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School Surface Area of Capelin Schools from Aerial Photographs as an Index of Relative Abundance

by

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Abstract

Total school surface area, mean and median school size, and number of schools observed per transect per day were estimated from photographs taken during aerial surveys from 1982-85. An index of relative abundance based upon the maximum surface area measured per transect was developed. Trends in the school surface area index were similar to projections of mature biomass from acoustic surveys. A catch rate index derived from commercial capelin trap data was the same as the school surface area index except in 1985 when catch rates may have been biased upwards. From the results presented we conclude that an index of relative abundance from the aerial photographic surveys conducted annually in June and July can be employed to validate projections of mature biomass from offshore acoustic surveys. The catch rate index from capelin traps was similar to the aerial survey results except for 1985 when the magnitude of the increase between 1984 and 1985 was much higher with the commercial fishery data than expected from the aerial and acoustic surveys. This slight discrepancy reinforces the need to have indices of abundance which are independent of the fishery.

Introduction

One key goal when assessing fish stocks is to estimate the strength of year-classes before they are recruited into the fishery. This is especially true for capelin (*Mallotus villosus*) which have a short life span (generally six years or less) with three- and four-year-olds comprising the majority of the catch in recent years (Carscadden 1982, Nakashima and Harnum 1986). Since 1982 the mature biomass in Div. 3L has been estimated from projections based on the size of immature one- and two-year-old fish observed during acoustic surveys (Anon. 1982, 1983, 1984). Given the two year time period between when fish are sampled on acoustic surveys and when they arrive inshore to spawn, it is of vital concern to determine the accuracy of the initial projections. Since the 1981 inshore fishery, commercial catch rates (Nakashima and Harnum 1986) have been available to assess the relative abundance of the inshore spawning biomass. However catch rates from the fishery if they are to reflect abundance require that fishing effort be constant or at least be applied in a similar fashion from year to year. In Div. 3L in 1985 this may not have been the case (Nakashima and Harnum 1986). In addition there is always the danger that the commercial fishery may cease completely and interrupt the catch rate series as occurred with the offshore capelin fishery in the Newfoundland Region (Carscadden 1982). To minimize the reliance on commercial catch rate data we sought a method to estimate relative abundance inshore to aid in the validation of acoustic projections which would be independent of the commercial fishery.

After some preliminary flights in 1981, we developed the use of aerial surveys to calculate an index of relative spawning abundance of mature capelin inshore (Nakashima 1985). Such an index while not useful for projections would be beneficial in validating how well current methodology worked in predicting mature biomass in Div. 3L and would be independent of the uncertainties sometimes associated with obtaining reliable catch rate data for the capelin fishery (Nakashima 1984, Nakashima and Harnum 1986).

Materials and Methods

The rationale and survey criteria to employ aerial photographic surveys to estimate the relative abundance of inshore capelin schools were presented in detail by Nakashima (1985). Some of the methodology is recapitulated herein to familiarize readers with this somewhat unique approach.

The technical aspects of the equipment used and the survey methodology followed from 1982-85 are shown in Table 1. During the spawning period in late June to early July photographic flights were conducted over prescribed transects within Trinity and Conception Bays (Fig. 1). The four transects chosen for the study were the outside of Trinity Bay from the Horse Chops to Gooseberry Cove, the inside of Trinity Bay from Gooseberry Cove to Hopeall, the outside of Conception Bay from Caplin Cove to Harbour Grace Islands, and the inside of Conception Bay from Harbour Grace Islands to Portugal Cove (Fig. 1). Due to time restrictions, we were unable to survey the entire coastline of Trinity and Conception Bays on a frequent basis. Areas of the coastline which were difficult to manoeuvre around to photograph properly, areas with low reported landings, or locations where little or no fixed gear fishery occurred which prevented adequate groundtruthing of daily abundance estimates were excluded from the survey.

Photography was best restricted to a window between 0900-1100 and 1400-1630 NDT to assure optimal conditions for color photography. Optimal weather conditions required sun and little or no wind. When these conditions were present, glare was reduced, land shadows were negligible along the shore, and visibility was maximum which enhanced our ability to locate capelin schools. During the capelin spawning season such ideal weather situations were not a daily occurrence which resulted in some flights being flown in less than ideal conditions to prevent wide gaps in transect coverage.

Color photographs were scrutinized for capelin schools which were greyish in color and had distinct shapes. Underwater rocks and kelp beds may have confused novice observers, however these were darker and very irregular in shape. The surface area of each positively-identified school was measured three times with a compensating polar planimeter. The mean value was taken as an estimate of school surface area. Measured surface areas were corrected for altitude and expressed in m^2.

From 1982-85 for each transect flown per day the total number of schools measured, the mean and the median school surface areas, and the total school surface area along the transect were recorded (Tables 2a, b, c, and d). A relative abundance index was predicated upon the maximum school surface area observed along the four transects in any given year as a good estimator of that year's overall abundance. This was calculated by finding the highest total surface area observed along each of the four transects (Tables 2a, b, c, and d) and summing them to give the annual estimate. Some minor computational errors in Tables 2a, b, c and d in Nakashima (1985) have been corrected in this version.

To examine annual trends in relative abundance, the trends in total surface area index were compared to those calculated from a catch/effort index for capelin traps (Nakashima and Harnum 1986) and to projections of mature biomass based on year-class sizes from acoustic surveys (Anon. 1982, 1983, 1984).

Results

Coverage of the four transects was frequent and complete except in 1982 when the outside transects of Trinity and Conception Bays (Tables 2a, b, c and d) were surveyed only a few times each. There was a noticeable delay in the appearance of capelin inshore in 1985 which was readily detected by the aerial survey. In previous years the number of capelin schools and their surface areas were fairly noticeable by June 25, however this did not occur until June 28 in Conception Bay and July 1 in Trinity Bay in 1985 (Tables 2a, b, c and d). The median schools size was smaller than the mean school size in all comparisons. This parameter was included in the analysis since the mean school size was thought to be biased in several cases where a few extremely large schools were present. From a general examination of the daily schooling data it appears that capelin schools in 1984-85 were more numerous and smaller than those photographed in 1982-83. Also the correspondence between school numbers and total surface area per transect alluded to by Nakashima (1985) for the 1982-84 observations was not supported by the 1985 data. Schools in 1985 were more numerous on days when the total area was less than the maximum observed. Surface area measurements peaked in Conception Bay before Trinity Bay from 1982-84, however in 1985 the peak occurred in both bays on July 2 except for the inside Conception Bay transect where the peak was observed on July 1. The 1985 results were indicative of schooling behavior which was different from previous years and may be attributed to the cooler than average spring water temperatures which could have delayed the inshore arrival of capelin (Nakashima and Harnum 1986).

Although not included in this report, the daily pattern of relative abundance inshore observed from aerial surveys was supported to some extent by purchase slip data (Nakashima 1985). The school area peaked two to three days prior to peaks in daily landings in 1985. Nakashima (1985) noted that the relationship between landings and school surface area was not always synchronous, attributing these differences to uneven coverage by aerial surveys and/or the questionable value of daily purchase slip data from Statistics Branch (Nakashima 1984). Further the aerial survey data in 1985 demonstrated that capelin were inshore before the fishery had opened on June 27 in Conception Bay and June 28 in Trinity Bay (Tables 2a, b, c and d).

Discussion

School surface area measured from aerial photographs is an index which is independent of the commercial fishery and can be used to validate mature biomass projections from acoustic surveys. Nakashima (1985) noted this correspondence with three year's data and the relationship continues to hold with the inclusion of the 1985 results (Table 3). The three indices used in the comparison were the commercial catch rates from capelin traps, the projections of mature biomass from acoustic surveys, and the school surface area from aerial surveys. The catch/day (C/day) of capelin traps as recorded in research logbooks was chosen as the best of the available commercial indices since it incorporated landings and discards and since traps captured capelin close to spawning beaches (Nakashima 1984). Projections of mature biomass based on year-class sizes of one- and two-year-old fish estimated from acoustic surveys are employed by NAFO to estimate stock biomass and recommend TAC's. The school surface area was measured as described earlier in this report.

The three indices in Table 3 followed the same pattern from 1982-84. In 1985 the C/day indicates a high abundance however this rate may have been biased upwards due to the reduction in fishing effort in 1985 as a result of a later opening fishery (Nakashima and Harnum 1986). The mature biomass projections and school surface area indices described similar trends for all years. Thus the aerial survey index confirmed the mature biomass projections from 1982-85. Catch rates like the aerial surveys are a measure of the mature biomass that has migrated inshore to spawn. It differed from the other two indices in 1985 in the level of relative abundance attained. Catch rates suggested that inshore abundance in 1985 was higher than any year in the series while the other two indices indicated higher abundance than 1984 but not quite as high as in 1983 (Table 3). In this analysis the school surface area estimated from aerial photographs supported the trends in mature biomass projected from acoustic surveys. We conclude that aerial surveys are independent of the commercial fishery which may not always reflect inshore abundance because of changes in fishing effort that are not accounted for in current analyses.

While the utility of the method has been demonstrated to date, it is not without its limitations. The greatest uncertainty is weather which dictates the frequency of coverage and can influence the quality of the photographs. Moreover only schools in shallow water (generally less than 30 m) and near the shoreline (approximately 70 m) will be detected with this method. The total surface area calculation assumes that the maximum area observed on a transect is indicative of total abundance for the season. Capelin spawn in waves such that new fish are arriving on the beaches during the spawning season. This is especially true in a prolonged spawning season. Due to time and financial constraints it is not possible to measure the surface area on a daily basis throughout spawning to test for this effect. Finally using surface area as a measure of school size assumes that schools photographed are of uniform density which is not always true (Nakashima 1985).

Despite these restrictions, the data collected thus far have shown that aerial surveys can be used to verify the mature biomass projections derived from acoustic surveys. Its major asset is that it is independent of any problems which may occur with commercial catch rates. The total surface area remains an index of relative abundance. As noted by Nakashima (1985) the ability to convert the index into an absolute estimate faces many problems which will require several years of research to determine if it is possible.

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Table 1. Summary of aerial surveys conducted from 1982 to 1985.

	1982	1983	1984	1985
Survey aircraft:	Piper Aztec	Aero-Commander 500B	Cessna 310	Aero-Commander 500B
Camera type:	RC 10	RC 10	RC 10	RC 10
Lens (mm):	152	152	152	152
Filter type:	clear, anti-vignetting	clear, anti-vignetting	clear, anti-vignetting	clear, anti-vignetting
Film type:	Aerocolour Negative 2445	Aerocolour Negative 2445	Aerocolour Negative 2445	Aerocolour Negative 2445
Radar altimeter:	No	Yes	Yes	Yes
Survey period:	June 18-July 5	June 19-July 9	June 17-July 7	June 18-July 3
Altitude for photography (m):	152-610	457	457	290-610

Table 2a. Schooling data for the outside part of Trinity Bay from the Horse Chops to Gooseberry Cove, 1982-85.

Date	No. of schools	Total surface area (m^2)	School size (m^2) Mean ± SD	Median
June 19, 1982	7	2963	423 ± 502	125
June 26, 1982	0			
July 3, 1982	1	522	522	522
June 23, 1983	7	11330	1619 ± 1315	1283
June 24, 1983	10	13671	1367 ± 1260	1088
June 25, 1983	7	11662	1666 ± 2151	725
June 29, 1983	8	2288	286 ± 228	195
June 30, 1983	13	18470	1420 ± 1613	1116
July 1, 1983	3	6417	2139 ± 2176	1172
June 18, 1984	9	3236	360 ± 423	223
June 19, 1984	8	3962	495 ± 703	279
June 25, 1984	22	30467	1385 ± 1959	502
June 26, 1984	38	37219	979 ± 1718	167
June 29, 1984	9	2790	310 ± 223	279
July 3, 1984	48	43412	904 ± 3010	223
July 6, 1984	34	16015	471 ± 485	167
June 21, 1985	0	0		
June 25, 1985	0	0		
June 29, 1985	18	15536	863 ± 983	316
July 1, 1985	32	48808	1525 ± 1622	893
July 2, 1985	24	49216	2051 ± 2965	949
July 3, 1985	9	2498	278 ± 183	270

Table 2b. Schooling data for the inside part of Trinity Bay from Gooseberry Cove to Hopeall, 1982-85.

Date	No. of schools	Total surface area (m^2)	School size (m^2) Mean ± SD	Median
June 19, 1982	31	12724	411 ± 712	149
June 26, 1982	29	35607	1228 ± 2755	299
June 29, 1982	11	62397	5672 ± 8378	592
July 2, 1982	8	31365	3921 ± 9281	705
July 3, 1982	2	1920	960 ± 17	960
June 23, 1983	11	69583	6326 ± 6299	4241
June 24, 1983	26	39004	1500 ± 1880	753
June 25, 1983	30	174487	5816 ± 12759	781
June 29, 1983	35	152557	4359 ± 11139	781
June 30, 1983	46	199373	4334 ± 6927	558
July 1, 1983	25	189497	7580 ± 19791	2288
June 19, 1984	13	15624	1202 ± 1770	335
June 23, 1984	9	8314	924 ± 888	502
June 25, 1984	96	31526	328 ± 505	117
June 26, 1984	96	40510	422 ± 679	223
June 29, 1984	47	12053	256 ± 314	167
July 3, 1984	57	23827	418 ± 814	167
July 7, 1984	77	43245	562 ± 1124	223
June 21, 1985	13	7041	542 ± 706	270
June 25, 1985	35	22459	642 ± 1144	211
June 26, 1985	30	16540	551 ± 721	214
July 1, 1985	125	60245	482 ± 963	181
July 2, 1985	130	195659	1503 ± 6046[a]	179

[a] calculation excludes capelin in traps

Table 2c. Schooling data for the outside of Conception Bay from Caplin Cove to Harbour Grace Islands, 1982-85.

Date	No. of schools	Total surface area (m^2)	School size (m^2)	
			Mean ± SD	Median
June 29, 1982	10	6577	658 ± 366	642
July 2, 1982	2	1357	679 ± 554	679
June 23, 1983	34	51838	1374 ± 2266[a]	530
June 24, 1983	16	10658	666 ± 823	447
June 25, 1983	4	4408	349 ± 184	279
July 1, 1983	5	5413	1083 ± 1884	112
June 18, 1984	1	391	391	
June 19, 1984	0	0		
June 25, 1984	49	63779	1294 ± 2874	391
June 26, 1984	67	65956	697 ± 1091[a]	279
June 30, 1984	21	22320	818 ± 1509[a]	223
July 3, 1984	4	1786	446 ± 599	195
June 20, 1985	0	0		
June 24, 1985	0	0		
June 27, 1985	30	8840	268 ± 378[a]	120
June 28, 1985	125	50837	386 ± 800[a]	132
June 29, 1985	22	19253	875 ± 1169	291
July 1, 1985	28	28036	991 ± 1616[a]	264
July 2, 1985	66	69166	914 ± 2064[a]	223

[a] calculation excludes capelin in traps

Table 2d. Schooling data for the inside of Conception Bay from Harbour Grace Islands to Portugal Cove, 1982-85.

Date	No. of schools	Total surface area (m^2)	School size (m^2)	
			Mean ± SD	Median
June 26, 1982 AM	33	19408	571 ± 907[a]	135
June 26, 1982 PM	20	36513	1826 ± 1914	2089
June 27, 1982	48	151214	3134 ± 6015[a]	527
June 29, 1982	27	30275	1121 ± 1707	418
July 4, 1982	3	13042	4347 ± 4951	1409
July 5, 1982	7	5127	732 ± 582	592
June 23, 1983	53	97595	1787 ± 2754[a]	558
June 24, 1983	30	56860	1819 ± 2965[a]	558
June 25, 1983	29	79961	2677 ± 3725[a]	781
June 30, 1983	7	8091	1156 ± 1181	558
July 1, 1983	1	2009	2009	
June 18, 1984	0	0		
June 23, 1984	8	17689	2085 ± 2556[a]	949
June 25, 1984	70	63891	879 ± 1789[a]	223
June 26, 1984	33	23603	703 ± 1708[a]	223
June 30, 1984	29	16852	508 ± 467[a]	335
July 3, 1984	18	9040	329 ± 254[a]	223
July 5, 1984	0	0		
June 20, 1985	0	0		
June 24, 1985	2	1600	800 ± 834	800
June 26, 1985	17	10124	596 ± 1145	314
June 27, 1985	76	16552	214 ± 426[a]	78
June 28, 1985	120	33858	274 ± 938[a]	67
July 1, 1985	16	43228	2702 ± 5140	308
July 2, 1985	17	13436	676 ± 1872[a]	191

[a] calculation exludes capelin in traps

Table 3. Comparison of three indices for estimating trends in relative spawning biomass. The catch/day index was based on capelin trap data from logbook surveys (Nakashima and Harnum 1986), the mature biomass index originated from NAFO Scientific Council Reports (Anon. 1982-84), and the school surface area index came from this study.

Year	Catch (t)/day	Mature biomass (+)	School surface area (m^2)
1982	3.1	›346,000	223,151
1983	3.4	658,000	367,276
1984	2.9	384,000	216,504
1985	4.6	596,000	357,268

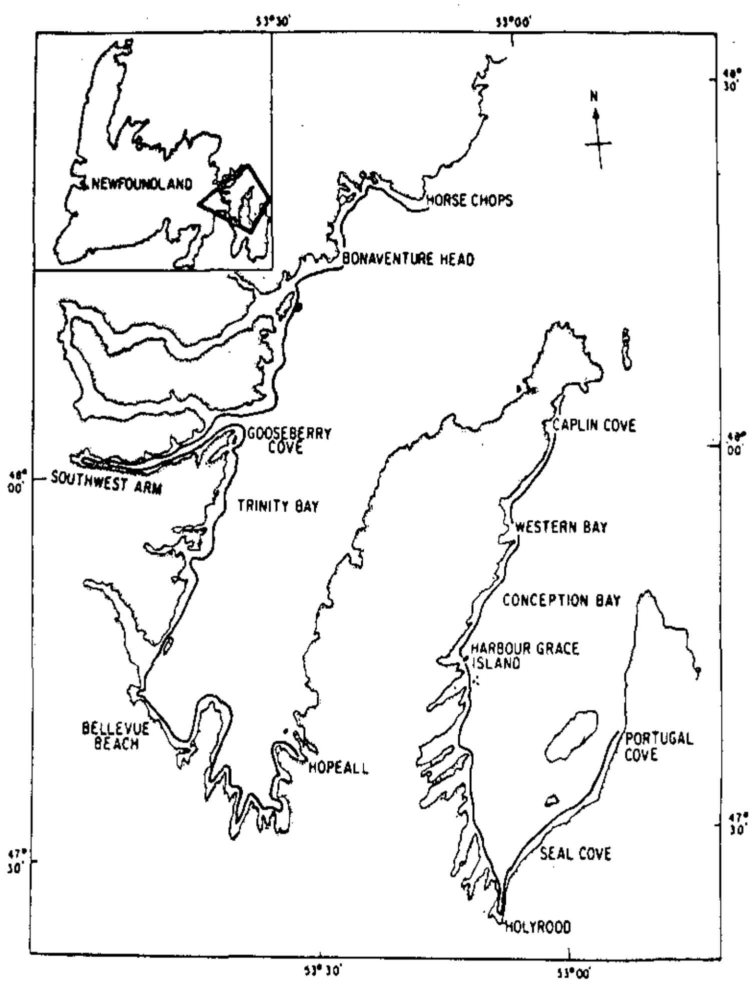

Fig. 1. Survey track for aerial survey.