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Acoustic surveys of Smith Sound, Trinity Bay, 1995-2000

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Abstract

A dense spawning aggegation of cod was first observed in Smith Sound, Trinity Bay in the spring of 1995. Since that time several acoustic surveys have been attempted. The original survey results have been reworked here to conform with revised analytical protocols comparable to those used in present surveys. The first 1995 survey indicated the presence of approximately 9.5 million adult cod, primarily of year-classes 1990, 1989, and 1988. A survey in the spring of 1998 indicated the presence of approximately 7 million adult cod primarily of the 1990 and 1992 year-classes. A survey in January 1999 indicated the presence of approximately 11.5 million fish with high proportions of the 1995, 1994, and 1992 year-classes. Relatively strong recruitment from the 1995 spawning suggests a difference between the recruitment patterns in offshore (where the 1994 year-class dominates) and Smith Sound. Surveys in June 1999 indicated the presence of less than 1 million adult cod, and it is thought that these surveys occurred toward the end of spawning in 1999, and that most cod had already left the Sound. Surveys in January 2000 found a large abundance of cod of ages 2-15 (ca. 11-12 million fish in total). These fish were segregated by size and maturity within the Sound and comprised a total mean biomass of ca. 22,000 t (mean of 2 surveys). The 1990 and 1992 year classes were present in relatively large numbers and the year-classes of 95, 96, and 97 were also relatively well represented.

Résumé

Au printemps de 1995, on a observé pour la première fois un banc dense de morues reproductrices dans Smith Sound, Trinity Bay. Depuis, plusieurs relevés acoustiques y ont été effectués. Les résultats du premier relevé ont été remaniés pour qu'ils se conforment aux protocoles analytiques révisés comparables à ceux utilisés dans les relevés actuels. Selon le premier relevé, effectué en 1995, environ 9,5 millions de morues adultes étaient présentes, surtout des classes d'âge de 1990, de 1989 et de 1988. Un relevé effectué au printemps de 1998 a révélé la présence d'environ 7 millions de morues adultes, principalement des classes d'âge de 1990 et de 1992, tandis qu'un autre effectué en janvier 1999 a indiqué une présence d'environ 11,5 millions de poissons, avec une forte représentation des classes d'âge de 1995, de 1994 et de 1992. Le recrutement relativement fort découlant de la fraye de 1995 porte à croire que le régime de recrutement dans Smith Sound diffère de celui au large (où la classe d'âge de 1994 domine). Des relevés effectués en juin 1999 ont indiqué la présence de moins d'un million de morues adultes; on croit que ces relevés ont été réalisés vers la fin de la fraye de 1999 et que la plupart des morues avaient déjà quitté le détroit. Des relevés effectués en janvier 2000 ont indiqué que les morues âgées de 2 à 15 ans étaient très abondantes (environ 11-12 millions de poissons au total); leur biomasse moyenne totalisait environ 22 000 tonnes (moyenne de deux relevés). À l'intérieur du détroit, elles formaient des bancs selon la taille et le degré de maturité. Les classes d'âge de 1990 et de 1992 étaient présentes en nombre relativement grand, et les classes d'âge de 1995, de 1996 et de 1997 étaient aussi assez bien représentées.

Background

Dense aggregations of cod were first observed with echosounders in Smith Sound in late April of 1995 from the vessel CCGS Shamook by researchers from Memorial University of Newfoundland and DFO working on an ongoing research program. The first acoustic survey took place from May 3-5, 1995, employing a 38 kHz analogue echosounder supported by bottom trawls from the Shamook. A second survey was conducted from May 15-18, 1995, also from the Shamook. A third survey was conducted from the CCGS Teleost during the last week of June, 1995. These sequential surveys indicated that from early May until late June cod moved outwards in the Sound and into Trinity Bay, and the largely adult composition of the spawning aggregation in May changed as large numbers of juveniles joined the group in June (Rose 1996).

The origin of the Smith Sound cod remains uncertain. Experienced observers, including Capt. Scott and crew of the Shamook, C. George, and K. Smedbol and W. Hiscock (MUN graduate students working in the Sound), had not seen such densities prior to 1995. Egg densities were near an order of magnitude higher in 1995 than in previous years (Smedbol et al. 1997). The lack of antifreeze proteins in the blood argued that these fish wintered in deeper waters or offshore. There are 3 possibilities as to their origin: 1) some of these fish might be survivors and progeny of shelf cod last observed in 1992 in the Bonavista corridor which leads directly to Smith Sound; 2) some may have emigrated from 3Ps (where year class strength is remarkably similar to Smith Sound); and 3) there has been a rapid local population growth since the moratorium in 1992 (local knowledge suggests spawning always occurred in this area, if not particularly concentrated in Smith Sound). These hypotheses are not mutually exclusive and will be addressed in an additional paper.

Acoustic observations in February, 1996, using a BioSonics digital transducer and an EK500 split beam system (both 38 kHz) indicated that cod were aggregated at very high densities (>5 m^2) in Smith Sound in winter (Rose, unpublished). No biomass estimate was attempted during that trip as a result of time constraints (but local densities were very high, >10 fish. m^{-2}).

From spring 1996 until the fall of 1998 several attempts were made to survey Smith Sound using analogue 38 kHz echosounders (eg., Brattey and Porter 1997, Anderson et al., 1998).

Acoustic surveys employing an EK500 split-beam system (38 kHz) and improved methods of data capture and analysis were conducted in June, 1998, January, 1999, June 1999, and January 2000 from the Teleost, and in August 1999 from the Shamook. The methods and results of these later surveys are described in this paper.

Methods

Snith Sound was surveyed acoustically from the Teleost on June 8th and 16th, 1999 and January 6th and 12th, 2000. The survey was also run on August 20th from the Shamook. In all surveys, similar methods were used. Sixteen blocks were used as the basis for surveying (Fig. 1). Survey conditions were good in all instances in terms of weather and qualitative estimations of detectability. Transects across the blocks were run more or less diagonally as navigation permitted. Depths < 50 m and in some areas <100 m cannot be surveyed as a result of navigation dangers. Where these shallower waters could be surveyed few fish were encountered (except in August when most fish were in these shallow waters). In all surveys a calibrated EK500 38 kHz split-beam system was used with settings as indicated in Table 1. Calibrations were undertaken employing tungsten-carbide and copper standard targets (Teleost system calibrated by NWAFC Hydroacoustics section). Calibration values never varied more than 0.5 dB from standard values in series of calibrations over several years. Digital data were collected using the EP data collection package (Simrad) at high resolution (10 cm vertical) and using the full dynamic range available with no threshold. Editing and analysis was done using the FASIT software package (Memorial University of Newfoundland) for PC's. FASIT output S_A values in units of $m^2.m^{-2}$ each 100 m. Bottom tracking was performed manually at high resolution (10 cm). FASIT uses standard integration algorithms as specified by Simrad (Simrad EK500 manual), with the exception that S_A units are not given in m^2 nautical $mile^{-2}$.

To estimate sampling uncertainty, autocorrelation functions were examined for each block. Autocorrelation was significant only over the first few lags. Hence, for each block, a bootstrapping method was employed to estimate uncertainty, based on repeated 50% sampling of the data (25 times). There was no significant autocorrelation in the 50% sampled data. The random means were then used to calculate the bootstrapped mean density and 95% CI's. Note that the uncertainty included in these estimates is only that associated with within block sampling and likely underestimates a fuller treatment of uncertainty in acoustic surveys (Rose et al., in press).

S_A was then scaled by TS (sigma) and a detectability coefficient as follows:

For block i, total $S_{A\,i}$ = mean $S_{A\,i}$ * block $area_I$

Sa_i was decomposed by 4 cm length groups, the proportions determined from the catch. The model used as the basis for the length scaling was TS (dB) = 20 Log length (cm) – 67.5 (Rose, unpublished), which is very close to the ICES model of TS (dB) = 20 Log length (cm) –67.6 and the general model for gadoid-type fishes (Foote, 1987). Accordingly, if abundance of length group l in block I is A_{il}:

$$A_i\ (\#/area_i) = S_{A\,i} / \sum [\ Sigma_l * P_l] * D^{-1}$$

Note that we follow the Norwegian and European nomenclature for these terms (S_A is areal backscatter and Sigma = [10^(TS/10)]*4pi.

A_{il} ($\#_l$/area$_i$) = $A_i * P_l$

Note that densities may be calculated in the same way by substituting mean $S_{A\ i}$ for total $S_{A\ i}$. The 95% CI's are calculated by inserting a 2 SE range above and below the S_{ai} and repeating the calculations (for each calculation there are actually 3 computations, one for the mean and one each for the high and low CI).

Calculation of biomass for each block and length group (B_{il}) was done by scaling the abundance of each length group (A_{il}) by the mean weight of that group as determined from the best fit model of the catch data following: $Wt = K * L^3$.

$B_{il} = A_{il} * W_l$

Abundance at age was calculated from the total abundance by proportioning the totals by the age structure of the catch (P_a is the proportion of the catch of age a). Note that no correction for catchability by size or age can be made – so interpretations of results should keep that in mind.

$A_{ia} = A_i * P_a$

Biomass at age was calculated by multiplying the abundance at age by a mean weight at age (W_a) determined from the logistic model which best fit the catch data.

$B_{ia} = A_{ia} * W_a$

The same methods were applied to the 1995 survey data (Shamook 239) with some differences: 1) the data reported here were edited and integrated with earlier software; 2) the survey blocks extended to 50 m minimum depth.

Fishing sets were conducted with both the Campelen 1800 bottom trawl and the IGYPT mid-water trawl on the Teleost. Handlining was done for the Shamook survey.

Detectability experiments were conducted during both the June 1999 and January 2000 surveys, as recommended by Lawson and Rose (1998). The strategy was to test during survey conditions the proportion of the total fish "missed" by the echosounder in the bottom shadow zone. For the trawl zone, acoustic densities were calculated for the full water column and for the bottom 4 m (corresponds to the volume fished with a 5 m head rope and a 1 m shadow zone at 200 m). The difference between the acoustic measure and the trawl measure was used to calculate D. The spring detectability from 1998 was applied to the 1995 data.

Results

May 1995
The acoustic estimate was 9.5 million cod (9.3-9.7 CI) comprising 12.7 Kt (12.4-13.0 CI) (Table 2a). The fish were concentrated in the outer parts of the Sound (blocks o and p) with lesser concentrations in blocks e-k (Table 2b).

Five year-old five (1990 y class) were the most numerous at 4.4 million fish, and six year-olds (1989 y class) were second at 3.1 million fish (Table 2c). There were also 1.1 million seven year-old fish (1988 y class). There were few fish younger than 5 y of age.

The dominant length was 48-60 cm. Very large and smaller fish were scarce (Fig. 2).

The weight to length coefficient used was 0.00850 L^3 (R^2 = 0.90).

The growth model used had upper boundary of 10 kg and b0 = 4.543 and b1 = 0.726.

The cod were approaching peak spawning during this survey.

June 1998
The acoustic estimate was 7.0 million cod (5.8-8.3 CI) comprising 14.4 Kt (11.9-16.9 CI) (Table 3a). The fish were concentrated in the outer parts of the Sound (blocks o and p) with a lesser concentration in blocks d-g (Table 3b).

Eight year-old fish (1990 y class) were the most numerous at 2.6 million fish, and six-year olds (1992 year class) were second at 1.9 million fish (Table 3c). Fish younger than 5 were scarce (total 0.4 million).

The dominant length was 56-68 cm. Very large and smaller fish were scarce (Fig. 2).

The weight to length coefficient used was 0.00873 L^3 (R^2 = 0.94).

The growth model used had upper boundary of 10 kg and b0 = 6.292 and b1 = 0.704.

Detectability was estimated to be 0.93 (Table 5a).

Cod were approaching peak spawning during this survey. Spawning occurred later in 1998 than in 1995.

January, 1999
The acoustic estimate was 11.4 million cod (10.4-12.4 CI) comprising 14.6 Kt (13.4-15.9 CI) (Table 4a). The fish were concentrated in the mid-part of the Sound (blocks e-i) at very high densities (Table 4b).

Four year old fish (1995 year class) were most numerous at 4.2 million fish (Table 4c). Five year olds (1994 year class) were the next most numerous at 2.1 million. There were 1.9 million seven year old fish (1992 year class), and only 0.4 million nine year olds (1990 year class).

The dominant length was 40-44 cm. (Fig. 4c).

The weight to length coefficient used was 0.00578 L^3 ($R^2 = 0.38$).

The growth model used had upper boundary of 10 kg and b0 = 5.7895 and b1 = 0.693.

Detectability was estimated to be 0.73 (Table 5b).

June, 1999

This survey was conducted on June 7-8, 1999. There were few fish in the Sound at this time. The acoustic estimate was 0.4 million cod (1.9-4.8 CI) comprising approximately 1 Kt (0.5-1.2 CI). The fish were concentrated in the most seaward block, p. An additional survey was also conducted about a week later. Even fewer fish were located then, and those that were present had moved into shallow waters and out of the survey area. It is unlikely that they comprised more than 1 Kt.

The dominant year classes were 1990 and 1992 (Fig.2). Most fish were between 60 and 70 cm in length. The aggregation in block p was a spawning shoal so few immature fish were expected or found.

The maturity states were mostly spent or matap/matp (Fig. 4).

January, 2000

Two surveys were conducted in January 2000. The first survey estimated 10.9 million cod (2.8-21.3) comprising 20.9 Kt (5.4-40.8) (Table 6). The fish were very concentrated during this survey making the survey design not as appropriate as has been on previous surveys, and resulting in higher CI's than is typical for this survey. The second survey was conducted a few days later. The second survey estimated 12.4 million cod (6.2-18.7) comprising 23.7 Kt (11.8-35.9). The cod has moved their centre of concentration to the middle blocks by this survey and were more evenly distributed within the blocks, but still highly concentrated.

The size, age, and maturity condition of the 2000 over-wintering aggregation was examined in greater detail than in previous years, as a consequence of uncertainty about the adequacy of previous sampling to capture spatial variation in size and age composition, and further interest in the spawning condition (e.g. Rideout et al, in press). The dominant older year classes overall were again the 1990 and 1992 year classes (Fig. 2). However, the 1995-1997 year classes were also relatively numerous. These results tend to confirm the finding of large numbers of 1995 year class in the aggregation in the winter of 1999, but cast doubt on the 1999 result that few fish of the 1990 year class were present. This doubt is reinforced by current results that show that the shoal is characterized by areas of large maturing fish, and other areas of juveniles (Fig. 3). It is now certain that sampling in only one part of the shoal may result in biased length and age estimates.

Discussion

The overall numbers of cod in the spawning aggregation in the Sound declined somewhat after 1995 (biomass and presumably reproductive potential has increased). This result reflects the weak year classes of the early 1990s. The 1995 aggregation contained mostly fish of ages 5 (1990 year class) at 46%, 6 (1989 year class) at 33%, and 7 (11%). Juvenile cod appeared in numbers only in the last survey in the spring of 1995 as they joined the post-spawning adults (reanalysis of these data to be completed). In the 1998 spawning survey, the 1990 year class remained the strongest, with little evidence of strong year classes from 1991-1994 (the 1992 year class appears to be strongest of these, and formed the bulk of the younger fish first observed in 1995).

To examine the internal consistency of these survey data, and to examine mortality rates, I compared the spring surveys in 1995 and 1998 and the winter survey in 2000 (Fig. 4; Table 7). Z appears to be low for the 1991 and 1992 year classes, higher in the later period for the older fish, with the exception of the oldest ages for which Z declines in the later period. These estimates assume zero net migration and equivalent survey conditions in terms of presence in the Sound. These results tend to support the internal consistency of these surveys (while acknowledging the known problems of trawl selectivity and potential bias in the sampling in January 1999).

The results of the two surveys conducted in June 1998 and January 1998 appeared to differ, even though the total biomass is near identical at approximately 14.5 Kt. The difference is in the age composition of the aggregations. The June survey encountered primarily adult fish in pre-spawning condition. The winter survey encountered a mixed group with a high proportion of juvenile fish. It is of note that the dominant year class in the January survey was from 1995, the first year the large aggregation was noted in Smith Sound. The 1994 year class, which is the only year class of any number on the shelf (eg., Anderson and Rose, in prep.), is poorer in Smith Sound than the 1995 year class. The January 2000 surveys confirms the relative strength of the 1995 and 1996 year classes relative to the 1994 (differs from shelf). The size structure and presence of the older year classes (1990 especially) in one area of the shoal casts doubt on the January 1999 result in which the 1990 year class was not present in the trawl samples. This suggest two things: 1) adds support to the notion that these fish were not aggregated in Smith Sound for spawning before 1995; and 2) that recruitment processes here and on the shelf may not be synchronous.

The June 1999 survey was almost certainly too late to capture the main spawning in the Sound (the 3 sequential surveys conducted in 1995 suggest that most cod leave the Sound sometime in June). However, it is curious that many of mature females were in the matap condition (no hydrated eggs), and few were actually spawning. Many fish were also fully spent. We are currently attempting to get a better understanding of the seasonal movement patterns. It is possible that there are staged events of spawning here and that not all spawning takes place in the Sound. A week later these matap females were not located in the Sound. At this time cod were widely distributed at much lower densities in Trinity Bay (results not presented here).

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Table 1. Specifications for EK500 on Teleost for surveys in June 1998 and January 1999.

Frequency	38 kHz
Transmit power	2 kW
Bandwidth	3.8 kHz
Pulse width	1.0 ms
Pulse rate	1 s^{-1}
Absorption coef.	10 dB km^{-1}
Sv gain	25.7 dB
TS gain	25.7 dB
2-way EBA	-20.6 dB
Raw Sv	250 or 500 m
Digital sampling resolution	10 cm
Bottom removal	None on raw data
Threshold	None on raw data
Vessel speed	5 knots

Table 2. May 1995 Smith Sound acoustic survey summary.

1995 April Shamook 239 Smith Sound Survey 1 cod summary by block

		Mean abundance	High 95% CI abundance	Low 95% CI abundance	Mean Biomass (t)	High 95% CI Biomass (t)	Low 95% CI Biomass (t)
		Sum	Sum	Sum	Sum	Sum	Sum
BLOCK	a	63720	73218	54222	85	98	72
	b	85080	88053	82108	114	118	110
	c	142065	146693	137437	190	196	183
	d	133614	137165	130062	178	183	174
	e	222378	227683	217073	297	304	290
	f	281652	287244	276060	376	383	369
	g	506973	515123	498822	677	688	666
	h	321490	331072	311903	429	442	417
	i	418010	427538	408483	558	571	546
	j	679981	688285	671678	908	919	897
	k	471193	479814	462573	629	641	618
	l	163315	168358	158274	218	225	211
	m	263880	268870	258889	353	359	346
	n	168580	175764	161393	225	235	215
	o	1978658	2023480	1933839	2643	2702	2583
	p	3645158	3704298	3586019	4868	4947	4789
Group Total		9545747	9742658	9348835	12748	13011	12485

1995 April Shamook 239 Smith Sound Survey 1 cod summary by age

	Mean abundance	High 95% CI abundance	Low 95% CI abundance	Mean Biomass (t)	High 95% CI Biomass (t)	Low 95% CI Biomass (t)
	Sum	Sum	Sum	Sum	Sum	Sum
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	506433	516876	495983	390	398	382
5	4395437	4486108	4304769	4608	4703	4513
6	3124582	3189037	3060129	4444	4536	4352
7	1079748	1102023	1057477	2072	2115	2029
8	315327	321831	308820	810	827	794
9	124220	126783	121657	423	432	415
Group Total	9545747	9742658	9348835	12748	13011	12485

Table 3. June 1998 Smith Sound acoustic survey summary.

Teleost 65 June 1998 Smith Sound Acoustic Survey Results By Block

		Mean abundance	High 95% CI abundance	Low 95% CI abundance	Mean Biomass (t)	High 95% CI Biomass (t)	Low 95% CI Biomass (t)
BLOCK	a	42699	54264	31133	87	111	64
	aa	4672	5710	3633	10	12	7
	b	42699	54264	31133	87	111	64
	c	6901	8572	5228	14	18	11
	d	226410	353952	98869	464	725	203
	e	200123	269379	130867	410	552	268
	f	250561	291527	209596	513	597	430
	g	747335	1181838	312828	1532	2422	641
	h	28489	34231	22745	58	70	47
	i	34268	41054	27483	70	84	56
	j	8067	8556	7576	17	18	16
	l	55648	63067	48229	114	129	99
	m	103266	117490	89039	212	241	182
	n	513598	596200	430995	1053	1222	883
	o	927361	1074485	780237	1900	2202	1599
	p	3840936	4096746	3585128	7871	8395	7347
Group Total		7033033	8251335	5814719	14412	16909	11916

Teleost 65 June 1998 Smith Sound Acoustic Survey Results By Age

	Mean abundance	High 95% CI abundance	Low 95% CI abundance	Mean Biomass (t)	High 95% CI Biomass (t)	Low 95% CI Biomass (t)
2	70400	82595	58205	20	24	17
3	168963	198231	139691	72	85	59
4	147842	173453	122230	93	108	77
5	471686	553393	389978	429	503	355
6	1879699	2205312	1554084	2451	2876	2027
7	739208	867257	611158	1357	1592	1122
8	2640028	3097345	2182705	6654	7807	5502
9	704006	825960	582057	2363	2772	1954
10	168963	198231	139691	728	854	602
11	21119	24779	17460	112	132	93
12	21119	24779	17460	133	156	110
Group Total	7033033	8251335	5814719	14412	16909	11916

Table 4. January 1999 Smith Sound acoustic survey summary.

Teleost 77 January 1999 Smith Sound Acoustic survey results by block

		Mean abundance	High 95% CI abundance	Low 95% CI abundance	Mean Biomass (t)	High 95% CI Biomass (t)	Low 95% CI Biomass (t)
BLOCK	a	572	628	514	1	1	1
	b	277	334	224	0	0	0
	c	11007	21230	787	14	27	1
	d	55220	69026	41414	71	88	53
	e	763296	886775	639813	978	1136	819
	f	3198290	3316490	3080088	4096	4247	3944
	g	2222629	2336736	2108523	2846	2992	2700
	h	2821700	3315100	2328297	3613	4246	2982
	i	1692866	1746464	1639266	2168	2236	2099
	j	324076	345223	302930	415	442	388
	k	182057	199433	164683	233	255	211
	l	59442	65025	53863	76	83	69
	m	37449	42798	32099	48	55	41
	n	465	514	420	1	1	0
	o	30435	37813	23056	39	48	29
	p	21541	22260	20823	28	28	27
Group Total		11421322	12405849	10436800	14626	15888	13365

Teleost 77 January 1999 Smith Sound Acoustic survey results by age

	Mean abundance	High 95% CI abundance	Low 95% CI abundance	Mean Biomass (t)	High 95% CI Biomass (t)	Low 95% CI Biomass (t)
2	34264	37216	31310	12	13	11
3	388323	421799	354851	192	208	175
4	4157363	4515729	3798996	2897	3146	2647
5	2158632	2344707	1972556	2105	2287	1924
6	1576142	1712009	1440279	2126	2310	1943
7	1895942	2059371	1732510	3483	3783	3182
8	491115	533451	448781	1204	1308	1100
9	422588	459016	386160	1348	1465	1232
10	262689	285335	240047	1060	1151	968
11	0	0	0	0	0	0
12	34264	37216	31310	200	218	183
Group Total	11421322	12405849	10436800	14626	15888	13365

Table 5a. Summary of results from detectability experiments in June 1998 and January 1999.

	Spring 1998	Winter 1999
Set duration (min)	5	5
Cod caught	118	576
Set cod density (m^2)	0.016	0.071
Full acoustic density (m^2)	0.066	0.096
Bottom 4 m density (m^2)	0.013	0.052
detectability	0.93	0.80

Table 5b. Detectability experiments in January 2000.

Experiment #	1	2	3	4
Set duration (min)	4	6	2	6
Cod caught	74	393	1217	340
Set cod density (m^2)	0.013	0.044	0.411	0.038
Full acoustic density (m^2)	0.012	0.111	0.128	0.027
Bottom 4 m density (m^2)	0.008	0.066	0.08	0.023
Detectability	0.72	1.24	.28	.63

Table 6a,b. Teleost 89 Jan 2000 Smith Sound surveys 1 and 2; abundance and biomass by survey block (eg., BIOHIGH = upper 95% CI).

		ABMEAN	ABLOW	ABHIGH	BIOMEAN	BIOLOW	BIOHIGH
		#	#	#	t	t	t
BLOCK	a	491828	150146	937331	950	290	1810
	b	3366799	759222	6020903	6502	1466	11627
	c	2440626	860555	4228231	4713	1662	8165
	d	206140	81147	409008	398	157	790
	e	56770	13503	164217	110	26	317
	f	357162	27816	939732	690	54	1815
	g	13503	7501	21371	26	14	41
	h	83728	44132	153250	162	85	296
	I	1818273	228095	3369878	3511	440	6508
	j	1887243	539362	4379046	3645	1042	8457
	k	54465	13441	153375	105	26	296
	l	124291	83884	453391	240	162	876
	m	72	5	134	0	0	0
	n	46	3	126	0	0	0
	o	238	62	480	0	0	1
	p	23692	4115	61559	46	8	119
Table Total		10924875	2812987	21292032	21098	5432	41119

		ABMEAN	ABLOW	ABHIGH	BIOMEAN	BIOLOW	BIOHIGH
		#	#	#	t	t	t
BLOCK	a	40	2	118	0	0	0
	b	246	10	514	0	0	1
	c	115725	56655	174944	223	109	338
	d	47235	25252	65670	92	49	128
	e	1079276	584702	1559739	2084	1129	3012
	f	2101190	1153453	2613080	4058	2228	5046
	g	3866163	2492602	5001955	7466	4814	9660
	h	1596446	945331	2419870	3083	1826	4673
	I	557049	394387	760316	1076	762	1468
	j	337284	216756	439648	651	419	849
	k	416722	264967	599553	805	512	1158
	l	56811	3440	121984	110	7	236
	m	424	31	721	1	0	1
	n	0	0	0	0	0	0
	o	1486	0	3002	3	0	6
	p	2203927	14985	4963550	4256	29	9586
Table Total		12380026	6152572	18724663	23909	11882	36162

Table 6c,d. Teleost 89 Jan 2000 Smith Sound surveys 1 and 2; abundance and biomass by age (eg., ABLOW is lower 96% CI).

		ABMEAN	ABLOW	ABHIGH	BIOMEAN	BIOLOW	BIOHIGH
		#	#	#	t	t	t
AGE	2	65549	16878	127752	21	5	41
	3	1092488	281299	2129203	502	129	979
	4	2632895	677930	5131380	1740	448	3391
	5	1813529	466956	3534477	1716	442	3345
	6	961389	247543	1873699	1297	334	2527
	7	677342	174405	1320106	1293	333	2519
	8	1715205	441639	3342849	4586	1181	8939
	9	644568	165966	1256230	2383	614	4645
	10	1016013	261608	1980159	5106	1315	9950
	11	207573	53447	404549	1386	357	2702
	12	54624	14065	106460	472	122	920
	13	10925	2813	21292	118	30	231
	14	10925	2813	21292	144	37	280
	15	10925	2813	21292	168	43	328
	16	0	0	0	0	0	0
	17	0	0	0	0	0	0
	18	0	0	0	0	0	0
	19	0	0	0	0	0	0
	20	0	0	0	0	0	0
Table Total		10913951	2810174	21270740	20933	5390	40797

		ABMEAN	ABLOW	ABHIGH	BIOMEAN	BIOLOW	BIOHIGH
		#	#	#	t	t	t
AGE	2	74280	36915	112348	24	12	36
	3	1238003	615257	1872466	569	283	860
	4	2983586	1482770	4512644	1970	979	2979
	5	2055084	1021327	3108294	1944	966	2940
	6	1089442	541426	1647770	1469	730	2221
	7	767562	381459	1160929	1464	728	2215
	8	1943664	965954	2939772	5197	2583	7860
	9	730422	363002	1104755	2701	1342	4085
	10	1151342	572189	1741394	5787	2876	8753
	11	235220	116899	355769	1572	781	2377
	12	61900	30763	93623	535	266	810
	13	12380	6153	18725	134	67	203
	14	12380	6153	18725	163	81	246
	15	12380	6153	18725	191	95	289
	16	0	0	0	0	0	0
	17	0	0	0	0	0	0
	18	0	0	0	0	0	0
	19	0	0	0	0	0	0
	20	0	0	0	0	0	0
Table Total		12367646	6146420	18705939	23719	11788	35875

Table 7. Estimated Z for the various year classes.

	1992	1991	1990	1989	1988	1987	1986
95-98 Z			0.17	0.50	0.62	0.90	0.59
98-20 Z	0.05	0.07	0.48	0.61	0.56	0.33	0.33

Fig. 1. Smith Sound survey blocks.

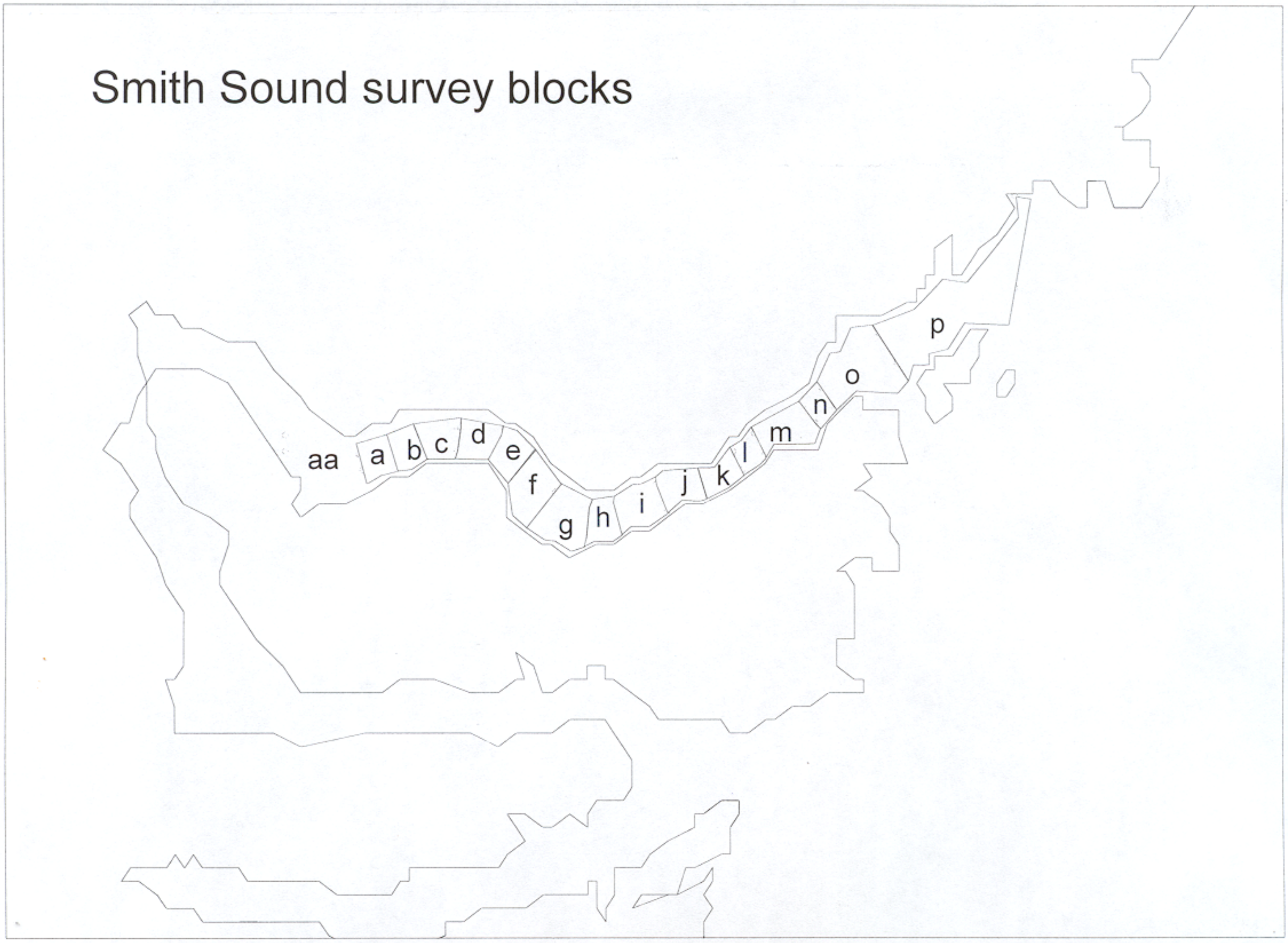

Fig. 2. Length and age frequency of cod in Smith Sound in May 1995, June 1998, January 1999, June 1999, and January 2000.

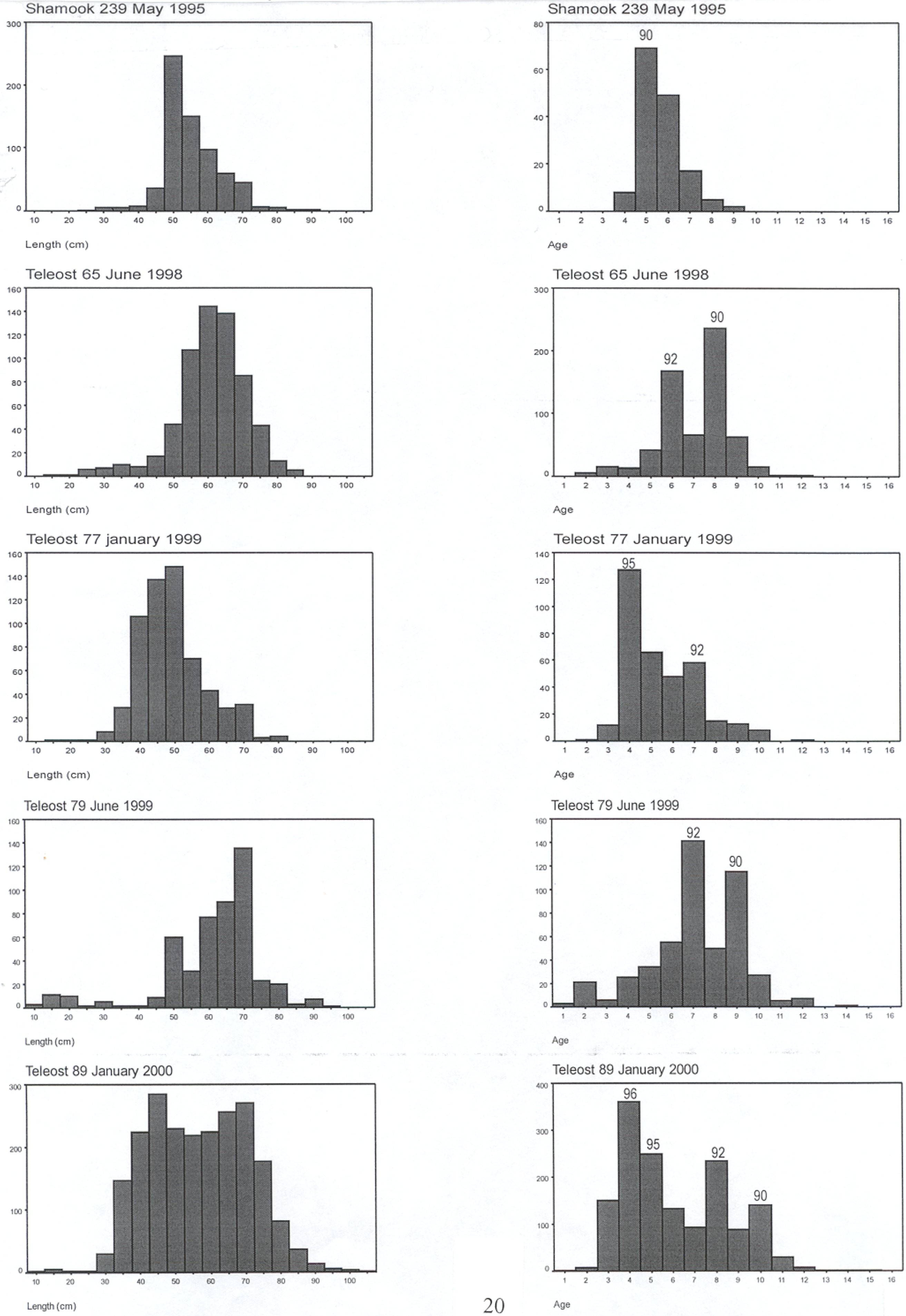

Fig. 3. January 2000 Smith Sound cod length (cm) distribution (%) by area (front of box is furthest East in Sound, back is West)

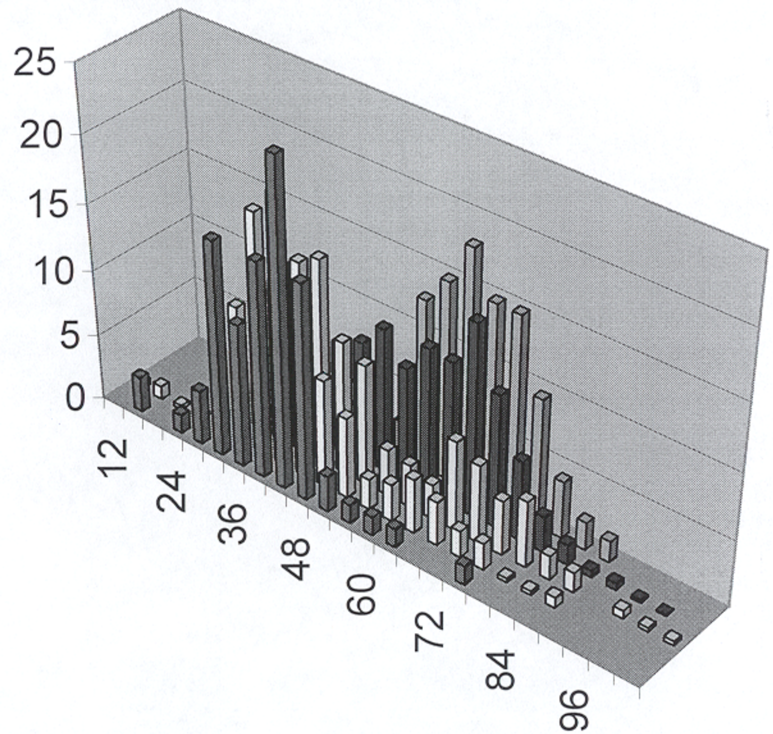

Fig. 4. Smith Sound year-class abundance in April 1995, June 1998, and January 2000.