REVISED ESTIMATES OF THE BYCATCH OF HERRING IN 1989 BERING SEA TRAWL FISHERIES

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Regional Information Report[1] No. 5J90-01

Alaska Department of Fish and Game
Division of Commercial Fisheries
Juneau, Alaska

January 1990

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[1] The Regional Information Report Series was established in 1988 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate needs for up-to-date information, reports in this series may contain preliminary data.

EXECUTIVE SUMMARY

Foreign fishing records and scale pattern analyses demonstrate that herring stocks that spawn in Bristol Bay migrate clockwise around Bristol Bay, arriving on the wintering grounds north and west of the Pribilofs in September. Herring stocks that spawn north of Bristol Bay appear to move more directly offshore after spawning. It is uncertain whether herring stocks from Kuskokwim Bay to Nelson Island move directly offshore or follow a clockwise migratory pattern like Bristol Bay stocks. Based on prior joint venture (JV) and foreign records, only 1989 Pacific cod and pollock trawl fisheries that occurred along the herring migration route had the potential to take significant amounts of herring. Yellowfin sole fisheries did not occur near herring spawning grounds during the herring spawning period in 1989.

Herring bycatch by JV fisheries in 1989 was estimated to be 2,588 tonnes. Most of the JV bycatch occurred in pollock fisheries in National Marine Fisheries Service (NMFS) reporting areas 521 and 522 (north and west of the Pribilofs) in the fall. The most comprehensive source of herring bycatch for domestic fisheries for 1989 was obtained by applying average 1983-88 foreign and JV observer bycatch rates by 1/2° latitude by 1° longitude area by month to 1989 fish ticket catches by 1/2° latitude by 1° longitude by month. Using this method, herring bycatch was estimated to be 559 tonnes for domestic Pacific cod fisheries, 1,808 tonnes for pollock bottom trawl fisheries and 346 tonnes for pollock midwater trawl fisheries. Although observer bycatch rates were computed based on the total catch, for ease of computation observer bycatch rates were applied only to the retained catch of the single target species in the fish ticket catch. Because of this, herring bycatch was underestimated by this method. The degree of was underestimation greater for bottom trawl data than for midwater trawl data, because there are usually more species in bottom trawl catches.

Landed discard reported on fish tickets and actual domestic observer catch reports for limited areas were also used to estimate herring bycatch in 1989 domestic trawl fisheries. These estimates were roughly comparable to the herring bycatch computed by applying 1983-88 average observer bycatch rates to the 1989 fish ticket catches. However, landed discard herring bycatch rates also underestimate herring bycatch when at-sea sorting occurs or when trawl cod-ends are released because they contain significant numbers of prohibited species. Total herring bycatch estimated for JV and domestic fisheries for 1989 ranged from 4,521-5,301 tonnes. Because several of the methods used underestimate herring bycatch rates, these estimates represent the lower bound of the actual 1989 herring bycatch.

Bering Sea herring stocks are declining and are projected to decline below threshold levels where commercial fisheries are allowed at Nelson Island and Nunivak Island in 1990. If no recruitment is observed in 1990, the Togiak stock will likely be below its threshold in 1991. Because herring stocks have declined while the bycatch of herring has increased, herring bycatch exploitation rates have increased from less than 2% in 1983 to 4%-5% in 1989, and are projected to increase further in 1990. When trawl herring bycatch is considered, the maximum allowable herring exploitation rates under the Alaska Board of Fisheries herring harvest policy are being exceeded.

Subsistence utilization of herring resources is high in some communities of western Alaska, particularly at Nelson Island. Although declines in herring abundance projected for 1990 would not result in subsistence closures for 1990, subsistence availability may be reduced and further declines in the resource could force reductions of subsistence harvests. Western Alaska communities experienced severe difficulties in harvesting herring for subsistence purposes during herring stock declines in the 1970s.

Fish ticket records of catch by 1/2° latitude by 1° longitude by date of landing allow relatively detailed distributions of fishing effort to be examined. Combining these fish ticket records with foreign and JV observer herring bycatch records in the same area and time strata could allow detailed examination of alternative herring bycatch control measures. Herring bycatch control measures were last examined when the draft Bering Sea herring fishery management plan was submitted by the NPFMC to the Secretary of Commerce in November 1983. Since that time, a considerable amount of new data has become available for herring bycatch analysis.

INTRODUCTION

Herring that spawn along the eastern shore of the Bering Sea migrate to wintering areas near the western edge of the Bering Sea continental shelf (Dudnik and Usol'tsev 1964, Rumyantsev and Darda 1970, Wespestad and Barton 1979) . During this annual migration, eastern Bering Sea herring pass through areas in which groundfish vessels are trawling. During the past decade, substantial incidental harvests of migrating herring were taken, first by foreign groundfish fleets, then by joint venture (JV) groundfish fleets, and more recently by domestic groundfish trawlers. Recent declines in the biomass of Bering Sea herring stocks have been accompanied by apparent increases in herring bycatch exploitation rates by groundfish trawl fisheries. This has prompted concern over the impact of trawl bycatches, particularly on the smaller discrete stocks of western Alaska. Several of these stocks are already below threshold levels for commercial harvests, and the important Togiak stock is projected to be below its threshold in 1991.

During the 1980s, observer coverage aboard foreign and JV fisheries was generally high enough to allow reliable reporting of herring bycatch. Because observer coverage of the domestic fleet through 1989 was minimal, herring bycatch estimates for domestic fisheries must be derived primarily from other sources. This document reports the available estimates of herring bycatch from 1989 domestic and JV trawl fisheries and reviews the available information about the distribution and stock status of herring in the eastern Bering Sea. Additional sources of bycatch data are examined from those reported in Funk and Watson (1989).

DISTRIBUTION OF HERRING IN THE BERING SEA

Information about the distribution of herring in the Bering Sea between spawning seasons is available from records of earlier foreign high seas directed herring fisheries and from scale pattern analysis studies conducted along the Alaska Peninsula. Soviet research vessels discovered large concentrations of Pacific herring overwintering northwest of the Pribilof Islands (Figure 1) between 1957-60, and Soviet commercial trawl vessels began to target herring in this area early in 1961 (Shaboneev 1968, Rumyantsev and Darda 1970). The Soviet fishery continued to concentrate in this area until the mid-1970s (Figure 2), with the heaviest fishing occurring during February. Japanese trawl vessels fished in the same area beginning in the mid-1960s (Figure 3). Japanese gill net vessels followed herring schools during late winter and spring and fished adjacent to the spawning grounds. Summaries of records compiled from the foreign fishery indicate that herring leave the wintering grounds in March or early April and begin to move eastward (Figure 4). Some of the herring from the northwest Pribilof wintering area move northeast to spawn along Kuskokwim Bay, Nunivak Island and possibly into Norton Sound, while others travel southeast to spawn in Bristol Bay and along the Alaska Peninsula. Herring spawning in Bristol Bay are thought to travel in a clockwise direction and inhabit areas adjacent to the Alaska Peninsula during the summer months before departing for the Pribilof

overwintering area in September (Figure 5). During the Soviet investigations, herring appeared in the overwintering area in September, and by October formed relatively tight aggregations (Rumyantsev and Darda 1970).

Stock identification studies using scale pattern analysis were conducted from 1982-85 by Rowell (1986), Walker and Schnepf (1982), Rogers et al. (1984), and Rogers and Schnepf (1985) to determine the origins of herring captured in the food/bait fishery that occurs in July and August near Dutch Harbor on Unalaska Island. These studies established that it would be difficult to distinguish differences among Security Cove, Goodnews Bay, and Togiak spawning stocks using scale pattern analysis. However these stocks were readily distinguishable from Nelson Island, Nunivak Island, Cape Romanzof, and Norton Sound spawning stocks using scale pattern analysis. Rogers and Schnepf (1985) performed the most comprehensive of the scale pattern studies and found that Togiak-spawning herring were by far the dominant stock in the Dutch Harbor food/bait fishery. The occurrence of substantial numbers of Togiak-spawning herring near Dutch Harbor in July and August strongly supports the clockwise annual migration around Bristol Bay hypothesized from foreign fishing records (Figures 4 and 5). Rogers and Schnepf (1985) also found some evidence that Nelson Island spawning herring occur in the Dutch Harbor catch, indicating that Kuskokwim Bay herring stocks may also follow a clockwise migrational pattern around Bristol Bay.

The Alaska Department of Fish and Game, in cooperation with the National Marine Fisheries Service conducted a more intensive herring scale pattern analysis study in the Bering Sea during the summer of 1989. Reference standards were collected from all commercially exploited eastern Bering Sea herring spawning stocks during the spring 1989 spawning season, with sample sizes substantially larger than in the earlier scale pattern studies. Samples of herring of unknown origins were collected from the Port Moller Pacific cod trawl fishery, the Unimak Pass pollock trawl fishery, and from the Dutch Harbor food and bait herring purse seine fishery. Results from this study will be available in February 1989 and should provide additional information about herring migratory patterns.

STATUS OF EASTERN BERING SEA HERRING STOCKS

Bering Sea herring stocks were once far more productive than at present. Shaboneev (1968) estimated that in 1962-63 the biomass of Bering Sea herring stocks exceeded 2 million metric tons. The reported foreign directed herring harvests in the Bering Sea exceeded 100,000 metric tons in 1969 and 1970 (NPFMC 1983). The large foreign harvests during the 1960s appear to have damaged the herring resource, as catches and catch per unit effort declined substantially in the early 1970s. Western Alaska residents also experienced extreme difficulty in harvesting herring for subsistence needs during the early 1970s, necessitating emergency supplies of food to be airlifted into communities with high dependence on herring (Pete 1989). Although herring stocks appeared to be rebuilding in the Bering Sea following the recruitment of the strong 1977-78 year classes, the lack of recruitment since that time has resulted in further declines of the Bering Sea herring stocks.

The abundance of eastern Bering Sea herring stocks from Togiak to Norton Sound has been declining in recent years (Figure 6), and is projected to decline further (Funk and Savikko *in press*). The total harvest from these stocks for 1990 is forecast to be only 12,449 tonnes, down substantially from the 24,202 tonnes harvested in 1989 (Table 1). The important Togiak stock is projected to decline in 1990 to 56,020 tonnes (Rowell and Brannian 1989). Without substantial recruitment in 1990, the Togiak stock may decline below the 31,752 tonne threshold which would result in no commercial fishery being allowed in 1991. Stocks at Nelson Island and Nunivak Island are projected to be below their thresholds for 1990 (Hamner 1989). Unless substantial recruitment is observed prior to spawning, no commercial fishery will be allowed on these stocks in 1990. The Nelson Island herring stock also supports an important and substantial subsistence harvest (Pete 1989). Earlier herring shortages, coincident with foreign overexploitation of Bering Sea herring resources, caused considerable hardship among Nelson Island residents (Pete 1989). The 1977 and 1978 year classes, which were very strong in all eastern Bering Sea herring populations, are now senescing rapidly. The remaining fish from these cohorts will be age 12 and 13 in 1990 and are experiencing relatively high rates of natural mortality. No substantial year classes have recruited to eastern Bering Sea herring stocks to replace the 1977 and 1978 year classes.

EASTERN BERING SEA GROUNDFISH FISHERIES IN 1989

The 1989 harvest of groundfish in the eastern Bering Sea/Aleutians area through early December totalled 1,572,721 tonnes (Table 2). Based on the previous patterns of bycatch observed in foreign and JV fisheries, only pollock and cod fisheries had a potential for significant herring bycatch in 1989. In earlier years herring bycatch was also a concern in yellowfin sole JV fisheries which occurred adjacent to herring spawning grounds in Bristol Bay during the herring spawning period. In 1989, fishing for yellowfin sole did not occur between April and August.

Joint venture groundfish harvests in the Bering Sea were reduced in 1989 as the harvests by the competing domestic trawl fleet increased dramatically over 1988. JV groundfish harvest estimates by NMFS through early December totalled only 514,710 tonnes for the Bering Sea/Aleutian Islands FMP area. Through August, JV fisheries had been allocated only 602,000 tonnes of the 2,000,000 tonne total allowable catch (TAC), whereas in 1988 JV fisheries had been allocated almost 1,300,000 tonnes. JV harvests will likely be much further reduced in 1990.

Summaries of fish ticket harvests by 1/2° latitude by 1° longitude statistical area indicate that the largest concentration of domestic pollock fishing effort occurs in the "horseshoe" area just north of Unimak pass, where the 100 fathom depth contour creates a "U" shape (Figure 7). Substantial pollock fishing effort is also spread out to the northwest along the continental shelf edge as far north as St. Matthew Island. Fish ticket harvests by 1/2° latitude by 1° longitude were smoothed by distance weighted least squares for plotting in Figure 7, to better reveal spatial patterns and to more appropriately reflect imprecision in the location of catch reporting. Unsmoothed data were used to compute bycatch

rates. The highest pollock catches in the 1989 domestic pollock fishery occurred in July, August, and September (Figure 8), when herring were transitting the shelf edge enroute to their wintering grounds north and west of the Pribilofs. Some pollock fishing by domestic vessels occurred in the area of the herring wintering grounds, north and west of the Pribilofs. A large JV pollock fishery also occurred in this area from September through November, coincident with the arrival of herring on the wintering grounds. Fish ticket records indicate that 58% of the domestic pollock harvest was taken by midwater trawl gear, with almost all of the remaining harvest taken by bottom trawl gear.

The 115,551 tonne domestic Pacific cod catch came primarily along the Alaska Peninsula just north and east of Unimak Pass (Figure 9). Under special regulations, a small domestic Pacific cod bottom trawl fishery has been allowed in the normally closed area just offshore of Port Moller. This fishery harvested only 5,604 tonnes of cod in 1989. Fish ticket records indicate that almost all the Pacific cod was caught using bottom trawl gear.

1989 JOINT VENTURE FISHERY HERRING BYCATCH ESTIMATES

The NMFS observer program gathers data on prohibited species catches from a significant proportion of the tows made by the JV fleet. NMFS observers estimated that 2,588 tonnes of herring were captured in the 527,862 tonnes of groundfish harvested in all 1989 JV fisheries, for an overall bycatch rate of 0.49% by weight (Table 3).

Very few herring were taken during yellowfin sole JV fisheries in 1989. The JV yellowfin sole fishery harvested 200,594 tonnes of which only 0.1 tonne was herring. Most of the yellowfin sole harvest occurred in February and March in the central and southeastern portion of Bristol Bay. No JV effort for yellowfin sole was reported from area NMFS reporting area 514 (Figure 10) near the Togiak spawning grounds during the spring herring spawning period. In 1987 and 1988, JV fisheries in this area during the herring spawning period had prompted concern over the potential for large herring bycatches.

Preliminary data are available showing herring bycatch by month for 1989 JV fisheries targetting pollock and "other species" (primarily Pacific cod). These data indicate that most of the herring bycatch occurred in September and October in areas 521 and 522 (Table 4), northwest of the Pribilof Islands.

Although the overall 1989 JV bycatch rate was relatively high, the amount of herring bycatch by the JV fleet was slightly less than in recent years. Herring bycatches by foreign and JV fleets have ranged from 1,000-4,000 tonnes (Table 5) since directed foreign fishing was prohibited in the late 1970s (Wespestad 1986, Nelson 1988). The JV bycatch of herring will probably be further reduced in 1990 as the JV groundfish allocation is likely to be reduced.

DOMESTIC TRAWL FISHERY HERRING BYCATCH ESTIMATES

During 1989, observer coverage of the domestic groundfish fleet was limited and was sufficient to directly estimated bycatch only in certain areas. Additional estimates of herring bycatch were derived from discard reported on Alaska Department of Fish and Game (ADF&G) fish tickets, and by applying foreign and JV bycatch rates from similar areas and months to the 1989 domestic groundfish harvest.

Area 521-522 Pollock Fishery, September-October, using 1989 JV Bycatch Rates

Domestic pollock vessels were fishing areas north and west of the Pribilofs during September and October (Figure 11), when JV pollock fisheries were occurring in the same area. The combined domestic pollock and cod harvest from areas 521-522 during September and October totalled 42,985 tonnes (Table 6). Applying the JV bycatch rates by month and NMFS reporting area (Table 4) to these harvests results in an estimated herring bycatch of 996 tonnes (Table 6).

Landed Herring Bycatch Estimates from Unimak Pass Area Fish Tickets

A previous report (Watson 1988) summarized herring bycatch based on 1988 fish tickets. In May 1988, Bering Sea pollock processors and vessels were asked to monitor and report on their fish tickets any herring that were landed along with pollock catches. For 1989, processors and fishing vessel operators were again asked to report this information. This year's estimates differ from the 1988 study in three ways:

(1) the 1989 study area was expanded (north and west) as herring bycatch was reported from a larger area than in 1988 (Figure 12),

(2) calculated herring bycatch rates were applied to pollock harvested by both midwater and bottom trawl gear as herring were reported on both gear types in 1989 (vs midwater trawl only in 1988), and

(3) fish tickets were screened by processor because some processors appeared to report herring bycatch more reliably than others.

The domestic catch of pollock in areas covered by the Bering Sea/Aleutians Fishery Management Plan (FMP) has increased annually since 1978 to a record high 591,901 mt in 1989 (PMFC 1989). Approximately 56% of the total 1989 Bering Sea pollock catch was been harvested from the Unimak Pass area in 1989. During 1989, 17 vessels which fished the Unimak Pass area reported herring bycatch on at least one fish ticket. Based on the prior year's experience, vessels which routinely fished the Unimak Pass area would have a very high probability of capturing herring on at least one trip. This initial screening removed vessels which always sorted their catch at sea or never complied with the landed discard reporting request. Data from the resulting sample of 17 vessels included both

shore-based and floating processor sectors.

The Unimak Pass study area was defined based on the ADF&G statistical areas from which the sample of 17 boats reported herring bycatch (Figure 12). Data gathered from the sample of 17 vessels represented 53% of the pollock harvested from the study area between July and October. During the months examined, these vessels made 237 landings of pollock. During July, 73 percent of the fish tickets listed a bycatch of herring, while the percentage of fish tickets reporting herring declined to 48 percent in August, 51 percent in September, and 47 percent in October.

The overall frequency distribution of the herring bycatch rates by landing ranged from 0% to 19% (Figure 13). However, there was a significant variation in the bycatch rates reported by processor. The data from one processor (Figure 14), indicated that less than 17% of the landings had no herring, while other processors were reporting that greater than 50% of the landings had no herring. Because the reporting program was voluntary and some processors were thought to have instructed their vessels to sort at sea if at all possible, the bycatch data from the processor that reported only 17% of landings with no herring was felt to be a more reliable estimate of the actual landed discard bycatch rate.

Estimates of the herring bycatch rate for the Unimak Pass area were calculated by month in two ways. The first method was to assume that the frequency distribution of Figure 13 was correct, and that there were no differences in reporting among processors. Using this method, the landed herring bycatch rate averaged 0.44% from July through October in the Unimak Pass area sample (Table 7). If the monthly bycatch rates were applied to the larger area encompassing NMFS reporting areas 511, 513, 515, and 517, the total estimated herring bycatch using this method was 1,058 tonnes. Because the distribution of harvest by month from these areas was different than in the Unimak Pass area, the average bycatch rate for the larger areas was 0.42%.

The second method assumes that frequency distribution of the landed discard herring bycatch rate for the processor shown in Figure 14 was correct. Using this method, the landed discard herring bycatch rate averaged 0.46% from July through October (Table 7). Applying these monthly bycatch rates to reporting areas 511, 513, 515, and 517, the total estimated herring bycatch would be 834 tonnes. The average bycatch rate for these reporting areas was 0.33% This rate is lower than the rate for just the Unimak Pass area because herring bycatch rates from the reliable processor were relatively low in September and October, while more harvest occurred in the larger areas later in the year than in just the Unimak Pass area. The sample size for landings for the reliable processor during September and October was small, and could account for the fact that hering bycatch rates were lower for this processor than for all processors during September and October.

Both estimates of herring bycatch are presumed to be conservative because there were probably at-sea discards of herring that were not recorded, particularly when entire codends were dumped due to considerable herring bycatch. Compared to the 1988 data, the bycatch zone appears to be expanding, perhaps as a result of better reporting by industry. Several other areas were identified as having significant herring bycatch (Pribilof Islands and St. Matthew Island) but there

was not enough reported landed discard data for a similar analysis.

Domestic Observer Herring Bycatch Estimates

Port Moller

Federal regulations allow a Pacific cod bottom trawl fishery in the inshore portion of area 512 (Figure 10), which has been designated the area of the "Port Moller Pacific cod fishery". Vessels fishing in this area were required to participate in a data-gathering program which sought to enumerate the catch of all species captured through an observer program. During 1989 observers spent a total of 62.4 days on the fishing grounds in the Port Moller area. The total 1989 herring bycatch in the Port Moller cod fishery was 103 tonnes accompanying a total harvest of 5,604 tonnes, for a bycatch rate of 1.84% (Table 8).

The 1989 fishery started in early June and closed when the red king crab prohibited species catch limit was reached on July 14. Although detailed records of the 1989 fishery are not yet available, the timing of the fishery was similar to the 1988 fishery which started in late May and ended on July 7th. During 1988, the largest herring bycatches occurred in late June (Hare 1988). Hare (1988) noted that herring bycatches during 1988 in the Port Moller area were extremely variable, and that the overall herring bycatch rate of 5.72% in the 1988 fishery was attributed primarily to a single large haul of herring. The 1988 fishery in area 512 occurred in almost all areas that were open to trawling, except for shallow inshore areas (Figure 15). Although there were reports that several cod-ends containing mostly herring were released, no bycatch estimates from released cod-ends are available.

Other Areas

Observer coverage of the domestic trawl fleet in 1989 was much less thorough than prior coverage of JV and foreign fleets. Several sources of funding were used to support limited domestic trawl observer coverage during 1989. NMFS planned to achieve 20% to 35% observer coverage of the domestic trawl fishing effort through the Marine Mammal Protection Act (MMPA) observer program and a NMFS/fishing industry matching funds observer program. Modifications to the MMPA implemented on July 21, 1989 allowed NMFS to place observers on classes of fishing vessels which were determined to incidentally capture marine mammals. These observers also routinely sampled the groundfish catch and enumerated prohibited species. As of late September observers had sampled aboard 10 catcher/processor vessels and 5 trawlers delivering their catch to processing plants in Dutch Harbor. Observer reports classify "target" species as follows:

1. Pollock midwater trawl fisheries: if the weight of the pollock composes 95% or more of the week's catch.

2. Pollock bottom trawl fisheries: if the weight of the pollock and Pacific cod combined composes more than 50% of the catch and the weight of cod is less than 5%.

3. "Other" bottom trawl fisheries: if the weight of the pollock and cod combined composes more than 50% of the catch and the weight of cod is greater than or equal to 5% of the catch; or if the fishery does not fit into any of the other categories.

The Pacific herring bycatch rate reported by observers in these fisheries ranged from <0.01% to 1.09% (Table 9). The highest bycatch rate was recorded by observers in area 511 "other" bottom trawl fisheries. Because of the relatively low level of sampling coverage, these bycatch estimates were not applied to the total catch.

Estimates from Average JV/Foreign Observer Bycatch Estimates, 1983-88

Recent NMFS JV and foreign observer estimates of herring bycatch rates by month and 1/2° latitude by 1° longitude provide another method of estimating bycatch rates in the domestic fishery. Foreign and JV observer herring bycatch estimates for "midwater trawls targetting on pollock" (> 95% pollock in the harvest) were applied to the fish ticket reported catches for midwater trawl gear. Observer bycatch estimates for "bottom trawls targetting on pollock" (pollock and cod > 50% of the total catch and cod < 5% of the catch) were applied to the fish ticket reported pollock catches for bottom trawl gear. Foreign and JV observer herring bycatch estimates for "other bottom trawls" were applied to the Pacific cod harvest.

Observer estimates of herring bycatch rate for each 1/2° latitude by 1° longitude area and month were averaged over the 1983-1988 period separately for pollock midwater trawl target data, pollock bottom trawl data, and "other bottom trawl" targetted data. Because the ratio of herring to pollock biomass change over the 1983-88 period, bycatch rates were adjusted for differences in relative abundance when pollock fishery bycatch rates were computed. The ratio of eastern Bering Sea herring to pollock biomass was standardized so that the ratio for 1989 was 1.0 (Table 10). Herring bycatch rates were multiplied by this standardized ratio before averaging over years. Observed herring bycatch rates for vessels targetting on cod were not adjusted for differences in relative stock size over the 1983-88 period. The resulting data provide fairly complete coverage of the 1/2° latitude by 1° longitude areas in the Bering Sea. For example, for the month of July, bycatch rates in pollock-targetted JV and foreign fisheries were high in the horseshoe area, similar to the 1989 landed discard reports from fish tickets, but also surprisingly high in the area southeast of St. Matthew Island and southwest of Nunivak Island (Figure 16). The high herring bycatch rates in this area in July may indicate the movement of Norton Sound and western Alaskan stocks directly offshore to the wintering grounds.

Observer bycatch rates for 1/2° latitude by 1° longitude area squares are computed as the ratio of the weight of herring to the total weight of all species in the catch. However for fish ticket data, only the total catch of the target species was readily available. Therefore the herring bycatch is underestimated when observer bycatch rates are applied to fish ticket data, to the extent that the total catch is much greater than the catch of just the target species. For

pollock midwater trawls the underestimation is relatively minor, but for cod and pollock bottom trawls the underestimation could be substantial.

Foreign and JV observer bycatch data were not available for all month and area combinations fished by the domestic trawl fleet. For areas with substantial catches (> 0.05% of the 1989 total harvest) but with no corresponding observer data, the herring bycatch rates for areas immediately surrounding the missing area were averaged. For areas that had no corresponding observer data but had relatively small amounts of catch (< 0.05% of the 1989 total harvest), annual average herring bycatch rates for all areas which had matching observer data were used.

For Pacific cod, 67% (52,878 tonnes) of the fish ticket catch occurred in 1/2° latitude by 1° longitude areas for which corresponding observer data were available. The total estimated herring bycatch from these areas was 203 tonnes, for an annual estimated bycatch rate of 0.38% (Table 11). Twenty one percent of the catch data occurred in areas that had more than 500 tons of catch, but could not be assigned a corresponding average observer herring bycatch rate from the same 1/2° latitude by 1° longitude area in the same month. Bycatch rates for these catches were assigned the average bycatch rate of the immediately surrounding areas with nonmissing observer data in the same month. The total estimated herring catch in this category was 319 tonnes, for an annual estimated herring bycatch rate of 1.94%. Twelve percent of the catch occurred in areas that had less than 500 tons of catch and could not be assigned a corresponding average observer herring bycatch rate. Bycatch rates for these areas were assigned the average bycatch rate for all areas with corresponding observer bycatches of 0.38%, for an estimated herring bycatch of 37 tonnes. The total estimated herring bycatch in 1989 domestic Pacific cod fisheries using these methods was 559 tonnes.

For pollock caught with bottom trawl gear, 64% (238,985 tonnes) of the fish ticket catch occurred in 1/2° latitude by 1° longitude area for which corresponding observer data were available. The total estimated herring bycatch from these areas was 1,437 tonnes, for an annual estimated bycatch rate of 0.60% (Table 11). Twenty five percent of the catch data occurred in areas that had more than 2,000 tons of catch, but could not be assigned a corresponding average observer herring bycatch rate from exactly same 1/2° latitude by 1° longitude area in the same month. Bycatch rates for these catches were assigned the average bycatch rate of the immediately surrounding areas with nonmissing observer data. The total estimated herring catch in these areas was 131 tonnes, for an annual estimated herring bycatch rate of 0.14%. Eleven percent of the catch occurred in areas that had less than 2,000 tons of catch and could not be assigned a corresponding average observer herring bycatch rate. Bycatch rates for these areas were assigned the average bycatch rate for all areas with corresponding observer bycatches of 0.60%, for an estimated herring bycatch of 240 tonnes. The total estimated herring bycatch in 1989 domestic pollock bottom trawl fisheries using these methods was 1,808 tonnes.

For pollock caught with midwater trawl gear, 81% (417,699 tonnes) of the fish ticket catch occurred in 1/2° latitude by 1° longitude area for which corresponding observer data were available. The total estimated herring bycatch from these areas was 248 tonnes, for an annual estimated bycatch rate of 0.06%

(Table 11). Fourteen percent of the catch data occurred in areas that had more than 3,000 tons of catch, but could not be assigned a corresponding average observer herring bycatch rate from exactly same 1/2° latitude by 1° longitude area in the same month. Bycatch rates for these catches were assigned the average bycatch rate of the immediately surrounding areas with nonmissing observer data. The total estimated herring catch in these areas was 83 tonnes, for an annual estimated herring bycatch rate of 0.11%. Five percent of the catch occurred in areas that had less than 3,000 tons of catch and could not be assigned a corresponding average observer herring bycatch rate. Bycatch rates for these areas were assigned the average bycatch rate for all areas with corresponding observer bycatches of 0.06%, for an estimated herring bycatch of 15 tonnes. An additional 728 tonnes of midwater trawl pollock catch could not be assigned to a 1/2° latitude by 1° longitude area. The average bycatch rate for matched areas was applied to this catch, resulting in an additional 0.4 tonne herring bycatch estimate. The total estimated herring bycatch in 1989 domestic pollock midwater trawl fisheries using these methods was 346 tonnes.

Midwater trawl and bottom trawl gear may not be completely separable in the fish ticket database. Incorrect reporting of gear codes occurs, as do multiple gear types for catch reported on individual fish tickets. In addition, the domestic fleet is reported to be increasingly proficient at fishing midwater trawl gear close to the bottom, and bottom trawl gear is occasionally fished off the bottom. For comparison, a similar analysis using pooled midwater trawl and bottom trawl fish ticket catch, and pooled pollock midwater trawl and pollock bottom trawl observer bycatch rates was performed. Using data pooled for both gear types, the 1989 herring bycatch in the domestic pollock fishery for both gears was estimated to be 2,249 tonnes, only slightly more than the 2,154 tonnes estimated for the analysis with each gear type separately.

TOTAL 1989 HERRING BYCATCH

Bycatch estimates from the various sources for 1989 groundfish trawl fisheries are summarized in Table 12. Herring bycatch in the domestic pollock fishery from reported landed discard rates and 1989 JV rates for areas 521 and 522 is estimated to total at least 1,830-2,034 tonnes. Although the bycatch reported on fish tickets may underestimate the actual bycatch because of unreported at-sea discards, the relatively large fish ticket sample size provides a reliable estimate of the lower bound of the herring bycatch rate. Estimates of the herring bycatch in domestic pollock fisheries computed by applying 1983-88 average JV and foreign bycatch rates totalled 2,154 tonnes.

The 103 tonne herring bycatch from the Port Moller cod fishery should be a reasonably reliable estimate for that fishery, given the relatively high proportion of observed tows in the area. This estimate would not include the bycatch from cod-ends that were released prior to observer sampling. The proportion of the harvest observed by NMFS observers in areas other than Port Moller was relatively small, given the numbers of vessels and short time period observed. Because of the small observer sample size in 1989, bycatch estimates from observers aboard domestic fishing vessels in areas other than Port Moller

are not likely to be highly reliable.

Estimates of herring bycatch in Pacific cod fisheries computed by applying 1983-88 average JV and foreign bycatch rates totalled 559 tonnes. However, the domestic cod fleet fishes in some areas that were not fished by foreign and JV fleets. Thirty three percent of the 1989 domestic cod catch occurred in 1/2° latitude by 1° longitude areas in months for which no comparable foreign or JV data were available.

The total herring bycatch computed by applying 1983-88 average JV and foreign observer bycatch rates to the 1989 domestic harvest and by using the 1989 observer reports of JV herring bycatch totals 5,301 tonnes (Table 12). This figure is slightly greater than the 4,521-4,725 tonne range computed by applying the 1989 JV bycatch rate in area 521-522 pollock fisheries to domestic harvests in those areas and the bycatch computed from landed discard rates in remaining areas.

1983-1989 HERRING BYCATCH EXPLOITATION RATES

Total herring bycatch from all sources increased slightly from 1983-86 when only foreign and JV fleets took significant amounts of catch (Table 5) to 1989 (Table 12). Domestic groundfish harvests became substantial in 1987 and 1988; no herring bycatch estimates are available for these years, although an estimate using 1/2° latitude by 1° longitude average observer bycatch rates could be performed. Herring bycatch exploitation rates were computed as the ratio of the estimated herring bycatch to the estimated stock size in August. Most herring bycatch was estimated to occur in August, based on the foreign-JV observer-based analysis. May herring spawning biomass estimates were projected to August assuming an instantaneous natural mortality rate of 0.45. Herring bycatch exploitation rates increased from less than 2% in 1983 to 4%-5% in 1989 (Figure 17). If the 1989 bycatch is compared to the projected 1990 herring stock size, bycatch exploitation rates would be 7%-8%.

These exploitation rates apply to the total biomass of herring spawning in the eastern Bering Sea. However, trawl bycatch removals may not be distributed equally across each discrete herring spawning stock. A stock identification study designed to test the hypothesis that herring travel in discrete schools by stock was performed by ADF&G and NMFS during the summer of 1989. Results of this study will be available in February 1990. If herring do aggregate by discrete stock during the annual migration, it is possible that bycatch exploitation rates could vary substantially from stock to stock. Several of the eastern Bering Sea stocks, particularly those at Nelson and Nunivak Islands are reduced in size and could be easily adversely affected by trawling effort on localized areas.

DISCUSSION

Areas of potential high herring bycatch occur along the late summer herring migration routes and on the herring wintering grounds in the central Bering Sea. Bristol Bay and Kuskokwim Bay herring occur along the Alaska Peninsula and are intercepted by the horseshoe area pollock fishery in July, August and September. Another area of high herring bycatch occurs southwest of Nunivak Island in July and August, likely involving stocks between Norton Sound and Kuskokwim Bay. As demonstrated by the high 1989 JV herring bycatches in NMFS reporting areas 521-522, concentrations of herring are still found north and west of the Pribilofs during the winter months.

The draft fishery management plan (FMP) for Bering Sea herring submitted by the North Pacific Fisheries Management Council (NPFMC) to the Secretary of Commerce in November 1983 (NPFMC 1983) contained a number of options for "herring savings areas" with measures to avoid substantial trawl bycatches of herring. Most of these areas were centered around the central Bering Sea herring wintering area. Aggregations of herring on the wintering grounds north and west of the Pribilof Islands were targetted by foreign fleets during the 1960s and 1970s. After the prohibition of targetted herring fishing by foreign vessels, federal foreign fishing regulations established a special herring zone northwest of the Pribilof Islands, bounded by latitudes 58°0′ to 59°30′ and longitudes 172° to 175°. Foreign fishing was allowed in the herring zone, but between September 1 and April 30 special detailed weekly reporting of catch and effort data was required of all vessels fishing in the zone. Little fishing effort occurred in the zone after the imposition of the reporting requirements, apparently due to the increased record keeping and reporting requirements (J. Smoker, National Marine Fisheries Service, Juneau, personal communication).

Further analyses of herring bycatches by time and area are possible than are documented in this report. The relatively small 1/2° latitude by 1° longitude strata available for both fish ticket catches and for JV, foreign, and domestic observer data allow for detailed analyses that could be used to indicate relatively precise time periods and areas where concentrations of herring are likely to be encountered. These data are considerably more recent than the data used to develop the herring bycatch control measures of the 1983 draft herring FMP (NPFMC 1983).

More detailed analysis of these bycatch data may reveal other features of herring migration. For example, the high herring bycatch rates southwest of Nunivak Island in July likely indicate the movement of Norton Sound, Cape Romanzof and other western Alaskan stocks directly offshore. While it has been clearly demonstrated that Togiak stocks migrate clockwise around Bristol Bay, the direction of movement for Kuskokwim Bay, Nelson Island, and Nunivak Island stocks is less clear. The scale pattern analyses of Rogers and Schnepf (1985) indicated that Nelson Island stocks might be present in July at Dutch Harbor, but the evidence was inconclusive. It is possible that these stocks move directly offshore and are represented in the high herring bycatch rates southwest of Nunivak Island in July.

No estimates of the amount of herring captured in trawl cod-ends and released

is available, although there were reports of such events occurring in the 1989 fishery. For this reason, the 4,521-5,301 tonne range of herring bycatch estimates computed for the domestic trawl fleet likely represents a lower bound of the actual harvest. Herring mortality in trawl gear is likely to be very high, even if cod-ends are opened immediately after the trawl is raised. Herring bycatch computed by applying JV and foreign herring bycatch rates to fish ticket catch data also underestimated herring bycatch. JV and foreign observer herring bycatch rates are computed as the ratio of the weight of herring to the total catch weight. For ease of computation, observer bycatch rates were applied only to the retained catch of the single target species in the fish ticket catch. The degree of underestimation is greater for bottom trawl data than for midwater trawl data.

Inshore herring fisheries are managed under an Alaska Board of Fisheries harvest policy that sets maximum exploitation rates at 20%. In some areas, the maximum commercial exploitation rate is set at 15% to allow for a historic subsistence utilization. If herring stock sizes decline, the Board has directed ADF&G to reduce the exploitation rate. When herring stock sizes decline below established thresholds in each area, commercial fisheries are closed. The Board of Fisheries has allowed mixed stock herring food and bait fisheries in some areas, but has directed that total exploitation rates not exceed 20%. Based on the stock identification analysis that showed that Togiak stocks were by far the dominant stock in the Dutch Harbor food and bait herring fishery, the Board of Fisheries assigned the Dutch Harbor harvest to the Togiak stock. The Board took action in November 1989 to reduce the Dutch Harbor food and bait herring harvest to no more than 7% of the allowable harvest at Togiak, with combined harvest in food and bait and sac roe fisheries not to exceed 20% of the Togiak stock. The Board further directed ADF&G to close the Dutch Harbor food and bait fishery if subsistence harvests of other stocks from Togiak to Norton Sound were threatened. Because the trawl bycatch exploitation rate has been small and domestic trawl bycatch was unknown, the Board has not previously incorporated trawl bycatch into their Bering Sea herring harvest policy. With the recent evidence that the trawl bycatch exploitation rate is significant, herring stocks are currently being overfished under the Board's harvest policy.

CONCLUSIONS

1. The total herring bycatch in trawl fisheries was estimated to be at least 4,521-5,301 tonnes in 1989.

2. Bering Sea herring stocks are declining and are projected to decline below threshold levels where commercial fisheries are allowed at Nelson Island and Nunivak Island in 1990.

3. Herring bycatch exploitation rates have increased from less than 2% in 1983 to 4%-5% in 1989, and are projected to increase further in 1990.

4. When trawl herring bycatch is considered, the maximum allowable herring exploitation rates under the Alaska Board of Fisheries herring harvest policy are being exceeded.

5. Western Alaskan communities experienced difficulties in harvesting herring for subsistence purposes during herring stock declines in the 1970s.

6. Foreign fishing records and scale pattern analyses demonstrate that herring stocks that spawn in Bristol Bay migrate clockwise around Bristol Bay, arriving on the wintering grounds north and west of the Pribilofs in September.

7. Herring stocks spawning north of Bristol Bay appear to move more directly offshore after spawning. It is uncertain whether herring stocks from Kuskokwim Bay to Nelson Island move directly offshore or follow a clockwise migratory pattern like Bristol Bay stocks.

8. Fish ticket records of herring landed discard underestimate total herring catch, but range from 834-1,038 tonnes for the Unimak Pass area.

9. Herring bycatch estimated by applying 1983-1988 average foreign and JV observer bycatch rates by 1/2° latitude by 1° longitude area by month to 1989 fish ticket catches by 1/2° latitude by 1° longitude by month was 559 tonnes for Pacific cod fisheries, 1,808 tonnes for pollock bottom trawl fisheries and 346 tonnes for pollock midwater trawl fisheries.

10. Additional analyses of 1983-1988 observer bycatch rates by 1/2° latitude by 1° longitude area by month could be used to determine appropriate areas and time periods for possible herring bycatch control measures.

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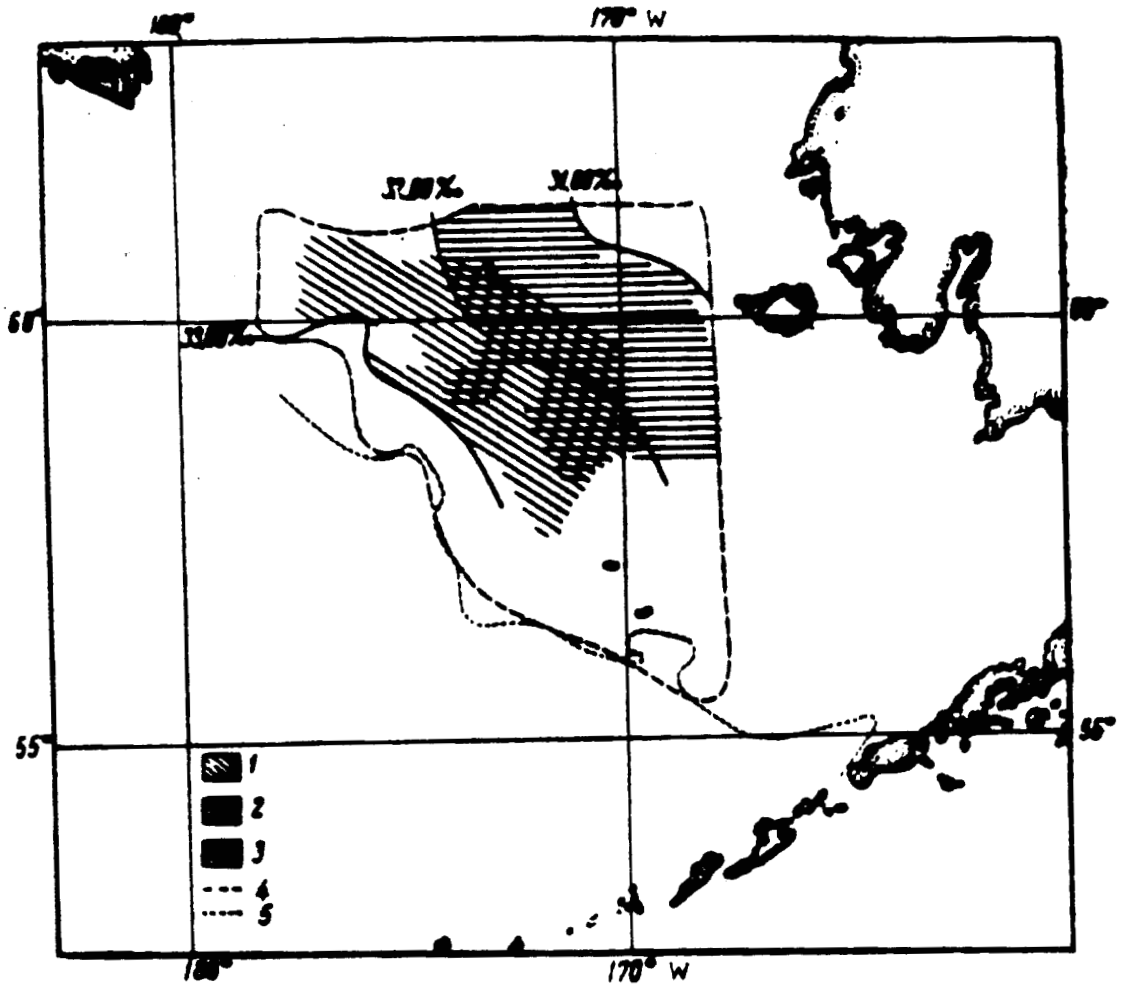

Figure 1. Distribution of herring in the eastern Bering Sea in October, 1964. (from Rumyantsev and Darda 1970).

1 = mature
2 = immature
3 = mixed
4 = investigated region
5 = 200 m isobath

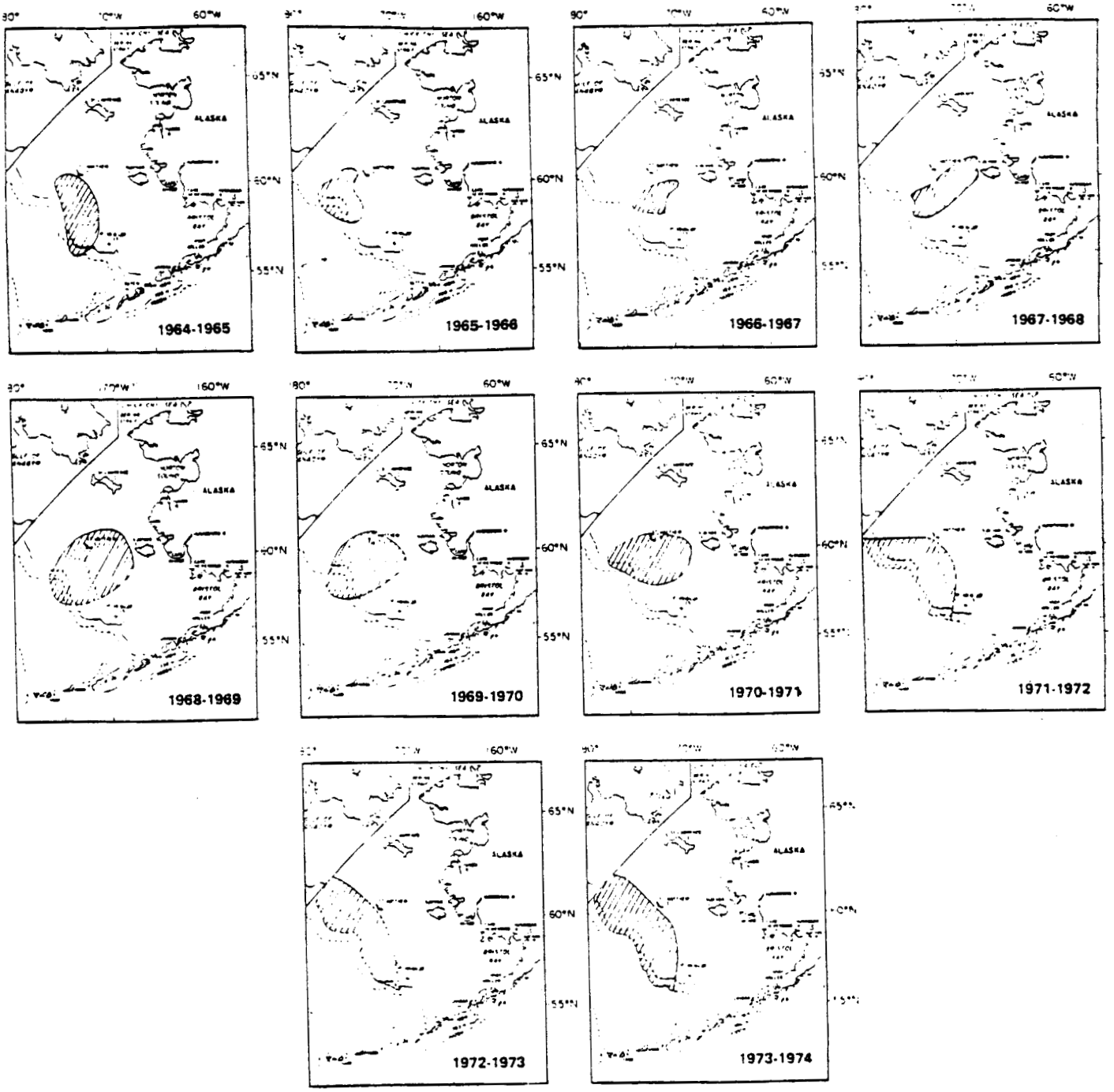

Figure 2. Location of Soviet herring fisheries in the eastern Bering Sea, 1964-65 to 1973-74 (from the draft Bering Sea Herring Fishery Management Plan, North Pacific Fisheries Management Council, Anchorage).

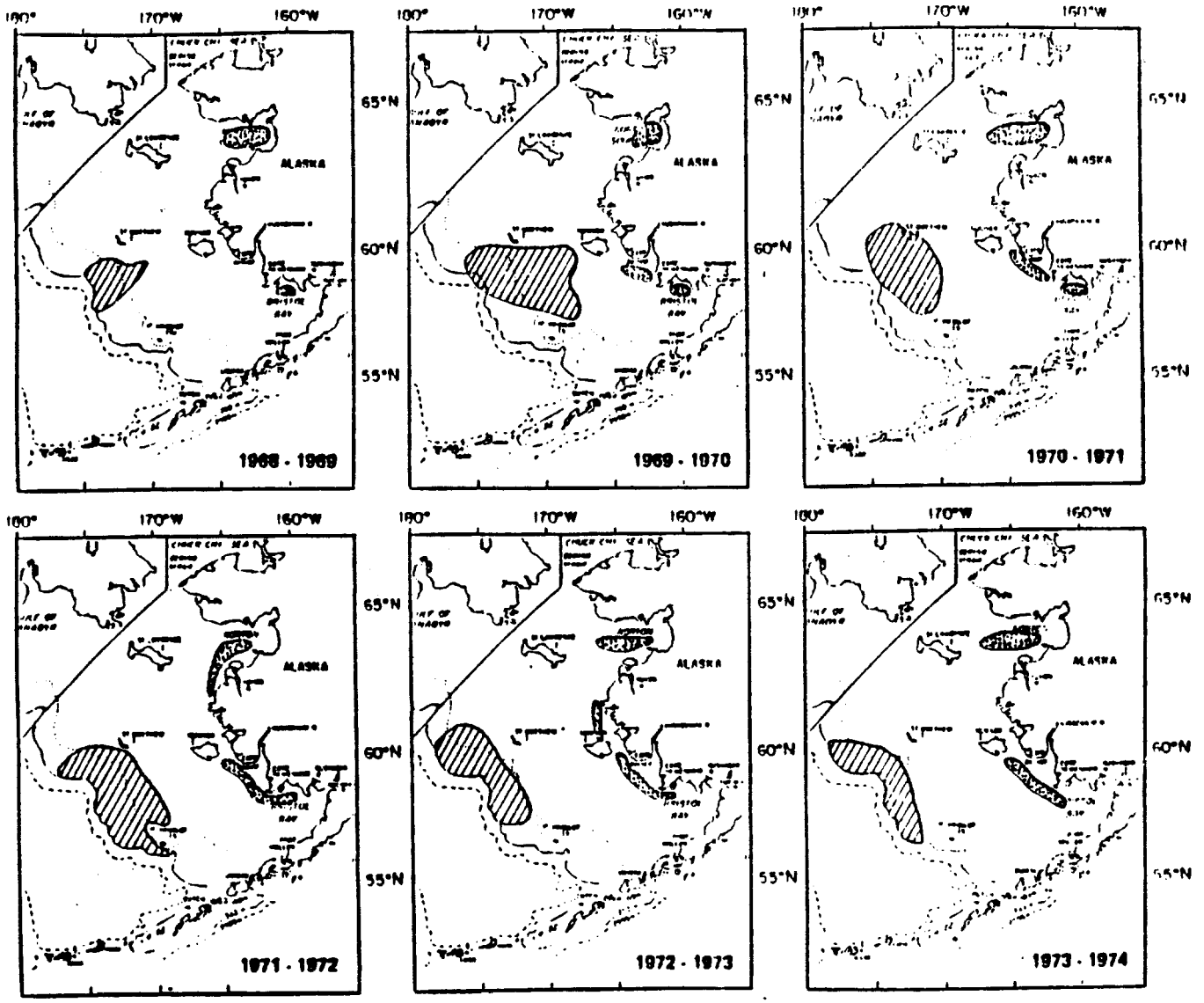

Figure 3. Location of Japanese trawl (striped) and gillnet (stipled) fisheries in the eastern Bering Sea, 1968-69 to 1973-74 (from the draft Bering Sea Herring Fishery Management Plan, North Pacific Fisheries Management Council, Anchorage).

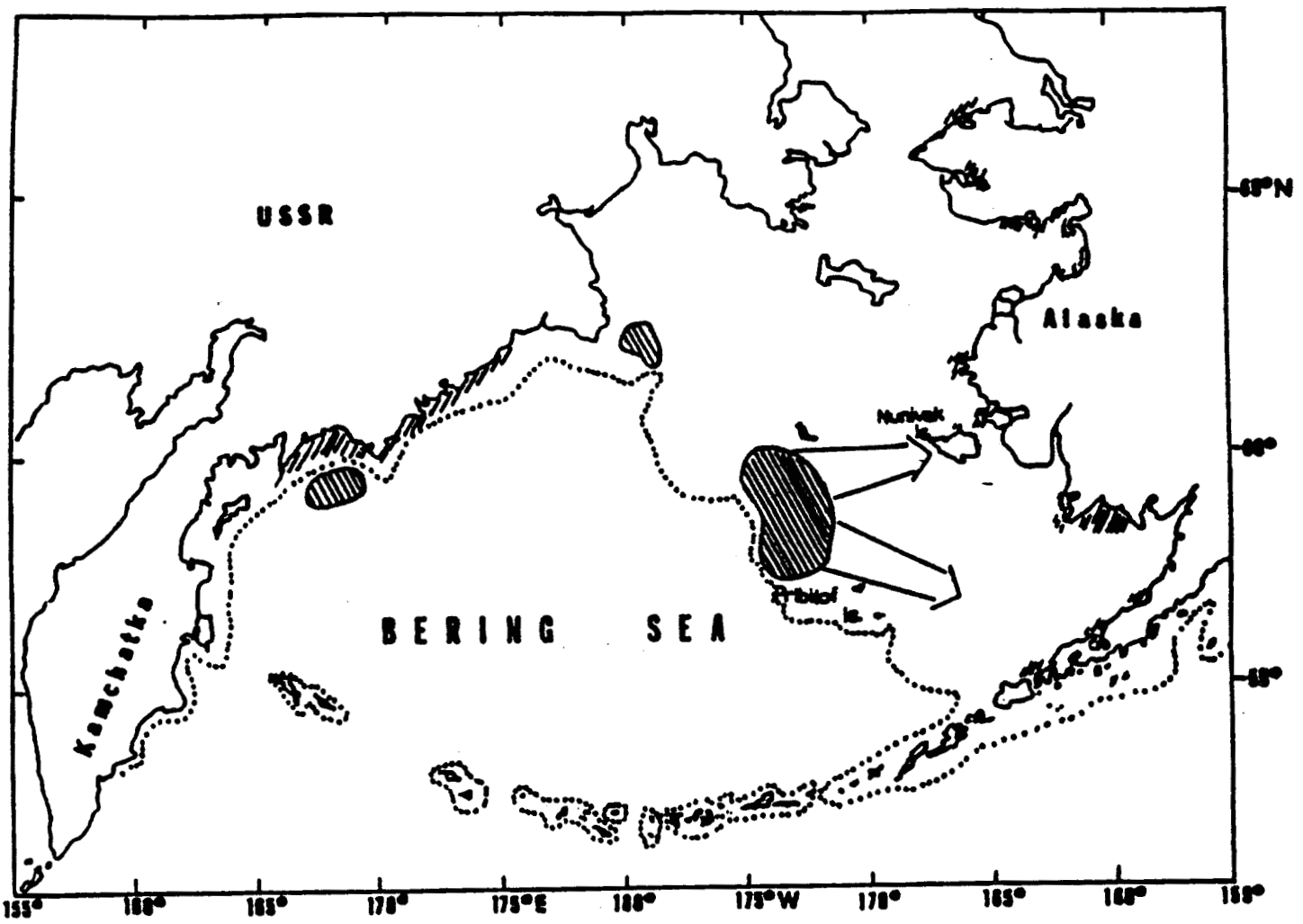

Figure 4. Location of the spawning and winter grounds (oval areas) of main western and eastern Bering Sea Pacific herring stocks and routes of migration of eastern stocks to spawning areas (from the draft Bering Sea Herring Fishery Management Plan, North Pacific Fisheries Management Council, Anchorage).

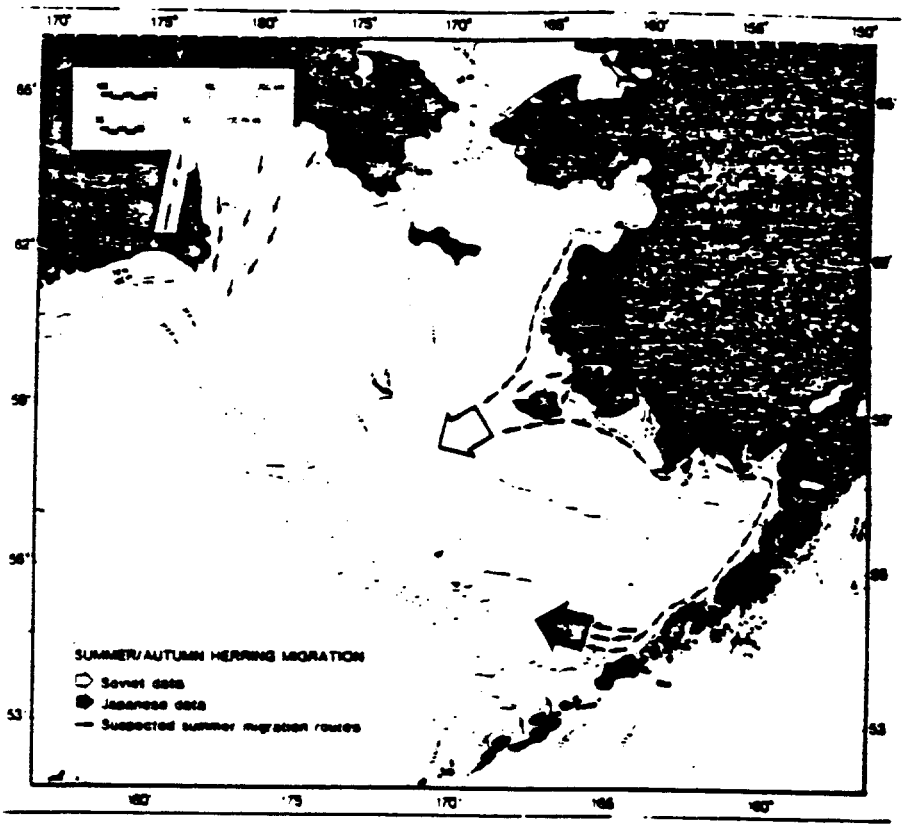

Figure 5. Summer and autumn migration routes to winter grounds. Large solid arrow: area of reappearance in offshore waters as determined by Soviet research and Japanese catches. Large dashed arrow: area of autumn reappearance in offshore waters reported from Soviet research. Small arrows possible summer feeding routes and autumn migration routes (from Wespestad and Barton 1979).

Figure 6. Spawning biomass of eastern Bering Sea herring stocks from 1983 through 1989, and the projected 1990 spawning biomass.

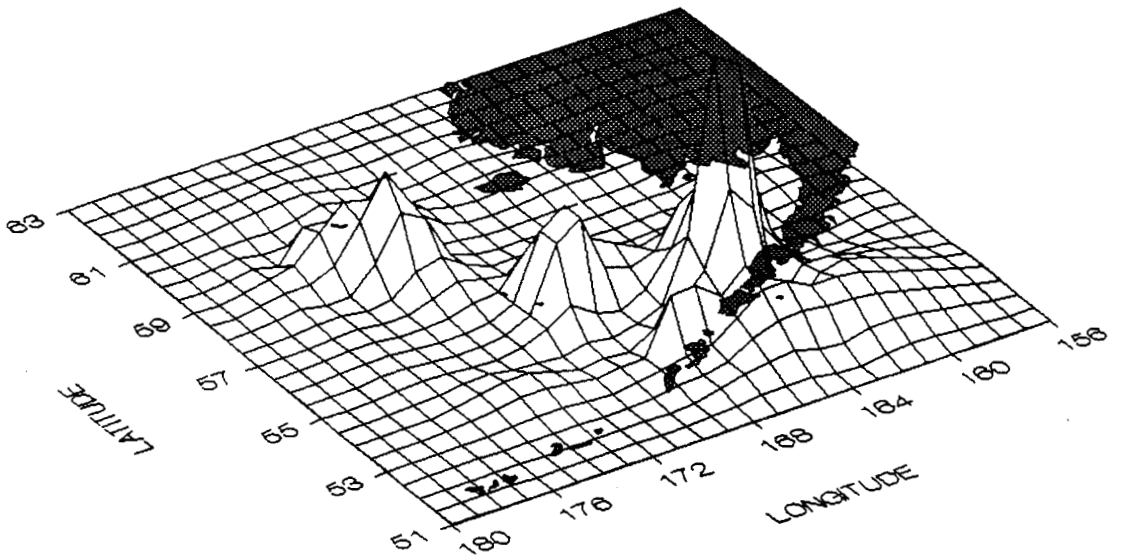

Figure 7. Spatial distribution of the pollock catch from the 1989 domestic groundfish trawl fishery in the Bering Sea/Aleutians area from fish tickets, by 1/2° by 1° statistical area, smoothed by distance weighted least squares.

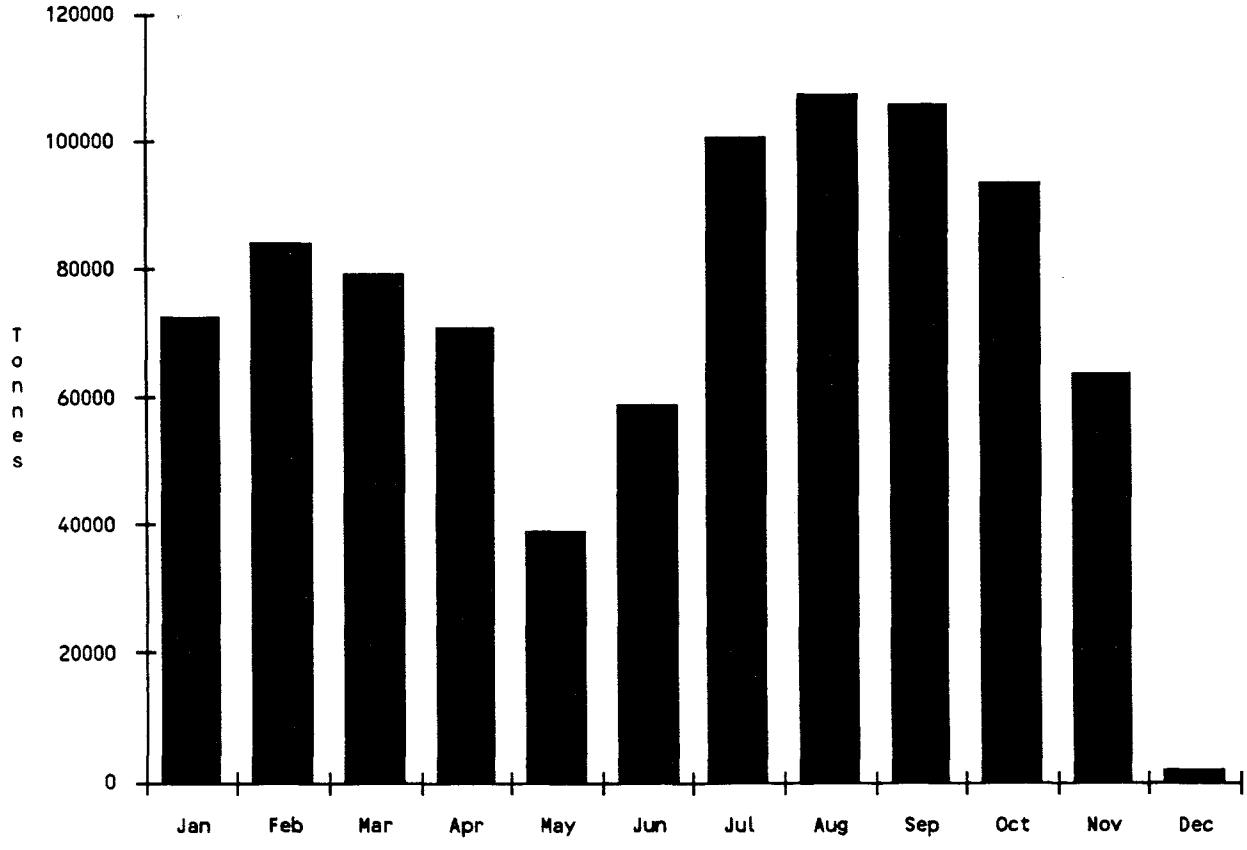

Figure 8. Monthly catch of pollock from the 1989 domestic trawl fishery in the Bering Sea/Aleutians area through December 9 (source: Pacific Coast Fishery Information System, Pacific States Marine Fisheries Commission, Portland).

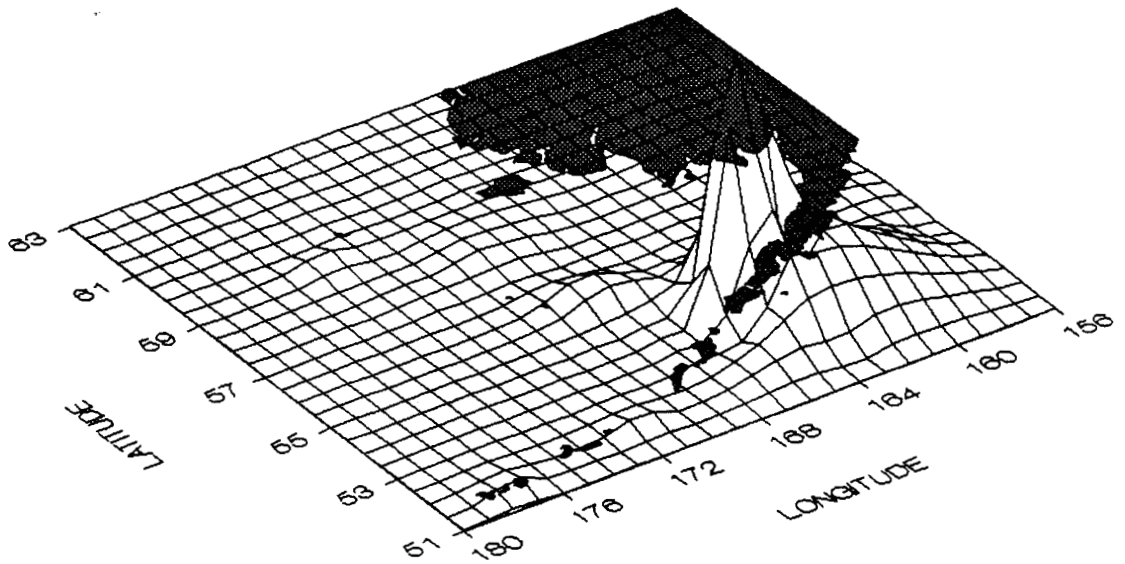

Figure 9. Spatial distribution of the Pacific cod catch from the 1989 domestic groundfish trawl fishery in the Bering Sea/Aleutians area from fish tickets, by 1/2° by 1° statistical area, smoothed by distance weighted least squares.

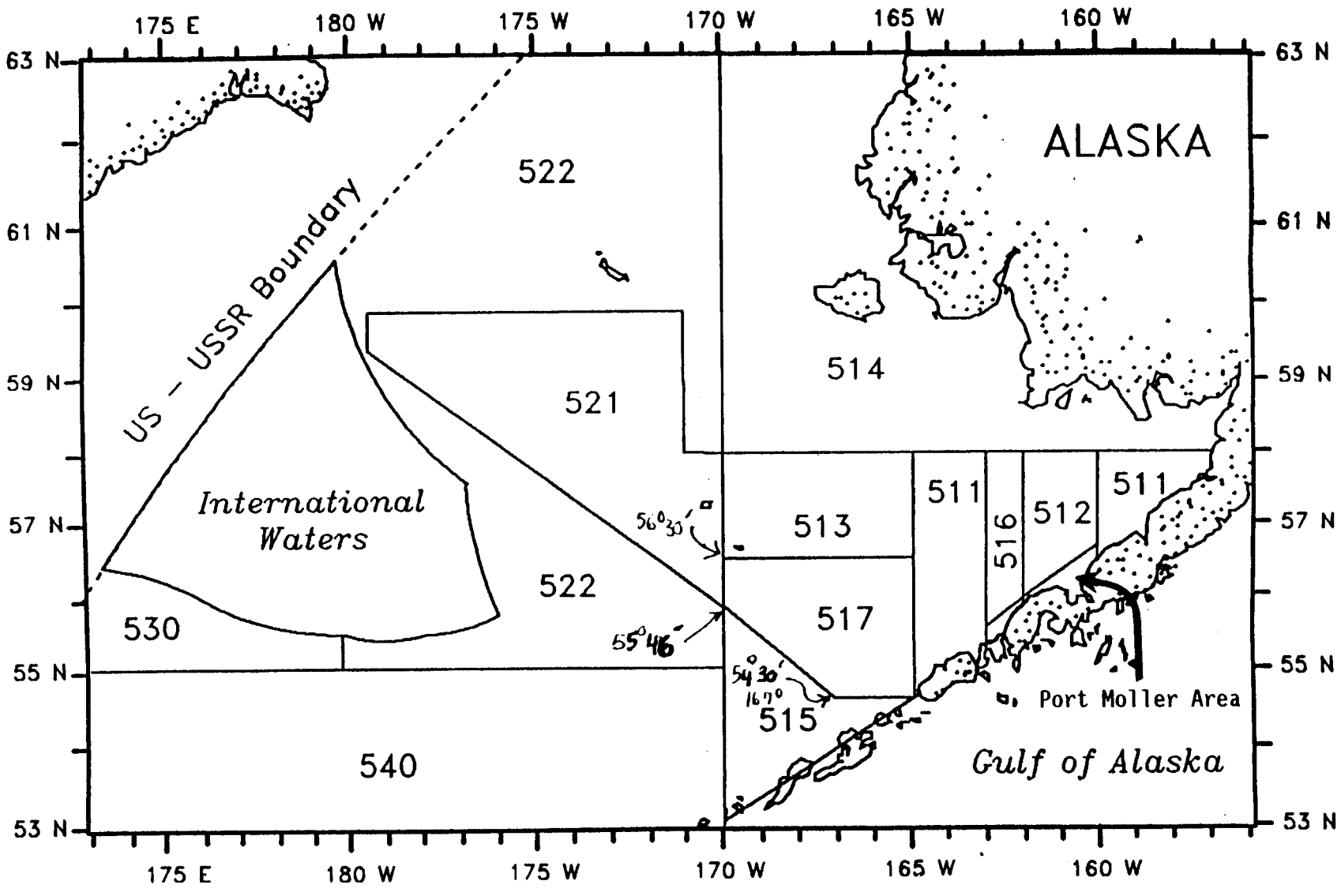

Figure 10. Statistical reporting areas in the BS/AI (Amendment 12A)

Bycatch protection zones: Zone 1 = 511 + 512 + 516
Zone 2 = 513 + 517 + 521
Zone 2H = 517

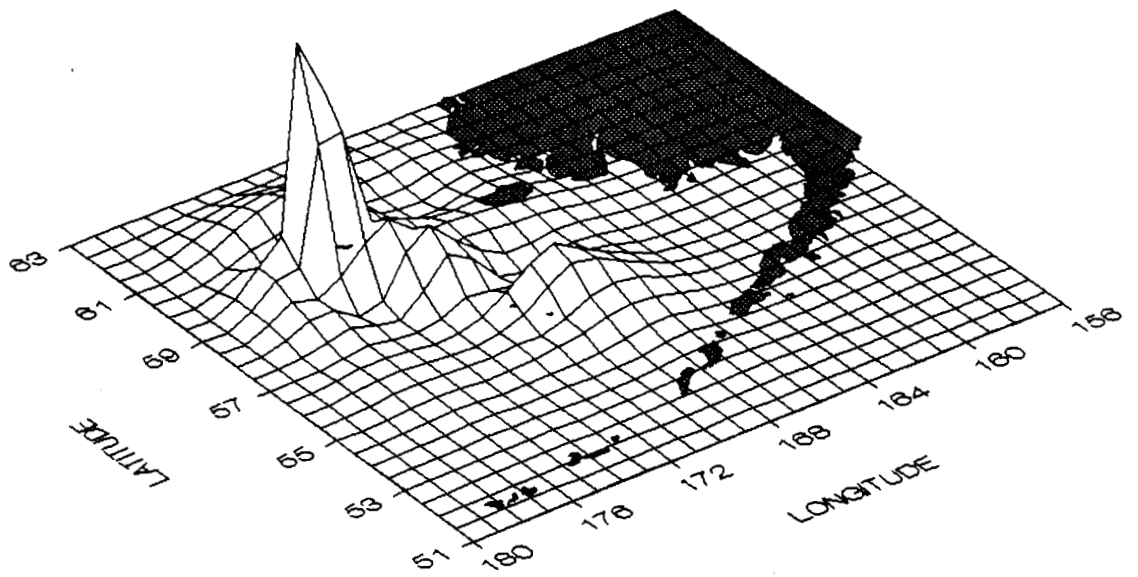

Figure 11. Spatial distribution of the combined 1989 domestic pollock and cod harvest in NMFS reporting areas 521 and 522 in September and October 1989, smoothed by distance weighted least squares.

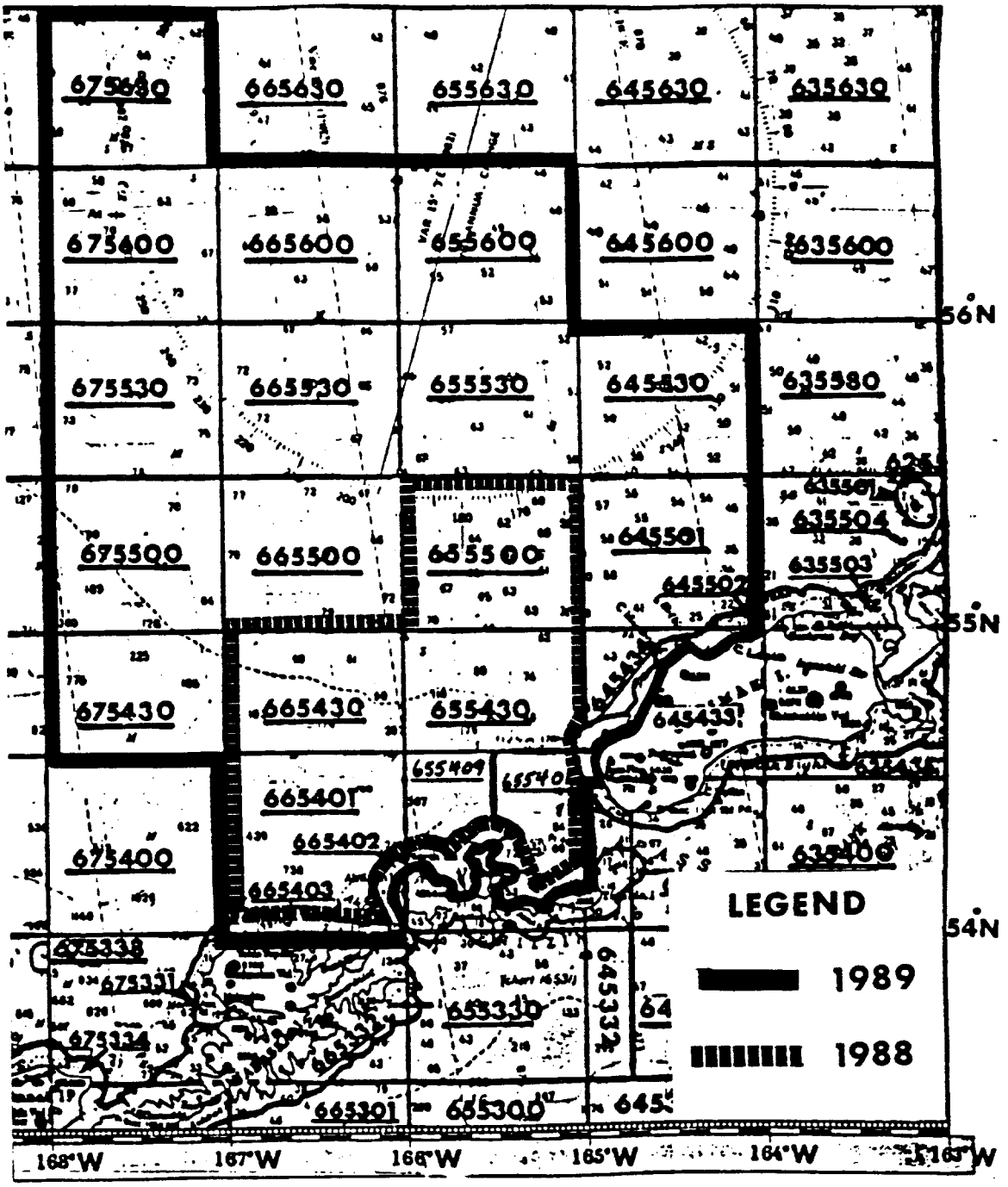

Figure 12. ADF&G statistical areas of the Unimak Pass DAP pollock fishery in 1988 and 1989.

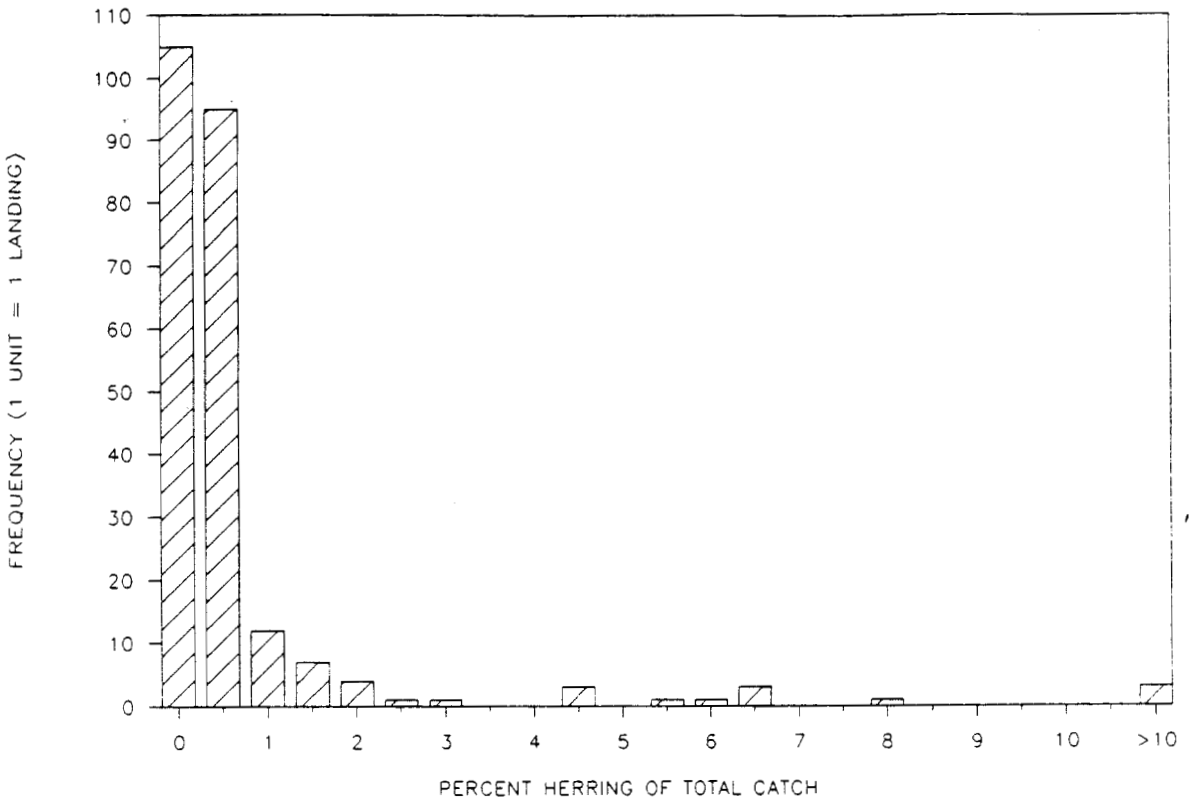

Figure 13. Frequency distribution of herring bycatch rates for all landings in the Unimak Pass fish ticket sample.

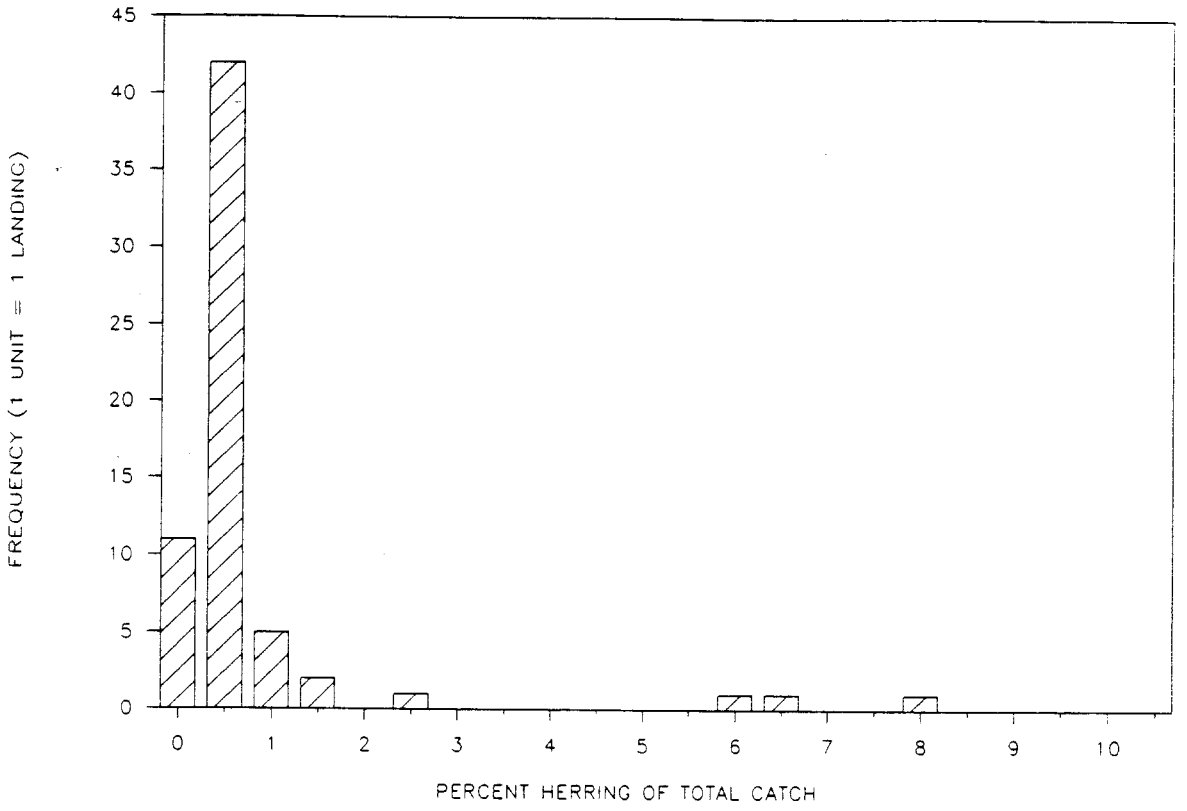

Figure 14. Frequency distribution of herring bycatch rates for deliveries to the processor judged most reliable in reporting herring landed discard.

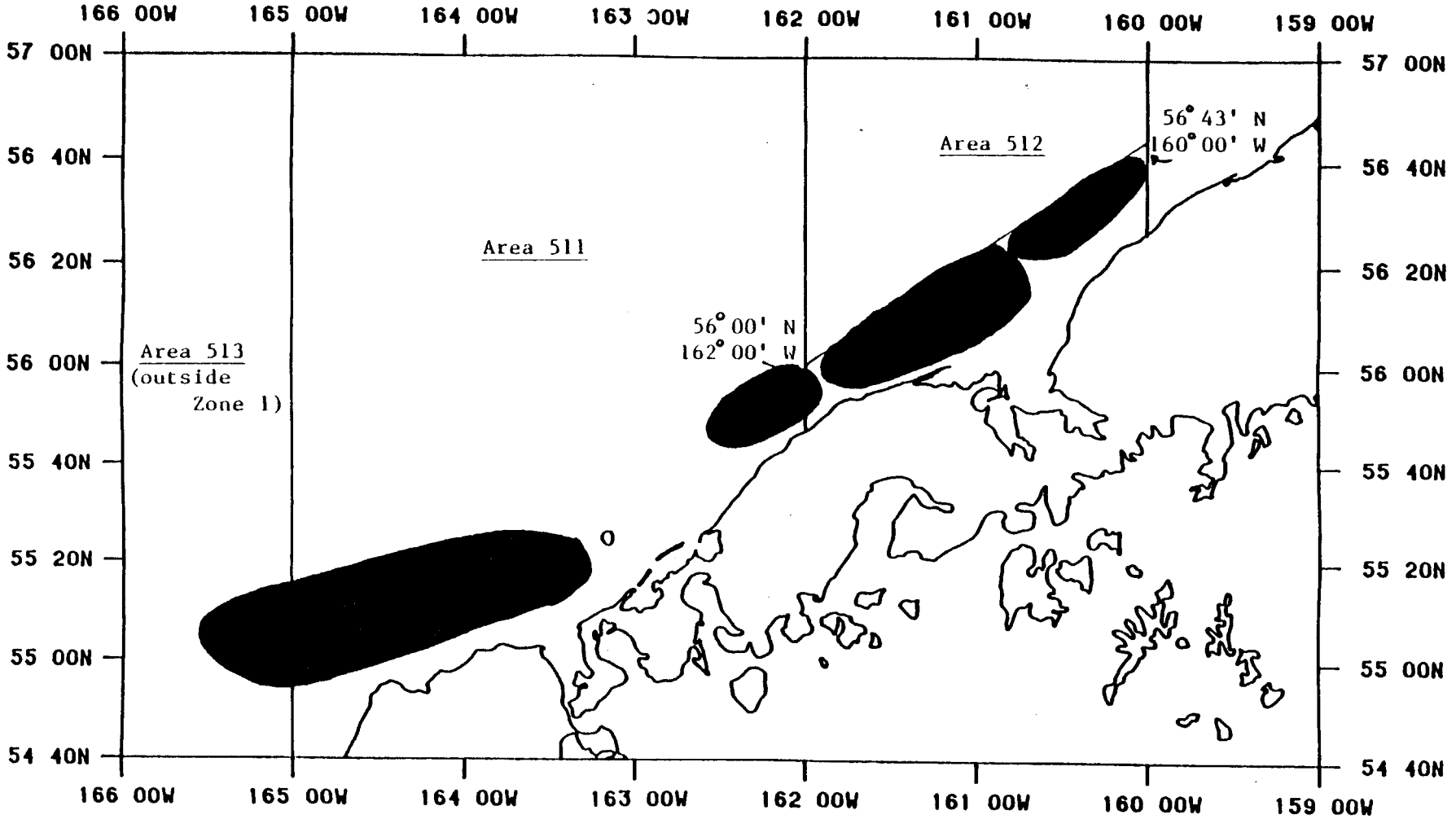

Figure 15. Retrieval positions for the Port Moller cod fishery (from Hare 1988).

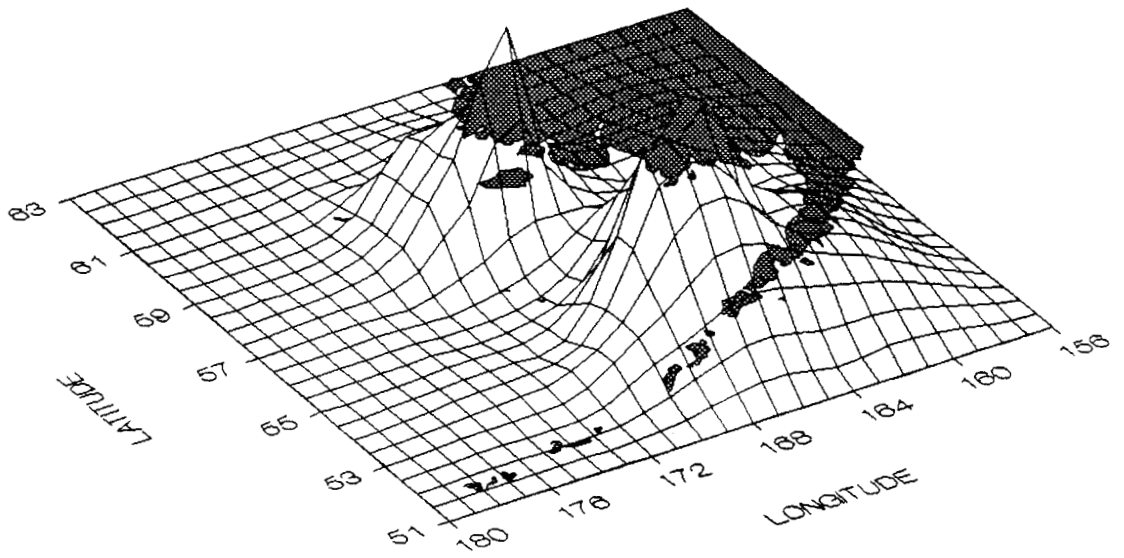

Figure 16. Spatial distribution of the 1983-1988 average herring bycatch rate in foreign and JV pollock fisheries during July, by 1/2° by 1° statistical area, smoothed by distance weighted least squares.

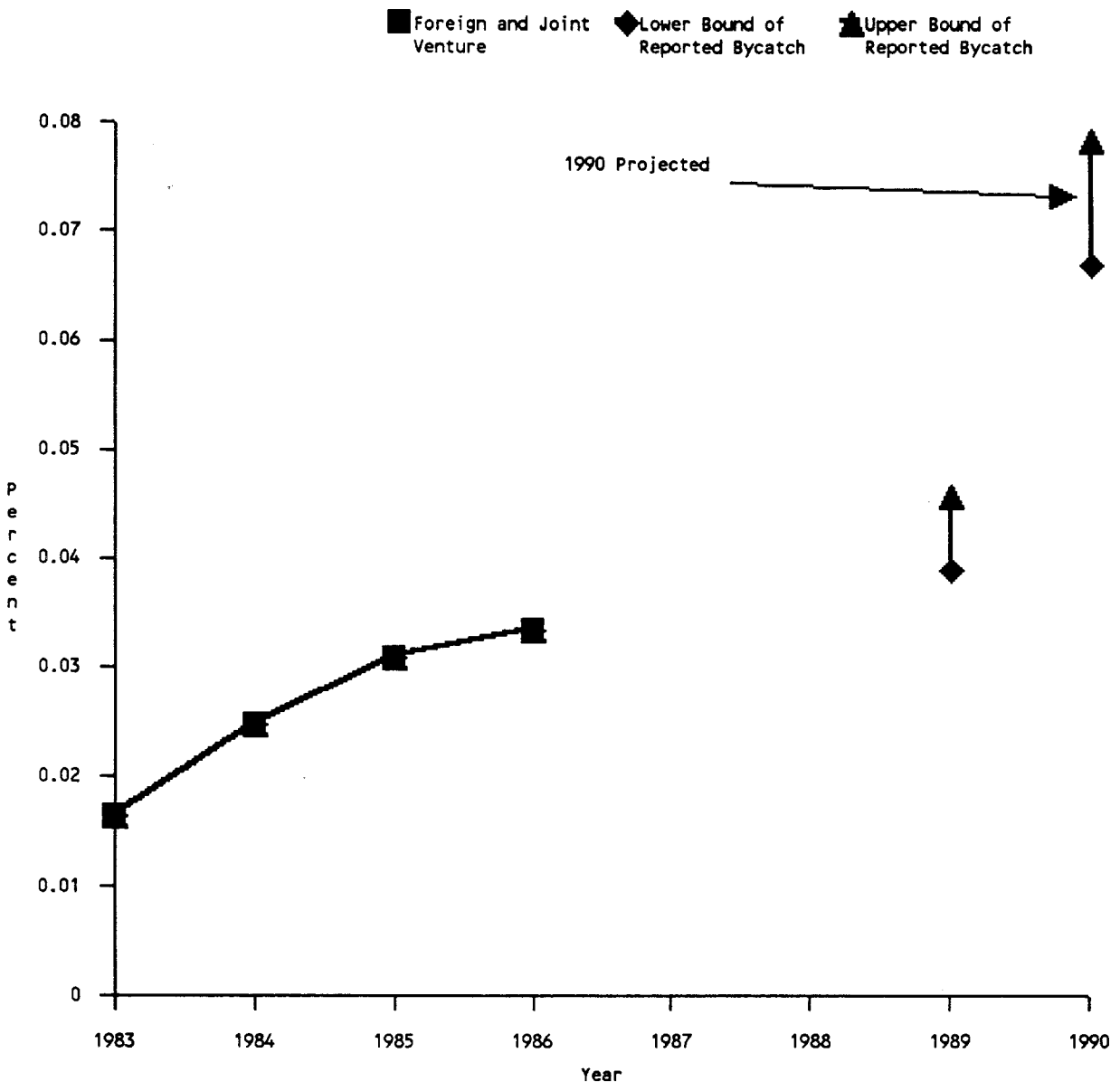

Figure 17. Herring bycatch exploitation rate in the Bering Sea/Aleutians area from 1983 through 1989.

Table 1. Summary of the 1989 Alaska herring season and the preliminary forecast for the 1990 season. Harvests and spawning biomasses are listed in short tons (2,000 lbs).

	1989		1990					
	Opening or First			Exploi-	Mean Wt.	Spawning	Stock Status	
Stock/Fishery	Harvest	Harvest	Harvest	Rate	(g)	Biomass	Level	Trend
Southeastern								
Kah Shakes	3/20	592	0			3,300	Depressed	Declining
Sitka	3/31	11,700	4,150	15.0%	118	27,000	Moderate	Declining
Seymour Canal	4/28	547	312	10.2%		3,150	Depressed	Declining
Lynn Canal	Closed due to low stock abundance						Depressed	Stable
Hoonah Snd. Pound			11[a]			4,000	High	
Food and Bait	1/01	3,400	3,400				Moderate	Stable
Prince Wm. Sound								
Seine	Closed due to oil		6,268					
Gill Net	Closed due to oil		367					
Pound Kelp	Closed due to oil		123[a]					
Wild Kelp	Closed due to oil		108[a]					
Food and Bait	11/01	190	1,759[b]					
Total			10,789[c]	20.0%	127	53,943	High	Stable
Lower Cook Inlet								
Eastern and Outer Districts	Closed due to oil		700					
Southern District	4/20	171	175					
Kamishak District	4/20	4,800	2,292	10.0%[d]	201	28,653	High	Stable
Upper Cook Inlet								
Sac Roe	4/22	172	80			Unknown	Depressed	Increasing
Food and Bait	4/30	45	50			Unknown	Depressed	Increasing
Kodiak								
Sac Roe	4/15	2,249	2,100		200		Moderate	Stable
Food and Bait								
Eastern Shelikof	8/01	327	573					
Other Kodiak	8/01	13	278		200	Unknown	Moderate	Stable
Chignik Sac Roe	4/15	66	65			Unknown		
Alaska Peninsula								
Port Moller	5/28	745	375		220	2,500	Moderate	stable
South Peninsula	5/13	310	400		250	Unknown	Moderate	stable
Dutch Harbor								
Food and Bait	7/16	3,101	679					
Bristol Bay (Togiak)								
Seine	5/12	9,413	6,769					
Gill Net	5/09	2,843	2,256					
Spawn on Kelp	5/14	280[a]	175[a]					
Total		16,857[e]	11,204[e]	20.0%	361	56,020	Moderate	Declining
Kuskokwim Area								
Security Cove	5/17	554	235	15.0%		1,560	Moderate	Declining
Goodnews Bay	5/23	616	350	15.0%		2,330	Moderate	
Cape Avinof	6/04	129	300	15.0%		2,020		
Nunivak Island	5/22	116	[f]	15.0%		320		Declining
Nelson Island	5/28	233	[f]	10.0%		2,050		Declining
Cape Romanzof	5/26	926	360	15.0%		2,410		Declining
Norton Sound								
Gill Net	5/27	4,381						
Beach Seine	5/27	390						
Total		4,771	3,300	20.0%		16,520	Moderate	Stable
Port Clarence	No harvest		165					
Sac Roe Harvest Total:[g]		40,952	31,019					
Food and Bait Harvest Total:		7,076	6,739					
Total Herring Harvest:		48,028	37,758					

[a] Harvest of spawn-on-kelp product in short tons.

[b] Preliminary 1989 food/bait guideline. The 1990 guideline will be set after 1990 sac-roe season.

[c] Includes mortality allowances of 1,532 and 863 tons for pound and wild spawn on kelp fisheries.

[d] Kamishak District exploitation rate includes the eastern Shelikof food and bait harvests.

[e] Togiak total harvest includes an allowance for 1,500 tons mortality for the spawn-on-kelp fishery.

[f] Projected biomass below minimum for commercial harvest; fishery will be opened if threshold biomass observe

[g] Sac roe statewide total harvests do not include allowances for spawn-on-kelp fishery mortality.

Table 2. Groundfish harvests in the eastern Bering Sea/Aleutians area reported through December 8, 1989[a], and the potential for significant herring bycatch.

Species	DAP	JVP	Total	Herring Bycatch Potential
Arrowtooth Flounder	816		816	Low
Greenland Turbot	55	8,737	8,791	Low
Rock Sole	22,350	19,892	42,241	Low
Yellowfin Sole	1,521	148,727	150,248	Potential
Other Flatfish	10,453	11,847	22,300	Low
Rockfish	6,812	54	6,865	Low
Atka Mackerel	17,761	26	17,787	Low
Pacific Cod	115,551	44,091	159,642	High
Sablefish	4,102	3	4,105	Low
Pollock	878,271	276,721	1,154,992	High
Other Groundfish	320	4,613	4,933	Low
Total	1,058,011	514,710	1,572,721	

[a]Source: Pacific Coast Fishery Information (PacFIN) report for December 8, 1989, Pacific States Marine Fishery Commission, Portland, Oregon.

Table 3. Herring bycatch (tonnes) by joint venture groundfish trawl vessels in the Bering Sea/Aleutians area in 1989 by NMFS reporting area and target fishery (Source: J. Berger, National Marine Fisheries Service, Seattle, personal communication).

NMFS Reporting Area	Yellowfin Sole	Pollock Bottom Trawl	Pollock Midwater Trawl	Other Bottom Trawl	Total
511	0.1	8.6	2.8	0.0	11.5
513	0.0	0.1	0.7	13.5	14.3
514	0.0				0.0
515		17.8	0.0	2.6	20.4
516	0.0				0.0
517	0.0	63.1	55.0	2.3	120.4
521	0.0	1,028.5	543.9	223.0	1,795.4
522	0.0	361.2	202.9	61.9	626.0
Total	0.1	1,479.3	805.3	303.3	2,588.0

Table 4. Herring bycatch, all species harvest, and herring bycatch rate from 1989 joint venture trawl fisheries targetting on pollock and "other" (primarily Pacific cod) species in the Bering Sea. October data are preliminary. Source: J. Smoker, NMFS Alaska Region.

A. Preliminary estimate of groundfish catch in tonnes:

	NMFS Reporting Area								
Month	511	513	514	515	516	517	521	522	Total
1	15,359	5,950	0	37	0	43,464	0	0	64,811
2	1,030	757	0	111	0	15,314	0	0	17,212
3	0	0	0	0	0	44	0	0	44
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	3,817	10,006	2,224	834	0	28,932	38,445	7,810	92,068
10	6	456	0	392	0	8,735	49,980	1,390	60,959

B. Preliminary estimate of herring bycatch in tonnes:

	NMFS Reporting Area								
Month	511	513	514	515	516	517	521	522	Total
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	12	14	1	20	0	70	886	327	1,329
10	0	1	0	0	0	1	848	167	1,017

C. Preliminary estimate of herring bycatch as percent by weight of total catch:

	NMFS Reporting Area								
Month	511	513	514	515	516	517	521	522	Total
1	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	0.30%	0.14%	0.02%	2.45%	0%	0.24%	2.30%	4.18%	1.44%
10	0%	0.11%	0%	0%	0%	0.01%	1.70%	12.04%	1.67%

Table 5. Estimated catches of groundfish (1,000s t) taken by the foreign and joint venture fisheries in the Bering Sea/Aleutian Islands region, 1977-1986.

Fisheries/ species group	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
	Foreign directed catches (metric tons)									
Pollock	978.4	979.4	944.0	1,006.1	986.9	959.3	891.5	933.0	820.3	352.3
Pacific cod	35.9	47.4	41.4	37.3	39.1	28.2	41.5	58.5	57.2	39.3
Sablefish	4.6	2.0	2.2	2.4	3.0	3.8	3.2	1.9	0.3	0.1
Atka mackerel	NA	24.2	23.3	20.2	18.1	7.4	1.2	0.1	<0.1	<0.1
All rockfish	10.8	7.5	7.2	8.5	7.3	4.9	2.0	0.9	0.1	<0.1
Yellowfin sole	0.3b	110.3	101.1	77.8	81.3	76.0	85.9	126.8	100.7	57.2
Turbots and other flatfish	136.4b	125.5	90.0	88.5	91.9	79.3	80.3	59.3	46.9	20.8
Pacific herring	19.3	8.4	7.5	0.8	0.3	1.9	1.4	1.3	1.5	0.3
Other fish	94.7	71.8	64.7	47.0	39.4	22.3	14.3	7.5	6.3	4.0
Squid	8.4	9.4	7.0	6.4	5.9	5.0	4.0	3.1	1.6	0.8
Snails	0.4	2.2	0.5	0.1	0.2	0.2	0.3	0.2	0.1	0.5
TOTAL	1,289.1	1,385.5	1,288.9	1,295.1	1,273.4	1,188.4	1125.5	1,192.7	1,035.0	475.9
	Joint venture catches (metric tons)									
Pollock				10.7	42.1	54.6	149.0	237.0	377.5	835.1
Pacific cod				8.5	9.2	13.6	14.4	30.8	41.3	63.9
Sablefish				<0.1	0.2	0.1	0.1	0.3	0.1	0.4
Atka mackerel				0.3	1.6	12.5	10.5	35.9	37.9	32.0
All rockfish				0.1	<0.1	<0.1	0.1	0.6	0.5	0.5
Yellowfin sole				9.6	16.0	17.4	22.5	32.8	126.4	151.4
Turbots and other flatfish				2.8	6.0	9.2	11.8	17.4	46.3	65.5
Pacific herring				0.0	0.0	<0.1	1.1	1.8	3.1	3.8
Other fish				0.7	3.4	1.1	1.6	2.6	6.3	7.6
Squid				0.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Snails				0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL				32.6	78.5	108.6	211.2	359.3	639.4	1,160.2

a Statistics for 1977-85 from Berger et al., 1987.

b Japan reported yellowfin sole combined with other flounders.

Table 6. Harvest of pollock and Pacific cod by domestic trawl vessels in NMFS reporting areas 521 and 522 in September and October, from ADF&G fish tickets, bycatch rates from JV fisheries in the same month and reporting area from Table 4, and the estimated bycatch of herring in the domestic trawl fishery in areas 521 and 522 computed by applying the JV bycatch rates to the domestic harvest.

A. Fish ticket estimates of pollock and cod harvest (tonnes):

	NMFS Reporting Area		
Month	521	522	Total
9	39,203	746	39,949
10	2,924	112	3,036
Total:	42,127	858	42,985

B. Preliminary estimate of herring bycatch rates from JV observer data:

	NMFS Reporting Area	
Month	521	522
9	2.30%	4.18%
10	1.70%	12.04%

C. Estimated of herring bycatch in tonnes:

	NMFS Reporting Area		
Month	521	522	Total
9	902	31	933
10	50	14	64
Total:	952	44	996

Table 7. Estimation of herring bycatch from fish ticket records of landed discard, using all vessels in the sample and only those vessels felt to report reliably.

Month	Source	Number of Landings	Herring Bycatch Rate	Unimak Pass Sample		Reporting Areas 511,513,515,517	
				Pollock Harvest (tonnes)	Estimated Herring Bycatch (tonnes)	Pollock Harvest (tonnes)	Estimated Herring Bycatch (tonnes)
July	All Vessels	64	0.92%	17,865	164	42,135	388
	Reliable Sample	15	1.38%		247		581
August	All Vessels	89	0.18%	23,809	43	51,937	93
	Reliable Sample	25	0.33%		79		171
September	All Vessels	67	0.38%	16,973	64	65,940	251
	Reliable Sample	17	0.11%		19		73
October	All Vessels	17	0.36%	16,973	61	90,632	326
	Reliable Sample	7	0.01%		2		9
Total	All Vessels	237	0.36%	75,620	333		1,058
	Reliable Sample	64	0.01%		345		834

Table 8. Summary of the species composition and incidence of prohibited species in the 1989 Port Moller Pacific cod fishery. (from NMFS domestic fishery report to the North Pacific Fishery Management Council, September 1989).

Summary of 1989 Port Moller Fishery
(62.4 days on the ground; target = Pacific cod/pollock)

A. Preliminary estimate of groundfish catch (area 512):

	Metric tons	Percent of catch
Yellowfin sole	728.80	13.0
Rock sole	831.78	14.8
Other flatfish	78.21	1.4
Arrowtooth flounder	16.42	0.3
Walleye pollock	651.38	11.6
Pacific cod	2,854.29	50.9
Sablefish	0.01	<0.1
Other fish	120.87	2.2
Nonallocated species	322.43	5.8
Total	5,604.20	100.0

B. Preliminary estimate of prohibited species catch (area 512):

	Estimated numbers	Number per metric ton
Red king crab	13,940	2.487
Bairdi Tanner crab	5,225	0.932
Other Tanner crab	34	0.006
Chinook salmon	9	0.002
Other salmon	14	0.002
Pacific halibut	44,914	8.014

C.

	Estimated weight (kg)	Kg per metric ton	Percent of catch
Pacific halibut	56,016	9.995	1.00
Pacific herring	102,870	18.358	1.84

Table 9. Preliminary summary of the Pacific herring bycatch rate (weight of Pacific herring divided by weight of all species, expressed as percentage) from NMFS observers placed aboard domestic trawl vessels during August and September 1989 (from unpublished NMFS domestic fishery report to the North Pacific Fishery Management Council, September, 1989).

Fishery	NMFS Reporting Area				
	511	513	515	517	521&522
Pollock midwater trawl	<0.01%	<0.01%	0.03%	0.18%	0.02%
	511&517				521
Pollock bottom trawl	<0.01%				0.01%
	511	513	515&517		
"Other" bottom trawl	1.09%	0.02%	0.02%		

Table 10. Comparison of relative strengths of herring and pollock stocks in the eastern Bering Sea, 1983-1988.

Year	Herring Spawning Biomass (tonnes)	Pollock Stock Size (tonnes)[a]	Ratio	Ratio Relative to 1989
1983	167,829	7,390,000	0.023	0.88
1984	139,072	7,280,000	0.019	1.05
1985	165,834	9,030,000	0.018	1.09
1986	136,441	8,410,000	0.016	1.24
1987	131,361	8,260,000	0.016	1.26
1988	178,016	7,990,000	0.022	0.90
1989	129,669	6,457,000	0.020	1.00
1990	75,505			

[a]Source: Wespestad (1989).

Table 11. Summary of herring bycatch estimated by applying 1983-88 average foreign and JV bycatch rates by 1/2° by 1° statistical area and month to the domestic fish ticket catch data by 1/2° by 1° statistical area and month for pollock and cod targetted groundfish trawl fisheries.

Target Fishery	Target Catch	Estimated Herring Catch	Estimated Bycatch Rate
Pacific Cod Trawl			
Matched Areas	52,878	203	0.38%
Unmatched areas, > 500 tonnes total harvest (using bycatch rate from adjoining areas)	16,453	319	1.94%
Unmatched areas, < 500 tonnes total harvest (using bycatch rate from matched areas)	9,725	37	0.38%
TOTAL:	79,056	559	0.71%
Pollock Bottom Trawl			
Matched Areas	238,985	1,437	0.60%
Unmatched areas, > 2,000 tonnes total harvest (using bycatch rate from adjoining areas)	91,544	131	0.14%
Unmatched areas, < 2,000 tonnes total harvest (using bycatch rate from matched areas)	39,961	240	0.60%
TOTAL:	370,490	1,808	0.49%
Pollock Midwater Trawl			
Matched Areas	417,699	248	0.06%
Unmatched areas, > 3,000 tonnes total harvest (using bycatch rate from adjoining areas)	74,334	83	0.11%
Unmatched areas, < 3,000 tonnes total harvest (using bycatch rate from matched areas)	25,362	15	0.06%
Unknown area (using bycatch rate from matched areas)	728	0.4	0.06%
TOTAL:	518,123	346	0.07%
ALL SPECIES TOTAL:		2,713	

Table 12. Summary of herring bycatch estimates for the 1989 eastern Bering Sea groundfish trawl fishery.

Fishery	Other	Historical Observer Samples
Domestic Trawl Fishery		
Pollock		
Sept.-Oct., areas 521/522 based on 1989 JV bycatch rates	996	
Areas 511,513,515,527, based on Unimak Pass landed discard rates	834-1,038	
Total Pollock	1,830-2,034	2,154
Cod		
Port Moller (from 1989 observers)	103	
All Bering Sea		559
Joint Venture (from 1989 observers)	2,588	2,588
TOTAL	4,521-4,725	5,301