PROC. N.S. INST. SCI. (1980)
Volume 30, pp. 31-40

OBSERVATIONS ON THE FOODS OF BROOK TROUT (SALVELINUS FONTINALIS) AND RAINBOW TROUT (SALMO GAIRDNERI) IN THE DUNK RIVER SYSTEM, PRINCE EDWARD ISLAND

C.E. JOHNSTON

Department of Biology
University of Prince Edward Island
Charlottetown, P.E.I. C1A 4P3

Brook trout and rainbow trout in the coastal Lower Dunk River have considerable overlap in feeding habits from June to September and depend substantially upon eggs of anadromous smelts (Osmerus mordax) and gaspereau (Alosa pseudoharengus) during June and July. Lacking these foods, trout later feed primarily upon ephemeropteran nymphs, and dipteran and trichopteran larvae. Volumes of food consumed by both species were positively related to water temperature and food abundance, and in warmer water rainbow trout consumed more food than did brook trout. Brook trout and rainbow trout in a small inland stream environment of the same river system, while consuming invertebrates similar to those of trout in the coastal river environment, ate more terrestrial forms and had smaller food volumes. Significant differences in the growth of trout in the two environments were related to differences in diet and trout densities.

Introduction

High standing crops and rapid growth of young salmonids in streams and ponds of Prince Edward Island have been documented by White (1927; 1930), Saunders and Smith (1955; 1962) and Johnston and Cheverie (1980), and are related to the few predatory or rival freshwater fish species, high nutrient levels, and very abundant food.

Information on the food source for salmonids in Island waters is limited to some very general observations (White 1927; 1930; Smith 1936). None has described the abundance of the food source, the primary foods eaten or the seasonal patterns in dietary preferences. This study was undertaken to provide such information for brook trout and rainbow trout in a coastal river environment and an inland stream environment of the Dunk River system and to investigate the relationships between food and trout growth in those two environments.

Description of the Study Area

The Dunk River flows through agricultural lands in central Prince Edward Island (Fig 1). It is divided by dams into the Lower Dunk River, a coastal-river environment; Scales Pond, a freshwater-pond environment; and the Upper Dunk River, a small inland-stream environment. Detailed descriptions of the physical, chemical and biological features of the three environments have been published (Anon. 1974; Johnston 1974; Johnston & McKenna 1976; Johnston & Cheverie 1980; Staker 1976).

For this study, benthic invertebrates and trout were collected from the Lower Dunk River at site sampling areas 1 to 4, and from the Upper Dunk River at site sampling areas 5 to 7 (Fig 1).

Materials and Methods

Collection of Benthos

Prior to sampling, barrier nets were installed to enclose the study area. Bottom organisms were then collected from randomly selected 0.093-m^2 areas of the river

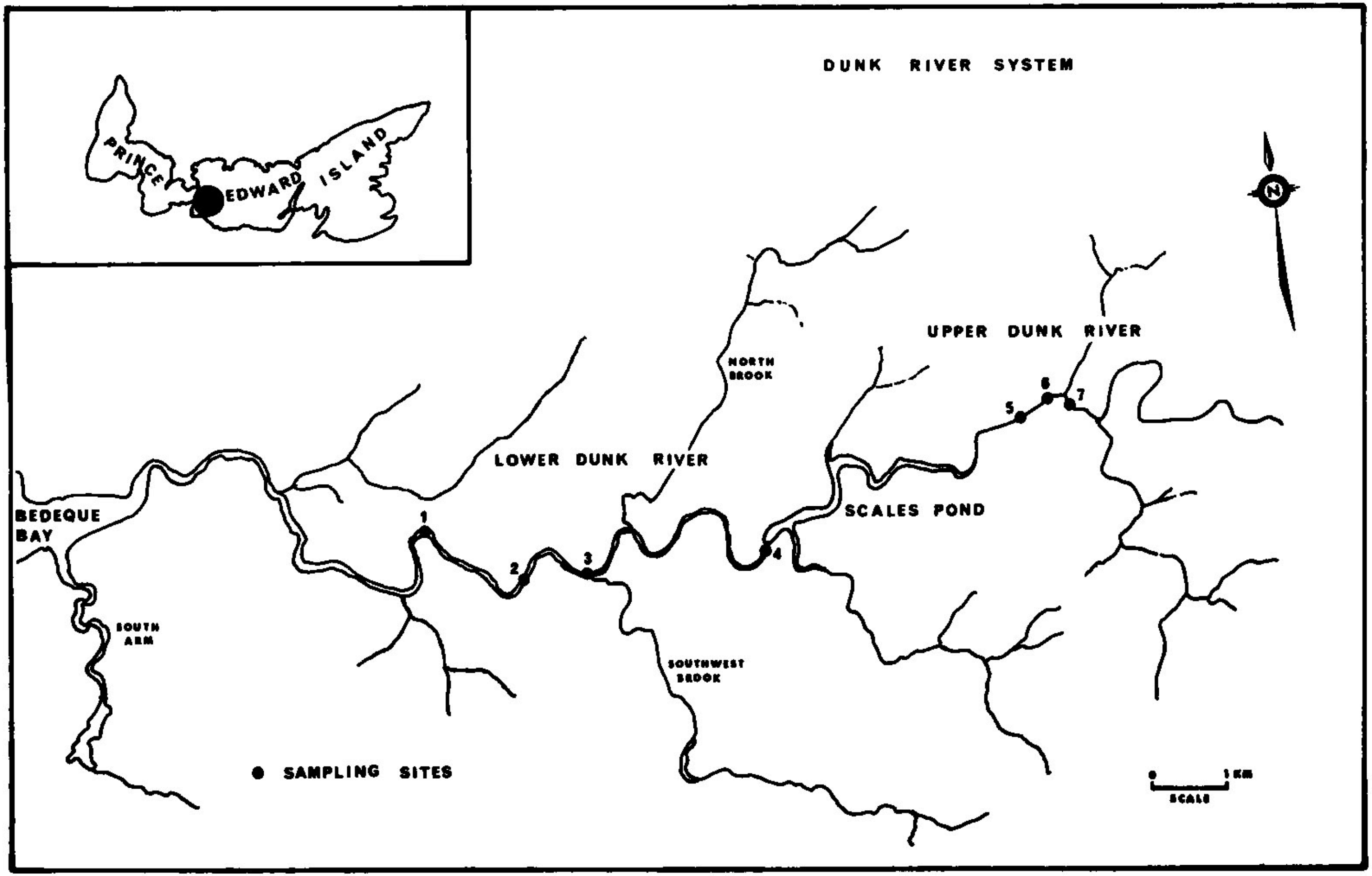

Fig 1. Location of the Dunk River study areas.

bottom using a Surber sampler. All stones and sediment in the sampling area were scrubbed by hand to wash benthic organisms into the collecting net. No attempt was made to prevent drift organisms from entering the collection net; however, collections were made as quickly as possible to prevent such contamination. Organisms collected from the net were preserved in a formalin-acetic acid-alcohol solution and later sorted, identified as to family and counted. Nymphs, larvae, pupae and adults were counted separately but later combined.

Collection of Trout and Stomach Samples

Brook trout and rainbow trout were collected from the areas between 0700 to 1000 using seining or electro-shocking equipment. Captured trout were quickly killed by a blow to the head and the entire gut and contents were removed and immediately fixed in 5-10% formalin. In the laboratory, each gut was carefully opened and the extent of stomach fullness assessed visually as: empty, trace, 1/4 full, 1/2 full, 3/4 full, full, distended. The gut contents were then removed and the food organisms separated, identified as to family and counted. The volume of each group of organisms was determined using volume-displacement techniques.

Because of their limited populations in the study areas, only small numbers of rainbow trout were retained for gut analysis.

Ivlev's (1961) elective index was computed using: $E_i = (C_i - P_i)/(P_i + C_i)$, where E_i is the Ivlev elective index for prey species i, P is the percentage composition of prey species i in the bottom sample and C_i is the percentage composition of prey species i in the stomach samples. Food preference is expressed by values from +1 to 0 while avoidance is expressed by values from 0 to -1.

Results

In June, a greater percentage of brook trout stomachs from the Lower Dunk River were full or distended with food than at other times of the study period or than brook trout stomachs from the Upper Dunk River (Table I). In the Lower Dunk River, the number of full stomachs declined and an increase in the number of empty stomachs occurred in late July. Empty or nearly empty stomachs in the Upper Dunk River did not increase in number until late August and September. The earlier increases in the number of empty stomachs in the Lower Dunk River may have been related to the presence of sea-running trout in the sample or to higher water temperatures.

Food Composition and Seasonal Trends

The data for the Lower Dunk River(Fig. 2)show that fish eggs, namely smelt and gaspereau eggs, play an important role in the diet of both brook trout and rainbow trout during June and July. Brook trout and rainbow trout ate 1.8 to 68.8% and 7.3 to 23.9% eggs (by volume), respectively, during this period. Ephemeropteran nymphs, dipteran larvae and trichopteran larvae were consumed by both species in smaller quantities. Most of the ephemeropterans belonged to the families Baetidae and Heptageniidae while the dipterans and trichopterans belonged in order of numerical importance to the families Chironomidae, Simuliidae, Tabanidae; Psychomiidae, Lepidostomatidae, Limnephilidae and Rhyacophilidae. In any sampling period, ephemeropterans never made up more than 25% of the total stomach volume in brook trout or 15% in rainbow trout; trichopterans never exceeded 10% in brook trout or 15% in rainbow trout. The number of dipteran larvae consumed by brook trout increased steadily during the summer and by August made up about 20% of the total stomach volume; values for rainbow trout were less than 10%.

Table I. Seasonal changes in the estimated stomach fullness of brook trout captured in the Lower and Upper Dunk River

Stomach fullness	June 5— June 14		June 26— July 6		July 17— July 26		August 14— August 23		September 4— September 10	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Empty	-	-	-	-	-	-	5.6	-	-	-
Trace	-	1.8[1]	13.6	3.7	17.8	6.7	9.3	17.5	2.0	20.0
1/4 Full	5.3	14.5	4.5	-	8.8	3.3	3.7	10.0	23.4	31.4
1/2 Full	12.2	20.2	11.4	14.9	17.8	13.3	27.8	27.5	21.6	14.3
3/4 Full	31.6	34.5	54.6	51.8	37.8	66.7	35.2	45.0	39.2	25.7
Full	45.6	29.0	15.9	29.6	17.8	10.0	18.5	-	11.8	8.6
Distended	5.3	-	-	-	-	-	-	-	2.0	-
Number sampled	57	55	59	74	58	30	94	40	51	35
Fork length range (cm)	10.0-26.3	7.2-18.3	8.7-26.0	8.8-17.5	6.8-22.5	6.6-17.3	7.0-20.5	6.6-17.1	8.1-21.5	6.7-13.6

[1] Percent of total sampled

In August and September, both trout species consumed large quantities of freshwater snails. The importance of snails in the diet remains obscure since samples from the hind gut were, except for erosion of the calcareous shells, mostly undigested. Trout may have eaten snails selectively to obtain algae on the shell or to obtain more calcium for the elaboration of gonadal tissue; alternatively they may have been feeding opportunistically, taking advantage of an abundant, less motile and more vulnerable organism. Elective index values (0.88-0.99) suggest that both brook and rainbow trout select this food.

In all the stomachs, 20 to 40% of the volume consisted of plant and other bottom debris such as small gravel, sand, and bits of wood. Most of the plant and bottom debris appeared to be from the cases of trichopteran larvae, however, some debris may have been ingested incidentally as trout foraged on the bottom or in the drift.

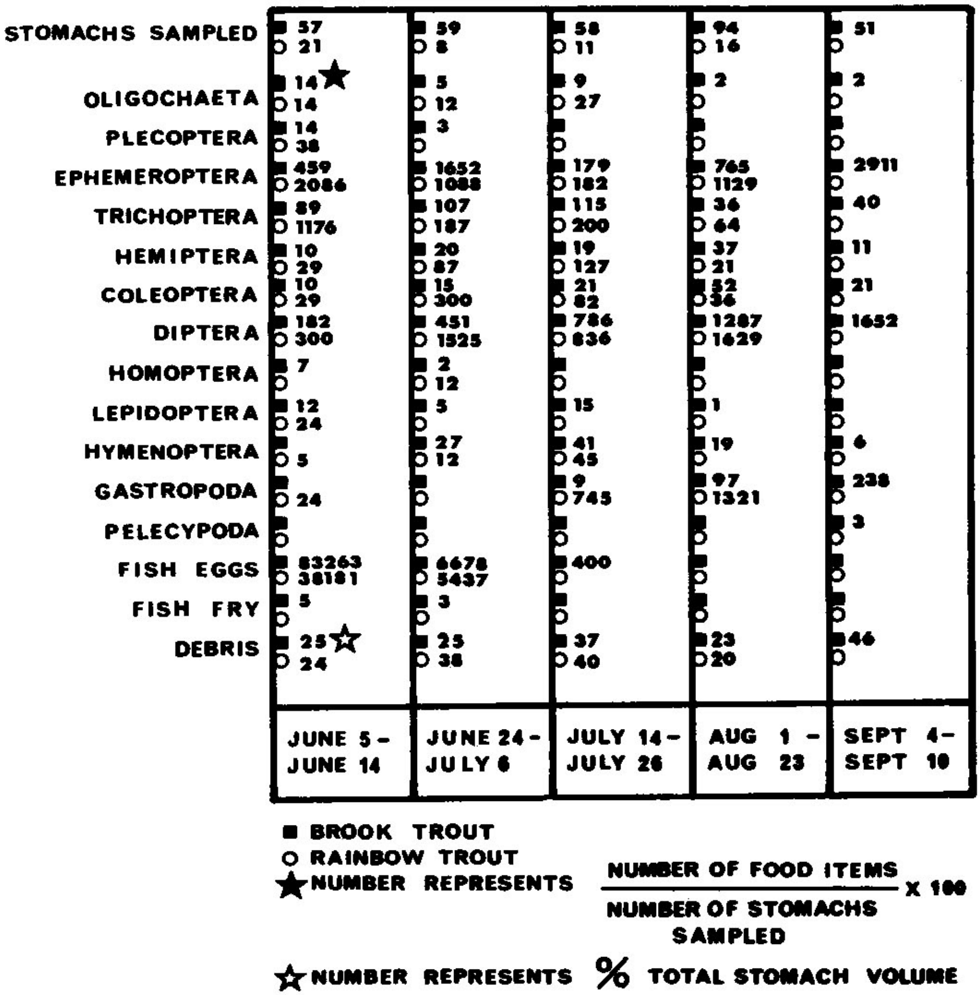

Fig 2. Relative frequency of food items in the stomachs of brook trout and rainbow trout sampled from 4 sites in the Lower Dunk River.

More detailed seasonal analysis of bottom samples in Area 2 in the Lower Dunk River (Table II) indicated that benthic organisms beçame most numerous at the end of July (19,472 organisms/m^2) and declined to lower levels by mid- to late August (3,866 organisms/m^2). In all areas studied, rainbow trout consumed more food items per fish during periods of warmer temperatures than did brook trout. Rainbow trout also appeared to have preferred more surface or subsurface foods than did brook trout.

In the Upper Dunk River, brook trout consumed mostly ephemeropterans, dipterans and trichopterans (Fig. 3). Most of the families in each group were similar to those in the Lower Dunk River; however, unlike trout in the Lower Dunk River, trout

	JUNE 5 - JUNE 14	JUNE 26 - JULY 6	JULY 17 - JULY 26	AUG 14 - AUG 23	SEPT 4 - SEPT 10
STOMACHS SAMPLED	55	74	30	40	35
OLIGOCHAETA	149★	32	3	2	9
PLECOPTERA	9	4	7	5	
EPHEMEROPTERA	710	740	207	40	97
HEMIPTERA	7	31	37	10	6
TRICHOPTERA	227	78	97	100	31
COLEOPTERA	171	188	47	62	60
DIPTERA	609	684	840	945	837
HOMOPTERA	7	3		2	
LEPIDOPTERA		8	143	5	
HYMENOPTERA	44	54	3	5	17
GASTROPODA	5	40		25	14
PELECYPODA	14				
NEMATODA	53	16	43	7	51
FISH FRY		12		12	6
DEBRIS	28☆	34	38	34	38

■ BROOK TROUT

★ NUMBER REPRESENTS $\frac{\text{NUMBER OF FOOD ITEMS}}{\text{NUMBER OF STOMACHS SAMPLED}} \times 100$

☆ NUMBER REPRESENTS % TOTAL STOMACH VOLUME

Fig 3. Relative frequency of food items in the stomachs of brook trout sampled from 3 sites in the Upper Dunk River.

Table II. Summary of bottom and food organisms taken from sampling site 2 in the Lower Dunk River during June to August

Date	June 24			July 14		
	Brook trout	Rainbow trout	Bottom	Brook trout	Rainbow trout	Bottom
Number of samples	15	2		14	3	4
Fork length range (cm)	13.0-22.0	13.4-13.5		13.1-25.5	13.1-27.5	
Mean fork length (cm)	16.9	15.3		16.5	22.4	
Mean fresh weight (g)	70.1	73.9		79.1	177.1	
Total number of food organisms	496	26		54	17	3286
Number of organisms consumed/fish	33.1	13.0		3.8	5.7	
Number of bottom organisms/m^2						8847
Number of fish with empty guts	0	0		1	1	

Date	July 30			August 18		
	Brook trout	Rainbow trout	Bottom	Brook trout	Rainbow trout	Bottom
Number of samples	17	4	4	24	11	2
Fork length range (cm)	12.1-44.7	14.5 43.0		8.7-32.2	7.5-30.0	
Mean fork length (cm)	20.7	26.5		15.3	17.3	
Mean fresh weight (g)	86.9	404.1		72.8	119.4	
Total number of food organisms	64	195	7235	799	400	718
Number of organisms consumed/fish	3.8	48.8		33.39	36.4	
Number of bottom organisms/m^2			19480			3787
Number of fish with empty guts	1	2		0	0	

in the Upper Dunk River consumed a much larger percentage of terrestrial invertebrates. Many of the terrestrial invertebrates such as ants and a variety of beetles probably fell from the dense alder overhang along the river banks to become part of the drift. Because of the narrowness of the Upper Dunk River (7.9-12.0 m), drift organisms were more readily available to trout than in the Lower Dunk River (width 9.6-17.0 m).

The stomach contents of the few rainbow trout from the Upper Dunk River differed little from those of brook trout. However, in both areas, rainbow trout had a greater preference for adult food organisms than did brook trout (Table III), and brook trout preferred nymphs more than did rainbow trout. Regardless of area, both species preferred nymphs to larvae, and fish predation and cannibalism contributed little to the diet of either species, reflecting the abundance of invertebrates in the Dunk River system.

Discussion

These results clearly demonstrate that anadromous fish species spawning in the spring and early summer, supply important foods for both salmonid species in the coastal river environment. Without this food source, growth of brook trout is

Table III. Number, percent occurrence of different insect stages observed in stomach and bottom samples, and elective index (E). Samples were taken from 4 sampling sites in the Lower Dunk River and 3 sampling sites in the Upper Dunk River between June 18 and July 30

	Lower Dunk River				
	Brook trout	E	Rainbow trout	E	Bottom samples
Larva	170[1] (16.3)[2]	-0.64	285 (47.1)	-0.22	7383 (74.1)
Nymph	830 (79.5)	0.63	290 (47.9)	0.45	1794 (18.0)
Pupa	22 (2.1)	-0.52	4 (0.7)	-0.81	665 (6.7)
Adult	22 (2.1)	0.27	26 (4.3)	0.56	116 (1.2)
Total	1044		605		9958

	Upper Dunk River				
	Brook trout	E	Rainbow trout	E	Bottom samples
Larva	65 (16.6)	-0.68	3 (7.9)	-0.83	2064 (86.5)
Nymph	193 (49.3)	0.61	15 (39.5)	0.54	281 (11.8)
Pupa	19 (4.8)	0.65	-		24 (1.0)
Adult	115 (29.3)	0.95	20 (52.6)	0.97	17 (0.7)
Total	392		38		2386

[1]Number of organisms
[2]Percent of total number of all stages

Table IV. Seasonal changes in the average volume of food per trout stomach. Debris was not included in volume determinations

Sampling period	Lower Dunk River				Upper Dunk River	
	Brook trout	N[1]	Rainbow trout	N	Brook trout	N
June 5—June 14	1.99[2] (15.1)[3]	57	1.41 (16.5)	21	0.31 (11.2)	55
June 24—July 6	0.49 (15.8)	59	0.65 (14.8)	8	0.37 (12.6)	74
July 14—July 26	0.15 (13.8)	58	0.32 (16.8)	11	0.19 (11.5)	30
Aug. 1—Aug. 23	0.20 (11.8)	94	0.40 (16.2)	16	0.12 (10.2)	40
Sept. 4—Sept. 10	0.55 (13.2)	51	-		0.06 (10.0)	35

[1]N = Sample size
[2]Average volume (ml) of food per trout stomach
[3]Mean fork length (cm)

significantly reduced (Johnston & Cheverie 1980). In view of the extensive overlap in foods consumed by brook trout and rainbow trout, growth of rainbow trout was probably influenced in a similar way, but insufficient growth data have been collected to verify this.

While brook trout and rainbow trout in the Upper Dunk River did not benefit from the organic influx from the marine environment, they did have the more available and probably more abundant terrestrial food source of the surrounding agricultural region. Such terrestrial foods appear to be more important in the diet of rainbow trout than of brook trout and this may be related to the more active surface or subsurface feeding behavior of the former species.

The great diversity of food organisms in the diet of both brook trout and rainbow trout suggests that they are opportunistic feeders. While most foods consumed were highly motile forms, others such as snails, fish eggs and pupae were not. It is difficult to know with certainty whether these inactive forms were in the drift or on the bottom, but probably foraging occurred both from the bottom and from the drift.

Seasonal changes in population density of benthic organisms and volume of foods in the stomach of both trout species were evident. More was eaten by brook trout when water temperatures were cooler and food abundant (Table IV). These findings are similar to studies elsewhere (Gibson & Galbraith 1975; Logan 1963). In rainbow trout, when water temperatures were warm, the food volumes were almost twice those of brook trout.

In the Upper Dunk River food volumes were much lower; this may be related to the food source, competition, or to the size of stomachs. While only minor differences were observed in the number of bottom organisms/m^2 for the Lower and Upper Dunk River areas between late June and early July, more obvious differences were apparent in trout densities (Johnston & Cheverie 1980) and in mean fork lengths.

Since growth and production of salmonids and benthic food organisms in coastal rivers of Prince Edward Island appear greatly enhanced by spawning smelts and gaspereau, fisheries managers should ensure in the future that such migratory anadromous species have unimpeded movement throughout an entire river system.

Acknowledgements

I acknowledge the assistance of Dr J.C. Cheverie, Diane Clark, and other University students who collected benthic invertebrates and trout samples. Mr Bruce Aho and the University Computer Center assisted in preparing the programs for data analysis.

This project was supported by the National Research Council of Canada, University of Prince Edward Island, Senate Research Committee, and the Prince Edward Island Government, Fish and Wildlife Division.

References

Anonymous 1975. *Dunk River Sedimentation Study. Surface Run-off and Suspended Sediment Load, 1974.* Environment Canada, Island Waters Directorate, Water Survey of Canada, Halifax.

Gibson, R.J. and **Galbraith, D.** 1975. The relationships between invertebrate drift and salmonid populations in the Matemek River, Quebec, below a lake. *Trans. Am. Fish. Soc.* 104: 529-535.

Ivlev, V.D. 1961. *Experimental Ecology of the Feeding of Fishes.* Yale Univ. Press, New Haven.

Johnston, C.E. 1974. The effects of water turbidity and weather conditions on fishing success in the Lower Dunk River, P.E.I. *Trans. Can. Soc. Environ. Biol.* (Atl. Chap.): 8-30.

Johnston, C.E. and **Cheverie, J.C.** 1980. Growth, harvest and survival of hatchery-reared and native brook trout *(Salvelinus fontinalis)* in the Dunk River system, Prince Edward Island. *Proc. N.S. Inst. Sci. 30:* 9-27

Johnston, C.E. and **McKenna, K.** 1974-76. Fecundity of brook trout *(Salvelinus fontinalis)* from a coastal stream in Prince Edward Island. *Proc. N.S. Inst. Sci.* 27: 160-170.

Logan, S.W. 1963. Winter observations on bottom organisms and trout in Badger Creek, Montana. *Trans. Am. Fish. Soc.* 92: 140-145.

Saunders, J.W. and **Smith, M.W.** 1955. Standing crops of trout in a small Prince Edward Island stream. *Can. Fish. Cult.* 17: 32-39.

Saunders, J.W. and **Smith, M.W.** 1962. Physical alterations of stream habitat to improve brook trout production. *Trans. Am. Fish. Soc.* 91: 185-188.

Smith, M.W. 1936. *Investigation of Prince Edward Island streams, September 3-10, 1936.* Manuscript report of the Biological Board of Canada No. 189B.

Staker, R. 1976. Algal composition and seasonal distributions in the Dunk River system, Prince Edward Island. *Nova Hedwigia* 27: 731-745.

White, H.C. 1927. A preliminary report on trout investigations in Forbes Brook in 1925 and 1926. *Contrib. Can. Biol. Fish.*, N.S. 3: 367-375.

White, H.C. 1930. Some observations on the eastern brook trout *(Salvelinus fontinalis)* of Prince Edward Island. *Trans. Am. Fish. Soc.* 60: 101-108.