

# Stream Habitat Comparisons in the Salt Plains National Wildlife Refuge, Oklahoma; Implications for Nesting Least Terns (*Sterna antillarum*)

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Oklahoma's Salt Plains National Wildlife Refuge supports a nesting population of endangered interior least terns (*Sterna antillarum*), which are piscivorous and depend on the aquatic habitats of the Salt Plains National Wildlife Refuge. Eight creek sites at the Salt Plains National Wildlife Refuge were surveyed for water quality and habitat parameters, and comparisons were made between creek sites proximal to the Great Salt Plains reservoir (downstream sites) and sites at least one kilometer away from the reservoir (upstream sites). Statistical analyses did not show significant differences in dissolved oxygen, temperature, turbidity, stream width, stream depth, substrate size, and run/riffle/pool ratios. However, tests showed consistently higher conductivity readings at downstream sites as compared to upstream sites; this finding is significant in light of other studies which indicate that downstream sites harbor substantially higher numbers of *Menidia beryllina*, the inland silverside, than do upstream sites; *M. beryllina* is an euryhaline marine species, and its correlation with sites with high water conductivity suggests that the Salt Plains National Wildlife Refuge provides an excellent habitat for this population. Moreover, the surface-schooling behavior, small size, and slender form of *M. beryllina*, suggest that it is an important food source for least terns. Therefore, monitoring and conserving the habitat of *M. beryllina* may be critical to the conservation of the least tern.

## INTRODUCTION

The interior population of least terns (*Sterna antillarum*) was listed as endangered by the U.S. Fish and Wildlife Service (USFWS) in 1985 (1). The decline in least tern numbers has been attributed to direct and indirect anthropogenic activities (e.g. dredging, damming, recreation), which have decreased nesting habitat along inland riverine systems and salt flats. The Salt Plains National Wildlife Refuge (SPNWR), located in Oklahoma's Alfalfa County, remains a significant nesting site for interior least terns (2). In light of this, the USFWS has been monitoring and attempting to encourage the recovery of the least tern population nesting at SPNWR.

The least tern is piscivorous (2), and therefore understanding and monitoring conditions of aquatic habitat and fish populations at SPNWR is a critical aspect of least tern conservation. However, at the present time very little is known about aquatic habitats at SPNWR. Studies by Taylor et al. (3) in southwestern Oklahoma have used canonical correspondence analysis to suggest that fish assemblages in Great Plains river systems are predictable along environmental gradients; conductivity was the most significant variable predicting fish assemblage structure, followed by stream width, alkalinity, woody debris, and turbidity. The present study surveys water quality and habitat parameters at eight creek sites within SPNWR. Many parameters surveyed (e.g. stream width, stream depth, substrate size) play a significant role in determining stream fish habitats (3,4). When compared with ichthyofauna surveys of the same sites (5), the data collected suggest that conductivity plays a role in predicting the habitat of the inland silverside (*Menidia beryllina*), a surface-schooling fish (6) that is a likely food source for nesting least terns.

## METHODS

**Study Sites:** Eight sites were surveyed at four different creeks: Clay Creek (ClayC), Cottonwood Creek (CotC), Twin Springs Creek (TSC), and the West Fork of Salt Fork Creek (WFSF) (see Figure 1). All four creeks flow into the Great Salt Plains

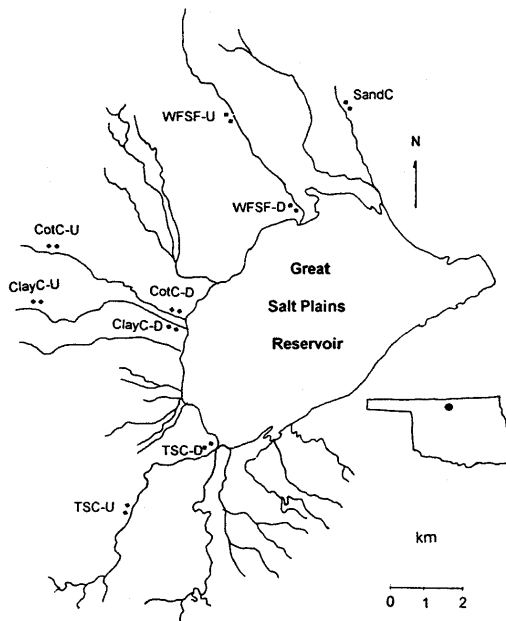


Figure 1. Location of stream habitat sampling sites within the Salt Plains National Wildlife Refuge, Alfalfa County, Oklahoma. WFSF=West Fork of the Salt Fork, CotC=Cottonwood Creek, ClayC=Clay Creek, TSC=Twin Spring Creek, downstream sites indicated by D (e.g. CotC-D), upstream sites by U (e.g. CotC-U). Note that SandC=Sandy Creek, sampled by Ashbaugh et al. in a concomitant ichthyofauna survey (5).

averaged. At each 50-m interval a tape measure was stretched across the creek to measure stream width. Along this tape measure, at 1/4, 1/2 and 3/4 total stream width, readings were taken for stream depth, substrate class, and run/riffle/pool data (providing 3 data points per 50-m interval and 15 data points per site). Substrate class was determined by feeling the substrate and bringing a handful to the surface. Class was based on particle diameter  $d$  as follows: sand,  $d < 1$  mm; gravel,  $0.1 < d < 5$  cm; rubble,  $5 < d < 30$  cm; boulder,  $d > 30$  cm; (silt and clay ratios were not determined). Run/riffle/pool data were visually estimated, and fitted into one of five categories: (a) run: fast moving water with a smooth surface; (b) riffle: fast moving water with a disturbed surface; (c) pool: slow-moving water with no surface disturbances; (d) backwater: water moving upstream instead of downstream; (e) pocketwater: water that is not flowing and is contained within a limited area, e.g. water directly downstream of a boulder.

## RESULTS

**Water Quality Measurements** (Table 1): Dissolved oxygen (DO) concentrations ranged from 10.0 mg/l to 13.2 mg/l, with no significant variation among downstream and upstream sites. Temperature readings ranged from 16.0 to 25.0 °C, with no significant intersite variation. Turbidity was more variable, ranging from 20.0 to 44.0 cm [at some sites the Secchi disc was visible while resting on the substrate, indicated as clear-to-bottom (CB)]; however, intersite variation was not significant. Specific conductivity ranged from 7  $\mu$ S/cm at ClayC-U to 1428  $\mu$ S/cm at CotC-D (U=upstream, D=downstream), and values at downstream sites were significantly higher than those at upstream sites ( $\alpha = 0.0366$ ).

**Habitat Parameters** (Table 2): As expected, downstream sites were wider than

Reservoir, and each creek was sampled at a downstream site (within 50 m of the reservoir) and an upstream site (at least 1 km from the reservoir). Downstream sites were sampled on 18-19 March 1995 between 10 am and 4 pm, and upstream sites were sampled on 1 April 1995, between 10 am and 4 pm. On these dates creek flow was moderate, i.e. there was no drought or flood condition. At each site water quality parameters (temperature, dissolved oxygen, turbidity, conductivity) and habitat parameters (stream width, stream depth, substrate size, and run/riffle/pool data) were surveyed.

**Statistical Methods:** Water quality and habitat characteristics at downstream sites were compared with upstream site characteristics by using a two-tailed student's t-test for comparison of population means (7). Any test with  $P \leq 0.05$  was considered statistically significant.

**Water Quality Measurements:** A Yellow Springs Instrument (YSI) Co. dissolved oxygen meter, model 571, was used to determine temperature and dissolved oxygen; a Secchi disk was suspended vertically in the stream and viewed from the surface to measure turbidity; a YSI 3000 Temperature-Level-Conductivity meter was used for temperature-compensated conductivity measurements.

**Habitat Parameters:** Each site was 200 m long, and habitat parameter measurements were taken at 50-m intervals and

TABLE 1. Water quality data collected at stream sites at the Salt Plains National Wildlife Refuge. Note that data from downstream were collected on 18-19 March, 1995, and data from upstream sites were collected on 1 April 1995.

Stream	Legal Description	TOD <sup>a</sup> hhmm	DO mg/l	Temp °C	Secchi <sup>b</sup> cm	Cond μS/cm
ClayC-D	R10WT26NS14	1255	12.5	21.0	20.0	1323
ClayC-U	R10WT26NS15	1335	12.0	25.0	CB <sup>c</sup>	7
CotC-D	R10WT26NS15	1400	13.2	25.0	CB <sup>c</sup>	1428
CotC-U	R10WT26NS10	1700	12.9	23.0	CB <sup>c</sup>	13
TSC-D	R10WT26NS25	1100	10.0	19.5	24.4	571
TSC-U	R10WT26NS36	1135	13.2	16.0	44.0	86
WFSF-D	R09WT26NS5	1500	10.0	22.0	25.6	496
WFSF-U	R10WT27NS25	1700	10.0	20.0	24.0	351

a TOD=time of day: hours (hh) and minutes (mm) since midnight (0000).

b greatest depth at which Secchi disk is visible.

c clear to bottom

upstream sites, averaging 34.3 m wide compared to 15.5 m upstream, but this difference was not statistically significant. Mean depth varied from 9.9 cm to 49.9 cm, but there was no significant difference between depths at upstream and downstream sites. Of all substrate observed 99.1 % was < 1 mm in diameter and therefore classified as sand. Run/riffle/pool data yielded a total of 50.0% run, 43.4% pool, 4.1% riffle, 1.7% backwater, and 0.8% pocketwater, and no significant differences were found between upstream and downstream sites.

## DISCUSSION

This is the first study of stream water quality and habitat parameters at SPNWR. Similar studies at other sites (3,4) have shown that these parameters play a role in determining stream fish community structure in Oklahoma and other parts of North America. Since nesting least terns forage for fish in SPNWR's streams, knowledge about the conditions of stream habitats is critical to the conservation of least tern habitat.

Measurements of DO, temperature, mean stream width, mean stream depth, and run/riffle/pool ratios indicate that streams at SPNWR are capable of supporting fish populations; however, these data do not provide immediate insight into the significance of these creeks as feeding grounds for least terns. Substrate class data indicate fine particles that may have a tendency to become suspended in the water column. Turbidity data reinforce this, with Secchi disc readings as low as 20.0 cm. Turbid waters are likely to affect feeding least terns, which are categorized as "surface plungers" - they search for fish while hovering five to ten meters above the water, and then dive for the prey upon sighting it (8). Only fish close to the surface of a turbid stream would be accessible prey.

Conductivity has been recognized as an important variable for predicting the structure of fish assemblages in Oklahoma Great Plains river systems (3). Therefore, the higher conductivity of downstream sites as compared to upstream sites suggests a possible difference in downstream and upstream fish assemblages. Ashbaugh et al. (5) have surveyed fish populations at the same eight

TABLE 2. Habitat parameter data collected at stream sites at the Salt Plains National Wildlife Refuge.

Stream	U/D <sup>a</sup>	Mean Width m	Mean Depth cm	Type of Flow <sup>b</sup>
ClayC	D	57.6	38.0	100% pool
ClayC	U	17.9	15.1	40% pool, 53% run, 7% bw
CotC	D	15.8	9.9	100% run
CotC	U	11.1	21.6	100% pool
TSC	D	31.1	41.3	100% pool
TSC <sup>c</sup>	U	4.5	18.0	7% pool, 60% run, 33% riffle
WFSF	D	32.7	49.9	100% run
WFSF	U	28.6	32.9	87% run, 7% bw <sup>b</sup> , 7% pw <sup>b</sup>

a U=upstream; D=downstream

b bw=backwater; pw=pocketwater; see text for details.

c In this stretch, the substrate was 93% sand and 7% gravel; for all other stretches described here, the substrate was 100% sand.

sites surveyed in this report, and the results were striking. The inland silverside, *M. beryllina*, was found in significantly higher numbers in downstream sites than in upstream sites, and in higher overall numbers than other fishes sampled (3,623 *M. beryllina* were collected compared to 578 *Notropis stramineus*, the next highest total). Moreover, the number of *M. beryllina* was more than an order of magnitude greater at the downstream sites of TSC, ClayC, WFSF than at the upstream sites (3,533 were found downstream, 86 upstream). At CotC, *M. beryllina* were poorly represented, with none at the upstream site and four at the downstream site.

The presence of large numbers of *M. beryllina* at downstream sites correlates with the high conductivity measurements at those sites. Other studies show that *M. beryllina* prefers estuaries and brackish waters, and is an euryhaline marine species that has established landlocked populations in fresh water (7,9). The hypersaline conditions of the salt flats may provide *M. beryllina* with a suitable habitat. Presumably, minerals dissolve as streams flow over the salt flats, and the concentration of minerals increases downstream (10); *M. beryllina* may prefer this saline water.

It is possible that the high conductivity of downstream sites may be due, in part, to an influx of salt from the Great Salt Plains Reservoir. However, in a study of groundwater geochemistry at SPNWR (10), tests for surface water mineral concentrations indicated that mineral concentrations were at least an order of magnitude higher in Clay Creek than in the Great Salt Plains Reservoir. The researchers hypothesize that the high concentrations of minerals in Clay Creek may be due to seepage of saline groundwater, suggesting that conductivity levels in SPNWR streams may not be easily predicted without extensive testing.

The large numbers of *M. beryllina* found in SPNWR streams may be strongly correlated to the success of nesting least terns. Least terns tend to forage within 6 km of their nesting area and, as surface plungers, tend to feed on surface-schooling fishes in shallow water (2). *M. beryllina* are surface-oriented atherinoids usually found schooling at the surface of clear, quiet water, over sand or gravel (6). Moreover, least terns are limited to eating small fish: 1.5 to 4.0 cm long for their young, 2.0 to 9.0 cm long for adults, with body depth less than 1.5 cm (2). *M. beryllina* are slender fish (11) that grow to a maximum length of 15 cm (6); young specimens would certainly be small enough for least terns to eat.

We have compared our data with reported patterns of least tern foraging at SPNWR. Heavy foraging has been observed at the downstream section of WFSF, light foraging at the upstream section of WFSF; heavy foraging has been observed at both upstream and downstream sites of ClayC and CotC, and no foraging has been observed at TSC (Rod Krey, Refuge Manager at SPNWR, pers. comm.). Krey's observations of heavier tern foraging at the downstream section of the WFSF as compared to upstream areas reinforce the putative link between high conductivity, high numbers of *M. beryllina*, and high density of least tern foraging. However, Krey's observations of heavy foraging at CotC-D and CotC-U do not correlate with conductivity readings or ichthyofauna surveys. Krey also reported observing no foraging at TSC, which had both high conductivity and a significant number of *M. beryllina* (445) at the downstream site (5).

The lack of clear correlation between our data and Krey's observations may be linked to the lack of clear boundaries of streams at SPNWR. Streams are constantly changing course and migrating, primarily due to large discharges of water during flood season (10,12, and M. Koenan, pers. comm.). It may prove more helpful to correlate tern foraging with certain habitat types, rather than with specific but ephemeral bodies of water at SPNWR.

Short-term sampling at variable time periods masks temporal variation in environmental conditions, and the data presented herein will become more conclusive as more studies take place at SPNWR. Nonetheless, this study strongly suggests that the high conductivity at stream sites adjoining the Great Salt Plains reservoir creates a suitable habitat for large numbers of *M. beryllina*, thereby providing nesting least terns with a significant food source. If this is the case, downstream sites may be better foraging areas for least terns than upstream sites. Further studies are certainly warranted if the USFWS is to effectively manage and monitor this critical

habitat in the best interests of the least tern.

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