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## Effect of Increased Water Temperatures on Survival of Adult Threespine Stickleback and Juvenile Yellow Perch in the Columbia River

### Abstract

Flow-through bioassay tests on the effects of temperature increases on yellow perch (*Perca flavescens*) and threespine stickleback (*Gasterosteus aculeatus*) were conducted on the lower Columbia River near Prescott, Oregon. The on-site tests of two weeks' duration were performed on (1) control samples of fish at a water temperature of 19° C and (2) on test samples of fish at water temperatures of 20°-26° C—in 1-degree increments—and at 29°, 32° and 38° C. Samples of threespine stickleback reached 50% mortality at 25° C in 1,725 minutes, and samples of yellow perch reached 50% mortality in 143 minutes.

### Introduction

Water-temperature criteria for species of fish associated with Pacific salmon (*Oncorhynchus* spp.) and steelhead trout (*Salmo gairdneri*) in the lower reaches of the Columbia River are noteworthy because of a probable increase in water temperature resulting from man's activities. Irrigation, hydroelectric developments, and the discharge of hot water from nuclear power plants could cause displacement of some salmon and steelhead trout by "warm water" species of less value to fishermen than the salmon and trout. We studied survival of juvenile yellow perch (*Perca flavescens*) and adult threespine stickleback (*Gasterosteus aculeatus*) at several temperatures to obtain information on their tolerance above ambient river temperatures which ranged from 17° to 21° C. Yellow perch and threespine stickleback were selected for our study because they are abundant in some areas of the lower Columbia (McConnell and Snyder, 1970) and could displace some salmon and trout if environmental conditions were altered in their favor. In the literature there is little reference to the preferred temperature range of the threespine stickleback. Juvenile yellow perch tested in Ontario, Canada, had a preferred temperature of 24.2° C (Ferguson, 1958); juvenile chinook salmon (*O. tshawytscha*, which are very abundant at certain times in the lower Columbia River), tested in British Columbia, Canada, had a preferred temperature of 12° to 14° C (Brett, 1952).

### Experimental Procedures

The fish were captured with a beach seine and transported in a holding tank by boat to the NMFS (National Marine Fisheries Service) experimental water temperature laboratory near Prescott, Oregon (Snyder, Blahm, and McConnell, 1971). The perch were captured on July 10 and the stickleback on July 25, 1969. Transport of fish to

the laboratory required about 10 min; river water was circulated through the holding tank during transport. At the laboratory the fish were transferred to large holding tanks (2500 liters) and held four days prior to testing. The holdings tanks were supplied with Columbia River water which was circulated at a rate of about one interchange per hour (Snyder, Blahm, and McConnell, 1971). The juvenile yellow perch and adult threespine stickleback averaged 49 mm and 37 mm, respectively, in length.

The general methods followed for these tests of thermal tolerance were those outlined by Fry (1947) and used by Brett (1952). The specific test procedure followed in this study is described by Blahm and McConnell (1970, 1971). The thermal tolerance tests were conducted on juvenile yellow perch beginning July 14, 1969, and on the adult threespine stickleback beginning July 29, 1969. The ambient temperature of the Columbia River water (19° C at the beginning of the tests) was used as the control temperature. The fish were placed in 188-liter tanks with preset water temperatures of 19° (control), 20°, 21°, 22°, 23°, 24°, 25°, 26°, 29°, 32°, and 38° C. Separate groups of yellow perch and 10 threespine stickleback were tested at each temperature. The time to mortality was recorded for each fish. The duration of the tests with each species was two weeks.

#### Tolerance of Fish to Increased Water Temperatures

Juvenile yellow perch reached 50% mortality at 32° C; adult threespine stickleback were less tolerant and reached 50% mortality at 26° C (Table 1). Both species were more resistant to a higher water temperature than juvenile chinook salmon (Fig. 1) tested at the same facility.

#### Significance of Increased Water Temperature to Fish Populations in the Lower Columbia

The above data suggest that juvenile yellow perch and adult threespine stickleback can withstand water temperatures that cause stress to Pacific salmon and steelhead trout. In addition, the data suggest that yellow perch could be among the species displacing juvenile salmon and trout if water temperature of the Columbia should rise to 20°-25° C. The

TABLE 1. Time to death (in minutes) of adult threespine stickleback and juvenile yellow perch, subjected to elevated water temperatures. The 5%, 50%, and 100% mortality levels are shown for samples of 20 fish each.

Temperature (°C)	Threespine stickleback <sup>1</sup> (Time to death by percent)			Yellow perch <sup>2</sup> (Time to death by percent)		
	5%	50%	100%	5%	50%	100%
	<i>Minutes to death</i>					
19 <sup>3</sup>	4,120	—	—	—	—	—
20	4,118	—	—	—	—	—
21	4,116	—	—	—	—	—
22	4,115	—	—	—	—	—
23	4,107	—	—	—	—	—
24	4,110	—	—	18,757	—	—
25	4,105	—	—	—	—	—
26	2,669	8,429	—	—	—	—
29	5	120.5	1,425	5,685	—	—
32	1.5	2.3	14	63.7	143.5	191
38	—	—	—	0.40	0.48	0.62

<sup>1</sup> Average weight of 0.5 g and average length of 37 mm.

<sup>2</sup> Average weight of 1.2 g and average length of 49 mm.

<sup>3</sup> Control and acclimation temperature.

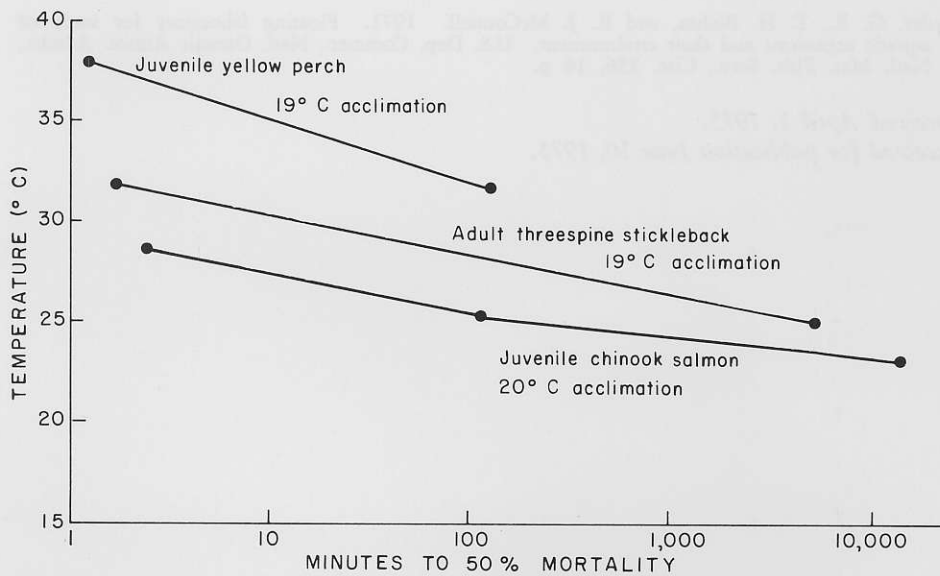


Figure 1. Temperature level and time required to produce 50% mortality in samples of juvenile perch, adult stickleback, and juvenile chinook salmon.

adult threespine stickleback seem to prefer a lower water temperature than do the juvenile yellow perch and would also have an advantage over salmon and trout at temperatures above 20° C. Although not tested in this study, species such as carp (*Cyprinus carpio*), bass (*Micropterus* spp.), and sunfish (*Lepomis* spp.) have been reported to prefer water temperatures above 20° C (Ferguson, 1958). These warm-water fishes are present in the lower Columbia River near Prescott (McConnell and Snyder, 1970) and would also be among the species capable of displacing salmon and trout if environmental conditions were altered in their favor.

#### Summary

1. Adult threespine stickleback reach 50% mortality at 26° C. 2. Juvenile yellow perch reach 50% mortality at 32° C. 3. Both species are able to withstand temperatures that would produce substantial mortalities in salmonid populations.

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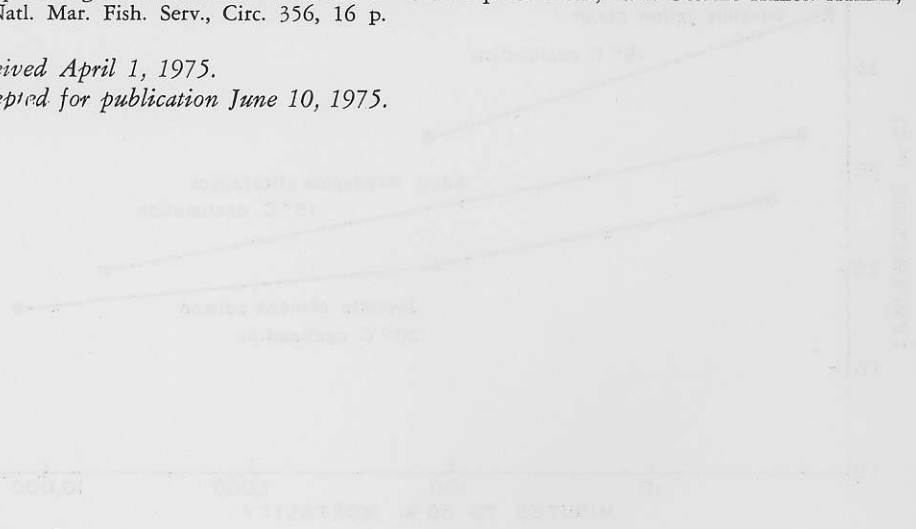


Figure 1. Temperature (°C) vs. wind speed (km/h) for the floating laboratory in 1971, 1972, and 1973.

The floating laboratory was used to study the relationship between wind speed and temperature. The data for 1971, 1972, and 1973 are shown in Figure 1. The data show a positive linear relationship between wind speed and temperature. The slope of the lines is approximately 0.5°C per km/h. The data for 1971 are the highest, followed by 1972, and then 1973. The data for 1971 are the most complete, with measurements taken at 0, 2, 4, 6, 8, and 10 km/h. The data for 1972 and 1973 are less complete, with measurements taken at 0, 2, 4, and 6 km/h.

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