

**Draft Discussion Paper**

**An analysis of red king crab bycatch in the Bering Sea with alternatives for  
trawl closures.**

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## **INTRODUCTION**

During the September 1994 Council meeting, Council members were briefed on the status of red king crab stocks in the Bering Sea. The estimated female red king crab abundance was below threshold in 1994, triggering closure of the directed Bristol Bay red king crab pot fishery by the Alaska Department of Fish and Game. Due to the closure of the Fish and Game shellfish management Area T red king crab fishery, the area east of 163° west longitude was closed to Tanner crab fishing for the 1994/1995 season as per State regulations (5 AAC 35.510). The Council also heard reports from the Crab Plan Team and from industry requesting closure of portions of Zone 1 to trawling in order to provide further protection of the red king crab stocks. Currently, all of Area 512 is permanently closed to trawling to protect red king crab stocks. The Crab Plan Team recommended closure of the area east of 163° west longitude to insure consistent treatment of all gear types lacking sufficient data on bycatch to recommend more specific action.

The closure alternatives considered in this discussion paper are based on whole or partial 1/2° latitude by 1/2° longitude blocks. The alternatives presented to the Council as well as some additional alternatives are as follows:

- 1) Close the portion of Zone 1 east of 163° West. This was suggested by the Crab Plan Team and comprises a band one degree longitude from the western edge of Area 512.
- 2) Close 5 blocks to the west of Area 512 as suggested by observer data and reported to the Crab Plan Team by Jerry Berger of the NMFS observer program.
- 3) Close two blocks as defined and volunteered by participants in the rock sole fishery (these defined blocks have been shifted up 1/2 degree since presentation to the Council).
- 4) Close two blocks as originally defined and volunteered by participants in the rock sole fishery.
- 5) Close the four blocks which form a square portion of the second alternative and as proposed by the Alaska Crab Coalition.

The National Marine Fisheries Service (NMFS) conducts trawl surveys annually during the summer months across the expanse of the Bering Sea shelf. Results from the trawl surveys are used to provide abundance estimates for red king crab among several crab and groundfish species. Trawl surveys indicate that crab abundance was high during the late 1970's and extended over a broad section of the Bering Sea shelf to the north of the Alaska Peninsula. Following a precipitous decline in abundance in the early 1980's the red king crab stocks have remained at low levels and concentrated in the area defined by Area 512 and often extending to the south and west along the Alaska Peninsula.

Red king crab bycatch in trawl fisheries tends to be highest during the first few months of the year and largely occurs in the directed trawl fishery for rock sole. Based on the distribution of red king crab bycatch early in the year, it appears that the distribution of red king crab may extend to the south and west of Area 512 during the winter months, with crab possibly attracted to the warmer waters moving into the Bering Sea from the Gulf of Alaska. The location of red king crab during this period is coincident with the spawning rock sole targeted by the directed trawl fishery. The closure of an area extending to the west from Area 512 could lead to reduced bycatch of red king crab and further protect depressed stocks.

## RED KING CRAB IN THE BERING SEA

After declining abundance throughout the 1960's and reaching a low during the years 1970-1972, recruitment to the Bristol Bay red king crab stock increased dramatically. New all-time record landings were established in each year from 1977 (31,750 t, 11.7 million crab) to 1980 (58,940 t, 20.8 million crab) (Figure 1). Declining recruitment, fishing pressure, and probably increased incidence of disease and predation led to an abrupt decline in fisheries in 1981 (15,240 t, 5.3 million crab) and 1982 (1,360 t, 0.5 million crab).

Declines in abundance of legal males were accompanied by declines in the abundance of mature females. The NMFS trawl survey abundance index for legal males fell from 36.1 million crab in 1980 to 1.5 million crab in 1983 (Figure 2). Similarly, the NMFS abundance index for mature females fell from 67.5 million crab in 1980 to only 9.7 million crab in 1983 (Figure 2). These precipitous declines led to a closure of the Bristol Bay fishery in 1983. In 1984 the stock showed some recovery and a limited fishery was reestablished.

Figure 2 illustrates the decline in abundance estimates of Bering Sea red king crab since the late 1970's. From previous estimated abundance levels of between roughly 200 - 350 million crab, estimated red king crab abundance declined to approximately 40 million crab in 1985. With the exception of an estimated abundance of 75 million crab in 1987, red king crab abundance has varied between 30 and 50 million crab since 1985.

Between 1984 and 1993, the fishery continued at levels considerably below those of the late 1970's. Landings during this period ranged from 1,900 t and 0.8 million crab (1985) to 9,240 t and 3.1 million crab (1990). Landings were 6,640 t or 2.3 million crab in 1993. Throughout the 1980's and 1990's there has been little sign of a large year-class in this stock, and from 1987 on very few immature crab have been captured during the trawl survey (Figure 2). The cause of the decline in red king crab stocks is unknown, however, increased predation from increasing stocks of flatfish and Pacific cod, competition for food and habitat, and oceanographic factors may all play a part.

The 1994 abundance index for legal male Bristol Bay red king crab was 5.5 million crab as compared to 7.3 million in 1993. The abundance index for mature female crab fell from 14.2 million crab in 1993 to 7.5 million crab in 1994, and was hence below the threshold value of 8.4 million crab established pursuant to the Fishery Management Plan for King and Tanner crabs in the Bering Sea and Aleutian Islands. These declines were corroborated by the length-based assessment model that was newly developed by the Alaska Department of Fish and Game (ADF&G). Because the abundance of female crab was below threshold, the Bristol Bay red king crab fishery was closed in 1994, as was the fishery for Tanner crab in Zone 1 east of 163° W longitude. The Bristol Bay stock continues to suffer from a long period of low recruitment abundance indices for juvenile crab, and sub-legal crab levels are among the lowest on record.

Figures 3 - 7 provide the location and relative abundance of red king crab encountered in the NMFS trawl surveys from 1990 - 1994. The information from the trawl surveys indicates the general distribution of red king crab during the summer months when the trawl survey is conducted. The circle centers indicate the locations of individual hauls, and the size of the circle indicates the total number of crab encountered in the trawl. A large circle does not represent an expansion into adjacent areas beyond the location of the haul. As discussed above and indicated in the figures, the abundance of crab has been low in the 1990's and few small female crab were encountered in 1994.

Area 512, which is closed to trawling, was originally chosen to protect mature female red king crab (indicated by thick lines in the figures) and red king crab are well distributed within this area. As the figures indicate, the distribution of red king crab, and especially large females, can also extend to the west and southwest of Area 512.

## **RED KING CRAB BYCATCH IN THE BERING SEA**

Data from individual hauls provided by the NMFS Observer Program was examined to determine the time and location of red king crab bycatch in the Bering Sea. The primary focus of the present analysis was on data from the domestic trawl fisheries during the years 1990 - 1994. The data from 1990 was incomplete during the first few months of the year because the program was just being initiated, and the data from 1994 was only available from the first four months of the year at the time of this analysis. Jerry Berger of the NMFS Observer Program conducted an initial analysis of the data and presented the results to the Crab Plan Team on September 26. The data presented in this analysis reflects catch and bycatch from observed hauls only, and has not been expanded to unobserved hauls.

The highest number of hauls and the greatest amount of groundfish catch in Bering Sea trawl fisheries are from the pelagic and bottom trawl fisheries for pollock (Figures 8 and 9). Among the flatfish fisheries, the yellowfin sole fishery comprises the most effort (in number of hauls) and greatest total catch<sup>1</sup>. By far the highest bycatch of king crab (all species) has been from the rock sole fishery, especially in 1993 and 1994 when the king crab bycatch from observed hauls was approximately 110,000 and 60,000 crab, respectively (Figure 10). The fishery which is designated as flatfish or "other" flatfish bycaught the next highest amount of king crab in 1992 and 1993 and the bottom trawl for pollock and yellowfin sole fisheries also took some king crab.

In examining the bycatch of other bottom species, the bycatch of Tanner crab in observed hauls was nearly 8 million crab in the flatfish fishery in 1992 and nearly 6.5 million crab in the yellowfin sole fishery in 1993 (Figure 11). The rock sole fishery did not catch especially high numbers of Tanner crab in any year. The highest bycatch in numbers of halibut was seen in the Pacific cod and bottom trawl for pollock fisheries (Figure 12). Among the flatfish fisheries, the rock sole fishery consistently bycaught the greatest number of halibut.

The monthly trends in effort, catch, and bycatch during the years 1991 - 1994 are provided in Figures 13 - 17. The highest proportion of groundfish catch is taken in the pollock fishery, and the shift in the "B" season opening for pollock from June 1 in 1991 and 1992 to August 15 in 1993 is evident in Figure 14. Groundfish catch in the rock sole fishery is highest during the first two months of the year, and catch in the yellowfin sole and flatfish fisheries is highest in May and June and late in the year. King crab bycatch has been greatest in the rock sole fishery in January and February (Figure 15). There is also bycatch of king crab between April and August by the rock sole and other bottom trawl fisheries. The bycatch of Tanner crab is usually highest between July and September in the flatfish and bottom trawl for pollock fisheries (Figure 16). Halibut are generally bycaught during the first half of the year by the rock sole, bottom trawl for pollock and Pacific cod trawl fisheries (Figure 17).

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<sup>1</sup> Note that the catch reported in this document is total catch and includes weight of discards. Retained catch is not consistently reported in the existing observer data.

## **DISTRIBUTION OF EFFORT AND BYCATCH**

The geographical distributions of the rock sole, flatfish and yellowfin sole fisheries are provided in Figures 18 - 20. Only hauls with more than 25 mt were chosen for ease of plotting. The rock sole fishery primarily occurs north of the Alaska Peninsula and between Unimak Island and Area 512. The yellowfin sole and flatfish fisheries are prosecuted later in the year and occur primarily in northern Bristol Bay and along the shelf from Area 512 to the Pribilof Islands and beyond.

King crab bycatch occurs primarily north of the Alaska Peninsula near the southwest portion of Area 512, and in the vicinity of the Pribilof Islands. Figure 21 provides the location of hauls exceeding 50 king crab (all species) in a haul during the years 1990 - 1994. Half-circles which curve to the left in the figure indicate a rock sole target, and half-circles which curve to the right indicate any other target, primarily flatfish or yellowfin sole. The majority of king crab bycaught by the rock sole fishery appear as the black band to the southwest of Area 512, an area which corresponds to a high amount of effort in the fishery. The bycatch of king crab in the yellowfin sole and flatfish fisheries extends to the north and west from this area.

The same hauls portrayed in Figure 21 have been coded to show time of year in Figure 22. Half-circles with the curve on the bottom indicate hauls made between January and March, and half-circles with the curve on the top indicate hauls made between April and December of 1990 - 1994. The majority of hauls taken in the area to the southwest of Area 512 were taken between January and March which also corresponds to the timing of the rock sole fishery. Most of the other incidences of king crab bycatch occur later in the year and along the border of Area 512 or to the north and west towards the Pribilof Islands.

Hauls with the highest bycatch of Tanner crab (all species) generally extend from the northwest border of Zone 1 to the area north of the Pribilof Islands (Figure 23). Hauls exceeding 2,000 crab were chosen for this figure. The hauls with the highest bycatch of halibut (more than 500 fish) generally occur in the vicinity of the "horseshoe" and north of Unimak Island and the Alaska Peninsula (Figure 24). The location of hauls with high king crab bycatch and high halibut bycatch overlap in the area above the Alaska Peninsula and to the southwest of Area 512.

## **AREAS PROPOSED FOR CLOSURE**

The five different areas proposed for closure in order to protect red king crab stocks are given in Figure 25 and described as follows:

- 1) The portion of Zone 1 east of 163° West. This was suggested by the Crab Plan Team and comprises a band one degree longitude from the western edge of Area 512. In total 5 blocks are included in this alternative extending from the Alaska Peninsula to latitude 58° N.
- 2) Five blocks to the west of Area 512 as suggested by observer data and reported to the Crab Plan Team by Jerry Berger of the NMFS observer program. This includes three blocks described in the first alternative extending north to 57° N. latitude and two blocks one degree west of these between 56° and 57° N. latitude. These blocks correspond to the areas numbered 1 through 9 in Figure 25.

- 3) Two blocks as defined and volunteered by participants in the rock sole fishery (these defined blocks have been shifted up 1/2 degree since presentation to the Council). The two blocks extend between 162° and 164° W. longitude and between 56.25° and 56.75° N. latitude. These blocks correspond to the areas numbered 3 through 6 in Figure 25.
- 4) Two blocks as originally defined and volunteered by participants in the rock sole fishery. These blocks extend between 162° and 164° W. longitude and between 56° and 56.5° N. latitude and correspond to areas numbered 5 through 8 in Figure 25.
- 5) Four blocks which form the square portion of the second alternative and as proposed by the Alaska Crab Coalition. The four blocks lie between 162° and 164° W. longitude and between 56° and 57° N. latitude and correspond to areas numbered 1 through 8 in Figure 25.

In order to compare the various alternatives, the proportion of effort, groundfish catch, and bycatch of king crab, Tanner crab and halibut were calculated and are presented graphically in Figures 26 - 30 for the years 1991 - 1994. The proportions expressed for 1994 from many of the fisheries only represent the first four months of the year, and thus refer to a small portion of the total projected annual catch since these fisheries are normally prosecuted later in the year. The rock sole fishery, which occurs largely in January and February, had the highest proportion of its catch and effort occur within several of the alternative areas in each year. The similarity in proportions between catch and number of hauls indicate that catch per unit of effort should be similar inside and outside of the proposed alternatives. Up to 5% of the groundfish catch from other fisheries has come from within the proposed alternatives, and approximately 10% of the groundfish catch in the flatfish and yellowfin sole fisheries was taken within these areas in 1992. Note again that the proportions in 1994 for these fisheries represent only a small portion of the total annual catch which normally occurs outside of these areas.

Among the five alternatives, the highest proportion of catch within the rock sole fishery is within the five block alternative (alternative 2), the four block alternative (alternative 5) and the initially proposed two block alternative (alternative 4) (Figure 27). Because the three are virtually indistinguishable, it would be expected that most of the catch and effort occurred within the two block alternative (4). Between 20% and 45% of the groundfish catch in the rock sole fishery has come from within these three proposed areas. The two blocks as amended by the rock sole fishery (alternative 3) generally accounted for 1/2 or less of the catch and effort compared with the other alternatives. The catch and effort within the area east of 163° W. longitude (alternative 1) is often less than that in the five block, four block and original two block alternatives (alternatives 2, 5 and 4, respectively).

Between 40% and 70% of the king crab bycaught in the rock sole fishery is taken within the areas defined by the four block and five block alternatives (alternatives 5 and 2, respectively, Figure 28). As discussed above, the highest number of king crab is consistently taken by the rock sole fishery. The two blocks as amended by the rock sole fishery (alternative 3) generally have accounted for between 10% and 30% of the king crab bycaught in this fishery. The two blocks as originally defined by rock sole fishery members have often accounted for the same percentages as the four and five blocks alternatives with the exception of 1993 when an additional 10% of king crab were taken outside of the two blocks and within the four and five blocks.

Although numbers of king crab have been bycaught in the flatfish and yellowfin sole fisheries, a small proportion of the total bycatch appears to be taken within the defined areas. King crab bycatch in these

fisheries generally occurs in the vicinity of the Pribilof Islands, or to the north and east of Zone 1. The high estimated proportions of king crab bycatch for several of the fisheries in 1994 and other years result from insignificant overall bycatch totals in these fisheries.

In general, a small to non-existent proportion of the bycatch of Tanner crab occurs within the defined areas (Figure 29). Several of the areas do, however, account for between 10% and 45% of the halibut bycaught in the rock sole fishery (Figure 30). As with catch and bycatch, the 5 block, 4 block, and two (original) block alternatives (alternatives 2, 5, and 4, respectively) account for the highest proportions of halibut bycatch. The area east of 163° W. longitude and the two blocks as amended by the rock sole fisheries group (alternatives 1 and 3, respectively) often account for a small proportion of the catch and/or bycatch.

### **BYCATCH RATES IN DEFINED BLOCKS AND ADJACENT AREAS**

Bycatch rates expressed as the ratio of the total number of bycatch species to the total metric tons of groundfish catch (annual number per metric ton) were estimated for a grid of individual blocks in and surrounding the areas proposed for closure. The purpose of this analysis was to estimate what bycatch might be like in areas which do not currently receive much effort. Known high bycatch blocks and blocks with the potential for high bycatch can thus be identified. For comparison purposes, the alternatives correspond to the following individual blocks (as indicated in Figure 31):

- 1) The area east of 163° W. longitude corresponds to blocks C, F, I and L in Figure 31.
- 2) The five blocks proposal corresponds to blocks E, F, H, I, and L in Figure 31.
- 3) The half-blocks which comprise the amended rock sole group proposal are not included in this full-block analysis, but make up a portion of blocks E, F, H and I in Figure 31.
- 4) The two blocks as originally proposed by the rock sole group correspond to blocks H and I in Figure 31.
- 5) The four block proposal corresponds to blocks E, F, H and I.

The annual bycatch rates by fishery and block are provided in Figures 32 - 35 for the years 1991 through 1994. Figure 36 also provides the rates from catch and bycatch totalled over the four-year period.

Bycatch rates for king crab are consistently low in the top three blocks (A, B and C) and generally low in the southern-most blocks (J, K and L). Block J had a higher rate in the 1992 flatfish fishery. There is year to year variability between blocks, however, the blocks with the highest king crab bycatch rates were blocks E, F, H and I, or those corresponding to the four block proposal (alternative 4). The blocks east of these four blocks, or blocks D and G can occasionally exhibit high bycatch rates as well.

The highest Tanner crab bycatch rates appear to occur in the more northerly and eastern blocks with high Tanner crab bycatch rates appearing in blocks A, B, C, G, and J. Halibut bycatch, on the other hand occurs in all but the most northerly blocks and can be high in blocks G, H, J, and K among the more southern blocks.



As a general observation, king crab bycatch rates are highest in the central blocks, E, F, H and I which are adjacent to Area 512. Tanner crab bycatch rates are higher to the north or east of these blocks. Halibut bycatch rates can be high both inside and outside of these blocks to the south and east. A closure of blocks under the alternatives would reduce halibut bycatch within the areas, but would transfer effort into adjacent areas with similarly high halibut bycatch rates.

### **DIRECTED CATCH OF KING CRAB WITHIN DEFINED BLOCKS**

The catch of red king crab in the directed pot fishery was also examined. This fishery is prosecuted in November and December, or in the months just preceding the trawl fishery for rock sole in January and February. As indicated in Figure 37, the directed catch of red king crab is highest in blocks E and F (Figure 31). These blocks make up the northern two blocks of the four block and five block alternatives (alternatives 5 and 2, respectively). There is also substantial catch in blocks H and I. Together, the four blocks E, F, H and I accounted for 76.0%, 39.5% and 81.6% of the total directed red king crab catch in 1991, 1992 and 1993, respectively.

Information of size and sex of crab from selected pots in the directed red king crab pot fishery are provided in Figure 38. Based on the samples taken, it appears that legal crab comprised the greatest proportion of the catch in 1991 and that sublegal males and females made up the greater proportion of the sampled catch in 1992 and 1993. Female crab were evident in blocks B and C in 1992, and in blocks B, C, F and I in 1993.

### **SUMMARY**

The NMFS annual trawl surveys indicate a low abundance of red king crab, especially small female crab, and directed fishing for Bristol Bay red king crab was curtailed in 1994. The directed pot fishery for Tanner crab in Zone 1 east of 163° W longitude was also cancelled in 1994 because of concerns for red king crab bycatch. The distribution of red king crab during the summer months, as indicated by the NMFS survey, is contained within Area 512 with crab also appearing to the west of this area and to the northeast further into Bristol Bay. Bycatch of king crab during the summer months is moderate and occurs in the yellowfin sole, flatfish and bottom trawl for pollock fisheries.

The bycatch of king crab is highest in the rock sole fishery which is prosecuted during the months of January and February. The directed pot fishery for red king crab occurs during the months of November and December. Together, the bycatch and directed catch information indicate that king crab are found primarily in the four squares which comprise alternative ~~5~~ (numbers 1 - 8 in Figure 25 and blocks E, F, H and I in Figure 31), especially during the winter months.

## FIGURES

Figure 1. Directed catch of Bering Sea red king crab in ADF&G area T pot fisheries. Catch is reported in numbers of crab.

Figure 2. Annual abundance of Bering Sea red king crab based on NMFS annual trawl surveys. Size and sex composition of the estimates are provided.

Figure 3. Distribution of hauls containing red king crab from the 1990 NMFS trawl survey. Categories indicate proportion of size/sex, and circle size is proportional to total catch.

Figure 4. Distribution of hauls containing red king crab from the 1991 NMFS trawl survey. Categories indicate proportion of size/sex, and circle size is proportional to total catch.

Figure 5. Distribution of hauls containing red king crab from the 1992 NMFS trawl survey. Categories indicate proportion of size/sex, and circle size is proportional to total catch.

Figure 6. Distribution of hauls containing red king crab from the 1993 NMFS trawl survey. Categories indicate proportion of size/sex, and circle size is proportional to total catch.

Figure 7. Distribution of hauls containing red king crab from the 1994 NMFS trawl survey. Categories indicate proportion of size/sex, and circle size is proportional to total catch.

Figure 8. Number of observed hauls by fishery and year from groundfish fisheries in the Bering Sea, 1991-1994.

Figure 9. Total groundfish catch from observed hauls by fishery and year from groundfish fisheries in the Bering Sea, 1991-1994.

Figure 10. Total king crab bycatch from observed hauls by fishery and year from groundfish fisheries in the Bering Sea, 1991-1994.

Figure 11. Total Tanner crab bycatch from observed hauls by fishery and year from groundfish fisheries in the Bering Sea, 1991-1994.

Figure 12. Total halibut bycatch (numbers) from observed hauls by fishery and year from groundfish fisheries in the Bering Sea, 1991-1994.

Figure 13. Number of observed hauls by fishery, month and year from groundfish fisheries in the Bering Sea, 1991-1994.

Figure 14. Total groundfish catch from observed hauls by fishery, month and year from groundfish fisheries in the Bering Sea, 1991-1994.

Figure 15. Total king crab bycatch from observed hauls by fishery, month and year from groundfish fisheries in the Bering Sea, 1991-1994.

Figure 16. Total Tanner crab bycatch from observed hauls by fishery, month and year from groundfish fisheries in the Bering Sea, 1991-1994.

Figure 17. Total halibut bycatch (numbers) from observed hauls by fishery, month and year from groundfish fisheries in the Bering Sea, 1991-1994.

Figure 18. Distribution of observed hauls with catch greater than 25 mt in the rock sole fishery, 1990 - 1994.

Figure 19. Distribution of observed hauls with catch greater than 25 mt in the flatfish fishery, 1990 - 1994.

Figure 20. Distribution of observed hauls with catch greater than 25 mt in the yellowfin sole fishery, 1990 - 1994.

Figure 21. Distribution of observed hauls with more than 50 king crab. Circles to the left = rock sole target, circles to right = any other target.

Figure 22. Distribution of observed hauls with more than 50 king crab. Circles on bottom = period January - February, circles on top = remainder of year.

Figure 23. Distribution of observed hauls with more than 2,000 Tanner crab, 1990 - 1994.

Figure 24. Distribution of observed hauls with more than 500 halibut, 1990 - 1994.

Figure 25. Description of areas defined for closure. Alternative 1 includes numbers 2, 4, 6, 8, and 9; alternative 2 includes numbers 3 - 9; alternative 3 includes numbers 3 - 6; alternative 4 includes numbers 5 - 8; alternative 5 includes numbers 1 - 8.

Figure 26. Percentage of hauls located within defined areas by fishery, 1991 - 1994.

Figure 27. Percentage of total catch from hauls located within defined areas by fishery, 1991 - 1994.

Figure 28. Percentage of king crab bycatch from hauls located within defined areas by fishery, 1991 - 1994.

Figure 29. Percentage of Tanner crab bycatch from hauls located within defined areas by fishery, 1991 - 1994.

Figure 30. Percentage of halibut bycatch from hauls located within defined areas by fishery, 1991 - 1994.

Figure 31. Blocks labelled A - L for reference.

Figure 32. Bycatch rates in numbers per metric ton of king crab, Tanner crab and halibut by fishery, 1991. Letters refer to blocks in Figure 30.

Figure 33. Bycatch rates in numbers per metric ton of king crab, Tanner crab and halibut by fishery, 1992. Letters refer to blocks in Figure 30.

Figure 34. Bycatch rates in numbers per metric ton of king crab, Tanner crab and halibut by fishery, 1993. Letters refer to blocks in Figure 30.

Figure 35. Bycatch rates in numbers per metric ton of king crab, Tanner crab and halibut by fishery, 1994. Letters refer to blocks in Figure 30.

Figure 36. Bycatch rates in numbers per metric ton of king crab, Tanner crab and halibut by fishery, for years 1991-94. Letters refer to blocks in Figure 30.

Figure 37. Number of crab taken by block from the directed king crab pot fishery in Bristol Bay, 1991-93.

Figure 38. Number of female, sublegal and legal male crab encountered in samples from the directed king crab pot fishery in Bristol Bay, 1991-93.

Figure 1. Directed catch of Bering Sea red king crab in ADF&G area T pot fisheries. Catch is reported in numbers of crab.

Number of red king crab captured in the Bristol Bay directed pot fishery, 1966-1994. Note closures in 1983 and 1994.

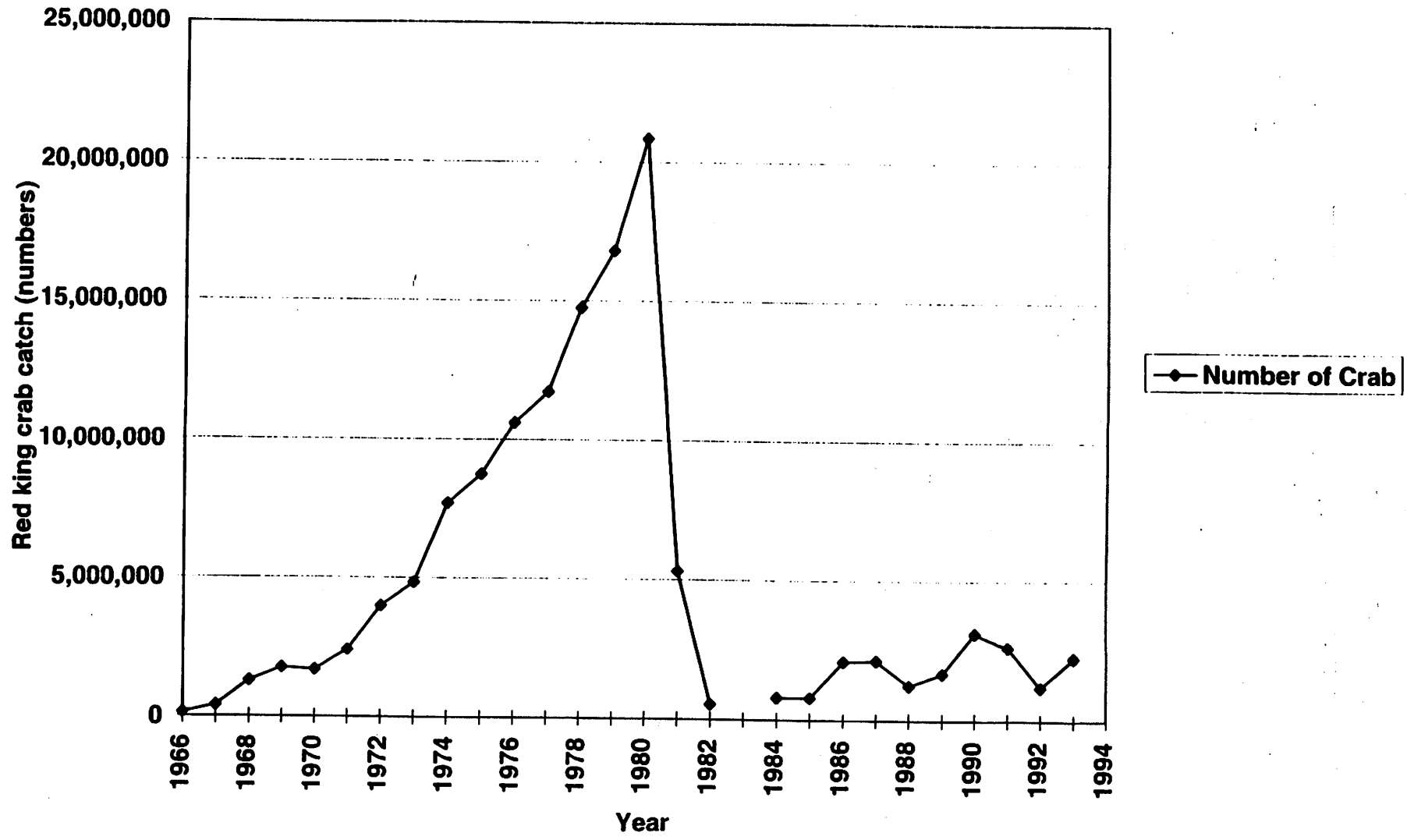


Figure 2.

Annual abundance of Bering Sea red king crab based on NMFS annual trawl surveys. Size and sex composition of the estimates are provided.

Annual abundance estimates for Bering Sea red king crab from NMFS trawl surveys.

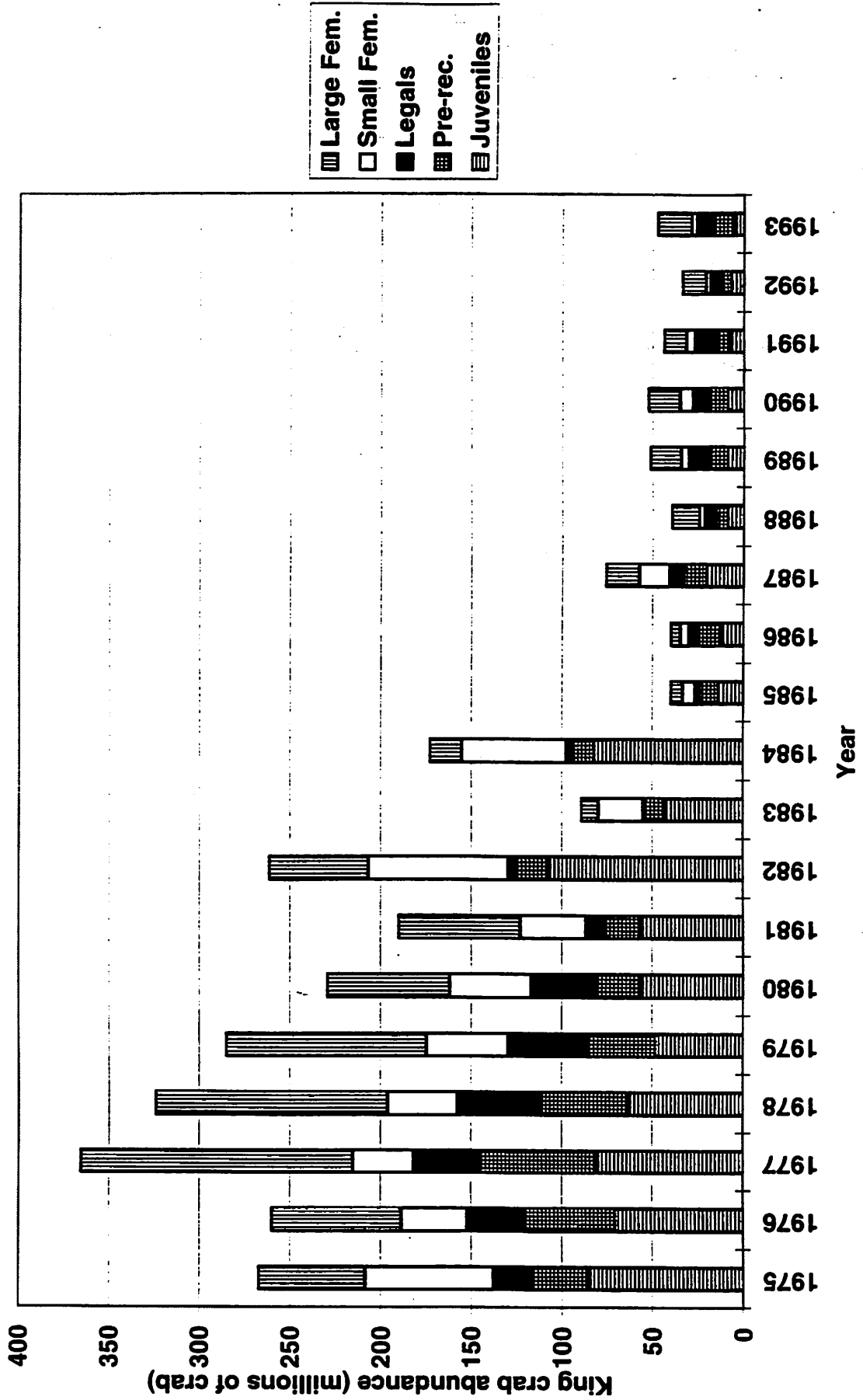
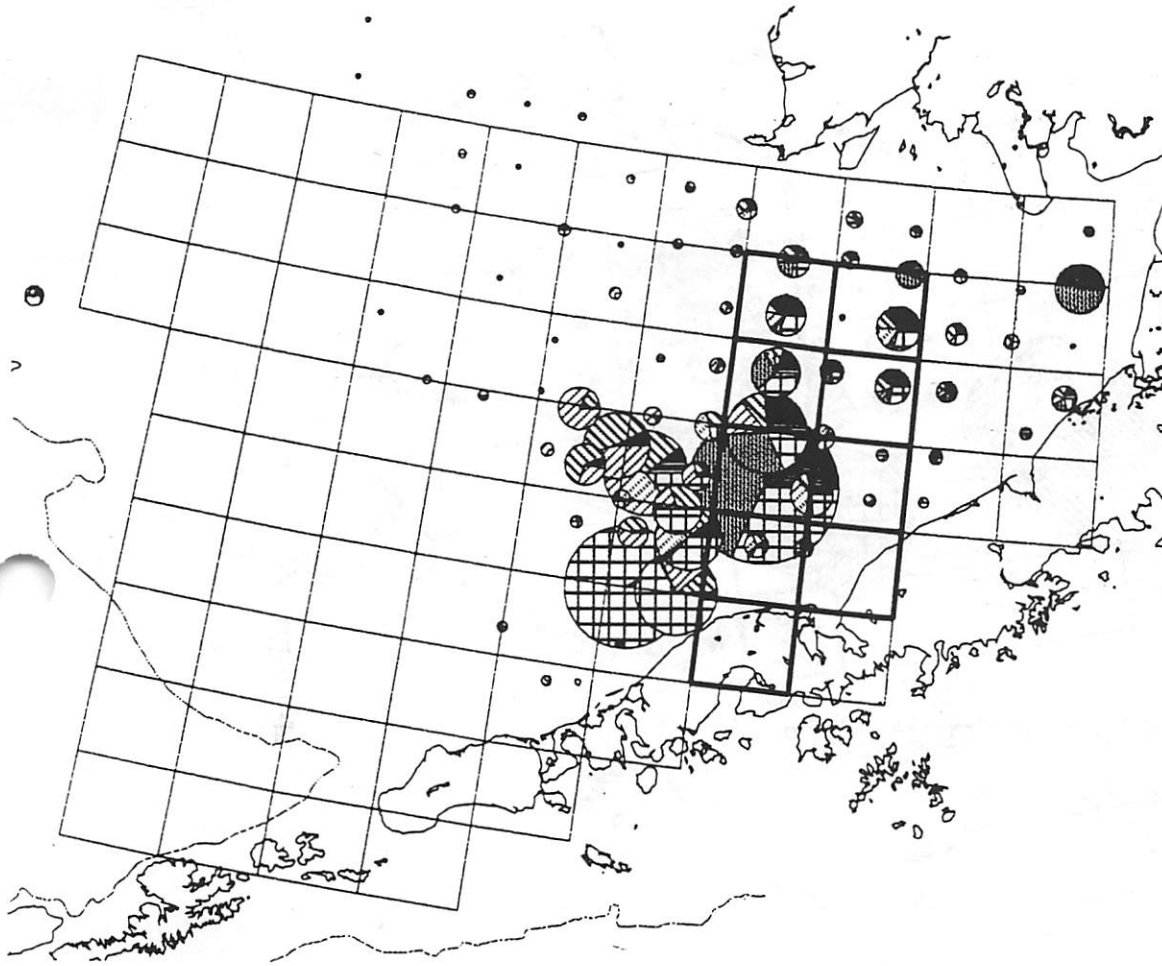


Figure 3. Distribution of hauls containing red king crab from the 1990 NMFS trawl survey. Categories indicate proportion of size/sex, and circle size is proportional to total catch.



Red King crab - 1990 NMFS Survey  
(Bold lines indicate permanent trawl closure)

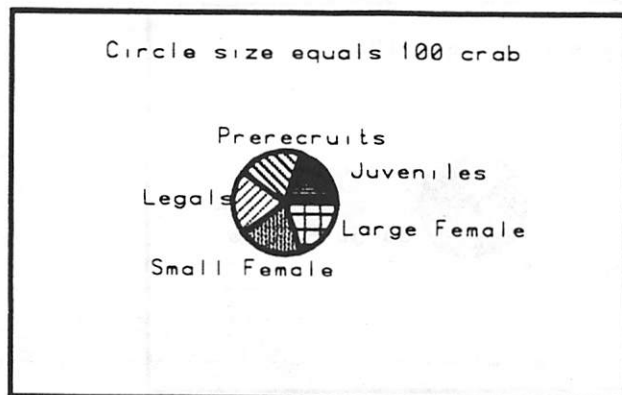
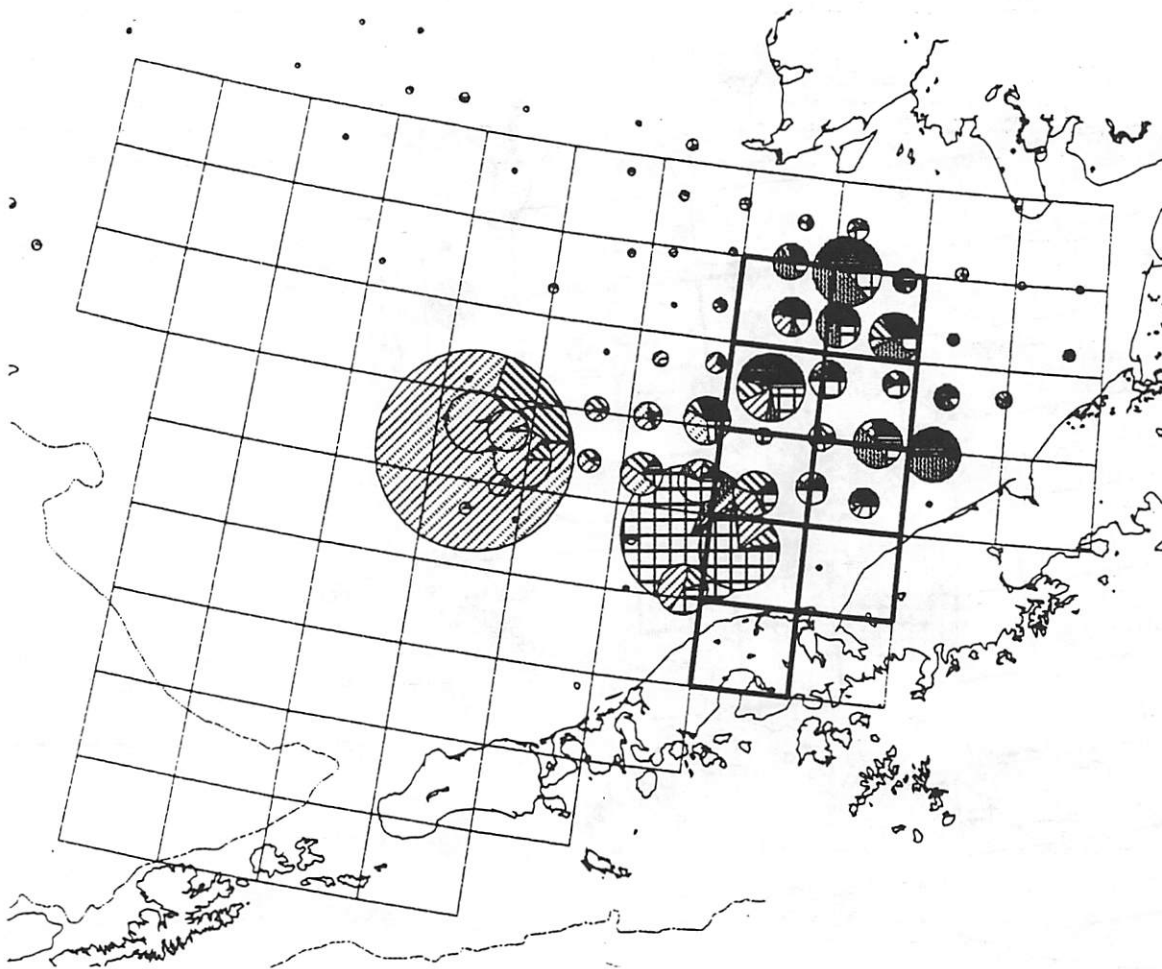


Figure 4. Distribution of hauls containing red king crab from the 1991 NMFS trawl survey. Categories indicate proportion of size/sex, and circle size is proportional to total catch.



Red King crab - 1991 NMFS Survey  
(Bold lines indicate permanent trawl closure)

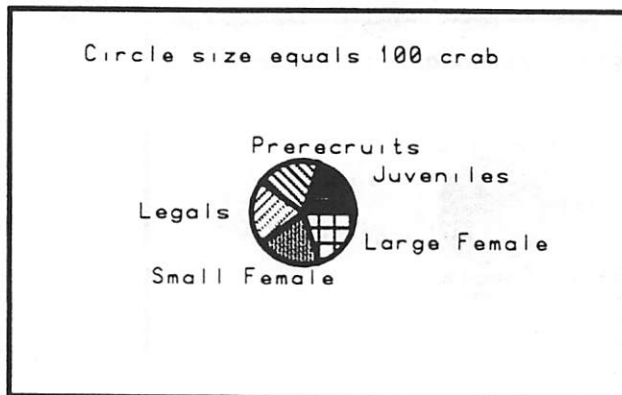
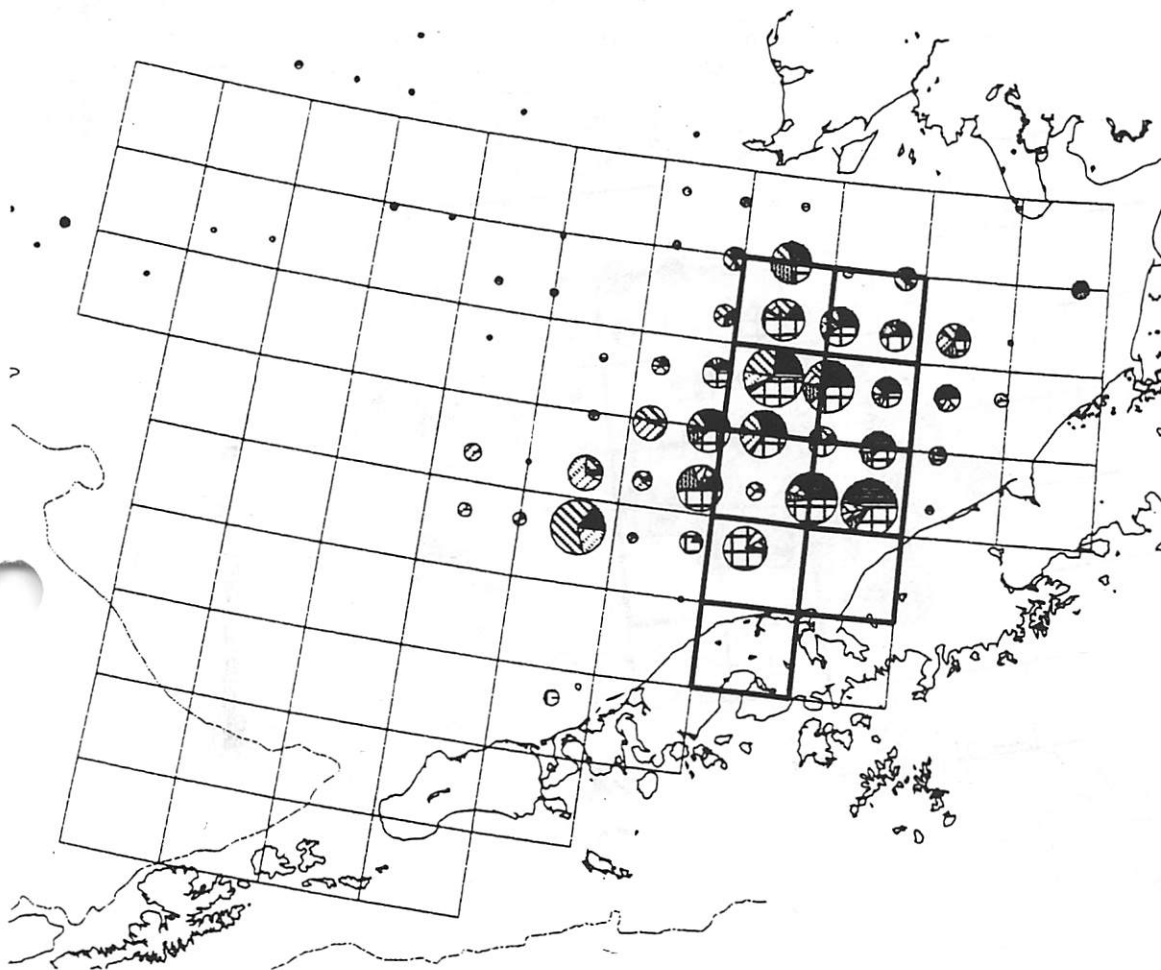




Figure 5. Distribution of hauls containing red king crab from the 1992 NMFS trawl survey. Categories indicate proportion of size/sex, and circle size is proportional to total catch.



Red King crab - 1992 NMFS Survey  
(Bold lines indicate permanent trawl closure)

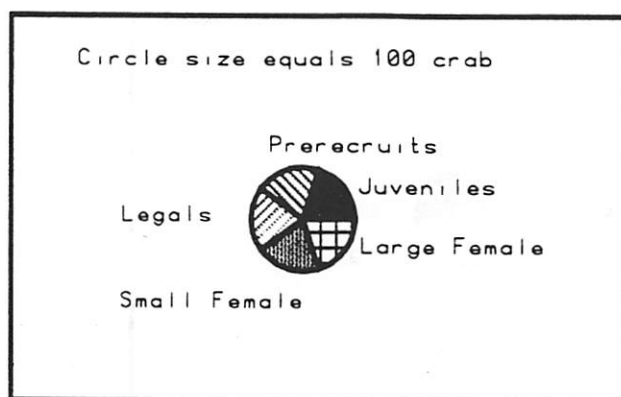
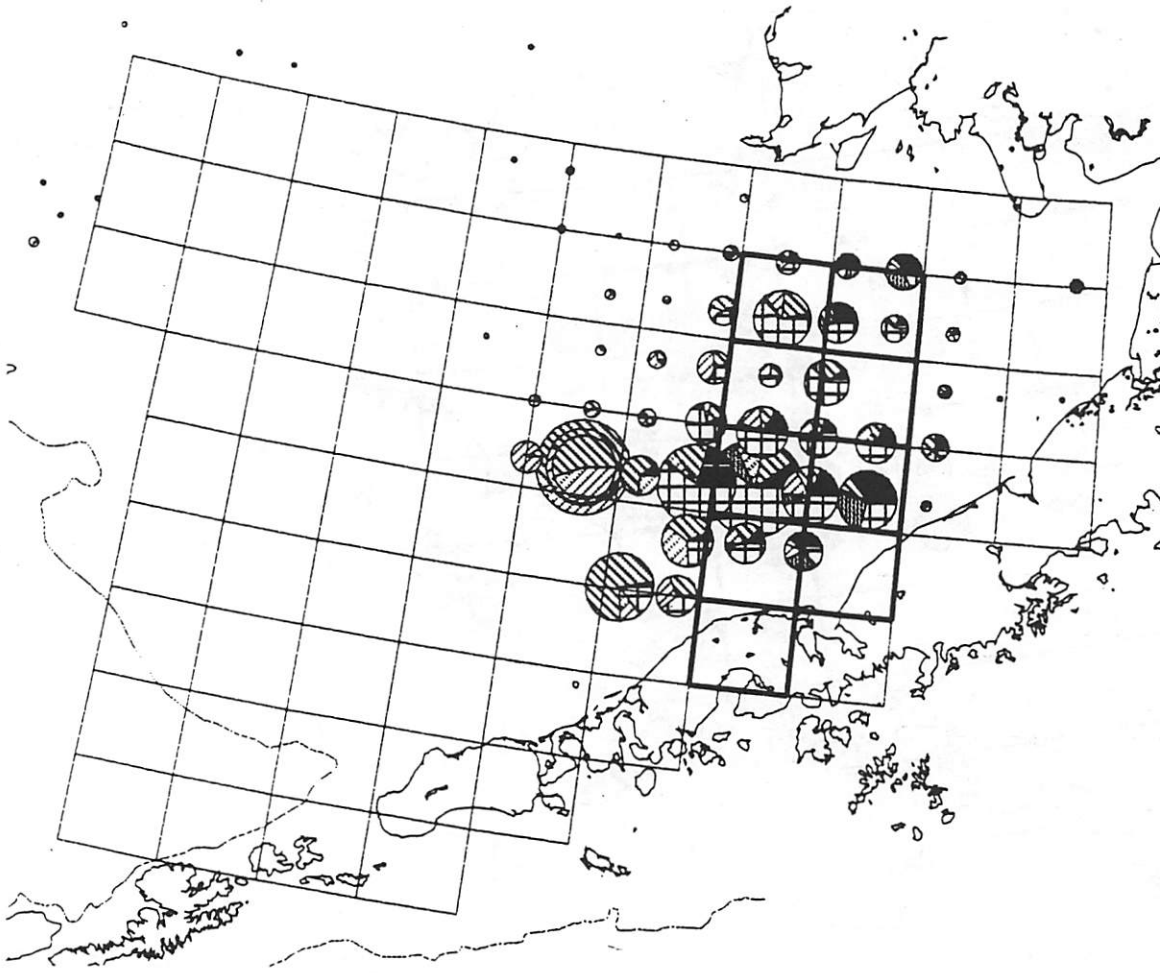


Figure 6. Distribution of hauls containing red king crab from the 1993 NMFS trawl survey. Categories indicate proportion of size/sex, and circle size is proportional to total catch.



Red King crab - 1993 NMFS Survey  
(Bold lines indicate permanent trawl closure)

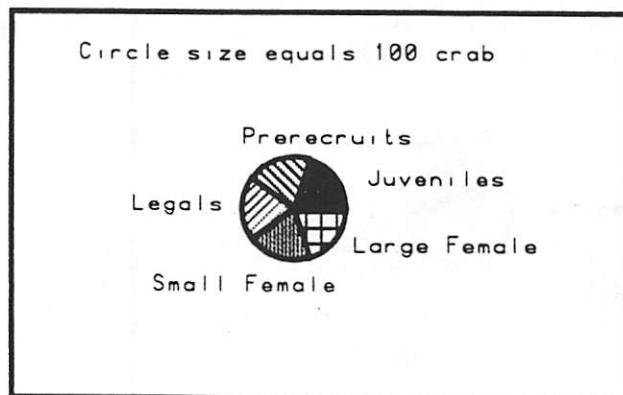
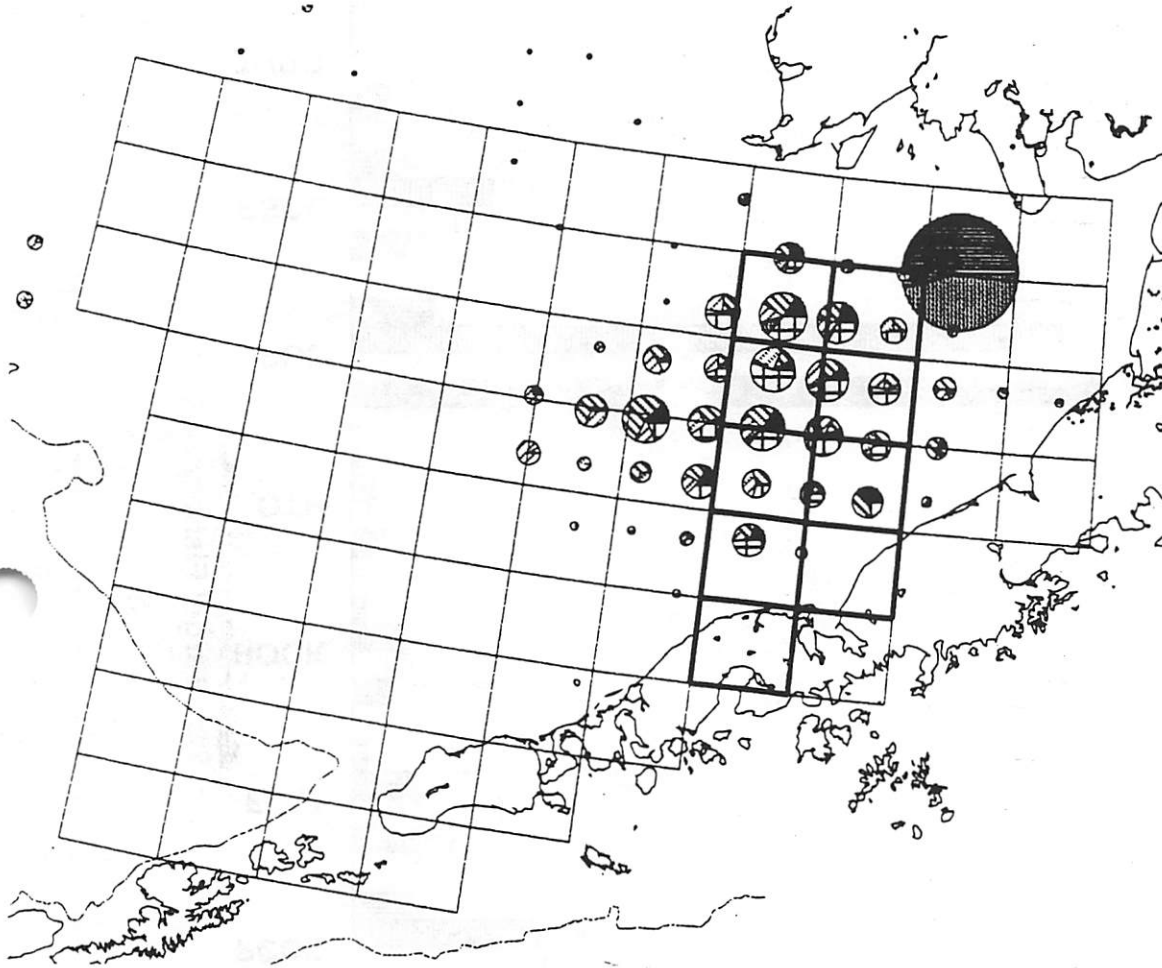


Figure 7. Distribution of hauls containing red king crab from the 1994 NMFS trawl survey. Categories indicate proportion of size/sex, and circle size is proportional to total catch.



Red King crab - 1994 NMFS Survey  
(Bold lines indicate permanent trawl closure)

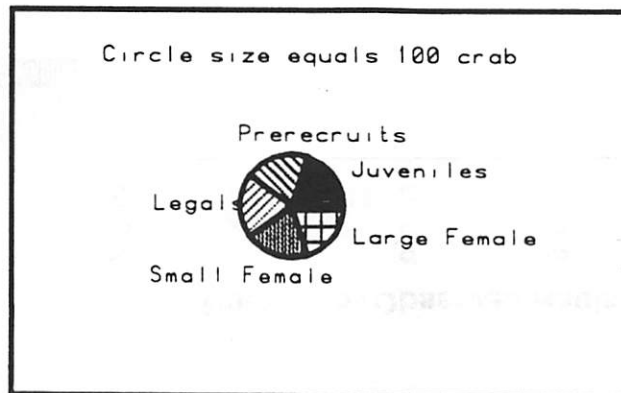


Figure 8. Number of observed hauls by fishery and year from groundfish fisheries in the Bering Sea, 1991-1994.

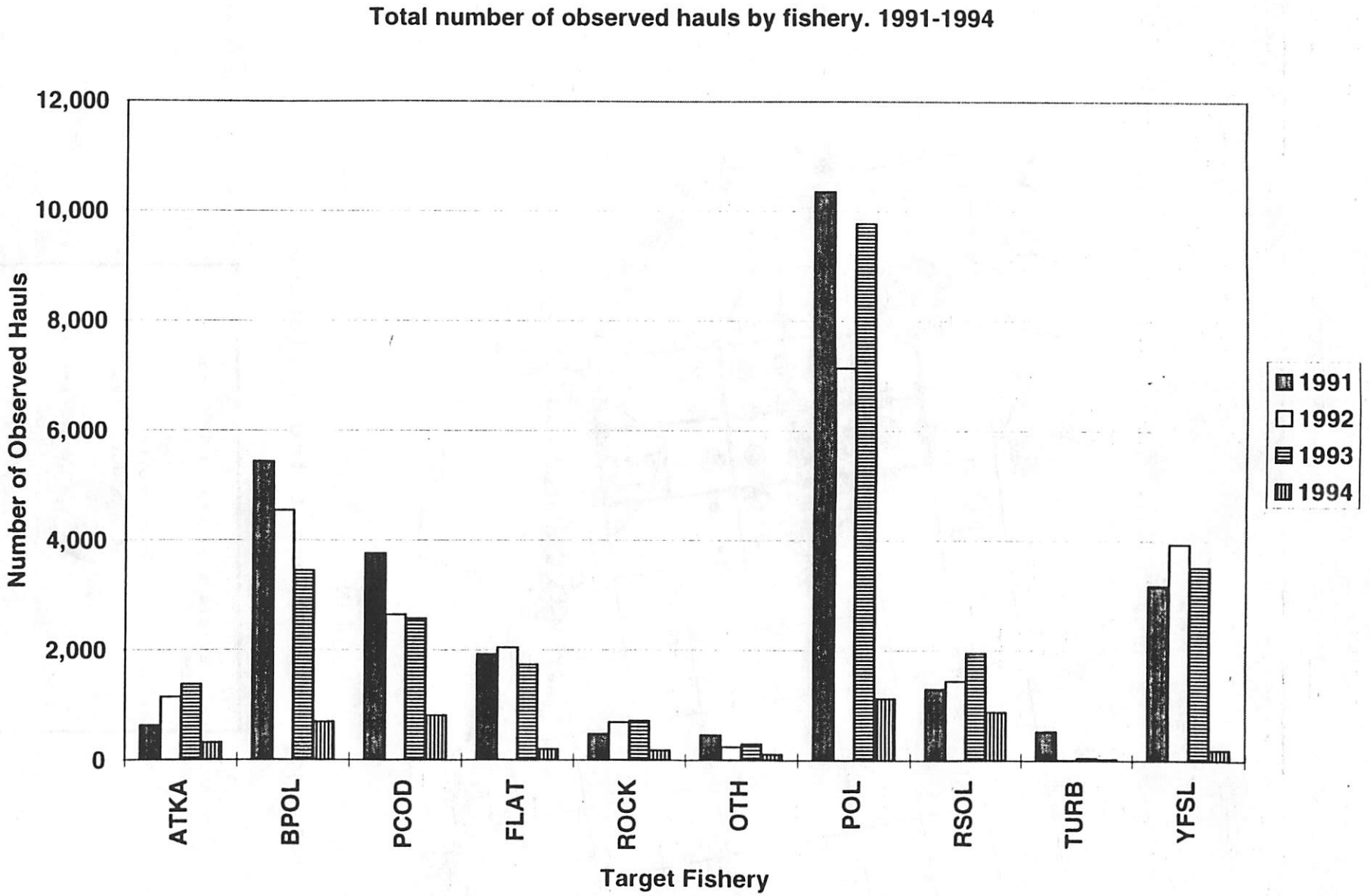


Figure 9.

Total groundfish catch from observed hauls by fishery and year from groundfish fisheries in the Bering Sea, 1991-1994.

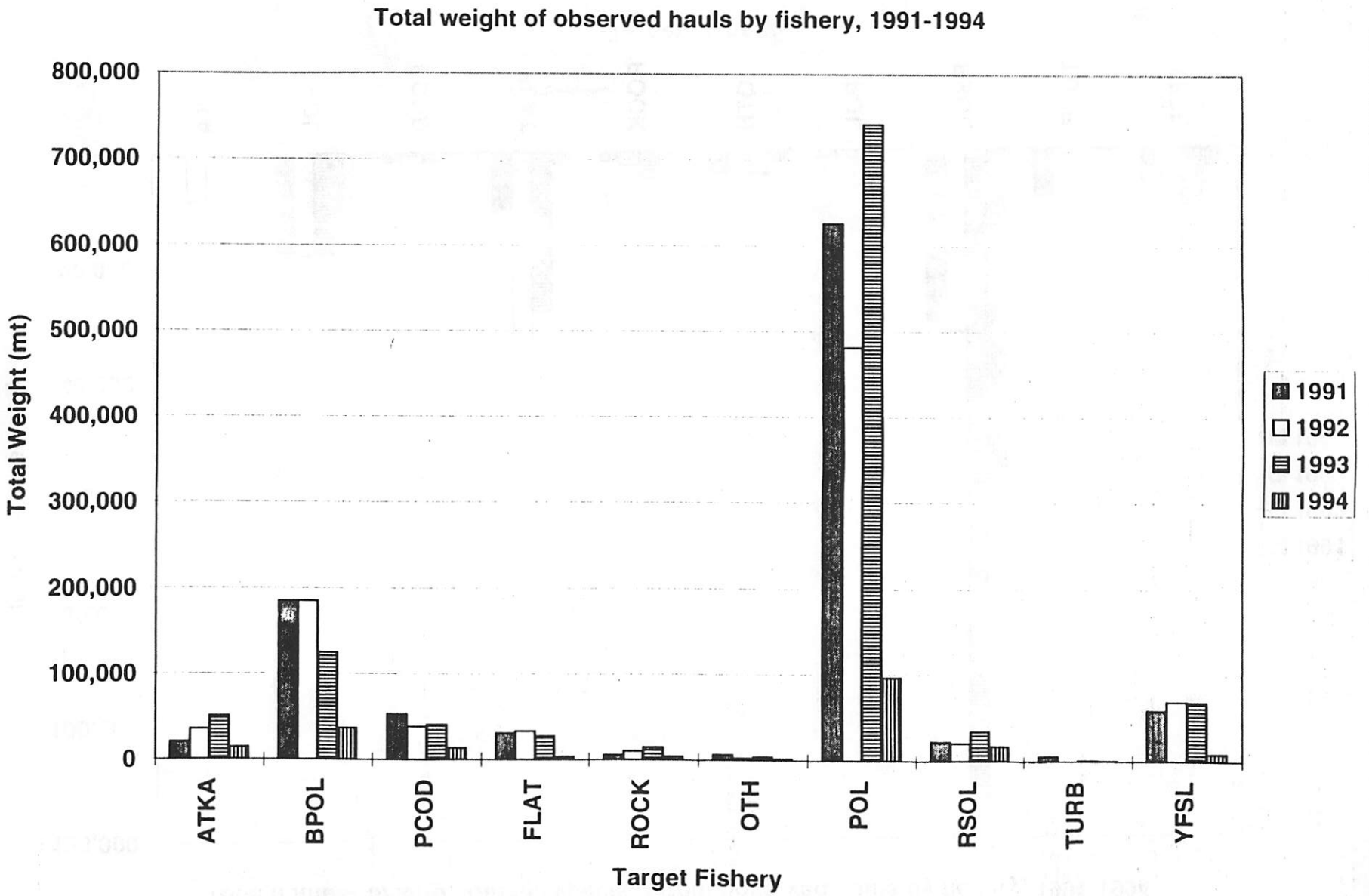


Figure 10. Total king crab bycatch from observed hauls by fishery and year from groundfish fisheries in the Bering Sea, 1991-1994.

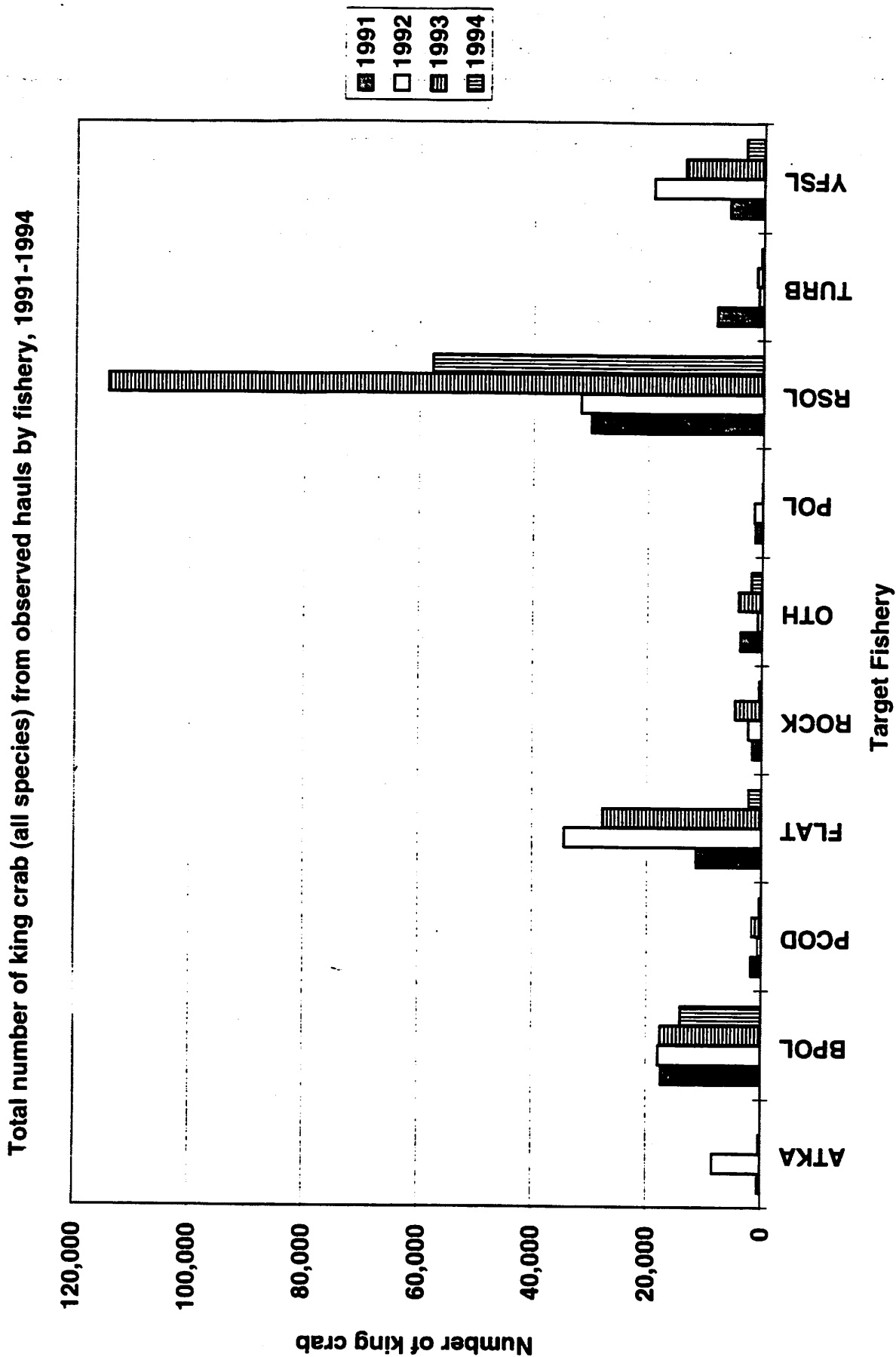


Figure 11.

Total Tanner crab bycatch from observed hauls by fishery and year from groundfish fisheries in the Bering Sea, 1991-1994.

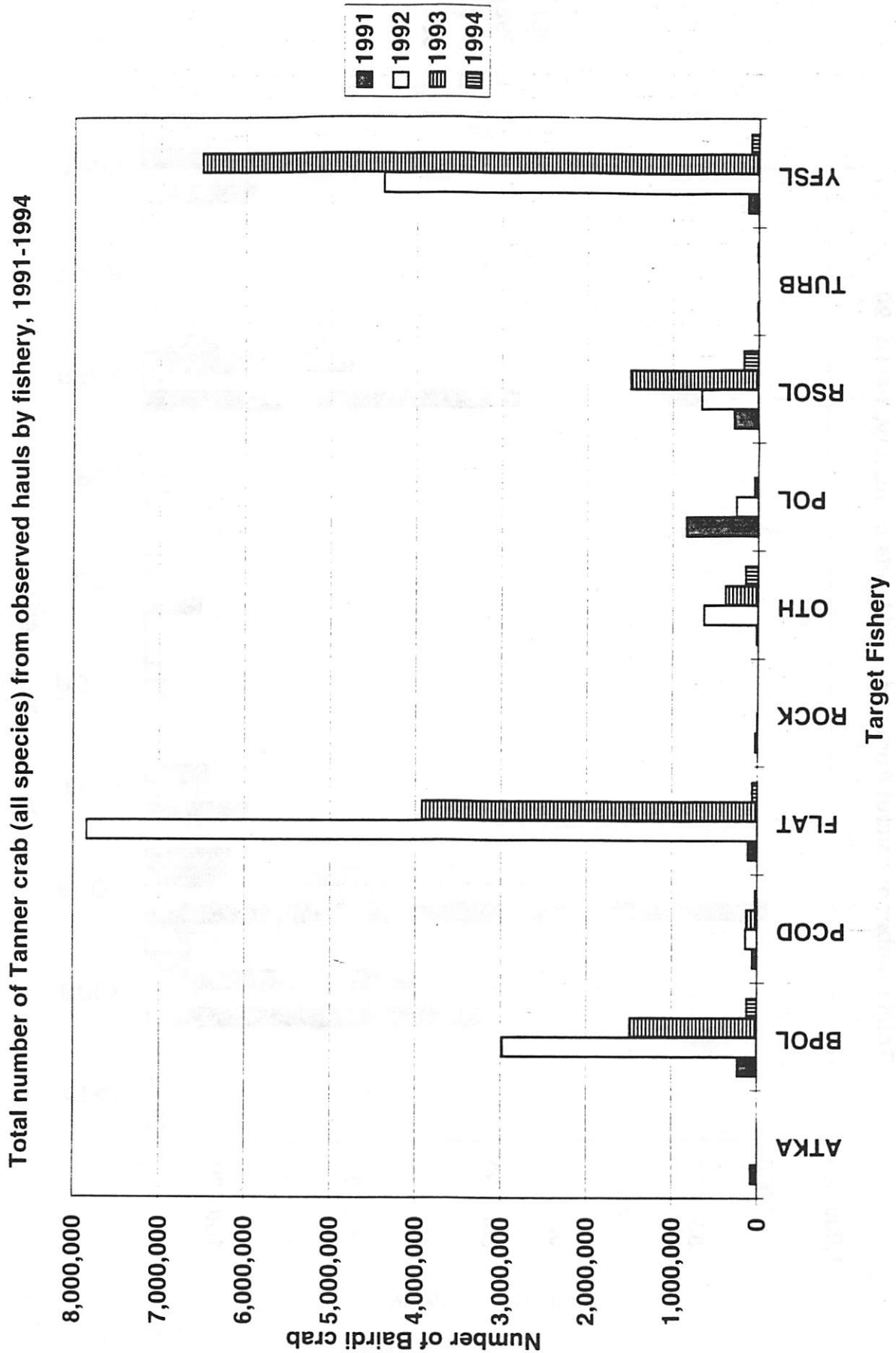


Figure 12. Total halibut bycatch (numbers) from observed hauls by fishery and year from groundfish fisheries in the Bering Sea, 1991-1994.

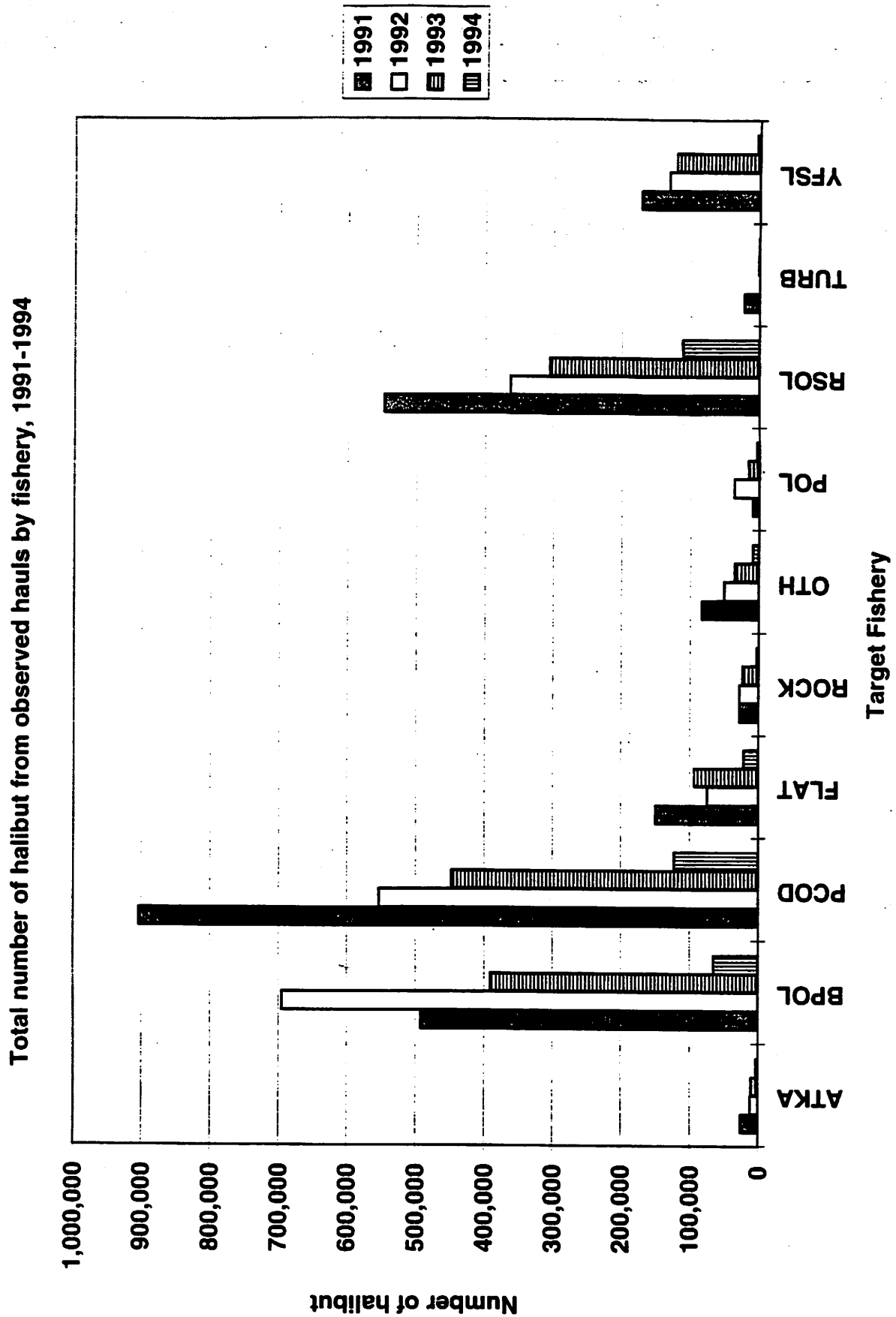












Figure 17. Total halibut bycatch (numbers) from observed hauls by fishery, month and year from groundfish fisheries in the Bering Sea, 1991-1994.

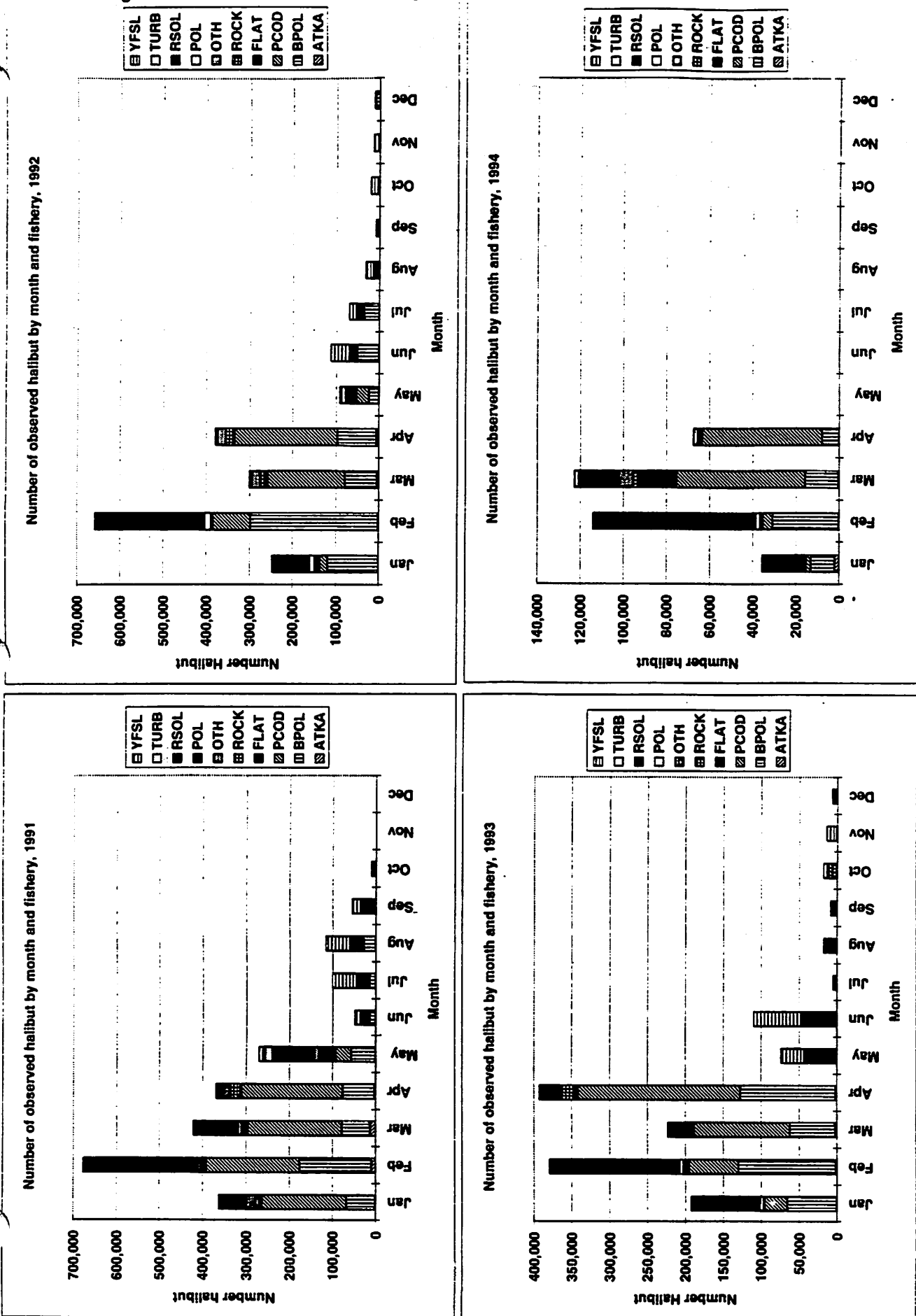


Figure 18. Distribution of observed hauls with catch greater than 25 mt in the rock sole fishery, 1990 - 1994.

Target Rocksole with haul > 25 mt, 1990-1994

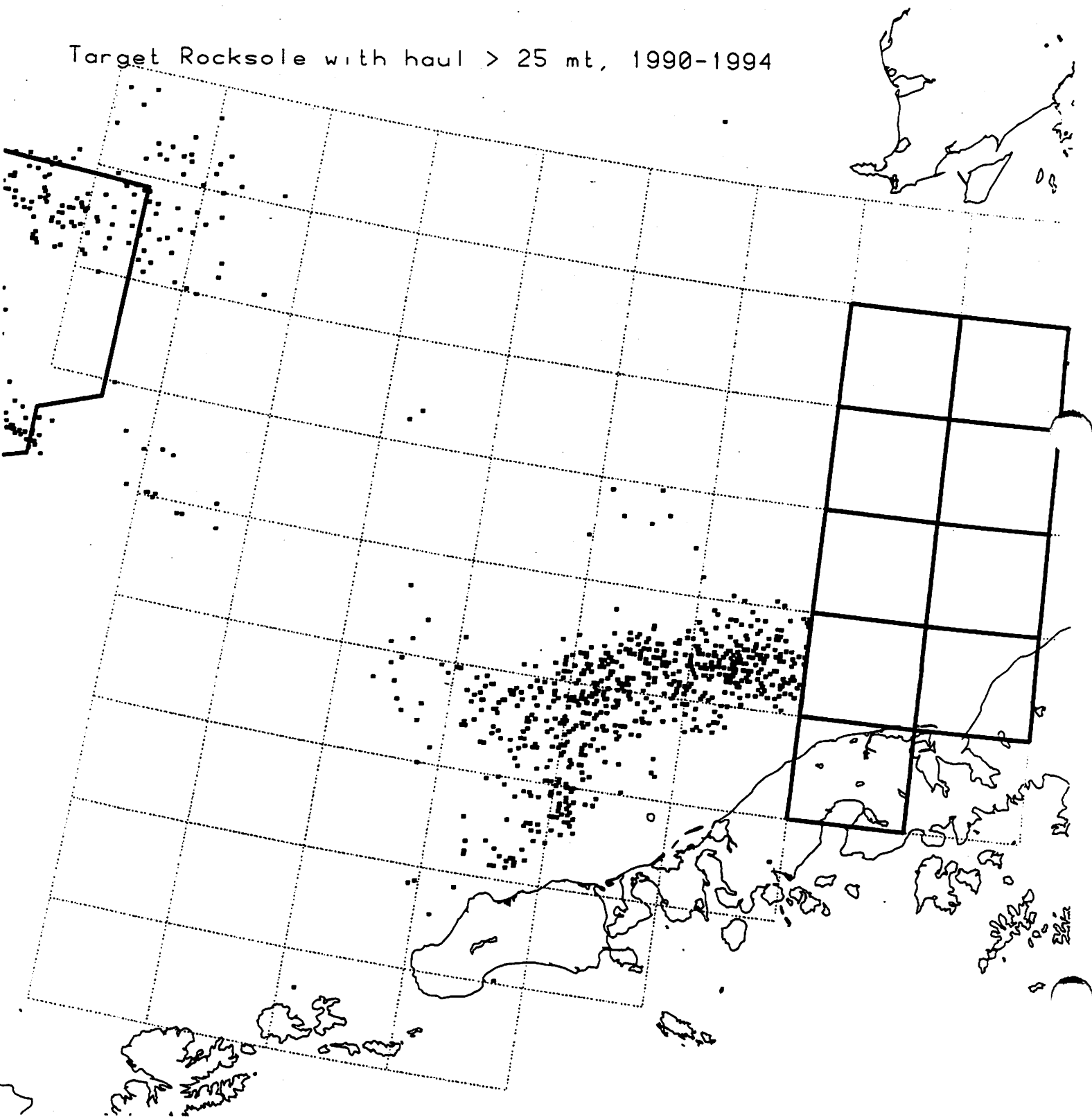


Figure 19. Distribution of observed hauls with catch greater than 25 mt in the flatfish fishery, 1990 - 1994.

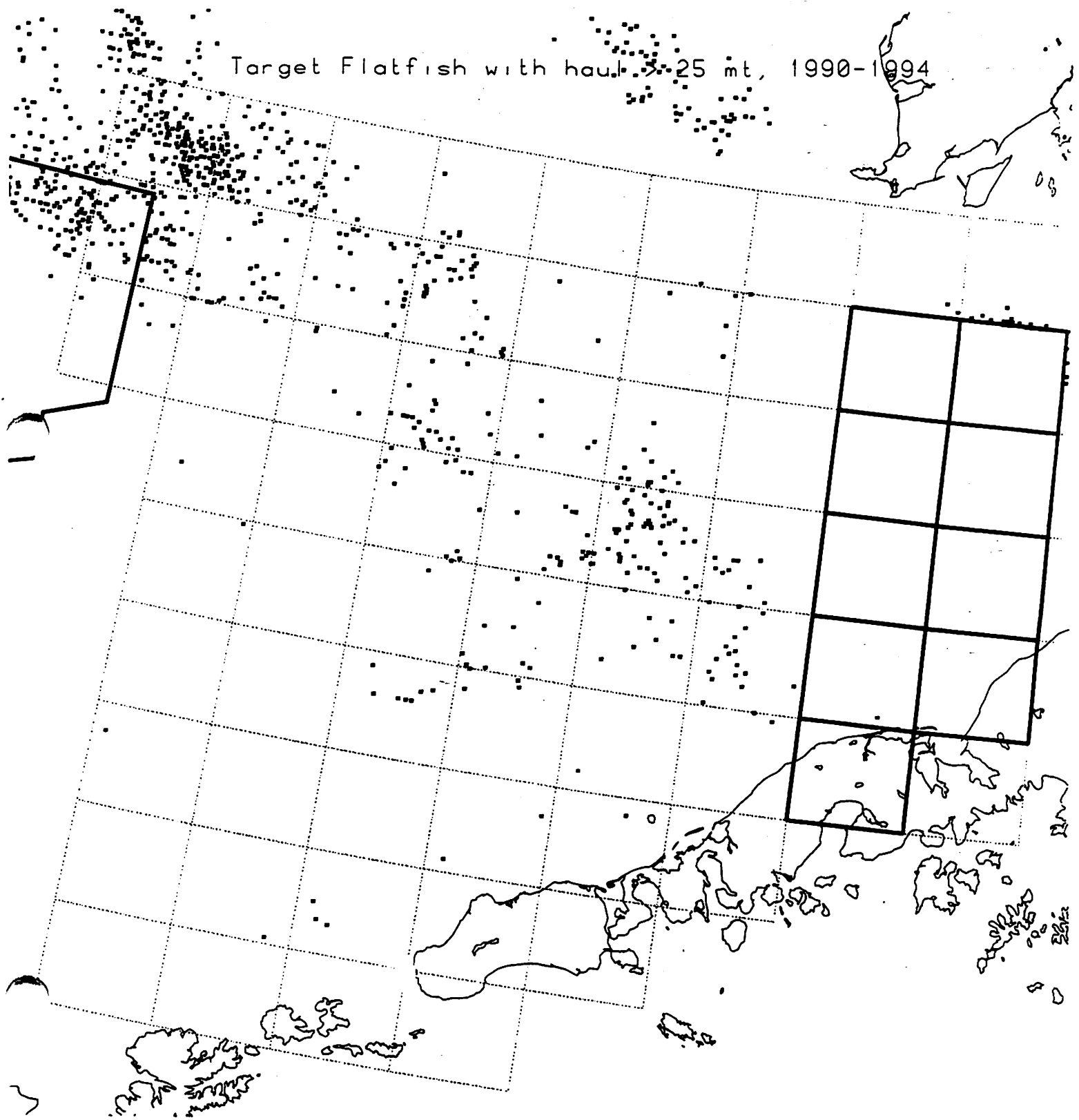


Figure 20. Distribution of observed hauls with catch greater than 25 mt in the yellowfin sole fishery, 1990 - 1994.

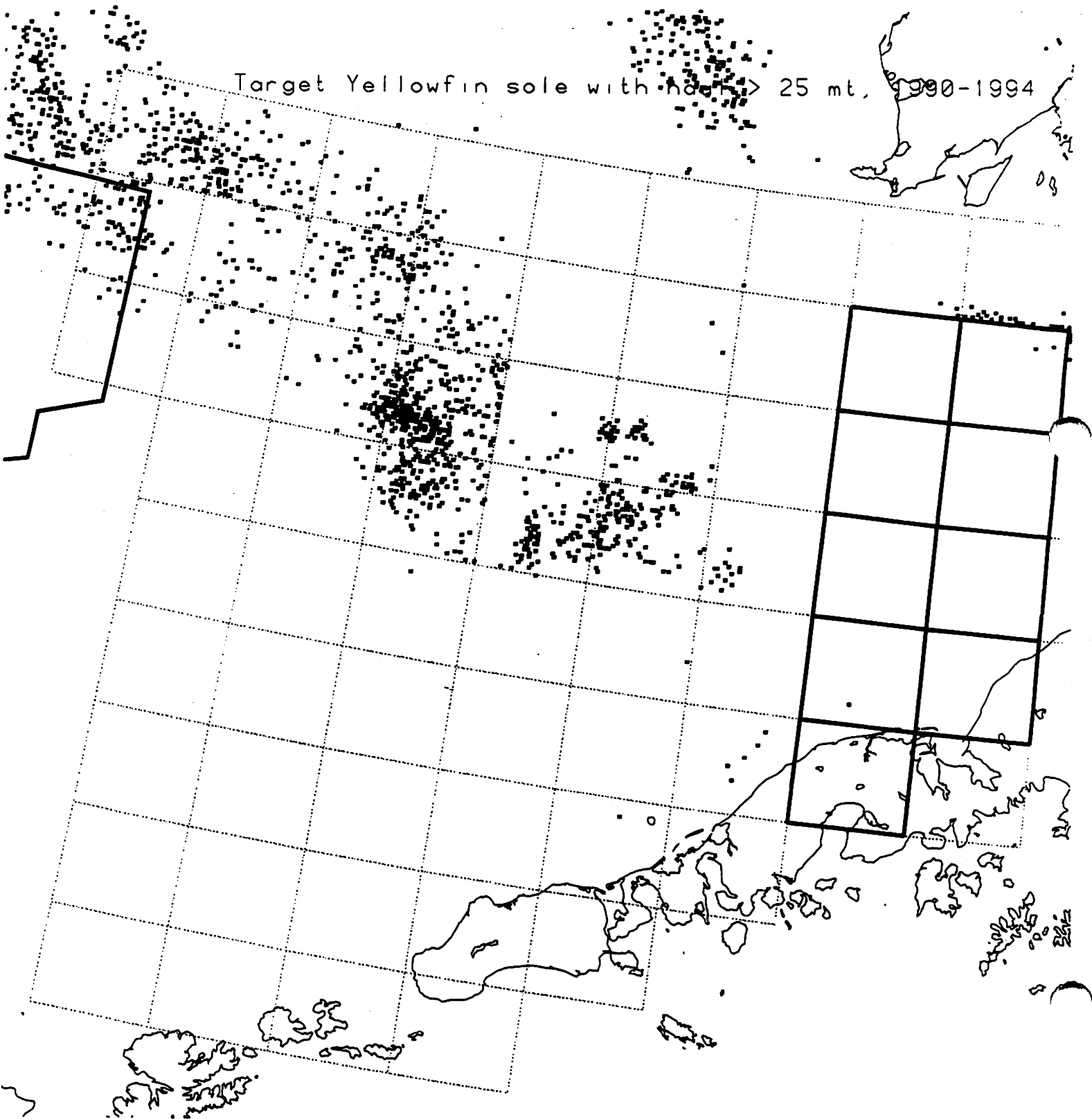




Figure 21. Distribution of observed hauls with more than 50 king crab. Circles to the left = rock sole target, circles to right = any other target.

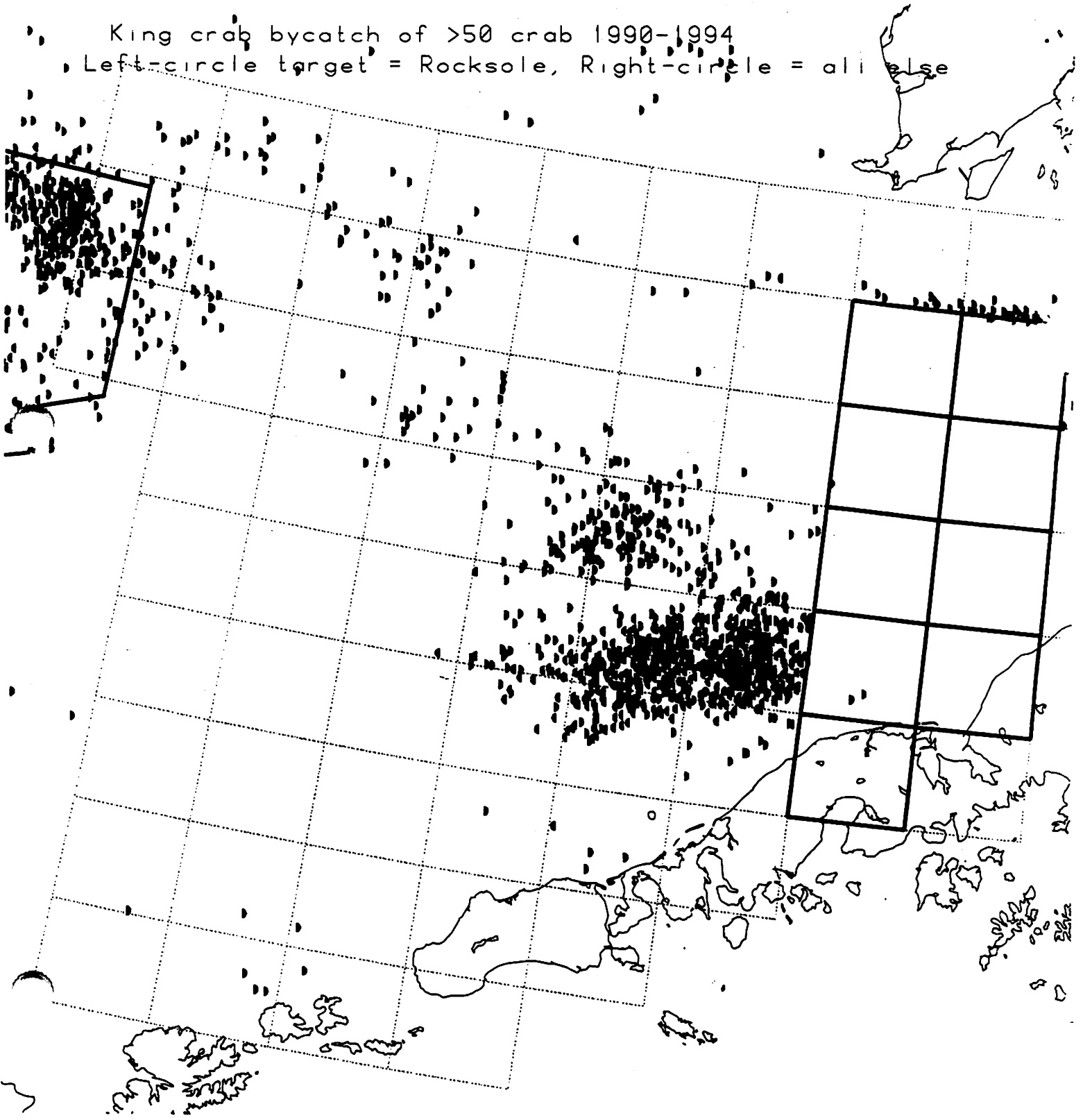


Figure 22. Distribution of observed hauls with more than 50 king crab. Circles on bottom = period January - February, circles on top = remainder of year.

King crab bycatch of >50 crab 1990-1994

Bottom-half = Jan - Mar , Upper-half = Apr - Dec

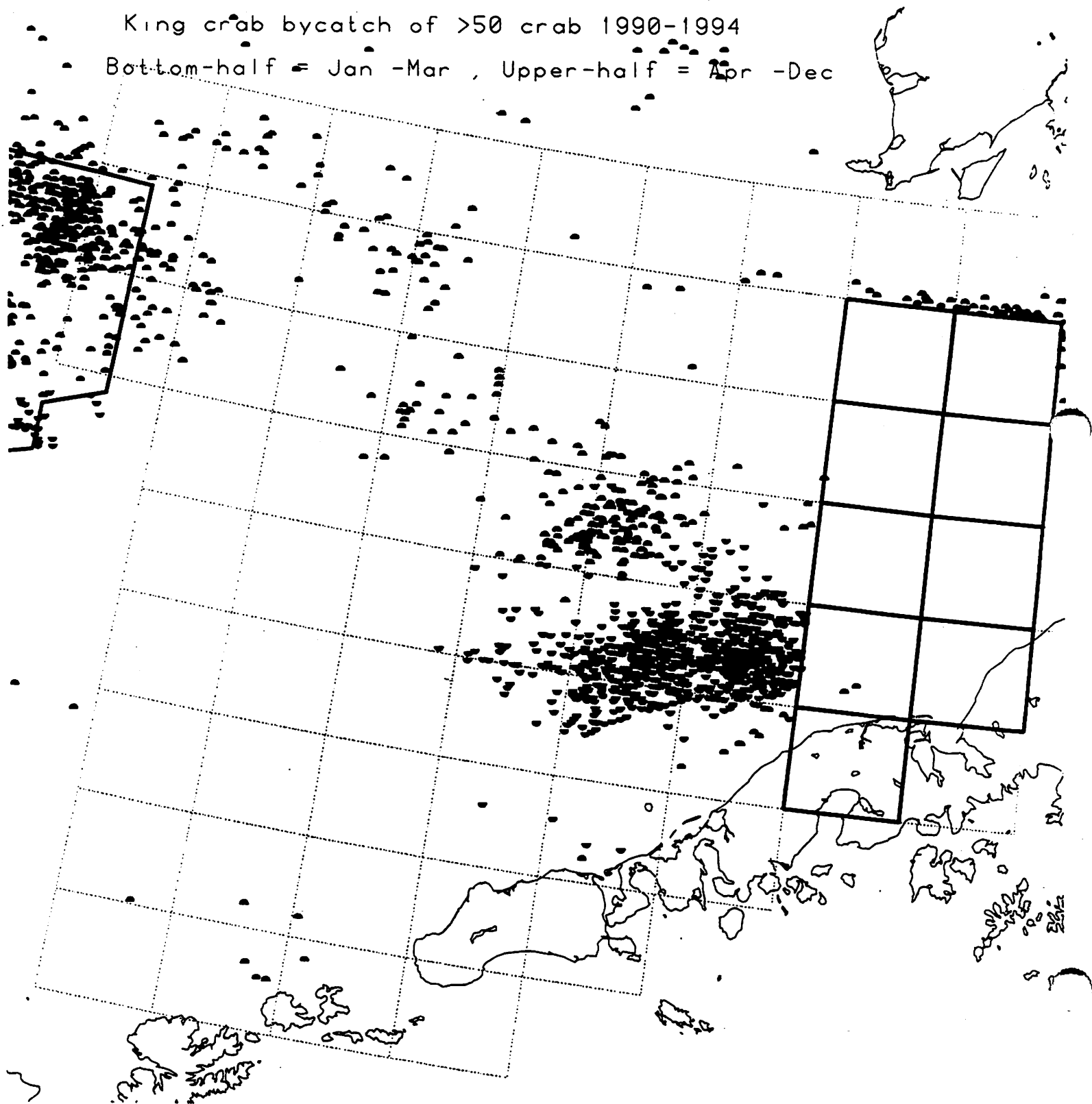


Figure 23. Distribution of observed hauls with more than 2,000 Tanner crab, 1990 - 1994.

Tanner crab bycatch of >2000 crab 1990-1994

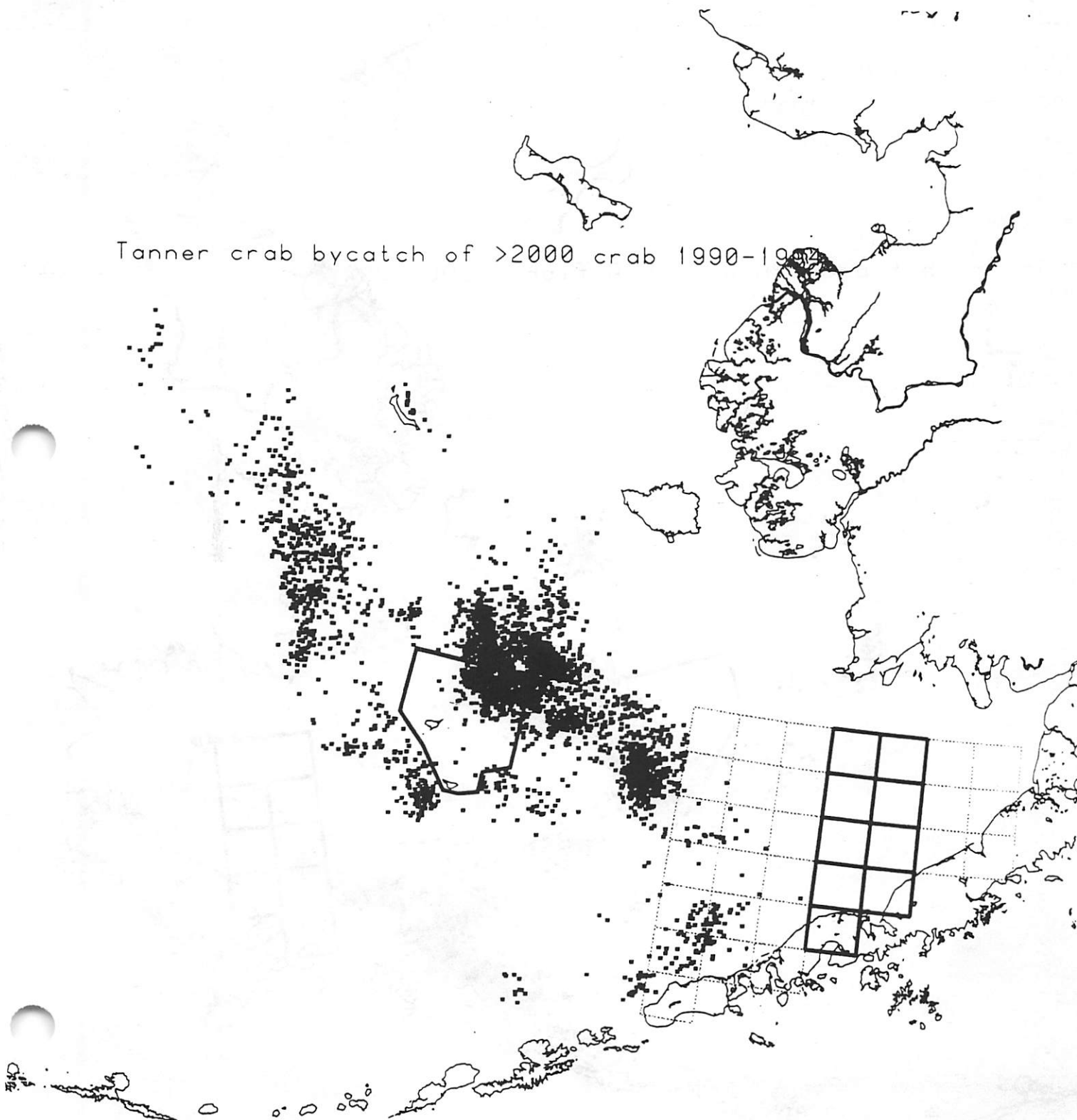


Figure 24. Distribution of observed hauls with more than 500 halibut, 1990 - 1994.

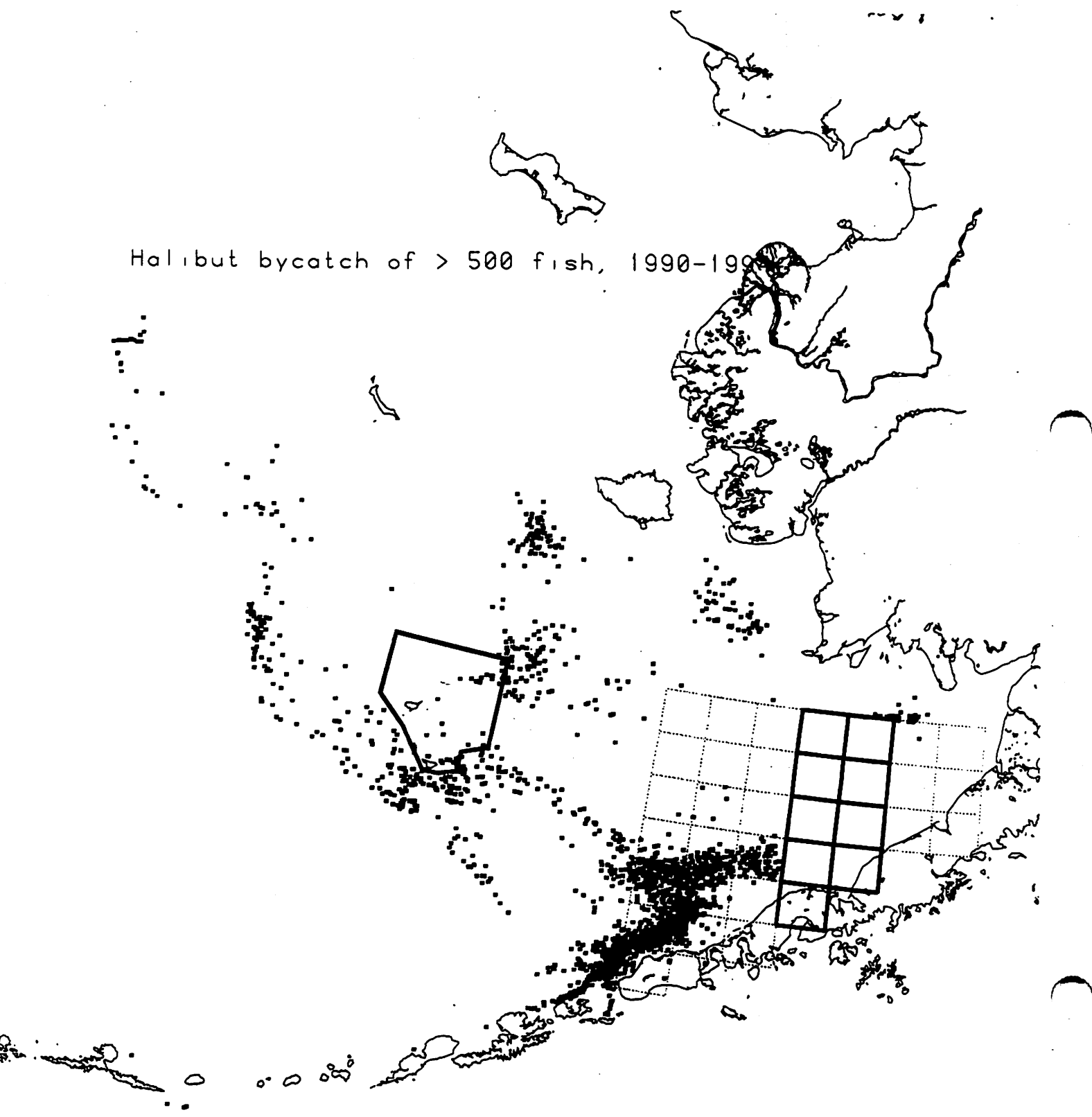
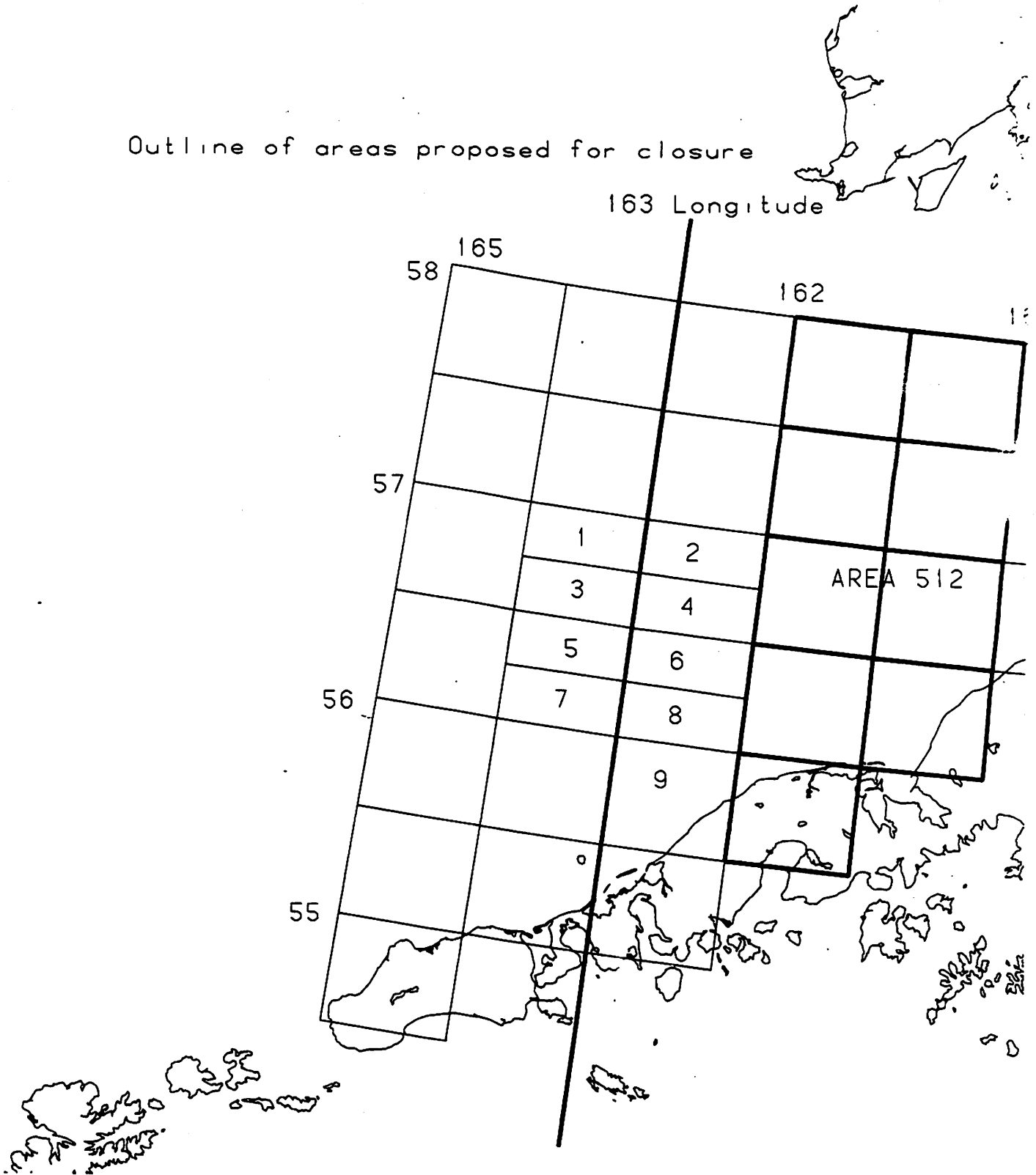


Figure 25. Description of areas defined for closure. Alternative 1 includes numbers 2, 4, 6, 8, and 9; alternative 2 includes numbers 3 - 9; alternative 3 includes numbers 3 - 6; alternative 4 includes numbers 5 - 8; alternative 5 includes numbers 1 - 8.

Outline of areas proposed for closure



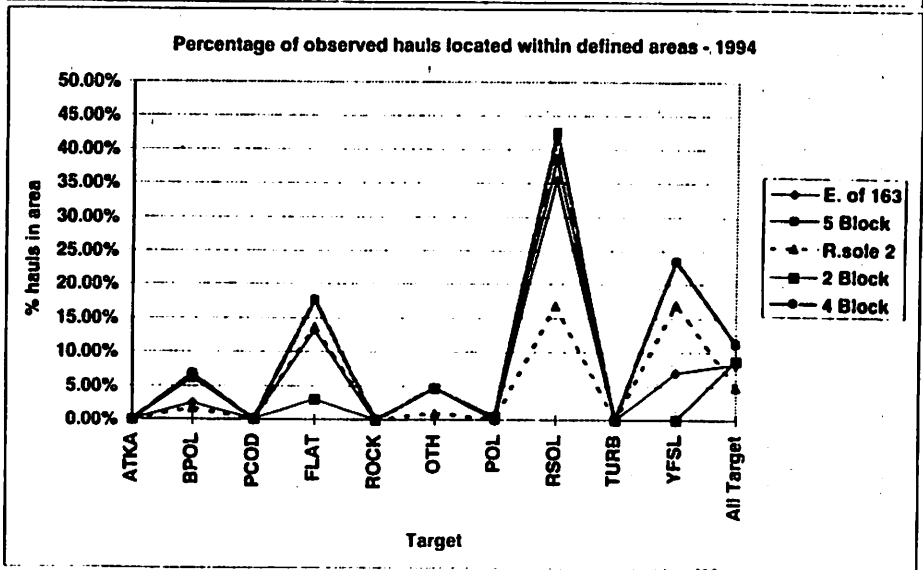
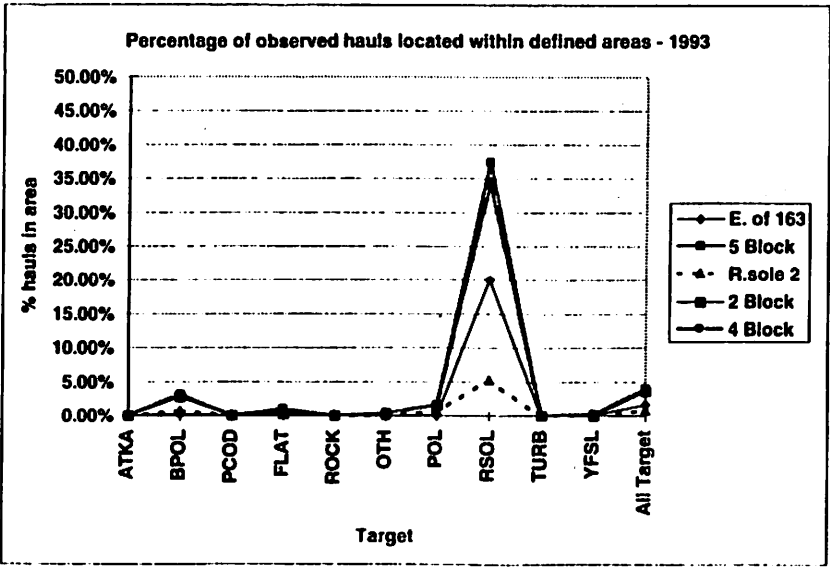
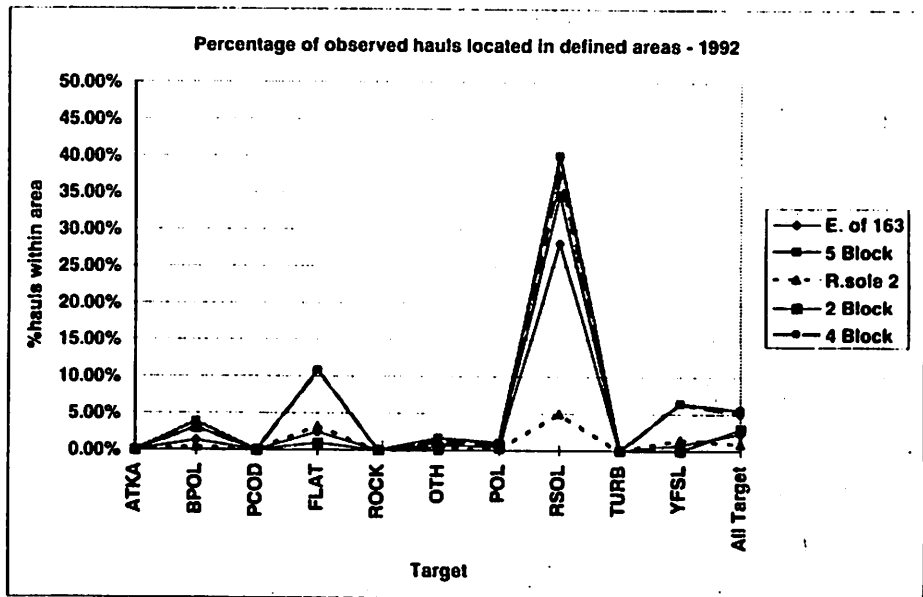
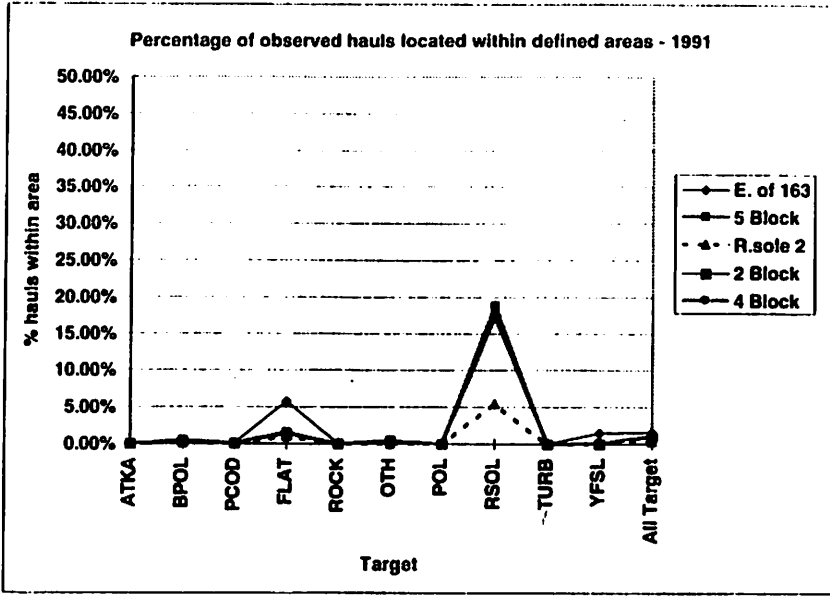


Figure 27. Percentage of total catch from hauls located within defined areas by fishery, 1991 - 1994.

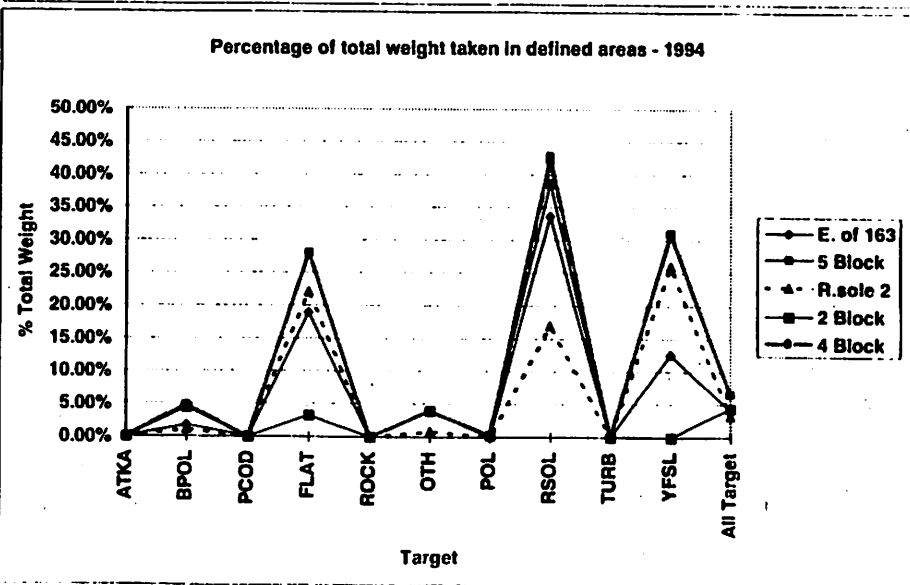
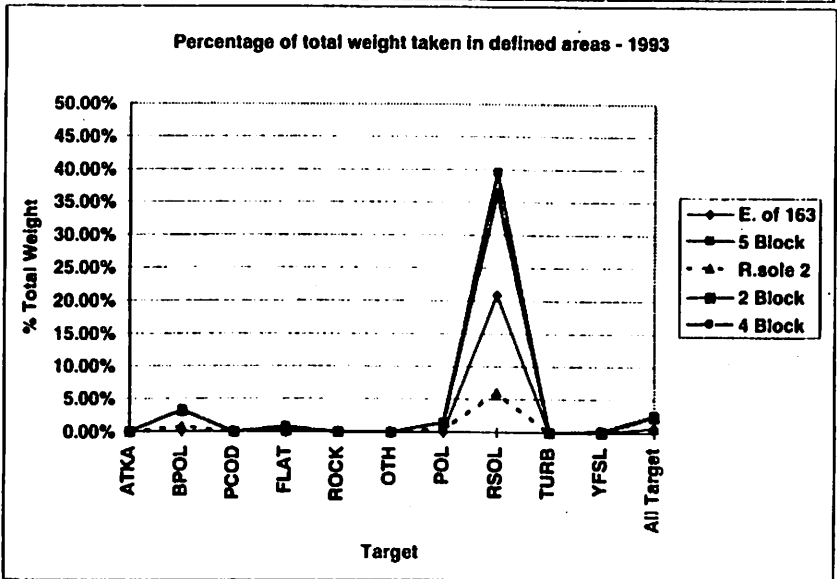
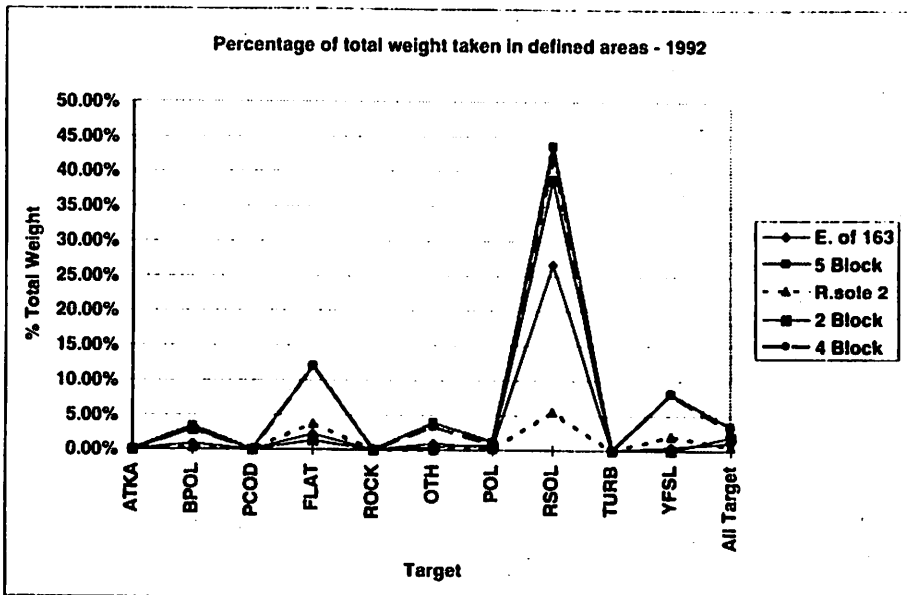
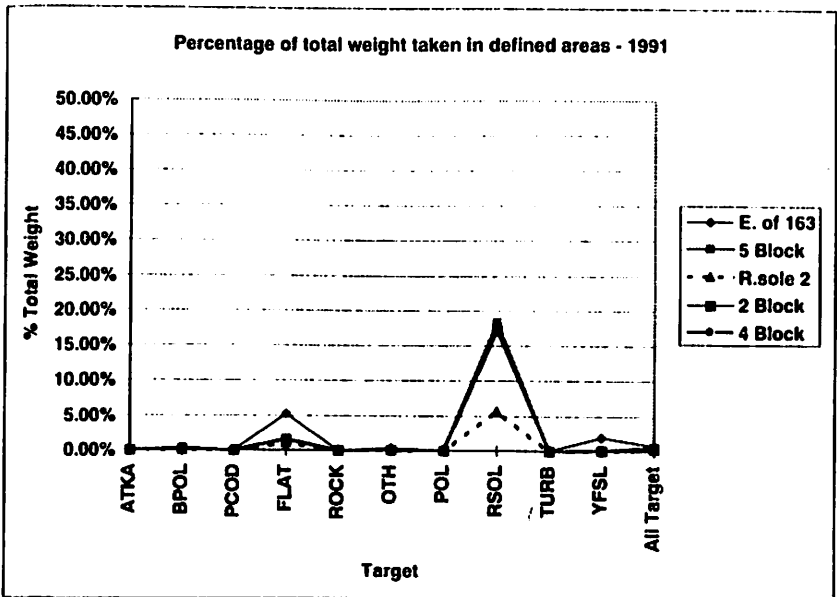


Figure 28. Percentage of king crab bycatch from hauls located within defined areas by fishery, 1991 - 1994.

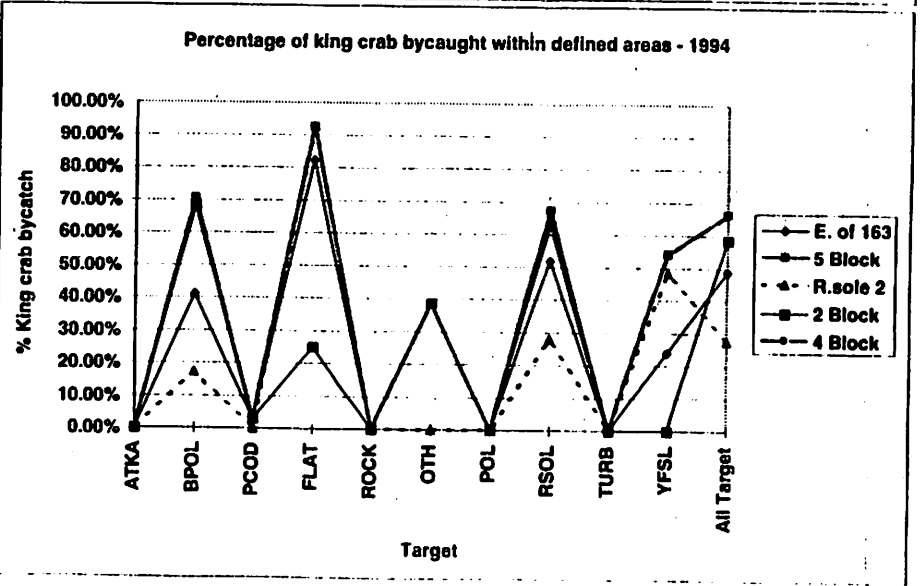
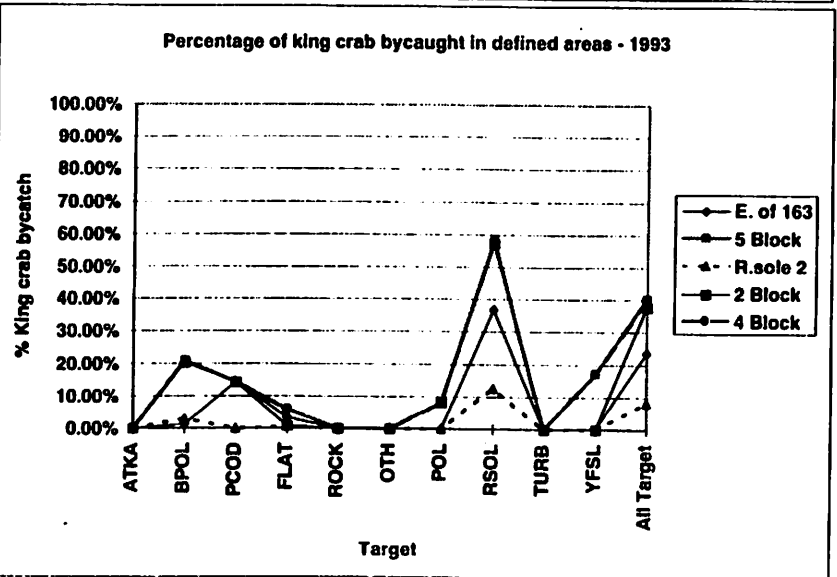
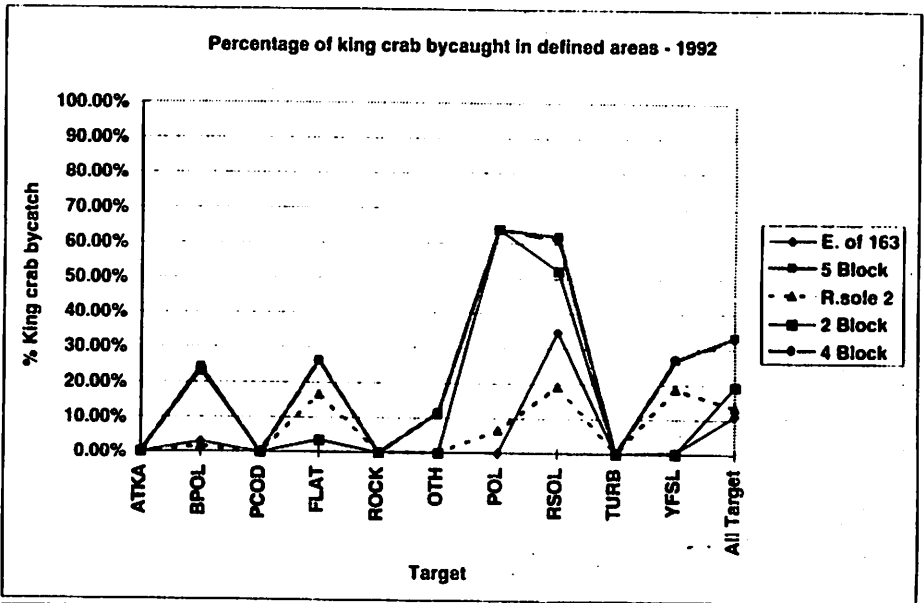
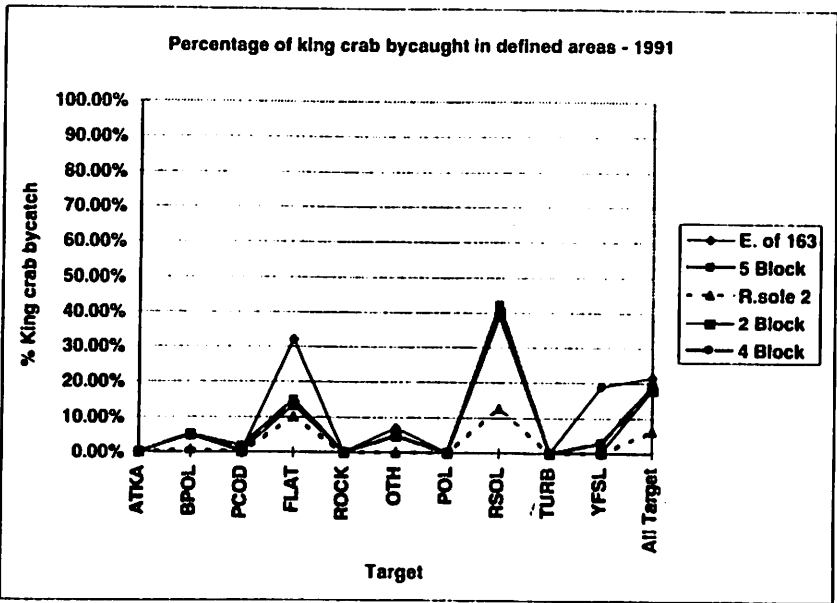




Figure 29. Percentage of Tanner crab bycatch from hauls located within defined areas by fishery, 1991 - 1994.

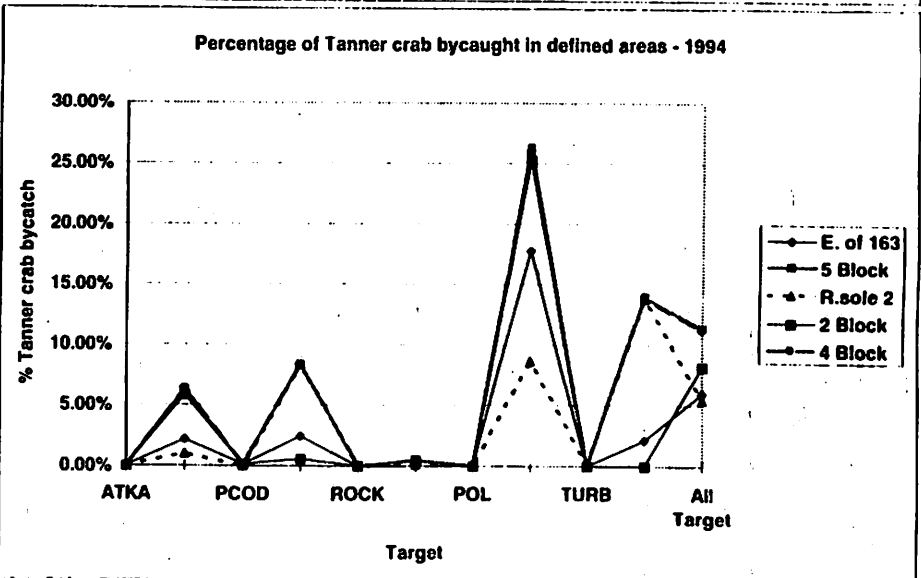
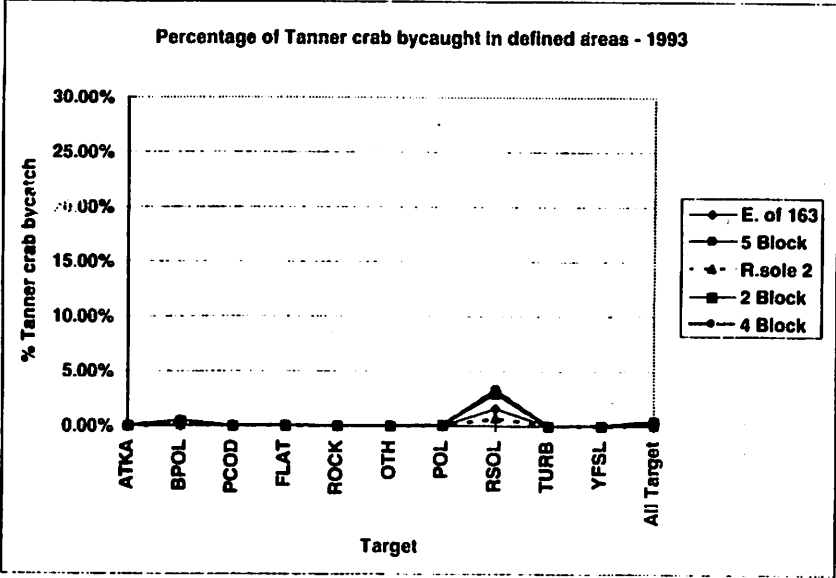
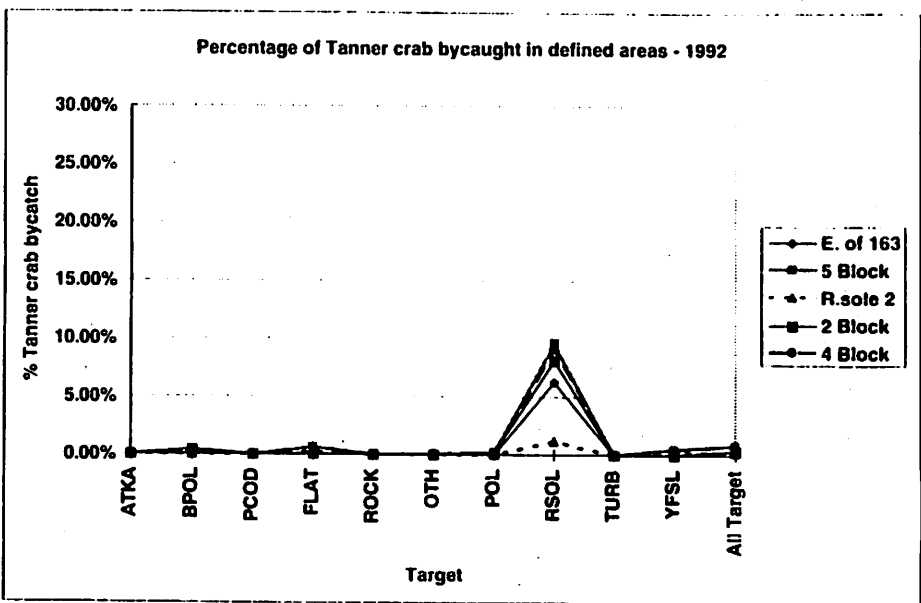
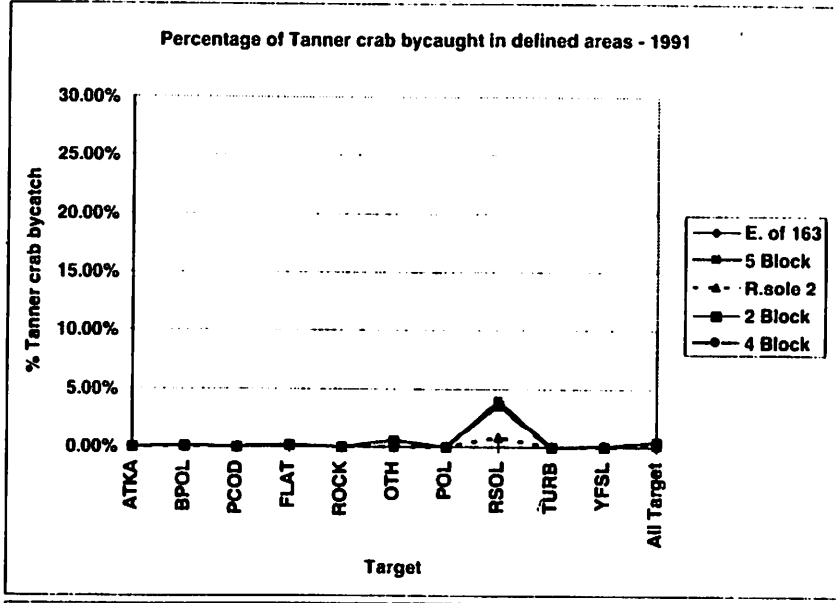


Figure 30.

Percentage of halibut bycatch from hauls located within defined areas by fishery, 1991 - 1994.

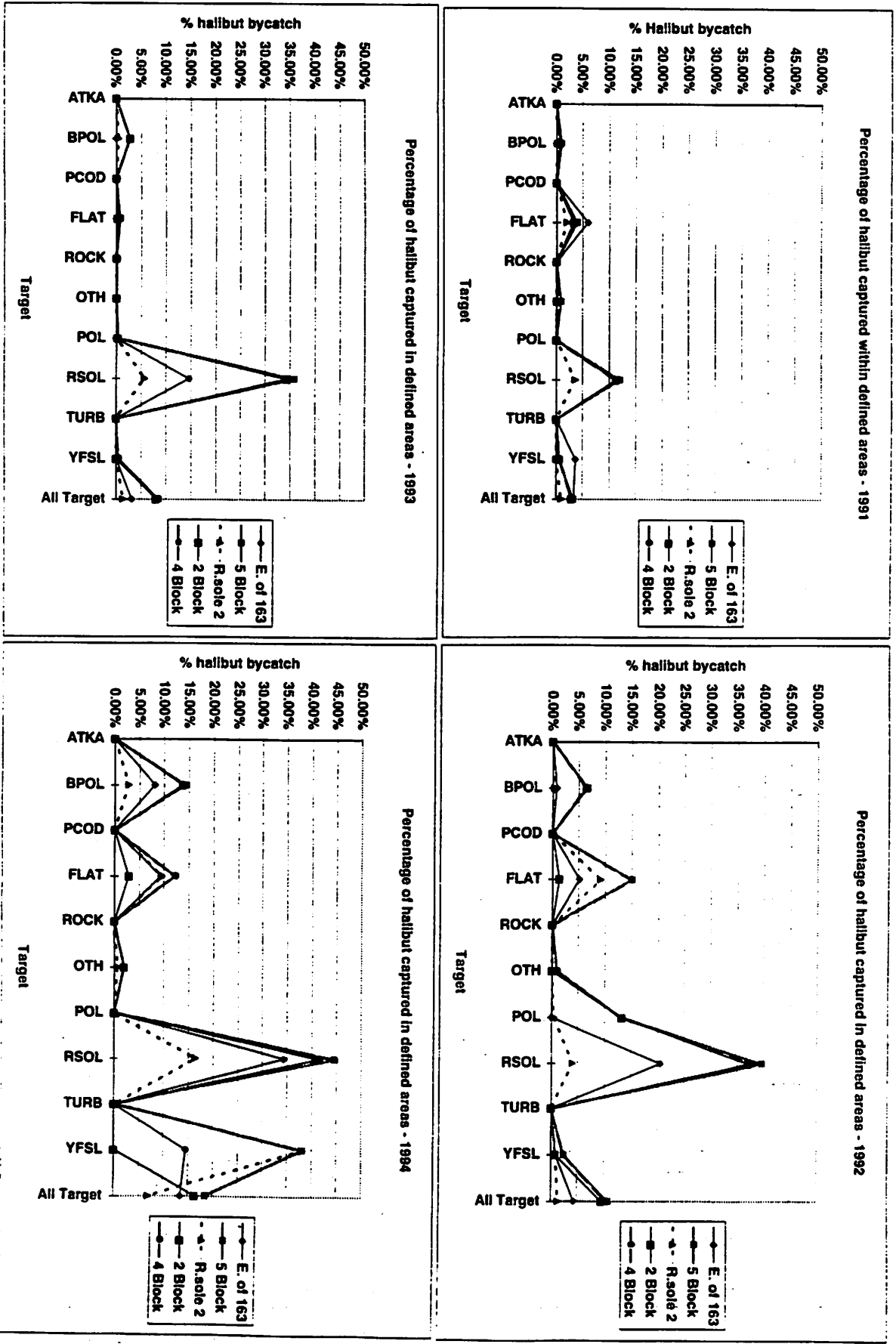


Figure 31. Blocks labelled A - L for reference.

Reference Squares for bycatch rates

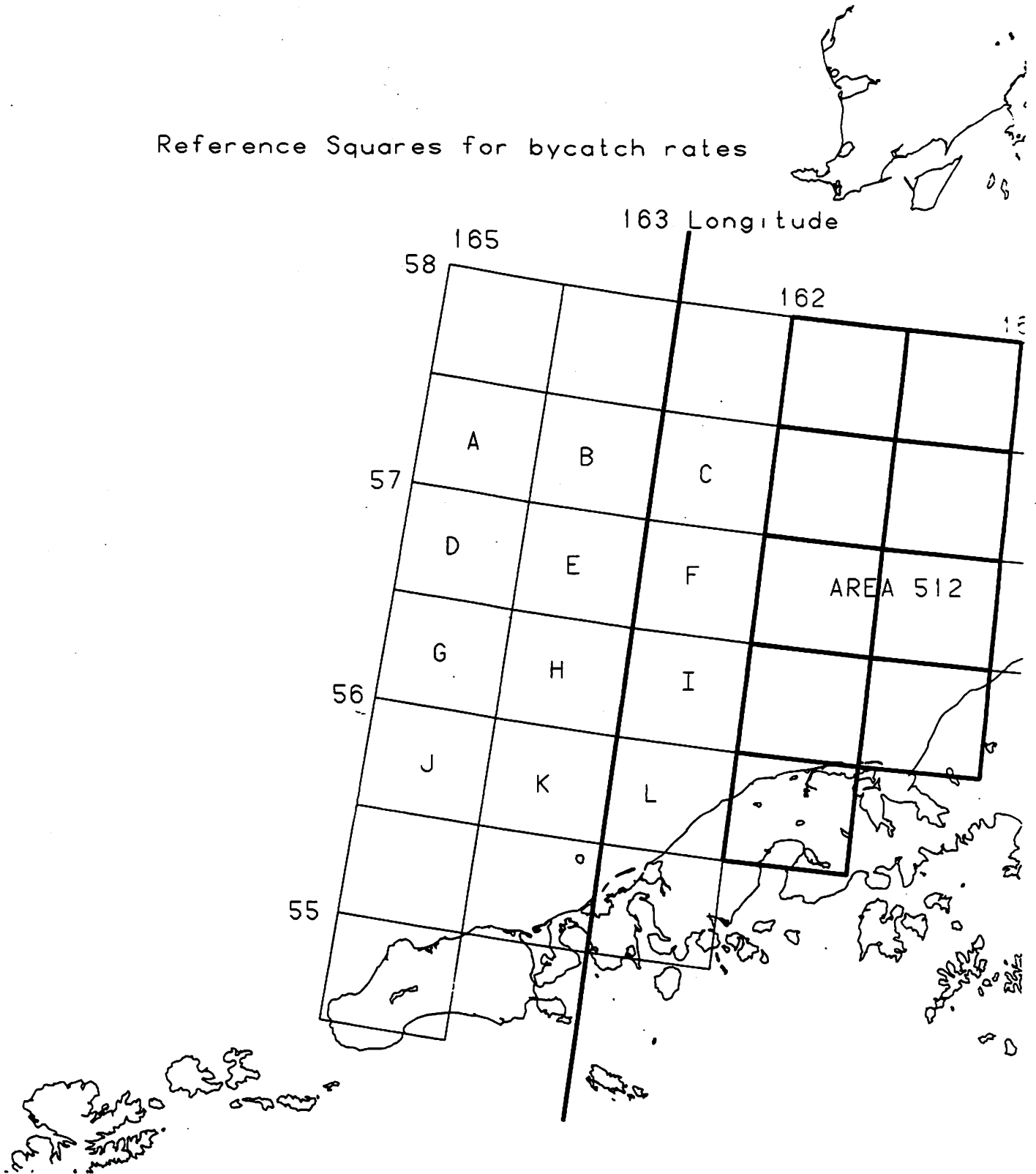




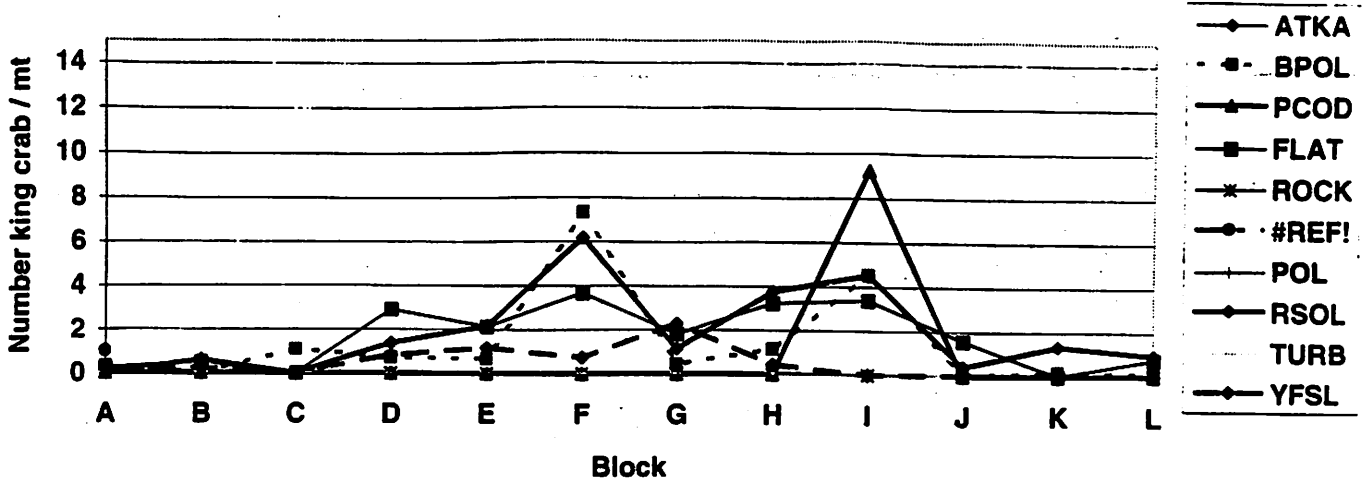




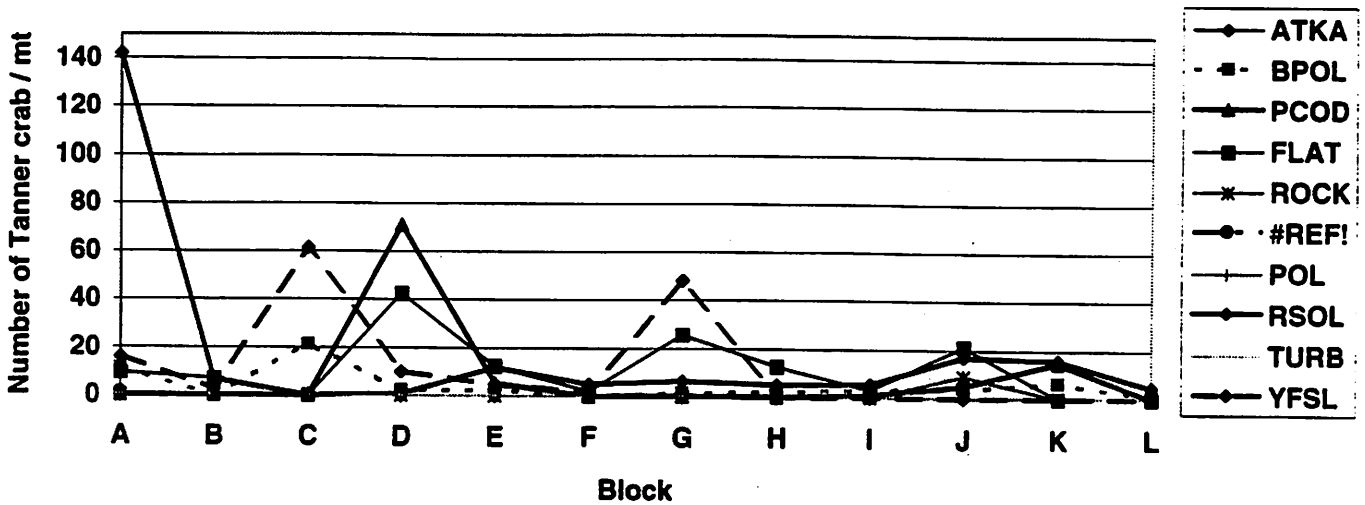


Figure 36. Bycatch rates in numbers per metric ton of king crab, Tanner crab and halibut by fishery, for years 1991-94. Letters refer to blocks in Figure 30.

Number of king crab per metric ton of groundfish catch, 1991-1994 combined



Number of Tanner crab per metric ton of groundfish catch, 1991-1994 combined



Number of halibut per metric ton of groundfish catch, 1991-1994 combined

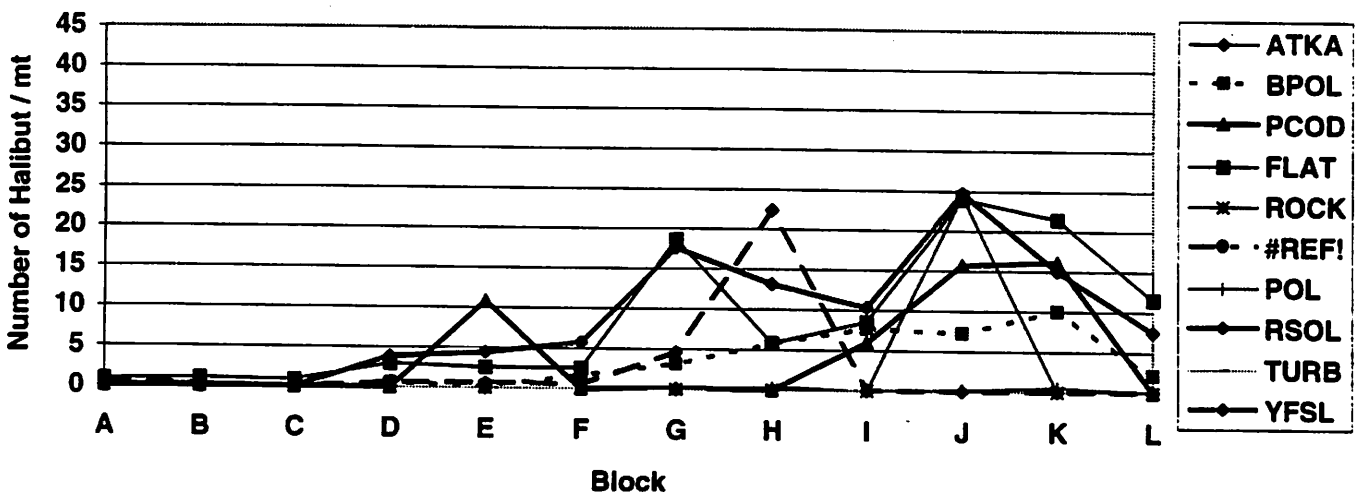




Figure 37. Number of crab taken by block from the directed king crab pot fishery in Bristol Bay, 1991-93.

Number of red king crab captured by block in the directed pot fishery, 1991-1993

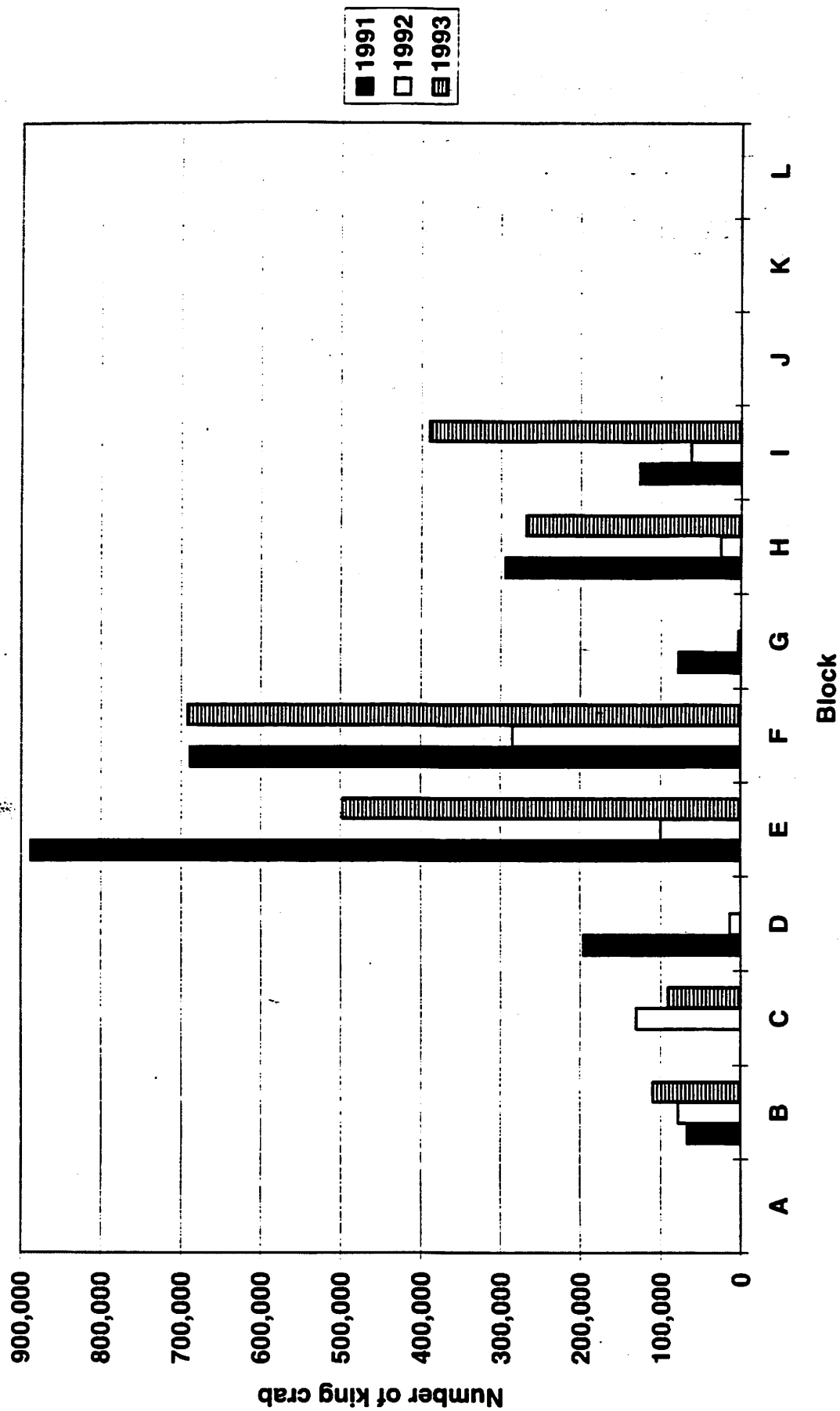
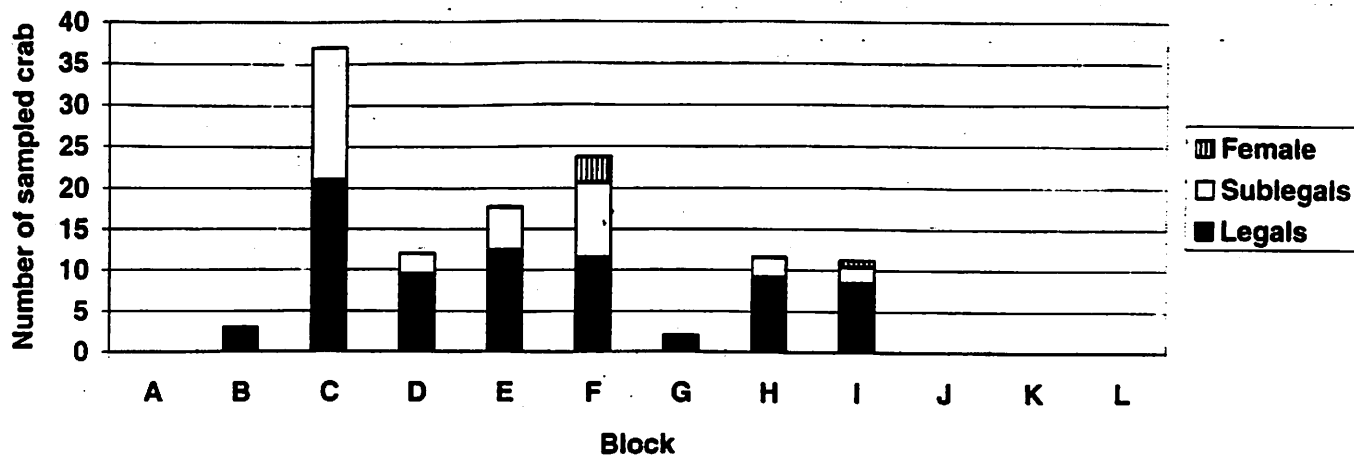
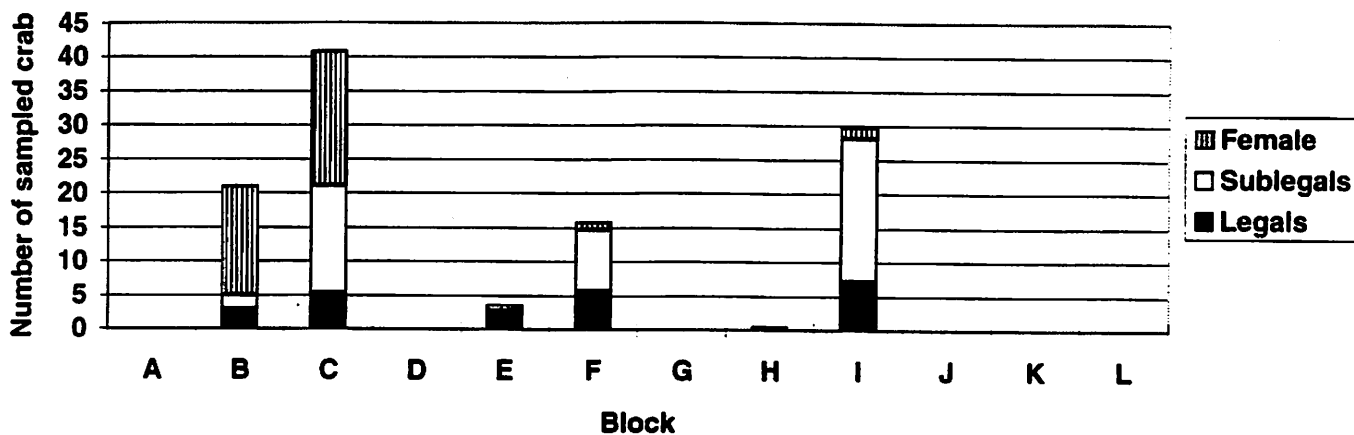


Figure 38. Number of female, sublegal and legal male crab encountered in samples from the directed king crab pot fishery in Bristol Bay, 1991-93.

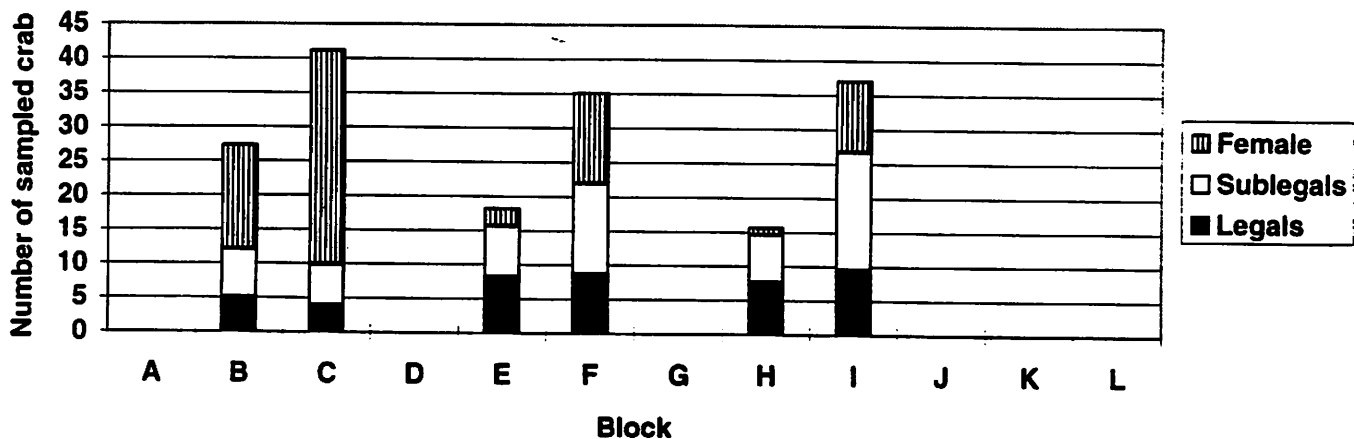
Number of crab by size/sex category as sampled from directed fishery, 1991



Number of crab by size/sex category as sampled from directed fishery, 1992



Number of crab by size/sex category as sampled from directed fishery, 1993



## ERRATA

### An analysis of red king crab bycatch in the Bering Sea with alternatives for trawl closures.

1) Page 6, Paragraph 4:

Bycatch rates for king crab are consistently low in the top three blocks (A, B and C) and generally low in the southern-most blocks (J, K and L). Block J had a higher rate in the 1992 flatfish fishery. There is year to year variability between blocks, however, the blocks with the highest king crab bycatch rates were blocks E, F, H and I, or those corresponding to the four block proposal (alternative 5). The blocks east of these four blocks, or blocks D and G can occasionally exhibit high bycatch rates as well.

2) Page 7. Final Paragraph:

The bycatch of king crab is highest in the rock sole fishery which is prosecuted during the months of January and February. The directed pot fishery for red king crab occurs during the months of November and December. Together, the bycatch and directed catch information indicate that king crab are found primarily in the four squares which comprise alternative 5 (numbers 1 - 8 in Figure 25 and blocks E, F, H and I in Figure 31), especially during the winter months.

3) Heading for Figure 25:

Figure 25. Description of areas defined for closure. Alternative 1 includes numbers 2, 4, 6, 8, and 9; alternative 2 includes numbers 1 - 9; alternative 3 includes numbers 3 - 6; alternative 4 includes numbers 5 - 8; alternative 5 includes numbers 1 - 8.