

UPPER COLORADO RIVER ENDANGERED FISH RECOVERY PROGRAM

FY 2021 ANNUAL REPORT

PROJECT: C-20

Project Title:

Operation, maintenance, and evaluation of fish escapement barriers in Colorado (Highline Lake and Elkhead Reservoir)

Bureau of Reclamation Agreement Number:

No agreement currently in place. Previous agreement number was R12AP40001.

Project/Grant Period:

Start date: Not applicable

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Is this the final report? Yes _____ No X

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Abstract:

This project includes the operation, maintenance, and evaluation of the Highline Lake and Elkhead Reservoir spillway nets, designed to control escapement of non-native, warmwater fishes. Overall, both spillway nets appear to be in good shape and performing as designed. As of December 2021, Colorado Parks and Wildlife (CPW) is in the process of procuring a new spillway net for Highline Lake, and is anticipating installing the new spillway net in the spring of 2022. The Elkhead Reservoir spillway net has no anticipated near-time replacement timeline. Operation and maintenance of both spillway nets were fully performed in 2021, including five underwater cleanings/inspections at Highline Lake and four at Elkhead Reservoir. The Highline Lake spillway net was partially submerged on several occasions in 2021 by high canal inflows or “surges”; the most notable event was in early November when the canal inflow occurred for approximately six days longer than usual. This extended canal surge resulted in increased catch rates of fish between the spillway net and the spillway during the fall survey and also increased catch rates in Mack Wash downstream of Highline Lake. Crews conducted a spring (pre-spill) and fall (post-spill) survey on Highline Lake between the spillway net and the spillway and also conducted surveys in Mack Wash at two sites downstream of Highline Lake. Crews also sampled Elkhead Reservoir, between the spillway net and the spillway, and in the stilling basin. Elkhead Reservoir fish sampling occurred across 10 days in the spring and fall of 2021.

Study Schedule:

1999 - Ongoing

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.

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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)

Accomplishment of FY 2021 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

A. FY 2021 Tasks and Deliverables-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

A. FY 2021 Tasks and Deliverables-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. An additional survey was completed in the fall following irrigation season to assess impacts of an extended canal surge which occurred in early November.

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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

A. FY 2021 Tasks and Deliverables-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

A. FY 2021 Tasks and Deliverables-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.

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B. 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, which Highline Lake drains into.

Operations and Maintenance

Study Methods/Approach

Formerly, the operations and maintenance of the original Highline Lake 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 that the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) cover the additional costs. CPW expended \$12,500 for five spillway net inspections/cleanings and maintenance at Highline Lake in FY 2021. This was \$2,500 beyond the \$10,000 CPW committed to. At this time, CPW has determined no need for the Recovery Program to assist with covering these additional costs.

Results and Discussion

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 but the spillway net continued to receive high inflow of canal water throughout most of the season. During the final spillway net inspection/cleaning event on October 2, several large buoys were partially submerged until the spillway net was cleaned, offering some relief from the high volume of water moving through the spillway net. A similar scenario, i.e. buoys partially submerged, was also observed in early November when the canal inflow occurred for approximately six days longer than usual. Monthly spillway net inspections and cleanings occurred early in the season, April and May, and again in July and August to try and get ahead of the excessive algae growth on the spillway net that generally occurs later in the summer as a result of algae-favorable environmental conditions.

Task 2. Spillway net cleaning and repair operations (in water): Five spillway net inspections/cleanings were performed by United Under Water Contractors (UUWC) in 2021: April 9, May 21, July 9, August 20, and October 2. The first inspection/cleaning of the spillway net in 2021 occurred six days later than in 2020. The remaining inspections/cleanings occurred about one to two months apart, with the first four events occurring monthly from April through August with only June omitted. This aggressive monthly schedule seemed to somewhat curtail the excessive algae growth typically observed later in the summer. A fifth inspection/cleaning was required however in October, after skipping September. The

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spillway net was cleaned manually on all five occasions by divers from UUWC. As of December 2021, CPW is in the process of procuring a new spillway net for Highline Lake, and is anticipating installing the new spillway net in the spring of 2022. CPW plans to continue with at least four and perhaps five spillway net inspections/cleanings in 2022 to keep the new spillway net in the best condition as possible, prolonging its lifespan. Reports from the five 2021 spillway net inspections/cleanings follow.

The highlights of the April 9 spillway net inspection/cleaning were: 1) Cleaning was completed and there were no significant holes, cuts, or gaps found in the spillway net. All holes observed were repaired. 2) Canal water was just starting to flow into the lake (day 7 +/- of inflow). The spillway was just starting to have about 4-6" of water moving through it. The spillway net was covered with a thin algae layer especially on the top half and the skirt area. Most of the algae was removed with heavy scrubbing from seven divers. Brush, tumbleweeds, and lures were entangled in the upper skirt of the spillway net. All debris and lures were removed. 3) All cables, anchors, manta bolts, shackles, and thimbles were inspected and found to be tight, in good condition, and working well with one exception—an anchor broke loose from the safety line and so two shackles were used to repair the system.

The highlights of the May 21 spillway net inspection/cleaning were: 1) Cleaning was completed and there were no significant holes, cuts, or gaps found in the spillway net. Some new small holes were found, and all holes observed were repaired. 2) Canal water was flowing into the lake, and the spillway had 5-7" of water moving through it. The spillway net was covered with a thick algae layer especially on the top half and the skirt area. Most of the algae was removed with heavy scrubbing from eight divers. Brush and lures (bigger lures than observed previously) were entangled in the upper skirt of the spillway net. All debris and lures were removed. 3) All cables, anchors, manta bolts, shackles, and thimbles were inspected and found to be tight, in good condition, and working well.

The highlights of the July 9 spillway net inspection/cleaning were: 1) Cleaning was completed and there were no significant holes, cuts, or gaps found in the spillway net. Some new small holes were found, and all holes observed were repaired. 2) Canal water was flowing into the lake, and the spillway had 4-6" of water moving through it. The spillway net was covered with a thick algae layer especially on the top half and the skirt area. Most of the algae was removed with heavy scrubbing from eight divers. Two divers focused on cleaning the upper skirt to facilitate movement of the water flow. Brush and lures were entangled in the upper skirt of the spillway net. All debris and lures were removed. A "no boats" buoy was on the dam next to the spillway net. A few larger sunfish and bass were observed on the downstream side of the spillway net which were more than normally observed. Small cobbles/rocks were also found in the skirt which caused it to sink in several places. All rocks were removed. 3) All cables, anchors, manta bolts, shackles, and thimbles were inspected and found to be tight, in good condition, and working well. The manta bolts holding the safety line were all exposed by 18".

The highlights of the August 20 spillway net inspection/cleaning were: 1) Cleaning was completed and there were no significant holes, cuts, or gaps found in the spillway net. No new holes were found. 2) Canal water was flowing into the lake, and the spillway had a solid stream of water moving through it. The spillway net was covered with a thick algae layer. Most of the algae was removed with heavy scrubbing from six divers. As the spillway net gets older, a thicker "crust" of algae is starting to form on various sections of the spillway net. Heavier wire brushes are required to clean these areas with caution as not to accelerate wear on the spillway net. This is an indication that the spillway net is nearing the end of its lifespan, as this crust has been noted on previous spillway nets shortly before they were

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replaced. Brush and lures were entangled in the upper skirt of the spillway net. All debris and lures were removed. Sunfish were observed on both sides of the spillway net. 3) All cables, anchors, manta bolts, shackles, and thimbles were inspected and found to be tight, in good condition, and working well. The manta bolts holding the safety line were all exposed by 18". Extra time was spent focusing on cleaning up the old cable, rope, and anchors that were entangled on the safety line.

The highlights of the October 2 spillway net inspection/cleaning were: 1) Cleaning was completed and there were no significant holes, cuts, or gaps found in the spillway net. Some new small holes were found especially on the east end around the dam where the spillway net lays against the rocks along the dam. All holes observed were repaired. 2) Canal water was flowing into the lake, and the spillway had a strong stream of water moving through it. The spillway net was quite dirty with an increase in trash and debris. Prior to cleaning the spillway net, there were nine anchor points that caused the larger buoys to be submerged to about 12". After cleaning the spillway net, five anchor points remained where the larger buoys were submerged to about 4". Brush and lures were entangled in the upper skirt of the spillway net. All debris and lures were removed. Numerous small shad (1.5") were observed on both sides of the spillway net. 3) All cables, anchors, manta bolts, shackles, and thimbles were inspected and found to be tight, in good condition, and working well. The manta bolts holding the safety line were all exposed by 15-18". Two shackles holding the safety signs to anchors and to the safety cable were replaced. The shackles appeared to have worn or worked away from the anchors. Two small buoys were loose on the east end of the main skirt, and those will be secured on the next spillway net inspection. Mini trees were starting to flourish on the main safety sign buoy system and all were removed.

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 was deployed for several hours and when time permitted, CPW would examine the spillway net from the water surface.

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 spillway net inspections/cleanings, which are available at the Park or on request.

Fish Monitoring

Highline Lake

Study Methods/Approach

CPW crews completed fish surveys within Highline Lake between the spillway net and the spillway in March 2012, March 2013, March 2016, March 2017, March 2018, November 2018, March 2019, August 2020, April 2021, and November 2021. 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. Timing of the sampling between the spillway net and spillway was delayed in 2020 due to COVID-19 agency protocols. A pre-irrigation season electrofishing survey was conducted on April 1,

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2021. Additionally, a second electrofishing survey was conducted following the irrigation season on November 15, 2021. This additional fall survey was conducted to evaluate the impacts of the Government Highline Canal operating until November 6, which is approximately six days later than usual. This extended irrigation season resulted in a “surge” event in Highline Lake that occurred between November 1 and November 7 as high canal flows entered the lake due to low irrigation demand. The large buoys of the spillway net were partially submerged for the duration of this surge in early November, compromising the spillway net. The summary that follows is primarily focused on the analysis of fish data gathered in 2019, 2020, and 2021. Please refer to previous years’ Annual Reports for Project C-20 for summaries of the pre-2019 data for Highline Lake.

Both surveys in 2021 consisted of nighttime boat electrofishing using a boat-mounted ETS unit and two netters. Historically, gill net surveys consisting of short-duration sets of 150’ experimental-mesh gill nets have been periodically conducted in this area between the spillway net and spillway as well, in conjunction with electrofishing efforts. However, no gill nets were set during the 2021 surveys. Electrofishing is the primary survey technique as it provides for the highest catch rates and removal efficiency. The objectives of the 2021 surveys were to determine fish species composition and relative abundance within the lake between the spillway net and the spillway. All fish were identified to species and measured in total length (tl) to the nearest millimeter (mm). The majority of adult fish captured were weighed to the nearest gram, while the majority of juvenile fish were not weighed. Fish collected were released back into Highline Lake upstream of the spillway net, with the exception of smallmouth bass and gizzard shad, which were lethally removed.

Results and Discussion

A total of 233 fish were collected during the survey between the spillway net and the spillway conducted on April 1, 2021 (Table 1). Green sunfish dominated the catch, comprising 64.4% of the fish captured (Figure 1). Other species collected in the spring 2021 survey included largemouth bass, bluegill, gizzard shad, rainbow trout, and two juvenile smallmouth bass (72 and 83 mm tl). A total of 318 fish were collected during the survey conducted in the same area on November 15, 2021 (Table 1). This survey consisted mostly of green sunfish as well (56.6% of overall fish captured; Figure 1). Other species captured during the fall 2021 survey included largemouth bass, bluegill, and gizzard shad. No smallmouth bass were captured during the fall electrofishing survey.

Although low densities of smallmouth bass are regularly documented in the annual surveys conducted in the main body of Highline Lake, the two juveniles caught during the spring sampling effort are the first smallmouth bass captured between the spillway net and the spillway since 2018. Multiple size classes of largemouth bass (Figure 2), green sunfish (Figure 3), and bluegill (Figure 4) were captured during the spring 2021 and fall 2021 surveys. Two gizzard shad (both adults) were captured in the spring of 2021 while 25 juvenile and adult gizzard shad (electrofishing catch per unit effort of 19.2 fish/hour) were caught during the fall 2021 survey (Figure 5 and Figure 6). The fall 2021 gizzard shad catch rate is the highest observed since the spring of 2018 when 340 gizzard shad were caught, resulting in an electrofishing catch per unit effort of 172.6 fish/hour (Figure 6). The high abundance of gizzard shad in 2018 was addressed through increased removal efforts on the first spring survey and also through a second spring survey to further decrease abundance of gizzard shad between the spillway net and the spillway prior to the reservoir spilling. Significant depletion was seen in gizzard shad catch rates during those removal efforts in 2018, which presumably reduced chances of gizzard shad escapement and also

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resulted in lower gizzard shad catch rates in 2019, 2020, and 2021. Largemouth bass catch rates during both surveys in 2021 were higher than any catch rates dating back to 2016, and bluegill catch rates were higher than they have been since 2017 (Figure 6). Green sunfish catch rates in 2021 were only slightly less than the highest observed catch rate which occurred in 2019 (Figure 6). The 2021 catch rate for all fish over 100 mm in tl was higher in the spring survey (98.1 fish/hour) than it was during the fall survey (54.6 fish/hour) (Figure 7). Previous catch rates (fish/hour) of fish over 100 mm were the greatest in the spring of 2017 and 2018. The high catch rate of fish in the spring 2018 survey was largely due to the high density of adult gizzard shad. Fish catch rates in the spring 2021 and fall 2021 were the highest and third highest (respectively) catch rates observed during the five sampling events since the peak catch rate in the spring of 2018.

Overall, catch rates of fish behind the spillway net were higher in 2021 than catch rates observed in 2019 and 2020. This is likely due to a combination of factors, including age and condition of the current spillway net (planned to be replaced in 2022) as well as the frequency, duration, and volume of canal surges. During canal surges, increased water from the canal flows through the reservoir resulting in periods of time in which there is a gap between the top of the spillway net and the surface of the water. The installation of a new spillway net combined with increased communication with the canal company should reduce the number of fish moving past the spillway net and escaping from Highline Lake.

Mack Wash

Study Methods/Approach

Mack Wash originates upstream of Highline Lake, and flows through the lake downstream approximately five miles 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 considered 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 (Figure 8) in the month of November from 2011-2021. Please refer to previous years' Annual Reports for Project C-20 for summaries of the pre-2019 data for Mack Wash. The summary that follows is primarily focused on the analysis of fish data gathered in 2019, 2020, and 2021. CPW biologists conducted single-pass, bank electrofishing surveys at two sites on Mack Wash downstream of Highline Lake on November 19, 2019; November 17, 2020; and November 17, 2021. 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.

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Specifically, CPW was interested in identifying potential escapement of non-native fishes from Highline Lake. All fish were identified to species, measured in tl to the nearest mm, and weighed to the nearest gram. All largemouth bass and rainbow trout from Site #1 were relocated to Highline Lake upstream of the spillway net. Otherwise, all non-native fish collected were lethally removed.

An additional sampling technique was utilized at Site #1 beginning in 2020. The upstream terminus of Site #1 is a deep pool at the downstream end of the Highline Lake spillway. In previous years, adult fish were observed in the spillway pool following the electrofishing survey due to electrofishing efficiency limitations in deep water and difficulty accessing the deeper water. CPW conducted two overnight experimental-mesh gill net surveys in conjunction with electrofishing efforts in the pool at the top of Site #1 in 2020 and 2021 to further evaluate escapement and reduce non-native fish densities downstream of Highline Lake. In 2021, the gill net was deployed two nights prior to the electrofishing survey and was retrieved during the electrofishing survey once the electrofishing crew reached the deep pool at the downstream end of Highline Lake spillway. The gill net was retrieved as the power to the electrofishing unit remained on to minimize the number of fish that could evade both sampling gears.

Results and Discussion

The 2021 electrofishing survey at Site #1 on Mack Wash consisted of a total of 28 fish, including largemouth bass, green sunfish, yellow perch, and rainbow trout (Table 2, Figure 9). The gill netting survey completed at Site #1 consisted of a total of 44 fish, including largemouth bass, green sunfish, rainbow trout, channel catfish, smallmouth bass, white sucker/hybrid sucker, and yellow perch. The 2021 electrofishing survey at Site #2 on Mack Wash consisted of a total of 219 fish, including red shiner, white sucker/hybrid sucker, green sunfish, roundtail chub, bluehead sucker, common carp, speckled dace, flannelmouth x bluehead sucker hybrid, largemouth bass, black bullhead, and flannelmouth sucker (Table 2, Figure 10). No gizzard shad were collected in Mack Wash at either site in 2021 (Table 2). This species has never been documented historically at either site (Tables 3 and 4), despite their continued high abundance within Highline Lake, including low densities between the spillway net and the spillway. Overall, total numbers of fish collected at both sites have been fairly consistent since at least 2019.

Multiple size-classes of largemouth bass and green sunfish were observed in the 2021 electrofishing survey at Site #1 (Figures 11 and 12, respectively). The size structure of largemouth bass consisted of fish ranging in tl from 60 mm to 144 mm (Table 2). Largemouth bass size structure was somewhat similar to those observed in 2019 and 2020 (Tables 2-4, Figure 11). Largemouth bass and green sunfish electrofishing catch rates at Site #1 in 2021 were higher than those observed in 2019 and 2020 (Tables 2-4, Figure 13). However, these catch rates were slightly lower than those observed in 2018 and considerably lower than those observed between 2011 and 2015 (Figure 13). One rainbow trout and two yellow perch were also captured during the electrofishing survey at Site #1; this is the first time either of these species have been documented at this site during electrofishing surveys.

The use of a 125' experimental-mesh gill net was very effective at capturing additional fish in the spillway pool at the upstream end of Site #1. The gill net survey resulted in the capture of an additional 44 fish (Table 2, Figure 9). The fish captured during the survey consisted of largemouth bass, green sunfish, rainbow trout, channel catfish, smallmouth bass, white sucker/hybrid sucker, and yellow perch. A larger proportion of largemouth bass and green sunfish captured during the gill net survey were adults

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compared to the size structure of fish captured during electrofishing efforts, which mostly consisted of younger fish (Figures 11 and 12, respectively). Gill netting at Site #1 was first utilized in 2020, although the gill netting was conducted following the electrofishing survey in 2020 rather than prior to and during the electrofishing survey as in 2021. Catch rates may be at least somewhat due to differences in the timing of the gill net set relative to electrofishing between years. Gill netting catch rates in 2021 for green sunfish and rainbow trout were lower than those observed in 2020 for the same species (Figure 14). Gill netting catch rate was higher in largemouth bass in 2021 than in 2020 (Figure 14). Gill netting efforts in 2021 also resulted in the capture of four additional species when compared to the 2020 survey, including channel catfish, smallmouth bass, white sucker/hybrid sucker, and yellow perch. One juvenile smallmouth bass (131 mm tl) was caught at Site #1 during gill netting efforts. This was the first time that smallmouth bass had been documented at Site #1 since 2011.

Two juvenile largemouth bass were captured at Site #2 (Figure 11), while multiple size classes of green sunfish were also collected (Figure 12). Catch rate for green sunfish in 2021 was considerably less than the peak observed in 2020, although it was the second highest catch rate ever observed since the project's inception in 2011 (Figure 15). The 2021 largemouth bass catch rate was also considerably less than those observed in 2020 and 2019 (Figure 15).

Despite the total numbers of fish collected at both Mack Wash sites remaining fairly consistent since at least 2019, 2021 survey data from Site #1 immediately downstream of Highline Lake suggest an increase in escapement for some species of fish compared to recent years. Increased 2021 electrofishing catch rates for largemouth bass and green sunfish combined with the presence of less-frequently surveyed species such as smallmouth bass, yellow perch, channel catfish, and rainbow trout at Site #1 are both indicative of increased escapement. A total of three yellow perch and three rainbow trout were captured during the survey in 2021. It is worth noting that only one channel catfish and one smallmouth bass were captured in 2021 and that these fish were captured in the gill net, which is a technique that was incorporated into the survey beginning in 2020. There was also increased gill netting effort in 2021 compared to 2020 which may also be responsible for the presence of these less-frequently surveyed species in the 2021 survey. The spillway net's effectiveness was likely reduced in early November 2021 due to the atypical six day extension of irrigation water delivery through the Highline Canal following the irrigation season which typically ends in late October. As a result, a surge of water for an extended period of time partially submerged the large buoys of the spillway net. The spillway net was compromised during this period.

These canal surges, which are typically a result of heavy rains and irrigators not diverting water from the canal, were especially pronounced in November 2021, but have been periodically documented over the last four years. Canal surges are most likely the primary cause of increased catch rates of some fish species in Mack Wash at Site #1 and in Highline Lake between the spillway net and the spillway in 2021. The age and condition of the spillway net may also be a factor in increased escapement, but it is worth noting that no major damage to the spillway net was documented during regular inspections conducted throughout 2021. Proposed spillway net modifications for the 2022 spillway net include the addition of more floats to increase buoyancy of the spillway net, which will allow it to better withstand canal surges. However, the primary recommendation for reducing fish escapement is increased coordination and communication with Grand Valley Water Users Canal personnel to reduce the magnitude and duration of these surge events.

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Conclusions

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

- 1) Continuing and improving coordination and communication efforts with operators of the canal system to ensure operation of the spillway net is not hindered as a result of irrigation water delivery practices.
- 2) Cleaning the spillway net more frequently and with a shorter time frame between cleanings to reduce strain, and wear and tear of the spillway net. The current spillway net was replaced in March 2014 after dredging activities within Highline Lake were completed. The spillway net is planned to be replaced in the spring of 2022. The 2022 spillway net will be modified with a more robust center buoy system to provide additional flotation to assist in countering the negative impacts of canal surges.
- 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. Furthermore, an anti-escapement net is deployed on the outlet structure to prevent fish escapement when the outlet is operated.

Overall, based on data gathered between the spillway net and the spillway in Highline Lake and the data from Mack Wash at Site #1 and Site #2, the spillway net continues to prevent the majority of fish from escaping Highline Lake. Despite an increase in largemouth bass and green sunfish escapement in 2021, overall escapement of these two species in addition to others has been greatly reduced compared to previous years in which the spillway net was compromised. Improvements in spillway net effectiveness can be made moving forward through increased communication with the canal operators to reduce the frequency and magnitude of canal surge events. The installation of the new spillway net with increased buoyancy in 2022 should also result in reduced fish escapement.

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.

Operations and Maintenance

Study Methods/Approach

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

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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 Recovery Program, subject to the mutual agreement of CPW and the 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 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 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 \$17,000 for cleaning/inspection of the spillway net in 2021. This was \$7,000 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 \$7,000 (which would be a cost of \$3,500) to CPW for operations and maintenance costs.

Results and Discussion

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.

Task 2. Spillway net cleaning and repair operations (in water): Four spillway net inspections/cleanings were performed by UUWC in 2021: April 23, June 12, July 30, and September 17. The first inspection/cleaning of the spillway net in 2021 occurred approximately nine days earlier than in 2020. With exceptions in May and August, the remaining inspections/cleanings occurred about one month apart. The spillway net was cleaned manually on all four occasions by divers from UUWC. CPW plans to continue with at least four spillway net inspections/cleanings in 2022. Reports from the four 2021 spillway net inspections/cleanings follow.

The highlights of the April 23 spillway net inspection/cleaning were: 1) Cleaning was completed, and there were no significant holes, cuts, or gaps observed in the spillway net. 2) UUWC observed that the water level was lower than normal and because of that, the month of May could be the best month to start inspections/cleanings for the year. Six divers focused on cleaning the top 90% of the spillway net. The top 4' of spillway net was very dirty, but it cleaned up well. Crayfish continued to stack in between the spillway net layers, but appear to die off and dissolve over a few months. Few lures were found and removed. All brush, weeds, and debris were removed from the spillway net above and below the water line. On the eastern one third and western one third of the spillway net the bank erosion is causing up to 12" of sand to build up on both sides of the spillway net. UUWC attempted to break up this sand pile where possible, and noted that hopefully as the water flow and pressure increase both will result in the sand falling off and shaking this weight off of the spillway net. 3) Hardware and the buoy system were inspected and in good condition. Most of the underwater chain was not well galvanized and does have a thick layer of rust, which won't be an issue for years as the links are quite thick. However, this does make inspections difficult to predict problems. The bars holding the bottom skirts on the debris barrier continue to show wear. In one particular area, the joint was completely missing a skirt which was to be repaired during the next inspection/cleaning event.

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The highlights of the June 12 inspection/cleaning were: 1) Cleaning was completed, and there were no significant holes, cuts, or gaps observed in the spillway net. Two new holes in the spillway net were found and repaired. 2) UUWC observed that the water volume remained low and water flow was not quite running over the spillway. Eight divers cleaned the entire spillway net. The top 8' of spillway net was very dirty, but it cleaned up well. Crayfish continued to stack in between the spillway net layers. Few lures were found and removed. All brush, weeds, and debris were removed from the spillway net above and below the water line. During the April inspection/cleaning event, sand had begun piling up on both sides of the spillway net on the eastern and western ends. UUWC noted that this sand pile had decreased as the water level has risen. 3) Hardware and the buoy system were inspected and in good condition. UUWC was unable to address the problem joint area on the debris barrier that was observed during the April inspection/cleaning event. A new skirt will be installed on the next inspection/cleaning event.

The highlights of the July 30 inspection/cleaning were: 1) Cleaning was completed, and there were no significant holes, cuts, or gaps observed in the spillway net. 2) UUWC observed that the water had just stopped flowing over the spillway. Seven divers cleaned 80%+ of the spillway net. The top section of the spillway net needed the most cleaning, and it cleaned up well. Crayfish continued to stack in between the spillway net layers. Few lures were found and removed. All brush, weeds, and debris were removed from the spillway net above and below the water line. Most of the sand pile that had settled on the lower portion of the spillway net has washed off. 3) Hardware and the buoy system were inspected and in good condition. Boats cause quite a bit of wave action for all of the moving parts of the spillway net and safety line. The missing skirt on the debris barrier was replaced, but another lower skirt was missing at the same joint. This new problem will be addressed during the next inspection/cleaning event.

The highlights of the September 17 inspection/cleaning were: 1) Cleaning was completed, and there were no significant holes, cuts, or gaps observed in the spillway net. 2) UUWC observed no water flowing over the spillway. Five divers cleaned the spillway net with the top section completely stretched out and cleaned. More lures were found and removed. All brush, weeds, and debris were removed from the spillway net above and below the water line. 3) Hardware and the buoy system were inspected and in good condition. The missing lower skirt on the debris barrier was replaced. These joints will continue to show wear year after year as boats cause quite a bit of wave action.

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.

Task 4. Underwater survey: The spillway net was inspected during each cleaning by UUWC. 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

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 considered critical habitat for state and federal listed fish species, as well as other native, non-listed fishes. Elkhead Reservoir was expanded in 2006, roughly

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doubling the water surface acreage. During the expansion, a ¼” 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.

Study Methods/Approach

In 2021, 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 16). The objectives of the fish surveys were to determine fish species composition and relative abundance in Elkhead Reservoir between the spillway net and the spillway, and also downstream of the reservoir’s spillway net. Experimental gill nets were set before and after water was released over the spillway. One, 150’ experimental gill net was set at the “spillway site,” which included the area between the spillway net and spillway. 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 2021. Gill nets were set at both the spillway site and stilling basin for nine nights each between April 9 and April 18, before the reservoir spilled. Additionally, gill nets were set at both the spillway site and stilling basin from September 9 to September 10, after the reservoir stopped spilling. All fish were identified to species, measured in tl to the nearest mm, and weighed to the nearest gram. All largemouth bass, black crappie, and bluegill were relocated to Elkhead Reservoir upstream of the spillway net if found alive. Otherwise, all non-native fish collected were lethally removed with the exception of one northern pike that escaped from the gill net prior to capture.

Results and Discussion

Pre-spill sampling (April 9 - April 18) at the spillway site yielded one largemouth bass with a tl of 216 mm, one northern pike that escaped the gill net prior to capture, and two smallmouth bass (205 and 286 mm tl) (Table 5). One smallmouth bass (254 mm tl) and 42 white suckers (304-386 mm tl) were captured in the stilling basin during pre-spill sampling. During post-spill sampling (September 9 - September 10), one partially scavenged northern pike was captured at the spillway site. Additionally, two smallmouth bass, of which only one could be measured (240 mm tl), were captured at the spillway site. It is possible that the northern pike captured at the spillway site during pre-spill sampling is the same northern pike that was captured at the spillway site during post-spill sampling. The post-spill stilling basin gill net captured four smallmouth bass (286-344 mm tl) and 45 white suckers (301-366 mm tl).

Sampling effort (i.e. the number of nights that gill nets were set) has varied between years and between pre-spill and post-spill sampling trips in the same year. Therefore, catch rate (number of fish captured per overnight gill net set) was calculated for each pre-spill and post-spill sampling trip from 2017-2021 (Figure 17). Electrofishing effort occurred in conjunction with gill net effort in 2018 but has not occurred since 2018 (Figure 17). Since 2018, post-spill gill net sampling effort was deemed sufficient without the addition of electrofishing effort. In 2020 and 2021, low water conditions in Elkhead Reservoir had reduced the spillway site to a small, isolated pool. Post-spill catch rate in the spillway site was lower in 2021 (three fish/night) compared to all previous years with the exception of 2019 (zero

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fish/night). Post-spill catch rate in the stilling basin was much greater in 2021 compared to previous years. The increase in catch rate observed during post-spill sampling in the stilling basin is largely due to the capture of 45 white suckers in one overnight gill net set (Table 5, Figure 17). It is likely that the white suckers captured in the stilling basin originated in Elkhead Creek instead of Elkhead Reservoir, as white suckers have never been captured at the spillway site during spillway net evaluation efforts (2017-2021). Additionally, the last year in which a white sucker was captured during annual sampling within Elkhead Reservoir was 2019. Overall, the few number of total fish collected at the spillway site (n=7) is comparable to or less than previous years and suggests that the Elkhead Reservoir spillway net continues to be an effective tool at greatly reducing the opportunity for fish to escape the reservoir over the spillway.

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 were first collected between the spillway net and the spillway, including the pre-irrigation survey in 2018 in which 362 gizzard shad were removed. Gizzard shad catch rate between the spillway net and the spillway has decreased since the peak in the spring of 2018. The majority of fish surveyed between the spillway net and spillway from 2018-2021 following the depletion in gizzard shad were juvenile green sunfish. No gizzard shad have been captured in Mack Wash downstream of Highline Lake.

CPW manages Highline Lake to provide warmwater fishing opportunities to anglers while also ensuring that stocked fish are compatible with native species present in the drainage. Therefore, CPW is only stocking fish species in Highline Lake that are approved by the FWS and states of Utah, Wyoming, and Colorado, and that are compatible with native fishes. In 2021, bluegill, channel catfish, largemouth bass, and rainbow trout were stocked into Highline Lake (Table 6).

Mack Mesa Lake

Northern pike were first documented in Mack Mesa Lake, which is a 20 surface acre lake located in Highline Lake State Park, in September of 2020. The source of these northern pike is believed to be a recent illicit introduction. Concerns regarding the illicit introduction of northern pike in Mack Mesa Lake were primarily focused on sportfish management at Mack Mesa as this popular fishery is stocked regularly with rainbow trout and a number of warmwater fish species including largemouth bass, black crappie, bluegill, and channel catfish. There is no natural escapement risk of northern pike out of Mack Mesa because the outlet is not functional and has not been operated in decades. However, the lake's proximity to Highline Lake (within 500 feet at its closest point) did raise concerns regarding the potential for illicit introductions of northern pike into Highline Lake from Mack Mesa Lake.

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Intensive removal operations (overnight gill netting and boat electrofishing) conducted at Mack Mesa in the fall of 2020 resulted in the removal of eight adult northern pike. Good depletion was observed throughout these efforts in 2020 and no northern pike were captured during the last two sampling events. However, five juvenile northern pike were removed from Mack Mesa Lake during spring removal efforts in 2021, which resulted in a decision to drain the lake. From April 12, 2021 to May 7, 2021, approximately seventy acre-feet of water was drained from Mack Mesa Lake using a trailer-mounted 8-inch pump. The pump's intake hose was screened with 0.25 mesh to ensure fish escapement in the outflow was not a concern. The draining project resulted in the complete drying of Mack Mesa Lake and the reservoir was subsequently refilled and restocked with catchable trout and warmwater fish in the summer and fall of 2021. The total project cost was estimated at more than \$35,000.

The north end of Highline Lake, which is shallow and has an abundance of aquatic vegetation, was surveyed in the fall of 2020 and the spring of 2021 using gill nets and boat electrofishing to ensure that northern pike were not also illicitly stocked in Highline Lake. No northern pike were captured or observed during these surveys. Furthermore, no northern pike have been caught during annual standardized fish surveys in Highline Lake, nor have any anglers reported catching northern pike in Highline Lake.

Elkhead Reservoir

Elkhead Reservoir was drawn down in 2021 to an elevation lower than any other since the reservoir was expanded in 2006. As a result, the spillway site was a small pool of water compared to when Elkhead Reservoir is at full pool, which congregated fish and likely increased the susceptibility of fish to capture during sampling efforts.

CPW manages Elkhead Reservoir to provide warmwater fishing opportunities to anglers while also ensuring that stocked fish are compatible with native fish species present in the drainage. Therefore, CPW is only stocking fish species in Elkhead Reservoir that are approved by the USFWS and states of Utah, Wyoming, and Colorado, and that are compatible with native fishes. In 2021, bluegill and largemouth bass were stocked into Elkhead Reservoir (Table 7).

Recommendations:

Highline Lake/Mack Wash

Operations and Maintenance

As of December 2021, CPW is in the process of procuring a new spillway net for Highline Lake, and is anticipating installing the new spillway net in the spring of 2022. The 2022 inspection/cleaning schedule for the new spillway net may be modified, but CPW is currently planning to complete at least four and perhaps five spillway net inspections/cleanings to keep the new spillway net in the best condition as possible, prolonging its lifespan.

Highline Lake State Park staff will continue to monitor the spillway net and debris washing into the lake in the spring, and will inform divers when cleaning of the spillway net will need to take place. This will include additional collaboration with water operators related to inflow rates from the canal system.

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Fish Monitoring

CPW will continue to complete fish surveys in Highline Lake between the spillway net and spillway, and at the two sites within Mack Wash downstream of Highline Lake, at least once annually. This sampling will be prioritized around the irrigation season to maximize the continued evaluation of the spillway net effectiveness at preventing fish escapement, pre- and post-spill.

Historically, surveys between the spillway net and spillway have typically occurred in the spring prior to irrigation season. However, additional surveys in this area were also conducted in the fall of 2018 and the fall of 2021 due to concerns regarding the potential for increased fish escapement during the irrigation season when canal surges likely reduced the effectiveness of the spillway net. Fall surveys following the irrigation season should be considered when necessary and feasible based on spillway net function throughout the irrigation season and results of the pre-spill surveys for that year.

The use of overnight gill netting in 2020 and 2021 at Site #1 on Mack Wash was extremely effective in at increasing the number of fish removed from the site, particularly in the deep water in the spillway pool. Continued gill net surveys at Site #1, completed in conjunction with electrofishing efforts, will allow for a more thorough removal effort and assessment of fish escapement out of Highline Lake.

Elkhead Reservoir

Operations and Maintenance

CPW will continue with at least four spillway net inspections/cleanings in 2022, following a similar schedule as past years. Monthly and bimonthly (twice a month) cleanings may be required, beginning in July. The first inspection/cleaning is expected to begin in April/May so that a clean spillway net is in place when the lake begins filling. April is the preferred month for the first annual spillway net inspection/cleaning, but may not be feasible if environmental conditions prohibit the inspection/cleaning from occurring. At least one cleaning will occur in the spring, followed by two cleanings during the summer, and a final cleaning once the reservoir is either no longer or minimally spilling. If additional cleanings are required in 2022, CPW may request financial assistance from the Colorado River Recovery Program as part of the current agreement between the two entities.

Elkhead Reservoir State Park staff will continue to monitor the spillway net and debris washing into the reservoir in the spring, and will inform divers when cleaning of the spillway net will need to take place.

Fish Monitoring

CPW will continue to complete fish surveys in Elkhead Reservoir between the spillway net and spillway, and in the stilling basin. This sampling will be prioritized around the irrigation season to maximize the continued evaluation of the spillway net effectiveness at preventing fish escapement, pre-spill and post-spill.

Project Status:

This project is considered on track and ongoing.

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FY 2021 Budget Status:

Funds Provided: --- N/A

Funds Expended: No Recovery Program dollars were expended in this fiscal year.

\$12,500 was expended by CPW for five spillway net inspections/cleanings and maintenance at Highline Lake in FY 2021 (CPW covers annual operations and maintenance up to \$10,000). \$17,000 was expended by CPW for four spillway net inspection/cleaning at Elkhead Reservoir in FY 2021 (CPW covers annual operations and maintenance up to \$10,000). At this time, CPW has determined no need for the Recovery Program to assist in covering these additional operations and maintenance costs at Highline Lake and Elkhead Reservoir.

Difference: --- N/A

Percent of the FY 2021 work completed, and projected costs to complete: --- 100%; cost to complete not applicable

Colorado River Recovery Program funds spent for publication charges: --- N/A

Status of Data Submission:

Not applicable

Signed:

Lori Martin

Program Manager

January 18, 2022

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Appendix: Figures and Tables

Table 1. Summary of fish surveys (species composition, total number of fish collected, total length range, and catch per unit effort) of fish collected between the spillway net and the spillway in Highline Lake in spring 2019, summer 2020, spring 2021, and fall 2021. See previous years' Annual Reports for summaries of pre-2019 data.

Collection Method	Fish Species	Total # of Fish Collected	Total Length Size Range in Millimeters	Catch per Unit Effort (# of fish/hour)
Spring 2019 (397 Fish Collected)				
Electrofishing	Bluegill	49	70-179	23.8
	Black Crappie	8	53-82	3.9
	Gizzard Shad	3	291-383	1.5
	Largemouth Bass	29	68-324	14.1
	Green Sunfish	307	30-191	149.0
Gill Nets	Gizzard Shad	1	322	0.2
Summer 2020 (130 Fish Collected)				
Electrofishing	Bluegill	14	71-163	10.9
	Common Carp	7	428-551	5.4
	Gizzard Shad	5	362-407	3.9
	Largemouth Bass	9	61-399	7.0
	Green Sunfish	85	22-202	65.9
	Yellow Perch	1	75	0.8
Gill Nets	Bluegill	3	119-148	0.3
	Channel Catfish	1	521	0.1
	Rainbow Trout	1	214	0.1
	Green Sunfish	4	127-182	0.4
Spring 2021 (233 Fish Collected)				
Electrofishing	Bluegill	32	64-186	31.1
	Gizzard Shad	2	325-374	1.9
	Largemouth Bass	45	49-305	43.7
	Rainbow Trout	2	293-315	1.9
	Smallmouth Bass	2	72-83	1.9
	Green Sunfish	150	40-207	145.6
Fall 2021 (318 Fish Collected)				
Electrofishing	Bluegill	46	39-180	35.4
	Gizzard Shad	25	82-354	19.2
	Largemouth Bass	67	54-205	51.5
	Green Sunfish	180	41-184	138.5

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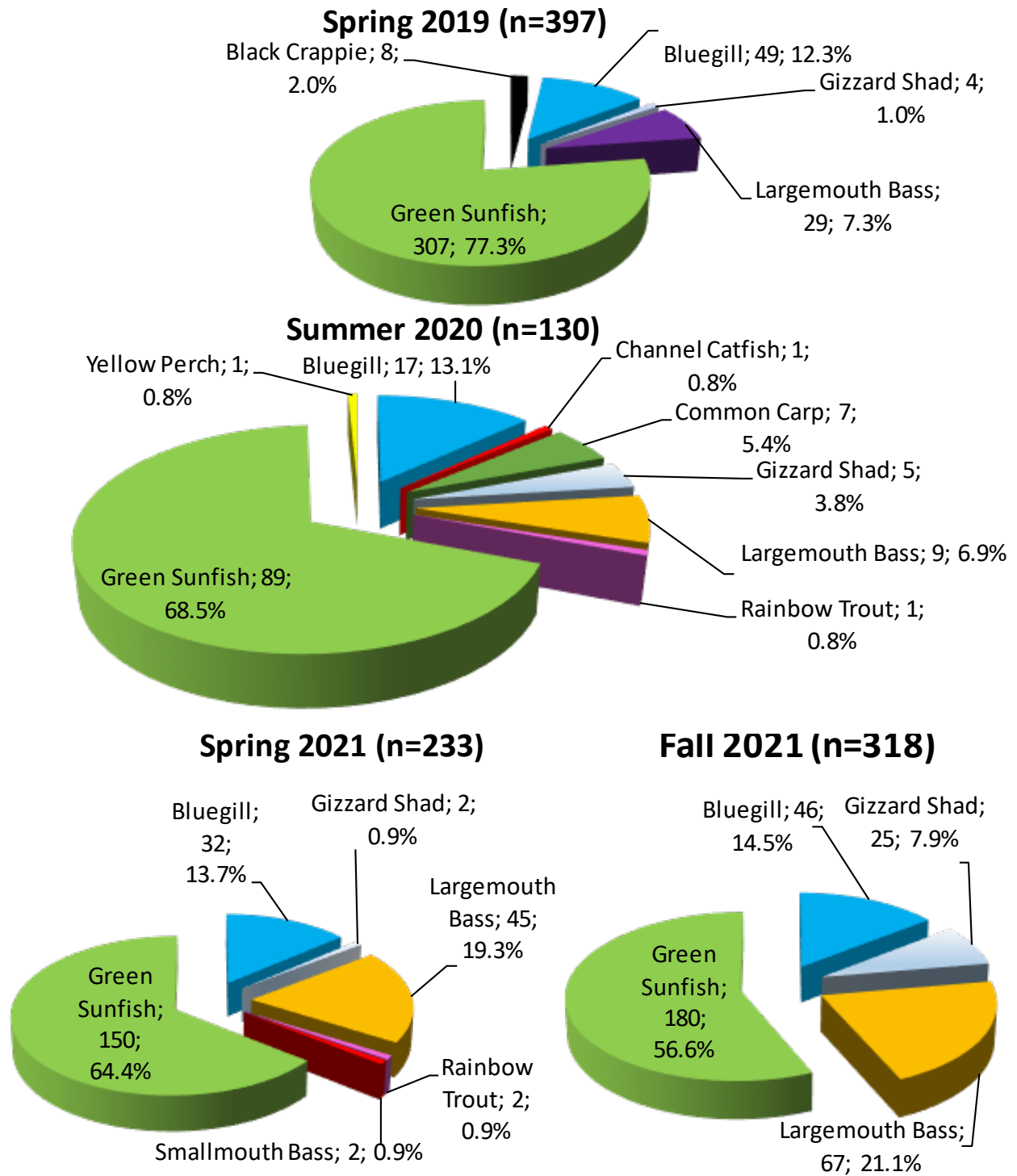


Figure 1. Species composition of fish surveyed (number of fish sampled and percentage of overall fish captured) in Highline Lake between the spillway net and the spillway from 2019-2021. Charts include fish captured using both gill nets and electrofishing. No gill netting was conducted during the 2021 surveys. See previous years' Annual Reports for summaries of pre-2019 data. Figure totals may sum to +/- 0.1% of 100% due to rounding.

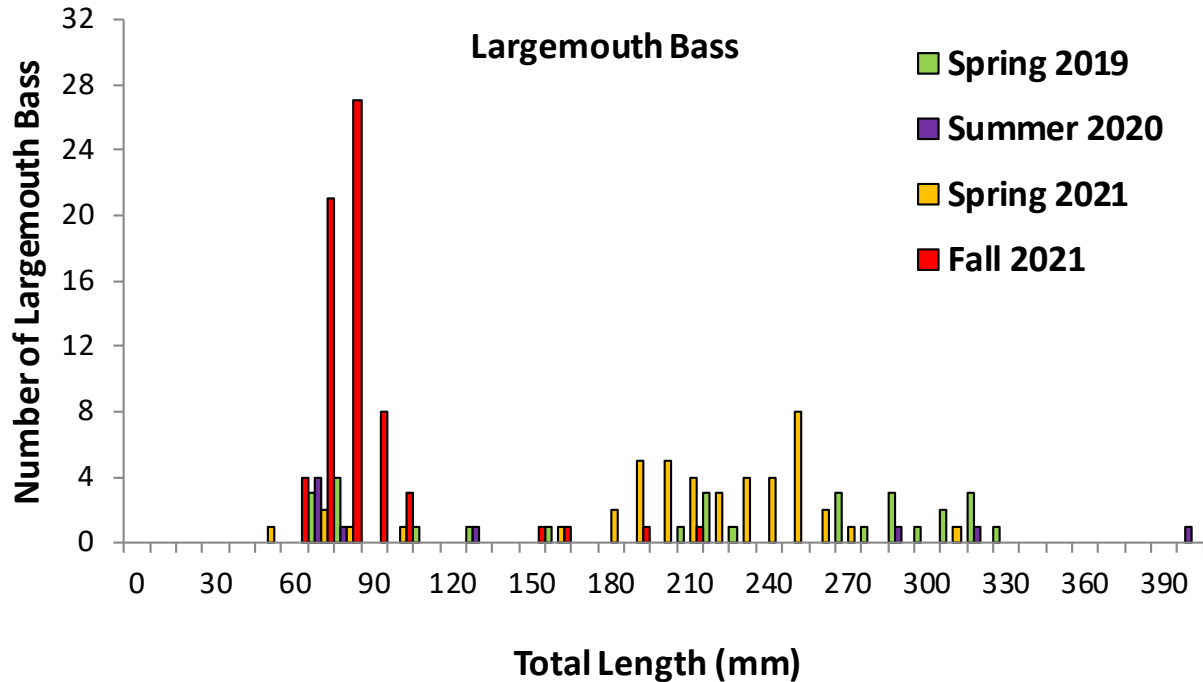


Figure 2. Length frequency histogram of largemouth bass surveyed in Highline Lake between the spillway net and the spillway from 2019-2021. Histogram includes fish captured using both gill nets and electrofishing. No gill netting was conducted during the 2021 surveys. See previous years’ Annual Reports for summaries of pre-2019 data.

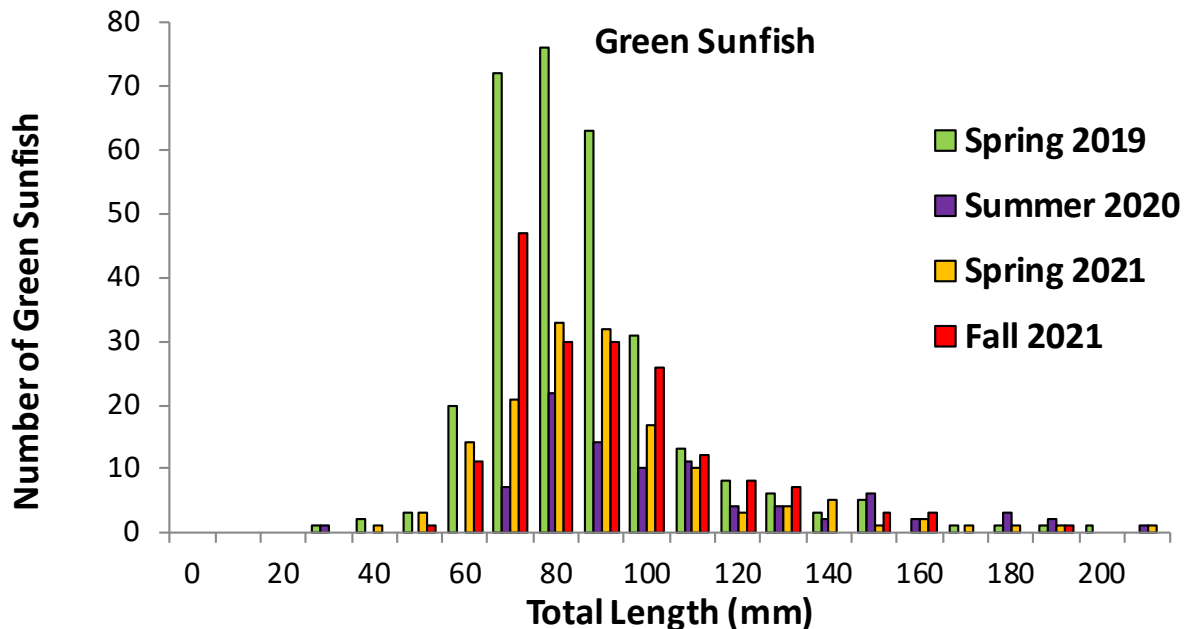


Figure 3. Length frequency histogram of green sunfish surveyed in Highline Lake between the spillway net and the spillway from 2019-2021. Histogram includes fish captured using both gill nets and electrofishing. No gill netting was conducted during the 2021 surveys. See previous years’ Annual Reports for summaries of pre-2019 data.

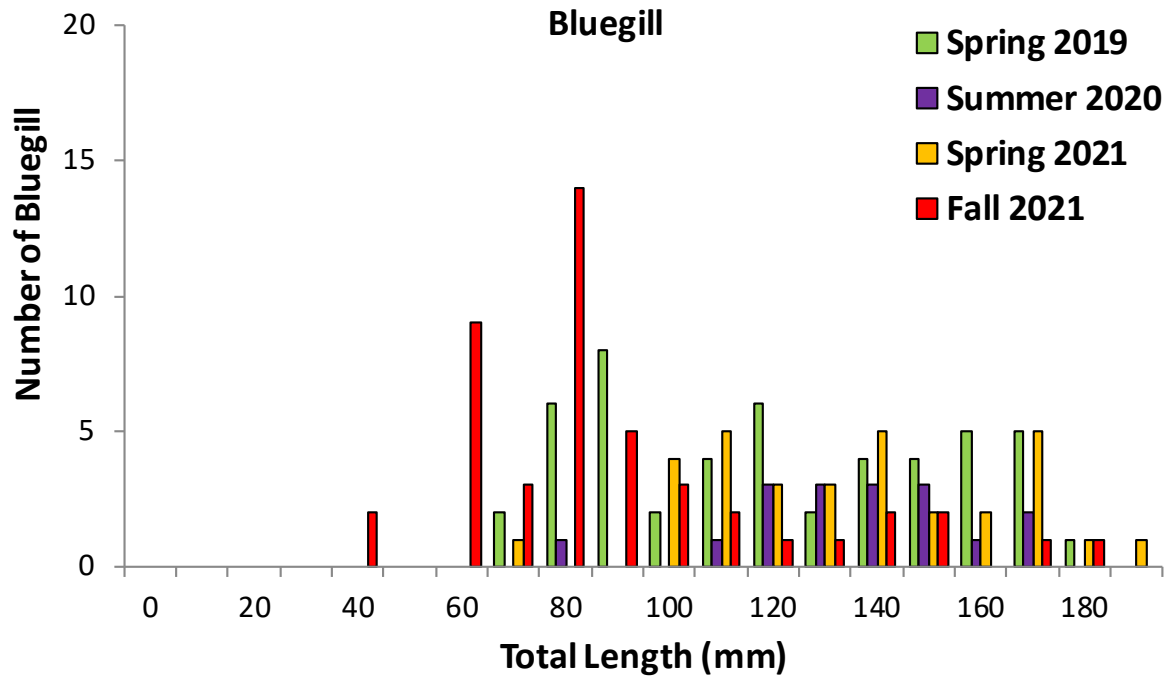


Figure 4. Length frequency histogram of bluegill surveyed in Highline Lake between the spillway net and the spillway from 2019-2021. Histogram includes fish captured using both gill nets and electrofishing. No gill netting was conducted during the 2021 surveys. See previous years’ Annual Reports for summaries of pre-2019 data.

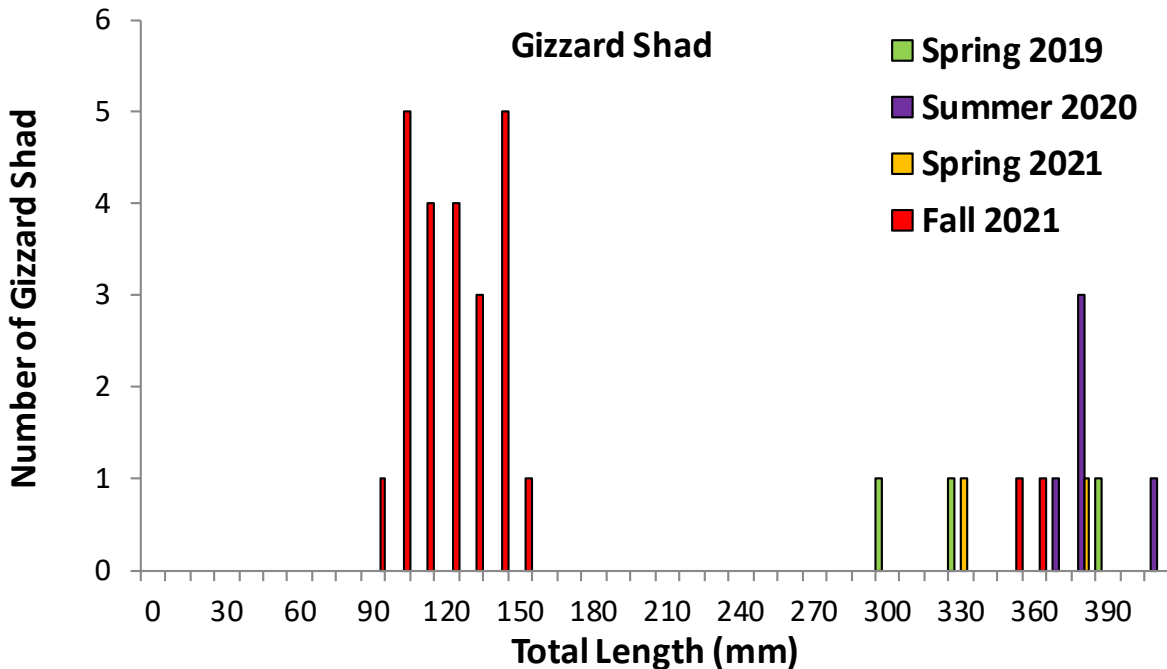


Figure 5. Length frequency histogram of gizzard shad surveyed in Highline Lake between the spillway net and the spillway from 2019-2021. Histogram includes fish captured using both gill nets and electrofishing. No gill netting was conducted during the 2021 surveys. See previous years’ Annual Reports for summaries of pre-2019 data.

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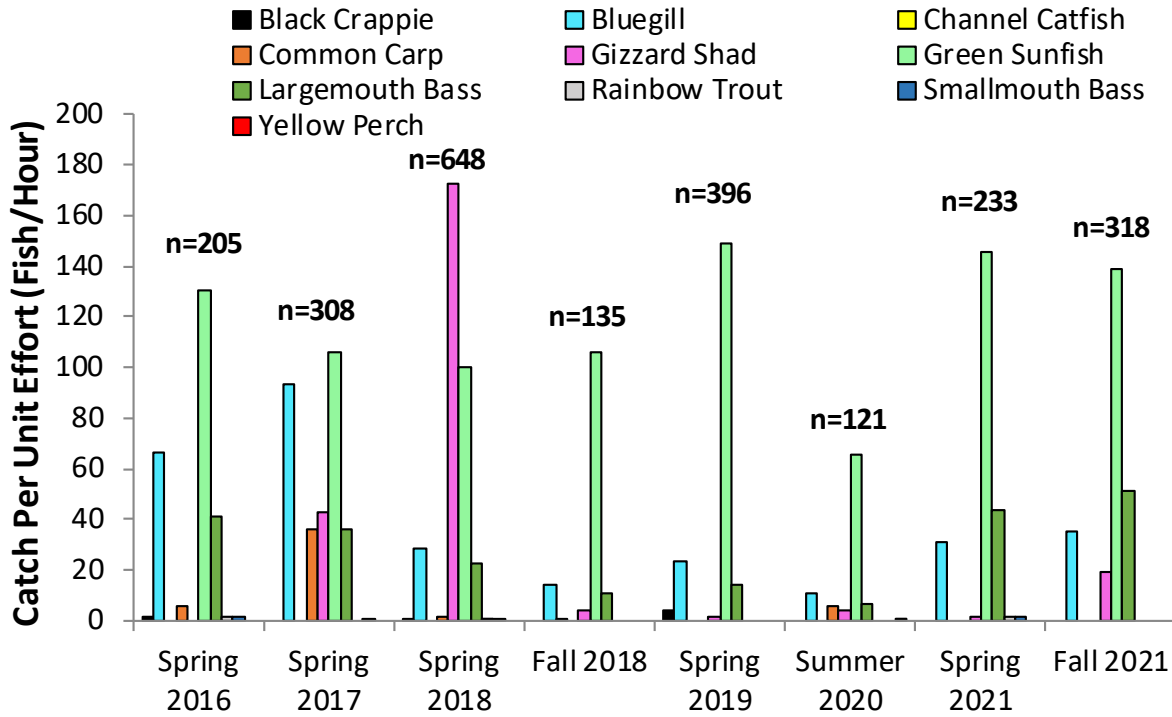


Figure 6. Historical electrofishing catch rate (number of fish captured per hour) of black crappie, bluegill, channel catfish, common carp, gizzard shad, green sunfish, largemouth bass, rainbow trout, smallmouth bass, and yellow perch in Highline Lake between the spillway net and the spillway from 2016 through 2021. Total number of fish (n=) captured shown above each sampling event.

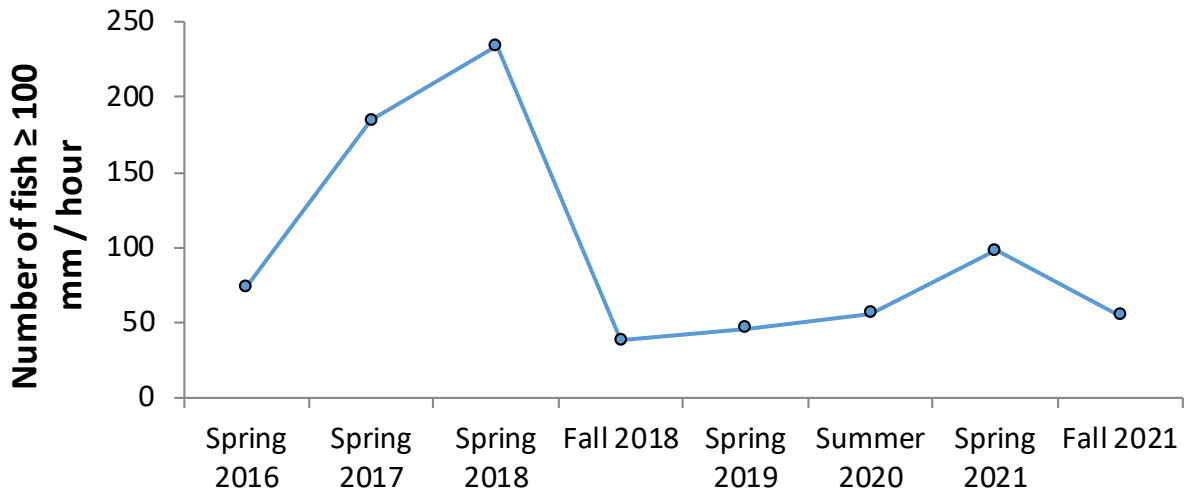


Figure 7. Historical electrofishing catch per unit effort (number of fish captured per hour) of individuals ≥ 100 millimeters (mm) in total length for all fish species combined (i.e. black crappie, bluegill, channel catfish, common carp, gizzard shad, green sunfish, largemouth bass, rainbow trout, smallmouth bass, and yellow perch) in Highline Lake between the spillway net and the spillway from 2016 through 2021.

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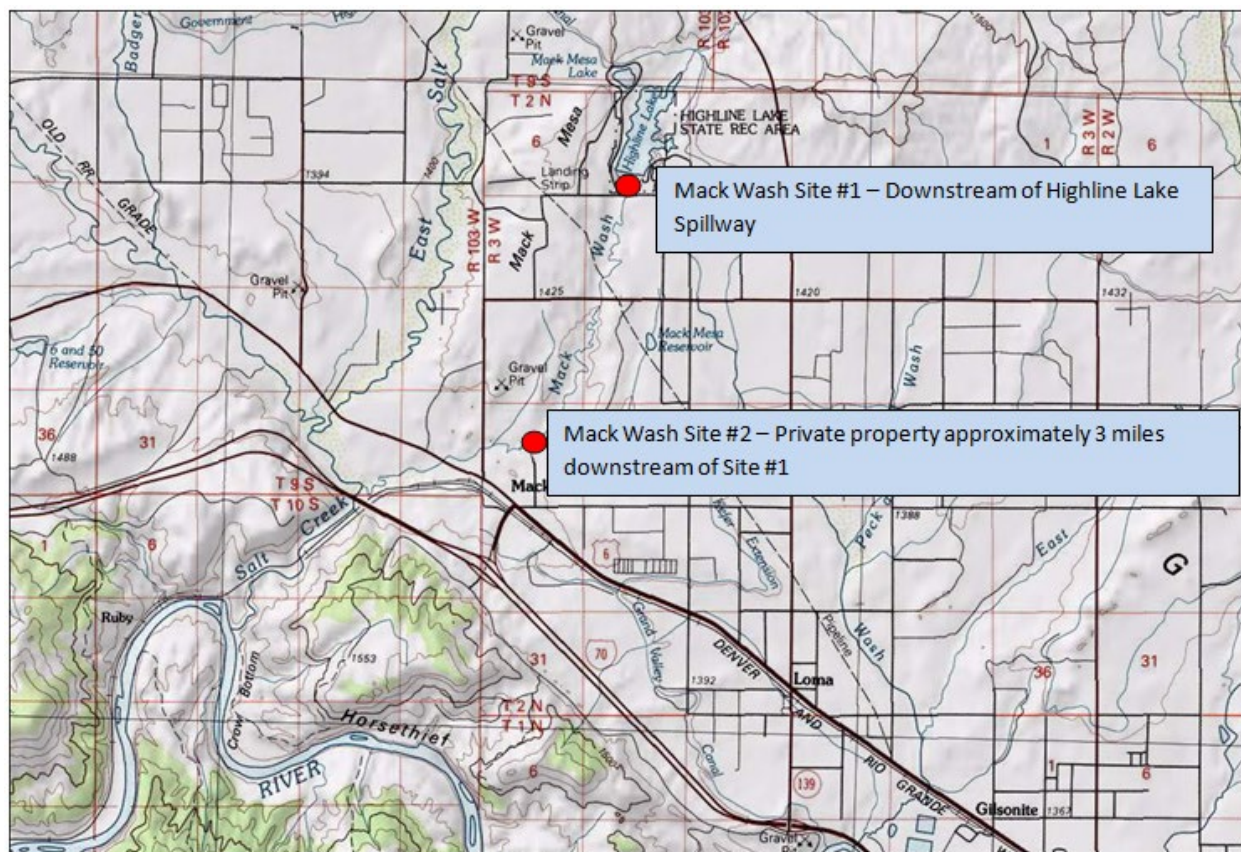


Figure 8. Map of sampling locations on Mack Wash surveyed in November 2019, 2020, and 2021 using a single-pass survey technique with a bank electrofishing unit. An overnight gill netting survey was also conducted at Site #1 in conjunction with electrofishing efforts in 2020 and 2021.

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Table 2. Total number of fish collected; total length size range in millimeters (mm); catch per unit effort (# of 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 **2021**. Native fish species identified by *.

Fish Species Collected	Site #1 (Electrofishing)	Site #1 (Gill Netting)	Site #2
Black Bullhead	0 fish	0 fish	1 fish; 258 mm; 1.2/hour
Bluehead Sucker*	0 fish	0 fish	7 fish; 70-200 mm; 8.6/hour
Bluegill	0 fish	0 fish	0 fish
Channel Catfish	0 fish	1 fish; 501 mm; <0.1/hour	0 fish
Common Carp	0 fish	0 fish	5 fish; 136-191 mm; 6.2/hour
Fathead Minnow	0 fish	0 fish	0 fish
Flannelmouth Sucker*	0 fish	0 fish	1 fish; 135 mm; 1.2/hour
Flannelmouth/Bluehead Sucker Hybrid*	0 fish	0 fish	2 fish; 106-134 mm; 2.5/hour
Gizzard Shad	0 fish	0 fish	0 fish
Green Sunfish	11 fish; 96-177 mm; 14.7/hour	19 fish, 113-204 mm; 0.4/hour	36 fish; 48-172 mm; 44.3/hour
Largemouth Bass	14 fish; 60-144 mm; 18.7/hour	19 fish; 121-368 mm; 0.4/hour	2 fish; 142-143 mm; 2.5/hour
Rainbow Trout	1 fish; 230 mm; 1.3/hour	2 fish; 236 and 340 mm; <0.1/hour	0 fish
Red Shiner	0 fish	0 fish	80 fish; 42-75 mm; 98.5/hour
Roundtail Chub*	0 fish	0 fish	8 fish; 136-157 mm; 9.9/hour
Smallmouth Bass	0 fish	1 fish; 131 mm; <0.1/hour	0 fish
Speckled Dace*	0 fish	0 fish	4 fish; 61-115 mm; 4.9/hour
White Sucker / Hybrid Sucker	0 fish	1 fish; 209 mm; <0.1/hour	73 fish; 60-329 mm; 89.9/hour
Yellow Perch	2 fish; 175 and 223 mm; 2.7/hour	1 fish; 187 mm; <0.1/hour	0 fish
Total Number of Fish Collected	28	44	219

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Table 3. Total number of fish collected; total length size range in millimeters (mm); catch per unit effort (# of 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 **2020**. Native fish species identified by *.

Fish Species Collected	Site #1 (Electrofishing)	Site #1 (Gill Netting)	Site #2
Black Bullhead	0 fish	0 fish	2 fish; 214 and 237 mm; 3.9/hour
Bluehead Sucker*	0 fish	0 fish	0 fish
Bluegill	0 fish	0 fish	0 fish
Channel Catfish	1 fish; 543 mm; 1.4/hour	0 fish	0 fish
Common Carp	0 fish	0 fish	0 fish
Fathead Minnow	0 fish	0 fish	0 fish
Flannelmouth Sucker*	0 fish	0 fish	0 fish
Flannelmouth x Bluehead Sucker Hybrid*	0 fish	0 fish	0 fish
Gizzard Shad	0 fish	0 fish	0 fish
Green Sunfish	2 fish; 122 and 148 mm; 2.9/hour	26 fish, 114-222 mm; 1.3/hour	34 fish; 58-152 mm; 66.3/hour
Largemouth Bass	9 fish; 58-101 mm; 13.0/hour	3 fish; 253-360 mm; 0.2/hour	11 fish; 63-202 mm; 21.5/hour
Rainbow Trout	0 fish	2 fish; 330 and 421 mm; 0.1/hour	0 fish
Red Shiner	0 fish	0 fish	90 fish; 52-89 mm; 175.6/hour
Roundtail Chub*	0 fish	0 fish	0 fish
Smallmouth Bass	0 fish	0 fish	0 fish
Speckled Dace*	0 fish	0 fish	4 fish; 72-92 mm; 7.8/hour
White Sucker / Hybrid Sucker	1 fish; 156 mm; 1.4 fish/hour	0 fish	74 fish; 79-299 mm; 144.4/hour
Yellow Perch	0 fish	0 fish	0 fish
Total Number of Fish Collected	13	31	215

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Table 4. Total number of fish collected; total length size range in millimeters (mm); catch per unit effort (# of 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 **2019**. Native fish species identified by *. See previous years' Annual Reports for summaries of pre-2019 data.

Fish Species Collected	Site #1	Site #2
Black Bullhead	0 fish	0 fish
Bluehead Sucker*	0 fish	0 fish
Bluegill	0 fish	0 fish
Channel Catfish	0 fish	0 fish
Common Carp	1 fish; 493 mm; 1.4/hour	0 fish
Fathead Minnow	0 fish	2 fish; 54 and 79 mm; 3.9/hour
Flannelmouth Sucker*	0 fish	0 fish
Flannelmouth x Bluehead Sucker Hybrid*	0 fish	0 fish
Gizzard Shad	0 fish	0 fish
Green Sunfish	7 fish; 78-202 mm; 10.1/hour	15 fish; 41-144 mm; 29.4/hour
Largemouth Bass	9 fish; 91-161 mm; 13.0/hour	3 fish; 86-121 mm; 5.9/hour
Rainbow Trout	0 fish	0 fish
Red Shiner	0 fish	142 fish; 38-77 mm; 278.4/hour
Roundtail Chub*	0 fish	0 fish
Smallmouth Bass	0 fish	0 fish
Speckled Dace*	0 fish	1 fish; 76 mm; 2.0/hour
White Sucker / Hybrid Sucker	1 fish; 200 mm; 1.4/hour	49 fish; 77-239 mm; 96.1/hour
Yellow Perch	0 fish	0 fish
Total Number of Fish Collected	18	212

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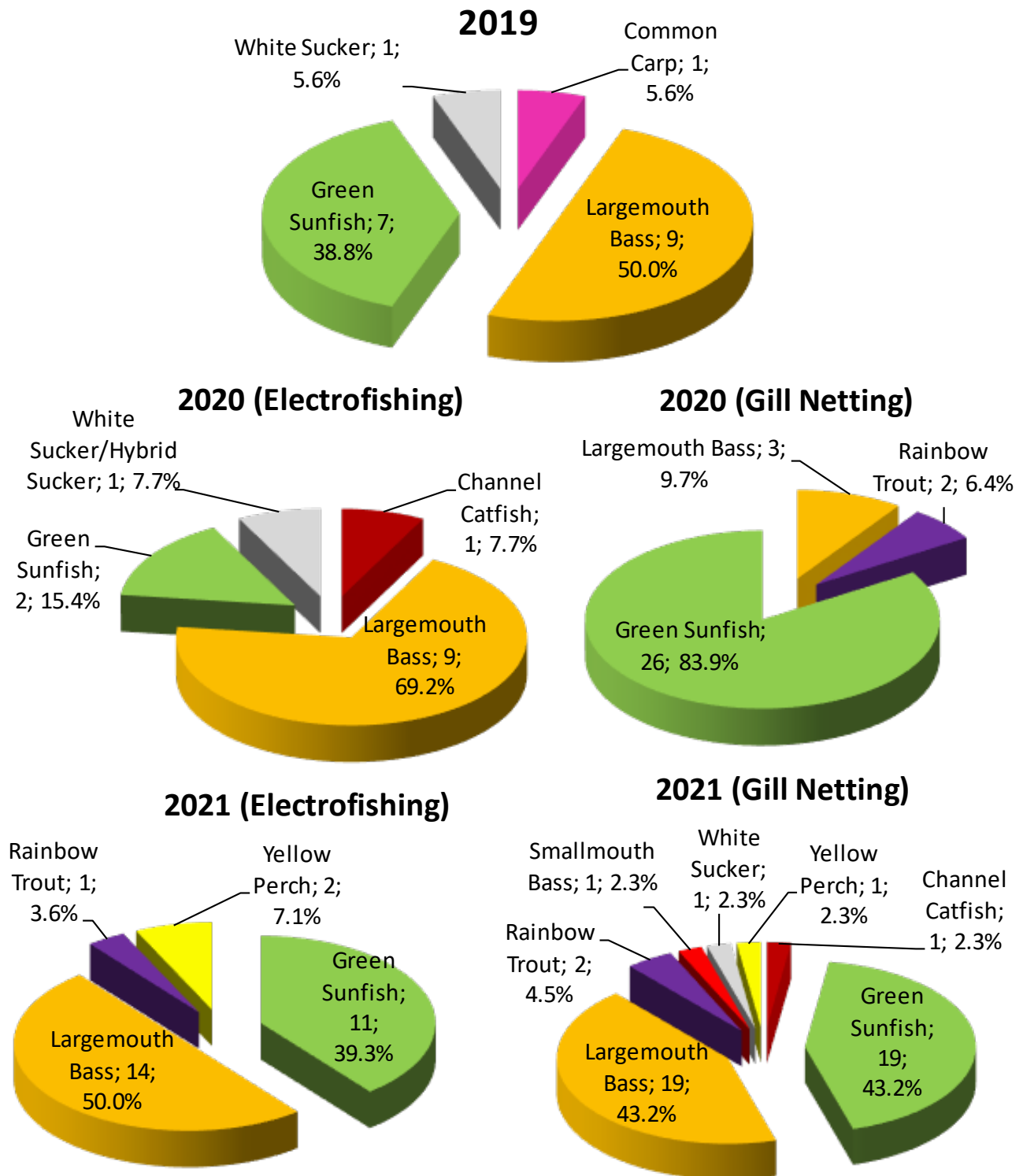


Figure 9. Species composition of fish surveyed (number of fish sampled and percentage of overall fish captured) in Mack Wash at Site #1 (immediately downstream of Highline Lake spillway) in 2019, 2020, and 2021. See previous years' Annual Reports for summaries of pre-2019 data. Figure totals may sum to +/- 0.1% of 100% due to rounding.

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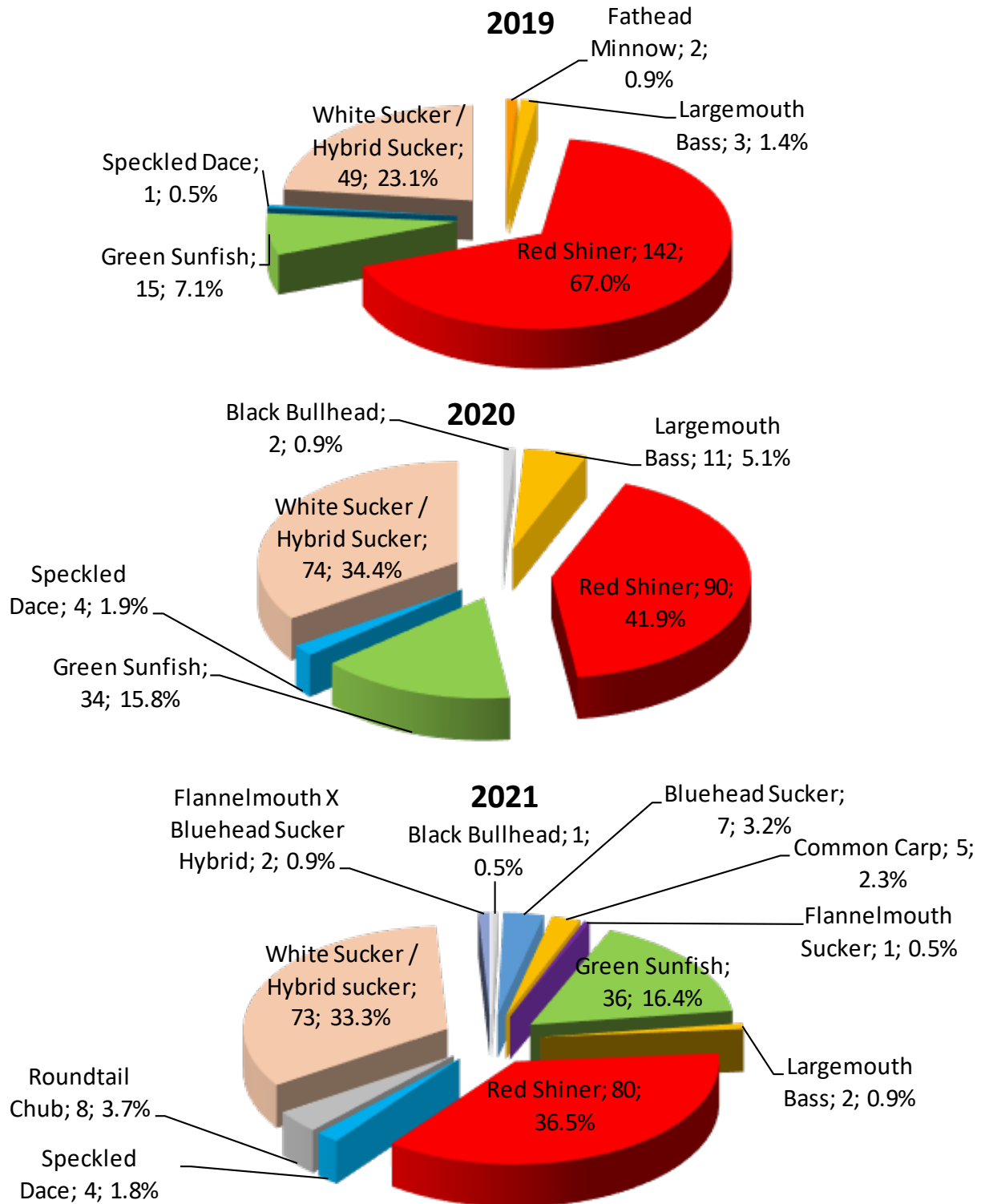


Figure 10. Species composition of fish surveyed (number of fish sampled and percentage of overall fish captured) in Mack Wash at Site #2 (approximately 3 miles downstream of Highline Lake spillway) in 2019, 2020, and 2021. See previous years' Annual Reports for summaries of pre-2019 data. Figure totals may sum to +/- 0.1% of 100% due to rounding.

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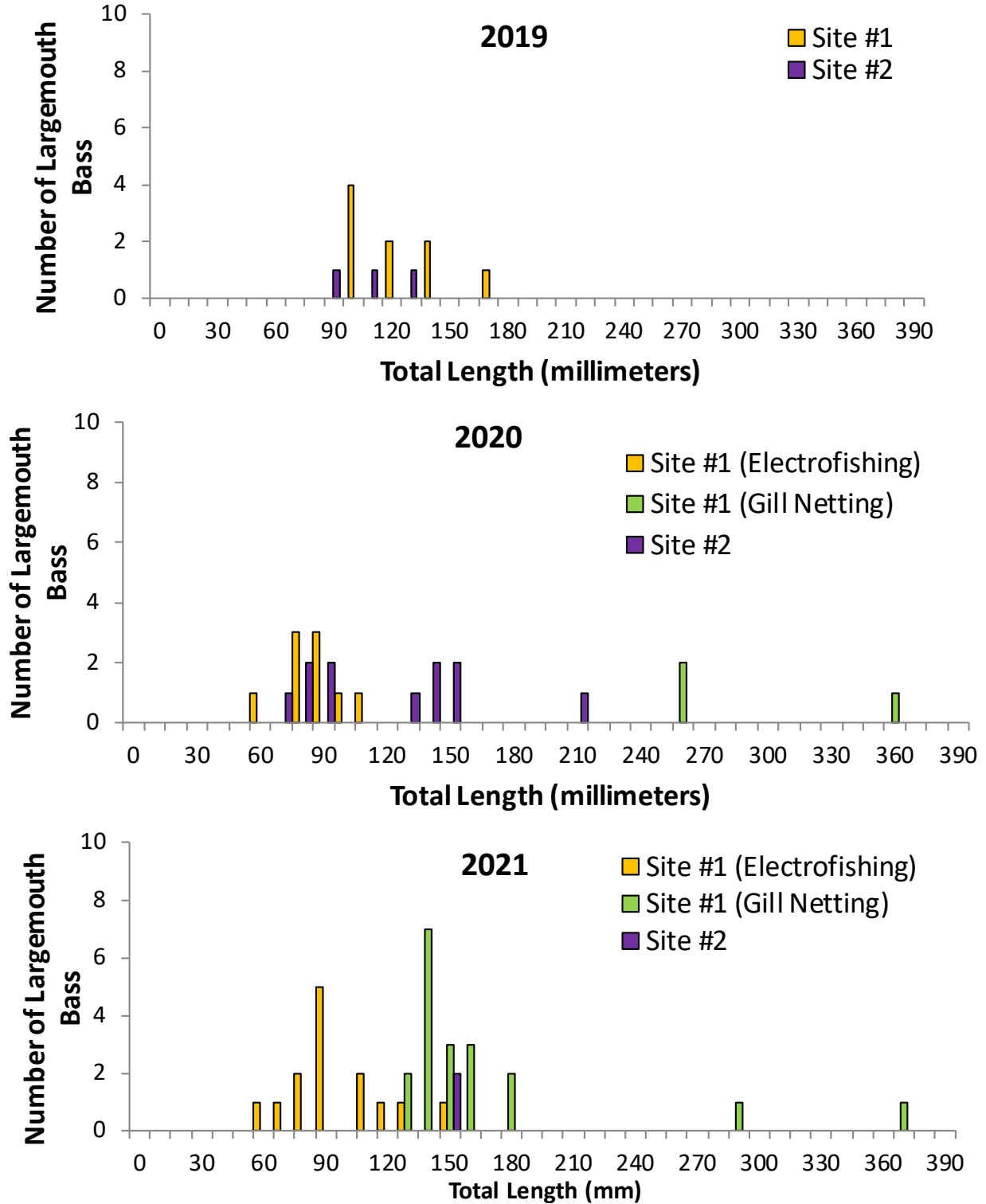


Figure 11. Length frequency histograms of largemouth bass surveyed in Mack Wash at Site #1 and Site #2 in 2019, 2020, and 2021. See previous years' Annual Reports for summaries of pre-2019 data.

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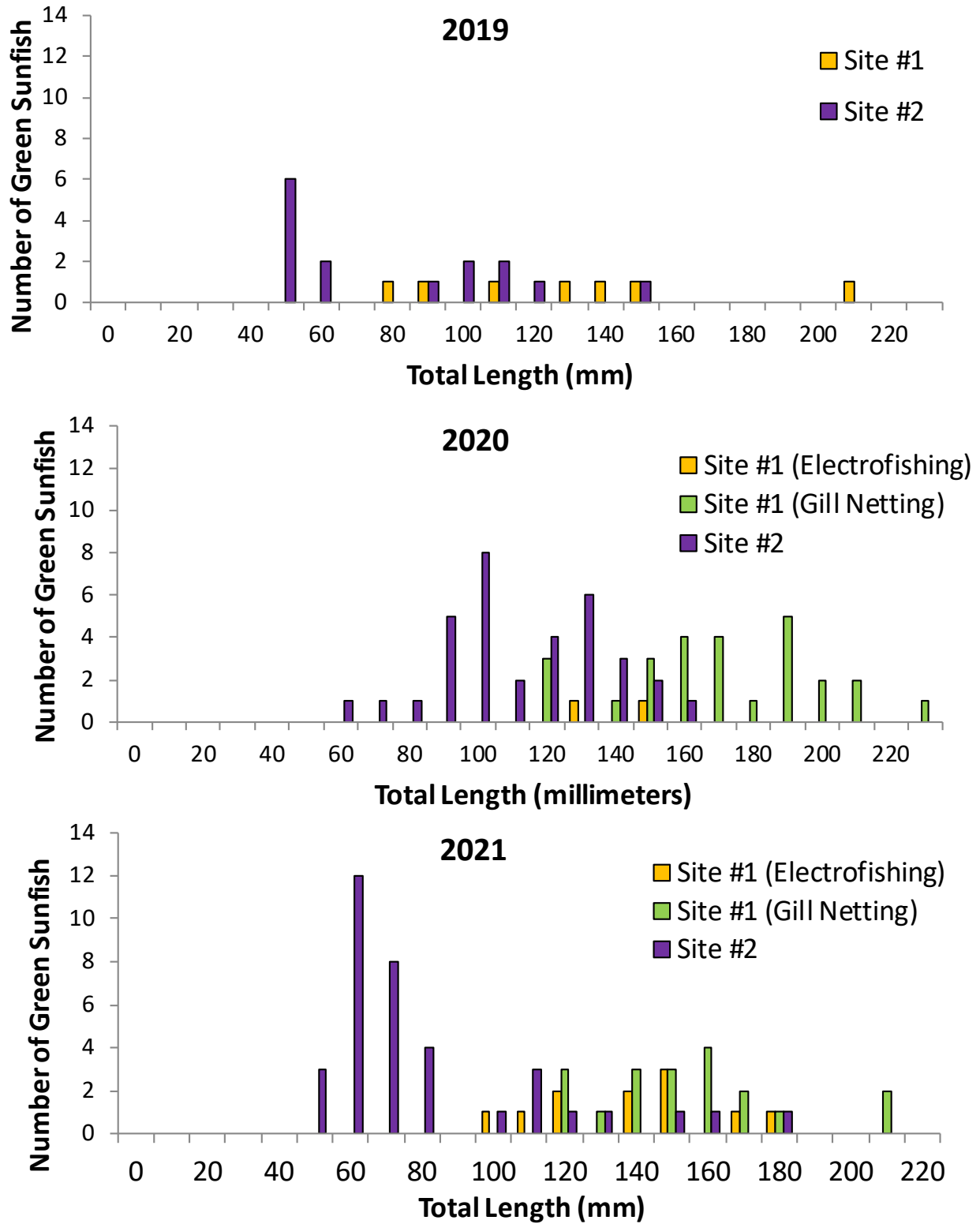


Figure 12. Length frequency histograms of green sunfish surveyed in Mack Wash at Site #1 and Site #2 in 2019, 2020, and 2021. See previous years' Annual Reports for summaries of pre-2019 data.

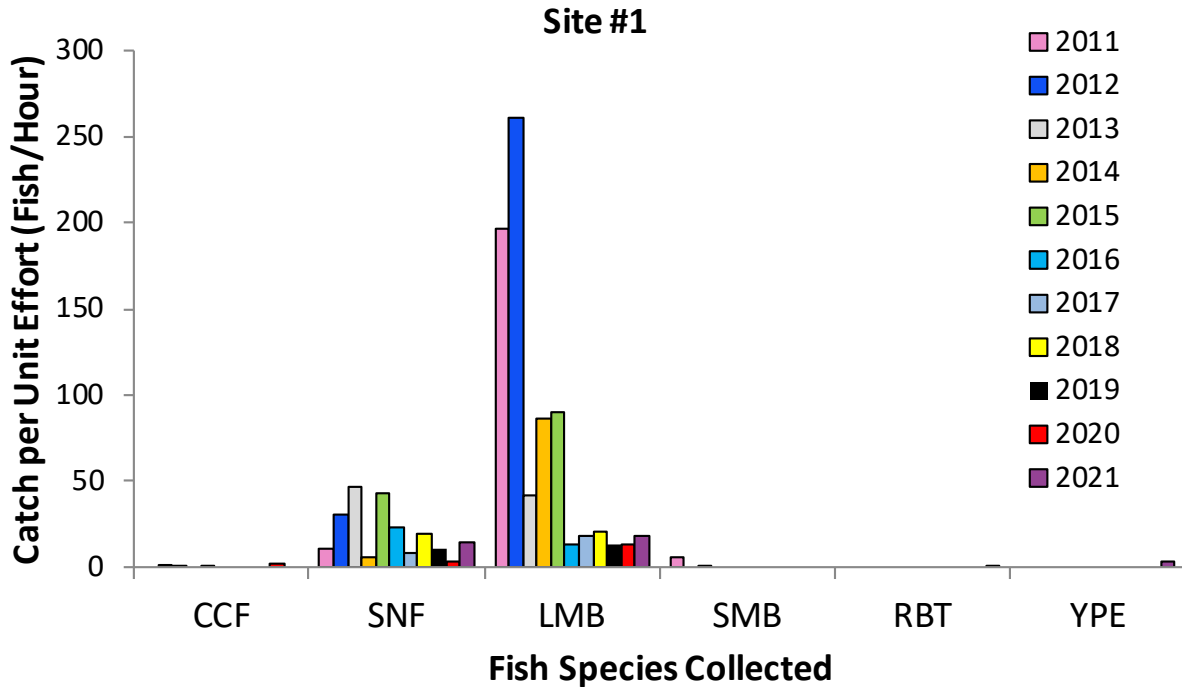


Figure 13. Historical electrofishing catch per unit effort (number of fish captured per hour) of channel catfish (CCF), green sunfish (SNF), largemouth bass (LMB), smallmouth bass (SMB), rainbow trout (RBT), and yellow perch (YPE) in Mack Wash at Site #1 from 2011-2021.

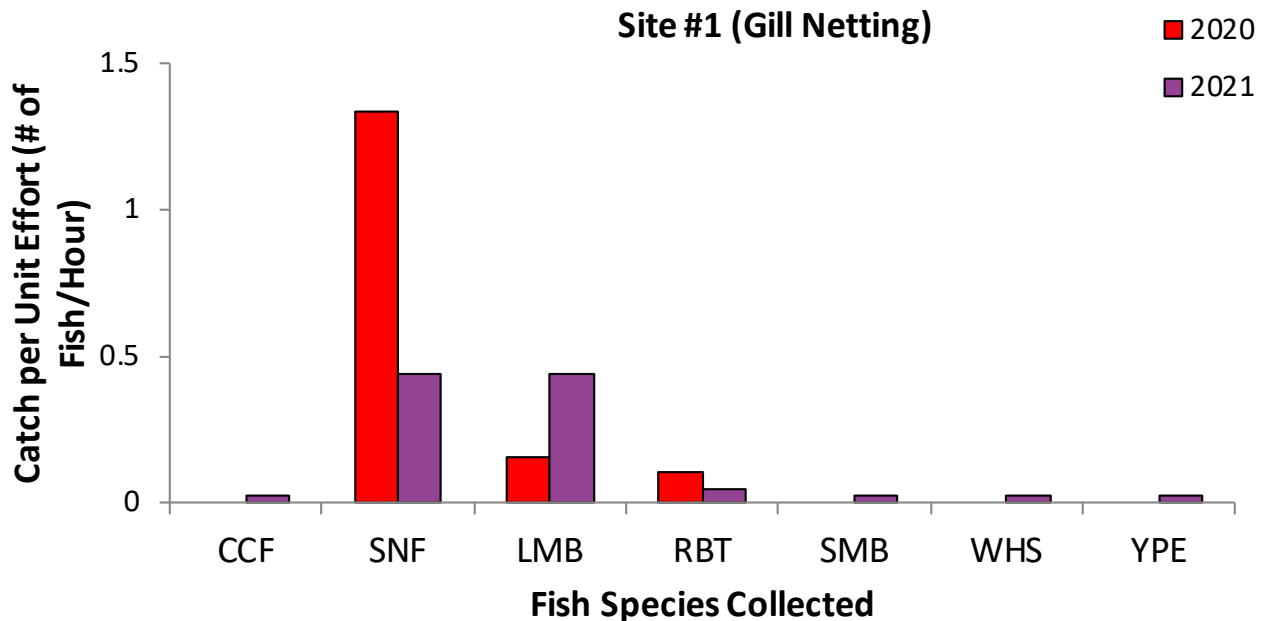


Figure 14. Gill netting catch per unit effort (number of fish captured per hour) of channel catfish (CCF), green sunfish (SNF), largemouth bass (LMB), rainbow trout (RBT), smallmouth bass (SMB), white sucker/hybrid sucker (WHS) and yellow perch (YPE) in Mack Wash at Site #1 in 2020 and 2021. Gill netting was first implemented in 2020.

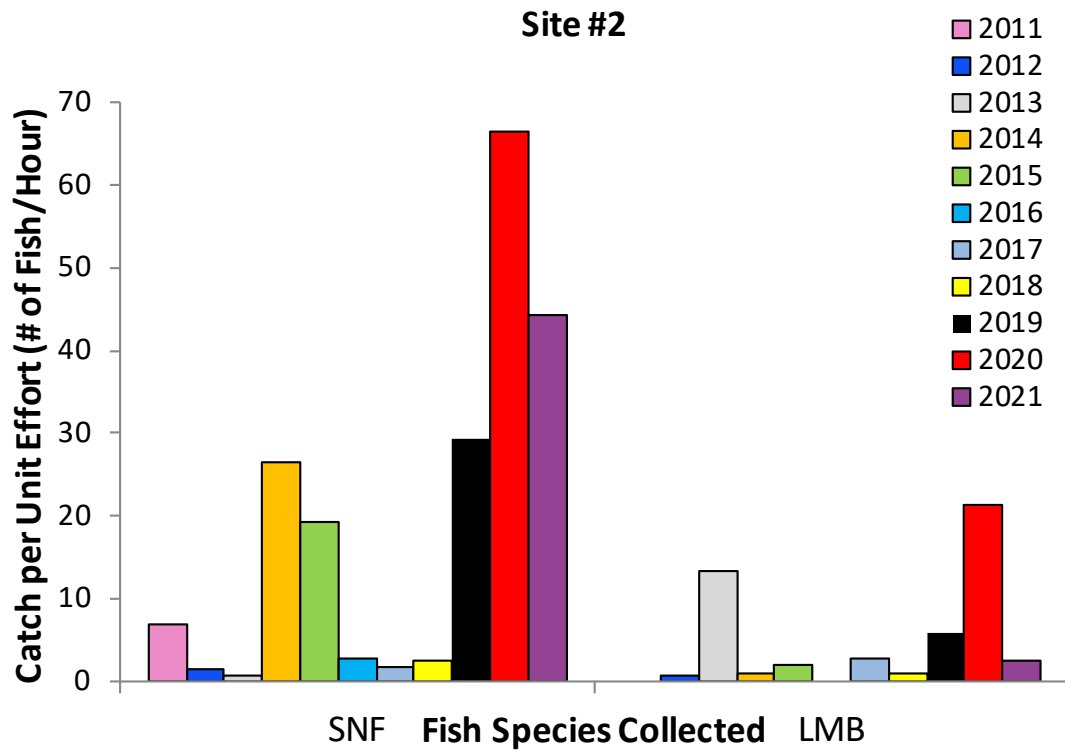


Figure 15. Historical electrofishing catch per unit effort (number of fish captured per hour) of green sunfish (SNF) and largemouth bass (LMB) in Mack Wash at Site #2 from 2011-2021.

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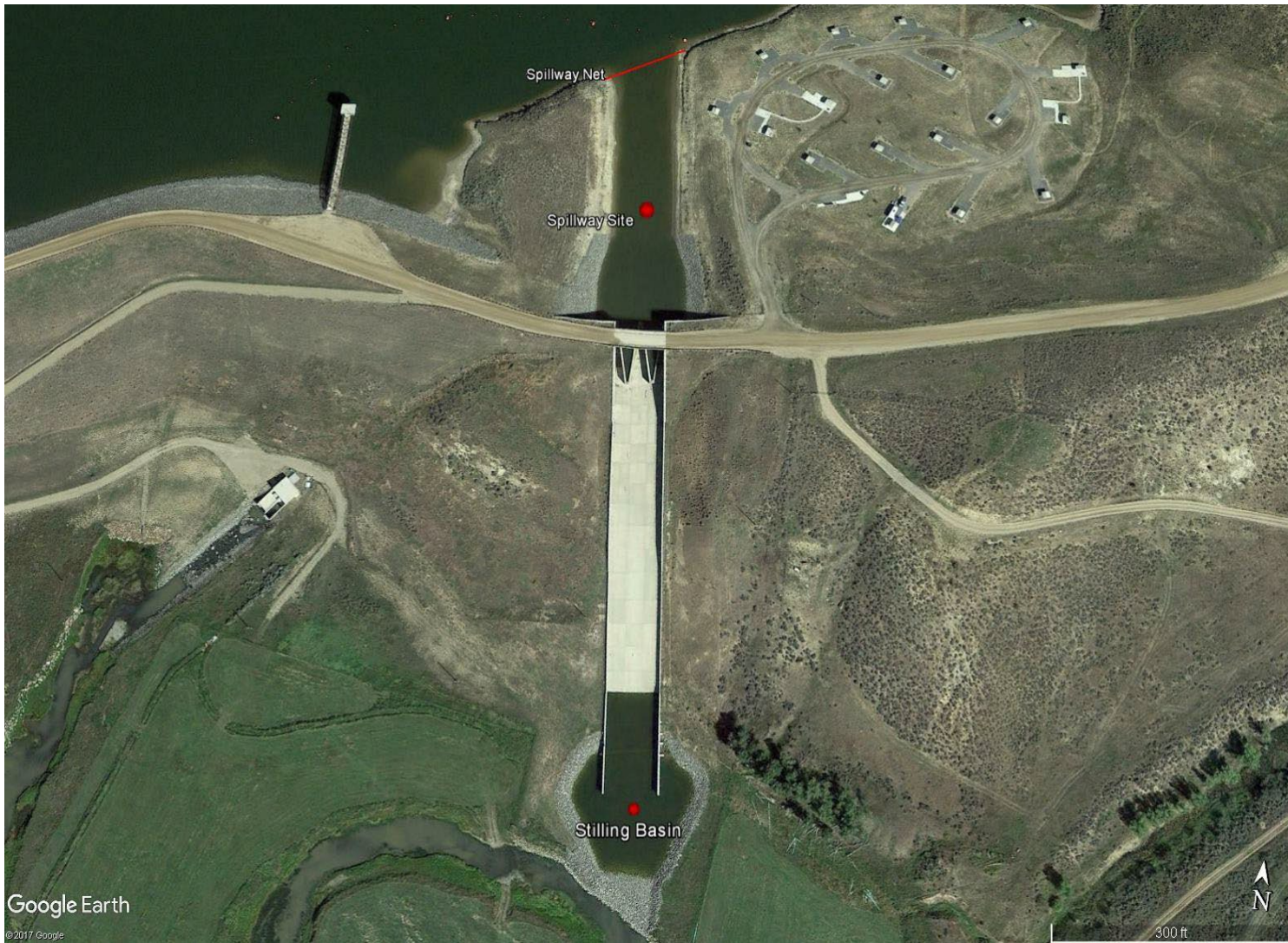


Figure 16. Satellite image of the Elkhead Reservoir spillway, fish sampling locations, and approximate location of the spillway net. Image courtesy of Google Earth.

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Table 5. Summary of fish collected (species composition, total number of fish collected, and total length size range in millimeters (mm)) pre-spill and post-spill at the spillway site and in the stilling basin of Elkhead Reservoir from 2017 to 2021. Fish captured by boat electrofishing in 2018 are included with fish captured by overnight gill net set. N/A=Not Applicable

Year	Species Collected	Pre Spill		Post Spill	
		Spillway Site	Stilling Basin	Spillway Site	Stilling Basin
2021	Black Crappie	0	0	0	0
-	Bluegill	0	0	0	0
	Largemouth Bass	1 fish (216 mm)	0	0	0
-	Northern Pike	1 fish (unmeasured)	0	1 fish (unmeasured)	0
-	Smallmouth Bass	2 fish (205-286 mm)	1 fish (254 mm)	2 fish (240 mm)	4 fish (286-344 mm)
-	White Sucker	0	42 fish (304-386 mm)	0	45 fish (301-366 mm)
2020	Black Crappie	N/A	N/A	1 fish (122 mm)	0
-	Bluegill	0	0	0	0
-	Largemouth Bass	N/A	N/A	0	0
-	Northern Pike	N/A	N/A	0	0
-	Smallmouth Bass	N/A	N/A	3 fish (257-266 mm)	0
-	White Sucker	N/A	N/A	0	12 fish (226-382 mm)
2019	Black Crappie	0	0	0	0
-	Bluegill	0	0	0	0
-	Largemouth Bass	0	0	0	0
-	Northern Pike	0	0	0	0
-	Smallmouth Bass	0	3 fish (258-324 mm)	0	0
-	White Sucker	0	0	0	28 fish (unmeasured)
2018	Black Crappie	0	0	2 fish (unmeasured)	0
-	Bluegill	0	0	8 fish (120-189 mm)	0
-	Largemouth Bass	0	0	4 fish (121-180 mm)	0
-	Northern Pike	0	0	0	0
-	Smallmouth Bass	0	3 fish (221-320 mm)	27 fish (96-257 mm)	6 fish (221-320 mm)
-	White Sucker	0	1 fish (unmeasured)	0	0
2017	Black Crappie	0	0	2 fish (106-209 mm)	0
-	Bluegill	0	2 fish (124-150 mm)	0	0
-	Largemouth Bass	0	0	1 fish (195 mm)	1 fish (191 mm)

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-	Northern Pike	1 fish (unmeasured)	0	0	0
-	Smallmouth Bass	0	2 fish (254-344 mm)	12 fish (168-294 mm)	0
-	White Sucker	0	16 fish (115-366 mm)	0	0

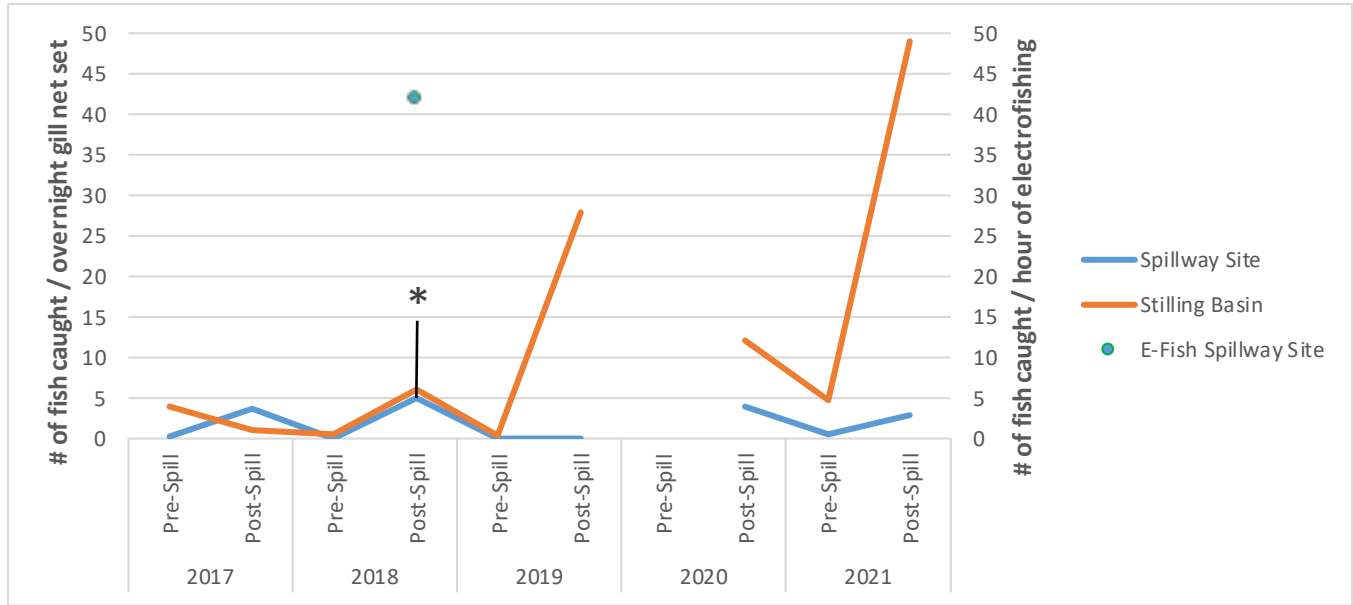


Figure 17. Historical catch per unit effort (number of fish captured per overnight gill net set and number of fish captured per hour of electrofishing) of individuals of all fish species combined (i.e. black crappie, bluegill, smallmouth bass, largemouth bass, and white sucker) in Elkhead Reservoir at the spillway site and in the stilling basin. * indicates a bias in 2018 post-spill catch rate at the spillway site because two methods of sampling were used where crews captured fish using boat electrofishing prior to setting gillnets. Pre-spill sampling did not occur in 2020 at both sites due to COVID-19 health concerns and agency guidelines.

Table 6. Summary of fish stocked by Colorado Parks and Wildlife into Highline Lake in 2021 (species, number of fish stocked, and length (inches)).

Species	Number of Fish Stocked	Length (Inches)
Bluegill	12,003	1.6
Channel Catfish	2,000	2.8
Channel Catfish	1,000	4.6
Largemouth Bass	92	18.4
Largemouth Bass	154,360	0.2
Largemouth Bass	5,105	1.5
Rainbow Trout	9,681	10.2 – 10.7

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Table 7. Summary of fish stocked into Elkhead Reservoir in 2020 (species, number of fish stocked, and length (inches)).

Species	Number of Fish Stocked	Length (Inches)
Bluegill	30,821	1.8
Largemouth Bass	109	18.4

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ANNUAL PERFORMANCE PROGRESS REPORT (PPR)

BUREAU OF RECLAMATION AGREEMENT NUMBER: No agreement currently in place.

UPPER COLORADO RIVER RECOVERY PROGRAM PROJECT NUMBER: C-20

Project Title:

Operation, maintenance, and evaluation of fish escapement barriers in Colorado (Highline Lake and Elkhead Reservoir)

Bureau of Reclamation Agreement Number:

No agreement currently in place. Previous agreement number was R12AP40001.

Project/Grant Period:

Start date: 09/22/2017

End date: 09/30/2022

Reporting period end date: 09/30/2021

Is this the final report? Yes _____ No X

Performance:

This project includes the operation, maintenance, and evaluation of the Highline Lake and Elkhead Reservoir spillway nets, designed to control escapement of non-native, warmwater fishes. Overall, both spillway nets appear to be in good shape and performing as designed. As of December 2021, Colorado Parks and Wildlife (CPW) is in the process of procuring a new spillway net for Highline Lake, and is anticipating installing the new spillway net in the spring of 2022. The Elkhead Reservoir spillway net has no anticipated near-time replacement timeline. Operation and maintenance of both spillway nets were fully performed in 2021, including five underwater cleanings/inspections at Highline Lake and four at Elkhead Reservoir. The Highline Lake spillway net was partially submerged on several occasions in 2021 by high canal inflows or “surges”; the most notable event was in early November when the canal inflow occurred for approximately six days longer than usual. This extended canal surge resulted in increased catch rates of fish between the spillway net and the spillway during the fall survey and also increased catch rates in Mack Wash downstream of Highline Lake. Crews conducted a spring (pre-spill) and fall (post-spill) survey on Highline Lake between the spillway net and the spillway and also conducted surveys in Mack Wash at two sites downstream of Highline Lake. Crews also sampled Elkhead Reservoir, between the spillway net and the spillway, and in the stilling basin. Elkhead Reservoir fish sampling occurred across 10 days in the spring and fall of 2021.