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Georges Bank Scallop Stock Assessment - 1992

by

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ABSTRACT

Georges Bank catches have been increasing steadily over the last 5 years from 4,336 t in 1988 to 6,151 t in 1992. Catch-rates have also improved for the same period except for a small decrease from 1991 to 1992. The 1992 stock survey recorded the highest biomass estimates since 1981. Survey results indicate that the 1988 and 1989 year classes are strong but it would appear that the 1990 year class is weak.

Biomass estimates using virtual population analysis has been rising over the last 5 years, due in part to strong 1988 and 1989 year classes. This biomass increase led to the rising trend in fishery performance. Biomass will likely decrease once the strong year classes pass out of the fishery. Different fishing scenarios are presented for 1993. Keeping the TAC at the 1992 level, 6,200 t, would balance production.

RESUME

Les prises du banc Georges ont augmenté graduellement durant les 5 dernières années de 4,336 t en 1988 a 6,151 t en 1992. Les taux de capture se sont aussi améliorés pour la même période sauf pour une légère baisse de 1991 a 1992. L'inventaire du stock en 1992 a enregistré des estimations de biomasse les plus élevées depuis 1981. Les résultats d'inventaire indiquent que les classes d'ages de 1988 et 1989 sont robustes mais il semblerait que la classes d'age de 1990 est faible.

Les estimations de biomasse d'après les analyses de population virtuelle se sont élevées au cours des 5 dernières années, ceci est dû en partie aux fortes classes d'ages de 1988 et 1989. Cette augmentation de la biomasse explique la tendance a la hausse du rendement de la pêche. La biomasse va probablement diminuer une fois que les fortes classes d'ages auront été pêchées. Différents scénarios de pêche sont présentés pour 1993. Garder le TPA au niveau de 1992, 6,200 t, permettrait de maintenir la biomasse constante.

INTRODUCTION

Prior to the establishment of the 200 - mile fishing zone in 1977 Canadian and American vessels fished Georges Bank (NAFO SA 5Ze) for scallops. The Canadian deep-sea fleet had to restrict its fishing activities to a national zone in 1985 after the World Court decision (October 1984) on the jurisdiction for fisheries of Canada and the United States on Georges Bank. The Canadian zone, NAFO subdivision 5Zc, is the portion of Georges Bank east of the International Court of Justice (ICJ) line. During the late 1970's, the fishery peaked at 11,000 t (SA 5Zc Table 1) produced by the strong 1972 year class; but such performance deteriorated rapidly. The lack of consensus in the management of the scallop resource in the disputed area coupled with increased effort, contributed as much to the decline in landings as the vanishing 1972 year class. The year of the dispute settlement, 1984, the Canadian fleet caught only 1,945 t of meats, its lowest catch in 25 years. The Canadian scallop industry then focused on stock rehabilitation through a better utilisation of the resource. An Enterprise Allocation (EA) regime was implemented in 1986 partly to reduce fishing effort. From 77 active license holders in 1984, the number of vessels dropped (25 %) to 57 in 1989. In 1992, only 42 vessels, about half the initial number of license holders, were actively involved in the Georges Bank fishery. The meat count (size limit) was also lowered to 33 meats per 500 g in January 1986 to direct exploitation toward slightly larger scallops.

During the post -1985 period catches have stabilised in the range of 4,300 - 6,800 t while catch-rates have varied between 0.4 - 0.7 kg/crhm. This is less variation than was experienced during the decade 1975 - 85 (Table 2). Figure 1 shows the monthly catches and CPUE's for the last three years. Research survey indices also suggest a dampening of the large variation previously experienced in the stock recruitment. The 1992 survey index rebounded with sizable quantities of age 4 and a strong pulse of age 3, the 1989 year class. TAC's had been increasing since 1989 (Table 1). The 6,200 t TAC set for 1992 was practically all caught (99 %). Figure 2 illustrates areas of different catch levels with varying shades of grey. An area along a northwest - southeast axis had catches over 10 t per one - minute (0.02 decimal degree) square. The next figure (Fig. 3) maps CPUE isopleths; a large area produced high to very high catch-rates, over 1 kg / crhm. Catch-rates that had increased steadily since 1988 dropped slightly (5 %) from 1991 to 1992. The average meat weight in the catch has been fairly consistent throughout the year in 1992 (Table 3) and above the 15.15 g weight referring to the 33 count. The monthly average decreased during the last quarter (October - December) likely due to the influx of an abundant class of age 4 scallops. Table 4 values for the last quarter of 1992 also show high frequencies in the 9 - 13 g range.

METHODS

Fishery data

Catch and effort data are compiled from logbooks. Logs with complete effort data are called Class 1 and are used to estimate catch-rates. The Class 1 data represent more than 90% of the total (Table 2). Effort is measured in fishing days (fd), towed hours (h), and towed hours times the width of the 2 drags used times the number of crew (crhm). Catch-rate is presented as catch (kg) per fishing day, per hour, and per crew-hour-meter. Catch per fd is a simple concept to grasp, yet, a somewhat crude estimate. Catch per h considers only the period that gear was actively fishing. It does not consider how wide the gear is to estimate how much ground is covered by the tow. Gear width may vary from 8.5 to 15.5 m. CPUE in hours is used in the cohort tuning analysis. Scallop meats caught have to be shucked at sea; the smaller the meats, the more crew needed to shuck. Common fishing practices will first change the number of crew if effort has to be modified. A freezer trawler has conducted its second year of activity on Georges Bank. The operational procedures are somewhat different from a conventional vessel and may influence the determination of catch-rates. This is under study. For both 1991 and 1992 its catch-rates have been pro-rated to the catch-rates of the fleet.

Size distributions of meats from the commercial fleet are derived from port samples. Characteristics of monthly meat weight frequencies for selected years are given in Table 3. An experimental port sampling program was begun in July 1991 to extend the catch sampling to all the enterprises making up the deep-sea fleet. Previously, only one or two enterprises contributed information to the catch sampling database. The extended sampling may lead to a slightly different meat weight profile depending on the fishing strategies of the companies involved. Work is underway to investigate differences in meat weight distribution profiles. Canadian port sampling data were applied to the Canadian and U.S. total catch east of the ICJ line. This assumes similar fishing practices for both fleets. The meat weight frequency distribution in 2 - g intervals is given in Table 4 on a quarterly basis for the last 3 years. Table 5 lists the frequency distribution but on an annual basis.

Catch in numbers-at-age (Table 11) for the cohort analysis are derived from the port sampling data and the sum of U.S. and Canadian catches in NAFO SA 5Zc. The total catch (U.S. prior to 1985 and Canadian) from the Canadian zone is decomposed into 2 - g weight frequencies. The weights were converted to shell heights using the allometric relationship derived from 1982 -1985 research and commercial data (Robert and Lundy 1987). The values expressing meat weight as a function of shell height use the parameters 9.102^{-6} for the regression coefficient and 3.097 for the exponent of height. These values agree closely with those of Serchuck et al. (1982) for the same stock. Shell heights were clustered into age groups according to a Von Bertalanffy growth equation (Brown et al. 1972, cf. Table 6). The conversion of height to age was done by linear interpolation between intervals. As a check another approach was carried out where the meat weight frequencies from the catch were directly partitioned into age groups according to the meat weight - age relationship in Table 6. Results were very similar except for age 3 where a slight divergence occurred.

Traditionally, catch statistics are compiled on an annual basis and recruitment to a fishery is discussed in terms of year class strength. It is generally accepted that, in any given year the majority of Georges Bank scallops are born in October and the first annual ring is laid down the following spring. This is typically less than 10 mm and becomes difficult to discern as the animal grows. For this reason the ring, which is approximately 25 mm from the umbo is often referred to as the first annulus (Naidu 1970). The convention which we shall adopt is that animals born in the fall of a year will be of that year class and it will be further assumed that they were born on January 1 of that year (cohort ages). The deposition of the ring less than 10 mm will take place during the first year of life. The date of the deposition will be assumed to take place on April 1. A back calculation is then made to estimate the shell height for January 1 (eg. cohort age 3 has a shell height of 61 mm on January 1st, while its biological age is 2.25 years). The annual growth rates for weights, given in Table 6, are converted into rates for heights and this results in a 16% reduction of the ring size being used for the January 1 size. For example, an animal born in the fall of 1978 is of the 1978 year class and will be approximately 25 mm on its second birthday (January 1, 1980) although the ring would not be deposited for a few months. Table 6, as well as all other age data, uses this convention, with correction of ring sizes back to January 1. The actual weights used are mid-quarter values in age - weight analyses and projections.

Research survey data

The annual research survey was carried out on Georges Bank during August 1992. The design of the survey was based on a stratification by commercial effort (Robert and Jamieson 1986). The logbooks of the commercial fleet in the preceding 9 months were analyzed to determine areas of very high, high, medium, low, and very low catch-rates. The areas of very high and high catch-rates were sampled more heavily as they represent the area most important to the fleet (and presumably the areas of greatest abundance). It was felt necessary in 1991 to add a very high stratum to reduce the variability of the high stratum. The range of catch-rate values encountered has increased markedly; 41 % of the total catch-rate points used were over 1 kg / crhm, the minimum benchmark of the high stratum. The maximum value in the data set was over 9 kg / crhm. This also reflects the steady rise in average catch-rates. The average number of scallops at age per tow is given in Table 7. The details of the survey results on a per stratum basis are given in Table 9.

In addition to establishing a stratified mean number per tow, the data are contoured to represent the spatial distribution of the scallop aggregations (Fig. 4). Data points describe a three dimensional surface with latitude, longitude, and density to be plotted. A surface is formed by defining Delaunay triangles where the data points form the vertices of triangles connecting neighbouring points. The algorithm used to define the triangles is found in Watson (1982). Collectively, the triangles form a surface. The surface between adjacent contour levels (density of scallops) is illustrated by varying shades of grey. Smoothing of the contours may be performed by interpolating over the surface using inverse weighting of gradients (perpendicular to the planes of the triangles). The interpolation points are found by dividing the sides of the triangle into equal segments. Dividing the sides into 4 segments produces 16 subtriangles. Interpolation is performed on all the new vertices. This method assumes that the data points near the point in question contribute more than distant points (Watson and Philip 1985). The summation of the volumes of all triangles (integration) under the contoured surface approximates the total volume, here the relative abundance estimate for the area covered by the survey. These estimates are presented in Table 8a for ages 3 to 6. The degree of interpolation will affect the volume estimates. For the Georges Bank survey data, the estimates stabilize using 16 or more subtriangles when they vary less than 5%. A more complete description of the contouring method and volume estimation may be found in Black (MS 1993).

Biomass estimates (Table 8b) from aerial expansion of numbers of scallops per standard tow have been computed using weights at age for the middle of the third quarter (August) found in table 6. These estimates correspond to a minimum dredgeable biomass as they are not adjusted for the survey gear efficiency. Data prior to the establishment of the ICJ line, from 1981 to 1985 inclusive, have been recomputed (Tables 7 and 8) to provide density and biomass estimates for the Canadian side of Georges Bank only.

There is a correlation of 94 % between survey biomass for recruited ages 4 to 6 determined by volume estimates and the biomass computed by aerial expansion of stratified means (Fig. 5).

Stock analysis

In the first year of recruitment the animals experience approximately a 300% increase in weight. To reduce the magnitude of the errors caused by ignoring growth effects, the cohort analysis was carried out on a quarterly basis. This required that catch-at-age, effort distribution, and partial recruitment be determined on a quarterly basis. This was done by adjusting recent year's selectivity pattern to reflect the port sampling data for the last quarter of 1992. This pattern, multiplied by the F determined from tuning for the last quarter year (F_{Q4} 1992), was used as a starting vector for the quarterly cohort analysis. Natural mortality was set at .025 per quarter (M = 0.1 on an annual basis, Dickie 1955; Merrill and Posgay 1964) and no attempt was made to include a seasonal, age or time dependent effects.

The SPA is tuned against a number of independent, and sometimes contradictory, sets of observations. The most important are the commercial CPUE and the research survey estimates. F versus effort is sometimes used to aid in the tuning process. It was not generally useful. Tuning selectivity is more difficult in scallop data than for most fisheries. This is because the SPA is done on a quarterly basis and the F's on the most recent year affect only the last quarter. Thus one cannot 'dial up' the exact numbers or F's one might want for the most recent year as can be done with annually collated data. F on the oldest animals was found by multiplying the effort pattern by the mean terminal F from the older ages. Because the selectivity is highly domed toward ages 4 and 5, these values are not critical and the normal iterative determination was not undertaken. (At the 1989 CAFSAC retrospective analysis workshop it was shown that iteratively estimating the terminal F from younger ages diverged rather than converged.) For the purposes of tuning, the terminal F (quarterly rate) ranged from 0.08 to 0.18 (Table 10). This range of terminal F's was more than adequate to examine the best fit of the tuning variables. The maximum correlation coefficient, 0.764, for the regression of cohort biomass on CPUE corresponded to an F_{Q4} of 0.10; the residual (1992) crosses the regression line of cohort biomass on research survey biomass estimates at an F_{Q4} equal to 0.15. The residuals of the last two year's data and the correlation coefficient were used as tuning criteria. Seventy-six % of the variability could be explained by CPUE versus cohort biomass and 61 % by research survey versus cohort biomass. The positive residual values in table 10 denote that the residuals are below the regression line and the negative ones, above. It should be noted that the annual CPUE values are compared to the second quarter biomasses. Q2 corresponds to the quarter where the largest catches are encountered. The research survey biomass estimates are derived from the average weights at the third quarter. These are compared to third quarter biomasses from the cohort analysis. The regression of F on effort was not helpful for tuning. Contrary to the two other tuning variables, there is a poor fit for a maximum correlation coefficient under the selected F_{Q4}'s although the 1992 residual crosses the regression line at the same F_{Q4} than for CPUE tuning (Table 10). The correlation coefficient is also of lower value, around 50 %. Tuning of F on effort is not considered further.

The strongest relation between CPUE versus cohort biomass (R^2 of 0.764) occurred at an F_{Q4} of 0.10. The 1992 residual value crosses the regression line at an $F_{Q4} = 0.13$. The research survey biomass via aerial expansion versus cohort biomass regression line has its maximum R^2 (0.608) and the 1992 residual is slightly above the line at an $F_{Q4} = 0.14$. It is practically on the line with almost the same R at the next F_{Q4} increment. The upper part of Figure 6 illustrates the regression of cohort biomass on CPUE with the 1992 residual value just below the line while the previous two year's residuals are just a little farther but well within the spread occupied by the CPUE residual values. Extreme values, 1984 to the left and 1977 to the right fit the line quite well. The lower part of figure 6 deals with the regression of cohort biomass on research survey biomass. At an $F_{Q4} = 0.14$ the 12 values (since 1981) show the strongest linear fit. The 1992 residual is virtually on the line at the right end. Throughout the research survey series the 1992 index is the highest encountered. A cluster of 3 survey indices are slightly below the line at the left end. The 1990 and 1991 residuals belong to a cluster of points in the middle section of the line. All these points are relatively close to the line except for 1991. Of all the survey values the 1991 residual is the farthest away from the line (outlier). Figure 7 plots residuals between cohort biomass (COH) and research survey biomass (RV) by age and by year. Residual values are represented by cells painted with varying shades of grey. A good fit is a medium to light shade. Poor fits i.e. black would indicate RV >> COH while white shows COH >> RV. For example, survey results do not provide a very good estimate of age 6 scallops that have been exploited for over 2 years, hence the cohort biomass for age 6 is much greater than survey estimates. The resulting residual has a large positive difference and age 6 'cells' tend to be white. Ages 3, not fished yet, tend to be relatively better represented in RV than COH, hence a tendency toward dark shades for age 3 cells. For the recent past the plot of residuals should have medium to light shades of grey. The 1991 column of cells has a very poor fit, COH >>> RV, especially ages 4 and 5 (if we discount age 6) , suggesting that the research survey results would have underestimated the stock. Ship time restrictions had curtailed the planned cruise tract and led to unrepresentative results. Despite the 1991 poor fit, the terminal F ($F_{Q4} = 0.14$) generated by the cohort biomass versus research survey tuning is in close agreement with the terminal F generated by the cohort biomass versus CPUE tuning. Generally speaking, it might be more difficult to get a tight relationship in cohort biomass versus research survey tuning since only ages 3 - 7 are considered from survey results; they are the main age groups in the stock though. Also the selectivity of the research survey gear is not taken into account. The terminal F_{Q4} should be set at 0.13 when the relationship cohort biomass on CPUE explains 74 % of the variability; the 1992 residual located very close to the regression line and the 1991 value in close proximity.

A Thompson-Bell type yield per recruit analysis with quarterly time steps is used to take into account the dynamic growth of the younger age groups of scallops. However, this method does not include the effects of blending. A change in fishing strategy to adapt to the 33 meat count regulation required a re-calculation of the yield per recruit in the 1988 stock evaluation (Mohn et al 1989) and redefinition of the partial recruitment pattern. Subsequently, the yield per recruit was re-examined but there was no need for a re-evaluation as the fishing strategy, hence partial recruitment remained practically the same. Improvements in the fishery in 1991 - 1992 required a re-evaluation as older age groups (>age 7) became more represented in the catch (Table 4).

The regulations in effect on the offshore fleet are that the catch should average no more than 33 meats per 500 grams which corresponds to an average weight of 15 grams per meat. Placing a limitation on the average instead of stipulating a minimum means that the fishermen may take small animals and then balance them with larger ones. Such a practice, called blending, renders the use of most yield models and stock projections inappropriate. If there are not enough larger animals to blend in, then the mortality on the small ones will have to be reduced. Thus, the partial recruitment is a function of abundance-at-age. In order to take this practice into account, a stock projection program was written (Mohn et al. 1984) in which the mortality on the animals beneath the stipulated average meat weight is adjusted until the mean weight of the catch is within 1% of the required average. The only other way in which this program differs from the normal stock projection is that the variables are updated quarterly. The annual growth is divided into quarterly components of 10, 35, 35, and 20 % and annual effort is partitioned into quarters by the rates of 20, 35, 30, and 15 %, which reflects the 1992 fishery. The effort figure for the first quarter is twice the historical value; conversely, the second quarter usually had 50 % of the annual effort. Since 1987 the annual distribution of effort has shifted markedly not only toward the beginning of the year but also in-between quarters. Selectivity for the stock projections follows the pattern of the fishery as revealed from the cohort analysis rather than that of the gear (Caddy 1972). Starting numbers-at-age for the projections are derived by projecting ahead the fourth quarter cohort estimates of the present year to January of the next year.

Stock projections and fishing scenarios were carried out for different rates of F including $F_{0.1}$ and F_{max}, to present TAC options and their respective implications on the stock biomass.

RESULTS

Research surveys

Sampling locations of the 1992 research survey are plotted in Figure 4. Station locations are indicated in the plot for age 6. No stations were allocated to the area deeper than 100 m as the catch data showed no commercial activity below this isobath. In years of good abundance, the fleet does not venture in these marginally exploitable areas. Research survey results for 1992 are high for each age (Table 7) except age 2. Age 2 scallops are not well estimated by the survey gear. Densities of ages 5, 6, and 7 have increased gradually in the recent past. Relatively speaking, 2 age 7 scallops per tow had not been observed since 1987. The strong pulse of the 1989 year class (age 3) is ranked second over the last decade. Good aggregations of age 3 are showing up over 2 main areas of the Bank (Fig. 4). Quantities of incoming age 4 are also important. All strata (Table 9) followed the same general trend on an age basis. The survey biomass of 1992 by volume estimation or aerial expansion is the highest recorded since 1981 (Tables 8a, b). On an age basis, there had been more age 4 biomass in 1986 (and more age 3 biomass in 1985). Fully recruited age groups (ages 5 - 6) have good biomass levels. The 1992 results cannot be compared to the previous year. The 1991 results are not representative because of the difficulties experienced in completing the survey.

Cohort analysis

The SPA results are given in terms of numbers-at-age, biomass-at-age, and F-at-age (Tables 12 to 14); they have been combined into annual values from quarterly analysis for the terminal F_{Q4} level of 0.13. In terms of numbers-at-age (Table 12), there has been improvements in the survival of older age groups (ages 7+) since 1989 and it would appear that the 1988 year class be as important as the 1982 year class had been, the largest seen in the last 11 years. Stock biomass has been rising steadily over the last 5 years, up to 16,000 t and may continue with the strong pulse of new recruits. F-at-age estimates show a shift in targeted ages from 1985 to 1986 with the drop in meat counts to 33 meats per 500 g forcing the targeted age to be of an older, bigger scallop while there is almost no fishing directed on age 3. Age 5 is very strongly targeted; although there has been a slight reduction in 1991-92 compared to 1989-90. Over the last 5 years average F values (ages 3 - 11) have shown a certain degree of stability (range 0.32 - 0.37). The 1992 mean value has dropped slightly from 1991. However, the average F values over the targetted ages 4 to 6 is higher, ranging between 0.62 and 0.75 over that period.

The quarterly based yield per recruit analysis uses mid-quarter meat weights and the quarterly expanded selectivity derived from the cohort analysis (See Mohn et al. 1987). The 1988 and 1989 assessments had an F_{max} which was estimated to be at an F of 0.97 and $F_{0.1}$ at 0.59. The 1992 estimate would be 1.097 for F_{max} and 0.700 for $F_{0.1}$. The difference between the newly calculated values and the ones used previously should justify a recalculation of the yield per recruit model. The same selectivity is used in the cohort analysis, yield per recruit, and the stock projections (Table 15). The projections are carried out at $F_{0.1}$ and F_{max} using the numbers-at-age of the last quarter from the 1992 cohort analysis aged forward to the first quarter of 1993. The projections for a one year period assume a recruitment level of only 300 millions scallops to reflect the low densities observed in the research survey results and anecdotal information from the fleet. The partial recruitment vector used : 0.02, 0.45, 1.00, 0.43, 0.26, 0.18, 0.18, 0.16, and 0.09 compared to the vector determined in 1988 : 0.04, 0.52, 1.00, 0.63, 0.36, 0.21, 0.17, 0.10, and 0.05 are somewhat different (Fig. 8). The new vector is similar on the left (age 4), age 5 acting as the pivot, while the slope is steeper for ages 6 to 9 on the right side.

Projections at $F_{0.1}$ and F_{max} with a terminal F_{Q4} at 0.13 are 5,200 t and 7,150 t respectively (Table 15). The meat count will be met without difficulties; the mean weight of the catch being 16.5 g at its lowest value in the winter fishery. Under the assumed recruitment pattern, the projected biomass increases by 6 % under $F_{0.1}$ and decreases by 9 % under the F_{max} scenario.

Other fishing scenarios are briefly presented in table 16. They encompass a wide range of catch levels and F values. Keeping the TAC at the 1992 level, 6,200 t, would roughly be equivalent to the replacement yield scenario.

CONCLUSIONS

Biomass, catches, and catch-rates have been rising steadily over the last five years (Tables 2 and 13); the 1992 CPUE decreased insignificantly. A build-up of biomass and good to strong 1988 and 1989 year classes are responsible for this rising trend in the fishery performance. Catches may still be on the rise in 1993 but it will be more difficult for the stock biomass to maintain this ascending pattern as the 1990 year class appears weak according to survey results.

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Table 1.- Estimated (pre-1985) catches (t of meats) from Georges Bank, NAFO subarea 5Zc. Since October 1984 the ICJ line separates fishing areas for both countries.

Year	U.S.A.	Canada	Total
1957	3562	732	4294
1958	3024	1167	4191
1959	2601	2235	4836
1960	2008	2568	4576
1961	4472	4382	8854
1962	3200	5315	8515
1963	1953	5270	7223
1964	462	5034	5496
1965	24	3059	3083
1966	25	2537	2562
1967	34	3212	3246
1968	41	3904	3945
1969	97	3368	3465
1970	51	2868	2919
1971	3	2345	2348
1972	26	2746	2772
1973	5	1975	1980
1974	0	4541	4541
1975	0	6524	6524
1976	0	7809	7809
1977	77	11126	11203
1978	212	10970	11182
1979	314	7642	7956
1980	761	4751	5512
1981	2000	7612	9612
1982	1054	3918	4972
1983	714	2418	3132
1984	889	1945	2834
1985	0	3812	3812
1986	0	4900	4900
1987	0	6793	6793
1988	0	4336	4336
1989	0	4676	4676
1990	0	5218	5218
1991	0	5805	5805
1992	0	6151	6151

Year	Recommended TAC	Set TAC	Catch
1986	---	4300	4900
1987	6500	6850	6793
1988	4800	5400	4336
1989	4700	4700	4676
1990	4800	5200	5218
1991	5200	5800	5805
1992	5800	6200	6151

Table 2.- Catch and effort data. Canadian catches (t of meats) in NAFO subarea 5Zc. Canadian total effort is derived from effort from Class 1 data.

Year	Catch	Effort			CPUE		
*		days	hours 10^3	crhm* 10^3	kg/ fd*	kg/ h*	kg/crhm
1972	2746	5404	75	9220	508.14	36.61	0.298
1973	1975	3716	54	6333	531.49	36.67	0.312
1974	4541	6071	90	10810	747.98	50.46	0.420
1975	6524	7234	105	13389	901.85	62.13	0.487
1976	7809	6129	90	12222	1274.11	86.77	0.639
1977	11126	7386	82	11051	1506.36	135.68	1.007
1978	10970	7692	100	13686	1426.16	109.70	0.802
1979	7642	7327	105	14372	1042.99	72.78	0.532
1980	4751	6232	86	11785	762.36	55.24	0.403
1981	7612	8020	100	14484	949.13	76.12	0.526
1982	3918	5564	73	9977	704.17	53.67	0.393
1983	2418	4825	67	8690	501.14	36.09	0.278
1984	1945	5716	70	8598	340.27	27.79	0.226
1985	3812	7376	105	12644	516.81	36.31	0.301
1986	4900	3915	52	6957	1251.60	94.23	0.704
1987	6793	5736	78	10808	1184.27	87.09	0.629
1988	4336	5853	85	11283	740.82	51.01	0.385
1989	4676	5154	78	10774	907.26	59.96	0.434
1990	5218	4724	72	10570	1104.57	72.09	0.494
1991	5805	4272	66	9687	1358.90	88.40	0.599
1992	6151	4697	73	10957	1309.52	84.10	0.561

* crew-hour-meter; fishing day; hour

Table 3.- Monthly profile of the catch from NAFO Subarea 5Zc from the frequency distribution of scallop meat weights for selected years.

%	catch examined / catch landed	meat weight (g) mean	min	max	s.e.	n meats
1981	0.01306					
January		0.00	0.00	0.00	0.00	0
February		8.96	3.26	53.21	0.06	1386
March		11.00	2.58	65.10	0.05	3673
April		10.19	4.70	54.38	0.08	402
May		11.56	3.37	76.60	0.02	19036
June		12.15	2.26	79.87	0.02	24514
July		11.44	2.55	73.25	0.02	16301
August		10.50	2.37	74.49	0.02	15204
September		9.90	2.23	59.09	0.03	4321
October		7.28	2.37	56.52	0.03	3165
November		8.13	2.10	54.47	0.03	4146
December		8.56	2.30	53.68	0.04	3004
1992	0.00532					
January		16.81	6.68	50.99	0.07	1022
February		16.61	5.90	49.00	0.06	1287
March		16.49	4.33	49.69	0.04	2692
April		16.62	6.22	61.76	0.05	2480
May		16.71	5.76	62.80	0.09	837
June		17.51	6.85	43.54	0.08	817
July		16.91	8.07	51.74	0.07	886
August		16.81	6.08	58.48	0.05	2377
September		16.43	6.30	44.70	0.05	1323
October		15.94	5.12	51.62	0.04	3126
November		15.44	5.41	52.79	0.04	2576
December		15.69	6.91	47.64	0.08	535

Table 4- Frequencies of numbers at weight in 2-g intervals (normalized to 1000) by quarter for recent years

Grams	1989	Q1	Q2	Q3	Q4	1990	Q1	Q2	Q3	Q4
1		0	0	0	0		0	0	0	0
3		0	0	0	0		0	0	0	0
5		1	0	0	3		4	0	0	1
7		15	7	0	28		50	10	15	18
9		90	52	0	133		161	57	76	83
11		191	157	0	208		221	134	151	146
13		218	230	0	201		195	178	178	158
15		159	211	0	154		133	155	152	146
17		96	141	0	94		86	128	123	117
19		67	78	0	67		56	95	86	86
21		46	42	0	42		37	79	63	71
23		36	28	0	26		22	52	49	49
25		23	15	0	17		13	39	36	36
27		17	13	0	11		8	25	21	24
29		9	6	0	4		4	14	16	19
31		8	6	0	5		3	11	11	13
33		5	4	0	1		2	6	8	9
35		5	4	0	1		2	6	5	6
37		3	1	0	1		1	4	2	5
39		4	2	0	1		1	1	2	5
41		2	1	0	0		0	3	2	2
43		2	0	0	0		0	1	1	2
45		1	0	0	0		0	1	1	1
47		0	0	0	0		0	0	0	1
49		0	0	0	0		0	0	0	1

Grams	1991	Q1	Q2	Q3	Q4	1992	Q1	Q2	Q3	Q4
1		0	0	0	0		0	0	0	0
3		0	0	0	0		0	0	0	0
5		1	0	0	2		0	0	0	1
7		11	6	8	12		6	8	8	8
9		73	45	58	70		41	60	43	59
11		147	140	150	121		112	151	121	160
13		170	210	184	147		188	201	176	218
15		148	177	167	139		191	168	182	186
17		131	117	132	133		158	106	147	128
19		105	76	95	114		107	83	103	89
21		68	53	66	76		68	47	80	49
23		41	39	50	53		49	42	46	33
25		30	29	22	35		26	34	33	18
27		19	20	16	20		17	29	18	15
29		17	22	14	16		13	18	15	8
31		12	13	6	12		8	13	9	7
33		8	12	8	11		6	8	6	6
35		5	10	4	6		3	7	4	5
37		5	7	6	9		3	4	2	3
39		3	5	1	6		1	5	3	2
41		2	5	4	6		1	3	1	1
43		1	3	3	3		1	5	0	1
45		1	5	2	2		1	1	1	1
47		1	1	2	2		0	2	1	1
49		0	2	2	2		1	1	0	0

Table 5.- Frequencies of numbers at weight in 2-g intervals (normalized to 1000) by year.

	Year									
Grams	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0	0	0	0	0	0	0	0	0	0
3	12	7	1	0	0	0	0	0	0	0
5	66	96	20	0	2	3	1	2	1	0
7	110	205	112	6	17	28	14	24	9	8
9	118	169	211	41	79	98	83	96	60	51
11	125	108	197	125	150	163	179	164	139	137
13	111	69	136	209	175	179	219	177	181	197
15	190	55	87	225	168	152	182	146	159	182
17	70	46	57	160	129	104	117	113	127	135
19	53	41	42	96	89	75	72	80	95	95
21	44	37	30	55	59	54	43	62	64	60
23	36	30	21	28	44	36	30	43	44	42
25	27	25	17	17	29	27	18	30	29	27
27	23	20	13	11	18	22	14	19	19	19
29	18	18	11	8	12	16	7	13	18	13
31	15	15	9	3	9	11	6	9	11	9
33	13	12	7	3	6	9	4	6	10	6
35	10	11	6	3	4	6	4	5	7	5
37	8	8	5	2	3	5	2	3	7	3
39	8	6	4	1	2	4	2	2	4	2
41	6	5	3	2	1	3	1	2	4	2
43	6	4	3	1	1	2	1	1	3	2
45	5	3	2	0	0	1	1	1	3	1
47	4	2	2	0	0	1	0	0	1	1
49	4	2	1	0	1	1	0	0	2	1
51	2	2	1	1	0	1	0	0	1	0
53	3	1	1	0	0	0	0	0	1	0
55	3	1	1	0	0	0	0	0	1	0
57	1	1	0	0	0	0	0	0	0	0
59	2	0	0	0	0	0	0	0	0	0
61	2	0	0	0	0	0	0	0	0	0
63	1	0	0	0	0	0	0	0	0	0
65	2	0	0	0	0	0	0	0	0	0
67	1	0	0	0	0	0	0	0	0	0
69	1	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0	0	0
73	0	1	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0
77	1	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0	0

Table 6.- Shell height (mm), meat weight (g) and meat count per 500 grams at age, biological and cohort. Height and weight as of first day of quarter.

Biological age	Cohort age	Shell height	Meat weight	Count /500g
2.25	3.00	61.23	3.11	161
2.50	3.25	63.22	3.44	145
2.75	3.50	74.57	5.73	87
3.00	3.75	83.13	8.03	62
3.25	4.00	87.30	9.34	54
3.50	4.25	89.23	10.00	50
3.75	4.50	96.26	12.64	40
4.00	4.75	102.35	15.29	33
4.25	5.00	105.51	16.80	30
4.50	5.25	107.02	17.55	28
4.75	5.50	111.60	19.99	25
5.00	5.75	115.81	22.42	22
5.25	6.00	118.08	23.81	21
5.50	6.25	119.18	24.50	20
5.75	6.50	122.23	26.49	19
6.00	6.75	125.13	28.49	18
6.25	7.00	126.72	29.63	17
6.50	7.25	127.50	30.20	17
6.75	7.50	129.55	31.73	16
7.00	7.75	131.54	33.26	15
7.25	8.00	132.65	34.13	15
7.50	8.25	133.19	34.57	14
7.75	8.50	134.58	35.69	14
8.00	8.75	135.94	36.82	14
8.25	9.00	136.70	37.47	13
8.50	9.25	137.08	37.79	13
8.75	9.50	138.03	38.60	13
9.00	9.75	138.96	39.41	13
9.25	10.00	139.48	39.88	13
9.50	10.25	139.74	40.11	12
9.75	10.50	140.39	40.68	12
10.00	10.75	141.02	41.26	12
10.25	11.00	141.38	41.58	12
10.50	11.25	141.56	41.75	12
10.75	11.50	142.00	42.15	12
11.00	11.75	142.44	42.55	12

Table 7.- Total weighted average (by stratum) number of scallops at age per tow.

Sampling dates	Age (years)								
	2	3	4	5	6	7	8	9	10^+
1981	177	191	24	5	2	1	0	0	0
1982	26	49	23	6	1	0	0	0	0
1983	44	31	18	5	1	1	0	0	0
1984	271	35	14	3	1	0	0	0	0
1985	104	206	18	2	0	0	0	0	0
1986	198	136	145	12	1	0	0	0	0
1987	94	98	63	17	5	2	0	0	0
1988	98	110	52	10	2	1	0	0	0
1989	117	131	71	13	2	1	0	0	0
1990	105	89	39	15	4	1	0	0	0
1991	359	103	49	13	3	1	0	0	0
1992	83	195	108	23	6	2	0	0	0

Table 8a.- Indices of abundance of scallop age-classes by volume estimates: numbers-at-age (10^6), minimum dredgeable biomass at survey time (t of meats).

Sampling dates	Age (years)				
	3	4	5	6	Biomass
1981	279.47	53.60	9.34	3.48	2965
1982	121.76	56.95	15.47	3.43	2056
1983	99.32	50.76	14.31	5.28	1841
1984	85.74	30.32	8.08	2.21	1245
1985	557.64	45.29	5.88	1.26	4628
1986	309.16	225.53	26.46	3.81	5942
1987	214.58	145.50	41.78	11.27	4704
1988	238.53	105.06	23.45	5.05	3744
1989	266.38	161.01	31.79	5.24	4899
1990	188.70	72.16	31.18	8.72	3207
1991	158.67	89.56	29.10	7.79	3174
1992	347.56	188.88	40.19	11.89	6209

Table 8b.- Minimum dredgeable biomass at age (t of meats) using aerial expansion as per number of scallops per standard tow. Weights at age for the middle of the third quarter (August) are used.

Sampling dates	Age (years)				
	3	4	5	6	Total biomass
1981	3,435.56	876.56	277.26	143.74	4,733.12
1982	881.37	840.04	332.71	71.87	2,126.00
1983	557.60	657.42	277.26	71.87	1,564.15
1984	629.55	511.33	166.36	71.87	1,379.11
1985	3,705.36	657.42	110.90	35.94	4,509.63
1986	2,446.25	5,295.89	665.36	71.75	8,479.25
1987	1,762.72	2,301.00	942.78	359.29	5,365.79
1988	1,978.62	1,899.22	554.43	143.77	4,576.04
1989	2,356.33	2,593.11	720.93	143.77	5,814.14
1990	1,600.84	1,424.38	831.86	287.55	4,144.63
1991	1,852.68	1,789.70	720.93	215.52	4,578.83
1992	3,507.50	3,944.53	1,275.39	431.22	9,158.65

Table 9.- Stratified average number of scallops at age per tow and stratified total number of scallops per tow, N.

Stratum	Sampling dates	Age (years) 2	3	4	5	6	7	8	9	10+	N	s.e.
Very low	1988	39	104	67	9	1	0	0	0	0	236	104
	1989	50	55	95	16	2	0	0	0	0	225	64
	1990	40	41	33	19	5	1	0	0	0	148	34
	1991	132	15	21	10	3	1	0	0	0	185	121
	1992	22	105	86	28	6	2	1	0	0	250	143
Low	1988	50	116	57	12	2	0	0	0	0	250	52
	1989	44	68	73	13	2	1	0	0	0	203	77
	1990	70	39	27	10	5	1	0	0	0	161	61
	1991	411	49	40	17	4	1	0	0	1	532	165
	1992	32	86	72	28	10	1	0	0	0	230	74
Medium	1988	17	45	37	9	3	1	0	0	0	112	39
	1989	155	143	88	22	3	0	0	0	0	412	96
	1990	105	142	21	13	3	1	0	0	0	290	116
	1991	378	95	53	16	3	1	0	0	0	555	166
	1992	56	167	92	44	11	2	0	0	0	372	67
High	1988	141	113	48	10	2	1	0	0	0	317	30
	1989	138	161	57	9	2	1	0	0	0	369	51
	1990	131	99	47	15	3	1	0	0	0	298	32
	1991	305	68	43	12	3	1	0	0	0	476	153
	1992	85	171	104	19	6	2	0	0	0	387	47
Very high	1991	408	157	58	12	3	1	0	0	0	672	142
	1992	111	263	127	15	4	1	0	0	0	521	74

Table 10. - Tuning criteria for the regressions of cohort biomass on CPUE's and on research survey biomass estimates and of fishing mortality on effort for selected F_{Q4} , from 0.08 to 0.18.

	CPUE(hour)			Research Survey Biomass			Effort (hours)		
F_{Q4}	R^2	1991*	1992*	R^2	1991*	1992*	R^2	1991*	1992*
0.08	0.742	-570	-5888	0.522	-6182	-5071	0.542	0.00	0.08
0.09	0.759	223	-4100	0.545	-5315	-3876	0.533	-0.01	0.07
0.10	0.764	857	-2669	0.565	-4621	-2920	0.523	-0.02	0.05
0.11	0.762	1376	-1499	0.583	-4054	-2138	0.511	-0.03	0.03
0.12	0.754	1809	-523	0.597	-3581	-1487	0.498	-0.04	0.01
0.13	0.743	2175	302	0.606	-3181	-936	0.484	-0.05	0.00
0.14	0.732	2488	1009	0.608	-2838	-463	0.468	-0.06	-0.02
0.15	0.720	2760	1622	0.604	-2541	-54	0.451	-0.07	-0.03
0.16	0.708	2998	2158	0.592	-2281	304	0.434	-0.08	-0.05
0.17	0.696	3207	2631	0.572	-2052	620	0.416	-0.09	-0.07
0.18	0.685	3394	3052	0.547	-1848	901	0.398	-0.09	-0.08

* Residual value with respect to regression line

Table 11.- Catch-at-age in numbers (10^6) east of the ICJ line.

Ages	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	239	148	192	381	166	174	115	65	127
4	97	84	199	273	366	568	320	201	177
5	32	17	45	50	93	144	198	114	69
6	3	4	6	8	16	13	70	44	20
7	2	1	3	2	7	4	25	23	12
8	1	0	1	1	3	2	13	8	6
9	0	0	0	0	3	1	10	5	3
10	0	0	0	0	1	1	8	5	2
11	0	0	0	0	1	0	8	3	2
Total	374	253	446	717	656	908	767	469	420

Ages	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	289	45	33	65	65	2	21	21	16
4	492	170	90	68	144	185	186	119	159
5	75	93	65	33	37	108	188	96	103
6	16	13	14	20	11	10	16	22	19
7	8	6	3	8	10	3	3	5	9
8	5	3	2	2	4	2	2	1	2
9	4	3	2	1	1	1	3	1	0
10	2	3	3	1	1	0	1	2	0
11	2	1	2	2	1	0	0	1	1
Total	894	338	215	202	275	311	420	268	308

Ages	1990	1991	1992
3	11	11	16
4	173	151	183
5	124	140	131
6	13	19	26
7	8	6	7
8	5	6	2
9	1	7	3
10	0	3	4
11	0	1	1
Total	335	344	373

Table 12.- Population numbers (at beginning of the first quarter) (10^6) east of the ICJ line from cohort analysis using a terminal F_{Q4} of 0.13.

Ages	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	492	527	730	1191	1248	772	489	411	878
4	177	215	334	473	709	968	528	331	309
5	113	68	116	113	170	294	333	173	109
6	10	72	46	63	55	66	130	114	49
7	11	6	62	36	49	35	47	51	61
8	2	9	5	53	30	38	27	18	24
9	1	1	8	4	47	25	33	12	9
10	0	1	1	7	3	39	21	20	6
11	0	0	0	0	6	2	35	12	14
Total	807	899	1301	1940	2317	2238	1644	1143	1459

Ages	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	652	232	211	435	622	424	345	434	490
4	672	309	167	160	330	500	381	291	372
5	112	145	118	66	80	162	276	167	149
6	33	30	43	46	28	37	44	73	60
7	25	15	15	26	22	15	23	25	46
8	43	15	7	10	15	11	11	18	18
9	16	34	11	5	8	10	8	8	16
10	6	11	28	8	3	6	9	5	6
11	3	3	7	22	6	2	5	6	3
Total	1563	794	607	777	1114	1165	1102	1027	1159

Ages	1990	1991	1992
3	438	619	556
4	428	385	549
5	185	224	205
6	38	51	71
7	37	22	29
8	33	26	15
9	15	25	18
10	14	12	17
11	5	12	9
Total	1194	1377	1467

Table 13.- Biomass Q2 (t of meats) east of the ICJ line from cohort analysis using a terminal F_{Q4} of 0.13.

Ages	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	2145	2324	3250	5298	5574	3447	2184	1838	3909
4	1733	2210	3424	4858	7394	10227	5449	3383	3217
5	1997	1208	2007	1963	2852	4937	5481	2741	1879
6	251	1778	1131	1540	1320	1591	3032	2700	1181
7	341	184	1851	1074	1467	1037	1333	1488	1815
8	51	303	165	1813	1025	1305	897	608	827
9	32	32	286	145	1735	914	1190	455	331
10	16	22	23	262	124	1549	812	791	241
11	13	9	16	14	237	67	1396	473	563
Total	6579	8070	12154	16968	21729	25074	21773	14477	13963

Ages	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	2891	1038	909	1941	2779	1895	1542	1938	2191
4	6637	3224	1534	1718	3620	5476	4021	3134	3873
5	1854	2345	1852	1125	1433	2868	4067	2818	2197
6	768	707	1048	1068	689	893	967	1742	1356
7	723	422	450	737	660	433	679	736	1301
8	1447	518	255	345	525	361	343	624	601
9	574	1259	397	168	282	378	277	278	577
10	200	425	1089	291	113	224	326	171	227
11	126	109	299	892	224	64	202	253	92
Total	15220	10048	7834	8287	10325	12594	12424	11695	12416

Ages	1990	1991	1992
3	1956	2767	2486
4	4023	4027	5847
5	2383	3292	2916
6	870	1161	1620
7	1058	625	813
8	1103	830	484
9	546	894	640
10	541	464	631
11	202	491	341
Total	12682	14551	15778

Table 14.- Annualised fishing mortality east of the ICJ line from cohort analysis using a terminal F_{Q4} of 0.13.

Ages	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	0.73	0.36	0.33	0.42	0.15	0.28	0.29	0.19	0.17
4	0.85	0.52	0.98	0.92	0.78	0.97	1.01	1.01	0.92
5	0.35	0.29	0.52	0.63	0.85	0.72	0.98	1.17	1.10
6	0.43	0.05	0.16	0.14	0.36	0.24	0.84	0.52	0.56
7	0.15	0.14	0.05	0.07	0.15	0.14	0.84	0.63	0.24
8	0.46	0.04	0.12	0.02	0.10	0.05	0.69	0.60	0.31
9	0.36	0.30	0.05	0.08	0.07	0.05	0.39	0.60	0.39
10	0.45	0.22	0.41	0.03	0.57	0.03	0.50	0.28	0.51
11	0.28	0.34	0.28	0.28	0.21	0.21	0.30	0.37	0.15
Mean	0.45	0.25	0.32	0.29	0.36	0.30	0.65	0.60	0.48

Ages	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	0.65	0.23	0.18	0.17	0.12	0.01	0.07	0.05	0.03
4	1.44	0.86	0.83	0.59	0.62	0.49	0.73	0.57	0.60
5	1.21	1.11	0.85	0.75	0.68	1.19	1.23	0.92	1.26
6	0.72	0.60	0.42	0.62	0.56	0.35	0.46	0.37	0.39
7	0.39	0.57	0.27	0.40	0.63	0.22	0.14	0.23	0.22
8	0.14	0.26	0.35	0.21	0.31	0.18	0.21	0.06	0.09
9	0.30	0.11	0.23	0.40	0.18	0.08	0.43	0.17	0.02
10	0.62	0.29	0.12	0.22	0.49	0.03	0.19	0.54	0.07
11	0.71	0.65	0.43	0.08	0.21	0.08	0.08	0.20	0.27
Mean	0.69	0.52	0.41	0.38	0.42	0.29	0.39	0.35	0.33

Ages	1990	1991	1992
3	0.03	0.02	0.03
4	0.55	0.53	0.43
5	1.18	1.04	1.09
6	0.46	0.49	0.47
7	0.26	0.30	0.29
8	0.17	0.26	0.18
9	0.10	0.32	0.19
10	0.03	0.26	0.25
11	0.09	0.07	0.15
Mean	0.32	0.37	0.34

Table 15 .-Stock projections at $F_{0.1}$ (0.700) and at F_{max} (1.097) using starting numbers from cohort analysis with a terminal F_{Q4} of 0.13.

F = 0.700	1993_{Q1}	1993_{Q2}	1993_{Q3}	1993_{Q4}
Rate on smalls	1.00	1.00	1.00	1.00
Mean Wgt. Catch	16.54	17.23	18.70	22.91
Catch (Mill.)	62.01	103.93	85.78	34.66
Catch (t)	1,026	1,791	1,604	794
Cum. Catch (t)	1,026	2,817	4,421	5,215
Biomass	16,360	16,641	16,364	17,058

F = 1.097	1993_{Q1}	1993_{Q2}	1993_{Q3}	1993_{Q4}
Rate on smalls	1.00	1.00	1.00	1.00
Mean Wgt. Catch	16.52	17.14	18.49	22.73
Catch (Mill.)	94.41	147.59	113.58	43.13
Catch (t)	1,560	2,529	2,100	980
Cum. Catch (t)	1,560	4,089	6,189	7,169
Biomass	15,783	15,170	14,250	14,754

Table 16.- Fishing scenarios established for 1993 given different options of fishing mortality rate. Biomass figures are for the end of 1993. Catch figures are rounded off to the nearest 50 t.

No.	Options	Fvalues	Biomass (t)	Catch (t)
1	$F_{0.1}$	0.70	17,058	5,200
2	$F_{replacement}$ yield	0.86	16,044	6,100
3	F_{1992} TAC	0.89	15,880	6,200
4	F_{1992} effort	1.09	14,790	7,150
5	F_{max}	1.10	14,754	7,150

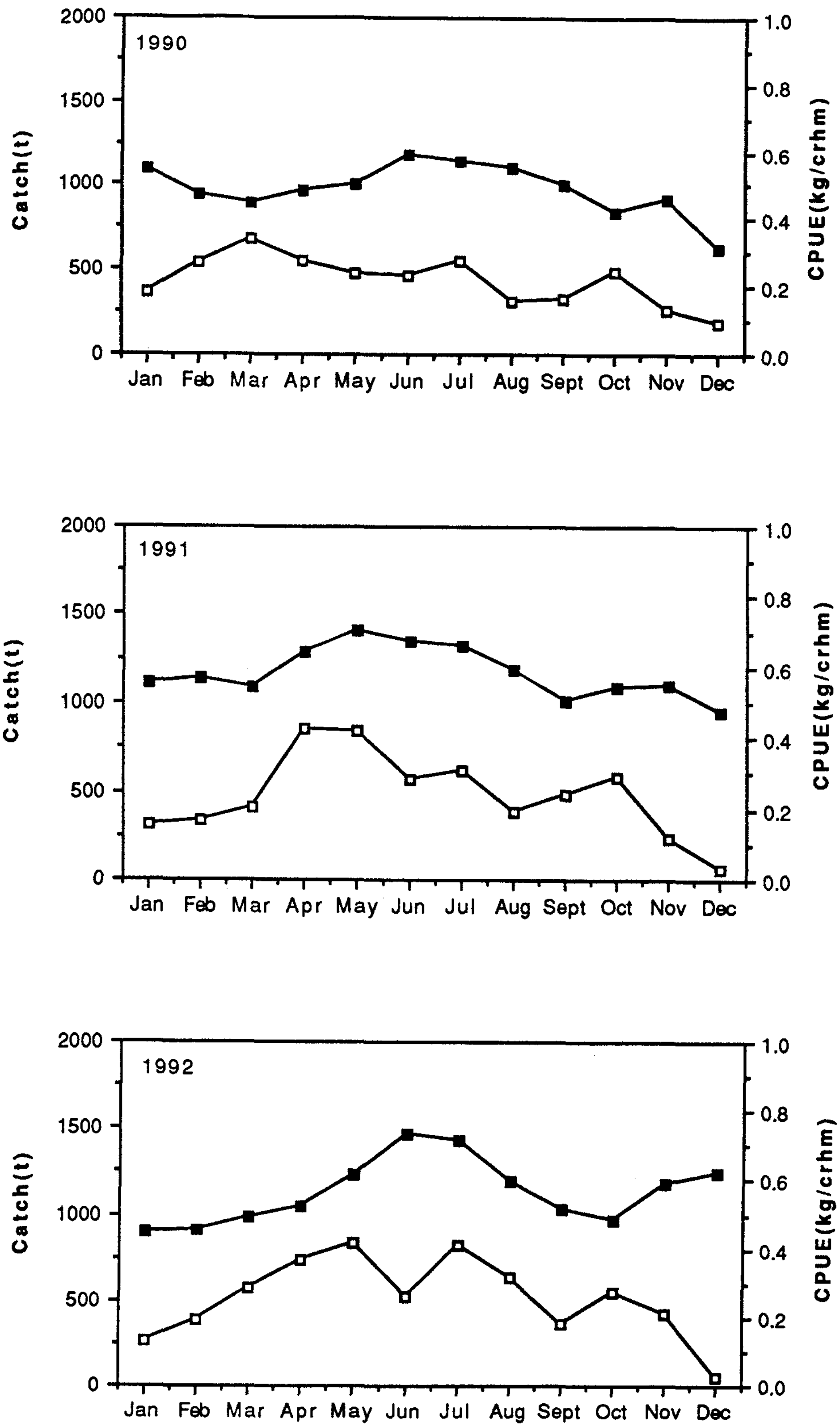


Figure 1.- Monthly CPUE (filled square) and catch in tons of meats (open square) for the deep-sea fleet fishing Georges Bank.

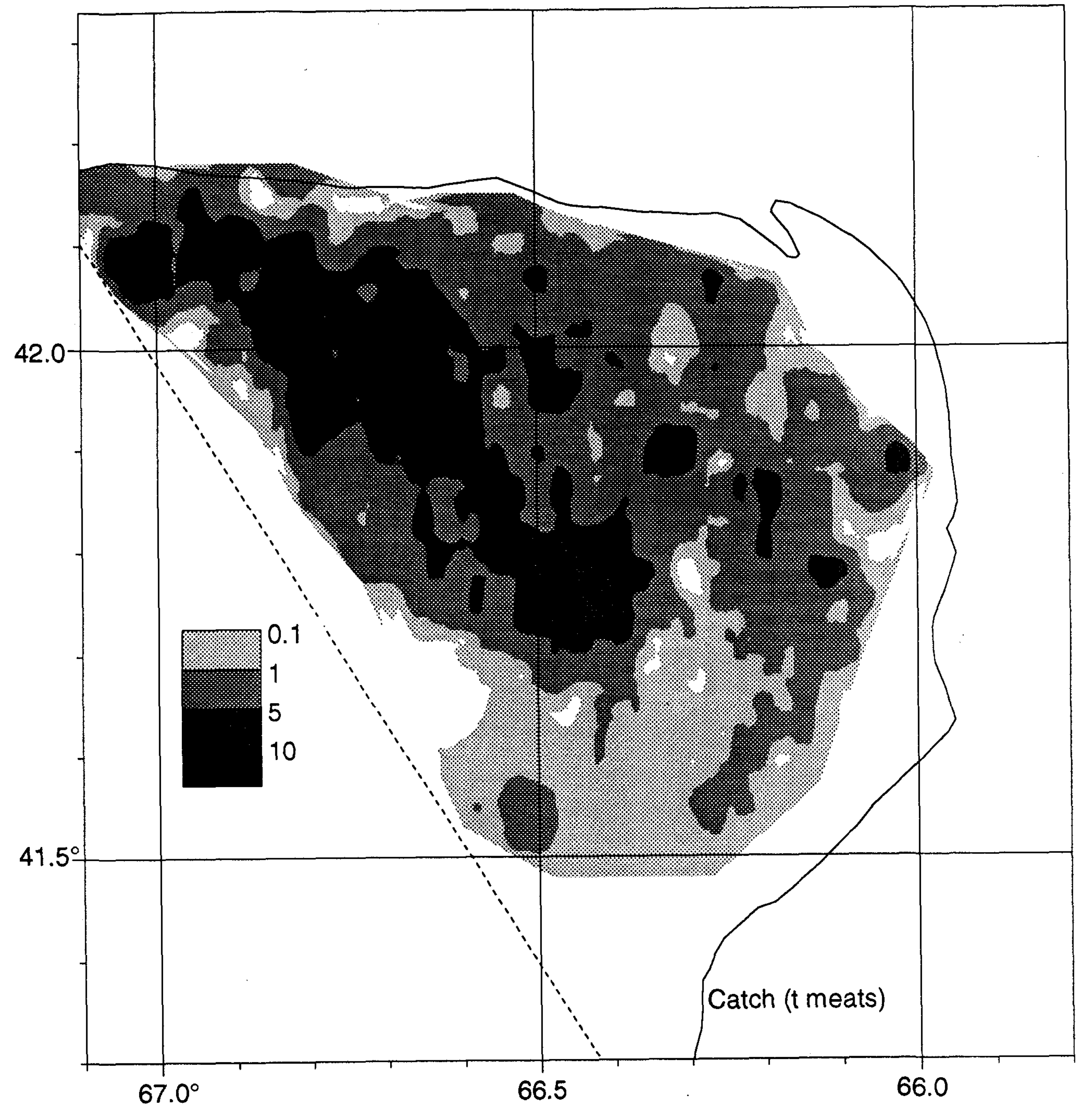


Figure 2.- Isopleths of catch levels on Georges Bank for 1992. The scale of grey shades is ascending up to 10+ t of meats per one-minute square.

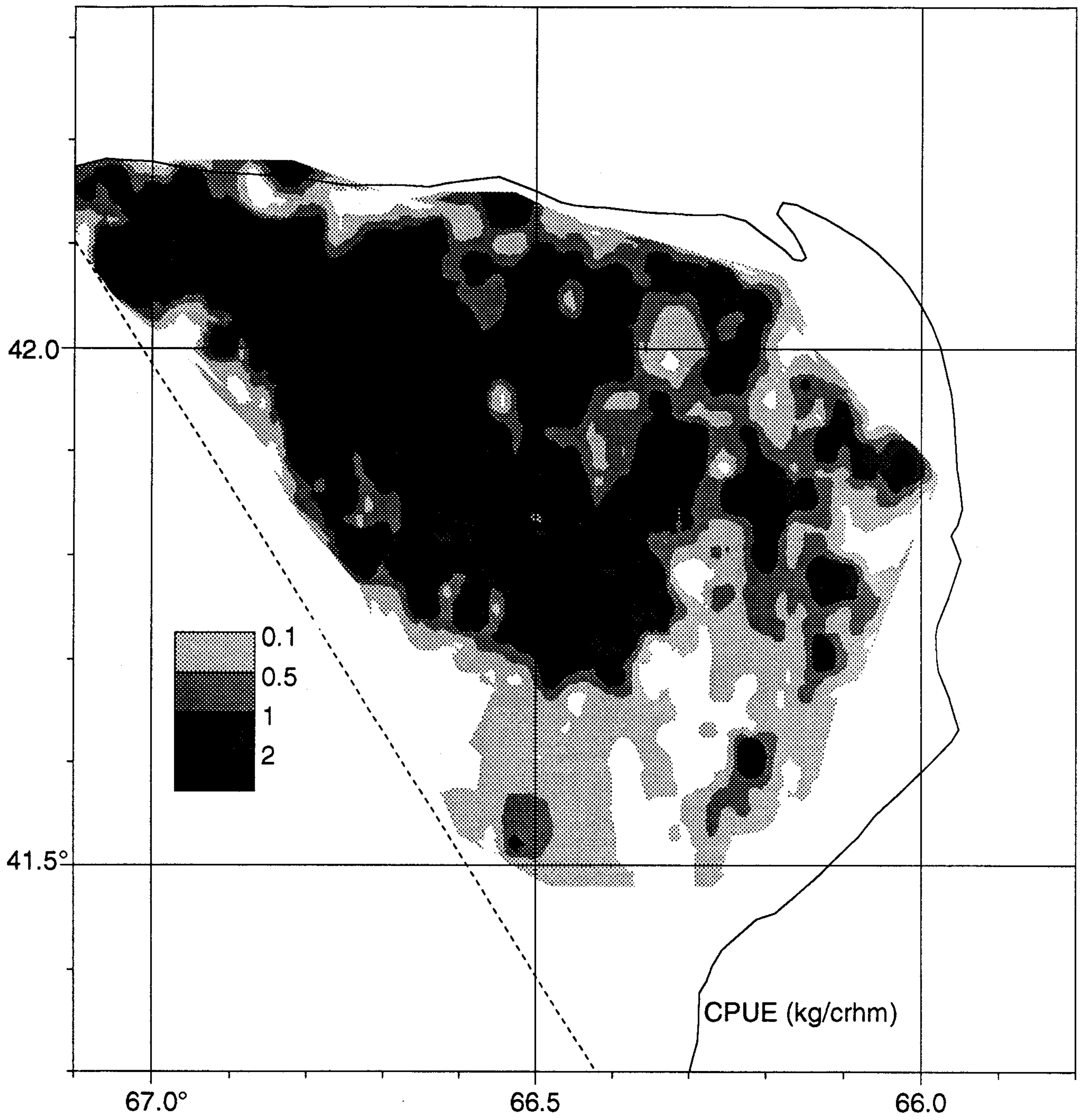


Figure 3.- Catch-rates encountered on Georges Bank in 1992. The scale of grey shades represents an ascending catch-rate up to 2+ kg / crhm.

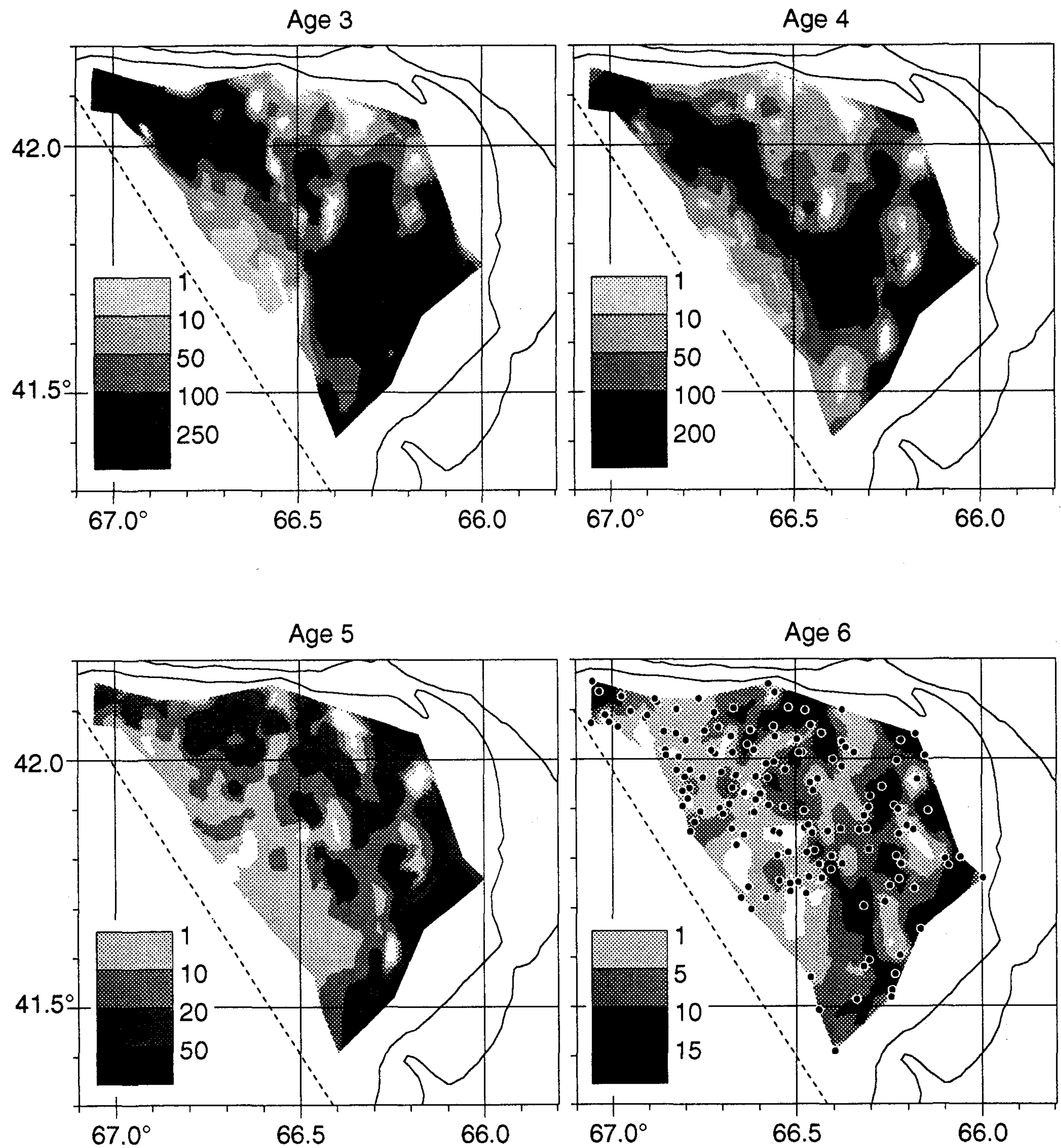


Figure 4.- Scallop distribution according to age from the research survey of August 1992. Location of sampling stations is indicated on the graph for age 6 scallops. The shading scale represents number of scallops per standard tow.

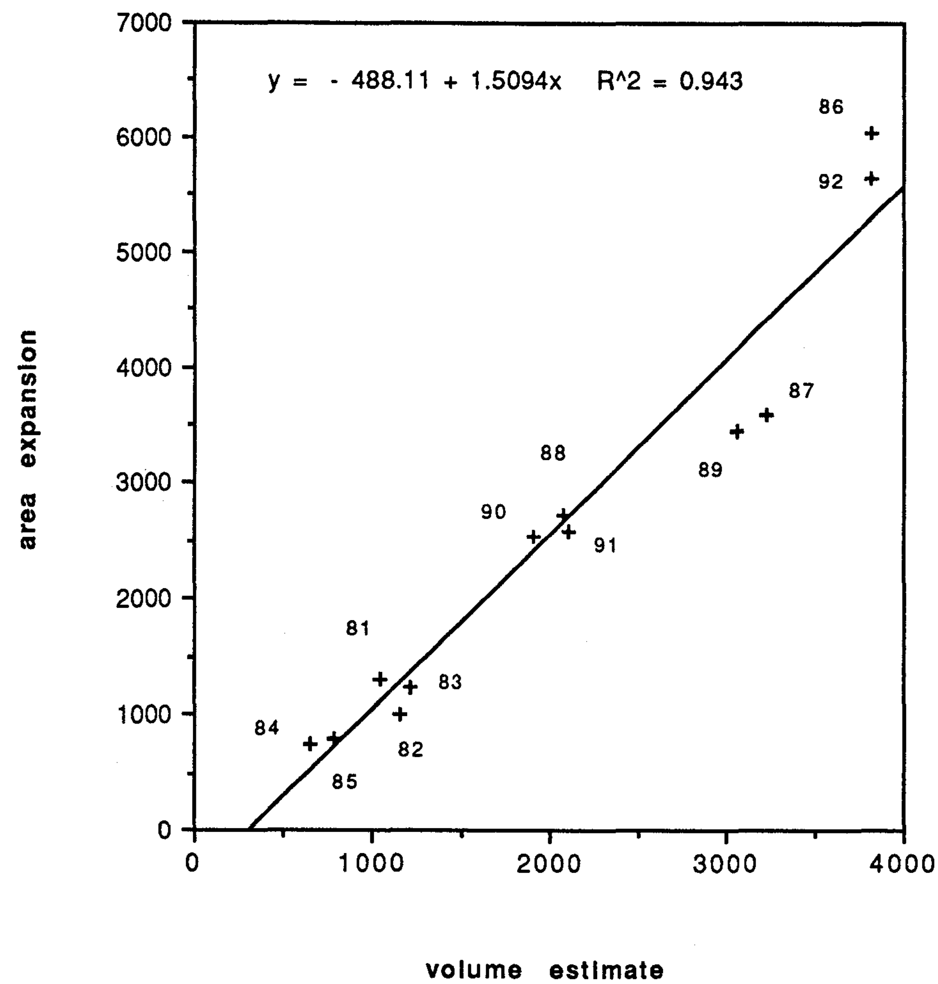
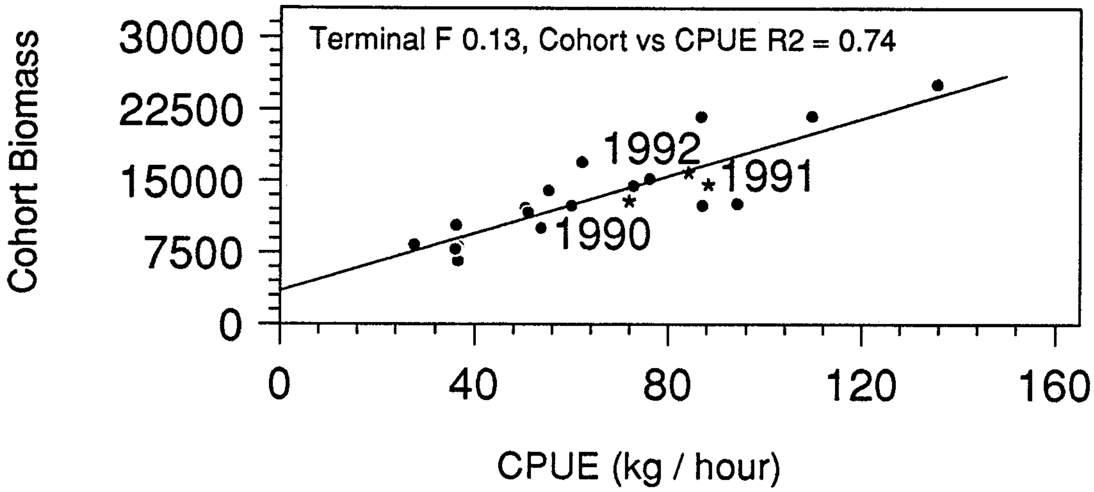


Figure 5.- Relationship between survey biomass for recruited ages 4 - 6 computed by aerial expansion and by volume estimates for the period 1981 to 1992.



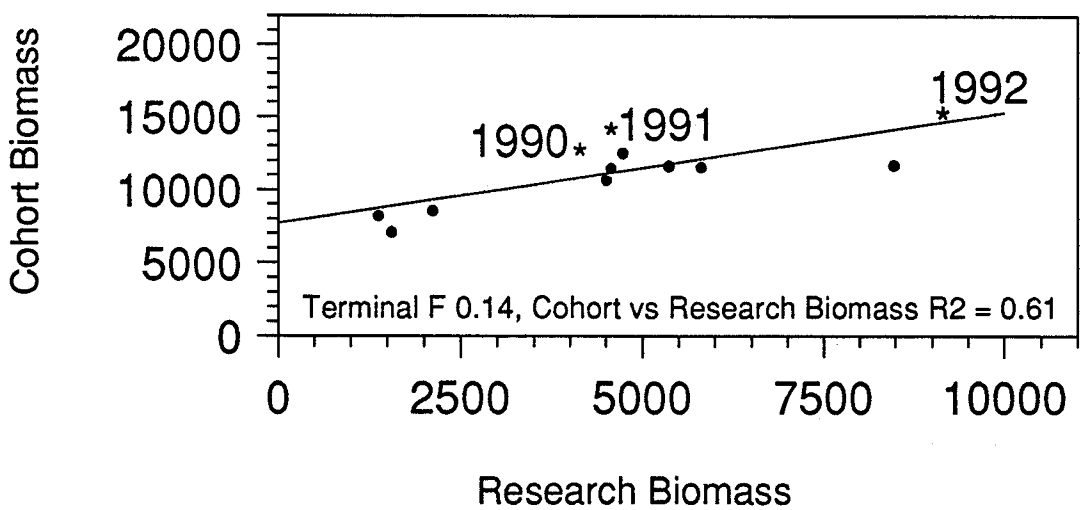


Figure 6.- Cohort biomass (t of meats) versus CPUE (kg / h) and cohort biomass versus research survey biomass (t of meats) using a terminal F_{Q4} as shown.

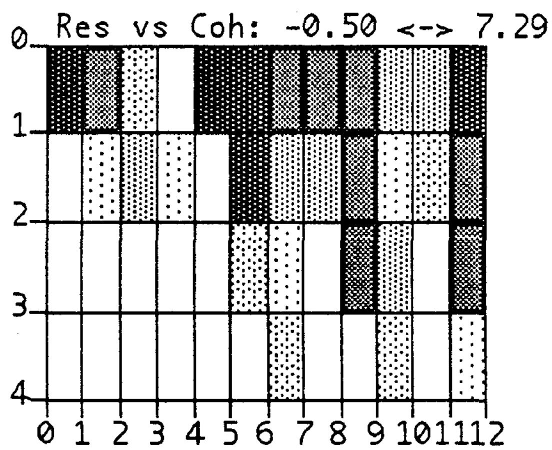


Figure 7.- Plot of residuals between cohort biomass (COH) and research survey biomass (RV) by year and by age. On the x-axis, values 1 to 12 corresponds to 1981 survey to 1992 survey. On the y-axis, values 1 to 4 corresponds to ages 3 to 6. Each age in each survey year is represented by a cell painted a different shade of grey depending on the difference of residuals. (See text)

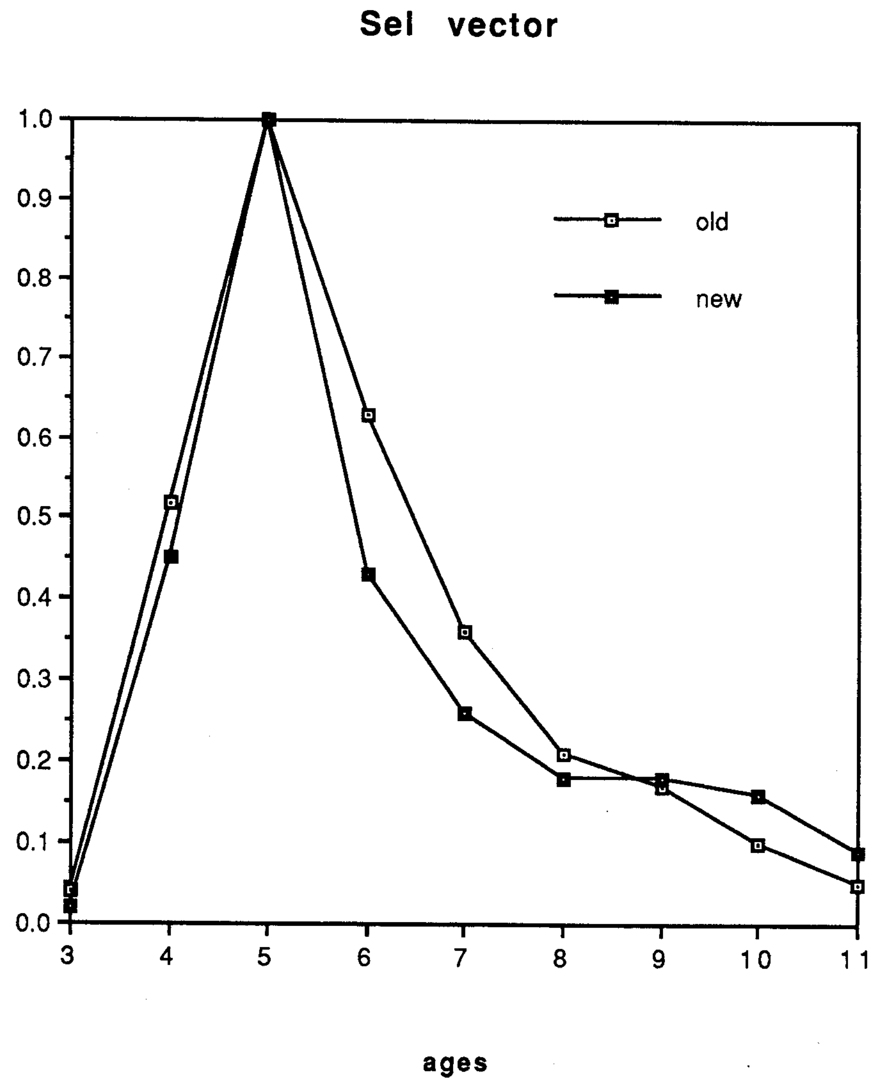


Figure 8.- Comparison of the partial recruitment vector from the 1988 stock assessment, "old" (data 1986-88) and the "new" vector established from the 1992 stock assessment data (1990-92).