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1990 Bay of Fundy Scallop Stock Assessment

By

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ABSTRACT

The strong recruitment pulse first observed in the 1986 research stock survey is now only evidenced by slightly inflated abundances of 5, 6 and 7 year old scallops in the inside zone. The number of scallops in the traditional beds have been depleted to 1985 and 1986 levels. The decline is partly attributable to a mass mortality of scallops in the inside zone beginning in the spring of 1989 and apparently culminating in the fall of that year.

Despite this change in abundance, 1990 landings overall remain high. This is due to the exploitation of a sizable scallop bed off Cape Spencer, N.B. by the Digby fleet. Relaxed fishing pressure in the inside zone in 1989-90, due to this movement of the fleet off the Digby beds, resulted in a relatively high meat yield when this zone re-opened in October 1990.

With poor log compliance and irregular fleet movements through the year, it is extremely difficult to establish an estimate of scallop production.

RESUME

Le fort recrutement qu'on avait décelé dans l'inventaire de recherche de 1986 ne peut maintenant être tracé que par les nombres tant soit peu élevés de pétoncles entre 5 et 7 ans dans la zone intérieure. L'abondance de pétoncles sur les bancs traditionnels est retombée aux niveaux de 1985 et 1986. Le déclin est attribué, en partie à une mortalité massive dans la zone intérieure qui a commencé au printemps de 1989 pour culminer semble-t-il, durant l'automne.

Malgré ce changement en abondance, les débarquements de 1990 demeurent élevés en général grâce à l'exploitation d'un banc important au large du Cap Spencer, N.-B. par la flottille de Digby. Le relâchement de l'effort de pêche sur la zone intérieure en 1989-90, la flottille ayant déplacé son effort des bancs de Digby vers le Cap Spencer, a permis un rendement en viandes relativement élevé lorsque la zone a été ré-ouverte en Octobre 1990.

Etant donné le peu de journaux de bord complétés et les déplacements irréguliers de la flottille durant l'année, il est extrêmement difficile d'établir un estimé de production de pétoncles.

BACKGROUND

The scallop beds off Digby, N.S. have been in a state of flux over the last five years. Two strong recruitment pulses, first observed in 1986 and 1987 as 2 yr olds, contributed to unprecedentedly high landings in 1988 through to 1990. While scallop abundance increased in many parts of the Bay due to these year classes, the greatest concentration of scallops was centered on the inside fishing zone from Parkers Cove to Gulliver's Head and off Cape Spencer, N.B. (Fig.1). In the spring of 1989, the incidence of "clappers" (empty paired shells) off Digby rose from an average of 3% over the previous four years to an estimated 23%. By the fall, this value further increased to 51%, with over 90% dead in some areas. Consequently, the fleet targeted the Cape Spencer bed during the winter of 1989-90. In a fishery where log compliance is negligible, such movements off the traditional beds further erode the management database by complicating interpretation of the landings. The fleet returned to fish the inside zone in October 1990, with the depletion of the Cape Spencer bed. Although abundances are down, a larger meat size was landed compared to October 1989 values.

This document presents data on scallop abundance on the Digby grounds, an update of the mass mortality event which occurred since 1990 report (Robert et al. 1990), and a record of fleet activity throughout the year with predictions for landings in 1991.

METHODS

Fishery Data

Information on fishing effort is calculated using data from two main sources: logbooks and sales slips.

Captains of all scallop vessels over 25.5 G.T. are legally required to maintain logbooks. Logbooks provide information on vessel position and effort data and are issued at the time of licensing. While many small vessel operators (less than 25.5 G.T. and/or under 14 m L.O.A.) provide log information, they are not required to do so by law. Vessel compliance with log regulations has been very poor over recent years; only 13 of the over 25.5 G.T. full Bay of Fundy licensed vessels submitted logs in 1990 (Table 1).

Fleet activity has been monitored through sales slip records and port sampling information.

Survey Procedures

The 1990 stock assessment survey was carried out from June 18 to June 29 following the protocols used in previous years.

100 survey stations were randomly selected within one of three strata defined according to commercial catch levels, and post-stratified by fishing area and distance from shore (Robert et al. 1984). Normally the strata are determined from the previous year's log information. However, the paucity of log coverage in 1989, particularly on the Digby grounds, precluded this procedure. As a result, the 1990 survey strata were defined by historical log information. Log analysis was performed on combined 1988 - 1989 Bay of Fundy log data. 1988 data consisted of the period May 1 to December 31. 1989 data consisted of logs received to May 1989. Only Class 1 data (complete information) were used.

A further thirty-six stations were added to accommodate a genetic sampling program.

These additional stations were randomly selected within 2 mile distance intervals per area, in order to ensure two stations per interval. Where two or more stations randomly occurred within a distance interval from the survey allocation, no new stations were added. Where less than two sites occurred within an interval, additional sites were added to bring the total number to two. As sampling procedures were the same at these additional stations, the catch was assessed and included in analyses.

The research vessel "J.L. Hart" was used to sample the survey stations. A 4-gang Digby drag was used with alternating lined and unlined buckets. At each station the catch per bucket (live animals plus clappers) is weighed and the number of animals in 5 mm increment shell height classes is recorded. Live animals are processed separately from "clappers". The data are prorated to 7-gang catches and 800 m tow distance to provide comparison with historical data fished with conventional gear. Only data from the inside lined bucket and the outside unlined bucket are used. The number of 2 - 4 year olds from the lined bucket are added to the number of 5+ year olds from the unlined bucket to give a single catch value. This number is prorated to an 800 meter tow by a distance coefficient and then multiplied by 7.

Spatial distribution of the scallops was contoured using ACON 4.18 (Black 1988) derived from Delaunay triangles and inverse distance weighted interpolation (Watson and Phillip 1985) as detailed in Robert et al. (1990). The resulting "volume" estimates (i.e. abundance density integrated over area) are more accurate in areas of high station densities (Fig. 1).

Biological Data

Three depth-dependent von Bertalanffy growth curves have been established using data from 1982-85 to convert shell height to numbers-at-age matrices (Robert et al. 1985, Robert et al. 1990). The parameters of the curves are as follows:

Depth (m)	Asymptotic Shell Height (mm)	t_0	k
100-85	143.210	1.3800	0.2221
86-105	133.763	1.4011	0.2414
>105	125.989	1.4469	0.2610

Meat count per area, and meat yield data were collected by a port sampler. 500 g meat samples were collected from the vessels as they landed. Individual meat weights and numbers were recorded from each sample. Port sampling was conducted from May through to November 1990.

RESULTS

Fishery performance

The number of Bay of Fundy licences remained the same in 1990 as in 1989 (Table 1). However, the number of active licences declined to 94; 5 vessels over 25.5 G.T. being inactive. Of these 5, 4 were active in the groundfish fishery. While there has been little change in the overall log compliance of this fleet, the quality and quantity of logs per vessel has improved.

As in previous years, the majority of Bay of Fundy scallop licence holders carried additional licences (Table 2). These include groundfish, swordfish, squid, herring, shrimp and lobster. However, with the exception of groundfish licences, one lobster and one herring licence, none of these were used for commercial purposes in 1990. However, over 50% of the groundfish licences

held by these fishermen were in use at some time during the year.

Annual landings on the Nova Scotia side of the Bay of Fundy may indicate general trends in this fishery. Table 3 gives an historical profile of landings for statistical districts 37 (Digby Neck), 38 (Digby) and 39 (Annapolis). The landings data do not identify the location of the catch. In the last decade varying proportions of the landings of vessels over 25.5 G.T. have been attributable to fishing scallop beds outside the Bay (Robert et al. 1990). However in 1988 the high abundance of scallops in the Bay led to negligible fishing outside. In 1989 the catches off Digby were supplemented by Cape Spencer catches. The 1990 landings are down by over 1400 t for these statistical areas. Approximately 2200 t were landed. This level is still high in comparison to previous years. However landings outside of district 38 have drastically diminished in particular those landings in district 37.

The total catch landed in the Bay of Fundy in 1990 was approximately 3065 t. 71% of this was landed in Digby by the vessels over 25.5 G.T.

The traditional beds off Digby are fished on a seasonal basis according to zones. The inside fishing zone is closed from May 1 to September 30. Therefore catches from October to April are normally assumed to come from this inside zone. Statistical catches for NAFO sub-subarea 4Xr covering that time period normally matches the catches from the inside zone. However, log book compliance is inadequate and when the fleet lands catches from other parts of the Bay in Digby, estimates for the inside zone are seriously compromised. In 1989-90 a large proportion of the landings for the October - April time frame were not caught in the inside zone (Robert et al. 1990). This was due to the fleet targeting the Cape Spencer grounds. Table 4 gives the 1990 landings in tons of scallop meats by statistical district throughout the Bay. The landings for the Saint John district (districts 48 and 49) are much higher than normal. However, virtually all of this catch was landed before October 1990. If we extend this trend to the Digby fleet we can assume that the October- December 1990 catches came from the inside zone. Conversely, since the fleet for the most part did not fish the inside zone last winter, landings from January - October 1990 form the basis of our estimate for the outside zone. Interviews with selected fishermen confirm these assumptions. These catch estimates appear in Table 5. With only a few logs available, Class 1 data is extremely rare. It is very difficult to estimate a meaningful CPUE with only 13 vessels submitting logs. It is furthermore difficult to assume that effort and catch rates of these vessels are representative of overall fishing performance. However, we can compare the 1989-90 CPUE to that of 1990-91, as virtually the same vessels filled out logs.

Prior to 1980-81 catch rates of about 7 kg/hm and catches of about 250 t per season were maintained in the inside zone. Catches and CPUE then fluctuated through the decade. In 1986-87 both indices were low and the inside fishing zone was closed prematurely. In 1988-89 catch and CPUE were at all time record highs (Table 5, Robert et al. 1990). In 1990-91 catches in the inside zone were down 28% along with a decrease in CPUE from 1989-90 values. Catches in the outside zone are the highest on record. This value represents the harvesting of the small, high density scallops from Cape Spencer in the first quarter of the year. CPUE is lower than in 1989-90.

Monthly CPUE for both the inside and outside zones in 1989 and 1990 from the limited Class 1 log data is given in figure 2. From Jan-Mar 1990 the outside zone CPUE was high while the fleet fished the Cape Spencer grounds. At this time only 1 to 3 boats reported fishing in the inside zone and the CPUE values are consequently unreliable. Thereafter it fell to moderate to low levels as the reporting vessels moved to other grounds. CPUE was moderate in the inside zone after it re-opened in October.

Meat weights in the inside zone reached a size more typical of the area (Table 6). The meat count in October was well under the 55 meats per 500 g legal limit. Even with growth slowing through the winter, it is not expected that counts will not be met during the 1990-91 season.

In summary, overall catches by the Bay of Fundy fleet were spectacularly high with landings of over 2500 t in 1990. However, most of this catch was taken from the outside zone in contrast to historical patterns. With the depletion of the Cape Spencer beds, catches for the

outside zone are expected to decline in 1991-92. Catches and CPUE for the inside zone have already assumed more typical levels.

Stock survey

Annual stock surveys have been carried out for a number of years (Robert et al. 1990) with slight changes in sampling design according to fishery performance. The strong recruitment pulses that settled off Digby were concentrated between 3 - 8 mile from shore from Delaps Cove to Gulliver's Head. Hence more stations were targeted in that area in the 1989 survey. With minimal log information from the inside zone in 1989, the 1990 survey used the same catch strata as the 1989 survey. Table 7 presents the results of the 1990 stock survey. It is immediately noticeable that the average number of scallops caught is lowest in the high catch stratum. This is partially due to a mass mortality of scallops which occurred in this zone between surveys. The distribution of scallops by area (Tables 7, 8), shows that the areas off Digby Gut and Delaps Cove have the lowest abundance. No substantial numbers of pre-recruits were collected in any of the areas. The large number of scallops entering the fishery in 1987 and 1988 are still detected in the 5,6 and 7 yr old animals in most areas (Table 8).

The distribution of these age classes is given in figure 3 using contour plots. The scale on each figure varies with the darkest shadings given to the highest abundance for that age. The large numbers of 5 and 6 yr olds were concentrated off Centreville and in the 8-12 mi strata from Delaps Cove to Hampton. Only the older animals (7-9 yrs) showed highest concentrations in the inside zone.

Abundance estimates were derived from the survey data by calculating volumes under the contoured surface (Tables 9, 10). Subtriangulation of the surface may be used as an interpolation technique to smooth the contours, hence adding refinement to the volume estimates. Following Robert et al. (1990) we derived our estimates with 16 subtriangles. The beds around Digby have been subdivided into 3 sectors (Fig.1): 1) the Core area from south of Gulliver's Head to north of Delaps Cove 2) the area below Digby (Centreville) and 3) the area above Digby (Parkers Cove to Hampton). The core area has the greater number of stations and hence the data from that area is more accurate. Abundance in the core area has fallen by 58% from 1989 (Table 9). The area below Digby showed a 32% fall in abundance, while the area above Digby remained relatively unaffected with only an 8% decline. Over the whole area the numbers of scallops have fallen to levels more consistent with 1985 values. Table 10 shows the volume estimates of the number of scallops at age caught in the core area and in the total area. The sharp decrease in numbers in the core and total areas illustrated in Table 9 can be attributable to a fall in all age classes except the 8 and 9 yr olds. Table 10 also shows that in 1990 there were more "clappers" in the 4-7 year classes in the core area than live animals.

The incidence of "clappers" remained a relatively constant 3% of the total catch (Fig. 4) from June 1985 - June 1988. In June of 1989 the research survey collected an average 22.6% "clappers". The distribution of these "clappers" is given in Fig. 4. The animals began to die in a zone from Delaps Cove to Gulliver's Head with up to 70% clappers in certain areas. By June 1990 the research survey found 50.5% "clappers" on average with over 80% dead in a large area of the grounds (Fig 4). The relaxation of the hinge ligament combined with fouling of the interior of the shells suggested that the animals had died the previous autumn. There was also a lag in the size frequency distribution of "clappers" versus live animals which would be accounted for by the 6+ months growth of the latter (Fig. 5). No moribund animals were found in June 1990.

Fig. 6 shows the distribution of animals of all ages over the Digby grounds from 1985-1990. The area of high density in 1988 was that hit hardest by the mass mortality of 1989. Whether this die off was due to indirect fishing mortality, starvation or disease can only be speculative at this late date. Animals collected in October of 1990 were free of disease and parasites. The distribution of the scallops over the beds in 1990 has virtually returned to the pattern shown before the recruitment pulse (Fig 6).

DISCUSSION

Landings for the 1990-91 fishing season remain high to date - the third highest on record. However, the future does not look good. The bulk of these landings came from the exploitation and subsequent depletion of a high density scallop bed off Cape Spencer, N.B. On the traditional beds a mass mortality of scallops has eroded the abundance to near 1985 levels. The remnants of the recruitment pulse are still seen in higher numbers of 5, 6 and 7 yr old animals which are concentrated in the outside zone. However, the pulse first observed in the 1986 stock survey is now largely gone. The distribution of scallops of all ages is now more or less uniform across the inside and outside zones, which is a change from the previous three years when the inside zone had markedly higher scallop densities. With the exhaustion of the Cape Spencer bed it is expected that landings will decline in 1990-91 possibly to 700 - 1000 t.

Causal factors implicated in the decline of scallops in the inside fishing zone have not been identified. The majority of animals died during a period when the zone was closed to fishing. The die-off began in the spring of 1989 and continued through to the fall and appears to have been restricted to the same area throughout. Analysis of specimens collected in June of 1990 were disease free. However, the pattern of mortality, with a sharp boundary between Delaps Cove and Parkers Cove and a gradation towards Gulliver's Head at the other extreme, is suggestive of disease (Dr. J. Cornick, Fish Health Unit, Dept. of Fisheries & Oceans, Halifax). Certainly, scallops as well as other bivalves are vulnerable to infestation by macroparasites, bacterial, mycotic and protozoan diseases, viruses and reoviruses (Fisher, 1988). Summer mortality in bivalves has also previously been observed and may be linked to physiological stress associated with spawning (Fisher, 1988). Similar rapid declines have been noted for this species in New England where numbers fell by 73% in a Rhode Island population. In this case an outbreak of an epizootic disease known as dark meat disease was implicated. No dark meats were observed in the Digby area however. Our surveys indicate that the abundance of scallops dropped from 3.5 / m² in 1988 to 1 / m² in 1990. This would not appear to be dense enough to suggest food limitation, however these numbers do not take into account gear efficiency, and even a 10% change could introduce density-dependent factors.

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Table 1.- 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
1989	99	96	14
1990	99	94	13

Table 2.- Additional licenses carried by Bay of Fundy scallop license-holders for the year 1990. Source: Licensing Unit, Department of Fisheries and Oceans, Halifax.

Types and number of other licenses	
Groundfish (otter trawl, long lining, etc.)	60
Swordfish	41
Herring	11
Lobster	6
Squid	12
Shrimp	2
total	132

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

22 license-holders do not carry additional license(s).			
40	"	carry	1 additional license.
28	"	"	2 additional licenses.
9	"	"	3 " "
1	"	"	4 " "
1	"	"	5 " "

Table 3.- 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	
	(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
1989	-	58.19	54.94	3412.90	16.39	105.18
1990*	-	9.60	1.44	2137.34	0.48	39.24

*preliminary

Table 4.- 1990 landings in t of scallop meats by statistical districts in the Bay of Fundy. Digby Co.: 37,38; Annapolis Co.: 39; King's Co.: 40; Colchester Co.: 43; Cumberland Co.: 44; Saint John: 48,49; Grand Manan: 50; Campobello: 51; Charlotte Co.: 52,53; Albert Co.: 79. (1 indicates landings from vessels < 25.5 G.T., 2 indicates landings from vessels ≥ 25.5 G.T.) Source: Statistics Division, D.F.O., Halifax.

Month	37		38		39		40		43		44		48	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Jan	-	3.24	1.44	146.70	0.48	1.32	-	-	-	-	0.60	-	0.36	1.08
Feb	-	0.96	-	109.12	-	-	-	-	-	-	-	-	1.56	0.96
Mar	-	1.20	-	233.85	-	1.08	-	-	-	-	1.68	-	2.16	2.16
April	-	0.48	-	197.84	-	2.16	-	-	-	-	1.92	-	12.48	2.28
May	-	1.32	-	269.87	-	5.28	1.08	-	-	-	9.12	-	16.21	11.88
June	-	-	-	191.60	-	3.48	0.36	-	-	-	9.84	-	14.05	6.48
July	-	0.60	-	168.79	-	6.72	0.72	-	0.12	-	8.28	3.48	19.81	4.32
Aug	-	-	-	203.24	-	6.48	0.12	-	-	-	12.36	4.56	29.17	7.44
Sep	-	0.96	-	142.74	-	9.48	0.96	-	-	-	7.68	2.76	16.21	1.80
Oct	-	-	-	268.19	-	3.24	0.36	-	-	-	4.08	1.08	4.44	0.60
Nov	-	0.84	-	144.78	-	-	-	-	-	-	0.24	0.60	2.04	1.08
Dec	-	-	-	60.62	-	-	0.96	-	-	-	-	-	0.96	.96
Total	-	9.60	1.44	2137.34	0.48	39.24	4.56	-	0.12	-	55.80	12.48	119.45	41.04

Month	49		50		51		52		53		79	
	1	2	1	2	1	2	1	2	1	2	1	2
Jan	4.44	2.16	25.81	23.53	14.17	6.36	0.96	-	6.48	1.68	0.48	-
Feb	4.44	2.16	18.25	16.09	4.32	6.12	0.48	-	0.60	1.92	0.36	-
Mar	9.84	3.24	22.57	32.17	11.76	15.49	0.48	-	1.32	0.84	-	-
April	7.56	2.52	7.32	29.17	8.52	7.32	-	-	-	-	9.60	3.00
May	5.76	0.60	11.76	25.33	7.80	10.80	-	-	2.40	-	13.21	2.04
June	2.40	0.12	2.52	12.36	7.08	7.92	-	-	0.84	1.56	8.88	3.00
July	1.56	-	1.44	9.84	4.68	9.24	-	-	1.08	2.28	6.12	1.80
Aug	1.92	1.20	1.56	7.80	9.72	13.09	-	-	-	-	12.24	2.16
Sept	1.68	0.36	3.48	6.60	6.36	7.92	-	-	-	-	7.80	1.44
Oct	0.24	-	2.64	21.01	4.08	9.12	-	-	-	-	0.96	-
Nov	-	-	0.96	8.16	1.68	5.40	-	-	-	-	0.72	-
Dec	0.60	-	0.84	3.60	3.84	3.36	-	-	-	0.36	0.72	.24
Total	40.44	12.36	99.15	195.66	84.01	102.14	1.92	-	12.72	8.64	61.09	13.68

Combined landings = 3053.36 t

Table 5.- 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	*3034.52	263.26	15.09	*929.41	86.13	6.06
1989-90	*625.47	63.44	6.96	*1827.06	113.92	5.05
1990-91	****522.30	57.18	5.44	*****1911.00	115.59	3.87

*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.

****preliminary Jan. - Apr. stats for 1991.

*****Jan. 1 to Sept. 30, 1990.

Table 6.- Characteristics of the meat size distribution in the commercial fishery while fishing the inside zone.

Season	Month	Meat weight				Sample size (n meats)	Meat count per 500 g
		Mean	Min	Max	S.E.		
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
	Apr	10.7	5.4	23.7	0.3	103	46.7
1989-90	Oct	18.9	2.3	58.9	0.2	1802	26.4
1990-91	Oct	26.3	6.9	66.4	0.2	1300	19.0
	Nov	24.1	6.6	47.0	0.5	90	20.7

Table 7.- 1990 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)									Total	No. of Stations	
	2	3	4	5	6	7	8	9	10+			
Catch stratum:												
low	2	9	19	57	50	51	28	13	12	241	26	
medium	-	3	11	9	33	67	51	18	11	203	9	
high	1	2	7	10	22	41	33	18	10	144	41	
exploratory	1	8	33	110	93	61	33	12	15	366	60	
Area stratum:												
Centreville	2	13	77	134	93	73	52	19	29	492	16	
Gulliver's Head	1	9	26	72	70	75	50	22	21	346	25	
Digby Gut	1	2	8	14	37	68	55	24	20	229	35	
Delaps Cove	-	2	5	15	44	61	34	145	5	180	30	
Parker's Cove	-	2	17	186	127	41	15	5	1	394	8	
Young Cove	-	4	15	110	120	38	14	2	1	304	4	
Hampton	3	12	22	111	63	26	10	4	7	258	16	
Zone stratum:												
inside 6-mile	1	4	22	53	53	70	49	21	18	291	57	
outside 6-mile	1	8	20	71	68	53	32	13	13	279	79	

Table 8. 1986-1990 stock surveys: 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+
Centreville										
	1986	77	24	22	13	29	37	33	22	35
	1987	14	76	53	31	66	52	56	38	92
	1988	-	-	-	-	-	-	-	-	-
	1989	23	329	167	229	261	221	81	22	31
	1990	2	13	77	134	93	73	52	19	29
Gullivers Head										
	1986	201	72	20	22	29	33	30	19	27
	1987	220	195	208	83	28	22	21	15	24
	1988	153	446	930	848	368	69	22	13	22
	1989	12	185	157	319	350	183	45	21	27
	1990	1	9	26	72	70	75	50	22	21
Digby Gut										
	1986	671	176	22	20	21	24	25	22	34
	1987	276	554	775	182	25	19	14	11	34
	1988	4	235	552	1239	514	48	11	7	23
	1989	1	8	33	218	253	137	35	11	8
	1990	1	2	8	14	37	68	55	24	20
Delaps Cove										
	1986	744	97	19	24	20	21	19	13	24
	1987	208	641	824	101	20	18	22	8	19
	1988	2	103	217	1010	226	24	15	9	20
	1989	2	4	26	245	228	114	21	5	2
	1990	0	2	5	15	44	61	34	14	5

Table 8. Continued. 1986-1990 stock surveys.

		Age (years)								
		2	3	4	5	6	7	8	9	10+
Parkers Cove										
1986		15	5	3	34	44	25	10	2	4
1987		19	154	48	18	32	21	11	3	3
1988		12	60	85	173	36	22	21	12	7
1989		1	8	84	326	41	16	6	4	2
1990		0	2	17	186	127	41	15	5	1
Young Cove										
1986		40	4	0	27	51	69	6	4	6
1987		39	82	13	37	42	24	7	6	13
1988		5	43	68	98	32	31	16	6	8
1989		3	5	11	119	140	48	12	4	2
1990		0	4	15	110	120	38	14	2	1
Hampton										
1986		48	7	7	45	51	39	8	7	7
1987		55	189	20	13	23	26	11	3	1
1988		29	106	149	91	50	41	22	7	2
1989		4	21	92	348	103	30	16	8	4
1990		3	12	22	111	63	26	10	4	7

Table 9.- Number of scallops (N 10⁶) per survey area calculated from the June 1990 survey volume estimates.

Year	Total Area	Core Area	Below Core Area	Above Core Area	Area Surveyed (km ²)
1985	79.54	52.30	5.67	21.57	1823.53
1986	255.88	188.52	8.42	42.21	1719.27
1987	389.13	351.78	4.82	31.39	1649.80
1988	438.99	376.42	N/A	62.04	1222.55
1989	182.17	123.08	16.88	41.89	1262.34
1990	100.61	51.56	11.50	38.42	1505.07

Table 10.- Surveyed areas of the traditional Digby grounds. The area has been subdivided: below core area; core area; above core area as, except for the core area, the other ones are not always represented at the same level (see text). Survey catch-rates (Numbers are in 10^6) on an age basis have been derived by volume calculations (smoothing interpolation technique with 16 subtriangles).

Area (km ²)				
Year	Below	Core	Above	Total
1985	134.87	1085.40	603.26	1823.53
1986	113.89	1036.95	568.43	1719.27
1987	77.52	959.38	612.91	1649.80
1988	0.00	683.22	539.32	1222.55
1989	51.47	735.06	475.80	1262.34
1990	94.46	868.41	542.21	1505.07

Abundance (x 10 ⁶)	Age (years)							
	2	3	4	5	6	7	8	9
Core area only (N 10 ⁶)								
1985	0.40	1.06	2.27	4.51	7.18	8.62	8.73	6.15
1986	117.79	26.94	4.76	5.81	6.44	6.73	6.18	5.00
1987	57.17	98.33	139.20	31.97	5.93	5.09	4.28	2.64
1988	3.10	35.24	75.48	192.70	53.68	7.46	2.75	1.70
1989	0.58	7.13	8.33	34.02	42.30	21.72	5.06	1.78
1990	0.19	0.97	2.53	7.20	11.10	12.99	8.81	3.73
Clappers 1989	0.38	1.06	5.04	19.56	13.75	5.87	1.39	0.43
Clappers 1990	0.03	0.83	3.75	18.76	27.23	20.39	7.28	2.28
Total area (N 10 ⁶)								
1985	0.44	1.20	3.27	10.52	14.45	15.11	12.13	7.29
1986	137.43	30.54	6.93	16.98	16.71	14.36	10.99	7.62
1987	61.70	114.47	143.12	33.86	9.07	7.75	5.86	3.28
1988	4.99	46.67	92.88	209.02	60.61	11.02	5.32	2.83
1989	1.07	10.96	14.71	59.66	55.58	26.97	7.37	2.53
1990	0.39	1.77	6.29	28.05	25.08	18.86	11.40	4.60
Clappers 1989	0.53	1.55	5.75	21.44	14.51	6.39	1.54	0.55
Clappers 1990	0.10	1.53	5.37	25.81	32.43	22.64	7.98	2.62

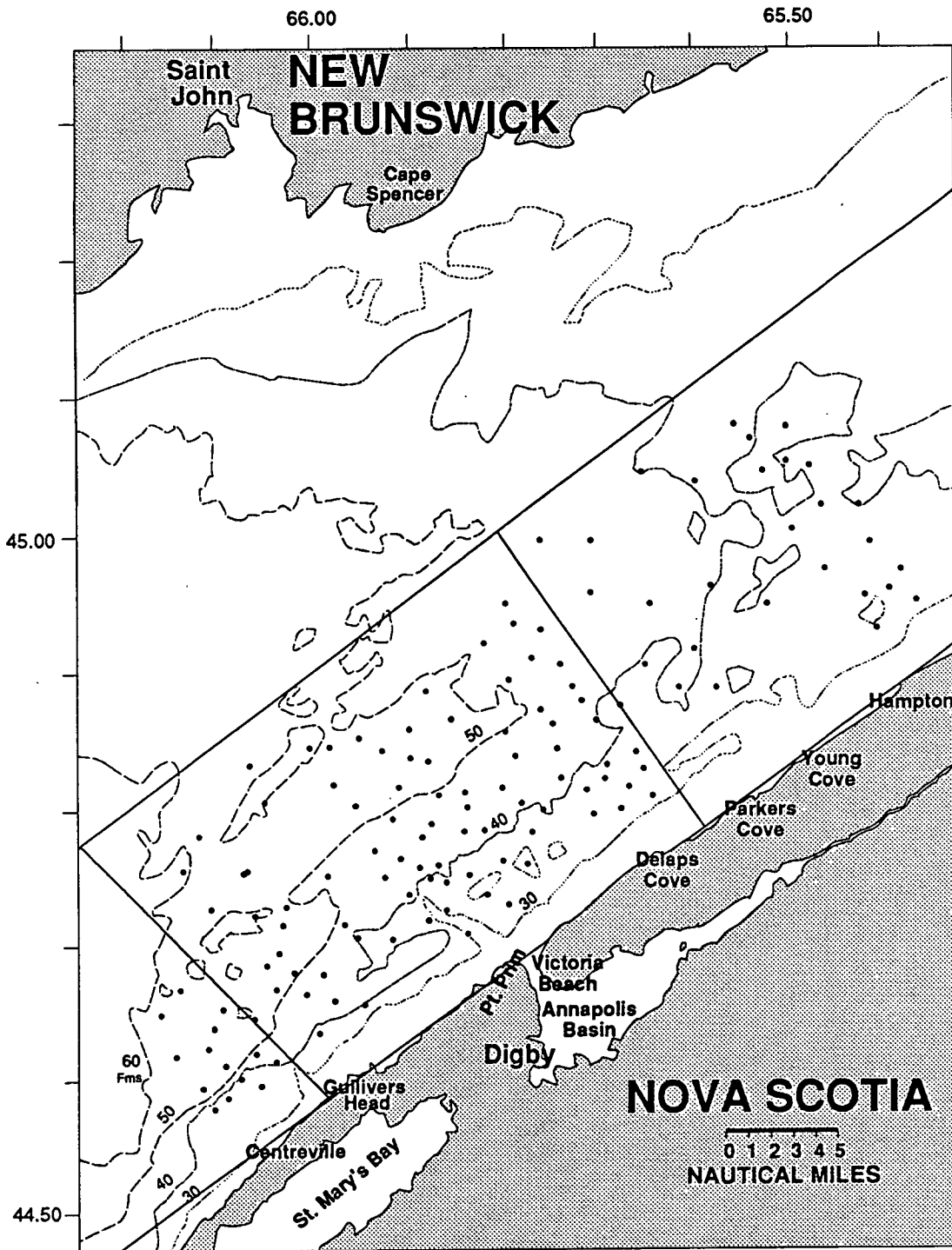
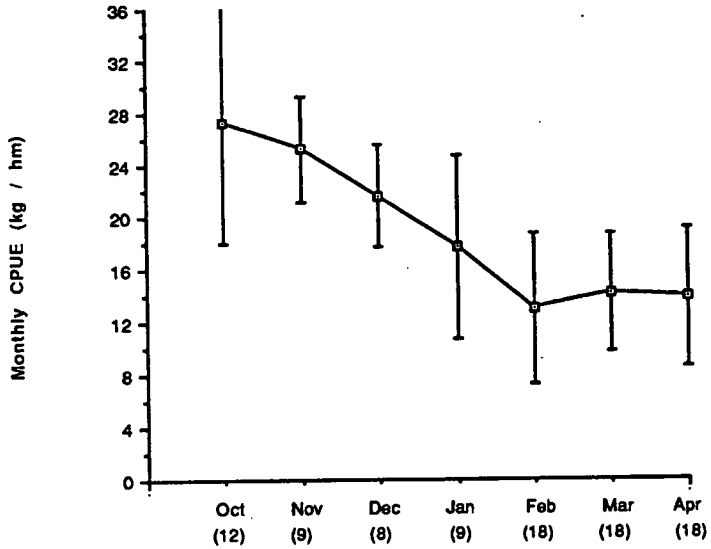
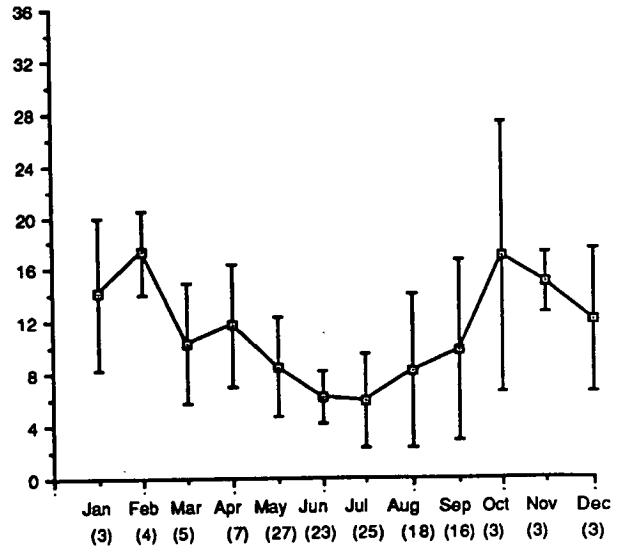


Figure 1.- The traditional Digby grounds with 1990 survey stations indicated by solid dots. The survey area has been divided into three areas for establishing abundance estimates.

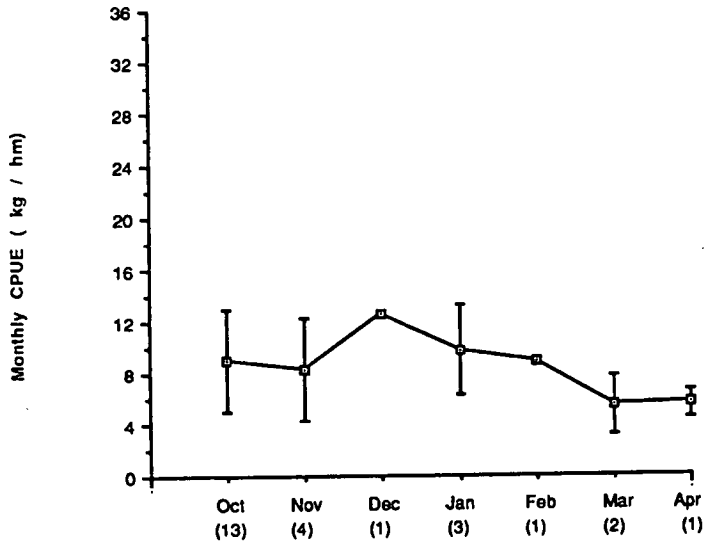
1988 - 89 Inside Zone



1989 Outside Zone



1989 - 90 Inside Zone



1990 Outside Zone

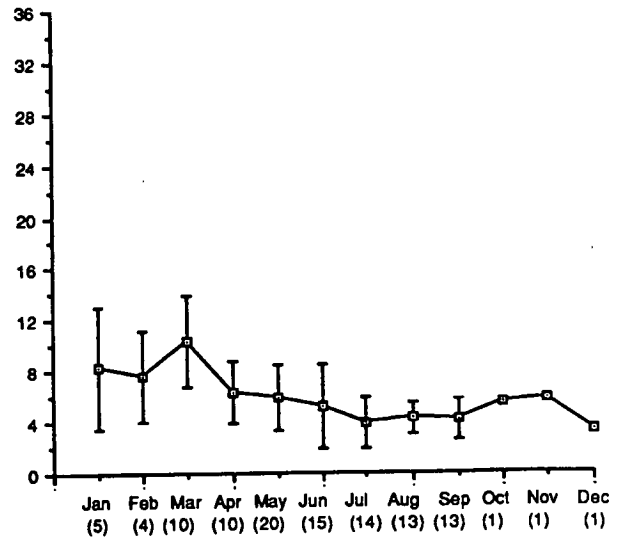


Figure 2.- Monthly CPUE for the inside and outside fishing zones. Values are calculated from Class 1 log data. The number of areas fished incorporated into the calculation are listed below the month on the x-axis.

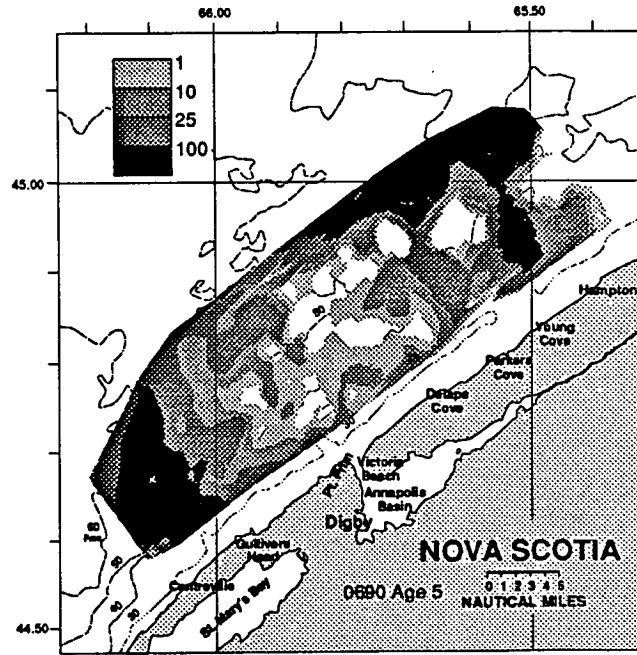
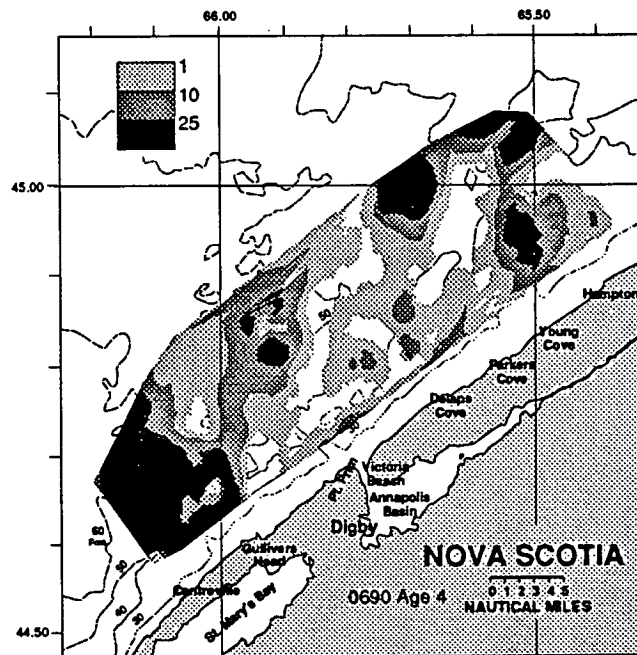
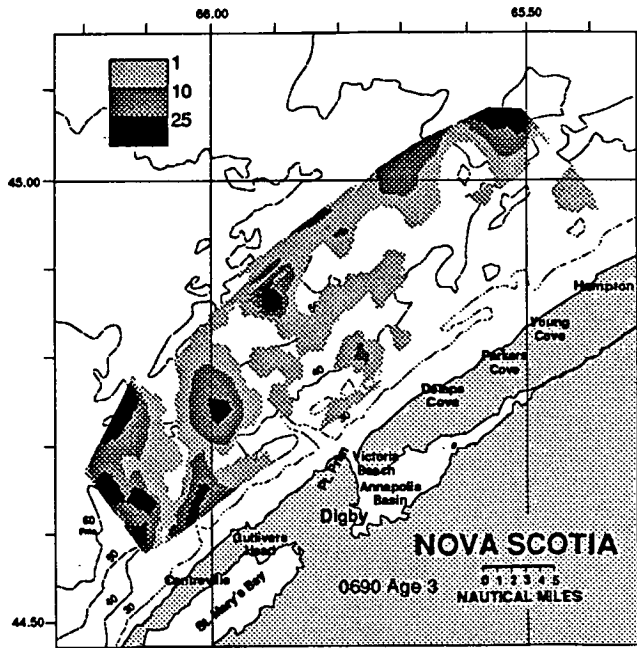
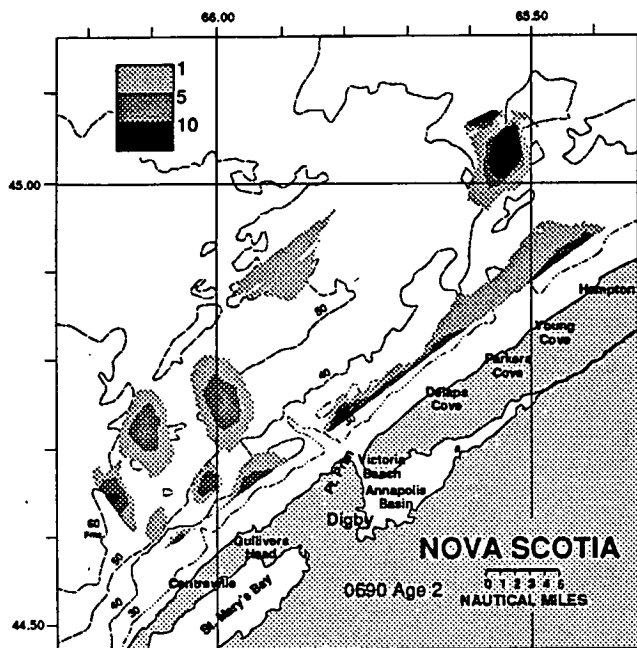


Figure 3-1990 survey catch rates. Scallop distribution on an age basis from abundance isopleths of survey data. Darkening shades of grey within isopleths refer to increasing number of scallops per standard tow (grey scale in upper corner of plot).

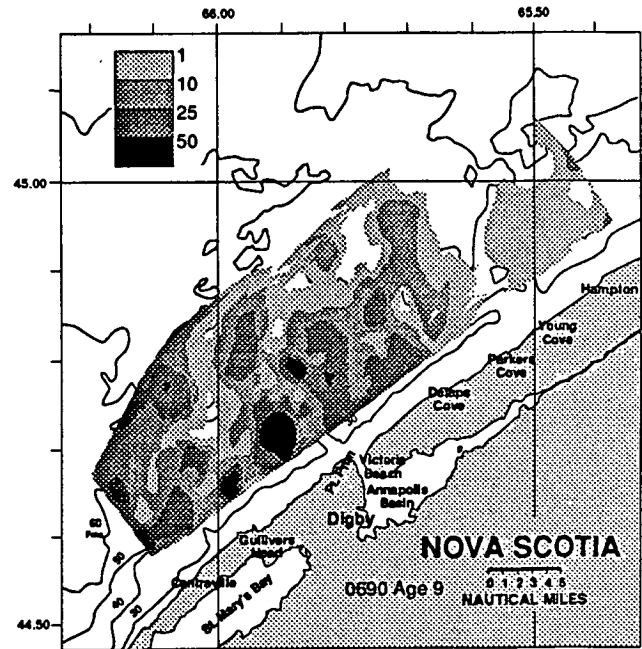
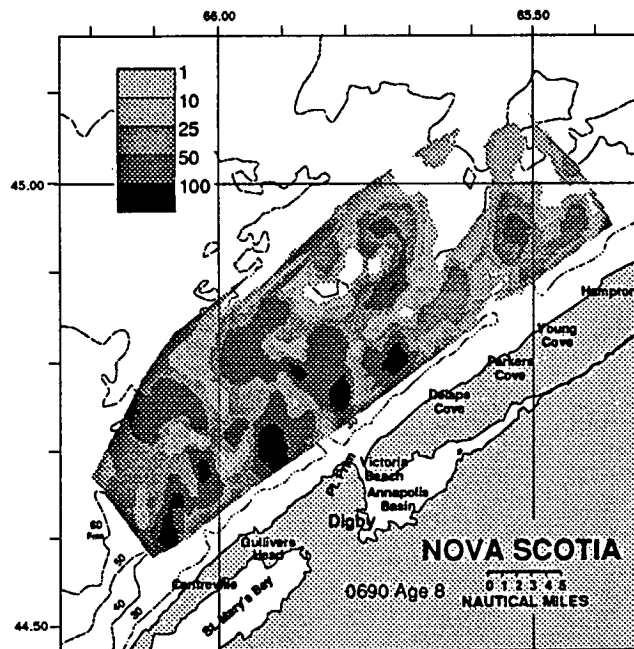
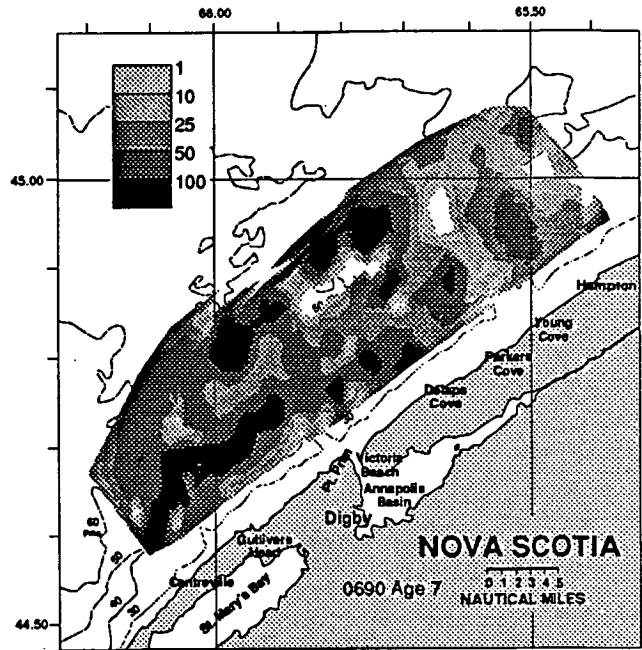
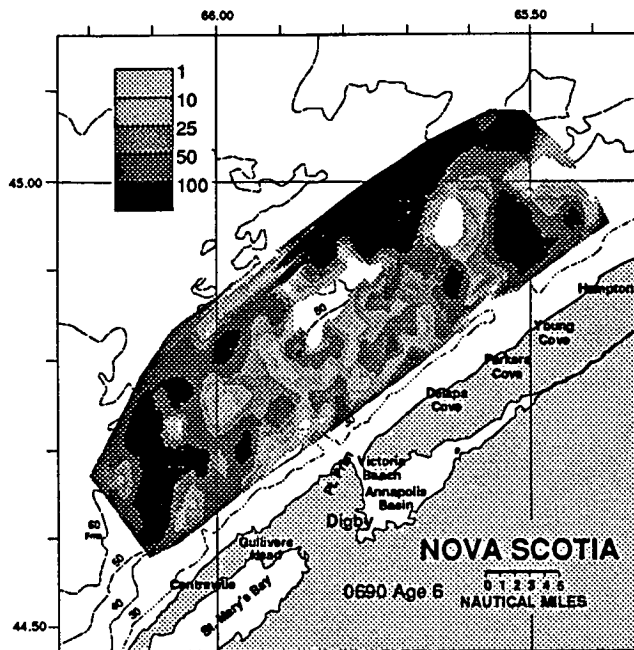


Figure 3. - Continued. 1990 survey catch rates.

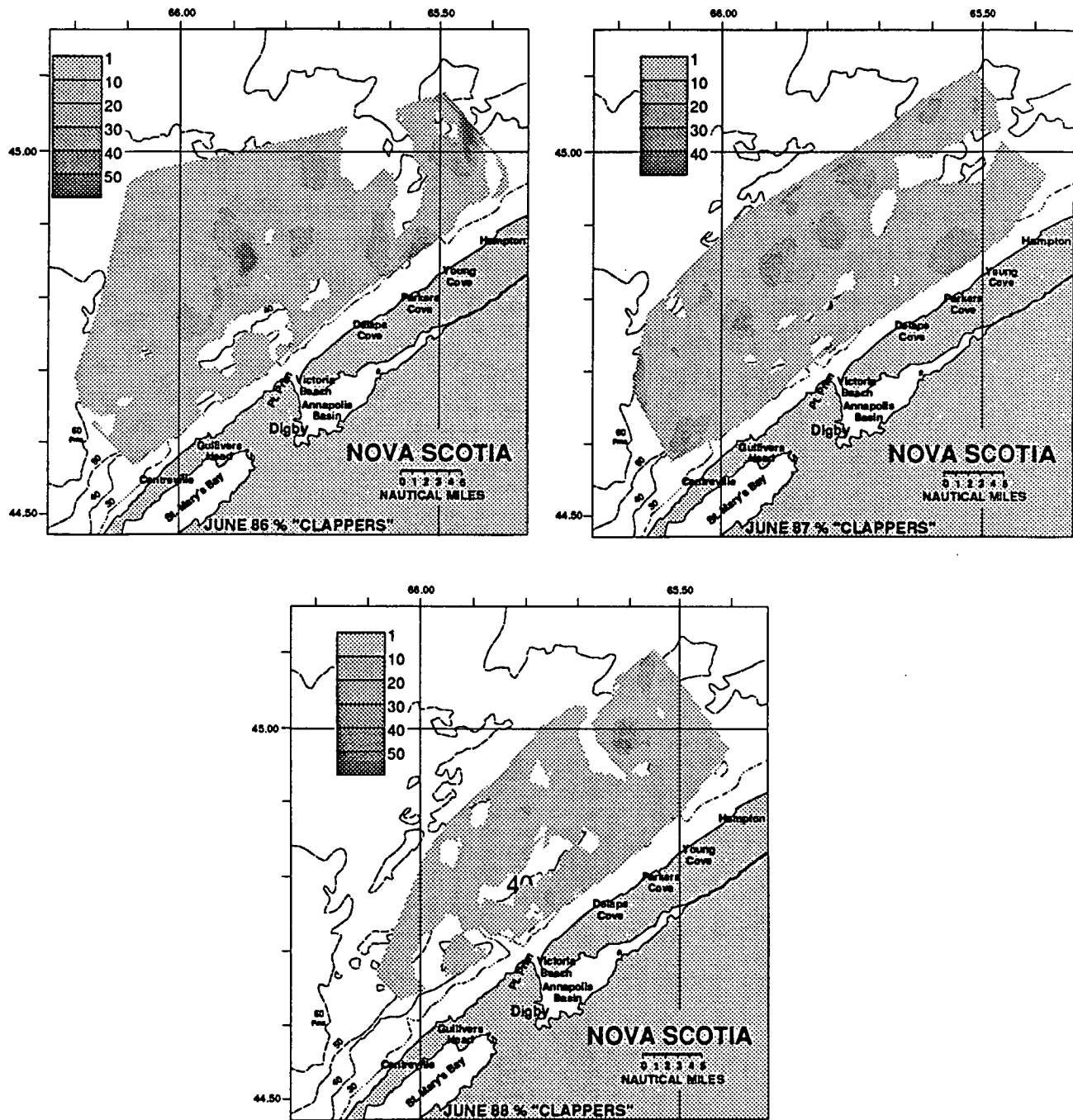


Figure 4-1986-90 surveys. "Clapper" distribution on a percentage basis from abundance isopleths of survey data. Darkening shades of grey within isopleths refer to increasing percentage of "clappers" per standard tow (grey scale in upper corner of plot).

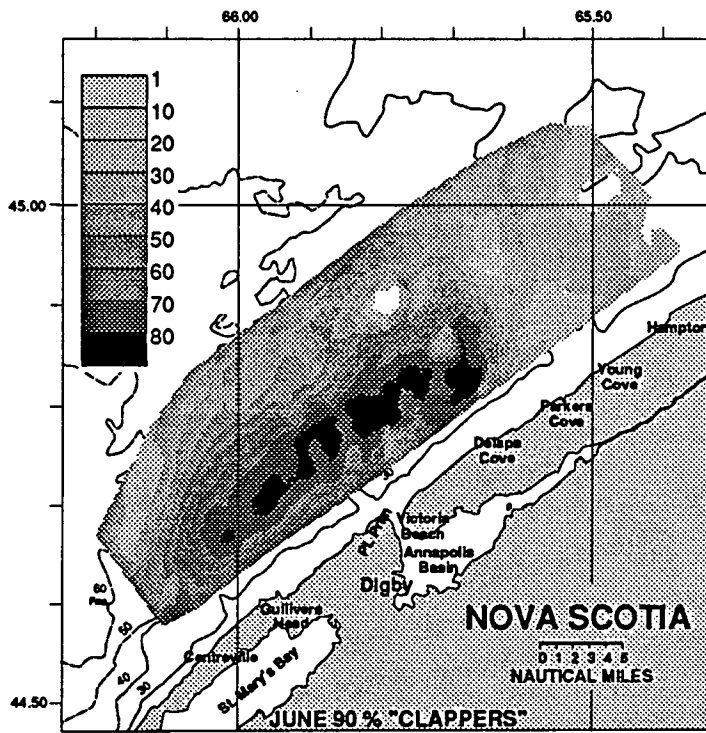
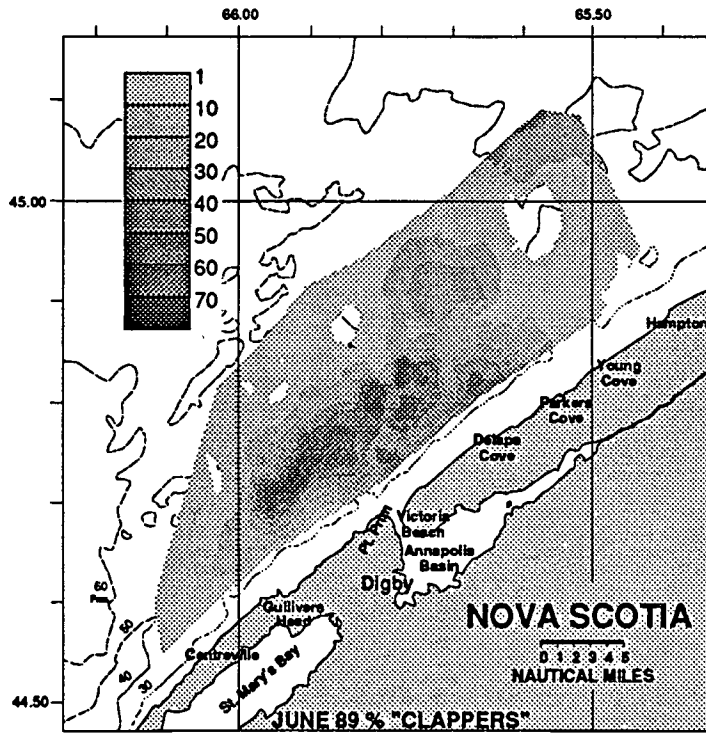


Figure 4. - Continued. 1986-90 survey 'clapper' distribution.

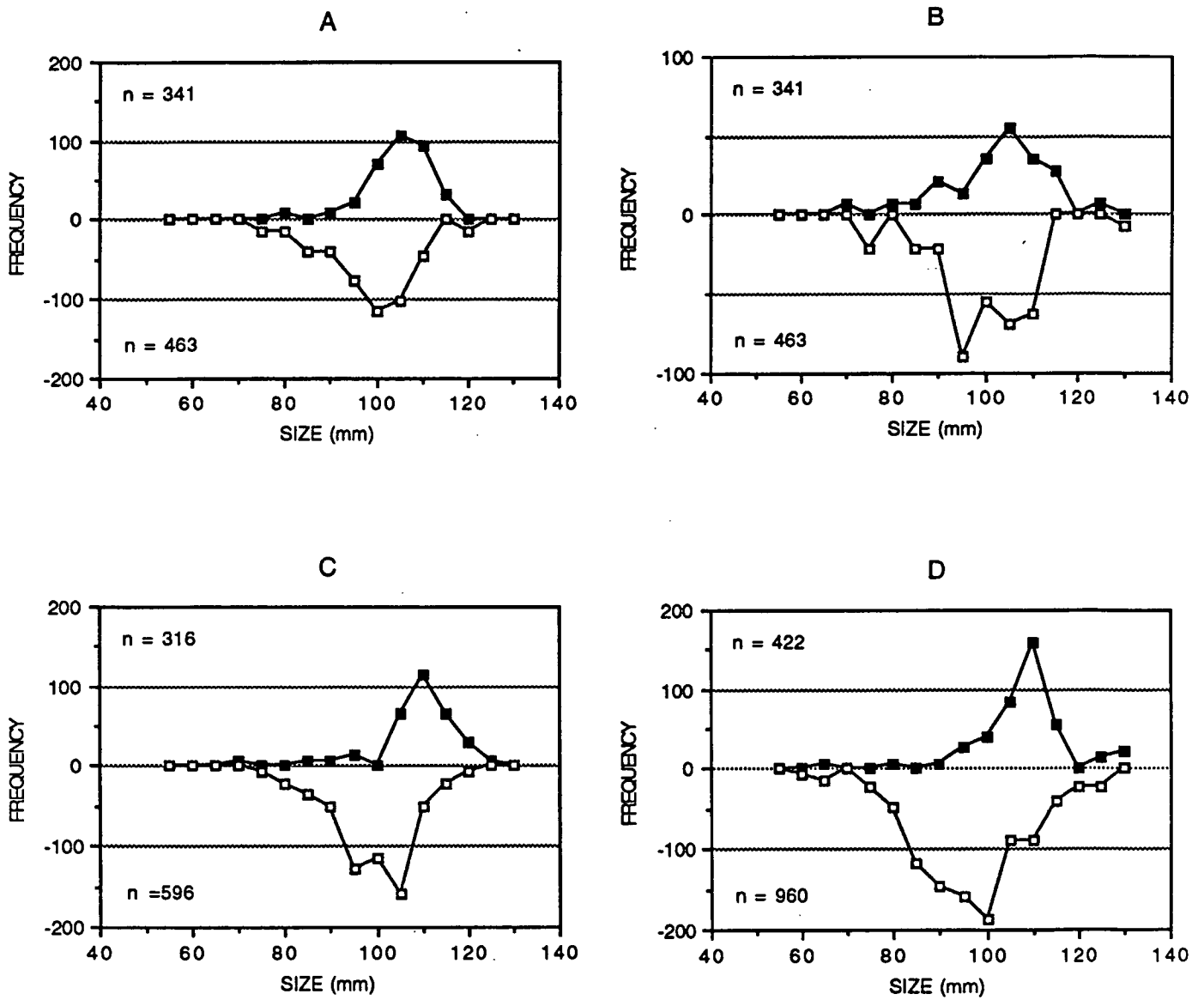


Figure 5.- Shell height frequency distribution of live animals (+ values) and clappers (- values) collected from 4 representative tows within the high mortality zone, (A & B = 7 miles off Delaps Cove, C = 4 miles off Gullivers Head, D = 4 miles off Digby Gut).

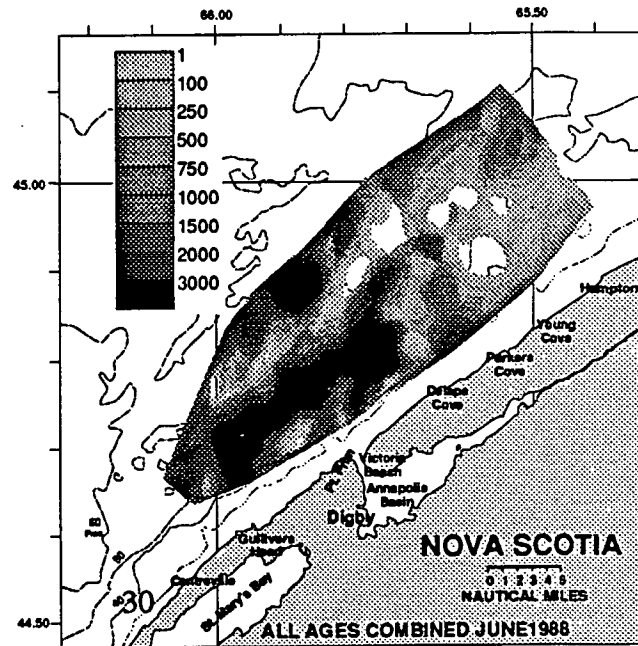
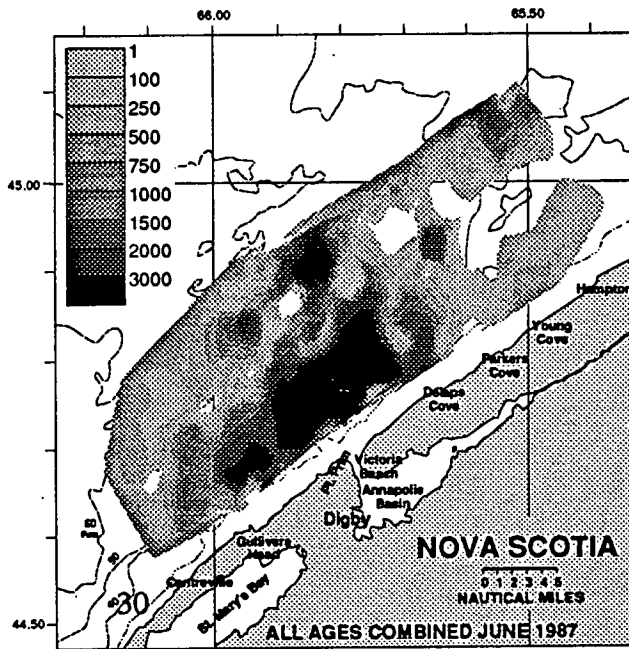
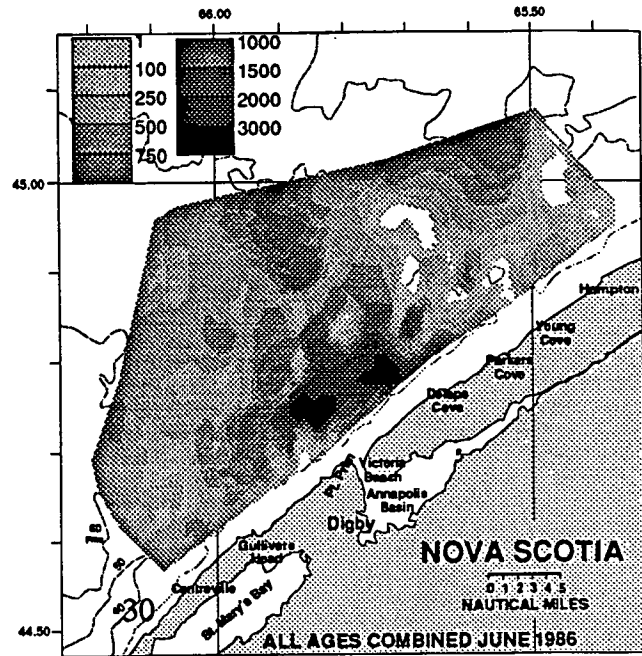
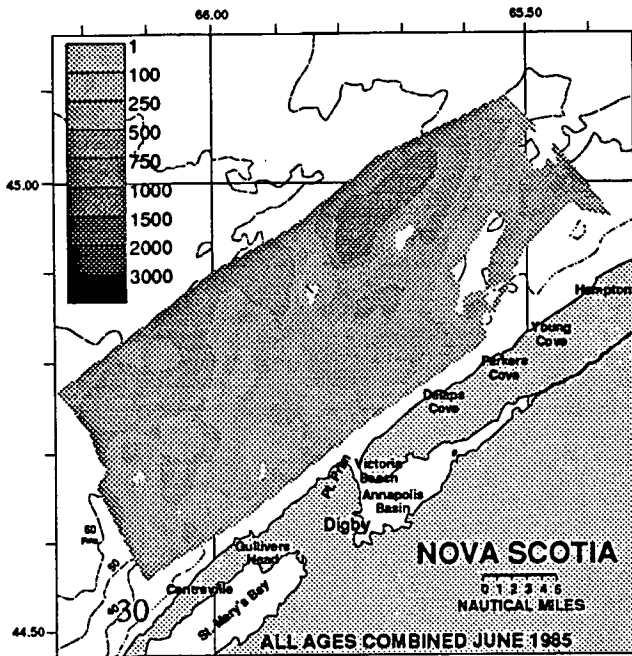


Figure 6.-1985-90 survey catch rates. Scallop distribution of all ages combined on a yearly basis from abundance isopleths of survey data. Darkening shades of grey within isopleths refer to increasing number of scallops per standard tow (grey scale in upper corner of plot).

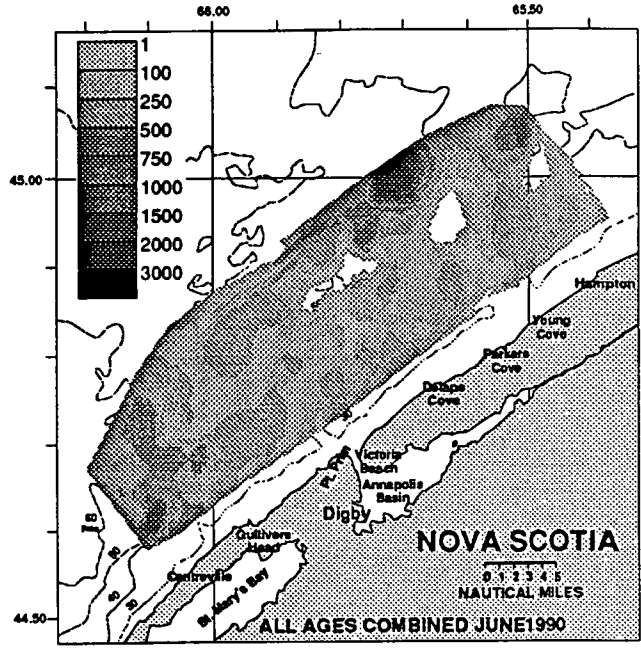
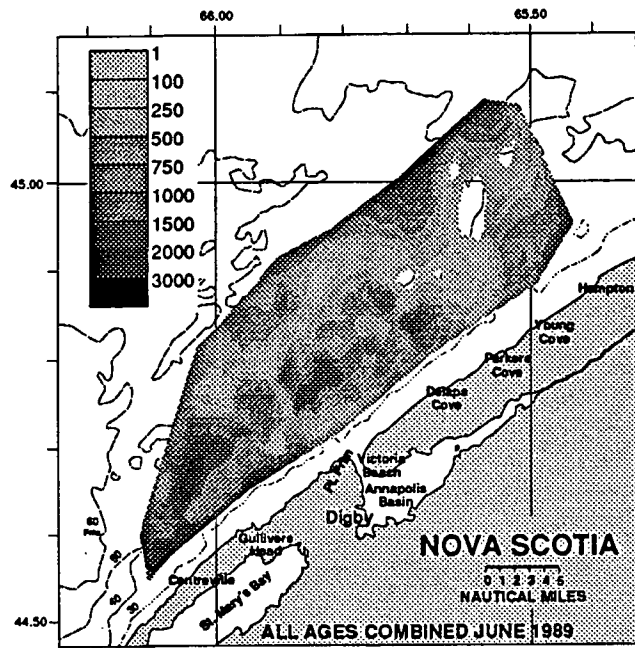


Figure 6. - Continued. 1985 - 90 survey catch rates.