THERMAL DISCHARGE RESIDENCE BY LAKE MICHIGAN SALMONIDS

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Lake Michigan salmon and trout were tagged with a thermoluminescent dosimeter (TLD) temperature tag to estimate their thermal exposure and residence time at a warm water discharge. Fish were collected, tagged, and released at the Point Beach Nuclear Plant, Two Rivers, Wisconsin, in the fall of 1973 and 1974. Tags were recovered during the same season, primarily from fish recaptured at Point Beach.

Average uniform temperature exposure and maximum possible discharge residence time were determined, as previously described.[1,2] Appropriate hourly intake and discharge temperatures were averaged to calculate mean temperature exposure for the case of maximum discharge residence. Lowest discharge temperature not included within the period of maximum residence was identified to serve as a possible indicator of avoidance temperature. Mean values for the above parameters were calculated for fish species for each tagging year and are reported in Table 1 with the accompanying range of intake and discharge temperatures.

Water temperatures during the 1974 study were typically less than during 1973. Total tag recoveries each year were in excess of 15% for the three species; however, only a limited number were collected at locations where TLD tags could be properly preserved. Recaptures typically occurred over a long time span and mean number of hours vary greatly between species and years. Residence times were converted to percent of total tag time (% residence time) to allow direct comparison between species and years.

In 1973, mean percent residence time for rainbow trout, brown trout, and chinook salmon approximated 20%. Temperature exposure values were lowest for rainbow trout and highest for brown trout. The 0.3 to 0.4 C differences between mean residence temperature exposures and average uniform temperature exposures is due to the nonsymmetric change in TLD fade with varying temperatures. Lowest discharge temperatures during the assumed

Table 1. Maximum discharge residence time and temperature exposure for salmonids tagged at Point Beach.

	1973			1974		
Intake Temperature Range (°C)	8.6 — 17.2			6.9 — 10.4		
Discharge Temperature Range (°C)	14.5 — 27.0			14.2 — 20.3		
Species	Rainbow Trout	Chinook Salmon	Brown Trout	Rainbow Trout	Chinook Salmon	Brown Trout
Number tagged with TLD tags	92	37	124	211	38	252
Usable recaptures	5	4	10	20	1	11
Tag time (hrs)	255 ± 99[a]	474 ± 76	483 ± 49	482 ± 47	44	274 ± 39
Maximum residence (hrs)	35 ± 11	102 ± 35	107 ± 32	149 ± 37	14	166 ± 31
Percent residence time (°C)	18 ± 9	20 ± 5	22 ± 6	31 ± 6	32	61 ± 9
Mean residence temperature (°C)	13.5 ± 1.0	15.2 ± 0.4	15.8 ± 0.4	11.5 ± 0.6	10.8	14.3 ± 0.9
Average uniform temperature	13.9 ± 1.2	15.5 ± 0.4	16.1 ± 0.4	11.8 ± 0.8	12.2	14.7 ± 0.9
Lowest non-residence discharge temperature	19.3 ± 0.1	19.2 ± 0.8	20.3 ± 0.6	17.0 ± 0.3	17.1	18.0 ± 0.4

(a) mean ± S.E.

period of nonresidence (at temperatures > 19 to 20 C) approximate reported avoidance temperatures for these species and correspond with temperatures at which visual observations indicate most salmonids leave the discharge flumes.

With lower discharge temperatures during 1974, mean percent residence times increased to approximately 30% for rainbow trout and chinook salmon and to 60% for brown trout. Corresponding temperature exposures decreased for all species; however, the value for brown trout remained highest. Lowest assumed nonresident discharge temperatures decreased to 17 to 18 C, well below predicted avoidance temperatures.

TLD tag data suggest that during 1973 discharge residence times were limited by the occurrence of upper avoidance temperatures. While the percent residence times increased with lower discharge temperatures in 1974, even greater residence times would have been required to raise temperature exposures to levels observed in 1973. The implication is that factors other than temperature, such as spawning migrations, feeding habits, or energy requirements limited residence times in 1974.

References

1. G. P. Romberg and W. Prepejchal, Characteristics of temperature-sensitive fish tags used in 1974, Radiological and Environmental Research Division Annual Report, January-December 1974, ANL-75-3, Part III, pp. 155–160.
2. G. P. Romberg and W. Prepejchal, Improvements in TLD temperature tag calculations, this report.