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Fish species composition before and after construction of a main stem reservoir on the White River, Colorado

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Synopsis

The completion in the fall of 1984 of Taylor Draw Dam on the White River, Colorado, formed Kenney Reservoir – thus impounding the last significant free-flowing tributary in the Upper Colorado River Basin. Fishes were sampled above and below the dam axis prior to closure of the dam and in the reservoir and river downstream following impoundment. While immediate effects of the dam to the ichthyofauna included blockage of upstream migration to 80 km of documented range for endangered Colorado squawfish, the reservoir also proved to have profound delayed effects on the river's species composition. Pre-impoundment investigations in 1983–1984 showed strong domination by native species above, within, and below the reservoir basin. By 1989–1990, non-native species comprised roughly 90% of the fishes collected in the reservoir and 80% of the fishes collected in the river below the dam. Initially, fathead minnow, whose numbers quickly increased in the new reservoir, dominated all post-impoundment collections, but red shiner became the most abundant fish collected in the river below the dam by 1989–1990. While agency stocking programs for the reservoir sought to emphasize a sport fishery for salmonids, primarily rainbow trout, local enthusiasm for warmwater sport fishes resulted in illicit transfers of these species from nearby impoundments. Several species, formerly rare or unreported in the White River in Colorado, including white sucker, northern pike, green sunfish, bluegill, largemouth bass and black crappie, were present in the river following impoundment. Our investigation indicates smaller-scale, main-stem impoundments that do not radically alter hydrologic or thermal regimes can still have a profound influence on native ichthyofauna by facilitating establishment and proliferation of nonnative species.

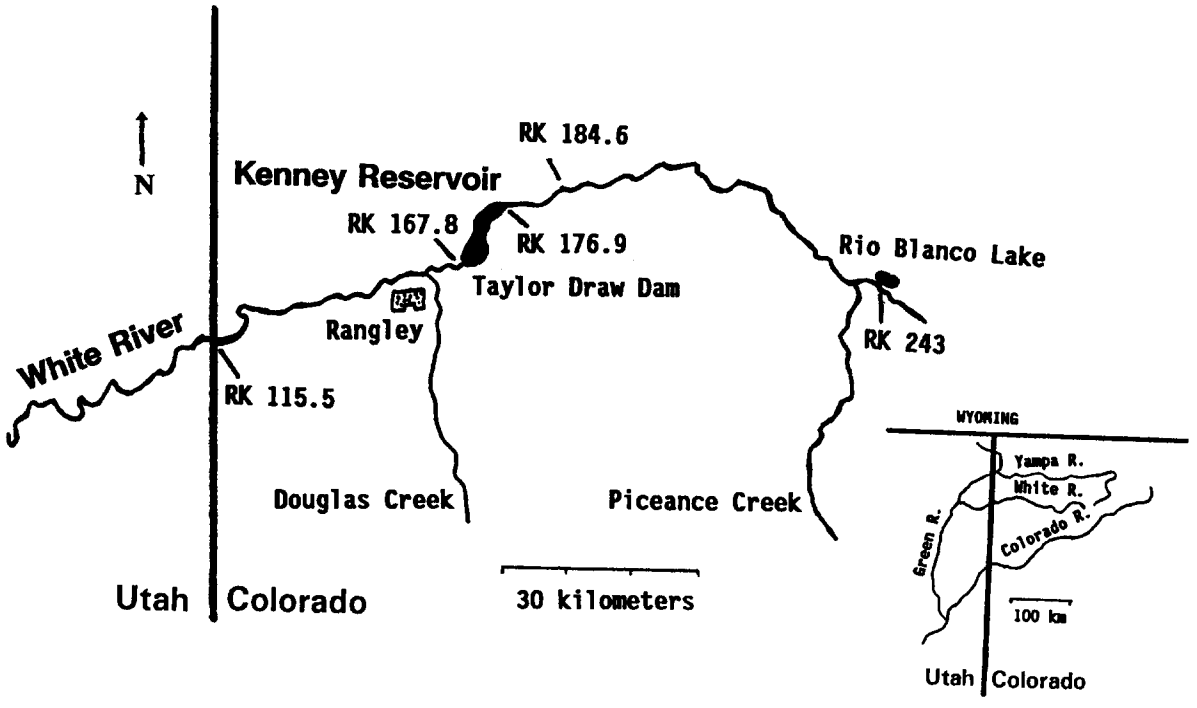

Fig. 1. White River/Kenney Reservoir study area. River kilometers (RK) are demarcated from the confluence of the White and Green rivers in Utah (see inset).

Introduction

Dams and reservoirs have had profound effects on the ecology of the Colorado River system (Mullan et al. 1976, Stanford & Ward 1986a, b, c). Its endemic fishes have been negatively affected by modifications resulting from impoundments (Behnke & Benson,[1] Hickman 1983, Holden & Stalnaker 1975, Miller 1946, 1961, Minckley & Deacon 1968, Tyus et al. 1982, Vanicek et al. 1970). Further, competition with non-native fish species, many of which thrived in the modified environments within and downstream from reservoirs, may also have contributed to the decline of native species (Stanford & Ward 1986c). Effects of damming a river have been classified as immediate and delayed (Holden 1979). Immediate effects include those that become apparent when a dam becomes operational. Delayed effects become evident several years after dam completion (Holden 1979). The closure of Taylor Draw dam on the main stem White River in October 1984, proved to have both immediate and delayed impacts on the river's fish community.

Immediate effects included blockage of upstream migration to 80 km of river known to contain Colorado squawfish *Ptychoceilus lucius* (Martinez,[2] Chart 1986), a large piscivorous minnow listed as endangered by the U.S. Department of the Interior. Summertime aggregations of adult Colorado squawfish below the dam following its closure were believed to be composed of post-spawners returning to home ranges from spawning sites in the Green and Yampa rivers. The death of several of these adult fish in 1985 due to angling activity below the dam prompted an emergency regulation prohibiting angling in this area (Martinez[2]).

In addition to these immediate effects on Colorado squawfish, the fish community of the White River also experienced both immediate and delayed

[1] Behnke, R.J. & D.E. Benson. 1980. Endangered and threatened fishes of the Upper Colorado River Basin. Cooperative Extension Service Bulletin 503A, Colorado State University, Fort Collins. 34 pp.

[2] Martinez, P.J. 1986. White River Taylor Draw Project pre- and postimpoundment fish community investigations. Colorado Division of Wildlife, Fort Collins. 121 pp.

changes in species composition. Construction disturbance of the river channel, habitat conditions of the reservoir, and changes in conditions below the dam all appeared to favor proliferation of certain non-native species. The final provision of the biological opinion issued for the Taylor Draw Reservoir Project (U.S. Department of the Interior, Fish and Wildlife Service, 20 May 1982) required development of a fishery in Kenney Reservoir that would not compete with endangered species in the White River. While agency stocking programs emphasized a salmonid fishery to accommodate this provision, local enthusiasm for warmwater sport fishes resulted in illicit introductions of warmwater sport fishes from nearby impoundments in both Colorado and Utah. In this paper we document these changes in the ichthyofauna in the White River, Colorado, following the construction of Taylor Draw Dam and formation of Kenney Reservoir.

Study area

The White River was one of the few remaining free-flowing tributaries in the entire Colorado River Basin (Stanford & Ward 1986a). A major tributary in the Green River subbasin (Fig. 1), the White River drains more than 13 000 km^2 in Colorado and Utah. The White River flows about 400 km from its source in Colorado's Flattop Mountains to its confluence with the Green River at Ouray, Utah. Locations along the river were demarcated as river kilometers (RK) upstream from its confluence with the Green River.

Taylor Draw Dam was completed on the White River in October 1984, about 16 km east of Rangely, Colorado, at RK 167.8. Kenney Reservoir, which filled by January 1985, inundated about 10 km of the river (to RK 176.9; Fig. 1). The reservoir was originally 275 ha, had a maximum depth of 15.2 m, and a volume of 17 million cubic meters of water at a maximum elevation of 1620 meters above sea level; however, these capacities have decreased an undetermined amount due to sediment deposition, particularly in the upper portion of the reservoir (Trammell 1991). Kenney Reservoir is about 8 km long and 1.2 km at its widest point. Aside from impoundment, the dam's influence on hydrologic and thermal conditions in the White River were subtle (Chart & Bergersen 1992).

Fish collections were made from RK 115.5, the Colorado/Utah stateline, to RK 184.6, about 9 km above the reservoir basin. The White River in this area ranged in width from 20 to 50 m. Channel substrates were primarily cobble and rubble in flowing areas and silt and sand in slower moving sections. The hydrologic regime is characterized by extremes in flow, with highest discharge during snowmelt in spring and early summer, and lowest in late summer and early fall. Turbidities of the river are typically high in spring and during summer rainstorms. Summer water temperatures exceed 20° C, and the environment has been described as coolwater/warmwater (Martinez[2], McConnell et al.[3]). This segment of the White River meanders through an agricultural valley bordered by low rocky hills. Near the Colorado/Utah state line, surrounding lands become more barren as the river flows through canyon areas. This topography supports vegetation characteristic of this semi-arid region (Wullschleger 1990).

Investigations of the river's fish community in Colorado in the years preceding construction of the dam showed that native species dominated (Carlson et al.[4] and Tyus et al. 1982). Fish collections reported in Carlson et al.[4] during 1975–1977 revealed that seven native species comprised 94.0% of fishes collected while five non-native species accounted for 6.0%. Miller et al.[5] recorded five native species accounting for 75.8% of the ichthyofauna and six non-native species comprising 24.2% in two reaches included in our study area. Lanigan & Berry (1981) showed non-native species dominated fish collections in Utah in 1978–1979, but native fishes

[3] McConnell, W.J., E.P. Bergersen & K.L. Williamson. 1984. Habitat suitability index models: a low effort system for planned coolwater and coldwater reservoirs (revised). U.S. Fish and Wildlife Service FWS/OBS-82/10.3A, Fort Collins. 62 pp.

[4] Carlson, C.A., C.G. Prewitt, D.E. Snyder, E.J. Wick, E.L. Ames & W.D. Fronk. 1979. Fishes and macroinvertebrates of the White and Yampa River, Colorado. Biological Sciences Series 1, Bureau of Land Management, Denver. 276 pp.

[5] Miller, W.H., D.L. Archer, H.M. Tyus & K.C. Harper. 1982. White River fishes study. Colorado River Fishery Project, U.S. Fish and Wildlife Service, Salt Lake City. 23 pp.

Table 1. Numbers of fishes collected in the White River, Colorado, above Kenney Reservoir basin (river kilometers 176.9–184.6) from 1983–1985, and below Taylor Draw Dam (river kilometers 115.5–167.8) from 1983–1985, and 1989 and 1990. Sampling methods included combinations of drift nets (d), electrofishing (e), gill nets (g), and seining (s) as indicated. * = < 0.5%.

	Above reservoir			Below dam				
Year	1983	1984	1985	1983	1984	1985	1989	1990
Sampling methods	e,s	e,s	e,s	e,s	e,s	e,s	d,g,s	d,g,s
		Native						
Roundtail chub	186	463	128	1562	1609	902	758	3377
	5.0	**2.7**	**1.3**	**20.0**	**8.2**	**2.4**	**3.2**	**8.4**
Colorado squawfish	1	1	1	1	5	7	223	110
	*	*	*	*	*	*	**0.9**	*
Speckled dace	1226	3469	1704	2452	4235	12629	600	720
	33.1	**20.1**	**17.3**	**31.4**	**21.4**	**33.7**	**2.6**	**1.8**
Bluehead sucker	1138	8237	2467	2346	4509	6607	47	2
	30.8	**47.8**	**25.1**	**30.0**	**22.9**	**17.7**	*	*
Flannelmouth sucker	1032	2985	3232	1222	3508	7792	2513	5249
	27.9	**17.3**	**32.8**	**15.6**	**17.8**	**20.8**	**10.7**	**13.0**
Mountain whitefish	15		13	34	2	18	25	33
	*		*	*	*	*	*	*
Mottled sculpin	4	12	3	1		1	3	
	*	*	*	*		*	*	
Total native	3602	15167	7548	7618	13868	27956	4169	9491
		Non-native						
Red shiner	56	116	18	14	792	133	11591	18406
	1.5	**0.7**	*	*	**4.0**	*	**49.5**	**45.6**
Common carp	17	24	3	78	136	205	1136	2684
	0.5	*	*	**1.0**	**0.7**	**0.5**	**4.8**	**6.6**
Fathead minnow	12	1920	2101	25	4828	8769	6140	7944
	*	**11.1**	**21.3**	*	**24.5**	**23.4**	**26.2**	**19.7**
Black bullhead				2	7	2	48	1604
				*	*	*	*	**4.0**
Channel catfish	11	5	7	76	67	98	20	2
	*	*	*	**0.9**	*	*	*	*
Rainbow trout			170			254	6	1
			1.7			**0.7**	*	*
Brown trout							9	
							*	
Green sunfish							13	80
							*	*
Largemouth bass							1	
							*	
Black crappie						1	300	143
						*	**1.3**	*
Total non-native	96	2065	2299	195	5831	9461	19263	30864
Total fish	3698	17232	9847	7813	19699	37417	23432	40355

Table 2. Numbers of fishes collected in the White River, Colorado, encompassed by Kenney Reservoir basin (river kilometers 167.9–176.8), 1983 and 1984, and in Kenney Reservoir, 1985 and 1987–1990. Sampling methods included combinations of electrofishing (e), gill nets (g), and seining (s) as indicated. * = < 0.5%.

	River		Reservoir				
Year	1983	1984	1985	1987	1988	1989	1990
Sampling methods	s	s	e,s	e,g,s	e,g,s	e,g,s	e,g,s
	Native						
Roundtail chub	344	992	604	63	333	595	1688
	12.0	**7.4**	**2.7**	**11.5**	**4.4**	**0.7**	**1.9**
Colorado squawfish					66	246	325
					0.9	*	*
Speckled dace	709	3696	405	4	407	481	477
	24.8	**27.5**	**1.8**	**0.7**	**5.4**	**0.7**	**0.5**
Bluehead sucker	1440	5614	5866	75	198	123	105
	50.4	**41.8**	**26.8**	**13.8**	**2.6**	*	*
Flannelmouth sucker	343	1601	1621	70	1309	6942	5257
	12.0	**11.9**	**7.4**	**12.8**	**17.2**	**10.0**	**5.9**
Mountain whitefish					8	2	17
					*	*	*
Mottled sculpin			1				
			*				
Total native	2836	11903	8497	212	2321	8389	7869
	Non-native						
Red shiner	8	143	144	8	28	251	99
	*	**1.1**	**0.7**	**1.5**	*	*	*
Common carp			24	37	73	211	746
			*	**6.8**	**1.0**	*	**0.8**
Fathead minnow	13	1380	13208	191	3519	57099	64302
	*	**10.3**	**60.2**	**35.0**	**46.4**	**82.6**	**72.6**
White sucker						63	14
						*	*
Black bullhead				7	1309	29	28
				1.3	**17.2**	*	*
Channel catfish				10	5	3	1
				1.8	*	*	*
Rainbow trout			47	78	286	396	82
			*	**14.3**	**3.8**	**0.6**	*
Brown trout				3		2	
				0.5		*	
Green sunfish					2		
					*		
Bluegill					4		158
					*		*
Largemouth bass					1		
					*		
Black crappie					34	2660	15220
					*	**3.8**	**17.2**
Total non-native	21	1523	13423	334	5261	60714	80650
Total fish	2857	13426	21920	546	7582	69103	88519

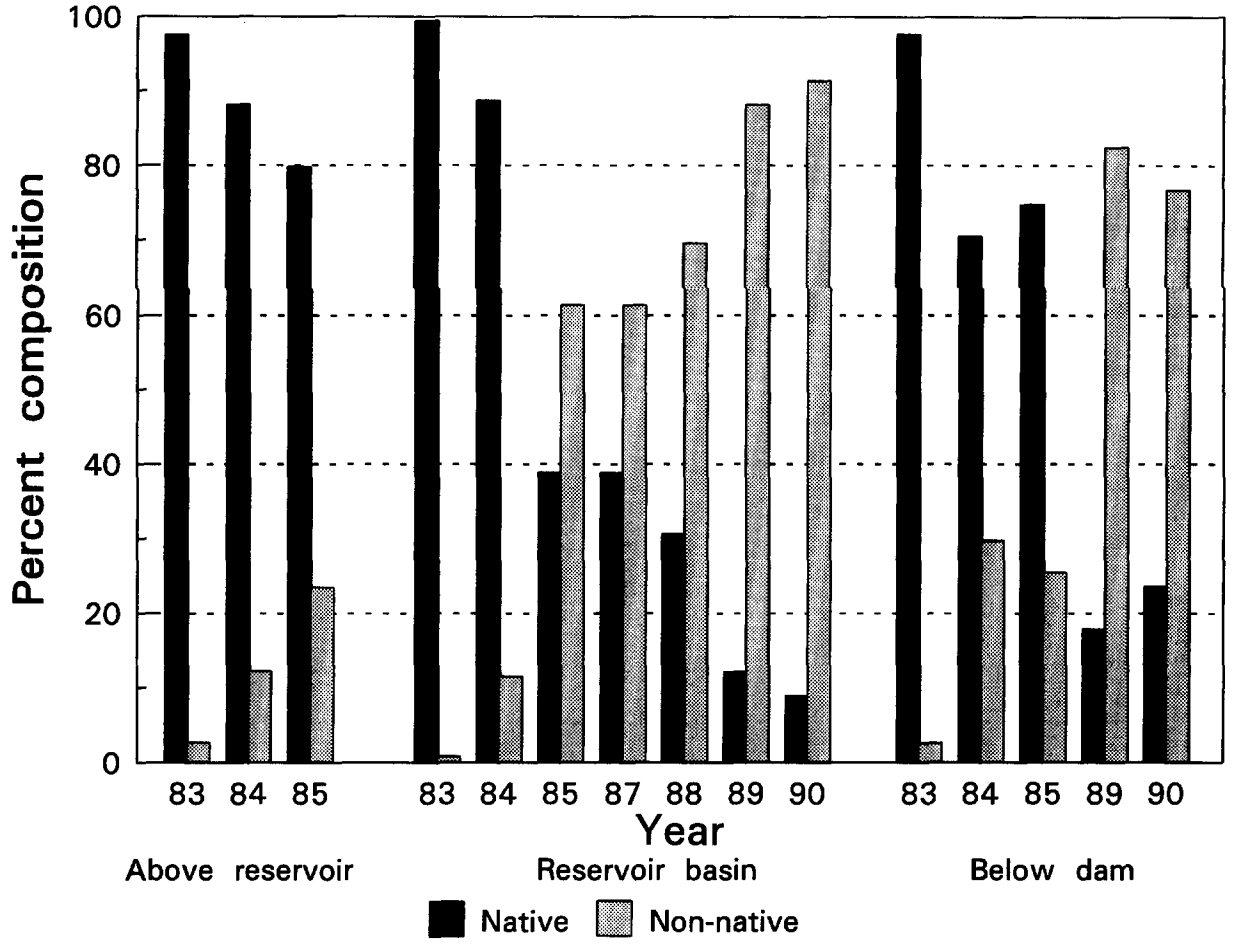

Fig. 2. Percentage comparison of native and non-native fishes sampled above Kenney Reservoir basin, within the basin and reservoir following completion, and downstream of Taylor Draw Dam, 1983–1990.

comprised the greater proportion in samples nearest to the Colorado/Utah stateline. These studies indicate prior to this investigation, the ichthyofauna of the White River within the section described in this paper was dominated by native species.

Methods

Fish samples were taken above the reservoir basin from RK 176.9–184.6 (1983–1985), within the river and basin encompassed by the reservoir from RK 167.9–176.8 (1983–1985, 1987, 1989–1990), and below Taylor Dam from RK 115.5–167.8 (1983–1985 and 1989–1990). Sampling in the river was performed by various combinations of seining, electrofishing, gill netting, and drift nets, typically from June to October. Details of these samplings are given in Martinez, Chart (1987) and Trammell (1991). Seining was performed in backwater and low velocity habitats using a 4.5 ×1.2 m two-man seine with 15 mm mesh. Electrofishing (pulsed DC) from a boat was performed during the day along shoreline areas in all habitat types. Gill nets (multifilament 45.7 × 3.6 m × 19 mm square mesh or 30.5 m × 1.5 m × 19 mm square mesh) were used immediately below the dam and in the reservoir. Drift nets (0.6 m × 2.4 m frames holding 1.2 m diameter trawls fitted with 6.3 mm mesh) were set in the channels directly below the spillway. In addition to gill nets, sampling in the reservoir was conducted using bag seines and electrofishing gear. The seine, 12.2 × 1.2 m, 9.5 mm wing mesh and 3.2 mm bag mesh, was used to sample shoreline areas. Electrofishing was

performed using boat-mounted equipment at night near shore along the reservoir's length. Gill nets were set overnight in all major habitats (shallow and deep coves, cliff and sloping areas, surface, bottom and midlake). Seining accounted for 85–99% of fishes collected (Martinez[2], Trammell 1991). Typically, larger fish, and all Colorado squawfish, were identified and released. Large samples of small fish were preserved in 10% formalin and returned to the laboratory for identification and enumeration.

Results

Pre-impoundment species composition

Fish samples taken in 1983–1984 prior to closure of Taylor Draw dam were dominated by four native species; roundtail club *Gila robusta,* speckled dace *Rhinichthys osculus,* bluehead sucker *Catostomus discobolus* and flannelmouth sucker *Catostomus lattipinnis* (Tables 1, 2). Three other native species reported in pre-impoundment collections, Colorado squawfish, mountain whitefish *Prosopium williamsoni* and mottled sculpin *Cottus bairdi,* comprised no more than 0.5% in 1983 or 1984. Overall, native species accounted for over 97% of the fish collected in 1983 (Fig. 2). In 1984, dominance by native species persisted, but not as overwhelmingly as observed in 1983. Species composition above the dam construction site in 1983 was about 88% native and 12% non-native while below the dam axis 70.4% of the fish collected were native and 29.6% were non-native.

Among introduced species, fathead minnows *Pimephales promelas* were rarely collected in 1983, but after 1984, fathead minnow numbers increased dramatically in samples both above and below the dam axis (Tables 1, 2). The greater proportion of this species below the dam axis may have been due to ponding in the vicinity of the dam construction area that probably enhanced fathead minnow reproduction. Additionally, other non-native species were collected including red shiner *Cyprinella lutrensis,* common carp *Cyprinus carpio,* black bullhead *Ameiurus melas* and channel catfish *Ictalurus punctatus,* none exceeding 1.5%. A single, 200 mm black crappie *Pomoxis nigromaculatus* was sampled below the dam in 1984 (Table 1). These data further substantiated preimpoundment dominance by native fishes within the study area (Fig. 2).

Post-impoundment fish community changes

The White River fish community began showing increased abundance of non-native species in 1984, during construction of the dam; however, marked changes occurred primarily in the reservoir in 1985, the first year of impoundment. Fathead minnows increased from 10.3% in the pre-impoundment reservoir basin in 1984 to 60.2% of all fishes collected in the reservoir in 1985 (Table 2). In this initial year of impoundment, relative abundance of other non-native species remained low. The most marked decrease among native species in the reservoir was observed for speckled dace. Comprising about 20% to 30% of the fish collected throughout the study area before impoundment, speckled dace accounted for only 1.8% of the fish collected in the reservoir in 1985.

Subsequent fish collections made in the reservoir in 1987 consisted of 61.2% non-native species (Fig. 2). Although fathead minnow numbers dominated samples, and undoubtedly the reservoir's fish population, their relative abundance was offset by increased collection of stocked rainbow trout *Oncorhynchus mykiss* (Table 2). Originally stocked as the reservoir began to fill in 1984, rainbow trout have been stocked annually to provide a sport fishery in Kenney Reservoir. The apparent increase in relative abundance of roundtail club, flannelmouth sucker, and common carp in 1987 seemed due to their susceptibility to gill nets set in shallower depths. Bluehead sucker abundance, however, was much lower in the reservoir in 1987 than in 1985. Numbers of speckled dace collected in 1987 continued to be conspicuously low.

Fathead minnows also dominated reservoir fish collections (46.4%) in 1988 (Table 2). Black bullheads increased from 1.3% in 1985 to 17.2% (over 99% young-of-year) in 1988. The presence of adult-sized green sunfish *Lepomis cyanellus*, bluegill *Lepomis machrochirus*, largemouth bass *Micropterus*

salmoides and black crappie was attributed to illicit introductions. Of the other native species collected, most declined or increased little in relative abundance from previous observations, except Colorado squawfish. Their appearance was due to the stocking of 17 000 juveniles in April 1988 as part of an experiment to determine if they could be managed in a reservoir environment as a sport fish (Trammell 1991, Trammell et al. 1993).

Native fishes comprised only 12.1% of fish collected in the reservoir in 1989 (Fig. 2) while the remainder were non-native species, primarily fathead minnows (Table 2). While percentages of other non-native species were low, black crappie increased in relative abundance. Rare in 1988, black crappie composed 3.8% of all fishes collected in the reservoir in 1989. White suckers *Catostomus commersoni* were first recorded in the reservoir in 1989. The only native species composing a notable percentage in the reservoir was the flannelmouth sucker (10%); all other native species accounted for less than 1.0% in 1989. Of 246 Colorado squawfish collected in the reservoir in 1989, 243 were from 32 000 fingerlings that had been stocked in April 1989. The other three specimens had been stocked in 1988 (Trammell 1991, Trammell et al. 1993).

Non-native species in reservoir fish collections increased to 91.1% in 1990 (Fig. 1). Fathead minnow numbers remained high (72.6%), their abundance probably facilitating rapid expansion of black crappie whose numbers rose to 17.2% in 1990 (Table 2). Relative abundance of other non-native species was low, although common carp and bluegill were collected in greater numbers than in 1989. Collection of white suckers in 1990 suggested that they had become permanent residents within the drainage. Six native species accounted for only 8.9% of the fishes in 1990 reservoir samples with flannelmouth sucker (5.9%) and roundtail chub (1.9%) being the only species collected in appreciable numbers. Colorado squawfish collected in 1990 were from the final plants of juveniles in May (32 000), August (1 397), and September (14 200) (Trammell 1991, Trammell et al. 1993).

Fish collections above Kenney Reservoir following impoundment were made only in 1985. While native fishes dominated (79.9%), fathead minnows, particularly in the reservoir inflow, accounted for over 90% (Table 1) of the 23.3% non-native fish component (Fig. 2). Prior to impoundment, fish collections above the reservoir basin were dominated by three native species, speckled dace – 17.3%, bluehead sucker – 25.1%, and flannelmouth sucker – 32.8%.

After impoundment in 1985, native species, primarily speckled dace, bluehead sucker and flannelmouth sucker, comprised 74.7% of fishes collected in the river below Taylor Draw Dam (Table 1, Fig. 2). Fathead minnows, comprising 23.4% of all fishes collected in 1985, greatly outnumbered all other non-native species, none of which exceeded 1%. In 1989 and 1990, fish collections below the dam were roughly 80% non-native and only 20% native. The two native species seemingly most affected following impoundment were bluehead sucker and speckled dace. Both species formerly shared dominance among native fishes with flannelmouth sucker and roundtail chub in both pre- and post-impoundment collections below the dam. In 1989–1990, speckled dace composed about 2% of all fishes collected below the dam while bluehead sucker accounted for less than 0.5%. Increased captures of Colorado squawfish below the dam in 1989–1990 resulted from escapement of juveniles stocked in the reservoir (Trammell 1991, Trammell et al. 1993).

Non-native red shiner and common carp showed the most notable increases below the dam (Table 1). While fathead minnows composed 20–26% of the fishes collected below the dam in 1989 and 1990, red shiners outnumbered them two-fold in both years becoming the most collected species below the dam. Common carp, scarce in this segment of the White River prior to impoundment, increased noticeably in both 1989–1990, particularly the incidence of juveniles in seine samples (Trammell 1991). As believed in the case of common carp, increased abundance of black crappie below the dam in 1989–1990 most likely resulted from increased abundance of these species in the reservoir. These black crappie young-of-year and juveniles, were taken in seine or drift net samples (Trammell 1991).

Discussion

Effects on the native fish component

Holden (1979) considered riverine fishes to include obligate and facultative riverine species. He further divided obligate riverine species into species requiring rivers for all their ecological needs and those requiring rivers for a portion of their life history. The effect of damming a river on obligate riverine species is generally negative and is a major cause in the decline of these species (Holden 1979). Observations made during this study, suggest the most obligate riverine species, *i.e.* Colorado squawfish, speckled dace and bluehead sucker, were most affected by impoundment of the White River.

During our study, a single wild Colorado squawfish was captured above the dam following its closure. This adult specimen, captured in 1985, was the last wild Colorado squawfish verified in the White River above Taylor Draw Dam. Adult Colorado squawfish from the White River undertake extensive potamodromous migrations for spawning in the Green and Yampa rivers (Martinez[2], Tyus 1990). Martinez[2] reported the migrations of one adult Colorado squawfish captured near Rangely, Colorado, in 1983. This fish, recaptured near known spawning sites in the Yampa River in 1984, was subsequently caught by an angler in the White River near its original capture site in 1985, thus confirming at least 700 km of upstream and downstream movements in three rivers (Martinez[2]). The effect on Colorado squawfish, formerly resident in the river above the dam prior to impoundment, becomes obvious. Further, stocking there does not seem a long-term solution to maintaining this species in its historic range above Taylor Draw Dam (Trammell 1991, Trammell et al. 1993).

The decline in relative abundance of both speckled dace and bluehead sucker following impoundment is probably attributable to their obligate riverine life histories. Speckled dace, a more lotic adapted species (Minckley 1973, Woodling,[6] Sublette et al. 1990), and bluehead sucker, largely limited to relatively swift-flowing waters over cobble or gravel (Baxter & Simon 1970, McAda & Wydoski 1983, Sublette et al. 1990), displayed an affinity for flowing habitats in the White River (Chart 1987). While their reduced abundance in the reservoir could be attributed to their lotic preferences, reductions of these species below the dam in 1989–1990 was not as readily explained.

Chart (1987) reported speckled dace reproduction to be especially high below the dam in 1985. He suggested that habitat preference of adult speckled dace should preclude competition with the burgeoning fathead minnow population, but young speckled dace would likely face considerable competition from this species. Red shiner, the most abundant species below the dam in 1989–1990, may be a serious competitor with native species in the Colorado River Basin (Holden 1979, Nesler[7]). The combined effects of fathead minnow and red shiner (Karp & Tyus 1990) may have contributed to the reduction of speckled dace. Because speckled dace are short-lived (few live beyond 3 years, Sigler & Sigler 1987), mortality of their young due to competition and lack of recruitment may explain their demise below the dam.

Chart (1987) suggested bluehead suckers in the lower reaches of the White River in Colorado came from reproduction by this species in and above the vicinity of Kenney Reservoir. This belief was substantiated by Lanigan & Berry (1981) who showed bluehead suckers in the White River in Utah were scarce, composing less than 0.5% of all fish collected. During our investigation, bluehead suckers were most abundant above the dam axis from 1983 to 1985. Chart (1987) attributed the reduction in young-of-year bluehead suckers below the dam in 1985 to poor drift of larvae through the reservoir. He further reasoned that this loss of supplemental recruits from upstream spawning areas would result in the long-term decline of bluehead suckers below the dam. This mechanism explained the stark reductions of this species below the dam in 1989–1990.

[6] Woodling, J. 1985. Colorado's little fish: a guide to the minnows and other lesser known fishes in the state of Colorado. Colorado Division of Wildlife, Denver: 77 pp.

[7] Nesler, T.P. 1991. Endangered fishes investigations. Job Progress Report, Federal Aid in Fish and Wildlife Restoration Project SE-3, Colorado Division of Wildlife. Fort Collins. 69 pp.

Young-of-year and older juvenile bluehead suckers dominated seine samples from the White River from 1983 to 1985 (Martinez[2], Chart 1987); seining was also the principle means of sampling fish in the river in 1989–1990 (Trammell 1991).

While evidence is lacking to show roundtail chub and flannelmouth sucker benefitted from impoundment of the White River, neither should be as adversely affected as bluehead sucker and speckled dace. Roundtail chubs and flannelmouth suckers continued to be commonly collected in Kenney Reservoir, although their abundance relative to numbers of non-native fishes was low. Behnke[8] predicted roundtail chub would increase following impoundment. Chart (1987) suggested roundtail chub, unless replaced by further introductions of non-native species, could flourish in Kenney Reservoir. Chart & Bergersen (1992) indicated Taylor Draw Dam would not affect flannelmouth suckers in the White River due to their distribution and movement patterns. Both roundtail chub and flannelmouth sucker occur in reservoirs (Baxter & Simon 1970); both occur in Elkhead Reservoir, an off-stem impoundment in the Yampa River drainage where their persistence indicates recruitment has occurred (Martinez unpublished data).

Mountain whitefish and mottled sculpin inhabit the White River, primarily upstream of Kenney Reservoir (Tyus et al. 1982). Immediate effects of impoundment on these species appeared negligible and significant delayed effects are not expected.

Consequences of non-native fishes

Lanigan & Berry (1981) suggested native fishes in the White River in Utah were being replaced by non-native species. They believed habitat deterioration and competition were operative in the lower White River, and were responsible for a pattern of native fish displacement in other western rivers and streams. While they demonstrated the relative abundance of native fishes was greater than that of non-native species in their uppermost stations nearest to Colorado, non-native species accounted for 80.4% of the fish collected in their middle and lower stations (Lanigan & Berry 1981). Replacement of the predominantly native ichthyofauna by non-native fishes in the lower White River in Colorado was facilitated and certainly greatly accelerated by construction of Kenney Reservoir. Relative abundance of non-native species in the White River below Taylor Draw Dam in 1989 and 1990 averaged 79.4%; thus, in less than a decade, the riverine ichthyofauna of the lower White River in Colorado has shifted from 90% native to 80% non-native species.

All non-native fish species recorded during this study were formerly known to occur in the White river drainage, either upstream or downstream of the study site or in Rio Blanco Lake, a shallow, off-stem impoundment at RK 243 (Fig. 1) managed for warmwater sport fishes. Nesler[7] listed six non-native species posing the greatest threat to native fishes in the upper Colorado River basin: red shiner, common carp, fathead minnow, channel catfish, northern pike, and green sunfish. In addition, McConnell et al.[3] predicted Kenney Reservoir would provide highly suitable habitat for common carp, white sucker and black crappie. While non-native species collected during this investigation, except largemouth bass, had been previously reported from the White River (Tyus et al. 1982, Martinez[2]), none were formerly dominant in the river in Colorado.

Red shiner was reported by Lanigan & Berry (1981) and Miller et al.[5] to be the most abundant fish from their lowermost stations in the White River, Utah. The combined percentage for red shiner in these stations was about 66% in 1978 and 1979 (Lanigan & Berry 1981) and 1981 (Miller et al.[5]). Formerly composing much lower percentages in the White River in Colorado prior to impoundment (Carlson et al.[4], Miller et al.[5]), red shiner accounted for about 47% of all fishes collected in 1989 and 1990. It appears the segment of the White River in which red shiners dominate has increased by more than 50% since impoundment.

Common carp and fathead minnow were rare in the White River in Colorado prior to formation of Kenney Reservoir (Tyus et al. 1982). Carlson et al.[4] and Miller et al.[5] showed neither species accounted

[8] Behnke, R.J. 1981. Taylor Draw Reservoir: aquatic biology assessment. Western Engineers Inc., Grand Junction. 16 pp.

for more than 5% of the fishes collected during their studies. McConnell et al.[3] suggested prevailing habitat conditions in Kenney Reservoir would favor common carp. While common carp numbers did not increase as rapidly as expected (Chart 1987), its numbers in the reservoir did increase and its relative abundance below the dam increased noticeably. We expect the segment of the White River below the dam where common carp and fathead minnow are common will extend downstream in time.

White suckers were reported by Pettus[9],[10] from the White River near the mouth of Piceance Creek. These records were questioned by Carlson et al.[4] because white suckers had not been reported in the White River by other investigators. Tyus et al. (1982) also considered the species to be absent in the White River, however, a single specimen was reported in collections from the White River in Utah by ERI.[11] It appears white suckers were virtually absent in the White River prior to impoundment, and none were found in our river collections. The individuals captured in Kenney Reservoir in 1989–1990 were taken in gill nets by Trammell (1991) who found no evidence of reproduction or recruitment. Despite this it seems that white sucker abundance and distribution will increase due to favorable habitat conditions for this species in the reservoir (McConnell et al.[3]).

In addition to concerns about non-native fishes replacing native species, juveniles of endangered fishes in nursery backwaters of the Green River in Utah (Archer & Tyus[12]) may be at greater predation risk if Kenney Reservoir becomes a chronic source of non-native piscivores. Martinez believed warmwater sport fish escaping from Rio Blanco Lake (Fig. 1) prior to formation of Kenney Reservoir would not proliferate in the White River due to the lack of suitable habitat. However, Kenney Reservoir offers more favorable habitat for these species and may contribute to their increased abundance and distribution (Martinez[2], Trammell 1991). Concern about northern pike *Esox lucius* from Rio Blanco Lake proliferating in the White River as they did in the Yampa River following their escape from Elkhead Reservoir was a primary factor warranting isolation of Rio Blanco Lake following impoundment of the White River (Martinez[2]). No northern pike were collected during our investigation; however, two were caught by anglers in the White River below Taylor Draw Dam, one each in 1987 and 1990. Anglers also reported catching northern pike in Kenney Reservoir in 1989–1990 (Trammell 1991). Behnke[8] suggested that this species would flourish in Kenney Reservoir if introduced there; however, no evidence to date indicates this species has become established in the White River.

Wiltzius[13] reported channel catfish were stocked in the White River in 1910. Lemons[14] stated channel catfish inhabited the White River in Colorado only within the lower 32 km from Rangely to the state line. Habitat suitable for channel catfish in the White River is poor in comparison to other rivers in western Colorado (Lemons[14]). This species was considered rare throughout the White River (Carlson et al.[4], Lanigan & Berry 1981, Tyus et al. 1982), and this continued to be the case during our investigation. Lemons[14] found no evidence of reproduction by this species, and only a single young-of-year specimen was collected near the state line in 1985 (Martinez[2]). Behnke[8] predicted channel catfish would increase in Kenney Reservoir, however, the number of channel catfish collected in the reservoir decreased during our investigation. Their decline was most likely due to harvest by anglers and lack of natural reproduction due to inadequate temper-

[9] Pettus, D. 1973. Cold-blooded vertebrates of the Piceance Creek Basin, Rio Blanco and Garfield counties, Colorado. Thorne Ecological Institute, Boulder. 19 pp.

[10] Pettus, D. 1974. Inventory and impact analysis of fishes, Piceance Creek Basin, Rio Blanco and Garfield counties, Colorado. Thorne Ecological Institute, Boulder. 13 pp.

[11] Ecosystem Research Institute (ERI). 1983. Investigation of fish distribution, habitat, and food preference in the White River, Utah and Colorado for White River Shale Oil Corporation, Logan. 162 pp.

[12] Archer, D.L. & H.M. Tyus. 1984. Colorado squawfish spawning study, Yampa River. U.S. Fish and Wildlife Service, Salt Lake City. 34 pp.

[13] Wiltzius, W.J. 1985. Fish culture and stocking in Colorado, 1872–1978. Division Report No. 12, Colorado Division of wildlife, Fort Collins. 102 pp.

[14] Lemons, D.G. 1955. Channel cat study. Project Number 121, Colorado Game. Fish and Parks Department, Fort Collins. 9 pp.

atures (Martinez unpublished data). Unless stocked, channel catfish should not increase in abundance in Kenney Reservoir or in the White River above the reservoir.

Green sunfish were considered rare in the White River and restricted largely to Utah (Tyus et al. 1982). Adult and young-of-year green sunfish were collected below the dam in 1989–1990 suggesting this species could spread throughout in the lower White River. Conditions in Kenney Reservoir proved favorable for black crappie; this species reproduced successfully in the reservoir and may reproduce in the river immediately below the dam (Trammell 1991). Reports of black crappie in the White and Green rivers near their confluence in Utah in 1989 (S. Cranney personal communication) confirmed that its distribution increased greatly beyond that reported by Tyus et al. (1982). Other warmwater sport fish collected, black bullhead, bluegill and largemouth bass, are not expected to increase dramatically, but the reservoir provides more favorable habitat for them than occurred in the unimpounded White River.

Large numbers of trout stocked in Kenney Reservoir moved over the dam resulting in as many trout being harvested in the plunge pool and channels immediately below the dam as in the reservoir itself. While trout were reported in the White River as much as 50 km below the dam. few were reported after springtime suggesting that trout moving downstream out of the reservoir were caught, had dispersed widely, or had died. Trout escapement from the reservoir was presumed innocuous, however, large numbers of trout in the river increased angling activity that may have increased incidental catch of Colorado squawfish.

Construction of large main stem dams on the upper Colorado River and its tributaries have contributed to highly altered flow, water temperature, and sediment transport at the expense of native fishes (Wydoski & Hammill 1991). Aside from the resulting loss of stream habitat through inundation and blockage of migration routes due to impoundment (Wydoski & Hammil 1991), Taylor Draw Dam and Kenney Reservoir imparted comparatively subtle physical changes to the White River (Wullschleger 1990, Chart & Bergersen 1992). Despite this, our investigation indicates smaller-scale, main stem impoundments pose a substantial threat to native ichthyofauna by facilitating establishment and proliferation of non-native fishes. Probably the greatest boon to non-native species resulting from Kenney Reservoir is that it provides suitable habitat for their recruitment. It is this ecological benefit to non-native species that will facilitate their continued proliferation in the White River.

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References cited

Baxter, G.T. & J.R. Simon. 1970. Wyoming fishes. Wyoming Game and Fish Department Bulletin 4, Cheyenne. 168 pp.

Chart, T.E. 1987. The initial effect of impoundment on the fish community of the White River, Colorado. M. Sc. Thesis, Colorado State University, Fort Collins. 112 pp.

Chart, T.E. & E.P. Bergersen. 1992. Impact of mainstream impoundment on the distribution and movements of the resident flannelmouth sucker (Catostomidae: *Catostomus latipinnis*) population in the White River, Colorado. Southw. Nat. 37: 9–15.

Hickman, T.J. 1983. Effects of habitat alteration by energy resource developments in the Upper Colorado River Basin on endangered fishes. pp. 537–550. *In:* V.D. Adams & V.A. Lamarra (ed.) Aquatic Resources Management of the Colorado River Ecosystem, Ann Arbor Science Publishers, Ann Arbor.

Holden, P.B. 1979. Ecology of riverine fishes in regulated streams with emphasis on the Colorado River. pp. 57–74. *In:* J.V. Ward & J.A. Stanford (ed.) Ecology of Regulated Streams, Plenum Press, New York.

Holden, P. & C. Stalnaker. 1975. Distribution and abundance of mainstream fishes of the middle and upper Colorado River basins, 1967–1973. Trans. Amer. Fish. Soc. 104: 217–231.

Karp, C.A. & H.M. Tyus. 1990. Behavioral interactions between young Colorado squawfish and six fish species. Copeia 1990: 25–34.

Lanigan, S.H. & C.R. Berry, Jr. 1981. Distribution of fishes in the White River, Utah. Southw. Nat. 26: 389–393.

McAda, C.W. & L.R. Kaeding. 1991. Movements of adult Colorado squawfish during the spawning season in the upper Colorado River. Trans. Amer. Fish. Soc. 120: 339–345.

McAda, C.W. & R.S. Wydoski. 1983. Maturity and fecundity of the bluehead sucker, *Catostomus discobolus* (Catostomidae), in the Upper Colorado River Basin, 1975–76. Southw. Nat. 28: 120–123.

Miller, R.R. 1946. The need for ichthyological surveys of the major rivers of western North America. Science 104: 517–519.

Miller, R.R. 1961. Man and the changing fish fauna of the American Southwest. Papers of the Mich. Acad. of Sci., Arts, and Let. 46: 365–404.

Minckley, W.L. 1973. Fishes of Arizona. Arizona Game and Fish Department, Phoenix. 293 pp.

Minckley, W.L. & J.E. Deacon. 1968. Southwestern fishes and the enigma of 'endangered species'. Science 159: 1424–1432.

Mullan, J.W., V.J. Starostka, J.L. Stone, R.W. Wiley & W.J. Wiltzius. 1976. Factors affecting upper Colorado River reservoir tailwater trout fisheries. Proceedings of the Symposium and Specialty Conference in Instream Flow Needs. Amer. Fish. Soc., Bethesda.

Sigler, W.F. & J.W. Sigler. 1987. Fishes of the Great Basin. University of Nevada Press, Reno. 425 pp.

Stanford, J.A. & J.V. Ward. 1986a. The Colorado River system. pp. 353–374. *In:* B.R. Davies & K.F. Walker (ed.) The Ecology of River Systems, Dr W. Junk Publishers, Dordrecht.

Stanford, J.A. & J.V. Ward. 1986b. Reservoirs of the Colorado system. pp. 374–383. *In:* B.R. Davies & K.F. Walker (ed.) The Ecology of River Systems, Dr W. Junk Publishers, Dordrecht.

Stanford, J.A. & J.V. Ward. 1986c. Fish of the Colorado River system. pp. 385–402. *In:* B.R. Davies & K.F. Walker (ed.) The Ecology of River Systems, Dr W. Junk Publishers, Dordrecht.

Sublette, J.E., M.D. Hatch & M. Sublette. 1990. The fishes of New Mexico. University of New Mexico Press, Albuquerque. 393 pp.

Trammell, M.A. 1991. Evaluation of Colorado squawfish stocking in Kenney Reservoir, Rangely, Colorado. M. Sc. Thesis, Colorado State University, Fort Collins. 64 pp.

Trammell, M.A., E.P. Bergersen & P.J. Martinez. 1993. Evaluation of an introduction of Colorado squawfish in a main stem impoundment on the White River. Colorado. Southw. Nat. 38: 362–369.

Tyus, H.M. 1990. Potamodromy and reproduction of Colorado squawfish in the Green River basin. Colorado and Utah. Trans. Amer. Fish. Soc. 119: 1035–1047.

Tyus, H.M., B.D. Burdick, R.A. Valdez, C.M. Haynes, T.A. Lytle & C.R. Berry. 1982. Fishes of the Upper Colorado River Basin: distribution, abundance, and status. pp. 12–70. *In:* W.H. Miller, H.M. Tyus & C.A. Carlson (ed.) Fishes of the Upper Colorado River System: Present and Future. American Fisheries Society, Bethesda.

Tyus, H.M. & C.W. McAda. 1984. Migration, movements and habitat preferences of Colorado squawfish, *Ptychocheilus lucius,* in the Green, White and Yampa rivers. Colorado and Utah. Southw. Nat. 29: 289–299.

Vanicek, C.D., R.H. Kramer & D.R. Franklin. 1970. Distribution of Green River fishes in Utah and Colorado following closure of Flaming Gorge Dam. Southw. Nat. 14: 297–315.

Wullschleger, J.G. 1990. Initial impacts of an impoundment on downstream benthic invertebrate fauna. M.Sc. Thesis, Colorado State University, Fort Collins. 106 pp.

Wydoski, R.S. & J. Hamill. 1991. Evolution of a cooperative recovery program for endangered fishes in the upper Colorado River basin. pp. 123–135. *In:* W.L. Minckley & J.E. Deacon (ed.) Battle Against Extinction: Native Fish Management in the American West. The University of Arizona Press, Tucson.