb)[a]
Mean catch from single systematic sample	58.9	3,758,889	2,170,608	5,347,170	375,889	29,809
Median catch from single systematic sample	24	1,531,152	669,879[a]	3,598,890[b]	153,115	12,143
Mean catches from both strata of post-stratified sample	35 and 550	3,012,937	2,502,305	3,523,569	301,294	23,894
Mean catch from one stratum of post-stratified sample	35	2,177,487	1,659,264	2,695,710	217,749	17,268

[a] Shucked meat calculated from the mean recovery of 7.9% of whole weight obtained from scallops collected during the survey.
[b] First quartile value
[c] Third quartile value

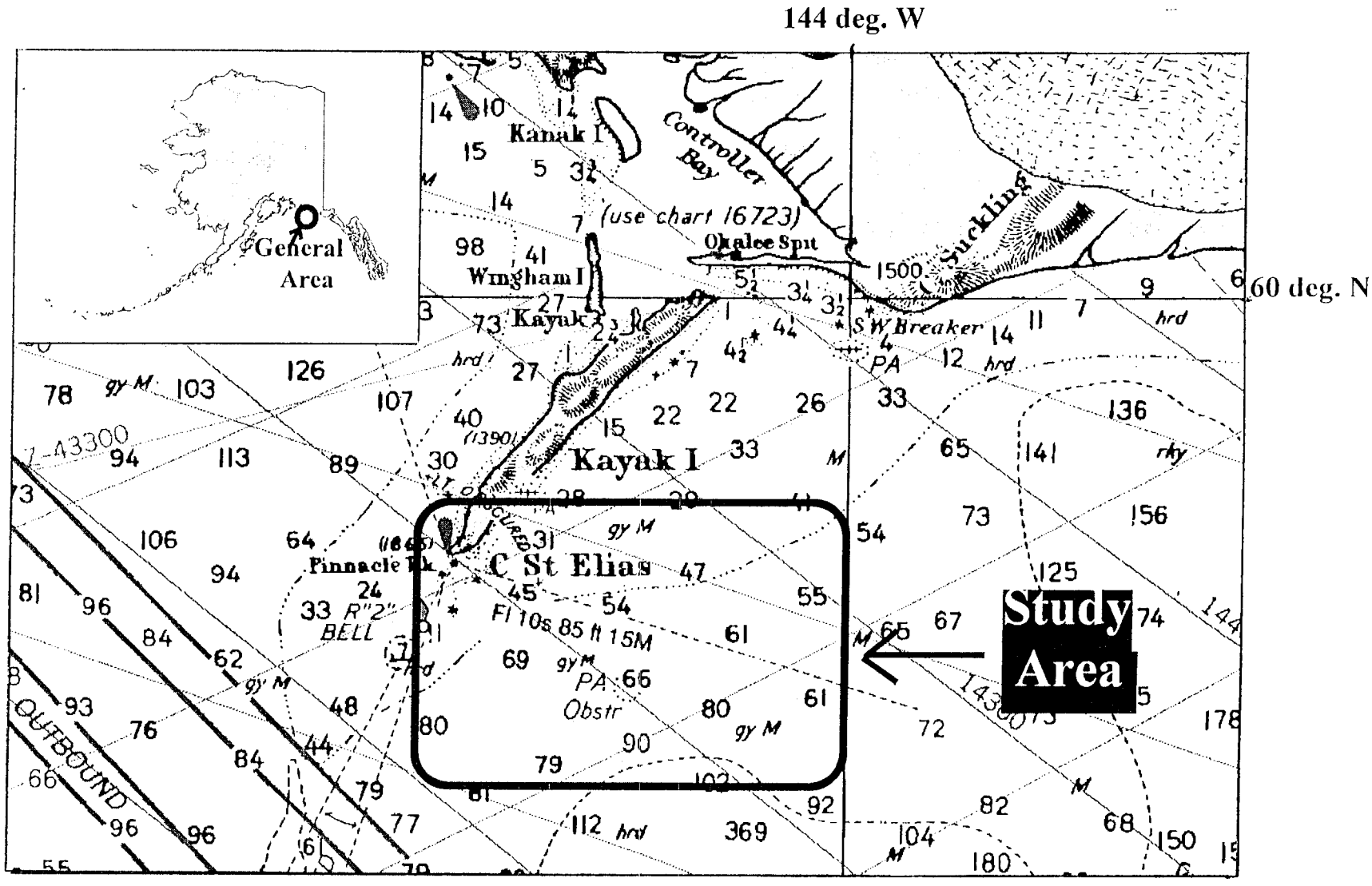

Figure 1. General bathymetry of the weathervane scallop survey area near Kayak Island, Alaska.

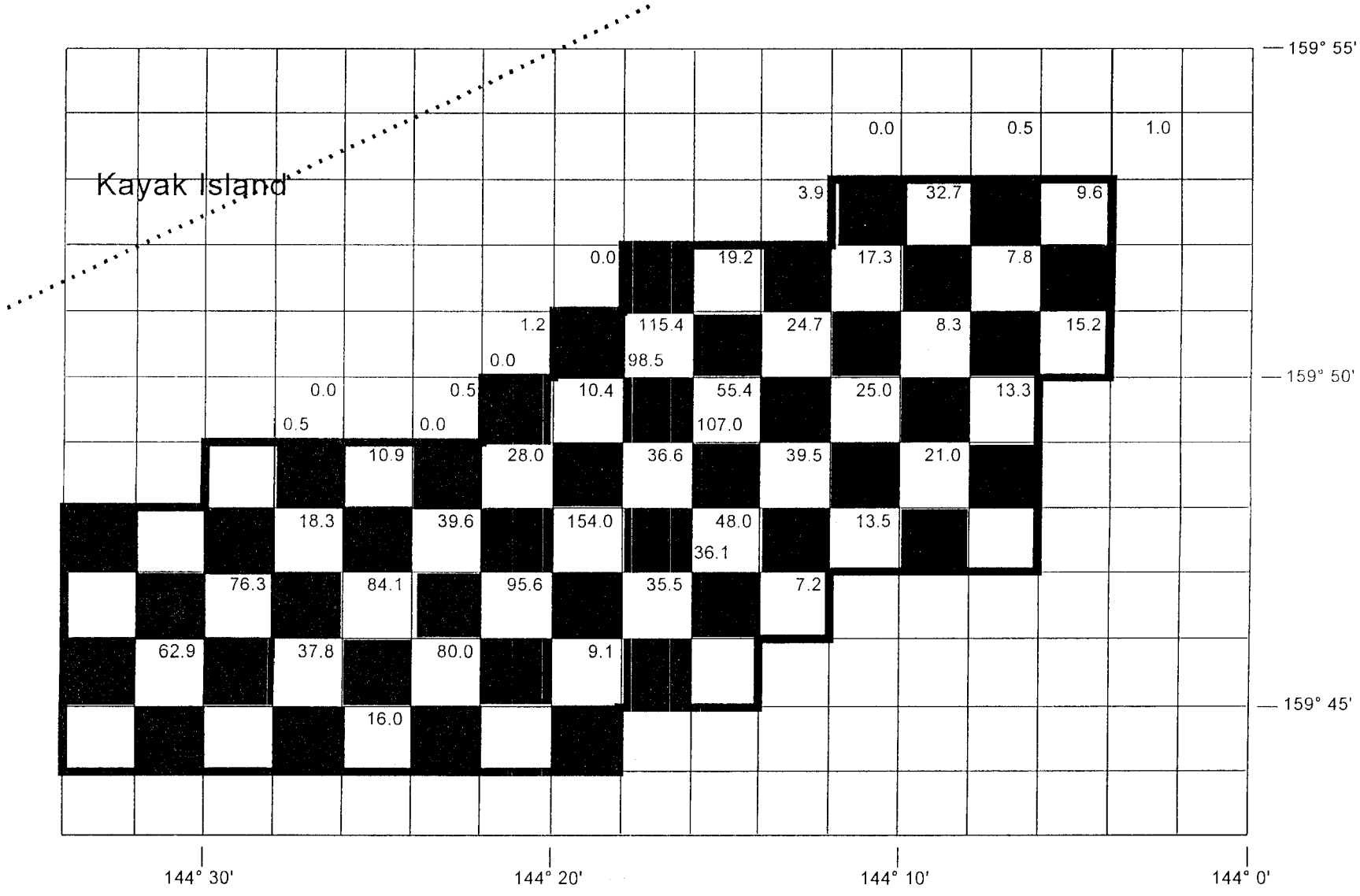

Figure 2. Sampling stations (black squares) initially proposed for the 1996 weathervane scallop dredge survey near Kayak Island, Alaska, and scallop catch data (white squares; lb per nautical mile) from a 1995 survey.

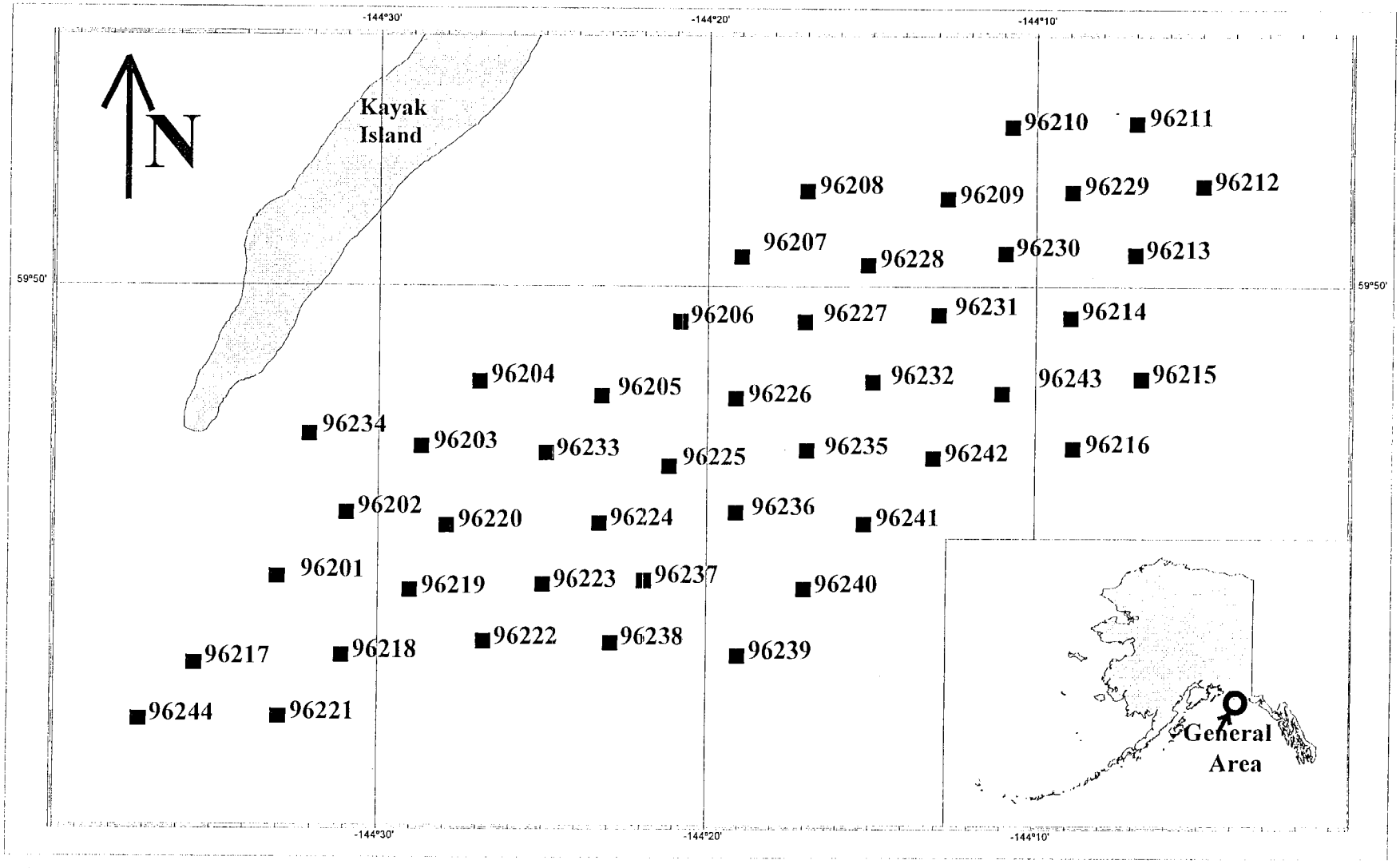

Figure 3. Mid-points of dredge tows, identified by tow number, for stations sampled during a weathervane scallop survey near Kayak Island, Alaska, 1996.

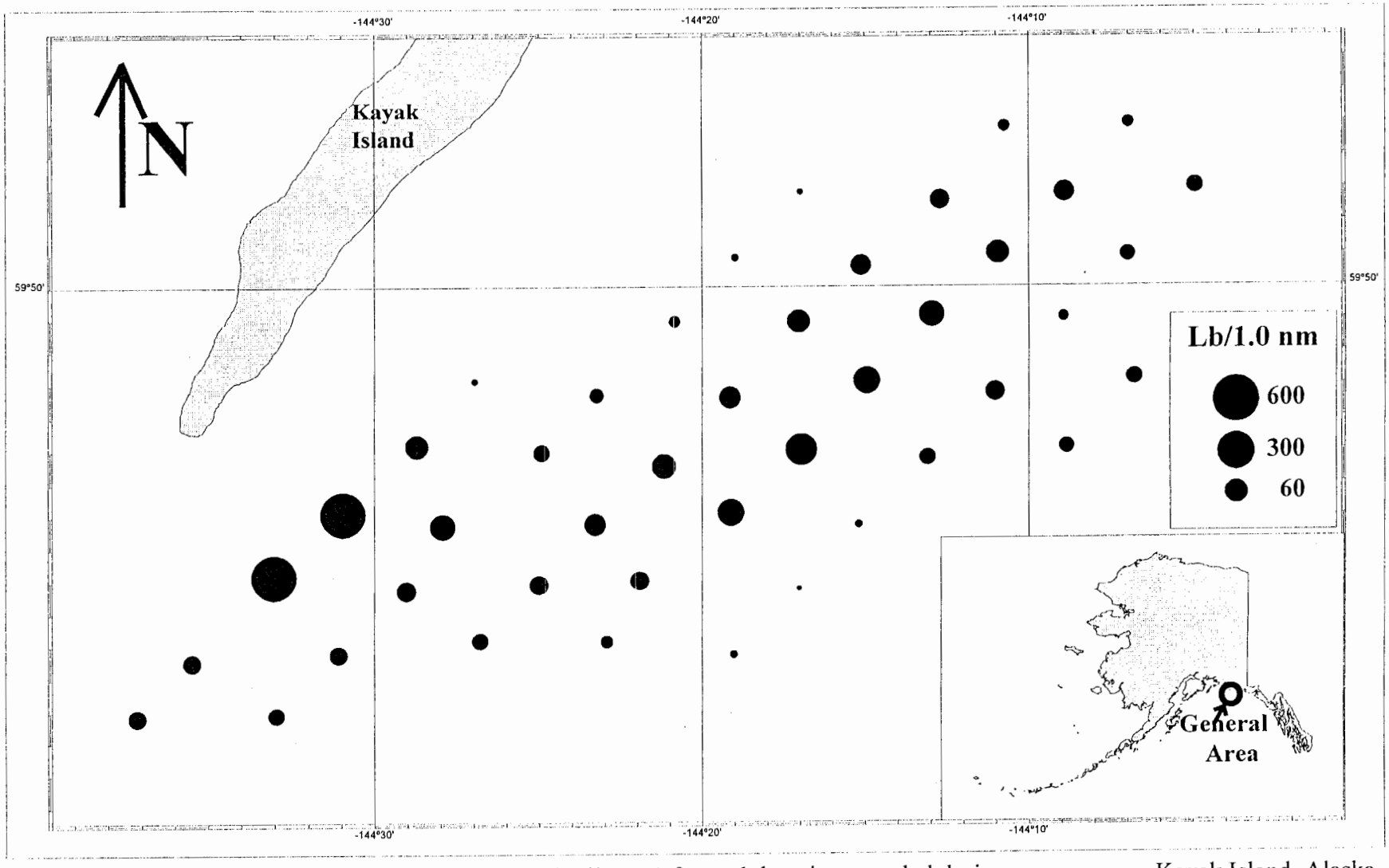

Figure 4. Weathervane scallop catch (lb per nautical mile tow) for each location sampled during a survey near Kayak Island, Alaska, 1996.

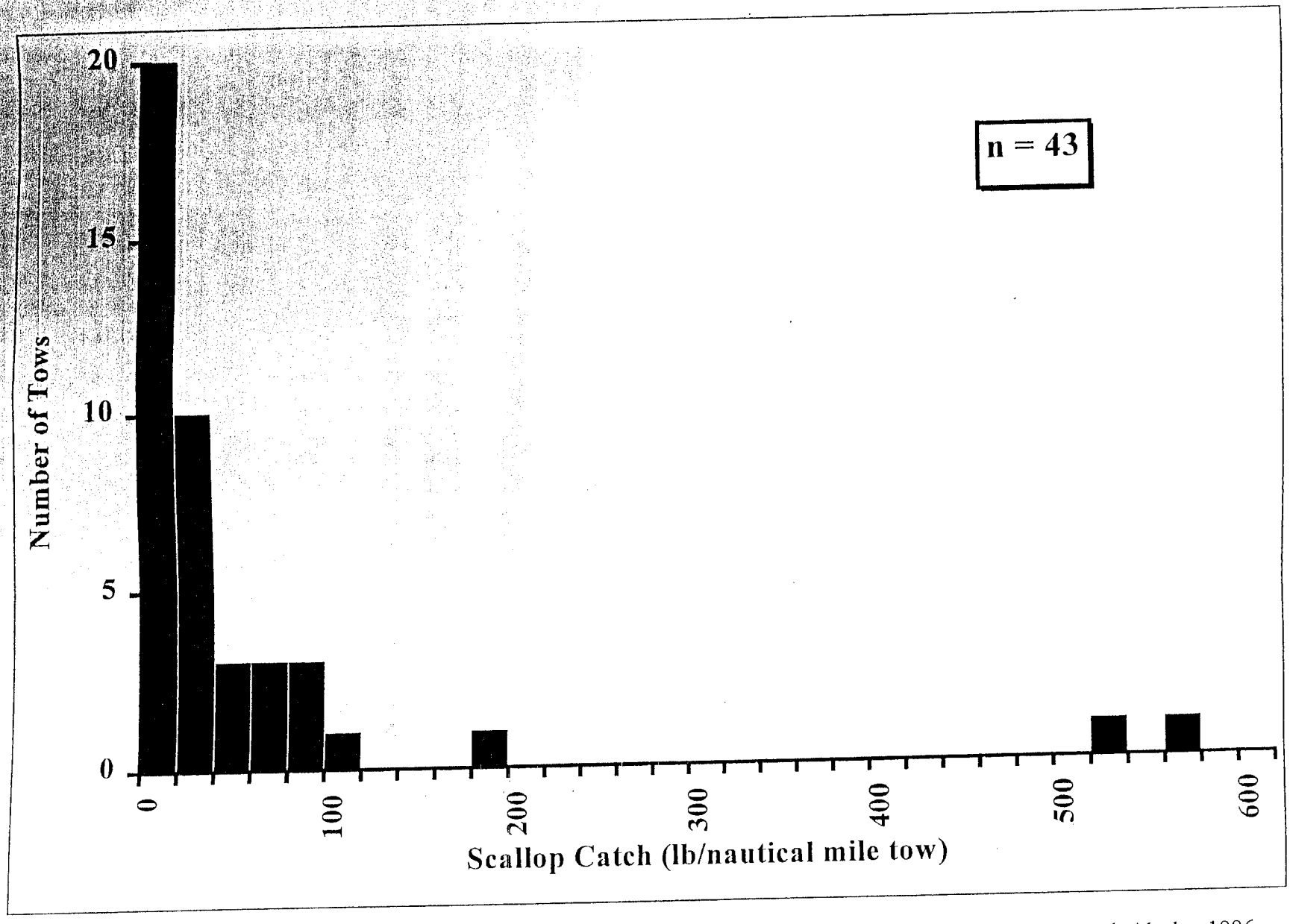

Figure 5. Frequency distribution of tow catch weights from a weathervane scallop dredge survey near Kayak Island, Alaska, 1996.

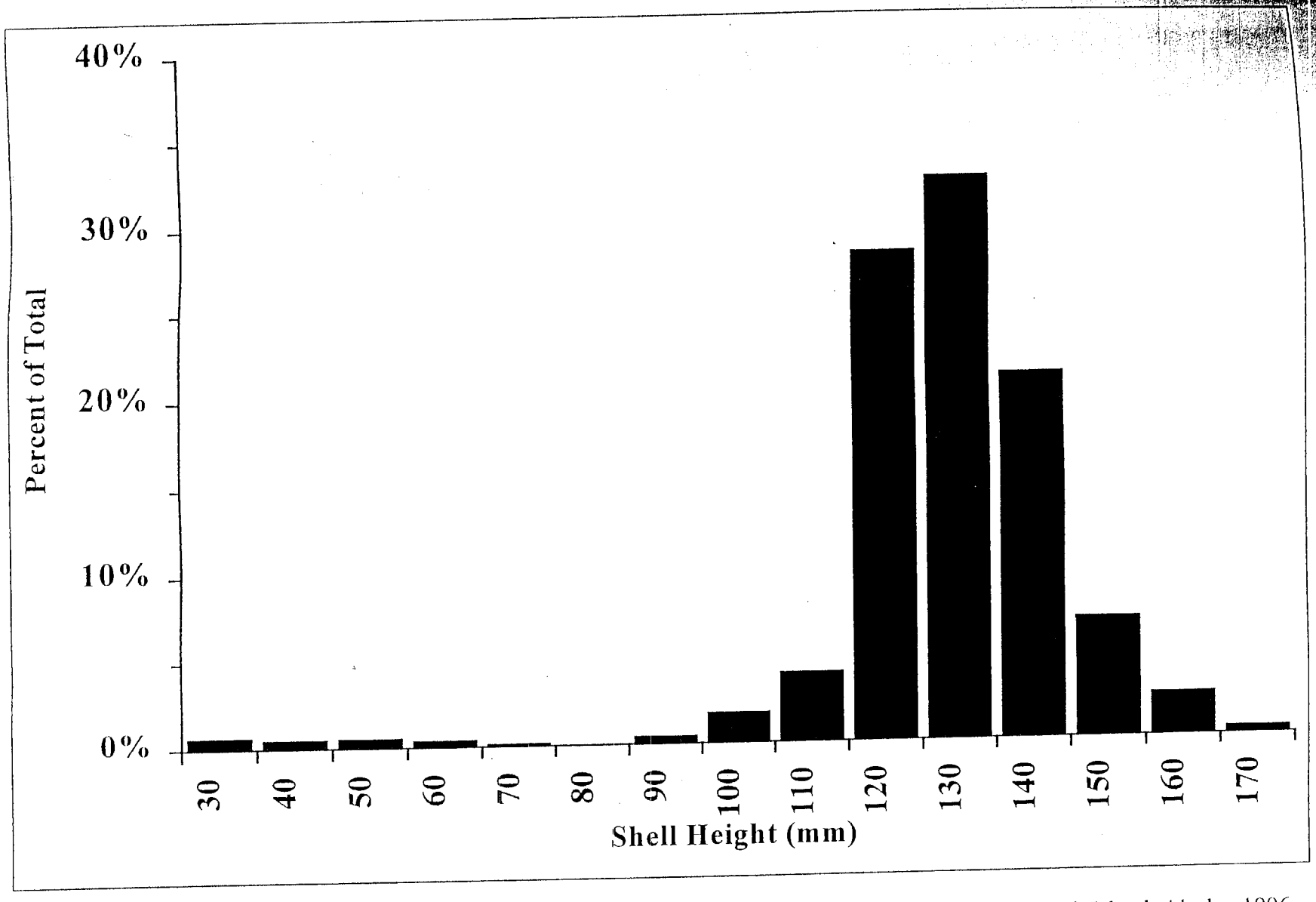

Figure 6. Distribution of shell heights from weathervane scallops captured during a dredge survey near Kayak Island, Alaska, 1996.

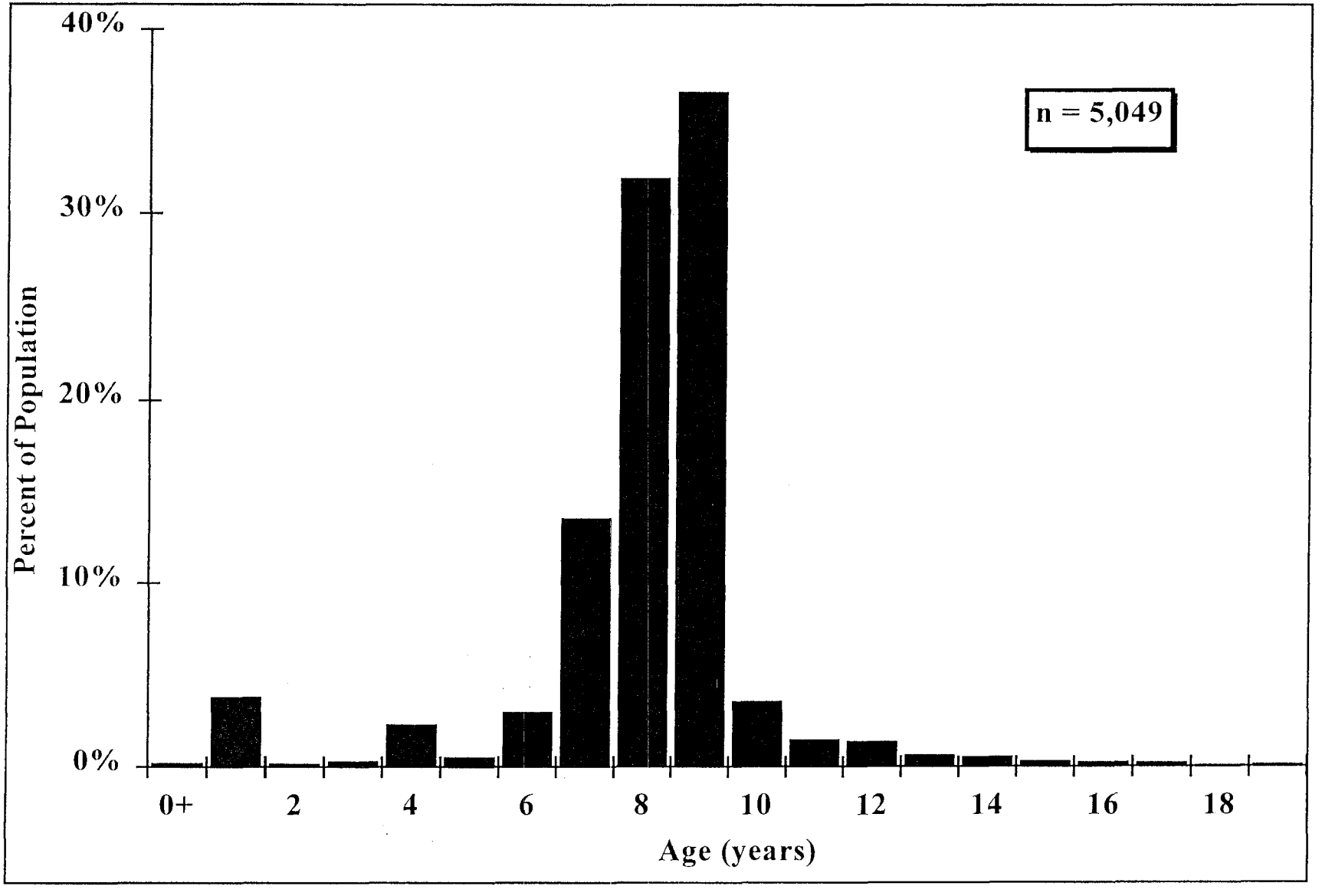

Figure 7. Age class contribution to population abundance of weathervane scallops off Kayak Island, 1996.

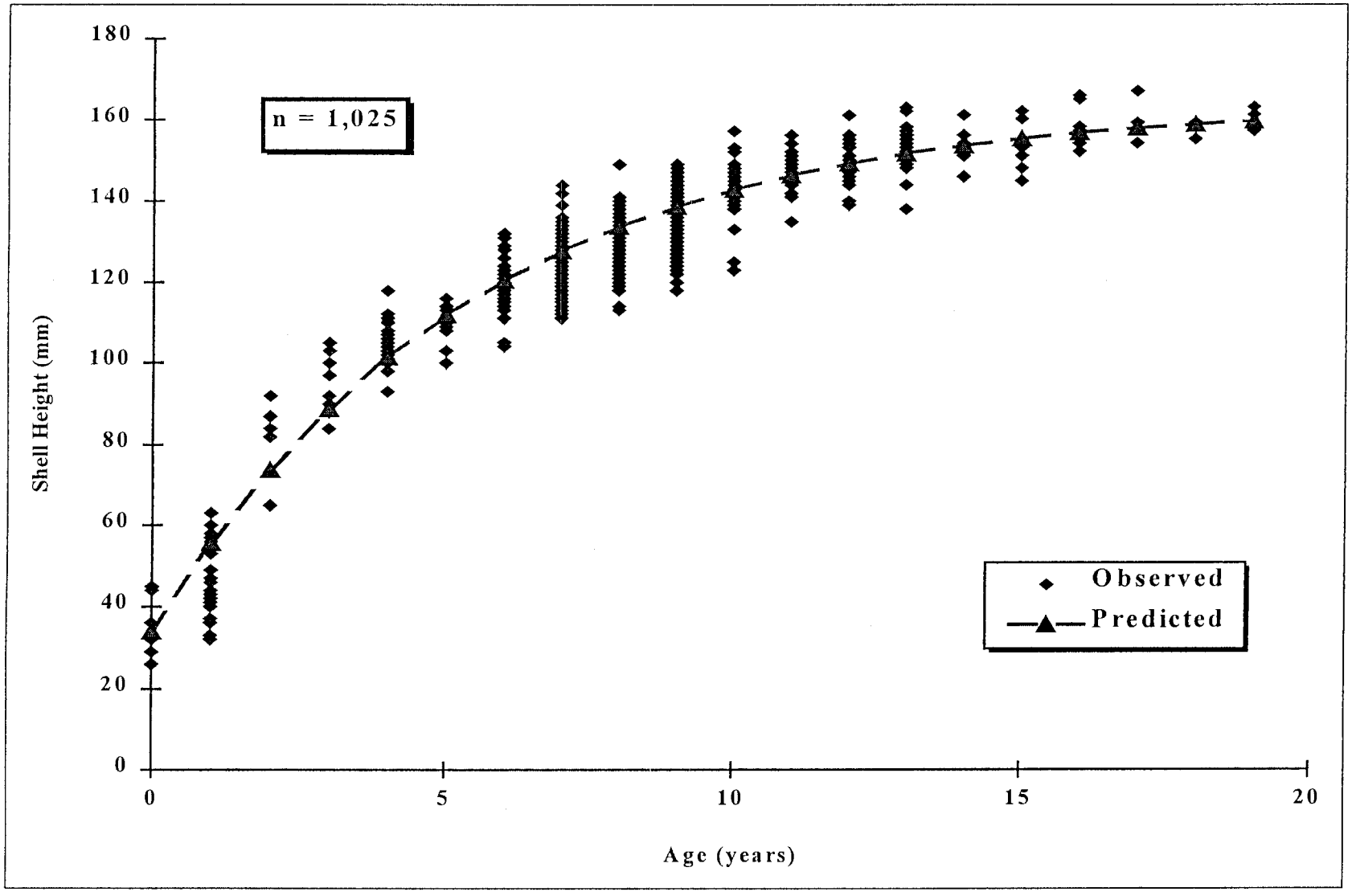

Figure 8. Shell height-at-age for weathervane scallops from the Kayak Island survey, 1996.

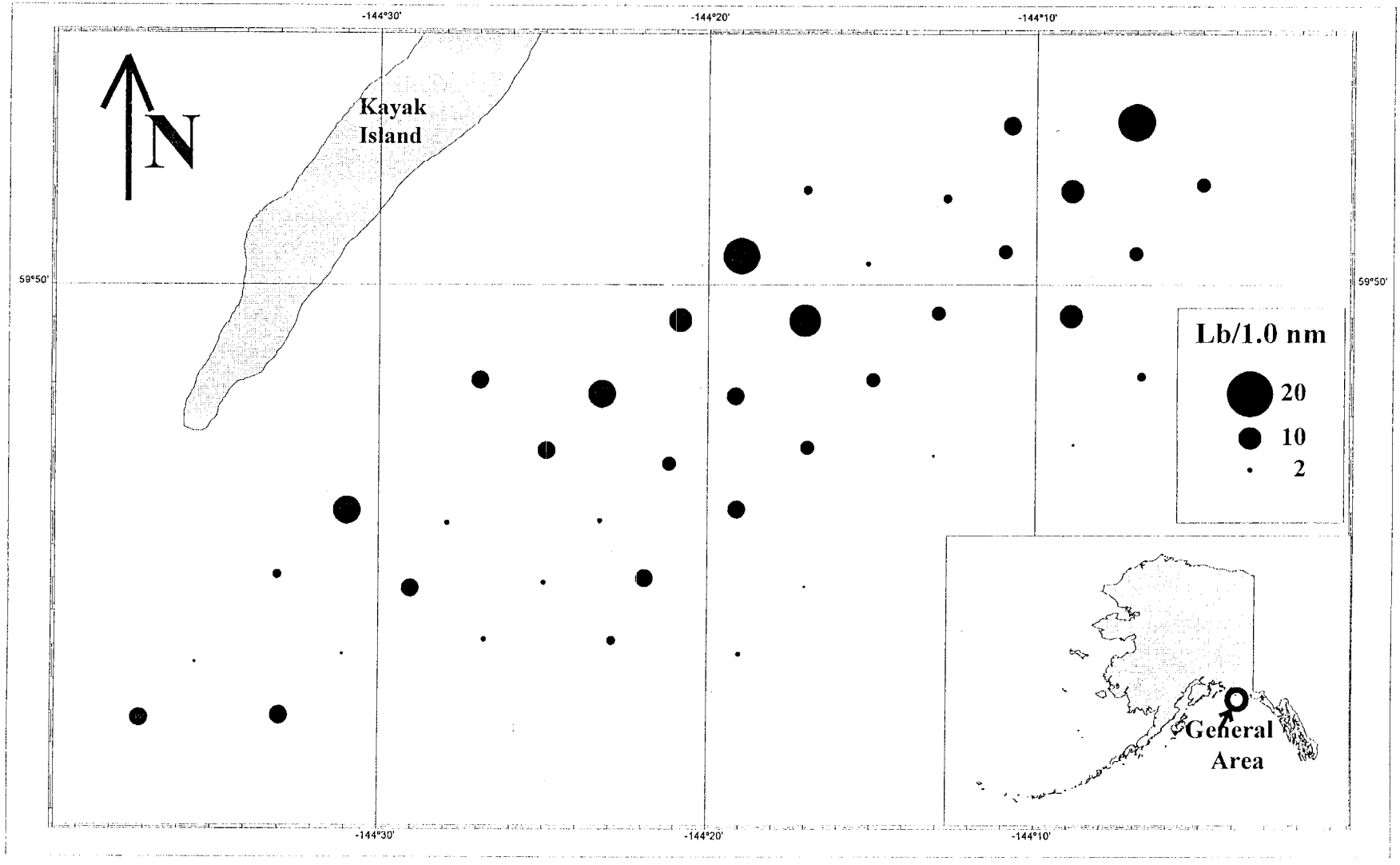

Figure 9. Location of fish catches during the weathervane scallop survey at Kayak Island, 1996.

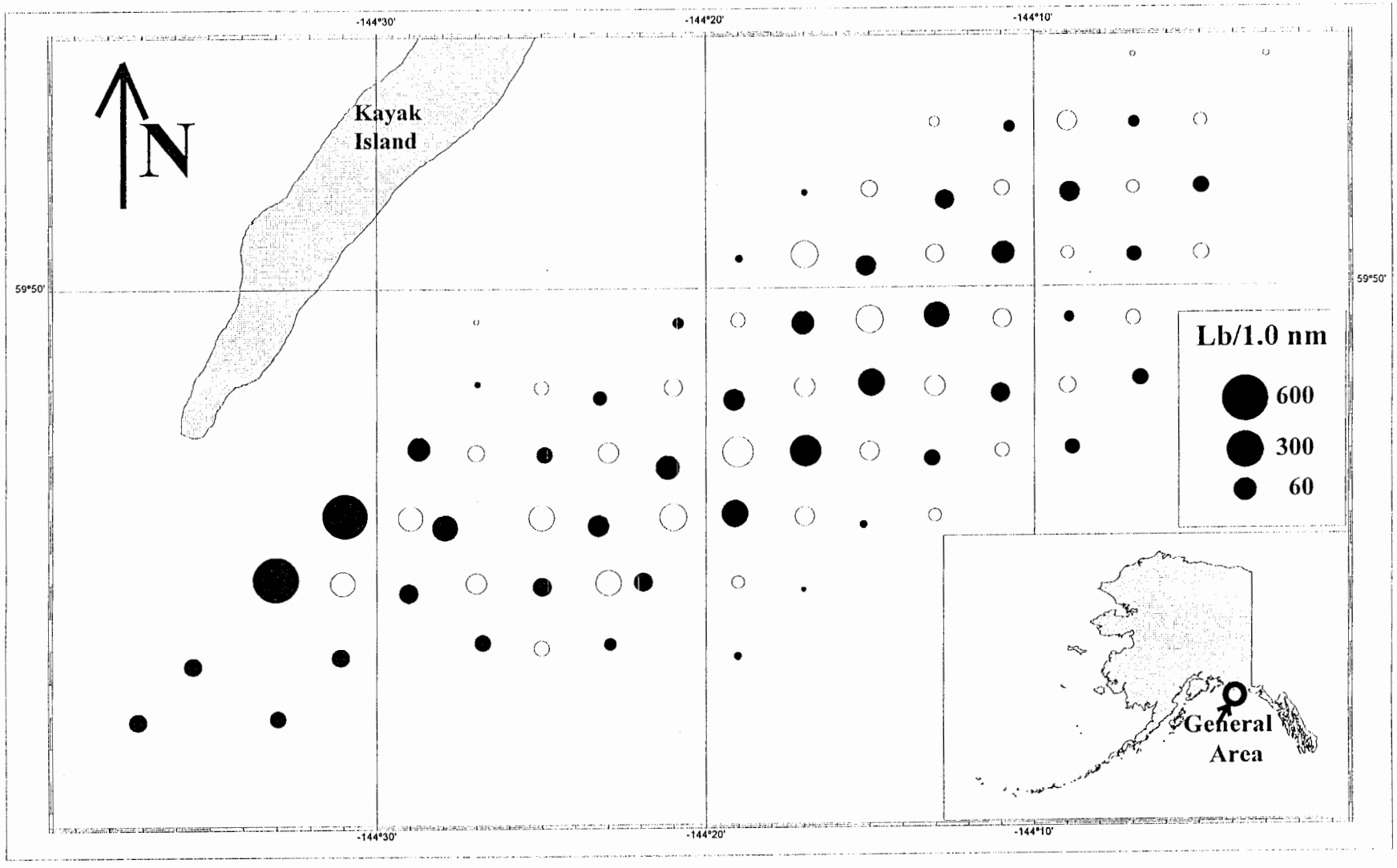

Figure 10. Comparison of weathervane scallop catches from dredge surveys off Kayak Island, Alaska in 1995 (empty circles) and 1996 (filled circles).

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