Colorado River Recovery Program
FY 2004 Annual Report

Recovery Program
Project Number: 98b

I. Project Title: Translocation of northern pike from the Yampa River upstream of Craig, Colorado.

Note: Synthesis report of 2004, 2005, and 2006 due in March 2007.

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III. Project Summary

Northern pike is a large aggressive, esocid native in many North American drainages. The fish has been widely stocked outside of its natural drainages for recreational sportfishing purposes. Stocking of northern pike outside of its natural range can have many negative effects on native and endangered fishes, existing sport fisheries or commercial fisheries such as salmon in the Pacific Northwest (Conover 1986). Specifically, negative effects may include, but are not limited to, altering entire communities through top down effects (Colby et al. 1987), colonization of pike beyond the introduction point (McMahon and Bennett 1996), and competition with, and predation on, existing fish in the system (Findlay et al. 2000).

Northern pike have become well established in the Yampa River, Colorado. Northern pike escaped from Elkhead Reservoir (a reservoir on Elkhead River, a tributary to the Yampa River) where it was originally stocked to provide public fishing opportunities. Since escapement, northern pike have established a large, reproducing population in the Yampa River (Nesler 1995; J. Hawkins, Colorado State University, personal communication). The large population provides a source for continual movement of pike into the lower Yampa River and further downstream into the Green River where it coexists with three endangered fishes — Colorado pikeminnow (*Ptychocheilus lucius)*, razorback sucker (*Xyrauchen texanus*), and humpback chub (*Gila cypha*). Northern pike provide a significant predatory risk to these species, especially juveniles and small adults of Colorado pikeminnow and razorback sucker and a significant predatory risk to other native species in the basin (Martinez 1995; Nesler 1995). Northern pike were identified as presenting a significant risk to the endangered fishes by a majority of upper basin researchers in surveys conducted during the late 1980's (Hawkins and Nesler 1991).

The Upper Colorado River Endangered Fish Recovery Program (Recovery Program) has established an active program to control nonnative fishes in the main rivers of the upper basin to assist in recovery of the endangered fishes found there. To date, the Recovery Program has initiated nonnative reduction efforts for channel catfish, smallmouth bass, and northern pike in the Yampa and Green rivers, channel catfish and smallmouth bass in the Colorado River and small cyprinids in the Colorado and Green River drainages. In some cases, such as the Yampa River, northern pike have been removed from the main channel and stocked into off-channel impoundments to provide fishing opportunity for local anglers.

Temporarily reducing the pike population through mechanical means appears to be an option (Lentsch et al. 1996), although complete eradication is unlikely. A small, non-reproducing population of northern pike in the Gunnison River was reduced with relatively little effort applied at a time when pike were vulnerable (McAda 1997). Initial sampling efforts in the Yampa River suggest that substantial numbers of northern pike can be captured during spring when they enter shallow floodplain habitats for spawning (Nesler 1995; U.S. Fish and Wildlife Service, unpublished data).

This is the fourth year of sampling on this project and the fourth unique study design. In the first two years fyke netting was used to remove pike from the Yampa and in the past year and the current year a combination of electrofishing and fyke netting were used. As Recovery Program policy on nonnative fish management dictates, this project incorporates adaptive management wherein the study design and methods change on a yearly basis as we learn new and better capture techniques and as public opinion and perception change. Noteworthy recommendations to this years study, resulting from the 2003 nonnative fish management workshop were to eliminate control and treatment reaches, add a tagging pass to determine initial population size and removal effectiveness, and to increase overall effort. Objectives of this study are to reduce numbers of adult northern pike in the study reach, determine population size and structure of northern pike in the study reach and the subsequent changes in the population size and structure after translocation, maintain public support for the Recovery Program by providing off-channel angling opportunities, and to monitor the native fish community and smallmouth bass population in the study area.

IV. Study Schedule: To be continued as needed

V. Relationship to RIPRAP:
GREEN RIVER ACTION PLAN: YAMPA AND LITTLE SNAKE RIVERS
III.A.1.b Control northern pike.
III.A.1.b(1) Remove and translocate northern pike and other sportfishes from Yampa River

VI. Accomplishments of FY 2003 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

Study Site

The Yampa is a free flowing river that originates on the west slope of the Rocky Mountains and flows 320 km to its confluence with the Green River. The portion of the Yampa that makes up the study site flows through low gradient agricultural lands. Seasonal flows in the study reach fluctuate between 100 and 13,000 cubic feet per second (USGS, provisional data) however in recent years there has been a drought and flows have typically been lower.

All sampling for this study was conducted in a 38-mile reach of the Yampa River between Hayden and Craig, CO (hereafter referred to as the removal reach, Figure 1). The study reach was broken into two-mile segments. The two-mile segments allow for movement of fish to be more accurately monitored and to identify areas of juvenile and adult fish concentration as well as areas of high catchability.

Materials and Methods

Northern pike were collected using a combination of fyke nets and electrofishing. Electrofishing and fyke netting were accomplished during 6 and 5 passes, respectively, between May 2nd and June 10th 2004 and coinciding with spring runoff. During the first electrofishing pass all pike were marked and released. During the next five electrofishing passes pike were removed from the Yampa River, placed in fish hauling boats and trucks, and stocked into ponds accessible to the fishing public. Pike were marked using a T-bar tag with an individual tag number. Pike were also finclipped as a means of a double tag to prevent a lost mark and meet population estimation assumptions. Lengths of northern pike, discharge, capture reach, and the time spent sampling backwater habitats in a two-mile reach were recorded. During the fyke netting effort, all northern pike were removed from the Yampa River, tagged, and stocked into public accesible angling ponds. During our electrofishing effort all smallmouth bass and native fish were tagged, measured (TL), capture reach was recorded, and the fish were released. All white suckers captured during the fyke netting effort were euthanized. White suckers were not removed during electrofishing.

Movement Determination and Population Estimation Techniques

Movement Determination

In 2003, only upstream or downstream movement could be determined and estimates were poor at best (Pfeifer et al. 2003). In 2004 we are able to make a more accurate determination of movement using an averaging formula that incorporates the standardized two-mile reach system and the reach or exact location a tagged fish was recaptured in or released in.
Movement was analyzed both between and within years. Within year movement may be affected by our intensive sampling of fish and by our averaging formula. Fish tagged and released in a lotic ecosystem may exhibit a "fallback response" to being marked, where they are tagged and drift downstream (Moser and Ross 1993, Hughes 1998). We consider between year movements more accurate.

Movement was analyzed by taking the release location (bottom of the reach the fish is captured and released in) and assuming that when the fish is recaptured it is caught in the middle of the two-mile reach. For example, if a fish was caught between river miles 140.9 and 138.9 we know it was released at 138.9, which is the downstream part of the reach where fish were worked and released. If that fish was recaptured in reach 146.9 to 144.9, we do not know exactly where the fish was recaptured in the reach. However, if we assume it was recaptured in the middle of the reach then we determine its recapture location was 145.9. We eliminated fish that had moved less than 2 miles upstream or downstream. We did this to avoid biasing estimates towards downstream movement. We feel that since we released fish at the bottom of a reach we may have collected fish on the next pass a short distance downstream and erroneously concluded it had moved further without this elimination. We made the assumption that habitat and pike are randomly distributed within a reach. Large sample size of northern pike analyzed for movement in this study within and between years (n=104 and n=81, respectively), the Central Limit Theorem would dictate our averaging formula valid. Fewer smallmouth bass were analyzed for movement and movement estimates for these fish are not as accurate as for pike.

Population Estimation Techniques

Population estimates for northern pike were attempted using two simple techniques. The purpose of the first tagging pass was to estimate the population using standard mark recapture techniques (Petersen). In addition to estimating the population using standard mark recapture, the population was estimated using depletion analysis (DeLury).

The final population estimates derived from electrofishing data took into account the removal of pike through the fyke netting effort by adding the number of pike removed by fyke nets to the final point estimate. This was deemed accurate, as the number of pike removed by fyke nets is an absolute. Care was also taken to remove any electrofishing tagged fish from the data sets used to derive population point estimates that were captured by fyke nets, and removed before the possibility of recapture. Due to anomalies in capture locations and efficiency by pass, the population of smallmouth bass in the removal reach was estimated only for the portion of the removal reach from the Elkhead River confluence to the bottom of the study reach using data only from passes 4-6. The smallmouth bass population for this portion of the reach was estimated using standard multiple mark recapture methods and program CAPTURE (White et al. 1992) closed population models.
A population estimate for native fish was not possible due to low numbers sampled and no subsequent recaptures.

Results and Discussion

Northern Pike Overview

One hundred and thirty northern pike were collected in fyke nets, 1,110 by electrofishing. All 130 fish captured by fyke netting were removed from the river and 1002 of the 1110 fish captured from electrofishing were removed. Final disposition and location of all pike is outlined in Table 1.

Northern Pike Population Estimation and Removal Effectiveness

The population estimate of northern pike in the removal reach for 2004 was 1883 (1273 to 2370 95% C.I. excluding the fyke netting absolute). A summary of northern pike population estimates is available in Table 2. We believe that the estimate obtained from standard mark recapture is the most accurate.

Several problems occurred when estimating the population size of northern pike in the Yampa River. First, using two sampling techniques (fyke nets and electrofishing) introduces bias and error. Fyke netting, which removed pike during all sampling occasions, removed fish from the marked population before the recapture information from those fish could be utilized. While this error probably does not affect the accuracy of the point estimate itself, it definitely affects the precision by reducing number of individuals in the marked and recaptured populations sampled. Second, sampling efficiency may vary significantly by pass due to changing flow and sampling efficiency in the free flowing Yampa (Figure 2).

Of the estimated 1883 northern pike in the 38-mile stretch of upper Yampa River from Hayden to Craig, 1132 were removed. One thousand one hundred and thirty two is 60.11% of the point estimate of the population. However, we were unable to show a significant decrease in catch rates over the study time (d.f = 4, F = 3.805, P = 0.146, Figure 3). A theoretical removal time frame, using our catch rates and not accounting for immigration, emigration, or recruitment, shows that the population could be reduced to below 200 individuals in approximately 14 sampling passes (Figure 4).

We consider a removal of 60.11% of the population substantial, despite not showing a significant decline in catch per unit effort (CPUE). The lack of significance in CPUE decline is due to an outlier in catch data (Pass 4) associated with our perceived increase of sampling efficiency at that time. An additional pass or passes would probably show a significant decline in CPUE.

Localized areas of high pike catchability were present in the upper Yampa River (Figure 4) as were areas of larger pike (d.f. = 4, F = 9.452, P = <0.001, Figure 5). Time spent sampling backwater habitat in a particular two-mile reach increases pike catch rates (Figure 6) and backwater sampling time is loosely correlated to areas with higher catch rates (Figure 7).

The ability to target areas of high pike concentration and catchability can be used to increase removal effectiveness in the future. Localized areas of pike concentration coincide with low velocity vegetated areas preferred by riverine pike (Desantos 1991). If the focus of managers is to target pike of smaller size or larger size, areas that have concentrations of larger or smaller fish may be identified and targeted.

Length frequency of pike captured in all six passes by electrofishing and fyke netting (Figure 8) shows a difference in gear selectivity by size in 2004 and shifts in sizes captured by year during the fyke netting effort. Mean length of northern pike removed decreased as sampling continued (d.f. = 5, F= 30.932, P < 0.001, Figure 9). A least squares difference test indicated that mean length of northern pike during passes 1 and 2 combined and pass 3 were the same but different than passes 4, 5, and 6 (Figure 9). These differences likely indicate a gear selectivity of larger pike in earlier passes and an ability to remove larger fish with more effectiveness than smaller fish. Evidence that shifts in pike length frequency can be achieved by mechanical removal is further illustrated in Figure 10. There is a significant trend in length frequency shifts from larger size classes before removal effects to smaller size classes after removal effects (Kolmogorov-Smirnov Test, D_{max} 0.2068, P< 0.001, Figure 11).

We were more effective at removing large pike than small pike. After some initial amount of effort most of the large fish were removed from the population. Reasons for this were probably gear selectivity and human bias.

Northern Pike Movement

Movement of northern pike was detected 104 times from fish tagged and recaptured during this study. We removed 28 of these fish from analysis as they had moved less than 2 miles downstream. Average movement was 2.544 miles downstream (range 13 miles upstream to 17 miles downstream). Of the 76 movements anlayzed, 40 were downstream, 36 upstream.

Movement of northern pike was also detected from fish that had been tagged in previous years (Table 3). Movement was detected 72 times. Average movement was 1.80 miles downstream (range 32.35 miles downstream to 86.4 miles upstream). Fifty one times pike were detected moving downstream and 21 times moving upstream. Pike moving both between and within years is illustrated in Figure 12. In addition to pike from our study, a pike captured originally by the Colorado Cooperative Fish and Wildlife Research Unit (Chris Hill) was recaptured in Yampa Canyon during sampling for smallmouth bass (Project 110) that had moved downstream 100 miles over the course of one year and one month.

Northern pike in the removal area are moving downstream in the spring. There are several possible reasons for this downstream movement. One reason for this downstream movement may be competition for resources in the area is high and fish are seeking better foraging habitat downstream. Fish from downstream may be seeking quality spawning habitat in the spring before our sampling and consequently our data displays the post spawn movement back downstream. Finally, pike may be moving in response to high fluctuating seasonal flows and their effect on habitat availability.

Northern Pike Angler Tag Returns

Of 1132 northern pike stocked in CDOW managed, public accessible ponds, tags were returned from 5/12/2004 to 10/04/2004 for 282 fish (25 %). In 2002 and 2003 tag returns were 56% and 41% respectively. Of special note were a tag given to us by river anglers, indicating some cooperation (Table 1) and the recapture of 12 pike in the river this year that were stocked into S.W.A. ponds during last years study. However, only one of these 12 fish was stocked after the river had receded from connection with S.W.A. ponds and did not reconnect with the ponds.

Angler tag returns in 2004 likely underestimated the number of fish caught from ponds. There are many reasons for this underestimate. It is known that there is some angler resentment to our current management of northern pike in removal area. Fish are being caught by anglers and kept or released without returning the tags, or fish caught may be re-released with the tags still in them in either the angler accessible ponds or into the river itself (B. Atkinson, Colorado Division of Wildlife, personal communication). In addition to angler animosity, natural factors play a role in underestimation of tag returns. Personnel that stock pike on a daily basis have noticed mortalities in the bottom of the pond. Cannibalism is another natural occurrence that introduces bias into return estimates. We released such a large number of pike into such a small body of water that it is probable that pike preyed upon one another in the pond, especially considering such large size class differences of pike that are being released (Range 93 –1022mm). In addition, the smallest of size classes of pike released are probably not being harvested by anglers.

Smallmouth Bass Overview

Three hundred and twenty four individual smallmouth bass were captured during the study period. A length frequency plot (Figure 13) indicates representation of all size classes in the population but a high incidence of fish in mid to upper level size ranges.

Smallmouth Bass Population Estimate

The smallmouth bass population for the stretch of river from the confluence of the Elkhead River to the bottom of the study area was estimated to be 1469 (95% C.I. 872 to 2621) using the M(b) model (Table 4). Only a few smallmouth bass were captured in the removal reach during the first three passes (Figure 14). Also, fish were only sparsely present above the confluence of the Elkhead River for the entirety of the study (Figure 15). Other models that were less suited make point estimates varying from 433 to 1777 with 95% confidence intervals ranging from 323 to 3833.

The population estimate for smallmouth bass is not as accurate or precise as it could be if estimating smallmouth bass population size was a more focused objective of this study and sampling and analysis techniques were changed accordingly. It is apparent from movement data that this population is more open in nature (immigration and emigration) than the closed assumptions of CAPTURE models are designed to handle. Fish are distributing in the river later in the sampling period. We suspect that fish may be migrating into the Yampa River population from both the Elkhead River and to a lesser extent, Elkhead Reservoir. Exact escapement rates and levels from Elkhead Reservoir are currently being studied (Nesler and Miller 2003). Bass from the Elkhead River may be utilizing the mainstem Yampa and immigrating into and throughout the Yampa on a seasonal basis as temperature and flow regimes are more favorable for the fish at certain times of the year. Evidence that supports this is the increased catch rates of bass at later sampling times, increased occurrence of bass above the Elkhead confluence at later sampling times, and capture of smallmouth bass in higher river reaches later in the year (B. Atkinson, Colorado Division of Wildlife, personal communication).

Smallmouth Bass Movement

Smallmouth bass movement was detected from fish within this year's study and from fish collected that had been previously tagged by other investigators in previous years. Of the 18 smallmouth bass analyzed for movement from this year's tags, 6 had detectable movement in our study reach. Two fish moved downstream, four moved upstream with an average movement of 2.93 upstream. Smallmouth bass seemed to be moving up on later passes, which coincides with when the fish were detected by pass.

Smallmouth bass movement was detected from 14 fish that had moved into our study reach from downstream. All fish moved upstream with an average movement distance of 27.42 miles (Range 9.7 to 39.6). No smallmouth bass that we are aware of had been previously tagged upstream of our study reach.

Data on smallmouth bass movement is inconclusive. More data are needed either by increased focus on smallmouth bass movement in future study designs, capture of tagged fish at different times and places by different investigators, or, if necessary, by launching a smallmouth bass telemetry study.

Native Fish

The native fish community in the study area is poorly represented. During six passes through the study reach a total of 12 native fish were captured (Table 5). The majority of the fish captured were mountain whitefish. No native fish that were captured and released alive in this study were recaptured or had been previously captured to our knowledge.

Three notable aspects of the native fish stand out. The first is that not a single chub was captured. Roundtail chub have been present in this area in the past (Nesler 1995). Second are the lack of pure strain native suckers and the high incidence of hybrid suckers and white suckers in the study area. Third, is the capture of an adult Colorado pikeminnow at river mile 144.7. This fish is the furthest upstream capture of a Colorado pikeminnow by scientists in the basin (Recovery Program, unpublished data). The capture of this fish strengthens the argument for removing pike in this section of river. It is important to note that this pikeminnow would not meet criteria for being able to be ingested even by the largest pikeminnow removed (Nesler 1995). Decreasing the mean length of northern pike in our removal efforts is of great benefit to smaller pikeminnow that may be seasonally present.

VII. Recommendations:

1. End fyke netting
2. Remove smallmouth bass
3. Collect angler tag returns 3 times a week
4. Continue with 6 passes
5. Continue monitoring the native fish community
6. Develop a study and analysis design that will help more accurately determine seasonal and size dependent movement

VIII. Acknowledgements

The authors wish to thank numerous seasonal personnel for their help in the field, Billy Atkinson, John Hawkins, Tom Nesler, and Chris Hill for providing tag data. Tim Modde and Dave Irving provided valuable comments on an earlier version of this document.

IX. Project Status:

The project is considered on track but minor revisions are suggested. It is subject to review prior to continuation.

X. FY 04 Budget Status:

A. Funds provided: $111,136
B. Funds expended: $111,136
C. Difference: -0-
D. Percent of the FY 2003 work completed: 100
E. Recovery Program funds spent for publication charges: -0-

XI. Status of Data Submission:

Data will be sent to the database manager in 2004. Data are currently being entered in Microsoft™ Excel spreadsheets.

XII. Signed: Sam Finney — Principal Investigator; November 8, 2004 — Date

Table 1.—Transport mortality and final disposition of Northern Pike captured and translocated in the removal reach 2004.

2004 Fyke Netting

130	Total northern pike encountered
40	Stocked into State Wildlife Area, tag returned
76	Stocked into State Wildlife Area, fate unknown
14	Transportation/Sampling Mortality

Total Fish Removed= 130

2004 Electrofishing

1218	Total northern pike encounters of which 1110 were individual fish
108	Tagged on first pass not to be recovered
2	Fish too small for a tag
4	Stocked into Loudy-Simpson
1	Tag handed to staff by river angler
6	Fish taken out by fyke nets before possibility of recapture
242	Stocked into State Wildlife Area, tag returned
688	Stocked into State Wildlife Area, fate unknown
29	Sacrificed by CDOW for cleithra analysis
29	Transportation/Sampling Mortality
1	Tag found in transfer tank (fell out)

Total Fish Removed= 1002

Grand Total of Northern Pike Removed: 1132

Table 2.? Delury and Petersen population estimates for northern pike in the removal reach.

Method	N[a] (95% C. I.)	+	Fyke Net #[b]	=	Total
DeLury	1552 (N/A)		130		1682
Petersen	1790 (1273 to 2307)		93		1883

[a]N from electrofishing effort [b]Number removed by fyke netting that is an absolute or would effect the point estimate in the method used

Table 3. —Summary of northern pike tags analyzed for movement that were captured in the study reach that had been previously tagged by other investigators or in previous years.

Investigator	Tag Color	Number of Pike Analyzed
CSU	Blue	4
CSU	Yellow	1
Chris Hill/CDOW	Yellow	20
USFWS	Red	47
Unknown[a]	Red or Yellow	3

[a]Tags not analyzed

Table 4.—Population estimates for smallmouth bass in the Yampa River from the confluence of the Elkhead River to the bottom of the study area as determined by program CAPTURE. Program CAPTURE selected the time M(t) model as the most likely estimate.

Model	N (95% C.I.)	Standard Error	p-hat	Model Selection Criteria[a]
M(o)	1058 (716 to 1636)	228.4315	0.0750	0.16
M(h)[b]	433 (397 to 477)	2.000	0.1832	0.00
M(b)	498 (323 to 986)	153.4262	0.1803	0.26
M(bh)	498 (323 to 986)	153.4262	N/A	0.16
M(t)	1469 (872 to 2621)	428.0460	0.0566[c]	1.00
M (th)	1777[d] (893 to 3833)	7.000	0.0466[c]	0.88
M(tb)	NO TEST POSSIBLE			0.79
M(tbh)	NO TEST POSSIBLE			0.36

[a]Model selected has the highest value, [b]Interpolated, [c]Mean p-hat for all 3 passes [d]Bias-corrected estimate

Table 5.—Summary of all native fish captured in 6 electrofishing passes in the removal reach. No native fish were recaptured during the study period.

Species	Length	Disposition[a]	Reach/River Mile	Pass
Colorado Pikeminnow	616	RA	144.7	5
Flannelmouth Sucker	500	RA	158.9 to 156.9	6
Mountain Whitefish	440	RA	160.9 to 158.9	2
Mountain Whitefish	507	RA	158.9 to 156.9	2
Mountain Whitefish	231	RA	154.9 to 152.9	2
Mountain Whitefish	247	dead	162.9 to 160.9	2
Mountain Whitefish	136	RA	166.9 to 164.9	2
Mountain Whitefish	218	RA	166.9 to 164.9	2
Mountain Whitefish	450	RA	170.9 to 168.9	4
Mountain Whitefish	430	RA	162.9 to 160.9	6
Mountain Whitefish	185	RA	162.9 to 160.9	6
Mountain Whitefish	460	RA	170.9 to 168.9	6

[a] RA=Released Alive

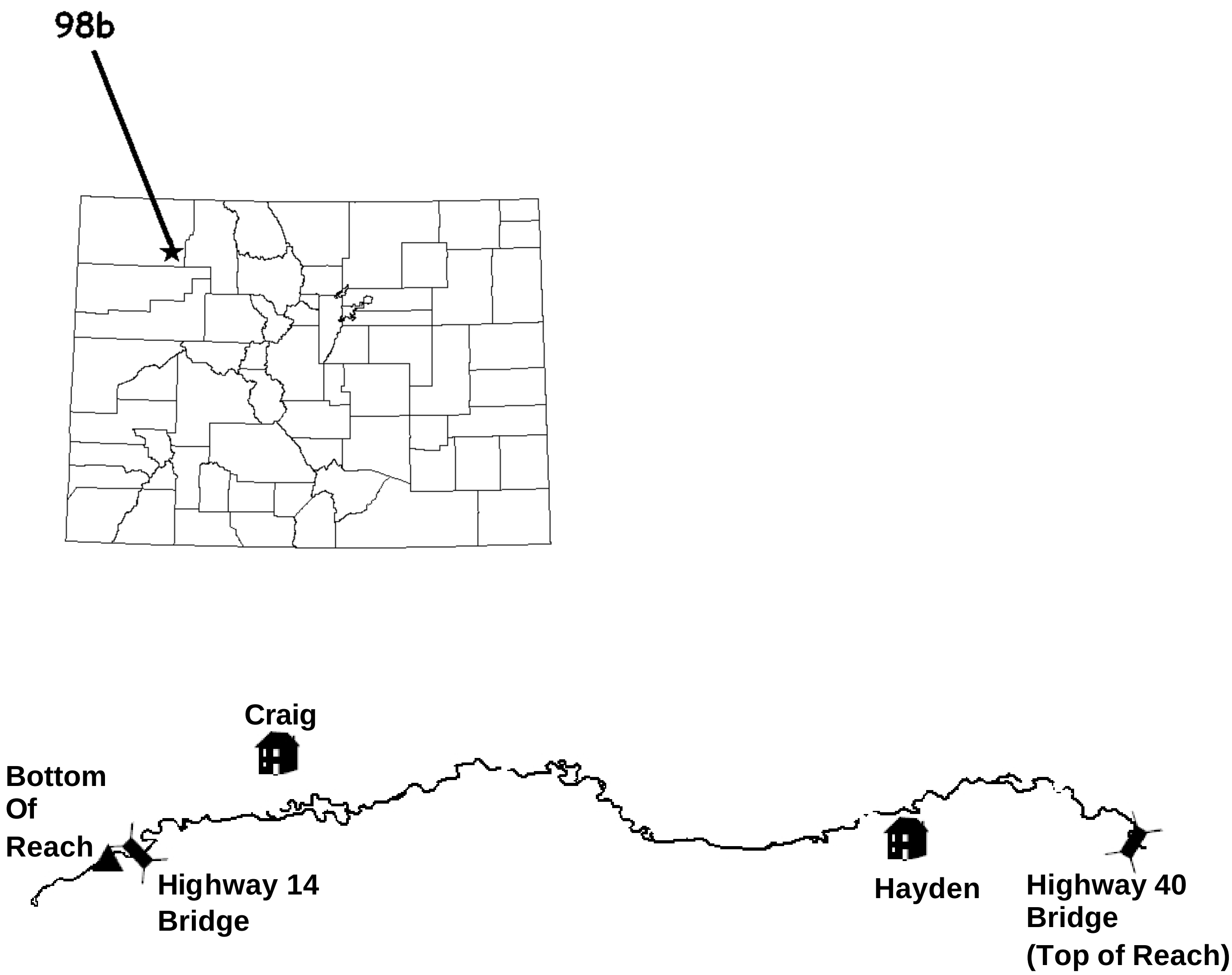


Figure 1.? Upper Yampa River Study Site.

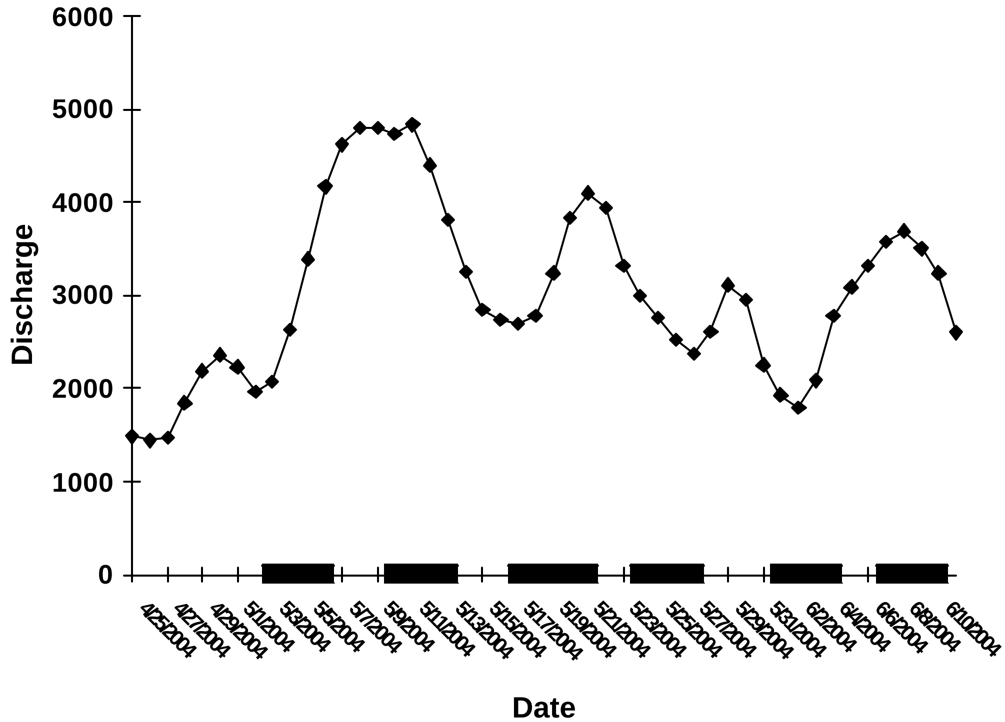


Figure 2.— Yampa River discharge (Dotted line) and electrofishshing sampling dates (dark bar on x-axis) comparison.

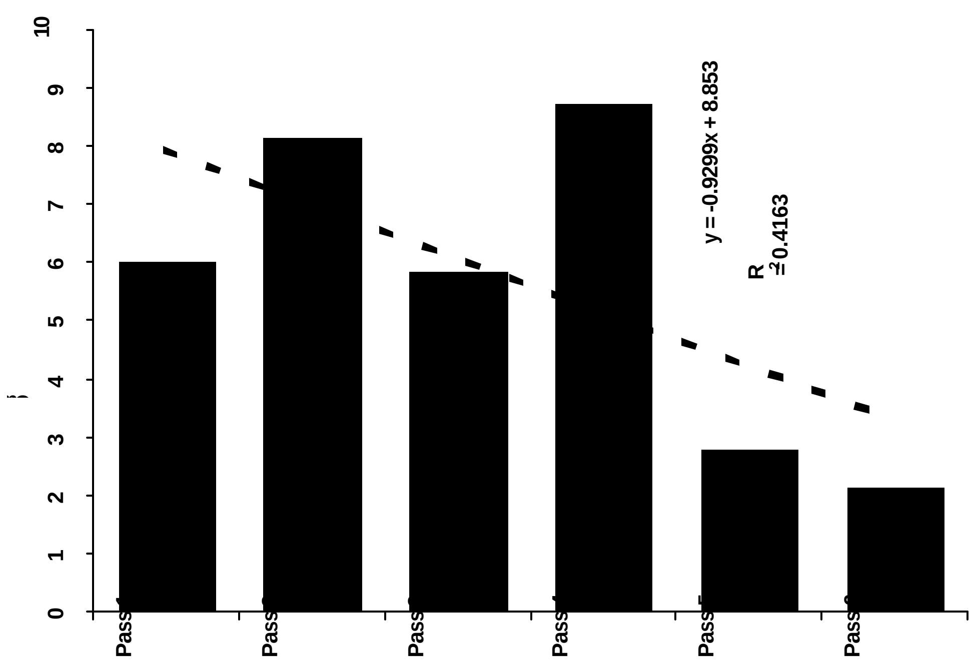


Figure 3.—Changes in northern pike catch rates through time in five reaches sampled in the Yampa River, Spring, 2004.

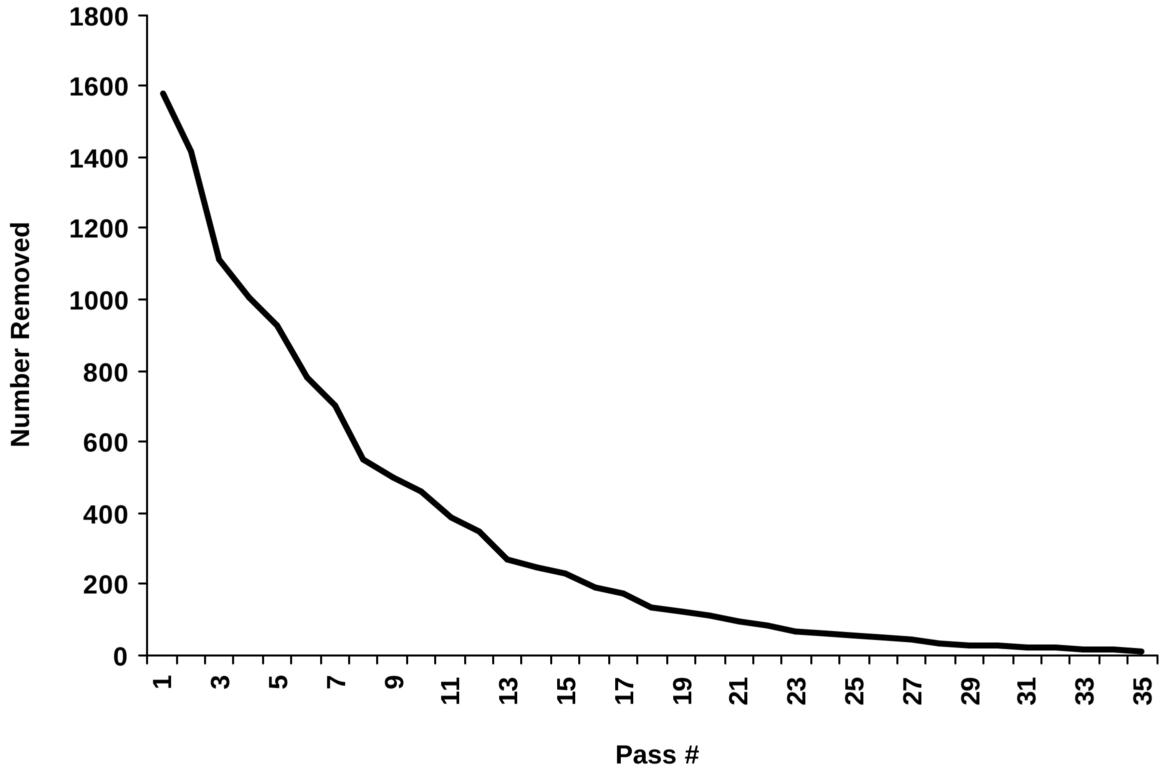


Figure 4.—Theoretical removal time frame for northern pike in the upper Yampa River.

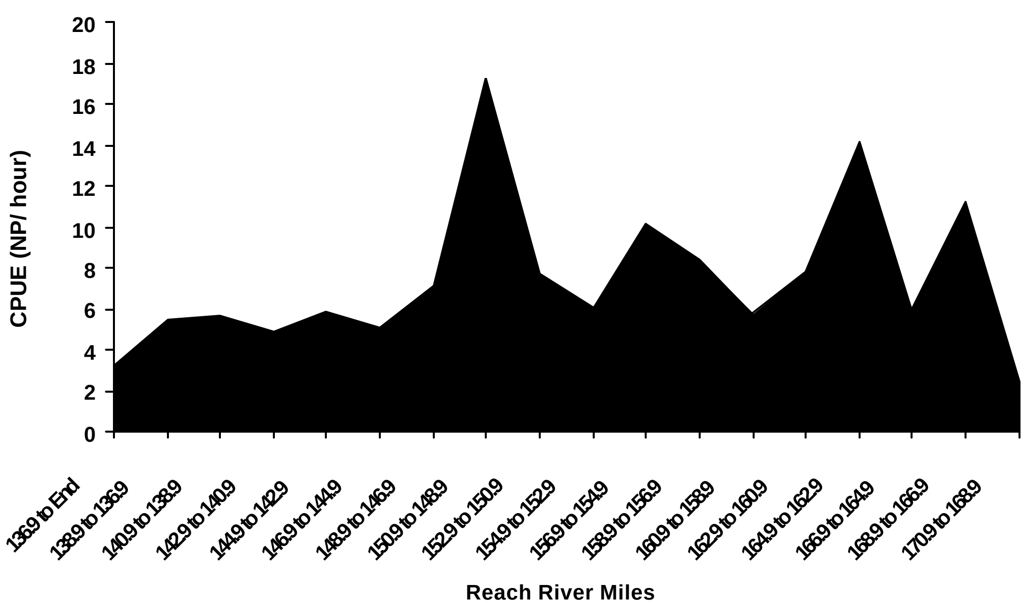


Figure 5.—Catch rates of northern pike in specific 2-mile reaches of the Yampa River, Colorado, 2004.

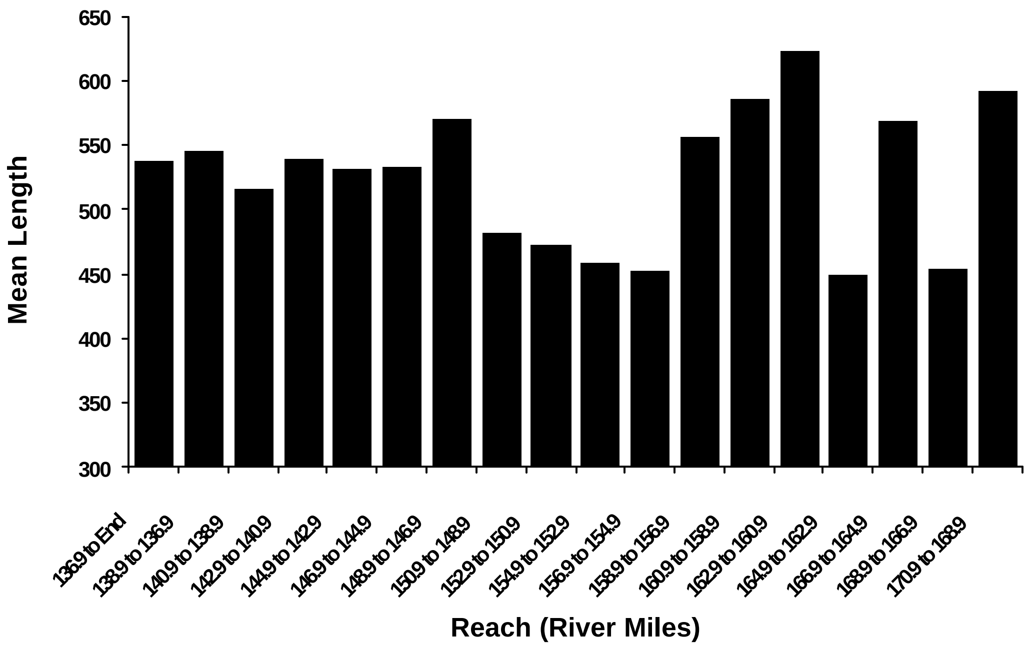


Figure 6.—Mean length of northern pike by reach, Yampa River, Colorado, 2004.

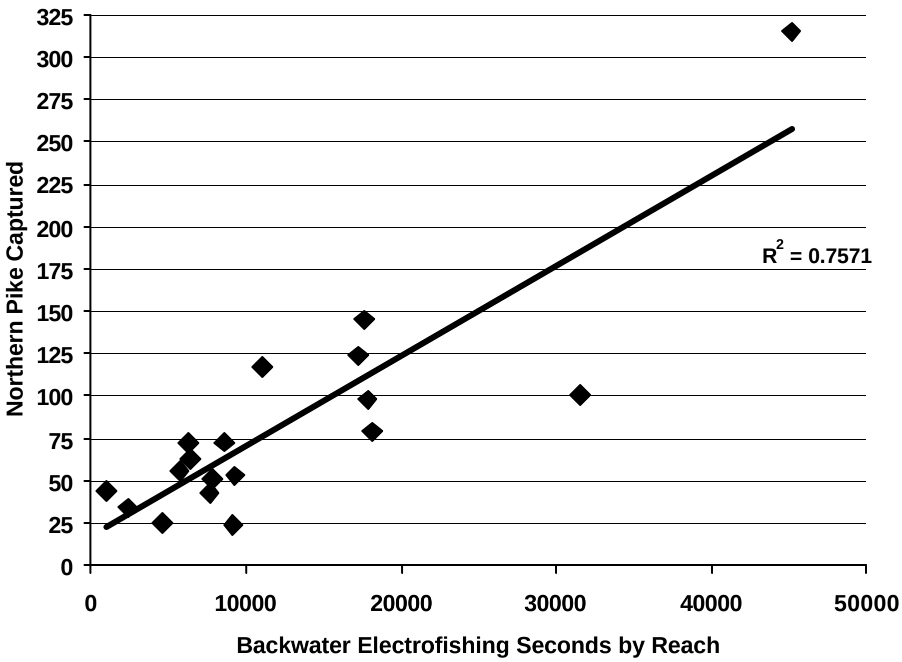


Figure 7.—Relationship between number of northern pike captured in an area and the amount of time spent sampling backwater habitats.

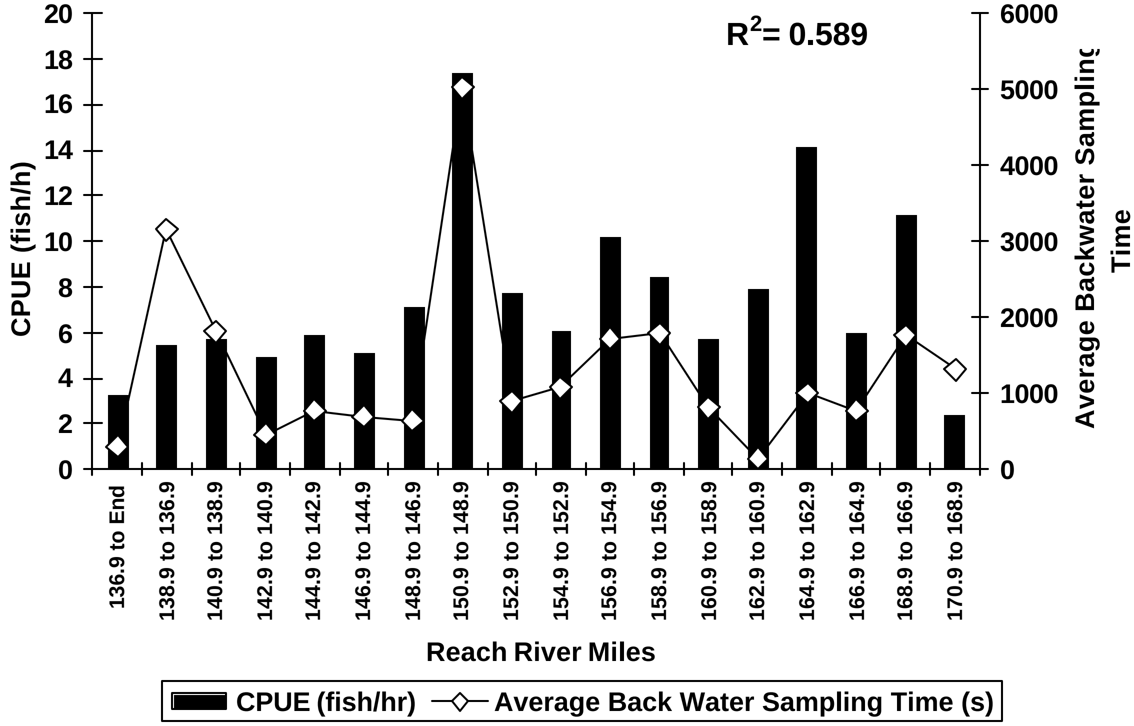
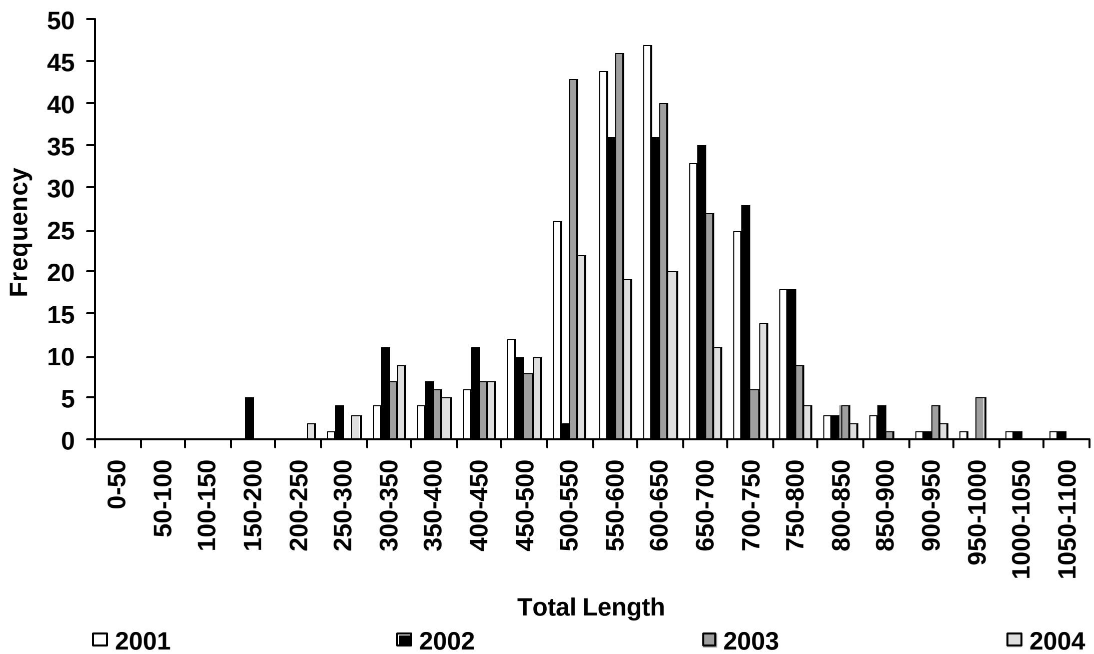


Figure 8.? Graph illustrating the relationship between catch rates of northern pike in a specific reach and the average time spent sampling backwater habitats in that reach.



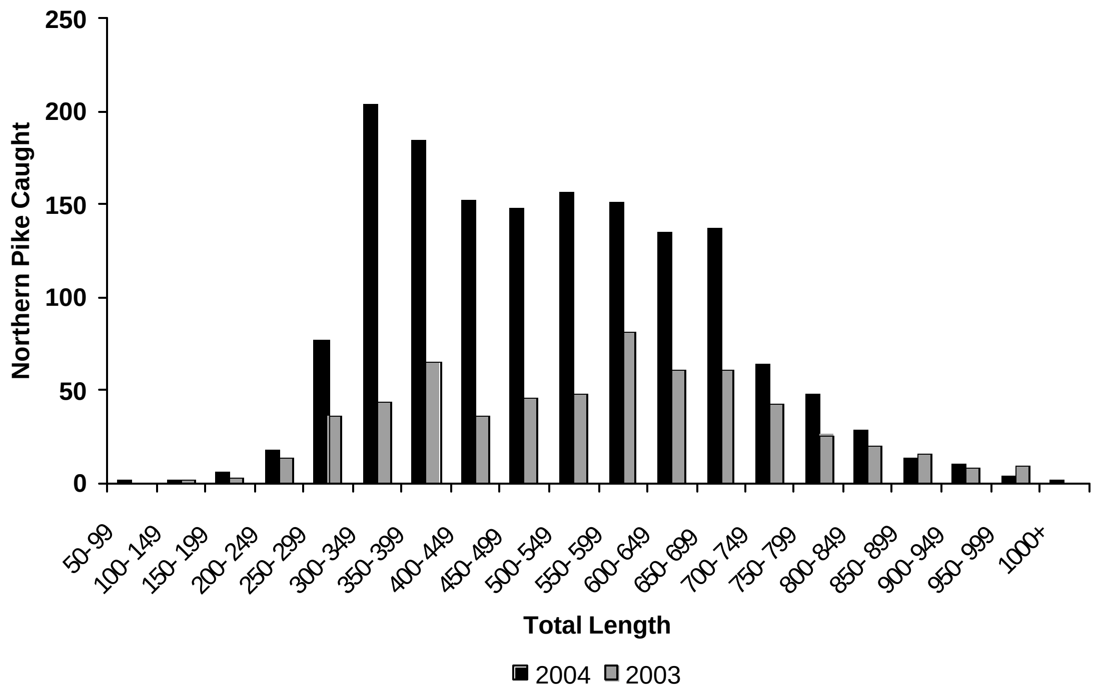


Figure 9.—Fyke net data length frequency from 2001-2004 (top) and 2003-2004 electrofishing data length frequency (bottom), Yampa River, Colorado.

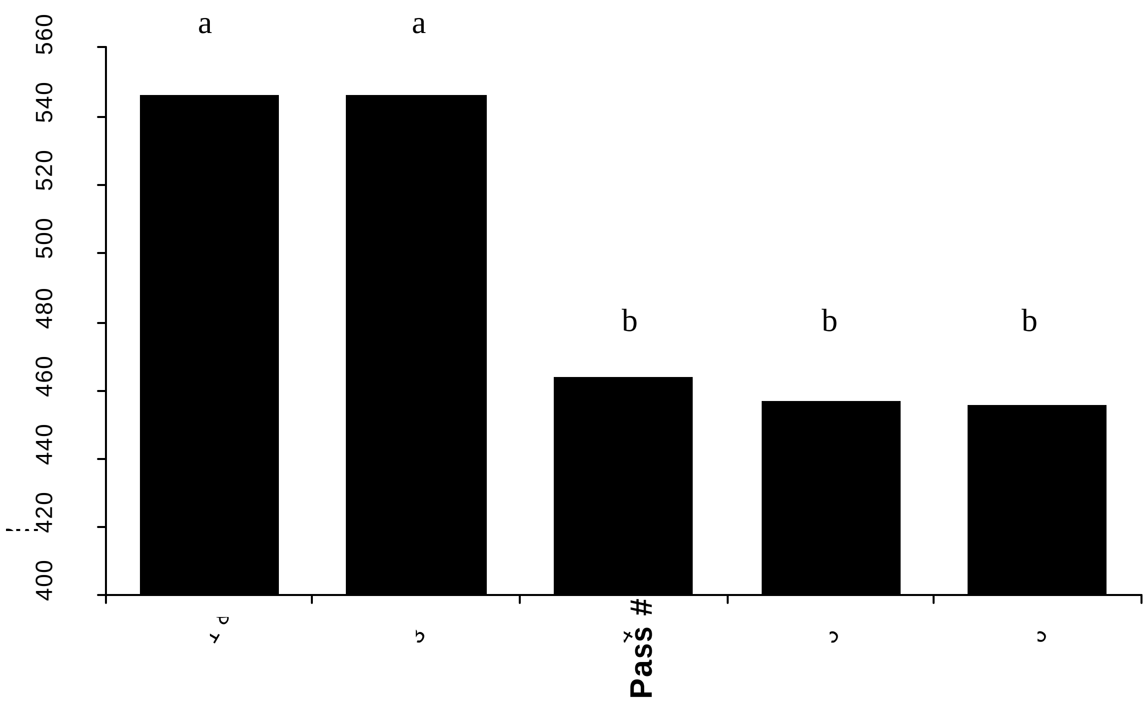
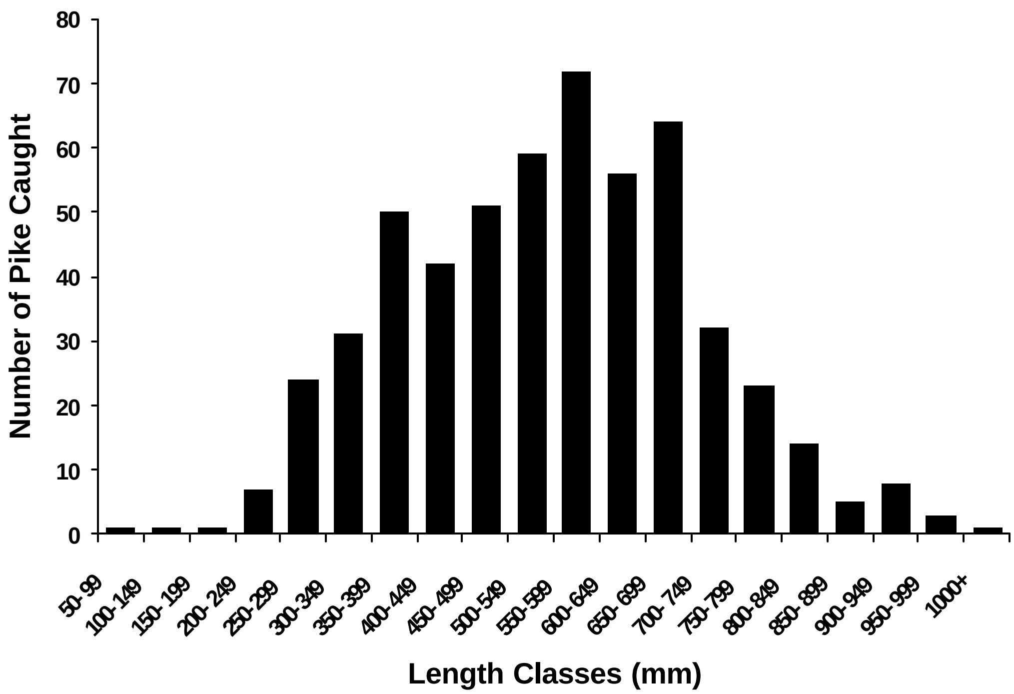
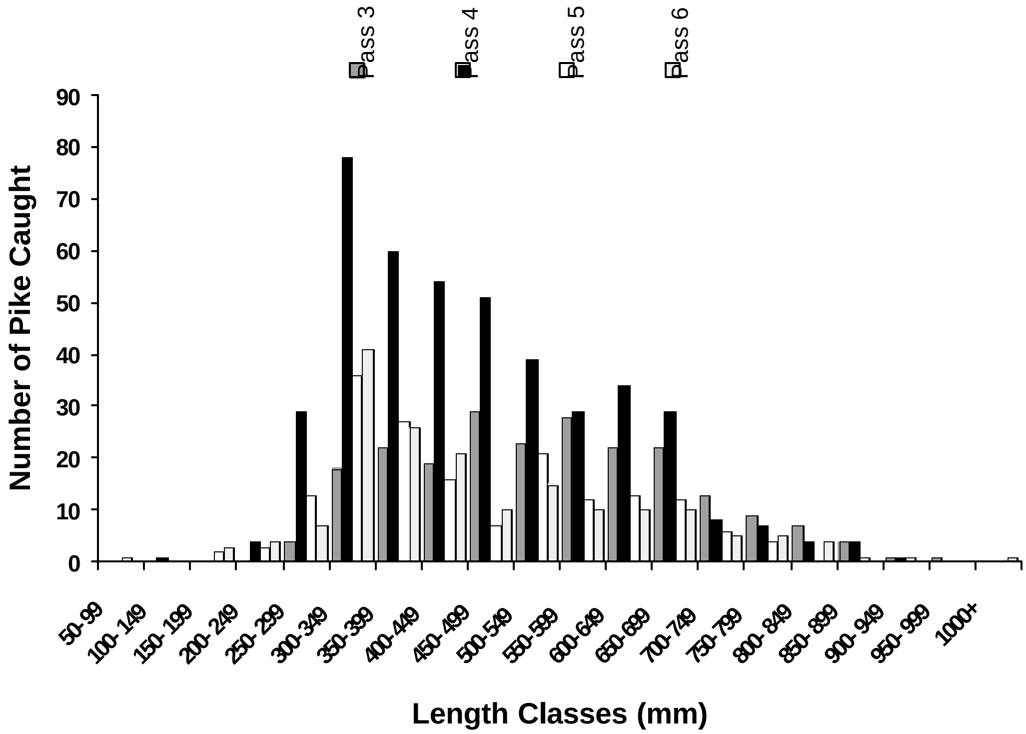


Figure 10.—Mean length of northern pike by pass in the Yampa River, Colorado, 2004. Different letters and same letters coincide with statistically significant differences or equivalences, between passes.


Number of Pike Caught
0
10
20
30
40
50
60
70
80
50-99
100-149
150-199
200-249
250-299
300-349
350-399
400-449
450-499
500-549
550-599
600-649
650-699
700-749
750-799
800-849
850-899
900-949
950-999
1000+
Length Classes (mm)

(a)



(b)

Figure 11.? Length frequency of pike caught in the removal reach on passes one and two before removal effects (a), and passes three, four, five, and six with removal effects (b).

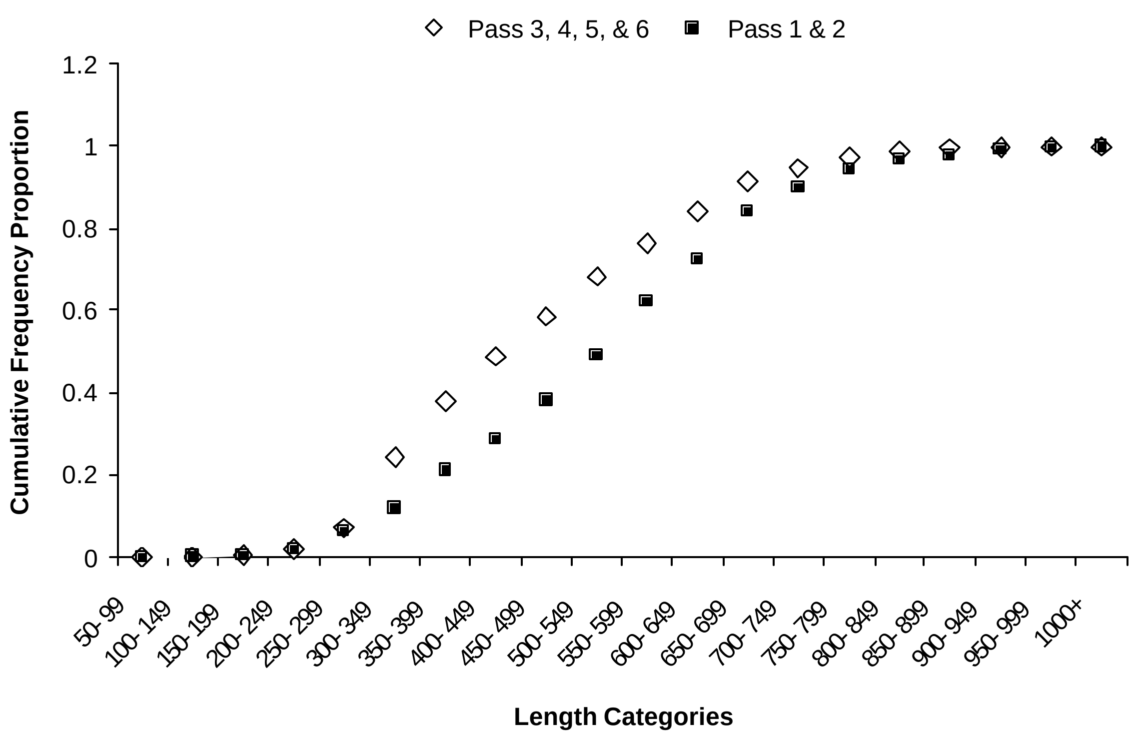


Figure 12.? Cumulative length frequency of northern pike from pass 1 & 2 (control) and passes 3-6 (with treatments effects).

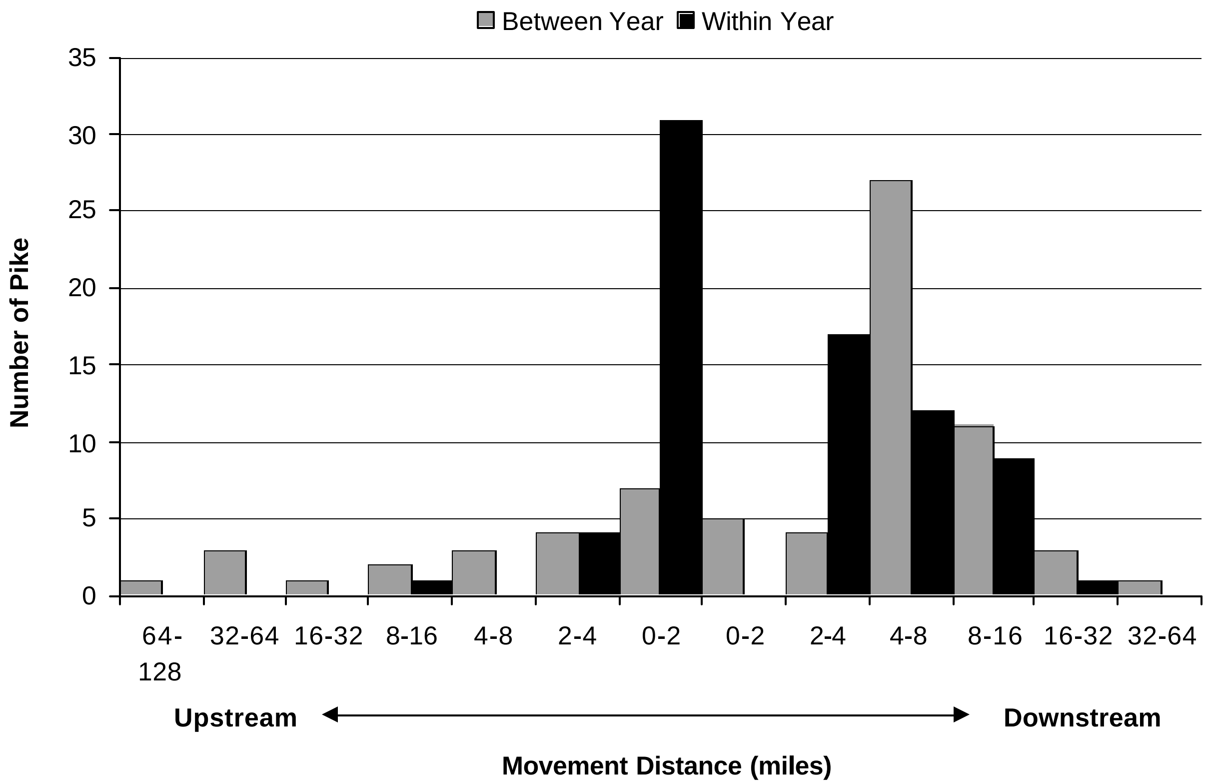


Figure 13.—Summary of within year and between year movement of northern pike in the removal reach.

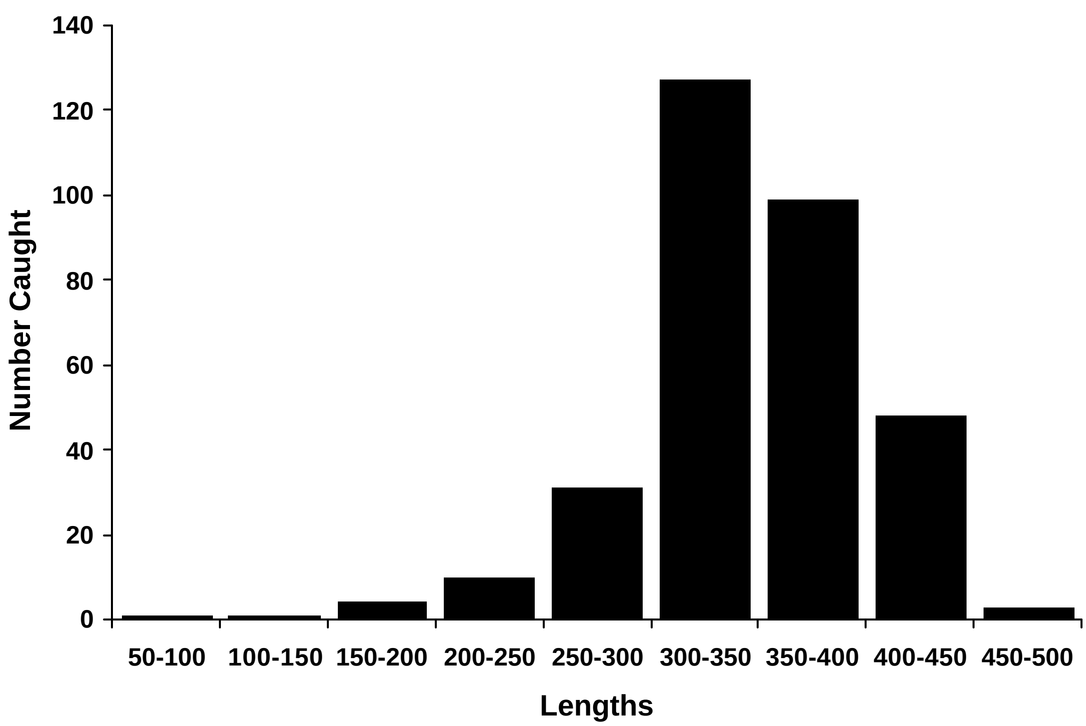


Figure 14.—Length frequency of smallmouth bass captured in the removal reach.

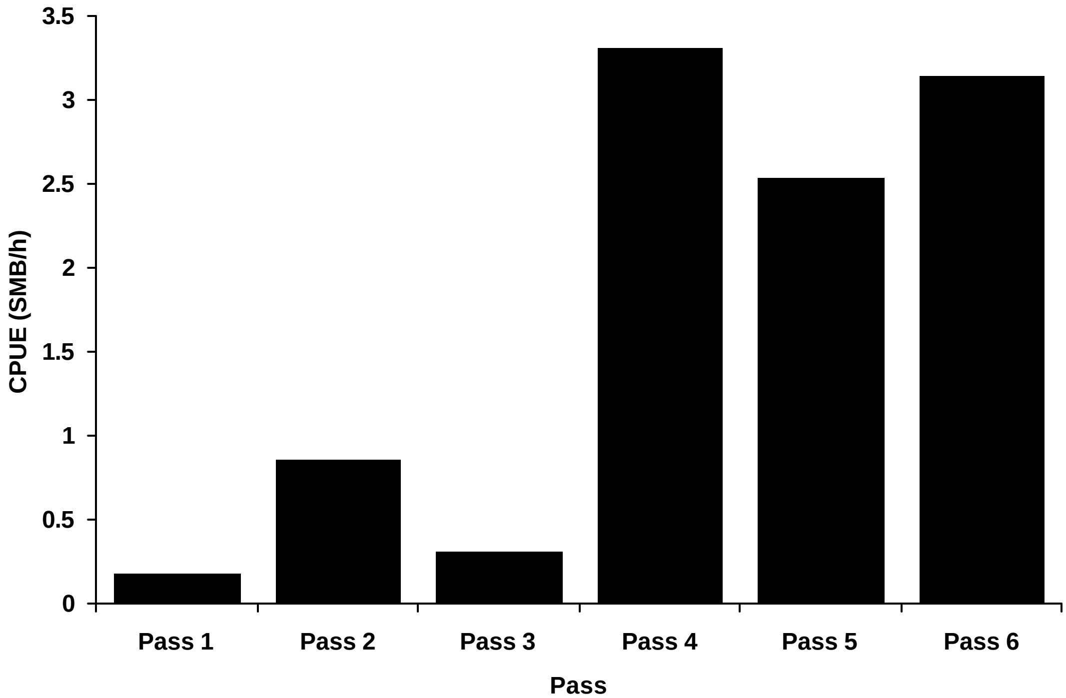


Figure 15.—Smallmouth catch rates by pass.

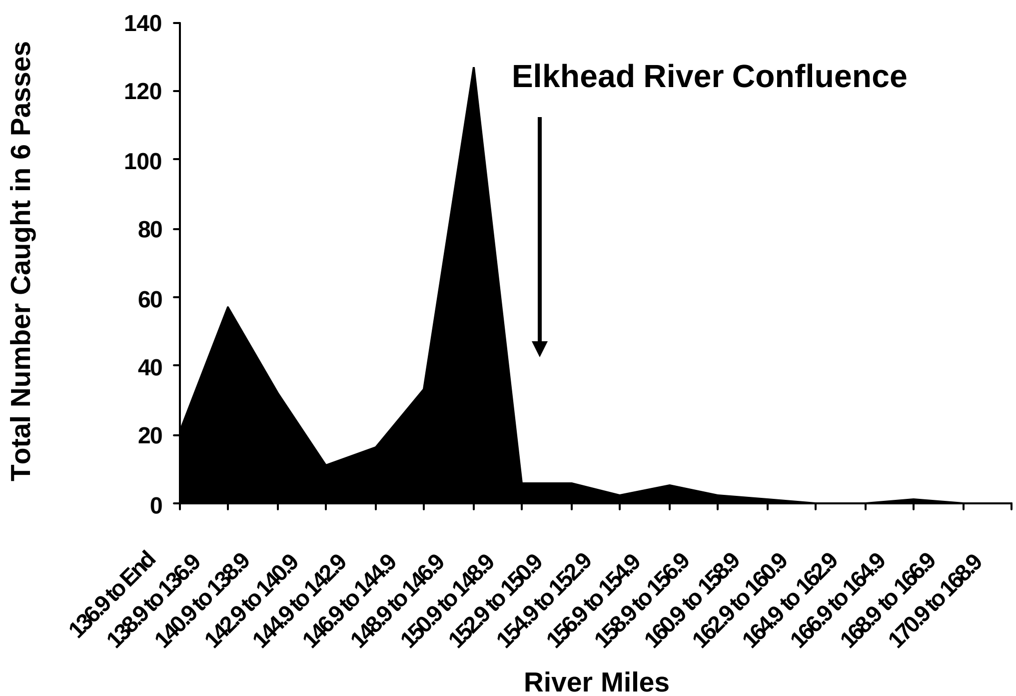


Figure 16.—Smallmouth bass occurrence by sub reach over all six passes in the 2004 study.

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