Bay of Fundy scallop stock assessment for 1988, a year of record landings

By

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ABSTRACT

With the Inshore / Offshore Agreement of September 1986 grounds fished by the offshore and inshore fleets are formally segregated at latitude 43^0 40' North with the offshore to the south of that line and the inshore to the north of it. New conservation measures were introduced in December 1987 for the Bay of Fundy and its approaches (meat count, minimum shell height, maximum gear width, and expansion of the inside fishing zone).

Statistics on catches are unreliable because of the extremely poor logbook compliance. According to our estimates, the fishery on the traditional Digby beds has experienced record landings in 1988. Commercial catch-rates have been high, over 25 kg/hm provided that the log information available is representative. Meat yields (13-15 g) were also good when sampled at the beginning of the 1988-89 season. From a point of view of yield per recruit such meat counts are almost optimal under low exploitation levels; however, under high exploitation they could still be reduced by 25 %. Survey results indicate the existence of appreciable quantities of young recruits and some prerecruits.

Given the minimum abundance estimates derived from the 1988 survey data represent the stocks over the core area, a minimum recruited (ages 5+) biomass figure can be calculated to get a better appreciation of the recruitment pulse now present on the traditional beds. With gear efficiency factored in, recruited biomass may vary between 17,200 and 8,600 t. Such figures would be in line with the recent catches and catch-rates that do not show any signs of reduction more particularly in the inside fishing zone.

RESUME

La flotte hauturière et les flottilles côtières en sont venues à une entente en Septembre 1986 pour se partager les zones de pêche à la latitude 43^0 40' Nord avec la flotte hauturière demeurant au sud de cette ligne et les côtières au nord. Des nouvelles mesures de conservation furent introduites en Décembre 1987 pour la Baie de Fundy et ses approches (compte de chairs, hauteur de coquille minimale, largeur d'engin de pêche maximale et agrandissement de la zone de pêche intérieure).

On ne peut se fier aux prises statistiques à cause du petit nombre rempli de journaux de bord. D'après nos estimés la pêche sur les bancs traditionels de Digby a eu une année record en 1988. Les taux de capture commerciaux ont été élevés, plus de 25 kg/hm si l'information provenant des journaux de bord est représentative. Les rendements en chair (13-15 g) étaient bons lors de l'échantillonnage au début de la saison 1988-89. Du point de vue rendement par recrue, de tels comptes de chair sont presque optimals à de bas niveaux d'exploitation; cependant, sous un régime d'exploitation plus élevée ils pourraient être réduits de 25 %. L'inventaire de recherche montre l'existence d'importantes quantités de jeunes recrues et la présence de prérecrues.

Si on considère les estimés minimum d'abondance dérivés de l'inventaire de 1988 représentatifs des stocks dans les bancs principaux, on peut calculer une biomasse recrutée (ages 5+) minimale pour évaluer le recrutement présent sur les bancs traditionels. Tenant compte de l'efficacité de l'engin la biomasse recrutée peut varier entre 17,200 et 8,600 t. Ces valeurs sont en ligne avec les niveaux de prises et les taux de capture actuels qui ne donnent aucun signe de ralentissement surtout dans la zone de pêche intérieure.

INTRODUCTION

According to our estimates the Bay of Fundy fleet will have landed almost 3,100 t of scallop meats from the traditional grounds off Digby during 1988. These are the highest landings recorded since the beginning of that fishery in 1922. However, the official statistics report 605 t only; this is largely due to poor logbook compliance. The inside fishing zone (area 8 nautical miles from shore between Parker's Cove and Centreville open for scallop dragging from October to the end of April) has produced very high catches during the 1987-88 season; 1,100 t approximately, (Figure 1) but meats were of small size, 10 g on average. An important recruitment pulse identified in the 1986 stock survey (Robert et al 1987) is responsible for the upward surge in catches. Upon completion of the (1988) summer growth, fishing performance improved even more. For the first half of the 1988-89 season (Oct. - Dec.) we estimate that the fleet caught 1,570 t of meats with a mean weight of 15 g.

In comparison, the outside fishing zone (area beyond 8 miles from shore with no seasonal closure) which is exploited when fishing is prohibited in the inside zone has not been as productive. While CPUEs reached only 6.1 kg/hm in that zone during the summer of 1988, they had risen, on average, to 12.7 and 22.4 kg/hm in the inside zone, just before and just after the summer season. Despite these lower catch-rates, the outside summer season brought some high monthly landings, over 200 t / month for July, August, and September. But, it was an unusually foggy summer and it is a popular belief that fishing activity was conducted inside the 8-mile line in the more productive but prohibited area.

Changes to existing regulations and new measures came into effect in December 1987 (Canada Gazette Part II, Vol. 121 no.25, SOR / DORS / 87-672). This was the first year of fishing operations under this new management regime. These measures include: the introduction of meat counts, 72 meats per 500 g during the period May 1 to September 30 and 55 meats per 500 g during the period October 1 to April 30; a minimum shell height of 76 mm; the re-introduction of a maximum overall gear width set at 5.5 m; and the expansion of the inside fishing zone from 6 to 8 nautical miles from shore.

METHODS

Fishing Information

All vessels over 25.5 G.T. are required to maintain logbooks where daily fishing activities are recorded. Catch-rates are computed from Class 1 data when information is provided on the catch and its location, and effort in terms of hours fished and width of the gear (m). It is not possible to get effort data and areas fished from vessels less than 25.5 G.T. and / or under 14 m L.O.A.. However, their participation in the fishery and landings on a vessel basis may be estimated through sales slip records. This type of information collection was recently initiated by the Statistics Division, Department of Fisheries and Oceans, Halifax for scallop-licensed vessels.

Survey Procedures

Survey stations are randomly stratified according to the catch distribution. Stations are distributed in 3 to 4-mile bands running perpendicular to the shore. A description of the survey procedures may be found in Robert et al (1984). The logged data for 1987 was used to establish the randomly catch-stratified stations; the low stock abundance in the outside zone reduced our

coverage of that zone. Extremely low fishing activity characterised the Centreville area so that no survey locations were identified for that area. However the stock survey extended upstream, beyond the conventional scallop beds with stations off Hampton and off Young's Cove to cover those extra grounds visited by the fleet as had been the case in the most recent surveys. At the analysis stage, survey data are also post-stratified according to fishing areas, usually referred to by a prominent location or a headland, and according to fishing zones.

The total number of sampling locations was reduced from 120 to 100 because of the lengthy processing time for much of the samples coming from the inside zone due to the extremely high abundance of certain age classes. Also, the annual stock survey was coupled with a selectivity study of different ring sizes and washer types for the Digby gear. The experimental gear was tested in Annapolis Basin for 4 tows.

In addition to establishing a stratified mean number per tow, the data was contoured to represent the spatial distribution of the scallop aggregations. Abundance estimates are also derived. Data points describe a three dimensional surface with latitude, longitude, and value to be plotted. A surface is formed by defining Delaunay triangles; the data points become the vertices of triangles connecting neighbouring points. The algorithm used to shape the triangles is found in Watson (1982). The surface between adjacent contour levels in this case, the abundance of scallops, is represented as darkening shades of grey. Contours may be smoothed by interpolating the surface by inverse weighing of gradients (slopes of triangles). The sides of the Delaunay triangles are divided into equal segments (chords) to establish the interpolation points. For example, dividing the sides into 3 segments gives 9 subtriangles. The interpolation points become new vertices. This method assumes that the data points near the point in question contribute more than distant points (see also Watson and Philip 1985). Each triangle is assumed to have a flat surface. The summation of the volumes of all triangles under the contoured surface is equal to the total volume, here the abundance estimate for the survey area. The degree of interpolation will affect the volume estimates. Work is still in progress to refine the procedure. A complete description may be found in Black (MS 1988).

Absolute abundance or biomass estimates require a population census derived independently from the survey gear such as an inventory by divers or underwater camera and / or a measure of the efficiency of capture of the gear i.e. percentage of animals retained versus the number of animals present in the path of the drag. So far, there is information on gear selectivity but no direct estimation of its efficiency.

The relative abundance estimates presented are not corrected with respect to the fishing behaviour of the Digby drags both in terms of gear selectivity and efficiency. A recent study (Robert and Lundy MS 1989) shed some light on the retention potential of the commercial gear currently used (bucket made of looped rings of 75-78 mm inside diameter knitted together with rubber washers). As far as gear selectivity influences the abundance estimates one could relate the lowest possible density estimate to the highest number of scallops in each age class retained by different bucket configurations of ring sizes (78-100 mm) and washer types (rubber and steel). Since gear efficiency is not 100%, this density estimate relates to the minimum number of scallops in the drag path. For age classes where the conventionally used bucket does not retain the highest number of animals, prorating from the highest values of other buckets is used:

Age (years)	2	3	4	5	6	7	8	9	10	11+
Prorating factor	4.14	1.13	1.00	1.00	1.03	1.41	1.25	1.22	1.40	1.50
Mean values conventional	7	163	516	754	280	41	16	9	5	12
Highest values obtained	29	184	516	754	287	58	20	11	7	18

Prorating for prerecruits (ages 2-4) is not used that way because a lined bucket is towed simultaneously with the conventional bucket to estimate such age classes. But prorating for older recruits could be applied to the values obtained from the conventional bucket.

Biological Data

Data has been collected since 1982 to study ageing, somatic and gonadal growth cycles in the Bay of Fundy. Like previous investigators we have observed (Robert et al 1985) that growth (age) measured by shell ring-reading was a function of depth. Three depth-intervals have shown the most significance, under 85 m, 86-105 m, and over 105 m. This is an on-going study. At this point, 7,051 scallops have been examined from samples taken between 1982 and 1985. Three von Bertalanffy growth curves have been established with the following parameters:

Depth(m)	Height $_\infty$ (mm)	t_0	k
00-85	143.210	1.3800	0.2221
86-105	133.763	1.4011	0.2414
> 105	125.989	1.4469	0.2610

The meat weight on shell height allometric relationship was fitted by a least square regression. Allometric values derived from samples collected throughout the year, from 1982 to 1986 were selected to represent year round conditions.Summaries of the data specifications are found in table 1. Equations generated by grouping data on an annual basis and a general one combining data from all years to reduce inter-annual variability were derived. These data are presented in this report only as supporting information. Briefly, it may be said that the variability in the yield of scallop meats may amount to 25 % between different years of data. An equation combining values from 1982 to 1986 has reduced to 8 % the difference between itself and the maximum value given by any equation representing a single year of data.

RESULTS

The spatial distribution of scallop beds and their exploitation by scallop fishing fleets in Bay of Fundy waters is quite complex. For 1988, this report covers two main areas of scallop-producing grounds in the Bay of Fundy: 1) the traditional beds in the vicinity of Digby, N.S.; and 2) the Upper Parts of the Bay of Fundy.

The Traditional Beds in the Vicinity of Digby, N.S.

Since 1981 the total number of vessels with a Bay of Fundy scallop license and involved in the fishery has remained virtually constant both in Nova Scotia and in New Brunswick with the vast majority of vessels being in the largest category of vessels allowed (Table 2). The high performance achieved in 1987 has attracted all banked licenses back into the fishery for 1988. Furthermore, 3 additional licenses were granted. In all, 98 licenses were renewed or applied for. After a gradual decline in participation rate from 1984 to 1986, activity rose up to 20 % in 1987 but more significantly in 1988 when all but one licensed vessel over 25.5 G.T. actually fished (Table 3). Unfortunately, only 18 % of vessels complied with the logbook requirement. This trend has worsened over the past three years.

Most Bay of Fundy scallop license holders carry additional license(s) (Table 4); a few

license holders carry up to 4 or 5 additional licenses. Only 13 out of 99 license holders rely entirely on scallop fishing for their livelihood. Also, two-thirds of the vessels carry a 'groundfish' license and / or swordfish; other species fished include herring, mainly in New Brunswick, lobster, squid, shrimp, and mackerel. Fishery performance for scallop and groundfish justify to a great extent the involvement from one fishery to the other and vice versa. Besides the attraction caused by high scallop catch-rates, many vessels switched trawl gear for scallop drags near the end of the year when there were no extra fish quotas available for that sector of the groundfish fleet. In other years they may have stopped fishing entirely while in 1988 scallop dragging extended their fishing season. But, at the same time this re-directed effort pushed scallop fishing exploitation levels to new heights (cf. figure 3: 80-87 % active licenses in Oct-Dec).

Annual landings on the Nova Scotia side of the Bay of Fundy may indicate general trends in this fishery. Table 5 lists an historical profile of landings for statistical district 37 (Digby Neck), 38 (Digby), and 39 (Annapolis). After record highs in 1981 and 1982, landings have decreased steadily and markedly, until 1987. These figures may be misleading. When the traditional Digby stocks were not as abundant, the Bay of Fundy fleet ventured opportunistically on the western Scotian Shelf and sometimes, for a considerable fraction of the fleet's landings, to Georges Bank. During the 1980's this has taken place on a regular basis. Landing figures do not make the distinction as to location of the catch. In 1986 and 1987, Georges Bank contributed appreciably to the landings of the Bay of Fundy fleet (in the order of 500 t +). In 1988, almost 2,800 t were landed in Digby alone. However, with good catch-rates at home, the fleet did not venture very far and only 15 t may be attributed to Georges Bank.

Moreover, it is very difficult to get a reliable estimate of the total catches of the inner Bay of Fundy because of the delineation of the statistical areas 4Xr and 4Xs and the involvement of more than one fleet in the pursuit of the Bay of Fundy scallop fishery. In the early 1980s stocks in the Brier Island area located in the approaches to the Bay of Fundy sustained a fair exploitation according to logged catches (Robert et al 1984); statistically speaking, these catches were recorded from NAFO sub-subarea 4Xr to the same extent as catches from the traditional grounds. Since 1986, fishing around Brier Island has been minimal. Statistical catches from NAFO sub-subarea 4Xs include catches from the Upper Bay of Fundy fleet near the upper end of the Bay, some of the catches from the distant side of the traditional grounds and all the catches from the Grand Manan area and the nearshore beds along the New Brunswick coast fished mainly by the Mid-Bay license holders of New Brunswick. Since1986 a sizable and increasing fraction of catches are statistically recorded under the generalistic sub-area 4X.

Adequate estimates for catches on the traditional grounds are difficult to obtain as, for one main reason, all catches which should be logged are not. Non-compliance with logbook completion has developed into a serious problem over the last few years. Since this fishery operates on the equivalent of seasonal closures i.e. inside and outside fishing zones, catches may be partitioned according to the zones and we may assume that catches from October to April, coming from the inside zone and statistical catches for sub-subarea 4Xr covering that time period should match relatively well. That is, providing for no activity in the area when the season is closed. We further assume that effort and catch-rates associated with Class 1 catch data for that area during that time period are representative of the overall fishing performance. Statistical catches from the outside fishing zone (4Xr + 4Xs) i.e. May-September fit more loosely with Class 1 logged catches (Table 6). With very high levels of catches being statistically recorded under the generalistic sub-area 4X, especially since the last two years, we had to devise our own catch tabulation system to derive a better estimate of the productivity of the grounds than what the statistical catches could offer. These catch estimates appear in table 6. They correspond better to the landings profile than the statistical catches. With enhanced productivity in the Bay it is also safe to postulate that the fleet landings have, in all probabilities, not originated outside the Bay during that time period.

If we relate the inside statistical catches and catch-rates on a per season basis (Table 6), catch-rates around 7 kg/hm and about 250 t per season were maintained prior to 1980-81. Then catches increased sharply, up to 565 t in 1982-83, while CPUE went down to 5 kg/hm. This was followed by a dramatic decline both in terms of quantities caught and catch-rates with a very poor performance for 1985-86. Catch-rates continued to drop when the 1986-87 season opened and

catches were very low. Only small scallops were beginning to get caught in any amounts and the area was closed prematurely at the request of the fishermen. After an unusual opening to the 1987-88 inside season, the monthly catch-rate for October reached 25 kg/hm; mean catch-rates for the season rose significantly to 13 kg/hm. Only 10 % of our estimated catches (1,100 t) refer to class 1 logged data. This is a very low fraction of our estimated total. But at present, the fleet has not got access to any other grounds but the traditional beds off Digby to account for such high figures. Selected fishermen interviews and surveillance reports also support these estimates. The resurgence of the fishery has not carried over to the outside fishing zone though. There is only a slight improvement in the outside zone catch-rates (3.52 kg/hm for the 1987 summer and 6.06 kg/hm for the 1988 summer). Catches for the 1988 summer are questionably high at 930 t but this value is highly suspected to contain an unknown, large, quantity caught inside the 8-mile line.

At the beginning of the 1988-89 inside season, CPUE have almost doubled at 22.4 kg/hm from the previous season (12.9 kg/hm) while for the first half of the season, until December only, catches were already 50 % more than the 1987-88 season.

A catch history series (over 65 years) for the inside zone (or time period October-May when a restricted fishing zone was not in effect) illustrates (Fig. 1) that sharp rises and downfalls have often taken place over the existence of this fishery. However, despite landings over 1,100 t during 1987-88, catches have not peaked yet given the preliminary figure for the first half of the 1988-89 season. Such figures surpass any other height experienced by that fishery.

Monthly catch-rates (kg/hm) during the inside fishing season (Fig. 2) show a slight decrease from the beginning to the end within each fishing season. Since the 1983-84 season CPUE had remained in the range of 2-4 kg/hm with relatively little variation within a month and between months until the fishery closed prematurely in December 1986. At that time considerable amounts of small scallops (75 mm shell height) were being caught but the meat size was too small to improve CPUE. When the fishery resumed a year later (1987-88 season) performance had improved considerably. October had a mean catch-rate of 25 kg/hm (s.d. 17.68). Although CPUE stayed high throughout the season compared to previously, there was a downward progression from October (25 kg/hm) to April (7 kg/hm). The within season CPUE decrease was not caused by the lack of scallops but rather by their small size. The average meat weight was only 10 g when the season opened (Table 7).

There is relatively little information available on meat weight distribution of catch from the inside zone. Port sampling activities outside of the summer season have always been minimal and the fragmentary data may not be representative. It seems that, until the 1987-88 season, meat weights were of good size giving meat counts in the 20 - 30 (meats per 500 g) range (Table 7). Meats fished in October 1987 weighted 10 g on average and belonged to the abundant pulse coming into the fishery. This is an important reduction in size compared to the traditional meat size associated with the Digby fishery. A meat count of 55 meats per 500 g became regulation for the inside zone in December 1987 so that this meat size is the smallest that may be legally caught. The fact that the actual meat count experienced in October 1987, 50.3 meats per 500 g was close to the regulated 55 meats and that growth processes slow down from October onward may be responsible for the declining performance during the 1987-88 season. The 1988 summer growth season made a difference as, while exploiting the same scallop beds, the average meat weight increased to 13.5 g (October) and 15.1 g (November) when the 1988-89 season opened.

By whatever yardstick one chooses, 1988 was an exceptional year for the Bay of Fundy fleet. Most months saw landings of over 200 t of scallop meats (Figure 3) with a spectacular increase in the fall opening of the inside zone. Catches reached 835 t for October with a mean CPUE of 27.7 kg/hm (s.d. 8.6) at a meat count of 37 per 500 g. Over 80 % of the Bay of Fundy license holders were involved in the fishery after a gradual increase in participation rate from June on. Weather took its toll as Nov.-Dec. catches are lower than October's. CPUE also decreased but stayed high enough to retain well over 80 % of the participants active in the fishery.

Annual stock surveys have been carried out for a number of years (Table 8) with slight changes in the number of stations per stratum according to the fishery performance from a catch

or an area perspective. For example, lately the fleet had shifted from the Centreville area to the Young Cove-Hampton area. For the survey to represent the areas fished, sampling stations were added in 1985 and the Centreville area was phased out in 1988 while the core area remained intact. Tables 9-11 present a detailed history of survey catch-rates by catch, area, and zone stratum for the last 3 years. Average number per tow started to improve with age 2 in 1986 although the gear, even lined, is not catching this age class reliably. An important recruitment pulse manifested itself more clearly in the 1987 survey with sizable numbers of prerecruits (ages 2-4) per standard tow, especially in the Digby Gut area. This pulse is followed through in 1988. However, results for that last survey indicate that the abundance of the youngest class (age 2) sampled is declining again, except for a small patch in the Gulliver's Head area.

Table 12 and Figure 4 give a time series profile for prerecruits and recruits since 1981. Prior to 1986, the recruitment outlook was rather bleak but it improved considerably afterward (fig. 4). Increased abundance of prerecruits was most noticeable in the core area from Gulliver's Head to Delaps Cove; adjacent areas do not appear to have received as many prerecruits. The pattern of young recruits (ages 5-7) also initiated an upward trend in 1986 when the fleet intensified its exploitation of scallop beds upstream from Parker's Cove. This rise was continued in 1987 and 1988 with the first segments of the strong pulse coming of recruiting age.

Abundance at age per standard tow may also be plotted in an isopleth fashion, linking points of similar value along a 'contour' line, then graphically filling the surface between two isopleths with shades of grey, the darker the grey, the higher the abundance. Scallop distribution for the three most recent surveys was plotted for ages 2-9 (Figures 5, 6, and 7). Of interest, one may follow the apparent geographical dimensions of the strong pulse announced in 1986 with age 2 scallops. Survey catch-rates over 1,000 animals per tow are found again in 1987 and 1988 (although they overlap more than one age class). The high density patch stretches over the core area with its longest dimension parallel to the coastline but it is not very wide, 5 nautical miles at most. In quite a few contour plots important aggregations show a tendency to deploy themselves with their longest axis parallel to the coast. This is most noticeable in young age groups that fishing activities have least disturbed yet (cf. ages 3-4 in 1986; 2,4, and 5 in 1987; 3-5 in 1988). Recruited age groups show less definition in their distribution patterns; such densities are also much lower of course. These plots confirm the restricted location of the recruitment pulse to the inside fishing zone, leaving the outside fishing zone with much lower densities of both prerecruits and recruits (1988 in particular for recruited age groups beyond age 5).

Abundance estimates may also be derived from the survey data by calculating volumes under the contoured surface (Table 13). Subtriangulation of the surface may be used as an interpolation technique to smooth the contours, hence adding refinement to the volume estimates. But one has to balance smooth drawing of the contoured surface with a realistic representation of the scallop distribution. Depending on the level of smoothness reached, we used up to 100 subtriangles, the difference between the lowest and highest volume computed usually ranges from under 1 to about 5 % (Table 13). This technique also identifies the passage of the strong recruitment pulse in the stock; furthermore, it too found an important reduction in the youngest incoming year class in 1988.

The Upper Parts of the Bay of Fundy

The Upper Parts of the Bay of Fundy designation applies to the waters of the Bay included in the Upper Bay Management Zone. This zone includes the area east of a line drawn between Annapolis and Kings County on the Nova Scotia side of the Bay and between Saint John and Albert Co. on the New Brunswick side. Historically speaking, Minas Basin and Chignecto Bay at the upper end of the Bay of Fundy are not scallop-producing areas. Until recently, landings of less thant 10 t of meats per year had been recorded. Local fishermen have become interested in the scallop fishery in the 1980's. To participate in the fishery, vessels, all under 14 m L.O.A., are issued a Upper Bay (3-mile) scallop license. Up to 1986 there had been 14 licenses issued annually with only one vessel over 25.5 G.T. (Table 14); licenses have increased by 2-3 since then. Most of these licenses used the privilege. A few of these licenses are issued in New Brunswick (Albert Co. where there are also Mid-Bay scallop license holders) with the remainder in Colchester and

Cumberland, Kings Counties, Nova Scotia. In all likelihood these small vessels land their catches at home ports in Cumberland Co. (statistical districts 24, 40, 43, and 44) and Albert Co. (79). Landings from these districts reflect the productivity of the Upper Parts of the Bay of Fundy (Isle Haute, Quaco Ledge, areas northeast of the Ledge). Since 1983, landings were gradually increasing (Table 16) with fishing taking place between April and October; 1986 shows a temporary decline before rebounding in 1987. Landings continued to surge in 1988, to 80 t, almost doubling the previous year's value. Advocate Harbour (district 44) and Alma (district 79) witnessed this increased activity, mainly in May and August. Landings for district 79 include catches from both Mid-Bay and Upper Bay license holders. Landings by statistical district compare well with the summation of landings of all vessels located in the area. Concurrently to a sizable improvement in total landings, average annual landing per vessel has tripled (Table 15) from 1,000 kg per vessel in 1986 to almost 3,000 kg in 1988. Some vessels have landed considerably more than average while others landed as little as 100 kg. Scallop fishing may only be considered as an accessory activity in a multi-fishery system. Since these vessels are under 25.5 G.T. they are not required to provide effort data by logbooks; hence there is little fishery information available. According to recent surveys, scallop abundance is fairly limited in the immediate area (Chandler et al 1989). The recent catch improvement is more likely the result of increased effort as reported by local fishermen rather than a rise in available stocks.

DISCUSSION

Fishery performance

Statistics on catches are unreliable because of the extremely poor logbook compliance. According to our estimates, the fishery on the traditional Digby beds has experienced record landings in 1988. Commercial catch-rates have been high, over 25 kg/hm provided that the log information available is representative. Meat yields (13-15 g) were also good when sampled at the beginning of the 1988-89 season. From a point of view of yield per recruit such meat counts are almost optimal under low exploitation (F under 0.8) levels; however, under high exploitation (F over 0.8) they could still be reduced by 25 % (Robert et al 1988). Survey results indicate the existence of appreciable quantities of young recruits and some prerecruits on the commercial beds. They discount the idea that juveniles (under 75 mm shell height) scallops settle and live on feeder beds to later migrate on beds where adults are found.

Impact of regulations

Newly introduced regulations: meat counts for the inside and outside fishing zones, a minimum shell height of 76 mm, and the extension of the seasonal closure line from 6 to 8 miles have had some effects on the fishery. For the time period Jan.-Apr 1988 average monthly meat counts performed by Fisheries Officers range between 51 and 55, the regulation stipulating a 55 count for the zone fished at that time. The minimum shell height measure had been required because of the small size animals belonging to the strong recruitment pulse captured when the 1987-88 inside season had opened; but the effects of that measure were considerably less at the opening of the 1988-89 season. The pulse scallops had grown above the 76-mm threshold. The extension of the seasonal closure line has limited access to some productive scallop beds in the summer time to save more for winter fishing or at least such was the intention. The implementation of this measure has encountered some difficulties.

Survey abundance estimates

Although survey abundance estimates derived from volume computations are presented; a few cautionary notes are in order. Differences exist between the areas surveyed each year and the figures are not necessarily comparative. A procedure is being developed toward this end. The smoothing interpolation technique produces a range of volume estimates (see figure 8 number of

chords used). For a particular set of data no smoothing (chord 1) may produce the smallest volume estimate; in fewer cases, it will give the highest estimate. It seems that a certain level of stability is reached with the number of chords equal to 4. Youngest age groups seem to offer the greatest spread (of volume estimates) within one set of data. A biological explanation may be that young scallops are more highly aggregated over an area than older animals that have been thinned out and dispersed by fishing activities. Therefore the contouring of young age groups may deal with steeper gradients over a particular distance. The abundance of scallops at the site sampled and the distances to neighboring points have both to be taken into consideration like moments in mechanical physics.

Given the minimum abundance estimates derived from the 1988 survey data represent the stocks over the core area, a minimum recruited (ages 5+) biomass figure can be calculated to obtain an appreciation of the recruitment pulse now present on the traditional beds. Gear efficiency should also be factored in with a value of 10-20 %(see Robert and Lundy 1988) for the purpose of the exercise. Then, recruited biomass may vary between 17,200 and 8,600 t respectively. Such figures would be in line with the recent catches and catch-rates that do not show any signs of reduction more particularly in the inside fishing zone.

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Table 1.- Characteristics of scallop samples collected from the commercial fleet for meat yield analysis from 1982 to 1986.

Temporal variability of collection. N(n): Number of samples(number of scallops in samples).

	1982	1983	1984	1985	1986	Totals
First quarter	2(57)	2(48)	2(60)	8(240)	3(90)	17(495)
Second "	5(149)	9(268)	4(118)	9(270)	6(180)	33(985)
Third "	9(267)	10(300)	7(210)	13(390)	7(209)	46(1376)
Fourth "	2(44)	2(60)	7(190)	7(208)	1(30)	19(532)
Totals	18(517)	23(676)	20(578)	37(1108)	17(509)	115(3388)

Statistics of scallop data collected

Year	N	Mean	S.D.	Min	Max
Shell height (mm)					
1982	517	102	13.5	65	145
1983	676	105	11.7	75	145
1984	578	105	13.8	53	150
1985	1108	102	12.6	65	145
1986	509	99	10.2	72	129
Meat weight (g)					
1982	517	13.38	7.39	2.95	55.75
1983	676	12.53	6.98	3.60	53.52
1984	578	14.91	7.49	1.44	46.71
1985	1108	13.67	6.71	2.94	47.63
1986	509	9.05	3.76	2.48	23.44

Grouping on a percentage basis according to:

Shell height

Year	N	% <100mm	% ≥100mm
1982	517	44	56
1983	676	36	64
1984	578	30	70
1985	1108	42	58
1986	509	52	48

Meat weight

Year	N	% <10g	% 10-11.9g	% 12-14.9g	% ≥15g
1982	517	38	12	20	30
1983	676	43	20	16	21
1984	578	26	16	19	39
1985	1108	36	11	18	35
1986	509	67	16	9	8

Table 2.- Number of vessels carrying a Bay of Fundy scallop license from 1979 to 1988. Eligible and banked licenses are not included here. Source: Licensing Unit, Fisheries and Oceans, Halifax. Number of vessels based in Nova Scotia + number of vessels based in New Brunswick.

Year	under 25.5 G.T.		over 25.5 G.T.		Total
	under 14m	14-19.8m	under 14m	14-19.8 m	
1979	9 + 13	2 + 0	1 + 0	41 + 7	73
1980	5 + 13	1 + 0	2 + 0	52 + 7	80
1981	8 + 14	1 + 0	3 + 0	64 + 6	96
1982	8 + 8	1 + 0	4 + 4	65 + 4	94
1983	3 + 7	1 + 0	7 + 5	67 + 5	95
1984	2 + 7	0 + 0	7 + 5	70 + 5	96
1985	2 + 7	0 + 0	7 + 4	71 + 3	94
1986	1 + 7	0 + 0	7 + 5	70 + 3	93
1987	0 + 6	0 + 0	8 + 4	68 + 5	91
1988	1 + 5	0 + 0	9 + 4	72 + 7	98

Table 3.- Number of (1) Bay of Fundy licensed vessels (Source: Licensing Unit, Fisheries and Oceans, Halifax), (2) active fishing licenses for vessels over 25.5 G.T. supposed to follow log procedures, and (3) vessels complying with log procedures.

Year	(1)	(2)	(3)
1981	96	68	65
1982	94	66	63
1983	95	77	74
1984	96	82	76
1985	94	70	67
1986	93	67	57
1987	91	80	44
1988	98	91	16

Table 4.- Additional licenses carried by Bay of Fundy scallop license-holders for the year 1988. This table considers 99 Bay of Fundy scallop licenses only. During 1988, 3 Bay of Fundy licenses were new issues; another one was eligible but not renewed. Source: Licensing Unit, Department of Fisheries and Oceans, Halifax.

Types and number of other licenses	
Groundfish (otter trawl, long lining, etc.)	67
Swordfish	50
Herring	17
Lobster	9
Squid	12
Shrimp	2
Mackerel	1
None	13
total	171

Number of Bay of Fundy scallop license-holders with ' n' additional licenses.

13	license-holders	do not carry	additional license(s).
32	"	carry	1 additional license.
41	"	"	2 additional licenses.
10	"	"	3 " "
1	"	"	4 " "
2	"	"	5 " "
total 99			

Table 5.- Annual landings (t of scallop meats) by statistical district (Digby Neck, Digby, and Annapolis); by vessel tonnage, (1): ≤ 25.5 G.T., (2): > 25.5 G.T. Prior to 1967, landings were not segregated by vessel tonnage. Source: Statistics Division., Fisheries and Oceans, Halifax.

District	37		38		39	
Tonnage	(1)	(2)	(1)	(2)	(1)	(2)
1960		102.17		157.23		0.84
1961		80.60		303.49		1.93
1962		-		355.42		8.43
1963		17.47		512.29		0.48
1964		90.48		530.48		2.89
1965		-		476.99		19.16
1966		-		234.94		7.23
1967	0.96	5.42	39.04	115.66	-	4.94
1968	-	5.42	53.49	329.28	-	5.42
1969	4.10	56.27	33.13	176.87	-	6.75
1970	2.29	74.82	18.55	161.93	0.48	1.81
1971	4.94	69.88	10.00	104.34	3.61	3.61
1972	17.23	24.94	16.75	222.77	-	4.10
1973	0.96	10.00	16.39	130.24	-	7.23
1974	-	0.60	11.69	54.22	-	3.13
1975	-	-	22.29	96.99	-	6.27
1976	-	21.81	24.46	479.76	-	21.33
1977	10.00	96.75	35.66	766.99	1.08	24.22
1978	-	120.00	33.49	570.24	1.45	20.96
1979	2.29	54.94	22.53	685.42	6.27	15.90
1980	10.60	49.40	18.31	696.02	4.34	5.90
1981	28.55	147.35	3.98	1080.24	0.48	1.69
1982	28.31	106.51	21.20	915.42	-	7.95
1983	12.05	43.61	19.28	722.53	0.72	26.99
1984	5.90	53.98	7.59	564.22	0.24	29.88
1985	-	28.67	8.18	554.34	0.48	18.31
1986	-	45.05	2.52	398.43	1.68	10.34
1987	-	56.75	21.55	844.23	-	26.99
1988	-	59.40	27.71	2735.66	-	75.54

Table 6.- Fishery characteristics for Bay of Fundy licensed vessels (14-19m) on a fishing zone basis. Statistical catches (Stats) for the inside zone corresponds to NAFO sub-subarea 4Xr; statistical catches for the outside zone are for NAFO sub-subareas 4Xr plus 4Xs. Class 1 logged catches were used to estimate CPUE.

Year	Inside zone (Oct-Apr)			Outside zone (May-Sep)		
	Catches (t meats)		CPUE	Catches (t meats)		CPUE
	Stats	Class 1	kg/hm	Stats	Class 1	kg/hm
1976-77	251.71	99.83	7.99	122.80	24.33	3.38
1977-78	238.27	180.18	7.29	188.02	141.84	4.88
1978-79	247.70	220.01	6.85	214.02	167.89	4.54
1979-80	280.22	245.44	6.95	161.33	131.80	3.88
1980-81	413.60	290.15	6.87	390.07	173.04	4.78
1981-82	417.80	304.40	6.86	429.65	160.74	4.65
1982-83	565.16	372.57	5.03	479.49	205.00	4.71
1983-84	319.15	267.66	3.59	397.35	267.22	3.06
1984-85	270.26	277.85	3.15	322.77	262.13	2.56
1985-86	121.33	142.37	2.36	282.51	274.86	2.25
1986-87	39.24	**21.21	1.81	90.54	56.62	1.92
1987-88	*1096.28	103.78	12.73	***129.97	26.39	3.52
1988-89	****1570.41	111.30	22.41	*929.41	86.13	6.06

*our estimate.
**The inside zone was closed from Jan. 1 to April 30, 1987 (end of season). During that time period, CPUE was 2.09 kg / hm in the remainder of the Bay (NAFO 4Xr plus 4Xs).
***we estimate over 100 t. to have been caught in the inside zone during Aug - Sept.
****our estimate for October to December only.

Table 7.- Characteristics of the meat size distribution in the commercial fishery while fishing the inside zone.

Season	Month	Meat weight				Sample size	Meat count
		Mean	Min	Max	S.E.	(n meats)	per 500 g
1978-79	Apr	17.9	5.6	33.7	0.4	78	27.9
1979-80	Oct	20.6	6.5	86.4	0.4	229	24.3
	Nov	21.8	5.3	44.4	0.3	374	23.0
1980-81	Oct	26.0	5.6	60.2	0.5	329	19.2
	Dec	24.5	5.1	59.5	0.8	137	20.5
	Feb	22.0	5.2	50.5	0.3	681	22.8
	Mar	22.0	6.3	50.0	0.3	572	22.8
1981-82	Oct	27.2	5.7	54.2	0.6	177	18.4
	Nov	24.1	3.7	77.9	0.3	849	20.8
1982-83	Oct	24.9	5.0	69.4	0.4	632	20.1
	Nov	27.4	5.9	62.6	0.6	231	18.3
1983-84	Apr	18.8	2.3	55.5	0.1	1807	26.6
1984-85	Oct	25.1	4.2	63.6	0.1	2250	19.9
	Apr	19.6	3.7	57.5	0.3	503	25.5
1985-86	Oct	28.5	5.9	56.2	0.2	809	17.6
1986-87	Oct	17.7	2.3	57.5	0.2	1743	28.2
1987-88	Oct	10.0	2.5	55.1	0.1	3215	50.3
1988-89	Oct	13.5	3.3	48.0	0.1	3770	37.1
	Nov	15.1	5.5	51.2	0.1	1100	33.0

Table 8.- Number of survey stations in the Digby area by year and by stratum types. In 1988, there were also 4 stations located in the Annapolis Basin; this is not indicated on a per area stratum.

Year	1981	1982	1983	1984	1985	1986	1987	1988
Catch stratum:								
low (0 - 1%)	15	29	40	40	48	49	48	19
medium (1 - 3%)*	17	20	20	20	28	27	27	26
high (> 3%)*	38	22	15	15	14	14	14	30
exploratory	--	30	25	25	30	30	30	29
total	70	101	100	100	120	120	119	104
Area stratum:								
Centreville	3	19	20	20	21	16	4	0
Gulliver's Head	22	20	28	23	29	21	23	15
Digby Gut	41	49	35	40	30	42	45	34
Delaps Cove	4	9	14	12	18	14	13	18
Parker's Cove	--	4	3	5	14	12	13	12
Young Cove	--	--	--	--	--	3	10	10
Hampton	--	--	--	--	8	9	11	11
Zone stratum:								
inside 6-mile	27	50	40	49	58	48	38**	45
outside 6-mile	43	51	60	51	62	72	81**	59

* 2% in 1981.
** ratio is 53, 66 stations for inside / outside 8-mile.

Table 9.- 1986 stock survey. Average number of scallops at age caught in a seven-gang Digby drag projected from an end, unlined bucket for recruits (age >4 years) and from a centre, lined bucket for prerecruits (age ≤4 years).

	Age (years)								
	2	3	4	5	6	7	8	9	10+
Catch stratum:									
low	146	19	12	33	41	38	25	15	18
medium	556	157	16	18	20	21	17	16	23
high	482	110	25	19	19	18	18	13	20
exploratory	534	136	23	16	24	29	26	20	42
Area stratum:									
Centreville	77	24	22	13	29	37	33	22	35
Gulliver's Head	201	72	20	22	29	33	30	19	27
Digby Gut	671	176	22	20	21	24	25	22	34
Delaps Cove	744	97	19	24	20	21	19	13	24
Parker's Cove	15	5	3	34	44	25	10	2	4
Young Cove	40	4	0	27	51	69	6	4	6
Hampton	48	7	7	45	51	39	8	7	7
Zone stratum:									
inside 6-mile	591	186	18	10	16	17	10	9	17
outside 6-mile	230	26	17	33	38	38	31	21	30

Table 10.- 1987 stock survey. Average number of scallops at age caught in a seven-gang Digby drag projected from an end, unlined bucket for recruits (age >4 years) and from a centre, lined bucket for prerecruits (age ≤4 years).

	Age (years)								
	2	3	4	5	6	7	8	9	10+
Catch stratum:									
low	167	445	469	71	25	23	17	10	22
medium	217	328	617	124	24	15	8	9	19
high	480	464	490	333	45	20	10	2	7
exploratory	29	209	184	26	23	21	20	16	31
Area stratum:									
Centreville	14	76	53	31	66	52	56	38	92
Gulliver's Head	220	195	208	83	28	22	21	15	24
Digby Gut	276	554	775	182	25	19	14	11	34
Delaps Cove	208	641	824	101	20	18	22	8	19
Parker's Cove	19	154	48	18	32	21	11	3	3
Young Cove	39	82	13	37	42	24	7	6	13
Hampton	55	189	20	13	23	26	11	3	1
Zone stratum:									
inside 6-mile	457	373	727	253	18	10	8	7	22
outside 6-mile	51	355	296	31	31	26	18	11	22

Table 11.- 1988 stock survey. Average number of scallops at age caught in a seven-gang Digby drag projected from an end, unlined bucket for recruits (age >4 years) and from a centre, lined bucket for prerecruits (age ⩽4 years).

	Age (years)								
	2	3	4	5	6	7	8	9	10+
Catch stratum:									
low	19	94	141	390	95	26	17	7	7
medium	6	97	180	887	114	38	23	12	17
high	4	241	572	885	540	47	9	5	20
exploratory	82	255	545	712	271	46	17	11	20
Area stratum:									
Annapolis Basin	25	69	372	146	115	22	4	4	28
Gulliver's Head	153	446	930	848	368	69	22	13	22
Digby Gut	4	235	552	1239	514	48	11	7	23
Delaps Cove	2	103	217	1010	226	24	15	9	20
Parker's Cove	12	60	85	173	36	22	21	12	7
Young Cove	5	43	68	98	32	31	16	6	8
Hampton	29	106	149	91	50	41	22	7	2
Zone stratum:									
inside 6-mile	52	298	662	788	527	55	12	7	19
outside 6-mile	11	94	178	715	87	30	19	10	15

Table 12.- Summary of average number of scallops at age caught for prerecruits and recruits by area stratum.

	Age (years)		
	2-4	5-7	8 +
1981			
Centreville	31	222	174
Gulliver's Head	475	208	85
Digby Gut	47	167	94
Delaps Cove	13	35	172
1982			
Centreville	35	237	129
Gulliver's Head	41	175	123
Digby Gut	23	130	74
Delaps Cove	10	93	90
Parker's Cove	0	1	29
1983			
Centreville	24	113	73
Gulliver's Head	38	166	75
Digby Gut	32	122	81
Delaps Cove	22	139	96
Parker's Cove	0	3	0
1984			
Centreville	31	71	44
Gulliver's Head	33	147	71
Digby Gut	17	75	49
Delaps Cove	12	57	50
Parker's Cove	0	30	4
1985			
Centreville	26	82	77
Gulliver's Head	13	79	59
Digby Gut	14	53	64
Delaps Cove	9	55	71
Parker's Cove	3	45	33
Hampton	0	39	67
1986			
Centreville	123	79	90
Gulliver's Head	293	84	76
Digby Gut	869	65	81
Delaps Cove	860	65	56
Parker's Cove	23	103	16
Young Cove	46	147	16
Hampton	62	135	22

continued

Table 12.- Continued. Summary of average number of scallops at age caught for prerecruits and recruits by area stratum.

	Age (years)		
	2-4	5-7	8 +
1987			
Centreville	143	149	186
Gulliver's Head	623	133	60
Digby Gut	1605	226	59
Delaps Cove	1673	139	49
Parker's Cove	221	71	17
Young Cove	134	103	26
Hampton	264	62	15
1988			
Annapolis Basin	116	283	36
Gulliver's Head	1529	1285	57
Digby Gut	791	1801	41
Delaps Cove	322	1260	44
Parker's Cove	1897	231	40
Young Cove	116	161	30
Hampton	284	182	31

Table 13.- Abundance estimates on an age basis for the 1986-88 surveys from the summation of volumes underneath a contoured surface. Estimate varies depending on the refinement of the subtriangulation process (see text). Minimum and maximum estimates are given with the percentage difference between the two. Numbers are in 10^6.

	Age (years)							
	2	3	4	5	6	7	8	9
1986 survey, 1897 km ^{2}								
minimum volume	130.81	28.60	6.58	16.86	16.68	14.33	10.97	7.59
maximum volume	137.42	30.64	6.93	17.16	17.62	15.22	11.34	7.67
percentage difference	4.8	6.7	5.1	1.7	5.3	5.8	3.3	1.0
1987 survey, 1650 km ^{2}								
minimum volume	58.21	111.54	136.85	31.86	9.07	7.69	5.82	3.27
maximum volume	61.74	114.73	143.17	34.28	9.18	7.76	5.99	3.41
percentage difference	5.7	2.8	4.6	7.1	1.2	0.9	2.8	4.1
1988 survey, 1223 km ^{2}								
minimum volume	4.72	46.66	92.87	203.84	60.32	10.46	5.05	2.80
maximum volume	5.51	47.49	94.43	209.79	60.76	11.06	5.33	2.83
percentage difference	14.3	1.7	1.7	2.8	0.7	5.4	5.3	1.1

Table 14.- Vessels licensed for scallop fishing in the upper parts of the Bay of Fundy. These licenses used to be called 'Cumberland' or 3-mile licenses. Their present appellation is 'Upper Bay of Fundy'. All vessels are less than 14 m long. Numbers in parenthesis indicate active licenses that submitted at least one sales slip during the year.

Year	under 25.5 G.T.	over 25.5 G.T.	Total
1983	14 (N / A)	0	14
1984	13 (N /A)	1 (1)	14
1985	13 (6)	1 (1)	14 (7)
1986	16 (10)	0	16 (10)
1987	16 (13)	0	16 (13)
1988	17 (16)	0	17 (16)

Table 15.- Mean annual landings per active vessel with an Upper Bay of Fundy or a Mid-Bay license landing in the Upper Bay statistical districts.

Year	Active licenses	Mean landing (kg)
	Upper Bay + Mid-Bay	
1985	7 + 11	1,597
1986	10 + 6	1,050
1987	13 + 4	1,903
1988	16 + 9	2,929

Table 16.- Landings in t of scallop meats by statistical districts in the upper parts of the Bay of Fundy. Districts 24 and 44 are in Cumberland Co., district 40 in Kings Co., district 43 in Colchester Co., Nova Scotia; district 79 is in Albert Co., New Brunswick. Source: Statistics Division, Fisheries and Oceans, Halifax, N.S.

Year	District	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983	24	--	--	--	0.24	--	--	--	--	--	--	--	--
	44	--	--	--	0.60	0.12	1.57	2.17	0.84	0.36	0.48	0.48	--
	79	--	--	--	2.77	0.24	0.72	0.84	4.22	2.89	0.60	--	0.24
		--	--	--	3.61	0.36	2.29	3.01	5.06	3.25	1.08	0.48	0.24
	total for year:	19.38											
1984	24	--	--	--	--	--	--	--	0.12	--	--	--	--
	44	0.12	0.24	0.84	--	--	--	--	--	--	--	--	--
	79	0.12	--	0.84	1.69	4.10	5.18	1.93	3.86	3.25	2.65	0.84	0.36
		0.24	0.24	1.68	1.69	4.10	5.18	1.93	3.98	3.25	2.65	0.84	0.36
	total for year:	26.14											
1985	24	--	--	--	--	--	--	--	--	--	--	--	--
	44	--	--	--	--	--	--	--	0.48	0.48	0.36	--	--
	79	--	--	--	4.46	4.94	3.01	3.37	6.14	4.10	0.72	--	--
		--	--	--	4.46	4.94	3.01	3.37	6.62	4.58	1.08	--	--
	total for year:	28.06											

Table 16.- Continued.

Year	District	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	40	--	--	--	--	0.12	--	0.24	0.12	0.24	--	--	--
	44	0.12	0.24	--	0.24	0.72	0.24	0.36	0.24	0.12	0.12	--	0.24
	79	--	--	--	2.65	4.34	2.29	1.93	2.41	1.69	0.24	--	--
		0.12	0.24	--	2.89	5.18	2.53	2.53	2.77	2.05	0.36	--	0.24
	total for year:	18.91											
1987	24	--	--	--	--	--	--	--	--	0.72	2.89	--	--
	40	--	--	--	0.12	0.24	--	--	--	0.24	--	--	--
	44	0.24	0.12	0.24	1.33	1.20	0.96	3.73	4.10	5.42	1.93	0.72	1.08
	79	--	--	--	1.20	0.72	0.12	--	7.71	5.66	0.36	--	--
		0.24	0.12	0.24	2.65	2.16	1.08	3.73	11.81	12.04	5.18	0.72	1.08
	total for year:	41.05											
1988	24	--	--	--	--	0.36	0.60	0.48	0.60	1.69	0.72	0.48	--
	40	--	--	--	0.36	1.33	0.60	0.36	--	0.96	--	--	--
	43	--	--	--	--	--	--	--	0.24	0.24	--	--	--
	44	--	--	1.57	4.22	4.82	2.17	5.42	12.29	6.87	2.41	1.20	1.08
	79	--	--	--	1.57	4.58	3.98	2.77	11.20	3.13	0.96	0.36	0.12
		0.00	0.00	1.57	6.15	11.09	7.35	9.03	24.33	12.89	4.09	2.04	1.20
	total for year:	79.74											

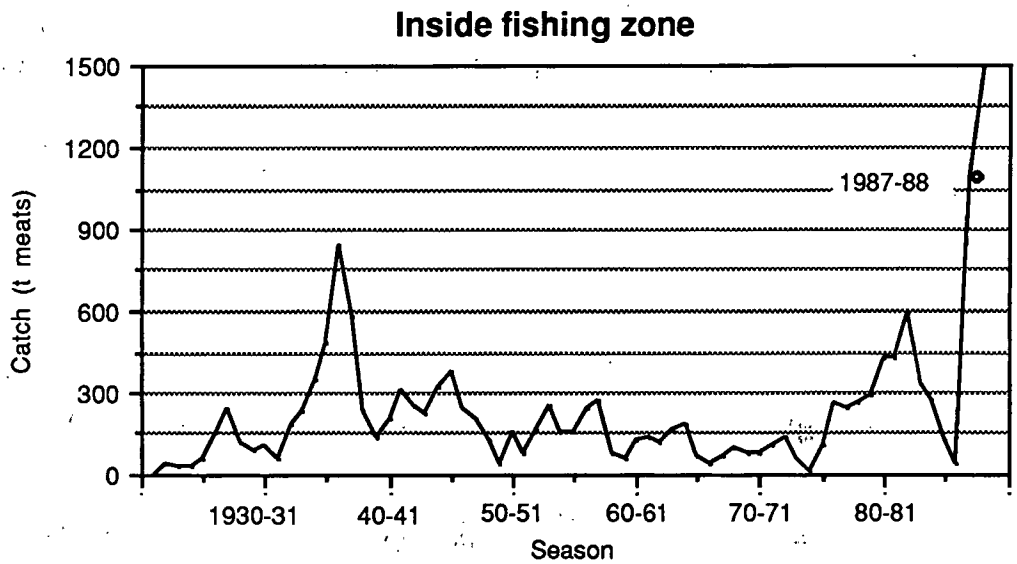

Figure 1.- Catch profile of a 65+ years time series for the traditional grounds off Digby of the inside fishing zone or catches recorded from October to April in NAFO sub-subarea 4Xr when a fishing zone did not exist. Source: Caddy (1979) up to 1972; then catches in NAFO sub-subarea 4Xr from October to April for vessels under 19.8m, Statistics Division, Fisheries and Oceans, Halifax. Catches for 1987 - 89 are from our estimates. The 1987-88 figure is at the level of the bold circle (●) on the steep incline. The 1988-89 figure is for the first half of the season only.

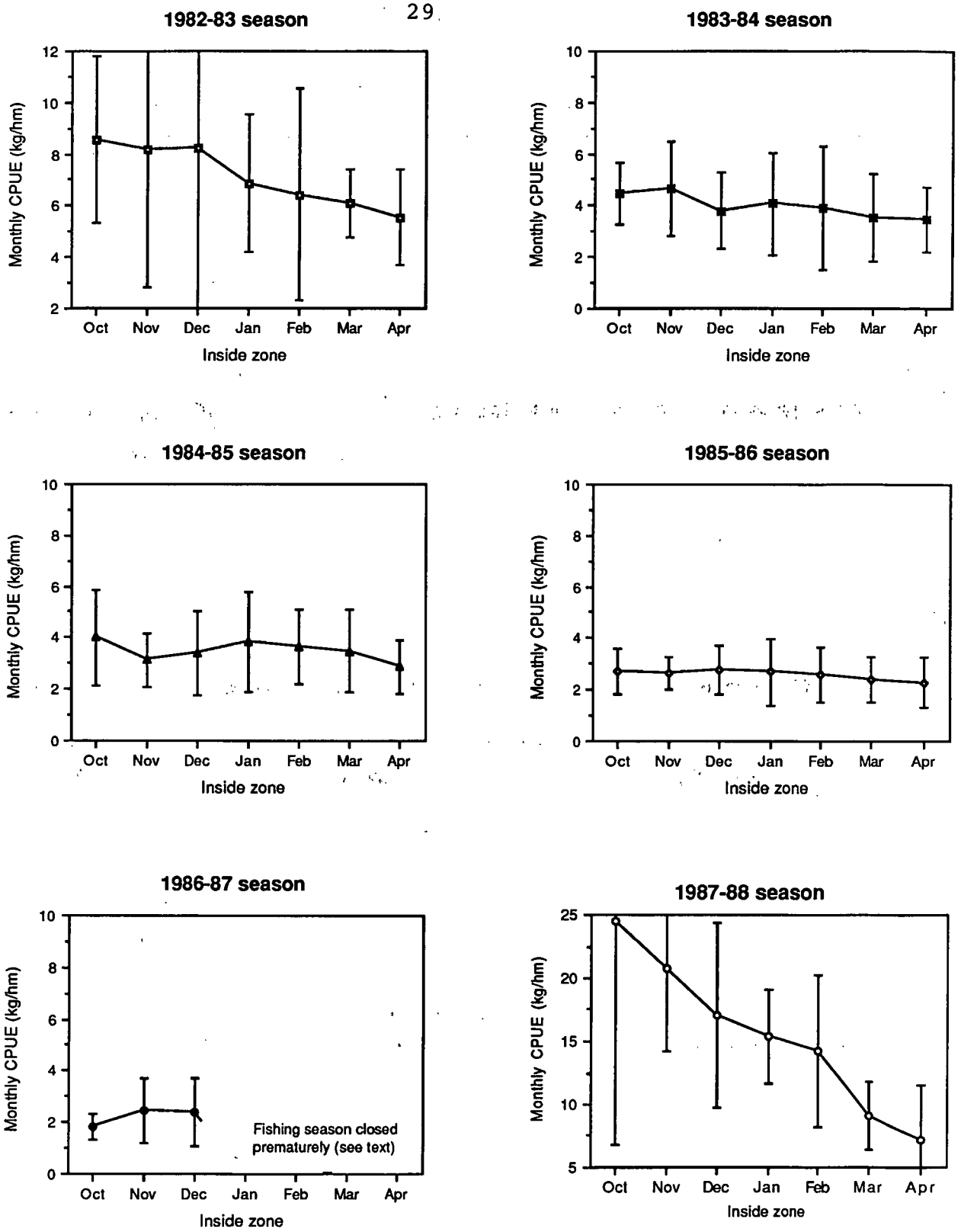

Figure 2.- Bay of Fundy fleet fishery performance. Monthly catch-rates (kilograms per hour-meter) during the inside fishing season in Nova Scotia for the period 1982 to 1988. Means and standard deviation are plotted.

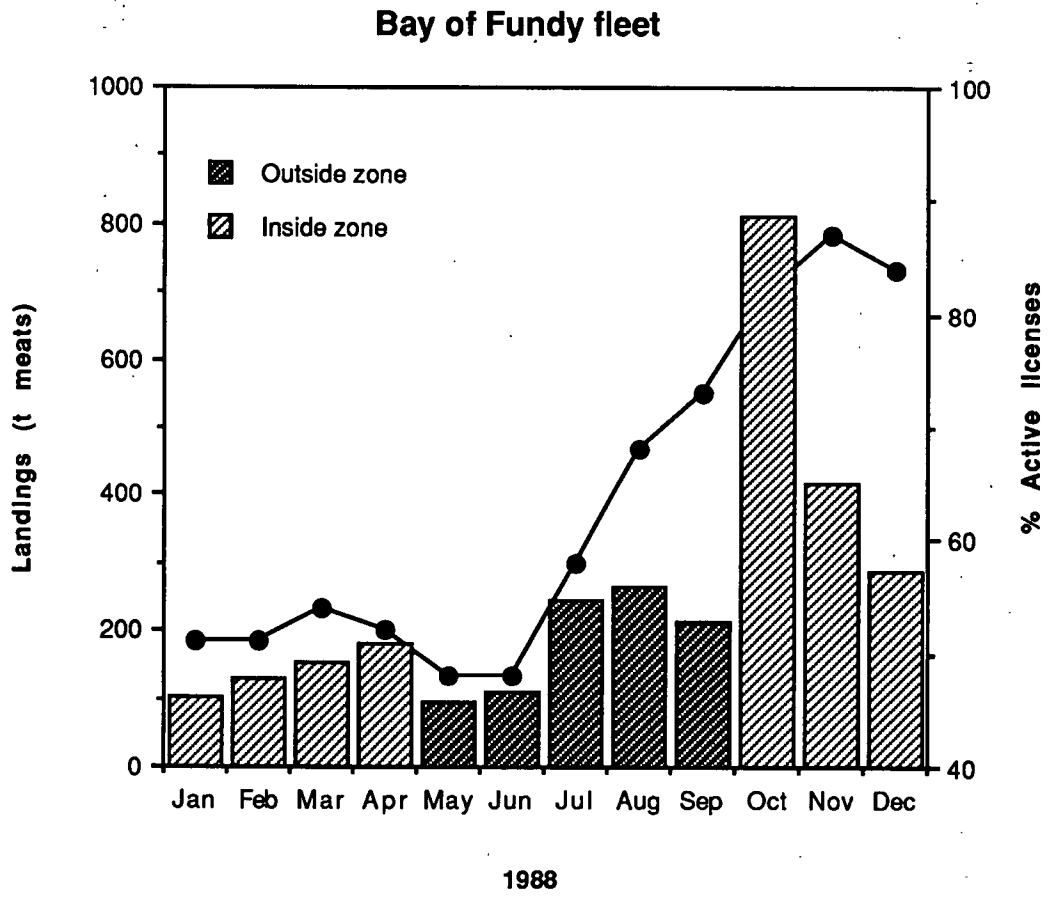

Figure 3.- Monthly landings according to zone fished during 1988 and percentage of Bay of Fundy license holders fishing on a monthly basis.

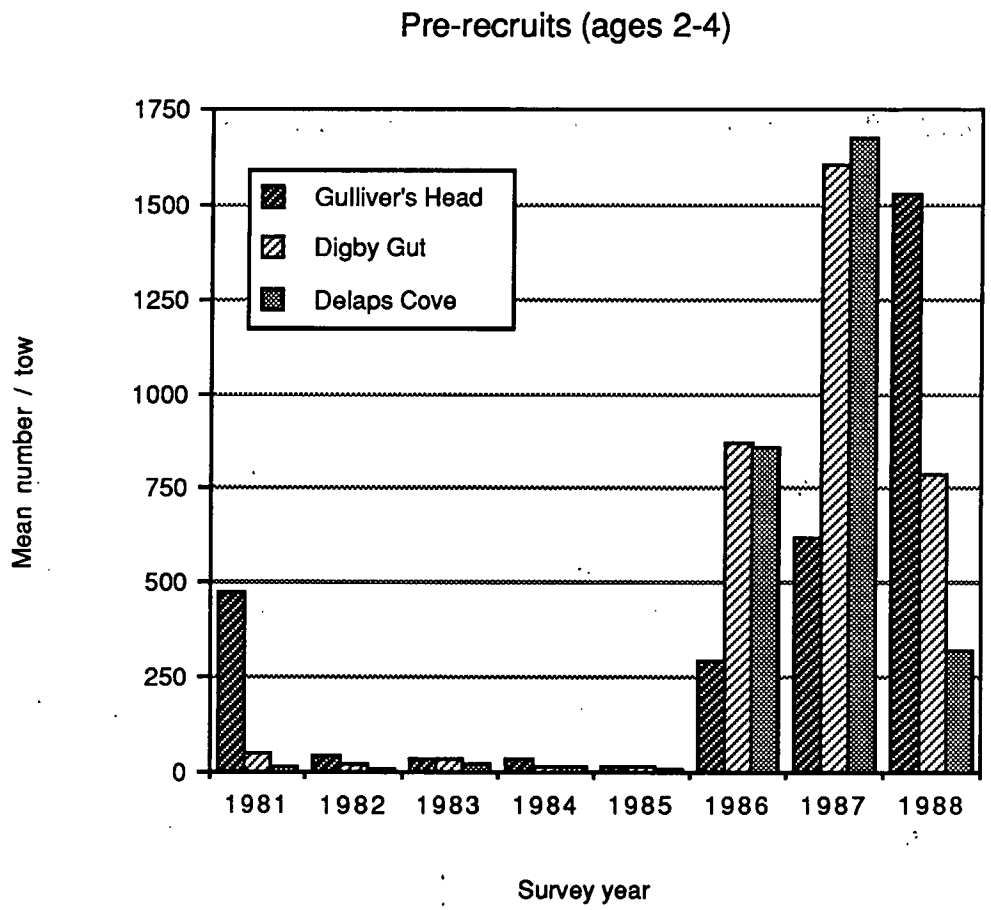

Figure 4.- Survey time series of the abundance of prerecruits. Survey catch-rates improved markedly starting in 1986 after a severe reduction that lasted 4 years.

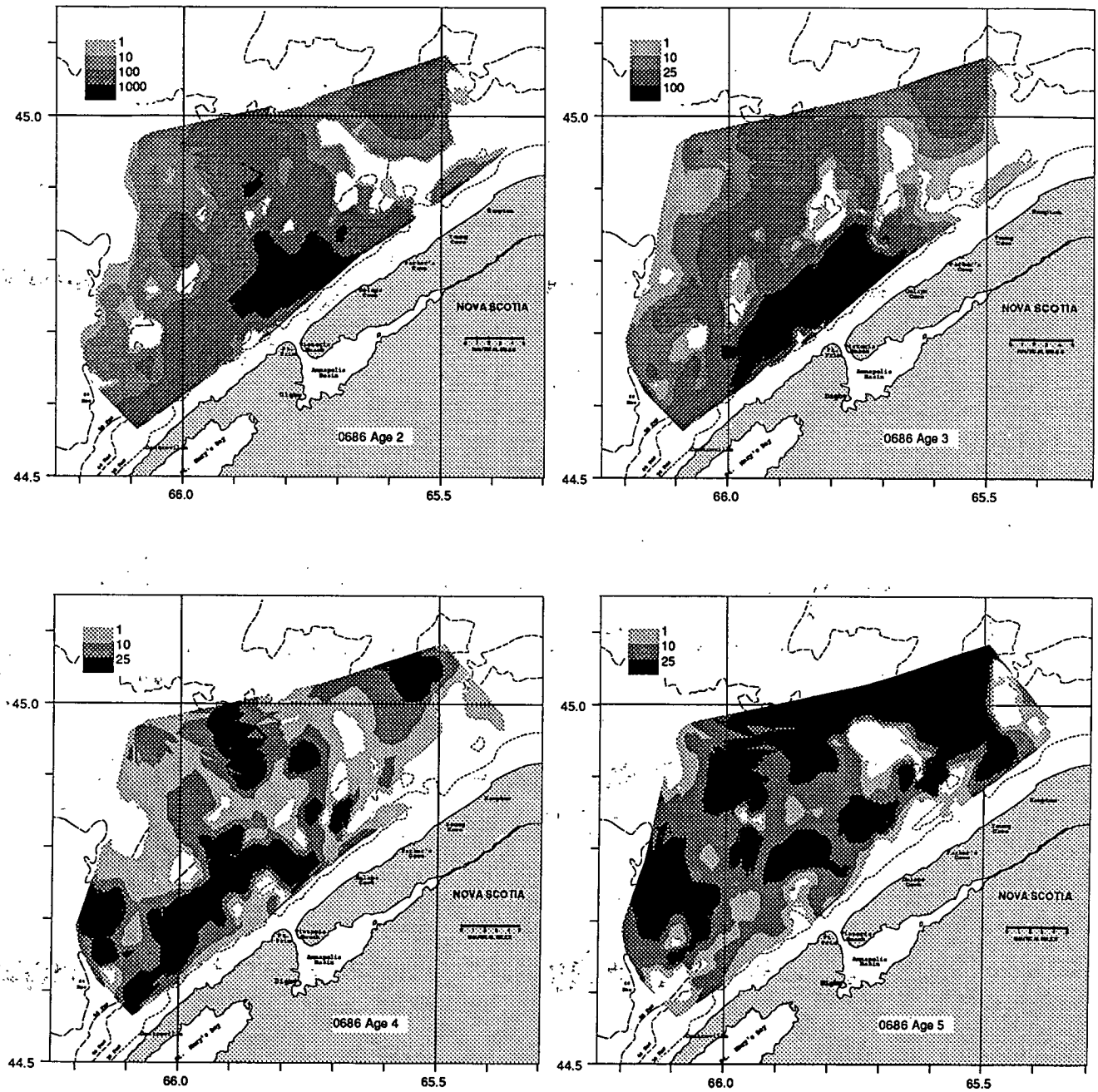

Figure 5.- 1986 survey catch-rates. Scallop distribution on an age basis from abundance isopleths of survey data. Darkening shades of gray within isopleths refer to increasing number of scallops per standard tow (see grey scale in upper left corner of the plot).

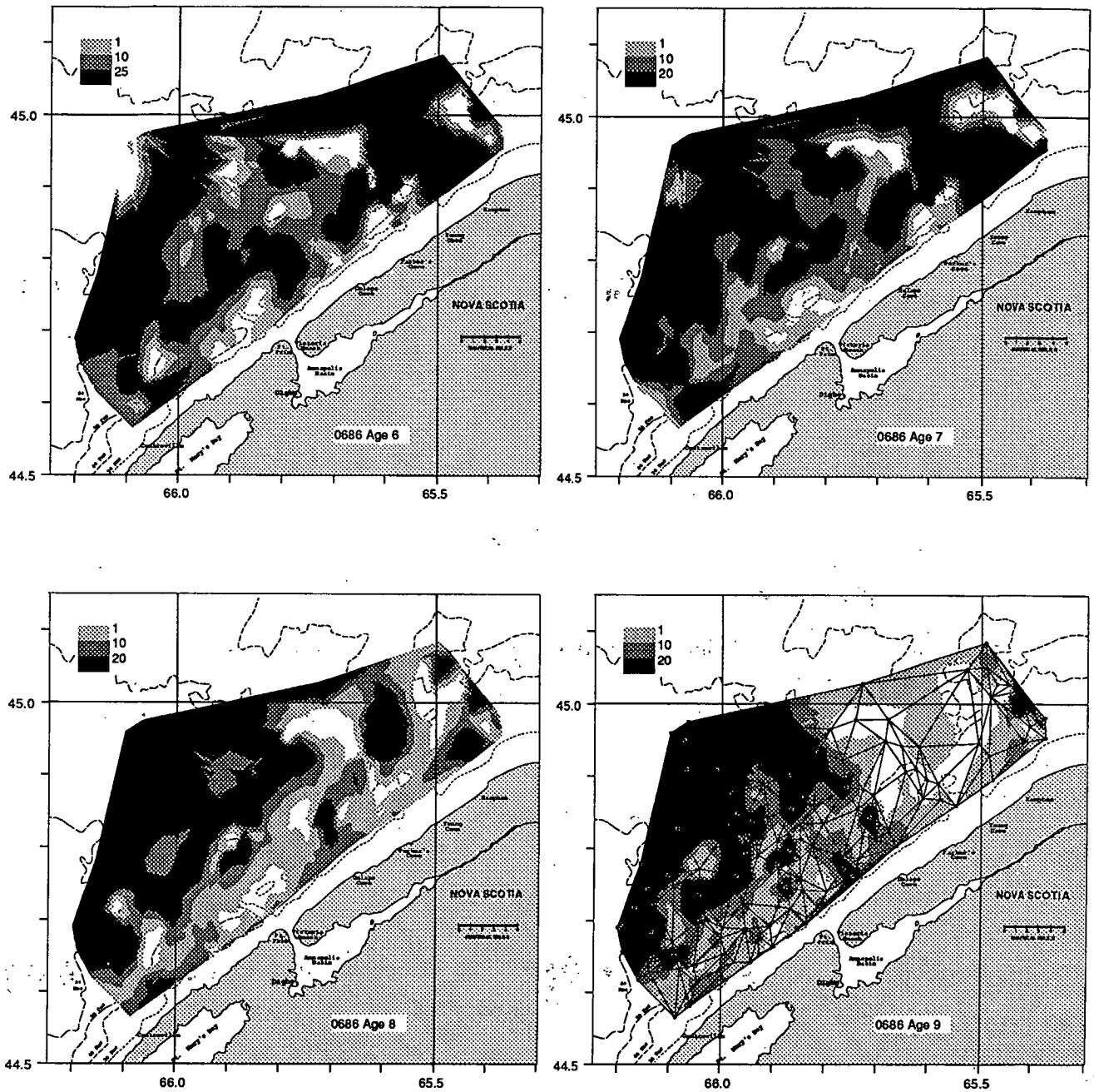

Figure 5.- Continued. 1986 survey catch-rates. The contour plot for age 9 shows the data points and Delaunay triangles.

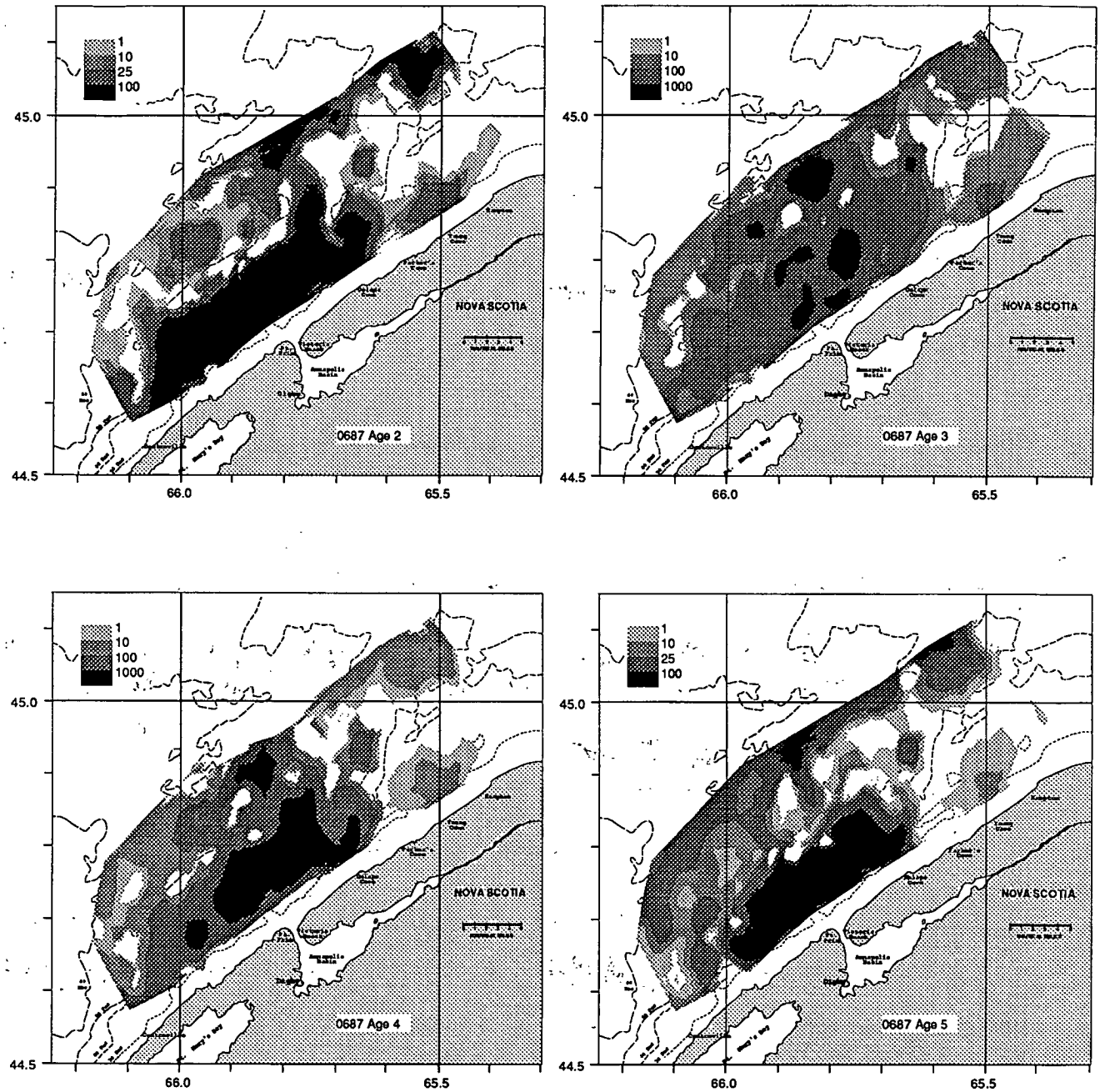

Figure 6.- 1987 survey catch-rates. Scallop distribution on an age basis from abundance isopleths of survey data. Darkening shades of gray within isopleths refer to increasing number of scallops per standard tow (see grey scale in upper left corner of the plot).

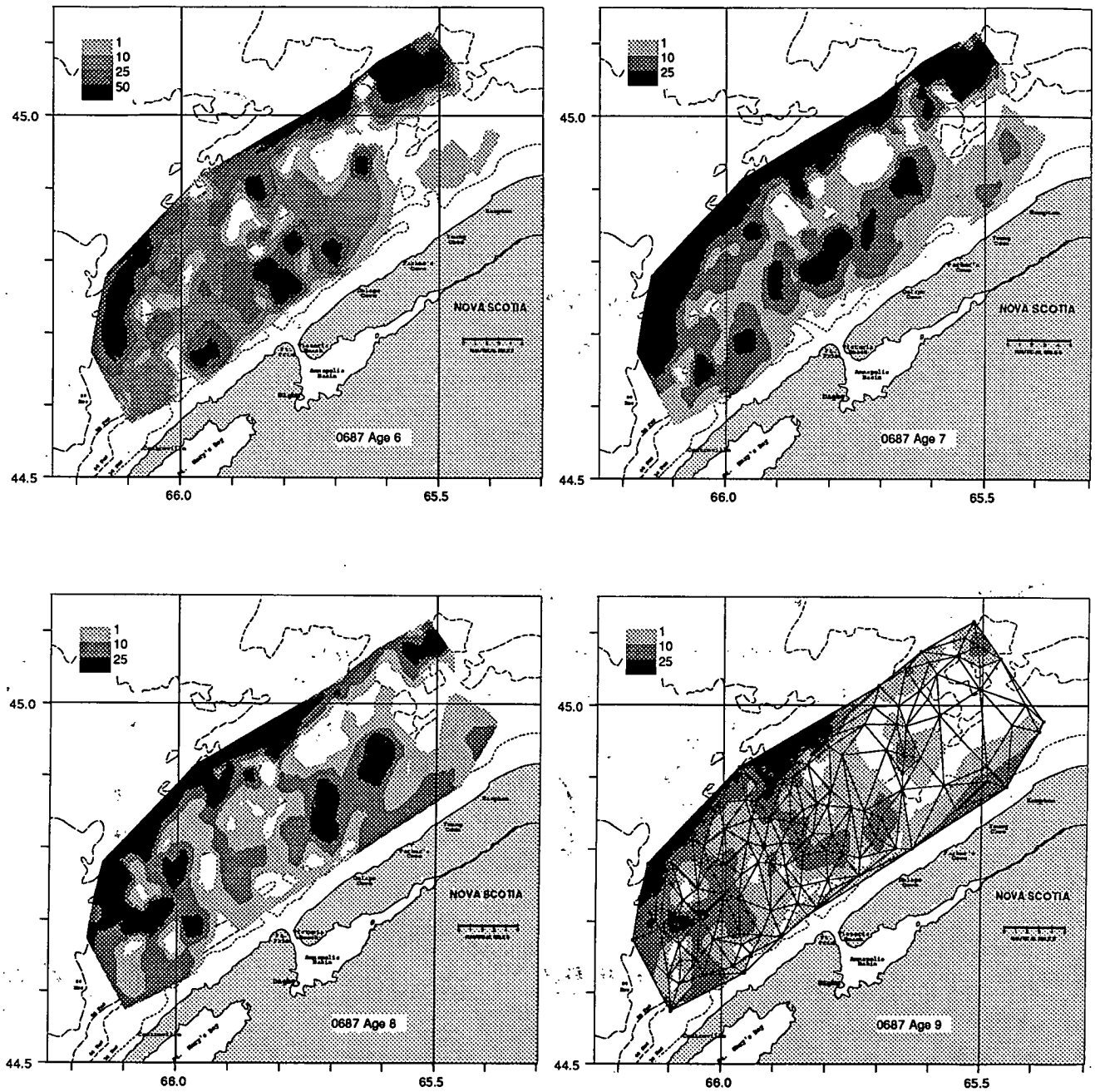

Figure 6.- Continued. 1987 survey catch-rates. The contour plot for age 9 shows the data points and Delaunay triangles.

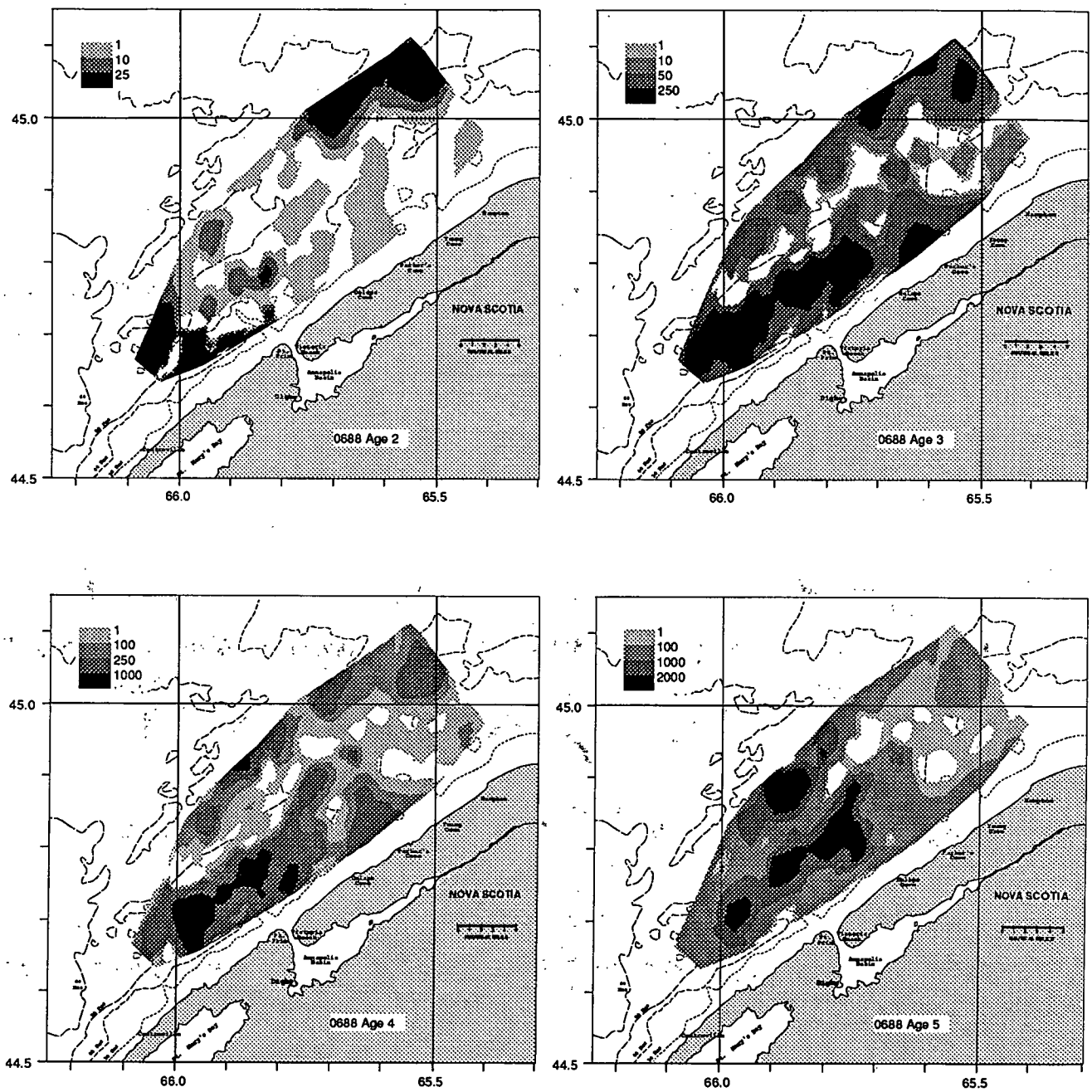

Figure 7.- 1988 survey catch-rates. Scallop distribution on an age basis from abundance isopleths of survey data. Darkening shades of grey within isopleths refer to increasing number of scallops per standard tow (see grey scale in upper left corner of the plot).

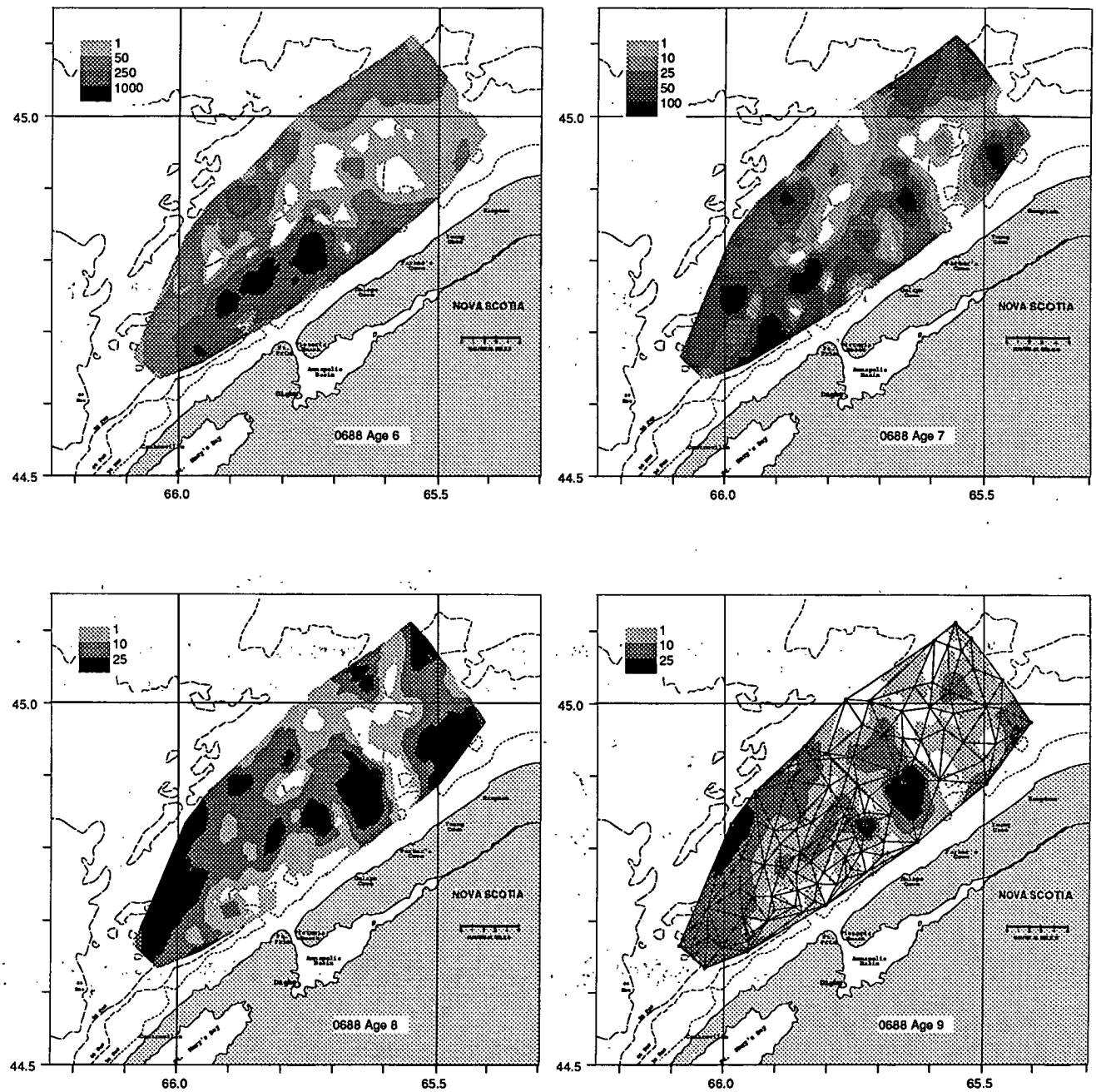

Figure 7.- Continued. 1988 survey catch-rates. The contour plot for age 9 shows the data points and Delaunay triangles.

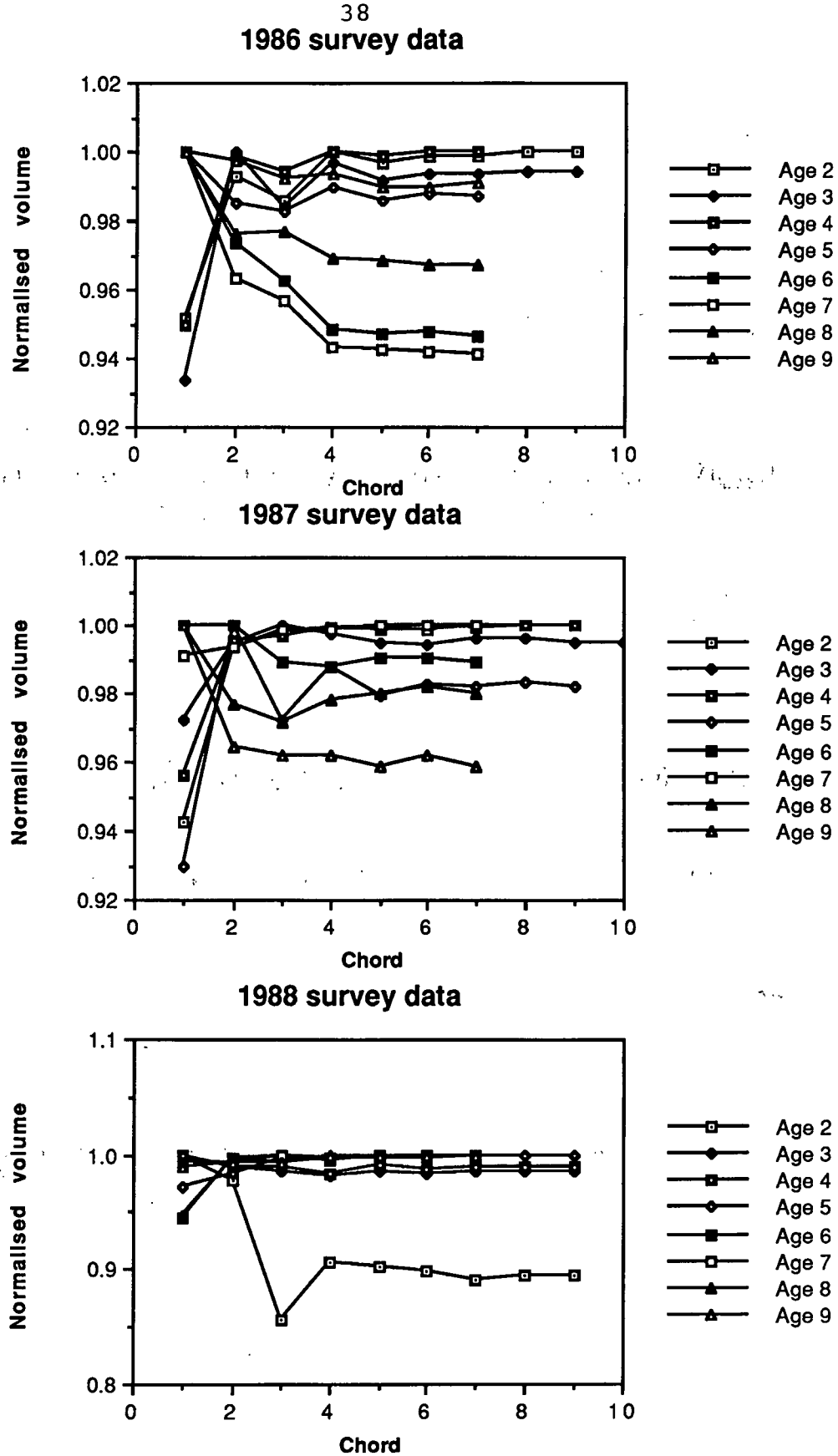

Figure 8.- Volume computations for a 3-yr series of survey data for ages 2-9. Each volume is normalised to the maximum volume estimated. Volumes are calculated according to a smoothing interpolation technique by subtriangulation. A chord is the number of times each side of a Delaunay triangle is divided to produce subtriangles (see text).