

- I. **Project Title: Operation, maintenance, and fish escapement evaluation of the Highline Lake spillway net (fish barrier); operation, maintenance, and fish escapement evaluation of the Elkhead Reservoir spillway net (fish barrier)**
- II. Bureau of Reclamation Agreement Number(s): No agreement currently in place. Previous agreement number was R12AP40001

Project/Grant Period: Start date: NA  
End date: NA  
Reporting period end date: December 31, 2018  
Is this the final report? The study is ongoing.

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IV. Abstract:

This project includes the operation and maintenance of the Highline Lake spillway net, designed to control escapement of non-native, warm water fishes from Highline Lake, and evaluation of that spillway net as an anti-fish escapement device. This project also includes the operation and maintenance of the Elkhead Reservoir spillway net, designed

to control escapement of non-native, warm water fishes from Elkhead Reservoir, and evaluation of that spillway net as an anti-fish escapement device. Overall, both spillway nets appear to be in good shape and performing as designed.

V. Study Schedule:

Initial Year: 1999

Final Year: Ongoing

VI. Relationship to RIPRAP:

This report provides details on the operation and maintenance of the Highline Lake spillway net, and fish monitoring to determine spillway net performance. The report also provides details on the operation and maintenance of the Elkhead Reservoir spillway net, and fish monitoring to determine spillway net performance.

*General Recovery Program Support Action Plan*

- III. Reduce negative impacts of nonnative fishes and sportfish management activities (nonnative and sportfish management).
- III.A. Reduce negative interactions between nonnative and endangered fishes.
- III.A.2. Identify and implement viable active control measures.
- III.A.2.c. Evaluate the effectiveness (e.g., nonnative and native fish response) and develop and implement an integrated, viable active control program.
- III.B. Reduce negative impacts to endangered fishes from sportfish management activities

*Colorado River Action Plan: Mainstem*

- III.B. Reduce negative impacts to endangered fishes from sportfish management activities
- III.B.1. Evaluate control options and implement measures to control nonnative fish escapement from Highline Reservoir
- III.B.1.a. Operate and maintain Highline Reservoir net

*Green River Action Plan: Yampa and Little Snake Rivers*

- III.B.1. Prevent nonnative fish introduction; reduce invasion and recruitment
- III.B.1.a.(2) Implement control measures as needed to control escapement (during and after Elkhead expansion construction). Post-construction: monitor and maintain Elkhead screens (YS C-1)

VII. Accomplishment of FY 2018 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

A. *Highline Lake Operations and Maintenance*

Task 1. Maintain protective buoy line

Schedule: March/April - October

Deliverable: **Task Completed**

Task 2. Spillway net cleaning and repair operations (in water)  
Schedule: March/April - October  
Deliverable: **Task Completed**

Task 3. Weekly visual survey  
Schedule: March/April - October  
Deliverable: **Task Completed**

Task 4. Underwater survey  
Schedule: March/April – October  
Deliverable: **Task Completed**

Task 5. Preparation of final report documenting operations and maintenance, and related costs  
Schedule: November/December  
Deliverable: **Task Completed**; Annual Report completed

*B. Highline Lake Fish Monitoring*

Task 1. Fish sampling to monitor fish escapement downstream of the spillway net (within the reservoir, between the spillway net and spillway)  
Schedule: February/March (pre-spill conditions)  
Deliverable: **Task Completed**

Task 2. Fish sampling to monitor fish escapement downstream of the spillway net (outside of the reservoir, within Mack Wash and/or Salt Creek)  
Schedule: November (post-spill conditions)  
Deliverable: **Task Completed**

Task 3. Equipment maintenance, data entry, data analysis, and preparation of fisheries final report  
Schedule: February/March-November/December  
Deliverable: **Task Completed**. Annual Report completed.

*C. Elkhead Reservoir Operations and Maintenance*

Task 1. Maintain protective debris boom  
Schedule: March/April - September  
Deliverable: **Task Completed**

Task 2. Spillway net cleaning and repair operations (in water)  
Schedule: March/April - September  
Deliverable: **Task Completed**

Task 3. Weekly visual survey  
Schedule: March/April - September  
Deliverable: **Task Completed**

Task 4. Underwater survey  
Schedule: March/April - September  
Deliverable: **Task Completed**

Task 5. Preparation of final report documenting operations and maintenance, and related costs  
Schedule: November/December  
Deliverable: **Task Completed.** Annual Report completed.

*D. Elkhead Reservoir Fish Monitoring*

Task 1. Fish sampling to monitor fish escapement downstream of the spillway net (within the reservoir, between the spillway net and spillway)  
Schedule: March (pre-spill conditions) and September/October (post-spill conditions)  
Deliverable: **Task Completed**

Task 2. Fish sampling to monitor fish escapement downstream of the spillway net (outside of the reservoir, within the stilling basin and prior to and post-connection with Elkhead Creek)  
Schedule: March (pre-spill conditions) and September/October (post-spill conditions)  
Deliverable: **Task Completed**

Task 3. Equipment maintenance, data entry, data analysis, and preparation of fisheries final report  
Schedule: March-November/December  
Deliverable: **Task Completed.** Annual Report completed.

*E. Discussion of Initial Findings and Shortcomings-Highline Lake first, followed by Elkhead Reservoir*

Highline Lake/Mack Wash

**Study Area**

The study area for this project is Highline Lake State Park, Loma, Colorado, including Mack Wash, into which Highline Lake drains.

**Study Methods/Approach and Results**

*Operations and Maintenance*

Formerly, the operations and maintenance of the original spillway net were funded via a cooperative agreement between Colorado State Parks and the Colorado Division of Wildlife (CDOW) to cover up to \$10,000 in annual costs incurred by Highline Lake State Park. Colorado State Parks and the CDOW merged to form Colorado Parks and Wildlife (CPW) in 2011. As of July 1, 2011, CPW has been responsible for covering the operations and maintenance costs of the

spillway net up to \$10,000 annually, contingent on availability of funds. If annual costs exceed \$10,000, then CPW may request the Colorado River Recovery Program cover the additional costs. This scenario has not occurred to date at Highline Lake.

Task 1. Maintain protective buoy line: The buoy line was inspected on a weekly schedule with the Park's patrol boat during the summer season. No issues or problems were identified until the spillway net inspection on May 17, when the safety line had lost its eastern most anchor but was still functional. That anchor was found during the July 2 inspection, and the safety line was replaced with that anchor along with all new hardware on September 17. During this inspection, the main cable for the safety line was also noted to be in poor condition. All new cable (400 feet of 7/16" galvanized aircraft coated cable with tensile strength of 14,400 pounds) and hardware (galvanized cable clamps) for the safety line were installed on December 20. The estimated life of this cable is five to six years in this environment. The remaining connecting cable, shackles, and U bolts were all in good working order as of the final net inspection on November 30.

Task 2. Spillway net cleaning and repair operations (in water): Five spillway net inspections/cleanings were performed by United UnderWater Contractors (UUWC) in 2018: March 28, May 17, July 2, September 17, and November 30. The first inspection/cleaning of the spillway net in 2018 took place near the same time as 2017, in early spring, because of fish survey results between the spillway net and spillway (see Fish Monitoring section). The remaining inspections/cleanings took place about two months apart to control the algae growth, with an additional cleaning required in November. The extreme weather conditions (long, hot summer days with very little precipitation) in 2018 facilitated additional algae growth, resulting in the need for a fifth cleaning. The spillway net was cleaned manually all five times by divers from UUWC. As the spillway net ages, there will be a continual increase in algal buildup. CPW plans to continue with at least four net spillway net cleanings/inspections in 2019. Reports from the five spillway net cleanings/inspections follow.

The highlights of the March 28 inspection/cleaning were: 1) Cleaning was completed and there were no holes, cuts, or gaps found in the spillway net. There were numerous brush and tumble weeds entangled in the spillway net, and all of this material was removed. 2) The spillway net was covered with matted algae, especially on the top half and the skirt area. Most of this algae was removed with heavy scrubbing. 3) Numerous fish had been collected by CPW on March 13 and March 19 between the spillway net and spillway. To try and address where fish might be passing the spillway net, UUWC divers flipped the upper skirt from the north side of the main spillway net to the south side of the spillway net, which places the spillway net over the main buoy line and eliminates the gap areas at the water surface around the buoys. The hope is that this action will allow the skirt to flow downstream with the current and push of boat wakes, creating less drag on the overall spillway net. This should also further reduce the chance of surface swimming fish from swimming through the spillway net. 4) All cables, anchors, manta bolts, shackles, and thimbles were inspected and found to be tight and in good condition. Stainless steel wire on the shackles was still holding.

The highlights of the May 17 inspection/cleaning were: 1) Cleaning was completed and one, 2" hole was observed in the spillway net, located in the middle of the spillway net between the third and fourth safety buoys, about mid-way down the spillway net, from the west side. This hole was likely caused by a treble hook used by an angler. The hole was repaired. There were

numerous brush and tumble weeds entangled in the spillway net, and all of this material was removed. 2) There were several anchor points where the spillway net was just below the water level due to high flow, a dirty spillway net, or both. Additional divers were brought in to super clean the spillway net. To completely clean the spillway net of no algae required about an hour per 25' x 25' section, per side of the spillway net with seven divers. 3) The suspenders for the skirt were removed during the March inspection/cleaning, and the skirt was laying in the new position floating downstream and away from boat wakes. The skirt was still heavy with algae, causing the skirt to hold tighter to the spillway net than normal. In this new position, the skirt creates an additional 6" of safety (freeboard). The divers will attempt to scrape the skirt clean during the July inspection/cleaning. 4) The safety line lost its eastern most anchor, but still was functional. The divers will attempt to locate the anchor and replace the necessary hardware during the July inspection/cleaning. All other cables, anchors, manta bolts, shackles, and thimbles were inspected and found to be tight and in good condition. Stainless steel wire on the shackles was still holding.

The highlights of the July 2 inspection/cleaning were: 1) Cleaning was completed and there were no holes, cuts, or gaps observed in the spillway net. However, a large amount of fishing line and hooks was observed and removed. There were also numerous brush and tumble weeds entangled in the spillway net, and those were also removed. 2) There were several anchor points where the spillway net was just below the water level despite no elevated flow level. Additional divers were brought in to super clean the spillway net. To completely clean the spillway net of no algae required about an hour per 25' x 25' section, per side of the spillway net with six divers. The skirt had a lot more algae than expected so one diver was assigned to clean the skirt portion of the spillway net, which required a different set of tools but was successful. 3) The skirt in the new position seems to be functioning as intended, providing an additional 6" of safety. 4) All cables, anchors, manta bolts, shackles, and thimbles were inspected and found to be tight and in good condition. The stainless steel wire on the shackles was still holding. The missing anchor was found, and the anchor system will be rebuilt during the September inspection/cleaning.

The highlights of the September 17 inspection/cleaning were: 1) Cleaning was completed and there were no holes, cuts, or gaps observed in the spillway net. The spillway net was extremely dirty, likely due to environmental conditions favorable to increased algal growth (warmer water temperature, and more exposure to the sun). 2) Water was flowing through the spillway net, and the five main buoys in the center of the spillway net were just below the water level at their anchor points. The divers stretched the spillway net over these main buoys so that the spillway net was covering these areas. The large, white buoys were all repositioned to wear on different areas. Small buoys were cut away from the spillway net on the west side above the water level; these do not affect the use of the spillway net. 3) The inside section of the skirt had numerous rocks, gravel, trash, and debris in it. All of this material was emptied to allow the skirt to float better. 4) The safety line was replaced with the missing anchor, along with all new hardware. During this inspection, the main cable for the safety line was also noted to be in poor condition, and replacement should occur before next spring. All cables, anchors, manta bolts, shackles, and thimbles were inspected and found to be tight and in good condition. The stainless steel wire on the shackles was still holding.

The highlights of the November 30 inspection/cleaning were: 1) Cleaning was completed and there were no holes, cuts, or gaps observed in the spillway net. The spillway net was extremely

dirty, likely due to expanded environmental conditions favorable to increased algal growth (warmer water temperature, and more exposure to the sun), and extreme surges in water elevation due to an increase in canal water volume from heavy rains and lack of water use for irrigation. 2) Water was just barely flowing over the spillway, and the five main buoys in the center of the spillway net were just below the water level at their anchor points. The divers stretched the spillway net over these main buoys so that the spillway net was covering these areas. The large, white buoys were all repositioned to wear on different areas. The skirt had more algae than expected so additional divers were assigned for six hours to clean the skirt portion of the spillway net, and release some of the additional weight to the spillway net. The overall weight of the spillway net seems to be barely supported by the existing buoy system, and may need further modification (and/or additional cleanings in the future). 3) The inside section of the skirt had numerous pieces of wood, brush, rocks, gravel, trash, and debris in it. All of this material was emptied to allow the skirt to float better. 4) The safety line that was replaced in September with the missing anchor, along with all new hardware was working well. The main cable for the safety line will be replaced in December. All cables, anchors, manta bolts, shackles, and thimbles were inspected and found to be tight and in good condition. The stainless steel wire on the shackles was still holding.

Task 3. Weekly visual survey: The spillway net top line and floats along with the skirt were visually checked on a weekly basis with the Park's patrol boat. On weekends, the patrol boat would be deployed for several hours and when time permitted, CPW would examine the spillway net from the water surface. The ¼" poly line that was originally installed to keep the skirt stretched from the safety line was replaced in 2018 to reduce escapement over the top of the spillway net.

Task 4. Underwater survey: The spillway net was inspected during each cleaning by UUWC, the same divers that have been checking the spillway net for the last several years. See Task 2 above for details. UUWC prepared reports for each of these inspections/cleanings, which are available at the Park or on request.

### *Fish Monitoring*

Mack Wash originates from Highline Lake and flows approximately five miles downstream to the confluence with Salt Creek. Salt Creek flows approximately two miles before the confluence with the Colorado River. The Colorado River and its 100-year floodplain (including Salt Creek at the confluence of the Colorado River), are designated critical habitat for state and federally listed fish species, as well as other native, non-listed fishes.

Fish can escape into Mack Wash from Highline Lake by moving past the spillway net and/or through the bottom release on the dam when no anti-escapement device is in place. Irrigation water is delivered annually to water users downstream of Highline Lake typically from the beginning of April through the end of October. Thus, fish surveys in both Mack Wash downstream of Highline Lake as well as Highline Lake between the spillway net and the spillway occur annually when water is not being delivered downstream.

CPW biologists completed annual fish surveys at two sites in Mack Wash downstream of Highline Lake in the month of November from 2011-2018. Additionally, CPW biologists

completed fish surveys within Highline Lake between the spillway net and the spillway in March 2012, March 2013, March 2016, March 2017, March 2018, and November 2018. In March 2014, the spillway net was replaced with a new net, and no sampling was completed in Highline Lake between the spillway net and the spillway. Sampling for this same area was scheduled for the spring of 2015, but water delivery from Highline Lake downstream into Mack Wash began earlier than anticipated, preventing CPW crews from sampling.

This summary is focused on the analysis of fish data gathered in 2016, 2017, and 2018. Please refer to the 2015 Annual Report for Project C-20 for extensive summaries of the 2011 through 2015 data for both Mack Wash and Highline Lake. A map (Figure 1) of the Mack Wash fish survey sites is also included, along with 2016, 2017, and 2018 fish survey results from both Mack Wash (Tables 1-3, Figures 2-6) and Highline Lake (Table 3, Figures 7-14).

### Mack Wash

CPW biologists conducted single-pass, bank electrofishing surveys at two sites on Mack Wash downstream of Highline Lake on November 15 and 16, 2016, November 15, 2017, and November 14, 2018. Site #1 was located immediately downstream of the Highline Lake spillway and Site #2 was located on private property approximately three miles downstream of Site #1. The objectives of the fish surveys were to determine fish species composition and relative abundance downstream of the Highline Lake spillway net. Specifically, CPW was interested in identifying potential escapement of non-native fishes from Highline Lake. In 2018, all largemouth bass from Site #1 were relocated to Highline Lake. Otherwise, all non-native, non-salmonid fishes collected were lethally removed.

The 2018 sample at Site #1 on Mack Wash consisted of bluegill, common carp, largemouth bass, and green sunfish (Table 3, Figure 2). The 2018 sample at Site #2 on Mack Wash consisted of red shiner, white sucker / hybrid sucker, speckled dace, bluehead sucker, flannelmouth sucker, green sunfish, fathead minnow, and largemouth bass (Table 3, Figure 3). Despite their continued presence between the spillway net and the spillway, no gizzard shad were surveyed in Mack Wash at either site. Multiple age-classes of green sunfish and largemouth bass were found in Mack Wash at Site #1. Size structure of green sunfish surveyed was similar to past years. Historically, the largemouth bass surveyed at Site #1 consisted of juveniles and small adults. However, the 2018 survey yielded five largemouth bass that were larger than those individuals observed the last 2 years; the total length of these fish were: 222 mm, 225 mm, 241 mm, 322 mm, and 382 mm. It is possible that these larger fish were present immediately downstream of the spillway due to the canal surges that had occurred approximately five weeks prior to the Mack Wash survey. Minimal increases were seen in electrofishing catch per unit effort in green sunfish and largemouth bass at Site #1, and these catch rates were still much lower than those observed in 2011 and 2012 when the canal surges had compromised the spillway net. At Site #2, species-specific catch per unit effort data indicated that catch rates were slightly higher in green sunfish in 2018 compared to 2017, while catch rates for largemouth bass were slightly lower. Species-specific population size structures and relative abundance of species at Site #2 were similar to data gathered in recent years. These 2018 data do not show any substantial increases in the number of non-native fish present in Mack Wash downstream of Highline Lake despite increases in non-native fish abundance behind the spillway net, and the canal surge in the fall of 2018 which likely reduced the effectiveness of the spillway net. These data suggest that the

spillway net continues to prevent the majority of fish from escaping Highline Lake, and that fish escapement has been greatly reduced compared to years in which the spillway net had been significantly compromised.

### Highline Lake

CPW biologists surveyed Highline Lake between the spillway net and the spillway using a combination of night-time boat-electrofishing and day-time experimental gill net sets in the spring of 2018. The gill net survey was conducted on March 13, 2018 and the night-time electrofishing was conducted on March 19, 2018. This survey was staggered over two days due to a mechanical issue with the boat. A post-irrigation season survey using only night-time boat electrofishing was conducted between the spillway net and the spillway on November 14, 2018. This second survey was conducted due to the high abundance of fish behind the net in the pre-irrigation survey and also due to concerns associated with a surge in flows moving through the reservoir in October 2018 that potentially reduced the effectiveness of the spillway net. The objectives of the fish surveys were to determine fish species composition and relative abundance within the lake between the spillway net and the spillway. Surveys were completed during the non-irrigation season in which no water was being delivered downstream over the spillway. Fish collected were released back into Highline Lake upstream of the spillway net with the exception of smallmouth bass, common carp, and gizzard shad which were lethally removed.

A total of 673 fish, including 362 gizzard shad, were surveyed utilizing gill nets and electrofishing in Highline Lake during the pre-irrigation survey in 2018. This represents the largest number of gizzard shad surveyed between the spillway net and the spillway that CPW has seen during these annual surveys. Other species surveyed in the spring sampling event included bluegill, black crappie, common carp, largemouth bass, rainbow trout, smallmouth bass, and green sunfish (Table 3, Figure 7). Multiple age-classes, including adult-sized fish, were observed for common carp, green sunfish, largemouth bass, gizzard shad, and bluegill surveyed behind the spillway net during the pre-irrigation season survey (Figures 8-12).

The post-irrigation season electrofishing survey between the spillway net and the spillway yielded 135 fish which was a substantial decrease compared to the 648 fish surveyed during electrofishing in the pre-irrigation survey. The majority of the post-irrigation survey consisted of green sunfish 60-100 mm in total length; only four gizzard shad were surveyed in the post-irrigation survey. A dramatic decrease in electrofishing catch per unit effort of fish at least 100 mm in total length between the pre-irrigation survey and the post-irrigation survey is shown in Figure 14. The catch rates of these larger fish reached a historical high of 234.0 fish/hour during the pre-irrigation survey and then dropped to a historical low of 38.4 fish/hour during the post-irrigation survey. It is possible that differences in electrofishing efficiency associated with time of year was partially responsible for differences in catch rates. However, an increased effort was conducted during the pre-irrigation survey in an attempt to reduce the number of fish behind the spillway net; it is also possible that the low catch rates observed during the post-irrigation surveys may reflect reductions in fish density behind the spillway net as a result of the pre-irrigation removal efforts.

## Discussion

Historically, the spillway net at Highline Lake was compromised during canal surges across 2011, 2012, and 2013, and during an extended bottom release in 2013 in preparation for lake dredging across 2013-2014. The spillway net was replaced in March 2014 after the dredging of the lake was completed and has been operational since its replacement. After CPW's survey in the spring of 2017 showed an unexpectedly high number of fish present behind the spillway net, including multiple age classes of gizzard shad, the spillway net was inspected by UUWC and re-adjusted in March 2017. The inspection revealed that the spillway net was not damaged, but there were multiple gaps under the bottom skirt through which fish could enter. The skirt was re-positioned during the inspection to close these gaps prior to the irrigation season. Although 2017 was the first time gizzard shad had been documented between the spillway net and the spillway, gizzard shad were first documented in Highline Lake in 2015.

Due to the numerous fish collected by CPW during the pre-irrigation surveys in 2018, UUWC completed the spillway net cleaning/inspection shortly after the surveys were completed (see Task 2 of the Operations/Maintenance section for Highline Lake). No substantial damage to the spillway net was observed at this time, but gaps within the upper portion of the spillway net at the water surface were noticed that could have provided routes for fish to move through. These gaps were addressed during the March spillway net cleaning/inspection, prior to the irrigation season. Further, fewer fish were collected by CPW during the post-irrigation survey in 2018, when compared to the number of fish collected during the pre-irrigation survey. The number of fish collected during the post-irrigation survey and the five adult largemouth bass that were collected at Site #1 on Mack Wash may be explained by a surge in water volume in October. This surge from the canal was as a result of heavy rains, and the lack of water needed for irrigation purposes due to the rains. This surge likely resulted in the spillway net being compromised also in the fall of 2018.

CPW staff have taken several actions to reduce the chance of fish escaping from Highline Lake. These actions include:

- 1) Continuing coordination and communication efforts with operators of the Government Highline canal system to ensure operation of the spillway net is not hindered because of water delivery practices.
- 2) Cleaning the spillway net more frequently and with a shorter period between cleanings to reduce strain and wear and tear of the spillway net. The existing spillway net was replaced in March 2014 after dredging activities within Highline Lake were completed.
- 3) Adjustment of the skirt and maintenance of several cables and hardware appear to be holding the spillway net in better position, keeping the skirt from washing over the spillway net, and improving the effectiveness of the spillway net.
- 4) Operating the outlet structure/bottom release only when dissolved oxygen concentrations are minimal, and fish are less likely to be present in the water column near the outlet structure.

## Elkhead Reservoir

### **Study Area**

The study area for this project is Elkhead Reservoir State Park, Craig, Colorado, including the stilling basin downstream of the reservoir's spillway.

### **Study Methods/Approach and Results**

#### *Operations and Maintenance*

Per a May 20, 2015 CPW letter to the U.S. Bureau of Reclamation (BOR) outlining CPW's obligations related to the "Elkhead Reservoir Fish Escapement Net," CPW will be responsible for covering the operations and maintenance costs of the spillway net up to \$10,000 annually, contingent on the availability of funds. Operations and maintenance costs exceeding the \$10,000 per year limit will be cost shared equally (50:50) between CPW and the Colorado River Recovery Program, subject to the mutual agreement of CPW and the Colorado River Recovery Program. If mutual agreement on the expenditure of funds exceeding the first \$10,000 in any calendar year cannot be obtained, the issue will be referred to the Colorado River Recovery Program's Implementation Committee for resolution. Resolution will occur in a timely manner, to avoid impacting the safe and prudent operation of Elkhead Reservoir. At the end of the useful life cycle of the spillway net, the Colorado River Recovery Program, CPW, Colorado River Water Conservation District (CRWCD), and BOR will consult on the need to replace the spillway net, and if needed, who will assume responsibility for installation, operations, and maintenance.

CPW did expend a total of \$12,000 for cleaning/inspection of the spillway net in 2018. This was \$2,000 beyond the \$10,000 CPW committed to. At this time, CPW has determined no need for the Colorado River Recovery Program to reimburse its 50:50 share of \$2,000 (which would be a cost of \$1,000) to CPW for operations and maintenance costs.

Task 1. Maintain protective debris boom: The debris boom was inspected several times weekly throughout the open-water season from land and water (the shoreline near the spillway and using the Park's patrol boat). All materials and connections were in good working order.

The CRWCD reported to CPW that there was an operational challenge in March when the reservoir water level came up, and the ice sheet on the reservoir could have pushed into the debris boom, and potentially into the spillway net if the ice sheet broke up into chunks. The reservoir water release was increased, and by spilling and keeping the reservoir water level down, potential loads on the debris boom and spillway net were avoided. The ice then melted off before the reservoir water level rose.

Task 2. Spillway net cleaning and repair operations (in water): Four spillway net inspections/cleanings were performed by UUWC in 2018: April 27, June 14, July 15, and October 6. Two spillway net inspections were also completed by Pacific Netting Products (PNP) on May 9 and August 13-14, as part of their final, annual warranty inspection. PNP is the manufacturer and installer of the spillway net. CPW plans to continue with at least four net

spillway cleanings/inspections in 2019. Reports from all of the spillway net cleanings/inspections follow.

UUWC completed the first inspection/cleaning of 2018 on April 27. The highlights of this inspection/cleaning were: 1) Cleaning was completed and there were no holes, cuts, or gaps observed in the spillway net. 2) The top half portion of the spillway net was extremely covered with algae. Only about 20% of this top portion of the spillway net was not covered completely with algae. The top 6' of the spillway net is double layered, making it difficult and nearly impossible to clean 100%. Most of the divers' time was spent cleaning this area. The bottom half portion of the spillway net was only about 20% covered with algae, and this cleaned well. The thought that algae would dissipate or not be active in the winter is not holding true. Large, active growths of green algae were floating in the upper skirt of the spillway net. This long green algae was also actively growing over most of the upper half portion of the spillway net, despite very cold water. If this continues, more frequent cleaning (once per month) may be required. Numerous wood and debris was collected in the skirt of the spillway net (which is difficult to access), and was removed. It is likely that the yellow buoys were probably underwater before, and the skirt was probably on the water surface collecting debris during earlier flooding. 3) When the divers first arrived to the spillway net, they noticed that the skirt, which floats about 5' from the main spillway net and is supported by the white buoys, was submerged in the center for about 40' in length. The yellow buoys, which support the main spillway net, were completely submerged for about 150' in the middle of the spillway net. Water was forcefully moving through and over the spillway net for about an hour, when the flow of the water subsided. The white buoys were back on the water surface, and 95% of the yellow buoys were back on the water surface providing safe conditions to clean and inspect the spillway net. The spillway net was observed in several locations to see if the spillway net was stuck in any mud on the bottom, but that was not the case. Most of the cemented blocks with manta bolts, however, were very exposed, in some cases by 3-4'. If possible, these need to be adjusted to allow the spillway net to entirely reach the water surface. There also appeared to be plenty of net bowing in the water current to reach the water surface. It could be that the spillway net, increased algae within the top portion of the spillway net, or doubled layer at the top of the spillway net may be too restrictive for this water flow. One quick fix may include extending the anchors by 3-4'. The UUWC divers contacted the CRWCD (Ray Tenney) to report these findings, as PNP still had at least one annual warranty inspection to complete and could be potentially address these concerns during that time. 4) Most of the hardware was inspected and in good condition.

The CRWCD also visited the spillway net on April 27 as a result of the observations made by UUWC on the same day related to the partial submerging of the spillway net. The CRWCD observed the center portion of the top of the spillway net cork line to be submerged during spilling of the reservoir, with 0.8' of spillway surge. Water flow through the outlet works was off at the time, and the entire discharge of the reservoir (which was about 740 cfs) was flowing over the spillway. For reference, the spillway net was designed to screen reservoir levels up to two feet above the spillway crest, or approximately 2,500 cfs passing through the spillway net and over the spillway. This scenario presumes the spillway net will be 50% clogged, with an approach velocity of 0.5 fps to avoid fish impingement. Further, this situation would accommodate screening as much as a 1 in 100-year event, rainfall or snowmelt.

City of Craig reservoir operators opened the screened tower outlet works in two steps to bring reservoir water level down to reduce water flow through the net. By late afternoon of April 27, the reservoir water level had dropped to 0.5' of spillway surge, and the top cork line was no longer submerged. Discharge through the spillway net was estimated to be about 600 cfs at 3:30pm.

PNP was contacted by the CRWCD and was on site May 9 to complete a near surface visual inspection of the spillway net. To facilitate a "loaded" spillway net condition, the reservoir outlet was closed on May 8, and the reservoir water surface raised to the point of sending the entire outflow (about 500 cfs) through the spillway net. The reservoir was spilling 0.6' over the spillway on May 9. Depth was measured at each of the anchor points along the spillway net, and PNP verified that the fabricated spillway net was at least 4' greater height than the depth of the water measured. The spillway net was fabricated with 27' of height and water depth that day was measured at 22' all the way across the spillway net. The upper accessible portion of the spillway net was observed to be very dirty and clogged with silt and a growing algae mass, which would both create hydraulic flow resistance and additional weight on the spillway net. Water clarity was poor on this day, and did not allow for underwater photography.

On this date, PNP considered enhancing the operation of the spillway net by including additional flotation to keep the spillway net more upright with the additional hydraulic and dead load in a soiled condition and removal of the double layer of netting in the top 6' of the spillway net, which was designed to help resist ice damage. PNP also recommended a mechanical scrubber be considered for more thorough cleaning of the spillway net.

The highlights of the June 14 cleaning/inspection by UUWC were: 1) Cleaning was completed and there were no holes, cuts, or gaps observed in the spillway net. 2) The top half of the spillway net had most of the algae growth, and most of this algae was removed with lots of scrubbing. The bottom half of the spillway net had very little growth, and was also cleaned. Three large sections of the spillway net in shallow water on the NW side had a very thick blanket of algae that was scrubbed clean. Wood continues to float directly into the spillway net, somehow. Large branches were floating in and around the spillway net, and were removed. 3) All buoys were floating on the surface of the water, and water flow was very light. In the middle of the spillway net, 7' lay on the ground, and there was about 2' of chain between the spillway net and manta bolt. The double-layered portion of the spillway net continues to hold algae growth that is near impossible to remove. Crayfish were observed within the double-layered portion of the spillway net. Fishing lures were caught in the spillway net, mostly along either end of the spillway net. 4) Most of the hardware was inspected and in good condition.

The highlights of the July 15 cleaning/inspection by UUWC were: 1) Cleaning was completed and there were no holes, cuts, or gaps observed in the spillway net. 2) The top half of the spillway net had most of the algae growth, and this cleaned off well for the most part. The bottom half of the spillway net was only about 20% covered with algae, and this cleaned off well. Maximum depth at the base of the spillway net was 17'. Wood continues to drift into the spillway net area, and the debris boom was above the water line on the east end. 3) All buoys were floating on the surface of the water, and water was not flowing over the spillway. The double-layered portion of the spillway net continues to hold algae growth that is near impossible to remove. Crayfish were observed within the double-layered portion of the spillway net, and

bass (and anglers) were working the spillway net. More fishing lures were caught in the spillway net. Juvenile bass (4"-6") were observed on the downstream side of the spillway net; these fish likely made it around or over the spillway net in April when water was overtopping the spillway net. 4) Most of the hardware was inspected and in good condition. One thimble was unattached on the western one third of the spillway net's anchor system.

The CRWCD also investigated the spillway net on July 25 with an underwater camera. Despite hand cleaning the spillway net just eight days prior, the CRWCD noted significant development of algal growth in the upper portion of the spillway net where light penetration was greater. A gap between the water surface and the top of the spillway net where the spillway net was attached to the cork line was observed. There was sufficient space here to allow small life stages of fish to pass through the spillway net downstream. PNP proposed a remedy to the cork line/spillway net interface gap, which included the addition of a second cork line under the skirt where this attaches to the spillway net, raising the skirt to block these openings. This solution would also provide additional flotation to the spillway net.

During the August 13-14 inspection by PNP, two divers surveyed and videoed the spillway net. Pile pin connections were in great condition, and appeared to be in the same condition as the day of installation in September 2016. Anchor chain shackles and chain to pile pins were in good condition, with very little corrosion. All split rings were still visible. The bottom spillway net chain was in contact the entire length of the spillway net with the reservoir floor, and had silted in more than the last inspection in the fall of 2017. There was no erosion of the reservoir floor to expose any anchors, and erosion control mats appeared to be doing their job by holding back sediment. There was more sediment observed around these mats than during the 2017 inspection. Overall, 90% of the spillway net was clean, and compared to a visual surface inspection on May 9, the spillway net was very clean apart from a few areas in the jump panel that could be cleaned. In some areas of the spillway net, a sponge-like algae was observed, similar to observations during the fall 2017 inspection. No holes or excessive wear and tear on the netting, corkline, and jump net were observed.

To correct the gaps between the spillway net and water interface observed on July 25, PNP added extra flotation to the entire length of the spillway net during the August 13-14 inspection. The cork line was pulled under the jump panel, and connected every 2' with 5mm poly rope to the existing net cork line. This created a wall of netting between the two cork lines, allowing no fish to get into the jump panel. In addition, because of shoreline erosion, PNP assisted in tightening the debris boom by pulling this up 6' further up the beach on the west side. All dry ground anchor points looked great along with the boom. PNP advised pressure washing (4,000-5,000 psi) of the spillway net to completely clean the spillway net of algae, and to prevent rapid regrowth and reclogging of the spillway net. PNP reported that pressure washing is not damaging to the spillway net, and is preferred as this process removes residual algae delaying recolonization, reducing the frequency of spillway net cleaning required.

The highlights of the October 6 cleaning/inspection by UUWC were: 1) Cleaning was completed and there were no holes, cuts, or gaps observed in the spillway net. 2) All sections of the spillway net cleaned off well, but the top half of the spillway net continues to be the most challenging portion to clean. Water level was very low, buoys were near the shore, and the spillway net was in shallow water. These conditions provided a great opportunity to clean off

the trees, stumps, and brush that the spillway net was constantly entangled on. Six divers spent two hours sawing, digging, and removing all possible wood and debris on the downstream side of the spillway net. Driftwood continues to get into the spillway area, possibly around the sides during high water. 3) A new row of large yellow buoys had been installed the full length of the spillway net by PNP, with nine red buoys positioned in the middle of and on the spillway net. No metal thimbles or shackles were used; everything was tied on to the existing ends and the current yellow buoys. Buoys were tied together every 24" with orange poly line (1/4"). Each end was secured with a clove hitch and two half hitches. This line has a limited lifetime, and these simple knots will likely not hold up to the constant movement of the spillway net. The double-layered portion of the spillway net continues to hold algae growth that is near impossible to remove. Crayfish were observed within the double-layered portion of the spillway net, and bass were the working the spillway net. 4) All of the hardware was inspected and in good condition for the most part. Most of the heavy chain had a layer of rust. Two of the anchor eyes were completely buried, while the rest of the anchor eyes extend out of the bottom by 10"-20".

Task 3. Weekly visual survey: The spillway net top line and floats along with the skirt were visually checked on a weekly basis with the Park's patrol boat, and they were also visually inspected from shore. Nothing adverse was noted from above the waterline, other than the submerged spillway net observed on April 27.

Task 4. Underwater survey: The spillway net was inspected during each cleaning by UUWC, and also by PNP on August 13-14. See Task 2 above for details. UUWC and PNP prepared reports for each of these inspections/cleanings, which are available at the Park or on request.

### *Fish Monitoring*

Elkhead Reservoir drains into Elkhead Creek and continues for approximately nine miles, where it connects with the Yampa River between river mile 148 and 149. Beginning at Colo. Hwy. 394, the Yampa River and its 100-year floodplain are designated critical habitat for state and federal listed fish species, as well as other native, non-listed fishes. Elkhead Reservoir was expanded in 2006, roughly doubling the water surface acreage. During the expansion, a 1/4" mesh screen was installed on the outlet of the reservoir to drastically reduce fish escapement through the outlet when water is released from the reservoir. Fish escapement was still possible over the spillway when the reservoir spilled. A spillway net was installed upstream of the reservoir's spillway on September 23, 2016 to control non-native fish escapement when the reservoir spills.

In 2018, CPW biologists completed fish surveys within Elkhead Reservoir, between the spillway net and the spillway, as well as in the stilling basin downstream of the spillway (Figure 14). The objectives of the fish surveys were to determine fish species composition and relative abundance within the reservoir between the spillway net and the spillway, and also downstream of the Elkhead Reservoir spillway net. Experimental gill nets were set before and after water was released over the spillway. Two to three, 150' experimental gill nets were set at the "spillway site," which included the area between the spillway net and spillway (Figure 14). Additionally, CPW surveyed the stilling basin using one, 150' experimental gill net that spanned from one side of the stilling basin pool to the other. Experimental gill nets were set overnight and checked the following day.

The spillway site and stilling basin were sampled on two occasions for a total of 10 overnight sets throughout 2018. Gill nets were set at both the spillway site and stilling basin for nine nights each between April 2 and April 11, before the reservoir spilled. Additionally gill nets were set at both the spillway site and stilling basin from July 24 to July 25, after the reservoir stopped spilling. During the post-spill sampling trip, crews also used an electrofishing boat equipped with an ETS electrofishing unit to sample the spillway site during the day on July 24, expending 51 minutes and 27 seconds of electrofishing effort.

During pre-spill sampling (April 2 - April 11) at the spillway site, no fish were captured (Table 4). Four fish were captured in the stilling basin during pre-spill sampling, including one unmeasurable white sucker and three smallmouth bass ranging from 243-251 mm total length (Table 4, Table 5). In 2017, pre-spill sampling (March 21 – March 26) yielded one unmeasurable northern pike at the spillway site and 20 total fish in the stilling basin, including 16 white suckers (115-336 mm total length), two smallmouth bass (254-344 mm total length), and two bluegill (124-150 mm total length).

During post-spill sampling (July 24 - July 25), crews set experimental gill nets overnight at both the spillway site (two gill nets) and stilling basin (1 gill net). Three smallmouth bass and two black crappie were captured by gill net at the spillway site, and six smallmouth bass were captured by gill net in the stilling basin (Table 4). Electrofishing efforts between the spillway net and the spillway occurred on July 24 prior to setting the gill nets. During day-time electrofishing, 36 fish were captured including bluegill, largemouth bass, and smallmouth bass (Table 4). 2018 is the first year that the spillway site was sampled by electrofishing since installation of the spillway net in September 2016.

Overall sampling effort included 29 net-nights (combined number of nights that each gillnet was set) at the spillway site and 10 net-nights in the stilling basin. Catch per unit effort (# of fish captured per net-night) was calculated for all species captured in the stilling basin (Table 5). Catch rates were not calculated for fish captured at the spillway site since two different sampling methods were used. Catch per unit effort could be calculated for fish only caught in the gill nets at the spillway site, but results would be inaccurate since post-spill electrofishing occurred immediately before the gill nets were set. Overall catch per unit effort for smallmouth bass captured in the stilling basin increased in 2018 compared to 2017 (2018=0.9, 2017=0.33 fish per net night). Catch per unit effort for white sucker, largemouth bass, and bluegill captured in the stilling basin decreased in 2018 compared to 2017. Catch per unit effort for white sucker was 2.67 fish per net night in 2018 and 0.1 fish per net night in 2017. Catch per unit effort for largemouth bass was 0 fish per net night in 2018 and 0.16 fish per net night in 2017. Catch per unit effort for bluegill was 0 fish per net night in 2018 and 0.33 fish per net night in 2017.

## **Discussion**

No fish were captured at the spillway site during pre-spill sampling. Post spill sampling at the spillway site yielded a total of 41 fish from four species. It is likely that fish moved into the spillway site in between pre- and post- spill sampling as a result of the spillway net being submerged (documented on April 27 and described in Task 2 of the Operations/Maintenance section for Elkhead Reservoir). A review of 2018 reservoir operations and hydrology suggests there may have been other times during the April runoff period when the spillway net may have

been compromised (overtopped) when water flow exceeded 600 cfs. Although the total time that the spillway net was compromised is unknown, this situation presented an opportunity for fish to pass over the spillway net and enter the spillway site.

In 2019, CPW will continue fish sampling to monitor escapement of fish at the spillway site and stilling basin before and after Elkhead Reservoir spills. CPW will also plan for spillway net cleanings and inspections, with at least four of these occasions spaced appropriately across the year. Cleanings and inspections will be further evaluated to determine when manual (hand scrubbing) vs. machine (pressure washing) methods are most appropriate, and also the frequency required to enhance the effectiveness of the spillway net. CPW will continue coordination with the CRWCD related to reservoir operations and maintenance/operation of the spillway net.

#### VIII. Additional Noteworthy Observations:

##### *Highline Lake/Mack Wash*

Gizzard shad were first discovered in Highline Lake during standard annual sampling in October 2015, and continue to be very abundant. Possible sources include the Government Highline Canal, illegal introductions, and/or illegal use of live fish as bait. However, it is unlikely that gizzard shad were introduced from the Government Highline Canal; U.S. Fish and Wildlife Service (FWS) crews did not encounter gizzard shad during the FWS' extensive post-irrigation annual fish salvage operations in the canal, prior to the discovery of the fish in Highline Lake. Gizzard shad were first collected between the spillway net and spillway in March 2017. Gizzard shad have been found in every subsequent survey between the spillway net and the spillway, including the pre-irrigation survey in 2018 in which 362 gizzard shad were removed. There was concern regarding the potential for fish to move past the spillway net and potentially into Mack Wash based on a surge in canal flows into Highline Lake (150-170 cfs; normal canal flow is approximately 50 cfs) during one week in October 2018; further, a flooding event (unknown inflow rate) into the north end of Highline Lake off of the desert also occurred. The combination of both events resulted in high water levels in Highline Lake and the likely compromise of the spillway net. Only four gizzard shad were removed during the post-irrigation survey in 2018 and the majority of the fish surveyed behind the net were small green sunfish. No gizzard shad were collected in Mack Wash downstream of Highline Lake in 2015, 2016, 2017, or 2018. The lake outlet structure/bottom release was not operated in 2018 and is scheduled to be operated in 2019 to address dam safety concerns. A net sock, which was previously utilized successfully in 2013 during drawdown of the lake, will be installed on the downstream side of the outlet structure to prevent fish from escaping into Mack Wash during the bottom release event.

##### *Elkhead Reservoir*

Species composition at both the spillway site and within the stilling basin was dominated by smallmouth bass (Figures 6 and 7). It is unclear whether fish found in the stilling basin are fish that escaped over the spillway or fish that swam from Elkhead Creek into the stilling basin when the creek periodically connects with the stilling basin. Additionally, all of the smallmouth bass captured in the stilling basin in 2018 were adults (> 300 mm total length), which could have originated downstream of the spillway. It is also possible that some fish did leave the reservoir after passing over the spillway net when the spillway net was compromised in April 2018.

## IX. Recommendations:

### *Highline Lake/Mack Wash*

#### Operations and Maintenance

- CPW will continue with at least four spillway net inspections/cleanings in 2019. Inspections will take place at approximately the same time as in 2018 so that a clean spillway net is in place when the lake begins filling. One cleaning will occur in the spring, followed by two cleanings during the summer, and a final cleaning before the inlet water is shut off.
- Park staff will continue to monitor the spillway net and debris being washed into the reservoir in the spring, and will inform divers when the cleaning of the spillway net will need to take place.
- Park staff will continue to monitor the buoy system associated with the spillway net. If this system is deemed ineffective, then CPW will request technical and potentially financial assistance from the Colorado River Recovery Program and other partners to evaluate further options.

#### Fish Monitoring

- CPW biologists will continue to complete annual fish surveys in Highline Lake between the spillway net and spillway in the spring prior to irrigation season, as well as at the two sites in Mack Wash downstream of the Highline Lake spillway net in the fall, post-irrigation season. Post-irrigation surveys between the spillway net and the spillway may also occur if there is a high abundance of fish during the pre-irrigation survey or if there is reason to believe fish may have moved past the net during the irrigation season.

### *Elkhead Reservoir*

#### Operations and Maintenance

- CPW will meet with the CRWCD, PNP, and UUWC over the winter of 2018-2019 and before the spring of 2019 to discuss previous cleanings and inspections of the spillway net. CPW will gather information from these entities to develop appropriate spillway net cleaning/inspection protocols based on previous experiences.
- Park staff will continue to monitor the spillway net and debris washing into the reservoir in the spring, and will inform divers when the cleaning of the spillway net will need to take place.
- A barrier fence will be installed in 2019 (funding and materials were secured in 2018) to serve as a physical reminder for folks to stay away from the net area (coordination between CPW and CRWCD).

#### Fish Monitoring

- CPW biologists will continue to complete annual fish surveys in Elkhead Reservoir between the spillway net and spillway, and in the stilling basin during spring prior to the reservoir spilling and in the fall, post-spill. Sampling the spillway site by boat electrofishing was effective at capturing size classes and

species of fish that are less susceptible to capture by experimental gill nets. CPW recommends continuing to sample the spillway site by both gill net and electrofishing when feasible.

X. Project Status: This project is on track and ongoing.

XI. FY 2018 Budget Status:

A. Funds Provided: ---

B. Funds Expended: No Colorado River Recovery Program dollars were expended in this fiscal year. \$7,215 was expended by CPW for five spillway net inspections/cleanings and maintenance at Highline Lake in FY 2018 (CPW covers annual operations and maintenance up to \$10,000). \$12,000 was expended by CPW for four spillway net inspection/cleaning at Elkhead Reservoir in FY 2018 (CPW covers annual operations and maintenance up to \$10,000). At this time, CPW has determined no need for the Colorado River Recovery Program to reimburse its 50:50 cost share of \$2,000 (which would be a cost of \$1,000) to CPW for operations and maintenance costs.

C. Difference: ---

D. Percent of the FY 2018 work completed, and projected costs to complete: 100%; \$7,215 at Highline Lake and \$12,000 at Elkhead Reservoir

E. Colorado River Recovery Program funds spent for publication charges: \$0

XII. Status of Data Submission (Where applicable): N/A

XIII. Signed:

Lori Martin  
Program Manager

January 4, 2019  
Date



**Table 1.** Total number of fish collected; total length size range in millimeters; catch per unit effort (# fish/hour) by species at Site #1 (immediately downstream of Highline Lake spillway; station length 0.12 mile) and Site #2 (Private property approximately 3 miles downstream of Site #1; station length 0.15 mile) in Mack Wash in **2016**. Native fish species identified by \*.

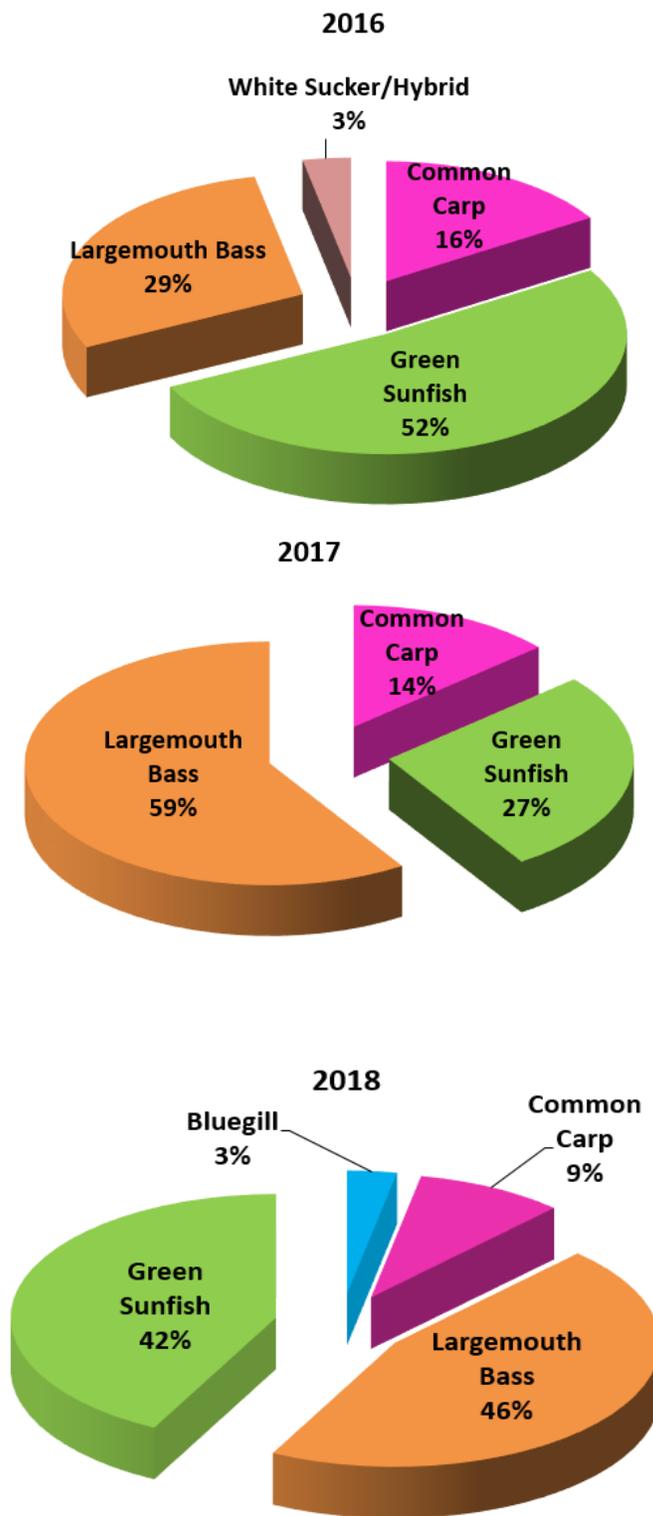
<b>Fish Species Collected</b>	<b>Site #1</b>	<b>Site #2</b>
Black Bullhead	0 fish	0 fish
Bluehead Sucker*	0 fish	29 fish; 49-262mm; 39.2/hour
Bluegill	0 fish	0 fish
Common Carp	5 fish; 449-521 mm; 7.0/ hour	0 fish
Fathead Minnow	0 fish	1 fish ; 52 mm; 1.4/hour
Flannelmouth Sucker*	0 fish	72 fish; 48-112 mm; 97.3/hour
Green Sunfish	16 fish; 72-170 mm; 22.5/hour	2 fish; 105-122mm; 2.7/hour
Largemouth Bass	9 fish; 75-100 mm; 12.7/hour	0 fish
Red Shiner	0 fish	48 fish; 21-85 mm; 114.9/hour
Speckled Dace*	0 fish	18 fish; 34-65 mm; 25.3/hour
White Sucker / Hybrid	1 fish; 185 mm; 1.4/hour	22 fish; 32-125 mm; 29.7/hour
Yellow Perch	0 fish	0 fish
<b><u>Total Number of Fish Collected</u></b>	31 fish	192 fish

**Table 2.** Total number of fish collected; total length size range in millimeters; catch per unit effort (# fish/hour) by species at Site #1 (immediately downstream of Highline Lake spillway; station length 0.12 mile) and Site #2 (Private property approximately 3 miles downstream of Site #1; station length 0.15 mile) in Mack Wash in **2017**. Native fish species identified by \*.

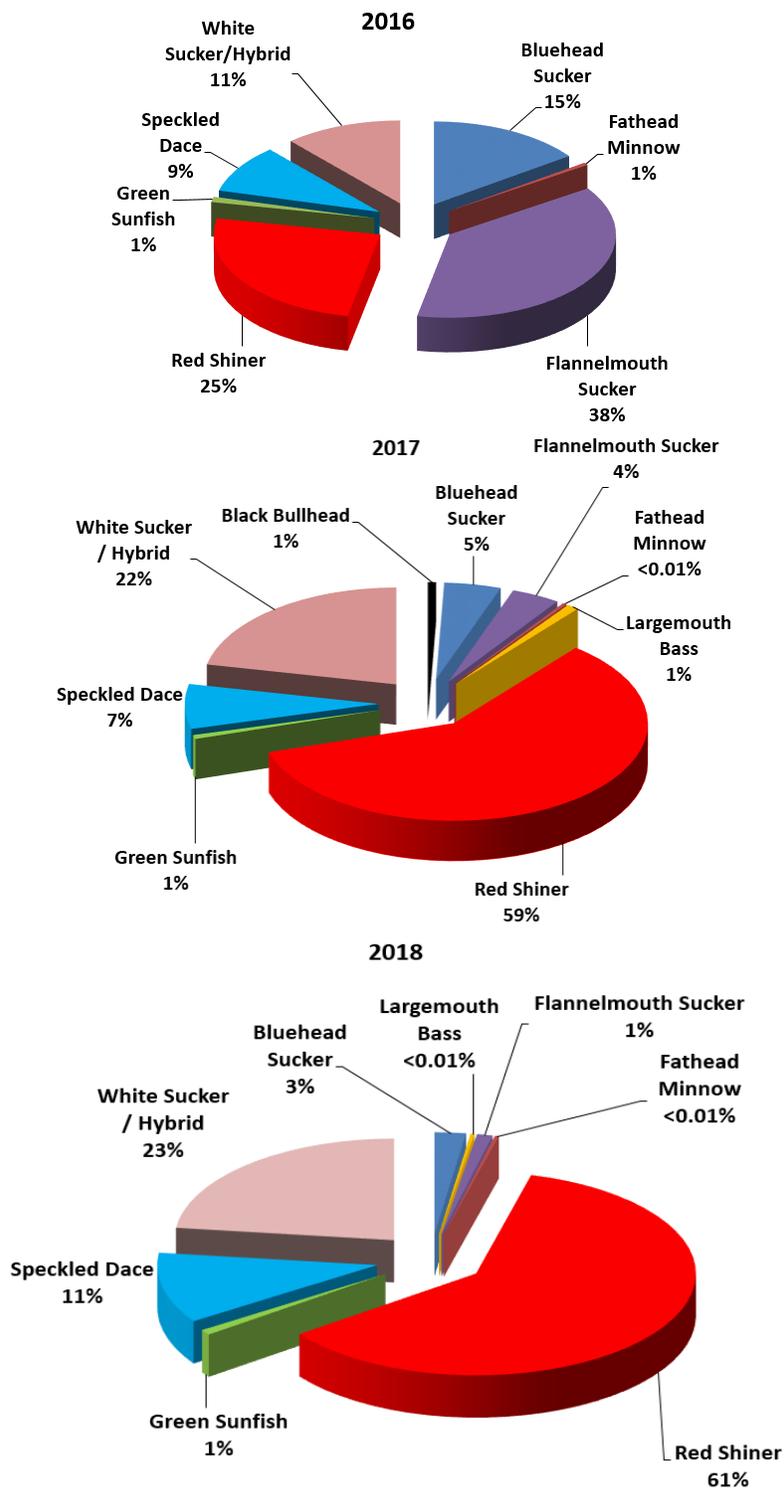
<b>Fish Species Collected</b>	<b>Site #1</b>	<b>Site #2</b>
Black Bullhead	0 fish	2 fish; 71-77 mm; 1.8/hour
Bluehead Sucker*	0 fish	14 fish; 64-192 mm; 12.6/hour
Bluegill	0 fish	0 fish
Common Carp	3 fish; 168-497 mm; 4.2/hour	0 fish
Fathead Minnow	0 fish	1 fish; 40 mm; 0.9/hour
Flannelmouth Sucker*	0 fish	12 fish; 81-112 mm; 10.8/hour
Green Sunfish	6 fish; 108-175 mm; 8.5/hour	2 fish; 72-77 mm; 1.8/hour
Largemouth Bass	13 fish; 61-150 mm; 18.3/hour	3 fish; 98-160 mm; 2.7/hour
Red Shiner	0 fish	175 fish; 27-76 mm; 157.7/hour
Speckled Dace*	0 fish	22 fish; 53-91 mm; 19.8/hour
White Sucker / Hybrid	0 fish	64 fish; 52-242 mm; 57.7/hour
Yellow Perch	0 fish	0 fish
<b><u>Total Number of Fish Collected</u></b>	22	295

**Table 3.** Total number of fish collected; total length size range in millimeters; catch per unit effort (# fish/hour) by species at Site #1 (immediately downstream of Highline Lake spillway; station length 0.12 mile) and Site #2 (Private property approximately 3 miles downstream of Site #1; station length 0.15 mile) in Mack Wash in **2018**. Native fish species identified by \*.

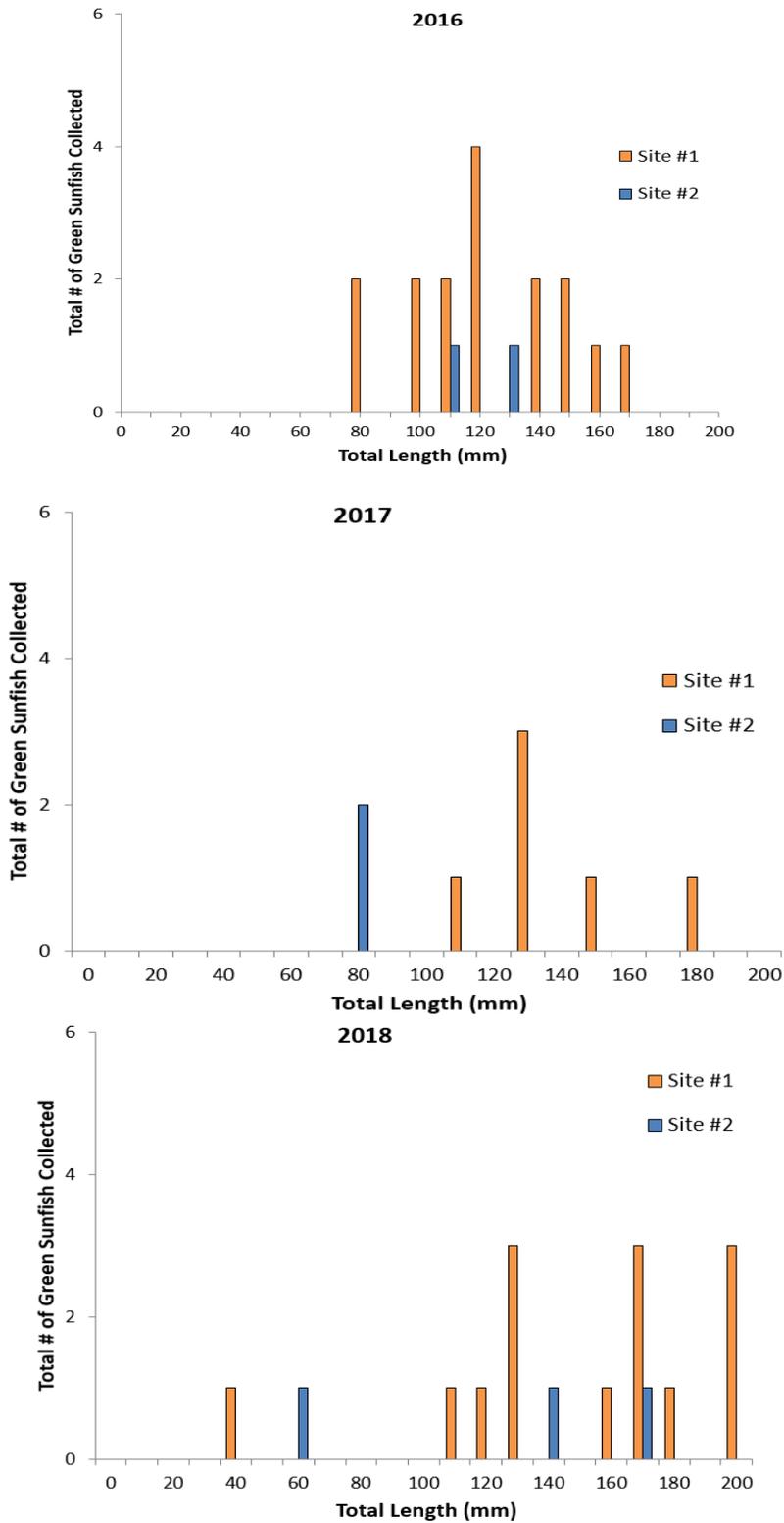
<b>Fish Species Collected</b>	<b>Site #1</b>	<b>Site #2</b>
Black Bullhead	0 fish	0 fish
Bluehead Sucker*	0 fish	8 fish; 71-171 mm; 7.6/hour
Bluegill	1 fish; 189 mm; 1.3/hour	0 fish
Common Carp	3 fish; 369-567 mm; 4.0/hour	0 fish
Fathead Minnow	0 fish	1 fish; 56 mm; 1.0/hour
Flannelmouth Sucker*	0 fish	4 fish; 75-197 mm; 3.8/hour
Green Sunfish	14 fish; 40-196 mm; 18.8/hour	3 fish; 52-162 mm; 2.6/hour
Largemouth Bass	15 fish; 55-382 mm; 20.2/hour	1 fish; 96 mm; 1.0/hour
Red Shiner	0 fish	211 fish; 24-82 mm; 201.0/hour
Speckled Dace*	0 fish	39 fish; 50-94 mm; 37.1/hour
White Sucker / Hybrid	0 fish	80 fish; 54-298 mm; 76.2/hour
Yellow Perch	0 fish	0 fish
<b><u>Total Number of Fish Collected</u></b>	33	347



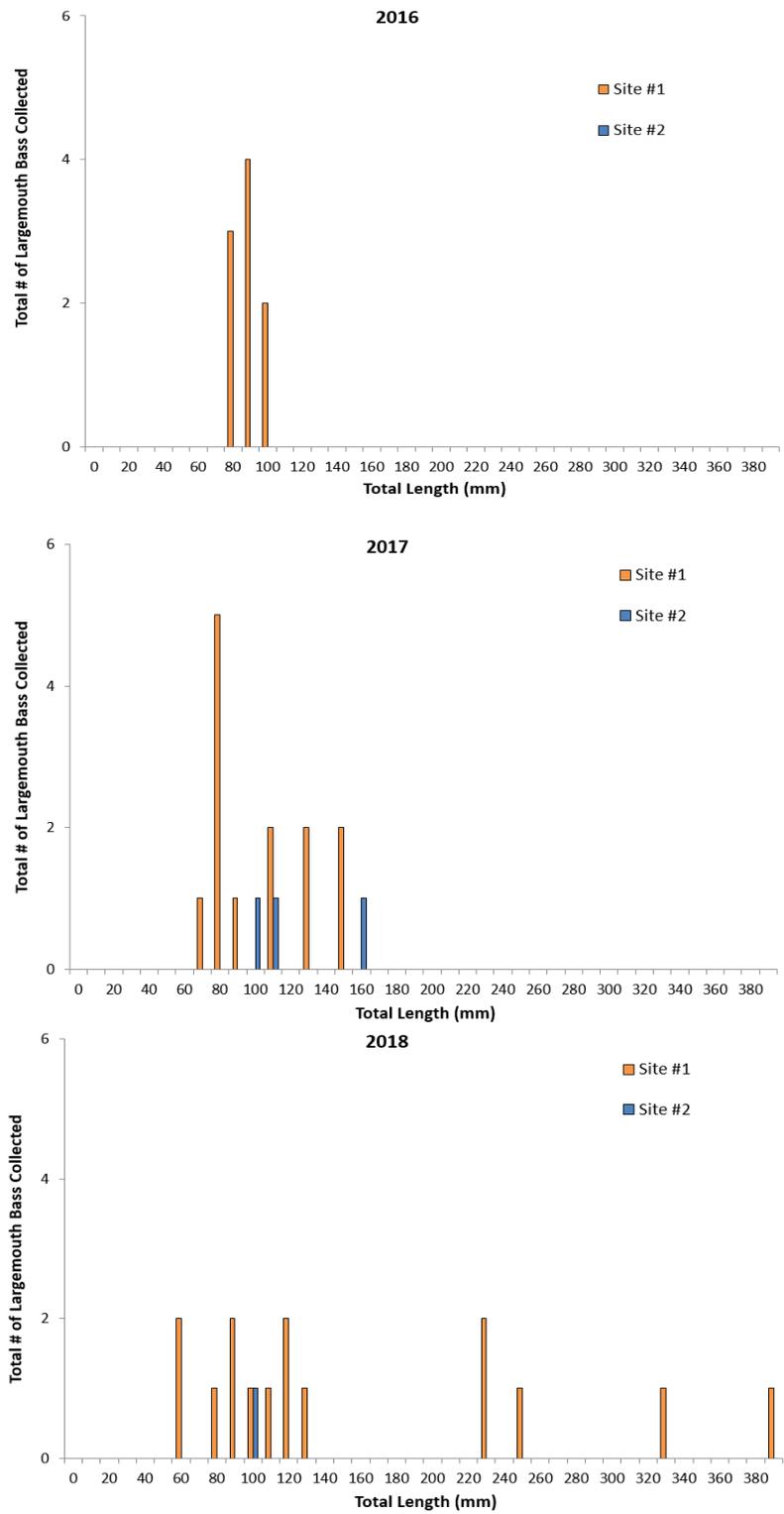
**Figure 2.** Species composition of fish surveyed in Mack Wash at Site #1 (immediately downstream of Highline Lake spillway) in 2016, 2017, and 2018.



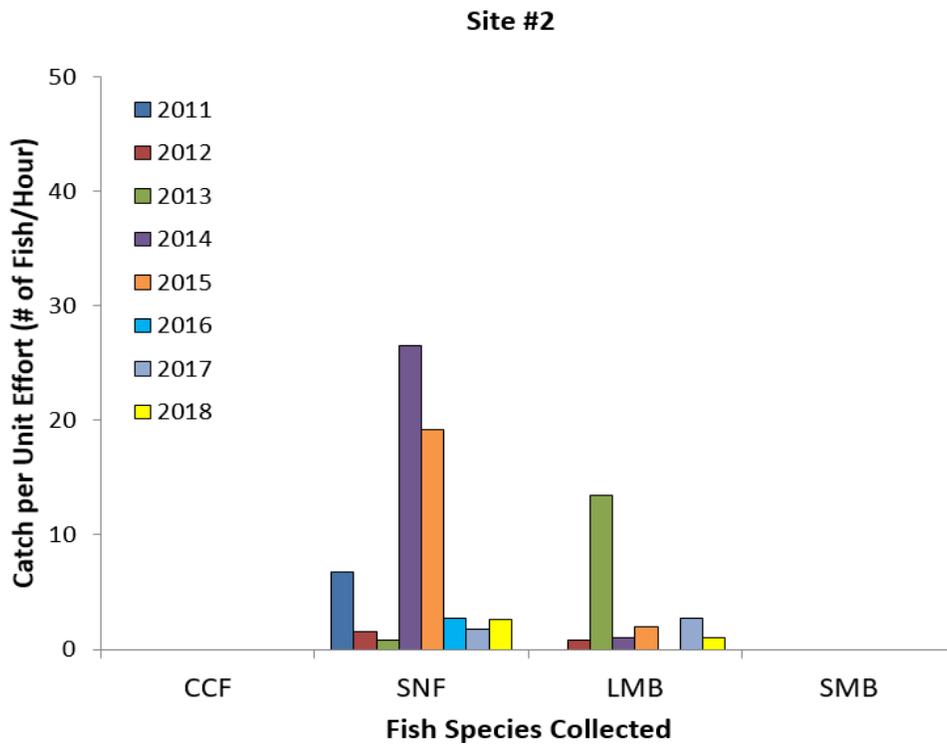
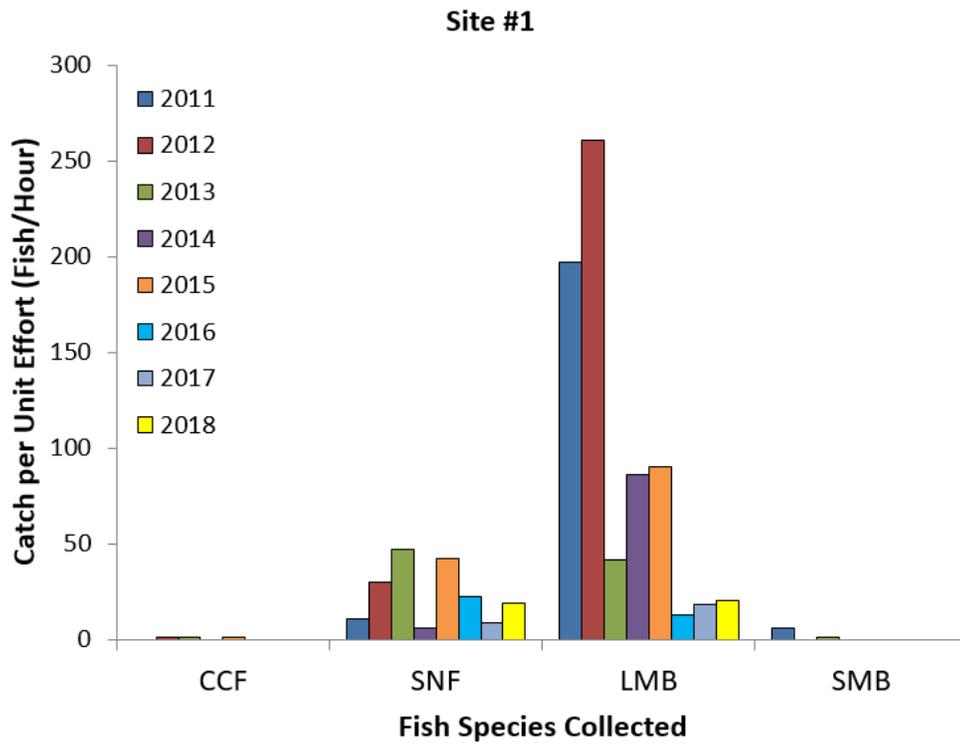
**Figure 3.** Species composition of fish surveyed in Mack Wash at Site #2 (approximately 3 miles downstream of Highline Lake spillway) in 2016, 2017, and 2018.



**Figure 4.** Length frequency histograms of green sunfish surveyed in Mack Wash at Site #1 and Site #2 in 2016, 2017, and 2018.



**Figure 5.** Length frequency histograms of largemouth bass surveyed in Mack Wash at Site #1 and Site #2 in 2016, 2017, and 2018.

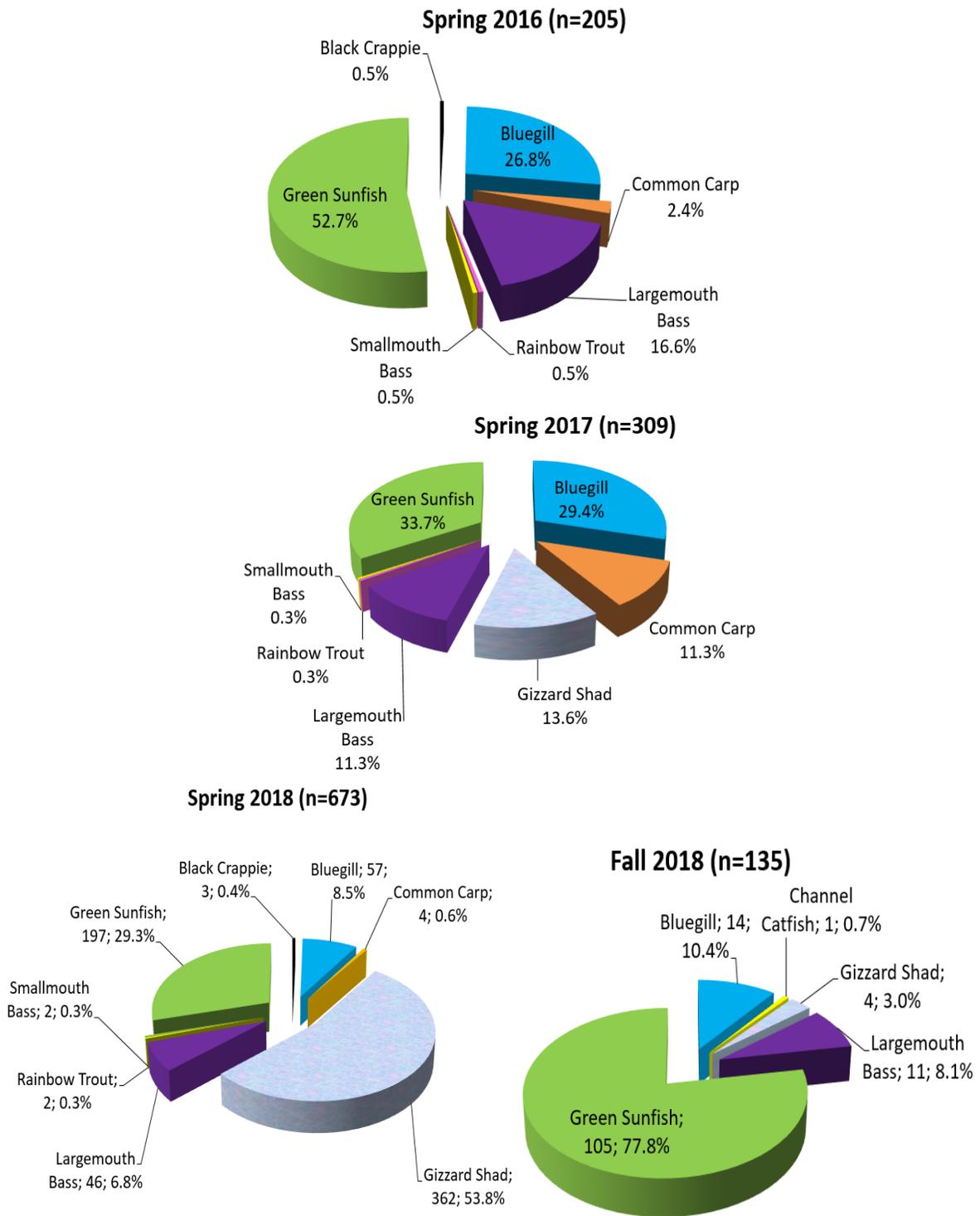


**Figure 6.** Historical (2011-2018) catch per unit effort of channel catfish (CCF), green sunfish (SNF), largemouth bass (LMB), and smallmouth bass (SMB) in Mack Wash at Site #1 and Site #2.

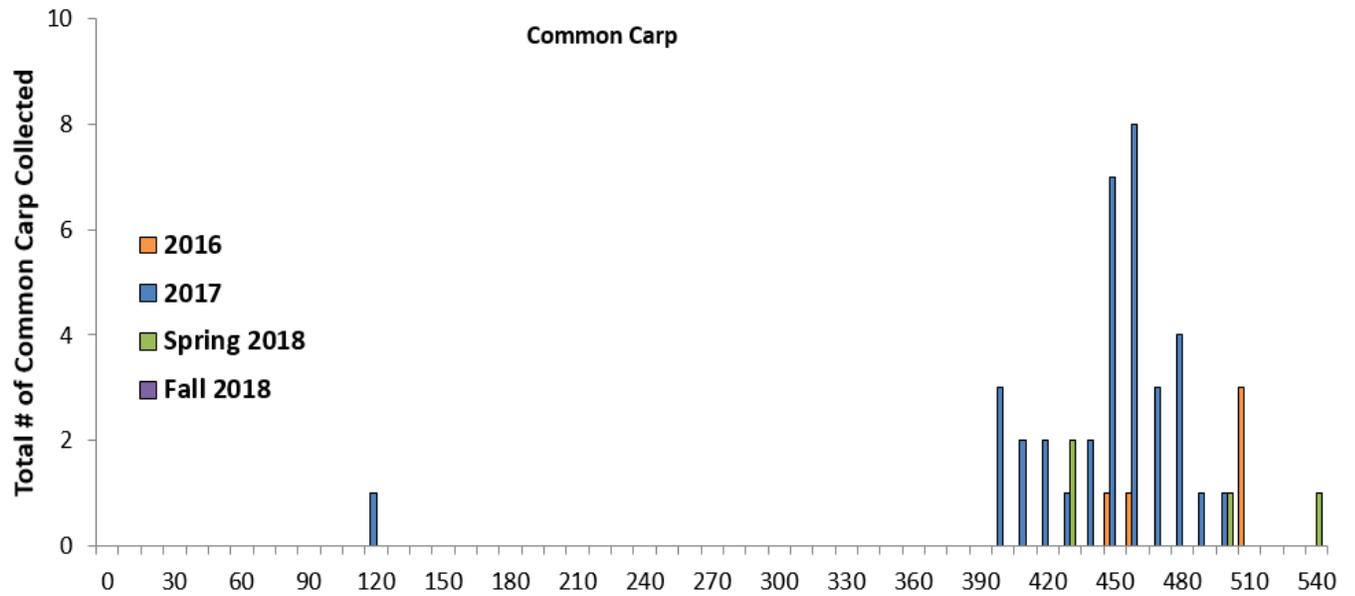
**Table 3.** Summary of sample (species composition, number of fish collected, length range, and catch per unit effort) of fish gathered between the spillway net and the spillway in Highline Lake in March of 2012, 2013, 2016, 2018, and November of 2018.

<b>Collection Method</b>	<b>Fish Species Collected</b>	<b>Total # Fish Collected</b>	<b>Total Length Size Range in Millimeters</b>	<b>Catch per Unit Effort (# fish/hour)</b>	
<b>Spring 2012 (300 fish collected)</b>					
Electrofishing	Bluegill	47	57-188	75.0	
	Common Carp	1	483	1.6	
	Green Sunfish	223	42-157	355.9	
	Largemouth Bass	24	56-296	38.3	
	Red Shiner	3	58-71	4.8	
	Smallmouth Bass	1	77	1.6	
	Gill Nets	Rainbow Trout	1	284	0.02
<b>Spring 2013 (163 Fish Collected)</b>					
Electrofishing	Bluegill	23	47-170	30.7	
	Common Carp	1	502	1.3	
	Green Sunfish	126	40-190	168.0	
	Largemouth Bass	13	67-123	17.3	
<b>Spring 2016 (205 Fish Collected)</b>					
Electrofishing	Black Crappie	1	119-119	1.2	
	Bluegill	55	63-144	66	
	Common Carp	5	443-510	6	
	Largemouth Bass	34	57-281	40.8	
	Rainbow Trout	1	259-259	1.2	
	Smallmouth Bass	1	127-127	1.2	
	Green Sunfish	108	53-166	129.6	
<b>Spring 2017 (309 Fish Collected)</b>					
Electrofishing	Bluegill	91	65-159	93.0	
	Common Carp	35	120-495	35.8	
	Gizzard Shad	42	94-345	42.9	
	Largemouth Bass	35	55-289	35.8	

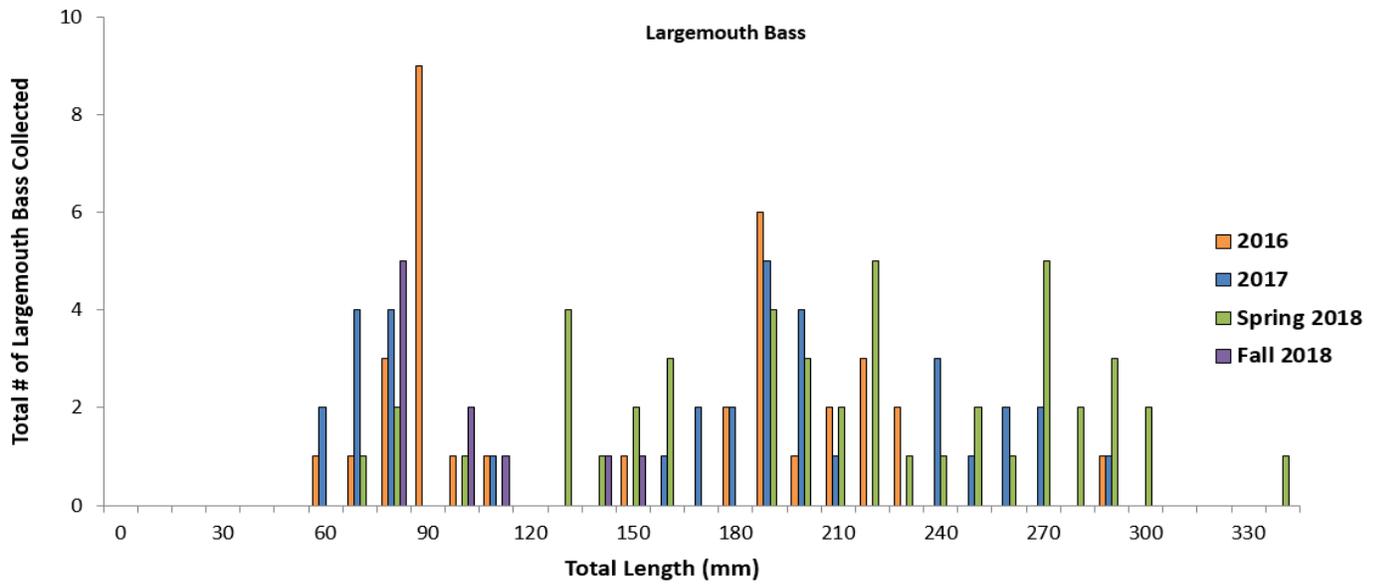
	Smallmouth Bass	1	167	1.0
	Green Sunfish	104	51-185	106.3
Gill Nets	Rainbow Trout	1	297	0.2
<b>Spring 2018 (673 Fish Collected)</b>				
Electrofishing	Black Crappie	2	86-92	1.01
	Bluegill	57	46-166	28.9
	Common Carp	4	421-531	2.0
	Gizzard Shad	340	114-342	172.6
	Largemouth Bass	45	70-334	22.8
	Rainbow Trout	1	266	0.5
	Smallmouth Bass	2		1.02
	Green Sunfish	197	43-160	100
Gill Nets	Black Crappie	1	65	0.1
	Gizzard Shad	22	171-331	3.1
	Largemouth Bass	1	268	0.1
	Rainbow Trout	1	325	0.1
<b>Fall 2018 (135 Fish Collected)</b>				
Electrofishing	Bluegill	14	86-150	14.1
	Channel Catfish	1	73	1.0
	Gizzard Shad	4	311-355	4.0
	Largemouth Bass	11	72-142	11.1
	Green Sunfish	105	57-156	106.1



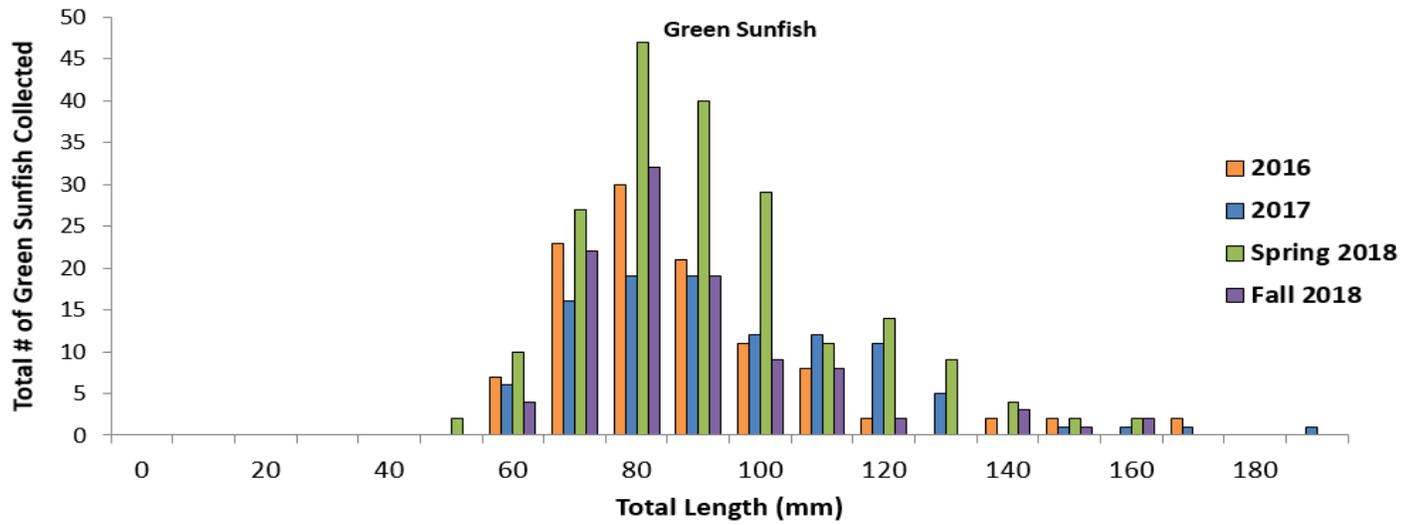
**Figure 7.** Species composition of Highline Lake survey between the spillway net and the spillway from 2016-2018. Charts include fish captured using both gill nets and electrofishing. No gill netting was conducted during the Fall 2018 survey.



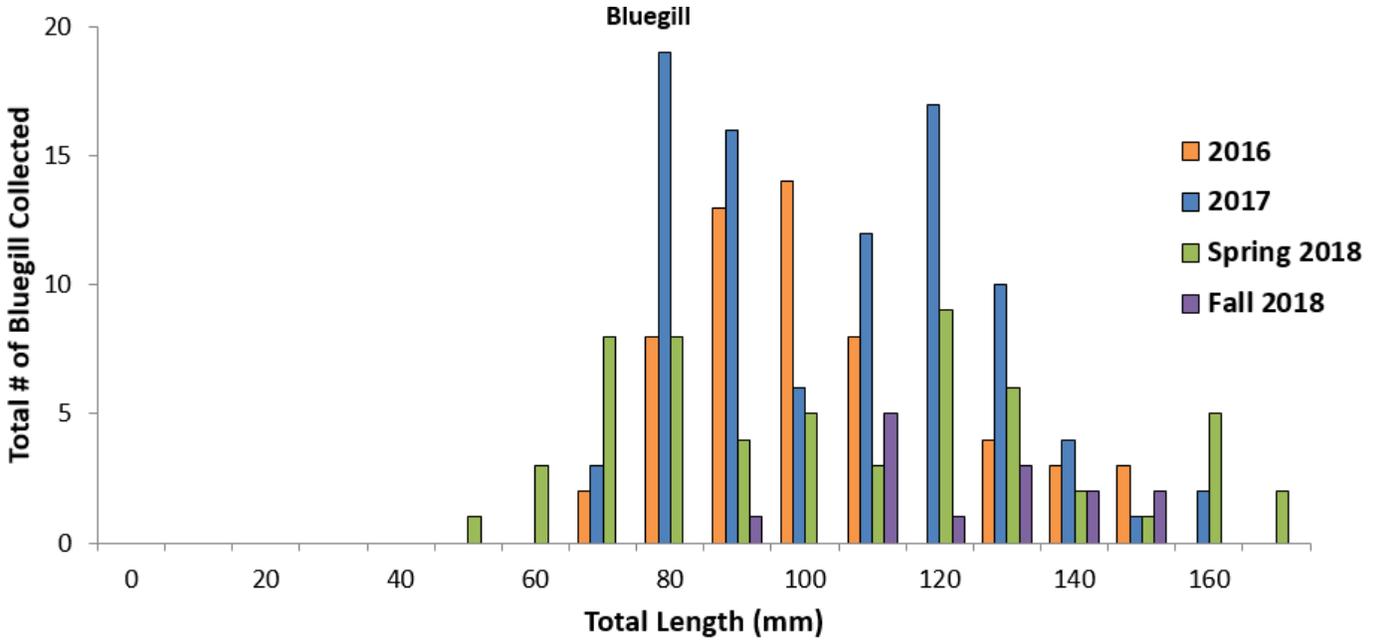
**Figure 8.** Length frequency histogram of common carp surveyed in Highline Lake between the spillway net and the spillway in 2016-2018. Includes fish captured using both gill nets and electrofishing. No gill netting was conducted during the Fall 2018 survey.



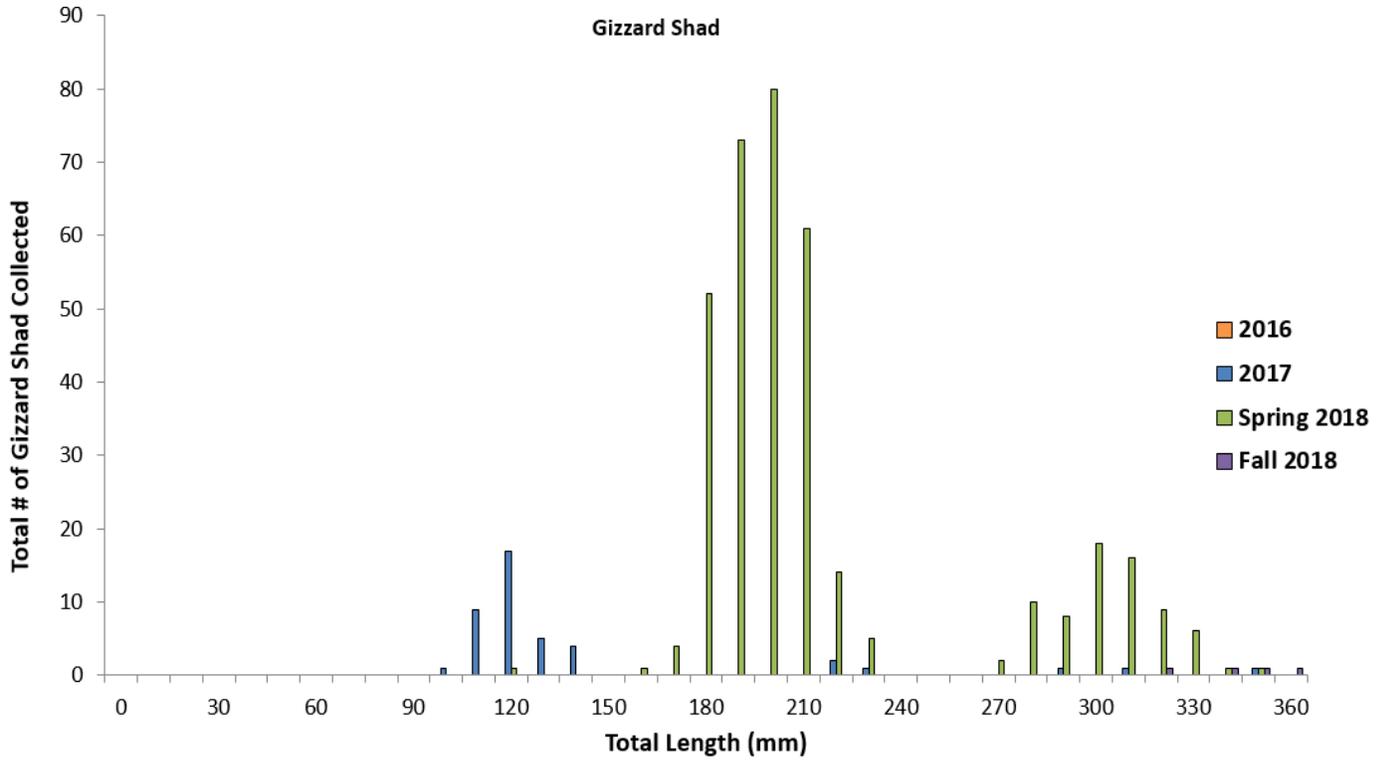
**Figure 9.** Length frequency histogram of largemouth bass surveyed in Highline Lake between the spillway net and the spillway in 2016 and 2017. Includes fish captured using both gill nets and electrofishing. No gill netting was conducted during the Fall 2018 survey.



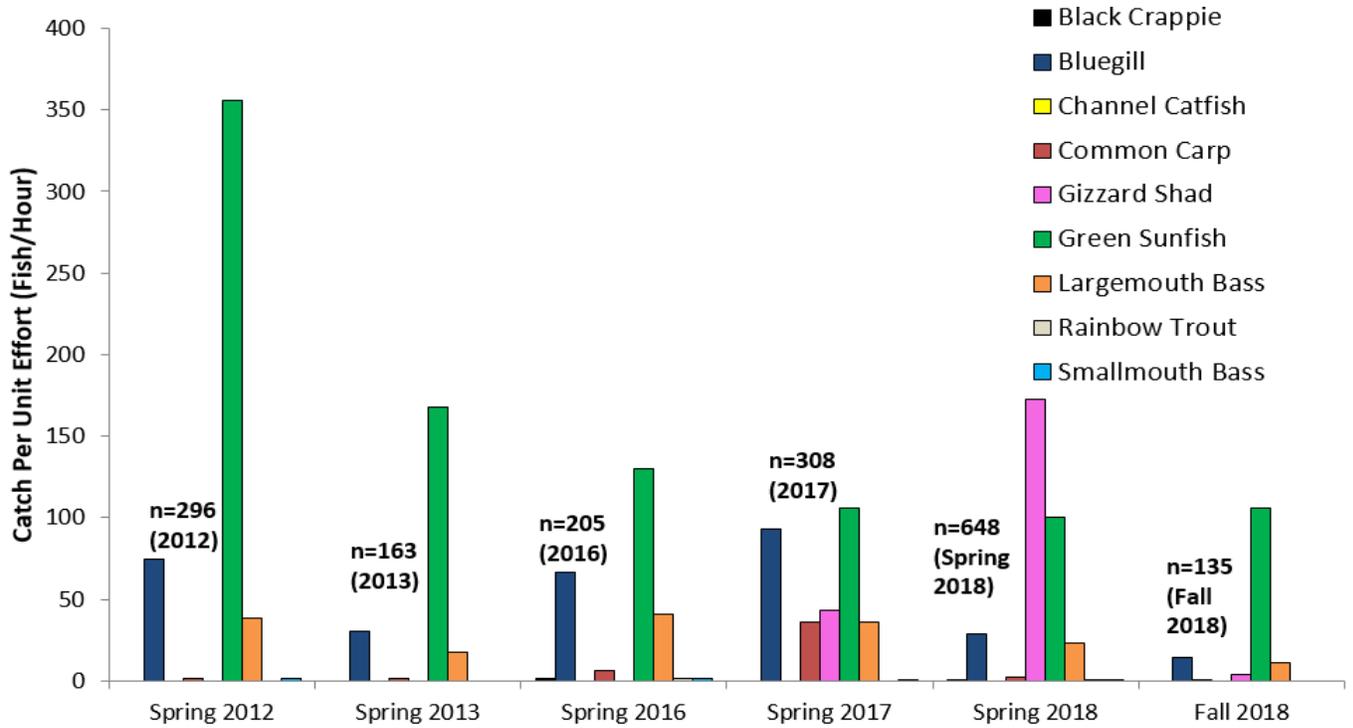
**Figure 10.** Length frequency histogram of green sunfish surveyed in Highline Lake between the spillway net and the spillway in 2016-2018. Includes fish captured using both gill nets and electrofishing. No gill netting was conducted during the Fall 2018 survey.



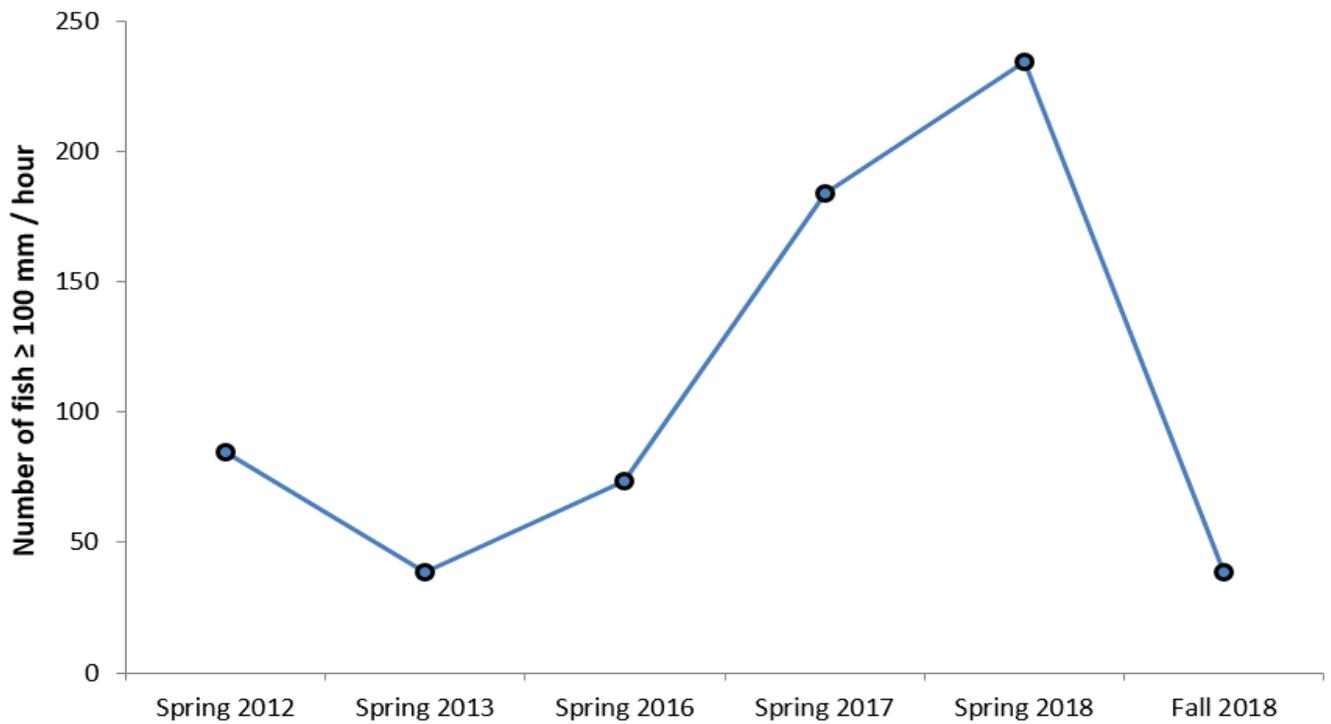
**Figure 11.** Length frequency histogram of bluegill surveyed in Highline Lake between the spillway net and the spillway in 2016-2018. Includes fish captured using both gill nets and electrofishing. No gill netting was conducted during the Fall 2018 survey.



**Figure 12.** Length frequency histogram of gizzard shad surveyed in Highline Lake between the spillway net and the spillway in 2016-2018. No gizzard shad were surveyed in 2016. Includes fish captured using both gill nets and electrofishing. No gill netting was conducted during the Fall 2018 survey.



**Figure 13.** Historical electrofishing catch per unit effort (in number of fish captured per hour) of black crappie, bluegill, channel catfish, common carp, largemouth bass, rainbow trout, smallmouth bass, and green sunfish in Highline Lake between the spillway net and the spillway.



**Figure 14.** Historical electrofishing catch per unit effort (in number of fish captured per hour) of individuals  $\geq 100$  mm of all fish species combined (i.e. black crappie, bluegill, channel catfish, common carp, largemouth bass, rainbow trout, smallmouth bass, and green sunfish) in Highline Lake between the spillway net and the spillway.



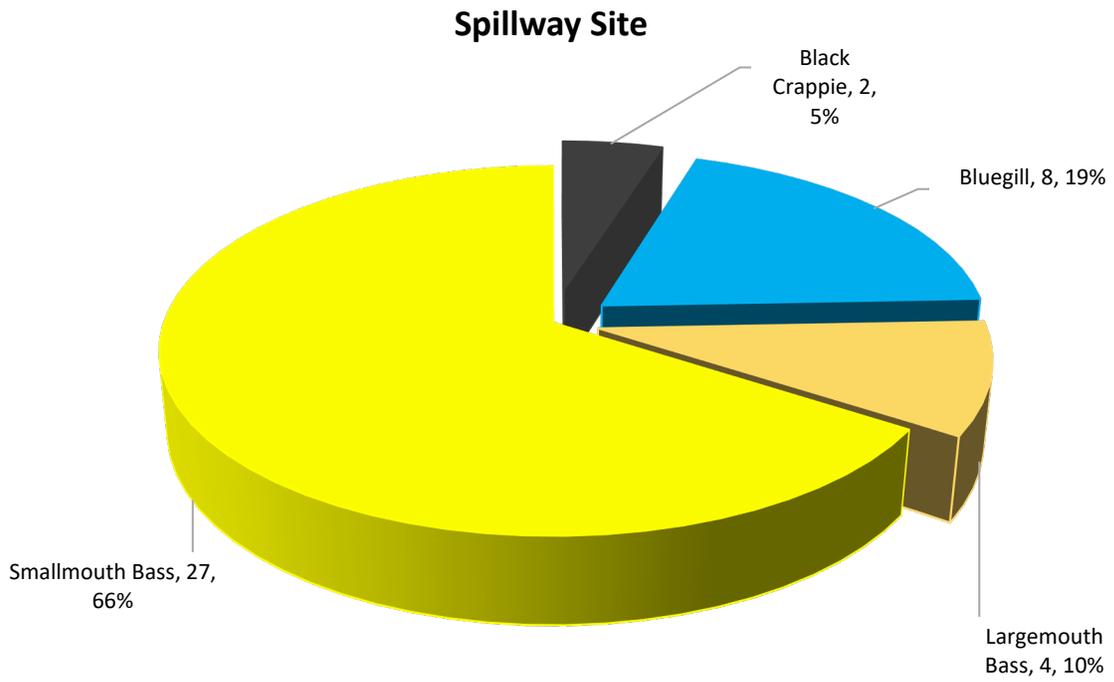
**Figure 15.** Satellite image of the Elkhead Reservoir spillway, fish sampling locations, and approximate location of the spillway net. Image courtesy of Google Earth.

**Table 4.** Overall catch per unit effort and total fish of each species captured in 2018 before compared to during/after Elkhead Reservoir started to spill water over the spillway.

<u>Location</u>	<u>Species</u>	<u>Total # Fish Collected</u>	<u># Fish Collected Pre-Spill</u>	<u># Fish Collected Post-Spill</u>	<u>CPUE (# Fish / Net Night)</u>
Spillway	Black Crappie	2	0	2	
	Bluegill	8	0	8	
	Largemouth Bass	4	0	4	
	Smallmouth Bass	27	0	27	
Stilling Basin	Smallmouth Bass	9	3	6	0.9
	White Sucker	1	1	0	0.1

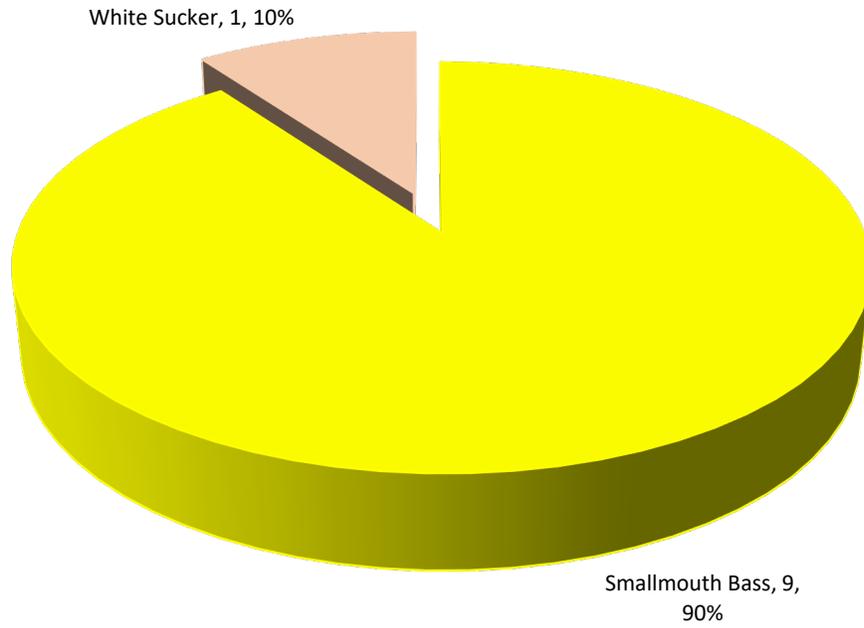
**Table 5.** Summary of all species captured, with length ranges, during 2018 sampling efforts at the spillway site and in the stilling basin at Elkhead Reservoir.

<b><u>Fish Species Collected</u></b>	<b><u>Spillway Site</u></b>	<b><u>Stilling Basin</u></b>
Black Crappie	2 fish; unmeasurable	0 fish
Bluegill	8 fish; 120-189 mm	0 fish
Largemouth Bass	4 fish; 121-180 mm	0 fish
Smallmouth Bass	27 fish; 96-257 mm	9 fish; 221-320 mm
White Sucker	0 fish	1 fish; unmeasurable
<b><u>Total Number of Fish Collected</u></b>	41	10



**Figure 16.** Species composition of fish sampled at the spillway site of Elkhead Reservoir in 2018.

### Stilling Basin



**Figure 17.** Species composition of fish sampled in the stilling basin below Elkhead Reservoir in 2018.

## **ANNUAL PERFORMANCE PROGRESS REPORT (PPR)**

BUREAU OF RECLAMATION AGREEMENT NUMBER: No agreement currently in place.  
Previous agreement number was R12AP40001

UPPER COLORADO RIVER RECOVERY PROGRAM PROJECT NUMBER: C-20

Project Title: Operation, maintenance, and fish escapement evaluation of the Highline Lake spillway net (fish barrier); operation, maintenance, and fish escapement evaluation of the Elkhead Reservoir spillway net (fish barrier)

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Project/Grant Period: Start date: NA  
End date: NA  
Reporting period end date: December 31, 2018  
Is this the final report? The study is ongoing.

Performance: All operations, maintenance, and fish sampling tasks were completed as outlined in the Scope of Work for this project.