prey in the stomachs was not equal. Cephalopod beaks are not always passed through the intestinal tract and may remain in the stomach for several days before they are regurgitated (Pitcher unpubl. data). This increases the probability of detection thereby exaggerating estimates of their utilization.

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PRODUCTION AND GROWTH OF SUBYEARLING COHO SALMON, *ONCORHYNCHUS KISUTCH*, CHINOOK SALMON, *ONCORHYNCHUS TSHAWYTSCHA*, AND STEELHEAD, SALMO GAIRDNERI, IN ORWELL BROOK, TRIBUTARY OF SALMON RIVER, NEW YORK

Decline of lake trout, *Salvelinus namaycush*, and burbot, *Lota lota*, populations in the Great Lakes from 1930 to 1950 created a void of a large offshore piscivore in these waters. Smith (1968) attributed the decline to overexploitation by the commerical fishery and predation by the sea lamprey, *Petromyzon marinus*. The decline was followed by proliferation of the alewife, *Alosa pseudoharengus*, in Lakes Ontario, Huron, and Michigan

(Berst and Spangler 1973; Christie 1973; Wells and McLain 1973). As a result the State of Michigan in 1966 undertook a program to establish coho salmon, *Oncorhynchus kisutch*, in Lakes Michigan and Superior in hopes of creating a valuable sport fishery based on alewife as the major forage species (Tody and Tanner[1]). The success of the Michigan program provided an incentive to other states and provinces bordering the Great Lakes to undertake similar programs.

New York State began its salmonid program for Lake Ontario in 1968 when 41,000 coho salmon were planted in the Salmon River. The following year 70,000 chinook salmon, *O. tshawytscha*, were planted in the Little Salmon River (Parsons 1973). Stocking of steelhead, *Salmo gairdneri*, commenced in 1974 (Parker[2]). Stockings of coho salmon and steelhead have continued annually since their inception. Chinook salmon plantings were stopped after releases in the spring of 1976 because contaminant levels in their flesh generally exceeded action levels for Mirex[3] and PCB's when these fish first became available to anglers as precocious jacks on their maiden spawning run at 1.8-2.7 kg (New York State Department of Environmental Conservation[4]). However, chinook salmon stocking was resumed in 1979.

From its inception, Michigan's salmonid program has given high priority to natural reproduction as a supplement to hatchery production (Tody and Tanner footnote 1). Subsequent studies have focused on the extent of natural reproduction in Michigan (Stauffer[5]) and other ecological aspects of spawning activity (Taube[6]). Reproductive success of Pacific salmonids has been examined in Minnesota (Hassinger et al. 1974) and Wisconsin (Avery[7]). Canadian studies on Great Lakes tributaries have mainly focused on steelhead reproduction (Alexander and MacCrimmon 1974).

In New York, chinook salmon begin their spawning run from Lake Ontario in late August and early September (Jolliff[8]). Chinook salmon redds are present as early as mid-September in the Salmon River in Oswego County. Although most chinook salmon spawning occurs in the Salmon River, smaller tributaries are also utilized. Spawning in smaller tributaries usually does not begin until late September with the peak occurring in mid-October. The selection of larger tributaries such as the Salmon River for spawning is characteristic of chinook salmon in their native range (Stein et al. 1972; Scott and Crossman 1973). Coho salmon run somewhat later than chinook salmon, usually beginning in late September and peaking in late October to early November. Limited coho salmon spawning activity occurs in the Salmon River, possibly because of the large size of the substrate materials. Adult steelhead are present in the Salmon River throughout the fall and into early summer. Steelhead can be found in the smaller tributaries from March through June with most spawning activity occurring in April and May. Stream residence time for juvenile salmonids in the Salmon River system is <1 yr for chinook salmon, up to 1 yr for coho salmon, and up to 2 yr for steelhead (Johnson 1978).

Prior to 1977 the reproductive success of Pacific salmonids was unknown in New York tributaries of Lake Ontario. In 1977, five streams in the Salmon River system were examined for evidence of successful spawning of coho salmon, chinook salmon, and steelhead (Johnson 1978). Initial evidence indicated substantial reproduction of coho salmon and steelhead in some of the streams. The purpose of this study was to quantify reproductive success of Pacific salmonids in one tributary of the Salmon River.

Methods

Orwell Brook was selected as it contained high densities of coho and chinook salmon and steelhead juveniles. Orwell Brook flows for ap-

[1]Tody, W. H., and H. A. Tanner. 1966. Coho salmon for the Great Lakes. Mich. Cons. Dep. Fish. Manage. Rep. 1, 38 p. Fish Division, Michigan Department of Natural Resources, Mason Building, Lansing, MI 48926.

[2]C. E. Parker, Chief, Bureau of Fisheries, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, NY 12233, pers. commun. October 1979.

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

[4]New York State Department of Environmental Conservation. 1977. Monthly report on toxic substances impacting on fish and wildlife. Rep. 1, April 20, 1977.

[5]Stauffer, T. M. 1977. Numbers of juvenile salmonids produced in five Lake Superior tributaries and the effect of juvenile coho salmon on their numbers and growth, 1967-1974. Mich. Dep. Nat. Resour., Fish. Res. Rep. 1846, 29 p. Institute for Fisheries Research, Museums Annex Building, Ann Arbor, MI 48109.

[6]Taube, C. M. 1975. Abundance, growth, biomass, and interrelationship of trout and coho salmon in the Platte River. Mich. Dep. Nat. Resour., Fish. Res. Rep. 1830, 82 p. Institute for Fisheries Research, Museums Annex Building, Ann Arbor, MI 48109.

[7]Avery, E. L. 1974. Reproduction and recruitment of anadromous salmonids in Wisconsin tributaries of Lake Michigan. Dingell-Johnson final Rep., Proj. F-33-R, Study 108, Wis. Dep. Nat. Resour., 32 p.

[8]T. Jolliff, Associate Aquatic Biologist, Bureau of Fisheries, New York State Department of Environmental Conservation, Cape Vincent, NY 13618, pers. commun.

proximately 14.5 km before entering the Salmon River, 17 km from Lake Ontario (Figure 1). About 60% of Orwell Brook is considered adequate for successful salmonid reproduction with suitable substrate generally consisting of gravel (1-2 cm in diameter) and pebbles (3-6 cm in diameter). The maximum summer water temperature recorded during 1977 and 1978 was 21° C. Mean monthly stream discharge from June to October 1978 was 0.26 m^3/s. Salmonids, cyprinids, and catostomids, in order of abundance are the principal components of the Orwell Brook fish fauna.

A single 100 m station was established on Orwell Brook 3 km above the Salmon River. This section was generally characteristic of the lower portion of Orwell Brook. Sections of the stream were visually examined weekly from early May to mid-June in 1978 in order to estimate the approximate time of peak emergence of salmon fry. Peak emergence, as used in this study, occurred when the densities of coho and chinook salmon and steelhead were highest in Orwell Brook. Collections of juvenile salmonids were made monthly from May to October with a 3 m minnow seine. Supplemental observations on salmon emergence were also made in May 1979. Monthly population estimates derived using the Chapman mark-recapture index (Ricker 1975) and average monthly weights of juvenile salmonids were plotted with the area beneath the curve providing an estimate of total production (Chapman 1968). A logarithmic plot assuming an exponential decline in monthly densities was used to determine the population size at peak emergence for coho and chinook salmon. This method, based on the assumption that natural mortality is greatest just after emergence and then gradually diminishes, has previously been employed to estimate the

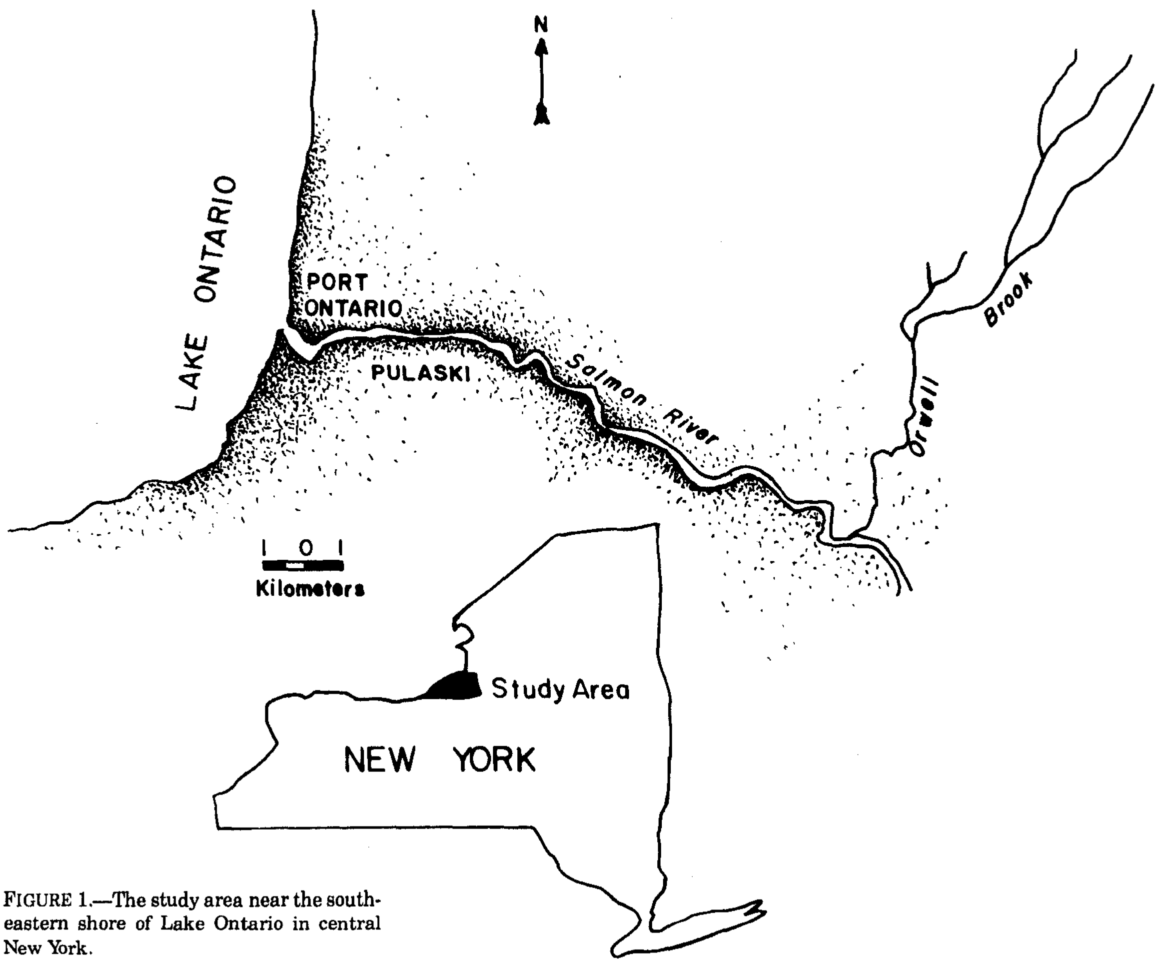

FIGURE 1.—The study area near the southeastern shore of Lake Ontario in central New York.

population size at peak emergence in salmonid populations (Hunt 1966; O'Connor and Power 1976). Total production of each species was divided by the smallest stream area within the 100 m section that was recorded during the study in order to give an estimate of production per unit area.

Results and Discussion

Recently emerged coho and chinook salmon were first observed in Orwell Brook in 1978 on May 13. In 1979, coho salmon were first observed on May 9th and chinook salmon on May 10. Peak emergence of both species occurred during early June 1978. Steelhead began emerging during mid-June and peaked in early to mid-July.

Population estimates were initiated in mid-June about 2 wk after peak salmon emergence. At this time both salmon species were abundant in the main stream and steelhead had started to emerge. Estimates of population size at peak emergence were 718 coho salmon and 189 chinook salmon fry/100 m in the section (Table 1). Densities of fry (number per square meter) at this time were 1.30 and 0.34 for coho and chinook salmon (Table 1). The initial estimate of steelhead in June was 103 fry/100 m or 0.20 fry/m² of stream bottom. However, the highest densities of steelhead fry were not recorded until August (Table 1).

Total production of subyearling coho salmon from 1 June to 30 October 1978 was 1,248 g. This was substantially greater than production of chinook salmon, 282 g and steelhead, 404 g (17 June-10 October) (Figure 2). Production per square meter was 2.7, 0.6, and 0.9 g for coho and chinook salmon and steelhead. Combined total production of the three species was 4.2 g/m² for the period of study.

Production of subyearling coho salmon in Orwell Brook during 1978 was intermediate between

TABLE 1.—Estimated monthly numbers (with 95% confidence limits) and densities (number per square meter) of subyearling coho salmon, chinook salmon, and steelhead in 100 m study area of Orwell Brook, Oswego County, N.Y., during 1978.

Date	Stream area (m²)	Coho salmon		Chinook salmon		Steelhead	
		Number	Density	Number	Density	Number	Density
1 June	553	[1]718	1.30	[1]189	0.34	—	—
17 June	521	500±101	1.04	139±43	.27	103±41	0.20
16 July	483	428±184	.89	121±50	.25	212±72	.44
12 Aug.	469	118±64	.25	51±29	.11	262±84	.56
10 Sept.	476	104±62	.22	36±25	.08	199±58	.42
10 Oct.	495	68±23	.14	31±16	.06	138±34	.28

[1]Logarithmic extrapolation.

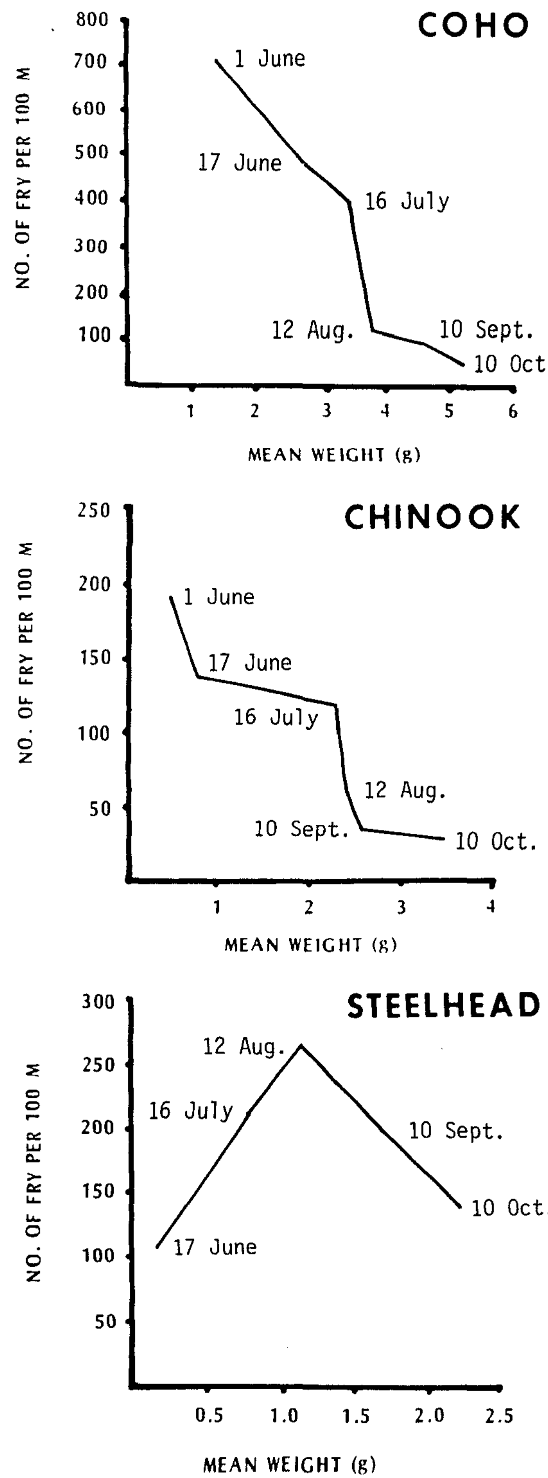

FIGURE 2.—Production curves of subyearling coho and chinook salmon in Orwell Brook, Oswego County, N.Y., 1 June-10 October 1978, and steelhead 17 June-10 October 1978.

that observed in Oregon, 5.6 g/m^2 (Chapman 1965) and Michigan, 0-1.9 g/m^2 (Stauffer[9]) during a similar time interval. Production of coho salmon in the 100 m section of Orwell Brook from 1 June to 15 October 1977 was 5.9 g/m^2 (Johnson 1978). Although the 1978 production estimate for coho salmon represents a 54% decrease from 1977, the variation in production between years is within the range reported by Chapman (1965) for coho salmon in Oregon coastal streams.

No information on chinook salmon production is available for the Great Lakes region; however, production of chinook salmon in Orwell Brook was intermediate to that recorded in the Lemhi River and Big Springs Creek, Idaho (Goodnight and Bjornn 1971). Production of steelhead is less than recorded in Michigan (Hannuksela[10]) and intermediate between the two Idaho streams (Goodnight and Bjornn 1971).

From emergence in May until the termination of sampling in November, subyearling coho salmon were larger than either subyearling chinook salmon or steelhead (Table 2). However, since chinook salmon characteristically leave their natal streams earlier than coho salmon, larger chinook salmon smolts may be migrating early. The growth rate (total length in millimeters per day) of coho and chinook salmon and steelhead was greatest during the first 2 mo following emergence (Table 2). Growth during this 2 mo period was 0.44, 0.47, and 0.39 mm/d for coho and chinook salmon and steelhead (Table 2). High initial growth rates of subyearling coho salmon and steelhead have previously been reported by Chapman (1965) and Stauffer (footnote 9). For the entire period (175 d for salmon, 145 d for steelhead) the growth rates of chinook salmon and steelhead were identical, 0.27 mm/d, with coho salmon being only slightly slower, 0.26 mm/d. In Michigan, growth rates of subyearling coho salmon and steelhead from June to November were 0.29 and 0.26 mm/d (Stauffer footnote 9). However, although these estimates are similar to those obtained in Orwell Brook, both coho salmon and steelhead are initially larger in June in Orwell Brook and this size differential (especially for coho salmon) is retained throughout the fall. There is no available information on chinook salmon growth in the Great Lakes region; however, growth in New York is slower than reported in Washington (Becker 1973).

[9]Stauffer, T. M. 1975. Population characteristics and summer-to-autumn survival of juvenile rainbow trout and coho salmon in two Lake Superior tributaries, 1969-1972. Mich. Dep. Nat. Resour., Fish. Res. Rep. 1825, 21 p. Institute for Fisheries Research, Museums Annex Building, Ann Arbor, MI 48109.

[10]Hannuksela, P. R. 1973. Food interrelationships of the mottled sculpin, *Cottus bairdi*, and juveniles of the rainbow trout, *Salmo gairdneri*, in a tributary of Lake Superior. Mich. Dep. Nat. Resour., Fish. Res. Rep. 1801, 21 p. Institute for Fisheries Research, Museums Annex Building, Ann Arbor, MI 48109.

TABLE 2.—Number examined, mean total length (millimeters) (with 95% confidence limits), and daily growth increments (mm/d) of subyearling coho salmon, chinook salmon, and steelhead from Orwell Brook, May-November 1978.

	Coho salmon			Chinook salmon			Steelhead		
Date	No.	$\overline{TL}$	mm/d	No.	$\overline{TL}$	mm/d	No.	$\overline{TL}$	mm/d
18 May	10	45.1±4.4		10	36.7±3.9				
			0.65			0.34			
17 June	20	63.6±5.7		20	46.7±1.9		10	29.7±1.8	
			0.26			0.61			0.52
16 July	40	71.1±2.8		40	64.5±2.0		30	44.9±1.6	
			0.13			0.06			0.24
12 Aug.	30	74.7±2.5		20	66.0±3.0		25	51.5±1.7	
			0.27			0.11			0.19
10 Sept.	20	82.4±4.9		20	69.2±3.0		30	57.0±3.2	
			0.05			0.22			0.16
10 Oct.	20	83.9±4.9		10	75.7±3.4		25	61.7±3.8	
			0.22			0.28			0.26
9 Nov.	10	90.4±5.2		10	84.0±4.3		10	69.5±4.1	

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