The Lower Milk River Fishery Study: Larval Fish Distribution and Abundance

Final Report
To
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ABSTRACT

Larval fish were sampled from mid-May to mid-July 2004 to describe the temporal and spatial distribution of fish species spawning in the Milk River, Montana and to identify multi-year trends concerning the influence of discharge on reproductive success. Total larval catch-per-unit-effort (CPUE) in 2004 (1.78 fish/100m^3) was an estimated 1.8 times greater than in 2003 (0.99 fish/100m^3) and 16 times less than in 2002 (28.9 fish/100m^3). In 2004 as well as 2003, more than one third of the total catch occurred before June 12 whereas in 2002, only 5% of the total catch was made before June 12. Peak discharge in 2004 occurred 32 days earlier than in 2002 and 15 days later than in 2003. The temporal distribution and magnitude of weekly larval fish catches in 2004 were similar to those of 2003 despite higher peak flow in 2004 (163 m^3/s) than in 2003 (73 m^3/s) and 2002 (77 m^3/s). Multivariate analysis of covariance was used to test for differences in community structure and total CPUE of larval fishes in relation to river reach and flow conditions. Community structure differed between locations (Wilks' lambda, p=.0002) with the lower 163 km of the Milk River yielding the highest CPUE of all community categories. Turbidity (p=0.03) and discharge (p=0.01) were significant covariates in terms of total larval fish densities. These results indicate that the timing, not necessarily the magnitude, of peak spring discharge may influence spawning success, as indicated by larval fish CPUE. Even in years of early peak spring discharge, the quasi-natural reach of the lower 188 km of the Milk River appears to provide better spawning conditions than do the more regulated river reaches sampled in this study. Further flow regulation, especially water withdrawals during mid-June through mid-July, may have a deleterious effect on fish reproduction in the Milk River.

INTRODUCTION

Tributaries play an integral role in the ecological functions of large river systems by providing important sources of water, sediments and nutrients to the main channel. Distinct physical and hydraulic habitat characteristics (e.g. substrates, depths, and velocities) in tributaries also provide important spawning and rearing conditions for fish species utilizing different portions of large rivers for their life cycles. As a result, in warm water drainages, fish species composition in tributaries typically resembles that of the main channel more than headwater areas (Osborne and Wiley 1992).

The Milk River is an important main channel tributary to the upper Missouri River, Montana. This long tributary (1,126 km) is an alluvial river with wide meandering banks, traversing northern Montana and the southern portion of the province of Alberta, Canada. Incised channels with well-developed riparian zones and cobble riffles characterize the lower 188 km of the river below Vandalia Dam (Stash et. al 2001). This portion of the river supports a diversity of macrohabitats for numerous fish species common to the Missouri River.

The warm turbid character of the lower Milk River contrasts sharply with conditions in the Missouri River at their confluence, 10 km below Fort Peck Dam. Downstream of the dam, the Missouri River is cold (15^{o} C, July) and clear (10 nephelometric turbidity units (NTU), July) because of hypolimnetic discharge from Fort Peck Dam and sediment trapping by the reservoir. Substrate, especially important riffle spawning grounds, has been altered and abundance and distribution of native fishes has been reduced (Pflieger and Grace 1987; Hesse and Sheets 1993). Shields et al. (2000) reported that since the closure of Fort Peck Dam in 1937, there has been a four-fold decrease in the mean rate of erosion and sedimentation below the dam, resulting in reduced lateral migration for 200 km downstream of the dam. This reduced channel movement limits the ability of the river to create and maintain floodplains and backwater areas that are critical habitat for spawning and rearing of fish.

With these major habitat changes in the Missouri River, remnant habitat in tributaries such as the lower Milk River may assume critical importance in species survival. Stash et al. (2001) observed that three migratory species from the Missouri River, blue sucker *Cycleptus elongatus*, shovelnose sturgeon *Scaphirhynchus platorynchus*, and paddlefish *Polyodon spathula* were found only in the lower 188 km section of the Milk River below Vandalia Dam. Six other native fish species, bigmouth buffalo *Ictiobus cyprinellus*, freshwater drum *Aplodinotus grunniens*, goldeye *Hiodon alosoides*, river carpsucker *Carpiodes carpio*, shorthead redhorse *Moxostoma macrolepidotum*, and smallmouth buffalo *Ictiobus bubalus* were captured only in the lowermost 400 km of the Milk River.

In years of high spring flows, the lower Milk River exhibits characteristics much like a natural river in terms of increases in depth, velocity, and turbidity. However, there has been a 60 % decrease in the magnitude of the two-year flood and similar decreases in low frequency, high intensity flood events because of seven irrigation impoundments on the river (Shields et. al 2000). The impoundments extend from 188 km to 699 km upstream of the confluence with the Missouri River. These alterations to the Milk River have caused a reduction in high spring flows and, in some instances, created impassable barriers to fish. Such alterations may affect the spawning and rearing ability of resident fish, as well as native migratory fish from the Missouri River.

A water development project has been proposed that would divert water from the Milk River during high spring flows into an off-stream storage reservoir with up to a 74 million m^3 capacity. The proposed project would further decrease the magnitude of the two-year flood and the frequency of other chance flooding. The potential impacts of this proposed water development project are not adequately understood. In this three-year evaluation, Bednarski (2004) investigated the first two years and reported a significant increase in larval fish abundance in 2002 than 2003, associated with a later (mid-June) peak in discharge in 2002 than in 2003 (mid-May). The major difference in larval fish density, an approximate index of reproductive success, associated with these differences called for further investigation of the relationship between timing and magnitude of peak discharge and reproductive success. Although Bednarski (2004) investigated both larval and adult fish populations in 2002 and 2003, investigations in 2004 strictly involved an evaluation of larval fish densities in relation to discharge, turbidity and water temperature. The objective of this study was to investigate temporal and spatial distribution of larval fish in the lower Milk River in order to assess what impact future habitat alterations may have on fish reproduction and community structure.

STUDY AREA

The Milk River is one of the largest tributaries to the upper Missouri River (Figure 1). It is 1,126 km in length and drains an area of approximately 57,839 km^2. From its headwaters in Glacier National Park, Montana, it flows northeastward, crossing into Canada for 348 km. It re-enters the United States in Hill County, Montana, and flows through most of the northeastern portion of the state to its confluence with the Missouri River immediately downstream of Fort Peck Dam.

In the past century, the Milk River has become an important source of irrigation and municipal water. The river irrigates approximately 558 km^2 of land, primarily in crops of alfalfa, native hay, oats, wheat, and barley (United States Bureau of Reclamation 1983; Simonds 1998). Twelve municipalities rely on the river for drinking water and sewage treatment. Most of the water comes from the Milk River Project, a U.S. Bureau of Reclamation irrigation project developed in 1902. This project diverts and stores water with three storage dams, four diversion dams, and a pumping plant (Simonds 1998).

The portion of the Milk River included in this study extends approximately 225 km upriver from the confluence of the Milk River with the Missouri River, to 37 km above Vandalia Dam. The study area also included the first 4.8 river km of the Missouri River downstream of the Milk River. Three locations constituted the study area. Location 1 was in the Missouri River immediately below its confluence with the Milk River. Location 1 was characterized by turbulent, cold, clear, deepwater habitat. Location 2 extended 163 km upstream from the mouth of the Milk River to 25 km below Vandalia Dam. Location 2 had slow, warm, turbid, shallow-water habitat with incised channels and riffles. Location 3 extended 37 km above Vandalia Dam; slow, warm, deep water was the common habitat.

METHODS

Whenever possible, larval fish sampling procedures in 2004 were designed to match those conducted by Bednarski (2004) in 2002 and 2003. Riffle and run habitats in each location were randomly selected and sampled weekly during daylight hours (weather permitting) from mid-May to mid-July 2004. Locations 1 and 3 each contained three sample sites; Location 2 contained 12 sample sites. Boat access to all sites within location 2 was often unreliable (impassable roads) and therefore not all sites could be sampled each week. However, site conditions were relatively homogenous within location 2. Bednarski (2004) separated location 2 into four locations coded L2-L5 and coded location 3 as L6. At each site, two 0.5 m x 1.8 m long conical nets (750 um Nitex mesh) submerged with 4.5 kg lead weights were slowly towed upstream for a ten minute duration. A General Oceanics 230 OR flow meter suspended in the mouth of the net estimated total water volume of each sample using the following equation:

$$V(m^3) = [3.14*(n^2)*(d)]/4;$$

Where,

n = net diameter (m);

d= [difference in flow meter counts*26,873]/999999.

A mixture of 10% formalin and Phloxene-B preserved and stained the sample contents, which were then stored in an airtight container and returned to a laboratory for sorting and identification.

Identification of larval fishes was performed using a key based on information from Auer (1982), Holland-Bartels et al. (1990) Wallus et al. (1990) and Kay et al. (1994). Each fish was enumerated, assigned a developmental stage (egg, protolarvae, mesolarvae, metalarvae or juvenile) and taxonomic classification (typically genus or species). Eggs were enumerated but not identified. A U.S. Geological Survey gauging station on the Milk River near Nashua, Montana provided daily discharge measurements (m^3/s). A portable turbidimeter and thermometer provided site-specific measurements of water temperatures (^oC) and turbidity (NTU).

Data analysis

Four categories (native, non-native, game, and non-game) were used to group larval fish. Only fish identified to a taxonomic level low enough for their status to be determined were placed in a category. For example, the game fish category included larvae of the genus *Sander*. However, we were unable to differentiate between walleye *S. vitreus* and sauger *S. canadensis* and therefore these fishes' status as native or non-native was not determined. A species' categorical status was determined based on definitions provided by the Montana state fishing regulations and the Missouri River Adopt-A-Fish program (Montana Fish, Wildlife and Parks 2005a; Montana Fish, Wildlife and Parks 2005b). In addition, summing all fish captures regardless of taxonomic level or grouping created an index of total reproduction (total fish) for each location and week.

Samples were converted to a catch-per-unit-effort (CPUE) of fish per $100m^3$ and $Log_{10}(X+1)$ transformed to normalize their distributions. Category CPUE values were then analyzed in relation to temporal changes in river conditions using two sets of variables: 1) absolute levels of temperature, discharge and turbidity and, 2) relative changes in these river conditions. The relative change in river conditions for each sample was calculated using the following equation:

$$X_{\Delta} = Log_{10}(X_{(t)} / X_{(t-d)});$$

Where,

X_{Δ} = relative change in river condition;

$X_{(t)}$ = river condition on latter sample date; and

$X_{(t\text{-}d)}$ = river condition on former sample date.

Multivariate analysis of covariance (MANCOVA) was performed to investigate differences in relative abundance of each category in relation to location and river conditions (Johnson and Wichern 2002). Each category was combined to form a y-vector defined as community structure. The null hypothesis of no overall location effect on community structure was tested with each river condition controlled for as a covariate in stepwise fashion. The 0.05 probability level determined significance in *F* values. Canonical structure and least squares means clarified which community structure categories were responsible for any significant differences.

Bednarski (2004) used the negative binomial distribution described by Power and Moser (1999) to estimate larval densities in 2002 and 2003. Instead of using the negative binomial distribution, we standardized larval catches for all three years to the number of larvae per 100 m^3 of filtered water (CPUE) using the following equation:

$$CPUE = (F_i / V_i) * 100;$$

Where,

F_i = total number of larval fish captured by week, year, location or taxa;

V_i = total volume of water (m^3) filtered by week, year or location.

Expressing larval densities in a standardized CPUE of fish per volume of water is commonly used in current literature and allows for between study comparisons of relative abundance (Humphries et al. 2002; Oesmann 2003; Reichard and Jurajda 2004).

(Revised graphs using our method showing standardized CPUE values from Bednarski (2004) are given in Figures 2,7,8 and 21-35).

RESULTS

In 2004, two hundred eleven fish representing 12 taxa from nine families were collected from 176 net tows (Table 1). Aside from the 1860 eggs captured, proto-larvae and meso-larvae were the most common developmental stages with juveniles representing less than 2% of the total catch. Native fishes accounted for 68% of the total catch, followed by non-native fishes (15%) and individuals of undetermined status. Non-game fishes accounted for 73% of the total catch, followed by game fishes (16%) and individuals of undetermined status. Shorthead redhorse, buffalo *Ictiobus spp.*, and river carpsucker were the most common native fishes accounting for 30% of the total catch. Centrarchids were the most common non-native fishes accounting for 6% of the total catch. Yellow perch *Perca flavescens* and *Sander spp.* accounted for 8% of the total catch and were the most common game fish larvae sampled. Total larval fish CPUE for all locations combined was estimated at 1.78 fish/100 m^3 (Figure 2). Community structure differed significantly between locations (Wilks' lambda, $p<0.001$) with location 2 (the lower Milk River proper from the mouth to 25 km below Vandalia Dam) yielding the highest catch of all four community structure categories (Figure 3). Egg CPUE did not differ between locations and total fish CPUE did not differ between locations 1 and 2.

Turbidity (Wilks' lambda, $p=0.03$) and discharge ($p=0.01$) were significant covariates in terms of total larval fish CPUE. No significant covariates were identified for individual community structure categories. A positive relationship was seen between total larval CPUE and turbidity measurements less than 150 NTU ($r^2 = 0.24$). A negative relationship was seen between total larval CPUE and turbidity when turbidity exceeded 150 NTU ($r^2 = 0.17$). Mean weekly turbidity was highest in location 2 (Figure 5). Mean turbidity in location 1 was 190 NTU and ranged from 0.23 to 902 NTU. Mean turbidity in location 2 was 283 NTU and ranged from 20 to 2,920 NTU. Mean turbidity in location 3 was 177 NTU and ranged from 13 to 1,082 NTU.

Mean weekly water temperatures were consistently lowest in location 1(Figure 4). Mean water temperature in location 1 during the study period was 13.1 ^oC and ranged from 7.8 to 15.5 ^oC. Mean water temperature in location 2 was 16.7 ^oC and ranged from 10 to 21.2 ^oC. Mean water temperature in location 3 was 15.8 ^oC and ranged from 9.9 to 21.3 ^oC.

Peak discharge in 2004 occurred 15 days later than the 2003 peak and 32 days earlier than the 2002 peak (Figure 6). A peak discharge of approximately 163 m^3/s occurred on May 28, 2004. A secondary peak in discharge of 70 m^3/s occurred on June 14. Discharge increased monotonically for four days prior to the first peak and for two days prior to the second peak.

Larval CPUE of early spawning non-native fishes (primarily yellow perch) peaked early, before the ascending limb of the first crest in discharge whereas late spawning non-native larval CPUE (primarily Centrarchids) peaked well after the secondary crest in discharge. Native fish CPUE peaked at approximately 2.8 fish/100m^3 on May 18, 2004 when discharge was approximately 7.8 m^3/s. A secondary peak in native CPUE of approximately 2.4 fish/100m^3 occurred on June 24, 2004, 10 days after a secondary peak in discharge of 70 m^3/s. Game fish CPUE peaked at approximately 1.3

fish/100m^3 on June 24, 2004 when discharge was 7.8 m^3/s; a secondary peak of approximately 1.1 game fish /100m^3 occurred after flows had dropped below 10 m^3/s. Non-game fish CPUE peaked at approximately 2.7 fish/100m^3 on the ascending limb (3.8 m^3/s) of the first crest in discharge. A secondary peak in non-game fish CPUE of approximately 1.8 fish/100m^3 occurred 10 days after a secondary crest in discharge of approximately 70 m^3/s.

Total larval CPUE in 2004 (1.78 fish/100m^3) was an estimated 1.8 times greater than in 2003 (0.99 fish/100m^3) but 16 times less than in 2002 (28.9 fish/100m^3). The temporal distribution and magnitude of weekly larval fish catches in 2004 were similar to those of 2003 (Figures 7-9). This difference occurred even though a higher peak flow occurred in 2004 (163 m^3/s) than in 2003 (73 m^3/s) or 2002 (77 m^3/s). In 2003 and 2004, more than one-third of the total larval catch occurred before June 12 whereas in 2002, only 5% of the total larval catch occurred before June 12.

DISCUSSION

Results from 2004 compared with those of 2002 and 2003 suggest that the timing, and not solely the magnitude, of peak discharge influences the reproductive success of fishes spawning in the Milk River. Total larval densities were lower than expected based on the magnitude of spring discharge in 2004 in comparison with the two previous years (Figures 10-19). We calculated a 29-fold higher larval CPUE in the Milk River during 2002 compared to 2003 despite similar magnitudes of peak flow between years. Total larval CPUE in 2002 was an estimated 16 times greater than in 2004 despite more than two times a greater magnitude of peak flow in 2004. Extended spring discharge peaked in mid-June during 2002 whereas 2003 exhibited a rapid rise and fall in discharge in mid-

May. Peak discharge in 2004 occurred 15 days later than the 2003 peak but 32 days earlier than the 2002 peak. High flows at a given period may not necessarily result in better reproduction of all species. Rulifson and Manooch (1990) found that striped bass *Morone saxatilis* recruitment in the lower Roanoke River, North Carolina was maximized during years of moderate (140-300 m^3/s) discharge and poor during years of high ($\geq$ 280 m^3/s) discharge. Moreover, Smith et al. (2005) suggested that the timing of high spring flows helped explain annual variation in smallmouth bass *Micropterus dolomieui* recruitment in the James, Rappahannock, and Shenandoah Rivers, Virginia.

Marked differences in species composition was also observed between years, suggesting that a later peak in discharge may benefit some species more than others. In another study, Finger and Stewart (1987) found that larval abundance of pygmy sunfish *Elassoma zonatum* and flier *Centrarchus macropterus* in hardwood wetlands in Missouri was greater when flooding occurred earlier (mid-spring) than later (early summer) in the year. In the present study, carp were much more abundant in 2002 (10.7 fish/100m^3) than in 2003 (0.07 fish/100m^3) or 2004 (0.03 fish/100m^3). A similar pattern was observed for *Ictiobus spp.* and river carpsucker. In 2002, the majority (87%) of carp were captured during the three-week period of highest spring discharge. Mean water temperature for all locations combined was 20.3 ^{o}C during this period. In 2003, the majority (77%) of carp were captured during a one-week period in mid-June when mean water temperature for all locations combined was 21.7 ^{o}C. However, this occurred five weeks after peak discharge for the year. Peak discharge in 2003 was associated with colder (14.3 ^{o}C) mean water temperatures. These results are consistent with other studies that have suggested that common carp (McCrimmon 1968; Panek 1987) and species with similar life histories (Schrank et al. 2001) may reproduce most effectively when high spring discharge coincides with warm (17 ^{o}C to 22 ^{o}C) water temperatures.

In contrast to the pattern seen for carp, shorthead redhorse abundance was nearly identical in all three years with a CPUE of 0.4 fish/100m^3 in 2002, 0.5 fish/100m^3 in 2003, and 0.39 fish/100m^3 in 2004. At the latitude of the lower Milk River, most native fish species spawn late May to early August. In such a situation, the more predictable rising hydrograph from yearly snowmelt may trigger movement of spawners in preparation for the later rise in discharge produced by seasonal precipitation. In the lower Milk River study area, the month of June has the highest average seasonal rainfall at approximately 6.2 cm. June precipitation in 2002 was above average (7.5 cm) while 2003 (5.2 cm) and 2004 (6.0 cm) exhibited below normal June rainfall (Western Regional Climate Center 2001). Despite these differences in precipitation patterns and flow regimes between years, shorthead redhorse were able to partition their spawning over a greater period than most of the other fishes sampled.

Differences in the spatial distribution of larval fish observed in this study may be associated with more natural conditions in terms of flow, turbidity, temperature and physical habitat in location 2. In 2004, location 2 exhibited both higher mean weekly measurements and less extreme variations in daily water temperature than the other sample locations. The range of temperatures observed in location 2 during the study period contained those previously reported for spawning of shorthead redhorse (11.1 to 16 ^{o}C), *Ictiobus spp*. (15.5 to 18.3 ^{o}C), and river carpsucker (18.3 to 23.9 ^{o}C), the most commonly observed native fishes in 2004 (Scott and Crossman 1973; Buynak and Mohr 1979). Moreover, higher mean levels of turbidity in location 2 may have provided better protection of larval fishes from predation by sight-feeding piscivores (Flecker 1992). Humphries et al. (2002) reported greater larval fish abundance in run habitats for a large Australian river that had more natural temperature and turbidity regimes (76.7 larvae/sample) than a highly regulated, neighboring river (2.7 larvae/sample).

Although our study did not quantify physical habitat characteristics, qualitative observations indicated a greater abundance of riffle habitats and low-velocity backwaters in location 2. Brown and Coon (1994) found that low mean channel depth and high percentages of coarse substrates were highly correlated with larval fish abundance in tributaries of the lower Missouri River, Missouri. Shallow riffles have been shown to be preferred spawning habitats of many catostomids and cyprinids (Scott and Crossman 1973). Furthermore, Bowen et al. (1998) suggested that persistent slow-water habitats during spring and summer were associated with increased abundance of juvenile percids, catostomids, cyprinids, and centrarchids in warm-water drainages.

Even in years of early peak spring discharge, the quasi-natural reach of the lower 188 km of the Milk River (location 2) appears to provide better spawning conditions than do the more regulated river reaches (locations 1 and 3) sampled in this study. Moreover, the timing of spring discharge may influence spawning success, as indicated by total larval fish densities. Further flow regulation, especially water withdrawals in mid-June through mid-July, may have a deleterious effect on fish reproduction in the Milk River. Further research is needed on the timing, magnitude, and duration of spring discharge necessary to maintain spawning populations of native and game fish species. In addition, quantitative description of spawning habitat in the lower Milk River below Vandalia dam would provide useful information for future research.

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Table 1. Family, common name, scientific name and community structure category of larval fishes identified from the lower Milk River, Montana 2004.

Salmonidae	lake whitefish	*Coregonus clupeaformis*	3		X	X	
Hiodontidae	goldeye	*Hiodon alosoides*	11	X			X
Esocidae	northern pike	*Esox lucius*	1		X	X	
Cyprinidae	emerald shiner	*Notropis atherinoides*	3	X			X
	common carp	*Cyprinus carpio*	3		X		X
	minnows		8				
Catostomidae	sucker	*Catostomus spp.*	37	X			X
	river carpsucker	*Carpiodes carpio*	18	X			X
	shorthead redhorse	*Moxostoma macrolepidotum*	47	X			X
	buffalo	*Ictiobus spp.*	18	X			X
Percichthyidae	white bass	*Morone chrysops*	1		X	X	
Centrarchidae	sunfishes		13		X	X	
Percidae	yellow perch	*Perca flavescens*	9		X	X	
		Sander spp.	8			X	
Sciaenidae	freshwater drum	*Aplodinotus grunniens*	9	X			X
Unknown			22				
Total			211				

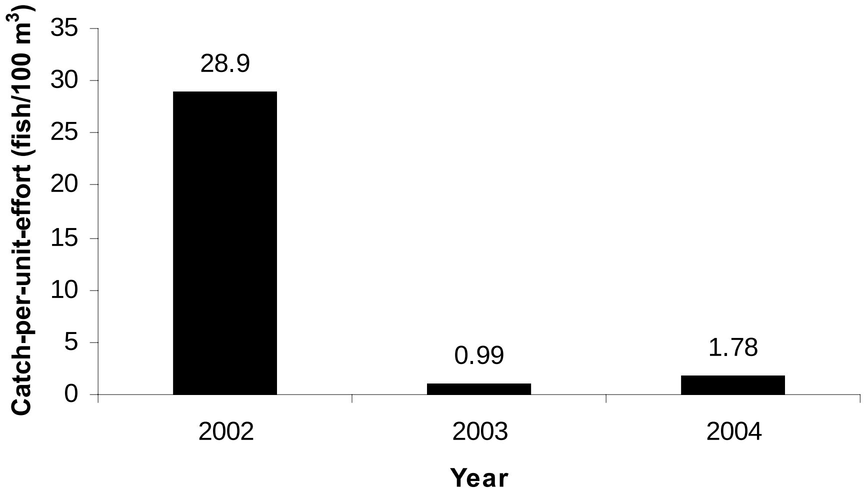


Figure 2. Total larval fish catch-per-unit-effort from the lower Milk River and Missouri River, Montana, 2002, 2003 and 2004.

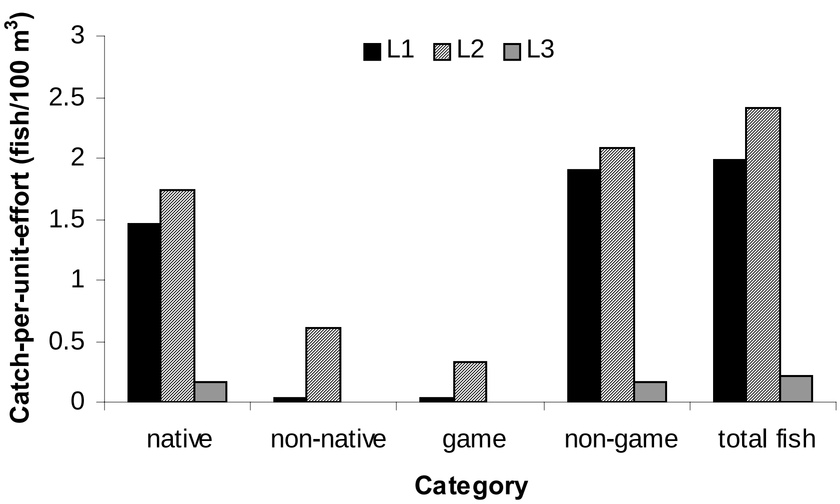


Figure 3. Catch-per-unit-effort of native, non-native, game, non-game and total larval fishes by location (L1-L3) from the lower Milk River and Missouri River, Montana 2004.

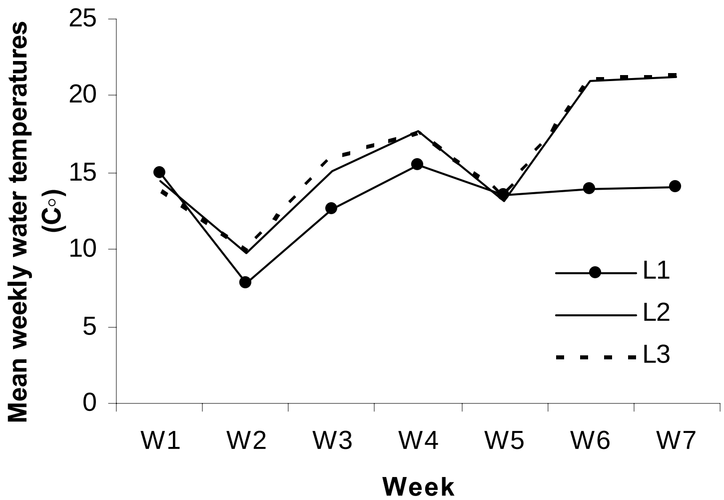


Figure 4. Estimated mean weekly water temperatures for sample locations along the Milk River and Missouri River, Montana. Week 1 (May 17-21); Week 2 (May 24-28); Week 3 (May 31-June 4); Week 4 (June 14-18); Week 5 (June 21-25); Week 6 (June 28-July 3); Week 7 (July 5-9).

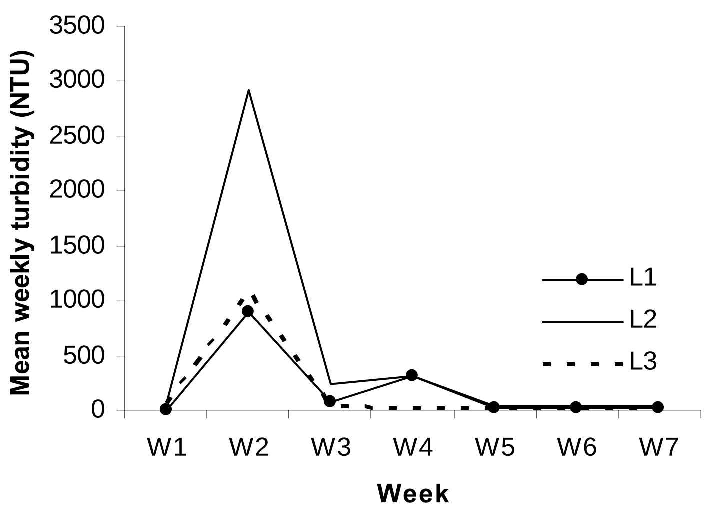


Figure 5. Estimated mean weekly turbidity for sample locations along the Milk River and Missouri River, Montana from May 18, 2004 (W1) to July 9, 2004 (W7).

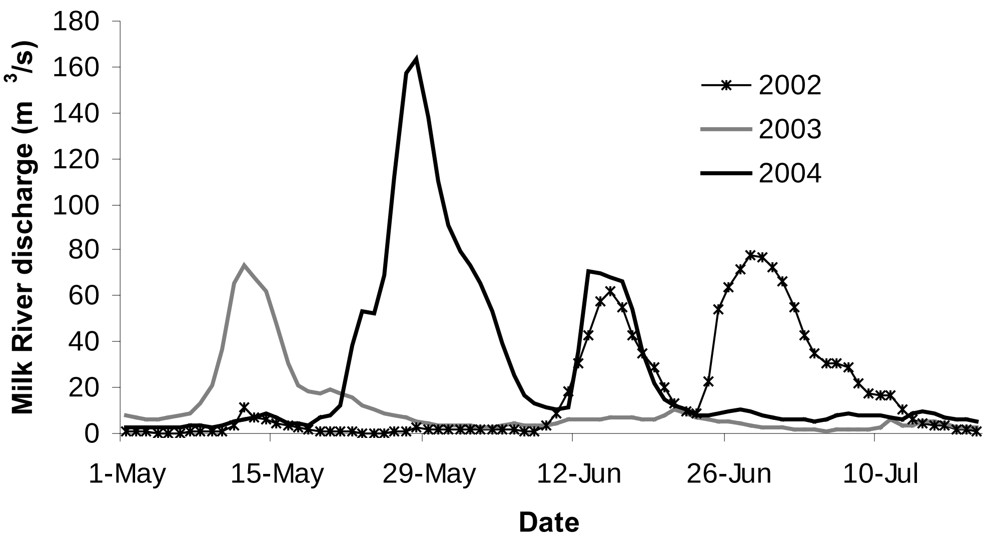


Figure 6. Mean daily discharge for the lower Milk River near Nashua, Montana 2002-2004 for the period of May 10 through July 19.

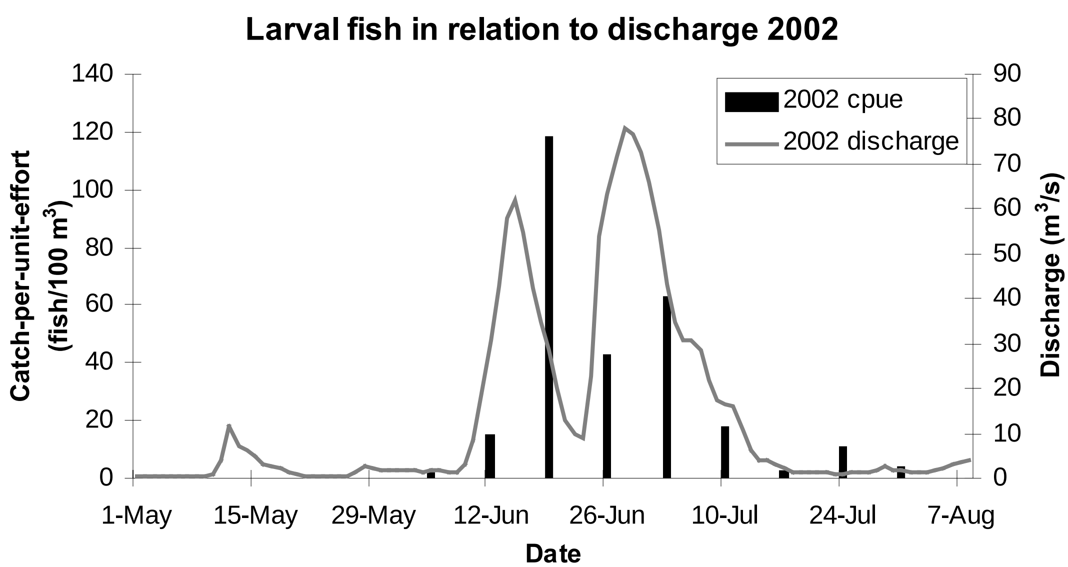


Figure 7. Total weekly catch-per-unit-effort of larval fish sampled in the Milk River and Missouri River, Montana during 2002 in relation to Milk River discharge near Nashua, Montana.

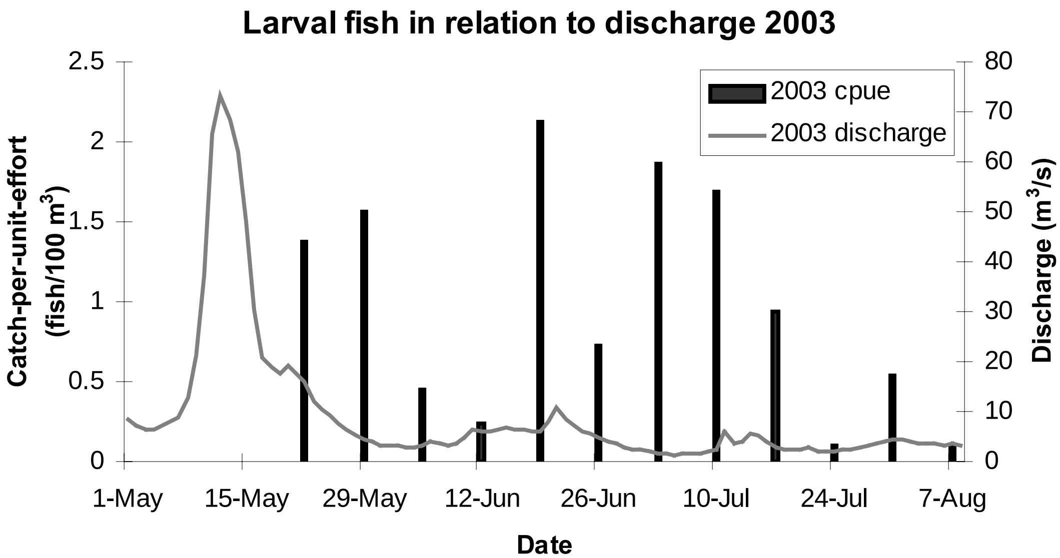


Figure 8. Total weekly catch-per-unit-effort of larval fish sampled in the Milk River and Missouri River, Montana during 2003 in relation to Milk River discharge near Nashua, Montana.

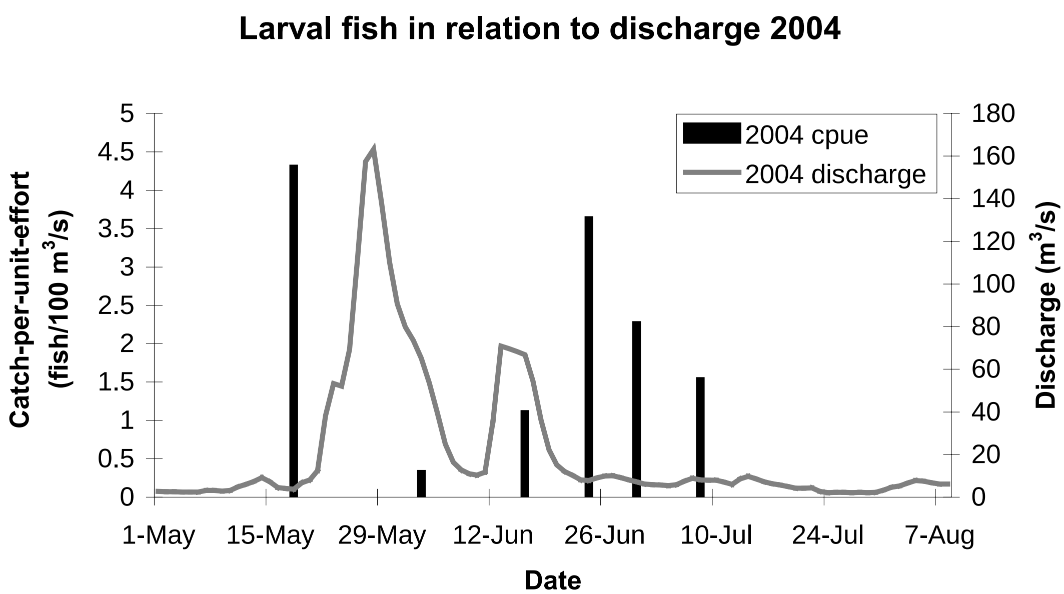
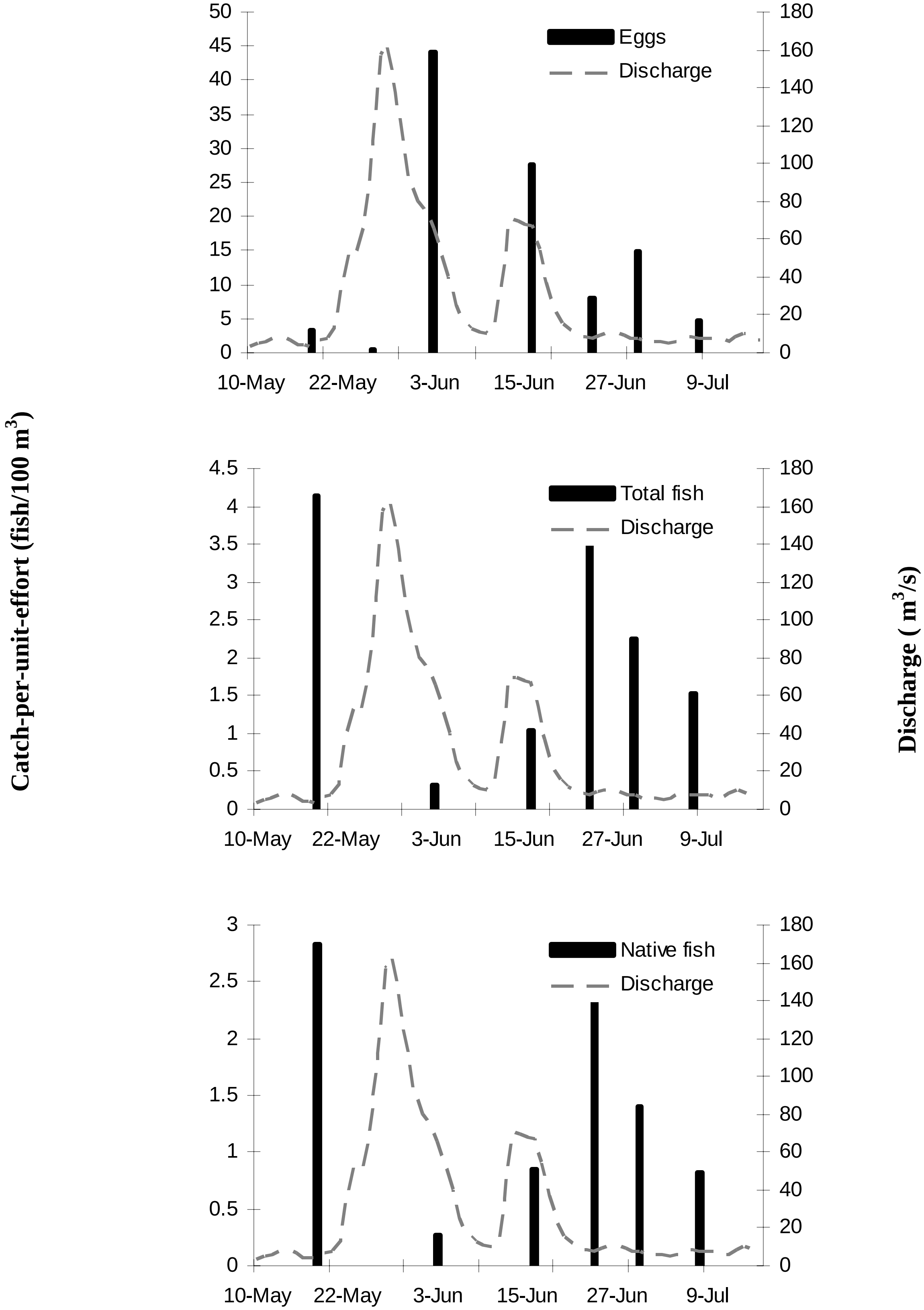
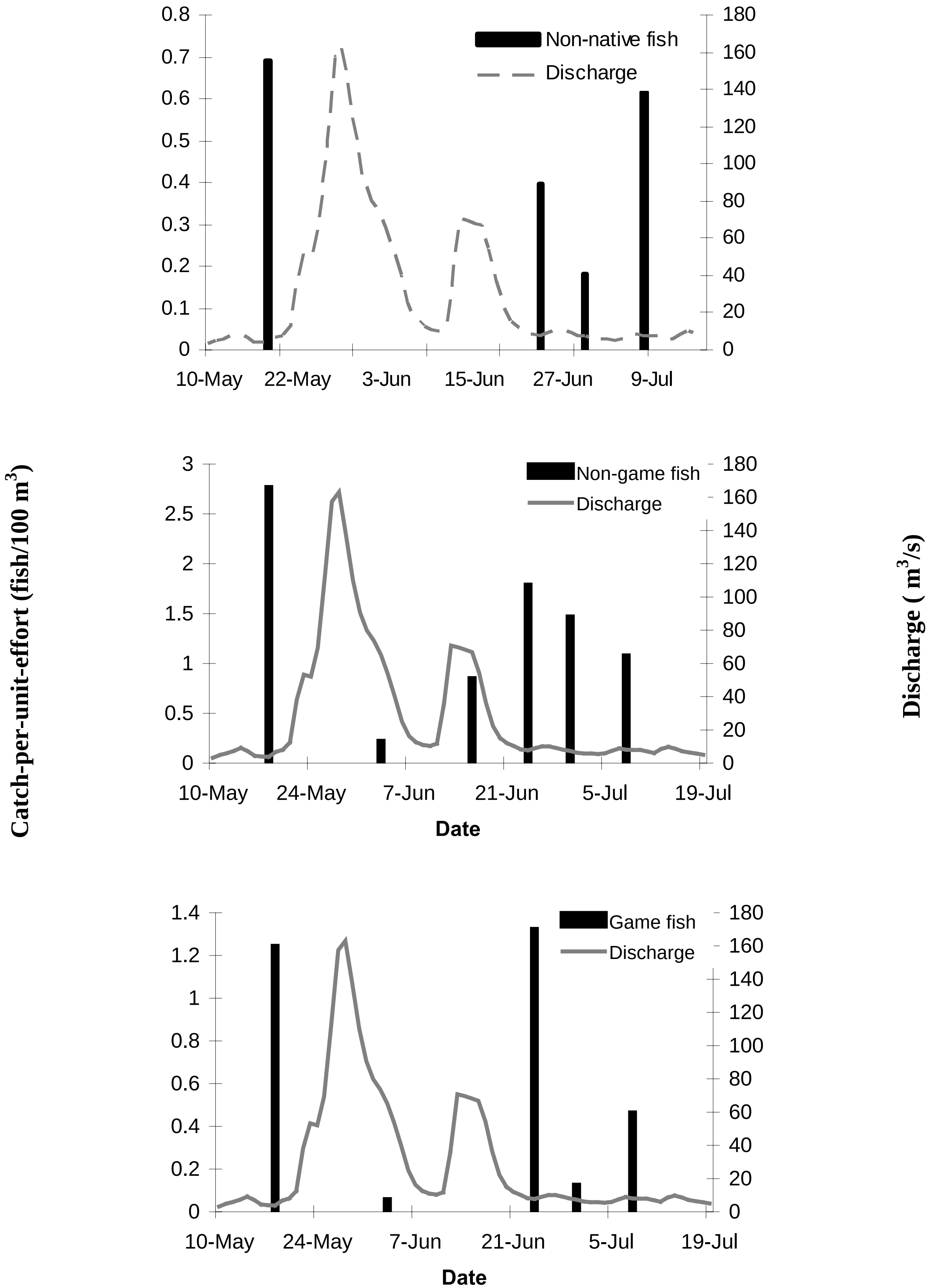


Figure 9. Total weekly catch-per-unit-effort of larval fish sampled in the Milk River and Missouri River, Montana during 2004 in relation to Milk River discharge near Nashua, Montana.


Catch-per-unit-effort (fish/100 m3)
Discharge (m3/s)
Eggs
Discharge
50
45
40
35
30
25
20
15
10
5
0
180
160
140
120
100
80
60
40
20
0
10-May
22-May
3-Jun
15-Jun
27-Jun
9-Jul
Total fish
Discharge
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
180
160
140
120
100
80
60
40
20
0
10-May
22-May
3-Jun
15-Jun
27-Jun
9-Jul
Native fish
Discharge
3
2.5
2
1.5
1
0.5
0
180
160
140
120
100
80
60
40
20
0
10-May
22-May
3-Jun
15-Jun
27-Jun
9-Jul



Catch-per-unit-effort (fish/100 m^3)
Discharge (m^3/s)
Non-native fish
Discharge
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
180
160
140
120
100
80
60
40
20
0
10-May
22-May
3-Jun
15-Jun
27-Jun
9-Jul
Non-game fish
Discharge
3
2.5
2
1.5
1
0.5
0
10-May
24-May
7-Jun
21-Jun
5-Jul
19-Jul
Date
Game fish
Discharge
1.4
1.2
1
0.8
0.6
0.4
0.2
0
10-May
24-May
7-Jun
21-Jun
5-Jul
19-Jul
Date

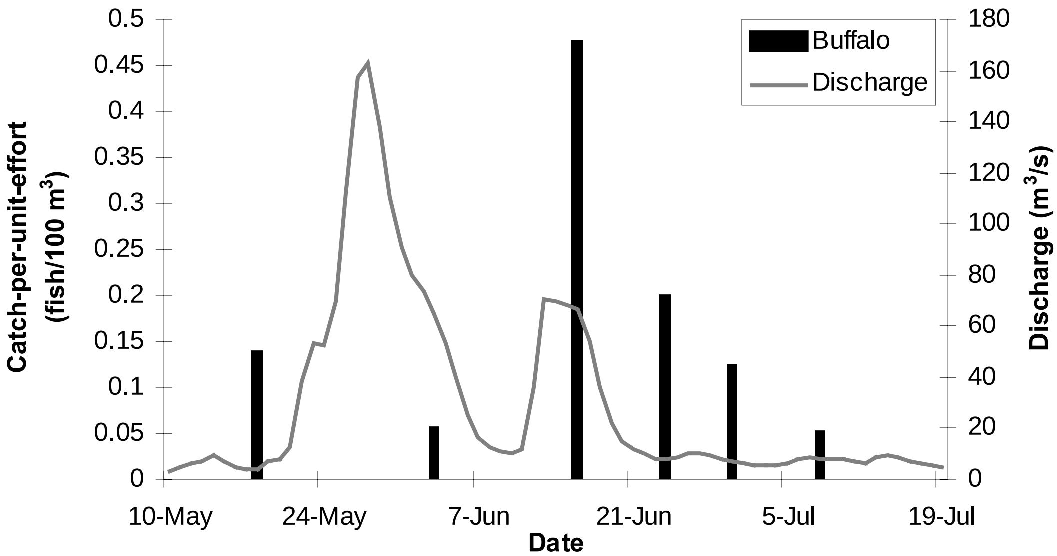


Figure 11. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Ictiobus spp.* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2004.

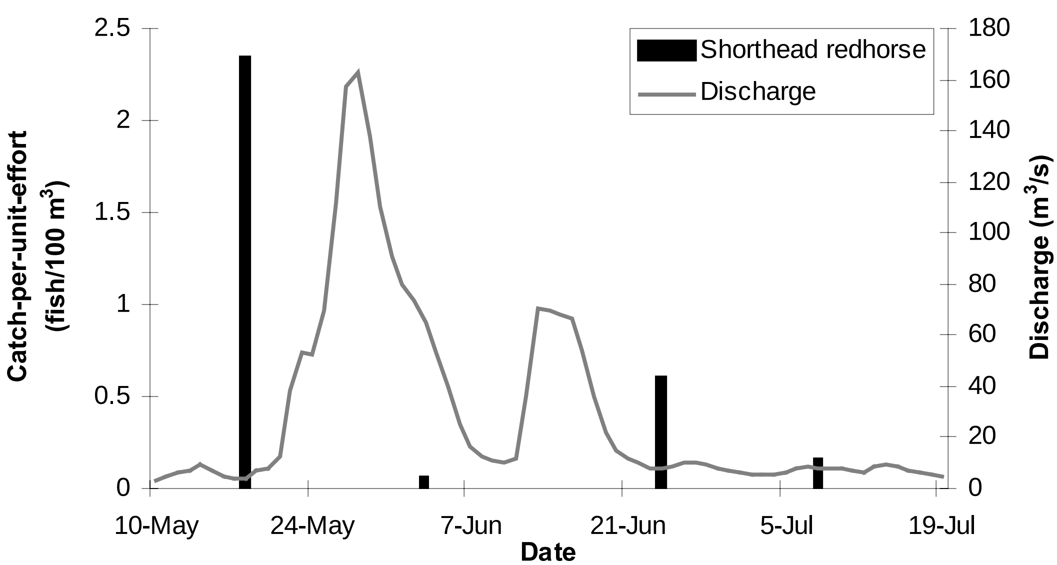


Figure 12. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Moxostoma macrolepidotum* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2004.

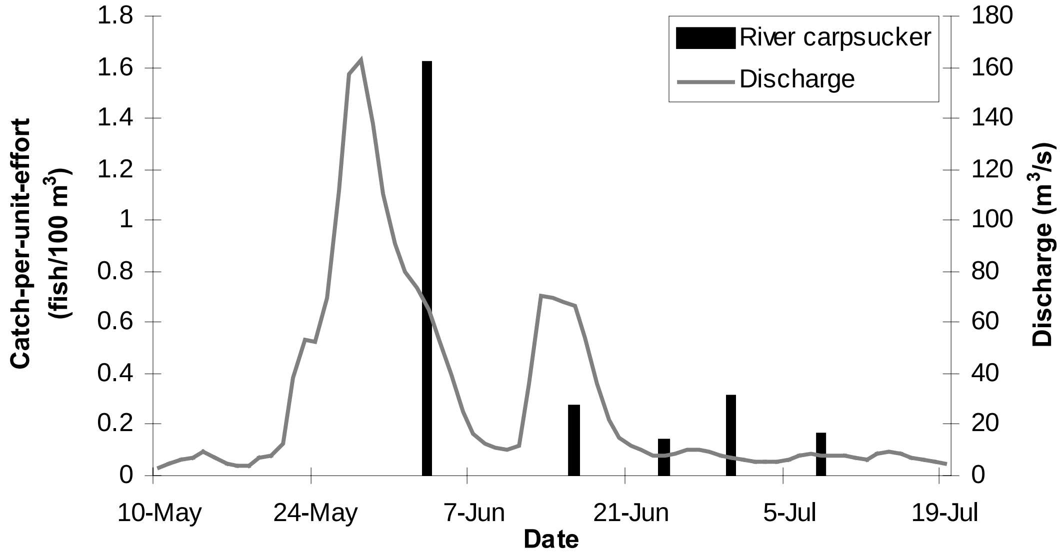


Figure 13. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Carpoides carpio* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2004.

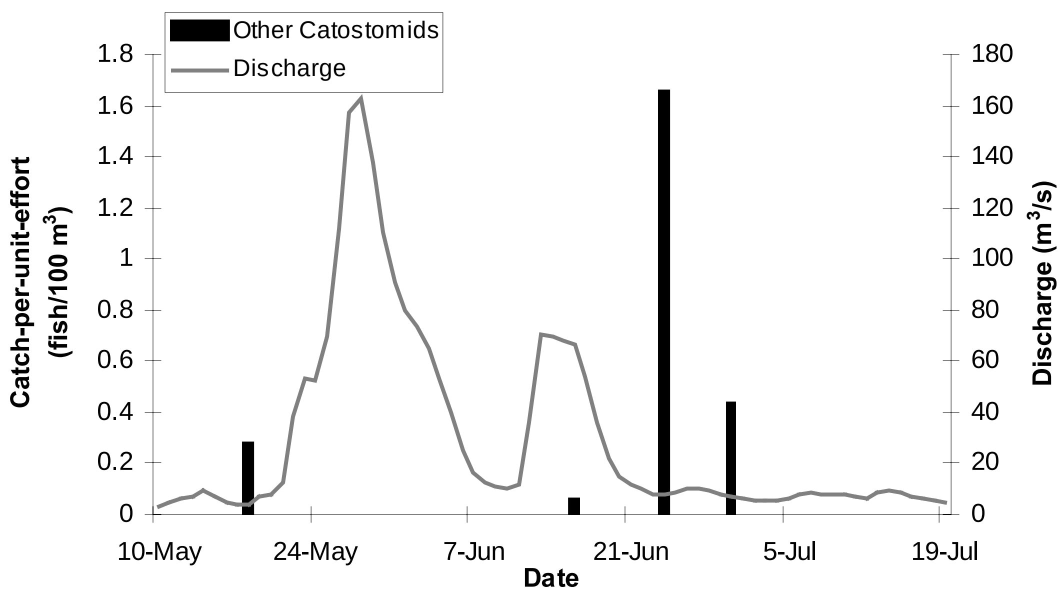


Figure 14. Weekly larval catch-per-unit-effort (fish/100 m^3) of fishes from the family Catostomidae (excluding *Carpoides carpio* , *Ictiobus spp.* and *Moxostoma macrolepidotum*) from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2004.

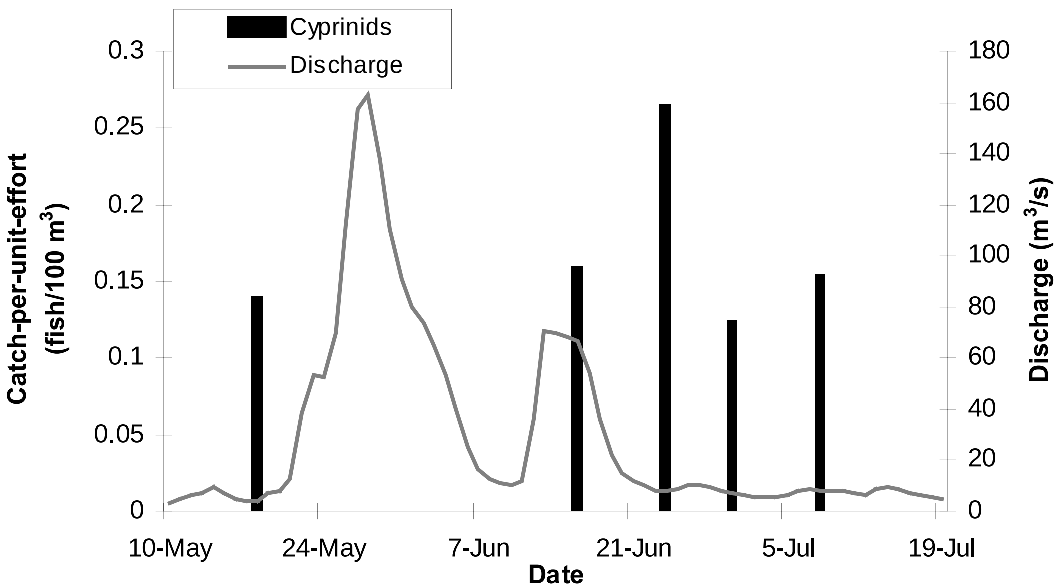


Figure 15. Weekly larval catch-per-unit-effort (fish/100 m^3) of fishes from the family Cyprinidae from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2004.

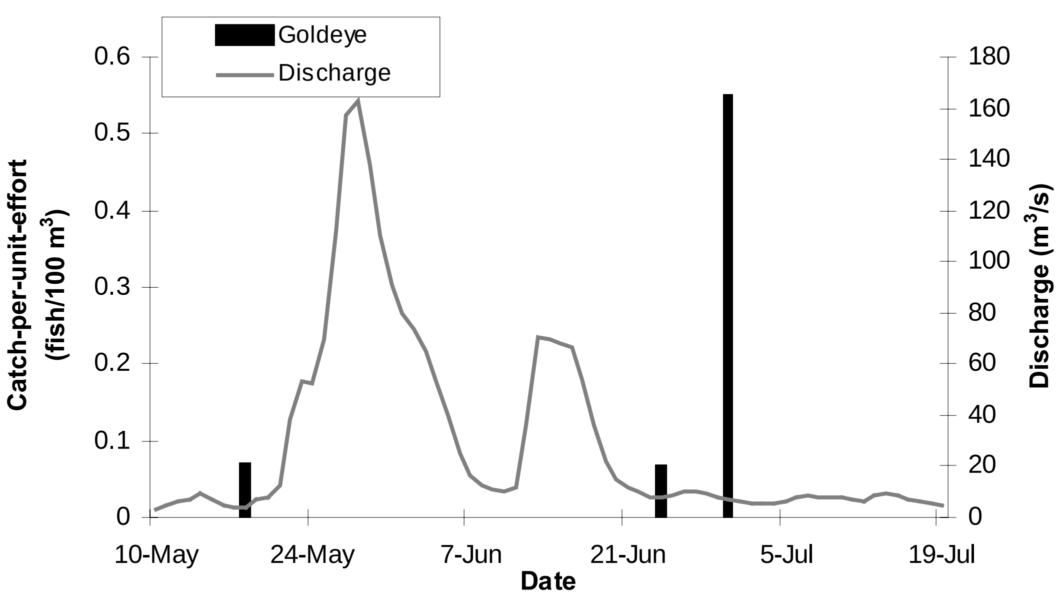


Figure 16. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Hiodon alosoides* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2004.

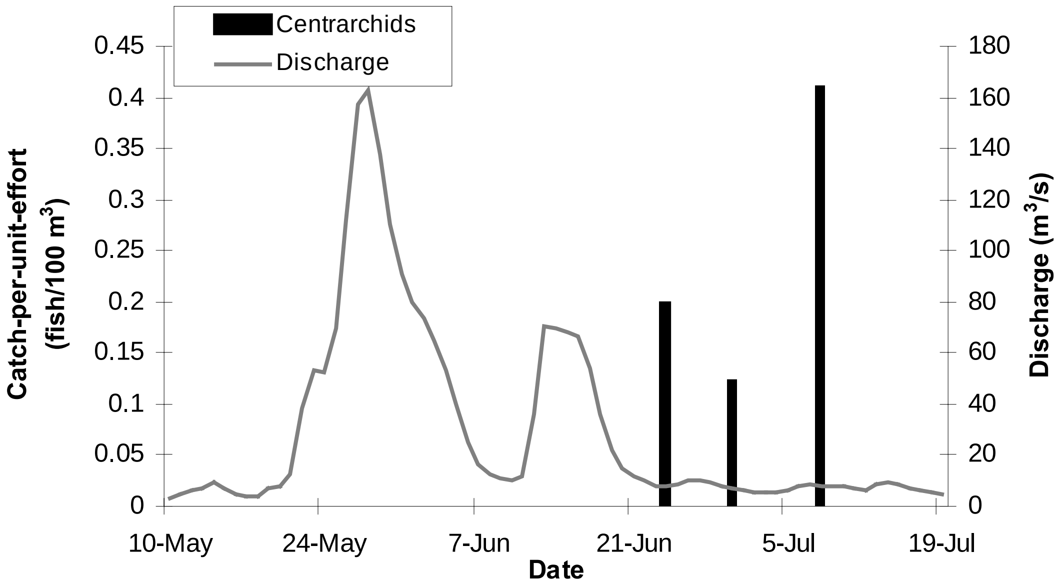


Figure 17. Weekly larval catch-per-unit-effort (fish/100 m^3) of fishes from the family Centrarchidae from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2004.

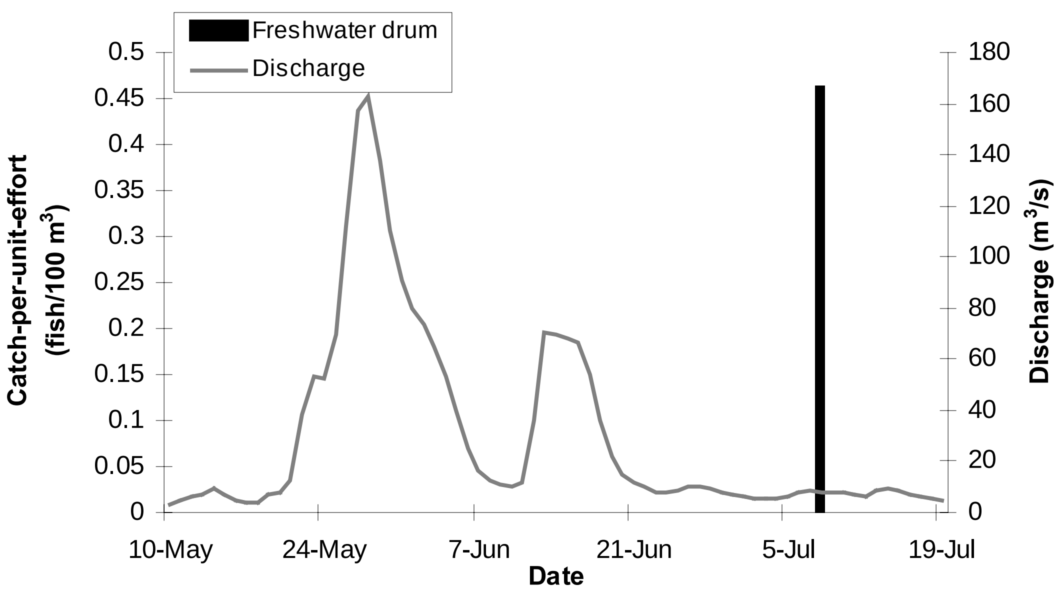


Figure 18. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Aplodinotus grunniens* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2004.

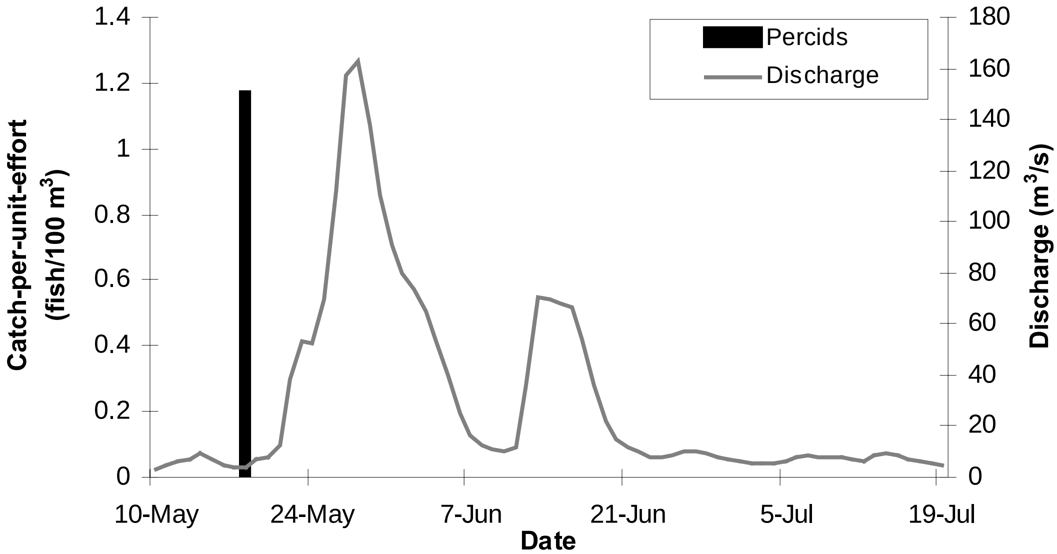
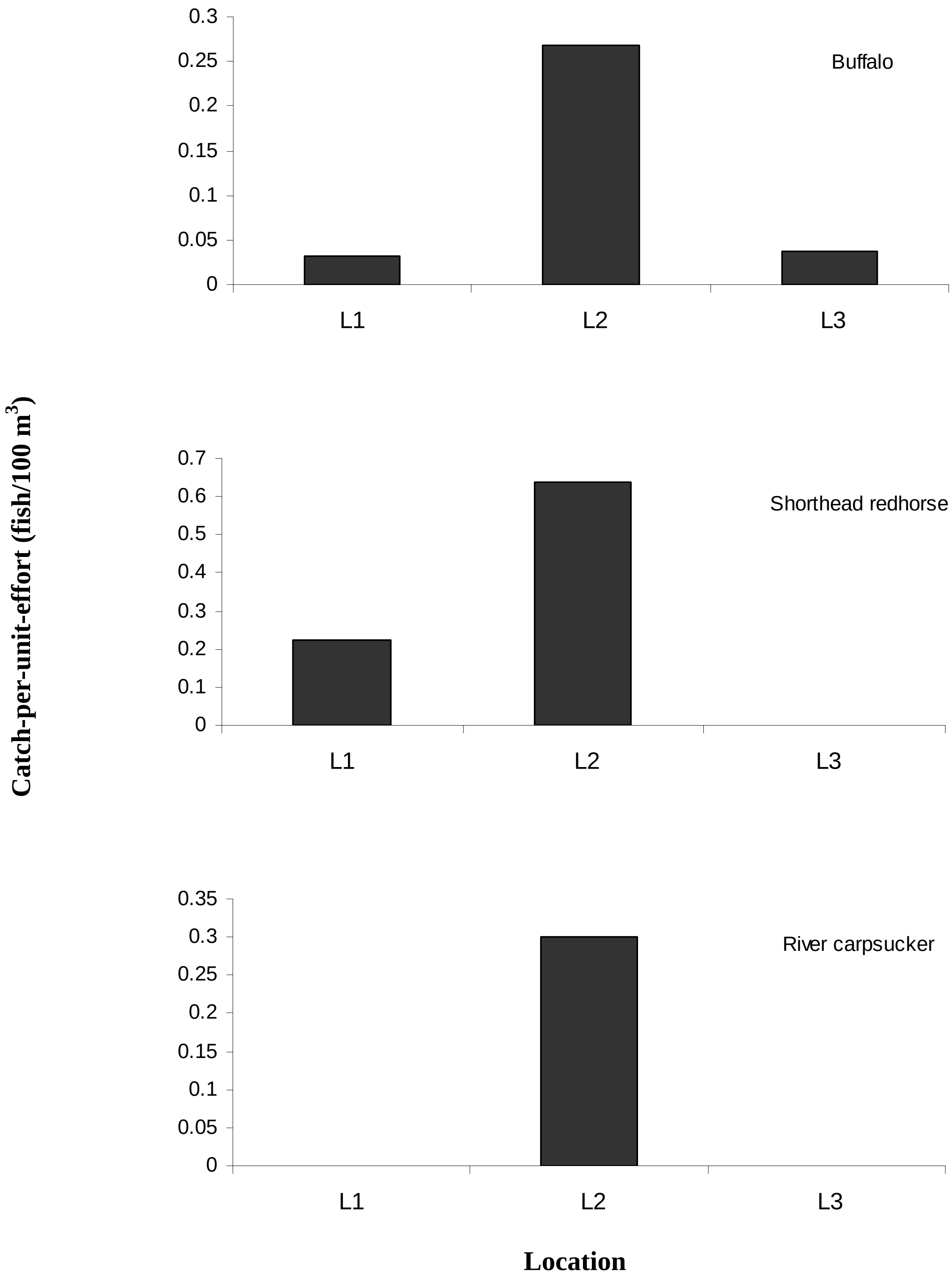
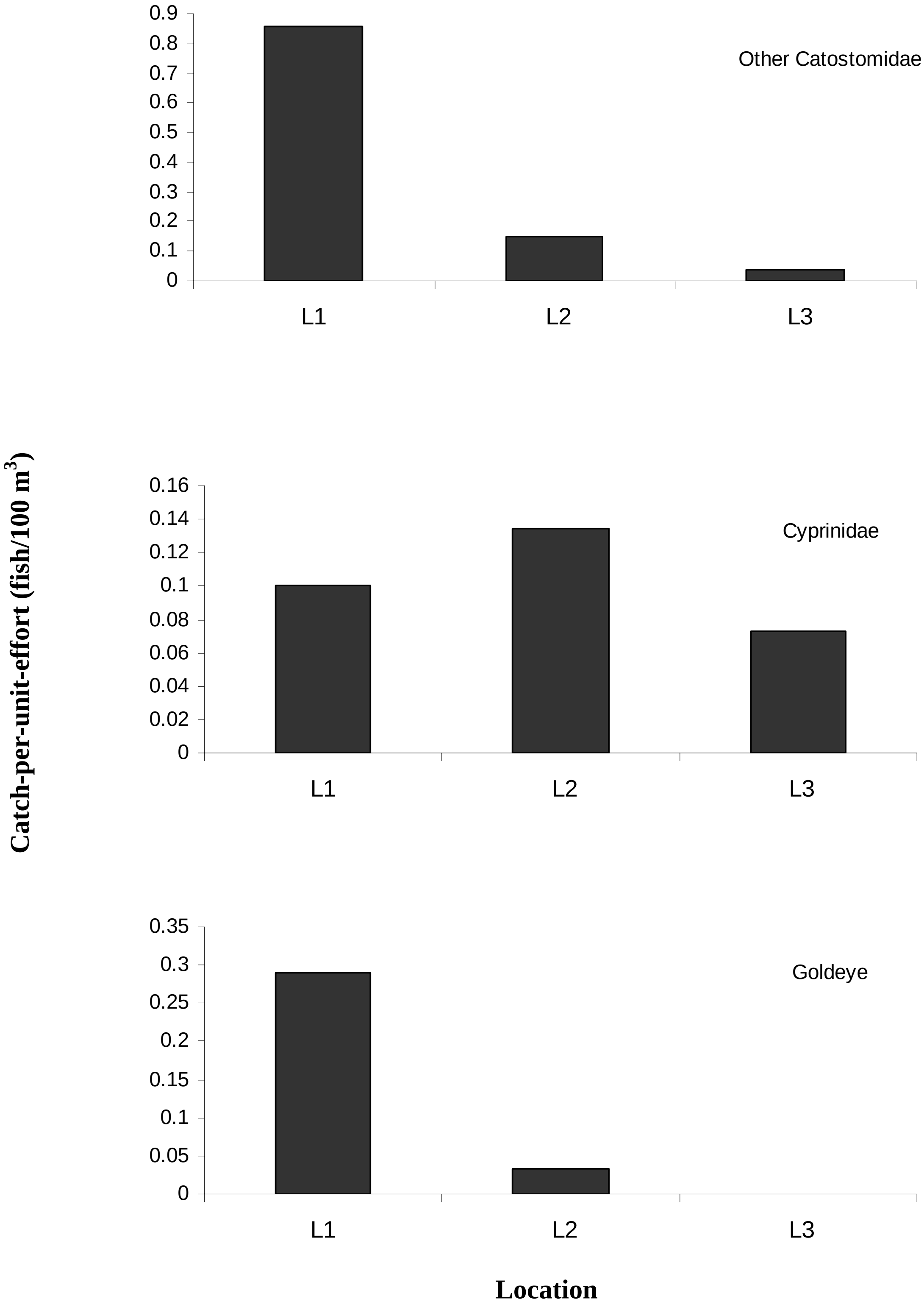


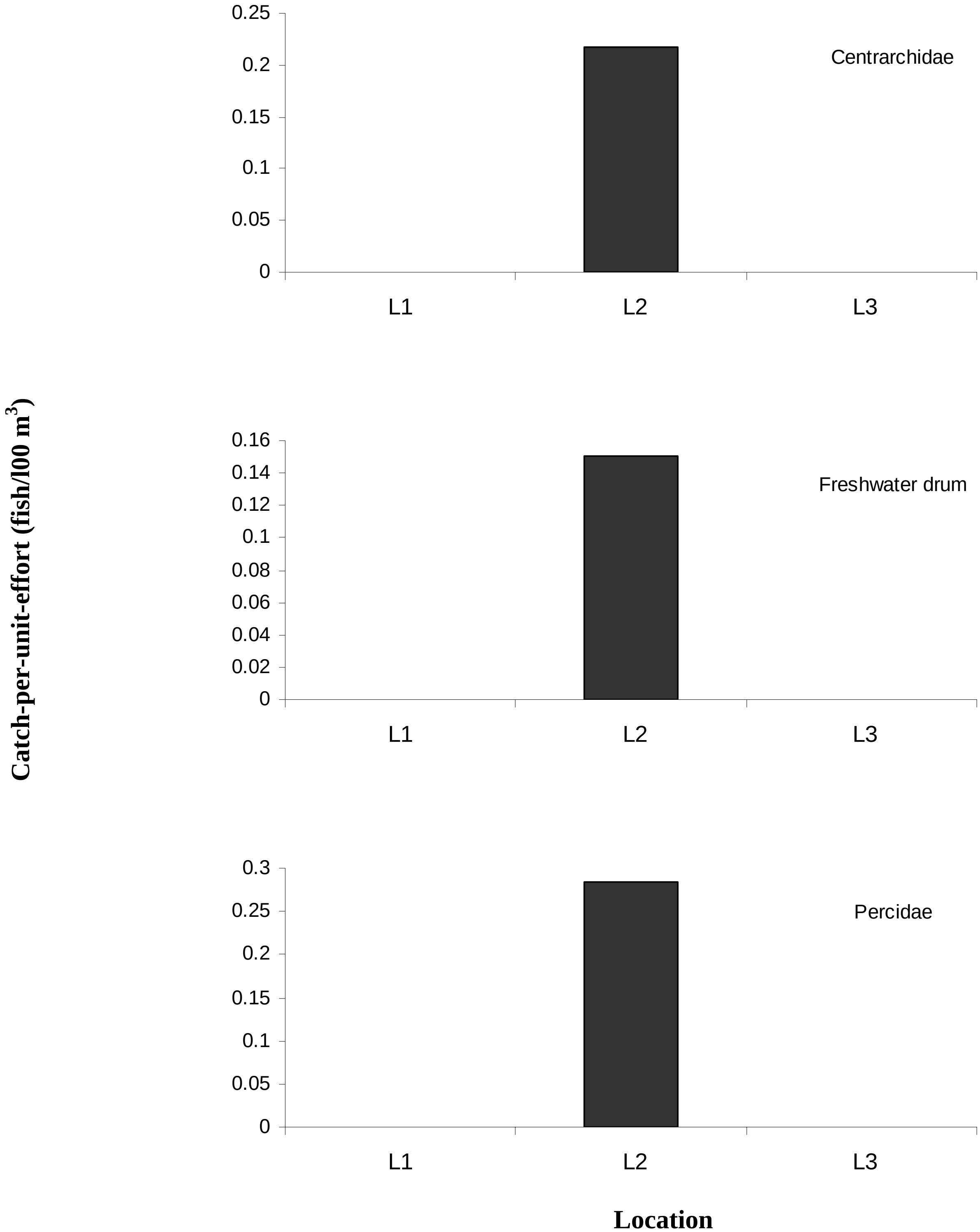
Figure 19. Weekly larval catch-per-unit-effort (fish/100 m^3) of fishes from the family Percidae from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2004.



0.3
0.25
0.2
0.15
0.1
0.05
0
Buffalo
L1
L2
L3
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Shorthead redhorse
L1
L2
L3
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
River carpsucker
L1
L2
L3
Catch-per-unit-effort (fish/100 m3)
Location



Other Catostomidae
Cyprinidae
Goldeye
L1
L2
L3
Catch-per-unit-effort (fish/100 m³)
Location


Catch-per-unit-effort (fish/100 m3)
0.25
0.2
0.15
0.1
0.05
0
L1
L2
L3
Centrarchidae
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
L1
L2
L3
Freshwater drum
0.3
0.25
0.2
0.15
0.1
0.05
0
L1
L2
L3
Percidae
Location

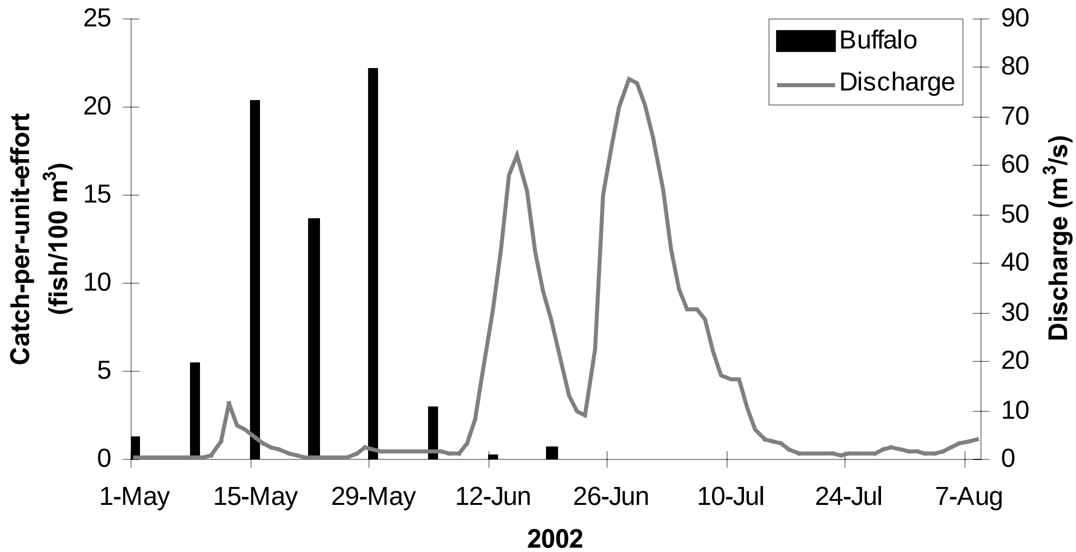


Figure 21. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Ictiobus spp.* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2002.

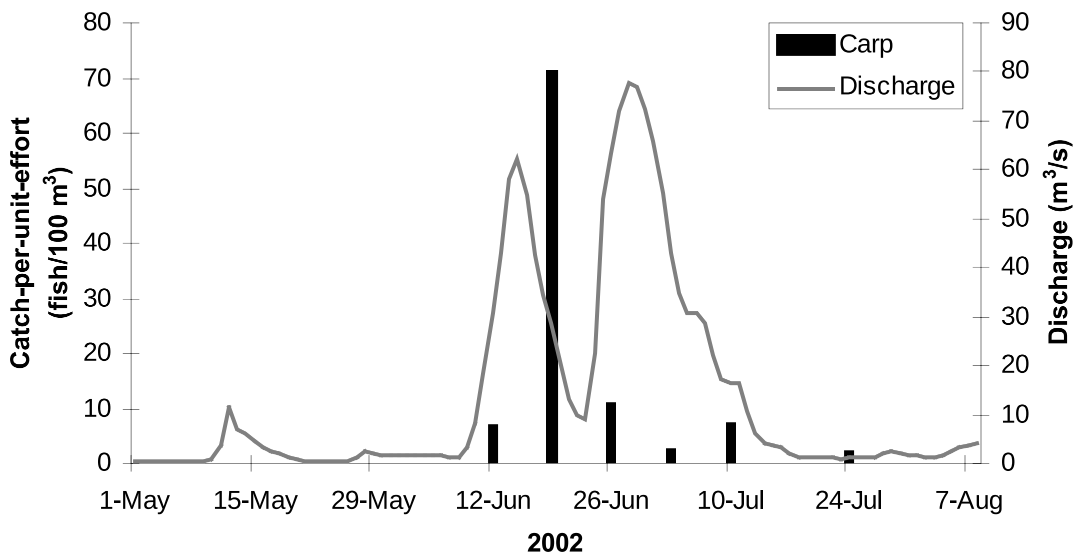


Figure 22. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Cyprinus carpio* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2002.

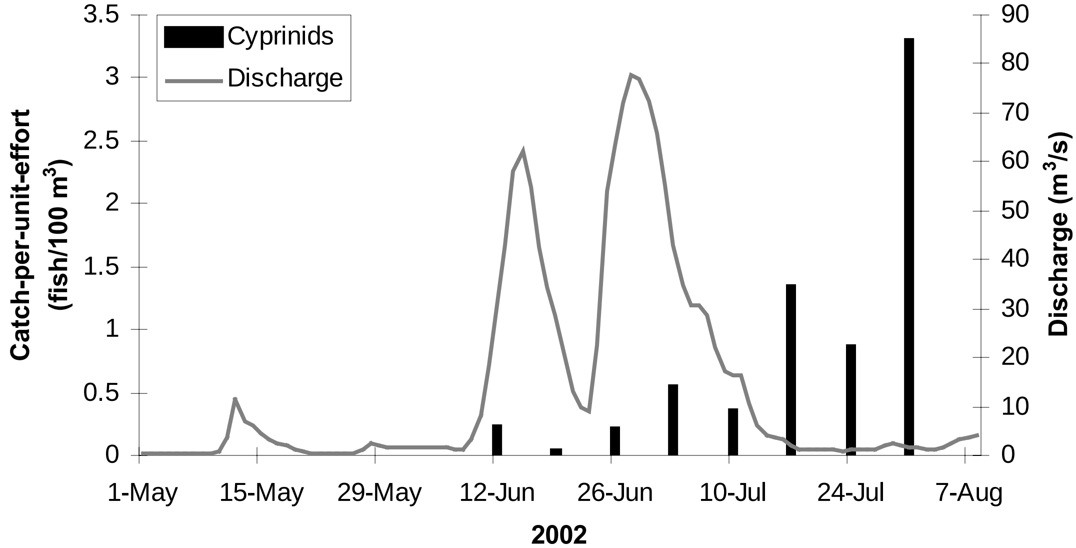


Figure 23. Weekly larval catch-per-unit-effort (fish/100 m^3) of fishes from the family Cyprinidae (excluding *Cyprinus carpio*) from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2002.

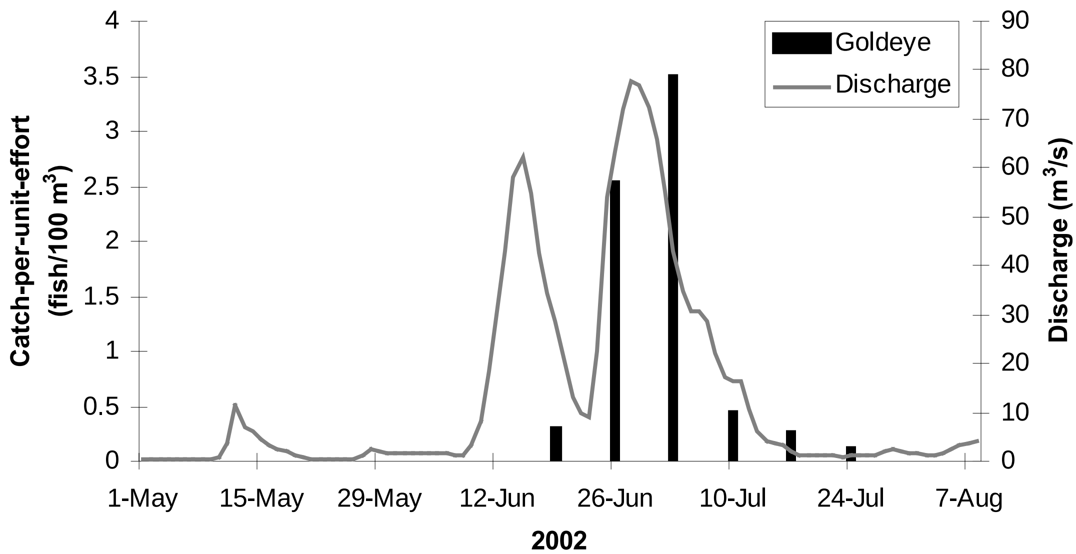


Figure 24. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Hiodon alosoides* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2002.

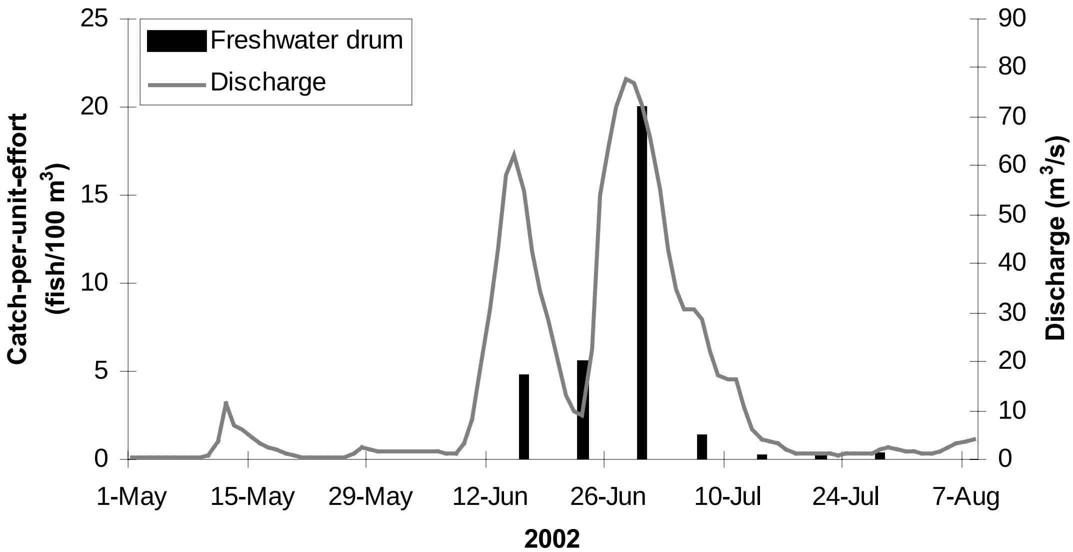


Figure 25. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Aplodinotus grunniens* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2002.

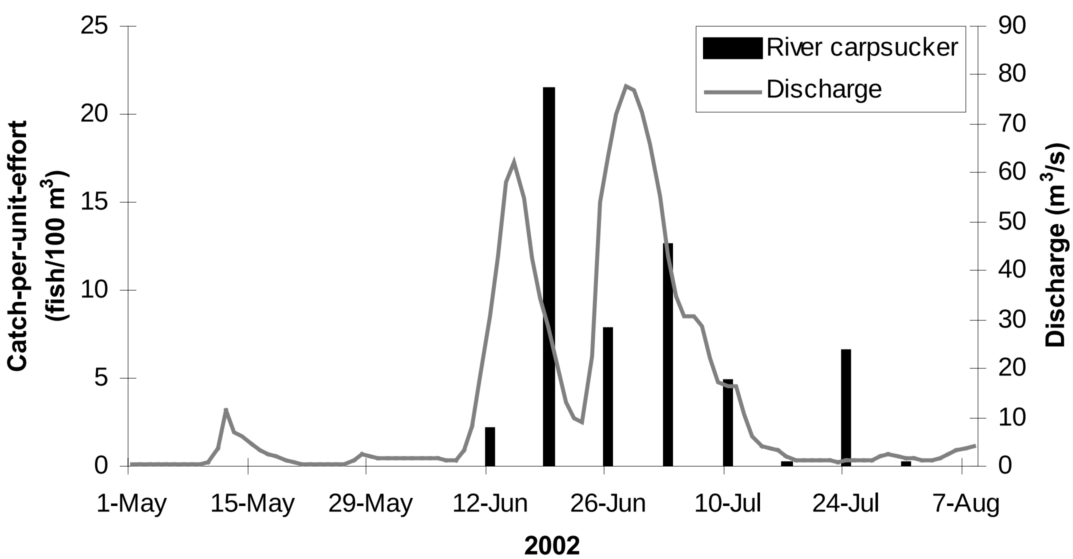


Figure 26. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Carpoides carpio* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2002.

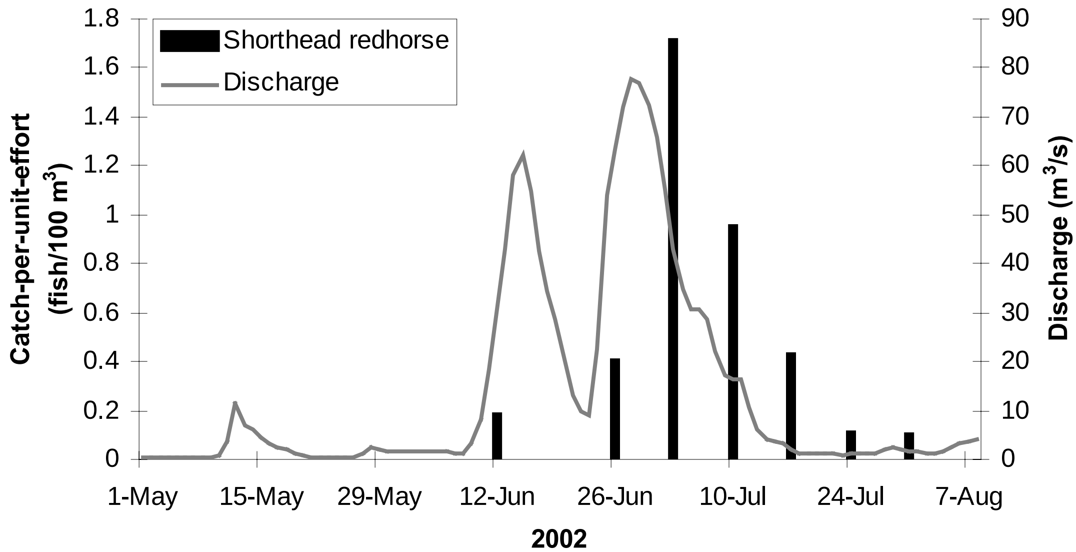


Figure 27. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Moxostoma macrolepidotum* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2002.

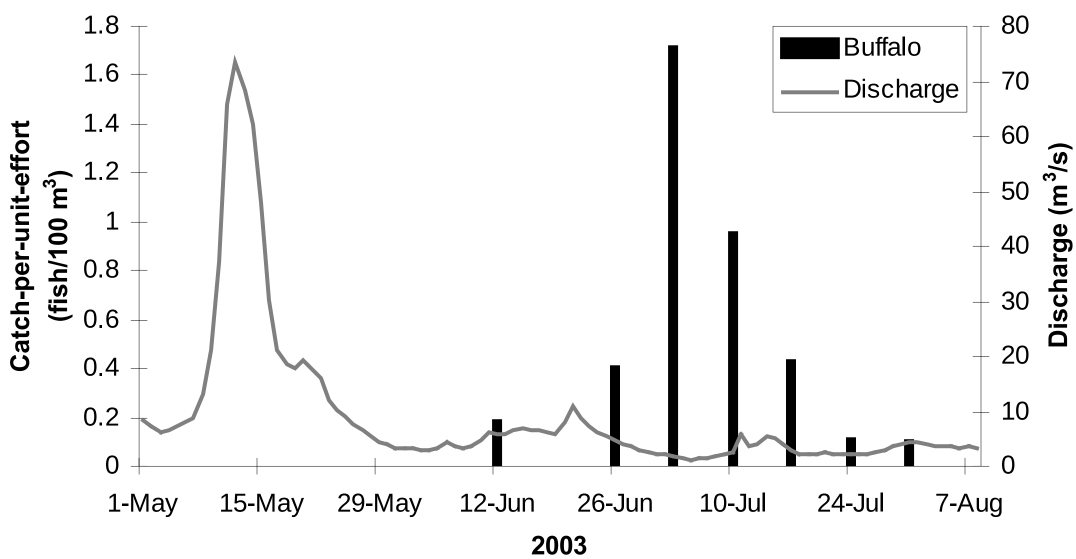


Figure 28. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Ictiobus spp.* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2003.

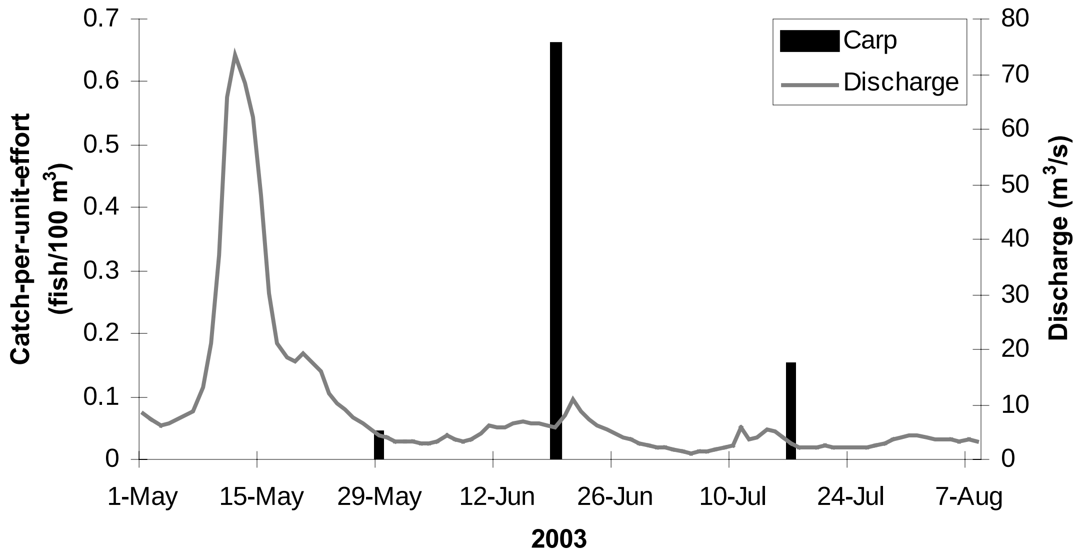


Figure 29. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Cyprinus carpio* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2003.

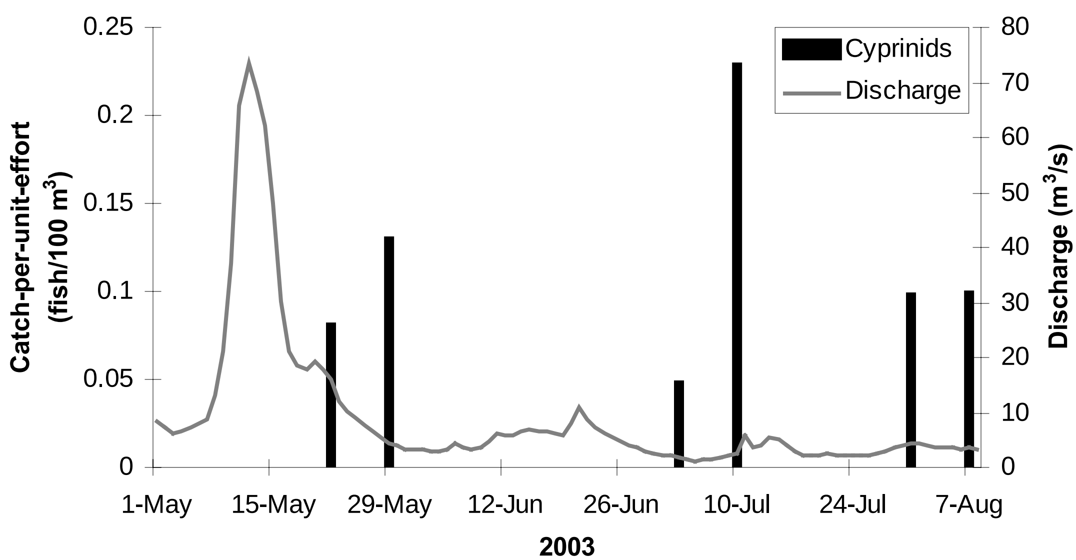


Figure 30. Weekly larval catch-per-unit-effort (fish/100 m^3) of fishes from the family Cyprinidae (excluding *Cyprinus carpio*) from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2003.

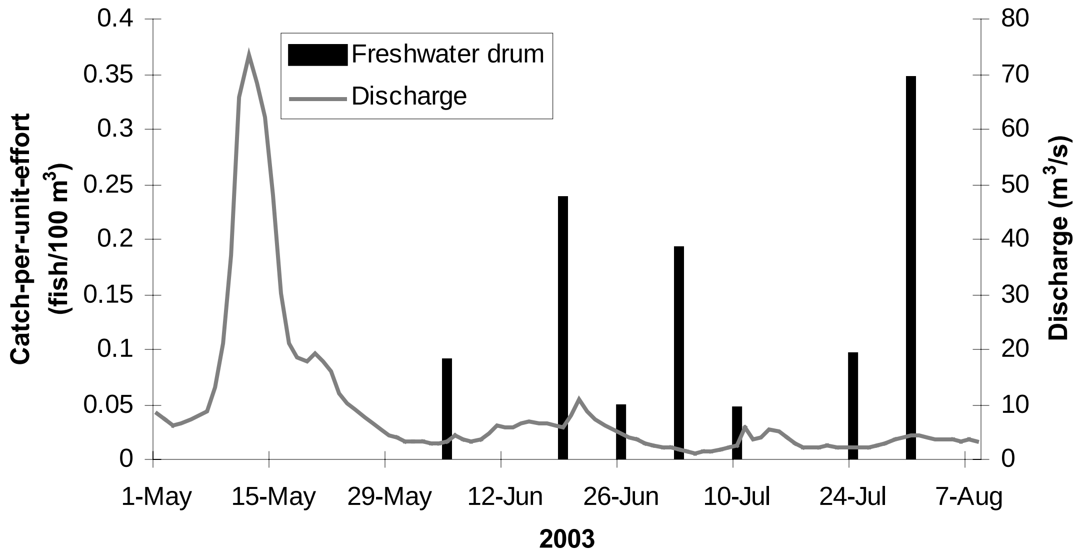


Figure 31. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Aplodinotus grunniens* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2003.

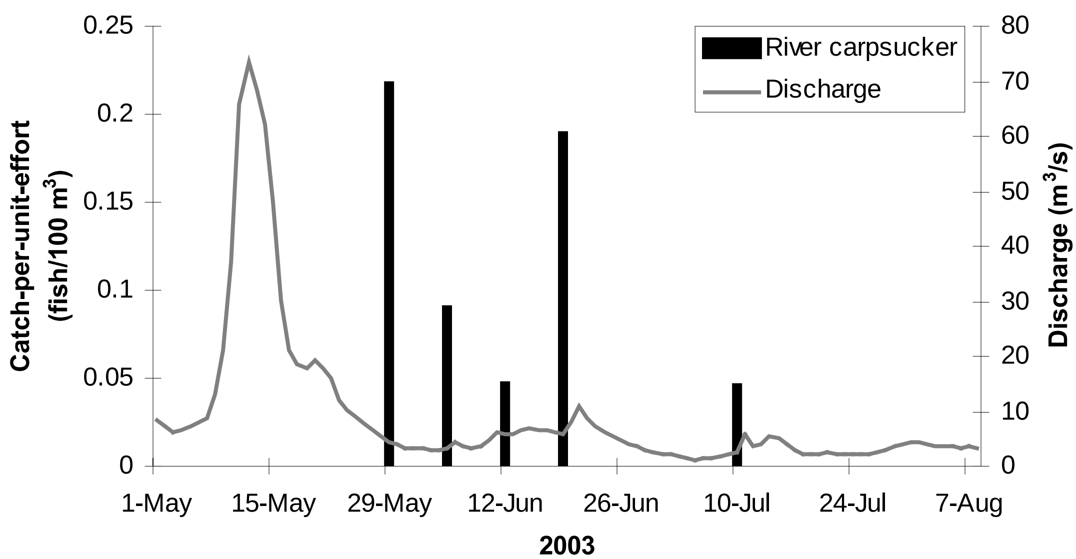


Figure 32. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Carpoides carpio* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2003.

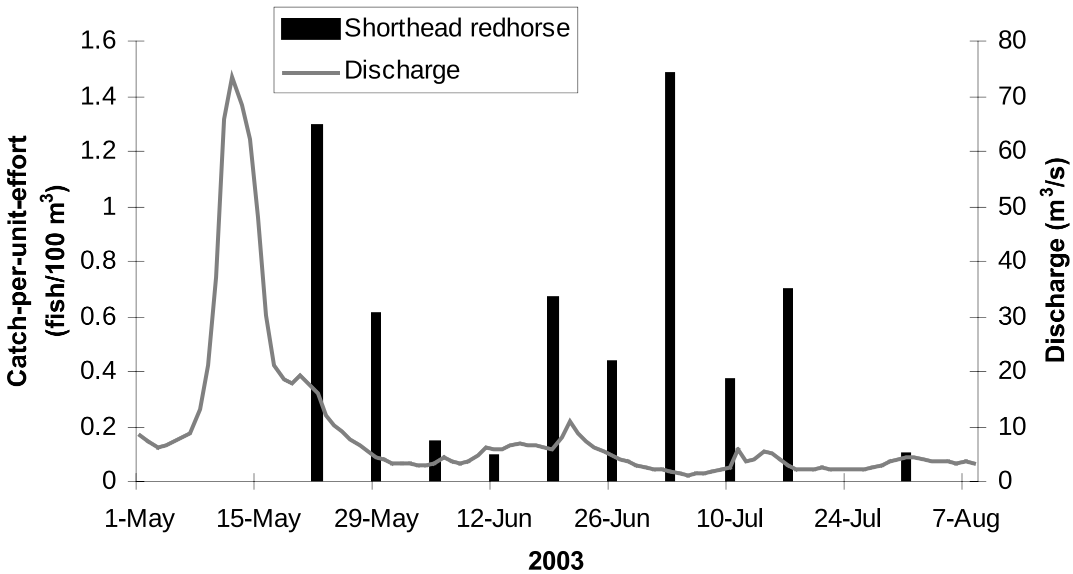


Figure 33. Weekly larval catch-per-unit-effort (fish/100 m^3) of *Moxostoma macrolepidotum* from the Milk River, Montana in relation to discharge measured near Nashua, Montana 2003.

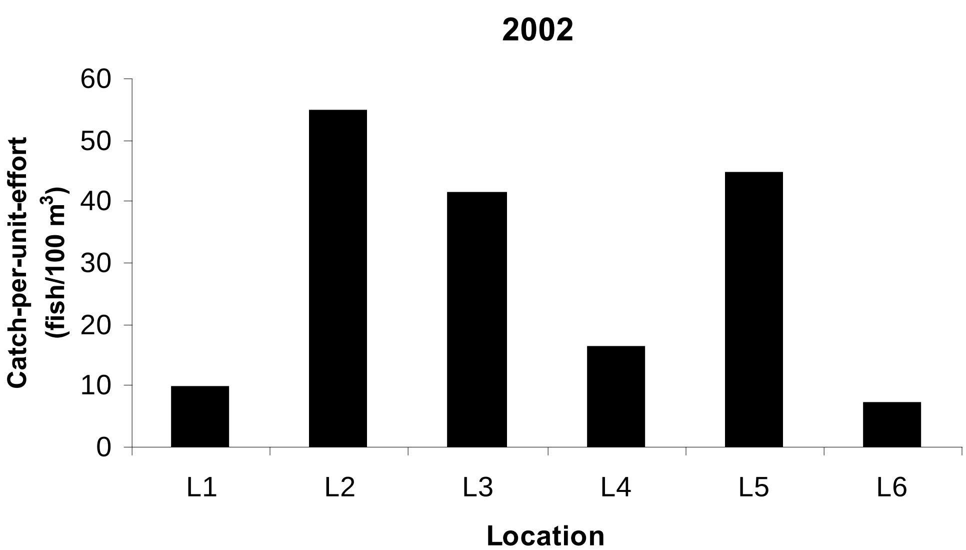


Figure 34. Larval fish catch-per-unit-effort (fish/100 m^3) at sampling locations along the lower Milk River, Montana in 2002. L1-L6 represents the furthest downstream location to the most upstream location.

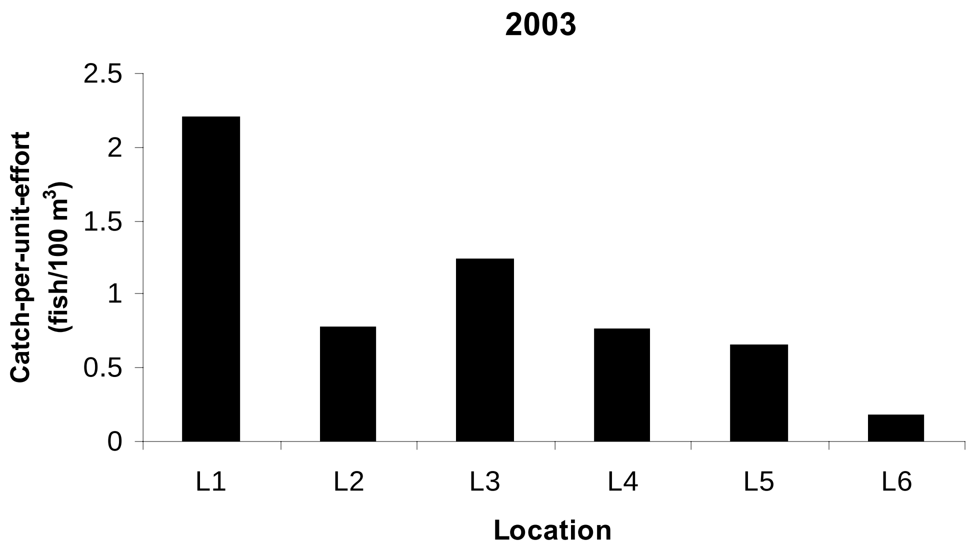


Figure 35. Larval fish catch-per-unit-effort (fish/100 m^3) at sampling locations along the lower Milk River, Montana in 2003. L1-L6 represents the furthest downstream location to the most upstream location.