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PRINCE WILLIAM SOUND MANAGEMENT AREA
Scallop Fishery Review 1992-1995

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INTRODUCTION

Scallop fisheries have occurred off the coast of Alaska since the late 1960's. They have generally followed a pattern described as "boom and bust" wherein shortly after inception, harvests reach a historic high followed by several years of low or no harvest. This cycle is evidenced by the high harvests during the early fishery years including the historic high of 1.9 million pounds in 1968 and the decline to zero during the mid to late 1970's (Table 1). Beginning in 1990 harvests statewide again began approaching the historic high.

This report will provide an overview of the scallop fishery regulatory framework as it pertains to the Prince William Sound (PWS) Management Area (Figure 1), a summary of scallop biology (Kruse, 1994), and a history of the PWS scallop fishery.

In 1992 a commercial fishery for weathervane scallops *(Pecten caurinus)* began in the eastern portion of the Prince William Sound (PWS) Management Area near Kayak Island. This was the first documented harvest of weathervane scallops from the management area, although landings have occurred in the Yakutat area to the east since the late 1960's. Subsequent to the 1992 fishery, harvests in the PWS Management Area occurred in 1993 and 1995.

In 1993 the Alaska Department of Fish and Game (ADF&G) implemented a statewide interim management plan and associated regulations for the commercial harvest of scallops under the Alaska Commercial Fishing regulation 5 AAC 39.210. Management Plan for High Impact and Emerging Fisheries. This significantly altered the prosecution of commercial scallop fisheries in Alaska. Impetus for development of the plan was threefold. First, harvests were near levels achieved prior to the fishery's collapse in the late 1970's. Secondly, the proportion of small scallops comprising the catch was increasing, and finally, interest among prospective fishery participants was increasing (Kruse, 1994).

In 1994 the Alaska Board of Fisheries (BOF) adopted the statewide scallop management plan and regulations. Plan objectives were the basis for the regulatory framework. They addressed:

1) Biological conservation of scallop stocks.
2) Bycatch of other species and gear induced habitat alteration.
3) Sustainable and orderly fisheries that promote long-term economic and social benefits received from stable landings of high quality large scallops.
4) Maintenance of resource availability to subsistence users.
5) Fishery research to increase the information base for future management decisions.

SCALLOP REGULATIONS

Key regulatory components of the PWS portion of the Statewide Scallop Management Plan adopted by the Alaska BOF in 1994 include:

1. Area registration.
2. Gear requirements including 4" ring size and a limit of 2 dredges per vessel.
3. 50,000 pound meat weight guideline harvest level (ghl).
4. Bycatch caps of 500 and 130 Tanner crabs east and west of 147°00' W. longitude.
5. Season opening date of January 10 with closure set by emergency order.
6. Industry-funded Observer Program.
7. Crew size limit of 12.
8. Ban on automatic shucking machines.
9. Waters closed to scallop fishing.

The intent of these regulations is to meet plan objectives relating to the prosecution of a sustainable and orderly fishery while addressing biological and bycatch concerns.

The industry funded Observer Program is the primary tool used to meet the aforementioned objectives. It provides increased accuracy of catch and bycatch reporting in addition to the collection of biological information on scallops within management areas. It functions as both a management and research tool. In the PWS Management Area all vessels must have observers.

Regulations governing the Onboard Observer Program are found under 5 AAC 39.141, 39.142, 39.143, and 39.645. Additionally, the responsibilities of the department, vessel operators, observers, and contractors are outlined in the ADF&G Scallop Observer Manual. Observers must be hired from an approved third party observer contractor. Vessel operators are responsible for procuring observers from the contractors. In addition to other requirements, each observer must successfully complete a department approved scallop training course prior to deployment.

Observers receive a pre-fishery briefing and a post-fishery debriefing. At the pre-fishery briefing, observer sampling goals and methods are reviewed and special data collection projects assigned. Observers routinely collect data on total catch, haul composition, crab and halibut bycatch, scallop shell height, and estimated shell age. Additionally, observers are expected to detail all aspects of fishing and processing operations via photograph, sketch, and written description. Special projects are intended to expand available knowledge of scallops or the fishery and are conducted in addition to regular sampling. They may include collection of small scallops which are less worn and therefore provide better indication of the first annulus, sampling for meat weight to whole weight relationship, or determining the amount of discards.

Specific daily data collection goals for observers include the following:

1) Measure shell height and age 100 shells from the retained catch.
2) Sample six tows for crab and halibut bycatch, documenting size and condition of these species.
3) Sample two tows for total species composition.
4) Collect and age 50 shells from the retained catch.

Observers are required to make regular contact with the department during the fishery. These contacts provide important management information such as catch, catch location, and bycatch. This provides managers "real time" data on which to base decisions regarding the fishery.

At the post-fishery debriefing, observers are interviewed, all data are submitted to the department, sampling forms are reviewed for completeness and accuracy, and observers are evaluated on job performance.

SCALLOP BIOLOGY

Kruse provided an overview of weathervane scallop biology and life history in the Draft Fishery Managment Plan for Commercial Scallop Fisheries in Alaska (1994). His overview is reproduced here.

Species

The primary pectinid harvested in Alaska is the weathervane scallop. Sporadic attempts have been made to harvest the pink scallop *(Chlamys rubida)*, arctic pink scallop *(C. pseudoislandica)* and spiny scallop *(C. hastata)*. Because *Chlamys* species account for little of the overall landings, only the weathervane scallop is considered in this section.

Distribution

Weathervane scallops are distributed from Point Reyes, California to the Pribilof Islands, Alaska, in the Bering Sea (BS). The highest known densities in Alaska occur along the eastern Gulf of Alaska (GOA) from Cape Spencer to Cape St. Elias, and in the western GOA off Kodiak Island, Unalaska Island (Aleutian Islands) and in the BS (Kaiser 1986; Foster 1991). Lesser concentrations occur in Southeast Alaska, Prince William Sound, lower Cook Inlet, and along the Alaska Peninsula and other Aleutian Islands. Scallops are found from intertidal waters and to 300 m (985 feet) on beds of mud, clay, sand, and gravel (Hennick 1973). Similar to patterns documented for other scallop species (Caddy 1989; Robert and Jamieson 1986), beds tend to be elongated along the direction of current flow, and aggregations often represent different age or size groups. A combination of large-scale (overall spawning population size and oceanographic conditions) and small-scale processes (site suitability for settlement) influence recruitment of scallops to these beds (Orensanz 1986).

Reproduction and Early Life History

With rare exception (Hennick 1971), the sexes are separate. Mature males and females are distinguishable: female gonads are pink or orange-red whereas gonads of males are creamy white (Haynes and Powell 1968; Robinson and Breese 1984). The spawning season varies with depth (MacDonald and Bourne 1987) and latitude. Spawning occurs from mid-January to July off Oregon (Robinson and Breese 1984; Starr and McCrae 1983) and from mid-April to mid-June in the Strait of Georgia, British Columbia (MacDonald and Bourne 1987). In Alaska weathervane scallops appear to mature in mid-December to late January and spawn from June to early July (Hennick 1970a).

External fertilization takes place after release of gametes into the sea (Cragg and Crisp 1991). At 14°C, fertilized eggs of weathervane scallops develop to the veliger larval stage by 72 h (Bourne 1991). Larvae are pelagic and drift with ocean currents until metamorphosis to the juvenile stage at age 30 d (Bourne, 1991). Metamorphosis includes loss of the velum, development of an operational gill system, and commencement of filter feeding (Cragg and Crisp 1991). Within a few months the shell becomes pigmented, and juveniles begin to more closely resemble the adults.

Growth

Generally, many juvenile scallops mature by age 3 at about 7.6 cm (3 inches) in shell height (SH), and virtually all scallops are mature by age 4 (Haynes and Powell 1968; Hennick 1970b, 1973). Growth is most rapid during the first 10-11 years (Hennick 1973). The largest recorded specimen measured 250 mm (9.8 inches) SH and weighed 340 grams (12 ounces, Hennick 1973).

As with other scallop species (Orensanz 1986; Caddy 1989), growth, maximum size, and size at maturity of weathervane scallops vary significantly within and between beds and geographic areas (Haynes and Hitz 1971; MacDonald and Bourne 1987). Differences may be due to density-dependent growth and mortality (Orensanz 1986) or spatial variation in temperature or feeding conditions (MacDonald and Thompson 1985).

Based on von Bertalanffy growth estimates (Kaiser 1986), weathervane scallops from Marmot Flats off the northeast side of Kodiak Island achieve 131 mm (5.2 inches) SH at age 4 and reach an asymptotic maximum size, $L\infty$, of 190 mm (7.5 inches) SH. On the other hand, scallops from Cape St. Elias to Cape Fairweather in the eastern GOA reach only 91 mm (3.6 inches) SH at age 4 and attain $L\infty$ = 144 mm (5.7 inches) SH. That is, weathervane scallops off the northeast side of Kodiak grow faster and reach larger sizes than scallops off Yakutat.

Longevity and Natural Mortality

Weathervane scallops are long-lived; individuals may live 28 years old or more (Hennick 1973). Weathervane scallops possess low rates of natural mortality. I conducted a preliminary investigation of scallop natural mortality. I used a variety of estimation methods including those of Alverson and Carney (1975), Beverton (1963), Hoenig (1983), Gunderson (1980), and Gunderson and Dygert (1988). These procedures are based on life history features, such as estimates of maximum age, gonad-somatic weight indices, and growth parameters. Resultant estimates of instantaneous natural mortality (M) ranged between 0.04 and 0.25. These correspond to annual mortality rates of 4-22%.

Based on a maximum age of 28 (Hennick 1973), Hoenigs's (1983) method resulted in a median estimate of M = 0.16 corrresponding to 15% annual mortality.

Stock Structure

The stock structure of weathervane scallops has not been studied. Until a decade ago, a widely-held view among benthic ecologists was that, in general, invertebrate species have "open" populations that are well-connected to other, geographically-distinct populations by advection of pelagic larvae (Sinclair 1988; Orensanz et al. 1991). Indeed, given the 30-d larval period of weathervane scallops, it may have seemed logical to suggest that scallop populations are well-connected throughout the GOA by larval drift caused by the Alaska Current and Alaska Stream which flow in a counter-clockwise direction around the gulf.

Although there is evidence that populations of some invertebrate species are well-connected through larval dispersal, for a number of other species there is growing evidence that invertebrate megapopulations are actually comprised of multiple discrete, self-sustaining populations (Sinclair 1988; Orensanz et al. 1991). Sinclair et al. (1985) suggested that three species of scallop, *Chlamys opercularis, Pecten maximus,* and the Atlantic sea scallop, *Placopecten magellanicus,* in the North Atlantic Ocean were composed of a number of discrete, self-sustaining populations. From Virginia to Newfoundland there are at least 19 discrete concentrations of Atlantic sea scallops that may be self-sustaining populations (Sinclair 1988).

Sinclair's hypothesis about relatively discrete, self-sustaining populations is supported by recent studies. Based on extensive sampling of sea scallop larvae, Tremblay and Sinclair (1992) concluded that larval exchange between Georges Bank and the Scotia Shelf was extremely limited. More recently, McGarvey et al. (1993) estimated stock (egg production) recruitment relationships that provided evidence of further population subdivision on Georges Bank itself.

Despite a long pelagic larval stage ($\approx$60 d) a study of genetic differentiation of the Iceland scallop *(Chlamys islandica)* provided strong evidence for restricted gene flow in the northeast Atlantic Ocean (Fevolden 1989). A high degree of allozyme polymorphism and heterogeneity among scallop sampled from northern Norway, Bear Island, Jan Mayen Island and Spitzbergen Island lead Fevolden (1989) to conclude that each area should be treated as discrete genetic units for management purposes.

Caddy (1989) concluded that it is reasonable to assume that historically-maintained centers of scallop concentrations are self-sustaining populations. Further, he recommended that these commercially-important scallop beds should compose the unit stock upon which management measures are based. Caddy (1989) noted that a scallop fishing ground may contain several beds of high scallop density that are surrounded by a number of low-density scallop fishing areas.

1992 FISHERY

Although scallop fishing permits were issued in previous years, 1992 was the first year in which documented landings occurred from the PWS Management Area.

The 1992 harvest of weathervane scallops in the PWS Management Area totalled 208,836 lb of meats taken by 4 boats. This poundage equates to approximately 2.1 million lb whole scallop weight. Average catch per hour towed ranged from 85 to 340 lb in meat weight. Tow length ranged from 30 to 60 min. The commissioner's permit was the management tool used to require fishermen to submit logbooks and weekly catch reports. There were no observers aboard vessels because at that time there was no regulation requiring observers in the fishery. Harvest occurred from two statistical subareas (202-09 and 202-10) in the Kayak Island vicinity with virtually all of the harvest coming from federal waters outside the three mile limit (Figure 2). The waters of PWS itself and nearshore Gulf of Alaska (GOA) waters remained closed to scallop dredging due to department bycatch concerns for depressed Tanner and Dungeness crab stocks. Fishing began in late February and closed by emergency order on April 23. The closure was based upon an allowable harvest of 64,000 lb meat weight. The allowable harvest was set via an inseason area swept scallop biomass estimate utilizing fishery performance data and applying a 10% harvest rate. This harvest rate was identical to that specified by the Board of Fisheries for the Cook Inlet scallop fishery.

Vessel length ranged from 74 to 147 ft. Each towed two 15 ft New Bedford style dredges. Participants delivered both fresh and frozen product. The average price was $3.98 per lb making the fishery worth approximately $831,000.

The discrepancy between allowable (64,000 lb) and actual harvest (208,836 lb) was attributed to a lack of timely and accurate catch reporting. As the fishery progressed, both effort and the fishing area increased. Information gathering was difficult because the majority of landings occurred at a port with no department staffing. Collection of inseason data was accomplished by weekly radio reports yielding estimated catch; however, actual catch by each vessel was not ascertained until the time of landing. Estimated catch errors from radio reports were not evident in some cases for up to 2 weeks. The time delay was attributable to fishing trip length and the time necessary for a fish ticket to arrive via mail. Additionally, fishing logs were largely incomplete to non-existent. By the time that the department had sufficient information to develop the inseason biomass estimate and set the allowable harvest, the catch had progressed to an estimated 150,000 lb. When the fishery closed by emergency order 3 days later the total harvest was approximately 209,000 lb meat weight.

After Kayak Island closed, participants expressed an interest in exploratory fishing in the western GOA portion of the area. Eventual effort in the area was low with only two participants and no reported harvest.

1993 FISHERY

Prior to the 1993 fishery the state implemented the interim Fisheries Management Plan and associated regulations. The interim management plan was identical to the 1994 plan eventually adopted by the BOF except that season dates and closed waters were set by emergency order rather than by regulation.

Prior to fishing, each vessel was required to register and each observer was briefed. Radio contacts were made twice daily with each observer reporting fishing area, number of tows, sampling intensity, crab bycatch, and scallop catch.

Two fishing areas were established within the PWS Management Area (Figure 3). The eastern area had a ghl of 50,000 lb meat weight. The western area was formed to provide further opportunity for exploratory fishing with an initial ghl of 5,000 lb.

The 1993 scallop fishery in the PWS management area opened on July 15 at 12:00 noon. The entire scallop harvest of 63,068 lb meat weight was taken by 7 vessels fishing in the eastern area. Harvest was reported from two statistical areas (202-09; 202-10). Catch per tow-hour averaged 197 lb meat weight. Tow length averaged 51 min. The fishery closed in the eastern area by emergency order on July 18, 1993 at 7:00 a.m. resulting in a fishery duration of 67 h (2.8 d). Length of the 7 vessels participating in the fishery ranged from 81 to 145 ft. All participants were catcher-processors and each towed two 15 ft New Bedford style dredges.

Observer information indicated that fishing practices vary between vessels. Because the ghl was relatively low given the number of participants, a variety of strategies was utilized to maximize production over the short term. Strategies included fishing intensively to obtain a deck load (shellstocking) and laying to for processing as well as varying watch lengths.

Crab and halibut bycatch in the fishery was extremely low with 69 Tanner crabs and less than 30 halibut reported. Crab size averaged 23 mm. Halibut length averaged 70 cm.

Length frequency data from the retained catch indicated a fairly narrow range of sizes and ages occurred in the fishery (Figure 4). Additionally, observer reports indicated very few scallops below 100 mm in shell height. Laboratory aging of scallops from the 1993 shell collection has not been completed. The 1993 shell collections will be processed after the 1995 fishery shell collections are processed.

Four vessels made tows in the western Gulf area after the eastern area closed. Observer reports from this area indicated very little bycatch and no catch of scallops.

1995 FISHERY

The Scallop Fishery Management Plan ultimately adopted by the Alaska BOF during the spring 1994 meeting changed the PWS Management Area regulatory season opening date to January 10. Therefore, in order to avoid harvesting scallops twice during the same spawning cycle, the scheduled July 1994 season was delayed to January 1995. The plan also established areas closed to scallop dredging (Figure 5).

The PWS Management Area opened to scallop fishing at 12:00 noon on January 10, 1995 with a 50,000 lb ghl (meat weight). Two vessels, both catcher-processors, participated in the fishery. The actual catch is confidential. The harvest, however, was within 10% of the ghl. The department's policy on confidentiality states that any time a fishery or statistical area has fewer than 3 participants, catch information may not be made public. Catch per tow-hour averaged 219 lb meat weight. Average tow duration was 54 min. Identical to other seasons, harvest occurred in two statistical subareas (202-09, 202-10).

Observer data including shell aging from the 1995 fishery are not available as of this report. These data will be reported at a later date.

1995 ILLEGAL HARVEST

Following the 1995 scallop fishery an unlicensed, unregistered scallop vessel fished in the federal waters off Kayak Island. The estimated subsequent harvest from the area was a minimum of 60,000 lb meat weight. The resultant 1995 harvest, both legal and illegal, was approximately 110,000 lb meat weight.

Department concerns for overharvest due to the illegal fishing may result in closure of the 1996 PWS scallop fishery. Kruse (1994) indicates that on a worldwide basis, few scallop fisheries have escaped overfishing; subsequent stock recovery has been slow to non-existent. Overfishing can lead to long-term recruitment failure when stocks are reduced to such low levels that insufficient young are produced to eventually maintain recruitment.

FUTURE MANAGEMENT

Many factors influence the management strategy for a species. Some of these factors are life history, species mobility, gear efficiency, and effort. Weathervane scallops are long lived, experience low natural mortality, and are not mobile over long distances. Species with these life history characteristics cannot be harvested at a rate as high as species with a shorter life

cycle and higher natural mortality. The relatively low degree of mobility facilitates removals once beds are located.

There are no data in the literature to indicate what efficiency is associated with the New Bedford style dredge on weathervane scallops. These data are available, however, for the New Bedford style dredge and Atlantic sea scallop *(Placopecten magellanicus)* combination and indicate an efficiency of 20%. This figure only accounts for direct fishing mortality. In addition to direct fishing mortality, evidence is strong that higher indirect mortality is associated with two types of events:

1) Scallops that are caught but discarded. These discards are held on deck for varying amounts of time. Air exposure, temperature, and crushing during gear operations increase mortality. In fisheries where shellstocking occurs or scallop size is small this type of mortality will be higher. Shellstocking and subfreezing temperatures occur during the PWS fishery and contribute to indirect mortality.

2) Scallop/gear interactions on the bottom. This includes stress from fishing activity as well as injury through dredge contact (McLoughlin et al. 1991).

The 1993 length frequency data indicated a relatively narrow size range of scallops from the Kayak Island area. This is an indication of irregular recruitment and further supports a conservative harvest approach for this long lived species. Developing a harvest strategy that utilizes a biomass estimate and application of a conservative harvest rate (10%) will contribute to the long term sustainability of the scallop fishery in the PWS management area.

During the summer of 1995 the department will conduct an assessment of the Kayak Island scallop stock and develop a biomass estimate. Details are included in the Prince William Sound Area Scallop Assessment Project Operational Plan (Trowbridge, 1995). The resultant data, in conjunction with historical stock descriptors, will be used to develop a management strategy for future PWS Management Area scallop fisheries.

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Table 1. Historical number of vessels, number of landings, and landed weight of shucked meats for the weathervane scallop fishery in Alaska during 1967-1993. 1 (Kruse 1994).

Year	Number of vessels	Number of landings	Landed weight (lb)
1967	--	--	--
1968	19	125	1,677,268
1969	19	157	1,850,187
1970	7	137	1,440,338
1971	5	60	931,151
1972	5	65	1,167,034
1973	5	45	1,109,405
1974	--	--	--
1975	4	56	435,672
1976	--	--	--
1977	--	--	--
1978	0	0	0
1979	--	--	--
1980	8	56	632,535
1981	18	101	924,441
1982	13	120	913,996
1983	6	31	194,116
1984	9	61	389,817
1985	8	54	647,292
1986	9	86	682,622
1987	4	55	583,043
1988	4	47	341,070
1989	7	54	525,598
1990	9	144	1,488,642
1991	6	125	1,136,649
1992	7	137	1,810,788
1993	11	155	1,428,976

1 Data for 1967-1993 were taken from the Kaiser (1986), data for 1993 come from regional offices of ADF&G and all other data were summarized from ADF&G fish ticket files. In years when less than four vessels participated in a fishery data are confidential. (Kruse 1994).

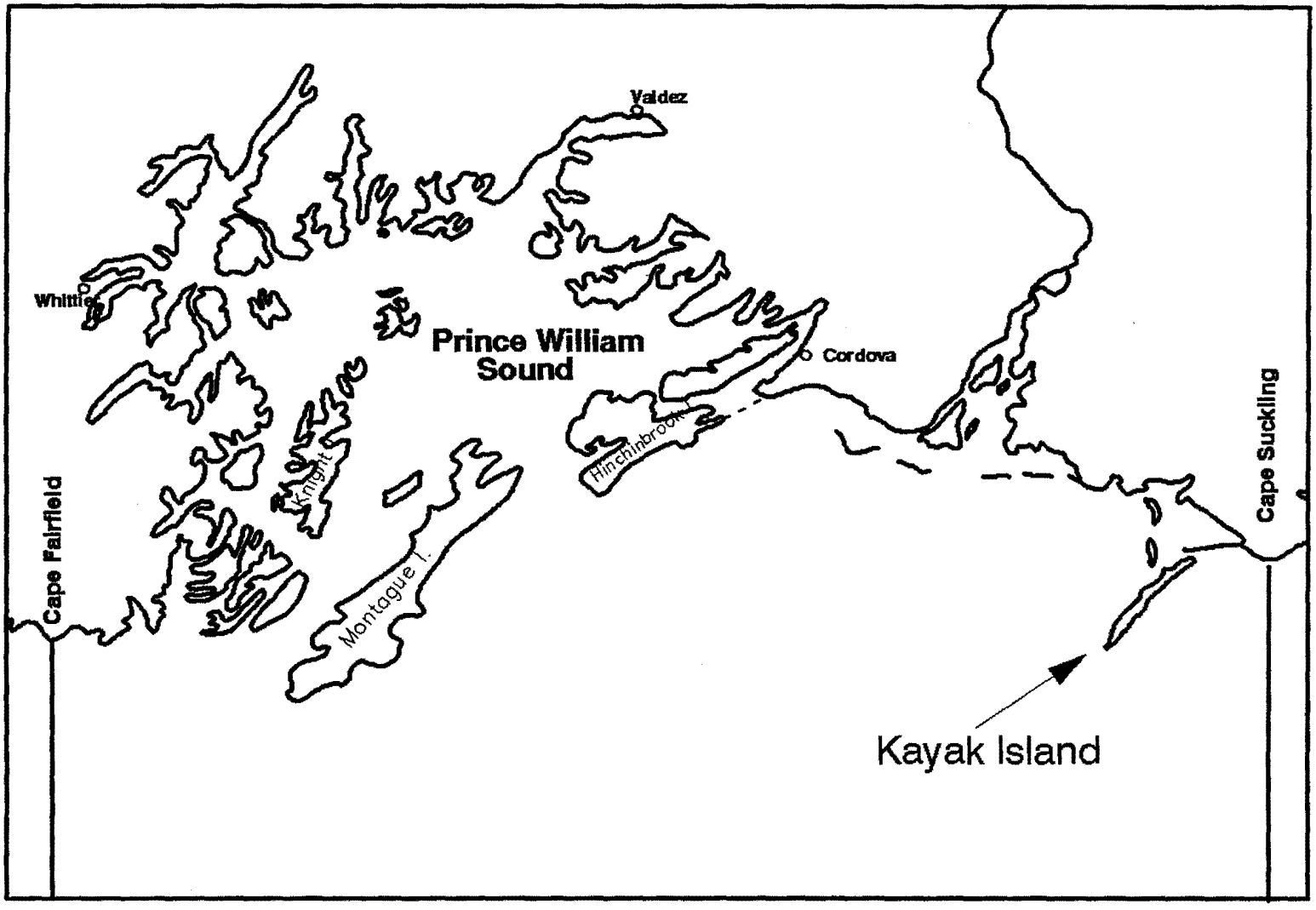

Figure 1. Prince William Sound Management Area.

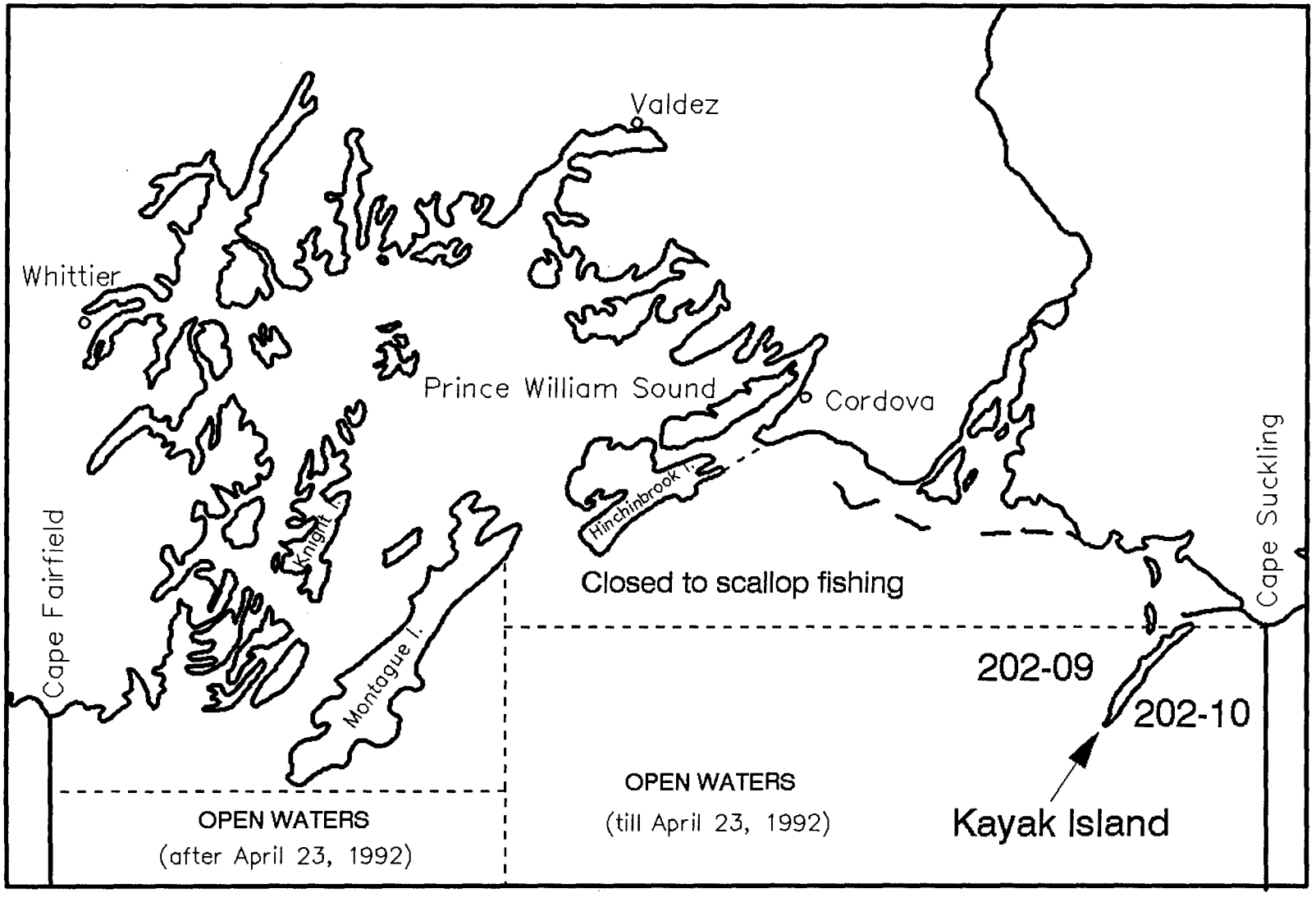

Figure 2. Prince William Sound scallop fishing areas and dates in 1992.

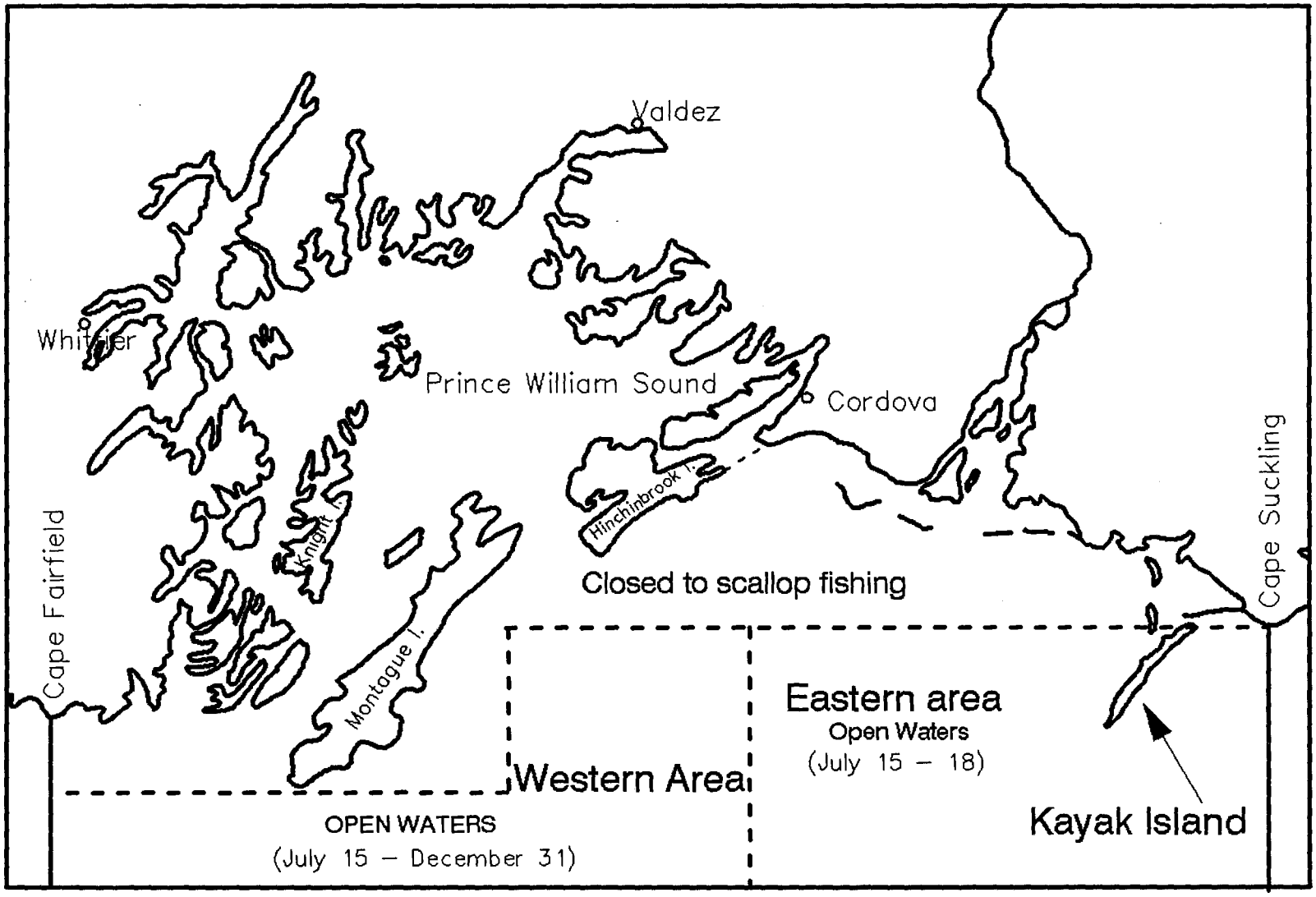

Figure 3. Prince William Sound scallop fishing areas and dates in 1993.

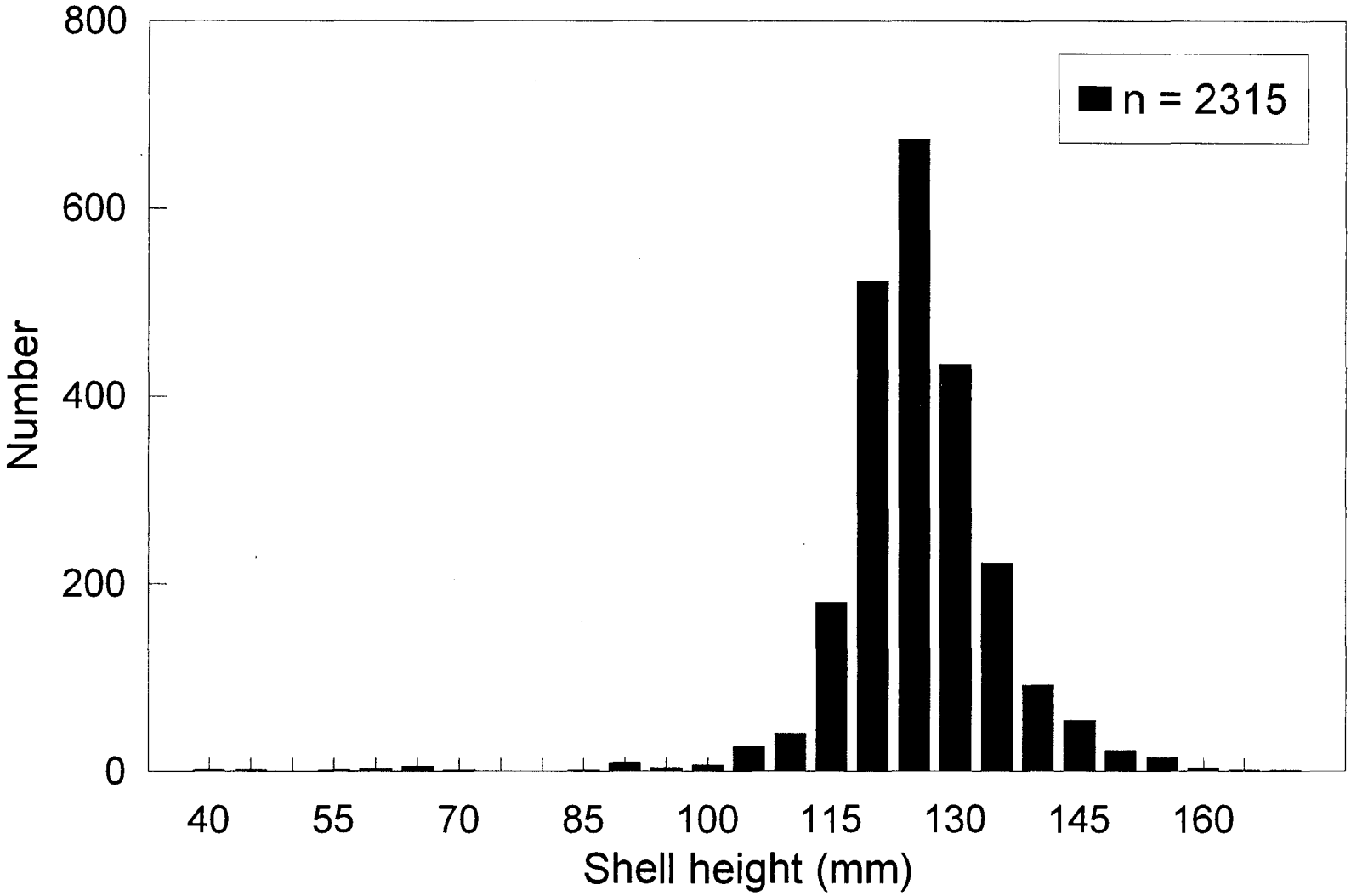

Figure 4. Size frequency of scallops from the 1993 PWS fishery.

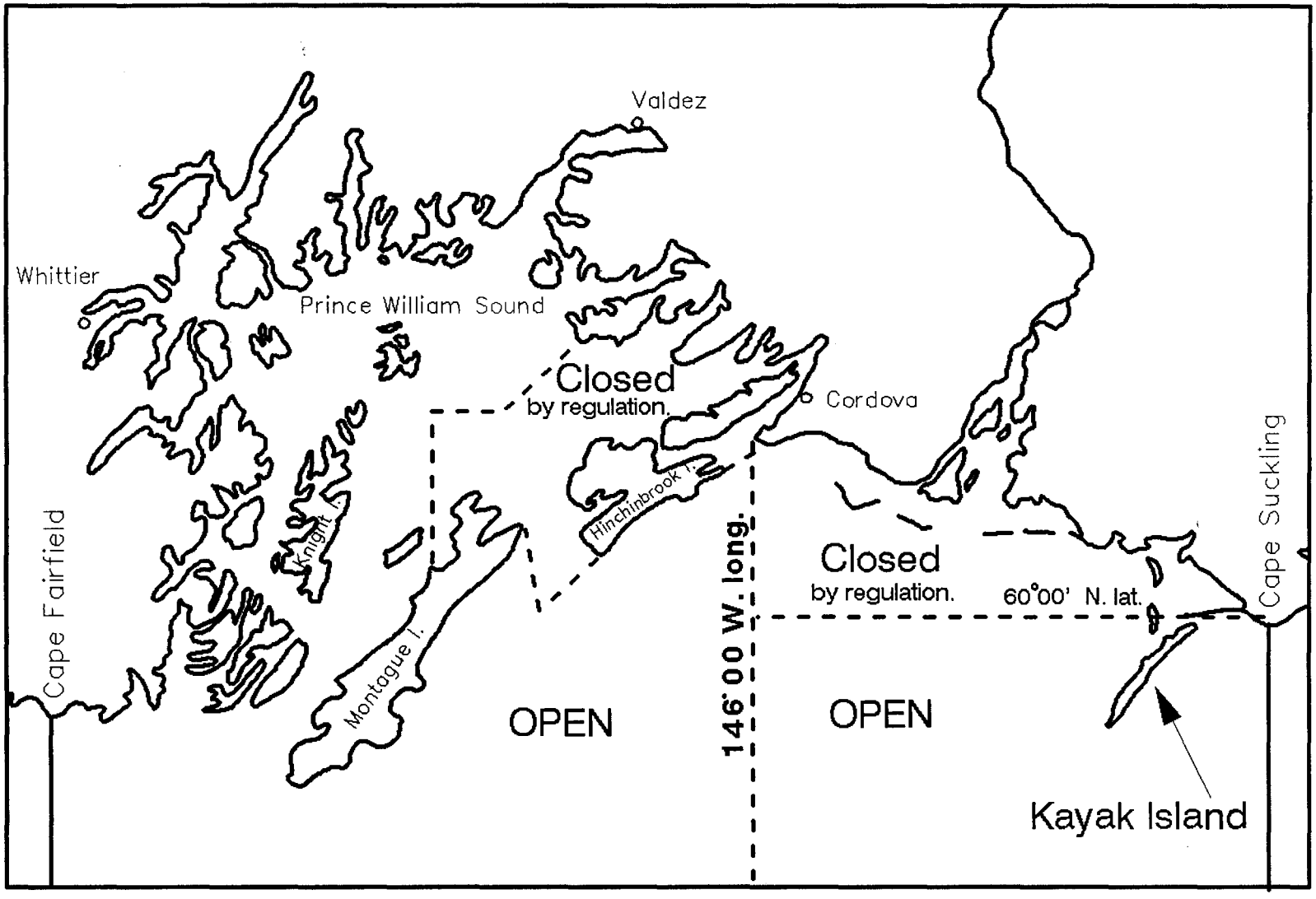

Figure 5. Prince William Sound scallop fishing areas in 1995.