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Profile of the Canadian Offshore Scallop Fishery on Georges Bank, 1978 to 1981

by

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ABSTRACT

During 1977 to 1978, the Georges Bank scallop fishery catches reached 17,000 t then fell to 10,000 t in 1980. The 1981 total catch increased to 16,000 t as a result of increased Canadian and American effort and a relaxation of the enforcement of the meat count regulation on the Canadian fleet. The increase in American effort cannot be quantified; however, a 15% increase in Canadian effort was observed from 1980 to 1981, as well as a 33% increase in Canadian catch rate. This increased catch rate reflects greater availability due to higher partial recruitment of younger animals brought about by a relaxation of enforcement of the meat count regulation. Catch composition shows a steady decline in average meat weight and age as the fishery moves from a multi-age composition to a strong dependence on a single year-class. The falling average meat weights and ages seen in the fishery data are reflected in the research data by the decrease of age 4+ scallops.

As the fishery has become increasingly dependent upon single recruiting year-classes, year-to-year variability will be high and low recruitment will produce drastic reductions in catches.

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RÉSUMÉ

Au cours des années 1977-1978 les débarquements de pétoncles provenant du banc Georges ont atteint 17,000 t pour ensuite diminuer à 10,000 t en 1980. Les débarquements de 1981 se sont élevés à 16,000 t au total et ont résulté d'un effort accru tant canadien qu'américain et du relâchement de l'application du règlement limitant le nombre de chairs sur la flottille canadienne. On ne peut pas quantifier l'augmentation d'effort de pêche américain, cependant on observa une augmentation de 15% de l'effort de pêche canadien de 1980 à 1981 et une augmentation de 33% du taux des prises canadiennes. Cette élévation du taux des prises reflète une plus grande possibilité de capture des jeunes pétoncles qui ne sont que partiellement recrutées à cause du relâchement de l'application du règlement limitant le nombre de chairs. L'examen de la nature des prises révèle un déclin continu du poids de chair et de l'âge moyens alors que la pêche basée sur des prises à âges multiples en vient à dépendre de plus en plus sur une seule classe d'âge. Le déclin du poids de chair et de l'âge moyens observé dans les prises commerciales se manifeste dans les relevés de la ressource par la réduction des pétoncles d'âge 4+.

Etant donné que la pêche dépend de plus en plus sur une seule classe d'âge aussitôt que celle-ci recrute, la variabilité des prises sera élevée d'année en année et un recrutement faible produira des réductions sévères des prises.

INTRODUCTION

The Georges Bank scallop fishery (5Ze) has experienced two periods of high catches since 1959. Between 1959 and 1964, combined Canadian and U.S. catches averaged record highs of 10,000 to 15,000 t. Catches then dropped to slightly below 5,000 t until 1976 when they reached the 10,000 t level again. Highest catches on record of nearly 18,000 t were reported for 1977 and 1978. Since then, catches have dropped but are still greater than 10,000 t per year (Table 1).

Years of exceptionally strong recruitment in 1957 and 1972 are mainly responsible for both peaks in landings. Nominal catch, effort, and average meat count (39 meats per 0.5 kg) for the greater part of the catch, were similar for those years (1958 and 1975) preceeding the record landings (Caddy and Jamieson, 1977). One could expect that the fishery would now return to catch conditions fairly similar to non-peak landings. Some elements of the second period of high catches differ, though, from the first one.

From the late 1960's on, the Canadian offshore scallop fishery has been subjected to various fisheries regulations (Table 2). The regulation on average meat count may partly explain the maximum catches of 1977 to 1978 because of higher yield resulting from an increase in age at first capture.

As a result of the declaration of the 200-mile limit (effective January 1, 1977, for Canada), a boundary dispute has ensued between Canada and the U.S. over Georges Bank. The dispute ultimately was referred to the International Court at La Haye for arbitration, a process which may still take a few years.

To date, the U.S. scallop fishery does not have regulations in effect. Because of a particular set of circumstances which was putting Canadian fishermen on an uneven footing vis-à-vis their U.S. counterparts, Canadian scallop fishery regulations were gradually relaxed in early 1981.

In this document, the status of the scallop population on the northeast part of Georges Bank is assessed by analysis of research vessel survey results and the characteristics of the Canadian offshore scallop fishery during the period 1978 to 1981.

METHODS

Resource stock surveys

Survey work has been carried out annually to assess relative year-class strengths and meat yield on commercial grounds. The survey design utilizes a stratified random sampling technique with areas stratified according to commercial CPUE data of at least the previous six months. The percentage of stations allotted per stratum varied annually, depending on the relative area of the strata. Generally, 25% of the stations were located within the low CPUE stratum, 25-40% in the medium and high CPUE strata, and a few stations were randomly located in areas where fishing might have taken place but where commercial data were insufficient to calculate CPUE values. Characteristics of the stock surveys are presented in Table 3. Survey procedures and sampling gear description may be found in Jamieson and Chandler (1980).

Scallops are contagiously distributed. It is possible to delineate scallop concentrations by determining isopleths of scallop abundance. Better computer techniques and more powerful machines allow for finer resolution isopleth mapping; OMS (1 minute latitute and longitude) compared to TMS (10 minutes latitude and longitude) (Caddy, 1975). The contouring technique has been described in Jamieson and Chandler (1980). Hopefully, it will improve our knowledge of the stock distribution and allow for the calculation of more accurate relative indices of abundance.

Fishery data

Log analysis

Fishermen report in daily logs catch figures [number of bags (18 kg) of shucked meats], fishing bearings, effort data (such as gear width, number of crewmen, time gear is fishing), and general comments. Data quality is maintained at a high level since the adequacy of reporting is in the skipper's interest as a reference on performance. Log data are not used in connection with enforcement of fishery regulations. Fishing positions reported in logbooks are checked against surveillance reports from planes and fishery patrol vessels as a control on data quality (Table 4). Widespread use of Loran-type navigational systems has greatly improved the accuracy of position reporting over the past few years.

Sales slip data, not log data, are compiled into the official landings statistics. A total catch figure originating from log data will be an underestimate of the real catch as some

logs may be incomplete. Therefore, a catch-prorating coefficient is applied to catch from log data. At times, logs will provide catch data but will lack fishing locations or effort data. An additional effort-prorating coefficient is further applied to effort data. CPUE data are calculated only from logs with complete information on both catch and effort data to avoid possible expansion error.

Commercial meat weights sampling

To characterize the age composition of the catch the landings of the offshore fleet are sampled (meat count per 0.5 kg, individual meat weights) on a year-round basis. Sampling is conducted mainly from the Lunenburg/Riverport area, homeport for two-thirds of the offshore scallop fleet, and from the Yarmouth/Saulnierville area. The six remaining offshore scallop landing ports are monitored on an ad hoc basis depending on personnel resources.

RESULTS

Resource stock surveys

Patterns of age distribution

Age distribution is presented in Table 5 according to average number at age per tow in different strata. In all strata, old scallops (age 7+) are present in 1979 but disappear almost completely afterwards. In the low stratum, the remaining fully recruited scallops ($\geq$ 90 mm shell height; $\geq$ age 4) follow a substantial declining trend from 61 per tow in 1979 to 12 per tow in 1981. The pre-recruits ($<$ 90 mm shell height; $<$ age 4) were most abundant in 1980 with a relatively strong recruitment pulse by the 1977 year-class. The distribution of fully recruited age classes also shows a decreasing trend in the medium stratum. Here there is an important increase of pre-recruits contributed largely by the 1977 year-class but also by the 1978 year-class to a certain extent. In the high stratum, a reduction of almost 50% over the past three years takes place among the three main recruited age groups (ages 4, 5, and 6). The pre-recruits (consisting mainly of the 1977 year-class) as sampled in 1980 are twice as important as 1979 and 1981 ones. Results from exploration stations or stations located in the very low stratum indicated the same trends as in the other stratas. Data were all combined in a total weighted average, by number of stations, which shows a lack of old scallops ($>$ age 7) and a gradual decline of recruited scallops to half the level of the three years previous. The pre-recruits are represented mainly by the 1977 year-class.

Relative indices of abundance

The geographical location of scallop concentrations as determined by contour analysis is illustrated in the different figures of the appendix. Pre-recruit age groups show up in discrete beds, while recruited age groups are spread over greater areas. Lower densities and greater dispersion of these age groups are due largely to fishing activities and to natural mortality.

Year-classes are sampled for the first time when they are two years old; however, gear retention is not 100% effective for this year-class (Caddy, 1971). Through the four years of data analysed, 1978 to 1981, year-classes at age 2 showed up in a heavy concentration, tongue-shaped with a north/south axis, right on the edge of the northeast peak three years out of four. The 1978 year-class does not show this formation; it appears to be also a weak recruitment pulse, three "knobs" south of latitude 42°N. Increasing concentrations of age 2 scallops (1975 year-class) were observed westward of longitude 66.5°W in 1978. This front gradually retreated to north of latitude 42°N so that the 1978 year-class was not found in this area when sampled in 1981.

The densest concentrations of the 1975 and 1976 year-classes show up year after year in the same general location, even though the patches are considerably thinned down by age 5.

Sampling design does not always allow the coverage of the same scallop concentrations at the same intensity. It is therefore difficult to follow the distribution of one year-class through time; however, it is possible to look at the geographical overlapping of many year-classes at one time. At sampling time in 1978, age 2 scallop concentrations did not overlap with any other age group patches, but there was good overlap between ages 3 and 4, between ages 5 and 6, and between ages 7 and 8 scallop beds. In 1979, age 2 concentrations stood out but there was general overlapping of scallop beds of ages 3 with 4, 5 with 6, and 7 with 8, as previously observed. In 1980, overlapping of age groups is limited to age 2 with 3 and age 4 with 5. In 1981, characterized by lower population density, the age groups are generally more segregated and the distribution of year-classes does not overlap to any extent.

Between 1978 and 1981, stronger recruitment pulses were observed twice (Table 6) - the 1975 and 1977 year-classes; the 1976 and 1978 year-classes were much less important. In 1978 a considerable number of the 1973 year-class recruited to the fishery; it was extensively fished as only 13% (in numbers) was left in 1979. From May 1980 to August 1981, there was an important reduction of the 1975, 1976, and 1977 year-classes;

only 7%, 13%, and 15% of the respective year-classes remained after 15 months. Notwithstanding sampling variability, fishing pressure has been heavy on the 1975 and 1976 year-classes and even on pre-recruits (1977 year-class) to a certain extent (Table 16).

There is a relative balance between abundance of pre-recruits versus recruits in 1978 and 1979 (Table 7). This process shifted to a very large proportion of pre-recruits (84% to 90%) versus recruits in the two latter years. The ratio pre-recruits:recruits is similar between 1980 and 1981, but it should be noticed that total numbers of scallops in 1981 is 23% of the total 1980 relative abundance.

Relative estimates of biomass

Through the four years studied, biomass estimates of the 1972 and 1973 year-classes were the greatest in 1978 (Table 8). Seventy percent to 80% of the biomass represented by 1973 and older year-classes was removed from July 1978 to June 1979. The 1973 year-class alone experienced a decline of 73% in its first year into the fishery. It further decreased by an additional 87% in its second year into the fishery to very low levels. The decline of older year-classes (< 1973) was quite rapid. Most of them were reduced to negligible levels within three years, from 1978 to 1981. In 1981, the biomass of the important 1977 year-class, which was first observed in 1980 has decreased by 40%. Recruiting year-classes' (1975 and 1976) biomasses have experienced an annual decrease of 84% and 61% respectively.

In 1978 and 1979, the biomass of recruited ages contributed over 80% of the total biomass (Table 9). This pattern changed in 1980 with the increased biomass of pre-recruits due in part to the appearance of the sizable 1977 year-class and the rapid decline of recruited stocks. Lately, pre-recruits have been responsible for most of the biomass; and even though relative estimates are lower in 1981 compared to 1980, this trend is rising on a percentage basis.

The number-at-age analysis had not revealed noticeable scallop concentrations in 1981 west of longitude 66.5°, but the biomass analysis indicated the presence of some small concentrations, especially recruits. The contour interval chosen for the number-at-age analysis should have been too high and numbers too few to be analysed.

Fishery characteristics

Catch and effort statistics

Prorating coefficients for catch and effort used in the analysis are listed in Table 10. Little variation is observed during the period 1978 to 1981. Catches (Table 1) declined from peak 1977-1978 values until 1980 to increase over 50% in 1981 (offshore landings of 5,221 t in 1980 to 7,870 t in 1981).

Effort values (Table 10) considered as fishing days, hours, and hour-m-man vary between 8,300 to 8,800 days, 1,000 to 1,300 hours (10^{-3}), and 1,500 to 1,750 hour-m-man (10^{-4}) respectively. However, the 1980 values fall below the range just mentioned.

The offshore scallop fishery is a limited-entry fishery; no more than 77 vessels are licensed in any one year. The fleet size has been at its maximum for the past two years (Table 11) and has been conducting approximately 1,300 trips annually, 17 trips per vessel. Average catch per vessel has declined since 1978, down 39% in 1981. The lowest figure for 5Ze catches, the 1980 average catch per vessel, was down more than half (60%) the peak 1979 values.

The average annual landed meat price has continually increased (Table 12) and reached $9 per kg in 1981. Landed value per vessel (Table 11) was highest in 1981 despite the lower catches.

Measures of effort

Different components for measuring fishing effort expended in the offshore fishery on Georges Bank are presented in Tables 13 and 14. The offshore fleet has been fishing almost exclusively on Georges Bank, except in 1980 when 22% of the fleet's fishing days was spent on the Scotian Shelf (19% on German/Lurcher, 3% on Browns Bank). From 1978 to 1980, the average fishing hours per day increased, while the number of crewmembers was slightly decreasing. In 1981 when the fleet returned to Georges Bank (96% fishing days), the average fishing hours per day decreased; but the number of crewmembers increased. Gear width did not change appreciably. When these components are put together in a single measure of effort expressed as hour-m-man (Table 10), it appears that effort has ranged from 1,300 to 1,750 hour-m-man.

Catch per unit effort (kg/hour-m-man) computed from only the log data providing effort information on fishing hours, crewmembers, and width of gear is briefly presented in Table 15.

The five highest CPUE's are listed for each year; CPUE values gradually declined from 1978 to 1981. Values for 1981 are half or less than half 1978 values. Ten-minute squares providing those CPUE's differ from year to year.

Commercial meat weights analysis

Time and personnel restrictions allowed ≥ 0.1% meats measured out of the total catch originating from Georges Bank (5Ze). Data are presented on the monthly distribution of age, weight, meat count (meats per 0.5 kg = MC), and sample size for 1978 to 1981 in Table 16. A general trend of decreasing average meat weight of caught scallops is observed from 18.94 g in 1978 to 11.17 g in 1981; correspondingly, there is a gradual increase in the average meat count from 26.61 in 1978, 29.70 in 1979, 37.57 in 1980, to 44.77 in 1981. Figure 1 illustrates the annual weight frequency distribution, while Figure 2 relates to the annual age frequency distribution. It is shown that, during the period considered, average scallop meat weight was decreasing and small, young scallops were caught at a greater rate (in 1981, 61% of the scallops caught were age 4). Within any single year, the monthly average meat weight is greater during the peak of the growing season, from April to September, than during the remainder of the year. Correspondingly, monthly meat counts from April to September are usually lower than meat counts from September to April.

Highest meat counts were recorded during 1981; the annual weighted average reached a value of 44.77 meats per 0.5 kg. Unusually low meat weights of less than 10 g were observed during the fall season, which led to meat counts in the order of 57 (s.e. 5).

DISCUSSION AND CONCLUSIONS

Resource stock surveys

The strength of different year-classes varied markedly. Assessing scallop stocks by the relative abundance of age groups may overrepresent large numbers of small, low-yielding pre-recruit scallops. Scallop biomass recruiting to the fishery may be better estimated by an index of biomass at age, especially because of a rapid growth rate. Age 3 scallops have increased their meat weights by 180% when reaching age 4, and a further 65% from age 4 to age 5.

Strong year-classes like the 1972 and 1973 year-classes and the 1974 year-class have sustained record catches in 1977 to 1978 (Serchuk et al., 1979) and 1979 to a lesser extent; but in 1980, these year-classes had been depleted markedly and were constituting a small fraction of the fishery (Fig. 2). A moderate recruitment pulse took place in 1977. This year-class was partly prosecuted by the fishery in the fall of 1981 even though it was well below a size for optimal yield or fully recruited to the fishery. The shell height (75 mm to 90 mm) of these scallops is $\geq$ 50% available to the offshore dredge (Caddy, 1972). The yield of this size group is approximately 85 meats per 0.5 kg in early fall and may still be harvested by blending with larger meats. Moreover, the meat count regulation was relaxed in early 1981 such that the 1977 year-class may have made up a large fraction of the fall catches.

Pulse recruitment causes shift in the relative importance of the biomass of the recruited age class versus the biomass of pre-recruits. During the early part of the period considered, most of the biomass was at the recruiting stage, but the 1977 recruitment pulse shifted this trend to the pre-recruits. As no outstanding recruitment pulse has been experienced through this period, the relative estimates of recruited biomass have gradually but markedly decreased since 1978 (from 56.4 t to 3.4 t).

Fishery characteristics

Fluctuations in catches

Decline in catches from the peak 1977-1978 landings resulted partly from the gradual depletion of the strong recruitment pulses of the early 1970's. The Canadian offshore scallop fleet usually concentrates its fishing activity on Georges Bank (Jamieson et al., 1982), but for the first time since 1966, 23% of the offshore catches came from the Scotian Shelf in 1980. The fleet returned to its traditional grounds in 1981 with 96% of the fishing activity taking place on Georges Bank. Offshore catches (5Ze) in 1981 increased 50% from the 1980 values. Relaxed regulations permitting exploitation of smaller scallops contributed to the increased catch rates and total catch.

Effort and CPUE

Effort expressed as vessel days has more or less been maintained near the maximum possible (8,800 vessel days per year) since 1978. Effort measured as hour-m-man is a more adequate indicator to explain the occurring trends. Average

fishing hours per day decreased markedly in 1981, but the number of crew increased so that even though average m-man was rising, less fishing hours per day compensated to give a fairly uniform effort measure (hour-m-man). Up to 1981, fishing time was greater, but the status of the stocks allowed for the fishing of less-concentrated, large meat-yielding scallops and shorter time required to shuck the catch. With their gradual disappearance, emphasis was shifted to smaller, low-yielding scallops which take considerably more time to shuck, hence the addition of crewmember(s) to accelerate the processing of the catch. It appears that even with the addition of extra shuckers, average fishing hours was reduced. This may also be explained by the fishing strategy of some Canadian offshore vessels (Caddy and Sreedharan, 1971), which is to exploit dense concentrations of small scallops and limit tow time. Record high landed prices contributed to offset the extra labour cost.

Briefly, it may be said that the fishery went from a peak CPUE of 1.0 to 0.8 kg/hour-m-man in 1977-1978 to 0.39 kg/hour-m-man in 1980, then to a slightly higher value (0.53 kg/hour-m-man) in 1981 as most large scallops were being fished out. CPUE reflects scallop density rather than allow for an estimate of overall scallop abundance; and since the stocks are contagiously distributed, CPUE would not necessarily be a good measure of fishery performance unless its patchiness is investigated.

Commercial meat weight sampling

With the depletion of the larger scallops, the fishery has relied almost exclusively on a single year-class, as it recruits to the gear. As a result, the average weight of landed scallops has been considerably reduced. Cull size has followed a similar trend.

Under the "very few year-classes" fishing regime, blending of scallop meats becomes more difficult. As one main year-class gets depleted and the next younger year-class is being exploited, seasonal variation may even appear in the catch composition. Important variations in meat yield for a given shell length are associated with a seasonal pattern (Haynes, 1966).

Catch and Effort

Canadian landings versus effort data from the Canadian fleet only are plotted in Figure 3. No clear-cut relationship seems to be present between catch and effort. During the latter

part of the 1970's catches have ranged from 5,000 t to 13,000 t with considerably less variation in effort, which hovered near the maximum permissible. In years when the recruiting year-class is moderate or weak, it appears that the only way to improve the yield and increase landings is by a higher cull size, as was the case with the 1974 and 1975 catches after the implementation of a meat count regulation starting in 1973 (Caddy and Jamieson, 1977). The relaxed regulation in 1981 allowed for an increase in landings in 1981 from 1980, but this is only a short-term phenomena. Over the long term, the absence of a cull size or too low a cull size would only result in catches at levels comparable to the pre-regulations era (prior to 1973).

It is anticipated that unless above-average recruitment takes place or new exploitable scallop beds are discovered, landings will decline as the scallops are being fished at ages considerably lower than the ages producing optimal yields (Brown et al., 1972). The Canadian fishery is of limited entry, but the U.S. fishery is not. A tremendous increase in U.S. landings has taken place since 1976 (Table 1) up to 8,200 t in 1981 (Serchuk, pers. comm.). Landings will likely decrease to historic average levels (Caddy and Jamieson, 1977). Yields may even decrease further if the fishery is directed at pre-recruits because of a lack of meat count regulation and uncontrolled effort.

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Table 1. Catch statistics (t of scallop meats) from Georges Bank (5Ze) from 1959 to 1981.

Year	U.S.	Canada	Total
1959	8,910	2,378	11,288
1960	10,039	3,470	13,509
1961	10,698	4,565	15,263
1962	9,725	5,715	15,440
1963	7,938	5,898	13,836
1964	6,322	5,922	12,244
1965	1,515	4,434	5,949
1966	905	4,878	5,783
1967	1,234	5,019	6,253
1968	998	4,820	5,818
1969	1,329	4,318	5,647
1970	1,420	4,097	5,517
1971	1,334	3,908	5,242
1972	824	4,161	4,985
1973	1,084	4,223	5,307
1974	929	6,137	7,066
1975	860	7,414	8,274
1976	1,777	9,761	11,538
1977	4,823	13,089	17,912
1978	5,589	12,189	17,778
1979	6,412	9,207	15,619
1980	5,477	5,221	10,698
1981	8,200*	8,013	16,200*

*Preliminary figures. 1959-1978: ICNAF Statistical Bulletin; 1979-1980: NAFO Statistical Bulletin. Conversion coefficient from round weight to meat weight is 8.3.

Table 2. Canadian fishery regulations for the Georges Bank offshore scallop fishery.

Regulation	Activation date
Log submission	late 1960's
Limited entry	1973
Meat count*	
60 meats/lb	1973, June
50 meats/lb	1974, May
45 meats/lb	1975, June
40 meats/lb	1976, May
Maximum catch per trip of 30,000 lbs shucked meats	1977, March
Trip maximum duration of 12 days dock to dock	1977, March
Maximum landed weight per boat over a four-month period of 180,000 lb	1977, March

*Average meat count per trip is based on no less than nine independent representative samples per catch; a tolerance of 10% is allowed over the maximum meat count.

Table 3. Characteristics of the resource stock surveys on the northern part of Georges Bank, 1979-1981 inclusive. 1978 survey results have been reported on in Jamieson and Chandler (1980).

	No. of stations	Strata	(kg/h)
June, 1979	38	low	(< 45)
	54	medium	(45-91)
	39	high	(> 91)
	24	unknown	
	155		
			(kg/h-m-man)
May, 1980	72	low	(< 1)
	79	medium	(1-2)
	120	high	(> 2)
	42	unknown	
	313		
August, 1981	12	very low	(< 0.1) (or unknown)
	37	low	(0.1-0.2)
	35	medium	(0.21-0.5)
	30	high	(> 0.5)
	114		

Table 4. Quality control of position reporting from logs as estimated by distance discrepancy statistics with surveillance reports on vessel locations.

Year	Reports	Vessels	Average number of matched reports/vessel	Distance discrepancy (km)				
				min.	max.	avge.	s.d.	s.e.
1978	243	62	3.9	1.3	260.5	36.0	31.3	2.0
1979	667	72	9.3	0.5	427.8	20.6	30.8	1.2
1980	863	73	8.6	0.4	479.4	25.9	40.8	1.6
1981	402	72	4.3	0.4	88.2	17.3	16.0	0.9

Table 5. Stratified average number of scallops at age* (year) per tow, total weighted average per tow at age, and stratified total number of scallops per tow, N.

	Sampling dates	Age (year)									N	(s.d.)
		2	3	4	5	6	7	8	9	10		
Low stratum	1979	17	36	26	26	9	4	3	2	7	130	(229)
	1980	65	28	18	8	3	1	1	0	1	125	(256)
	1981	24	26	9	2	1	1	0	0	0	78	(102)
Medium stratum	1979	41	117	39	21	9	5	2	1	3	238	(234)
	1980	550	74	36	10	2	1	0	0	0	674	(1725)
	1981	377	279	24	7	2	1	0	0	0	712	(1025)
High stratum	1979	27	147	42	19	9	3	1	0	1	249	(231)
	1980	727	104	66	6	2	1	0	0	1	908	(1256)
	1981	133	285	32	5	2	1	0	0	0	458	(674)
Unknown stratum	1979	3	18	6	9	8	4	2	1	5	39	(40)
	1980	39	5	6	4	2	2	1	1	2	62	(92)
	1981	71	92	48	6	1	1	0	0	0	239	(325)
Total weighted average	1979	26	108	31	20	9	4	2	1	4		
	1980	432	56	34	6	2	1	0	0	1		
	1981	166	179	24	5	2	1	0	0	0		

*For the purpose of this report, an arbitrary birth date of October 15 has been assigned (Posgay and Norman, 1958). Hence, age refers to age as of mid October. For example, age 2 scallops sampled in August 1981 reached age 3 in October 1981 and belong to the 1978 year-class.

Table 6. Relative indices of abundance of different scallop age-classes as determined by contour analysis. Number (10^{-3}).

Sampling dates	Age						
	2	3	4	5	6	7	8
July 1978	2,778.691	874.822	2,091.439	796.787	175.875	104.463	38.943
June 1979	182.187	577.315	498.245	265.835	107.235	43.372	20.970
May 1980	4,607.078	924.616	555.644	334.725	119.318	35.450	
August 1981	657.105	699.927	117.218	38.847			

Table 7. Relative indices of abundance of pre-recruits (shell height < 90 mm) and fully recruited scallops (shell height ≥ 90 mm) from contouring analysis. Number (10^{-6}).

Year	Pre-recruits	(%)	Recruits	(%)
1978	3.654	(53)	3.208	(47)
1979	0.760	(45)	0.936	(55)
1980	5.532	(84)	1.045	(16)
1981	1.357	(90)	0.156	(10)

Table 8. Relative estimates of biomass of different scallop age-classes as determined by contouring analysis. Biomass is in t. Biomass was estimated according to size at age [von Bertalanffy equation: $l_t = 145.4\ (1-e^{-0.38(t-1.5)})$] and meat weight-shell height relationship: $\ln(W) = -10.8421 + 2.949\ \ln(h)$ (Haynes, 1966).

Sampling dates	Age						
	2	3	4	5	6	7	8
July 1978	1.813	9.212	26.842	15.973	5.728	5.177	2.714
June 1979	0.286	3.969	6.500	7.324	2.550	1.711	0.947
May 1980	8.939	6.098	6.498	2.481	0.986		
August 1981	1.042	5.236	2.379	1.069			

Table 9. Relative estimates of biomass of pre-recruits (shell height < 90 mm) and fully recruited scallops (shell height ≥ 90 mm). Biomass is in t.

Year	Pre-recruits	(%)	Recruits	(%)
1978	11.025	(16)	56.434	(84)
1979	4.255	(18)	19.032	(82)
1980	15.037	(59)	10.416	(41)
1981	6.278	(65)	3.448	(35)

Table 10. Prorating coefficients for catch and effort values for the offshore scallop fishery in 5Ze from 1978-1981.

Year	Prorating coefficient		Effort		
	Catch	Effort	Days	Hour (10^{-3})	Hour-m-man (10^{-4})
1978	1.19	1.06	8799	1,105	1,520
1979	1.19	1.07	8746	1,268	1,741
1980	1.19	1.05	6863	955	1,302
1981	1.21	1.06	8285	1,030	1,498

Table 11. Fleet size and average landings statistics for the offshore scallop fishery on Georges Bank, 1978-81.

Year	Trips*	Vessels	Average per vessel		
			Trips	Catch (t)	Landed value ($\$10^{-3}$)
1978	1,335	73	18.3	167.0	807
1979	1,250	75	16.7	122.8	850
1980	1,267	77	16.5	67.8	549
1981	1,319	77	17.0	104.6	941

*Number of trips is prorated by catch coefficient.

Table 12. Average annual landed scallop meat prices based on Nova Scotia landings.

Year	Average price ($) per kg
1978	4.83
1979	6.92
1980	8.09
1981	9.00

Table 13. Measures of fishing effort per trip for the offshore scallop fishery and estimated percentage of fishing days spent on Georges Bank.

Year	Average fishing			% fishing days on Georges Bank
	days/trip	hours/trip	hours/day	
1978	6.6	83	12.8	100
1979	7.0	101	14.4	97
1980	5.4	75	13.9	78
1981	6.3	78	12.4	96

Table 14. Components of measures of fishing effort: offshore scallop gear and number of crewmembers (in relation to shucking operations performed at sea).

Year	Gear width (m)	Crewmembers	Average m-men per vessel
1978	8.22	16.7	137.2
1979	8.34	16.5	137.6
1980	8.43	16.2	136.6
1981	8.24	17.1	141.0

Table 15. Catch per unit effort (kg/h-m-man) for Class 1 data (all effort information provided in logs). Ten-minute squares (TMS) where the five highest CPUE originated during the period are considered. TMS is identified according to the first three digits of latitude and longitude (degrees, minutes, seconds) of the bottom right corner.

Year	TMS	CPUE	Year	TMS	CPUE
1978	415672	3.754	1980	404663	0.792
	421672	2.182		420655	0.766
	421671	1.538		412660	0.745
	421670	1.451		414681	0.732
	412660	1.377		415674	0.679
1979	421673	2.046	1981	414672	5.552*
	412665	1.036		413671	1.987*
	413671	0.741		414664	0.786
	421665	0.706		420663	0.712
	413664	0.698		420673	0.700

*Less than 10 t was caught in this TMS.

Table 16. Characteristics of offshore scallop landings from commercial meat weight sampling - 5Ze, 1978-1981.

Month	Age		Weight (g)				Meats/0.5 kg		Sample size	
	avge.	s.e.	avge.	min.	max.	s.e.	Port sampler	Fisheries officer	Port sampler	Fisheries officer
Year = 1978			Total meat landed = 10,829.65 (t) Total meat measured = 133.49 (kg) or 0.00123%							
January	4.71		15.94	4.62	44.07		31.63	36.67	293	
February	4.94		17.05	3.74	56.04		29.56	25.56	385	
March	4.75		15.92	5.71	50.11		31.66	31.89	404	
April	6.20		23.35	7.85	65.54		21.59	0.00	213	
May	5.81		22.27	4.24	64.40		22.63	26.00	740	
June	6.45		24.25	6.20	70.04		20.78	25.67	756	
July	5.55		20.09	8.00	63.38		25.08	24.44	268	
August	5.94		22.54	5.51	84.19		22.36	33.00	664	
September	5.21		18.99	7.51	51.93		26.54	29.33	402	
October	5.15		18.27	4.65	55.70		27.59	34.44	543	
November	5.25		18.35	2.93	63.70		27.46	33.67	1,592	
December	4.09		11.33	3.15	47.37		44.49	28.11	787	
Weighted avge.	5.34		18.94	2.93	84.19		26.61	30.54	Total 7,047	
Year = 1979			Total meat landed 9,207.47 (t) Total meat measured = 3,602.43 (kg) or 0.03913%							
January	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
February	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
March	4.56	0.01	14.58	3.42	55.87	0.06	34.30	0.00	11,850	0
April	5.22	0.02	17.67	3.11	74.60	0.10	28.30	0.00	10,955	0
May	4.78	0.01	15.09	2.56	78.15	0.04	33.13	29.76	41,185	120
June	5.07	0.01	16.11	1.16	81.81	0.05	31.04	0.00	49,995	0
July	5.73	0.02	19.38	2.22	93.48	0.06	25.80	29.87	45,160	150
August	5.41	0.02	18.42	3.00	88.98	0.07	27.15	28.77	27,330	600
September	4.63	0.02	14.26	2.98	63.47	0.08	35.03	47.56	11,895	720
October	4.95	0.02	16.99	3.05	63.22	0.09	29.43	41.76	10,110	4,875
November	4.92	0.03	16.27	3.62	56.35	0.12	30.72	0.00	5,490	0
December	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.11	0	2,265
Weighted avge.	5.14	0.01	16.84	1.16	93.48	0.02	29.70	41.33	TOTAL 213,970	8,730

...Contd.

Table 16 Contd...

Month	Age		Weight (g)				Meats/0.5 kg			Sample size	
	avge.	s.e.	avge.	min.	max.	s.e.	Port sampler	Fisheries officer		Port sampler	Fisheries officer
Year = 1980				Total meat landed = 5,220.84 (t) Total meat measured = 5,746.33 (kg) or 0.11007%							
January	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0	0
February	4.08	0.02	10.93	2.41	52.68	0.09	45.77	39.47		6,340	260
March	4.27	0.03	12.59	2.98	45.03	0.18	39.72	0.00		1,845	0
April	4.59	0.01	14.21	1.66	68.78	0.06	35.19	41.66		18,555	640
May	4.41	0.01	12.76	1.23	86.32	0.03	39.17	23.83		98,135	130
June	4.60	0.01	13.70	1.30	92.09	0.03	36.49	40.08		109,445	470
July	4.58	0.01	13.74	1.88	87.24	0.03	36.39	38.93		90,565	2,970
August	4.78	0.01	14.59	2.80	80.97	0.04	34.27	0.00		49,410	0
September	4.20	0.01	11.84	2.99	74.82	0.04	42.23	45.18		25,815	2,770
October	4.20	0.02	11.74	3.60	67.89	0.08	42.59	43.99		6,585	4,490
November	4.30	0.02	11.88	2.38	60.55	0.06	42.08	0.00		19,335	0
December	4.00	0.02	10.35	2.14	49.99	0.10	48.33	42.49		5,800	550
Weighted avge.	4.51	0.00	13.31	1.23	92.09	0.01	37.57	42.39	TOTAL	431,830	12,280
Year = 1981				Total meat landed = 7,869.88 (t) Total meat measured = 5,044.11 (kg) or 0.06409%							
January	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0	0
February	3.81	0.02	8.96	3.26	53.21	0.07	55.82	0.00		6,930	0
March	4.25	0.02	11.40	2.58	65.10	0.06	43.86	47.98		17,885	1,710
April	3.98	0.03	10.19	4.70	54.38	0.10	49.05	65.25		2,010	40
May	4.18	0.00	11.62	3.37	76.60	0.02	43.05	46.69		89,940	605
June	4.32	0.01	12.37	2.26	79.87	0.02	40.41	51.17		107,835	465
July	4.22	0.01	11.64	2.55	73.25	0.03	42.94	61.51		74,040	190
August	4.08	0.01	10.87	2.47	76.90	0.02	46.02	35.38		78,710	170
September	3.92	0.01	9.98	2.23	59.09	0.03	50.11	0.00		24,850	0
October	3.64	0.01	8.07	2.37	57.54	0.03	61.95	49.65		21,885	100
November	3.68	0.01	8.48	2.10	45.54	0.04	58.99	43.98		16,885	385
December	3.72	0.01	8.79	2.30	53.68	0.05	56.86	58.53		10,650	85
Weighted avge.	4.13	0.00	11.17	2.10	79.87	0.01	44.77	48.34	TOTAL	451,620	3,750

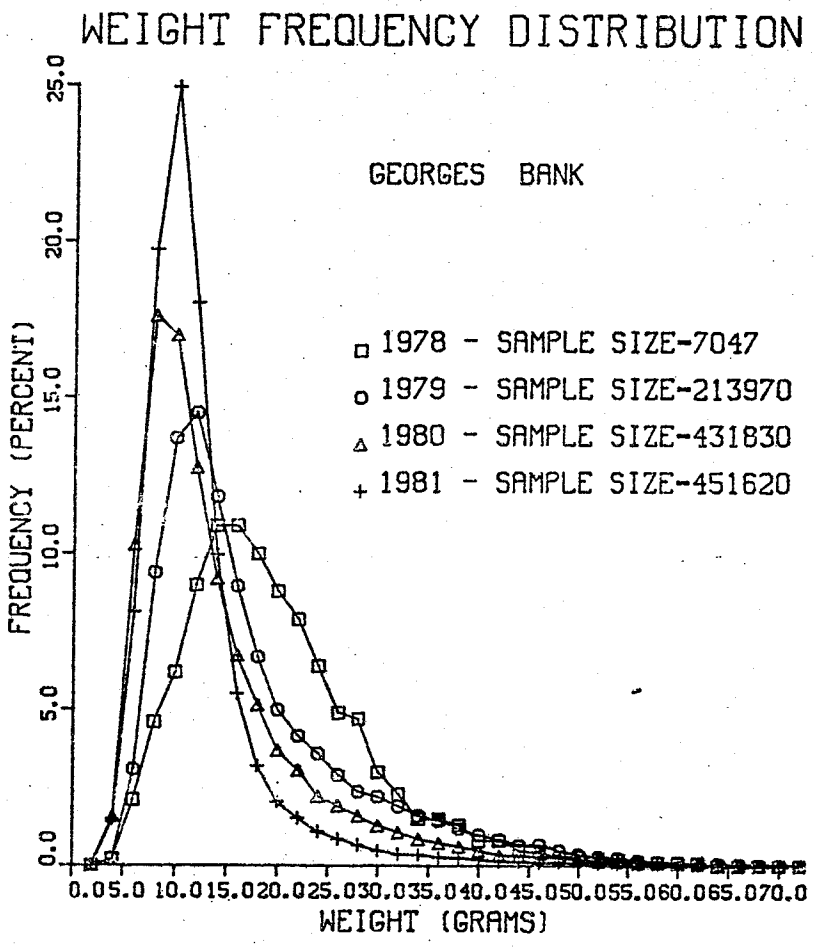


Figure 1. Weight frequency distribution of commercial meat weight samples.

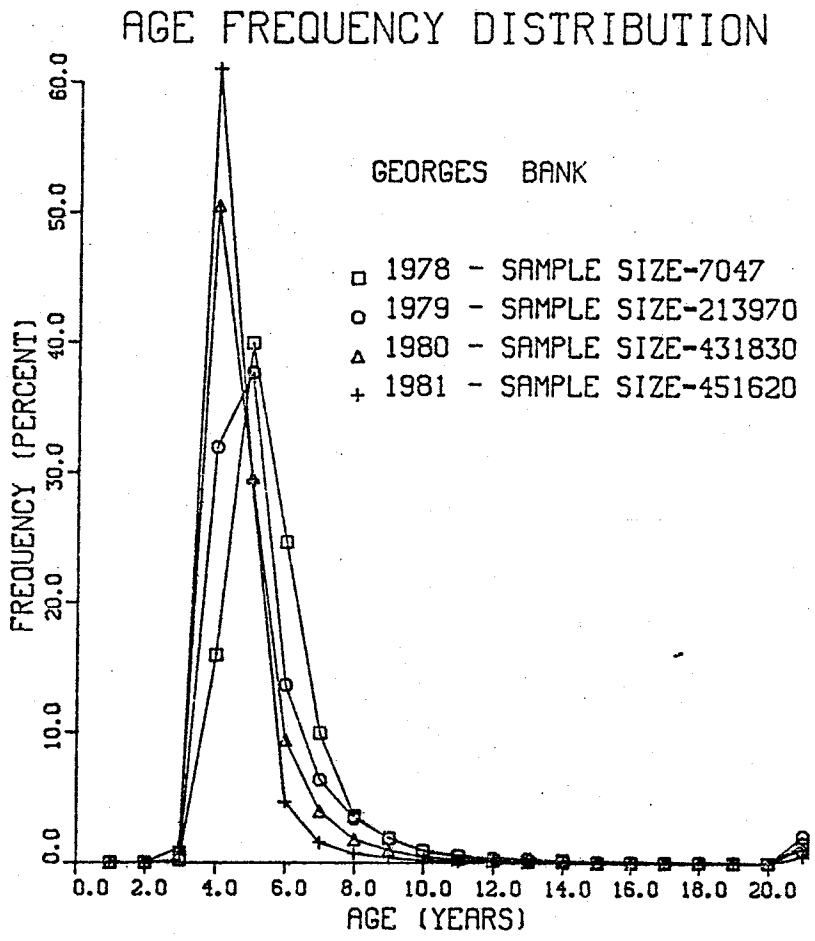


Figure 2. Age frequency distribution of commercial meat weight samples.

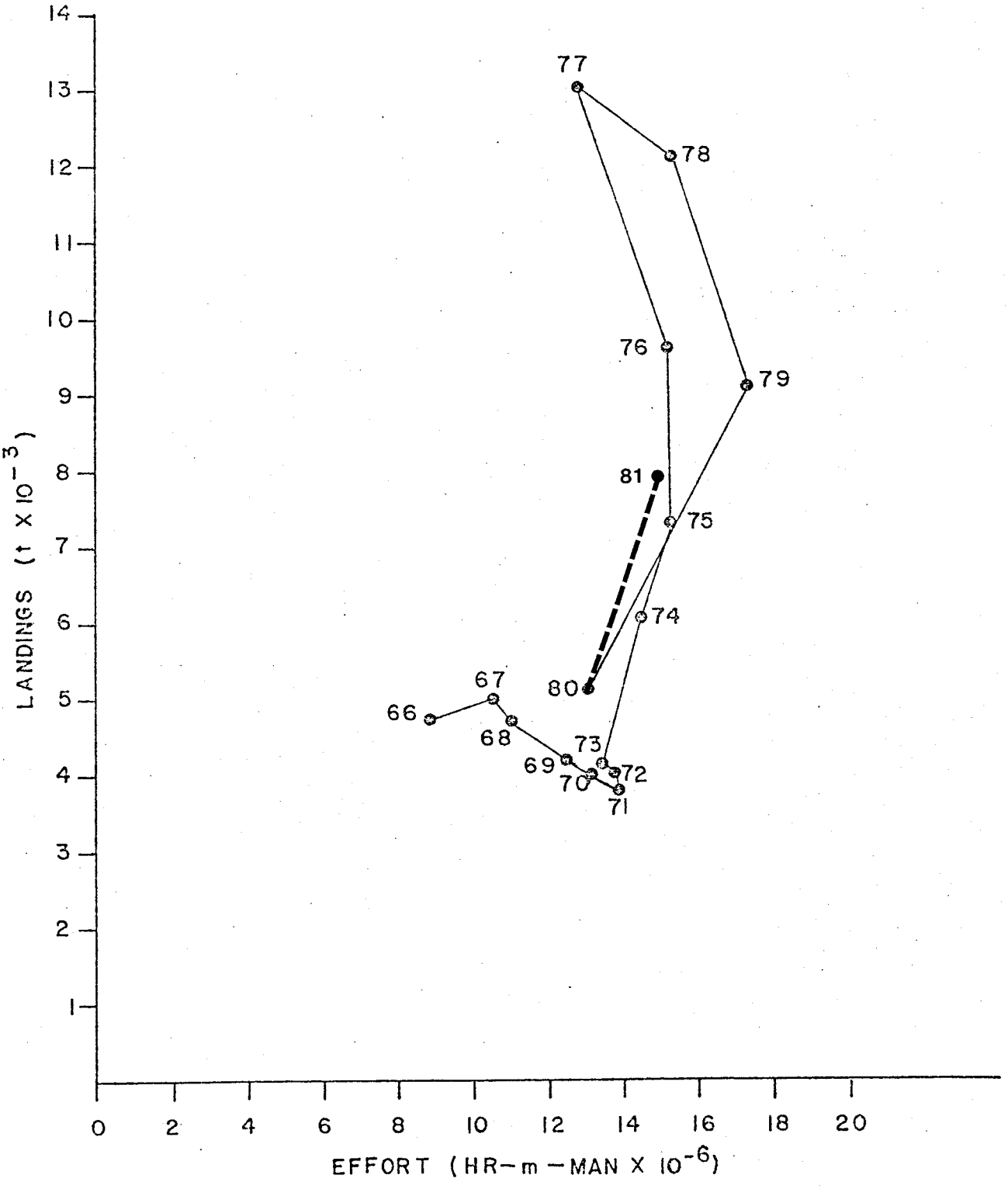


Figure 3. Annual Canadian scallop catches from Georges Bank versus effort measured as hour-m-man, Canadian data only (from Jamieson et al., 1982, except for 1981 data).

A P P E N D I X

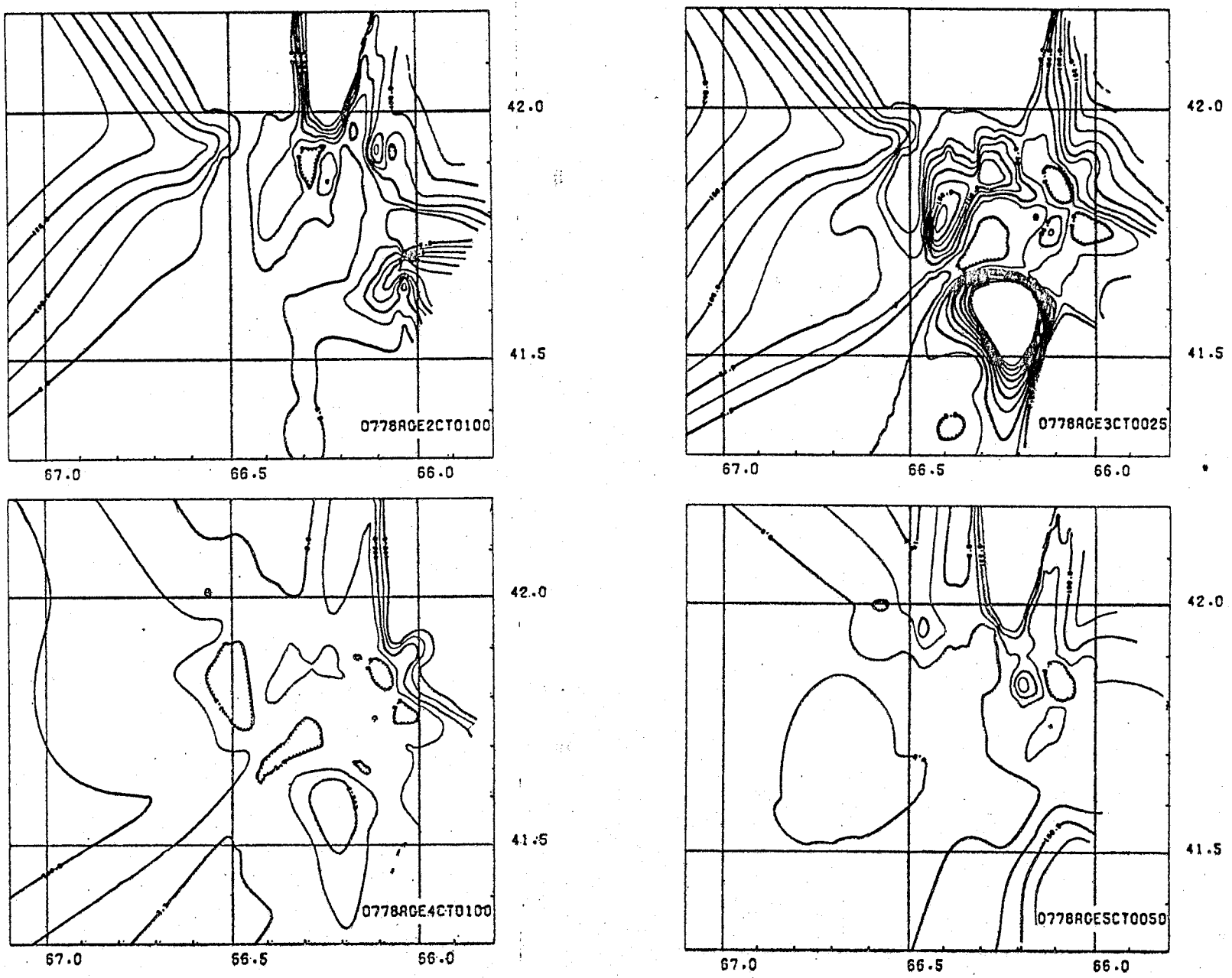
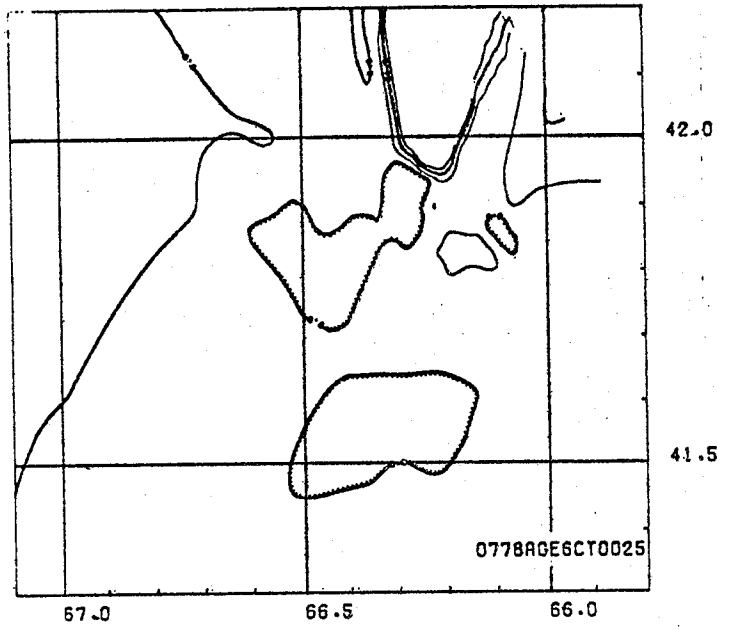
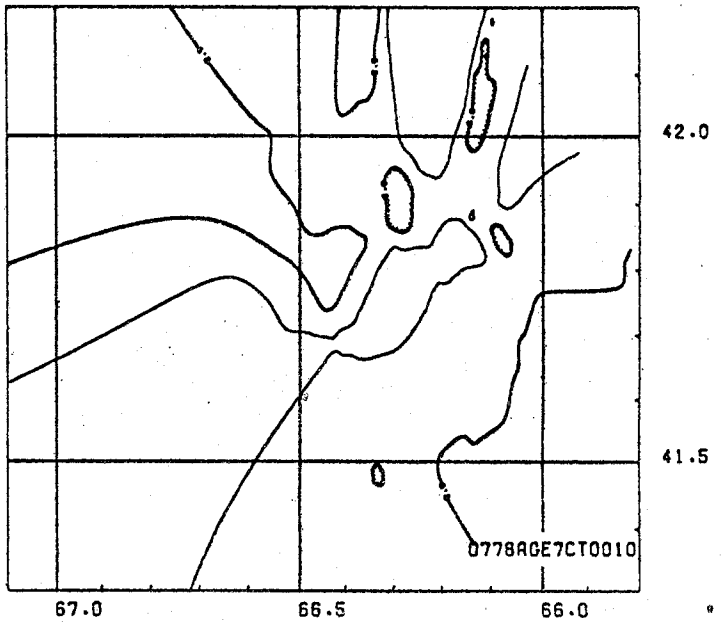
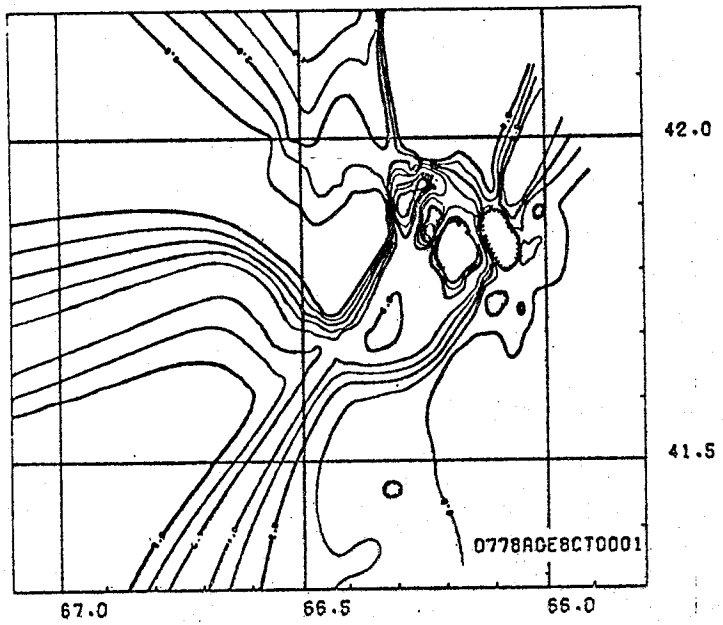


Fig. A1. 1978 survey data. Relative indices of abundance (number at age) according to geographical locations. (CT 0100: isopleth of number at age=100)







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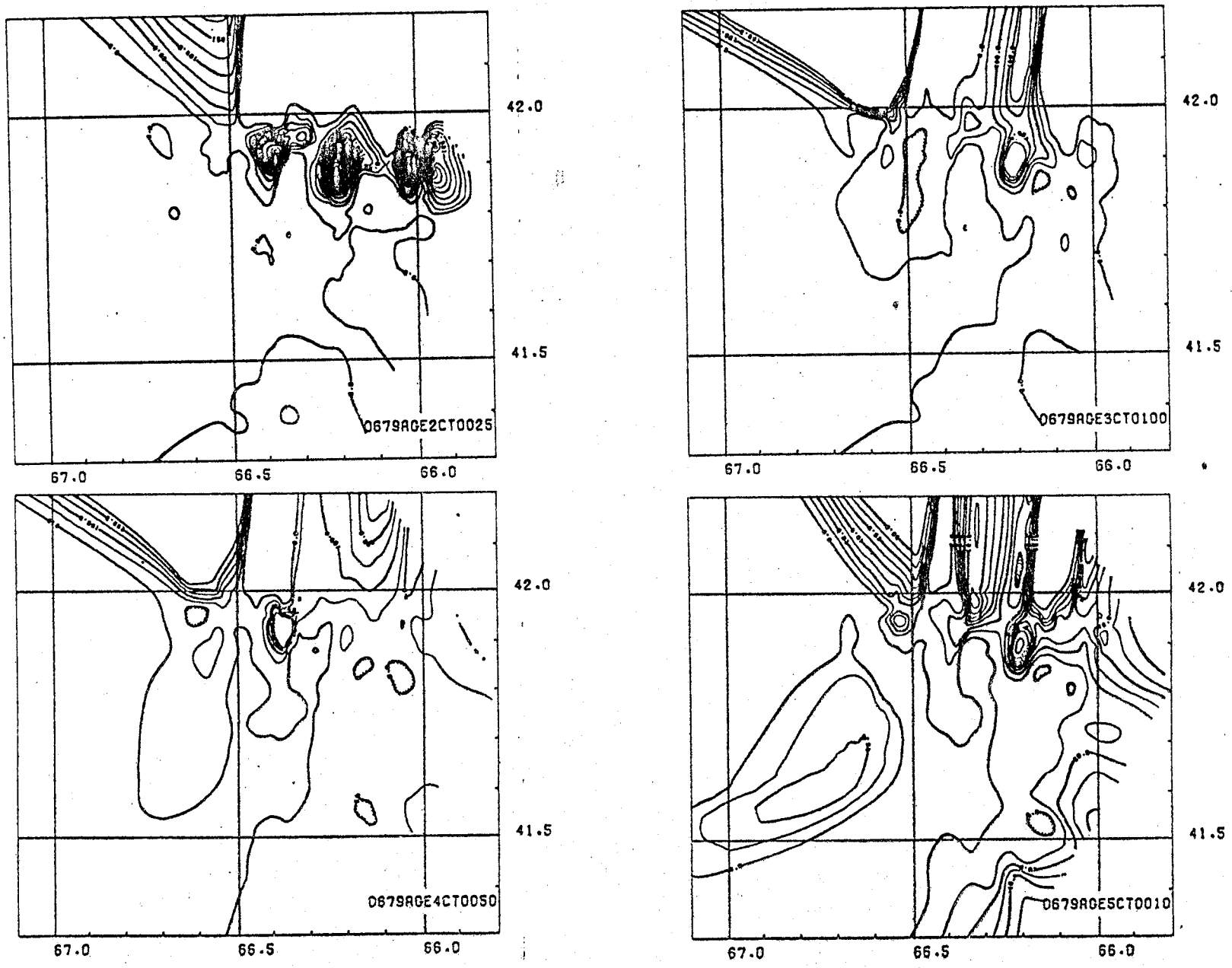
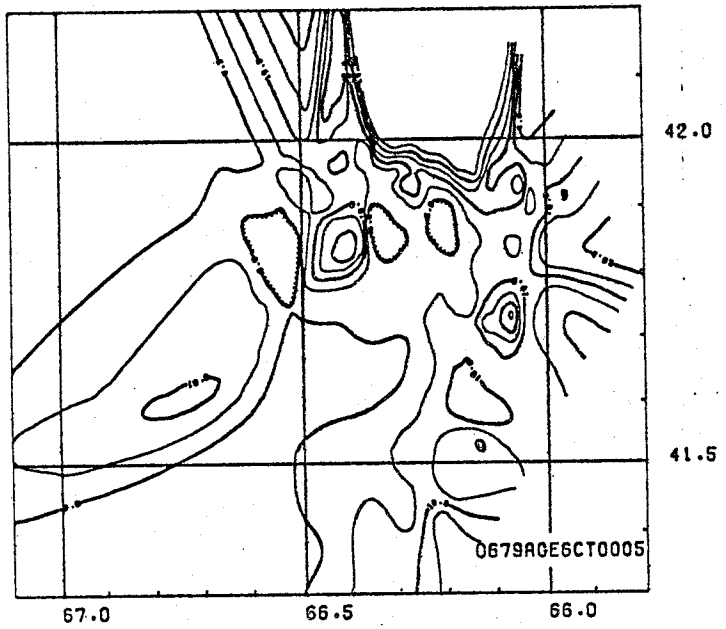
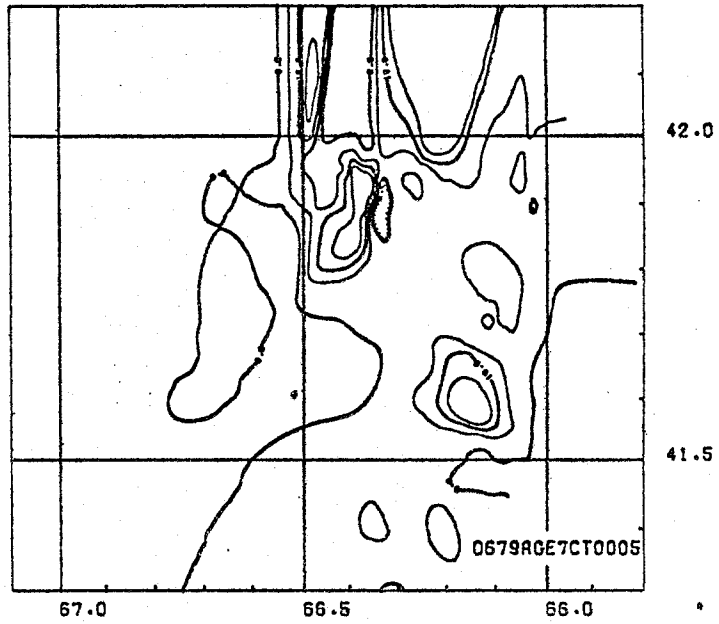
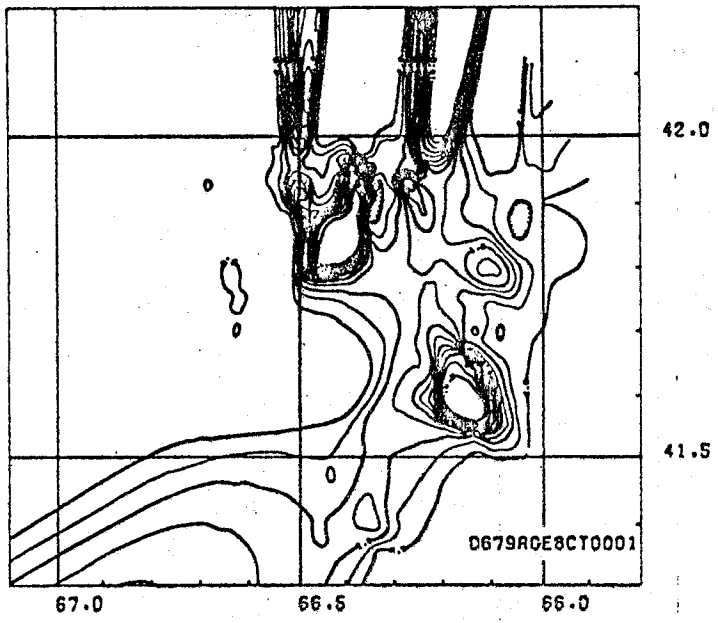


Fig. A2. 1979 survey data. Relative indices of abundance (number at age) according to geographical locations. (CT 0100: isopleth of number at age=100)







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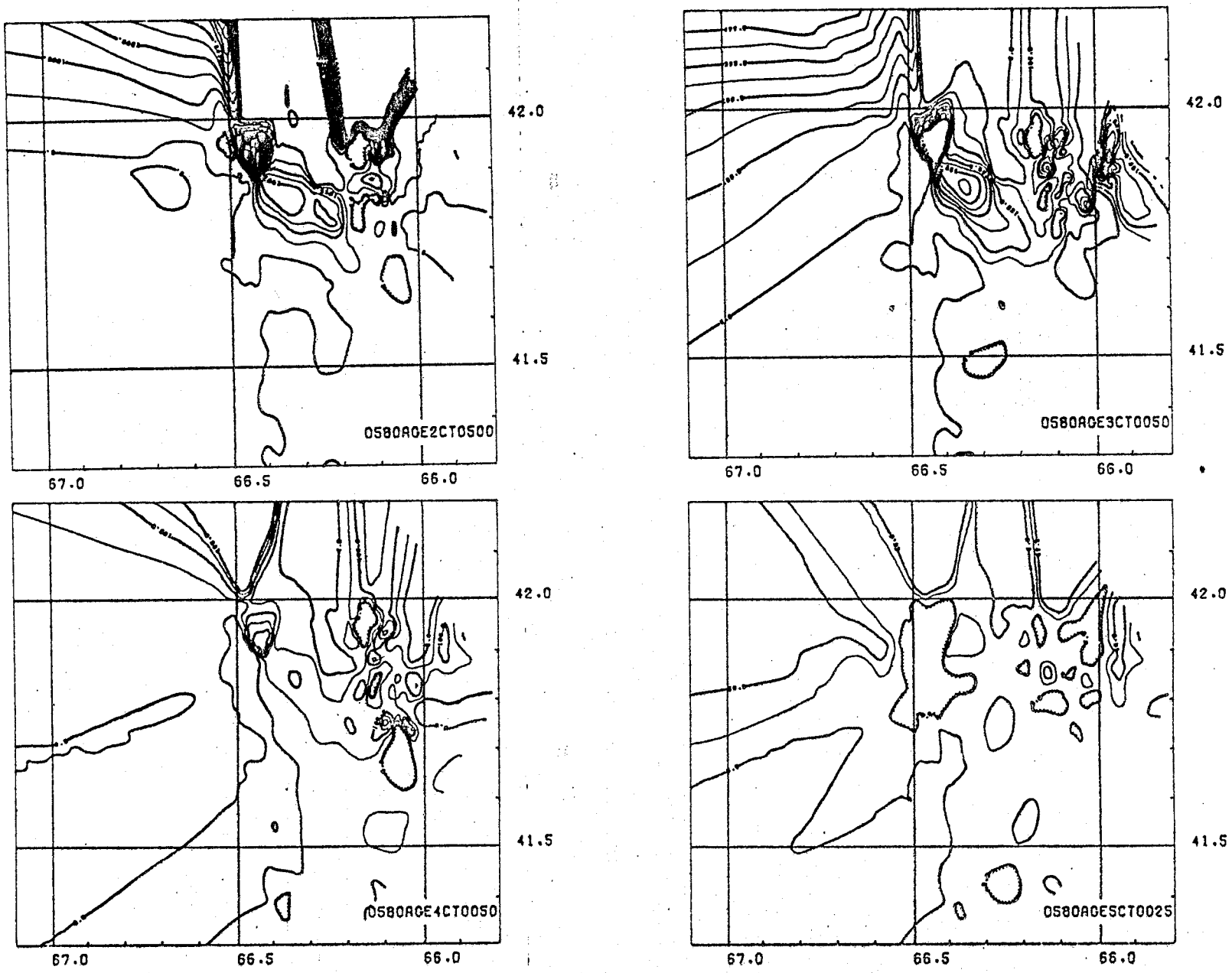
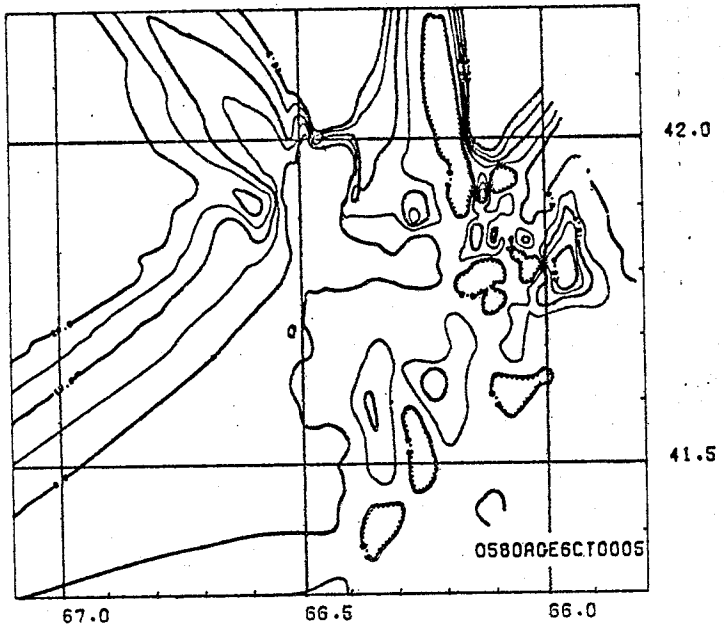
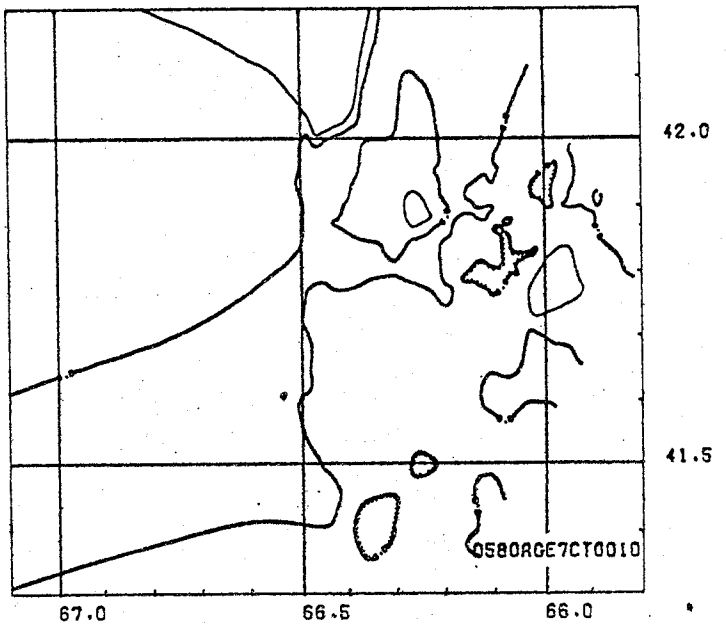


Fig. A3. 1980 survey data. Relative indices of abundance (number at age) according to geographical locations. (CT 0100: isopleth of number at age=100)





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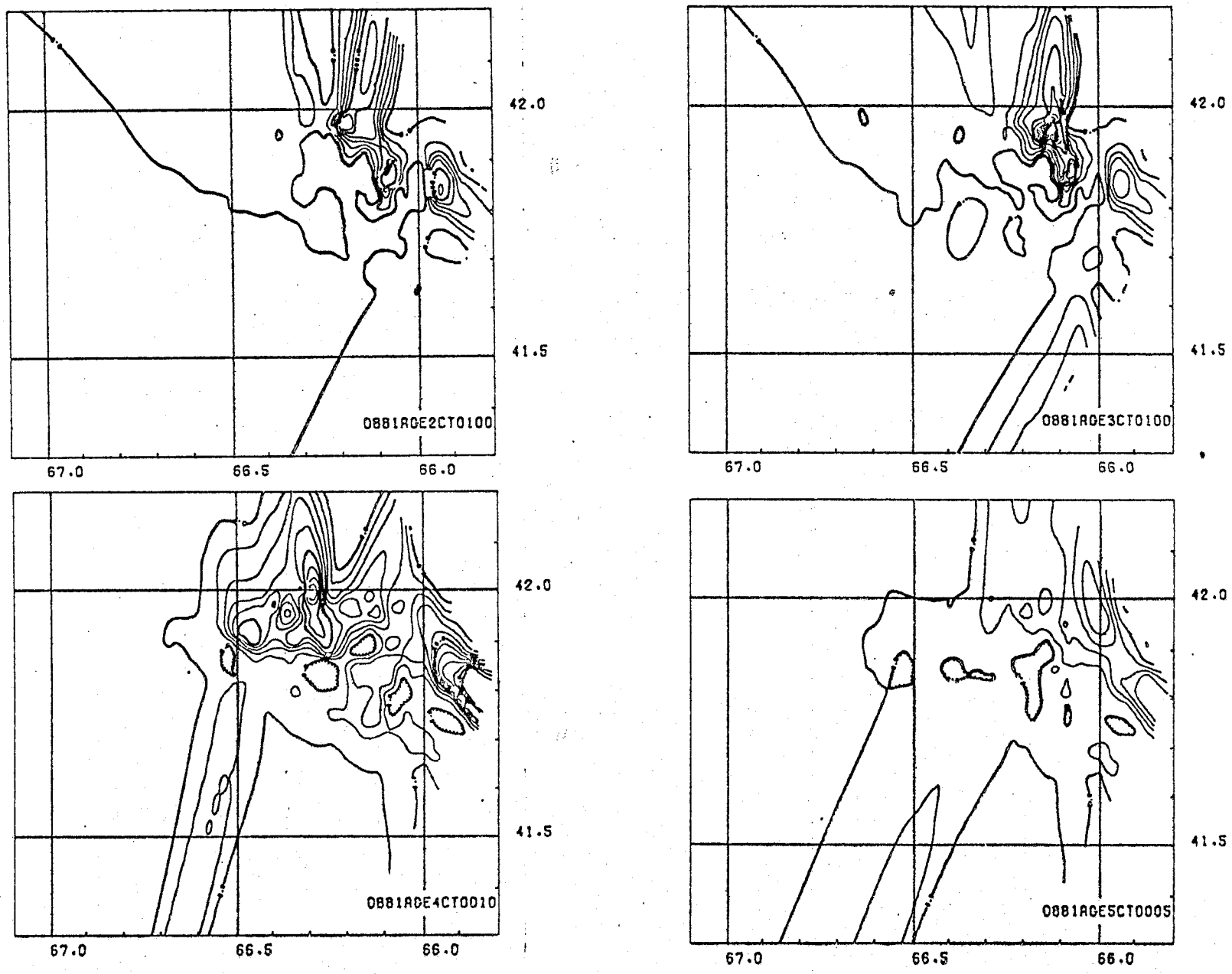


Fig. A4. 1981 survey data. Relative indices of abundance (number at age) according to geographical locations. (CT 0100: isopleth of number at age=100)

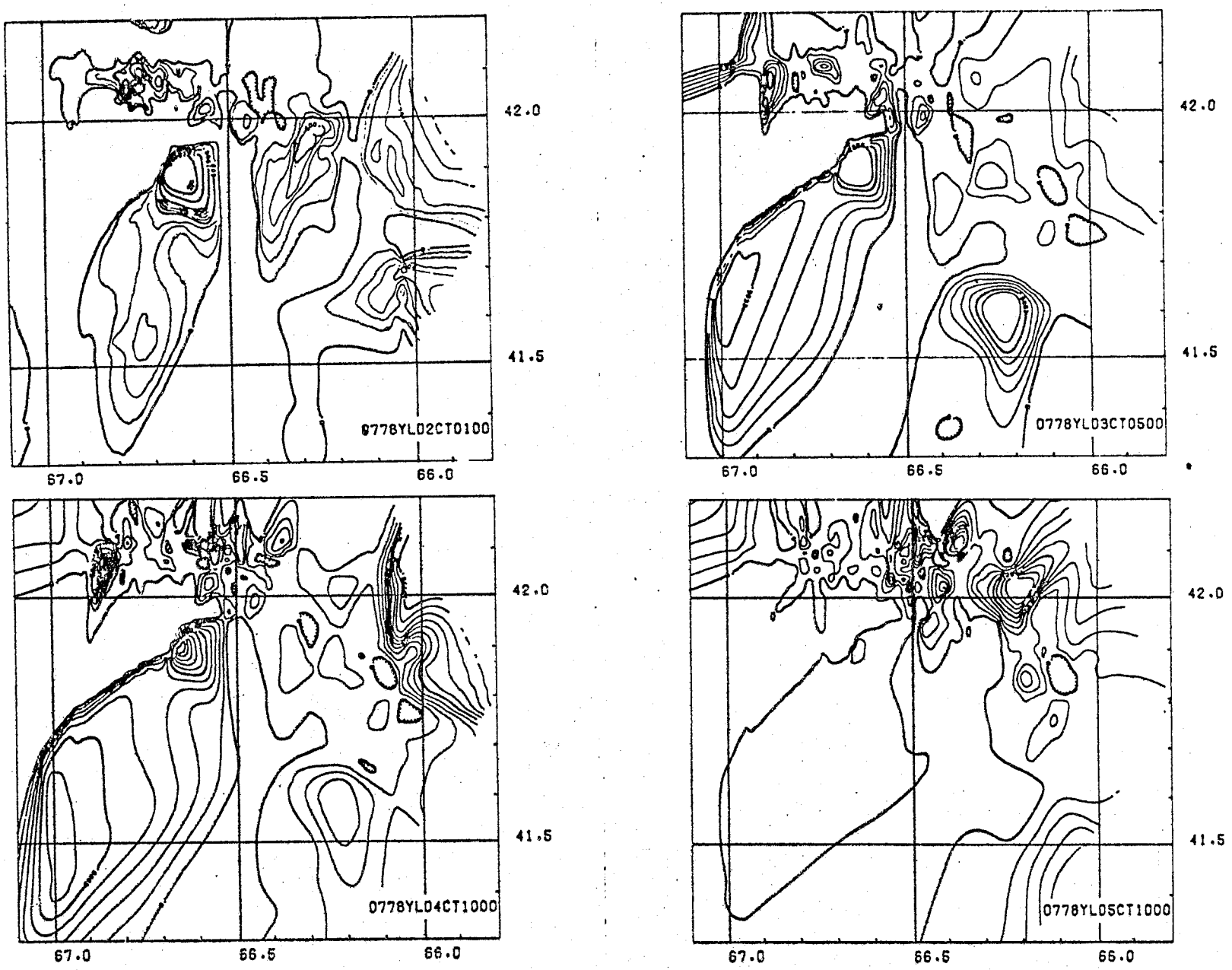
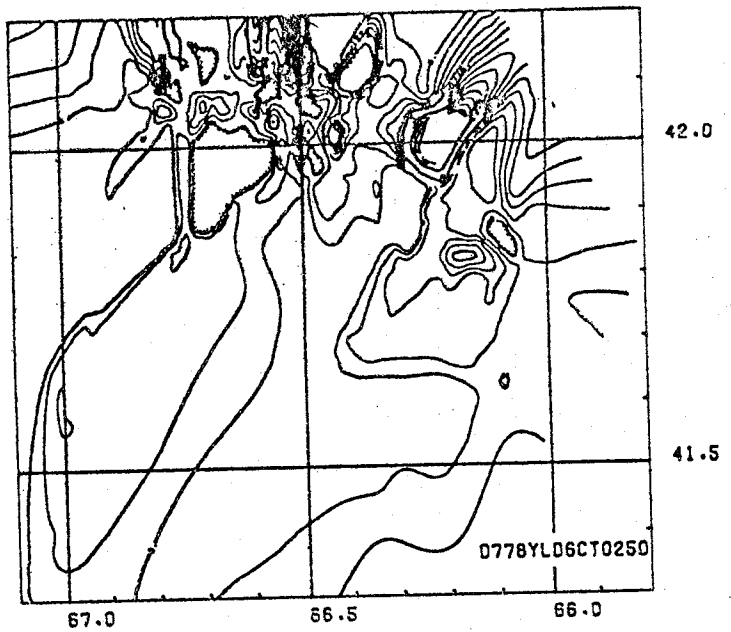
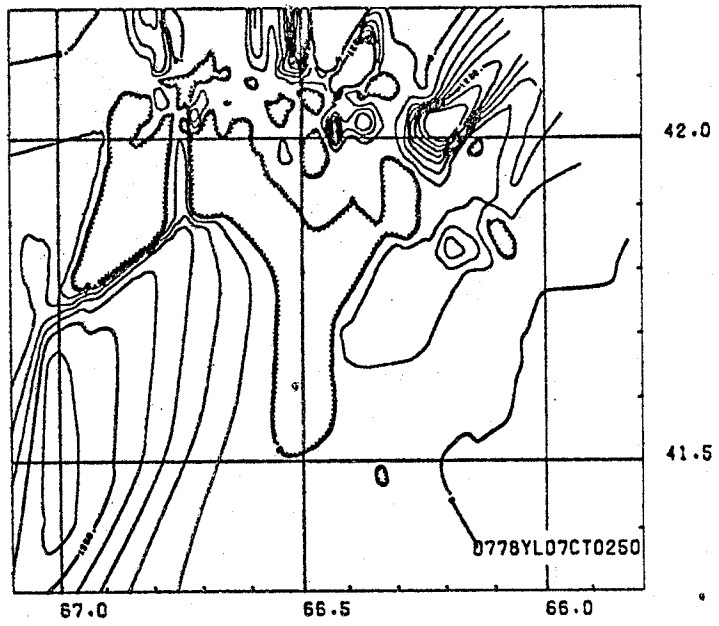
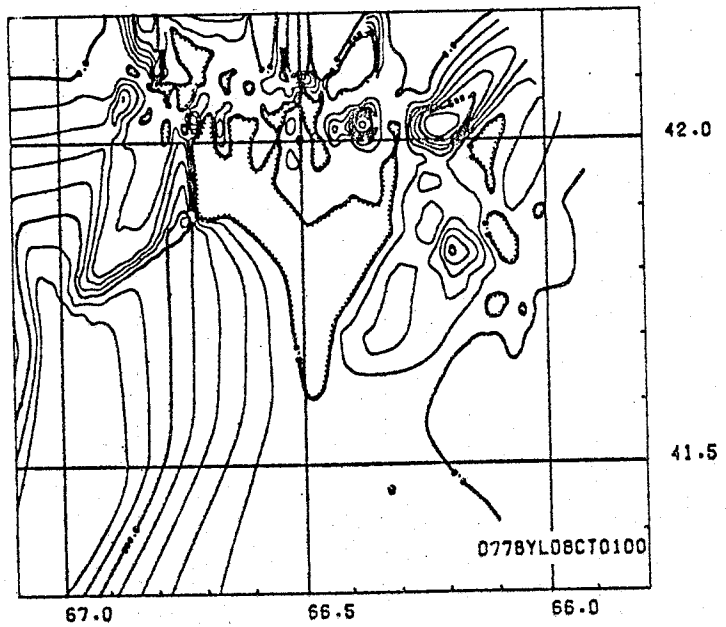


Fig. A5. 1978 survey data. Relative estimates of biomass at age according to geographical locations. (CT 0100: isopleth of biomass at age=100g)







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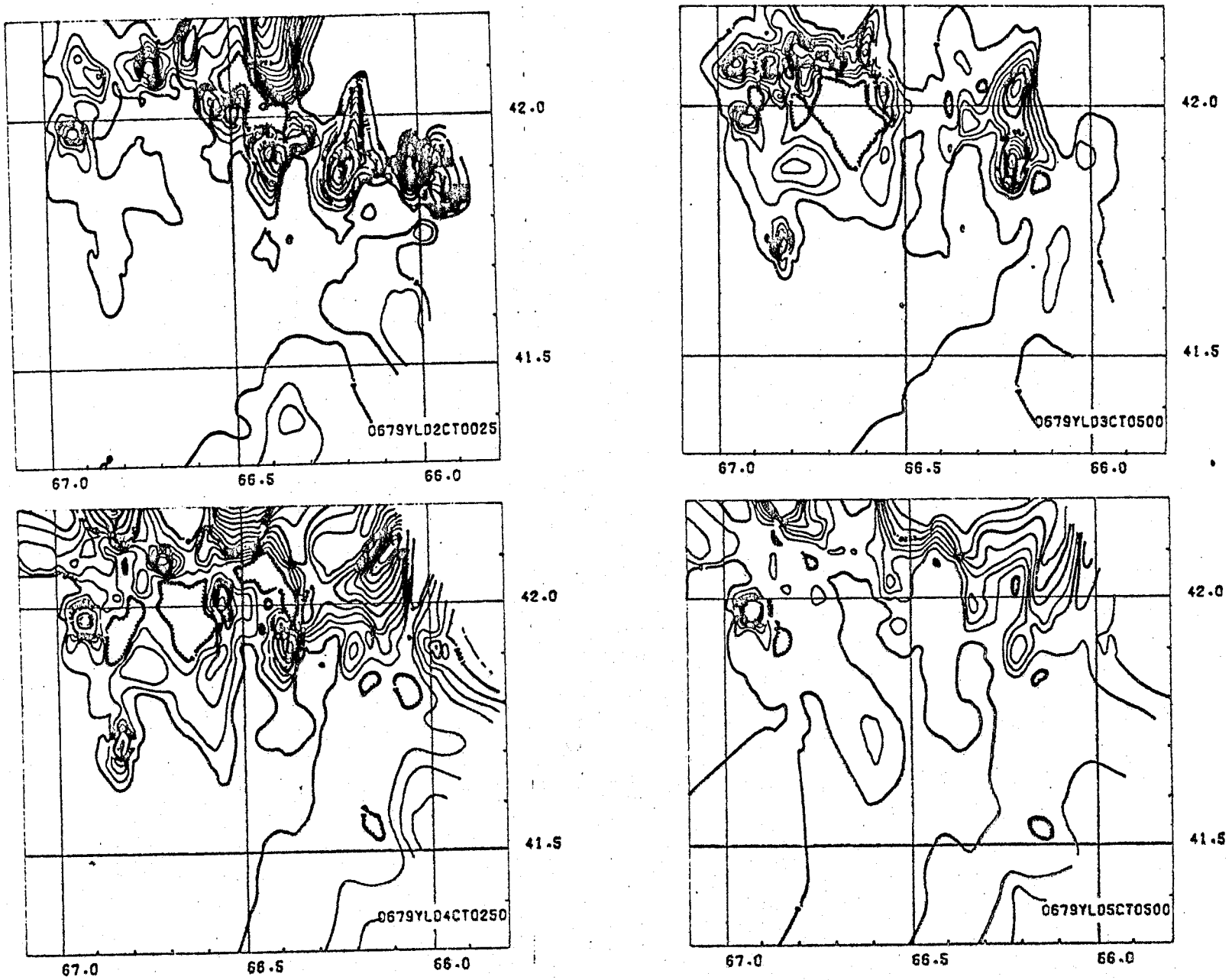
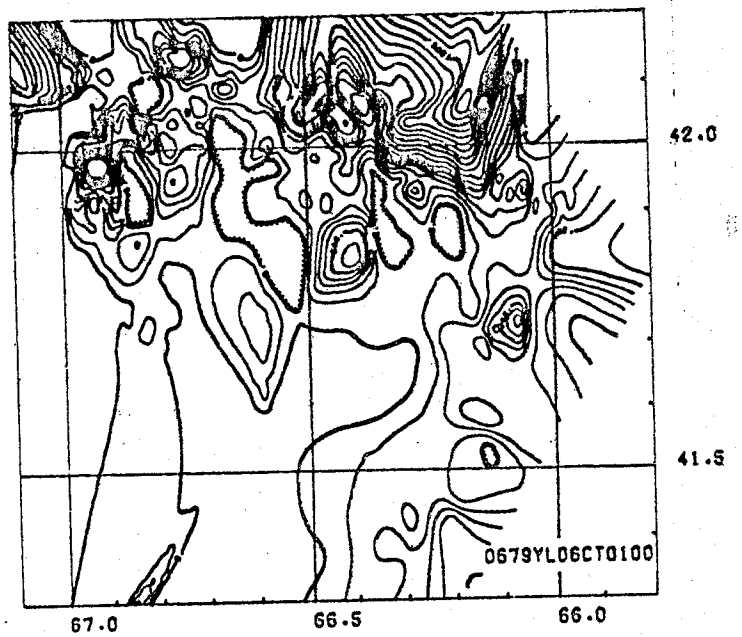
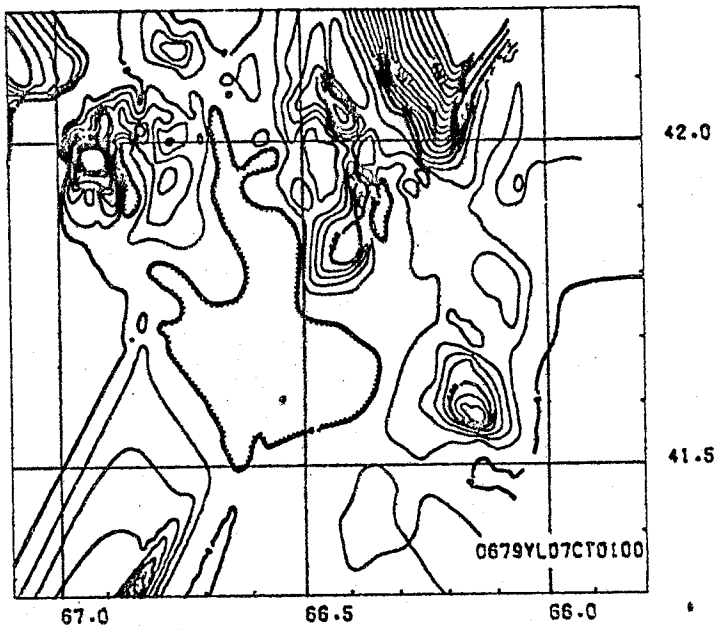
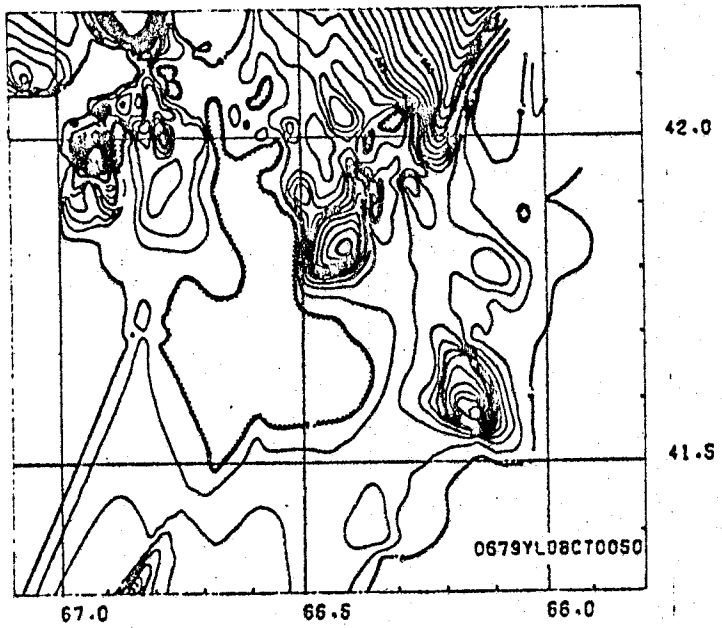


Fig. A6. 1979 survey data. Relative estimates of biomass at age according to geographical locations. (CT 0100: isopleth of biomass at age=100g)







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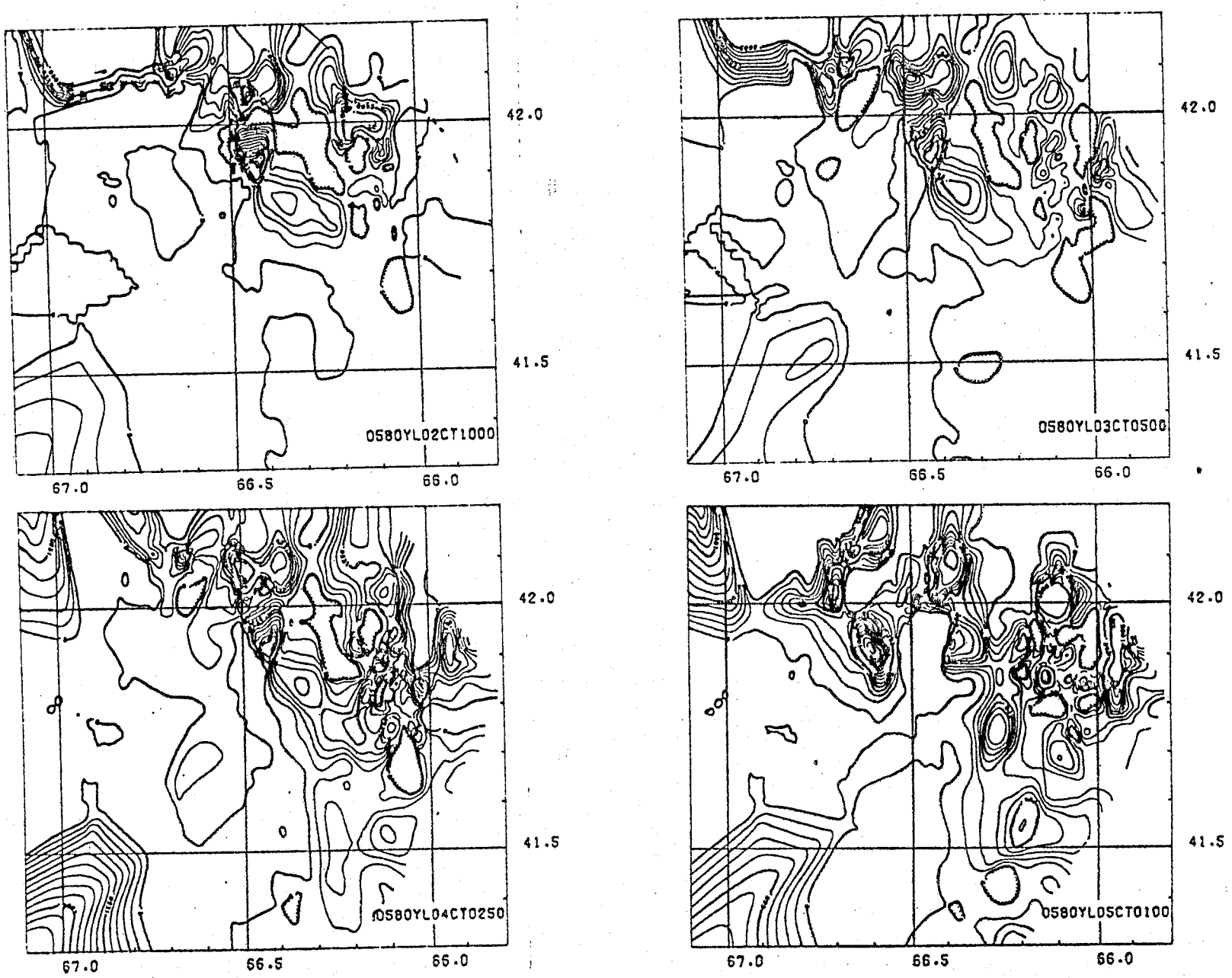
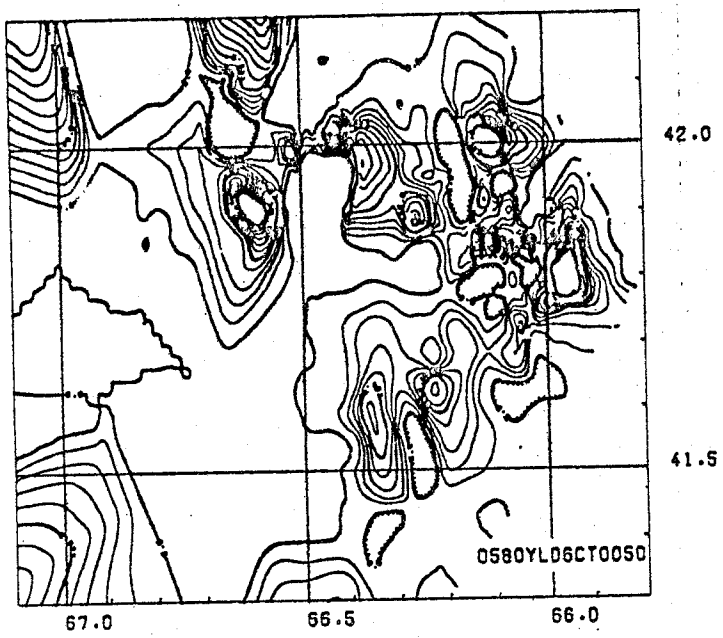
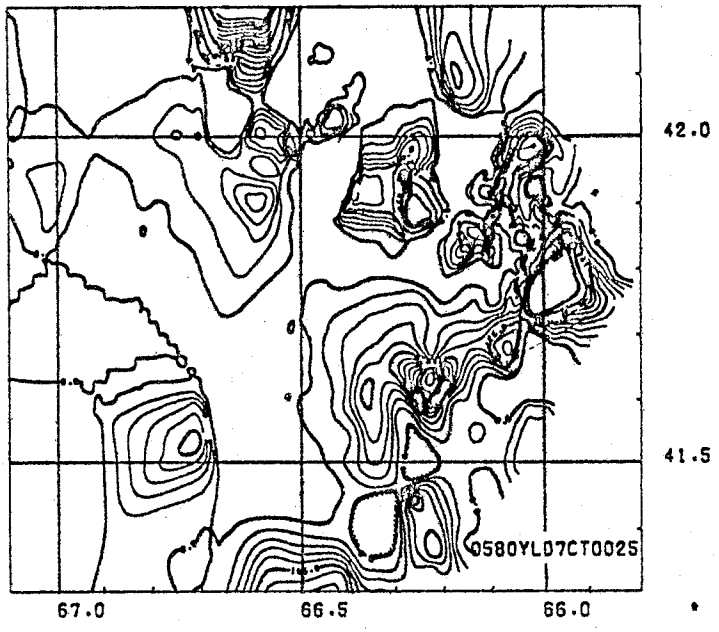


Fig. A7. 1980 survey data. Relative estimates of biomass at age according to geographical locations. (CT 0100: isopleth of biomass at age=100g)





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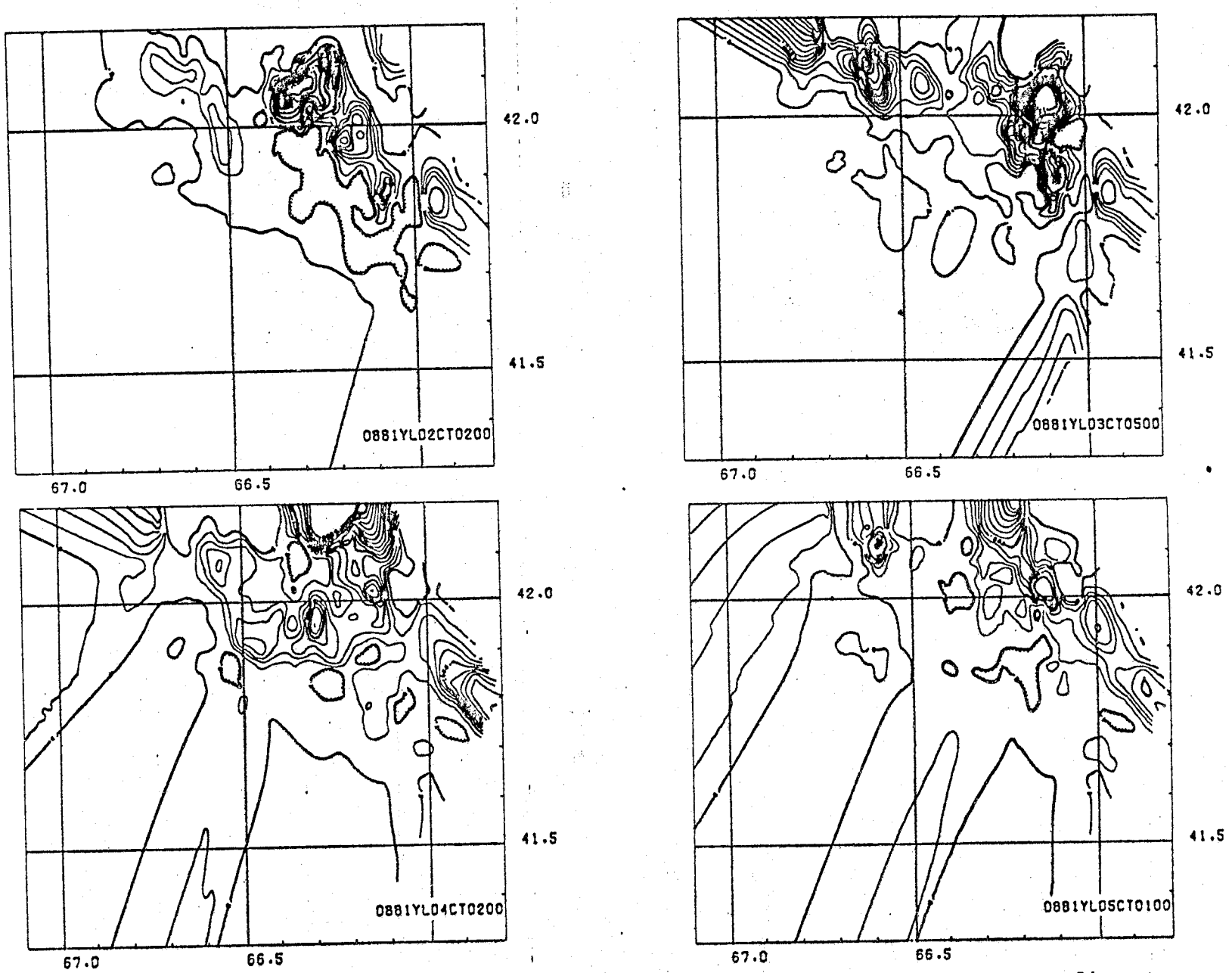

Fig. A8. 1981 survey data. Relative estimates of biomass at age according to geographical locations. (CM 0100: isopleth of biomass at age=100g)