RECLAMATION
Managing Water in the West

ENV-2019-031

Lower Yellowstone Project Fish Entrainment 2013

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
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Cover photo: New Intake Structure Upstream of Historical Intake

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Technical Service Center
Fisheries and Wildlife Resources Group, 86-68290

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Acronyms and Abbreviations

ac-ft	acre-foot
cfs	cubic feet per second
cm	centimeter
ESA	Endangered Species Act
ft	foot
LYP	Lower Yellowstone Project
m	meter
m^3	cubic meter
mm	millimeter
n	sample size
N	population size
PVC	polyvinyl chloride
Reclamation	Bureau of Reclamation
rkm	river kilometer
SD	Standard Deviation
TL	total length
TSC	Technical Service Center
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service

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Executive Summary

Researchers examined larval fish entrainment into the Lower Yellowstone Project Main Canal (Intake Canal), northeast of Glendive, Montana, during the 2013 irrigation seasons.

As part of an overall retrofit for the Lower Yellowstone Project, the headworks structure for Intake Canal was replaced in 2012. The new headworks use rotating cylindrical fish screens which have a maximum mesh slot size of 1.75 mm and were designed to keep fish larger than 40 millimeters out of the canal. The Bureau of Reclamation's (Reclamation) Technical Service Center (TSC) was tasked with evaluating the entrainment rates of larval fish into the Intake Canal with the new fish screens in place and to further compare entrainment rates among larger fishes between screened and unscreened intakes, with special consideration given to monitoring for Pallid sturgeon.

Larval sampling began in mid-May, soon after the irrigation season started, and ended in late August. Sampling occurred over a 48-hour period every other week during this time. Larval samples were collected using two 30 cm plankton nets deployed 0.4-kilometers downstream of the canal headworks to capture fish larvae and eggs. During the larval sampling effort, 418 samples containing 3,296 fish and 251 fish eggs were collected. Over 90 percent of the larvae captured were protolarvae. Samples were dominated by Cyprinids and Catostomids, though one Acipenserid larvae was captured.

Fish entrainment sampling began in mid-August and ended in late September. Three large entrainment nets were deployed on the discharge side of 3 of the 12 box culvert outlets at the upstream, mid-section and downstream sections of the canal. With fish screens in place a total of 24 entrainment net sets (all 3 nets operating simultaneously) collected 1,839 fish and were predominately long-nosed dace. Most of these fish were likely already residents in the canal, and other than some smaller fish, were probably not entrained through the screen. No adult or juvenile sturgeon were captured. During the last week of August, one screen was raised to compare entrainment between screened and unscreened intakes. During that time period, over 10,000 fish were collected from the single unscreened intake—compared to approximately 800 from the other two nets combined.

Introduction

The Lower Yellowstone Project (LYP) was authorized by the Secretary of the Interior in 1904 under the Reclamation Act of 1902. Construction of the diversion dam, canal headworks, and delivery canals for the LYP began in 1905. The Intake Diversion Dam is a 12-foot-high and 700-foot-long rocked-filled timber crib weir structure that spans the width of the Yellowstone River and diverts water into the Intake Canal (also termed the “Main Canal”). The diversion dam raises the upstream water elevation from two to five feet depending on river flows. The diversion dam is located approximately 70 river miles upstream from the confluence of the Yellowstone and Missouri Rivers (Figure 1) and is about 17 miles northeast of Glendive, Montana. The LYP includes the Intake Diversion Dam, canal headworks, Thomas Point Pumping Plant, Intake Canal, 225 miles of lateral canals and 118 miles of drains. The LYP provides a dependable water supply sufficient enough to irrigate approximately 58,000 acres of bench lands above the west bank of the Yellowstone River in eastern Montana and western North Dakota. Water is carried by gravity to the greater portion of project lands and is also pumped from the Intake Canal to irrigate approximately 823 acres in the Intake Irrigation Project and 2,300 acres in the Savage Irrigation Unit. The average annual volume of water diverted for these projects is 327,046 acre-feet.

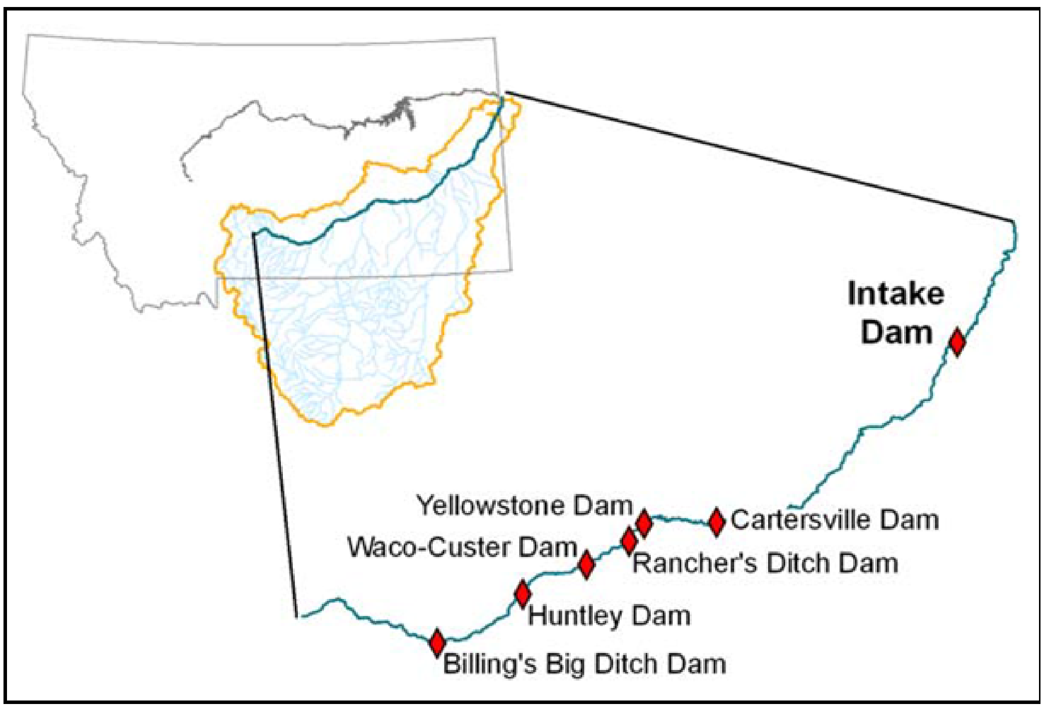
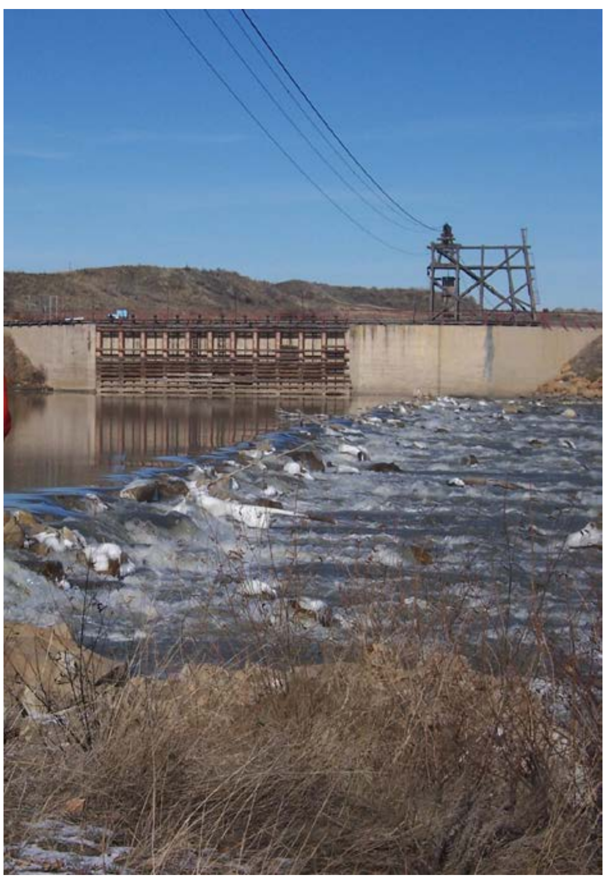


Figure 1.Intake Diversion Dam and the other low-head diversion dams on the Yellowstone River (adopted from Jenkins 2007 and Bureau of Reclamation [Reclamation] 2014).

The rock-filled timber crib weir structure across the Yellowstone River is a partial barrier to many fish species and is likely a total barrier during to species such as Pallid Sturgeon (*Scaphirhynchus albus*), Shovelnose Sturgeon (*S. platorynchus*), and Paddlefish (*Polydon spathula*) (Glickman et al., 2004). Pallid Sturgeon are one of the rarest fish species in the Missouri and Mississippi River basins and were listed as endangered in 1990 (55 FR 36641-36647) under the 1973 Endangered Species Act (ESA). The original canal headworks, where water is diverted from the Yellowstone River into the Intake Canal, did not include fish screens or a fish bypass structure. Fish entrainment monitoring by Hiebert et al. (2000) indicated thousands of fish from 36 different species were entrained annually into the canal.

Modifications to reduce fish entrainment have included constructing a new headworks facility and installing fish screens on the upstream (Yellowstone River) side of the intake conduits. The second component of the retrofit to the LYP is a proposed modification to the low-head diversion dam to allow fish passage.

Previous Fish Entrainment Monitoring



Prior to the new headworks and fish screens, the original canal headworks was an unscreened diversion with horizontally spaced timbers which served as the only barrier to canal entrainment (Figure 2). The original headworks had 11 circular sluice intake conduits 5-feet in diameter controlled by slide gates and had a capacity of 1,380 cubic-feet-per-second (cfs) (Hiebert et al., 2000). Fish smaller in height and/or width than the spacing between the timbers could be entrained into the canal.

Figure 2.View of original canal headworks, photo courtesy of the U.S. Army Corps of Engineers.

Hiebert et al. (2000) conducted a fish entrainment study during the 1996 - 1998 irrigation seasons, using half-inch mesh nets. No sampling occurred for larval stages. Flathead Chub (*Platygobio gracilis*), Stonecat (*Noturus flavus*), and Sturgeon Chub (*Macrhybopsis gelida*) were the most commonly entrained fish. These three species, as well as all other fish that were entrained in high numbers, exhibited monthly and diel trends in entrainment with greatest entrainment during crepuscular periods. The authors found little difference in total entrainment between years. Fish entrained into the canal were not evenly distributed between nets, and the furthest downstream net collected the most fish. This difference was thought to be partly due to the positioning of the Intake Canal headworks on the outside of the river bend, near the thalweg (Hiebert et al. 2000). Floy tagging of released fish indicated a percentage of the catch may have been of fish already residing in the canal. In 1997, forty-four Shovelnose Sturgeon were collected (range 390-923 fork-length).

In 2004, Montana Fish, Wildlife, and Parks released 21 hatchery-reared juvenile Pallid Sturgeon in the Yellowstone River between Forsyth and Fallon (Montana) with surgically implanted radio-transmitters. Of the 21 telemetered fish released, three were entrained into Intake Canal after traveling downstream between approximately 139 - 148 miles (Jaeger et al. 2006).

In the spring of 2009, 129 larval samples, of which 125 contained larval fish and or eggs, were collected from the canal (Best 2009). Over 800 larvae and 57 eggs were collected from which three families of fish were identified: Hiodontidae, Catostomidae and Cyprinidae. In 2012, 174 samples were collected, of which 117 contained larval fish or eggs. A total of 1,769 larvae and 147 eggs were collected from four families of fish, although 99 percent of all fish were either Cyprinids or Catastomids and the majority of larvae were <10 mm TL (Horn 2012).

Fish Screens

The purpose of the headworks replacement was an effort to protect Pallid Sturgeon as well as other native fish in the lower Yellowstone River by reducing incidental fish entrainment of fish less than 40 mm. The new headworks has 12 rotating cylindrical screens (ISI T78-100 Tee Fish Screens) that are track mounted and located on the river-side of the inlet conduit. The top of the headworks is approximately 1.5 m (5 feet) above the 100-year, ice-impacted water surface and are individually controlled with the ability to be raised or lowered as necessary (Reclamation 2014) (Figure 3).

Figure 3. New Intake Headworks structure under construction showing the river side with Intake Screens, Inc. fish screens (ISI T78-100 Tee Screen) over intake inlet conduit while the others are in the up position (photo from Intake Screens, Inc.).

Eleven of the intake conduits are used to fulfill the LYP full water right (1,374 cfs) with one additional inlet conduit (and screen) as a back-up. Each screen measures approximately 2 m (6.5 feet) in diameter and 7.6 m (25 feet) in total length. The screens have a maximum mesh slot size of 1.75 mm (Figure 4). Fixed brushes are mounted on the inside and outside of the screen and are automated to intermittently rotate to clean accumulated debris from both sides of the screen (Reclamation 2014). Because fish screen criteria specific to Pallid [Sturgeon are lacking (U.S. Fish and Wildlife Service [USFWS] 2007), the fish screens were designed to meet salmonid screening criteria established by the USFWS and the National Marine Fisheries Service (Reclamation 2014).

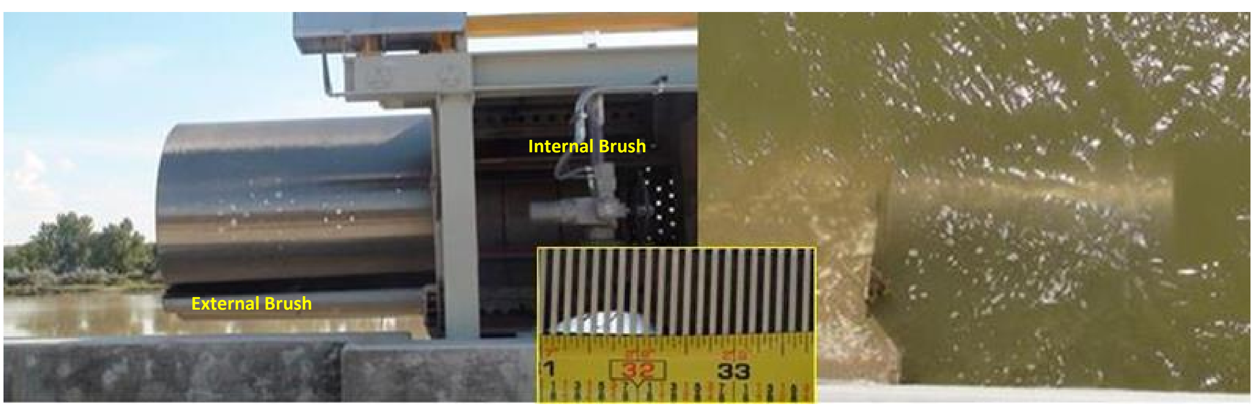


Figure 4. ISI T78-100 Tee Screen in raised (left) and submerged position (right) with inset photo showing 1.75-mm slots of wedge wire screen.

Fish in the Lower Yellowstone River

The Yellowstone River is the longest free-flowing river in the in the contiguous 48 United States. The Yellowstone River flows from its headwaters in the Absaroka Range and flows into Yellowstone Lake where the mainstem originates and then flows in a north-east direction through Wyoming, Montana, and North Dakota until it empties into the Missouri River above Lake Sakakawea (Figure 5). Because the mainstem is not impounded, the river retains a nearly natural hydrograph fed by mountain snow-melt and maintains high turbidity levels in the lower section. From its headwaters, the river changes from a cold water alpine system to a warm water prairie river system. Based on the fish distribution, the river can be divided into three zones where the upper portion, 802 - 993 river kilometers (rkm) is considered as the salmonid zone, the middle portion (477 - 801-rkm) a transition zone and the lower portion (0 - 476-rkm) as a warm water zone. The mean annual discharge near the mouth is 362 cubic meters per second (m^3/s) or 12,800 (cfs) and the average annual discharge is about 9.3 million acre feet (ac-ft) (White and Bramblett 1993).

A total of 56 fish species representing 16 families are found in the main stem Yellowstone, and 20 species are not native to the river. The salmonid zone of the Yellowstone River is dominated by salmonids and is inhabited by 16 fish species representing 6 families. The transition zone has 30 fish species representing 7 families, and the warm water zone has 50 fish species representing 15 families. Additionally, Brook Stickleback (*Culaea inconstans*), Cisco (*Coregonus artedi*), Sicklefin Chub (*Macrhybopsis meeki*) and Spottail Shiner (*Notropis hudsonius*) have been documented in the lower Yellowstone River (White and Bramblett 1993; Hiebert et al. 2000; and Montana Fish, Wildlife, and Parks 2003) (Table 1).

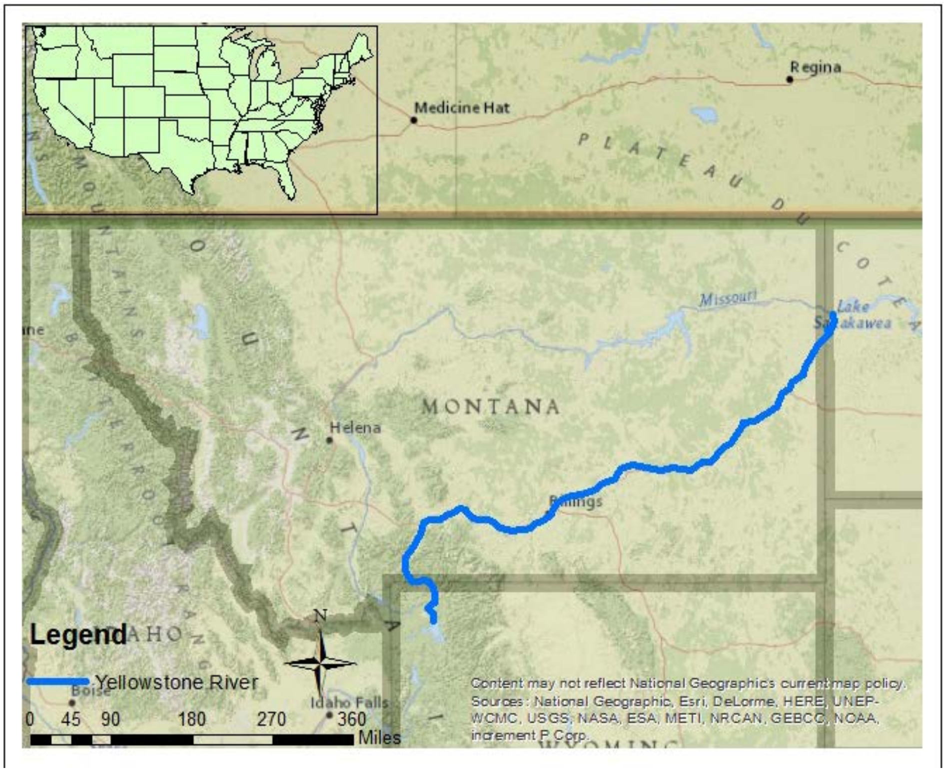


Figure 5. Map of the Yellowstone River from Yellowstone Lake downriver to Lake Sakakawea.

The larvae and eggs of many fish species found in the lower Yellowstone River have limited mobility during early life stages and instead drift with the current (Moser and Watson 2006). Free embryo Pallid and Shovelnose Sturgeon were found to drift from 94 rkm to 530 rkm (58.4 to 329.3 river miles) in the Missouri River, depending on water velocities (Braaten et al. 2008). Drifting larval fish in rivers and streams are highly susceptible to entrainment into water diversions such as canals and pumping facilities (Paller 1992). Settlement and concentration of large numbers of drifting eggs and larvae in dam pools and within river sediment may also lead to poor survival and dispersal of the affected species (Gilligan and Schiller2004). Table 1 lists fish species found near the Intake Division.

Table 1. Fish Species Found in the Lower Yellowstone River near the Intake Diversion (White and Bramblett 1993; Hiebert et al 2000; and Montana Fish, Wildlife and Parks 2003).

Common Name	*Scientific Name*
Sturgeons	**Acipenseridae**
Pallid Sturgeon	*Scaphirhynchus albus*
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*
Paddlefishes	**Polyodonitdae**
Paddlefish	*Polydon spathula*
Mooneyes	**Hiodontidae**
Goldeye	*Hiodon alosoides*
Carps and Minnows	**Cyprinidae**
Lake Chub	*Couesius plumbeus*
Common Carp	*Cyprinus carpio*
Western Silvery Minnow	*Hybognathus argyritis*
Brassy Minnow	*Hybognathus hankinsoni*
Plains Minnow	*Hybognathus placitus*
Sturgeon Chub	*Macrhybopsis gelida*
Sicklefin Chub	*Macrhybopsis meeki*
Golden Shiner	*Notemigonus crysoleucas*
Emerald Shiner	*Notropis atherinoides*
Spottail Shiner	*Notropis hudsonius*
Sand Shiner	*Notropis stramineus*
Fathead Minnow	*Pimephales promela* s
Flathead Chub	*Platygobio gracilis*
Longnose Dace	*Rhinichthys cataractae*
Creek Chub	*Semotilus atromaculatus*
Suckers	**Catostomidae**
River Carpsucker	*Carpiodes carpio*
White Sucker	*Catostomus commersonii*
Longnose Sucker	*Catastomus catastomus*
Mountain Sucker	*Catastomus platyrhynchus*
Smallmouth Buffalo	*Ictiobus bubalus*
Bigmouth Buffalo	*Ictiobus cyprinellus*
Shorthead Redhorse	*Moxostoma macrolepidotum*
Bullheads and Catfishes	**Ictaluridae**
Black Bullhead	*Ameiurus melas*
Yellow Bullhead	*Ameiurus natalis*
Channel Catfish	*Ictalurus punctatus*
Stonecat	*Noturus flavus*

Common Name	*Scientific Name*
Continued	
Pikes	**Esocidae**
Northern Pike	*Esox lucius*
Trouts and Salmons	**Salmonidae**
Cisco	*Coregonus artedi*
Rainbow Trout	*Oncorhynchus mykiss*
Mountain Whitefish	*Prosopium williamsoni*
Brown Trout	*Salmo trutta*
Cods	**Gadidae**
Burbot	*Lota lota*
Killifishes	**Cyprinodontidae**
Plains Killifish	*Fundulus zebrinus*
Sticklebacks	**Gasterosteidae**
Brook Stickleback	*Culaea inconstans*
Sunfishes	**Centrarchidae**
Rock Bass	*Ambloplites rupestris*
Green Sunfish	*Lepomis cyanellus*
Pumkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Smallmouth Bass	*Micropterus dolomieu*
Largemouth Bass	*Micropterus salmoides*
White Crappie	*Pomoxis annularis*
Black Crappie	*Pomoxis nigromaculatus*
Perciforms	**Percidae**
Yellow Perch	*Perca flavescens*
Sauger	*Sander canadensis*
Walleye	*Sander vitreus*
Drums and Croakers	**Sciaenidae**
Freshwater Drum	*Aplodinotus grunniens*

Methods

Entrainment Net Sampling

Entrainment nets were used to evaluate entrainment of larger juvenile and adult fishes through the Intake Canal inlets with and without fish screens in place. The entrainment effort intended to evaluate Yellowstone River fish small enough to pass through the fish screen (Figure 6). Three of the 12 intake inlets, inlet numbers 2, 7 and 11, thought to be representative of the diversion, were selected for sampling. These three inlets were sampled between August 6 and September 18, 2013 (Figure 7). The entrainment nets were designed to cover the outlet pipe and were 1.22 m (4 feet) wide and 1.83 m (6 feet) high and about 10 m (32 feet) long. Nets were constructed from square heavy black delta mesh ($^{1}/_{8}$ inch), with a cod end consisting of a 6-inch diameter removable polyvinyl chloride (PVC) bucket. Nets were attached to an aluminum frame connected to guide cables strung from a framework mounted to the concrete railing on the intake deck. Nets were raised and lowered from the top of the diversion dam using a steel cable attached to a manual winch (Figure 7 and Figure 8).

Figure 6. Aerial image of Lower Yellowstone Irrigation Project, including headworks where entrainment nets were deployed and Canal Road where larval nets were deployed.

Figure 7. Intake Canal headworks directly inside the diversion, showing the locations of the large fish entrainment nets at Inlet numbers 2, 7, and 11.

Figure 8. (A) (left) Photo of steel frame structure used to extend the entrainment net frame out about 2.5 meters to line up over the outlet area of the box culvert. (B) (right). Photo of receiving frame structure made from stock plate aluminum constructed onto the outlet of the box culvert to further guide the net into position and hold it in place.

Due to flow rates and large numbers of fish living in the afterbay, aluminum guide frames were added to the culverts to help hold the nets in place and limit the number of fish entering the net from the surrounding water.

During deployment, one operator lowered the net, and another person stood on the culvert and helped guide the net into position. The net deployment process took approximately 5 minutes per net, and nets were deployed sequentially. Nets were fished for 0.5 to 3 hours, depending on debris and fish loads (Table 2). Species, total length, and body condition were recorded for the fish captured. If a large number of fish were captured, only 20 - 30 fish of each species were measured, and the rest were simply counted. Comparisons with and without screens could only be done during low water in late August due to operational concerns at the facility. Having the screen raised while the intake was open imparts some risk to the facility, as if a large piece of debris became lodged in the intake, there would be no way to shut off the flow to the canal.

Table 2. 2013 Sample Dates, Net Deployment, and Fish Screen Status

Date	Hours Fished/Net	Number of Nets
7/11/2013	4.25	2
8/6/2013	8.94	3
8/7/2013	5.2	3
8/20/2013	7.85	3
8/21/2013	4.36	3
8/22/2013	3.42	3
8/27/2013	1.5	3
8/27/2013	4.75	2*
8/27/2013	1.75	1**
8/28/2013	3.83	2*
8/28/2013	1.0	1**
9/17/2013	5.72	3
9/18/2013	6.26	3

*Two nets were deployed with fish screens in place.
** One net was deployed with fish screen raised for comparison.

Larval Sampling

To evaluate larval fish entrainment through the fish screens, two 30-centimeter (cm) x 3.0 m plankton trawl nets were fished off the Intake Dam fishing and camping access bridge about 0.4km downstream of the diversion dam (Figure 6 and Figure 9). The distance from the headworks to the bridge was thought to be enough to allow for sufficient mixing of all of the 12 inlet conduits. Both nets were deployed near the center of the canal with one fished near the surface and the other just off the bottom. A net weight tied in below the net was used to adjust position in the water column. A General Oceanics mechanical flowmeter was attached to each net and start and stop counts used to calculate volume of water filtered.

The nets were deployed for 30 minutes every 2 hours for a 48-hour period each trip. Sampling trips were conducted every other week starting in mid-late May and ending mid-late August and encompassed most of the irrigation season and descending hydrograph (Figure 10). The larval sampling effort also encompassed the period when Shovelnose and Pallid Sturgeon spawn and their embryos and larvae could be present in the lower Yellowstone River (Backes 2012 Personal Communication).

Figure 9 (A) (left). Photo of larval sampling gear showing plankton net, depressor weight, flow meter, and PVC collecting bucket at the cod end. (B) (right). Photo of Intake Canal looking downstream showing the surface sampling net (left) and the rope leading to the bottom sampling net (right).

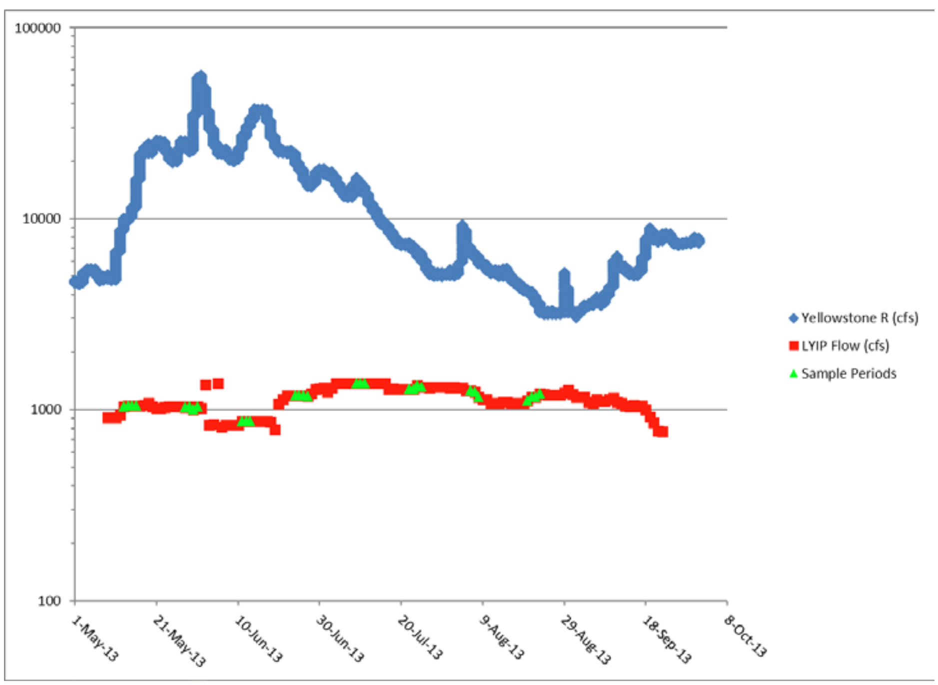


Figure 10. Larval sampling periods (green triangles) during the 2013 LYP irrigation season and flow in the Yellowstone River (U.S. Geological Survey [USGS] gage 06327500 near Glendive, MT).

All samples retrieved from the nets were placed into a 0.95 liter plastic jar and preserved in 10 percent formalin with diluted Rose Bengal as a larval stain. The samples were labeled numerically and logged into a notebook along with the date, time, location, depth, and flow meter count. Samples were then transported to a lab for processing. In the lab, the samples were poured into a number 40 sieve (0.42-mm or 0.0165-inch), thoroughly rinsed with tap water, and placed onto one side of a deep-dish white plastic container (Figure 11A). Similar to Wanner et al (2011), the sample was then carefully spread out and the larval fish and eggs separated from detritus (Figure 11B). Larval fish and eggs were placed into a scintillation vial filled with 10 percent formalin and labeled with the appropriate sample number. The number of larval fish and eggs was tallied for each sample, and density was calculated based on the volume of water filtered (using the formula in the General Oceanics Flowmeter Manual 2008) and extrapolated using daily canal flows to estimate daily entrainment rates (e.g. density larvae /m^3 and density eggs/m^3).

All larvae collected during 2013 were sent to the University of New Mexico, Museum of Southwestern Biology for identification. The Museum of Southwestern Biology (University of New Mexico) used morphometric information to identify larvae. For some of the larvae, the caudal fin was damaged to the extent that the total length of the specimen could not be accurately determined, and alternative keys based on standard length were employed to classify to the species level or family level.

Figure 11 (A) (left). Laboratory larval separating equipment. (B) (right). Separating the larvae (stained red) from detritus.

Results

Entrainment Sampling

Sampling using the large entrainment nets occurred August 6 - 7, 20 - 22, and 27 - 28 as well as September 17-18. A total of 13,517 fish were captured. The majority of those fish were caught over a two day period, August 27 - 28, when the fish screen was removed from inlet #2 when almost 9,000 fish (predominately Emerald Shiner and Flathead Chub) were caught in two net sets (Table 4). Only 1,839 fish were captured from the two nets with fish screens in place (Table 3). No sturgeon or paddlefish were caught. Flathead Chub, Emerald Shiner, Sand Shiner and Longnose Dace were the most commonly captured species (Table 3). The entrained fish represented 6 of the 14 families found in the lower Yellowstone River and were dominated by Cyprinids (Figure 12).

Table 3. 2013 Fish Captures from LYP Intake Canal Entrainment Nets with Fish Screens in Place, including Total Length (mm) and Length Range.

Species	N	Mean TL (mm)	Minimum Range	Maximum Range
Longnose Dace	1,531	42.28	27	68
Sturgeon Chub	95	49.15	31	78
Unidentified	73	24.17	13	38
Flathead Chub	36	120.91	41	225
Stonecat	21	158.16	74	195
Creek Chub	15	41.20	25	54
Lake Chub	15	53.40	29	59
Sand Shiner	12	55.73	43	65
River Carpsucker	9	206.78	167	357
White Sucker	9	210.00	148	260
Goldeye	8	124.94	70	202
Emerald Shiner	7	72.00	72	74
W. Silvery Minnow	4	48.25	44	55
Channel Catfish	2	115.00	51	179
Sauger	2	285.00	280	290
Total	**1,839**	**107.13**	**13**	**290**

N= population size

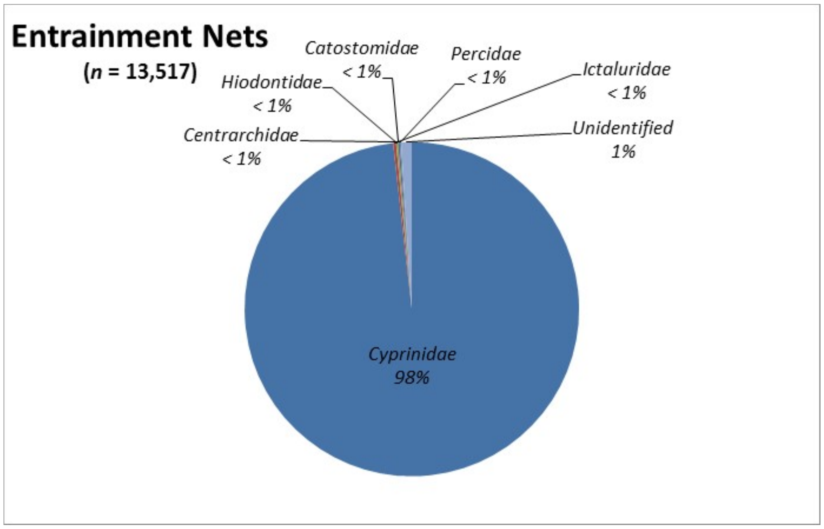


Figure 12. Family composition of the fish collected in the LYP Intake Canal entrainment nets during August- September, 2013.

Table 4. 2013 Fish Captures from LYP Intake Canal Entrainment Nets with Fish Screens Raised, Including Total Length (mm) and Length Range

Species	N	Mean TL (mm)	Minimum Range	Maximum Range
Flathead Chub	4,924	60.4	41	160
Emerald Shiner	4,519	68.9	35	80
Sand Shiner	990	44.5	28	60
Longnose Dace	808	40.8	30	63
W. Silvery Minnow	297	49.2	35	72
Unidentified	65	30.7	27	31
Goldeye	16	75.5	55	108
Sturgeon Chub	16	40	40	40
Channel Catfish	16	296	296	296
Bluegill	16	35	35	35
White Sucker	5	172.5	165	180
Lake Chub	3	55	55	55
Common Carp	3	265	265	265
Total	**11,678**	**94.8**	**27**	**296**

Larval Entrainment

A total of 418 samples were collected encompassing most of the irrigation season and the spring-summer period when most of the Yellowstone River fish spawned. A total of 3,296 larvae and 251 eggs were collected (Table 5). The majority of larva were identified as either Catostomidae or Cyprinidae (Table 6). One Acipenseridae, identified as Shovelnose Sturgeon, was captured.

A common issue with drift net sampling is that specimens become compacted in the back of the net. About 20 percent of the larval fish collection were in poor condition. Damage to these specimens made identification difficult. Greater than 90 percent of the larval samples were protolarvae (earliest ontogenetic life stage). Protolarvae have fewer morphological characteristics available to determine species identification. Hatching lengths and body length relative to ontogenetic stage were used to determine family and species identification (Museum of Southwestern Biology 2014). The majority of Catostomids were categorized as either *Carpiodes* or *Ictiobus*. Some Catostomid individuals could not be clearly distinguished as either of these so they were categorized as *Carpiodes/Ictiobus*. Early ontogenetic life stages of Cyprinids that did not clearly fall within the known published range of means of species-specific morphology and morphometrics (because they were too damaged to determine diagnostic characters), were assigned to one of the three primary Cyprinid morphological sets: A, B, or C (Table 6).

Table 5. Summary of Larval Captures and Native Status in the LYP Intake Canal for May - August, 2013.

Common Name	*Scientific Name*	N	Native Status
Sturgeons	**Acipenseridae**		
Shovelnose Sturgeon	Scaphirhynchus platorynchus	1	Y
Mooneyes	**Hiodontidae**		
Goldeye	Hiodon alosoides	87	Y
CarPs and minnow	**Cyprinidae**		
Common Carp	Cyprinus carpio	12	N
Brassy Minnow	Hybognathus hankinsoni	2	Y
Emerald Shiner	Notropis atherinoides	22	Y
Spottail Shiner	Notropis hudsonius	28	N
Fathead Minnow	Pimphales promelas	6	Y
Flathead chub	Platygobio gracilis	149	Y
Longnose Dace	Rhinichthys cataractae	86	Y
Creek Chub	Semotilus atromaculatus	7	Y
Silvery Minnows	Hybognathus spp.	39	Y
Chubs	Macrhybopsis spp.	154	Y
Minnows	Cyprinidae	165	
Minnows	Cyprinidae A	28	
Minnows	Cyprinidae B	258	
Minnows/Chubs	Cyprinidae B chubs	68	
Minnows	Cyprinidae C	78	

Common Name	*Scientific Name*	N	Native Status
Continued			
Suckers	**Catostomidae**		
Longnose Sucker	Catostomus catostomus	9	Y
White Sucker	Catostomus comersonii	2	Y
River Carpsucker	Carpiodes carpio	1,371	Y
Bigmouth Buffalo	Ictiobus cyprinellus	19	Y
Shorthead Readhorse	Moxostoma macrolepidotum	121	Y
River Carpsuscker or Buffalo	Carpiodes carpio lor Ictiobus spp.	147	Y
	unidentified Catostomidae	2	
	Ictiobus spp.	364	
	Catostomus spp.	14	
Cyprinidae or Catostomidae	Cypriniformes	13	N
North American catfishes	**Ictaluridae**		
Channel Catfish	Ictalurus punctatus	37	Y
Stonecat	Noturus flavus	3	Y
Killifishes	**Fundulidae**		
	Fundulus sp.	1	Y
Sunfishes	**Centrarchidae**		
Green Sunfish	Lepomis cyanellus	2	N
Perches and darters	**Percidae**		
	Sander spp.	1	Y
	Fish eggs	251	
GRAND TOTAL		**3,547**	

Table 6. Summary of the Larval Species Grouped as Cyprinid A, B, B – Chub Subset, and C (Museum of Southwestern Biology 2014).

Cyprinidae A	
Common Name	*Scientific Name*
Western Minnow	*Hybognathus argyritis*
Plains Minnow	*Hybognathus placitus*
Emerald Shiner	*Notropis athernoides*

Cyprinidae B - Chub subset	
Common Name	*Scientific Name*
Sturgeon Chub	*Macryhybopsis gelida*
Sicklefin Chub	*Macrhybopsis meeki*
Flathead Chub	*Platygobio gracilis*

Cyprinidae B	
Common Name	*Scientific Name*
Sturgeon Chub	*Macryhybopsis gelida*
Sicklefin Chub	*Macrhybopsis meeki*
Flathead Chub	*Platygobio gracilis*
Longnose Dace	*Rhinichthys cataractae*
Creek Chub	*Semotilus atromaculatus*

Cyprinidae C	
Common Name	*Scientific Name*
Brassy Minnow	*Hybognathus hankinsoni*
Spottail Shiner	*Notropis hudsonius*
Fathead Minnow	*Pimephales promela*s

Daily entrainment rates were calculated using canal discharge data and the volumes of water sampled for each net. For this estimate, canal gage measurements were assumed to remain relatively constant over each 24-hour period. Both the density of larvae and density of eggs per acre-foot of canal water began to increase in May, peaked in mid-June, and then quickly decreased to near zero by late August (Figure 13 through Figure 16). At the peak, almost one million larvae per day are entrained into the canal. Species composition also changed as the season progressed with Hiodontidae dominating May sampling events, catostomids dominating in June, an almost equal mix of cyprinids and catastomids in July, and primarily Cyprinids in August (Figure 17).

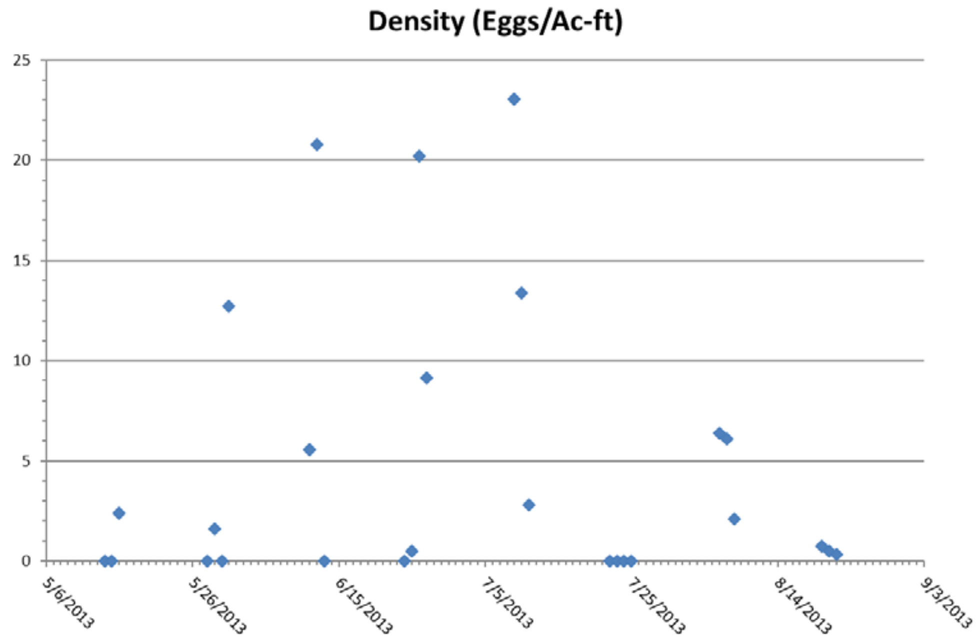


Figure 13. Estimated daily average density of fish eggs entrained per acre-foot of canal water.

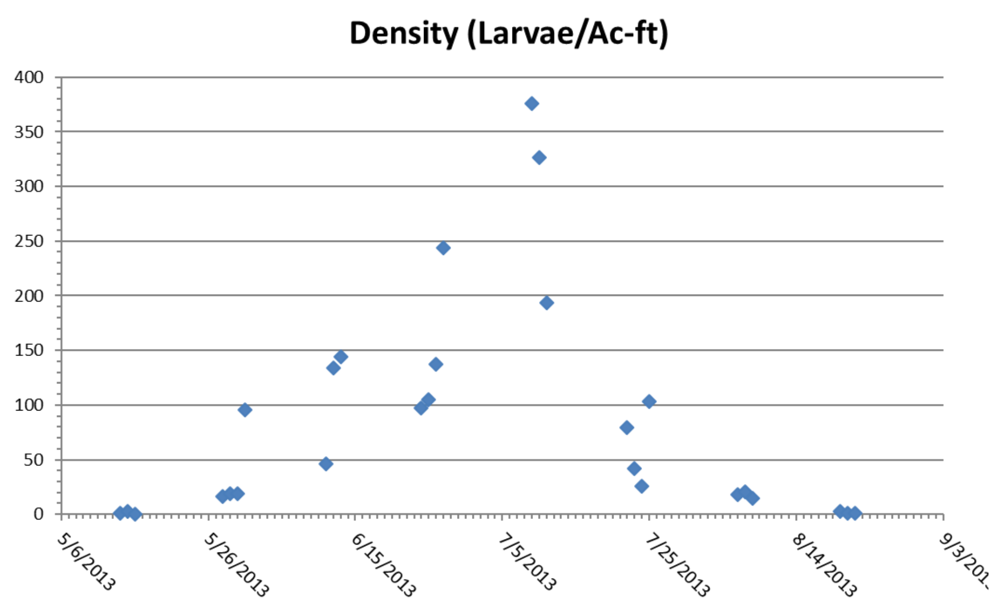


Figure 14. Estimated daily average density of larval fish entrained per acre-foot of canal water.

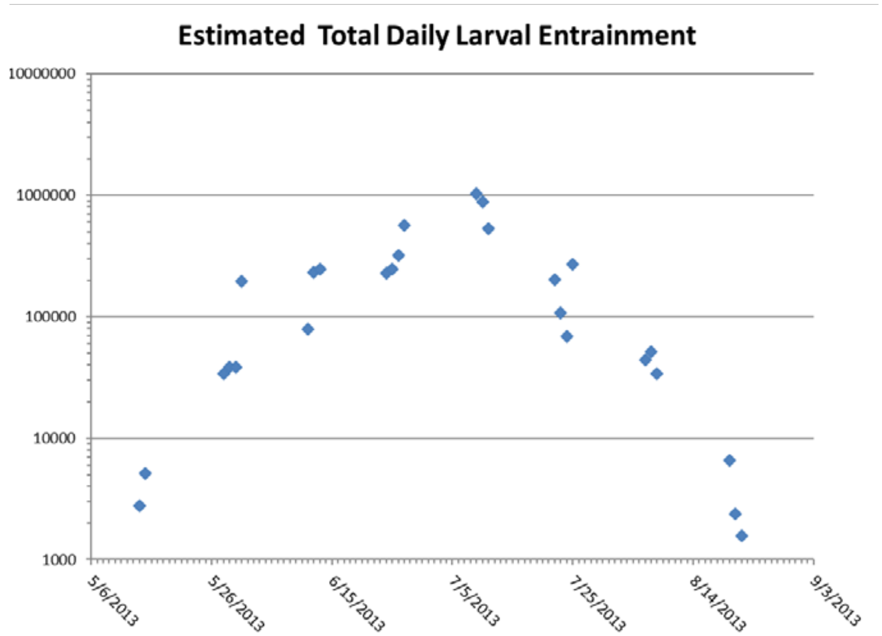


Figure 15. Total estimated daily larvae entrainment per day during May - August larval sampling periods.

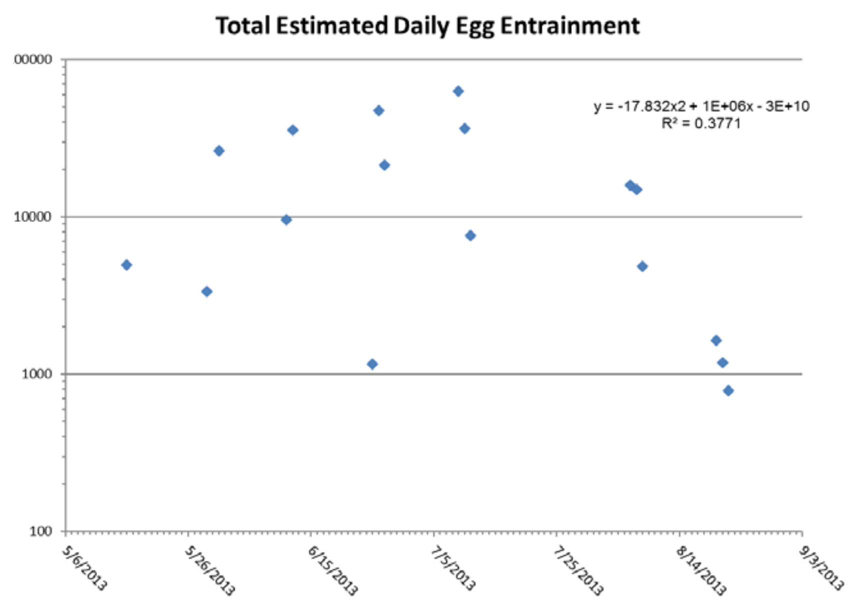


Figure 16. Total estimated daily fish egg entrainment per day during May - August larval sampling periods.

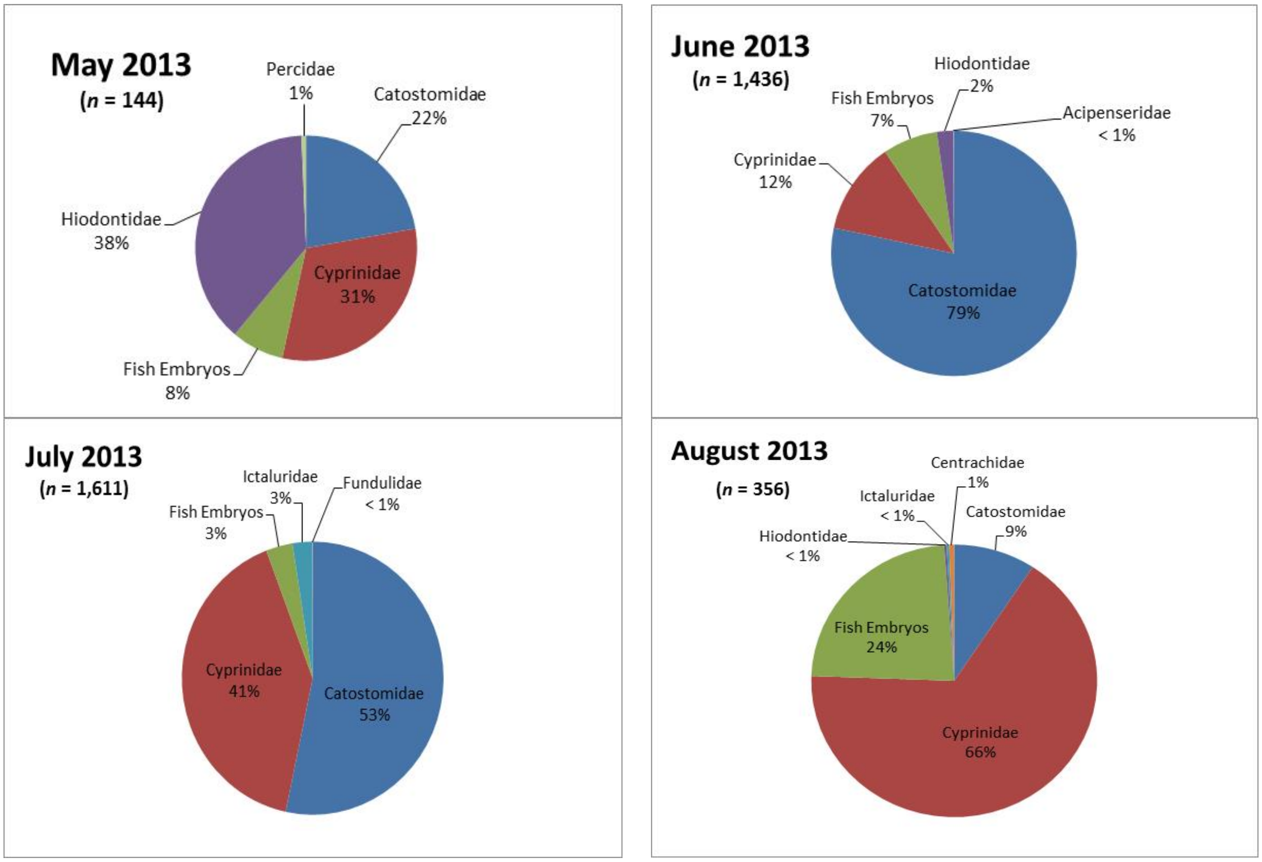


Figure 17. Species composition of larval samples collected from May -August 2013.

Conclusion

Removing one of the intake screens resulted in high numbers of adult and juvenile fish being entrained, which was not unexpected, given results of studies completed prior to the installation of the new intake structure (Hiebert et al. 2000, Jaeger et al. 2006, and Best 2009). Limited larval data was collected prior to construction of the new screen—so it is not possible to say whether the screen installation has had any impact on larval entrainment. It should be pointed out though the screens were not designed with the idea of excluding larval fish. While the estimate of up to a million larvae per day seems high, it is only a small fraction of the daily drift down the Yellowstone. We did not find any evidence for larger fish being entrained into the canal when the screens were in place.

Velocities across the screens themselves are very low. During times when the river was less turbid in late summer, schools of small fish could often be observed swimming and feeding in very close proximity to the screens. We captured significant numbers of a few species in the nets covering culverts that were screened, but during the course of study it was apparent most, if not all of these fish, were already present in the canal. Looking down over the intake structure above our nets, schools of dace and small chubs could be observed to be actively swimming around in eddies created by the nets. Using an underwater video camera, we were also able to observe many fish swimming in the afterbay. Larger fish were also quite common, including catfish and walleye which could be caught using hook and line. Many of these larger fish are thought to overwinter in one of several siphons along the canal that hold water even after the irrigation season has ended.

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