FISH ASSEMBLAGE STRUCTURE FROM 20 YEARS OF COLLECTIONS IN THE KIAMICHI RIVER, OKLAHOMA

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ABSTRACT—We tested for long-term changes in fish assemblages using collections made from 1972 to 1992 in the Kiamichi River, Oklahoma. Reservoirs were constructed in the Kiamichi River basin in 1974 (mainstem) and 1983 (tributary). A significant difference was found for local species richness but not Shannon-Wiener diversity nor evenness in comparisons from before and after reservoir construction. There was an effect of collection date on the relationship between species richness and upstream distance from the mainstem reservoir; species richness was highest prior to reservoir construction. Sites further from the tributary reservoir outflow were more similar in species composition over time than sites closer to the outflow. Comparisons of site scores for principal components revealed that Fundulus olivaceus, Notropis atherinoides, and Labidesthes siculus decreased in abundance following reservoir construction. Although the Kiamichi River retains its overall species richness, our results indicate that reservoir construction has influenced fish assemblage structure.

RESUMEN—Experimentamos cambios a largo plazo en bancos de peces usando colecciones hechas entre 1972 a 1992 en el río Kiamichi, Oklahoma. Se construyeron embalses en la cuenca del río Kiamichi en 1974 (ríos principales) y en 1985 (en un afluente). Se encontró una diferencia significativa en la riqueza local de especies pero no en la diversidad Shannon-Wiener, ni en la igualdad de proporciones de especies en pruebas provenientes de la época antes y después de la construcción de los embalses. Hubo un efecto de la fecha de colección en la relación entre la riqueza de especies y la distancia río arriba del embalse principal; la riqueza de especies fue más alta antes de la construcción de embalse. La composición de especies en sitios lejos de la boca de embalse del afluente fue más estable a través del tiempo que en aquellos sitios cerca de la boca. Comparaciones entre índices por sitio de los componentes principales mostraron que Fundulus olivaceus, Notropis atherinoides, y Labidesthes siculus fueron menos abundantes después de la construcción de los embalses. Aunque el río Kiamichi mantiene su riqueza de especies, nuestros resultados indican que la construcción de los embalses ha influido la estructura poblacional de los peces.

Fish assemblages often show negative effects in response to major environmental perturbations, including reservoir construction (Neves and Angermeier, 1990; Edwards and Contreras-Balderas, 1991; Warren and Burr, 1994). These effects may include changes in species composition upstream and downstream of reservoirs (Smith, 1971; Richards, 1976; Hansen and Ramm, 1994). Downstream fish communities appear to be most severely affected by modifications in natural flow regimes that occur below reservoirs (Bain et al., 1988; Travnichek et al., 1995), although dams also prevent dispersal of migrating fishes. Our objective was to compare fish assemblages in the Kiamichi River to test the hypothesis that changes occurred after impoundment.

The Kiamichi River is a medium-sized river (180 km length, drainage area of 4,800 km²) in southeastern Oklahoma with moderate gradient (0.47 m/km). Ninety-nine fish species have been collected in the Kiamichi River (Pigg and Hill, 1974; Taylor et al., 1998). Two reservoirs influence the river. Hugo Reservoir, constructed in 1974 impounds the mainstem of the river (Fig. 1). Sardis Reservoir, con-
structed in 1983, impounds a major tributary of the river (Fig. 1). Other anthropogenic effects on river biota derive from agricultural and forest harvesting activities, although these effects appear minimal, perhaps due to the narrow river basin (5–20 km in width) (Vaughn and Pyron, 1995).

METHODS—Analyses were based on 185 fish collections from the Kiamichi River from 1972 to 1992 (these data have been archived at the Oklahoma Biological Survey). Collections were made by ourselves, Matthews (1986), and R. Cashner (pers. comm.). All of these surveys were conducted in summer or fall with the exception of five winter and nine spring collections. Collections were made by seineing at least a 100-m river reach at each site to sample every available habitat, with gill-netting at some sites, following best professional judgment. Earlier surveys in the Kiamichi River reported only presence/absence of species (Meek, 1895; Ortenburger and Hubbs, 1927; Pigg and Hill, 1974).

All of the fish collections discussed in this paper were made upstream of the mainstem reservoir (Hugo). We were interested in two types of reservoir influences on fish assemblages; those from the tributary reservoir and those from the mainstem reservoir (Hugo). Sites 7–12 were upstream of the tributary reservoir (Fig. 1). Prior to reservoir construction 32 collections were made at these sites; 50 collections were made following construction. Sites 1–6 were downstream of the tributary reservoir but upstream of the mainstem reservoir (Fig. 1); 35 collections were made at these sites prior to reservoir construction and 68 collections following reservoir construction. Although more collections were made after reservoir construction, collections represented equitable sampling for our comparisons.

To determine the influence of the downstream mainstem reservoir on fish assemblages we examined the relationship between species richness, Shannon-Wiener diversity, evenness (modified Hill's ratio, Ludwig and Reynolds, 1988), and the upstream distance of sites (from the mainstem reser-
voir) for an effect of time (before and after Sardis Reservoir construction) with ANCOVA. A positive relationship between species richness and stream size (or stream distance) is common (Angermeier and Schlosser, 1989; Watters, 1992).

To examine influences of the tributary reservoir on fish assemblages we conducted the following analyses. We compared Jaccard’s index of similarity before and after reservoir construction (Ludwig and Reynolds, 1988) from sites below the Sardis Reservoir inflow (Fig. 1) to sites above the Sardis inflow with an independent t-test, to test for temporal changes in species composition. Jaccard’s index was calculated from presence/absence data for summed collections prior to 1984 and after 1984 by site (for 11 sites with collections made during both time periods), for collections made during summer and fall months. We chose to make comparisons with a presence/absence index (Jaccard’s) as a more conservative approach than using an index based on abundances, because sites were not equally sampled. We used a regression approach to test for a relationship between the distance (upstream or downstream) from Sardis Reservoir outflow for each site and Jaccard’s similarity values at sites. Finally, for three sites sampled regularly during the study period, we tested if the slopes of regressions of species richness and H’ against collection date were different from zero, which may indicate negative effects of reservoirs or time.

In our multivariate approach, collections were separated into before and after construction of Sardis Reservoir (before and after 1984) and combined by site. This analysis tested for changes in the ordination position of sites from before and after reservoir construction. Rare species were not used in principal components analysis; species were eliminated if they did not represent more than one percent of the total number of fishes collected, or if they did not occur at more than two sites. Transformed (log10+1) species abundances were subjected to principal components (PC) analysis, and the subsequent site factor scores compared by time of collection (before and after 1984) with paired t-tests for the PC axes that explain greater than 10% of total variance. All statistical analyses were done with SYSTAT (1992).

RESULTS—A total of 101 fish species was taken in 185 collections at 12 sites (localities are listed in Appendix 1). Several rare species (occurred in only one or two collections) are at the edge of their geographic ranges (Lee et al., 1980): Lepomis marginatus, Etheostoma vivax, Etheostoma chlorosomum, and E. proliare. Morone chrysops probably was rare in collections because it is not commonly captured by seine.

Crystallaria aspella was a new occurrence for the Kiamichi River (Taylor et al., 1995) and Notropis sutkusi (formerly N. rubellus) recently was described by Humphries and Cashner (1994).

No interactions existed between collection date (before or after Sardis Reservoir) and upstream distance in an ANCOVA with species richness as the dependent variable ($F_{2,179} = 0.003, P > 0.997$). There was a significant effect of collection date on the relationship between upstream distance and richness ($F_{2,181} = 33.5, P < 0.04$, Fig. 2). Fisher’s LSD multiple comparisons resulted in significance for comparisons between collections in the earliest time period and collections made in the second time period ($P < 0.02$), and in comparisons between the most recent and second time period ($P < 0.05$). No significant interaction occurred between the date of collection and river distance in a test with Shannon-Wiener diversity as the dependent variable (ANCOVA; $F_{2,179} = 1.1, P < 0.336$) and no significant difference was found for date of collection ($F_{2,181} = 1.4, P < 0.24$). No significant interaction occurred between the date of collection and river distance in a test with evenness as the dependent variable (ANCOVA; $F_{2,179} = 0.28, P < 0.75$) and no significant difference was found for date of collection ($F_{2,181} = 0.03, P < 0.97$; Fig. 2).

There was no significant difference in Jaccard’s similarity index for collections from downstream of the Sardis input ($\bar{X} = 0.38, SD = 0.15$) compared to collections upstream of the input ($\bar{X} = 0.47, SD = 0.14$; ind. $r_2 = -1.1, P < 0.30$; Fig. 3). A significant positive relationship was found between stream distance from the Sardis Reservoir outflow and Jaccard’s similarity index ($R^2 = 0.724; P < 0.012$; Fig. 3). Comparisons of species richness and diversity at the three regularly sampled sites resulted in regression slopes not significantly different than zero for collections at Antlers and Clayton. Species richness and diversity increased with collection date for Big Cedar collections.

There was a significant difference in site scores for the third PC axis from before and after construction of Sardis Reservoir (Table 1). Scores on this axis primarily reflect numbers of Fundulus olivaceus, Notropis atherinoides, and Labidesthes sicculus, with lower numbers in
Fig. 2—Species richness (upper plot), Shannon-Wiener diversity (middle plot), and evenness (lower plot) versus upstream distance of sites for collections made during three time periods.
FIG. 3—Community similarity (Jaccard's index) for collections prior to 1984 and after 1984 and upstream distance for 11 sites. Site numbers are from Fig. 1.

TABLE 1—Principal component loadings greater than 0.500, t-values (T) and associated probabilities (P) from paired t-tests (df = 10) comparing principal component scores for collections before and after construction of Sardis Reservoir (before and after 1984).

<table>
<thead>
<tr>
<th>Species</th>
<th>PC1</th>
<th>PC2</th>
<th>PC3</th>
<th>PC4</th>
</tr>
</thead>
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<tr>
<td><em>Campostoma anomalum</em></td>
<td>0.774</td>
<td></td>
<td></td>
<td></td>
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<td><em>Lepomis megalotis</em></td>
<td>0.772</td>
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<td></td>
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<td><em>Gambusia affinis</em></td>
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<td></td>
<td></td>
</tr>
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<td><em>Lythrurus umbratilis</em></td>
<td>-0.728</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Notropis boops</em></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Oxynelia whippeli</em></td>
<td></td>
<td>-0.756</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Notropis suttkusi</em></td>
<td></td>
<td>-0.678</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Notropis ortenburgeri</em></td>
<td></td>
<td>0.549</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Fundulus olivaceus</em></td>
<td></td>
<td></td>
<td>-0.807</td>
<td></td>
</tr>
<tr>
<td><em>Notropis atherinoides</em></td>
<td></td>
<td></td>
<td>-0.673</td>
<td></td>
</tr>
<tr>
<td><em>Labidesthes sicculus</em></td>
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<td></td>
<td>-0.532</td>
<td></td>
</tr>
<tr>
<td><em>Etheostoma radiosum</em></td>
<td></td>
<td></td>
<td></td>
<td>-0.737</td>
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<tr>
<td><em>Lepomis macrochirus</em></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Notropis volucellus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent of total variance</td>
<td>22.6</td>
<td>18.1</td>
<td>12.8</td>
<td>10.5</td>
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<td>T</td>
<td>-0.685</td>
<td>1.32</td>
<td>2.76</td>
<td>0.415</td>
</tr>
<tr>
<td>(P)</td>
<td>(0.509)</td>
<td>(0.215)</td>
<td>(0.020)</td>
<td>(0.687)</td>
</tr>
</tbody>
</table>
collections after 1984. No differences between

collection periods were found for the other PC

axes (Table 1).

**DISCUSSION**—We found significant changes

in local fish assemblages in the Kiamichi River

in comparisons of collections made before and

after construction of the tributary reservoir.

Basin-wide species richness of fishes did not
decrease. Species richness decreased at local sites

in comparisons between the earliest and sec-

ond collection time period, and increased after

the second collection time period. The in-

crease in local species richness in the third
time period may be due to more sampling dur-
ing this period. Fish community similarity, in

comparisons of local sites from before and af-

ter reservoirs, was a function of distance from

the tributary reservoir. Sites adjacent to the

reservoir outflow were less similar over time

than sites that were farther from the outflow

(Fig. 3), suggesting a negative effect of the re-

ervoir.

We did not find decreases in species richness

and diversity over time at three regularly sam-

pled sites. Species richness and diversity in-

creased over time at the regularly sampled up-

stream site. Only one PC axis was related to
time of reservoir construction: three species of

fishes decreased in abundance after construc-

tion of the tributary reservoir. This PC axis ac-
dcounted for only 13% of total variation.

Eley et al. (1981), working in a nearby river,

the Mountain Fork, found changes in species

composition and decreases in diversity of fish

assemblages from construction of a mainstem

reservoir. One of the major effects of reser-

voirs on fish communities is from disruptions

do natural flow regimes (Travnichek et al.,

1995). Severe alterations in both discharge vol-

ume and seasonality have been observed in the

Kiamichi River below the tributary outflow

(Vaughn, pers. obs.); but without a suitable

control river for comparison we have only

identified correlative evidence. However, an ef-

fect of reservoirs in the Kiamichi River basin

was also found for the endangered mussel, 

*Arkansa wheeleri*. The mussel is extirpated in

reaches of the Kiamichi River below Hugo Res-

ervoir and reduced in abundance below inflow

from Sardis Reservoir (Vaughn and Pyron,

1995). Mussels appear to be more sensitive

than fishes to reservoir-caused environmental

changes (Bogan, 1993).

Echelle and Schnell (1976) predicted that

construction of reservoirs on the Kiamichi Riv-
er would result in increases in lacustrine spe-
cies and decreases in riverine species. This is

not what we observed in our comparisons of

local collections upstream from the mainstem

impoundment. However, such changes would

most likely occur in reaches with lacustrine

habitats (within and downstream of Hugo Re-

servoir, where we did not collect). Winston et

al. (1991) linked the extirpation of four min-

now species in tributaries of the Red River,

Oklahoma to reservoir construction. Migratory

fish species are predicted to be extirpated by

mainstem reservoirs. Known migratory species

in the Kiamichi River include *Anguilla rostrata*

and *Hybognathus nuchalis*; *H. placitus* was col-
lected at a site downstream from ours (Pigg

and Hill, 1974). We do not know if other fish

species we captured are migratory or if reser-

voirs are affecting fish movements.

Our results also likely reflect natural fluctu-

tions in local fish assemblages. Temporal

changes are expected in stream fish assem-

blages from natural disturbances, largely deter-

mined by geographic location and stream or-

der (Detenbeck et al., 1992). Matthews et al.

(1988) used similarity indices and concor-
dance of rank abundance of common fishes to

examine stability and persistence of the Kimi-


They concluded that rank order of common

species varied among years and locations in the

Kiamichi River over a shorter time period

when reservoirs were already in place.

Many river ecosystems are being lost at an

alarming rate (Dynesius and Nilsson, 1994).
The Kiamichi River retains most of it’s species

of fishes and mussels, and the insect fauna is

only beginning to be described. This rich sys-

tem should be protected from further human

alterations of the watershed (reservoirs, in-

creased agriculture, and poor forestry practic-

es).

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ported by the United States Fish and Wildlife Service

and the Oklahoma Department of Wildlife Conser-

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data, and W. J. Matthews, C. M. Taylor, and three
anonymous reviewers for comments on the manuscript.

LITERATURE CITED


TAYLOR, C. M., AND R. WINSTON. 1990. Zoogeographic implications for the first record of Crystallaria asperrila (Percidae) from the Kiamichi River drainage, and for the occurrence of Notropis hoops (Cyprinidae) and Luxilus chrysoscepha/us (Cyprinidae) in the Wichita Mountains, Oklahoma. Southwestern Naturalist 38:302–303.


APPENDIX 1.—Descriptions of collection sites on the Kiamichi River.
Site 1. Lake Hugo. Pushmataha County, T5S, R18E
Site 2. Antlers Bridge. Pushmataha County, T3S, R16E
Site 3. Payne’s Bridge. Pushmataha County, T1S, R16E
Site 4. Dunbar. Pushmataha County, T1S, R17E
Site 5. Stanley. Pushmataha County, T1N, R17E
Site 6. Clayton City Park. Pushmataha County, T1N, R19E

Site 7. Tuskahoma Bridge. Pushmataha County, T2N, R19E
Site 8. Walnut Creek. Pushmataha County, T2N, R21E
Site 9. Albion. Pushmataha County, T2N, R20E
Site 10. Whitesboro. Leflore County, T3N, R22E
Site 11. Muse. Leflore County, T2N, R24E
Site 12. Big Cedar. Leflore County, T2N, R25E