

Sonic Tags in Sockeye Salmon, *Oncorhynchus nerka*, Give Travel Time Through Metropolitan Waters

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INTRODUCTION

Sonic tags were inserted in the stomachs of sockeye salmon returning from the Pacific Ocean to a large lake (3 x 30 km; 80 m deep) adjacent to Seattle, Wash. These fish contribute to a growing sport fishery, and State officials were concerned with their rates of travel through the waters of a metropolitan area. Their travel route lay between Puget Sound and Lake Washington, a distance of about 10.5 km.

From initial plantings in the 1930's, returns of sockeye salmon to Lake Washington rose from a few thousand fish to well over the 100,000 level in the past several years. In 1971, estimates placed the returns at approximately 250,000 fish.

To enter the lake from Puget Sound, fish must travel through the Lake Washington Ship Canal (Figure 1), including parts of Lake Union. Because the Canal is a relatively shallow passageway, surrounded by heavy industrial and urban development, the Washington State Department of Fisheries (WDF) was concerned that the migration of the fish might be delayed or subjected to harmful environmental conditions.

To determine travel time of the

sockeye salmon from the Hiram M. Chittenden Locks into Lake Washington, a study was made in the summer of 1971 by the Northwest Fisheries Center, National Marine Fisheries Service, in cooperation with WDF.

EQUIPMENT AND PROCEDURES

Migration paths and travel rates of fish were determined by means of a sonic tag placed in the stomach. The tag had a high-frequency sound transmitter that operated on a carrier frequency of 70 kHz. The transmitter was battery-powered with a transmitting life of 3 weeks. Transmitter and battery were sealed in a plastic capsule 73 mm long and 19 mm in diameter (Figure 2A). The tag emitted a pulse-coded signal; thus, a number of tags (and fish) could be individually identified.

Tag signals were monitored from an open boat (with a portable hydrophone and receiver (Figure 2B)) and by fixed recording monitors on shore. The receiver was a self-contained unit that amplified the signal from the hydrophone and converted it to an audible tone. By rotating the directional hydrophone in the water, while listening for the loudest tone, the operator could determine the direction of the tagged fish from his position. Directional ranges of 1.6 km (1 mile) could be obtained with the hydrophone.

Tagged fish approaching within

range of fixed shore monitors were automatically detected and their presence was recorded on tape. A fixed monitor station consisted of a receiver-tapedeck unit on shore connected to two hydrophones placed in the water. By proper placement of the pair of hydrophones under water, the direction in which the fish were travelling could be determined and recorded. Time reference marks were recorded on the tape to provide a chronological record on the entry and departure of the fish at specific areas.

Three shore-based recording monitors were used to determine timing of sockeye salmon between the locks and Lake Washington (Figure 1). In addition, nine fish were individually tracked to determine their patterns of movement between monitors, located at three points:

- (1) in the Fremont cut (3.7 km from Locks),
- (2) under the Interstate 5 Freeway bridge (7.1 km from Locks), and
- (3) at the east end of the Montlake cut (9.0 km from Locks).

Each monitor was serviced daily, at which time the used portion of the recording tape was removed and interrogated.

Three groups of five sockeye salmon were tagged with sonic tags and released. For identification of individual fish, each tag within a group transmitted at a different pulse rate. Once a group was released, the fish were monitored until all had passed the study area, after which a subsequent group was released.

Fish for study were captured by WDF personnel with a purse seine fished in salt¹ water below the dam at the Chittenden Locks. After the fish were tagged, they were transported and released immediately above the dam into the fresh¹ water of the Lake Washington Ship Canal.

¹ Some mixing of fresh with salt water undoubtedly occurs below the dam, with the reverse applying in the area immediately above the dam due to frequent lockages. Essentially, water below the dam is predominantly salt, whereas that immediately above is primarily fresh.

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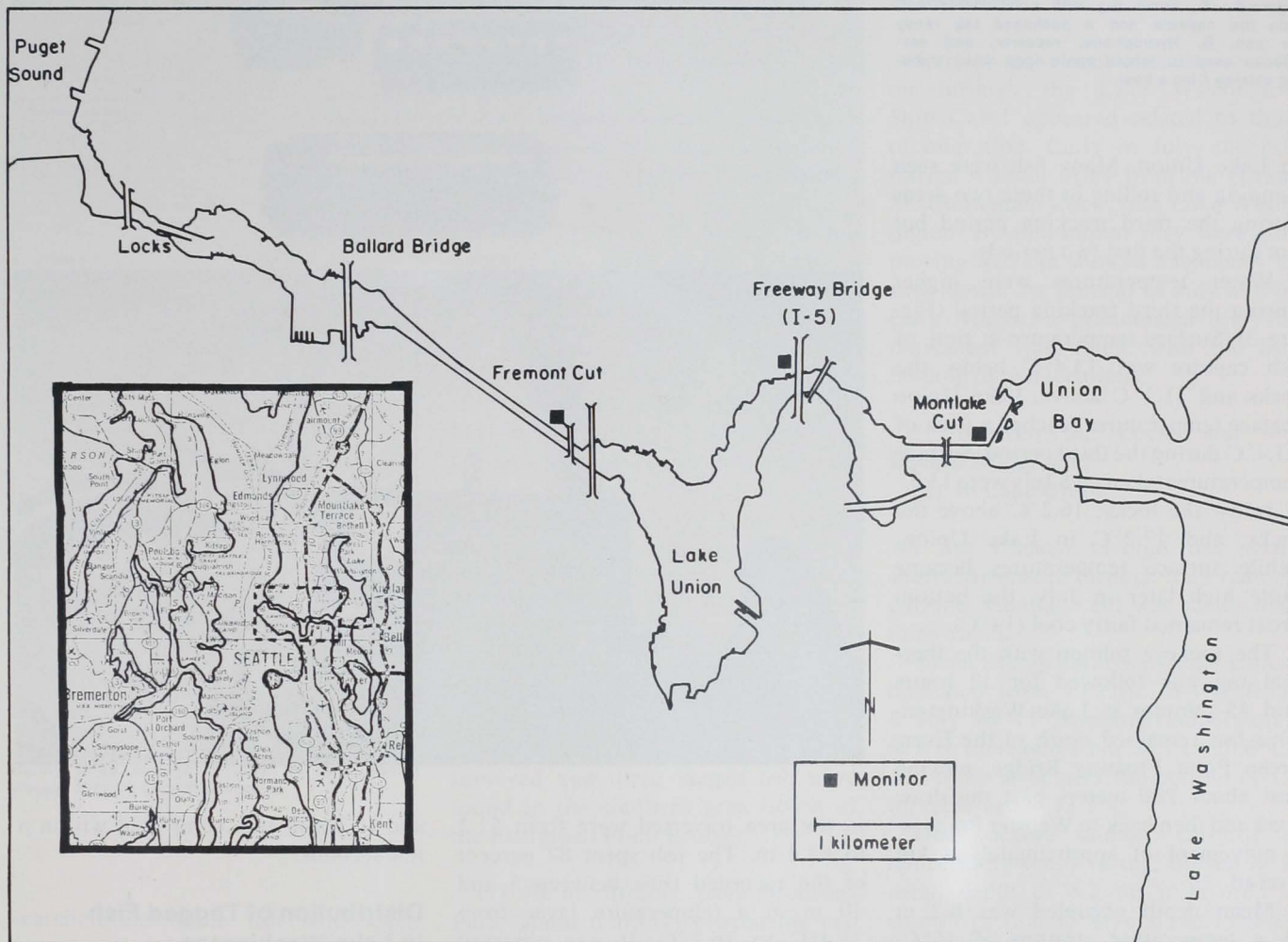


Figure 1.—Lake Washington Ship Canal: Puget Sound to Lake Washington.

Following release, the first fish to begin moving away from the lock area was tracked either until it entered Lake Washington, or until nightfall. Tracks interrupted by darkness were resumed at dawn the following day. As each tagged fish entered the lake, the tracker would return to the ship canal and locate the next fish coming through and proceed to track it. Remaining tagged sockeye were tracked from time to time to check their progress. This procedure was repeated until all fish had reached Lake Washington. Surveys of Lake Washington were also made to determine the distribution of tagged fish.

During the interval between the

second and third tag releases, we tagged one sockeye salmon with a thermal (temperature-sensitive) tag and released it directly into Lake Washington. This gave us an opportunity to observe the depths and temperature ranges of the water. Temperature data received from the tag were correlated with the lake's temperature profiles.

RESULTS

Five sonic-tagged sockeye salmon were released on each of the following dates—July 6, 13, and 27, 1971. The average size of the tagged fish was 58.4 cm (23 inches fork length). Pas-

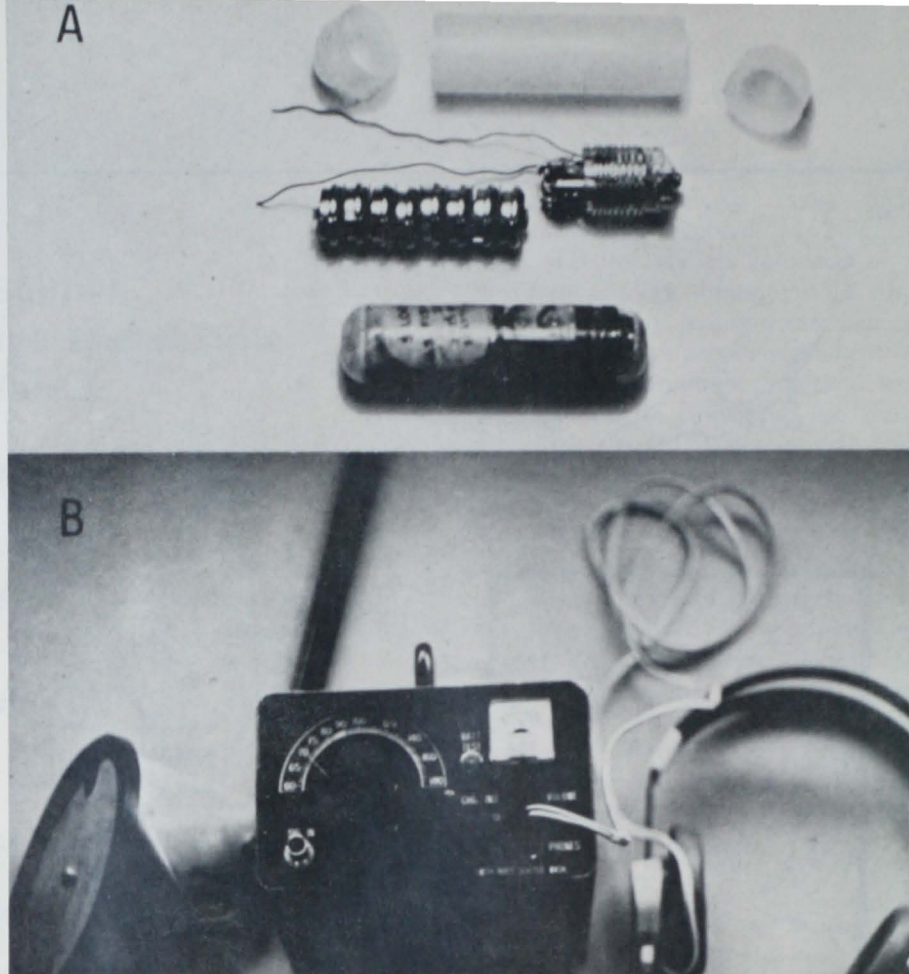
sage times for the fish of the three groups are shown in Table 1.

Travel Patterns

Basically, the pattern of travel for the first two groups was the same. The fish hesitated at the locks but, once on their way, tended to move steadily (except for periods of darkness), keeping primarily to the north shore.

During the third tracking period (27 July), the fish delayed in two areas: (1) between the locks and Ballard Bridge (1.5 km from the locks) and (2)

Figure 2.—A. Sonic tag with components outside the capsule and a packaged tag ready for use. B. Hydrophone, receiver, and ear-phones used to locate sonic tags when tracking salmon from a boat.



in Lake Union. Many fish were seen jumping and rolling in these two areas during the third tracking period but not during the first two periods.

Water temperatures were higher during the third tracking period (Figure 3). Surface temperature at time of fish capture was 13.4°C below the locks and 21.1°C above. Lake Union surface temperatures reached a peak of 23.4°C during the third period. Surface temperatures taken on 8 July were 11.7°C below the locks; 16.2°C above the locks; and 17.2°C in Lake Union. While surface temperatures became quite high later in July, the bottom areas remained fairly cool (14°C).

The sockeye salmon with the thermal tag was followed for 12 hours and 45 minutes in Lake Washington. This fish remained north of the Evergreen Point Floating Bridge, moving east about 200 meters past the draw span and then back to Webster Point—a movement of approximately 4 km overall.

Mean depth occupied was 8.2 m in a temperature stratum of 15°C; vertical movement ranged from the surface to 17.1 m. Maximum depths

in the area traversed were from 51.2 to 63.4 m. The fish spent 82 percent of the recorded time between 5 and 10 m in a temperature layer from 13.4°C to 16.7°C. It was observed ascending to the surface on four occasions; movement to the surface

and to depth was completed within a few seconds.

Distribution of Tagged Fish In Lake Washington

Three surveys were made of fish distribution in Lake Washington (Figure 4). On 9 July, the lake north of the Evergreen Point Bridge was

Table 1.—Passage times for sonic-tagged sockeye salmon traveling from Hiram M. Chittenden Locks to Lake Washington, 1971.

Group and date	Tag code	Ingress to Lake Washington		Total passage time		
		Date	Time	Days	Hours	Minutes
I, 6 July	1	7-6	1900	—	8	—
	2	7-6	1945	—	8	45
	4	7-7	0600	—	19	—
	3	7-7	1200	1	1	—
	5	7-7 ¹	—	—	23	+
II, 13 July	3	7-14	0610	—	20	26
	1	7-14 ²	—	1	+	+
	5	7-14 ²	—	1	+	+
	2	7-15	0930	1	23	46
III, 27 July	4	7-15	1715	2	7	31
	1	—	— ³	—	—	—
	2	7-29	1720	2	6	40
	3	8-4	1545	8	5	5
	5	8-7	1445	11	4	5
	4	8-14	0230	17	15	50

¹ Not recorded on Montlake cut monitor tape (probably obscured by boat motor noise). Date of passage estimated from data on the monitor below Freeway Bridge.

² Not recorded on Montlake cut monitor. Time estimated from data on the monitor below Freeway Bridge.

³ Tag malfunctioned immediately after release.

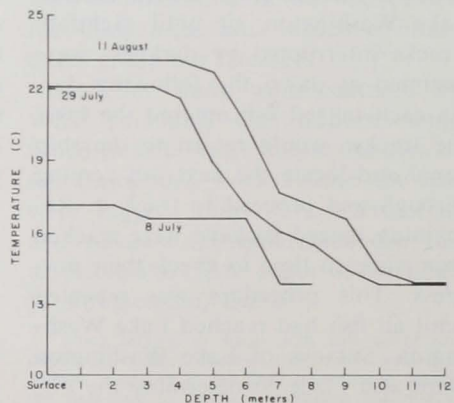


Figure 3.—Water temperatures and depth in Lake Union, 1971.

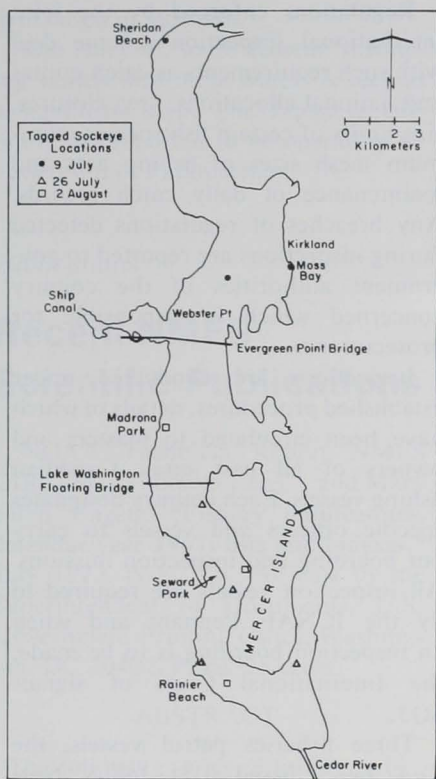


Figure 4.—Locations of tagged sockeye salmon during three surveys (9 July, 26 July, and 2 August 1971) in Lake Washington.

searched and three fish with sonic tags were found:

(1) 2 km offshore and west of Kirkland, Washington (mid-lake and approximately 3 km north of the Evergreen Point Bridge).

(2) 90 m offshore from Moss Bay at Kirkland, and

(3) 15 m off extreme northwest shore of Lake Washington (Sheridan Beach), approximately 11 km north of the Evergreen Point Bridge. Fish

found in the 9 July survey were all from the initial group, tagged and released above the locks on 6 July.

Four tagged fish were located on 26 July when the lake area was searched south of the Evergreen Point Bridge:

(1) west shore of Mercer Island about 6 km south of the Evergreen Point Bridge,

(2) about mid-lake 9 km south of the Evergreen Point Bridge and off Baily Point (Seward Park),

(3) about 90 m off west shore of Lake Washington, 12 km south of the Evergreen Point Bridge in the Rainier District, and

(4) about 450 m off southeast tip of Mercer Island in the east channel.

Tagged fish at locations (1) and (4) had the same code, which indicated one of the tags was from the 6 July tagging. The north end of the lake was not surveyed on 26 July.

On 2 August, the entire lake was surveyed and three tagged fish were found in the southern area (south of the Evergreen Point Bridge):

(1) 30 m offshore from Madrona Park (about midway between the two Lake Washington floating bridges),

(2) 15 m off west shore of Mercer Island (approximately mid-island), and

(3) 1 km off southwest tip of Mercer Island.

No tagged fish were found in the northern part of the lake. While some of these fish may have been tagged earlier, it is more likely that all the tagged fish located during the third survey came from the 27 July tagging.

SUMMARY

Rate of movement of sockeye salmon through the Lake Washington Ship Canal appeared related to time of migration. Early in July, the fish moved without delay from the Hiram M. Chittenden Locks into Lake Washington. By mid-month they were still moving well but showed a tendency to slow down. At the end of July and in early August, a pronounced delay in movement was noted, with the fish holding in two locations:

- (1) between the Locks and the Ballard Bridge, and
- (2) in Lake Union.

All fish tracked favored the north shore. Movement through the Fremont cut and Montlake cut was steady and fairly rapid.

Surface temperatures in Lake Union increased from 17.2 to 23.4°C from 6 July to 11 August. Temperatures at 6 m increased from 16.7 to 20.6°C, and those at or near the bottom (7-12 m) remained at 13.9°C.

One sockeye salmon, carrying a temperature-sensitive tag, moved at a mean depth of 8.2 m; it favored a stratum of 15.0°C. Several rapid movements to the surface and return to depth were observed.

Limited surveys of Lake Washington indicated that the distribution of tagged fish was widespread, especially early in the run when tagged fish were found in the north end of the lake. The tendency, however, was for the fish to concentrate in the south end of the lake in the vicinity of Cedar River, the principal sockeye spawning stream entering Lake Washington.