they move toward shore and into the estuary. Two primary factors that seem to affect growth are water temperature and the amount of plankton "blooms" present (Williams et al. 1968). Therefore, in February and March, with some exceptions, as water temperatures start to rise, collections will have larger individuals by area than during colder months. By considering a specific point along this route as larvae move from offshore areas to the estuary and then by looking at the monthly means, we note that size increases seasonally.

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SURVIVAL AND HOMING OF JUVENILE COHO SALMON, *ONCORHYNCHUS KISUTCH*, TRANSPORTED BY BARGE

During the winter and spring of 1976-77 the Pacific Northwest experienced its worst drought in recent times. Flow in the Columbia River, which is dammed extensively for hydroelectric generation and irrigation, was extremely low during the spring of 1977 (averaging $<4,245$ m^3/s). In low flow years, very little water is diverted over spillways at the hydroelectric projects. Consequently, many migrating juvenile Pacific salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdneri*, were destined in 1977 to pass through the turbines, where substantial numbers would be killed (Chaney and Perry 1976[1]) unless remedial steps were taken. Realizing that the losses of juvenile salmonids could be catastrophic, the National Marine Fisheries Service (NMFS) and the U.S. Army Corps of Engineers (CofE) prepared two barges to supplement trucking as a means of transporting juvenile salmonids around dams on the Columbia and Snake Rivers (McCabe et al. 1979).

To assess the effectiveness of barging, various experiments were conducted. One, a joint activity by NMFS, the U.S. Fish and Wildlife Service (FWS), and CofE, involved transporting tagged coho salmon, *Oncorhynchus kisutch*, from Willard National Fish Hatchery (Little White Salmon River), Wash., to a release site on the Columbia River downstream from Bonneville Dam (Fig. 1). Objectives of the experi-

[1]Chaney, E., and L. E. Perry. 1976. Columbia Basin salmon and steelhead analysis: Summary report; 1 September 1976. Pac. Northwest Reg. Comm., Vancouver, Wash., 74 p.

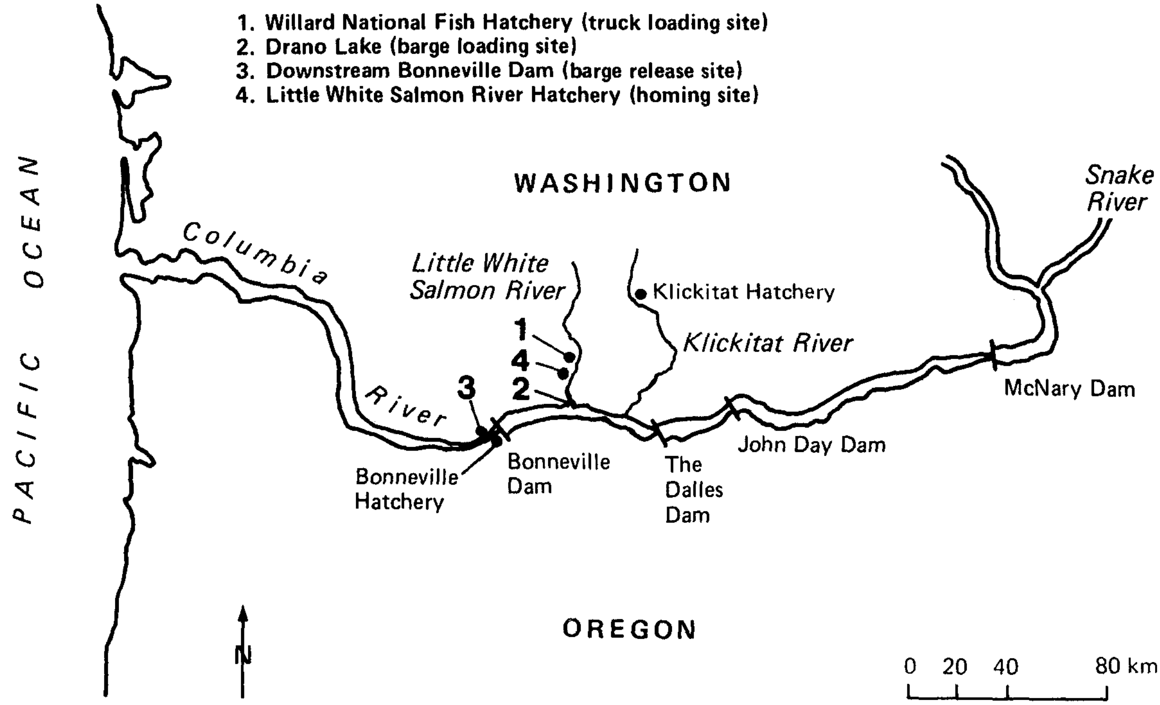

FIGURE 1.—Lower Columbia River and features of the study on transported coho salmon.

ment were to 1) determine if juvenile coho salmon transported by barge around Bonneville Dam would return as adults to the Little White Salmon River Hatchery and 2) determine if survival to the adult stage could be enhanced by barging the fish around Bonneville Dam.

Methods

Two lots of coho salmon from Willard Hatchery were identified by tagging with magnetic microwire tags (Ebel 1974), and adipose fins were excised from fish in both lots to identify them as wire-tagged. A control lot (20,625 fish) was released at the hatchery on 18 April 1977. On 22 April 1977 the test lot (19,785 fish) was transported by tanker truck about 9 km to Drano Lake on the Columbia River, where the fish were loaded via flexible hose onto a waiting barge. Shortly after loading, the barge departed; about 4 h later the coho salmon were released into the river downstream from Bonneville Dam.

The barge, with a steel cargo tank 33.2 m long × 8.5 m wide, was essentially a floating raceway (McCabe et al. 1979). One or two stern pumps supplied river water to a bow spray bar. After exiting the spray bar, water flowed through eight screened compartments and exited via four stern overflow scuppers. One complete turnover of water took about 20 min with both pumps operating.

Evaluation of the effectiveness of barging was based on a comparison of the percentage of fish from control (hatchery-released) and test (barged) lots that either 1) returned to the Willard Hatchery in the fall of 1977 (these early-arriving fish were precocious males), 2) returned to the hatchery in 1978 as full-term adults, or 3) were intercepted by commercial or sport fisheries. Adult fish returning to the Willard Hatchery were collected in a trap at the Little White Salmon National Fish Hatchery, located about 7 km downstream from Willard Hatchery. All coho salmon collected in this trap in 1977 and 1978 were examined for the wire tags used in this experiment. Tag information on coho salmon caught in sport and commercial fisheries was provided by fish and wildlife agencies in Washington, Oregon, California, and Canada.

Results And Discussion

Returns of coho salmon to the trap at Little White Salmon Hatchery and to the fisheries (both sport and commercial) are presented in Table 1. Total recoveries of tagged releases were 0.19% for the control group and 0.39% for the test group. There was no dif-

TABLE 1.—Summary of test and control releases of coho salmon from Willard National Fish Hatchery and returns to the hatchery and fisheries.

Category	Releases and returns	
	Control	Test
Release date	18 Apr. 1977	22 Apr. 1977
No. tagged juveniles released	20,625	19,785
Weight at release (no. fish/kg)	10.2	10.9
Total no. returns	40	77
to Willard Hatchery		
precocious males	1	4
full-term adults	13	10
to Bonneville Hatchery[1]	2	1
to sport and commercial fisheries	[2]24	[3]62
Total percent returns	0.19	0.39
to Willard Hatchery	0.07	0.07
to fisheries	0.12	0.32

[1]Only precocious males were recovered at Bonneville Hatchery.
[2]Numbers of fish landed in the following areas: Washington 5; Oregon 16; California 3.
[3]Numbers of fish landed in the following areas: Washington 20; Oregon 34; California 7; Canada 1.

ference in hatchery returns between the control and test groups; however, there was a highly significant difference between the two groups in returns to the fisheries (Table 2). The overall contribution to the fisheries was 170% greater (adjusted for the difference in numbers released) from the test group than from the control group.

Although it was expected that both groups of fish (controls were released 4 d earlier) would mix below Bonneville Dam and encounter the same environmental conditions, we do not know for certain that this occurred. However, when the catches were separated by fisheries in Washington, Oregon, and California and compared, the proportion of test to control fish did not differ significantly from one fishery to another (chi-square, df = 2, $P>0.05$), indicating that the test and control groups were mixed as adults. Consequently, we believe the two groups were adequately mixed as juveniles.

The degree to which the trucking of coho salmon from Willard Hatchery to the barge contributed to their increased survival is unknown; no information is available on juvenile mortality of the control group during its migration from Willard Hatchery to Drano

TABLE 2.—Chi-square tests of null hypotheses regarding catch and return data on coho salmon in the Columbia River.

Hypothesis	Chi-square[1]
Returns of adult coho salmon to the Little White Salmon River Hatchery are the same for transported (test) as for nontransported (control)	0.00
Coho salmon from the transport and control groups contribute equally to sport and commercial fisheries.	17.55***
Total returns of coho salmon (to fisheries and hatcheries) are the same for both transport and control groups.	12.64***

[1]Adjusted chi-square, using Yates correction for continuity.
*** = $P<0.001$.

Lake. Although coho salmon from the test group did return to the Little White Salmon River (the homing site), the number of returns was smaller than expected, based on returns to the fisheries. This seems to indicate that the homing ability of the test group was impaired.

Columbia River flow was unusually low (averaging $<4{,}245\ m^3/s$) in the spring of 1977, and there was essentially no water passing over the spillways at Bonneville Dam during the experimental release. Consequently, fish released from the hatchery had to pass Bonneville Dam via the turbines. These unusual conditions no doubt contributed to the significantly lower survival of the hatchery release. However, with the completion of the second powerhouse at Bonneville Dam in the early 1980's, reduction or elimination of spills will become an increasing reality. Therefore, transportation may be a practical way to enhance survival of salmonids reared in hatcheries above Bonneville Dam.

Other researchers have studied the effect of transportation on the survival and homing ability of Pacific salmon and steelhead in the Columbia River system. Ebel et al. (1973) collected migrating juvenile chinook salmon, *O. tshawytscha*, and steelhead trout at a lower Snake River dam and transported them via tanker truck to a release site downstream from Bonneville Dam. Based on the number of returning adults, they concluded that survival of the transport group was higher than that of the control group; in addition, the homing ability of the transported fish was not impaired. Slatick et al. (1975) also concluded that the homing process of chinook salmon and steelhead trout transported from the same lower Snake River dam had not been impaired. Ellis and Noble (1960) were unable to increase adult returns to the Klickitat Hatchery (Fig. 1) by transporting juvenile fall chinook salmon; both trucks and a screened barge were used in their tests. In the barge test, fall chinook salmon from the Klickitat Hatchery were loaded into the barge (from a truck) at the confluence of the Klickitat and Columbia Rivers, transported 265.5 km downstream, and released. Returns to the Klickitat River were less for fall chinook salmon barged as juveniles than for hatchery-released controls; also there was considerable straying among returning transported adults. Adult returns were less for fall chinook salmon transported as juveniles in trucks from the Klickitat Hatchery and released in the lower Columbia River than were returns from hatchery-released controls. Ebel et al. (1973) and Slatick et al. (1975) transported juvenile salmonids that were actively migrating and had completed part of their seaward journey, whereas Ellis and Noble's (1960) test groups of fall chinook salmon were transported directly from the Klickitat Hatchery.

Transporting hatchery fish by barge around the Columbia River dams to avoid mortality remains a viable management option. In spite of an impaired homing ability, barged fish in this study returned to the hatchery at a rate equal to that of the controls. Barging not only increased survival, which benefited the sports and commercial fisheries, but also provided an adequate number of fish returns to the hatchery for reproduction purposes.

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MOVEMENT OF SABLEFISH, *ANOPLOPOMA FIMBRIA*, IN THE NORTHEASTERN PACIFIC OCEAN AS DETERMINED BY TAGGING EXPERIMENTS (1971-80)

The sablefish, *Anoplopoma fimbria*, is a North Pacific species distributed along the North American coast from Mexico to the Bering Sea and on the Asian coast east to Kamchatka and south to northeastern Japan. The maximum life span of sablefish appears to be near 40 yr (Beamish and Chilton in press). At 3 yr of age, sablefish reach a weight of about 1 kg and an average length of 47 cm. By 8 yr of age, sablefish have grown to about 3 kg and average 64 cm in length (Low et al.[1]).

The sablefish fishery in the northeastern Pacific Ocean and Bering Sea developed rapidly in the past 15-20 yr, growing from small United States and Canadian fisheries to large-scale multinational fisheries by Japan, the U.S.S.R., and the Republic of Korea (ROK). The increased exploitation of sablefish was followed by declines in catch per unit effort (CPUE) in many areas (Low et al. footnote 1). Because of this decline in CPUE, a tagging program was instituted to identify management areas and determine migration patterns.

Some studies of sablefish migration had been conducted in the 1950's and 1960's (Holmberg and Jones 1954; Edson 1954; Pruter 1959; Pasquale 1962; Novikov 1968; Pattie 1970). In these studies, most of the tagged fish were recovered near the area tagged. However, some fish were recovered over 1,000 km away (Holmberg and Jones 1954; Pruter 1959). Some fish tagged in the Gulf of Alaska were recovered off the California coast (Edson 1954) while other fish, tagged off the Washington coast, were recovered in the Bering Sea (Pasquale 1962; Pattie 1970). The results of these studies provided direct evidence of the occurrence of some long-range movement. The degree of long-range movement within the population could not be evaluated, since, in most of the studies, the number of fish tagged and recovered was small and each tagging project covered only a portion of the known range of sablefish.

Methods

To tag sablefish, over as much of its range as pos-

[1]Low, L. L., G. K. Tanonaka, and H. H. Shippen. 1976. Sablefish of the northeastern Pacific Ocean and Bering Sea. Processed rep., 115 p. Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.