ABUNDANCE ESTIMATION FOLLOWING INCREASED REMOVAL VERIFIES DECLINING TREND OF NORTHERN PIKE IN THE YAMPA RIVER, COLORADO

by

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Abundance estimation following increased removal verifies declining trends of northern pike in the Yampa River, Colorado

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Executive Summary

Widespread removal of northern pike *Esox lucius* in the Yampa River, northwestern Colorado, was conducted since 2004, with a goal to reduce the predatory threat of this invasive species and enhance recovery of native and endangered fishes including Colorado pikeminnow *Ptychocheilus lucius*. Analyses of northern pike capture-recapture data from 2004-2010 indicated substantial annual removal of northern pike, but populations were replenished each year via local recruitment and immigration from other reaches. Recommendations to increase removal effectiveness included increased focus on source populations, especially prior to spawning. Beginning in 2014, gill nets were used by Colorado Parks and Wildlife personnel in early spring in nearshore backwaters where northern pike spawning occurred, in addition to boat electrofishing in the main channel. Based on declining capture rates of northern pike through 2018, the addition of gill-net removals appeared effective, but verification of that trend with a more robust capture-tag-recapture technique was needed. To accomplish this, U. S. Fish and Wildlife Service crews used boat electrofishing to capture and tag 84 northern pike in the Hayden-Craig river reach before backwater netting began in April 2019. This reach was chosen because it formerly supported the largest population of northern pike in the Yampa River and was the focal area of backwater netting efforts. In-river boat electrofishing and gill netting subsequently captured 251 northern pike, of which 23 had tags. Abundance estimates showed 917 northern pike occurred in the reach prior to sampling in 2019, a large reduction compared to estimates from 2004-2010, when as many as 4,000 pike formerly existed. The 2019 abundance estimate was consistent with a low capture rate of northern pike in the reach and indicated that declining abundance trends postulated after 2014 were legitimate. Ongoing northern pike management in the Yampa River upstream of the study area may also contribute to downstream declines. These results support continued use of both boat electrofishing and backwater netting as effective northern pike removal techniques. Conducting additional abundance estimation in 2020, in the Hayden-Craig reach or others, was discussed and determined unnecessary given convincing evidence of removal efficacy and other demands on resources. Continued or expanded removal effort in other northern pike production areas is recommended to further reduce populations and facilitate recovery of native and endangered fishes.

Key words: removal, invasive species, native and endangered fishes, gill-netting, electrofishing, PIT tags, management

LIST OF FIGURES

Introduction

Management of invasive species dictates that the best available information be used to monitor trends in abundance. Abundance estimates and other vital rates of invasive northern pike *Esox lucius* in the Yampa River were estimated from 2004–2010, and Zelasko et al. (2015; 2016) concluded that annual northern pike abundance was suppressed by removal efforts. However, short-term positive effects were negated by recruitment and immigration, which were nearly always sufficient to increase abundance to pre-treatment levels by the next removal effort. Thus, they recommended increasing removal efforts with an emphasis on disrupting or preventing spawning in source areas, to reduce reproduction, immigration, and recruitment. Further, they recommended tagging northern pike if evaluation of control efforts is warranted, including in areas upstream of critical habitat for endangered Colorado pikeminnow *Ptychocheilus lucius*.

Since 2014, backwater gill netting in Yampa River reaches upstream of critical habitat (upstream of Craig, CO, mainly study reach 98b) has been adopted as an efficient method to reduce northern pike abundance (Battige 2014). That work focuses on side channel backwaters that northern pike can access before or immediately after river ice melts and runoff begins, and offers the dual benefit of not only reducing adult pike abundance, but also negating their reproduction in that year, if fish are captured prior to spawning. Recent data from both standardized electrofishing sampling and backwater netting (Recovery program annual reports for projects 98a and 98b; https://coloradoriverrecovery.org/documents-publications/work-plan-documents/project-annual-reports.html) indicated a steady and substantial decline in the number of northern pike being removed in reaches from Hayden, CO, downstream. For example, Figure 10 (reproduced in Results and Discussion section) from Eyre (2018) shows a recent, nearly 10-fold reduction in Yampa River pike catch-per-unit-effort based on electrofishing from 2004–2018.

Because investigators had not tagged northern pike since 2012, an estimate of abundance based on tag-recapture data has not been possible. Colorado Parks and Wildlife and the Recovery Program convened a group of Yampa River investigators to consider the need for, and feasibility of, conducting a northern pike abundance estimate in the Yampa River for 2019. There were several reasons for this recommendation:

1) An abundance estimate for northern pike is desirable to provide a more robust evaluation than catch-effort data of whether backwater netting paired with river wide removal is an effective method to reduce pike populations. This study may also be able to determine the relative contribution of the two gear types to removal.
2) It has been several years since any northern pike abundance estimate has been conducted in reaches where Zelasko et al. (2016) estimated abundances, and even longer since the robust estimates using the Recovery Program database have been completed.
3) Crews had flexibility to carry out additional required field sampling because other large-scale projects (Colorado pikeminnow abundance estimation) were not being conducted.

There might also be more effort available for removing northern pike that have been tagged and subsequently released as part of the abundance estimation effort.

4) Conducting this work in 2019 gives an opportunity to revise methods and repeat the work in 2020, if field conditions or other factors reduce the efficacy of the 2019 effort.

During the initial discussions to determine whether new northern pike estimates were warranted, the feasibility of carrying out this work was considered. Given the generally low numbers of pike caught in various reaches, particularly in a single pass, a main concern was tagging enough fish to have recaptures sufficient to achieve abundance estimates that were unbiased, relatively precise, and useful for making management decisions. Note that this is a good problem to have, because it appears that removal efforts are having the intended effect. However, this is an issue relative to the estimation process and is especially valid if electrofishing passes to tag fish could only begin after backwater netting commenced, which would reduce the number of fish available for tagging. Discussions also centered around which reach(es) of river would be the focus and whether to coordinate marking among different sections of river.

After weighing several options and discussing the advantages and challenges of each, the group came to a compromise proposal—conduct an abundance estimate of northern pike only in the Hayden-Craig reach used in Zelasko et al. (2015; 2016). Of the river reaches where northern pike removal is ongoing, this reach consistently has the highest number of pike, which increased the likelihood that enough fish could be tagged for the estimate. This reach also had the advantage of having more intensive backwater netting effort, which the group felt would maximize the potential for recaptures. Limiting this project to a single reach was a way to attempt abundance estimates at a smaller scale with the highest potential for success, while also attempting to maintain low pike abundance in downstream critical habitat. The group agreed that if estimates could not be performed with the historically large numbers of tagged and recaptured fish in this reach, it was likely not feasible at a larger scale across multiple reaches.

Study design

This study was a joint effort between USFWS, CPW, and CSU-LFL. USFWS conducted the tag and release portion of the study in mid-April, when discharge in the Yampa River at Craig was suitable for sampling; river flows during the pike marking pass (8–11 April) were 2,240–3,090 ft^3/sec (mean = 2,660 ft^3/sec; U. S. Geological Survey gage 09247600; Figure 1). Colorado Parks and Wildlife commenced backwater netting effort nearly immediately after tagging was completed (13 April), in a manner consistent with past years, and in parallel with river removal efforts conducted in the 98b study, even though backwater netting includes the subject Hayden-Craig reach as well as downstream areas. The backwater netting and in-river electrofishing provided removal of northern pike as has occurred in the past, as well as the recapture data needed for abundance estimation. CSU received the data for conducting the estimate in mid-December 2019, organized it, and completed the estimates and summary in January 2020 (this report).

The USFWS marked northern pike using Floy and PIT tags. PIT tags were inserted into northern pike cheeks to allow researchers to determine if carcasses in gill nets partially consumed by river otters were previously marked. Northern pike tagging occurred in the main channel and off-channel backwaters and sloughs to account for pike residing in all habitat types within the reach. Pike were processed for data collection and released at the site of capture, i.e. within the backwater or pool where they were collected. This methodology assisted with determining specific sites where northern pike were found and to what extent movement was occurring between sites believed to represent optimal habitat.

USFWS crews completed four additional sampling passes of reach-wide removal as outlined in Project 98b (17–19 April; 22–24 April; 25–30 April; 1–3 May). One additional removal pass was completed after that (29–31 May) which was not used in estimation, because it was evident population closure did not persist over that time duration. Pike tagging and removal passes occurred mainly during rising flows in late April and early May; late April flows peaked at slightly over 7,000 ft^3/sec (Figure 1). Backwater netting in the Hayden-Craig reach occurred from 13 April–10 May; backwater netting did not non-overlap with electrofishing effort in later May which further justified exclusion of the last electrofishing pass. Backwater netting commenced later in 2019 than 2018, because of cold weather and ice conditions, but began mostly before reproduction began; only 6% of female pike captured were spent while 27% and 62% were ripe or not yet in reproductive condition, respectively (Eyre 2019). Reproductive condition of the remaining 5% of northern pike was not assessed.

Data organization was straightforward; only a single marking pass and several removal passes were conducted, mostly similar to that in Zelasko et al. (2015; 2016). Sampling passes conducted in project 98b had discrete dates associated with them, while backwater netting was more continuous. Thus, backwater-netting events were assigned to the 98b time intervals accordingly. Movements of northern pike into and out of the reach based on recaptures of tagged fish were noted and used to discuss assumptions of study area closure. We incorporated data with that presented in Zelasko et al. (2015; 2016) to determine patterns in abundance and possible changes due to pike removal, including backwater gill netting and in-river removal.

Roles:

USFWS: tagged northern pike as early as possible in the first two weeks of April; conducted follow-up electrofishing removal in weeks after the tagging pass

CPW: conducted netting in 98b reach following tagging pass

CSU: wrote project proposal and analyzed combined netting and electrofishing data to generate an abundance estimate for the 98b reach that can be compared to previous work by Zelasko et al. (2016)

Objectives:

1. Obtain a pre-removal abundance estimate of northern pike in the Hayden-Craig reach of the Yampa River, 2019.

2. Compare current estimates to those of Zelasko et al. (2015; 2016) to assess trends in pike abundance and determine if in-river removal supplemented with backwater netting has reduced population abundance.
3. Discuss the need for additional abundance estimation in Hayden-Craig reach and others.

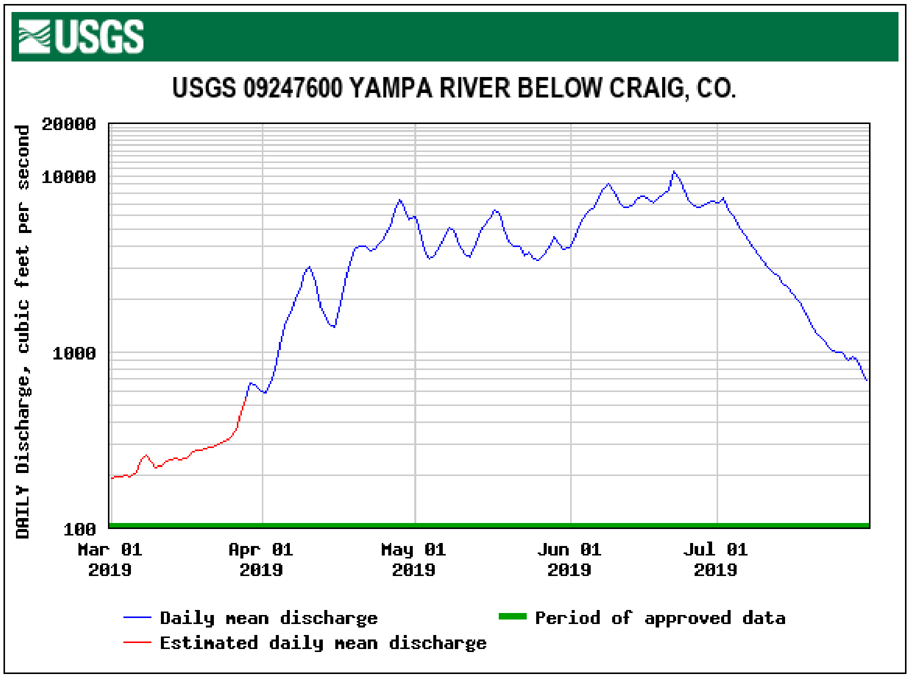

Figure 1. Hydrograph of the Yampa River, spring and early summer 2019.

Results and Discussion

We grouped results into analyses conducted prior to 2019 sampling in the Yampa River and the actual 2019 sampling effort. The work prior to sampling was completed to investigate trends and determine if patterns supported conducting an abundance estimate.

Pre-estimate analyses.—Data presented by Eyre (2018, reproduced below) indicated a declining trend in catch-effort data for northern pike in the Yampa River over the period 2004–2018. Abundance reductions were most evident after backwater gill netting began in spring 2014 by Colorado Parks and Wildlife (Battige 2014). We used numbers of fish removed by electrofishing from 2004–2018 and gill net captures from 2014–2018 to demonstrate declining trends in those data (Figure 2). For example, the number of pike captured in removal sampling with relatively consistent methods declined from just over 1,200 in 2004 and 2005 to 119 and 171 in 2017 and 2018, respectively. The major change in management in that period was intensive backwater gill-netting, which may be responsible, in combination with in-river electrofishing removal and other removal efforts elsewhere, for overall declines in Yampa River northern pike abundance. Those capture numbers also declined over the period 2014–2018.

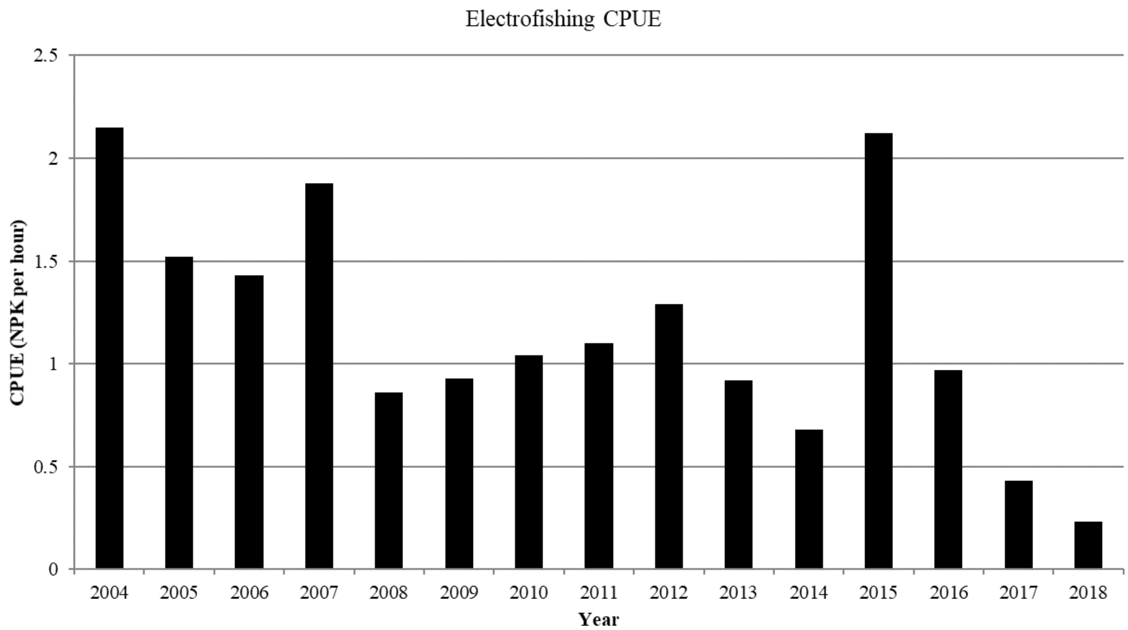

Figure 10 from Eyre (2018).

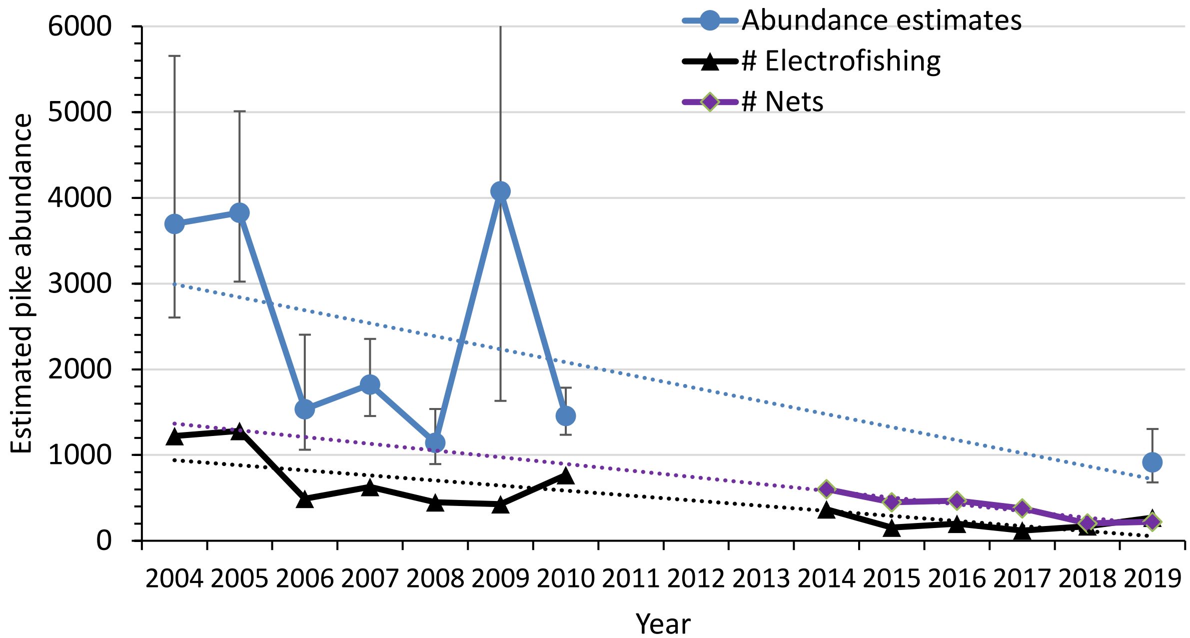

Figure 2. Abundance estimates (blue line with round symbols) and numbers of northern pike captured with electrofishing (black line with triangles) and gill nets (purple line with diamonds) in the Hayden-Craig reach (river mile [RM] 171.6–134.2) of the Yampa River, 2004–2019. Numbers in gillnets included samples just downstream of Hayden-Craig, but could not be separated. Abundance estimates for 2004–2010 were from mark-recapture-removal sampling by electrofishing (Zelasko et al. 2015; 2016). Error bars denote 95% confidence intervals; the upper confidence limit for the 2009 estimate is 7,444.

While the trends in catch rates were positive for managers interested in reducing negative effects of northern pike in the Yampa River, it was important to remember that capture probabilities were known to vary over reaches and time (Zelasko et al. 2015; 2016). Thus, it was important to validate the downward trends in numbers of fish captured with an abundance estimate in 2019 based on capture probabilities using contemporary tag and recapture data. Such information could also be used to determine if catch-effort statistics generally followed patterns of estimated northern pike abundance in the Yampa River, which may be useful for future monitoring.

Northern pike abundance estimation 2019.—A total of 84 northern pike were marked and released in the study area in mid-April during sampling pass 1, 251 were captured in subsequent netting (n = 84) and electrofishing (n = 167) in sampling passes 2–5, and of those, 23 were tagged fish marked in 2019 (13 captured with nets, 10 with electrofishing). The size distribution of tagged and recaptured fish indicated smaller fish were either unavailable for capture, were harder to capture, or both, during recapture passes 2–5, because no tagged fish ≤ 375 mm TL (smallest pike captured was 390 mm TL) were encountered after the marking pass (Figure 3). Sixteen of 84 (19%) marked northern pike captured in sampling pass 1 were ≤375 mm TL. No fish in that smaller size group (tagged or not) were encountered in backwater netting, likely because they were immature and not reproducing in backwaters, were avoiding presence of or consumed by large, potentially cannibalistic adults, or because of other unknown factors. Thirty-four untagged northern pike ≤375 mm TL were captured during electrofishing removal passes 2–5 (20% of the total, nearly identical to the 19% of fish in that size range in the marking sample). Although some electrofishing occurred in backwaters during recapture passes, gill nets set in backwater habitat may not a suitable method to detect smaller pike. Thus, the combination of electrofishing and netting gears is best to obtain a less biased sample of the size distribution of northern pike in the Yampa River.

Four capture-tag-recapture models were fit in program MARK, including time varying (M_t), behavior (M_b), and null (M_o) models such as those in program CAPTURE. M_t, where capture probabilities vary over sampling passes, had 96% of the total weight when only those three CAPTURE models were fit and is the only one interpreted here. Estimated pike abundance from M_t was 917 (SE = 155, 95% CI = 681–1,304).

We then added a model with TL as a continuous covariate, having noted that marked smaller pike were absent from the recapture sample. Those results indicated a relatively strong and positive length effect on capture (Figure 4), and that model had essentially all of the model weight in the set of four. The absence of recaptured pike ≤375 mm TL, and the low resultant capture probability for small fish, inflated the abundance estimate to 1,298 (SE = 372, 95% CI 794–2,330). Because of the relatively large SE and broad confidence intervals of the length-dependent model, we place more credence in the smaller model M_t estimate. The 2019 M_t estimate is the lowest to date recorded for that reach (Figure 2). Even the higher length-dependent abundance estimate indicated that numbers of northern pike in Hayden-Craig reach are considerably lower than estimates from 2004, 2005, or even 2014.

The relatively short, 1-month-long period over which northern pike marking and recapture occurred ensured some degree of closure in the study area, a key assumption when conducting closed population abundance estimates. We did find two pike moved into the Hayden-Craig reach from the upstream Steamboat reach that had been tagged just a few weeks earlier (Project 125). Only one fish tagged in our study area moved downstream into an adjacent reach (RM 123) and was encountered in the interval consistent with pass 5, relatively late in our study period. Our sampling also ended before the highest and long-sustained May and June flows occurred in the Yampa River in 2019, which likely reduced fish movement. Thus, we feel that population closure was assured to a reasonable degree.

The 2019 estimate demonstrated that the downward trend in northern pike abundance estimates beginning in 2015, based on number of fish captured and catch-effort statistics, was a legitimate trend. This pattern supported continued use of both boat electrofishing and backwater gillnetting as effective northern pike removal techniques. This was especially true in

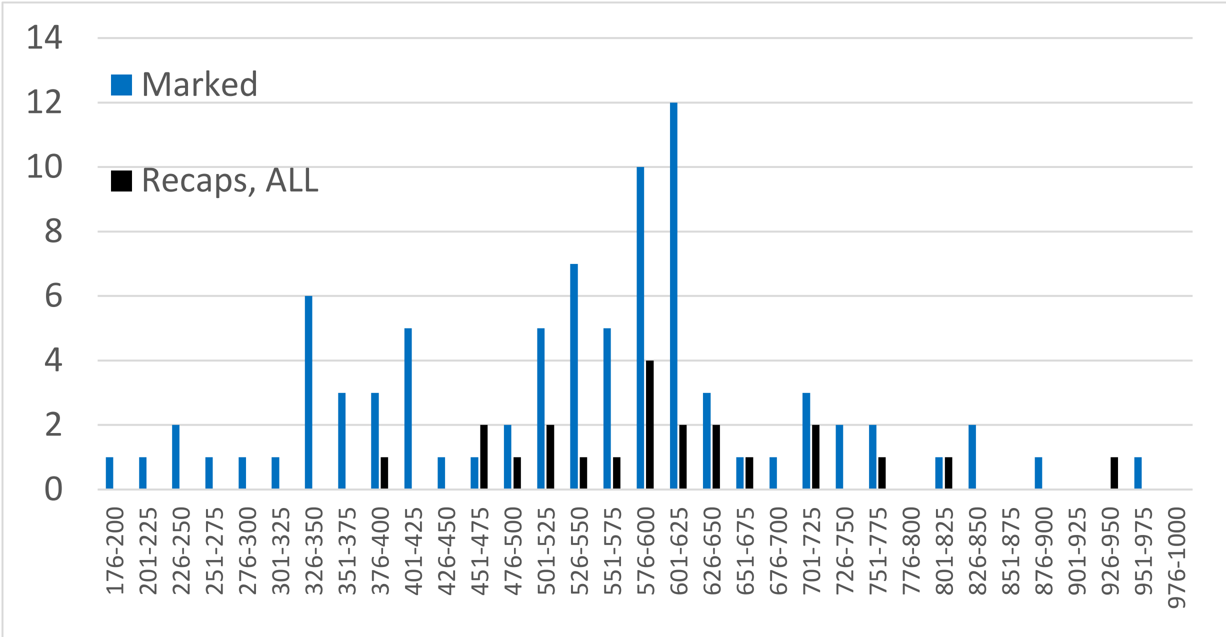

Figure 3. Length-frequency distribution of marked and recaptured northern pike in the Hayden-Craig reach (river mile [RM] 171.6–134.2) of the Yampa River, spring 2019.

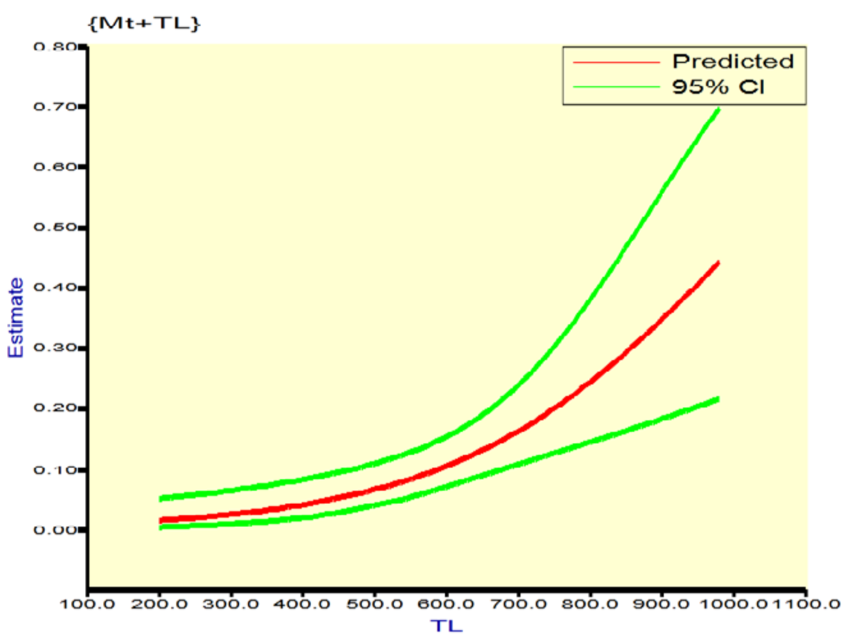

Figure 4. Length-dependent probability of capture for northern pike in the Hayden-Craig reach (river mile [RM] 171.6–134.2) of the Yampa River, spring 2019, where the predicted inner line is surrounded by the 95% confidence limits.

a year such as 2019, when even though gillnetting removed far fewer northern pike than electrofishing in this reach, those pike were captured mainly prior to spawning and so eliminated their reproductive contribution to the river. Another potential reason for declining trends is ongoing northern pike management in the Yampa River upstream of the study area, including removals from in-river and reservoir populations, as well as habitat manipulations designed to reduce pike access to spawning habitat. Apparently though, northern pike had a relatively successful year of reproduction in the Yampa River downstream of the Hayden-Craig reach, based on the large number of juvenile (< 300 mm TL) pike captured in summer removal sampling. This was especially true in the South Beach, Little Yampa Canyon, Juniper and upper Maybell reaches (Eyre 2019, Figures 7 and 8), when summer 2019 juvenile northern pike abundance was substantially higher than in 2017 or 2018. High reproduction or dispersal from upstream reaches in 2019 was likely aided by an extended runoff and late June peak (Figure 1).

The decision to continue a tag-recapture sampling program should be based on the need for such information. The 2019 estimate was based on relatively large numbers of marked and recaptured northern pike, which resulted in relatively small confidence intervals. Minimally, this abundance estimate was congruent with a continued declining trend in capture numbers for electrofishing in the reach, indicating consistency for the metrics. Thus, from a reliability standpoint, the need to complete another abundance estimate in the Hayden-Craig reach in 2020 was relatively low.

Statements regarding 2019 estimate reliability must be balanced with the knowledge that it was for only one year and in one reach. Further, there is evidence from 2019 sampling that indicated high reproduction and survival of age-0 northern pike in downstream reaches. Addition of a successful year class of fish will influence population dynamics and increase uncertainty regarding pike abundances everywhere in the river, including the Hayden-Craig reach. It should also be noted that the 60 total marked fish never recaptured during this and other Yampa River northern pike removal studies in 2019 constituted only 19% of the total captured and removed in the Hayden-Craig reach, and a much smaller proportion of the total removed from the river in 2019. Several other recommendations in support of the 2019 abundance estimation effort (see Introduction) still hold and are considerations when deciding whether to conduct additional abundance estimation for northern pike in the Yampa River in 2020 or other years.

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Reclamation and Colorado State University, the Department of Fish, Wildlife, and Conservation Biology, and the Larval Fish Laboratory (LFL). K. McAbee assisted with coordination and reviewed the draft report. Several other biologists (J. Hawkins) contributed pike capture data in 2019, and throughout the history of pike removal sampling, and their efforts under sometimes challenging conditions are appreciated. K. Battige, Colorado Parks and Wildlife, first used the backwater gill-netting technique in Yampa River backwaters.

References

Battige, K. 2014. Middle Yampa River northern pike removal and evaluation; smallmouth bass removal and evaluation. Annual report to the Upper Colorado River Endangered Fish Recovery Program. https://coloradoriverrecovery.org/documents-publications/work-plan-documents/arpts/2014/nna/98a.pdf

Eyre, T. 2018. Middle Yampa River northern pike removal and evaluation. Annual Report to the Upper Colorado River Endangered Fish Recovery Program.

Eyre, T. 2019. Middle Yampa River nonnative fish management. Project 98a. Annual Report to the Upper Colorado River Endangered Fish Recovery Program. https://coloradoriverrecovery.org/documents-publications/work-plan-documents/arpts/2019/nna/98a_FY19AR_YampaPikeCPW_Final.pdf

Zelasko, K. A., K. R. Bestgen, J. A. Hawkins, G. C. White. 2015. Abundance and population dynamics of invasive Northern Pike, Yampa River, Colorado, 2004–2010. Final report to the Upper Colorado River Endangered Fish Recovery Program, Project 161b, Denver, Colorado. Larval Fish Laboratory Contribution 185.

Zelasko, K. A., K. R. Bestgen, J. A. Hawkins, G. C. White. 2016. Evaluation of a long-term predator removal program: abundance and population dynamics of invasive northern pike *Esox lucius*, Yampa River, Colorado. Transactions of the American Fisheries Society 145:1153-1170.