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Division of Commercial Fisheries
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Stock Assessment and Management of Pacific Herring in Prince William Sound, Alaska, 1990

by

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The Technical Fishery Report Series was established in 1987, replacing the Technical Data Report Series. The scope of this new series has been broadened to include reports that may contain data analysis, although data oriented reports lacking substantial analysis will continue to be included. The new series maintains an emphasis on timely reporting of recently gathered information, and this may sometimes require use of data subject to minor future adjustments. Reports published in this series are generally interim, annual, or iterative rather than final reports summarizing a completed study or project. They are technically oriented and intended for use primarily by fishery professionals and technically oriented fishing industry representatives. Publications in this series have received several editorial reviews and at least one *blind* peer review refereed by the division's editor and have been determined to be consistent with the division's publication policies and standards.

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ABSTRACT

An estimated 10,639.2 tonnes of Pacific herring *Clupea harengus pallasi* were harvested in Prince William Sound during the 1989-90 management year. The 1989 fall food-and-bait fishery harvested 586.0 tonnes and the four 1990 spring sac roe fisheries harvested 10,053.2 tonnes as follows: the purse seine sac roe fishery 7,586.0 tonnes, the gill net sac roe fishery 458.5 tonnes, the wild spawn-on-kelp fishery 862.2 tonnes, and the pound spawn-on-kelp fishery 1,146.5 tonnes. The estimated exploitation rate for the 1989-90 management year was 9.3% by weight and 8.9% by number. The estimated exploitation rate for the 1990 spring fisheries was 8.8% by weight and 8.3% by number. There were five major spawning concentrations of herring in Prince William Sound during 1990: Montague Island area, Naked Island area, northeast-shore area, north-shore area, and southeast-shore area. Based on aerial surveys, 49,505.2 tonnes of herring spawned on 151.5 km of shoreline. The spawn deposition survey estimate of 104,325 tonnes was 2.11 times greater than the aerial survey estimate. The total 1990 spawning biomass of herring in Prince William Sound was estimated at 114,378.2 tonnes using the estimate from the spawn deposition survey and the harvests from the 1990 spring fisheries. The spawning herring had a mean weight of 131 g. An estimated 105,187.2 tonnes of herring escaped the harvest in 1990. The herring that escaped the harvest also had a mean weight of 131 g. The harvest, escapement biomass, and total spawning biomass during 1989-1990 were dominated by the 1984 year class of herring. As age-5 herring, they composed 40.0% by weight and 36.6% by number of the harvest from the 1989 food-and-bait fishery. As age-6 herring, they composed 65.5% by weight and 68.3% by number of the harvests from the 1990 sac roe and spawn-on-kelp fisheries; 72.5% by weight and 75.1% by number of the escapement biomass, and 71.9% by weight and 73.7% by number of the total spawning biomass.

KEY WORDS: Pacific herring, *Clupea harengus pallasi*, Prince William Sound, spawning biomass estimation, aerial survey, spawn deposition survey, age, weight, length, sex, food-and-bait, sac roe, spawn-on-kelp, pound fishery

INTRODUCTION

Pacific herring *Clupea harengus pallasi* spawn throughout Prince William Sound (PWS) each year from mid-April through early May. Although herring that spawn within PWS may be composed of several populations, they are managed as a single stock defined as those herring that spawn within the coastal waters between Point Whitshed and Cape Fairfield (Figure 1).

Each year five commercial fisheries harvest herring within PWS: purse seine food-and-bait, purse seine sac roe, gill net sac roe, wild spawn-on-kelp, and pound spawn-on-kelp. Since 1969 these fisheries have harvested an average of 6,457.7 tonnes of herring annually (Table 1). Of this amount, the purse seine sac roe fishery has accounted for an average of 71.0% (4,830.3 tonnes) annually, followed by the wild spawn-on-kelp fishery with 28.4%, or 1,260.4 tonnes of equivalent herring; the food-and-bait fishery with 9.3% (669.9 tonnes); the pound spawn-on-kelp fishery with 6.9%, or 554.0 tonnes of equivalent herring; and the gill net sac roe fishery with 3.4% (255.9 tonnes).

The food-and-bait fishery has harvested an average of 669.9 tonnes annually since 1970 (Table 2). The annual effort from 1970-1989 has averaged 4.2 boats. Purse seine harvests have dominated this fishery, ranging from 4.4 tonnes in 1972 to 1,157.8 tonnes in 1980. Since 1982, purse seine is the only gear type that has been used in this fishery.

The two spawn-on-kelp fisheries have annually harvested an average of 205.0 tonnes of spawn-on-kelp product since 1969 (Tables 3, 4). The wild spawn-on-kelp fishery has accounted for most of the harvest, averaging 160.7 tonnes (Table 3). However, the pound spawn-on-kelp fishery which developed from the wild spawn-on-kelp fishery in 1979, has been increasing rapidly since 1985 (Randall *et al.* 1985), and has had an average harvest of 44.3 tonnes (Table 4).

In 1990, Alaska Department of Fish and Game (ADF&G) began to assess herring stock in greater detail by: monitoring the harvest from each of the five fisheries; estimating the total spawning biomass; and estimating the age, weight, length, and sex (AWLS) composition of herring in the commercial harvest, escapement biomass, total spawning biomass, and total biomass. The commercial harvest of the five fisheries was monitored from harvest receipts, i.e., fish tickets, that were completed by processors when fishermen delivered their catch.

Aerial surveys of the spawning biomass of herring in PWS began in 1973, although the first spawning biomass estimate was not made until 1974. Annual estimates since 1974 have ranged from 6,649.7 tonnes in 1976 to 70,588.1 tonnes in 1981 (Table 5). Biomass estimates from aerial surveys are estimates of the observable biomass; they are used to manage the fisheries in-season and evaluate biomass projections. However, the accuracy of aerial survey estimates is not believed to be great due to differences in observers, weather, water visibility, varying school depths, and varying spawning potential of the herring caused by differences in age structure (Randall *et al.* 1985; Brady 1987). To supplement this data, spawn deposition surveys were used in 1990 to estimate the spawning biomass (Biggs and Funk 1988). Spawn deposition surveys have been used extensively in British Columbia and Southeast Alaska (Haegele *et al.* 1981; Blankenbeckler and Larson 1987).

Jackson and Randall (1983, 1984) studied the feasibility of spawn deposition survey techniques in PWS in 1983 and 1984. They concluded that spawning biomass estimates from spawn deposition surveys were more precise than aerial survey estimates. From these studies the spawning biomass was estimated at 19,958.1 tonnes in 1983, and 72,311.8 tonnes in 1984, whereas estimates based on aerial surveys were 37,965.7 tonnes in 1983 and 53,179.2 tonnes in 1984 (Table 5). The spawning biomass was estimated at 53,804.9 tonnes in 1988 and 52,235.5 tonnes in 1989 (Baker *et al.* 1990, 1991) from spawn deposition surveys.

The spawning success of herring has also been measured indirectly since 1973 by mapping the amount of shoreline where spawning was observed from aerial surveys (Table 5). Two indexes are calculated; the first, kilometers of spawning, has ranged from 51.4 km in 1976 to 267.7 km in 1988 (Table 5). The second index, kilometer-days of spawning, which accounts for multiple days of spawning along the same shoreline, has ranged from 51.4 km-days in 1976 to 381.4 km-days in 1988.

AWLS information has been collected each year since 1973 from the commercial harvest and test fishing conducted by ADF&G (McCurdy 1986; Sandone *et al.* 1988; Baker *et al.* 1990, 1991). This information has been used to estimate the age and sex composition, mean weight-at-age, and mean length-at-age, as well as the contribution of each age class to the harvest, escapement biomass, total spawning biomass, and total biomass. AWLS information has also been used to update harvest strategies, monitor year class strengths, measure recruitment, and prepare a forecast of abundance for the following year.

The objectives of the 1990 PWS stock assessment program were: (1) to estimate the age, sex, and size composition of the commercial harvest, escapement biomass, and total spawning biomass; (2) to measure the harvest and estimate the use of herring by the commercial fisheries; (3) to estimate the spawning biomass from both aerial surveys and spawn deposition surveys; and (4) to map the location, duration, and intensity of herring spawning along the shoreline.

The results of this program are presented in this report along with an overview of the management of the herring fisheries in PWS.

Management of the Herring Fisheries in Prince William Sound

The herring stock in PWS is managed on a sustained yield basis following guideline harvest levels set forth by the Alaska Board of Fisheries in 1988 in accordance with the Prince William Sound Herring Management Plan (ADF&G 1990). The spawning biomass is projected from the previous year's escapement biomass which is estimated from spawn deposition and aerial surveys adjusted for growth, mortality and recruitment. Guideline harvest levels prescribe a sliding-scale exploitation rate ranging from 0% to 20% of the projected spawning biomass. Commercial fishing is not allowed if the estimated spawning biomass is less than the threshold level of 7,620 tonnes. If the projected spawning biomass is between 7,620 and 38,556 tonnes, the harvest level is set between 0.0% and 20.0% based upon the Department's assessment of the status of the herring stock. A maximum

exploitation rate of 20% is used if the estimated spawning biomass is 38,556 tonnes or greater.

The harvest guideline is allocated among the five fisheries: 16.3% to the fall food-and-bait fishery, 8% to the wild spawn-on-kelp fishery, 14.2% to the pound spawn-on-kelp fishery, 58.1% to the purse seine sac roe fishery, and 3.4% to the gill net sac roe fishery (ADF&G 1990). Harvest quotas for the spawn-on-kelp fisheries are set using the following ratios: 1.0 tonne of wild spawn-on-kelp may be taken for every 8.0 tonnes of herring allocated to the wild spawn-on-kelp fishery, and 1.0 tonne of spawn-on-kelp in pounds may be taken for every 12.5 tonnes of herring allocated to the pound spawn-on-kelp fishery. For 1990 the projected spawning biomass of herring was 47,139.1 tonnes, and the total harvest allocation was 9,427.5 tonnes at 20.0% exploitation (Baker 1990). Following the management plan, the guideline harvest of herring was: 1,536.8 tonnes to the 1989 food-and-bait fishery; 753.8 tonnes to the wild spawn-on-kelp fishery resulting in 94.3 tonnes of wild spawn-on-kelp product; 107.1 tonnes to the pound spawn-on-kelp fishery resulting in 0.84 tonnes of spawn-on-kelp product; 3,368.5 tonnes to the purse seine sac roe fishery; and 197.1 tonnes to the gill net fishery (Baker 1990).

The food-and-bait purse seine fishery is the first to occur in the management year. The management year is from 1 July to 30 June the following year. The food-and-bait fishery opens by regulation 1 September and may extend through 31 January. However, the fishery is closed by emergency order if the guideline harvest level is attained prior to 31 January. Although the primary gear for the food-and-bait fishery is purse seine, gill net and trawl are also legal gear (ADF&G 1990).

The pound spawn-on-kelp fishery occurs during April and May. Purse seines are used to collect mature herring that have not yet spawned. The captured herring are transferred from the purse seine into a net pen using net doors. After the web of the purse seine door and the net pen have been laced together, the volume of water in the purse seine is reduced, forcing the herring into the net pen. The web of the net pen door is raised and closed. The net pen is then towed to the pound site where the herring are transferred into the pound. Fronds of imported *Macrocystis* kelp are suspended vertically from lines secured on the sides of the pounds to serve as spawning substrate for the adhesive herring eggs. The herring are released when spawning is completed and the resulting spawn-on-kelp product is harvested. The pound webbing also receives herring spawn and must remain in the water until the herring embryos have hatched. Although the adult herring are released after spawning, mortality of the pounded herring is assumed to be 100%. Participation in the pound fishery is regulated by the Commercial Fisheries Entry Commission (CFEC).

The wild spawn-on-kelp fishery usually occurs in late April or early May. The spawn-on-kelp product is harvested by divers who cut the fronds 10.2 cm above the stem. The location of the wild spawn-on-kelp fishery is determined from aerial surveys; those locations with the longest duration and intensity of spawning are opened for harvesting spawn-on-kelp product. The wild spawn-on-kelp fishery has a fixed allocation based on the guideline harvest level.

The timing of the purse seine and gill net sac roe fisheries is established for the later half of April, to coincide with peak roe recovery which will maximize fishery value. To prevent gear conflicts between the purse seine and gill net sac roe fisheries, the gill net sac roe fishery usually follows the closure of the purse seine fishery (ADF&G 1990). Participation in both sac roe fisheries is regulated by the CFEC.

METHODS

Harvest Information and Estimates

Information on the amount of herring harvested by the food-and-bait fishery and the sac roe fisheries, and the spawn-on-kelp product harvested by the spawn-on-kelp fisheries was obtained from fish tickets. Estimates of the amount of herring exploited for the wild and pound spawn-on-kelp fisheries were estimated from the weight of the harvested product.

Age, Weight, Length, and Sex Statistics

Data Collection

Age, weight, length, and sex (AWLS) information was randomly collected from the 1989 fall commercial food-and-bait fishery, the 1990 commercial purse seine and gill net sac roe fisheries, the 1990 pound spawn-on-kelp fishery, and from ADF&G samples taken at major sightings of herring spawning throughout PWS. Samples were taken during the food-and-bait and sac roe fisheries from randomly selected fishing vessels throughout a management area. Ideally, during each fishing period, samples from a minimum of five vessels were collected. Purse seine vessels unloading herring at tenders were sampled by dipnetting fish from the seine nets or from the tenders. Samples were collected from the hold or deck of the gill net vessels. In the pound spawn-on-kelp fishery, samples of herring were randomly collected before the herring were introduced into the pounds. Samples were also collected by an ADF&G vessel or industry-volunteered vessels from the major sightings of herring using gear types non-selective for size, i.e., purse and beach seines.

Herring samples were placed in polyethylene bags, clearly labeled with identification tags, and picked up daily, or as weather permitted, by the aerial survey plane or a chartered float plane. All samples were delivered to the department's laboratory in Cordova, placed in fish totes, chilled with ice, and logged in a sampling notebook.

Ten herring were placed on a sampling tray at a time. Their weights were measured to the nearest 0.01 g using an electronic scale. Their lengths, from tip of snout to the end of the hyperal plate, were measured to the nearest millimeter using calipers; sex was determined by inspecting the gonads, and one readable scale

from each fish was removed from the preferred area between the left pectoral fin and the lateral line approximately 3-4 scales posterior to the fin origin.

Each scale was cleaned and checked for regeneration. If the scale was regenerated or unreadable, another was removed until one readable scale was found for each herring. Individual scales from the ten fish were mounted on a single glass slide (25 x 75 x 1 mm) by dipping each scale into a mucilage glue solution (1:10 solution of mucilage glue and water) and placing it on the glass slide. Slides were labeled for year, fishery, location, sample number, gear type, dates, and slide number. Each scale was pressed firmly against the slide with a paper towel after mounting to remove excess glue. After all ten scales had been mounted, a second slide was placed on top of the first and the two slides were fastened together with cellophane tape. The completed scale mounts were stored in a slide box for subsequent age estimation and permanent storage.

Age of each herring sampled was estimated from the mounted scales by a committee of two or three persons. Scales were magnified using a microfiche reader at 50x and each individual estimated the age independently. If the individuals estimated the age differently, the differences were discussed and the age estimated by mutual consensus.

Annulus formulation was assumed to take place in the spring of the year prior to spawning. Therefore, all herring captured in the food-and-bait fishery were from 5 to 10 months older than the herring captured during the following spring spawning migration and were from a year class one year older. For example, age-4 herring from the 1989 food-and-bait fishery were from the 1985 year class, whereas age-4 herring in the 1990 spawning migration were from the 1986 year class. In addition, all herring sampled during the spawning migration were assumed to have an annulus on the outer edge of each scale. Herring captured in the food-and-bait fishery were not assumed to have an annulus on the outer edge of the scale unless one was clearly visible.

Sample Sizes

Sampling for AWLS information was stratified by time, area, and fishery. The goal was to select the smallest sample size for a random sample from a multinomial population such that the probability was at least $1-\alpha$ (precision) that all the estimated proportions were simultaneously within 5% (accuracy = 0.05) of the true population age proportions (Thompson 1987). It was shown that a sample size of 450 fish would guarantee at least this level of precision and accuracy for any number of age classes and proportions and allow for unreadable scales. Less than 5% of the scales collected were unreadable.

We also examined temporal and spatial differences in the AWLS composition of herring in PWS. Samples collected from the same location on successive days or from adjacent locations on the same day were tested for differences in age compositions between samples with a chi-square test. Subsamples of approximately 150 herring were sampled from each strata. If the age compositions of the herring in the subsamples were not significantly different ($\alpha < 0.05$), sampling continued until the subsamples could be pooled into one sample of 450 fish. However, if the

age composition were significantly different ($\alpha \geq 0.05$), sampling continued until 450 herring were collected from each stratum.

Data Analysis

The percent of age composition by sex, P_a, was estimated for each time-fishery stratum by:

$$P_a = \frac{n_a}{n} * 100 \quad , \tag{1}$$

where, n_a equals the number of male or female herring in the sample that were age a, and n equals the total number of herring in the sample.

The sex composition of herring for each time-fishery stratum was estimated by dividing the number of male or female fish in a sample by the total number of fish in a sample and multiplying by 100.

The mean weight-at-age, $\bar{W}_a$, for herring was estimated for each time-fishery stratum by:

$$\bar{W}_a = \frac{\sum_{i=1}^{n_a} W_{ai}}{n_a} \quad , \tag{2}$$

where, W_a equals the individual weight of the herring in the sample that were age a.

The variance for the sample weight-at-age, $Var[W_a]$, was estimated by:

$$Var[w_a] = \frac{\sum_{i=1}^{n_a} (W_{ai} - \bar{W}_a)^2}{n_a - 1} \quad . \tag{3}$$

The standard deviation of the sample weight-at-age was estimated by taking the square root of equation (4).

The mean length-at-age, variance, and standard deviation of the sample length-at-age measurements were calculated by substituting the individual length of each herring, L_{ai}, for W_{ai} in equations (2) and (3).

The contribution of each age class by weight to the harvest of each commercial fishery, escapement biomass, and total spawning biomass in each major spawning area was estimated by:

$$B_a = \frac{n_a \overline{W}_a}{\sum_{a=1}^{maxa} (n_a \overline{W}_a)} * B, \qquad (4)$$

where, B_a equals the biomass of herring that was age a in the harvest of each commercial fishery, escapement biomass, or total spawning biomass in each major spawning area; and B equals the total biomass of herring in the harvest of each commercial fishery, escapement biomass, or total spawning biomass in each major spawning area.

The contribution of each age class, N_a, by number, to the harvest of each commercial fishery, escapement biomass, and total spawning biomass for each major spawning area was estimated by:

$$N_a = \frac{B_a}{\overline{W}_a}. \qquad (5)$$

The contribution of each age class to the harvest of the commercial food-and-bait and sac roe fisheries was estimated based upon the age composition and mean weight-at-age of herring sampled during the harvest. The contribution of each age class of herring used in the pound spawn-on-kelp fishery was estimated based upon the age composition and mean weight-at-age of herring sampled prior to their introduction into the pounds. The contribution of each age class to the fishery was estimated based upon the age composition and mean weight-at-age of herring that were sampled using gear considered non-selective for size, i.e., purse and beach seines, near the areas where the wild spawn-on-kelp fishery occurred.

If there was more than one opening, the age composition and mean weight-at-age of herring was estimated for each opening separately. The estimated contribution of each age class by weight and number to the combined harvest of the fishery was

estimated by summing the estimated weight and number of herring in each age class from the separate openings. Mean weight-at-age for the combined harvest was then estimated by dividing the weight of each age class by the number of fish in each age class. Mean length-at-age was not estimated for the combined harvests or areas.

The contribution of each age class to the total harvest of herring by all the commercial fisheries in PWS was estimated by summing the estimated weight and number of fish in each age class from all the commercial fisheries. The mean weight-at-age of the total harvest was estimated by dividing the weight of each age class by the number of fish in each age class. Mean length-at-age was not estimated for the total harvest.

The contribution of each age class to the escapement biomass by weight and number, mean weight-at-age, and mean length-at-age of the escapement biomass was estimated for herring in each of the major spawning areas from (1) estimates of spawning biomass from spawn deposition surveys, (2) estimates of the use of herring in the wild spawn-on-kelp fishery, and (3) pooled samples of age, weight, and length data collected from herring captured by non size-selective gear types, e.g., purse and beach seines, within each major spawning area.

The contribution of each age class by weight and number to the escapement biomass was estimated by adding the estimated escapement from the major spawning areas to the estimated biomass exploited by the wild spawn-on-kelp fishery. It should be remembered that herring exploited in the wild spawn-on-kelp fishery were included in both the total harvest and escapement biomass estimates. The usage was included in the total harvest estimate because the eggs deposited on the kelp were harvested before the escapement biomass was estimated from spawn deposition surveys. Including the usage in the harvest would account for the loss of the reproductive capacity of the herring due to egg removal. On the other side, the usage was also included in the total escapement estimate because the adult fish that deposited the eggs escaped the harvest and should return to spawn next year. The mean weight-at-age for the escapement biomass was then estimated by dividing the weight of each age class by the number of fish in each age class. Mean length-at-age was not estimated for the escapement biomass.

The contribution of each age class to the total spawning biomass was estimated by adding the escapement biomass, the harvest by the sac roe fisheries, and the herring exploited by the pound spawn-on-kelp fishery. Herring exploited in the wild spawn-on-kelp fishery were only included in the total spawning biomass estimate as part of the escapement and not in the harvest because they were not actually harvested. Including these fish would have meant adding them twice, once in the escapement biomass and once in the harvest, to the total spawning biomass estimate. The mean weight-at-age for the total spawning biomass was then estimated by dividing the weight of each age class by the number of fish in each age class. Mean length-at-age was not estimated for the total spawning biomass.

The spring spawning exploitation rate by weight was estimated for each age class by dividing the weight of the harvest from the four spring fisheries by the weight of the total spawning biomass. The total exploitation rate by weight was estimated by dividing the weight of harvest from the four spring fisheries and the food-and-bait fishery by the weight of the total biomass. The spawning and

total exploitation rates by number were estimated for each age class by using number of herring instead of weight.

Aerial Surveys

Aerial Survey Methods

The first aerial survey was flown on 6 April 1990. Herring schools were recorded and biomass estimated along with the extent of spawning activity. Aerial surveys were usually flown from a float equipped Cessna 185. A typical survey covered up to 805 km of coastline and was limited by the endurance of the aircraft, approximately 5 h. Tide stage was not critical, but in general more herring were visible on a rising tide. Survey coverage of PWS normally included the mainland shoreline from St. Mathews Bay to Eaglek, the Naked Island group, Green Island and the northeastern portion of Montague Island (Figure 2). Areas of coverage were varied to focus on locations where spawning activity was concentrated. Spawning was observed on Smith Island in 1990 for the first time in twenty years.

Biomass estimates were made by converting an estimate of surface area to biomass. Schools of herring were classified into one of three size categories depending on the estimated surface diameter. A *small* school was about 15.25 m (50 ft) in diameter and approximately 9.1 tonnes of herring; a *medium* school was about 30.5 m (100 ft) in diameter and approximately 36.3 tonnes of herring; and a *large* school was about 61.0 m (200 ft) in diameter and approximately 145.1 tonnes of herring. Herring schools did not usually fall into one of the three size categories, and the observer converted these schools into a multiple of small, medium, or large schools.

To reduce variation in the estimates due to changes in the observer's distance to the water, surveys were flown at a standard altitude of 457.2 m (1,500 ft). This was occasionally modified because of low clouds or other reasons. A sighting tube was used to calibrate the observer to standard surface distances at a specified survey altitude and viewing angle.

Spawning Biomass Estimation

The annual peak biomass was estimated from the aerial survey data by adding the peak biomass estimates recorded for all survey areas. Only a single day's estimate was used for any given area unless two temporally distinct biomasses of herring spawned in the same area. In this instance, two peak estimates from the same area would be included in the annual peak biomass estimate.

Kilometers of Spawning and Kilometer-days of Spawning

Areas of herring spawning activity, as indicated by white milt in the water, were carefully charted to the nearest 0.16 km (0.1 mile). The annual kilometers of spawning was estimated from the aerial survey data as the sum of the kilometers of shoreline where milt was observed. No adjustment was made for the intensity

of the observed spawn. A 1 km section of beach that received spawn for 1 d was given the same weight as a 1 km section of beach that received spawn for 2 d or more. The intensity of observed spawn was accounted for with kilometer-days of spawning, which reflected spawn observed on a section of beach on 2 d or more: this section of beach was counted for each day of observed spawning. It should be noted that the kilometers of spawning and kilometer-days of spawning were indices of abundance for the herring that escaped the harvest by the sac roe fisheries.

Spawn Deposition Surveys

The objective of the spawn deposition surveys was to estimate the biomass of the spawning population of herring in PWS (Biggs and Funk 1988). Spawn deposition surveys were patterned after similar surveys in Southeast Alaska (Blankenbeckler 1987; Blankenbeckler and Larson 1982, 1985, 1987), and British Columbia (Schweigert *et al.* 1985). The spawning biomass was estimated in each major spawning area by estimating the total number of eggs deposited on the spawning grounds and incorporating estimates of mean weight, sex ratio, and fecundity. Major spawning areas were identified and mapped during aerial surveys. The total spawning biomass was estimated by summing the estimates from all the major spawning areas.

Comparison of Spawning Biomass Estimates

To compare the spawning biomass estimates from the aerial surveys and spawn deposition surveys, a biomass ratio was estimated as the peak aerial survey estimate divided by the spawn deposition survey estimate. In comparing the two spawning biomass estimates, it must be remembered that the peak aerial survey estimate was an estimate of the observable biomass and can be an estimate of the spawning biomass prior to the sac roe fisheries, whereas the spawn deposition survey estimates are estimates of the spawning biomass after the completion of the sac roe and spawn-on-kelp fisheries.

RESULTS

Harvest Estimates

1989 Food-and-Bait Fishery

The Prince William Sound food-and-bait fishery was opened by emergency order on 1 November 1989 and closed by regulation on 31 January 1990 (Table 6). Three purse seine vessels harvested 586.0 tonnes of herring from Knowles Head by 12 November 1989 (Table 7). The fishery remained opened until 31 January 1991. However, no herring were harvested after 12 November 1989. The guideline harvest level of 1,536.8 tonnes was never reached.

The herring sampled from the harvest had a mean weight of 111 g and mean length of 182 mm (Table 7). Age-5 fish represented 40.0% by weight and 36.6% by number of the food-and-bait harvest (Table 7); age-3 and -4 herring accounted for most of the remainder. The harvest was 49.5% females and 50.5% males. The contributions of each age class, mean weight, and sex composition of herring in the food-and-bait fishery were determined from AWLS samples (n=418) collected from the commercial harvest at Knowles Head, and Montague and Green Islands (Table 8).

Sac Roe Purse Seine Fishery

The purse seine sac roe fishery was opened in the north-shore area on 12 April 1990 for one 20 minute fishing period (Table 6). A total of 7,586.0 tonnes of herring were harvested by 97 purse seine boats; this harvest exceeded the guideline harvest level of 6,038 tonnes (Baker 1990). The estimated mean roe recovery was approximately 11%.

During the opening, 65.8% by weight and 68.4% by number of the harvest was composed of age-6 fish (1984 year class); the remainder was composed of age-5 through age-10 herring (Table 9). Herring sampled from the harvest had a mean weight of 138 g and a mean length of 218 mm. The harvest was 56.1% males and 43.9% females. The contributions of each age class, mean weight, and sex composition of herring in the purse seine sac roe harvest were determined from AWLS samples (n=551) collected from the commercial harvest in the northeast-shore area of PWS on 12 April 1990 (Table 10).

Sac Roe Gill Net Fishery

The gill net sac roe fishery was opened in the northeast-shore area on 13 April 1990 for a 4.0 h fishing period (Table 6). A total of 458.5 tonnes of herring were harvested by 24 boats, exceeding the guideline harvest of 320.2 tonnes (Baker 1990). The mean roe recovery was estimated at 10.6%.

The majority of the gill net sac roe harvest was composed of age-6 herring; 45.2% by weight and 48.6% by number (Table 11). The remainder of the harvest was composed of herring ranging from age-4 through age-13. Herring from this harvest had a mean weight of 157 g and a mean length of 231 mm. The harvest was 53.9% males and 46.1% females. The contributions of each age class, mean weight, and sex composition of herring in the harvest were determined from AWLS samples collected from the commercial gill net harvest at Tatitlek Narrows, Virgin, and Landlocked bays (n=255) and Boulder Bay (n=409) in the northeast-shore area of PWS on 13 April 1990 (Tables 12, 13).

In Tatitlek Narrows, Virgin and Landlocked bays, the herring had a mean weight of 165 g and mean length of 233 mm (Table 12). The sample was represented by 53.3% males and 46.7% females and composed of 45.9% age-6 fish; the balance was made up of age-5 through age-10 fish. The mean weight-at-age and mean length-at-age of the female herring was slightly larger than the male herring (NSC).

Herring from Boulder Bay had a mean weight of 152 g and mean length of 229 mm (Table 13). Of the fish sampled, 54.3% were males and 45.7% were females. The sample consisted of 50.4% age-6 fish; age-5 through age-10 herring represented most of the remaining harvest. The mean weight-at-age and mean length-at-age for the female herring was slightly larger than the male herring (NSC).

Wild Spawn-on-Kelp Fishery

The wild spawn-on-kelp fishery was opened in Tatitlek Narrows for 8.0 h on 21 April and 8.0 h on 22 April 1990 (Table 6); 134 divers harvested 107.8 tonnes of wild spawn-on-kelp product. The exploited herring biomass was estimated to be 862.2 tonnes, of which 344.0 tonnes were exploited during the first opening, and 518.2 tonnes during the second opening (Table 14). The total harvest exceeded the guideline harvest of 753.9 tonnes (Baker 1990).

An estimated 66.8% by weight and 69.4% by number of the herring used in the fishery were age-6, and the majority of the remaining harvest split between age-5 and age-10 herring (Table 14). The sampled herring had a mean weight of 137 g and mean length of 220 mm, and were 53.4% males and 46.6% females. The contributions of each age class, mean weight, mean length, and sex composition of herring used in the wild spawn-on-kelp harvest were determined from AWLS samples collected from purse seine catches for the sac roe fishery in the northeast-shore area (n=551; Table 10); from test fish purse seine catches at Galena Bay on 7 April (n=389; Table 15), Sawmill Bay on 7 April (n=144; Table 16), and Galena and Jack Bays on 11 April (n=204; Table 17); and from purse seine catches for the pound fishery in Galena Bay on 14 April 1990 (n=426; Table 18).

Pound Spawn-on-Kelp Fishery

The pound spawn-on-kelp fishery was opened to purse seine herring from 11-22 April 1990 (Table 6). A total harvest of 91.7 tonnes of spawn-on-kelp was produced by the 128 permit holders. From this, it was estimated that 1,146.5 tonnes of herring were used in this fishery.

In the pound spawn-on-kelp fishery 70.4% by weight and 73.5% by number of the herring used were age-6 (Table 19). The sampled herring had a mean weight of 133 g and mean length of 221 mm, and were 50.8% males and 49.2% females. The contributions of each age class, mean weight, and sex composition were determined from AWLS samples collected from herring used in the pound fishery in the northeast-shore area (n=426; Table 18).

In addition to the AWLS samples collected in Galena Bay on 14 April 1990 (Table 18), samples were also collected in Galena Bay on 15 April 1990 (Table 20) and on 20 April 1990. The samples collected on 15 April 1990 were determined to be unrepresentative because of the large number of age-3 herring. The sample was still composed primarily of age-6 herring (58.0%), however, 15.8% of the sample was age-3 herring. Herring in this sample had a mean weight of 102 g and a mean length of 201 mm, and were 58.0% males and 42.0% females.

The samples collected on 20 April 1990 were also determined to be unrepresentative because of the late date they were collected in the fishery (Table 21). The majority of the spawn on kelp had been harvested and the fishery was closed on 22 April 1990. The herring sampled were 67.0% age-6, had a mean weight of 125 g and mean length of 216 mm, and were 58.0% males and 42.0% females.

Total Harvest

The herring in the harvests of the 1990 spring fisheries were composed of age-6 fish 65.5% by weight and 68.3% by number (Table 22). The remainder of the herring were mostly composed of herring between age-5 and age-10. Herring in the 1990 harvest had a mean weight of 138 g. The harvest by the spring fisheries was 55.0% males and 45.0% females. The contribution of each age class by weight and number was determined by combining the estimated age composition of the harvest from the four spring fisheries (Tables 9, 11, 14, 19).

The total harvest for the four spring fisheries and the 1989 food-and-bait fishery was 10,639.2 tonnes of herring (Table 23). The herring in the combined harvest had a mean weight of 137 g. Age-6 herring made up 62.3% by weight and 64.2% by number of the harvest. The combined fisheries were 54.8% males and 45.2% females. The contribution of each age class, by weight and number, was determined by combining the estimated age composition of the harvest from the four spring fisheries in 1990 (Tables 9, 11, 14, 19) and the food-and-bait fishery in 1989 (Table 7). The 1989 food-and-bait fishery harvested 586.0 tonnes of herring. The 1990 sac roe fisheries harvested 8,044.5 tonnes of herring, and the 1990 spawn-on-kelp fisheries 199.5 tonnes of spawn-on-kelp product.

Spawning Biomass Estimates

Southeast-shore Area

In the southeast-shore area 380.0 tonnes of herring were estimated to have spawned based on spawn deposition surveys (Table 24), which was 1.35 times larger than the aerial survey estimate of 281.2 tonnes. An estimated 4.5 km-days of spawn were observed from aerial surveys along 4.2 km of shoreline. Most of the spawning biomass and spawning was observed on 31 March and 1 April 1990 (Tables 25, 26).

No AWLS samples were collected in the south-east shore area. Therefore the AWLS samples collected and considered to be representative of the northeast-shore area were used (Tables 10, 15,16,17,18). Using these samples, the spawning biomass was composed of age-6 herring 66.8% by weight and 69.4% by number (Table 27). The herring had a mean weight of 137 g and a mean length of 220 mm, and were 53.4% males and 46.6% females.

Northeast-shore Area

Based upon both aerial surveys and spawn deposition estimates, the largest biomass of spawning herring was near Tatitlek Narrows in the northeast-shore area (Table 24). In the northeast-shore area 48,888.0 tonnes were estimated from the spawn deposition survey; this was 1.75 times larger than the aerial survey biomass estimate of 27,868.7 tonnes 21. The majority of the spawning biomass was observed during an aerial survey on 11 April 1990 (Table 25). The majority of the spawning was observed on 14-16 April 1990 on an estimated 70.4 km of shoreline (Tables 24, 26).

An estimated 66.8% by weight and 69.4% by number of the herring in the northeast-shore area were age-6 fish (Table 28). Herring in this area had a mean weight of 137 g and mean length of 220 mm, and were 53.4% males and 46.6% females. The contribution of each age class, mean weight, mean length, and sex composition was estimated from AWLS samples collected from herring utilized in the pound fishery at Galena Bay (Table 28). For a comparison of the samples collected, see the pound spawn-on-kelp fishery section in the results.

Purse seines were used to sample herring (test fishing) in Galena Bay on 7 April 1990 and Sawmill Bay on 11 April (Tables 26, 27). On 7 April 1990, 389 herring were sampled (Table 26), 65.0% of which were age-6. Males composed 53.7% of the sample and females 46.3%. The herring had a mean weight of 141 g and mean length of 221 mm. On 11 April 1990, 144 herring were sampled (Table 27), 63.9% of which were age-6. Males composed 44.4% of the sample and females 55.6%. The herring had a mean weight of 137 g and mean length of 220 mm. The contribution of each age class, mean weight, mean length, and sex composition of herring in the northeast area were determined from AWLS samples collected from purse seine catches for the sac roe fishery in the northeast area (n=551; Table 10); from test fish purse seine catches at Galena Bay on 7 April (n=389; Table 15), Sawmill Bay on 7 April (n=144; Table 16), and Galena and Jack Bays on 11 April (n=204; Table 17); and from purse seine catches for the pound fishery in Galena Bay on 14 April 1990 (n=426; Table 18). The samples collected from the commercial purse sac roe and pound fisheries were presented previously under their appropriate headings.

Herring sampled at Galena Bay on 7 April were 65.0% age-6 fish (Table 15), had a mean weight of 141 g and mean length of 221 mm, and were 53.7% males and 46.3% females. In comparison, herring sampled at Sawmill Bay on 11 April were 63.9% age-6 fish (Table 16), had a mean weight of 137 g and mean length of 220 mm, and were 44.4% males and 55.6% females. Herring sampled at Galena and Jack Bays on 11 April 1990 were 76.0% age-6 (Table 17) and had a mean weight of 137 g and mean length of 220 mm. The sample was 56.9% males and 43.1% females.

North-shore Area

In the north-shore area, 13,256.0 tonnes of herring were estimated to have spawned based on spawn deposition surveys (Table 24). This estimate was 1.11 times larger than the 11,892.2 tonnes estimated from aerial surveys. Herring were observed spawning for 35.2 km-days on 35.2 km of shoreline in the area. The majority of the spawning herring were observed between 9 and 14 April 1990 (Table 25), though a large portion of the spawn was not observed until 16 April 1990.

An estimated 73.0% by weight and 74.3% by number of the herring in the north-shore area were age-6 fish (Table 29). Herring from this area had a mean weight of 134 g and mean length of 218 mm, and were 39.9% males and 60.1% females. The contribution of each age class, mean weight, mean length, and sex composition were determined from AWLS samples (n=424) collected from test fish purse seine catches at Wells Bay (Table 30).

Naked Island Area

In the Naked Island area, 2,877.0 tonnes of herring were estimated to have spawn based on spawn deposition surveys (Table 24). This estimate was 0.42 times smaller than the aerial survey estimate of 6,867.4 tonnes. Herring were observed to have spawned for 5.6 km-days on 8.7 km of shoreline. Herring and spawn were observed in the area between 8 and 18 April 1990 (Tables 25, 26).

Of the herring that spawned in the Naked Island area, 72.6% by weight and 75.2% by number were age-6 herring (Tables 31, 32). The herring sampled had a mean weight of 138 g and mean length of 220 mm, and were 43.7% males and 56.3% females. The contribution of each age class, mean weight, mean length, and sex composition was estimated based upon an AWLS sample collected from test fish purse seine catches in the Naked Island area on 10 April 1990 (Table 32).

Montague Island Area

In the Montague Island area 38,924.0 tonnes of herring were estimated to have spawned based on spawn deposition surveys (Table 24). This estimate was 15.00 times larger than the aerial survey estimate of 2,594.6 tonnes. Herring spawned for 85.2 km-days along 39.0 km of shoreline. The majority of the herring biomass and spawn was observed between 6 and 16 April 1990 (Tables 25, 26).

An estimated 79.7% by weight and 79.3% by number of the herring in the Montague Island area were age-6 fish (Table 33). Herring in this area had a mean weight of 121 g and a mean length of 217 mm; males composed 57.3% of the sample and females 42.7%. The contribution of each age class, mean weight, mean length, and sex composition was estimated based upon AWLS samples collected from test fish purse seine catches (n=438) in the Montague Island area on 17-18 April 1990 (Table 34).

Herring were also sampled for AWLS information at Port Chalmers in the Montague Island area (n=439; Table 35). However, these herring were not used to estimate age composition, mean weight, mean length, and sex composition for the area because the sample was considered to be unrepresentative of the herring in the area. The herring sampled at Port Chalmers were 75.9% age-6 fish, had a mean weight of 116 g and mean length of 210 mm, and were 44.4% males and 55.6% females.

All Areas Combined

Based upon spawn deposition surveys, 104,325.0 tonnes of herring spawned in the five major spawning areas in PWS (Table 24). This estimate was 2.11 times larger than the 49,505.2 tonnes of herring estimated from aerial surveys. Herring were observed to have spawned for 232.2 km-days along 151.5 km of shoreline. The majority of the herring were observed between 10 and 12 April 1990 (Tables 25), though the herring spawn was most visible between 14 and 19 April 1990 (Table 26). The spawning biomass estimated from the spawn deposition surveys were composed of age-6 fish 73.6% by weight and 75.2% by number (Table 36) and had a mean weight of 131 g. The sex composition of the spawning biomass was 53.0% males and 47.0% females.

Escapement Biomass, Total Spawning Biomass, and Exploitation Rate

An estimated 105,187.2 tonnes of herring escaped the harvest in PWS in 1990 (Table 37). An estimated 72.5% by weight and 75.1% by number were age-6 herring. The remainder of the escapement consisted of fish age-2 through age-13. Herring that escaped harvest had a mean weight of 131 g and were 53.0% males and 47.0% females. The escapement was the sum of the estimated spawning biomass from the spawn deposition surveys (Table 36) and the estimated use by the wild spawn-on-kelp fishery (Table 14).

The total spawning biomass was estimated at 114,378.2 tonnes (Table 38), of which 71.9% by weight and 73.7% by number were age-6 herring. The estimated mean weight for the herring population was 131 g. The sex composition was 53.2% males and 46.8% females. The total spawning biomass was the sum of the estimated spawning biomass from the spawn deposition surveys (Table 36) and the total harvest and use by the 1990 sac roe and spawn-on-kelp fisheries (Table 22).

The total biomass of herring was estimated at 114,964.2 tonnes (Table 39). The herring were 71.6% by weight and 73.3% by number age-6 herring. The estimated mean weight for the herring population was 131 g. The sex composition was 53.2% males and 46.8% females. The total spawning biomass was the sum of the estimated spawning biomass from the spawn deposition surveys (Table 36), the harvest by the 1989 food-and-bait fishery and the total harvest and use by the 1990 sac roe and spawn-on-kelp fisheries (Table 23).

The exploitation rate for the 1990 spring fisheries was 8.8% by weight and 8.3% by number (Tables 40, 41). The exploitation rate for the 1989 food-and-bait fishery and 1990 spring fisheries was 9.3% by weight and 8.9% by weight.

DISCUSSION

The total harvest of 10,639.2 tonnes of herring by the five commercial fisheries during 1989-1990 exceeded the harvest allocation of 9,427.5 tonnes by 12.9%, or

1,211.7 tonnes. The 1989 food-and-bait and spawn-on-kelp pound fisheries never reached their guideline harvest levels. The 1989 food-and-bait harvest of 586.0 tonnes was 950.8 tonnes less than the allocated 1,536.8 tonnes. The spawn-on-kelp pound fishery harvest of 91.7 tonnes of spawn-on-kelp product was 15.3 tonnes less than the harvest allocation of 107.0 tonnes. The wild spawn-on-kelp and both sac roe fisheries exceeded the guideline harvest levels. The largest difference in the harvest allocation was the purse seine sac roe fishery; which harvested 7,586.0 tonnes, 38.5% over the harvest allocation of 5,477.5 tonnes. The gill net sac roe fishery harvested 458.5 tonnes which exceeded the allocation of 320.3 tonnes by 43.2%, or 138.3 tonnes. Finally, the wild spawn-on-kelp fishery harvested 107.8 tonnes of spawn-on-kelp product, exceeding the allocation of 94.3 tonnes by 14.3%, or 13.5 tonnes.

There were five major spawning concentrations of herring in PWS: southeast-shore area, northeast-shore area, north-shore area, Naked Island area, and Montague Island area (Figure 2). Both aerial surveys and spawn deposition surveys were conducted to estimate the spawning biomass in the five areas. Differences between estimates from aerial surveys and spawn deposition surveys varied greatly within the five major spawning areas. Estimates in the southeast-shore area were similar: the spawn deposition survey estimate of 380.0 tonnes was 1.35 times larger than the aerial survey estimate of 281.2 tonnes. The slight difference may be because aerial surveys were not flown until 31 March 1990 and herring were observed on the first aerial survey and herring may have been missed before the first aerial survey was flown.

The largest spawning biomass of herring occurred in the northeast-shore area. A large portion of which was not observed during the aerial surveys. The spawn deposition survey estimate of 48,888.0 tonnes was 1.75 times larger than the aerial survey estimate of 27,868.7 tonnes. The difference between these estimates becomes even more dramatic if the harvest from the four spring fisheries is accounted for. All four spring fisheries took place in this area. If the harvest by the fisheries, 10,053.2 tonnes, is added to the spawn deposition survey estimate, then 58,941.2 tonnes of herring should have been observed by aerial surveys in this area.

In the north-shore area the biomass estimates were very similar; the 13,256.0 tonnes estimated from spawn deposition surveys was 1.11 times larger and than the 11,893.2 tonnes estimated from aerial surveys. The biomass estimates in the Naked Island area reversed the pattern evident in other areas. The estimate from the spawn deposition surveys was 0.42 smaller than the estimate from the aerial surveys. The difference probably arose from observing herring in the area that ultimately went to a different area to spawn. There is also the possibility that herring observed in this area retained their eggs and did not spawn; there is some indication that this behavior can occur under certain conditions.

The second largest spawning biomass based on spawn deposition surveys was in the Montague Island area. It was also the area which had the largest difference between biomass estimates. The biomass estimate of 38,924.0 tonnes from the spawn deposition surveys was 15.00 times larger than the 2,594.6 tonnes estimated from aerial surveys. The large difference may be a reflection of the behavior of the herring around Montague Island. Based upon the presence of a large number sea lions near Montague Island, there appeared to be a buildup of herring prior to

spawning. Extensive spawn was documented on the north end of Montague Island. However, very little biomass was observed. The combined area estimates from the spawn deposition survey estimates was 104,325 tonnes and 2.11 times larger than the aerial survey estimate of 49,505.2 tonnes. This difference is slightly larger than the biomass ratio of 1.73 in 1988, and substantially larger than the biomass ratio of 1.01 in 1989 (Baker *et al.* 1990, 1991).

The exploitation rate for the 1990 spring sac roe fisheries was estimated at 8.8% by weight and 8.3% by number. The total exploitation rate for the 1989-90 season was at 9.3% by weight and 8.9% by number, considerably less than the guideline exploitation rate of 20%. As was expected, the harvest and utilization by the five commercial fisheries, escapement, and total spawning biomass of herring in PWS during 1990 was dominated by the 1984 year class. This was as expected; the 1984 year class dominated the spawning biomass in 1988 and 1989 (Baker et al. 1990, 1991).

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Table 1. Harvest of herring by the commercial food-and-bait and sac roe fisheries, and the estimated equivalent harvest of herring in the wild and pound spawn-on-kelp fisheries in Prince William Sound, Alaska, 1969-1990.

Harvest Year[d]	Herring Harvest						Equivalent Herring Harvest				Total Spring Harvest (tonnes)	Total Harvest (tonnes)
	Food-and-Bait Fishery[a]		Sac Roe Fisheries				Spawn-on-Kelp Fisheries					
			Purse Seine		Gill Net		Pound Kelp[b]		Wild Kelp[c]			
	(tonnes)	%	(tonnes)	%	(tonnes)	%	(tonnes)	%	(tonnes)	%		
1969			322.7	94.4					19.2	5.6	341.9	341.9
1970	9.1	1.3							690.5	100.0	690.5	699.6
1971	18.1	0.5	834.0	23.0					2,791.6	77.0	3,625.6	3,643.7
1972	4.4	0.1	1,608.1	42.5					2,174.7	57.5	3,782.8	3,787.2
1973	7.7	0.1	6,336.1	85.1					1,111.5	14.9	7,447.6	7,455.3
1974			5,777.1	74.2	3.4	0.0			2,003.4	25.7	7,784.0	7,784.0
1975			5,517.1	62.4					3,327.9	37.6	8,845.0	8,845.0
1976			2,344.6	57.1					1,759.6	42.9	4,104.2	4,104.2
1977			2,071.0	57.8	1.5	0.0			1,513.2	42.2	3,585.7	3,585.7
1978	229.2	12.9	1,206.2	68.0	56.0	3.2			511.3	28.8	1,773.5	2,002.7
1979	1,170.2	21.4	3,754.5	68.6					1,717.1	31.4	5,471.6	6,641.8
1980	595.1	7.5	5,482.3	68.9	240.0	3.0	15.0	0.2	2,221.9	27.9	7,959.2	8,554.3
1981	1,285.0	9.7	12,492.5	94.2	212.8	1.6	109.5	0.8	444.2	3.3	13,259.0	14,544.0
1982	1,145.4	13.9	6,484.8	78.6	357.3	4.3	289.5	3.9	1,123.5	13.6	8,255.2	9,400.6
1983	801.2	20.1	2,471.4	62.1	95.6	2.4	314.5	7.9	1,100.2	27.6	3,981.7	4,783.0
1984	248.2	4.2	5,295.2	89.9	311.1	5.3	285.8	4.9			5,892.1	6,140.3
1985	926.9	12.5	6,423.1	86.8	374.9	5.1	455.5	6.2	149.9	2.0	7,403.5	8,330.3
1986	1,014.3	9.7	8,915.9	85.0	407.0	3.9	818.7	7.8	345.5	3.3	10,487.1	11,501.4
1987	1,157.8	18.3	4,519.8	71.3	483.8	7.6	694.0	11.0	640.1	10.1	6,337.7	7,495.4
1988	1,079.0	11.2	7,163.0	74.6	324.9	3.4	1,410.7	14.7	701.1	7.3	9,599.7	10,678.7
1989[e]	1,111.3											1,111.3
1990	586.0	5.8	7,586.0	75.5	458.5	4.6	1,146.5	11.4	862.2	8.6	10,053.2	10,639.2
n	17	16	20	20	13	13	10	10	20	20	21	22
Mean	669.9	9.3	4,830.3	71.0	255.9	3.4	554.0	6.9	1,260.4	28.4	6,222.9	6,457.7
SE	118.0	1.8	685.2	3.9	47.0	0.6	144.2	1.5	202.2	5.8	736.7	809.8
Min	4.4	0.1	322.7	23.0	1.5	0.0	15.0	0.2	19.2	2.0	341.9	341.9
Max	1,285.0	21.4	12,492.5	94.4	483.8	7.6	1,410.7	14.7	3,327.9	100.0	13,259.0	14,544.0

[a] Gear type used included purse seine, pair trawl, mid-water trawl, and otter trawl. However, since 1982 purse seines were used exclusively.
[b] The equivalent harvest of herring utilized in the pound spawn-on-kelp fishery was estimated based on the assumption that 12.5 tonnes of herring was utilized to produce 1.0 tonne of spawn-on-kelp product.
[c] The equivalent harvest of herring utilized in the natural spawn-on-kelp fishery was estimated based on the assumptions that the average roe recovery was 10%, and 80% of the spawn-on-kelp harvest consisted of roe (eggs).
[d] The harvest year for the fall food-and-bait fishery actually occurred in the year prior to the harvest year listed. As an example, the food-and-bait harvest in the 1988 harvest year was actually the harvest for the 1987 food-and-bait fishery. It was recorded this way because the management year for herring was defined to occur from 1 July through 31 June of the following year.
[e] There was no harvest or utilization of herring by the commercial sac roe and spawn-on-kelp fisheries in Prince William Sound during 1989. All the sac roe and spawn-on-kelp fisheries were closed in 1989 because of the M/V Exxon Valdez oil spill.

Table 2. Commercial harvest of herring by the food-and-bait fishery in Prince William Sound, Alaska, 1970-1989.

Harvest Year	Purse Seine		Pair Trawl		Mid-Water Trawl		Otter Trawl		Total	
	Effort (Boat)	Harvest (tonnes)	Effort (Boat)	Harvest (tonnes)	Effort (Boat)	Harvest (tonnes)	Effort (Boat)	Harvest (tonnes)	Effort (Boat)	Harvest (tonnes)
1970	1	9.1							1	9.1
1971	2	18.1							2	18.1
1972	1	4.4							1	4.4
1973	1	7.7							1	7.7
1974										
1975										
1976										
1977[a]	2	15.4	2	131.8	1	82.0			5	229.2
1978[b]	2	177.3	2	897.0	1	93.6	1	2.3	6	1,170.2
1979[c]	1	463.5	2	131.6					3	595.1
1980[d]	3	934.8	3	350.2					6	1,285.0
1981[e]	6	1,079.1	2	66.3					8	1,145.4
1982	5	801.2							5	801.2
1983	2	248.2							2	248.2
1984	2	926.9							2	926.9
1985[f]	5	1,014.3							5	1,014.3
1986[g]	5	1,157.8							5	1,157.8
1987[h]	7	1,079.0							7	1,079.0
1988	7	1,111.3							7	1,111.3
1989	6	586.0							6	586.0
n	17	17	5	5	2	2	1	1	17	17
Mean	3.4	507.9	2.2	315.4	1.0	87.8	1.0	2.3	4.2	669.9
SE	0.5	111.0	0.2	153.1	0.0	5.8			0.6	118.0
Min	1	4.4	2	66.3	1	82.0	1	2.3	1	4.4
Max	7	1,157.8	3	897.0	1	93.6	1	2.3	8	1,285.0

[a] Starting in 1977, food-and-bait herring season may have included two calendar years.
[b] Fishing season was opened by emergency order on 16 October 1978 and was extended on 7 January 1979. Deliveries were made through 2 March 1979.
[c] Fishing season was opened by emergency order 15 September 1980 and closed 31 December 1979. It was reopened by emergency order from 16 February 1980 and closed 28 February 1980.
[d] Fishing season was opened by regulation on 15 September 1980 and closed by emergency order on 7 November 1980.
[e] Fishing season was opened by regulation on 15 September 1981 and closed by emergency order on 30 September 1981.
[f] Fishing season was opened by regulation on 1 September 1985 and closed by emergency order on 15 February 1986.
[g] Fishing season was opened by regulation on 1 September 1986 and closed by emergency order on 24 October 1986.
[h] Fishing season was opened by regulation on 1 September 1987 in the General District. The Northern and Eastern Herring Districts opened on 23 September 1987. The fishing season was then closed by emergency order on 6 October for a five week period, reopened on 9 November, and closed for the duration of the 1987-1988 season on 12 November 1987.

Table 3. Summary of herring wild spawn-on-kelp harvest in Prince William Sound, Alaska, 1969-1990.

Year	Fishery Dates	Hours	Effort (Divers)	Spawn-on-Kelp Harvest kg	Spawn-on-Kelp Harvest tonnes	Equivalent Herring Harvest (tonnes)[a]
1969	18 May-31 May		3	2,404	2.4	19.2
1970	19 Apr- 6 Jun		29	86,319	86.3	690.5
1971	18 Apr-15 May		34	348,949	348.9	2,791.6
1972	30 Apr-20 May		397	271,838	271.8	2,174.7
1973	23 Apr-26 May		176	138,936	138.9	1,111.5
1974	22 Apr- 4 May		166	250,429	250.4	2,003.4
1975	25 Apr-10 May		437	415,990	416.0	3,327.9
1976	21 Apr- ?		357	219,947	219.9	1,759.6
1977	27 Apr-31 Dec		164	189,148	189.1	1,513.2
1978	20 Apr-30 Apr		66	63,911	63.9	511.3
1979	25 Apr- 3 May		198	214,640	214.6	1,717.1
1980	23 Apr-30 Apr	10	469	277,735	277.7	2,221.9
1981	25 Apr	12	214	55,520	55.5	444.2
1982	5 May- 8 May	73	151	140,432	140.4	1,123.5
1983	27 Apr	12	186	137,529	137.5	1,100.2
1984	Season Closed					
1985	6 May- 8 May	20	95	18,733	18.7	149.9
1986	30 Apr- 3 May	86	29	43,182	43.2	345.5
1987	15 Apr-17 Apr	44	60	80,014	80.0	640.1
1988	29 Apr-30 Apr	12	158	87,634	87.6	701.1
1989[b]	Season Closed					
1990	21 Apr-22 Apr	16	134	107,774	107.8	862.2
n		9	20	20	20	20
Mean		32	176	157,553	160.7	1,260.4
SE		10	31	25,277	25.1	202.2
Min		10	3	2,404	2.4	19.2
Max		86	469	415,990	416.0	3,327.9

[a] The estimate of herring used by the wild spawn-on-kelp fishery was based on a mean roe recovery of 10%, with 80% of the spawn-on-kelp harvest consisting of roe (eggs).

[b] The herring wild spawn-on-kelp fishery in Prince William Sound was closed in 1989 due to the oil spill resulting from the grounding of the *M/V Exxon Valdez*.

Table 4. Summary of herring pound spawn-on-kelp harvest in Prince William Sound, Alaska, 1979-1990.

Year	Fishery Dates[a]	Permits Issued[b]	Pounds Built[c]	Producing Pounds[d]	Spawn-on-Kelp Harvest[e]						Equivalent Herring Harvest[f] (tonnes)
					Ribbon		Macrocystis		Total		
					kg	tonnes	kg	tonnes	kg	tonnes	
1979		2	0								
1980	14 Apr	14	4	2	803	0.8	399	0.4	1,202	1.2	15.0
1981	14 Apr	18	18	7	7,810	7.8	953	1.0	8,762	8.8	109.5
1982	29 Apr-10 May	25	20	18	22,754	22.8	408	0.4	23,163	23.2	289.5
1983	30 Apr- 4 May	47	38	26	16,041	16.0	9,117	9.1	25,158	25.2	314.5
1984	24 Apr- 8 May	65	45	37	5,824	5.8	17,042	17.0	22,866	22.9	285.8
1985	25 Apr- 7 May	81	59	50	10,976	11.0	25,461	25.5	36,437	36.4	455.5
1986	21 Apr-28 Apr	104	82	81	0	0.0	65,499	65.5	65,499	65.5	818.7
1987	10 Apr-21 Apr	111	111	108	0	0.0	55,520	55.5	55,520	55.5	694.0
1988	12 Apr-23 Apr	122	122	119	0	0.0	112,854	112.9	112,854	112.9	1,410.7
1989[g]	Season Closed										
1990	11 Apr-26 Apr	128	128	128	0	0.0	90,809	91.7	90,809	91.7	1,146.7
n		11	11	10	10	10	10	10	10	10	10
Mean		65	57	58	6,421	6.4	37,806	37.9	44,227	44.3	554.0
SE		14	14	15	2,536	2.5	12,946	13.0	11,495	11.5	144.2
Min		2	0	2	0	0.0	399	0.4	1,202	1.2	15.0
Max		128	128	128	22,754	22.8	112,854	112.9	112,854	112.9	1,410.7

[a] Dates the fishery was opened to seine herring for placement into pounds.
[b] Permits issued to applicants on register prior to the March 1 deadline.
[c] Number of individual pounds constructed by the April 1 deadline, and consequently the number of individuals receiving an equal allocation of the guideline harvest.
[d] Number of pounds that were successful in producing roe-on-kelp product. Due to the group cooperation in this fishery, production is frequently reported for a few individuals whose pounds did not produce roe-on-kelp product.
[e] Production figures represent processed weights as reported on fish tickets.
[f] The herring utilized in the Pound spawn-on-kelp fishery was estimated based on the assumption that it takes 11.3 tonnes of herring to produce 1.0 tonnes of roe-on-kelp product.
[g] The herring pound spawn-on-kelp fishery in Prince William Sound was closed in 1989 due to the oil spill resulting from the grounding of the M/V Exxon Valdez.

Table 5. Spawning biomass estimates and indices for herring in Prince William Sound, Alaska, 1973-1990.

Year	Spawning Biomass Estimates: Peak Aerial Survey (tonnes)	Spawning Biomass Estimates: Spawn Deposition (tonnes)	Kilometers of Spawning	Kilometer-days of Spawning	Biomass of Herring per Kilometer (tonnes): Aerial Survey Estimate	Biomass of Herring per Kilometer (tonnes): Spawn Deposition Estimate	Biomass Ratio
1973			67.8	78.2			
1974	37,267.2		58.8	98.5	633.8		
1975			55.1	57.8			
1976	6,649.7		51.4	51.4	129.4		
1977	15,267.9		63.2	115.9	241.6		
1978	13,090.7		58.4	76.3	224.0		
1979	38,192.5		87.6	117.2	436.1		
1980	56,345.3		81.3	119.8	693.0		
1981	70,588.1		137.3	225.6	514.3		
1982	62,405.3		78.8	104.8	791.9		
1983	37,965.7	19,958.1	106.4	165.3	356.8	187.5	0.53
1984	53,179.2	72,311.8	96.3	139.7	552.4	751.1	1.36
1985	18,742.5		153.0	240.7	122.5		
1986	13,771.1		118.1	245.2	116.6		
1987	23,713.8		117.2	251.0	202.5		
1988	31,089.3	53,804.9	267.7	381.4	116.1	201.0	1.73
1989	51,632.5	52,235.5	158.4	295.8	325.9	329.7	1.01
1990	49,505.2	104,325.0	151.5	232.2	326.8	688.6	2.11
n	16	4	16	16	16	4	4
Mean	36,212.9	70,669.3[a]	111.3	176.3	362.7	492.6[a]	1.55[a]
SE	5,086.8	12,109.3	13.8	23.5	55.0	134.4	0.27
Min	6,649.7	52,235.5	51.4	51.4	116.1	201.0	1.01
Max	70,588.1	104,325.0	267.7	381.4	791.9	751.1	2.11

[a] Estimate from 1983 spawn deposition survey was not included in summary estimates because the survey was only a preliminary estimate.

Table 6. Season, location, effort, and harvest by gear type for the commercial herring fisheries in Prince William Sound, Alaska, 1989-1990.

	Fishing Information				Harvest (tonnes)	
Fishery	Area	Date	Duration	Effort	Spawn-on-kelp	Herring
1989 Food-and-bait	Knowles Head Montague-Green Islands	11/01/89-01/31/90		3 boats		586.0
Total 1989 Food-and-bait Harvest		11/01/89-01/31/90		3 boats		586.0
1990 Sac Roe and Spawn-on-kelp Fisheries						
Purse Seine Sac Roe	Tatitlek Narrows	04/12/90	20 min	97 boats		7,586.0
	Total	04/12/90	20 min	97 boats		7,586.0
Gill Net Sac Roe	Tatitlek Narrows	04/13/90	4 h	24 boats		458.5
	Total	04/13/90	4 h	24 boats		458.5
Wild Spawn-on-Kelp[a]	Tatitlek Narrows Tatitlek Narrows	04/21/90 04/21/90	8 h 8 h	86 divers 104 divers	43.0[b] 64.8[b]	344.0[c] 518.2[c]
	Total	04/21/90-04/22/90	16 h	134 divers	107.8[b]	862.2[c]
Pound Spawn-on-Kelp[d]	Galena Bay	04/11/90-04/22/90		128 permits	91.7	1,146.5[e]
	Total	04/11/90-04/22/90		128 permits	91.7	1,146.5[e]
Total 1990 Harvest and Use					199.5	10,053.2
Total 1989-1990 Harvest and Use					199.5	10,639.2

[a] The harvest by divers of naturally occurring herring roe on native kelp species in Prince William Sound.
[b] The harvest consisted of approximately 64% ribbon kelp, 24% sieve kelp, and 12% hair kelp.
[c] The equivalent harvest of herring (due to the removal of reproductive capacity of the population) was estimated based on a mean roe recovery of 10%, with 80% of the spawn-on-kelp harvest weight consisting of roe (eggs).
[d] The harvest of herring roe on kelp produced in net pens or pounds.
[e] The equivalent harvest of herring (due to stress mortality and the removal of the reproductive capacity of the population) was estimated based on the assumption that 12.5 tonnes of herring are used to produce 1.0 tonnes of spawn-on-kelp product.

Table 7. Estimates of the contributions of each age and year class to the herring harvested by the commercial food-and-bait fishery in Prince William Sound, Alaska, 1 November 1989 - 31 January 1990.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Harvest by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1988	1	0			0.0	0.0	0.0	0.0
1987	2	28	78	163	27.4	4.7	351.7	6.7
1986	3	74	94	174	87.4	14.9	929.5	17.7
1985	4	111	111	182	154.8	26.4	1,394.2	26.6
1984	5	153	122	186	234.5	40.0	1,921.8	36.6
1983	6	28	123	188	43.3	7.4	351.7	6.7
1982	7	19	130	195	31.0	5.3	238.7	4.5
1981	8	4	124	189	6.2	1.1	50.2	1.0
1980	9	1	120	205	1.5	0.3	12.6	0.2
1979	10	0			0.0	0.0	0.0	0.0
1978	11	0			0.0	0.0	0.0	0.0
1977	12	0			0.0	0.0	0.0	0.0
1976	13+	0			0.0	0.0	0.0	0.0
Total		418	111	182	586.0	100.0	5,250.3	100.0

Table 8. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from the commercial food-and-bait fishery at Knowles Head, and Montague and Green Islands, Prince William Sound, Alaska, 1 November 1989 - 31 January 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	13	3.1	13	3.1	28	6.7	88	23	74	13	78	22	168	12	164	8	163	16
3	36	8.6	36	8.6	74	17.7	97	18	93	18	94	19	174	8	174	9	174	9
4	63	15.0	48	11.5	111	26.5	110	17	113	15	111	16	181	8	184	8	182	8
5	75	17.9	78	18.6	153	36.5	123	19	121	18	122	18	185	10	186	9	186	9
6	13	3.1	15	3.6	28	6.7	126	19	122	23	123	21	191	9	186	11	188	10
7	4	1.0	15	3.6	19	4.5	136	20	128	22	130	22	197	14	194	12	195	12
8	1	0.2	3	0.7	4	1.0	118		125	18	124	15	185		191	4	189	4
9	0	0.0	1	0.2	1	0.2			120		120				205		205	
10	0	0.0	0	0.0	0	0.0												
11	0	0.0	0	0.0	0	0.0												
12	0	0.0	0	0.0	0	0.0												
13	0	0.0	0	0.0	0	0.0												
Total	205	49.5	209	50.5	418	100.0	112	22	112	23	111	23	182	11	183	12	182	12
Unaged	15	48.4	16	51.6	31	100	105	17	104	26	105	22	178	7	181	11	179	10

[a] In aging scales from the food-and-bait herring fishery, the growth on the outer margin of each scale was counted as plus growth and no annuli were assigned to the outer margins of these scales. This herring aging convention was adapted in order to keep the fall food-and-bait herring ages consistent with the spring sac roe herring ages. On all herring caught and aged in late March through April, an annulus is assumed to be present on the outer margin of each scale.

Table 9. Estimates of the contributions of each age and year class to the herring harvested by the commercial purse seine sac roe fishery in Prince William Sound, Alaska, 12 April 1990.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Harvest by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1	0			0.0	0.0	0.0	0.0
1988	2	0			0.0	0.0	0.0	0.0
1987	3	0			0.0	0.0	0.0	0.0
1986	4	1	106	206	10.6	0.1	99.6	0.2
1985	5	44	120	208	525.8	6.9	4,381.6	8.0
1984	6	377	133	218	4,993.1	65.8	37,542.0	68.4
1983	7	46	138	218	632.1	8.3	4,580.7	8.3
1982	8	31	156	230	481.6	6.3	3,087.0	5.6
1981	9	29	184	239	531.4	7.0	2,887.8	5.3
1980	10	19	175	236	331.1	4.4	1,892.0	3.4
1979	11	2	219	253	43.6	0.6	199.2	0.4
1978	12	1	180	235	17.9	0.2	99.6	0.2
1977	13	1	189	239	18.8	0.2	99.6	0.2
Total		551	138	218	7,586.0	100.0	54,869.1	100.0

Table 10. Age and sex composition, mean weight-at-age, and mean length-at-age for herring sampled from the harvest of the commercial purse seine sac roe fishery in the northeast-shore area, Prince William Sound, Alaska, 12 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	0	0.0	0	0.0	0	0.0												
4	0	0.0	1	0.2	1	0.2			106		106				206		206	
5	22	4.0	22	4.0	44	8.0	116	24	125	16	120	21	206	9	210	8	208	9
6	205	37.1	172	31.2	377	68.4	130	17	135	18	133	18	214	9	217	9	215	9
7	30	5.4	16	2.9	46	8.3	136	16	143	21	138	18	217	6	220	11	218	8
8	23	4.2	8	1.4	31	5.6	152	20	165	18	156	20	229	10	231	12	230	10
9	16	2.9	13	2.4	29	5.3	173	22	199	23	184	26	235	8	243	9	239	9
10	10	1.8	9	1.6	19	3.4	169	28	183	50	175	39	237	7	235	19	236	14
11	1	0.2	1	0.2	2	0.4	211		227		219	11	250		256		253	4
12	1	0.2	0	0.0	1	0.2	180				180		235				235	
13	1	0.2	0	0.0	1	0.2	189				189		239				239	
Total	309	56.1	242	43.9	551	100.0	136	23	141	27	138	25	217	12	219	12	218	12
Unaged	21	43.8	27	56.3	48	100	135	23	138	20	137	21	218	10	218	10	218	10

Table 11. Estimates of the contributions of each age and year class to the herring harvested by the commercial gill net sac roe fishery in the northeast-shore area, Prince William Sound, Alaska, 13 April 1990.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Harvest by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1	0			0.0	0.0	0.0	0.0
1988	2	0			0.0	0.0	0.0	0.0
1987	3	0			0.0	0.0	0.0	0.0
1986	4	2	134	213	1.2	0.3	8.8	0.3
1985	5	27	133	219	15.8	3.5	118.7	4.1
1984	6	323	146	225	207.2	45.2	1,420.2	48.6
1983	7	91	156	231	62.3	13.6	400.1	13.7
1982	8	86	170	236	64.2	14.0	378.1	13.0
1981	9	89	178	240	69.8	15.2	391.3	13.4
1980	10	35	193	246	29.7	6.5	153.9	5.3
1979	11	7	169	236	5.2	1.1	30.8	1.1
1978	12	3	174	245	2.3	0.5	13.2	0.5
1977	13	1	203	245	0.9	0.2	4.4	0.2
Total		664	157	231	458.5	100.0	2,919.5	100.0

Table 12. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from the harvest of the commercial gill net sac roe fishery at Tatitlek Narrows, and Virgin and Landlocked Bays, northeast-shore area, Prince William Sound, Alaska, 13 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	0	0.0	0	0.0	0	0.0												
4	1	0.4	0	0.0	1	0.4	151				151		226				226	
5	8	3.1	5	2.0	13	5.1	138	9	136	12	137	10	222	6	220	5	221	5
6	60	23.5	57	22.4	117	45.9	148	17	155	16	151	17	225	8	227	7	226	7
7	8	3.1	14	5.5	22	8.6	160	17	167	14	164	15	233	11	234	7	234	9
8	30	11.8	16	6.3	46	18.0	178	17	181	18	179	17	239	8	240	6	239	7
9	19	7.5	18	7.1	37	14.5	184	13	182	21	183	17	243	5	240	10	242	8
10	9	3.5	8	3.1	17	6.7	199	17	206	20	202	18	246	5	249	8	248	7
11	0	0.0	1	0.4	1	0.4			169		169				233		233	
12	1	0.4	0	0.0	1	0.4	190				190		243				243	
13	0	0.0	0	0.0	0	0.0												
Total	136	53.3	119	46.7	255	100.0	163	24	166	24	165	24	232	11	233	10	233	11
Unaged	13	44.8	16	55.2	29	100	159	21	159	14	159	17	230	14	233	14	232	14

Table 13. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from the harvest of the commercial gill net sac roe fishery at Boulder Bay, northeast-shore area, Prince William Sound, Alaska, 13 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	0	0.0	0	0.0	0	0.0												
4	1	0.2	0	0.0	1	0.2	117				117		199				199	
5	9	2.2	5	1.2	14	3.4	133	8	124	13	130	11	219	7	218	5	218	6
6	105	25.7	101	24.7	206	50.4	141	17	144	18	143	18	223	8	225	9	224	8
7	35	8.6	34	8.3	69	16.9	147	15	159	19	153	18	228	9	233	9	230	9
8	28	6.8	12	2.9	40	9.8	161	17	152	23	159	19	233	8	231	10	233	9
9	28	6.8	24	5.9	52	12.7	168	15	183	24	175	21	238	9	241	8	239	9
10	10	2.4	8	2.0	18	4.4	179	18	190	20	184	19	243	9	244	9	244	9
11	5	1.2	1	0.2	6	1.5	170	24	162		169	22	237	11	236		237	10
12	0	0.0	2	0.5	2	0.5			166	16	166	16			246	8	246	8
13	1	0.2	0	0.0	1	0.2	203				203		245				245	
Total	222	54.3	187	45.7	409	100.0	150	21	154	25	152	23	228	11	230	11	229	11
Unaged	17	41.5	24	58.5	41	100	164	28	156	30	160	29	233	11	227	11	229	11

Table 14. Estimates of the contributions of each age and year class to the herring which contributed spawn to the commercial wild spawn-on-kelp fishery in the northeast-shore area, Prince William Sound, Alaska, 21-22 April 1990.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Equivalent Harvest by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1	0			0.0	0.0	0.0	0.0
1988	2	0	0	0	0.0	0.0	0.0	0.0
1987	3	4	76	188	1.1	0.1	14.6	0.2
1986	4	5	99	202	1.8	0.2	18.3	0.3
1985	5	141	117	210	60.5	7.0	515.8	8.2
1984	6	1,190	132	217	576.1	66.8	4,353.4	69.4
1983	7	135	144	223	71.0	8.2	493.9	7.9
1982	8	94	163	234	56.0	6.5	343.9	5.5
1981	9	83	178	237	54.0	6.3	303.6	4.8
1980	10	50	178	238	32.6	3.8	182.9	2.9
1979	11	8	215	250	6.3	0.7	29.3	0.5
1978	12	2	174	235	1.3	0.1	7.3	0.1
1977	13+	2	206	247	1.5	0.2	7.3	0.1
Total		1,714	137	220	862.2	100.0	6,270.3	100.0

Table 15. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from the test fish purse seine catches at Galena Bay, northeast-shore area, Prince William Sound, Alaska, 7 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	1	0.3	0	0.0	1	0.3	89				89		192				192	
4	1	0.3	0	0.0	1	0.3	104				104		207				207	
5	17	4.4	14	3.6	31	8.0	111	12	123	21	116	17	208	7	213	11	210	9
6	127	32.6	126	32.4	253	65.0	132	20	136	18	134	19	217	9	218	8	217	8
7	24	6.2	20	5.1	44	11.3	146	21	153	24	149	23	223	10	228	13	225	11
8	20	5.1	9	2.3	29	7.5	169	28	191	31	175	30	234	14	244	9	237	13
9	12	3.1	6	1.5	18	4.6	172	23	202	26	182	27	236	9	248	8	240	10
10	7	1.8	5	1.3	12	3.1	178	24	191	33	183	27	238	7	240	13	239	9
11	0	0.0	0	0.0	0	0.0												
12	0	0.0	0	0.0	0	0.0												
13	0	0.0	0	0.0	0	0.0												
Total	209	53.7	180	46.3	389	100.0	139	27	144	28	141	27	220	12	221	13	221	12
Unaged	18	46.2	21	53.8	39	100	145	35	141	25	143	30	224	16	220	10	222	13

Table 16. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from test fish purse seine catches at Sawmill Bay, northeast-shore area, Prince William Sound, Alaska, 11 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	0	0.0	0	0.0	0	0.0												
4	1	0.7	0	0.0	1	0.7	97				97		205				205	
5	14	9.7	9	6.3	23	16.0	112	14	119	19	115	17	208	8	211	10	209	9
6	36	25.0	56	38.9	92	63.9	129	19	141	19	137	20	217	9	220	10	219	10
7	4	2.8	6	4.2	10	6.9	132	16	170	32	155	32	223	4	236	12	230	11
8	3	2.1	4	2.8	7	4.9	146	28	165	25	157	26	230	9	233	13	232	11
9	5	3.5	3	2.1	8	5.6	150	15	164	17	155	16	226	9	234	8	229	9
10	1	0.7	0	0.0	1	0.7	197				197		238				238	
11	0	0.0	2	1.4	2	1.4			188	30	188	30			241	16	241	16
12	0	0.0	0	0.0	0	0.0												
13	0	0.0	0	0.0	0	0.0												
Total	64	44.4	80	55.6	144	100.0	129	23	144	25	137	25	217	11	222	12	220	12
Unaged	3	50.0	3	50.0	6	100	155	46	156	50	155	43	227	26	225	21	226	21

Table 17. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from test fish purse seine catches at Galena and Jack Bays, northeast-shore area, Prince William Sound, Alaska, 11 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	0	0.0	0	0.0	0	0.0												
4	1	0.5	0	0.0	1	0.5	78				78		190				190	
5	9	4.4	7	3.4	16	7.8	116	16	129	18	122	17	213	6	220	13	216	10
6	83	40.7	72	35.3	155	76.0	129	17	139	17	134	18	217	8	220	7	219	8
7	9	4.4	4	2.0	13	6.4	149	24	139	16	146	22	226	9	220	8	224	9
8	6	2.9	2	1.0	8	3.9	165	17	174	6	167	15	232	7	246	18	235	11
9	5	2.5	1	0.5	6	2.9	171	29	171		171	26	219	45	240		222	41
10	2	1.0	1	0.5	3	1.5	176	40	199		183	32	240	19	251		243	15
11	0	0.0	1	0.5	1	0.5			217		217				241		241	
12	1	0.5	0	0.0	1	0.5	167				167		235				235	
13	0	0.0	0	0.0	0	0.0												
Total	116	56.9	88	43.1	204	100.0	134	24	141	21	137	23	219	13	222	10	220	12
Unaged	3	50.0	3	50.0	6	100	137	20	135	15	136	16	223	8	217	7	220	7

Table 18. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from purse seine catches in the pound fishery in Galena Bay, northeast-shore area, Prince William Sound, Alaska, 14 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	1	0.2	1	0.2	3	0.7	73		71		72	1	191		181		186	5
4	0	0.0	0	0.0	1	0.2					109						202	
5	9	2.1	13	3.1	27	6.3	109	17	114	18	114	18	209	8	210	7	211	7
6	142	33.3	133	31.2	313	73.5	125	18	129	16	128	18	217	9	219	8	218	8
7	7	1.6	11	2.6	22	5.2	125	18	144	18	139	20	218	10	230	9	227	11
8	7	1.6	10	2.3	19	4.5	139	29	169	31	156	33	224	16	243	12	234	16
9	11	2.6	9	2.1	22	5.2	168	26	187	19	176	24	238	9	240	9	238	9
10	9	2.1	4	0.9	15	3.5	165	23	200	41	176	31	237	8	245	14	240	10
11	1	0.2	1	0.2	3	0.7	197		264		229	34	246		264		257	9
12	0	0.0	0	0.0	0	0.0												
13	1	0.2	0	0.0	1	0.2	222				222		254				254	
Total	188	50.8	182	49.2	426	100.0	130	25	136	28	133	27	219	12	222	12	221	12
Unaged	7	29.2	13	54.2	24	100	129	15	140	27	133	23	223	10	223	11	222	10

Table 19. Estimates of the contributions of each age and year class to the herring used in the commercial pound spawn-on-kelp fishery in the northeast-shore area, Prince William Sound, Alaska, 11-22 April 1990.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Equivalent Harvest by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1	0			0.0	0.0	0.0	0.0
1988	2	0			0.0	0.0	0.0	0.0
1987	3	3	72	186	4.4	0.4	60.4	0.7
1986	4	1	109	202	2.2	0.2	20.1	0.2
1985	5	27	114	211	62.0	5.4	543.9	6.3
1984	6	313	128	218	807.1	70.4	6,305.6	73.5
1983	7	22	139	227	61.6	5.4	443.2	5.2
1982	8	19	156	234	59.7	5.2	382.8	4.5
1981	9	22	176	238	78.0	6.8	343.2	5.2
1980	10	15	176	240	53.2	4.6	302.2	3.5
1979	11	3	229	257	13.8	1.2	60.4	0.7
1978	12	0			0.0	0.0	0.0	0.0
1977	13+	1	222	254	4.5	0.4	20.1	0.2
Total		426	133	221	1,146.5	100.0	8,582.1	100.0

Table 20. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from purse seine catches in the pound fishery at Galena Bay, northeast-shore area, Prince William Sound, Alaska, 15 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	6	1.2	0	0.0	78	15.8	30	6			29	6	141	10			137	8
3	4	0.8	1	0.2	13	2.6	66	31	61		43	24	171	28	171		151	22
4	7	1.4	1	0.2	9	1.8	85	14	84		84	12	194	12	188		193	10
5	37	7.5	20	4.1	60	12.2	103	15	108	18	104	16	208	8	210	10	208	8
6	149	30.2	125	25.4	286	58.0	121	23	121	20	120	22	216	13	218	8	217	11
7	13	2.6	7	1.4	21	4.3	131	24	134	23	127	32	225	15	221	11	224	13
8	3	0.6	3	0.6	8	1.6	161	23	191	26	166	30	238	9	247	13	240	11
9	4	0.8	0	0.0	4	0.8	158	19			158	19	235	10			235	10
10	0	0.0	5	1.0	5	1.0			162	36	162	36			242	13	242	13
11	1	0.2	0	0.0	1	0.2	205				205		244				244	
12	0	0.0	0	0.0	0	0.0												
13	0	0.0	0	0.0	0	0.0												
Total	224	58.0	162	42.0	485	100.0	115	30	123	27	102	43	212	19	218	12	201	34
Unaged	11	37.9	14	48.3	29	100	134	19	112	26	114	34	223	9	214	14	212	24

Table 21. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from purse seine catches in the pound fishery at Galena Bay, northeast-shore area, Prince William Sound, Alaska, 20 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	3	0.9	0	0.0	3	0.9	66	4			66	4	177	5			177	5
4	1	0.3	3	0.9	4	1.1	67		96	8	89	16	181		195	12	192	12
5	14	4.0	15	4.3	29	8.2	101	15	111	15	106	16	207	8	205	9	206	8
6	141	40.1	95	27.0	236	67.0	114	15	130	17	121	18	213	9	216	9	214	9
7	12	3.4	14	4.0	26	7.4	124	29	144	27	135	29	216	12	222	15	219	14
8	9	2.6	9	2.6	18	5.1	148	26	163	33	155	30	229	16	233	13	231	14
9	12	3.4	6	1.7	18	5.1	152	24	173	23	159	25	231	9	239	8	234	9
10	7	2.0	4	1.1	11	3.1	148	15	162	35	153	24	233	9	233	17	233	11
11	2	0.6	1	0.3	3	0.9	161	34	198		173	32	233	6	240		235	6
12	3	0.9	0	0.0	3	0.9	164	11			164	11	249	10			249	10
13	0	0.0	1	0.3	1	0.3			194		194				259		259	
Total	204	58.0	148	42.0	352	100.0	119	24	134	26	125	26	215	13	218	14	216	14
Unaged	1	25.0	3	75.0	4	100	133		131	4	132	3	229		220	1	222	5

Table 22. Estimates of the contributions of each age and year class to the herring harvested by the commercial sac roe and spawn-on-kelp fisheries in Prince William Sound, Alaska, 1990.

Year Class	Age Class	Mean Weight (g)	Harvest by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1		0.0	0.0	0.0	0.0
1988	2		0.0	0.0	0.0	0.0
1987	3	73	5.5	0.1	75.1	0.1
1986	4	108	15.8	0.2	146.8	0.2
1985	5	119	664.1	6.6	5,560.1	7.7
1984	6	133	6,583.5	65.5	49,621.2	68.3
1983	7	140	827.0	8.2	5,917.9	8.1
1982	8	158	661.5	6.6	4,191.8	5.8
1981	9	182	733.2	7.3	4,025.9	5.5
1980	10	176	446.6	4.4	2,631.0	3.5
1979	11	216	68.9	0.7	319.7	0.4
1978	12	179	21.5	0.2	120.1	0.2
1977	13+	195	25.7	0.3	131.5	0.2
Total		138	10,053.2	100.0	72,641.0	100.0

Table 23. Estimates of the contributions of each age and year class to the herring harvested by the 1989 commercial food-and-bait fishery, and 1990 sac roe and spawn-on-kelp fisheries in Prince William Sound, Alaska.

Year Class	Age Class	Mean Weight (g)	Harvest by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1		0.0	0.0	0.0	0.0
1988	2	78	27.4	0.3	351.7	0.5
1987	3	92	92.9	0.9	1,004.6	1.3
1986	4	111	170.6	1.6	1,541.0	2.0
1985	5	120	898.6	8.4	7,481.9	9.6
1984	6	133	6,626.8	62.3	49,972.9	64.2
1983	7	139	858.0	8.1	6,156.6	7.9
1982	8	157	667.7	6.3	4,242.0	5.4
1981	9	182	734.7	6.9	4,038.5	5.2
1980	10	176	446.6	4.2	2,531.0	3.2
1979	11	216	68.9	0.6	319.7	0.4
1978	12	179	21.5	0.2	120.1	0.2
1977	13+	195	25.7	0.2	131.5	0.2
Total		137	10,639.2	100.0	77,891.4	100.0

Table 24. Spawning biomass estimates and indices, by area, for herring in Prince William Sound, Alaska, 1990.

Survey Area	Peak Aerial Survey Date	Spawning Biomass Estimates (tonnes)		Kilometer-days of Spawning[a]	Kilometers of Spawning[b]	Biomass of Herring per Kilometer (tonnes)		Biomass Ratio
		Peak Aerial Survey	Spawn Deposition			Peak Aerial Survey	Spawn Deposition	
Southeast-shore Area								
Simpson & Sheep Bays	16 April	0.0		0.0				
Hinchinbrook Island	14 April	63.5		1.1				
Port Gravina	31 March	217.7		3.4				
Area Total		281.2	380.0	4.5	4.2	67.0	90.5	1.35
Northeast-shore Area								
Port Fidalgo	14 April	5,171.0		38.0				
Tatitlek Narrows	11 April	11,775.3		46.0				
Valdez Arm and Port Valdez	10 & 14 April	10,922.5		17.7				
Area Total		27,868.7	48,888.0	101.7	70.4	395.9	694.4	1.75
North-shore Area								
Pt. Freemantle-Granite Pt.	10 & 14 April	1,369.9		6.0				
Granite Pt.-Esther Pass	9 & 13 April	10,523.4		29.1				
Area Total		11,893.2	13,256.0	35.2	29.3	405.9	452.4	1.11
Naked Island Area								
Naked Island	10 & 12 April	6,867.4		5.4				
Knight Island		0.0		0.2				
Area Total		9,867.4	2,877.0	5.6	8.7	789.4	330.7	0.42
Montague Island Area								
Montague Island	6 & 16 April	2,594.6		85.2				
Green Island		0.0		0.0				
Area Total		2,594.6	38,924.0	85.2	39.0	66.5	998.1	15.00
All Areas Combined		49,505.2	104,325.0	232.2	151.5	326.8	688.6	2.11

[a] The kilometer-days of spawning are measured and mapped during aerial surveys.
[b] The kilometers of spawning are measured during the spawn deposition surveys. The kilometers of spawning will usually be smaller than the kilometer-days of spawning. However, there are instances when the kilometers of spawning may exceed the kilometer-days of spawning. The kilometer-days of spawning are measured during aerial surveys and aerial surveys are not flown every day in all areas.

Table 25. Biomass estimates of herring based on aerial surveys in Prince William Sound, Alaska, 1990. Aerial surveys were not flown every day in all the areas because of limited flying time and were denoted by "NS". Aerial survey estimates that were included in the peak aerial survey estimate are denoted by an "*".

	Southeast-shore Area			Northeast-shore Area			North-shore Area		Naked Island Area		Montague Island Area		
Date	Simpson Sheep & Islands	Hinchin-Brook Island	Port Gravina	Port Fidalgo	Tatitlek Area	Valdez Arm & Port Valdez	Freemantle Granite Pt.	Granite Pt. Esther Pass.	Naked Island	Knight Island	Montague Island	Daily Survey Total	Date
03/31	NS	NS	217.7*	0.0	0.0	0.0	NS	NS	0.0	NS	0.0	217.7	03/31
04/01	NS	NS	27.2	2.7	0.0	0.0	0.0	0.0	0.0	NS	0.0	29.9	04/01
04/02	NS	NS	0.0	0.0	0.0	0.0	0.0	0.0	NS	NS	0.0	0.0	04/02
04/03	NS	NS	NS	NS	NS	0.0	0.0	NS	NS	NS	NS	NS	04/03
04/04	NS	NS	NS	NS	NS	0.0	0.0	NS	NS	NS	NS	NS	04/04
04/05	NS	NS	NS	NS	NS	NS	NS	NS	0.0	NS	0.0	0.0	04/05
04/06	NS	NS	36.3	0.0	36.3	172.4	NS	0.0	0.0	NS	235.9*	480.8	04/06
04/07	NS	NS	45.4	NS	45.4	99.8	0.0	0.0	0.0	0.0	154.2	344.7	04/07
04/07	NS	NS	72.6	0.0	72.6	326.6	NS	NS	NS	NS	NS	471.7	04/07
04/08	NS	NS	18.1	0.0	163.3	63.5	NS	0.0	2,376.8	NS	27.2	2,649.0	04/08
04/09	NS	NS	NS	NS	108.9	108.9	489.9	2,694.3	2,204.5	NS	0.0	5,606.4	04/09
04/09	NS	NS	NS	NS	95.3	1,515.0	689.5	2,921.1*	2,340.5	NS	NS	7,561.4	04/09
04/10	NS	NS	NS	NS	3,628.7	780.2	961.6*	1,052.3	3,020.9	NS	NS	9,443.8	04/10
04/10	NS	NS	NS	NS	4,526.9	9,806.7	NS	NS	NS	NS	0.0	14,333.5	04/10
04/10	NS	NS	NS	NS	11,648.3	10,441.7*	NS	NS	NS	NS	NS	22,090.0	04/10
04/11	NS	NS	NS	NS	11,775.3*	8,473.1	145.1	5,479.4	353.8	NS	0.0	26,226.7	04/11
04/12	NS	NS	NS	NS	6,994.4	2,721.6	18.1	2,494.8	6,867.4*	NS	0.0	19,096.3	04/12
04/13	NS	NS	NS	1,850.7	0.0	0.0	NS	NS	NS	NS	1,106.8	2,957.4	04/13
04/13	NS	NS	NS	NS	NS	NS	27.2	7,602.2*	186.0	NS	NS	7,815.4	04/13
04/14	NS	0.0	0.0	5,171.0*	0.0	480.8*	408.2*	1,796.2	18.1	NS	90.7	7,965.1	04/14
04/15	NS	NS	NS	535.2	9.1	31.8	NS	NS	NS	NS	NS	576.1	04/15
04/16	NS	63.5*	NS	9.1	0.0	9.1	0.0	72.6	9.1	0.0	2,358.7*	2,522.0	04/16
04/17	NS	NS	NS	18.1	18.1	0.0	NS	0.0	0.0	NS	861.8	898.1	04/17
04/18	NS	NS	NS	NS	NS	NS	NS	0.0	9.1	NS	99.8	108.9	04/18
04/19	NS	NS	NS	0.0	0.0	0.0	NS	0.0	0.0	NS	0.0	0.0	04/19
04/19	NS	NS	NS	NS	NS	NS	NS	NS	0.0	0.0	0.0	0.0	04/19
04/20	NS	NS	NS	0.0	0.0	0.0	NS	0.0	0.0	NS	0.0	0.0	04/20
04/21	NS	NS	NS	0.0	0.0	0.0	NS	0.0	NS	NS	NS	0.0	04/21
04/22	NS	NS	NS	0.0	0.0	154.2	NS	0.0	0.0	NS	0.0	154.2	04/22
04/23	NS	NS	NS	0.0	0.0	4.5	NS	0.0	0.0	NS	0.0	4.5	04/23
Number of Surveys	0	2	8	16	24	24	11	20	21	3	21	28	
Peak Aerial Estimates by Area	NS	63.5	217.7	5,171.0	11,775.3	10,922.5	1,369.9	10,523.4	6,867.4	0.0	2,594.6	49,505.2	
% of Total	0.0%	0.1%	0.4%	10.5%	23.8%	22.1%	2.8%	21.3%	13.9%	0.0%	5.2%	100.0%	
Summed by Major Area			281.2			27,868.7		11,893.2		6,867.3	2,594.6	49,505.2	
% of Total			0.6%			56.3%		24.0%		13.9%	5.2%	100.0%	

Table 26. Estimated kilometer-days of spawning by herring based upon aerial survey observations in Prince William Sound, Alaska, 1990. Aerial surveys were not flown every day in all the areas because of limited flying time and are denoted by "NS".

Date	Southeast-shore Area			Northeast-shore Area			North-shore Area		Naked Island Area		Montague Island Area	Daily Survey Total	Date
	Simpson Sheep & Islands	Hinchin-brook Island	Port Gravina	Port Fidalgo	Tatitlek Area	Valdez Arm & Port	Freemantle Granite Pt.	Granite Pt. Esther Pass.	Naked Island	Knight Island	Montague Island		
03/31	NS	NS	0.0	0.0	0.0	0.0	NS	NS	0.0	NS	0.0	0.0	03/31
04/01	NS	NS	2.4	0.0	0.0	0.0	0.0	0.0	0.0	NS	0.0	2.4	04/01
04/02	NS	NS	0.0	0.0	0.0	0.0	0.0	0.0	NS	NS	0.0	0.0	04/02
04/03	No Survey on this day												04/03
04/04	No Survey on this day												04/04
04/05	NS	NS	NS	NS	NS	NS	NS	NS	0.0	NS	0.0	0.0	04/05
04/06	NS	NS	0.0	0.0	1.6	0.0	NS	0.0	0.0	NS	0.0	1.6	04/06
04/07	NS	NS	0.8	NS	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.1	04/07
04/07	NS	NS	0.2	0.0	0.3	0.0	NS	NS	NS	NS	NS	0.5	04/07
04/08	NS	NS	0.0	0.0	0.3	0.0	NS	0.0	0.0	NS	4.8	5.2	04/08
04/09	NS	NS	NS	NS	0.8	0.0	0.0	0.0	0.0	NS	0.0	0.8	04/09
04/09	NS	NS	NS	NS	0.8	0.0	0.0	0.0	0.0	NS	NS	0.8	04/09
04/10	NS	NS	NS	NS	0.0	0.0	0.0	0.0	0.0	NS	NS	0.0	04/10
04/10	NS	NS	NS	NS	0.0	0.0	NS	NS	NS	NS	0.0	0.0	04/10
04/10	NS	NS	NS	NS	0.0	0.0	NS	NS	NS	NS	NS	0.0	04/10
04/11	NS	NS	NS	NS	0.0	0.0	0.0	0.4	0.0	NS	0.0	0.4	04/11
04/12	NS	NS	NS	NS	0.0	0.0	0.0	1.0	0.0	NS	0.0	1.0	04/12
04/13	NS	NS	NS	1.6	10.0	2.7	NS	NS	NS	NS	0.0	14.3	04/13
04/13	NS	NS	NS	NS	NS	NS	1.2	4.0	0.2	NS	NS	5.4	04/13
04/14	NS	1.1	0.0	5.6	16.9	4.3	1.6	4.8	1.6	NS	0.0	36.1	04/14
04/15	NS	NS	NS	8.9	10.9	4.3	NS	NS	NS	NS	NS	24.2	04/15
04/16	NS	0.0	NS	15.3	4.0	5.6	3.2	11.7	2.8	0.0	2.6	45.2	04/16
04/17	NS	NS	NS	5.6	0.0	0.4	NS	4.8	0.8	NS	17.7	29.4	04/17
04/18	NS	NS	NS	NS	NS	NS	NS	1.2	0.0	NS	19.3	20.5	04/18
04/19	NS	NS	NS	0.2	0.0	0.0	NS	0.0	0.0	NS	12.1	12.2	04/19
04/19	NS	NS	NS	NS	NS	NS	NS	NS	0.0	0.2	22.2	22.4	04/19
04/20	NS	NS	NS	0.8	0.0	0.0	NS	0.0	0.0	NS	0.0	0.8	04/20
04/21	NS	NS	NS	0.0	0.0	0.2	NS	1.2	NS	NS	NS	1.4	04/21
04/22	NS	NS	NS	0.0	0.0	0.0	NS	0.0	0.0	NS	3.2	3.2	04/22
04/23	NS	NS	NS	0.0	0.0	0.0	NS	0.0	0.0	NS	3.2	3.2	04/23
Number of Surveys	0	2	8	16	24	24	11	20	21	3	21	28	
Kilometer-days of Spawning by Area	NS	1.1	3.4	38.0	46.0	17.7	6.0	29.1	5.4	0.2	85.2	232.2	
% of Total	0.0%	0.5%	1.5%	16.4%	19.8%	7.6%	2.6%	12.6%	2.3%	0.1%	36.7%	100.0%	
Summed by Major Area			4.5			101.7		35.2		5.6	85.2	232.2	
% of Total			1.9%			43.8%		15.2%		2.4%	36.7%	100.0%	

Table 27. Estimates of the contributions of each age and year class to the estimated spawning biomass from spawn deposition surveys of herring in the southeast-shore area, Prince William Sound, Alaska, 1990.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Biomass by Age Class: Weight (tonnes)	Biomass by Age Class: Percent by Weight	Biomass by Age Class: Number of Fish (x 1,000)	Biomass by Age Class: Percent by Number
1989	1	0			0.0	0.0	0.0	0.0
1988	2	0			0.0	0.0	0.0	0.0
1987	3	4	76	188	0.5	0.1	6.4	0.2
1986	4	5	99	202	.8	0.2	8.1	0.3
1985	5	141	117	210	26.7	7.0	227.3	8.2
1984	6	1,190	132	217	253.9	66.8	1,918.7	69.4
1983	7	135	144	223	31.3	8.2	217.7	7.9
1982	8	94	163	234	24.7	6.5	151.6	5.5
1981	9	83	178	237	23.8	6.3	133.8	4.8
1980	10	50	178	238	14.4	3.8	80.6	2.9
1979	11	8	215	250	2.8	0.7	12.9	0.5
1978	12	2	174	235	0.6	0.1	3.2	0.1
1977	13+	2	206	247	0.7	0.2	3.2	0.1
Total		1,714[a]	137	220	380.0	100.0	2,763.5	100.0

[a] No age composition samples were collected in the southeast-shore area during 1990. Therefore, the age composition samples from the northeast-shore area were used.

Table 28. Estimates of the contributions of each age and year class to the estimated spawning biomass from spawn deposition surveys of herring in the northeast-shore area, Prince William Sound, Alaska, 1990.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Biomass by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1	0			0.0	0.0	0.0	0.0
1988	2	0			0.0	0.0	0.0	0.0
1987	3	4	76	188	63.3	0.1	829.7	0.2
1986	4	5	99	202	102.5	0.2	1,037.2	0.3
1985	5	141	117	210	3,433.2	7.0	29,247.7	8.2
1984	6	1,190	132	217	32,666.3	66.8	246,842.0	69.4
1983	7	135	144	223	4,026.4	8.2	28,003.1	7.9
1982	8	94	163	234	3,175.8	6.5	19,498.4	5.5
1981	9	83	178	237	3,059.6	6.3	17,216.7	4.8
1980	10	50	178	238	1,847.6	3.8	10,371.5	2.9
1979	11	8	215	250	356.4	0.7	1,659.4	0.5
1978	12	2	174	235	72.0	0.1	414.9	0.1
1977	13+	2	206	247	85.3	0.2	414.9	0.1
Total		1,714	137	220	48,880.0	100.0	355,535.5	100.0

Table 29. Estimates of the contributions of each age and year class to the estimated spawning biomass from spawn deposition surveys of herring in the north-shore area, Prince William Sound, Alaska, 1990.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Biomass by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1	0			0.0	0.0	0.0	0.0
1988	2	0			0.0	0.0	0.0	0.0
1987	3	0			0.0	0.0	0.0	0.0
1986	4	1	109	203	25.4	0.2	232.7	0.2
1985	5	45	112	207	1,172.8	8.8	10,471.5	10.6
1984	6	315	132	217	9,675.7	73.0	73,300.6	74.3
1983	7	36	150	225	1,256.6	9.5	8,377.2	8.5
1982	8	11	167	234	427.5	3.2	2,559.7	2.6
1981	9	14	189	244	615.7	4.6	3,257.8	3.3
1980	10	2	177	245	82.4	0.6	465.4	0.5
1979	11	0			0.0	0.0	0.0	0.0
1978	12	0			0.0	0.0	0.0	0.0
1977	13+	0			0.0	0.0	0.0	0.0
Total		424	134	218	13,256.0	100.0	98,664.9	100.0

Table 30. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from the test fish purse seine catches at Wells Bay, north-shore area, Prince William Sound, Alaska, 11 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	0	0.0	0	0.0	0	0.0												
4	0	0.0	1	0.2	1	0.2			109		109				203		203	
5	22	5.2	23	5.4	45	10.6	104	12	120	17	112	17	203	10	211	8	207	10
6	122	28.8	193	45.5	315	74.3	125	14	136	17	132	16	215	8	219	8	217	8
7	14	3.3	22	5.2	36	8.5	143	23	155	19	150	21	221	7	227	9	225	9
8	5	1.2	6	1.4	11	2.6	161	21	172	29	167	25	235	14	233	12	234	12
9	5	1.2	9	2.1	14	3.3	176	21	196	23	189	24	239	5	246	5	244	6
10	1	0.2	1	0.2	2	0.5	163		190		177	19	246		244		245	1
11	0	0.0	0	0.0	0	0.0												
12	0	0.0	0	0.0	0	0.0												
13	0	0.0	0	0.0	0	0.0												
Total	169	39.9	255	60.1	424	100.0	126	21	139	23	134	23	215	11	220	11	218	11
Unaged	11	42.3	15	57.7	26	100	141	37	133	21	137	29	221	16	218	9	219	12

Table 31. Estimates of the contributions of each age and year class to the estimated spawning biomass from spawn deposition surveys of herring in the Naked Island area, Prince William Sound, Alaska, 1990.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Biomass by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1	0			0.0	0.0	0.0	0.0
1988	2	0			0.0	0.0	0.0	0.0
1987	3	2	85	193	8.4	0.3	98.8	0.5
1986	4	3	105	202	15.6	0.5	148.2	0.7
1985	5	33	120	212	195.7	6.8	1,630.5	7.8
1984	6	318	133	218	2,089.7	72.6	15,712.1	75.2
1983	7	26	144	223	185.0	6.4	1,284.6	6.1
1982	8	10	179	236	88.4	3.1	494.1	2.4
1981	9	15	187	240	138.6	4.8	741.1	3.5
1980	10	13	192	244	123.3	4.3	642.3	3.1
1979	11	1	226	259	11.2	0.4	49.4	0.2
1978	12	1	174	241	8.6	0.3	49.4	0.2
1977	13+	1	254	265	12.5	0.4	49.4	0.2
Total		423	138	220	2,877.0	100.0	20,900.1	100.0

Table 32. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from test fish purse seine catches in the Naked Island area, Prince William Sound, Alaska, 10 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	1	0.2	1	0.2	2	0.5	85		84		85	1	191		194		193	2
4	1	0.2	2	0.5	3	0.7	116		100	8	105	11	209		199	3	202	6
5	17	4.0	16	3.8	33	7.8	121	18	120	12	120	15	214	10	210	7	212	9
6	140	33.1	178	42.1	318	75.2	128	16	137	17	133	17	216	8	220	8	218	8
7	11	2.6	15	3.5	26	6.1	139	15	148	24	144	21	222	8	225	10	223	9
8	4	0.9	6	1.4	10	2.4	151	20	198	14	179	29	226	11	242	7	236	12
9	5	1.2	10	2.4	15	3.5	172	9	195	22	187	21	232	13	243	8	240	11
10	5	1.2	8	1.9	13	3.1	186	20	196	35	192	29	243	7	245	14	244	12
11	0	0.0	1	0.2	1	0.2			226		226				259		259	
12	1	0.2	0	0.0	1	0.2	174				174		241				241	
13	0	0.0	1	0.2	1	0.2			254		254				265		265	
Total	185	43.7	238	56.3	423	100.0	131	21	143	28	138	26	218	10	222	12	220	12
Unaged	12	44.4	15	55.6	27	100	134	18	136	26	135	23	220	8	219	13	219	11

Table 33. Estimates of the contributions of each age and year class to the estimated spawning biomass from spawn deposition surveys of herring in the Montague Island area, Prince William Sound, Alaska, 1990.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Biomass by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1	0			0.0	0.0	0.0	0.0
1988	2	0			0.0	0.0	0.0	0.0
1987	3	2	79	189	115.4	0.3	1,461.2	0.5
1986	4	7	89	198	455.2	1.2	5,114.2	1.6
1985	5	43	105	209	3,298.6	8.5	31,415.7	9.8
1984	6	348	122	217	31,018.2	79.7	254,247.6	79.3
1983	7	17	126	219	1,564.9	4.0	12,420.1	3.9
1982	8	8	159	239	929.3	2.4	5,844.8	1.8
1981	9	9	155	234	1,019.2	2.6	6,575.4	2.1
1980	10	4	179	239	523.1	1.3	2,922.4	0.9
1979	11	0			0.0	0.0	0.0	0.0
1978	12	0			0.0	0.0	0.0	0.0
1977	13+	0			0.0	0.0	0.0	0.0
Total		438	121	217	38,924.0	100.0	320,001.4	100.0

Table 34. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from test fish half purse seine catches in the Montague Island area, Prince William Sound, Alaska, 17-18 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	0	0.0												
3	1	0.2	1	0.2	2	0.5	75		82		79	5	186		191		189	4
4	6	1.4	1	0.2	7	1.6	85	16	112		89	18	197	13	207		198	12
5	25	5.7	18	4.1	43	9.8	107	14	103	15	105	15	209	8	209	7	209	7
6	198	45.1	150	34.2	348	79.3	117	18	127	19	122	19	215	9	218	9	217	9
7	9	2.1	8	1.8	17	3.9	134	16	117	16	126	18	223	9	214	9	219	10
8	5	1.1	3	0.7	8	1.8	155	34	167	16	159	28	239	5	239	9	239	6
9	5	1.1	4	0.9	9	2.1	144	32	170	41	155	36	227	12	242	12	234	13
10	2	0.5	2	0.5	4	0.9	154	29	205	13	179	35	229	8	249	1	239	12
11	0	0.0	0	0.0	0	0.0												
12	0	0.0	0	0.0	0	0.0												
13	0	0.0	0	0.0	0	0.0												
Total	251	57.3	187	42.7	438	100.0	117	21	127	24	121	22	215	10	218	11	217	11
Unaged	7	63.6	4	36.4	11	100	142	46	149	56	145	47	228	19	226	20	228	19

Table 35. Age and sex composition, mean weight-at-age, and mean length-at-age of herring sampled from the test fish purse seine catches at Port Chalmers, Montague Island area, Prince William Sound, Alaska, 8 April 1990.

	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
Age	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	0	0.0	0	0.0	1	0.3					23						132	
3	3	1.0	0	0.0	3	1.0	68	6			68	6	179	7			179	7
4	4	1.3	1	0.3	5	1.6	82	28	90		84	24	190	21	198		191	19
5	14	4.6	28	9.1	42	13.7	106	9	107	17	107	14	206	9	208	10	207	10
6	107	34.9	126	41.0	233	75.9	114	15	121	18	118	17	210	8	212	8	211	8
7	4	1.3	13	4.2	17	5.5	112	15	132	18	127	19	211	10	219	6	217	8
8	1	0.3	1	0.3	2	0.7	142		153		148	8	228		225		227	2
9	1	0.3	1	0.3	2	0.7	143		202		173	42	239		251		245	8
10	2	0.7	0	0.0	2	0.7	141	16			141	16	230	4			230	4
11	0	0.0	0	0.0	0	0.0												
12	0	0.0	0	0.0	0	0.0												
13	0	0.0	0	0.0	0	0.0												
Total	136	44.4	170	55.6	307	100.0	112	18	120	20	116	20	209	11	212	10	210	11
Unaged	8	34.8	14	60.9	23	100	102	13	116	19	107	24	206	8	211	13	207	16

Table 36. Estimates of the contributions of each age and year class to the estimated spawning biomass from spawn deposition surveys of herring in Prince William Sound, Alaska, 1990.

Year Class	Age Class	Mean Weight (g)	Biomass by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1		0.0	0.0	0.0	0.0
1988	2		0.0	0.0	0.0	0.0
1987	3	78	187.6	0.2	2,396.2	0.3
1986	4	92	599.7	0.6	6,540.3	0.8
1985	5	111	8,127.0	7.8	72,992.7	8.7
1984	6	128	75,703.8	72.6	592,021.0	75.2
1983	7	140	7,064.0	6.8	50,203.7	6.2
1982	8	163	4,645.6	4.5	28,548.6	3.3
1981	9	174	4,856.9	4.7	27,924.6	3.4
1980	10	179	2,590.7	2.5	14,482.3	1.6
1979	11	215	370.4	0.4	1,721.8	0.3
1978	12	174	81.1	0.1	467.5	0.1
1977	13+	211	98.4	0.1	467.5	0.1
Total		131	104,325.0	100.0	797,865.4	100.0

Table 37. Estimates of the contributions of each age and year class to the estimated escapement biomass of herring in Prince William Sound, Alaska 1990.

Year Class	Age Class	Mean Weight (g)	Biomass by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1		0.0	0.0	0.0	0.0
1988	2		0.0	0.0	0.0	0.0
1987	3	78	188.7	0.2	2,410.8	0.3
1986	4	92	601.5	0.6	6,558.6	0.8
1985	5	111	8,187.5	7.8	73,508.5	8.7
1984	6	128	76,279.9	72.5	596,374.4	75.1
1983	7	140	7,135.0	6.8	50,796.5	6.2
1982	8	163	4,701.6	4.5	28,892.5	3.4
1981	9	174	4,910.8	4.7	28,228.5	3.4
1980	10	179	2,623.3	2.5	14,665.2	1.6
1979	11	215	376.6	0.4	1,751.0	0.3
1978	12	174	82.4	0.1	474.8	0.1
1977	13+	210	99.9	0.1	474.8	0.1
Total		131	105,187.2	100.0	804,135.7	100.0

Table 38. Estimates of the contributions of each age and year class to the estimated total spawning biomass of herring in Prince William Sound, Alaska, 1990.

Year Class	Age Class	Mean Weight (g)	Biomass by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1		0.0	0.0	0.0	0.0
1988	2		0.0	0.0	0.0	0.0
1987	3	78	193.0	0.2	2,471.2	0.3
1986	4	92	615.5	0.5	6,687.2	0.8
1985	5	112	8,791.1	7.7	75,240.9	9.0
1984	6	128	82,287.4	71.9	641,642.2	73.7
1983	7	140	7,891.0	6.9	56,220.6	6.5
1982	8	162	5,307.1	4.6	32,740.4	3.8
1981	9	175	5,590.0	4.9	31,950.8	3.7
1980	10	179	3,037.3	2.7	17,013.3	2.0
1979	11	215	439.3	0.4	2,041.5	0.2
1978	12	175	102.6	0.1	587.6	0.1
1977	13+	207	124.1	0.1	599.0	0.1
Total		131	114,378.2	100.0	870,506.5	100.0

Table 39. Estimates of the contributions of each age and year class to the estimated total biomass of herring in Prince William Sound, Alaska, 1989-1990.

Year Class	Age Class	Mean Weight (g)	Biomass by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1989	1		0.0	0.0	0.0	0.0
1988	2	78	27.4	0.1	351.7	0.1
1987	3	82	280.4	0.2	3,400.7	0.4
1986	4	95	770.2	0.7	8,081.4	0.9
1985	5	112	9,025.6	7.9	80,474.6	9.2
1984	6	128	82,330.6	71.6	641,993.9	73.3
1983	7	140	7,922.0	6.9	56,459.3	6.4
1982	8	162	5,313.3	4.6	32,690.6	3.7
1981	9	175	5,591.5	4.9	31,963.4	3.6
1980	10	179	3,037.5	2.6	17,013.3	1.9
1979	11	215	439.3	0.4	2,041.5	0.2
1978	12	175	102.6	0.1	587.6	0.1
1977	13+	207	124.1	0.1	599.0	0.1
Total		131	114,964.2	100.5	875,756.4	100.6

Table 40. Estimates of the contributions of each age and year class to the harvest, escapement biomass, total spawning biomass, and total biomass of herring in Prince William Sound, Alaska, 1990.

		Weight of Herring (tonnes)											
			1990 Sac Roe and Spawn-on-Kelp Fisheries									Estimated Exploitation Rate	
			Sac Roe Fisheries		Spawn-on-Kelp Fisheries								
Year Class	Age Class	1989 Food-and-Bait Fishery[a]	Purse Seine[b]	Gill Net	Wild[c]	Pound[d]	1990 Harvest	1989-90 Total Harvest	1990 Escapement Biomass	1990 Total Spawning Biomass	1989-90 Total Biomass	1990	1989-90
1989	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	2	27.4	0.0	0.0	0.0	0.0	0.0	27.4	0.0	0.0	27.4	0.0	100.0
1987	3	87.4	0.0	0.0	4.4	1.1	5.5	92.9	188.7	193.0	280.4	2.8	33.1
1986	4	154.8	10.6	1.2	2.2	1.8	15.8	170.6	601.5	615.5	770.2	2.6	22.1
1985	5	234.5	525.8	15.8	62.0	60.5	664.1	898.6	8,187.5	8,791.1	9,025.6	7.6	10.0
1984	6	43.3	4,993.1	207.2	807.1	576.1	6,583.5	6,626.8	76,279.9	82,287.4	82,330.6	8.0	8.0
1983	7	31.0	632.1	62.3	61.6	71.0	827.0	858.0	7,135.0	7,891.0	7,922.0	10.5	10.8
1982	8	6.2	481.6	64.2	59.7	56.0	661.5	667.7	4,701.6	5,307.1	5,313.3	12.5	12.6
1981	9	1.5	531.4	69.8	78.0	54.0	733.2	734.7	4,910.8	5,590.0	5,591.5	13.1	13.1
1980	10	0.0	331.1	29.7	53.2	32.6	446.6	446.6	2,623.3	3,037.3	3,037.3	14.7	14.7
1979	11	0.0	43.6	5.2	13.8	6.3	68.9	68.9	376.6	439.3	439.3	15.7	15.7
1978	12	0.0	17.9	2.3	0.0	1.3	21.5	21.5	82.4	102.6	102.6	20.9	20.9
1977	13+	0.0	18.8	0.9	4.5	1.5	25.7	25.7	99.9	124.1	124.1	20.7	20.7
Total		586.0	7,586.0	458.5	1,146.5	862.2	10,053.2	10,639.2	105,187.2	114,378.2	114,964.2	8.8	9.3

[a] The harvest year for the fall food-and-bait fishery actually occurred in the year prior to the harvest year listed in the table. As an example, the food-and-bait harvest in the 1988 harvest year was actually the harvest for the 1987 fall food-and-bait fishery. It was recorded this way because the management year for herring was defined to occur from 1 July through 31 June of the following year.

[b] Gear type used included purse seine, pair trawl, mid-water trawl, and otter trawl. However, since 1982 purse seines have been used exclusively.

[c] The biomass used by the wild spawn-on-kelp fishery was estimated based on a mean roe recovery of 10%, with 80% of the spawn-on-kelp harvest consisting of roe (eggs).

[d] The biomass used by the pound spawn-on-kelp fishery was estimated based on the assumption that 12.5 tonnes of herring were used to produce 1.0 tonnes of spawn-on-kelp product.

Table 41. Estimates of the contributions of each age and year class to the number of herring in the harvest, escapement biomass, total spawning biomass, and total biomass in Prince William Sound, Alaska, 1990.

		Number of Herring (x 1,000)											
			1990 Sac Roe and Spawn-on-Kelp Fisheries									Estimated Exploitation Rate	
			Sac Roe Fisheries		Spawn-on-Kelp Fisheries								
Year Class	Age Class	1989 Food-and-Bait Fishery[a]	Purse Seine[b]	Gill Net	Wild[c]	Pound[d]	1990 Harvest	1989-90 Total Harvest	1990 Escapement Biomass	1990 Total Spawning Biomass	1989-90 Total Biomass	1990	1989-90
1989	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	2	351.7	0.0	0.0	0.0	0.0	0.0	351.7	0.0	0.0	351.7	0.0	100.0
1987	3	929.5	0.0	0.0	60.4	14.6	75.1	1,004.6	2,410.8	2,471.2	3,400.7	3.0	29.5
1986	4	1,394.2	99.6	8.8	20.1	18.3	146.8	1,541.0	6,558.6	6,687.2	8,081.4	2.2	19.1
1985	5	1,921.8	4,381.6	118.7	543.9	515.8	5,560.1	7,481.9	73,508.5	78,552.8	80,474.6	7.1	9.3
1984	6	351.7	37,542.0	1,420.2	6,305.6	4,353.4	49,621.2	49,972.9	596,374.4	641,642.2	641,993.9	7.7	7.8
1983	7	238.7	4,580.7	400.1	443.2	493.9	5,917.9	6,156.6	50,796.5	56,220.6	56,459.3	10.5	10.9
1982	8	50.2	3,087.0	378.1	382.8	343.9	4,191.8	4,242.0	28,892.5	32,740.4	32,790.6	12.8	12.9
1981	9	12.6	2,887.8	391.3	443.2	303.6	4,025.9	4,038.5	28,228.5	31,950.8	31,963.4	12.6	12.6
1980	10	0.0	1,892.0	153.9	302.2	182.9	2,531.0	2,531.0	14,665.2	17,013.3	17,013.3	14.9	14.9
1979	11	0.0	199.2	30.8	60.4	29.3	319.7	319.7	1,751.0	2,041.5	2,041.5	15.7	15.7
1978	12	0.0	99.6	13.2	0.0	7.3	120.1	120.1	474.8	587.6	587.6	20.4	20.4
1977	13+	0.0	99.6	4.4	20.1	7.3	131.5	131.5	474.8	599.0	599.0	21.9	21.9
Total		5,250.4	54,869.1	2,919.5	8,582.1	6,270.3	72,641.0	77,891.4	804,135.7	870,506.5	875,756.9	8.3	8.9

[a] The harvest year for the fall food-and-bait fishery actually occurred in the year prior to the harvest year listed in the table. As an example, the food-and-bait harvest in the 1990 harvest year was actually the harvest for the 1989 fall food-and-bait fishery. It was recorded this way because the management year for herring was defined to occur from 1 July through 31 June of the following year.

[b] Gear type used included purse seine, pair trawl, mid-water trawl, and otter trawl. However, since 1982 purse seines have been used exclusively.

[c] The biomass used by the wild spawn-on-kelp fishery was estimated based on a mean roe recovery of 10%, with 80% of the spawn-on-kelp harvest consisting of roe (eggs).

[d] The biomass used by the pound spawn-on-kelp fishery was estimated based on the assumption that 12.5 tonnes of herring were used to produce 1.0 tonnes of spawn-on-kelp product.

FIGURES

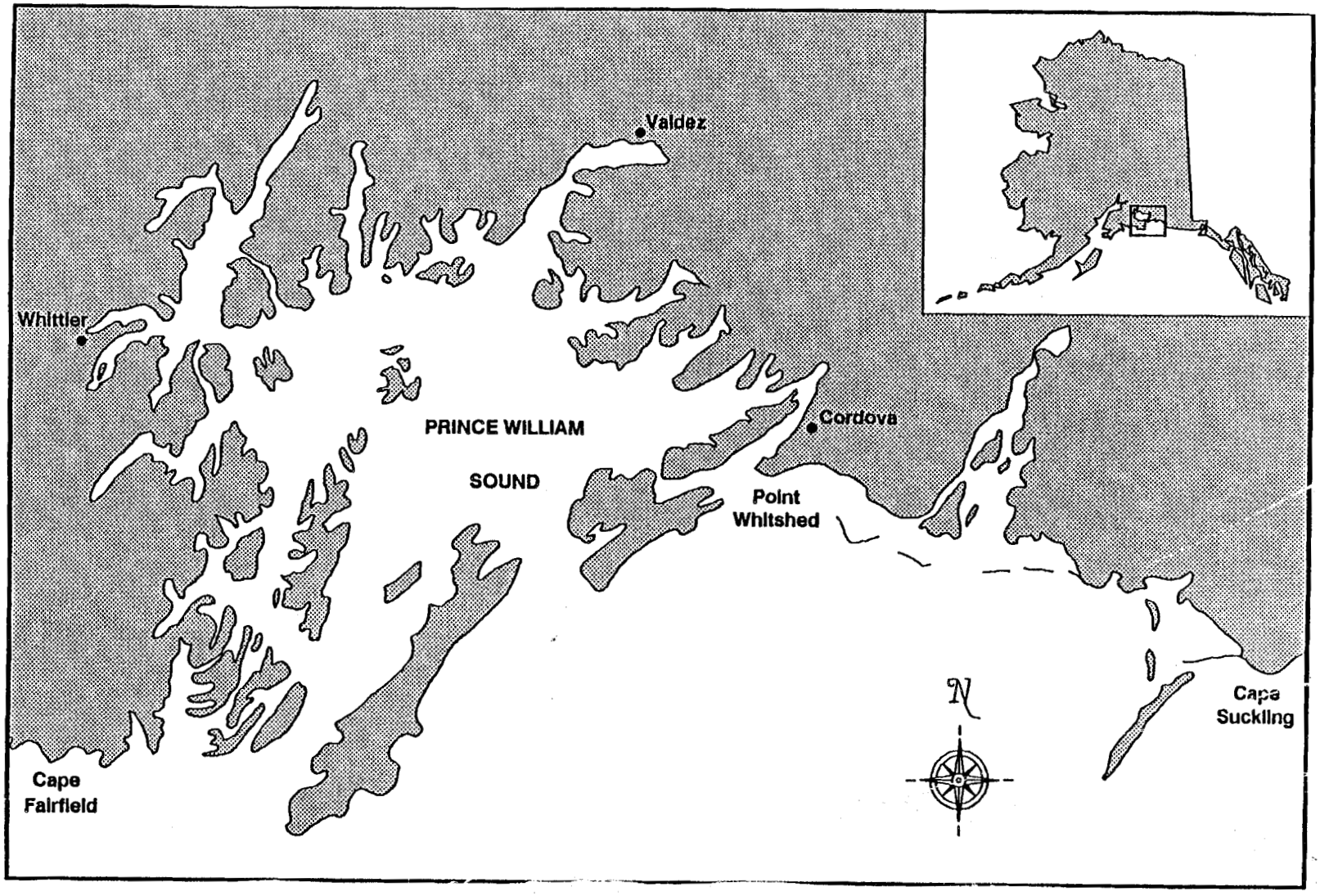

Figure 1. Map of Prince William Sound, Alaska.

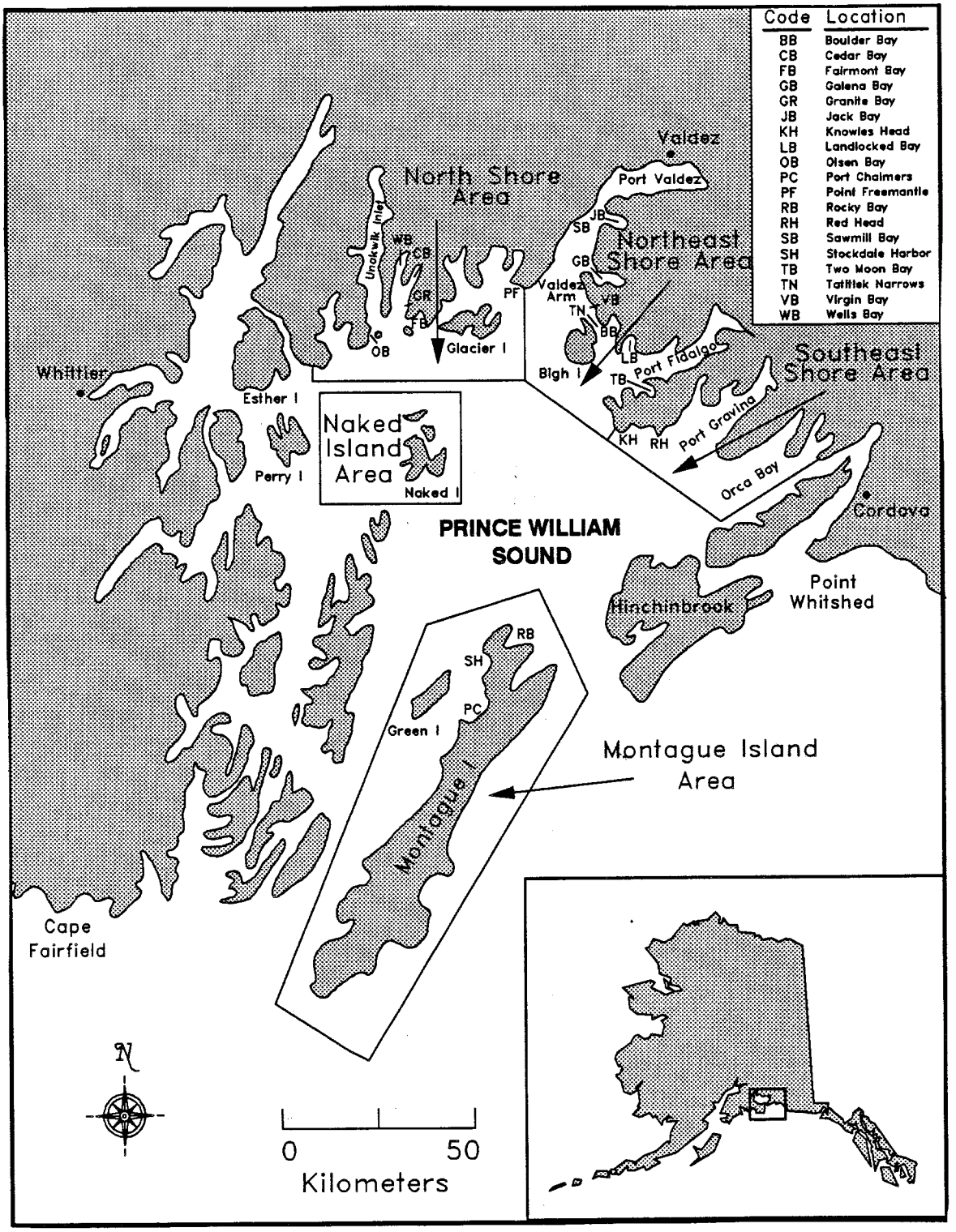

Figure 2. Location of the major spawning areas and commercial fisheries for herring in Prince William Sound, Alaska, 1990.