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Capelin *(Mallotus villosus)* egg deposition on fifteen spawning beaches in Conception Bay, Newfoundland in 1992

by

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Abstract

Egg deposition on the mid-zone of 15 beaches in Conception Bay varied from no eggs at Burkes Cove to 34.41 x 10^{10} eggs at Kingston. Samples were collected July 15-21 after peak spawning and before significant hatching of eggs had occurred. Spawning was later than observed in 1987 to 1990, however, it was not as late as observed in 1991. The level of egg deposition in 1992 was higher than in 1991.

Résumé

La ponte dans la partie centrale de quinze plages de la baie de Conception a été variable. Nulle à l'anse Burkes, elle a atteint 34,41 x 10^{10} oeufs à Kingston. Des échantillons ont été recueillis du 15 au 21 juillet, après la période intense de frai, mais avant que le processus de maturation des oeufs ne soit véritablement amorcé. Le frai a eu lieu plus tard que durant les années 1987-1990, mais pas aussi tardivement qu'en 1991. Quant à la ponte, elle a été supérieure à celle de 1991.

INTRODUCTION

Capelin (Mallotus villosus) spawn intertidally on gravel beaches during June and July in coastal areas of the northwest Atlantic Ocean. Eggs remain adhesive for as long as 2 hours after exposure to water (Fridgeirsson 1976), and attach to the surrounding beach substrates. The fertilized eggs incubate and develop in the beach sediments at depths of up to 20 cm (Taggart and Leggett 1987).

Capelin beaches are known to exhibit annual differences in the abundance of spawn. Fishermen have often reported that the abundance of capelin eggs observed along spawning beaches in Newfoundland is highly variable. Egg abundances estimated for the mid-tide area of 15 beaches in Conception Bay from 1987 to 1991 exhibited three orders of magnitude difference (Nakashima and Slaney 1992). Taggart and Nakashima (1987) reported a range of $9x10^8$ to $8x10^{10}$ eggs among 16 beaches on the western perimeter of Conception Bay in 1983.

We report on the results of sampling 15 spawning beaches along the perimeter of Conception Bay, Newfoundland in 1992 and compare the results to findings from previous years.

MATERIALS AND METHODS

Sampling Sites

We selected 15 known capelin spawning beaches around Conception Bay (Fig. 1). Thirteen beaches are accessible by land and two (Caplin Cove and Kingston) by sea. Beach sampling commenced immediately following the occurrence of significant numbers of spawning capelin schools along the coastline of Conception Bay. Peak spawning in Conception Bay was determined from aerial surveys (Nakashima 1993) and from periodic checks of a few beaches for evidence of egg deposition.

Samples were collected in the mid-tide (MT) zone during low tide conditions to maximize the sampling of several beaches in a short period of time. The MT zone is defined as the area of the intertidal zone which lies between the low and high tide water marks. The low-tide zone is covered by seawater except at low tide conditions which would restrict sampling to one daylight period of less than two hours. The high-tide zone is exposed during most of the tidal cycle and eggs are subjected to faster development and higher mortality than the low- and mid-tide zones (Frank and Leggett 1981). Capelin tend to spawn more on the falling tide than the rising tide and mass spawning usually occurs at intermediate tidal levels (Templeman 1948). Consequently eggs are more likely to be deposited in the mid-tide areas. Given the number of personnel and location of sites it was not feasible to sample all three tidal zones of each beach within the short time following peak spawning and hatching of eggs. Consequently we chose to sample only the MT zone assuming that the results would represent a minimum estimate of the number of eggs deposited there after peak spawning.

The area of the MT zone on each beach was calculated using length and width measurements estimated when samples were collected. The number of samples collected at each beach depended on a qualitative inspection of the egg distribution in the MT zone that consisted of visually examining the concentration of eggs along the entire length of the MT zone. Two qualitative and relative indices were employed: HC (high concentration) and LC (low concentration). When egg distribution was judged to be relatively heterogeneous the MT zone was stratified into HC and LC areas (each measured) and up to two sediment core samples were collected within each stratum. Beaches judged to have a relatively uniform egg distribution were sampled at two different locations randomly chosen in the MT zone.

A steel sediment corer (6.5 cm internal diameter) was used to collect each sediment core sample. At each sampling location the corer was manually "drilled" into the beach sediments to the greatest depth possible (limited by the strength of the operator or subsurface grains larger than 6.5 cm) and the depth was measured with a calibrated plunger inside the corer. Each core sample was fixed with a 4% formalin and seawater solution buffered with sodium borate to protect the eggs from deterioration. Egg concentration and development rate were assumed to be vertically homogeneous within the beach sediments (Frank and Leggett 1981).

Eggs and Pre-emergent Larvae

Adhesive capelin eggs were separated from beach sediments by rinsing each sample with fresh water over a 250 um-mesh screen followed by submersion in a 2% (by weight) KOH solution for a period of 24 to 36 hr. Separated eggs were subsequently washed from the sediments, decanted, and collected on a 250 um-mesh screen.

Egg abundance was estimated by subsampling the separated eggs with a ten-chamber whirling vessel (Pitt 1965). The entire sample was sequentially fractioned until the number of eggs per chamber was reduced to ~2500. Eggs from two randomly selected chambers were counted and averaged (Nakashima 1987). Egg abundance for each beach was estimated using the sediment-core egg concentration weighted by beach stratum area.

We examined variation in developmental stage among samples to ensure that our concentration estimates were not unduly biased by variations in egg development among beaches that might lead to a significant 'loss' of eggs through differential hatching. A minimum of 50 eggs from each core sample were placed in Stockard's solution (Bonnet 1939) and the eggs were classified as dead (opaque or showing arrested development), in early development (stages I-IV) as described by Fridgeirsson (1976) and generally associated with the first 6 days of development, or in the eyed (eyed embryo) stage.

Pre-emergent (hatched) larvae were enumerated from each core sample collected. For large numbers of larvae (>500) the sample was subdivided and estimates were made using the Huntsman Marine Laboratory beaker technique (Van Guelpen et al. 1982). When numbers of larvae were low, all larvae were counted. The average larval concentration per beach was estimated using the sediment-core larval concentration weighted by stratum area.

To compare the egg and larval concentrations between years the estimates were standardized to a MT area common for each beach. Prior to 1991 the MT area where eggs were observed was equal to or less than the standard area. In 1991 and 1992 the MT area was larger for most beaches compared to previous years because the width of the mid-tide zone was wider. This may have been due to the differences in tidal conditions occurring in late June-early July compared to the late July-early August period. Field observatios indicated that the slope or steepness of the beaches were more gradual in 1991 and 1992 than in the 1987 to 1990 period.

RESULTS

Sampling Time

Sampling times were variable between 1987 and 1992 (Table 2). The earliest sampling period was in 1987. In 1988 the beaches were surveyed about five days later than in 1987. Collections in 1989 were two days later and 1990 was seven days later than in 1987. From 1987 to 1990 timing of the survey varied within seven days, however, the 1991 survey was 30 days later than in 1987. The 1992 sampling was 22 days later than in 1987 but eight days earlier than in 1992.

Sampling times assume that all beaches are sampled after peak spawning and before significant hatching and larval release have occurred. Examination of the 1992 egg development stages showed that the proportion of dead eggs (at the time of sampling) varied among beaches (Table 1: 7-36%) but the annual mean of 19.9% was slightly lower and similar to means in previous years (Table 2). The proportion of eggs in the early and eyed developmental stages tend to show a decline in the proportion of early stage eggs and an increase in the ratio of eyed egg stages with time (Table 1).

If the proportion of eggs in early development is indicative of eggs recently fertilized then the 1992 survey was sampled closest to peak spawning and comparable to 1988 (Table 2). Estimates of concentrations of pre-emergent larval capelin indicated that in most instances beaches were sampled before significant hatching and release of larvae had occurred (Table 3). In 1992 every beach where spawning took place had some pre-emergent larvae. The presence of pre-emergent larvae in the core samples may indicate that spawning of small numbers of fish occurred prior to peak spawning. Daily observations at Chapel Cove confirmed this interpretation (unpublished data, Winters and Nakashima). Although Kingston and Spout Cove have relatively higher concentrations of pre-emergent larvae (Table 3) the mean of fourteen beaches (excluding Burkes Cove) is within the range of means estimated in 1987 and 1989-91. Based on these results we conclude that our beach sampling in 1992 occurred close to peak spawning.

Egg Deposition and Beach Observations

There was a high degree of variation in egg deposition among the 15 beaches we sampled (Table 3). The total egg abundance in the MT zone varied from no spawning on Burkes Cove to 34.41×10^{10} eggs on Kingston. A similar pattern is observed for egg concentration with Spout Cove and Caplin Cove having the highest estimates. Aside from a few exceptions, the spawning beaches on the western side of Conception Bay from Bristols Hope to Caplin Cove had higher abundances than those on the eastern side and bottom of Conception Bay from Burkes Cove to St. Phillips (Table 3). The pattern of annual mean egg concentrations mirrors the total egg abundance series, however, the geometric mean egg concentration suggests a different pattern with the 1992 estimate as the second lowest (Table 3).

Field teams noted that in 1992 capelin spawning was not observed directly and in fact very few capelin were observed near the sampling sites. Similarly, at seven sites monitored daily around Newfoundland, spawning occurred mostly at night (Winters and Nakashima, unpub. data).

DISCUSSION

Total abundance of eggs, the mean concentration of eggs, and the geometric mean concentration of eggs varied between 1987 and 1992. The total abundance and mean concentration were highest in 1988 followed by 1990, 1992, 1991, 1987, and 1989. The geometric mean egg concentration was also highest in 1988 and was twice the estimates for 1987, 1991, and 1990 and three times the 1989 and 1992 estimate. Annual egg deposition appeared to be unrelated to spawning biomass levels. For example 1988 had the highest concentration of eggs in the MT zone when the projected spawning biomass was lower than any other year from 1987 to 1991 (Nakashima 1993). If egg deposition in MT zones of beaches can be considered an index of spawning biomass then in Conception Bay in 1992, egg deposition was similar to 1990 levels and higher than estimated in 1991. Total egg abundance of 103.27×10^{10} in 1992 was higher than the average abundance of 84.59×10^{10} for the period of 1987-91.

This analysis assumes that eggs retained in the MT zone can be used as an index of egg deposition for Conception Bay provided the same beaches are always sampled, beaches are surveyed following peak spawning, and that a single spawning peak represents the most abundant portion of the spawning population. Spawning may occur several times and over several days on a beach (unpublished data, Winters and Nakashima), consequently our estimates do not represent the total egg deposition of any year's spawning biomass. Also we do not take into account eggs in the high-tide or low-tide areas due to the logistics of sampling. Finally spawning can occur in subtidal areas such as observed in 1991 to a lesser extent in 1992.

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Table 1. Collection dates, number of samples, and developmental stages of capelin eggs for 15 beaches in Conception Bay, Newfoundland in 1992. Burkes Cove was checked on July 22 and no spawning had occurred there.

Beach	Collection date	No. of samples	Developmental stages (%)		
			Early	Eyed	Dead
Chapel Cove	Jul 15	3	85.2	1.7	13.1
Holyrood	Jul 17	3	93.0	0	7.0
Topsail	Jul 18	6	40.7	41.1	18.2
Jobs Cove	Jul 18	3	78.2	5.8	16.1
Caplin Cove	Jul 18	4	76.7	1.5	21.9
Spout Cove	Jul 19	5	78.9	5.4	15.6
Kingston	Jul 19	6	72.9	4.6	22.4
St. Phillips	Jul 20	4	77.6	6.8	15.6
Coleys Point	Jul 20	5	73.2	16.8	20.1
Bristols Hope	Jul 20	3	62.5	9.5	28.0
Western Bay	Jul 20	5	52.2	11.8	36.0
Ochre Pit Cove	Jul 20	3	56.3	30.4	13.2
Bryant's Cove	Jul 21	3	15.2	65.4	19.4
Bears Cove	Jul 21	5	41.1	26.5	32.4
Grand Mean			64.5	16.2	19.9

Table 2. Summary of collection dates and grand mean of developmental stages of capelin eggs for capelin beaches in Conception Bay, Newfoundland, 1987-92. In 1992, Burkes Cove was not included because spawning had not taken place.

Year	Collection date	Developmental stages (%)		
		Early	Eyed	Dead
1987	Jun 23-30	39.3	36.0	24.7
1988	Jun 28-Jul 4	66.7	11.2	22.1
1989	Jun 26-Jul 2	32.6	43.5	24.3
1990	Jul 1-8	49.9	26.7	23.5
1991	Jul 23-Aug 2	49.5	24.3	26.0
1992	Jul 15-21	64.5	16.2	19.9

Table 3. Total abundance of capelin eggs (no. eggs x 10^{10}), egg concentration (no. eggs/cm^2), pre-emergent larval concentration (no. larvae/cm^2), and mid-tide area (m^2) for 15 beaches in Conception Bay, 1987-92.

Year	Caplin Cove	Jobs Cove	Ochre Pit Cove	Western Bay	Kingston	Spout Cove	Bristols Hope	Bears Cove	Bryants Cove	Coleys Point	Burkes Cove	Chapel Cove	Holyrood	Topsail	St. Phillips		
Egg Abundance																Total	
1987	8.50	3.02	2.49	8.57	22.10	4.29	2.52	3.28	6.40	3.18	0.30	2.07	0.52	0.91	0.26	68.41	
1988	6.73	3.16	5.33	13.45	6.73	9.47	5.11	16.73	5.06	12.90	7.23	5.39	0.45	27.90	1.03	126.67	
1989	4.18	2.81	0.91	6.99	13.44	6.55	1.90	0.27	1.40	1.53	0.55	1.10	0.35	3.08	1.11	46.17	
1990	7.45	2.58	5.27	26.94	21.19	11.83	4.63	4.29	5.77	14.96	0.07	1.02	0.04	2.06	0.17	108.27	
1991	1.25	4.56	1.49	18.45	20.88	5.46	3.65	4.04	5.57	0.74	3.29	1.75	1.17	0.70	0.44	73.44	
1992	10.76	3.34	0.79	8.19	34.41	14.08	4.87	3.99	1.28	15.51	0	1.26	0.55	3.34	0.90	103.27	
Egg Concentration																Mean	G Mean
1987	4254	2898	1684	2640	2947	1661	1563	946	3708	635	168	1762	2251	68	385	1838	1204
1988	3368	3033	3604	4144	898	3666	3170	4824	2932	2577	4050	4587	1948	2088	1481	3092	2846
1989	2092	2697	615	2153	1792	2536	1179	79	811	306	308	936	1515	230	1644	1260	873
1990	3729	2476	3563	8299	2826	4580	2872	1237	3343	2989	39	868	173	154	252	2493	1250
1991	626	4376	1007	5684	2785	2114	2264	1165	3227	148	1843	1489	5065	52	652	2166	1306
1992	5384	3202	532	2523	4589	5451	3020	1151	742	3098	0	1070	2381	250	1333	2315	1095
Pre-emergent Larval Concentration																Mean	
1987	0	0	0	0	0	38	0	0	0	0	0	0	0	97	8	10	
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1989	6	1	16	30	9	11	6	14	5	8	4	30	24	23	27	14	
1990	21	34	0	23	10	86	0	0	3	11	38	7	3	1	0	16	
1991	1	88	0	6	19	39	0	0	0	0	6	3	0	0	0	11	
1992	1	9	1	7	86	50	2	6	7	1	0	1	3	1	20	13	
MT	1998	1042	1479	3246	7498	2583	1612	3468	1726	5005	1785	1175	231	13363	675		

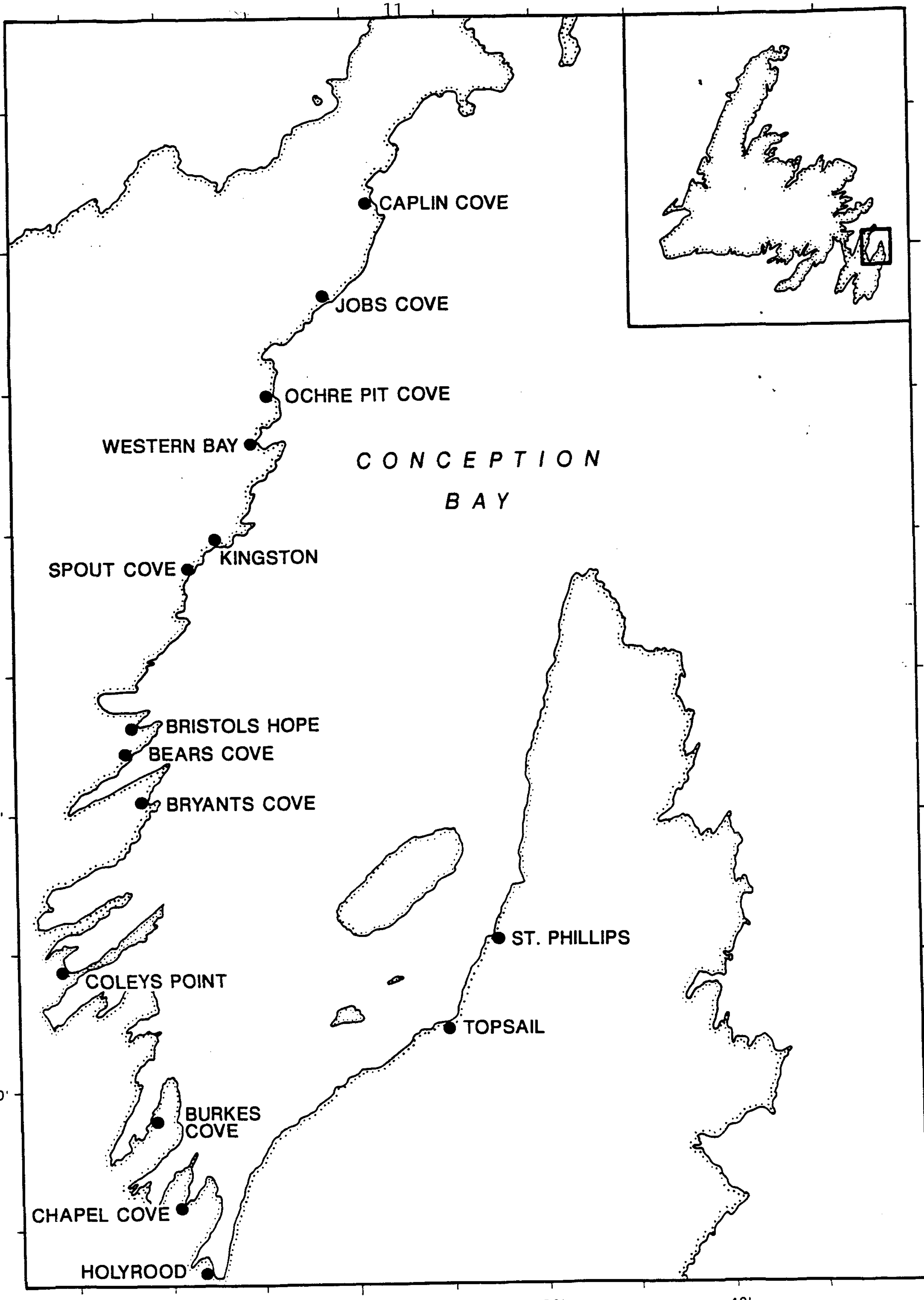

Fig. 1. Sampling sites in Conception Bay.