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Fishes of Oxbow Lakes of Washington

Abstract

Fish faunas of oxbow lakes in the Chehalis, Snoqualmie, and Okanogan drainages of Washington were sampled with a minnow seine. For comparison, collections were made in parent streams. We collected fewer fish species from oxbow lakes than from adjacent stream reaches. Most oxbow lake ichthyofaunas were dominated by non-native fishes, while native fishes dominated streams. Numbers of native species and non-native species were not significantly correlated in oxbow lakes ($r = 0.01$), but in Chehalis drainage collections the Olympic mudminnow (*Novumbra hubbsi*) was collected only where we did not collect non-native fishes.

Introduction

Oxbow lakes occur along low gradient, meandering streams. They are formed when a meander is isolated from the parent stream (Reid 1961, Beecher *et al.* 1977). Typically, a number of oxbow lakes occur at irregular intervals along such streams. Different oxbow lakes have been isolated from the parent stream for different lengths of time. Along a parent stream, oxbow lakes vary in age, successional stage, and area or length. Oxbow lake width is approximately equal to parent stream width and does not vary greatly among oxbow lakes along a reach of the parent stream. Consequently, area is proportional to length.

The strictly aquatic fauna of an oxbow lake is derived from the aquatic fauna of the parent stream (Beecher *et al.* 1977). The fauna of the parent stream is a pool of potential colonizers of the oxbow lake when it is formed. The aquatic fauna of the oxbow lake is a selective sample of the aquatic fauna of the parent stream, since isolation of the oxbow lake is a gradual process.

Comparison of a Florida oxbow lake to its parent stream, the Escambia River, showed that the oxbow lake had fewer species of fishes than the parent stream. Reduced habitat diversity was proposed as an explanation for the oxbow lake's lower fish species richness (Beecher *et al.* 1977). In the present study we compared fish species richness in 16 Washington oxbow lakes to that in parent streams.

Magnuson (1976) likened lakes to islands and suggested that they might conform to island biogeography theory. He suggested that introduction of non-native fishes might be expected to cause local extinctions of some other species. If this were true, the number of introduced species should be negatively correlated with the number of

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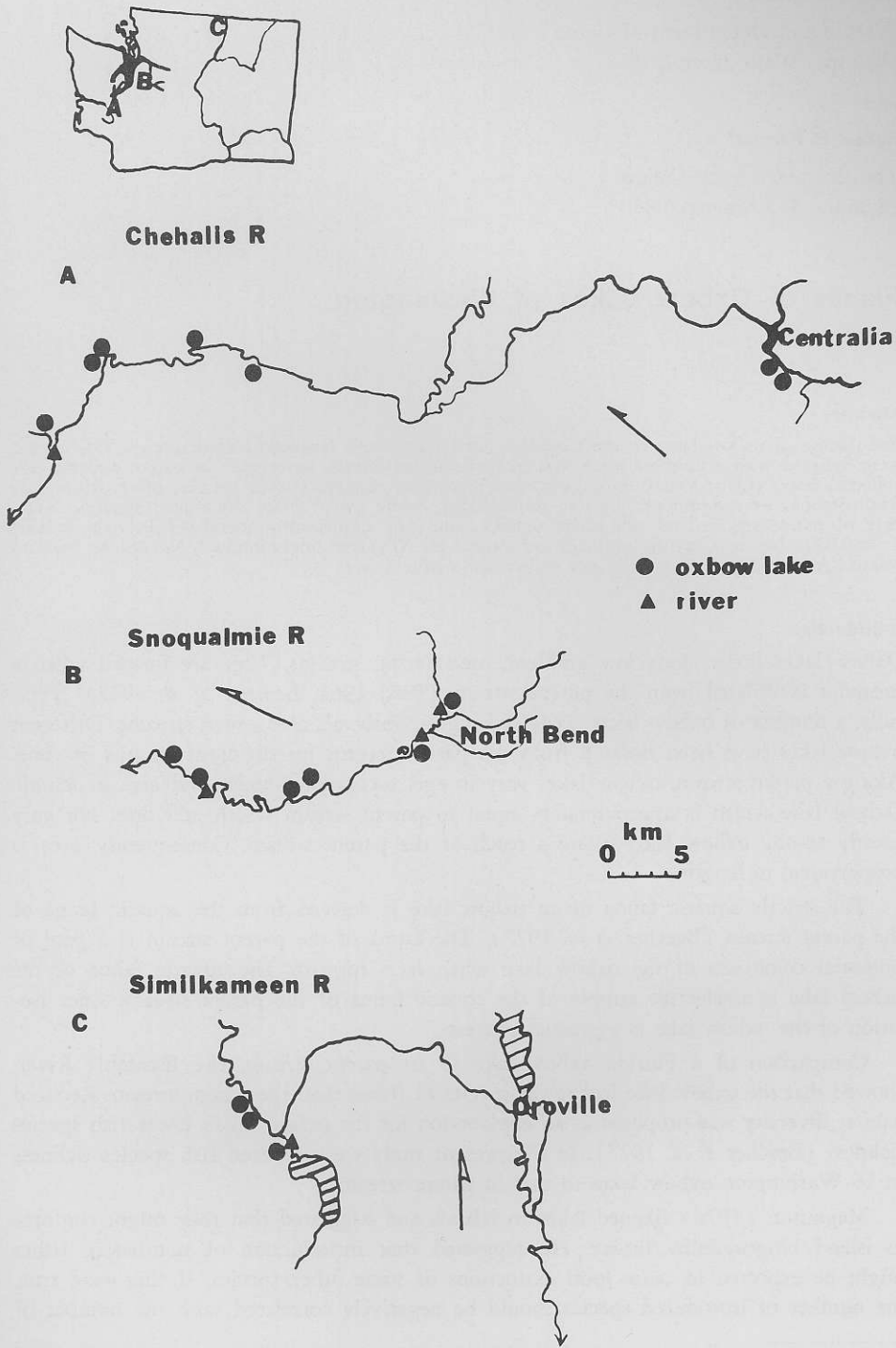


Figure 1. Locations of study sites. Inset shows locations of river systems in the state of Washington.

native species. We examined the relationship between number of native fish species and number of introduced fishes in oxbow lakes.

Methods and Materials

We sampled 16 oxbow lakes and five sites on three parent streams. Study areas were the Chehalis, Snolqualmie (Snohomish), and Similkameen (Okanogan-Columbia) drainages in Washington state (Fig. 1). Using minnow seines of 5.7 x 1.3 m and 4.3 x 1.9 m, with stretch meshes of 5 and 8 mm, respectively, we seined until all accessible habitats were represented in our sampling at each site and until additional seine hauls yielded no additional fish species. We identified, counted, and released salmonids, but other species were preserved in 10 percent formalin for identification and enumeration in the laboratory. Each seine haul was treated as a discrete subsample: the number of species and individuals in individual seine hauls was recorded, with all fish from one seine haul preserved together in a container, but no other specimens went into that container.

Use of small seines reduced our effectiveness in sampling large individuals, but smaller specimens were easily captured. Since most species are represented by more small than large individuals, seine size should not have biased our counts of species greatly. We were unable to sample deep (> 1.5 m) areas effectively.

Results

In all cases we found more fish species in parent streams than in oxbow lakes (Table 1; $t=4.26$, $df=19$, $P<0.01$). The number of fish species in parent stream collections ranged from 6 to 10. The number of fish species in oxbow lakes ranged from 1 to 8. Oxbow lakes with inlet streams generally had more species than did isolated oxbow lakes (Table 2; $t=2.14$, $df=14$, $P=0.05$). The number of species per seine haul followed the same pattern as the number of species per collection, with more species in parent streams than in oxbow lakes (Table 3; $t=2.02$, $df=85$, $P<0.05$).

Among eight species collected only in oxbow lakes, seven were non-native species. The most common non-native fish of oxbow lakes was the largemouth bass (*Micropterus salmoides*), although this was also the only non-native fish we collected in a parent stream; all of the other seven non-native fishes were collected only in oxbow lakes. The prickly sculpin (*Cottus asper*) was the only native fish that we collected only from an oxbow lake. Some oxbow lakes contained only native fishes.

In Washington oxbow lakes, numbers of introduced and native species were not correlated ($r=0.01$, $n=16$, $P>>0.05$). Only native fishes were collected with the Olympic mudminnow (*Novumbra hubbsi*) (Table 4). At each site where we found mudminnows we also collected threespine sticklebacks (*Gasterosteus aculeatus*). The Olympic mudminnow was absent from four Chehalis drainage collections in which non-native fishes were present. The largemouth bass (*Micropterus salmoides*) was either collected, observed, or reported from the four Chehalis basin sites where the Olympic mudminnow was not collected. Segregation of the Olympic mudminnow from non-native fishes appears to be significant ($X^2=8.0$, $df=1$, $P<0.01$).

In contrast to oxbow lakes, in which non-native fishes were a major component of the ichthyofauna, parent streams were dominated by native fishes. Two salmonids, the mountain whitefish (*Prosopium williamsoni*), and rainbow trout (*Salmo gairdneri*),

TABLE 1. Fishes of oxbow lakes and parent streams. Each column represents a different site. N=non-native fish, +=seen but not collected, *=collected.

Species	Chehalis R. Basin		Shoquahmie R. Basin		Similkameen R. Basin	
	parent stream	oxbow lakes	parent stream	oxbow lakes	parent stream	oxbow lakes
Petromyzonidae						
<i>Entosphenus tridentatus</i>	*	*	*			
unid. lamprey ammocoete						
Salmonidae						
<i>Prosopium willamsoni</i>			*	*	*	*
<i>Salmo clarki</i>			*			
<i>S. gairdneri</i>	*	*	*	*	*	*
<i>Oncorhynchus kisutch</i>				*		
Umbridae						
<i>Novumbra hubbsi</i>	*	*	*			
Cyprinidae						
<i>Cyprinus carpio</i> N		+				*
<i>Richardsonius balteatus</i>	*		*	*	*	*
<i>Rhinichthys cataractae</i>	*		*	*	*	*
<i>R. falcatus</i>	*		*	*	*	*
<i>R. osculus</i>	*		*	*	*	*
<i>Ptychocheilus oregonensis</i>		*				*
<i>Mylocheilus caurinus</i>						*
Catostomidae						
<i>Catostomus macrocheilus</i>		*	*	*	*	*
Ictaluridae N						*
<i>Ictalurus nebulosus</i> N		*				*
Gasterosteidae						
<i>Gasterosteus aculeatus</i>	*	*	*	*	*	*
Percidae N						
<i>Percina flavescens</i> N				*		*
Centrarchidae N						
<i>Micropterus salmoides</i> N		+		*	*	*
<i>Ambloplites rupestris</i> N		*		*	*	*
<i>Pomoxis nigromaculatus</i> N		*		*	*	*
<i>Lepomis macrochirus</i> N		*		*	*	*
<i>L. gibbosus</i> N		*		*	*	*
Cottidae						
<i>Cottus confusus</i>	*	*	*	*	*	*
<i>C. rhotheus</i>						
<i>C. asper</i>		*				
<i>C. gulosus</i>	*	*				
Number of species in collection	10	2 2 8 5 3 4 2	6 7 6	3 2 4 2 1 2	7	2 1 4
Number of non-native species in collection	0	0 0 3 4 0 3 1	0 0 0	1 0 2 0 0 1	1	2 1 4
Number of native species in collection	10	2 2 5 1 3 1 1	6 7 6	2 2 2 2 1 1	6	0 0 0

were collected frequently and exclusively in parent streams (Table 1). Several other fishes were collected infrequently but exclusively in parent streams. Among the latter was the redbreast shiner (*Richardsonius balteatus*), including one specimen from Palmer Creek (Similkameen drainage) having a tri-lobed caudal fin.

Discussion

A similarly lower species richness of a Florida oxbow lake compared to its parent stream was found by Beecher *et al.* (1977), who suggested that lower species richness

TABLE 2. Numbers of fishes in oxbow lakes with and without inlet streams.

Oxbow lakes with inlet streams				Isolated oxbow lakes			
n	x	s	range	n	x	s	range
1	8.0	—	8	6	3.0	1.3	2-5
2	3.0	1.4	2-4	4	2.0	0.8	1-3
0	—	—	—	3	2.3	1.5	1-4
Total				13	2.5	1.2	1-5

TABLE 3. Number of fishes per seine haul in oxbow lakes and parent streams.

Oxbow lakes				Parent streams			
n	x	s	range	n	x	s	range
24	2.2	1.3	1-6	8	3.2	2.2	1-7
19	1.5	0.7	1-3	23	2.0	0.8	1-4
8	1.9	1.3	1-4	5	3.0	1.6	1-5
Total				36	2.4	1.6	1-7

TABLE 4. Fish species in Chehalis basin seine collections with and without *Novumbra hubbsi*. Letter indicates native species and number indicates non-native species: A—*Entosphenus tridentatus*, B—*Oncorhynchus kisutch*, C—*Ptychocheilus oregonensis*, D—*Rhinichthys cataractae*, E—*R. osculus*, F—*Richardsonius balteatus*, G—*Catostomus macrocheilus*, H—*Cottus asper*, I—*C. gulosus*, J—*C. rhotheus*, K—*Gasterosteus aculeatus*, 1—*Cyprinus carpio*, 2—*Ictalurus nebulosus*, 3—*Ambloplites rupestris*, 4—*Lepomis gibbosus*, 5—*L. macrochirus*, 6—*Micropterus salmoides*, 7—*Pomoxis nigromaculatus*.

Location	Other native fishes present	Non-native fishes present
Fishes collected with <i>N. hubbsi</i>		
oxbow lake 0.8 km N of Chehalis R. nr South Elma	K	—
oxbow lake 0.1 km N of Chehalis R. nr South Elma	K	—
oxbow lake nr mouth Satsop R. slough at mouth of Satsop R.	I,K	—
	C,D,E,F,I,K	—
Fishes collected where <i>N. hubbsi</i> was not collected		
oxbow lake at Malone	A,B,E,G,I,J	2,3,5,6
oxbow lake at Ford's prairie	K	2,5,6,7
oxbow lake N end golf course, Centralia	H	1,4,(6-observed)
oxbow lake S end golf course, Centralia	C	4,(6-reported by fisherman)

was a result of lower habitat diversity in the oxbow lake. Current velocity alone has a much greater range in streams than in oxbow lakes and could account for the difference in species richness. The range of current velocities also leads to a broader range of substrates in a stream than in an oxbow lake. The greater number of species in oxbow lakes with inlet streams than in isolated oxbows supports the idea that habitat diversity affects species richness in oxbow lakes.

Lack of significant negative correlation between numbers of native and non-native fishes in Washington oxbow lakes suggests that these lakes had not reached a natural, or pre-introduction, equilibrium number of fish species, contrary to Magnuson's (1976) suggestion.

The non-native fishes which successfully invade Washington oxbow lakes are adapted to water with little or no current. Most of these fishes are native to eastern North America, where steep gradients are encountered less frequently than in western North America. In Washington state, few species are adapted to water with little or no current, and, consequently, there has been little displacement. One Washington exception to invasion or introduction without local extinction might be the Olympic mudminnow, an endemic fish of the Chehalis basin and adjacent drainage.

Do oxbow lakes, then, present examples of the filling of "vacant niches?" Hutchinson (1957) stated that "rapid spread of introduced species often gives evidence of empty niches, but such rapid spread in many instances has taken place in disturbed areas." Indeed, a totally undisturbed oxbow lake in Washington would be difficult to find. We did not sample any oxbow lakes not surrounded by farm, pasture, or golf course. The vacant niche concept is controversial (e.g., Mayr 1963: 87; Whittaker *et al.*, 1973: 333; Pianka 1978: 285), and these data do not resolve it.

The Olympic mudminnow is one of the few native fishes adapted to sluggish waters such as those in oxbow lakes. Our data suggest that mudminnows might be excluded from Chehalis drainage oxbow lakes by non-native fishes. Further studies, possibly including experimental introduction of non-native fishes into an oxbow lake containing mudminnows, or the reverse, are needed to test this hypothesis. Habitat disturbance appears inadequate to explain the absence of mudminnows from some oxbow lakes, since similar degrees of agricultural disturbance occurred at oxbow lakes with and without mudminnows.

Because of its restricted range and taxonomic uniqueness (Miller 1964), the Olympic mudminnow is considered a species of special concern by the Endangered Species Committee of the American Fisheries Society (Deacon *et al.* 1979), the Washington Department of Game, and the Washington Natural Heritage Program of The Nature Conservancy. It was listed in Threatened Wildlife of the U.S. (U.S. Office of Endangered Species and International Activities, 1973), an unofficial listing which predated the Endangered Species Act. Introduction of non-native fishes was listed as one of the threats to 24 of 34 fishes listed as endangered or threatened in the United States (Williams and Finnley 1977). A category which included introduction of non-native fishes was listed as a threat to 37 percent of 251 fish taxa listed as endangered, threatened, or of special concern in Canada, the United States, and northern Mexico, but only habitat loss was listed as a threat to the Olympic mudminnow (Deacon *et al.* 1979). However, Moyle (1976) stated that there is only limited evidence showing the direct effect of introductions on California native fishes because of the prevalence of environmental disturbances.

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