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SPAWNING OF THE AMERICAN SHAD (ALOSA SAPIDISSIMA) IN THE ANNAPOLIS RIVER, NOVA SCOTIA

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Plankton drift-net collections of American shad *(Alosa sapidissima)* eggs indicated that spawning in the Annapolis River, N.S., occurred from 7 May to 19 June in 1976. Spawning was related to water temperatures on the spawning grounds. Peak spawning (80% of eggs collected) occurred from 12-19 May when water temperatures were 14-15°C. Few eggs were netted at < 13°C (3%) or at > 18°C (1%). Spawning occurred throughout the day but most occurred during the evening and at night. Shad spawned in fresh water with the majority (98% of all egg collections) of spawning occurring > 22 km upstream from the tip of the salt wedge in this stratified estuary.

Les récoltes d'oeufs de l'alose américaine *(Alosa sapidissima)* effectuées a l'aide d'un filet planctonique dérivant indiquent que cette espèce s'est reproduite, dans la rivière Annapolis (Nouvelle-Ecosse) entre le 7 mai et le 10 juin 1976. La reproduction était reliée aux températures de l'eau des frayeres. Les maxima de reproduction (80% des oeufs récoltés) se sont produits entre le 12 et le 13 mai lorsque la température était inférieure a 13°C (3%) ou supérieure a 18°C (1%). Le frai se produit pendant toute la journeé mais la plus grande partie de celui-ci se produit pendant la soirée et durent la nuit. L'alose se reproduit en eau douce: la majorité du frai se produit à une distance supérieure à 22 km en amont de l'extremite du front salin de cet estuaire stratifié.

Introduction

The American shad *(Alosa sapidissima),* largest member of the herring family (Clupeidae) is native to the east coast of North America from Newfoundland to Florida. Introduced to the Pacific coast in 1871, it occurs from southern California to Cook Inlet, Alaska, and along the Kamchatka Peninsula on the Asiatic side (Scott & Crossman 1973). Shad are anadromous, the precise time of their upstream spawning migration depending on the water temperature (Walburg 1960; Leggett & Whitney 1972; Scott & Crossman 1973; Carscadden & Leggett 1975; Leggett & Carscadden 1978). In Canadian waters spawning occurs in May, June, or even as late as July (Scott & Crossman 1973; Gabriel et al. 1976). The spawning of this species in the United States' rivers has been well documented (Massmann 1952; Walburg 1960; Watson 1968; Chittenden 1976; March 1976), but apart from a detailed account of the shad population in the Shubenacadie River, N.S., by Leim (1924), data on other Canadian shad populations are limited. The Annapolis River shad population is the largest unexploited population in Atlantic Canada (Dadswell et al. 1983a, b) and is a population of great interest because of the recent construction of the Tidal Power Station at Annapolis Royal (Daborn et al. 1983). The objective of the present study was to define the spawning period and area of the native shad population in the Annapolis River during 1976.

Methods

Drift net and egg collections were used to determine the spawning area and period. Collection techniques are described in Williams et al. (1984). Nets used were set from 7 May to 30 June at four stations located at regular distances along the Annapolis River, beginning just downstream from the upper limit of the salt

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Table I Drift net American shad *(Alosa sapidissima)* egg collections made in the Annapolis River, Nova Scotia, during the 1976 shad spawning season

Date	Total no. of eggs collected	% of total	Drift net station no.	Time of day, h	Mean water [a] temperature, °C	No. of eggs collected	No. of eggs per hour
May 7-8	2174	2.7	2	1100-1100	11.0	237	9.9
			4	1635-1635	11.0	1937	80.7
8-9	2723	3.3	4	1700-1700	13.0	2723	113.5
12	3948	4.9	2	0920-1750	14.3	133	15.7
			3	0955-1840	14.1	41	4.7
			4	1155-2025	14.0	3774	444.0
12-13	29036	35.7	2	1810-0230	14.3	22	2.6
			4	2045-0400	14.0	29014	4001.9
14	14268	17.6	1 (20)[b]	0030-1230	14.8	198[c]	16.5
			2 (29)	0120-1350	14.5	15	1.2
			3 (35)	0222-1515	14.7	355	27.6
			4 (42)	0330-1800	14.6	13700	944.8
18-19	21724	26.7	2	2040-1100	14.6	147[c]	10.0
			3	1900-0800	14.5	374	28.8
			4	1940-0940	14.8	21203	1514.5
21-22	1611	2.0	2	0958-0010	12.8	7[c]	0.5
			3	0640-1935	12.8	29	2.3
			4	0730-2045	12.8	1575	117.5
25-26	596	0.7	2	2140-0945	10.5	2[c]	0.2
			4	1950-0810	10.5	594	48.2
30	2767	3.4	2	0920-2035	16.8	5[c]	0.4
			3	0810-1940	16.6	4	0.4
			4	0710-1820	16.2	2758	247.0
June 3-4	1934	2.4	4	2205-1050	17.8	1934	151.7
7	12	0.0	4	0805-1905	18.9	12	1.1
8-9	447	0.6	4	1830-0735	20.3	447	34.2
11	6	0.0	2	0915-2035	22.1	1[c]	0.1
			4	1220-2400	22.7	5	0.4
13-14	1	0.0	4	0045-1247	16.7	1	0.2
16	5	0.0	4	1313-2355	22.2	5	0.5
18-19	2	0.0	4	1950-0922	22.4	2	0.2
Total	81254						

[a](temperature at beginning of set + temperature at end of set)/2.
[b]Distance above the Annapolis River Causeway in kilometers.
[c]1.0 m diameter plankton net used; number of eggs collected adjusted to 0.6 diameter net.

wedge in early May, 20 km above the Annapolis River Causeway, to about 42 km above the causeway at Lawrencetown. Station 1 (km 20) was used from 12 May to 30 May, station 3 (km 35) from 12 May to 30 June, and stations 2 (km 29) and 4 (km 42) from 12 May to 30 June. Treatment and identification of samples follows that described by Williams et al. (1984).

Results and Discussion

Shad definitely spawned in the Annapolis River from 7 May to 19 June in 1976. A total of 81,254 eggs was collected during this period (Table I). Spawning was already in progress when sampling commenced on 7 May; however, since relatively few eggs were netted initially and optimum spawning temperatures were not reached until later, spawning may have just started. Virtually all egg collections (99.4%) were made between 7 May and 4 June with the period from 12-19 May being most productive (80.0%). Leim (1924) also found that shad in the Shubenacadie River, Nova Scotia, spawned in May and June, but peak egg collections were made in late May or early June during the four years of his study. Similarly, Gabriel et al. (1976) noted that spawning occurs from mid-May in the St. John River, New Brunswick.

Shad spawning in the Annapolis River was related to water temperatures. Increasing water temperatures to >13°C approximately coincided with egg collections while rapid temperature drops to <13°C resulted in temporary cessation of spawning (Fig 1). Although shad eggs were collected in water that ranged from 10.5-22.7°C, most eggs (96%) were netted at temperatures between 13 and 18°C with peak spawning (12-19 May) occurring when water temperatures were 14-15°C. Few eggs were collected when temperatures were <13°C (3%) or when temperatures exceeded 18°C (1%). Similarly, Leim (1924) found that shad in the Shubenacadie River spawned in the spring after water temperatures had reached 12°C and that a depression to <12°C caused almost complete cessation of spawning. Peak spawning occurred at temperatures between 14 and 16°C over the four years of his study. In Virginia rivers shad eggs are also not collected in abundance until water temperatures reach 12°C (Massmann 1952).

Egg collection times indicate that although shad in the Annapolis River may spawn during the day most spawning probably occurred during the evening and at night (Table I). This is in general agreement with other authors (e.g. Leim 1924; Massmann 1952; Mansueti & Kolb 1953; Mansueti & Hardy 1967; Chittenden 1976; Marcy 1976).

Shad spawned in the freshwater (< 0.1‰ salinity) section of the Annapolis River. All egg collections were made in fresh water except one: on 14 May 198 eggs were captured at station 1 (km 20) when the mean salinity was 0.5‰. However, since these eggs were near hatching they had undoubtedly originated in the freshwater section upstream. The main spawning area was located upstream from station 4 (km 42) since that station accounted for 98.1% of all eggs collected (Table I). During peak spawning the tip of the salt wedge fluctuated near station 1 (km 20), about 22 km downstream from the main spawning area (Williams 1978; Daborn et al. 1979). By the end of the spawning season in June the salt wedge was near station 2 (km 29).

Evidently most shad spawning occurred in the more slowly flowing section of the Annapolis River. The river upstream from station 4 (km 42) is shallow, usually <1.5 m, and widening, with a bottom composed of sand and mud interspersed with granite and basalt rocks and boulders. Few eggs (2%) were collected in the area downstream from station 4, a region characterized by deeper water, a faster current, and a more sandy bottom. Similar shad spawning areas have been described

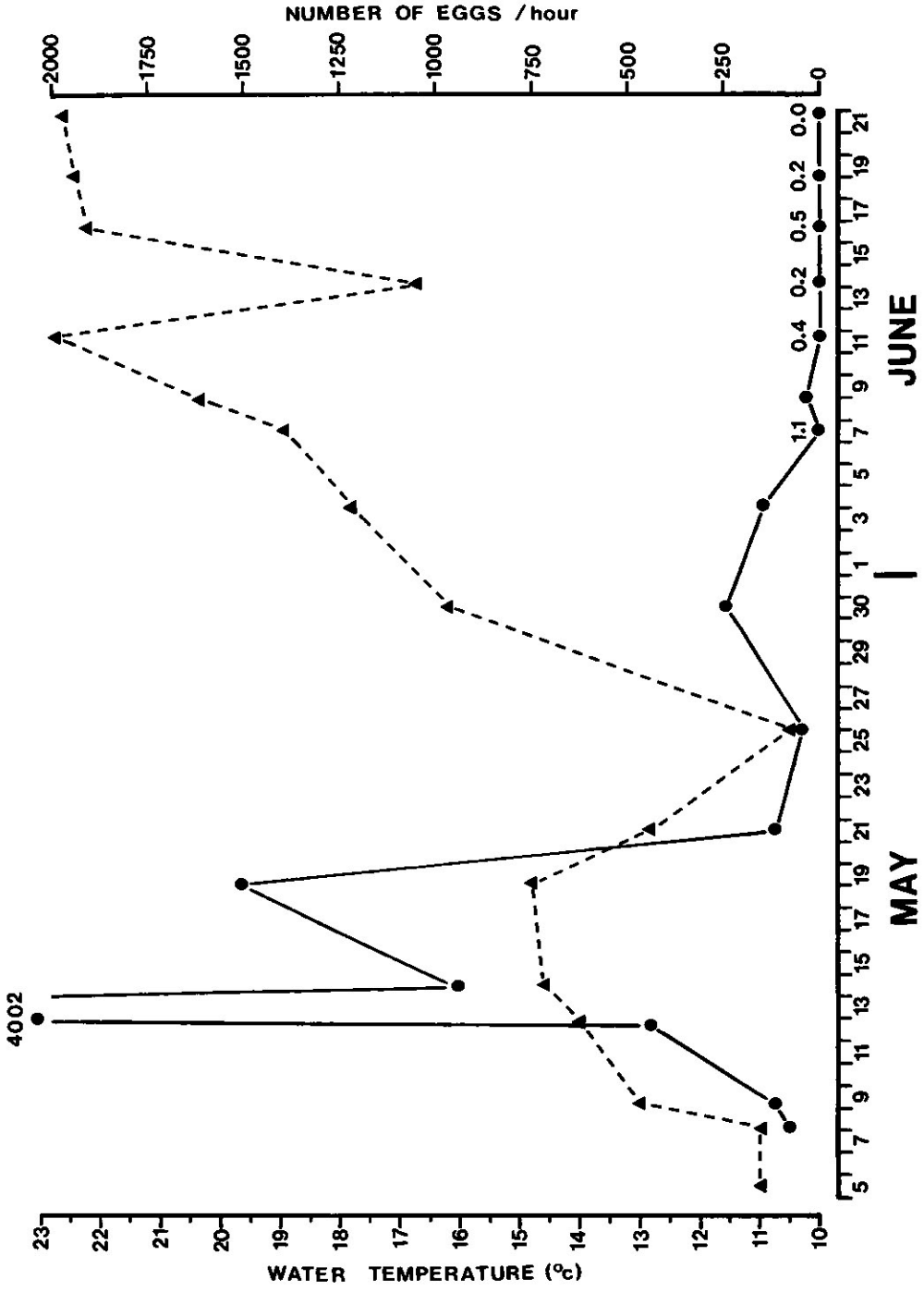

Fig 1. Relationship between water temperature and the number of shad eggs collected per hour at Annapolis River drift net station 4 (km 42) in 1976. ▲, mean water temperature (see Table I); ●, number of eggs collected per hour.

elsewhere although considerable variation exists (e.g. Leim 1924; Massmann 1952; Mansueti & Kolb 1953; Carl et al. 1959; Walburg 1960; Mansueti & Hardy 1967).

Shad larvae were relatively abundant in the Annapolis River from Station 2 (km 29) upstream after 12 May (Williams 1978).

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