

First Record of Swimming Speed of a Pacific Salmon Undertaking Oceanic Migration from the Central Bering Sea to the Japanese Coast

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Swimming speed of homing salmon is a key factor required to improve knowledge of the mechanism of their oceanic migration. If homing salmon are moving at their optimal cruising speed, then salmon would have to move along the shortest route from the open ocean to the spawning grounds. If orientation is less precise, swimming speed would have to exceed the optimal cruising speed to achieve observed ground speeds. This paper describes ca. 50 days of swimming behaviour of a chum salmon *Oncorhynchus keta* during 67 days of oceanic migration from the central Bering Sea to the Japanese coast. Our results are the first record of swimming speeds of homing salmon during the oceanic migration.

The study was conducted as part of a Japanese-U.S. cooperative high-seas salmonid research cruise. In June–July 2000, we caught chum salmon by longline in the central Bering Sea. Chum salmon caught in a healthy condition were put into a recovery tank immediately after removal from the longline. Scales were collected for age determination and for examination of scale patterns. Chum salmon with scale patterns typical of Japanese-origin fish were candidates for tagging. We selected 27 vigorous, maturing chum salmon, larger than 600 mm (fork length), older than ocean age-.3 (fish spent three winters at sea) for tagging.

The data logger (Little Leonard Ltd., Tokyo, Japan, model UWE-200 PDT: 42 g in air, 13 g in water, 20 mm in diameter, and 90 mm length), which records swimming speed (through the water), depth, and temperature (Tanaka et al. 2001), was attached externally in the dorsal musculature of the fish, anterior to the dorsal fin (Tanaka et al. 2000). Tagged fish were released once they swam voluntarily. The logger sample rates were 5 sec for depth and speed and 1 min for ambient temperature.

After 67 days at liberty, one chum salmon released in the central Bering Sea (56°30'N 179°00'E) on July 9, 2000 was caught in a set-net on the east coast of Hokkaido Island of Japan (43°20'N 145°46'E) on September 16, 2000. The fork length at the time of release was 685 mm and the fish was an ocean age-.4. The minimum distance over the ground between the release and recovery sites was 2,760 km. The recording period of depth and temperature was 52.9 days (22:47 hrs 9 July to 19:43 hrs 31 August), and swimming speed data was recorded for 42.1 days because the propeller sensor became blocked with debris at 01:00 hrs 21 August. We did not get any information about the fate of the other 26 salmon and loggers.

The chum salmon usually stayed shallower than 50 m (10.2 ± 12.5 m, $n = 911,907$), though the fish conducted three exceptionally deep dives. Swimming speeds rarely exceeded 1.0 m/s, and horizontal speed was 36.4 ± 15.2 km/day ($n = 42$ days). Estimated horizontal distance was approximately 2,500 km, which was equivalent to 90 percent of the minimum distance between release and recovery site. Swimming depth and speed peaked around dawn and sunset, and there was a smaller peak around midnight. The fish showed sequential up-and-down movement near the thermocline during daytime. Diurnal patterns of movement suggest homing chum salmon have a time allocation strategy for foraging that is different between daytime and nighttime. Our findings indicate that over large distances of ocean, a homing salmon maintains a strong orientation to its homeward direction, and that passive transport by favorable water currents may help the homeward migration.

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