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The Arctic surfclam fishery on Banquereau Bank

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Abstract

The Banquereau Bank fishery for Arctic surfclams has grown from landings of 29 t in 1986, to 11,608 t in 1995. The three vessels participating in this fishery exploit both Banquereau and Grand Bank. The fishery is managed with limited entry and a Total Allowable Catch (TAC) divided into Enterprise Allocations (EA's), but the TAC is based on sparse survey data from the early 1980's. Concerns for the future of this fishery have led Industry to propose supplying three years of vessel time for a stock assessment survey of Banquereau and Grand Banks if the Department of Fisheries and Oceans would design and carry out the biological assessment. The First two years of this study have been completed with the gathering of RoxAnn data on the two banks to be used to stratify a dredge survey to take place during 1996.

Until the information from this survey is available the long term future of this fishery will remain in doubt. Analysis of logbook and observer data show that CPUE has remained high as the vessels are still able to move to unexploited areas of the Bank. The ability of the present fleet to keep moving around and leaving fished areas alone for the length of time needed for the area to recover will be dependent on the extent of areas with commercially viable catch rates. This is still unknown and hopefully the survey taking place in 1996 will answer this question. With this information it will then be possible to look at which management tools are appropriate for this fishery.

Résumé

Les débarquements de mactre de Stimpson provenant du banc Banquereau sont passés de 29 t en 1986 à 11 608 t en 1995. Les trois bateaux qui pêchent cette espèce exploitent le banc Banquereau et le Grand Banc. La gestion de cette pêche se fait par accès limité et un total autorisé des captures (TAC) divisé en allocations aux entreprises (AE), mais le TAC est basé sur de rares données de relevés recueillies au début des années 1980. L'inquiétude que soulève l'avenir de cette pêche a mené l'industrie à proposer de consacrer trois années de temps de bateau pour mener un relevé d'évaluation du stock du banc Banquereau et du Grand Banc à la condition que le ministère des Pêches et des Océans conçoive et mène l'évaluation biologique. Les deux premières années de cette étude sont maintenant terminées, et les données RoxAnn recueillies sur les deux bancs serviront à stratifier un relevé à la drague qui sera mené en 1996.

Jusqu'à ce que l'information de ce relevé soit disponible, l'avenir de cette pêche demeurera incertain. L'analyse des données des registres de pêche et des observateurs indique que les PUE demeurent élevées étant donné que les bateaux ont encore accès à des secteurs inexploités du Grand Banc. La capacité de la flottille actuelle de changer de secteur et de laisser les pêcheries exploitées récupérer dépendra du nombre de secteurs qui abritent des bancs pouvant être récoltés de façon rentable. Ce nombre demeure toutefois inconnu, mais l'on espère que le relevé de 1996 répondra à cette question. On sera alors en mesure d'établir quels outils de gestion sont appropriés pour cette pêche.

Introduction

The offshore clam fishery has been operating on the Scotian Shelf since 1986, and the Eastern Grand Banks since 1989. Although it has developed into an industry with annual sales of $50 million, the lack of empirical information has forced the department to manage the fishery with a preemptive TAC.

From industries point of view, the fishery has developed to the point where they have to make decisions on capital investment in the fishery, and they have little information on the size of the resource. Furthermore, this is a fishery using highly efficient gear (Medcof and Caddy, 1974) to harvest a long lived, slow growing species. The lack of biological information means the Department does not know if the current harvesting rates are sustainable or if the resource is being "mined out" and heading for a collapse.

The lack of knowledge about the biomass and production of this resource has been a consistently identified concern during the development of the fishery, both by the Offshore Clam Advisory Committee (OCAC) and CAFSAC-AFRC. DFO does not have a vessel equipped to conduct a clam survey and the cost of equipping a DFO vessel or chartering a commercial vessel are prohibitive. In 1994, Industry, recognizing this, proposed a three year survey to cover both Banquereau Bank and Grand Bank. Industry said that they would commit to the estimated $1.3 million of vessel time if DFO would conduct the scientific assessment portion.

History of the Fishery:

A fisheries development plan was initiated in 1980 to determine the resource potential of the Ocean quahog (*Arctica islandica*) and other underutilized clam species in the Scotia-Fundy Region. During these surveys, which took place from 1980 to 1983, commercial quantities of Arctic surfclams, *Mactromeris polynyma*, were found on Banquereau Bank (Rowell and Chaisson, 1983; Chaisson and Rowell, 1985). Due to the exploratory nature of the surveys, other areas of the Scotian Shelf could not be precluded from containing commercial quantities of Arctic surfclams, although these were not found. There has been no commercial interest in *Arctica islandica*, due to the lack of a market.

In 1986 it was estimated that Banquereau Bank had a commercially exploitable biomass of 561,000 t and an MSY of 16,821 t (Rowell and Amaratunga, 1986). A three month test fishery took place with three companies participating. Each company used chartered U.S. vessels, equipped with a single hydraulic clam dredge.

The results from the test fishery increased the previous estimates to an MSY of 24,000 t (Amaratunga and Rowell, 1986). The MSY estimates were based on the model MSY = 0.5 MB_o, (B_o = virgin biomass, M estimated by $M=3/T_{max}$). It was recognized that this approach makes some assumptions that compromise the use of the model, especially that of equilibrium conditions within the population, and that it was based on limited data. Another approach used by Amaratunga and Rowell (1986) was to look at biomass as a finite resource, and not make any assumptions about natural mortality, growth or recruitment. In this way an annual level of exploitation is established that would, over a defined period of time, remove the existing biomass. For this analysis, assuming an initial biomass of 600,000 t, the level of removals required to have the resource last 10, 20 or 25 years were 60,000 t, 30,000 t and 24,000 t respectively.

In 1987 a three year offshore fishery program was developed with industry consensus. TACs and EAs were set for each of the three years of the program. They were based on biological information provided by the surveys and test fishery, and an economic break-even analysis on the required resource to make a vessel and processor viable. The TACs were set at 30,000 t for

Banquereau Bank and 15,000 t for the rest of the Scotian Shelf. Details on the development of the fishery up to 1989 can be found in Roddick and Kenchington (1990).

In February 1989, Arctic surfclams officially became a regulated species under the Atlantic Fishery regulations. Two exploratory licenses and two exploratory permits were issued for 3LNO in 1989, with a total "precautionary" TAC of 20,000. These were issued to the three current participants plus a fourth, Newfoundland based company, and the TAC for the Scotian Shelf outside of Banquereau Bank was increased to 20,000 t. Access to the Scotian Shelf was expanded to include the new company.

In 1990 the Offshore Clam Enterprise Allocation Program was extended for the five year period 1990 to 1994. In the spring of 1991, one company stopped fishing due to financial problems, and went out of business in 1992. Offshore Clam allocations were revised effective January 1, 1992, giving all offshore clam companies equal access and allocations on all banks. Any changes in the TAC would also be equally split between the license holders. Since early 1993 there have been 3 factory processors fishing year round. The Enterprise Allocation Program has been continued for the 1995 to 1997 period.

Methods

Industry-DFO Survey

The offshore clam vessels have been equipped for several years with RoxAnn acoustic bottom classification systems and the captains have confidence in them, mapping out new areas before they start dragging. The RoxAnn system classifies the bottom type using two scaled indices derived from echo sounder acoustics returns. These indices are said to correspond to bottom hardness and bottom roughness. Figure 1 shows how these indices are derived from the returning signal. The hardness index is derived from the integrated second return, which has bounced off the bottom, the surface and the bottom once again, before arriving at the receiver. The roughness index is derived by integrating the tail of the first return, which has only bounced off the bottom. These indices are scaled and the bottom type classified into rectangular areas as shown in Figure 2. Industry conducted the RoxAnn survey of Banquereau and Grand Bank during 1994 and 1995, using the M.V. Atlantic Dauphin, a 34 m scallop vessel. Industry's data has been loaned to DFO to use in preparing a stratified survey design for the two areas. During 1996 the M.V. Atlantic Dauphin, which has been equipped with a 5 foot hydraulic clam dredge and a diesel powered pump, will conduct standard tows at the selected survey stations. Industry is providing the vessel, crew, food, fuel and lubricant for the survey, while DFO is to provide technical personnel, sample processing and analysis. This survey will provide current biomass estimates for Banquereau Bank, and the only biomass estimates we have for Grand Bank. Comparisons were made between RoxAnn data and sidescan data, and with existing information on substrate and bedforms on Banquereau Bank. The areas noted as potential clam bottom were compared with existing log data to see if it appears to be selecting for high catch rate areas.

The survey of Banquereau Bank is scheduled to take place in June and July of this year. It is estimated that 200 dredge stations can be conducted during the time allocated. The vessel will start in May on Grand Bank and first do a trip to known clam grounds to determine the optimal tow length. It will then do a series of stations to test the gear and the sampling procedures. From May until June it will conduct part of the survey on Grand Bank before moving over to Banquereau Bank.

The use of the RoxAnn data to stratify the survey design is untested. There is also no way to predict in advance what the variance of these strata will be. The optimal allocation of stations to a stratum would be proportional to the product of the strata's area and the strata standard deviation.

Without any information on the strata standard deviation it is usually best to allocate stations proportionally to the area of the strata (Cochran, 1963). This should ensure that the variance of the biomass estimate cannot exceed that obtained by simple random sampling, but if the stratification scheme is successful the variance will be reduced.

Commercial Data

The data used in the analyses come from: 1) logbooks and sales slips from both test and commercial fisheries, 2) the international observer program.

Logbook analysis:

In this fishery, logbook coverage is 100% and there is good co-operation from owners and captains. The only deficiency in the data is the lack of accurate discard information. This has improved for the main bivalve species, but as most of the initial sorting is mechanical, there is no visual observation of the composition of this discard. Log data is recorded on a watch basis and log catches are prorated to sales slip information for the older data where logs are estimates of round weight. For the processing vessels this has little effect as the product is being weighed as it is processed, so the captain has the actual information at hand. Dockside monitors are replacing the sales slip system, but in 1995 there have been problems with the monitors not recording species or product type when weighing out the landings. Processed weights are converted to round weights using conversion factors of 5.37 and 6.51 applied to the raw and blanched Individually Quick Frozen (IQF) foot product. This differs from the official Statistics Branch numbers as they have used various conversion factors. (Roddick, 1996).

Catch and effort data from the commercial logs were aggregated by one minute squares of latitude and longitude to examine the distribution of catch and effort on the bank. CPUE was also averaged over one minute squares and plotted to show the distribution of high CPUE areas.

Data on the percentage of the bottom dredged in each one minute square were calculated from commercial log data. Area dredged was calculated from tow time, vessel speed (over bottom) and width of the gear. This was then aggregated over one minute squares, and the total plotted as a fraction of the bottom area of the one minute square. This was done to show the cumulative effect of the dredging and to give an indication of how much more effort different areas of the bank could sustain in the short term.

CPUE was aggregated by month and plotted to show trends over time. CPUE by month was also plotted for the five one minute squares receiving the most effort in the 1993-95 period to examine trends in localized, high effort areas.

International Observer Program:

Coverage targets for this program are 50% for domestic vessels; there are no foreign vessels involved in the fishery. The observers collect data on catch rates, length frequencies and species composition. The three vessels licensed for Banquereau are all landing processed products, processing and freezing on board. The products being produced are individually frozen and glazed foot portions, referred to as tongues, and frozen blocks of body meat. These weights have to be converted back to round weights, and so sampling is carried out to determine conversion factors for these vessels.

The observer records data on individual tows, discards, by-catch and catch data, and on dimensions of, and settings on, the dredges. The observers also compare their estimates with logbook records. Samples are collected as required for growth, aging and allometric studies.

Results

The RoxAnn Bottom Classification data for Banquereau Bank was comprised of 410,930 records. They consist of hardness and roughness indices, bottom classification, location and time taken every two seconds during the RoxAnn survey. With a survey speed of 7 knots this translates to a data point every 7.2 meters along the survey track. The diameter of the area being insonified ranges from 14 meters to 21 meters (Figure 10), giving overlapping coverage along the survey line. For the 1994 data 2.4% of the points were classified as clam grounds, 32.5% as possible clam grounds and 65.1% as either too hard or too soft.

Comparisons between RoxAnn and sidescan data were inconclusive as to the fine scale correspondence of the bottom type defined by the two systems. On a small scale the resolution of the sidescan data showed little differentiation over the area where it was used, while the RoxAnn data was showing a lot of variability. As almost the whole area was medium to coarse sand bottom a higher resolution sidescan (100 Khz used), or much better calibration, would be needed. On a broader scale the data sets agreed, with large areas of very hard or soft bottom corresponding. Comparisons with some of the high resolution side scan data from the Atlantic Geoscience Center (AGC) showed few areas where there was an overlap of the two data sets. Similar results were found with current contour maps of bottom type held in the AGC open file series. Again these maps have low resolution and only allowed for large scale comparisons.

Comparisons were made with logbook data on catches of clams. There were 630 locations on Grand Bank and 43 on Banquereau with logbook records showing at least a 1,000 kg catch in 1994, and a location corresponding to the RoxAnn track. Of these, 661 corresponded to clam or possible clam bottom and 12 as too hard or too soft, for a 98.2 percent agreement between commercial locations and the RoxAnn data.

The TACs, Catches and CPUE for each year are shown in Table 1. The catches increased to 1989 and then fell as the fishery concentrated on Grand Bank. In 1992 all fishing activity took place on Grand Bank; none on Banquereau. Since 1992 there has been increased effort on Banquereau Bank, and landings in 1995 are the highest on record, although still well below the TAC. CPUE is remaining high as the fishery can still move to unexploited areas. In 1986 Banquereau Bank had a total area of 0.37 km^2 dredged. This increased to 75.49 km^2 in 1989, before effort shifted to Grand Bank, and after falling to 0 in 1992 has now reached 98.80 km^2 (Table 1).

Analysis of logbook data showed how the fishery has developed, first through exploratory fishing and then by concentrating effort in a small area of the bank where catch rates were good. Initial fishing effort concentrated on the south eastern end of the Bank but then moved to explore the western and central areas. Since 1993 fishing has concentrated in the central area (Figures 3 and 4).

The plot of CPUE by month for 1986 to 1995 (Figure 5) does not show any strong trends. From 1988 to 1991, CPUE appeared stable, but this level was exceeded when fishing effort returned in 1994 and 1995. There is a drop in the winter of 1995, but as fishing conditions were poor during this time, it may rebound in 1996. How much of this is due to changes in the area fished versus greater experience gained over time by the captains is difficult to estimate.

The CPUE by month for the 5 one minute squares that have received the most effort in the 1992-1995 period are shown in Figure 6. These areas show a fairly constant catch rate. One square that received a lot of effort received it all within a one month period. The ability to map potential dragable clam bottom before starting to dredge, and the use of plotters to show the captain each vessel track that he has made while towing in the area, means that the patches of clams are covered fairly thoroughly. The lack of a significant drop in CPUE, even at this scale, may indicate that the decision to move is based more on how much activity has taken place than a drop in catch rate. Captains store their tow tracks on their plotters and can retrieve all tracks they have done in the area. In some cases the decision to move appears to be based on a subjective evaluation of how crowded the screen appears.

Vessels also make shorter term movements from an area to avoid catching clams killed by recent dredging activity. The market is for a quality product and would reject a supply that did not meet these standards. This means that the vessels will work an area in pulses, leaving it for a month or more before returning, to ensure that any incidental mortality caused by fishing activity has been removed from the area before they fish it again.

The map of percentage of bottom covered by one minute square is shown in Figure 7, and a histogram of one minute squares by percentage of bottom, in Figure 8. Mapped areas that have been intensively fished are clearly evident. The histogram shows that about 5 percent of the one minute squares fished have received enough effort to cover 50 percent of the bottom. Most of the ones that are noted as receiving enough effort to cover more than 99% of the bottom come from early in the fishery when the captains were not filling the logs correctly. In some cases they recorded one location for a week of fishing. Using maximum values and assuming little weather or gear problems, each vessel involved in the fishery could cover approximately 120 km^2 per year. In the US surfclam fishery, which is no longer exploiting a virgin resource, it is estimated that fishing activity in an area stops when it has covered approximately 50% of the bottom. Using these assumptions, the three vessels will fish an area of 720 km^2 per year. Using average values obtained from the 1995 logbooks instead of the upper limits, reduces the area dragged annually to 231 km^2. In addition, the captains report that they estimate that the modern positioning equipment will allow them to cover 75% of the bottom before catch rates would be too low.

The area enclosed by the 100 m isobath on Banquereau Bank is 9,182 km^2 (Rowell and Amaratunga, 1986). Estimating the area that can support commercial fishing is more difficult. The area of the 948 one minute squares that have received some effort to date is 2,434 km^2. This area would be covered in three years using the maximum values and 50% coverage. Using the average values and 75% coverage increases the time to 8 years. The area of Grand Bank that can support commercial fishing is even harder to estimate, but at present the fleet is spending over 50% of it's time there. In addition, this fishery is using a gear that probably causes high incidental mortality on the small clams left on the bottom. The growth data we have indicates that commercial sized clams are 10 to 15 years old. This means that the known area supporting commercial concentrations is unlikely to support a fishery of this size in the long term.

The shell length frequencies of *Mactromeris* from the International Observer Program (IOP) samples of the fishery from 1990-1995, can be seen in Figure 9. There was no coverage of the fishery on Banquereau Bank in 1992, 1993 and 1995. Areas that were fished in 1994 contain smaller sized clams than seen in 1990, perhaps due to targeting areas of smaller clams. One of the reasons effort switched to the Grand Bank was that it provided a smaller sized clam that was in high market demand.

Discussion

The effectiveness of using the RoxAnn data to stratify the survey design will not be known until the results are analysed. The comparisons with commercial fishing and sidescan data done to date indicate that it will be a valuable stratification tool for surveys of benthic organisms.

Analysis of the logbook data shows how the fishery still concentrates effort in a small area at any one time. The vessels are sent out to load up quickly, and go to where they know they can do this, with very little exploratory fishing.

The International Observer Program has never reached it's target of 50% coverage. In light of our lack of ability to conduct research surveys on this stock, good coverage and data from the commercial vessels are essential.

The lack of a drop in the CPUE on either a fleet scale or in localized areas, combined with the data on percent of the bottom covered, indicates that there is a significant amount of biomass left in an area when fishing effort ceases. This is good for the future of the fishery in the short term as it would indicate that a spawning population remains. In the long term, as the fishery runs out of unexploited areas and tries to harvest at sustainable levels, there will be more incentive to harvest these areas to a lower standing biomass level.

The length frequencies from the observer program (Figure 9) show a market driven shift to smaller clams. One good point is that there are some signs of recruitment in the new areas, something that was not seen in the past. A sampling program using van Veen bottom grabs during 1987 and 1988 did catch some clams less than 80 mm, but only in low numbers and in restricted areas of the Bank. Small clams showing up in the 1994 length frequency data are thus an encouraging sign. The gear should be of a size for nearly 100% retention at 32 mm shell width, corresponding to a shell length of 86 mm. In the areas fished in 1990, there was a gap between the modal length and this retention size. The modal length of the size frequency of the catch, in the area fished in 1994, has dropped to match retention size. This suggests that the stock is not having constant recruitment. A previous analysis of mean shell length of the catch from the observer program showed that this varies over the bank, again indicating that the population does not have a stable age distribution and that recruitment is patchy. There are no definite age modes, although this is not unexpected in a slow growing species due to the large overlap in size of successive age classes. Our knowledge of the recruitment process for this species is limited. There is a large mode of older animals over much of the bank. It is not known if their removal through fishing will enhance future recruitment by making more suitable bottom available and reducing the biomass of filter feeders in the area, or reduce it through a reduction in spawning stock biomass. The areas that appear to have the largest numbers of small clams in the grab sample surveys are in or near areas of high adult biomass. This may indicate a limited area of suitable habitat, and raises concerns about the incidental effects of dredging on pre-recruit clams. The effects of direct incidental mortality on small *Mactromeris polynyma* are not known for this area, but have been shown to be high for discards of adult *Spisula solidissima*, a closely related species fished with similar gear. Meyer et al. (1981) examined mortality rates for clams in two dredge tracks, and found they were 30 and 90% for large clams and 26 and 28% for small clams. This will be increased by the indirect effect of predation on small clams exposed on the surface (Kauwling and Bakus, 1979; Medcof and Caddy, 1974).

Except for other species of clams, the by-catches in this fishery are low and do not appear to be of concern. Table 2 indicates that that the only non-bivalve species making up more than one percent of the catch is sand dollars, with sea cucumbers being the next most important. There are some species that appear to be miscoded, such as long finned squid. It is unlikely that they were caught on Banquereau Bank and the code number used is similar to that for *Cyrtodaria siliquai*, a common bivalve in the by-catch. This may also be the case for sea urchins, which are uncommon on sand bottom, but have a similar code to that used for shell debris. Commercial fish species make up less than 0.1% of the by-catch. The by-catch of sea cucumbers was not seen in the 1989 data (Roddick and Kenchington, 1990) and this may be a reflection of the different areas being fished.

It has been stated in the past that the TAC set for Banquereau Bank is likely too high (Roddick and Kenchington, 1990) and it was fortunate that the exploitation rates were low. With the increased effort on Banquereau Bank it is more important than ever to have accurate biomass estimates so a sustainable management plan can be developed.

One thing to be considered is if a TAC is the appropriate management tool. With the slow growth rates, unknown recruitment levels and probable high mortality of clams left on the bottom, the fishery would not be able to return to an area that had been fished out for at least 10-15 years and maybe longer. Under these conditions, a TAC may not be appropriate. Other management techniques, such permanently closed broodstock areas and a rotation of fishing grounds could be better suited to this type of fishery. Permanently closed broodstock areas would prevent recruitment overfishing, while rotational fishing areas, which are in use for a few clam fisheries on the West coast, would prevent growth overfishing. The rotation of fishing areas would be on a schedule tied into the growth and recruitment pattern of the stock

Summary

The long term future of this fishery remains unclear. Catch rates remain high, but the fishery is still able to move into previously unexploited areas. The main areas of concern are the effects of a gear with both a high efficiency on commercial sized clams, and a possible high mortality of undersized clams. This combination means that an area that has been fished out of commercial sized clams has also reduced the numbers of pre-recruits, and is not likely to support commercial catch rates until newly settled spat have had a chance to reach commercial size. The ability of the present fleet to keep moving around and leaving fished areas alone for this length of time will be dependent on the extent of areas with commercially viable catch rates. This is still unknown and hopefully the survey taking place in 1996 will answer this question. With this information it will then be possible to look at which management tools are appropriate for this fishery.

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Table 1. TAC, Catch, Effort and CPUE for Banquereau Bank.

Yr	TAC (t)	Catch (t)	Effort (km Sq.)	CPUE Mean	CPUE Std. Dev.
86		29	0.37	0.10	0.10
87	30,000	1,220	8.86	0.15	0.10
88	30,000	2,836	25.08	0.11	0.06
89	30,000	8,350	75.49	0.11	0.06
90	30,000	5,629	67.52	0.09	0.04
91	30,000	731	9.63	0.08	0.03
92	30,000	0	0.00	0.00	0.00
93	30,000	60	2.09	0.04	0.02
94	30,000	5,329	37.69	0.15	0.08
95	30,000	11,608	98.80	0.15	0.11

Table 2. - Catch composition for the Banquereau Bank *Mactromeris polynyma* fishery from International Observer Program visual estimates made during 1990-95. Descriptions and Scientific names are from IOP database.

Weight (kg)	% of Total	Species code	Description	Scientific Name
706156	50.1559	4355	STIMPSON'S SURF CLAM	MACTROMERIS POLYNYMA
313012	22.2322	9400	FOREIGN ARTICLES,GARBAGE	FOREIGN ARTICLES,GARBAGE*
170395	12.1026	4312	BANK CLAM	CYRTODARIA SILIQUA
115341	8.1923	6500	SAND DOLLARS	CLYPEASTEROIDA O.
69044	4.9040	9200	STONES AND ROCKS	STONES AND ROCKS
12727	0.9040	6600	SEA CUCUMBERS	HOLOTHUROIDEA C.
10603	0.7531	4304	OCEAN QUAHAUG	ARCTICA ISLANDICA
1830	0.1300	4342	ICELAND COCKLE	CLINOCARDIUM CILIATUM
1478	0.1050	6400	SEA URCHINS	STRONGYLOCENTROTUS SP.
1270	0.0902	4210	WHELKS	BUCCINUM SP.
1230	0.0874	4311	QUAHAUG	VENUS MERCENARIA (OBSOLETE)
1183	0.0840	6100	ASTEROIDEA S.C.	ASTEROIDEA S.C.
1002	0.0712	211	SKATES (NS)	RAJIDAE F.
697	0.0495	3600	SEA SNAILS,DEA BUTTERFLIE	HETEROPODA/PTEROPODA
593	0.0421	4533	ALLOPOSIDAE F.	ALLOPOSIDAE F.
558	0.0396	3200	SEA MOUSE	APHRODITA HASTATA
250	0.0178	4314	MORRHUA VENUSNA	PITAR MORRHUANA
180	0.0128	4512	LONG-FINNED SQUID	LOLIGO PEALEI
155	0.0110	590	SAND LANCES (NS)	AMMODYTIDAE F.
120	0.0085	4212	SILKY BUCCINUM	BUCCINUM SCALARIFORME
44	0.0031	42	YELLOWTAIL FLOUNDER	LIMANDA FERRUGINEA
10	0.0007	9500	MUD	MUD
10	0.0007	40	AMERICAN PLAICE	HIPPOGLOSSOIDES PLATESSOIDES
9	0.0006	515	SEASNAIL (NS)	CAREPROCTUS SP.
5	0.0004	3500	POLYNOIDAE F.	POLYNOIDAE F.
5	0.0004	3210	APHRODITIDAE F.	APHRODITIDAE F.
4	0.0003	41	WITCH FLOUNDER	GLYPTOCEPHALUS CYNOGLOSSUS
4	0.0003	14	SILVER HAKE	MERLUCCIUS BILINEARIS
3	0.0002	400	MONKFISH,GOOSEFISH,ANGLER	LOPHIUS AMERICANUS
2	0.0001	4216	CANCELLATE LORA	PROPEBELA CANCELLATA
2	0.0001	2510	BRACHIURAN CRABS	BRACHYURA S.
1	0.0001	312	SCULPINS	COTTIDAE F.

* Code 9400 "FOREIGN ARTICLES,GARBAGE" was used for shell debris.

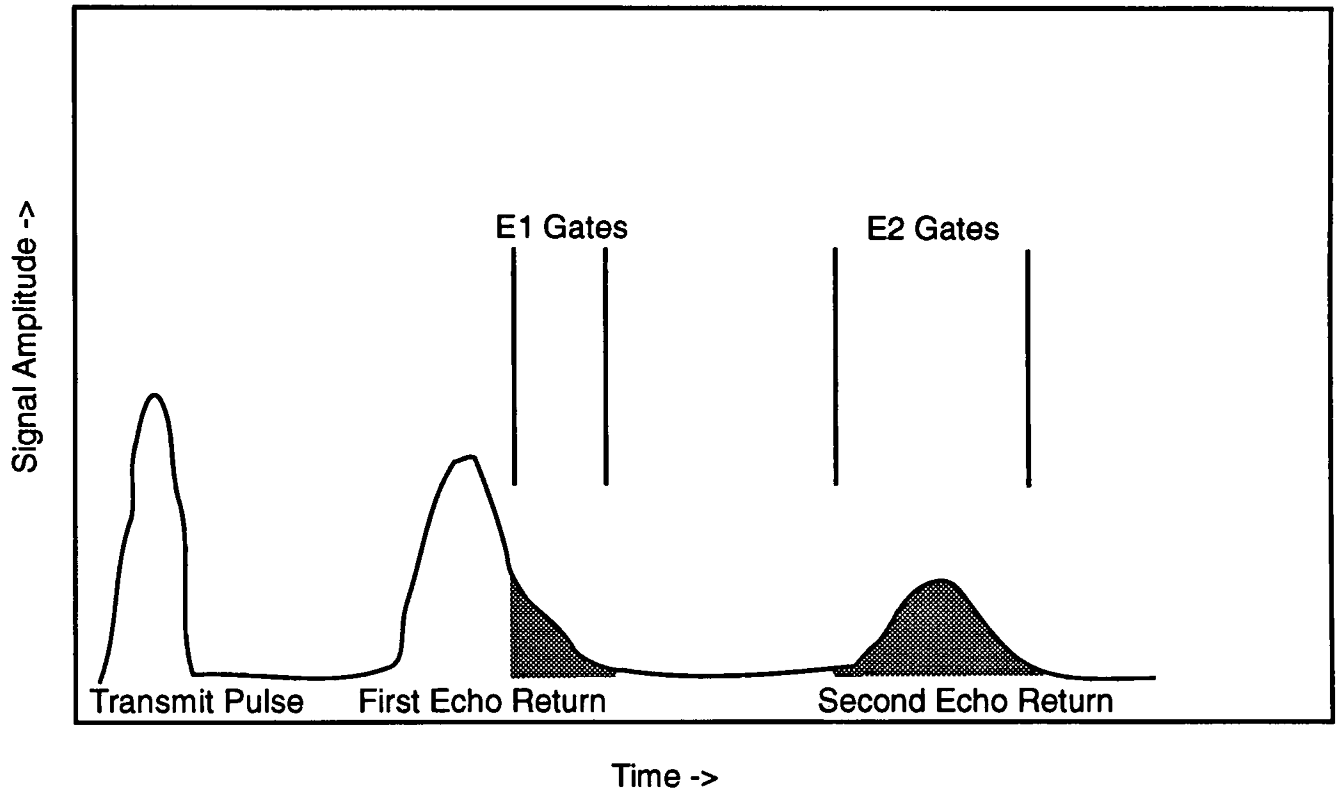

Figure 1. Portions of returning echo gated and integrated to obtain E1(Roughness) and E2 (Hardness).

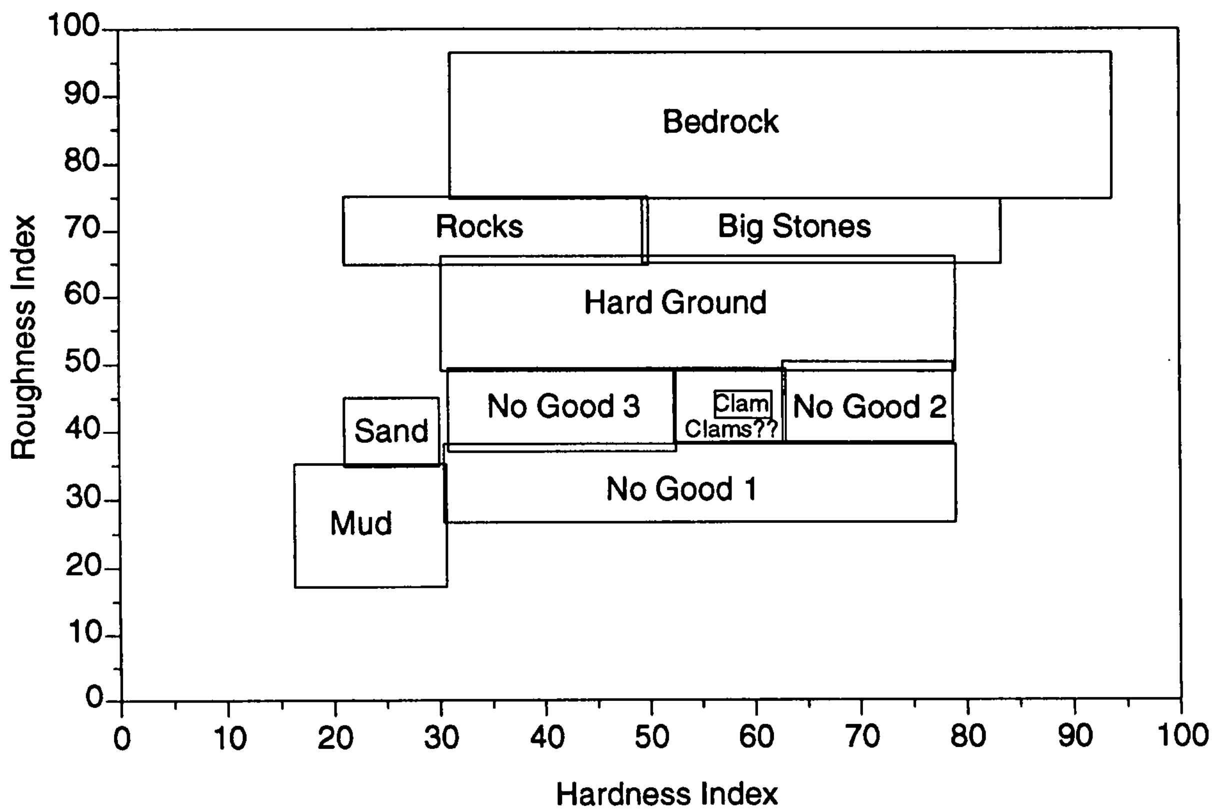

Figure 2. - Typical box file constructed with RoxAnn Bottom Classification System.

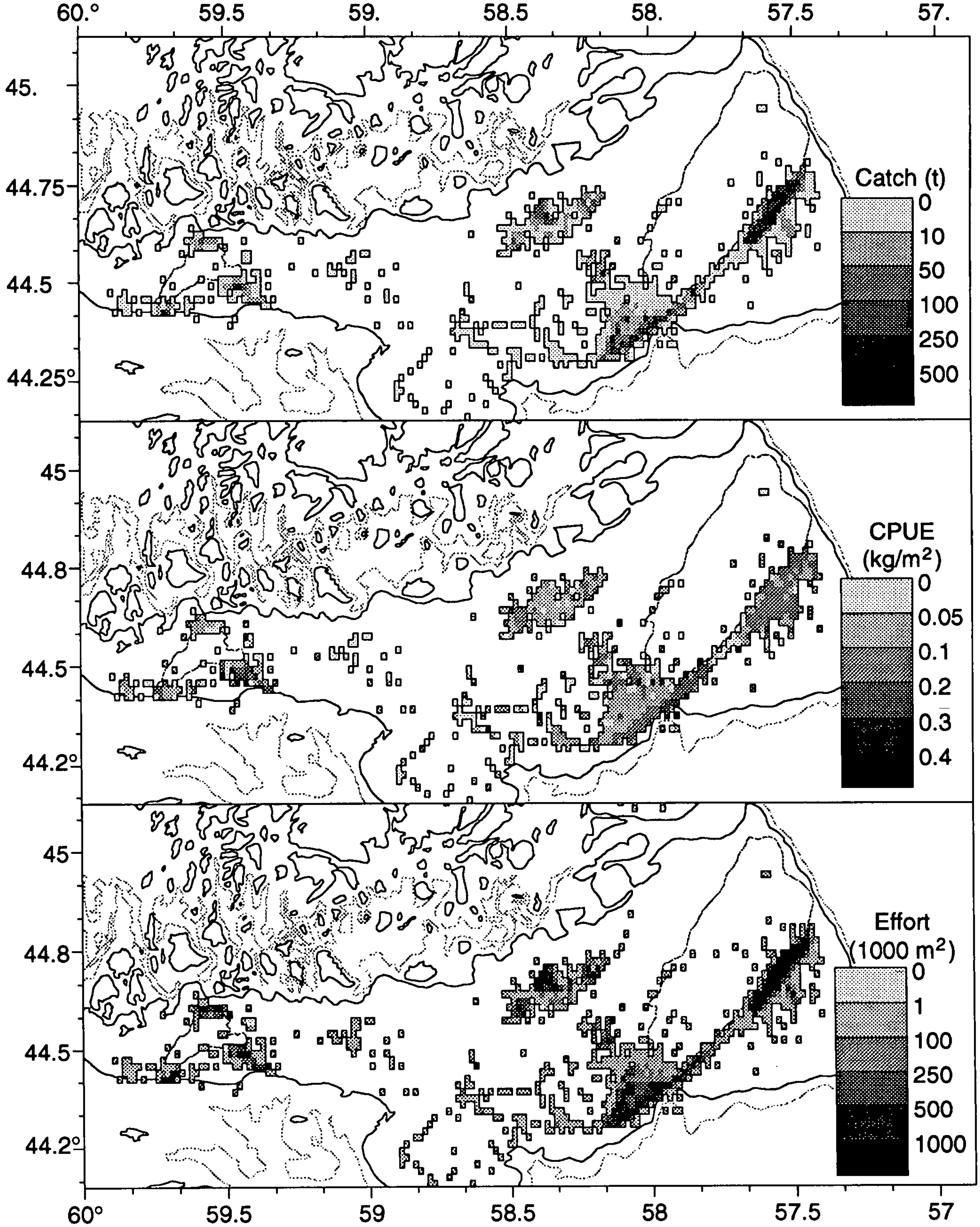

Figure 3. - Distribution of total catch, average CPUE and total effort for the 1986 to 1992 period, aggregated by one minute squares.

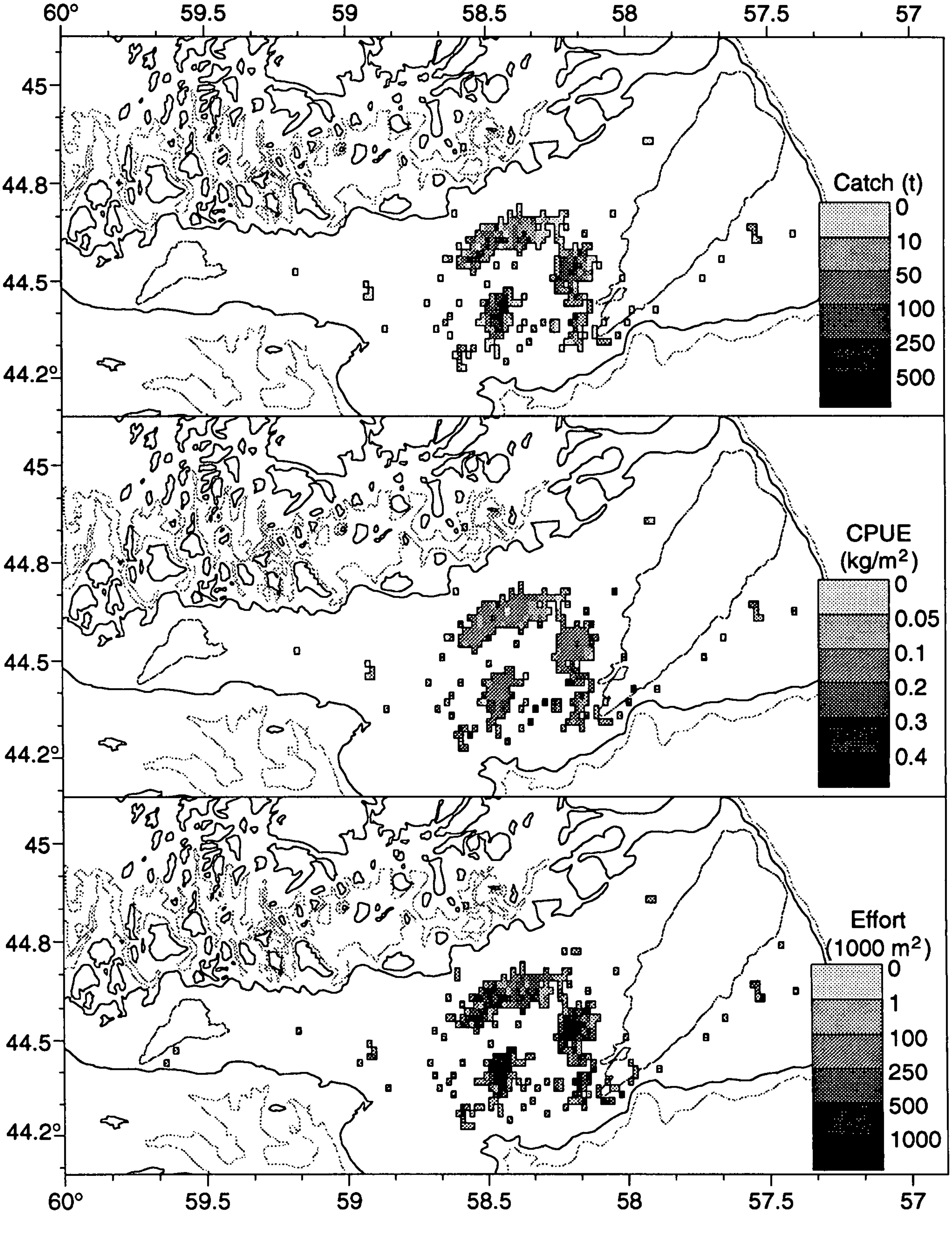

Figure 4. - Distribution of total catch, average CPUE and total effort for the 1993 to 1995 period, aggregated by one minute squares.

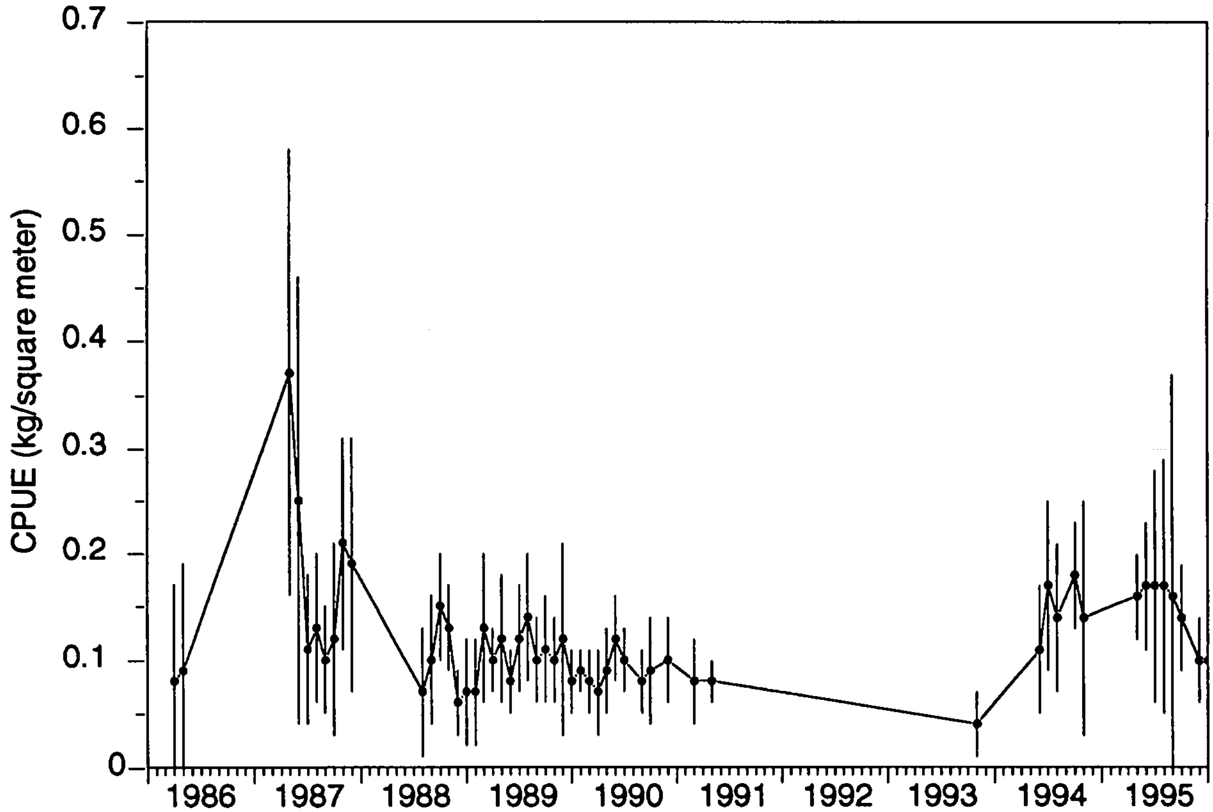

Figure 5. - Average CPUE (kg/square meter) by month for 1986 to 1995. Vertical lines are one standard deviation, only months with at least ten records are plotted.

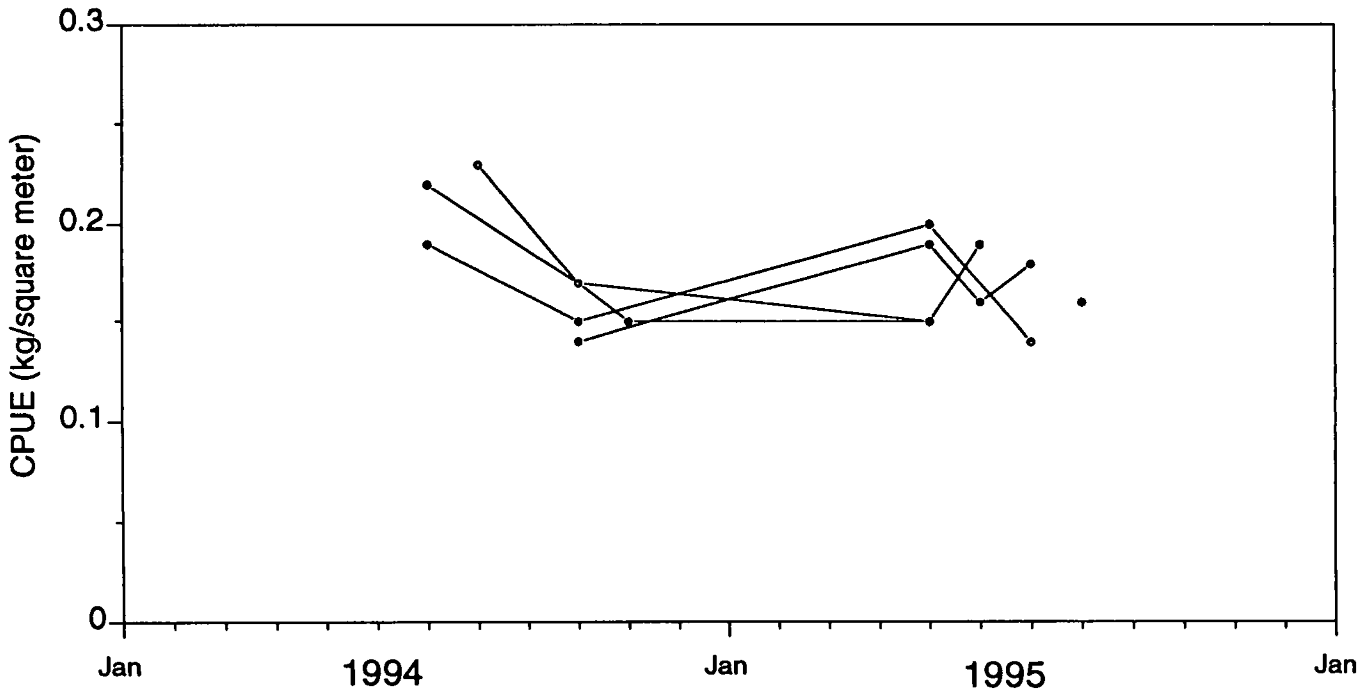

Figure 6. Average CPUE(kg/square meter) by month for the five one minute squares having the highest effort in the 1992-95 period.

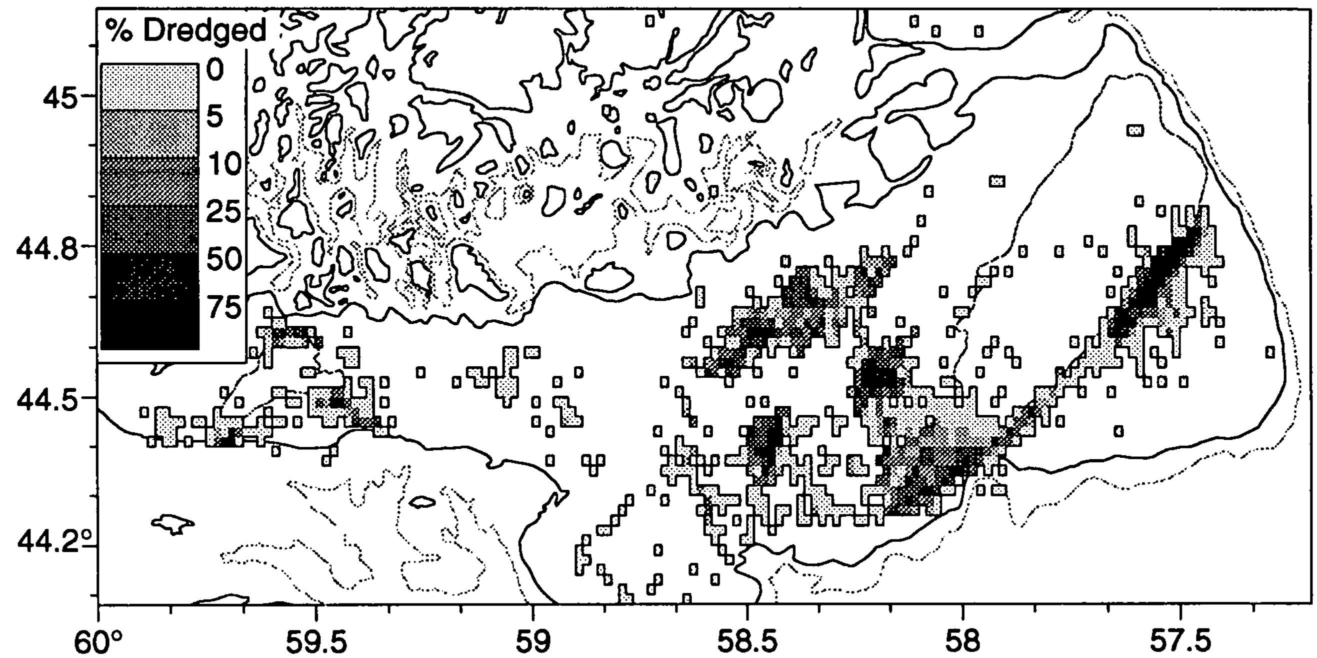

Figure 7. - Percentage of bottom covered by one minute square accumulated over 1982 to 1995.

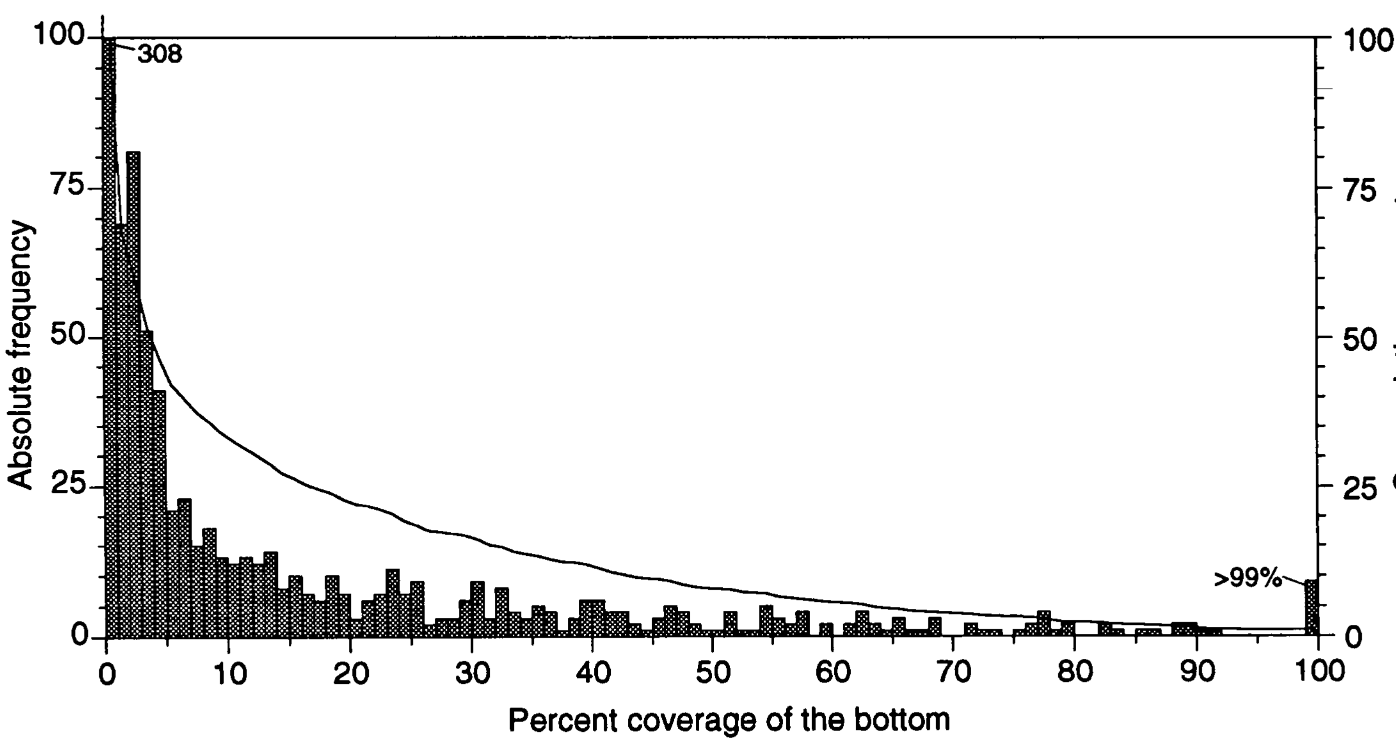

Figure 8. - Frequency of one minute squares by percent of the bottom covered by dredging. Dredging acivity is the total from 1982 to 1995, and coverage is assuming no overlap of tows. Line is cummulative percent distribution.

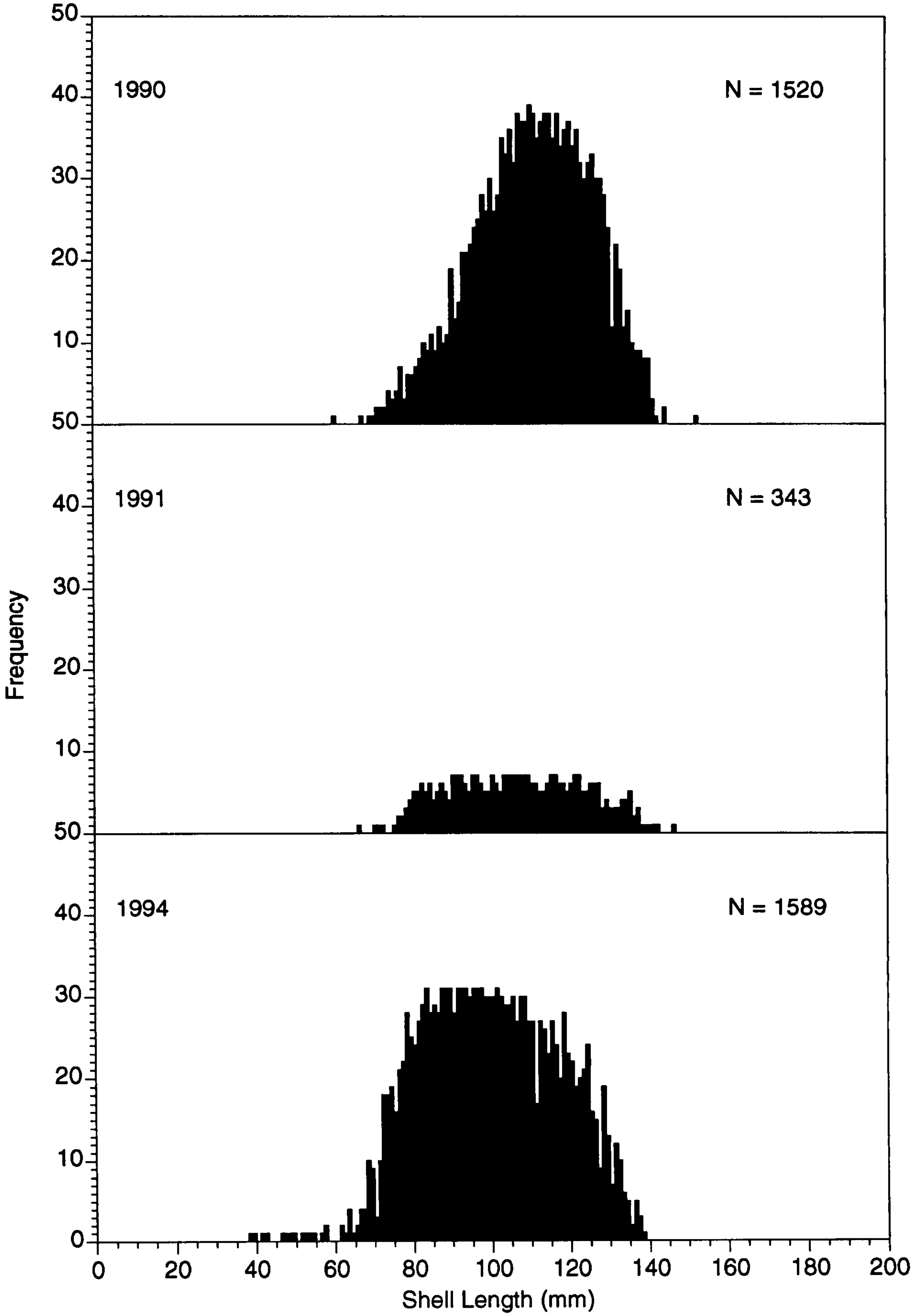

Figure 9. - Length frequency histograms of Arctic surfclams from unsorted catch samples on Banquereau Bank. Samples taken by the International Observer Program.

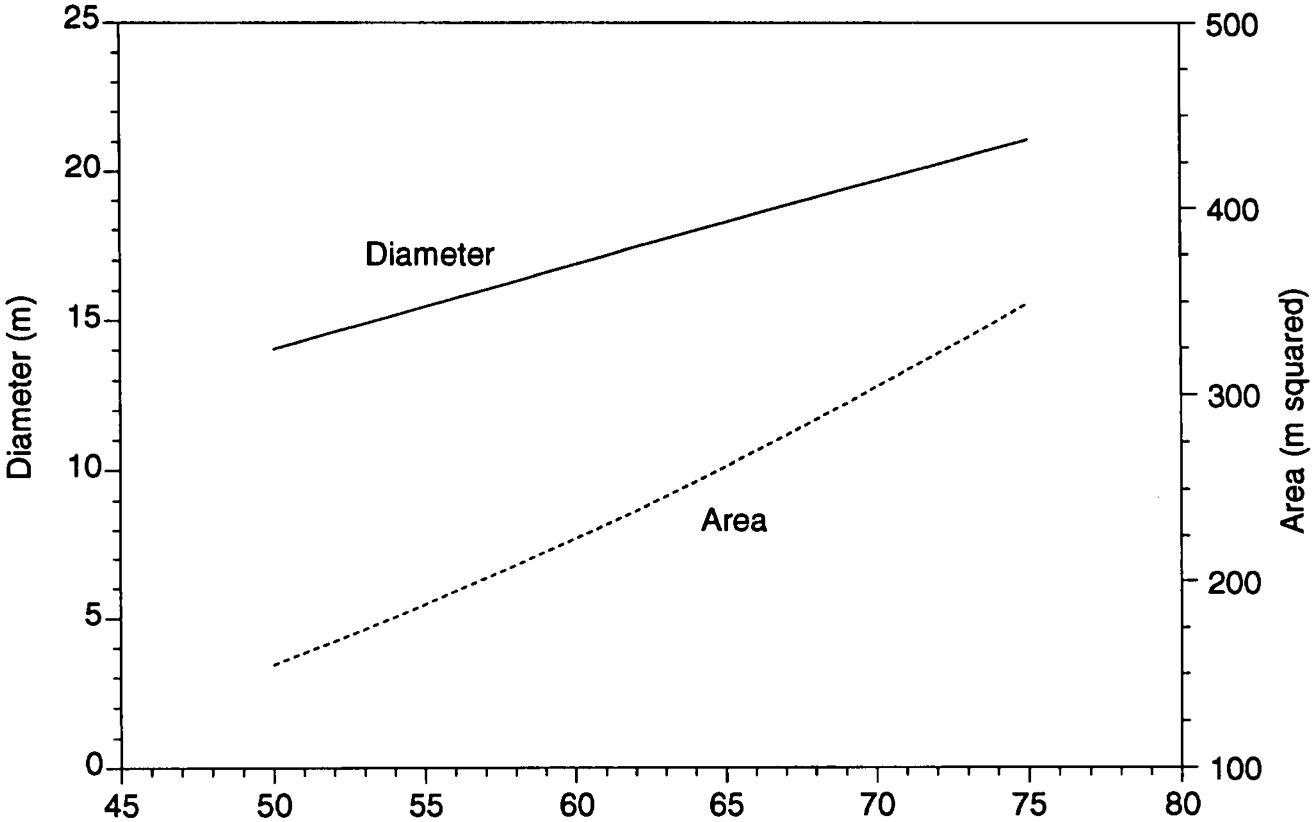

Figure 10. Diameter and area of insonified bottom by depth, using a 50 Khz transducer with a 16° beam width.