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MOVEMENTS IN RELATION TO COLUMBIA RIVER TEMPERATURES

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DIEL AND SEASONAL WHITE STURGEON (*Acipenser transmontanus*) MOVEMENTS IN RELATION TO COLUMBIA RIVER TEMPERATURES

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ABSTRACT

Radio-tagged white sturgeon, 12 with temperature sensing transmitters, were monitored, from April through December 1977 in the free-flowing Hanford Reach of the Columbia River. River temperatures appeared to influence diel and seasonal sturgeon movements. In summer, from late afternoon to late evening, sturgeon environmental temperatures were higher than main current river temperatures. Sturgeon position determinations suggested movements into warmer inshore areas as darkness approached, perhaps to feed. After midnight, recorded sturgeon environmental temperatures declined, indicating movements back to cooler, main channel areas, especially after sunrise. Movements farther than 2 km from release sites did not occur unless water temperatures were above 13°C.

DIEL AND SEASONAL WHITE STURGEON (Acipenser transmontanus) MOVEMENTS IN RELATION TO COLUMBIA RIVER TEMPERATURES

Introduction

Although seasonal movements of white sturgeon (Acipenser transmontanus) may be related to water temperature (Hayes et al. 1978), no quantitative data exist on temperature related diel activity patterns (Bajkov 1949, 1951, Chadwick 1951, Semakula and Larkin 1968, Miller 1972, Scott and Crossman 1973, Kohlhorst 1976, Coon et al. 1977). In spring and early summer 1977, we fitted 12 white sturgeon with environmental temperature sensors to evaluate the relationship between sturgeon movements and water temperature in the free-flowing Hanford Reach of the Columbia River.

Materials and Methods

Radio telemetry equipment was developed by the Bioelectronics Laboratory, University of Minnesota (Tester and Siniff 1976). Sturgeon were captured at White Bluffs Pool (Figure 1), about 48 km upstream from our Laboratories in Richland, Washington, with trammel nets and angling gear. Transmitters of various sizes were attached according to Haynes et al. (1978) and matched to sturgeon so as not to exceed 2% of estimated sturgeon body weight. Temperature sensing precision was ± 0.2°C (Kuechle, personal communication). An automatic, nondirectional, channel-scanning receiving and recording station, capable of monitoring 16 channels, was established at White Bluffs Pool to record sturgeon environmental temperature and movements in and out of the pool.

White Bluffs Pool is 1.5 km long and has three distinct habitats (Figure 1). The majority of the pool is part of the deep, swiftly flowing main current of the Columbia River and has a rock bottom. A deep, slow moving back eddy with a sandy bottom lies off the tip of White Bluffs Peninsula. Shallow White Bluffs slough has a mud rock bottom and extends 1 km upstream along the peninsula. The pool ranges in depth from 1 m in the slough to 20 m in mid-pool, and the main current is well mixed (Gray et al. 1976, Page et al. 1976). From Priest Rapids Dam to Richland, river temperatures rise about 1°C in summer. Deep, unmixed pockets of water between bottom rock formations and underground spring seepage areas may be 1-5°C colder, and slough areas may be 205°C warmer than mixed main currents in summer (Haynes 1978).

Mean river temperatures (standard deviation = 0.5°C) were calculated from 12 temperature readings taken daily at Priest Rapids Dam. Main current temperatures in White Bluffs Pool averaged within ± 0.5°C of Priest Rapids Dam temperatures throughout 1977 (Haynes 1978). Daily mean river temperatures were averaged weekly (Table 1). Weekly standard deviations averaged 0.5°C. Daily and weekly midriver temperatures were constant relative to temperature differences observed in spring seepage and slough areas in summer.

Results and Discussion

Previous studies involving radio-tagged sturgeon (Haynes et al. 1978), indicated sturgeon movements greater than 2 km occurred when Columbia River temperatures were above 13°C. Furthermore, sturgeon size, and possibly sexual maturity apparently influenced direction of movement in the river. Because of apparent June to November seasonality of movement in past years, it was difficult to separate the relative impacts of tagging and handling stress versus natural seasonal stimuli on movements for sturgeon tagged in summer. However, six sturgeon tagged and released at White Bluffs Pool in April 1977, were particularly noteworthy. Although one sturgeon moved 5 km above White Bluffs Pool the day after release, none of the others moved out of the pool until water temperature rose above 13°C in June, again indicating natural seasonal stimuli primarily influenced movement.

The possibility that photoperiodicity plays a role in initiation of long distance movement and termination of movement appears unlikely. Pacific Northwest drought conditions in 1977 resulted in extremely low Columbia River flows and higher than normal water temperatures. River temperatures did not drop below 13°C until early November and sturgeon movements continued throughout. In previous years, river temperatures declined below 13°C and sturgeon movements ceased by mid-October. Complete cessation of movement greater than 0.5 km in autumn may be related to cold-induced inactivity in poikilothermic sturgeon.

Regression analysis comparing distances moved by sturgeon with river flows at Priest Rapids Dam produced scatter diagrams with regression coefficients approaching zero. Hydroelectric dam flow regimes apparently had no influence on long distance sturgeon movements in the Hanford Reach, as they did in the Snake River (Coon et al. 1977).

Throughout summer 1977, individual sturgeon with temperature transmitters engaged in movements that often resulted in a 2-4°C daily change in recorded temperature. Because main river temperatures were relatively constant within and between days, recorded temperature changes indicated sturgeon movement into areas of differing environmental temperatures. Position determinations confirmed location changes, and indicated sturgeon generally occupied mid-channel areas from shortly before sunrise until late afternoon. Movements into near shore and slough areas were recorded in late afternoon and evening.

An analysis of variance was used to compare mean sturgeon environmental temperatures in six daily time periods (0200-0600, 0600-1000, 1000-1400, 1400-1800. 1800-2200 and 2200-0200hr). Within each period, all sturgeon temperature recordings for one week were compared to the weekly mean river temperature (Table 1). Differences between sturgeon environmental and weekly average river temperatures were experimental units within each time period. The analysis indicated significant differences in environmental temperatures (P 0.05), and Honest Significant Difference tests (Snedecor and Cockran 1972) were used to establish which periods differed.

From 0200-1000 hr, sturgeon environmental temperatures (Figure 2) were somewhat lower (0.35^{o}C) than weekly average river temperatures, suggesting presence in deep, cool, possible spring-fed areas. From 1400-2200 hr, sturgeon environmental temperatures were significantly (P 0.05) higher (0.85^{o}C) than the weekly average river temperature, indicating presence in warm, shallow slough areas. From 1000-1400hr and 2200-0200hr, sturgeon environmental temperatures were somewhat higher (0.32^{o}C) than the weekly average, suggesting transition periods when sturgeon moved between inshore and mid-channel areas.

Diel sturgeon movements may be influenced by light, since movement to cool, deep areas occurred prior to sunrise and movement to warm shallow areas peaked after sunset. Sturgeon were sensitive to light when captured and remained active until a towel was wrapped around their eyes. Evening movements to back eddy and slough areas of White Bluffs Pool, where detritus collected, suggested that diel movements were related to feeding. Daily environmental temperature records indicated sturgeon did not consistently engage in this diel movement pattern, but sometimes spent one or more days in cooler, mid-channel areas. Occasionally, sturgeon remained near inshore areas through mid-day. Variability within and among fish was common.

The complex interaction of water temperature, light cycle, feeding, urge to spawn, and other factors undoubtedly influence sturgeon movement in the mid-Columbia River. Although temperature appears to be the major influence stimulating seasonal movements, light cycle and feeding appear to be key factors influencing diel movements.

Acknowledgements

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TABLE 1. Weekly Average Columbia River Temperatures Recorded at Priest Rapids Dam from June to November 1977

June	°C
1-4	12.2 ± 0.2
5-11	14.0 ± 0.3
12-18	15.0 ± 0.6
19-25	16.3 ± 0.2
26-2	16.6 ± 0.3

July	°C
3-9	16.3 ± 0.5
10-16	16.5 ± 0.3
17-23	16.6 ± 0.5
24-30	17.5 ± 0.2

August	°C
31-6	18.4 ± 0.3
7-13	19.2 ± 0.4
14-20	20.1 ± 0.2
21-27	19.6 ± 0.5
28-3	18.5 ± 0.3

September	°C
4-10	18.1 ± 0.2
11-17	18.2 ± 0.4
18-24	17.6 ± 0.3
25-1	16.7 ± 0.2

October	°C
2-8	16.0 ± 0.2
9-15	15.3 ± 0.1
16-22	15.1 ± 0.2
23-29	14.3 ± 0.3
30-6	13.3 ± 0.4

FIGURE 1. Mid-Columbia River White Sturgeon Monitoring Area Showing White Bluffs Pool Main Channel, Back Eddies and Slough

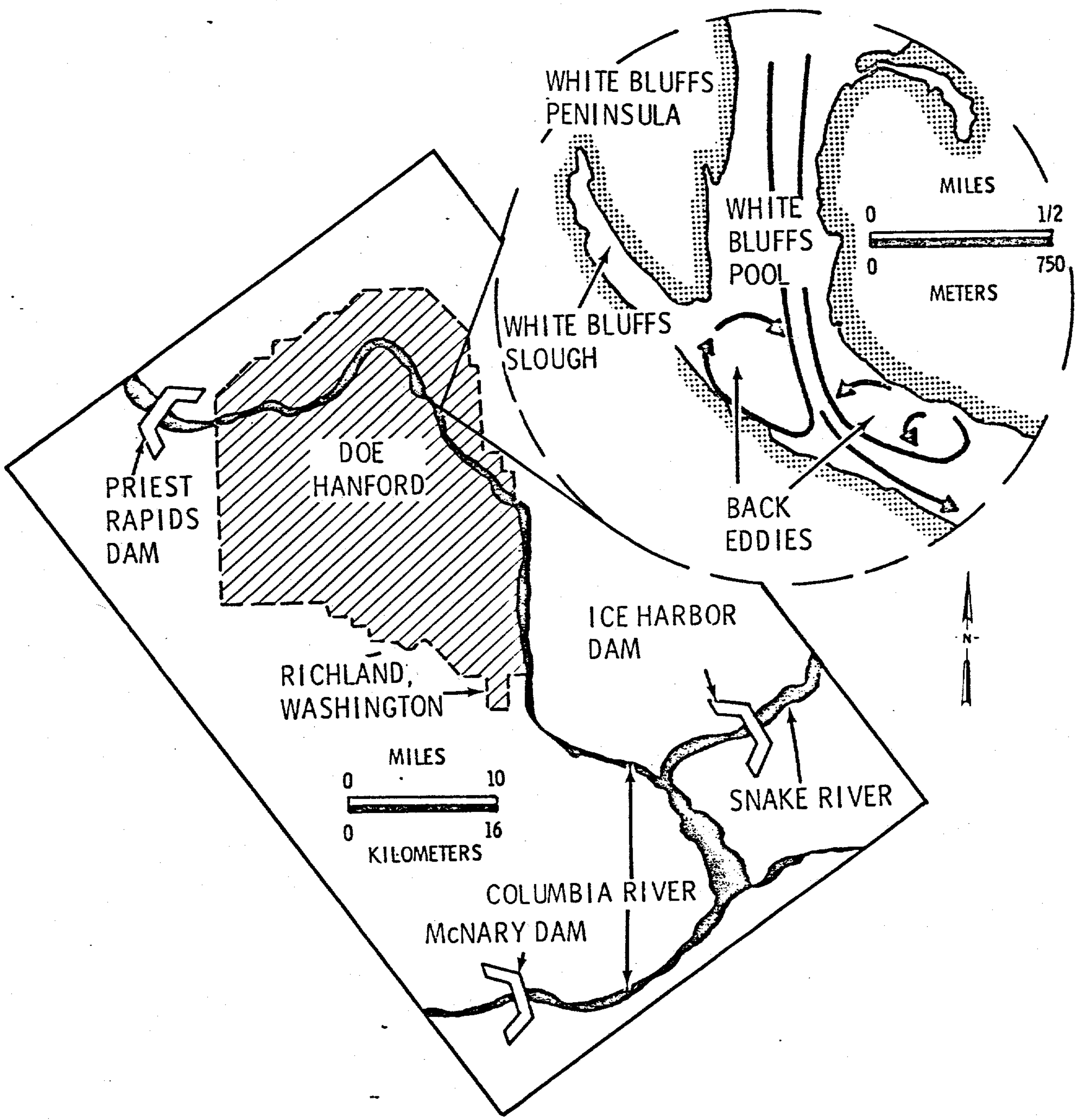
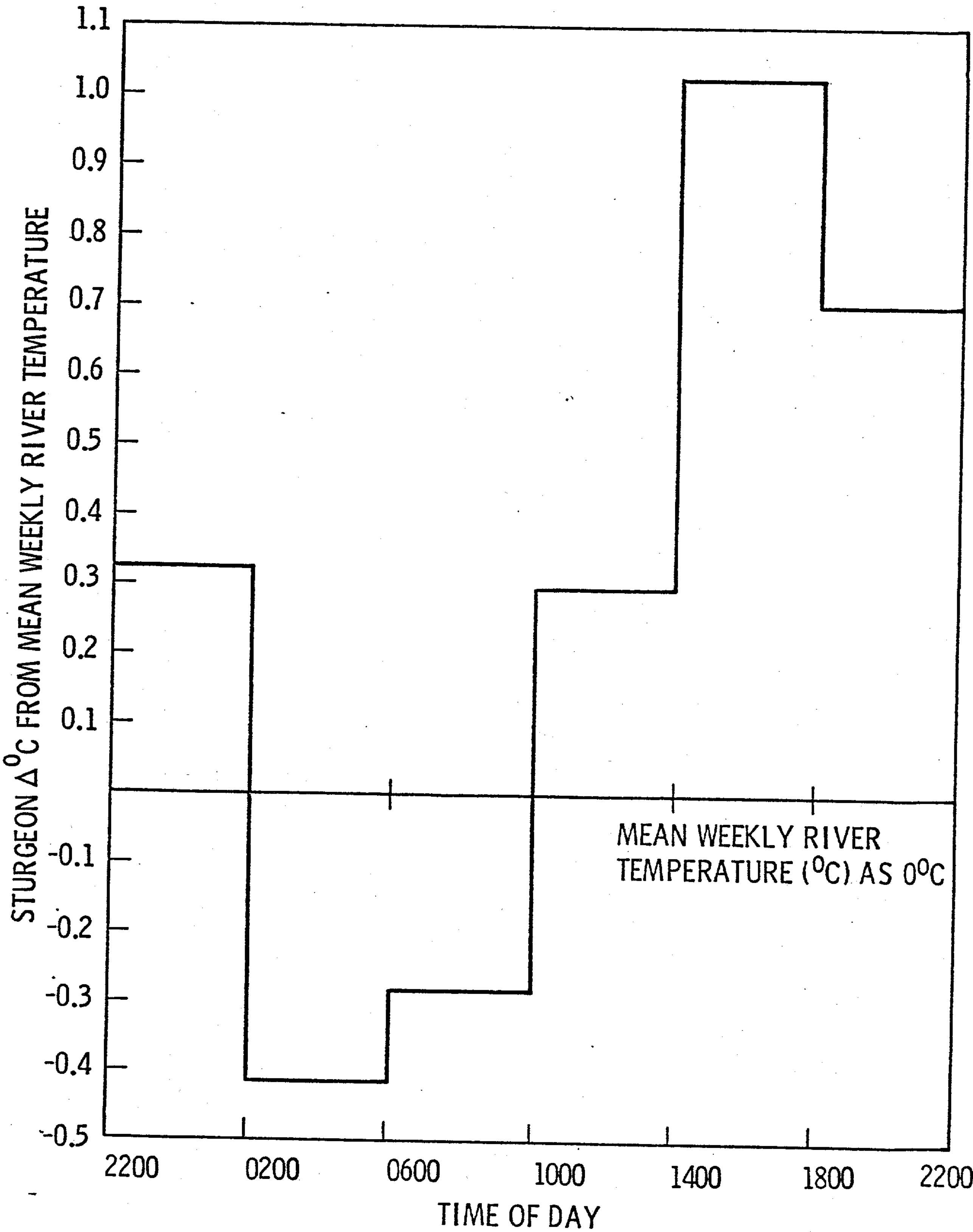

WHITE BLUFFS PENINSULA
WHITE BLUFFS POOL
MILES
0
1/2
0
750
METERS
WHITE BLUFFS SLOUGH
BACK EDDIES
N
PRIEST RAPIDS DAM
DOE HANFORD
ICE HARBOR DAM
RICHLAND, WASHINGTON
MILES
0
10
0
16
KILOMETERS
SNAKE RIVER
COLUMBIA RIVER
McNARY DAM

FIGURE 2. Mean Sturgeon Environmental Temperature Deviation ($\Delta^{o}C$) From Mean Weekly Columbia River Temperatures Averaged Over Four Hour Periods Within the Diel Cycle



1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
-0.1
-0.2
-0.3
-0.4
-0.5
STURGEON Δ °C FROM MEAN WEEKLY RIVER TEMPERATURE
MEAN WEEKLY RIVER TEMPERATURE (°C) AS 0°C
2200
0200
0600
1000
1400
1800
2200
TIME OF DAY