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FISHERY MANAGEMENT PLAN

FOR COMMERCIAL SCALLOP FISHERIES IN ALASKA

By

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FISHERY MANAGEMENT PLAN FOR COMMERCIAL SCALLOP FISHERIES IN ALASKA

EXECUTIVE SUMMARY

Purpose

The purpose of this document is to describe a comprehensive fishery management plan (FMP) for commercial scallop fisheries in the state of Alaska. Recent growth in the fishery prompted concerns particularly regarding resource conservation of scallops and incidentally-caught species, and no formal FMP existed to address these issues. To develop a sound FMP, principal factors that were considered were fishery history, biology and life history of weathervane scallops, resource conservation concerns, management goal and objectives, and management measures and associated regulations. This draft FMP will be presented to the Alaska Board of Fisheries (BOF) for review at their March 1994 meeting in Anchorage. If adopted, the FMP will be updated to reflect any additional BOF actions. Although modifications to the final plan and accompanying regulations can be made through future deliberations of the BOF, the FMP is intended as a description of the state's long-term management strategy for Alaskan scallop fisheries.

Fishery History

Weathervane scallop *(Patinopecten caurinus)* resources in Alaska were first explored by a few vessels in 1967. A major fishery soon developed when 19 vessels made 125 landings totalling 1.7 million pounds of shucked meats in 1968 and 157 landings totalling 1.9 million pounds in 1969. Landings from the early fishery were predominated by old scallops (7^+ years of age), but by the early 1970s the age composition began to shift toward younger ages (2- to 6-year-olds) as the largest scallops were cropped from previously unexploited stocks. During 1970-1989, participation and catches fluctuated at much lower levels than during the initial years of the fishery. On average, six vessels contributed 52 landings totalling 587,000 pounds annually during this 20 year period. During 1976-1979, landings averaged just 77,941 pounds annually. More recently, significant increases in deliveries and total landings occurred. On average, eight vessels made 133 landings weighing 1.5 million pounds annually during 1990-1992. The 1992 harvest of 1.8 million pounds was just 40,000 pounds short of the record harvest taken from virgin stocks in 1969.

Management Concerns

During 1992, concerns arose about conservation of scallop resources for several reasons. First, recent harvests were at levels comparable to those taken in the late 1960s and early 1970s which proved not to be sustainable by the fishery. Reduced scallop abundance was at least partly responsible for the fishery collapse in the 1970s. Second, during 1992, limited inseason catch reports from some areas indicated that small scallops were constituting an increased portion of landings as had occurred prior to the fishery decline in the mid-1970s. Removal of the older age groups by high harvest rates leads to a recruit-only fishery. For species with sporadic recruitment such as weathervane scallops, a recruit-only fishery experiences highly variable catches and the stocks are very vulnerable to collapse. A third concern was that interest among prospective participants was increasing rapidly. In 1993, 32 permits were issued and 11 vessels fished for scallops. This growth occurred despite considerable uncertainty about the ability of the weathervane scallop resource to support an economically viable fishery with increased participation. Last, the expanded scallop fishery heightened concerns about bycatch impacts on depressed stocks of king *(Paralithodes camtschaticus)* and Tanner crabs *(Chionoecetes bairdi)*.

Enabling Regulation

Given the growth of the scallop fishery and associated issues, it became readily apparent that a fishery management plan was required. Unfortunately, due to a three-year meeting cycle, scallop management was next scheduled for deliberation by the BOF in spring 1994. However, regulation 5 AAC 39.210 (Appendix A) permitted the Alaska Department of Fish and Game (ADF&G) to develop interim management plans and associated regulations for fisheries that meet at least one of four conditions of a high-impact emerging fishery: (1) harvesting effort has recently increased beyond a low sporadic level, (2) the resource is harvested by more than a single user group, (3) harvests approach levels that might not be sustainable on a local or regional level, and (4) the BOF has not developed comprehensive regulations to address issues of conservation, allocation, and conduct of an orderly fishery. ADF&G found that these conditions applied to the weathervane scallop fishery.

Schedule for Implementation

In July 1992, ADF&G published a report of scallop management options for public review. The report described a range of management options from passive to active inseason management. Valuable comments were received from members of the fishing and scientific communities during the ensuing two month review period. These comments, plus ADF&G staff analyses, were carefully considered, and an executive summary of a draft interim management plan was released for public comment in January 1993. The draft plan was presented at the January meeting of the North Pacific Fishery Management Council (NPFMC). During February 1993, the BOF adopted two new regulations: a ban on automatic shucking machines and a limit of 12 crew members per vessel. The interim management plan and associated fishing regulations became effective in June 1993. Since then, bycatch caps for king and Tanner crabs were adopted as an additional management measure by ADF&G.

Management Goal and Objectives

The goal of the scallop fishery management plan is to maximize the overall long-term benefit of scallop resources to residents of the state of Alaska and the nation while providing for conservation of scallop populations and their habitats. Within the scope of this goal, there are five specific objectives that address (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, and (5) conduct of fishery research to increase the information base for future management decisions.

Primary Management Measures

Overview

In developing this fishery management plan, the department attempted to provide for conservation of scallop and other benthic resources (e.g., king and Tanner crabs) while maintaining an economically viable fishery for existing users. At the same time, the department tried to construct a plan that provided for collection of much needed biological and fishery data for improved management which is not too costly.

Key management measures and associated regulations of the plan address (1) establishment of scallop fishery registration areas and registration requirements, (2) gear specifications, (3) area-specific guideline harvest ranges (GHRs) for traditional fishing grounds, (4) bycatch caps, (5) fishing seasons, (6) an industry-funded observer program, and (7) crew size limits. Some regulations (e.g., registration areas, observer requirements) apply to fishing for all scallop species, whereas other regulations (e.g., crew size limits, ban on automatic shucking) apply only to fishing for weathervane scallops. A summary of these principal management measures follows.

Registration Requirements

A total of eight scallop fishery registration areas were established, corresponding to the Southeastern, Yakutat, Prince William Sound, Cook Inlet, Kodiak, Alaska Peninsula, Dutch Harbor, and Bering Sea portions of the state. Scallop fishing vessels are required to register for each specific area prior to fishing, and vessels cannot be registered for scallop fishing in more than one area at any given time.

Gear Specifications

Prior scallop gear regulations were modified to specify a maximum dredge width of 15 feet with rings not less than four inches inside diameter, and restrictions were placed on chafing gear, liners and ring modifications. Scallop vessels may not operate more than two dredges at one time. More restrictive gear specifications, previously adopted by the Alaska Board of Fisheries, were maintained for portions (i.e., Kamishak Bay) of the Cook Inlet Registration Area.

Guideline Harvest Ranges

GHRs were established for each traditional weathervane scallop fishing area. For 1993, ADF&G managed the scallop fishery to achieve the upper end of the GHR in each traditional fishing area within constraints of crab bycatch caps. Fishing for weathervane scallops in the remaining portions of the state (Southeast Alaska, Alaska Peninsula, Bering Sea-Bristol Bay-Adak, and other non-traditional scallop fishing grounds) was allowed under the terms of a special exploratory harvest permit, similar to the permit needed to fish for scallop species other than weathervane scallops. In future years, based on an assessment of observer data, GHRs may be established for non-traditional areas. Also, after BOF review, GHRs in the traditional areas may be adjusted up or down based on changes in stock status. A summary of GHRs set for traditional areas follow:

Traditional Area	Upper Limit of GHR (pounds shucked meat)
Yakutat	250,000
Prince William Sound	50,000
Kamishak District of Cook Inlet	20,000
Kodiak	400,000
Dutch Harbor	170,000
Statewide Total	890,000

In an amended proposal to the BOF, ADF&G will recommend that District 16 be moved from Registration Area A (Southeast) to Registration Area D (Yakutat). Additionally, a separate GHR of 0 - 35,000 pounds will be recommended for District 16.

Bycatch Caps

With the exception of Southeastern Alaska and Yakutat, red king and Tanner crab bycatch caps were specified for scallop fisheries for each registration area. Caps were expressed in terms of numbers of crabs of all sizes caught in the scallop fishery. When assessment data were available for areas that had a commercial crab harvest during the past season, the crab bycatch cap for the scallop fishery was set at 1% of the total crab population. In areas closed to commercial crab fishing during the past season, the crab bycatch cap for a scallop fishery was 0.5% of the total crab population. The most recent survey data were used to estimate the crab stocks. This procedure was applied to the Kodiak, Alaska Peninsula, Dutch Harbor and Cook Inlet (Kamishak District) registration areas.

This approach for setting crab bycatch caps for scallop fisheries has precedent in federal and state fisheries management. For example, in the Bering Sea the NPFMC established a prohibited species cap for groundfish trawl fisheries of 1% of estimated herring spawning biomass (NPFMC 1991). When the 1% herring cap is exceeded, time-area closures are triggered for groundfish fishing. Likewise, in some state waters of the Gulf of Alaska, the BOF established regulations (5 AAC 28.430) under which the groundfish fishery is closed when 0.5% of the total estimated population of Tanner crabs has been taken as bycatch (ADF&G 1993a).

For the scallop fishery in Prince William Sound, crab bycatch was set only for Tanner crabs because no assessments are available for the small stock of red king crabs. Very low catches during the survey prevented estimation of Tanner crab population abundance for the Eastern District (waters east of 146° W) in 1992. Therefore, in the Eastern District Tanner crab bycatch was set at 0.5% of the average of the targeted crab catch during the past three fishing seasons

(1980/81-1982/83) in the district, whereas in the Western District (waters west of 146°) the Tanner crab bycatch was set at 0.5% of the Tanner crab population abundance from the most recent survey (1992).

No assessment surveys are conducted in the Outer and Eastern Districts of Cook Inlet. For these districts, crab bycatch caps were set at 1% of the average historical harvest.

Fishing for scallops in the Adak, Bristol Bay, and Bering Sea registration areas was limited or undocumented. Also, crab bycatch caps for groundfish fisheries in the Bering Sea have been set by the NPFMC. Therefore, to provide opportunity for the scallop fleet to explore Bering Sea scallop stocks while acknowledging pre-existing bycatch limits set by the NPFMC for crab resource conservation, conservative crab bycatch caps for these areas were based on the following parameters: 1 king crab per tow and 15 Tanner crabs per tow by 8 vessels fishing 24 tows per day for three months.

Bycatch caps for all registration areas follow:

Registration Area	Species	Bycatch Cap (No. Crabs)
Southeastern	N/A	N/A
Yakutat	N/A	N/A
PWS, Eastern District	Tanner crab	500
PWS, Western District	Tanner crab	130
Kodiak	King crab	283
	Tanner crab	199,500
Alaska Peninsula	King crab	85
	Tanner crab	52,530
Dutch Harbor	King crab	45
	Tanner crab	50,500
Cook Inlet, Kamishak District	King crab	40
	Tanner crab	15,900
Cook Inlet, Outer/Eastern District	King crab	98
	Tanner crab	2,170
Adak, Bristol Bay, and Bering Sea	King crab	17,000
	Tanner crab	260,000

Fishing Seasons

Scallop fishing seasons are specified by regulations previously adopted by the BOF. Due to the timing of implementation of the scallop FMP (June 1993) and onboard observer program (July 1993), ADF&G made use of split fishing seasons to ensure that much needed biological and fishery data could be collected for each management area in 1993. For example, in Yakutat, where the fishing season begins January 1, the season was closed when 50% of the upper end of the GHR was taken. The remainder of the GHR was reserved for the second fishing season which began July 1. The Yakutat fishery closed for the calendar year when the full GHR was taken. In other cases, it was not necessary to create a split season to provide for onboard observations. For instance, in Kodiak, established regulations specify season closure on March 31 and a reopening on July 1 or July 15 depending on location. In the Prince William Sound area, where the harvest guideline is small, the season was delayed until July 1 to provide for data collection. In some other instances (e.g., Dutch Harbor, Bering Sea), scallop fisheries opened in the second half of the year and onboard observations were obtained.

Observer Requirements

A mandatory, industry-funded observer program was initiated in July 1993. Onboard observations are required to attain management goals and objectives through inseason and long-term management actions. For inseason management, onboard observations provide timely data for monitoring scallop catches relative to GHRs and for monitoring incidental crab catches with respect to bycatch caps. For long-term management, onboard observations on scallop catch rates, size distributions and age compositions are required to estimate appropriate adjustments to GHRs based on changes in stock status.

Crew Size Limits

A vessel participating in the weathervane scallop fishery may have no more than 12 crew members. Crew members are all persons involved with the operations of the vessel and include the captain, mate, engineer, cook, deck hand and processing workers. Onboard observers are not considered as crew members.

FISHERY MANAGEMENT PLAN
FOR COMMERCIAL SCALLOP FISHERIES IN ALASKA

PURPOSE OF FISHERY MANAGEMENT PLAN

The purpose of this document, *Fishery Management Plan for Commercial Scallop Fisheries in Alaska*, is to describe a comprehensive fishery management plan (FMP) for commercial scallop fisheries in the state of Alaska. Recent growth in the fishery prompted concerns particularly regarding resource conservation of scallops and incidentally-caught species, and no formal FMP existed to address these issues. To develop a sound FMP, the following principal factors were addressed (1) overview of biology and life history of weathervane scallops *(Patinopecten caurinus)*, (2) history of the Alaskan scallop fishery and its management, (3) resource conservation concerns, (4) management goal and objectives, and (5) management measures and associated regulations. This draft FMP will be presented to the Alaska Board of Fisheries (BOF) for review at their March 1994 meeting in Anchorage. If adopted, the FMP will be updated to reflect any additional BOF actions. Although modifications to the final plan and accompanying regulations can be made through future deliberations of the BOF, the FMP is intended as a description of the state's long-term management strategy for Alaskan scallop fisheries.

It should be noted that the North Pacific Fishery Management Council (NPFMC) also has drafted a *Fishery Management Plan for the Scallop Fishery of the Gulf of Alaska, Bering Sea, and Aleutian Islands* (NPFMC 1993). This federal management plan was released for public review on November 30, 1993 and it is scheduled for action at the April 1994 meeting of the NPFMC. The primary purpose of the federal fishery management plan is to provide a mechanism for the NPFMC to consider limited entry alternatives that deal with perceived overcapitalization of the scallop fishery. A secondary objective of the federal plan is to address unresolved legal questions about the state of Alaska's authority and jurisdiction over fisheries in the Exclusive Economic Zone (EEZ). Consistent with the first objective, in January 1993, the NPFMC advised the industry that it might adopt a moratorium and an associated cut-off (control) date of January 20, 1993 was announced.

The state and federal fishery management plans are intended to be compatible. They serve different purposes. The federal plan specifies a state-federal agreement for cooperative management of the scallop resources off Alaska. The preferred alternative of this plan delegates most management authorities to the state of Alaska. A limited set of management measures fall under the purview of the NPFMC. In addition, the federal scallop plan includes requirements associated with all federal fishery management plans, such as an overfishing definition, optimum yield specification, environmental assessment, regulatory impact review, and initial regulatory flexibility analysis. On the other hand, the state FMP is intended as a comprehensive, yet concise, document on the operational management of the scallop fishery by the state of Alaska.

OVERVIEW OF SCALLOP BIOLOGY AND LIFE HISTORY

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) in depth (Foster 1991). Abundance tends to be greatest between depths of 45-130 m (≈150-430 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_∞, 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_∞ = 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 maximum age of 28 (Hennick 1973), Hoenig's (1983) method resulted in a median estimate of M = 0.16 corresponding 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 scallops, *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 Scotian 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 (≈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 scallops 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.

REVIEW OF THE FISHERY AND ITS MANAGEMENT

History of the Fishery

The history of the Alaskan scallop fishery was reviewed by Kaiser (1986), and it has been summarized more recently by Kruse and Shirley (1994, in press). Much of the following was derived from these descriptions.

Interest in an Alaskan scallop fishery has existed since the early 1950s when the Bureau of Commercial Fisheries began systematic surveys to determine whether commercial quantities were available. It was not until 1967 that the first commercial deliveries were made (Haynes and Powell 1968). One year later the fishery became fully developed when 19 vessels made 125 landings totalling 1.7 million pounds of shucked meats and reached its peak in 1969 with 157 landings totalling 1.9 million pounds (Table 1). Harvests off Kodiak and Yakutat accounted for 99% of the landings in these early years.

During the next twenty years, 1970-1989, the Alaskan scallop fishery was characterized by variable participation and catches which fluctuated at levels much lower than during the initial years of the fishery. On average, six vessels contributed 52 landings totalling 587,000 pounds annually during this period. In 1970, the year after peak landings (1969), participation dwindled to just seven vessels. The fishery began to change rapidly. Landings declined to 0.9 million pounds in 1971 and to 0.4 million pounds in 1975. Whereas catches from the early fishery were dominated by old scallops (7^{+} years of age), landings had shifted toward younger ages (2- to 6-year-olds) by the early 1970s as older scallops were cropped from previously unexploited stocks (Hennick 1973). As a result, the average landing per trip declined (Kaiser 1986).

The changes observed during the first few years of the Alaskan scallop fishery were not unlike the exploitation histories of many other fisheries worldwide (e.g., Walters 1986). Typically, early catches exceed sustained levels as the fishery crops off large, old individuals from the population including concentrations on marginal beds that rebuild slowly. This widely recognized phenomenon is known as the *"fishing-up effect"* or "removal of accumulated stock" (Ricker 1975; Walters 1986).

During 1976-1979, landings averaged just 77,941 pounds annually. Less than four vessels participated in the fishery during these four years, and state of Alaska confidentiality requirements prevent reporting their annual catches. No scallop landings were made anywhere in the state during 1978. Kaiser (1986) reported that the scallop industry supported several exploratory cruises to increase landings during 1974-1978 with little success. In addition to reduced stocks, fishing area restrictions and inflationary operating costs contributed to the fishery decline (Kaiser 1986). As a result, the converted halibut, crab, and shrimp vessels exited the scallop fishery during this period and only the more efficient east coast-type scallop vessels remained. Typically, the latter were 24-27 m (80-90 feet) in keel length and towed two 3.7-4.9 meters (12-16 feet) dredges (Kaiser 1986).

In the 1980s, the weathervane scallop fishery received renewed interest, in part due to increased exvessel prices. Overall, during the 1980s an average of nine vessels delivered 583,000 pounds annually. Unlike the 1970s when Kodiak and Yakutat accounted for 93% of the landings, during the 1980s 33% of the landings were taken from Dutch Harbor and other areas such as Southeast Alaska, Cook Inlet, Alaska Peninsula, and BS.

Significant increases in harvest occurred in the 1990s. During 1990-1993, two of the four highest annual landings ever were recorded. In 1990 nine vessels made 144 deliveries that totalled 1.5 million pounds. In 1992 landings, which exceeded 1.8 million pounds, were the highest harvest since catches from virgin stocks in 1969. There were indications that the fishery may have been going through a second fishing-up process. ADF&G received anecdotal reports that small scallops had composed larger portions of the harvest despite other reports that scallop fishers had moved to new areas or marginal beds to maintain catches. Landings data revealed geographic shifts in effort. In 1992, 210,000 pounds were landed from previously unfished beds off Prince William Sound. Likewise, a shift from inshore to offshore grounds accompanied a record harvest of more than 1.0 million pounds off Yakutat.

During 1993, effort increased to 11 vessels and harvests dropped to 1.4 million pounds. The decline in harvests was largely due to implementation of an interim fishery management plan that established a guideline harvest range of 0-890,000 pounds for traditional areas. GHRs were not set for non-traditional areas, but harvests were constrained by crab bycatch caps. Catches from previously unfished beds in the Bering Sea (532,000 pounds) accounted for 37% of total scallop harvests for 1993.

Data from the Alaska Commercial Fisheries Entry Commission (CFEC) on economic performance of the scallop fishery (all species) are shown for 1980-1992 (Table 2). Similar data are available since 1975, but data for 1976, 1977, and 1979 are confidential because fewer than four vessels fished scallops in those years and in 1978 no scallop fishing occurred. These data show that the Alaskan scallop fishery has become a very lucrative fishery for its participants in the 1990s. During the 1980s, total gross earnings for the scallop fleet averaged $2.0 million. This increased to $5.1 million in 1990 and $7.0 million in 1992. Mean gross earnings per vessel increased even more dramatically. During the 1980s, mean gross earnings per vessel were $266,000. By 1992, the average vessel grossed more than $1.0 million.

Management History Prior to 1993

Overview

Prior to 1993 no formal management plan existed for scallop fisheries in Alaska. The commercial scallop fishery was managed under miscellaneous shellfish regulations contained in Chapter 38 of the Alaska Administrative Code (see Appendix 1 of Kruse et al. 1992). These regulations were rather minimal, and the scallop fishery was managed very passively.

Registration and Statistical Areas

Through 1992 the entire state of Alaska was considered as a single registration area for scallop fishing. However, regulations designated five statistical areas: Southeast Alaska, Yakutat, Prince William Sound, Cook Inlet, and the Westward Area. In the absence of a federal fishery management plan, the state's management authority extended beyond Alaska's territorial sea to the adjoining waters of the EEZ.

Permit Requirements

To fish for scallops, an individual was required to obtain a CFEC permit (commercial fishing license) which was valid for all areas. However, in addition to this entry permit, scallop fishers were required to obtain an ADF&G commissioner's permit for each area to be fished. Conditions of the commissioner's permit might have included (1) location and duration of harvests, (2) restrictions on gear and other harvest procedures, and (3) periodic or annual reporting.

Gear Restrictions

Historically, legal commercial gear has been limited to dredges. Scallop dredges were required to have rings with minimum inside diameters of four inches with the exception of one fishing area. Three inch rings were legal in the area west of Sanak Island (in the Aleutian Islands).

Area-Specific Regulations

In addition to the statewide regulations just summarized, several area-specific regulations existed. In general, area specific regulations were designed largely to address crab bycatch issues rather than to directly regulate fishing for scallops. For example, regulations in the Southeastern Alaska and PWS areas specified no closed season for scallops. In the Yakutat area, the waters of Yakutat Bay were closed to scallop fishing. In Cook Inlet, regulations specified fishing seasons (August 15 through October 31 for Kamishak District; year-round elsewhere), area closures (three areas were specified), a maximum dredge opening of six feet, and a guideline harvest range of 10,000-20,000 pounds. In the Westward Area, area-specific regulations specified a number of closed areas and fishing seasons (e.g., June 1 through March 31, July 15 through March 31, or year-round) that differed among areas.

CURRENT MANAGEMENT CONCERNS

Overview

The Alaska Department of Fish and Game has a mandate to *manage, protect, maintain, improve, and extend the fish ... resources of the state in the interest of the economy and general well-being of the state* (State of Alaska 1987). Therefore, the impact of scallop fisheries on resource conservation is an important issue to be addressed by a scallop FMP. Potential concerns include overfishing of scallop stocks through cumulative effects of retained catch and incidental fishing mortality, bycatch of other benthic species, and habitat alteration. Economic considerations are embodied in ADF&G's mandate, as well. These concerns are reviewed in this section.

Scallop Resource Conservation

Recruitment Overfishing

Definition. It is widely accepted that fishery harvest levels should be prescribed in ways to prevent "recruitment overfishing" -- the condition that occurs when stocks are reduced to levels too low to produce adequate numbers of young scallops -- the future recruits to the fishery (Gulland 1983). Recruitment is a prerequisite for maintenance of viable populations, and is needed for sustainable harvests that support long-term economic benefits from the fishery.

Worldwide History of Scallop Overfishing. Although there are a number of cases of scallop fisheries that have been sustainable over long time periods (e.g., Brand et al. 1991; Sinclair et al. 1985), overfishing has occurred in many, if not most, scallop fisheries worldwide (e.g., Ansell et al. 1991; Aschan 1991; Bannister 1986; McLoughlin et al. 1991; Orensanz 1986; Orensanz et al. 1991; Sinclair et al. 1985; Young and Martin 1989). Stock recovery has been either slow or non-existent. Attempts to develop scallop aquaculture in many countries (Shumway 1991; Shumway and Sandifer 1991) are largely attributable to the collapse of natural populations. A detailed review of these numerous cases of scallop overfishing is well beyond the scope of this management plan, but a few examples are provided.

Numerous Australian fisheries for scallops of the genera *Pecten, Chlamys,* and *Amusium* have had a long history of overexploitation (Young and Martin 1989). For many of these, fishing ceased after the stocks were decimated. In few remaining areas where scallop fishing continues, stocks are depressed from persistent overfishing.

One of the oldest documented cases of overfishing occurred in Mahone Bay, Nova Scotia (Sinclair et al. 1985). During the early 1900s, this stock of Atlantic sea scallops supported a large fishery that was prosecuted by more than 250 license holders. As early as 1918, overfishing was recognized and conservation measures were imposed. However, despite these and subsequent conservation measures, the scallop stock has never recovered to levels observed in the 1910s.

There are a number of recent well-documented cases of overfishing for scallops of the genus *Chlamys* in the southern and northern hemispheres. For example, off northern Patagonia, Argentina, a fishery for tehuelche scallops *(C. tehuelcha)* developed in 1969 and quickly collapsed in 1971 (Orensanz 1986). This fishery was generally closed during 1972-1982, and the stock never recovered to unexploited levels. Similarly, at Jan Mayen Island off the coast of Norway intensive fishing on Iceland scallop *(Chlamys islandica)* began in 1985 (Fevolden 1989). In 1987, 26 vessels heavily depleted the resource. By 1990 only two vessels continued to fish, and landings declined by more than an order of magnitude from 1987 levels (Aschan 1991).

Implications of Stock Structure. Prevention of overfishing requires knowledge about a species' stock structure and the biological productivity of each stock. For species with populations that are well-connected by extensive larval drift, risk of overfishing is relatively low at least on an area-specific level. In such cases, local depletions can be replenished by settlement of larvae carried by ocean currents from spawning stocks located elsewhere. However, as described in the section *Overview of Scallop Biology and Life History*, a growing body of evidence indicates that many benthic invertebrates, such as scallops, exist as a number of discrete, self-sustaining populations. To prevent overfishing for species with such a population structure, it is necessary to manage each stock separately (Caddy 1989; Fevolden 1989; Sinclair et al. 1985).

Unfortunately, the stock structure of weathervane scallops in Alaska is not well understood. Studies of genetic stock structure and comparative population characteristics (e.g., growth rate, gonadal somatic index) are needed to resolve uncertainties. In the absence of such information, a reasonable and conservative approach is to assume that each major fishing area comprises a separate stock (Caddy 1989; Sinclair et al. 1985). However, even with this approach, the possibility exists that multiple self-sustaining populations exist within a fishing area. For example, the apparent existence of separate self-sustaining populations of sea scallops on the Northern Edge and Northeast Peak of Georges Bank (Tremblay and Sinclair 1992; McGarvey et al. 1993) is somewhat unexpected given ocean currents and proximity of these areas to other scallop fishing grounds on Georges Bank.

Importance of Spawning Stock Biomass. Even after scallop stocks have been defined, overfishing will occur unless fishing mortality is limited to a level commensurate with the productivity of each stock based on life history and other biological characteristics. Worldwide, scallop populations are characterized by recruitment variability (Hancock 1973; Orensanz 1986; Caddy 1989). Often, scallop populations are dominated by a few strong year classes that are separated by long periods of poor recruitment (Orensanz et al. 1991). For example, one stock of tehuelche scallops on the San Román grounds off Argentina demonstrated a 5-year cycle in year class strength (Orensanz 1986).

Potential stock-recruit relationships have not been well studied for scallops. A recent study by McGarvey et al. (1993) provides a rare example with good evidence of a relationship between spawning stock (total egg production) and recruitment for sea scallops on Georges Bank. In that instance, higher egg production was directly related to higher recruitment.

Rather, it is commonly assumed that scallop recruitment is linked to environmental conditions (Hancock 1973). For instance, Dickie (1955) suggested that Atlantic sea scallop recruitment in the Bay of Fundy was related to warm temperatures that hastened the larval period and formation of gyre-like circulation that retained larvae in the bay.

However, even when recruitment of a marine species is primarily driven by environmental effects, it is commonly held that parental spawning biomass affects recruitment, at least at low population sizes (e.g., Orensanz et al. 1991; Quinn et al. 1990; Zheng et al., in press). Recently, Peterson and Summerson (1992) showed that the bay scallop *(Argopecten irradians concentricus)* was recruitment limited due to reduced abundance of adults caused by a red tide *(Ptychodiscus brevis)* outbreak. In relating their findings to fishery management, the authors noted that a common assumption of shellfisheries management was that fishing pressure on adults will not adversely affect subsequent recruitment. Peterson and Summerson (1992) concluded that this assumption was unjustified.

Sustainable Yield

Preferred Approach. Ideally, an appropriate harvest rate is developed from yield models based on a species' life history traits and other biological parameters. Then, annual catches are specified by applying these harvest rates to annual biomass estimates derived from stock assessment surveys. Unfortunately, limited information on biological productivity is available for weathervane scallops to promote the conservation of stocks and sustained yields of the fishery. Biomass estimates are unavailable and yield models have not been developed.

In Alaska, most available information was collected during the early years of the fishery (Haynes and Powell 1968; Hennick 1970b, 1973), although it has been summarized more recently by Kaiser (1986). In the early 1950's the Bureau of Commercial Fisheries began systematic surveys to determine whether commercial quantities were available. The only assessment survey since 1972 was conducted in 1984 in lower Cook Inlet (Hammarstrom and Merritt 1985). Likewise, until the implementation of an onboard observer program in 1993, there have been no routine biological or fishery sampling programs conducted on weathervane scallops in Alaska.

Implications of Natural Mortality Rate. Natural mortality is one of the biological reference points commonly used in fisheries management to establish appropriate exploitation rates (Clark 1991). As discussed in the section *Overview of Scallop Biology and Life History*, the longevity (28 years) of weathervane scallops in Alaska (Hennick 1973) implies that this species experiences a very low natural mortality rate ($M \approx 0.16$ or 15% annual mortality). The biological reference point, obtained by setting instantaneous fishing mortality (F) equal to M, implies that scallop harvest rates should not exceed 15% annually on any given stock. Unfortunately, other potentially useful benchmarks that would bear on the choice of appropriate exploitation rates for weathervane scallops are not presently available. A study of alternatives is in progress.

The biological reference point, $F = M = 0.16$, implies that weathervane scallop stocks are at greater risk of overfishing than red king *(Paralithodes camtschaticus)* and Tanner crabs *(Chionoecetes bairdi)* for which $M = 0.3$ has been estimated (NPFMC 1990). Also, unlike many crab stocks throughout the GOA and BS, there are no stock assessments of weathervane scallop biomass. Given these two observations, maintenance of healthy weathervane scallop stocks poses a serious challenge to fishery managers.

Implications of Recruitment Variability. Large annual fluctuations in recruitment, typical of scallop populations, has management implications. Weathervane scallops spawn annually after reaching maturity at age 3 or 4. This feature of multiple spawning (termed *iteroparity*) is likely to be an evolutionary response to environmentally-induced recruitment variations (Murphy 1968). Iteroparous species, with highly variable recruitment, are particularly vulnerable to overfishing when high levels of harvest create a recruit-only fishery.

Murphy (1967) simulated the effects of fishing on Pacific sardine *(Sardinops sagax)* age structure so that the population approached a single reproducing age class. Compared to an unfished population with a protracted age structure, abundance of the fished population was much lower and more variable. The fished population recovered slowly even when fishing was terminated, and it had a higher probability of extinction than the unfished population.

These results led Murphy (1967) to assert the need to maintain age structure in populations with long life spans that experience environmentally-driven recruitment. This same advice was advanced by Leaman (1991) for the long-lived rockfishes *(Sebastes)*. By comparison of longevity with other scallop species (Orensanz et al. 1991), weathervane scallops, with a maximum age of 28 (Hennick 1973), may be the longest-lived scallop species in the world. That is, the advice of Murphy (1967, 1968) and Leaman (1991) is apropos.

Sustainability of Weathervane Scallop Harvests. Changes in the Alaskan scallop fishery through 1992 raised concerns that recent (through 1992) harvests may not be sustainable on a local or regional level for several reasons. First, recent landings were 2-3 times higher than the long-term average harvest taken over a 20 year period during the 1970s and 1980s. In fact, these harvests are at levels comparable to those taken in the late 1960s and early 1970s which proved not to be sustainable by the fishery. Reduced scallop abundance was at least partly responsible for the fishery collapse in the 1970s. Second, high harvests since 1990 were at least partly attributable to shifts in fishing effort to new scallop beds. Third, during 1992 limited inseason catch reports from some areas indicated that small scallops were constituting an increased portion of landings as had occurred prior to the fishery decline in the mid-1970s. Last, misreporting was suspected. If misreporting was widespread, it would seriously compromise the data base of historical catches upon which assessments of sustainable harvests are based.

Incidental Fishing Mortality on Scallops

Aside from appropriate levels of directed harvest just discussed, incidental mortality is another area of concern about fishery impacts with respect to scallop populations. Both direct and indirect sources of mortality must be considered in the fishery management plans that ensure long-term maintenance of healthy scallop stocks and productive fisheries.

Scallop dredges are relatively inefficient. This type of fishing gear typically harvests only 5-35% of the scallops in their path, depending on dredge design, target species, bottom type, and other factors (McLoughlin et al. 1991). Small scallops can swim out of the path of the oncoming dredge (Caddy 1968; Haynes and Powell 1968). However, some scallops experience injuries as a result of interactions with gear on the sea floor. In the Atlantic sea scallop fishery, injuries occur on rock substrates at rates 3-5 times higher than on sand (Shepard and Auster 1991). Sublethal injuries, such as chipped valve margins, are evidenced by shell deformities on live specimens (Naidu 1988; Caddy 1989). Such injuries may also occur during onboard handling of undersized scallops that are later returned to the sea.

Other scallops experience severe injuries that lead to immediate or subsequent mortality. Caddy (1968) estimated that 13-17% of uncaught sea scallops in the path of the dredge were lethally damaged and Naidu (1988) estimated that annual indirect fishing mortality of Iceland scallops could be as high as 17% for Digby dredges and 31% for New Bedford dredges.

Causes of death include separated hinges (Shepard and Auster 1991), crushing (Naidu 1988) or burial (Caddy 1968) by the dredge, body cavities that become impacted with sediment or shell fragments (Naidu 1988), reduced disease resistance (McLoughlin et al. 1991), and increased predation (Caddy 1968; Elner and Jamieson 1979). Caddy (1968) found that Atlantic sea scallops that were recessed into the sea floor by the passing dredge demonstrated no escape response when later approached by SCUBA divers. Moreover, dredge tracks attracted aggregations of predators (e.g., sculpins, starfish, and flatfishes). Within one hour after dredging, predatory fish and crabs were attracted to dredge tracks at densities 3-30 times greater than densities observed outside the tracks (Caddy 1973).

Incidental mortality may also be associated with the capture of small scallops that are handled and discarded at sea due to size regulations or economic considerations. Although many undamaged sea scallops that are quickly returned to the sea may experience no side effects (Naidu 1988), mortality may be significant particularly when scallop catches containing rocks are dumped on a vessel's deck (Naidu 1988) or when scallops experience prolonged exposure to unfavorable onboard conditions (Medcof and Bourne 1964), such as extreme air temperatures or prolonged desiccation.

Although weathervane scallop injuries are commonly observed, the magnitude of incidental fishing mortality in Alaska is unknown. Yet, ideally estimates of this important source of fishing mortality should be included in models used to estimate sustainable yield for scallops (Caddy 1989).

Fishery Effects on Other Species

Overview

Scallop dredges catch non-scallop species and may alter the structure of benthic communities. Recent growth of the scallop fishery in Alaska has heightened concerns about the bycatch of other commercially-valuable species, particularly king and Tanner crabs. Thus, bycatch concerns need to be considered in a scallop FMP. Although, effects of scallop dredges on benthic communities have not been studied in Alaska, dredging impacts on benthic communities have been studied elsewhere around the world. The objective of this section is to provide a short review of the effects of scallop dredging on benthic communities in general and a short summary of bycatch patterns in weathervane scallop fisheries as determined by observers during the early years of the fishery. Potential effects of scallop dredges on benthic habitats are reviewed in the next section.

Impacts on Benthic Communities

Effects of trawling and dredging were recently reviewed by Messieh et al. (1991) and Jones (1992). Many studies have documented short-term effects. However, few long-term studies have been conducted. Unfortunately, difficulties of statistical design inhibit detection of long-term changes in benthic communities and hamper ability to separate treatment (dredging) effects from other natural and human-induced causes.

Jones (1992) concluded that beam trawls, otter trawls, and dredges cause similar effects except that heavier gear causes greater damage. Specific effects vary depending on depth, bottom type, ocean currents, and the amount of gear in contact with the bottom. For example, recolonization of benthic organisms may occur quickly and effects may be short-term on sandy bottoms with strong tidal currents in shallow waters. However, in deep waters where benthic organisms may not be adapted to high sediment loads, effects may be long-term or permanent.

In their review, Messieh et al. (1991) found it difficult to generalize about effects of dredging and trawling. Effects ranged from minimal and short-term to major and long-term. Effects may vary by area. For instance, off Nova Scotia and Prince Edward Island, sea scallop dredging was found to have minimal impact on lobster *(Homarus americanus)* stocks because of little overlap of commercial quantities of the two species. However, this is contrary to findings off the northeastern United States where the two fisheries overlap and damage of scallop dredges to lobster stocks has been documented (Messieh et al. 1991).

Theoretical considerations lead to predictions about changes in benthic communities as a result of trawling or dredging (Jones 1992). It is expected that dredging will cause a relative increase in *r*-strategists (e.g., polychaetes) which are species that have life history attributes such as fast growth, small maximum size, young ages of maturity, and high rates of natural mortality. Dredging is predicted to cause declines in *K*-strategists (e.g., some clams and crabs) which are species that tend to grow slowly, achieve large maximum sizes, mature at relatively old ages, and experience low rates of natural mortality. As the slow-growing, longer-lived *K*-strategists are removed by dredging, a decline in diversity through time is anticipated.

Predicted changes in benthic communities as a result of trawling have been observed in the Wadden Sea over 112 years (Jones 1992). However, relative contributions of commercial trawling to these observed effects are confounded with concurrent changes in natural environmental conditions, chemical dumping and eutrophication. Reductions in diversity have been noted by New Zealand subsequent to development of new deep-water fishing grounds (Jones 1992). Likewise, Aschan (1991) found that the diversity of bottom communities declined within three years of dredging for Iceland scallops *(Chlamys islandica)* in the Northeast Atlantic Ocean.

Incidental Catches of Weathervane Scallop Fisheries

Some data are available on incidental catches of scallop dredges from research surveys in Oregon and Alaska and onboard observations of commercial catches from the early years of the fishery. An observer program was instituted in 1993, but analyses of recent bycatch were not available at the date this management plan was written. Results of the 1993 scallop observer program will be presented in a separate report.

During a survey off Oregon in November 1981, scallop dredge catches were comprised of 5.5% scallops, 56.2% other invertebrates, 21.8% fishes, and 16.5% debris, scallop shells, and algae by weight (Starr and McCrae 1983). Dungeness crabs constituted 3.4% by weight of the catches. Four species of flatfishes comprised 75.5% of the fish catch.

Off Alaska, bycatch from scallop dredging has been documented to include crabs, shrimps, octopi, and other bottom-dwelling invertebrates (Hennick 1973). Catches occasionally include flatfishes. Bycatch of cod, herring and salmon occur on rare occasion (Hennick 1973). Because of their economic importance, the remaining discussion focusses on crabs.

In some areas, the catches of king and Tanner crabs may be high, and many captured crabs may be lethally damaged (Haynes and Powell 1968; Hennick 1973; Kaiser 1986). In one scallop survey (Haynes and Powell 1968) conducted near Kodiak Island in January 1968, a scallop dredge incidentally caught an unspecified number (up to 33 per tow) of red king crabs. Of those captured, 79% were dead or so seriously injured that death was imminent. Catches of Tanner crabs were not discussed. In a more recent scallop survey in August 1984 (Hammarstrom and Merritt 1985), five red king crabs and more than 399 Tanner crabs were caught incidentally during 47 tows. Most Tanner crabs were small (5-8 cm carapace width, CW) and several stations contained substantial quantities of very small (<4 cm CW) Tanner crabs that were not enumerated. Approximately, 19% of the Tanner crabs suffered injuries and mortality was estimated to be 8%. Hammarstrom and Merritt (1985) noted that most crab injuries occurred while unloading gear on deck, and they felt that the low mortality during their research survey was due to careful handling.

In his review of sporadic onboard observations of the Kodiak scallop fishery in 1969-1971, Hennick (1973) noted an average bycatch of 20-40 Tanner crabs and 1-4 red king crabs per tow. Most Tanner crabs were 2-8 cm CW. He estimated that about 30% of Tanner crabs and 42% of king crabs were killed or injured by commercial scallop fishing. More recently, Kaiser (1986) estimated an average of 4.1 red king crabs and 42.5 Tanner crabs per tow for the Kodiak fishery during 1968-1972. His estimates of average mortality rates were 48% for red king crabs and 19% for Tanner crabs. An average of 0.6 Dungeness crabs were captured per tow with approximately 8% mortality. Likewise, Starr and McCrae (1983) estimated 8% mortality for Dungeness crabs captured during a cruise off Oregon during August 1992.

Incidental catch may vary by area, season, and depth. Off Yakutat Hennick (1973) noted no king crab bycatch. Haynes and Powell (1968) noted that king crabs were not captured in areas of highest weathervane scallops off Kodiak during January. Hennick (1973) found that king crab catches tended to increase in spring as adults migrated inshore for molting and mating. Off Oregon, male Dungeness crabs were caught at all depths on a scallop survey in August, but males were caught in shallow water only in November (Starr and McCrae 1983). Consistent with other handling studies (e.g., Kruse et al. 1994), newly molted crabs experience the highest rates of injury and mortality as a result of scallop dredges (Starr and McCrae 1983).

Habitat Alteration

The last area of conservation concern is the alteration of bottom habitat by dredges. Unfortunately, no studies have been conducted in Alaska. However, the New Bedford scallop dredges used in Alaska are essentially identical to dredges commonly used elsewhere, so inferences can be drawn from other studies.

Scallop dredges scrape and plough the sea bottom, suspend sediment, and may result in changes in bottom habitats (Messieh et al. 1991; Jones 1992). Dredging can damage biological structures (e.g., coral) and can cause a vertical redistribution of sediment (Messieh et al. 1991; Jones 1992). For example, observations in the Gulf of St. Lawrence showed that sea scallop dredging resuspends fine sediments, buries surface gravel, and overturns embedded large rocks (Caddy 1973). Likewise, observations in one area off the coast of Norway, found that dredging for Iceland scallops *(Chlamys islandica)* changed the bottom substrate from shell-sand to clay with large stones within a three-year period (Aschan 1991). Dredge marks on the sea floor may persist for long periods of time in low energy environments, but they may be short-lived particularly in areas of strong bottom currents (Messieh et al. 1991).

Mayer et al. (1991) investigated the effects of a New Bedford scallop dredge on sedimentology, biogeochemistry and microbiota of the bottom at a site in coastal Maine. They found that vertical redistribution of bottom sediments had greater implications than the horizontal translocation associated with scraping and ploughing the bottom. The scallop dredge tended to bury surficial metabolizable organic matter below the surface. This caused a shift in sediment metabolism away from aerobic respiration that occurred at the sediment-water interface and instead toward subsurface anaerobic respiration by bacteria. Potential ecological implications include reduced energy flow along pathways important to fisheries, such as the food chain from meiofauna to polychaetes to fish (Mayer et al. 1991).

Alterations in bottom habitats caused by dredging may have other biological feedbacks. Several studies have linked habitat perturbations to settlement success of young scallops to the bottom. For example, Olivier and Capitoli (1980), as cited by Orensanz (1986), suggested that removal of tons of shell hash from the San Matías grounds off Argentina during 1968-1971 led to poor tehuelche scallop *(Chlamys tehuelcha)* recruitment during the following decade. Similarly, Bull (1986), as cited by Jones (1992), found that survival of *Pecten novaezelandiae* spat in New Zealand after 9 months was 20% in an area closed to fishing and 0.8% in an area open to fishing. Finally, intensive dredging for bay scallops *(Argopecten irradians)* in Atlantic coast estuaries caused a decline in biomass of eelgrass *(Zostera marina)* which provides important nursery habitat for many species of fish and shellfish (Fonseca et al. 1984).

Economic Considerations

Aside from biological resource and habitat considerations, the recent expansion of the weathervane scallop fishery in Alaska raised economic concerns. In the last decade, fishing power of the Alaskan scallop fleet increased due to (1) increase in mean vessel size, (2) replacement of part-time scallop vessels with full-time scallop vessels, and (3) more participants. In 1992, 20 permits were issues but only 7 vessels made landings, whereas 32 permits were issued and 11 vessels made landings of scallops in 1993.

Interest among prospective participants remains high. New participation has been driven, in part, by reduced landings of sea scallops along the Atlantic coast, a vessel moratorium in the Atlantic sea scallop fishery (NEFMC 1993), and potential limitation in the weathervane scallop fishery in Alaska (NPFMC 1993). Growth in participation in the weathervane scallop fishery occurred despite considerable uncertainty about the ability of the resource to support an economically viable fishery with increased participation.

RECENT MANAGEMENT ACTIONS

Summary of State Actions

Given the growth of the scallop fishery and associated issues through 1992, it became readily apparent that a fishery management plan was required. Unfortunately, due to a three-year meeting cycle, scallop management was next scheduled for deliberation by the BOF in spring 1994. However, regulation 5 AAC 39.210 (Appendix A) permitted the Alaska Department of Fish and Game (ADF&G) to develop interim management plans and associated regulations for high-impact emerging fisheries in which (1) harvesting effort has recently increased beyond a low sporadic level, (2) the resource is harvested by more than a single user group, (3) harvests approach levels that might not be sustainable on a local or regional level, and (4) the BOF has not developed comprehensive regulations to address issues of conservation, allocation, and conduct of an orderly fishery. ADF&G found that these conditions applied to the weathervane scallop fishery.

Table 3 provides a chronology of recent scallop management actions by the state of Alaska. In July 1992, ADF&G published a report that provided scallop management options for public review. The report described a range of management options from passive to active inseason management. Valuable comments were received from members of the fishing and scientific communities during the ensuing two month review period. These comments, plus ADF&G staff analyses, were carefully considered, and an executive summary of a draft interim management plan was released for public comment in January 1993. This draft plan received further public review and was presented at the January meeting of the NPFMC.

During February 1993, the BOF adopted two new regulations: a ban on automatic shucking machines and a limit of 12 crew members per vessel. The interim management plan and associated fishing regulations became effective by the end of June 1993. Since then, bycatch caps for king and Tanner crabs were adopted as an additional management measure by ADF&G. The interim plan is intended to remain in effect until the BOF adopts permanent regulations.

Additionally, in January 1994 ADF&G petitioned the BOF to consider a moratorium on vessel licenses for the scallop fishery. Scallop management will be addressed during the March 1994 BOF meeting. It is anticipated that the BOF will take action on the proposed moratorium and that they will adopt a final FMP and associated regulations at that time.

Summary of Federal Actions

The NPFMC developed a draft federal fishery management plan to provide a mechanism to consider limited entry alternatives that address perceived overcapitalization of the scallop fishery (NPFMC 1993). The plan was released for public review in November 1993, and it is scheduled for action at the April 1994 meeting of the NPFMC. In anticipation of adopting a vessel moratorium, the NPFMC announced a cut-off (control) date of January 20, 1993.

MANAGEMENT GOAL AND OBJECTIVES

The management goal for scallop fisheries is to maximize the overall long-term benefit of scallop resources to residents of the state of Alaska and the nation while providing for conservation of scallop populations and their habitats. Within the scope of the management goal, five specific objectives have been identified. These objectives concern biological conservation, bycatch and habitat, sustainable and orderly fisheries, subsistence, and fishery research.

Biological Conservation Objective

The biological conservation objective is to ensure the long-term reproductive viability of scallop populations. The maintenance of adequate reproductive potential in each scallop population takes precedence over other economic, social, management and research considerations. To ensure continued reproductive viability of scallop stocks, management measures will be designed to avert recruitment overfishing by preventing the spawning stock from being reduced to too low a level to ensure adequate production of recruits to future fisheries. Management measures used to attain the biological conservation objective include (1) guideline harvest ranges, (2) gear restrictions, such as minimum dredge ring size and restrictions on liners and chafing gear, (3) inseason management measures, such as fishery closures, and (4) onboard observers.

Bycatch and Habitat Objective

The impacts of scallop dredges on other fish and shellfish populations and the quality and availability of habitat supporting populations of scallops and other species are of concern. The bycatch and habitat objective is to minimize adverse effects of this gear on other species and bottom habitat needed for recruitment and survival of scallops and other bottom-dwelling organisms, particularly those of commercial importance. Management measures used to attain this objective include (1) bycatch caps, (2) onboard observers, and (3) fishery closures in areas of high bycatch or sensitive benthic habitats.

Sustainable and Orderly Fishery Objective

The sustainable and orderly fishery objective is to ensure the conduct of manageable, steady-paced scallop fisheries that promote long-term economic and social benefits (e.g., stable employment opportunities) received from persistent landings of high quality, large scallops delivered to seafood markets. Toward this end, populations of large scallops will be perpetuated to enhance product marketability, favorable prices, and stability in landings, personal income, and employment. It is recognized that this objective will promote long-term economic and social benefits over and above short-term gains associated with "boom-and-bust" fisheries. Therefore, management measures will be designed to sustain scallop fisheries over the long-term despite sporadic recruitment events. Applicable management measures include (1) registration areas, (2) guideline harvest ranges, (3) onboard observers, (4) fishing seasons, and (5) crew size limits.

Subsistence Objective

Where appropriate, the subsistence objective is to ensure that scallop harvest requirements by subsistence users in coastal communities are met, as required by law. Management measures must assure that abundance and availability of local scallop stocks to subsistence users must be protected from deleterious effects of commercial fisheries. This objective is attained by closing local subsistence harvest areas to commercial harvest.

Research Objective

The research objective is to gather and analyze data relevant to attaining fishery management objectives and to ensure that management plans are adjusted to reflect up-to-date findings. Research topics include (1) stock abundance and size/age structure; (2) scallop biology, life history, and stock production parameters; (3) analyses of population thresholds and recruitment overfishing; (4) estimation of optimum dredge ring size or minimum shell height based on studies of rates of growth and mortality; (5) investigations of exploitation rates and alternative management strategies; (6) genetic stock structure; and (7) new gear designs to reduce bycatch and to minimize adverse effects on bottom habitat. This objective will be attained, in part, with data collected by the observer program. However, there is a need for the conduct of other scallop research through funding sources such as test fishing receipts, state of Alaska general fund appropriations, federal aid funds, or research grants.

MANAGEMENT MEASURES AND REGULATIONS

Overview

In developing this fishery management plan, the department attempted to provide for conservation of scallop and other benthic resources (e.g., king and Tanner crabs) while maintaining an economically viable fishery for existing users. At the same time, the department tried to construct a plan that provided for collection of much needed biological and fishery data for improved management without being too costly. Comments received by members of the fishing industry and scientific community on published management options (Kruse et al. 1992) were carefully considered while developing management measures and associated regulations.

Many of the management measures and accompanying regulations of this scallop FMP have been carried over from existing scallop fishery regulations, some existing regulations have been modified, and some new measures and regulations have been developed. Selected regulations that pertained to scallop fisheries management prior to this FMP in 1992 were presented in Appendix 1 of Kruse et al. (1992). Selected current (1993) regulations associated with this FMP are shown in Appendix A of this FMP. However, the Alaska Administrative Code or current shellfish regulation booklet (ADF&G 1993b) should be consulted for a full set of regulations.

Major differences that distinguish current (1993) from previous (1992) regulations are associated with the following management measures (1) registration requirements, (2) gear specifications, (3) area-specific GHRs for traditional fishing grounds, (4) area-specific crab bycatch caps, (5) an industry-funded observer program, (6) crew size limits, and (7) ban on automatic shucking machines. Most regulations apply to fishing for all scallop species, but some (e.g., crew size limits, ban on automatic shucking) apply only to fishing for weathervane scallops. All management measures are briefly summarized as follows.

Registration Requirements

A total of eight scallop fishery registration areas were established, corresponding to the Southeastern, Yakutat, Prince William Sound, Cook Inlet, Kodiak, Alaska Peninsula, Dutch Harbor, and Bering Sea portions of the state (Figure 1). This differs from previous regulations that designated the entire state of Alaska as a single registration area which was divided into five statistical areas (see 5 AAC 38.005 and 5 AAC 38.020 in Appendix 1 of Kruse et al. 1992). One of the previous five statistical areas, the "Westward Area," has been split into Kodiak, Alaska Peninsula, Dutch Harbor, and Bering Sea areas. Now each of the eight state statistical areas are considered separate fishery registration areas.

Scallop fishing vessels are required to register for each specific area prior to fishing for scallops. Vessels cannot register for scallop fishing in more than one registration area at any given time. This management measure helps attain the *Sustainable and Orderly Fishery Objective* by providing more accurate and timely catch and effort statistics by area.

Reporting Requirements

Persons and organizations involved with the catching and/or processing of scallops are required to report on these activities as directed by general provisions that are identical to all other fish and shellfish fisheries. Requirements include, but are not limited to: the name of permit holder and vessel, weight of shucked scallop meats landed, area of harvest, date of landing, and name of the company which purchased the catch. These requirements are specified in 5 AAC 39.130 (State of Alaska 1993). This management measure helps attain the *Sustainable and Orderly Fishery Objective* by providing accurate estimates of effort and catch by statistical area. Accurate harvest statistics are critical to attain the *Biological Conservation Objective*, as well.

Gear Specifications

Prior scallop gear regulations were modified to specify a maximum dredge width of 15 feet with rings not less than four inches inside diameter, and restrictions were placed on chafing gear, liners and ring modifications. Scallop vessels may not operate more than two dredges at one time. More restrictive gear specifications, previously adopted by the Alaska Board of Fisheries, were maintained for portions (i.e., Kamishak Bay) of the Cook Inlet Registration Area.

This management measure is designed to help achieve four of the five management objectives. The four inch minimum ring size will promote the catch of large scallops *(Sustainable and Orderly Fishery Objective)*, and will help limit the discard mortality of small scallops *(Biological Conservation Objective)* and small young-of-the-year crabs *(Bycatch and Habitat Objective)*. Standardization of the gear will increase the feasibility of analyses of fishery catch and effort data for estimation of biomass, recruitment, growth, mortality, and harvest rates *(Research Objective)*.

Guideline Harvest Ranges

To help prevent overfishing and maintain reproductive potential *(Biological Conservation Objective)* and to help prevent "boom and bust" fisheries *(Sustainable and Orderly Fishery Objective)*, GHRs were established for each of the traditional weathervane scallop fishing areas. In the absence of biomass estimates needed to implement an exploitation rate harvest strategy, GHRs were estimated as the long-term average productivity (catch) from each of traditional harvest area. Excluded from the averages were years considered as part of the fishing-up process (considered to over-estimate productivity) and years when catches were very low (<25,000 pounds shucked meats, considered to under-estimate productivity).

For 1993, ADF&G managed the scallop fishery to achieve the upper end of the GHR in each traditional fishing area within constraints of crab bycatch caps. Fishing for weathervane scallops in the remaining portions of the state (Southeast Alaska, Alaska Peninsula, Bering Sea-Bristol Bay-Adak, and other non-traditional scallop fishing grounds) was allowed under the terms of a special exploratory harvest permit, similar to the permit needed to fish for scallop species other than weathervane scallops. A summary of GHRs set for traditional areas follow:

Traditional Area	Upper Limit of GHR (pounds shucked meat)
Yakutat	250,000
Prince William Sound	50,000
Kamishak District of Cook Inlet	20,000
Kodiak	400,000
Dutch Harbor	170,000
Statewide Total	890,000

In an amended proposal to the BOF, ADF&G has recommended a separate GHR of 0 - 35,000 pounds for District 16 (currently in Statistical Area A) and that District 16 be included in Registration Area D.

In future years, based on an assessment of observer data, GHRs may be established for non-traditional areas. Also, after BOF review, GHRs in the traditional areas may be adjusted up or down based on changes in stock status. Generally, such adjustments would be based on shifts in population size/age structure coupled to changes in area-specific catch-per-unit-effort (CPUE). For example, declines in CPUE may indicate a decrease in stock abundance. A shift in age structure to younger, smaller scallops may indicate that rates of exploitation and scallop natural mortality exceed growth and recruitment of the stock. Taken together, these qualitative changes would indicate that the harvest should be lowered. Conversely, opposite trends in size/age structure and CPUE would suggest that the GHR could be raised. Conceivably, observer data on size/age structure of scallop stocks may be amenable to quantitative methods for estimation of stock abundance (Parrack 1992). If so, future GHRs could be specified as catch quotas based on a fixed exploitation rate of scallop stock biomass estimates. An appropriate exploitation rate could be based on life history traits (Clark 1991) of weathervane scallops such as $F = M = 0.16$.

Bycatch Caps

To help meet the *Bycatch and Habitat Objective*, bycatch caps were implemented to constrain the incidental mortality inflicted by the scallop fishery on king and Tanner crab stocks. Area-specific bycatch caps were established based on crab stock status.

With the exception of Southeastern Alaska and Yakutat, red king and Tanner crab bycatch caps were specified for scallop fisheries for each registration area. Caps were expressed in terms of numbers of crabs of all sizes caught in the scallop fishery. When assessment data were available for areas that had a commercial crab harvest during the past season, the crab bycatch cap for the scallop fishery was set at 1% of the total crab population. In areas closed to commercial crab fishing during the past season, the crab bycatch cap for a scallop fishery was 0.5% of the total crab population. The most recent survey data were used to estimate the crab stocks. This procedure was applied to Kodiak, Alaska Peninsula, Dutch Harbor and Cook Inlet (Kamishak District) registration areas.

This approach for setting bycatch caps has precedent in the federal and state management of other fisheries in Alaska. For example, the NPFMC established a prohibited species cap for BS groundfish trawl fisheries of 1% of estimated herring spawning biomass (NPFMC 1991). When the 1% herring cap is exceeded, time-area closures are triggered for groundfish fishing. Likewise, in some state waters of the GOA, the BOF established regulations (5 AAC 28.430) under which the groundfish fishery is closed when 0.5% of the total estimated population of Tanner crabs has been taken as bycatch (ADF&G 1993a).

For the scallop fishery in Prince William Sound, crab bycatch was set only for Tanner crabs because no assessments are available for the small stock of red king crabs. Very low catches during the survey prevented estimation of Tanner crab population abundance for the Eastern District (waters east of 146° W) in 1992. Therefore, in the Eastern District Tanner crab bycatch was set at 0.5% of the average of the targeted crab catch during the past three fishing seasons (1980/81-1982/83) in the district, whereas in the Western District (waters west of 146°) the Tanner crab bycatch was set at 0.5% of the Tanner crab population abundance from the most recent survey (1992).

No assessment surveys are conducted in the Outer and Eastern Districts of Cook Inlet. For these districts, crab bycatch caps were set at 1% of the average historical harvest.

Fishing for scallops in the Adak, Bristol Bay, and Bering Sea registration areas was limited or undocumented. Also, crab bycatch caps for groundfish fisheries in the Bering Sea have been set by the NPFMC. Therefore, to provide opportunity for the scallop fleet to explore Bering Sea scallop stocks while acknowledging pre-existing bycatch limits set by the NPFMC for crab resource conservation, conservative crab bycatch caps for these areas were based on the following parameters: 1 king crab per tow and 15 Tanner crabs per tow by 8 vessels fishing 24 tows per day for three months.

Bycatch caps for all registration areas follow:

Registration Area	Species	Bycatch Cap (No. Crabs)
Southeastern	N/A	N/A
Yakutat	N/A	N/A
PWS, Eastern District	Tanner crab	500
PWS, Western District	Tanner crab	130
Kodiak	King crab	283
	Tanner crab	199,500
Alaska Peninsula	King crab	85
	Tanner crab	52,530
Dutch Harbor	King crab	45
	Tanner crab	50,500
Cook Inlet, Kamishak District	King crab	40
	Tanner crab	15,900
Cook Inlet, Outer/Eastern District	King crab	98
	Tanner crab	2,170
Adak, Bristol Bay, and Bering Sea	King crab	17,000
	Tanner crab	260,000

Inseason Adjustments

Regulations permit the state of Alaska to make inseason adjustments to management measures such as GHRs, fishing season lengths, and to close areas. For example, 5 AAC 38.035 (State of Alaska 1993) authorizes the commissioner of ADF&G to close an area if inseason data indicate that continued fishing effort would jeopardize the viability of shellfish resources within any particular statistical area. Whereas GHRs and bycatch caps are specified pre-season to indicate to industry the planned annual allowances for directed and incidental catches for the scallop fishery within each area, the authorities associated with inseason adjustments allow the state to react to unforeseen significant changes that prompt new resource conservation concerns. Thus, inseason adjustments help attain the *Biological Conservation Objective*.

Closed Waters

Toward achievement of the *Bycatch and Habitat Objective*, closed areas are necessary to prevent scallop dredging in biologically critical areas, such as locations of high bycatch of other valuable species (e.g., crabs), nursery areas for young fish and shellfish, and areas of sensitive habitats. Also, area closures may be established to attain the *Subsistence Objective* by preventing adverse impacts of commercial scallop fisheries on small scallop stocks that are fully utilized by subsistence, personal use and sport users. Whereas closed waters have been utilized in various areas throughout the state to address bycatch and habitat issues, closures to meet subsistence priorities are relevant only to limited areas of the inside waters of Southeastern Alaska (Statistical Area A) where subsistence and personal use harvests are significant.

Areas are closed to scallop fishing in Southeastern Alaska (5 AAC 38.120), Yakutat (5 AAC 38.180), Cook Inlet (5 AAC 38.324) and Westward (5 AAC 38.425) areas of the state (Appendix A). During 1993, ADF&G permitted scallop fishing in some of these closed areas to provide for the collection of new data by observers to reevaluate the bases for the closures. This was deemed desirable because, in some cases, closure of these areas was based on crab bycatch and because the status and distribution of affected crab stocks may have changed since the closures were established.

Fishing Seasons

Fishing seasons are used to help attain the *Sustainable and Orderly Fishery Objective* and *Bycatch and Habitat Objective*. Toward the former, seasons can be structured to provide for stability in landings and employment. Toward the latter, seasons can be set to avoid sensitive periods of crab life histories, such as molting, mating, and migration periods when interactions with the scallop fishery would be most detrimental.

Scallop fishing seasons are specified by regulations previously adopted by the BOF (Appendix A). Seasons are not standardized statewide. Rather, they vary by Statistical Area: A (5 AAC 38.120), D (5 AAC 38.167), E (5 AAC 38.220), H (5 AAC 38.320), and K, M, O, and Q (5 AAC 38.420).

For 1993, because of the timing of implementation of the scallop FMP (June 1993) and onboard observer program (July 1993), ADF&G made use of split fishing seasons to ensure that much needed biological and fishery data could be collected for each management area for presentation to the BOF at their March 1994 meeting. For example, in Yakutat, where the fishing season begins January 1, the season was closed when 50% of the upper end of the GHR was taken. The remainder of the GHR was reserved for the second fishing season, which began July 1. The

Yakutat fishery closed for the calendar year when the full GHR was taken. In other cases it was not necessary to create a split season to provide for onboard observations. For instance, established regulations in Kodiak specify season closure on March 31 and a reopening on July 1 or July 15 depending on location. In the Prince William Sound area, where the harvest guideline is small, the season was delayed until July 1 to provide for data collection. In some other instances (e.g., Dutch Harbor, Bering Sea), scallop fisheries opened in the second half of the year and onboard observations were obtained.

Fishing seasons could be adjusted to better attain the *Sustainable and Orderly Fishery Objective*. In 1993, existing fishing seasons posed fishery management problems for ADF&G and scheduling difficulties for the scallop industry. For instance, due to coincidence with crab and groundfish fisheries, sufficient observers were not available to observe the scallop fleet. To make up the shortage, ADF&G staff were assigned to observer duties in some instances. Additionally, a July fishery for scallops in Yakutat posed logistical problems for area management staff due to coincidence with important salmon fisheries. From an industry perspective, fragmented season openings and closures increased operational costs associated with "down time." Alternative fishing seasons may provide for more optimal scheduling and operation of those vessels involved with the scallop fishery.

One alternative to the status quo is to revise scallop fishing seasons as follows. The scallop fishing season could be defined from July 1 (except August 15 for Cook Inlet) through February 15. Closure during February 15 through July 1 should accommodate molting, mating, and migration of crab populations in most areas of the state. In Kamishak District of Cook Inlet, survey and fishery data show that much of the red king crab population and a portion of the Tanner crab population remains on scallop fishing grounds during summer. However, by August 15 most crabs have migrated to deeper areas, so an August 15 opening is preferable. In all areas, the season would close when just one of the following three criteria were met: GHR is attained, bycatch cap is taken, or by February 15, whichever comes first.

Observer Requirements

In 1993 an onboard observer program was implemented for scallop fisheries. The program is mandatory and funded by the industry: each vessel is required to carry an observer at their own expense. An observer program is necessary for inseason and long-term management to attain all five objectives of the FMP. For inseason management, onboard observations provide timely data for monitoring scallop catches relative to GHRs and for monitoring incidental crab catches with respect to bycatch caps. For long-term management, onboard observations on scallop catch rates, size distributions and age compositions are required to adjust GHRs up or down based on changes in stock status and productivity.

The level of observer coverage has been somewhat controversial. ADF&G believes that 100% observer coverage is required for at least three reasons. First, observers are needed to acquire timely and accurate data on directed and incidental catches with respect to guideline harvest ranges and bycatch caps for inseason management. In many cases, harvest guidelines are caught in a matter of days so timely and accurate catch data are integral to the *Biological Conservation Objective* and *Sustainable and Orderly Fishery Objective*. Moreover, full observer coverage is the only method to obtain meaningful data on incidental catch needed to meet the *Bycatch and Habitat Objective*. Bycatch rates are highly variable on vessel to vessel and tow to tow bases.

Second, full observer coverage is required to collect unbiased data on scallop biology (e.g., age and size) requisite for the *Research Objective* and *Biological Conservation Objective*. As described in the section *Overview of Scallop Biology and Life History*, scallop age and size distributions can be extremely variable among beds within any given fishing area. Thus, if sample size is small because of few observed vessels, it becomes likely that sparse data will be representative only of the specific beds being fished by those few vessels and not representative of the catches from each scallop stock as a whole. Thus, reduced observer coverage below 100% will increase the risk that biased age and size data will obscure true changes in stock status that may signal, for example, recruitment overfishing.

Third, from a pragmatic standpoint, if fewer than four vessels are observed in a particular fishing area, then state of Alaska confidentiality requirements specify that all of those observations are confidential. Given the small size of the scallop fleet (7 vessels in 1992, 11 vessels in 1993) coupled to coincident fishery openings, less than 100% coverage would increase the likelihood that onboard observations would be confidential for some fishing areas. In such cases, important data on catch and bycatch would not be accessible to the public BOF process in which fishing regulations are established.

Crew Size Limits

As specified in 5 AAC 38.076 (Appendix A), a vessel participating in the weathervane scallop fishery may have no more than 12 crew members. Crew members are all persons involved with the operations of the vessel and include the captain, mate, engineer, cook, deck hand and processing workers. Onboard observers are not considered as crew members. Crew size limits were implemented to help achieve the *Sustainable and Orderly Fishery Objective* and the *Biological Conservation Objective* by reducing incentives to harvest small scallops.

Automatic Shucking Machines

As specified in 5 AAC 38.076 (Appendix A), weathervane scallops may be shucked by hand only. A mechanical shucking machine may not be on board a vessel that is fishing for weathervane scallops. A ban on automatic shucking machines was implemented to help achieve the *Sustainable and Orderly Fishery Objective* and the *Biological Conservation Objective* by reducing incentives to harvest small scallops.

Other Management Measures

The state of Alaska is authorized to consider other management measures. In general, such measures are adopted through the public BOF regulatory process. For example, potential measures could include a vessel moratorium, limited entry, minimum size limits for landed scallops, or bycatch caps for other species. A moratorium will be considered by the BOF at its March 1994 meeting. In general, proposals for future changes to scallop fishing regulations are considered by the BOF on a three-year meeting cycle. After March 1994, it is anticipated that the BOF will next address scallop management in spring 1997. Any interested person may submit a proposal to change scallop fishing regulations for consideration by the BOF.

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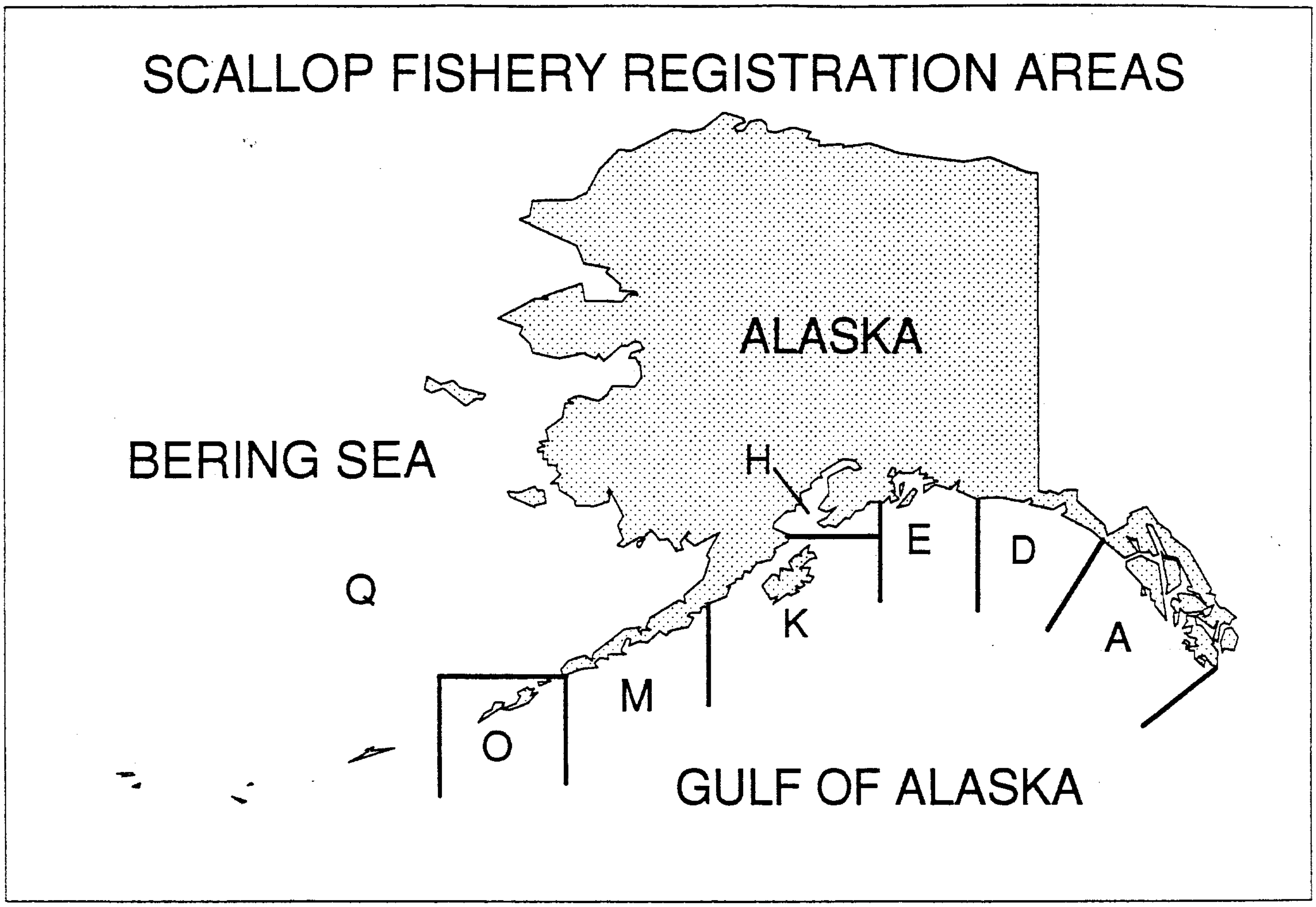

Figure 1. Scallop registration areas in the state of Alaska corresponding to Southeastern Alaska (A), Yakutat (D), Prince William Sound (E), Cook Inlet (H), Kodiak (K), Alaska Peninsula (M), Dutch Harbor (O), and Adak-Bristol Bay-Bering Sea (Q).

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. Data for 1967-1993 were taken from 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.

Year	No. of Vessels	No. of Landings	Landed Weight (lbs)
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

Table 2. Economic performance of Alaskan scallop fisheries (all species) in terms of landed weight (mean, median, total) and gross earnings (mean, median, total) during 1980-1992. Data are from Commercial Fisheries Entry Commission files. Statistics include all scallop landings (commercial, test fishing, experimental, etc.) and incidental harvest of scallops in other fisheries. Total landings include all species caught and landed in scallop fisheries. Weathervane scallops comprise the majority of landings and value.

Year	Vessels	Mean Pounds	Median Pounds	Total Pounds	Mean Earnings	Median Earnings	Total Earnings
1980	8	79,067	30,025	632,535	$288,174	$117,656	$2,305,393
1981	18	51,459	30,335	926,262	$167,700	$110,013	$2,683,198
1982	13	70,307	77,819	913,996	$265,506	$271,308	$3,186,066
1983	6	32,443	1,573	194,656	$151,918	$4,977	$911,510
1984	9	43,313	2,112	389,817	$132,045	$9,420	$924,312
1985	9	71,921	11,810	647,292	$281,711	$23,141	$2,253,688
1986	9	75,847	35,882	682,622	$258,789	$143,015	$2,329,101
1987	4	145,761	130,761	583,043	$525,830	$445,726	$2,103,319
1988	4	85,268	47,658	341,070	$300,392	$174,884	$1,201,567
1989	7	76,395	70,342	534,763	$287,222	$187,321	$2,010,551
1990	9	165,466	153,276	1,489,191	$563,364	$521,598	$5,070,273
1991[1]	8	148,885	179,122	1,191,078	$560,512	$685,765	$4,484,092
1992	7	258,684	281,857	1,810,788	$1,004,100	$1,099,796	$7,028,702

[1]Data for 1991 includes one vessel which made a small single landing without a valid scallop permit.

Table 3. Chronology of recent scallop management actions by the state of Alaska.

Date	Action
JUL 1992	ADF&G publishes scallop management options for public review
SEP 1992	Public review period closes
mid-JAN 1993	Executive summary of draft interim management plan released for public comment
late JAN 1993	Public comment period ends
FEB 1993	BOF accepts petition to consider crew size limits and ban on automatic shucking aboard scallop fishing vessels
MAR 1993	BOF adopts crew size limit of 12 and bans automatic shucking aboard scallop fishing vessels
MAY 1993	Interim management regulations filed
JUN 1993	Interim management plan associated regulations are implemented
JUL 1993	(1) Regulations concerning crew size limits and ban on automatic shucking are implemented; (2) scallop mandatory observer program commences; and (3) crab bycatch caps imposed on scallop fishery
JAN 1994	Commissioner of ADF&G petitions BOF to consider moratorium on scallop vessel licenses
FEB 1994	Executive summary of draft "final" scallop fishery management plan released for public comment
early MAR 1994	Draft scallop fishery management plan released for public comment
mid-MAR 1994	Fishery management plan considered by BOF for adoption

APPENDIX A. SELECTED REGULATIONS FROM THE ALASKA ADMINISTRATIVE CODE THAT PERTAIN TO SCALLOP FISHING (IN EFFECT FOR 1993)

CHAPTER 38 - MISCELLANEOUS SHELLFISH

ARTICLE 1. STATISTICAL AREAS

5 AAC 38.005. STATISTICAL AREAS ESTABLISHED. (b) Statistical areas are areas which the department shall utilize to obtain biological and fishing effort data and other information necessary for the formulation of comprehensive and effective conservation and management regulations governing miscellaneous shellfish resources inhabiting territorial waters of Alaska. However, regulations governing territorial waters will be applied to the remainder of the statistical area consistent with 5 AAC 38.010.

(c) The seaward boundary of a statistical area is a line drawn in such a manner that each point on it is 200 nautical miles from the baseline from which the territorial sea is measured.

5 AAC 38.020. REGISTRATION. (a) For the miscellaneous shellfish fishery, other than sea cucumbers and scallops, all territorial waters of Alaska are considered one registration area. For sea cucumbers, Statistical Area A is a registration area. For scallops, registration areas are described in 5 AAC 38.076(b). All miscellaneous shellfish gear must be registered, and all miscellaneous shellfish vessels must be licensed and registered before fishing for any miscellaneous shellfish during a registration year.

(b) Except for sea cucumbers, the registration year shall be January 1 through December 31. For sea cucumbers in Statistical Area A, the registration year coincides with the fishing season set out in 5 AAC 38.140.

ARTICLE 2. GENERAL SPECIFICATIONS AND RESTRICTIONS

5 AAC 38.076. ALASKA SCALLOP FISHERY MANAGEMENT PLAN. (a) The department has determined, that under 5 AAC 39.210, the scallop fishery is a high-impact emerging commercial fishery. The requirements of this management plan apply to vessels commercially fishing for scallops.

(b) The following scallop registration areas are established:

(1) Scallop Registration Area A (Southeastern Alaska) is Statistical Area A, described in 5 AAC 38.100;

(2) Scallop Registration Area D (Yakutat Area) is Statistical Area D, described in 5 AAC 38.160;

(3) Scallop Registration Area E (Prince William Sound) is Statistical Area E, described in 5 AAC 38.200;

(4) Scallop Registration Area H (Cook Inlet) is Statistical Area H, described in 5 AAC 38.300;

(5) Scallop Registration Area K (Kodiak) is Statistical Area K, described in 5 AAC 34.400;

(6) Scallop Registration Area M (Alaska Peninsula) is Statistical Area M, described in 5 AAC 34.500;

(7) Scallop Registration Area O (Dutch Harbor) is Statistical Area O, described in 5 AAC 34.600;

(8) Scallop Registration Area Q (Adak-Bristol Bay-Bering Sea) is the combination of the Adak, Bristol Bay, and Bering Sea Statistical Area, described in 5 AAC 34.700, 5 AAC 34.800, and 5 AAC 34.900.

(c) A person may use a vessel to take scallops only in a scallop registration area and its adjacent seaward biological influence zone and only if the owner or owner's authorized agent has registered the vessel with the department for that scallop registration area. In this subsection, "adjacent seaward biological influence zone" means all of the waters adjacent to a scallop registration area and seaward to a boundary that is a line drawn in such a manner that each point on it is 200 nautical miles from the baseline from which the territorial sea is measured.

(d) A vessel may be registered to fish in only one scallop registration area at a time.

(e) In addition to the other requirements of this section, a person who takes scallops other than weathervane scallops, and a person who takes weathervane scallops when a permit is required under this chapter, must obtain a permit issued by the department which might include:

(1) location and duration of harvests;

(2) gear limitations and other harvest procedures;

(3) periodic reporting, including logbook requirements;

(4) requirements for onboard observers; and

(5) catch or bycatch limits.

(f) Unless otherwise provided by permit issued under (e) of this section, scallops may be taken only as follows:

(1) a vessel fishing for weathervane scallops may use and carry only scallop dredges with rings having an inside diameter of four inches or larger;

(2) a vessel fishing for scallops other than weathervane scallops may use or carry only scallop dredges with rings having an inside diameter of three inches or larger;

(3) a person may not use chaffing gear or other devices that decrease the legal inside ring diameter of a scallop dredge;

(4) no more than two scallop dredges may be operated at one time from a vessel, and the opening of a scallop dredge may not be more than 15 feet wide.

(g) When taking scallops in a fishery with a guideline harvest range established by regulation, a vessel must carry an onboard observer as specified in 5 AAC 39.141, 5 AAC 39.142, 5 AAC 39.143, and 5 AAC 39.625 unless the department, in its discretion, determines that carrying an onboard observer will not serve the purposes of the onboard observer program. When taking scallops in a fishery without a guideline harvest range established by regulation, a vessel must carry an onboard observer as specified in 5 AAC 39.141, 5 AAC 39.142, 5 AAC 39.143, and 5 AAC 39.645.

(h) Fishing seasons, open and closed areas, and guideline harvest ranges for taking weathervane scallops are set out in 5 AAC 38.120, 5 AAC 38.167, 5 AAC 38.168, 5 AAC 38.180, 5 AAC 38.220, 5 AAC 38.221, 5 AAC 38.320, 5 AAC 38.324, 5 AAC 38.420, 5 AAC 38.425, and 5 AAC 38.430.

(i) Weathervane scallops may be shucked by hand only. A mechanical shucking machine may not be on board a vessel that is fishing for weathervane scallops.

(j) A vessel that is fishing for weathervane scallops may have on board no more than 12 persons who are crewmembers of the vessel. For the purposes of this subsection, "crewmember" means a person involved with the operations of the vessel, and may include a captain, mate, engineer, cook, deckhand and processor worker, but does not include an onboard observer.

ARTICLE 5.

STATISTICAL AREA A (SOUTHEASTERN ALASKA)

5 AAC 38.120. FISHING SEASONS FOR SCALLOPS. In Scallop Registration Area A, scallops may be taken only under the authority of a permit issued under 5 AAC 38.076(e) and only in District 16 and in the waters west of the surf line as described in 5 AAC 33.312(b).

STATISTICAL AREA D (YAKUTAT)

5 AAC 38.167. FISHING SEASONS FOR SCALLOPS. In Scallop Registration Area D, weathervane scallops may be taken from January 1 until 50 percent of the guideline harvest range is taken or through June 30, whichever is earlier, and from July 1 until the remainder of the guideline harvest range is taken or through December 31, whichever is earlier. When the season is closed, a person may take weathervane scallops only if the department issues the person a permit under 5 AAC 38.076(e).

5 AAC 38.168. GUIDELINE HARVEST RANGE FOR THE TAKING OF SCALLOPS. In Scallop Registration Area D, the guideline harvest range for the taking of weathervane scallops is zero to 250,000 pounds of shucked meat.

5 AAC 38.180. CLOSED WATERS. The waters of Yakutat Bay east of a line from the easternmost tip of Ocean Cape to the southernmost tip of Point Manby are closed to the taking of scallops.

ARTICLE 6. STATISTICAL AREA E (PRINCE WILLIAM SOUND)

5 AAC 38.220. FISHING SEASONS FOR SCALLOPS. In Scallop Registration Area E, weathervane scallops may be taken only during periods established by emergency order or only if the department issues the person the permit under 5 AAC 38.076(e).

5 AAC 38.221. GUIDELINE HARVEST RANGE FOR THE TAKING OF SCALLOPS. In Scallop Registration Area E, the guideline harvest range for weathervane scallops is zero to 50,000 pounds of shucked scallop meat.

ARTICLE 7. STATISTICAL AREA H (COOK INLET)

5 AAC 38.320. FISHING SEASONS FOR SCALLOPS. In Scallop Registration Area H, weathervane scallops may be taken or possessed in the Kamishak District from August 15 through October 31. In all others districts, from January 1 through December 31, a person may harvest weathervane scallops if the department issues the person a permit under 5 AAC 38.076(e).

5 AAC 38.322. GEAR FOR SCALLOPS. In the Kamishak, Southern, and Central districts, scallops may be taken only with a single dredge. The opening of a dredge may not be more than six feet in width.

5 AAC 38.324. CLOSED WATERS FOR SCALLOPS. Scallops may not be taken in the following waters:

(1) Cook Inlet north of a line from Cape Douglas to Point Adam, except for the Kamishak District;

(2) inshore from a line from Point Adam to Cape Elizabeth, then to the southwestern point of Perl Island, then to the southern point of East Chugach Island, then to Gore Point;

(3) Nuka Bay inside a line from Yalik Point to 59_27'30" N. lat., 150_22'50" W. long.

5 AAC 38.330. GUIDELINE HARVEST RANGE. The guideline harvest range for the taking of scallops from the Kamishak District is 10,000 to 20,000 pounds of shucked meat.

ARTICLE 8. WESTWARD

5 AAC 38.420. FISHING SEASONS FOR SCALLOPS. Scallops may be taken:

(1) from July 1 through March 31 in the Pacific Ocean waters north of 57_37'07" N. lat., and east of 152_09'01" W. long. (Cape Chiniak Light) and the waters of Shelikof Strait north of 57_17'20" N. lat. (the latitude of Cape Ikolik);

(2) from July 15 through March 31 in the Pacific Ocean waters south of the latitude of Cape Chiniak Light and waters east of the longitude of Cape Barnabas, excluding those waters northwest of a line from Cape Barnabas to Narrow Cape;

(3) in the remainder of scallop Registration Areas K, M, and Q, a person may take weathervane scallops only if the department issues the person a permit under 5 AAC 38.076(e);

(4) from July 1 through June 30 in Scallop Registration Area O.

5 AAC 38.425. CLOSED WATERS FOR SCALLOPS. Scallops may not be taken:

(1) in the Pacific Ocean waters of the Alaska Peninsula Area between the longitude of Scotch Cap and the longitude of Cape Pankof, and waters of king crab Registration Area M extending shoreward and three miles seaward of a line (the base line) beginning at the southernmost tip of Cape Kumlik to the eastern-most tip of Unavikshak Island to the southernmost tip of Atkulik Island to the eastern-most tip of Kak Island to the eastern-most tip of Castle Cap (Tuliumnit Point) to the eastern-most tip of Chankliut Island and from there along the seaward coast to the southernmost tip of Chankliut Island to the southernmost tip of Seal Cape to the eastern-most tip of Mitrofania Island to the southernmost tip of Spitz Island to the southernmost tip of Chiachi Island, and all waters west of the southernmost tip of Kupreanof Point which are depicted as Territorial Sea on NOAA Chart #16540 (10th Ed. Oct 10/81) entitled, "Shumagin Island to Sanak Island", and all waters east of the longitude of Scotch Cap Light and south of Unimak Island and the Alaska Peninsula which are depicted as Territorial Sea on NOAA Chart #16520 (20th Ed. July 10/82) entitled, "Unimak and Akutan Passes and Approaches;"

(2) in waters south of the latitude of Cape Ikolik (57_17'20"N.lat.), west of the longitude of Cape Barnabas (152_52'W. long.), east of the longitude of Kilokak Rocks (126_19'W. long.) and in Old Harbor Narrows west of 153_16'W. long.;

(3) all waters of Sitkalidak Strait, Kiliuda Bay, and Ugak Bay east of 153_ 16' W. long. in Sitkalidak Passage and enclosed by a line from Black Point (56_ 59'30" N. Lat., 153_18' W. long.) to 56_57'30" N. Lat., 153_ 13' W. long., then a line along the three mile contour to 57_ 20' N. lat., 152_ 23' W. long., then a straight line to the southernmost tip of Ugak Island (57_ 22' N. lat., 152_18'30" W. long.) and west of a line from the northernmost tip of Ugak Island (57_ 23'30" N. lat., 152_ 17' W. long.) to Narrow Cape (57_26' N. lat., 152_19' W. long.);

(4) all waters enclosed by a line from Cape Chiniak (57_38' N. Lat., 152_ 09' W. long.) to 57_38' N. lat., 151_47' W. long. then to Cape St. Hermogenes (58_15' N. lat., 151_47' W. long.) and from Marmot Cape (58_10' N. lat., 151_52' W. long) on Marmot Island to Pillar Cape on Afognak Island (58_09' N. lat., 152_07' W. long.)

(5) in waters of the Alaska Peninsula east of the longitude of Three Star Point (159_10' W. long.), west of the longitude of Seal Cape (158_25' W. long.), and north of the latitude of Kupreanof Point (55_34' N. lat.).

(6) in waters of Inanudak Bay enclosed by a line from Cape Kigunak to Cape Ilmalianuk on Umnak Island;

(7) all waters of Akutan Bay south of a line from Akun Head (54_18' N. lat., 165_38' W. long.) to North Head (54_14' N. lat., 165_56' W. long.),

(8) in waters of Kalekta Bay enclosed by a line from the tip of Erskine Point to the tip of Cape Kaletka on Unalaska Island.

(9) all waters of Akun Bay enclosed by a line from Billings Head (54_17'30" N. lat., 165_28'30" W. long.) to 54_13' N. lat., 165_24' 30" W. long. on the opposite shore; and

(10) all waters of Unalaska Bay enclosed by a line from Cape Cheerful (54_01' N. lat., 166_09'30" W. long.) to Cape Kalekta (54_ 00'30" N. lat.);

(11) all waters of Makushin Bay enclosed by a line from Cape Kovrizhka (53_51'N. lat., 167_09'30" W. long.) to Cape Idak (53_31' 20" N. lat., 167_47' W. long.) to Konets Head (53_19'30" N. lat., 167_50'45" W. long.);

(12) all waters of Beaver Inlet south of a line from Brundage Head (53_56' N. lat., 166_12'30" W. long.) to Cape Sedanka (53_50'30" N. lat., 166_05'20" W. long.) and north of 53_42' N. lat.; and

(13) all waters of Uyak Bay, Uganik Bay, Viekoda Bay, Kupreanof Strait, Raspberry Strait, Malina Bay, Paramanof Bay, Foul Bay, and Shuyak Strait east of a line from Cape Uyak (57_38'20" N. lat., 154_20'50" W. long.) to Cape Ugat (57_52'20" N. lat., 153_50'40" W. long.) to Raspberry Cape (58_03'35" N. lat., 153_25' W. long.) to Black Cape (58_24' 30" N. lat., 152_53' W. long) to Party Cape on Shuyak Island (58_31"N. lat., 152_34"W. long.) west of 152_30' W. long. in Shuyak Strait and west of 152_50' W. long. in Whale Pass and Afognak Strait.

5 AAC 38.430. GUIDELINE HARVEST RANGE FOR THE TAKING OF SCALLOPS. In Scallop Registration Areas K and O, the guideline harvest ranges for weathervane scallops are the following:

(1) in waters of Scallop Registration Area K, the guideline harvest range is zero to 400,000 pounds of shucked meat;

(2) in waters of Scallop Registration Area O, the guideline harvest range is zero to 170,000 pounds of shucked meat.

CHAPTER 39 - GENERAL PROVISIONS

ARTICLE 1. GENERAL

5 AAC 39.105. TYPES OF LEGAL GEAR. (d) Unless otherwise provided in this title, the following are legal types of gear;

(16) a scallop dredge is a dredge-line device designed specifically for and capable of taking scallops by being towed along the ocean floor;

5 AAC 39.210. MANAGEMENT PLAN FOR HIGH IMPACT EMERGING FISHERIES. (a) To guide the management of high impact emerging commercial fisheries, a plan is needed that ensures resource conservation, minimizes impacts in existing uses, and provides orderly development of new fishery resources.

(b) The department may regulate a commercial fishery as a high impact emerging commercial fishery if the commissioner determines that any of the following conditions apply to a species or species group in an area or region:

(1) harvesting effort has recently increased beyond a low sporadic level;

(2) interest has been expressed in harvesting the resource by more than a single user group;

(3) the level of harvest may be approaching what may not be sustainable on a local or regional level;

(4) the board has not developed comprehensive regulations to address issues of conservation, allocation, and conduct of an orderly fishery.

(c) The commissioner shall notify the board when a determination is made to manage a fishery as a high impact emerging fishery.

(d) The department shall close a high impact emerging fishery once it is designated as such by the commissioner and may not reopen the fishery until an interim management plan and associated regulations have been adopted by the commissioner. If an interim management plan and regulations have been adopted, the commissioner may allow the fishery to continue.

(e) The department shall develop interim management plans for each high impact emerging commercial fisheries. An interim management plans shall contain at least the following information:

(1) a review of the history of commercial exploitation of the species in Alaska and other relevant jurisdictions;

(2) a review of the life history of the organism;

(3) identification of specific management goals and objectives;

(4) an evaluation of potential impacts on existing users;

(5) designation and justification of the preferred management measures;

(6) an evaluation of the conservation impacts of the preferred management approach on non-target species and on non-target individuals of the same species;

(7) a plan for determining the productivity of the species and impact of the fishery;

(8) a listing of proposed interim regulations;

(9) a cost estimate for plan implementation;

(10) analysis of customary and tradition subsistence use patterns.

(f) The commissioner may adopt regulations and open the fishery consistent with measures identified in the plan. The regulations would remain in effect until the board adopts regulations under (g) of this section.

(g) Upon completion of a draft interim plan, the department shall petition the board under 5AAC 96.625 to consider adoption of the management plan and associated regulations at its next regularly scheduled meeting.

(h) The department may require onboard observes as specified in 5AAC 39.141 and 5AAC 39.645, on fishing vessels, catcher/processors and floating processors that participate in high impact emerging commercial fisheries.

ARTICLE 9. DEFINITIONS

5 AAC 39.975. DEFINITIONS. In 5 AAC 01 - 5 AAC 39

(27) guideline harvest level means the pre-season estimated level of allowable fish harvest which will not jeopardize the sustained yield of the fish stocks. An area, district, section or portion thereof may close to fishing before or after the guideline harvest level has been reached if principles of management and conservation dictate such action;

(35) onboard observer means a representative of the Department of Fish and Game or Public Safety who

(A) is certified by the Department of Fish and Game as having completed minimum training requirements;

(B) is living onboard a fishing or processing vessel for all or part of the period the vessel is at sea; and

(C) is monitoring fishing or processing activities and collecting harvest data essential to management and enforcement.

(40) weathervane scallop means the species *Patinopecten caurinus*.