Yampa River Nonnative Fish Control Strategy

By

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Executive Summary

Nonnative fish in the Yampa River threaten the endangered Colorado pikeminnow (*Ptychocheilus lucius*) and humpback chub (*Gila cypha*) through predation and competition. Northern pike (*Esox lucius*) and smallmouth bass (*Micropterus dolomieu*) are the most problematic species and control of their populations is vital to the long-term conservation of the endangered and native fishes. This nonnative fish control strategy identifies 14 tactics under six elements that are being implemented or need to be implemented to sufficiently reduce nonnative fish threats. The most effective control method is mechanical removal with electrofishing, hoop nets, and electric seines. Mechanical removal began in 2004 and northern pike have been reduced in parts of the Yampa River, but smallmouth bass reductions will require higher levels of exploitation. Model predictions suggest that the minimum annual removal rates needed to cause a long-term reduction in population size of smallmouth bass exceed 60%. Using the target removal criteria (30 fish per mile) and minimum exploitation, the approximate time period needed to cause a population crash is 20 years. However, if annual exploitation rates are increased to remove 85% of adult smallmouth bass (via a shift in Recovery Program effort and/or favorable environmental conditions), the period required to create a population crash could be reduced to almost 8 years. The Upper Colorado River Endangered Fish Recovery Program is increasing exploitation rates by increasing crew sizes and targeting source populations.

Purpose, Goals, and Objectives

This Yampa River Nonnative Fish Control Strategy (Strategy) was developed for the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) in response to a directive from the Recovery Implementation Committee, dated October 13, 2006. The purpose, goals, and objectives of the Strategy were adopted from the Implementation Committee's directive and are consistent with the Recovery Program's Nonnative Fish Management Policy.

The purpose of this Strategy is to identify and describe an aggressive approach based on defensible data and consensus interpretation for managing problematic nonnative fish in the Yampa River. The goals of the Strategy are to:

1. Provide an assessment of current efforts to manage problematic nonnative fish species in the Yampa River; and

2. Develop and implement a stronger adaptive management framework to identify nonnative fish management actions of sufficient scale and intensity to achieve measurable success criteria based on fish population responses over the shortest plausible timeframe.

The objectives of this Strategy are to:

1. Develop a set of nonnative fish control actions for the Yampa River of sufficient scale and intensity that can achieve specific quantitative goals over the shortest plausible timeframe;

2. Assess these actions against the current strategies for nonnative fish control in the Yampa River and the likelihood of achieving the quantitative goals;

3. Based on the assessment, recommend adjustments to the current strategies, even if the effectiveness of those adjustments may be unproven;

4. Establish a timeframe for implementing the adjustments and a progress reporting schedule through the Recovery Program's committee process; and

5. Evaluate the effectiveness of control actions, and refine and update the nonnative fish control strategy and management actions.

Background

The Yampa River is one of the most important rivers for recovery of the four federally endangered fish species in the Upper Colorado River Basin. Colorado pikeminnow (*Ptychocheilus lucius*) inhabit and spawn in the lower warm reaches and their young drift downstream into the Green River and contribute to a large portion of the Green River Subbasin population. Humpback chub (*Gila cypha*) inhabit the whitewater reach of Yampa Canyon as one of only six known self-sustaining populations in the Colorado River System. Razorback sucker (*Xyrauchen texanus*) and bonytail (*Gila elegans*) were found historically in the Yampa River and are currently rare. Four native non-endangered fish species also inhabit the warm reaches of the Yampa River; i.e., roundtail chub (*Gila robusta*), flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*Catostomus discobolus*), and speckled dace (*Rhinichthys osculus*). The first three are conservation species under a 2004 Range-Wide Conservation Agreement among the states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming.

Altogether, 14 species of fish are native to the Upper Colorado River Basin and there are now over 40 nonnative fish species that have been introduced into the basin. Ten nonnative species inhabit the Yampa River and most are competitors or predators of the native forms and threaten recovery of the four endangered species. Increases in abundance and distribution of some of these nonnative fish species during drought conditions in the last decade have prompted more aggressive management of these

species and the need for a coordinated strategy for the Yampa River. The most problematic fish species in the Yampa River have been identified as northern pike (*Esox lucius*) and smallmouth bass (*Micropterus dolomieu*).

Execution and Coordination

This Strategy will be executed and coordinated by the Recovery Program and its partners. The Strategy will initially follow an experimental approach to identify problematic nonnative species, assess distributions, and estimate abundances. This strategy describes effective tactics and actions that help identify the levels of management necessary to minimize or remove threats to the endangered fishes. Collected information will be evaluated annually to determine and refine nonnative fish management actions under the principles of adaptive management. This process has already begun and will not unduly delay timely and effective actions to minimize or remove the nonnative threat to the endangered fishes.

This Strategy is based on the following:

1 Nonnative fish have a negative impact on native fish through predation and competition and threaten recovery of the endangered fish species.

2 Nonnative fish are not the only threat to native and endangered fish species, but removal or reduction of nonnative fish will benefit native fish populations.

3 Removal strategies will not eliminate nonnative fish from the Yampa River and may require multiple and persistent actions through time.

4 Identifying and controlling sources of nonnative fish to the Yampa River will improve efficiency and effectiveness of nonnative fish population control.

5 The Yampa River is a complex and dynamic ecosystem and the threat of nonnative fish may change over time, including species posing the greatest risk.

Current Strategy

The core of the current strategy is mechanical removal. For both northern pike and smallmouth bass, extensive removal efforts are conducted annually in 171 miles of the Yampa River (Hayden to Green River confluence). An overview of the current control actions is provided in Appendix A. In addition, removal efforts for northern pike are conducted by the Colorado Division of Wildlife (CDOW) in upstream reservoirs. The overall purpose of the removal efforts is to reduce these two species to levels identified in interim criteria; i.e., <2.67 northern pike/mile (applies to 84 miles of Colorado pikeminnow critical habitat upstream of Yampa Canyon); <30 adult smallmouth bass/mile in main channel (applies to 24 miles of critical habitat upstream of Yampa Canyon), 10-30% YOY composition in low-velocity habitats. These interim criteria were approved by the Biology Committee and are based on what are believed to be acceptable

densities of smallmouth bass and northern pike. Identifying and implementing the level of effort required to achieve the criteria, identifying and reducing sources of nonnatives, and preventing further invasions are important considerations in achieving these criteria. The following summarizes the core and secondary components of the current strategy for reducing abundances of northern pike and smallmouth bass in the Yampa River:

Northern Pike—Core Components

1. Remove throughout critical habitat with $\leq$3 pike/mile as objective; electrofish river with block and shock of secondary channel and tributary backwaters.
2. Remove from upstream buffer (Hayden to Craig) to reduce downstream movement into critical habitat; electrofish river with block and shock of secondary channel and tributary backwaters.
3. Translocate captured fish to suitable, local public fishing waters (e.g., Yampa State Wildlife Area ponds, Loudy-Simpson Ponds, Craig Justice Center Pond) for subsequent angling recreation, harvest, and public support.
4. Sample entire reach during 1st and 2nd passes with mark and release in 1st pass to generate population estimates; focus subsequent removal passes on recognizable concentration, spawning, or nursery areas.
5. Identify primary sources of pike reproduction in basin to focus control/isolation on sources to river population (chemical fingerprinting via isotope research).
6. Isolate or treat reproduction source waters with access to Yampa River.
7. Annually evaluate effectiveness of actions, adjust as needed.

Northern Pike—Secondary Components

1. Remove pike and promote trout sport fishery in Catamount and Stagecoach Reservoirs and Steamboat reach.
2. Remove pike as encountered in Yampa Canyon and Green River.
3. Monitor escapement of tagged, translocated pike from receiving waters using recaptures in control sampling; define thresholds for action.

Smallmouth Bass—Core Components

1. Remove bass from 49 mi of study reaches (South Beach, Little Yampa Canyon and Lily Park) and 46 miles of the Lower Yampa River. Determine if significant reduction is possible with feasible effort to achieve interim criteria (30/mile adult and 10-30% YOY). Includes both adult electrofishing removal and summer YOY-juvenile electric seine removal.
2. Sample entire upper reaches during 1st and 2nd passes with mark and release in 1st pass to generate population estimates; focus subsequent removal passes on recognizable concentration, spawning, or nursery areas.
3. Mark and release captured fish in efforts outside the study reaches to provide qualitative index to movement, potential expansion of control with successful removal to high density reaches.

4. Translocate captured fish ≥10 inches to Elkhead Reservoir or Craig Justice Center Ponds for subsequent angling recreation, harvest, and public support.
5. Monitor escapement of tagged, translocated bass from Elkhead Reservoir using recaptures from control sampling in northern pike buffer and critical habitat reaches; define thresholds for action.
6. Conduct mark/recapture estimates in upper reaches annually; conduct every 3 years in Lower Yampa River.

Elements, Tactics, Assessment of Control Actions, and Adjustments

This Yampa River Strategy expands the current strategy and consists of six elements including: information and education; prevention; early detection and reporting; information and data management; mechanical removal; and research and development (Figure 1). The following describes each element and associated tactics, assesses the current actions, and identifies adjustments. Tactics and actions described in this Strategy were assimilated from an exchange of information among upper basin researchers in the 2006 nonnative fish workshop. Each element consists of one or more tactics and each tactic comprises one or more actions. The tactics describe major approaches that address problematic nonnative fish issues under each element, and the actions describe the activities being taken or to be taken to achieve the defined tactic. Actions and adjustments to those actions are identified and described, consistent with the principles of adaptive management.

I. Information and Education

This element includes tactics and actions that can be taken by Recovery Program partners, including state and federal agencies to disseminate information and promote public support.

Tactic A.—Disseminate Information and Promote Public Support for Nonnative Fish Management on the Yampa River.

Action A-1. Develop an information and education program for the Yampa River. An I&E program has been developed for the Yampa River as a part of the Recovery Program's Information, Education, and Public Involvement element. This action uses town meetings, news articles, radio and TV programs, pamphlets, and outdoor signs to raise public awareness of the problems posed by some nonnative fish. This action promotes public support for balanced management of nonnative fish, sportfish, and native fish. This action is adjusted by meeting with angler groups to provide them with information on the nonnative fish management program for the Yampa River and to better understand and address their concerns over removing northern pike and smallmouth bass from the river.

Action A-2. Secure cooperation from landowners where fish removal needs to be expanded. Landowners have generally been cooperative in granting access to areas or easements for specific nonnative fish control actions. No adjustments are

proposed for this action.

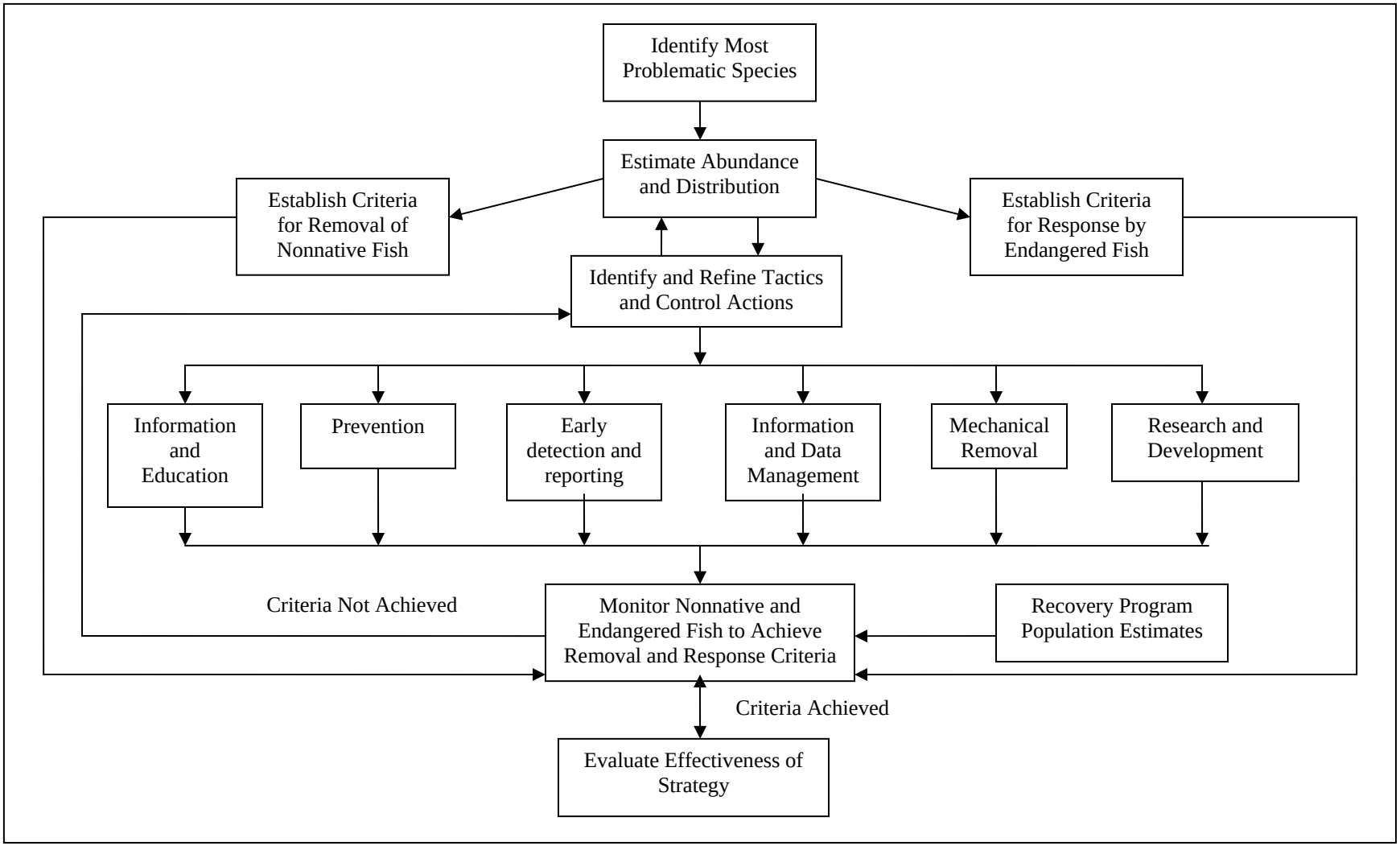


Figure 1. Nonnative fish control strategy for the Yampa River.

II. Prevention

Prevention actions are taken to regulate the transport and introduction of problematic fish species and to reduce the invasion and recruitment by these fish from outside sources.

Tactic B.—Regulate Transport and Introduction of Problematic Fish Species.

Action B-1. Regulate interstate and intrastate transport of fish. The State of Colorado currently regulates interstate and intrastate transport of fish. Regulation has largely reduced the import and translocation of problematic fish. No adjustments are proposed for this action and the State is encouraged to continue this regulation.

Action B-2. Enforce regulations to reduce illicit stocking of fish. New species continue to be found in various waters as evidence of illicit stockings. Illicit stocking is difficult to monitor and regulate, but enforcement of regulations that reduce illicit stocking of problematic nonnative fish should continue. Recommended adjustments are to increase penalties for illicit stocking and to provide $20,000 rewards for 'stop poaching' (for reporting illicit stocking).

Action B-3. Investigate and evaluate designation of the Yampa River downstream of Craig as a native fish conservation area. Specific geographical areas can be designated as conservation areas by the State of Colorado. The State is currently evaluating the designation of the Yampa River downstream of Craig as a native fish conservation area. This designation would establish this reach as a priority native fish management area and would help to reduce illicit transport and stocking of fish into this reach of the Yampa River.

Tactic C.—Reduce Invasion and Recruitment from Sources.

Action C-1. Monitor and maintain the screen at the Elkhead Reservoir outlet. A screen was placed in 2007 to prevent escapement of fish (especially northern pike and smallmouth bass) from Elkhead Reservoir into the Yampa River. The screen continues to be monitored and maintained. Fish that are translocated from the Yampa River to the reservoir are marked and used to monitor escapement. No adjustments are proposed for this action, although if escapement is found to be unacceptably high, further screening options should be considered.

Action C-2. Utilize isotope technology to determine natal origin and/or recent occupancy of fish. Isotopes of various elements can be used to trace spawning sources of fish or waters recently occupied by individual fish so that removal efforts can target these sources. This technology is being successfully used by various programs worldwide and is being used and evaluated in the Upper Colorado River Basin. No adjustments are proposed for this action, although refinements may be made with new, more effective isotope technology.

Action C-3. Mechanical removal of northern pike and smallmouth bass from identified sources upstream of critical habitat. Recent investigations show that northern pike and smallmouth bass are common upstream of Craig (upper end of critical habitat for Colorado pikeminnow) and may be an important source of these fish to the Yampa River downstream. A "buffer zone" has been established to mechanically remove these fish between Hayden and Craig. This action will reduce the number of fish moving downstream into the middle and lower Yampa River and the Green River. This action also includes removal of northern pike from Catamount Reservoir and from riverside floodplains above Craig primarily by the Colorado Division of Wildlife (CDOW). A reallocation of effort to these upstream sources of northern pike and smallmouth bass may be necessary to improve the effectiveness of basin-wide removal. Isotopic analysis may identify additional sources of fish that may also require fish removal. Additional adjustments may be made to this action pending the outcome of these activities.

Action C-4. Target spawning areas. Northern pike and smallmouth bass have fairly specific spawning requirements. Northern pike spawn in riverside floodplains in early spring and initial actions were taken to block access to these areas with screens. Screening floodplains was not entirely effective because icing and high spring flows can inundate or damage screens and allow the fish access to these areas. This action has been adjusted to remove spawning northern pike from floodplains with tandem electrofishing boats. Also, permeable rock berms are planned for some floodplains of the upper Yampa River to block fish access but allow water and nutrient exchange. Application of piscicides may be used to reduce numbers of spawning adults and young, but chemical treatment has not yet been implemented in the Yampa River. Adult smallmouth bass are effectively captured with boat electrofishing on rocky shoreline spawning areas, and large numbers of young are captured and displaced with electric seines. Adults can be forced to abandon their nests and recently hatched young can be displaced through physical disturbance with outboard motors. These actions will continue to be implemented and evaluated, and may be adjusted as new, more effective techniques are revealed.

Tactic D.—Implement and Comply with Basin-Wide Nonnative Fish Management Policy.

Action D-1. Support the Nonnative Fish Management Policy. The Recovery Program and its partners continue to support the Nonnative Fish Management Policy and agree that nonnative fish management is essential to achieve and maintain recovery of the endangered fishes. No adjustments are proposed for this action.

III. Early Detection and Reporting

Early detection and reporting of new species or sudden expansions of invasive aquatic species are important in preventing new problematic species from becoming established or sudden increases in distribution and abundance of existing species.

Tactic E.—Develop a Reporting System for New Species and for Sudden Expansion of Existing Species.

Action E-1. Establish a protocol for actions on new species. The Nonnative Fish Coordinator of the Recovery Program will develop a protocol for actions to be taken when a new aquatic species is reported in the Yampa River or when a sudden expansion of an existing species is reported. The protocol should include recommended actions to be approved by the Biology Committee. This is a new action for the Recovery Program.

Tactic F.—Establish and Maintain Communications with Other Programs.

Action F-1. Communicate and collaborate with agencies and programs that report on new invasive species across the United States. The Recovery Program's Nonnative Fish Coordinator will monitor the progress of invasive aquatic species in the United States and into the Upper Colorado River Basin by maintaining communications and collaboration with state and federal agencies, conservation programs, and task forces and groups that monitor invasive species. Included are such groups as the Lower Colorado River Multi-Species Conservation Program, Grand Canyon Monitoring and Research Center, USGS Nonindigenous Aquatic Species Program, Aquatic Nuisance Task Force, and Executive Order 13112 and the National Invasive Species Council Management Plan. This is not altogether a new action for the Recovery Program, as the program is in contact with these and other programs over various issues.

IV. Information and Data Management

A reliable and accessible data repository and reporting system is vital to assimilating information that leads to objective, science-based decisions on nonnative fish management consistent with the principles of adaptive management.

Tactic G.—Facilitate the Transfer and Assimilation of Data and Reports.

Action G-1. Maintain data archive and establish a standardized database. Data collected in the Upper Colorado River Basin are provided annually to a database manager with the U.S. Fish and Wildlife Service (USFWS). Data from nonnative fish removal projects will continue to be submitted annually to this data archive as required by the Recovery Program. As an adjustment to this action, the individual investigator datasets will be joined into one or more standardized datasets to facilitate data analyses. One such dataset will incorporate all tagging

data and associated information. Other datasets may incorporate movement data, mark-recapture data, removal data, etc. A standardized database will facilitate analysis and information tracking, as well as development of synthesis reports.

Action G-2. Maintain a peer-reviewed reporting system for all reports generated by Recovery Program funds. All Recovery Program reports are peer-reviewed and evaluated for approval by the Biology Committee and posted on the Recovery Program's web page. No adjustments are proposed for this action.

Action G-3. Periodically synthesize work. Periodic syntheses of data help to assimilate information and provide a consolidated assessment of the effectiveness of nonnative fish management in the Yampa River. Each investigator will provide a Level I synthesis report to assimilate their data and findings for a particular reach of river. The Recovery Program will further assimilate this information into a Level II synthesis report for a basin-wide and population scale analysis of the effectiveness of nonnative fish management on the Yampa River. The first round of these Level I synthesis reports will include work for 2003-2006. Level II synthesis reports will be produced in 2008. The Level II synthesis reporting is a new action for the nonnative fish management element of the Recovery Program.

Tactic H.—Insure Coordination and Communication Among Researchers, Managers, and Administrators.

Action H-1. Hold nonnative fish workshops. Workshops help to bring researchers, managers, and administrators together to assimilate data, coordinate efforts, and exchange information. The Recovery Program and the CDOW have coordinated the following workshops: Northern Pike Workshop (2001); Smallmouth Bass Summit (2005), and four Nonnative Fish Workshops (2002, 2005, 2006, 2007). The nonnative fish workshops have been effective for communications and collaboration among researchers, managers, and administrators. Workshops should be held as deemed necessary by the Biology Committee.

Action H-2. Establish a nonnative fish subcommittee. Nonnative fish management is a major element of the Recovery Program, and the concerted effort on the Yampa River requires a standing subcommittee to keep apprised of new and ongoing issues, evaluate progress, help to synthesize information, help to coordinate researchers and projects, and provide guidance on synthesis reports. This subcommittee should provide guidance on the nonnative fish management program for the Yampa River and report to the Biology Committee as needed. This subcommittee should be appointed by and serve under the Biology Committee.

V. Mechanical Removal

Mechanical removal strives to reduce numbers of problematic fish species, affect long-term population viability by suppressing sustainable numbers of fish, and effectively increase native fish populations to promote recovery of the endangered fishes. The first few years of this strategy are dedicated to understanding the magnitude and extent of the problematic species and the capability of existing mechanical removal techniques. Population estimates are generated by marking and releasing fish on the first capture and removing fish on subsequent captures. Periodic population estimates are necessary to assess the size of nonnative fish populations and the effectiveness of removal.

Tactic I.—Develop and Implement a Coordinated Effort for Mechanical Removal of Nonnative Fish in the Yampa River.

Action I-1. Identify removal reaches and responsibilities. The Yampa River has been divided into three reaches with defined responsibilities: (1) Lower Yampa River: Yampa Canyon (USFWS—Vernal, UT), (2) Middle Yampa River: Deerlodge Park to Craig (CDOW—Grand Junction, CO; Larval Fish Laboratory—Fort Collins, CO), and (3) Upper Yampa River: Craig to Hayden (USFWS—Vernal, UT). No adjustments are proposed for this action, although the reaches or responsibilities may be changed by the Biology Committee, as needed.

Action I-2. Identify the most problematic species. The most problematic fish species in the Yampa River have been identified as smallmouth bass and northern pike. Other species, such as channel catfish (*Ictalurus punctatus*) or white sucker (*Catostomus commersonii*), may be identified as problematic or existing species may be dropped from the list as populations are deemed to be adequately controlled. The Nonnative Fish Coordinator of the Recovery Program will keep apprised of species status on the Yampa River and report any potential changes to the Biology Committee for consideration of alternative actions.

Action I-3. Estimate abundance, status, trends, and distribution of the most problematic species. Mark-recapture population estimates are being used to assess these parameters, although catch rate indices are used where fish are in low abundance or where excessive fish movement occurs between passes. Where possible, mark-recapture population estimates should be used in favor of catch rate indices or other metrics.

Action I-4. Coordinate efforts of field researchers. Researchers are continuously coordinating efforts, knowledge, equipment, and personnel to improve efficiency and effectiveness of nonnative fish removal. Equipment redundancy, sharing, and maintenance are ongoing and important. No adjustments are proposed for this action.

Action I-5. Identify, evaluate, and implement the most effective gear types and associated methods. A variety of gear types and methods have been used to mechanically remove problematic fish from the Yampa River. Boat electrofishing is the most effective method for capturing northern pike and smallmouth bass; the block-and-shock technique is most effective in backwaters and floodplains. Large trap nets are effective in certain enclosed habitats. An electric seine has been implemented to capture juvenile smallmouth bass along shallow rocky shorelines where other gears are less effective. Screening of floodplains used by spawning northern pike was not effective when high spring flows inundated screens and allowed free movement of fish. Evaluation and refinement of gear types and methods are ongoing and new techniques may be introduced as appropriate and necessary.

Action I-6. Solicit outside expertise to identify new removal methods. The Recovery Program and researchers should establish ongoing communications with individuals currently involved in similar nonnative fish control programs on a global basis. This is not altogether a new action for the Recovery Program, as outside expertise is often solicited and received for various program issues.

Tactic J.—Use Problematic Nonnative Fish Where Possible to Provide Public Fishing Opportunities.

Action J-1. Translocate northern pike and smallmouth bass to ponds accessible to the public. The USFWS in cooperation and coordination with the CDOW has been translocating northern pike and smallmouth bass to isolated public fishing waters. The public, especially young anglers have responded positively to this translocation and support the program. However, fish may be escaping from riverside ponds that may become connected to the river at high flows, and berms that separate these ponds from the river will be raised to prevent escapement. Construction of permeable berms may be desirable to allow exchange of water and nutrients.

Action J-2. Properly dispose of all other nonnative fish removed. All target problem fish removed from the river and not translocated to public fishing waters are euthanized and properly and discretely disposed, as allowed by scientific collecting permits. No adjustments are proposed for this action.

VI. Research and Development

Research and development is an ongoing component that is integral to the principles of adaptive management. Research helps to provide a better understanding of the life history of problematic species and helps to develop, evaluate, and refine control methods. Research provides the objective scientific basis for making and refining decisions about future actions.

Tactic K.—Identify Necessary Levels of Removal For Nonnative Fish And Desired Response Levels by Native Fish.

Action K-1. Refine removal criteria for nonnative fish. Interim criteria have been developed by an *ad hoc* committee for northern pike (<2.67/mile on 84 miles of Colorado pikeminnow critical habitat upstream of Yampa Canyon) and smallmouth bass (<30 adults/mile in main channel on 24 miles of critical habitat upstream of Yampa Canyon, 10-30% YOY composition in low-velocity habitats) in the Yampa River and approved by the Biology Committee. These criteria are being evaluated and will be revised as new information is gathered to identify the level of population reduction necessary to affect long-term viability of problem species.

Action K-2. Refine response criteria for native fish. Interim response criteria have been developed by an *ad hoc* committee for native and endangered fishes in the Yampa River and approved by the Biology Committee (small-bodied natives should be 2-10% of fish composition in connected low velocity habitats). These criteria are being evaluated and will be revised as new information is gathered on long-term viability of native and endangered species.

Action K-3. Evaluate adequacy of existing removal efforts. Based on the Biology Committee's evaluation, it may be necessary to expand or focus the geographic scope of current removal efforts to affect a greater proportion of a target population or a specific life stage. Exploitation models may be helpful in making this evaluation. Reallocation of effort may require reduced efforts of lower priority projects in order to make personnel and/or funds available to affect concentration areas or source populations.

Tactic L.—Evaluate Responses by Target Nonnative Fish and Native Fish.

Action L-1. Monitor effectiveness of nonnative fish removal. The distributions and abundances of problematic fish are being monitored through removal efforts and population estimates to determine if target removal criteria are being achieved. Criteria are expressed as numbers of fish per mile and whenever possible, abundance of nonnative fish will be determined with mark and recapture population estimators.

Action L-2. Monitor responses of native and endangered fishes. Abundances of endangered fishes are being monitored through ongoing Recovery Program monitoring to determine if target response criteria are being achieved. Distributions and abundances of other native fish species are evaluated as by-catch of the monitoring program and this removal strategy. Criteria for other native species are expressed as a percentage of the fish community and abundance will be similarly expressed through this Strategy.

Tactic M.—Explore and Evaluate Additional Fisheries Techniques to Improve Fish Removal and Data Evaluation.

Action M-1. Make full use of available fisheries tools and methods to strengthen data analyses and interpretation. Researchers in the upper basin should make full use of a number of fisheries software programs to facilitate routine analyses and enable more advanced analyses of data. Techniques used to evaluate high seas fisheries, such as exploitation models, are being tested and evaluated to identify the level of reduction necessary so that the population is no longer able to recruit and sustain itself. Data collected on nonnative fish control will be more thoroughly evaluated to gain a better understanding of how to more effectively assess control means and implement new and more effective methods. Exploitation models have been developed and are being evaluated for smallmouth bass and may be appropriate for northern pike.

Action M-2. Investigate and evaluate ecosystem response models. Ecosystem models such as Ecopath and Ecosim are being used in other systems (e.g., Grand Canyon) to evaluate responses by various species to management or to other ecosystem changes. Upper basin researchers should determine if these models can provide insight into effects of nonnative fish removal on other species or certain components of the ecosystem.

Tactic N.—Investigate Other Opportunities to Remove, Deplete, or Otherwise Disadvantage Target Nonnative Species.

Action N-1. Investigate and evaluate the use of rivers flows and temperatures. Sudden increases or decreases in river flow or water temperature can disrupt spawning and survival of embryo smallmouth bass and other nonnative fish species. Further investigations, possibly laboratory studies, are needed to determine if fish can be disadvantaged with spike flows to cause adults to abandon nests, injure or kill embryos, and cause females to reabsorb their eggs. Before this action is implemented, there should be a scientific analysis of life history of the target nonnative fish species, the necessary flows and temperatures, and the timing, shape, duration, and frequency of desired flows. This may lead to an assessment of coordinated reservoir operations to determine water availability for special releases.

Action N-2. Investigate and evaluate the use fish attractants. Pheromones and scented baits can be used to attract and capture large numbers of target fish species. Use of these attractants are being investigated and evaluated by other programs world-wide. The Recovery Program will keep apprised of advancements in these techniques and opportunities to apply these in the wild.

Action N-3. Investigate and evaluate the use of species-specific pathogens or genetic manipulations. Research is being conducted in Australia, Europe, and the United States on development of pathogens that can create species-specific

epizootics to reduce particular fish populations. Research is also being conducted to develop genetically altered or sterile fish for release into the wild to cause reproductive failure of a population. These methods have not sufficiently developed for broad scale use in the wild and the Recovery Program will continue to monitor their development.

Action N-4. Evaluate and implement the use of chemical piscicides. Piscicides can be used to kill problematic fish in concentrations, on spawning beds, or at susceptible life stages. Rotenone, antimycin, and cyanide may be effective chemical treatments if used in proper enclosed settings with appropriate permitting and safety measures. Researchers will develop site-specific plans for approval by the Biology Committee and the CDOW before applying piscicides in the Yampa River.

Timeframe for Implementing Actions and Adjustments

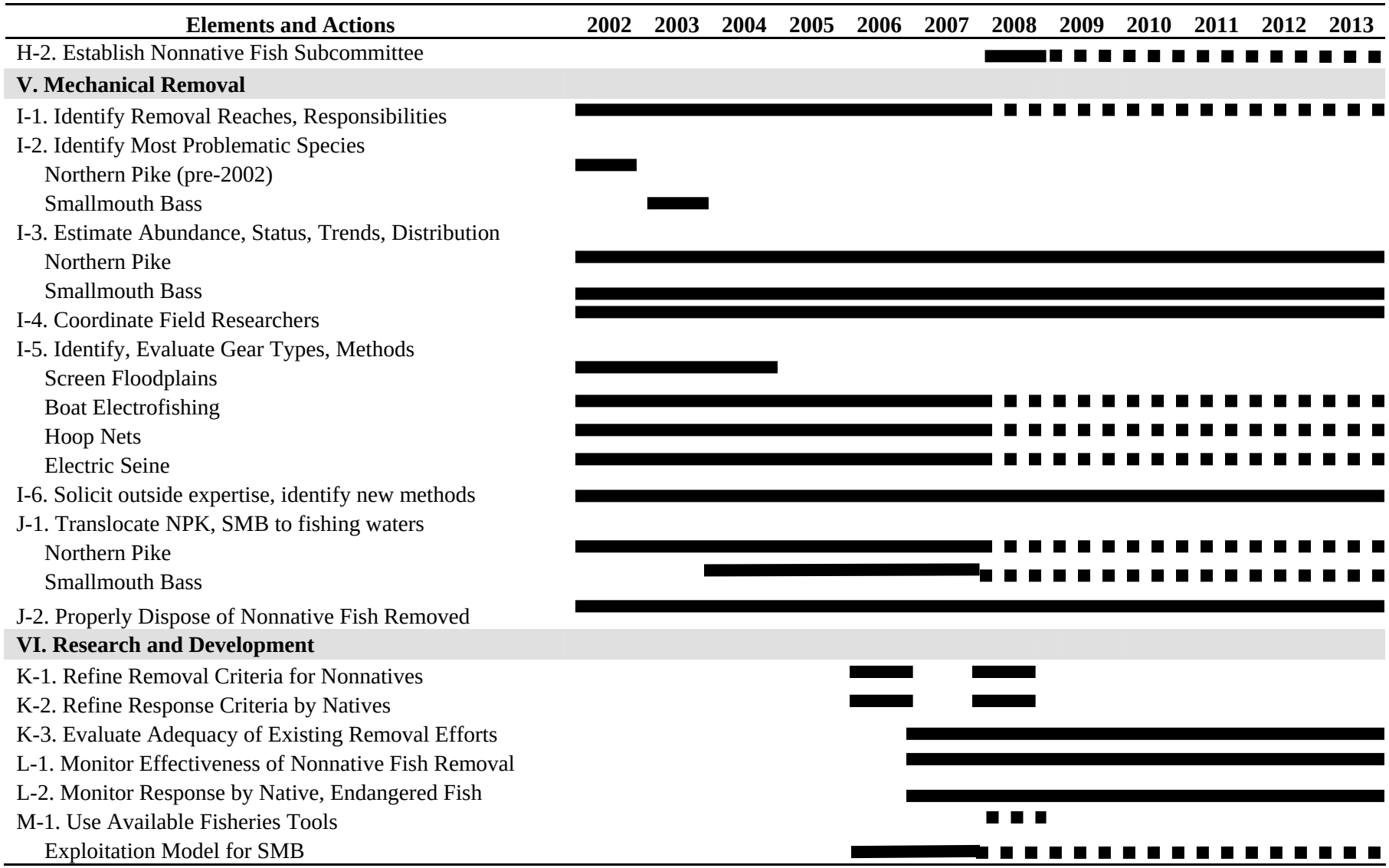
A timeframe for the actions and adjustments described previously is presented in Table 1. Many of the actions described herein have been previously implemented and this timeframe is retroactive to 2002 and extends through 2013. Although funding for the Recovery Program continues through 2010 under legislation passed in October 2000 (Upper Colorado and San Juan River Basins Recovery Implementation Program Act; P.L. 106-392), Recovery Program partner agreements extend to the year 2013.

The two actions under Information and Education are ongoing, and the only adjustment is an outreach effort to angler groups that use the middle and upper Yampa River as a sport fishery to inform them of this program and to identify and address their concerns over removal of northern pike and smallmouth bass. Of the eight Prevention actions, all are ongoing with some refinements, except for establishment of the Yampa River as a conservation area downstream of Craig. This action would need to be taken under consideration by the State of Colorado. The targeting of sensitive life stages of nonnative fish should continue to affect overall populations, and proper management (including isolation) of upstream floodplains will help to minimize sources of nonnative fish to downstream critical habitat. Isotope technology shows promise for tracing natal areas and recent occupancy of problematic fish and should continue to be implemented and evaluated. The two actions under Early Detection and Reporting are new or ongoing responsibilities of the Nonnative Fish Coordinator for the Recovery Program. An adjustment to the early detection action is establishment of a protocol when new or expanding species are reported.

Five actions are identified under Information and Data Management. These actions identify the need for a standardized database to facilitate data analyses and synthesis reporting. These actions also identify the need for Level I and II synthesis reports that provide a comprehensive assessment of the nonnative fish management program for the Yampa River. The first Level I synthesis reports were completed in 2007 for the work conducted during 2003-2006, and the first Level II reports will be completed in 2008.

Table 1. Timeframe for nonnative fish control actions and adjustments on the Yampa River. Ongoing actions are shown as solid bars and actions that undergo ongoing evaluation are shown as broken bars.

Elements and Actions	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
I. Information and Education												
A-1. Develop, Implement I&E Program	■	■	■	■	■	■	■	■	■	■	■	■
A-2. Secure Landowner Access	■	■	■	■	■	■	■	■	■	■	■	■
II. Prevention												
B-1. Regulate Transport of Fish	■	■	■	■	■	■	■	■	■	■	■	■
B-2. Enforce Regulations on Illicit Stocking of Fish	■	■	■	■	■	■	■	■	■	■	■	■
B-3. Evaluate Conservation Area Below Craig								▪	▪	▪	▪	▪
C-1. Monitor, Maintain Screen at Elkhead Reservoir					■	■	■	■	■	■	■	■
C-2. Utilize Isotope Technology			■	■	■	■	■	■	■	■	■	■
C-3. Remove NPK, SMB Above Craig						■	■	■	■	■	■	■
C-4. Target Spawning Areas												
Northern Pike	■	■	■	■	■	■	■	■	■	■	■	■
Smallmouth Bass					■	■	■	■	■	■	■	■
D-1. Support Nonnative Fish Management Policy	■	■	■	■	■	■	■	■	■	■	■	■
III. Early Detection and Reporting												
E-1. Establish Protocol for New Species Invasions							■	■				
F-1. Collaborate with Other Invasive Species Groups							■	■	■	■	■	■
IV. Information and Data Management												
G-1. Maintain Data Archive and Establish Database	■	■	■	■	■	■	■	■	■	■	■	■
G-2.Maintain Peer Review of Reports	■	■	■	■	■	■	■	■	■	■	■	■
G-3. Periodically Synthesize Reports												
Level I Synthesis Reports						■	■			▪	▪	▪
Level II Synthesis Reports							■	■	▪	▪	▪	▪
H-1. Hold Nonnative Fish Workshops	■			■	■	■	▪	▪	▪	▪	▪	▪


Elements and Actions
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
H-2. Establish Nonnative Fish Subcommittee
V. Mechanical Removal
I-1. Identify Removal Reaches, Responsibilities
I-2. Identify Most Problematic Species
Northern Pike (pre-2002)
Smallmouth Bass
I-3. Estimate Abundance, Status, Trends, Distribution
Northern Pike
Smallmouth Bass
I-4. Coordinate Field Researchers
I-5. Identify, Evaluate Gear Types, Methods
Screen Floodplains
Boat Electrofishing
Hoop Nets
Electric Seine
I-6. Solicit outside expertise, identify new methods
J-1. Translocate NPK, SMB to fishing waters
Northern Pike
Smallmouth Bass
J-2. Properly Dispose of Nonnative Fish Removed
VI. Research and Development
K-1. Refine Removal Criteria for Nonnatives
K-2. Refine Response Criteria by Natives
K-3. Evaluate Adequacy of Existing Removal Efforts
L-1. Monitor Effectiveness of Nonnative Fish Removal
L-2. Monitor Response by Native, Endangered Fish
M-1. Use Available Fisheries Tools
Exploitation Model for SMB

Elements and Actions	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Exploitation Model for NPK							■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■
M-2. Investigate, Evaluate Ecosystem Models							■ ■ ■	■ ■ ▪				
N-1. Investigate, Evaluate Use of Flows, Temperatures							■ ■ ■	■ ■ ▪				
N-2. Investigate, Evaluate Fish Attractants							■ ■ ■	■ ■ ▪				
N-3. Investigate, Evaluate Pathogens, Genetics							■ ■ ■	■ ■ ▪				
N-4. Investigate, Implement Chemical Piscicides							■ ■ ■	■ ■ ▪				

Progress reports on this Strategy will be made annually to the Biology Committee and at the Upper Colorado River Basin Researcher's Meeting. The effectiveness of the control actions described in this Strategy will be evaluated annually and the Strategy will be refined and updated as needed. Nonnative fish workshops are recognized as a valuable forum for integrating results of individual projects and for coordinating future work. Annual workshops may not be necessary and should be held as needed and as determined by the Biology Committee. A significant action of this element is the establishment of a Nonnative Fish Subcommittee under the direction of the Biology Committee to help coordinate researcher activities, data synthesis and analysis, and reports.

Mechanical Removal is the core of this strategy and consists of eight actions, all of which are ongoing. The Yampa River has been divided into three reaches, each with responsible parties designated for fish removal. Removal gears and methods continue to be evaluated to achieve maximum efficiency. When possible, northern pike and smallmouth bass are translocated to public fishing waters to provide recreational fishing opportunities. All of the 11 actions under Research and Development are new or adjusted actions. Interim criteria for northern pike and smallmouth bass and for native fish were developed in 2006 and are currently being evaluated. These may be refined or expanded as more is learned about the life history of these species or as new information comes forth from an exploitation model adopted for smallmouth bass. This model will enable researchers to predict the level of population reduction necessary to cause recruitment failure of smallmouth bass. Also, responses by native species are being evaluated. The use of flows and temperatures to disadvantage target nonnative fishes needs to be defined and designed before implementing. Chemical piscicides should be applied only in enclosed areas with proper permitting and precautions. Fish attractants such as hormones or strong food baits have not been tested in the Yampa River to attract and capture large numbers of fish. Species-specific pathogens and genetically altered or sterile fish are in the developmental stages elsewhere and their development will continue to be monitored by the Recovery Program.

Uncertainties, Risks, and Contingencies

The following are uncertainties, risks, and contingencies as to the effectiveness of this Strategy:

1. Invasion by new species or sudden expansion of existing species.—Invasions of new species or sudden expansions of existing species that are reported by researchers or the public will be evaluated by the Nonnative Fish Coordinator and appropriate actions will be taken through the Biology Committee. The ongoing removal program in the Yampa River should be able to detect new fish species, but other invasive aquatic species, such as crayfish, zebra mussels, or quagga mussels, may not be readily detected and current monitoring programs do not evaluate the abundances, distributions, or effects of these species.

2. Effect of mechanical removal on population viability.—The effect of mechanical removal on nonnative fish population viability continues to be evaluated. Year-to-year variation in populations of northern pike and smallmouth bass tend to confound the effects of removal and these need to be distinguished. The level of mechanical removal necessary to affect population self-sustainability is not known for any species, but it is believed that sustained removal will deplete overall population numbers. Exploitation models have been developed for smallmouth bass and are being evaluated as a tool to determining necessary levels of removal. If the current level of mechanical removal does not achieve target criteria, it will be necessary to substantially expand mechanical removal with larger numbers of crews and more and different equipment. If mechanical removal is not effective, it may be necessary to apply piscicides on controlled reaches of the Yampa River. This action could require removing native fish from the reach and stringent control of the piscicide and detoxification stations.

3. Time required to control problematic nonnative fish.—Exploitation models predict that the minimum annual removal rates needed to cause a long-term reduction in population size of smallmouth bass exceed 60%. Using the minimum exploitation rate as our target (30 fish per mile), the approximate time period needed to cause a population crash was 20 years. However, if exploitation rates were increased to remove 85% of adult smallmouth bass, the period required to create a population crash could be reduced to almost 8 years. These preliminary model outputs were based on less than 5 years of exploitation data from the Yampa River. Researchers are increasing exploitation rates and will be able to better assess the time necessary to achieve removal criteria with additional data from the ongoing removal program.

4. Compensatory response by target species.—Fish populations can compensate to reductions in numbers by increasing their reproductive success and survival of young because of a greater food supply and available habitat. Hence, target populations can increase in numbers of young fish following removal, but it is believed that sustained removal can eventually affect this reproductive capacity and deplete the overall population.

5. Response by native and endangered fishes.—The response by native and endangered fish populations to management actions may take a number of years to occur and can be difficult to detect. This nonnative fish control strategy is based on the assumption that native and endangered fish populations will benefit from removal of nonnative fish. The interim criterion for small-bodied native fishes is 2-10% of fish composition in connected low velocity habitats. If endangered fish populations become too low, it may be necessary for the Recovery Program to remove fish from the wild for culture in hatchery facilities and subsequent augmentation of wild stocks with hatchery fish. Approximately 400 juvenile chub (a mix of humpback chub and roundtail chub) were removed from Yampa Canyon in October 2007 and translocated to two hatcheries. The decision to remove or augment wild populations will be made by the Recovery

Program through the Biology Committee.

6. Minimize source populations.—Sources of northern pike and smallmouth bass, especially those located upstream of Craig are being targeted with various management methods including screening of Elkhead Reservoir, removal of northern pike from Catamount Reservoir, and reductions of northern pike in riverside floodplains. The effectiveness of these actions has not been evaluated.

7. Concerns by anglers.—Anglers and fishing guides use the upper and middle reaches of the Yampa River as a sport fishery for northern pike and smallmouth bass and are concerned over the removal of these fish from the river. Public relations will need to reach out to angler groups to provide information on this Strategy and to understand their concerns over removal of fish from the river. In the upper Yampa River, angler groups support the removal of northern pike to enhance the trout fishery.

8. Effect of other nonnative fish.—The effect of other nonnative fish in the Yampa River is not fully known. The best available scientific information indicates that northern pike and smallmouth bass currently pose the greatest threat to native and endangered fish species. Channel catfish have been identified in the past as a potential threat, but it is recognized that this species has been in the Upper Colorado River Basin for nearly 75 years. Also, small-bodied cyprinids, such as red shiner (*Cyprinella lutrensis*) and fathead minnow (*Pimephales promelas*) are known predators and competitors of young native fish. Furthermore, it is recognized that the white sucker hybridizes with native suckers and affect genetic viability. These species are not currently targeted for control and may be removed as by-catch to other efforts.

9. Time at which to stop removal or reallocate effort.—Removal of smallmouth bass from the middle Green River has reduced numbers to a point at which additional removal is no longer economically beneficial. The time at which removal effort should stop or be reallocated has not been determined. The decision to stop or reallocate effort should be made by the Biology Committee based on information presented by the principal investigators.

APPENDIX A: Overview of Control Actions

Coordinated efforts to control nonnative fish in the Yampa River began in 2004 in each of the three reaches identified in Figure A-1: (1) Lower Yampa River: Yampa Canyon, (2) Middle Yampa River: Deerlodge Park to Craig, and (3) Upper Yampa River: Craig to Hayden.

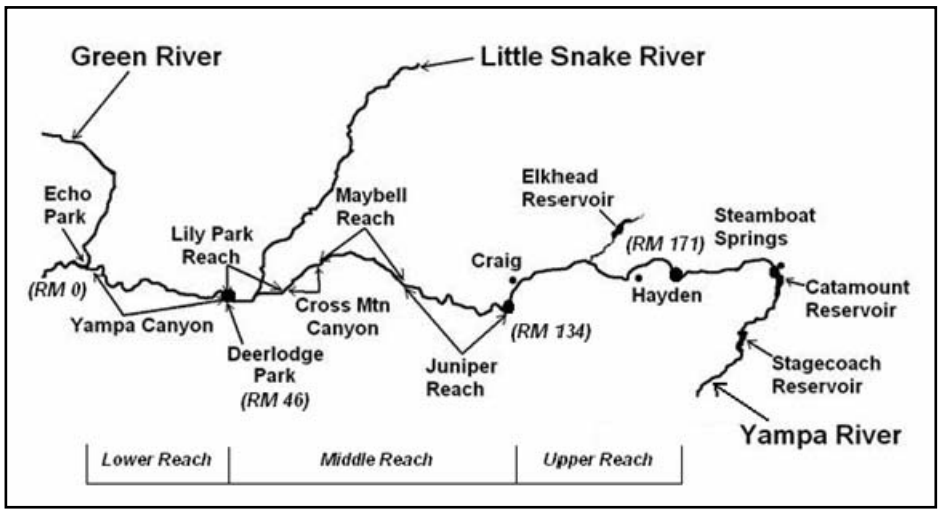


Figure A-1. Prominent land marks and the three reaches of the Yampa River.

In the lower Yampa River, 2,989 and 1,914 smallmouth bass were removed from 2004 to 2006 with an apparent depletion effect that reduced the annual density from about 25 to 10 fish/hour of electrofishing (Figure A-2). From 2,402 to 7,254 channel catfish were removed annually, but no depletion effect was shown. Annual density of channel catfish varied from 23 to 40 fish/hour of electrofishing. Between Northern pike are found in small numbers in the lower Yampa River and are removed as by-catch to other removal efforts.

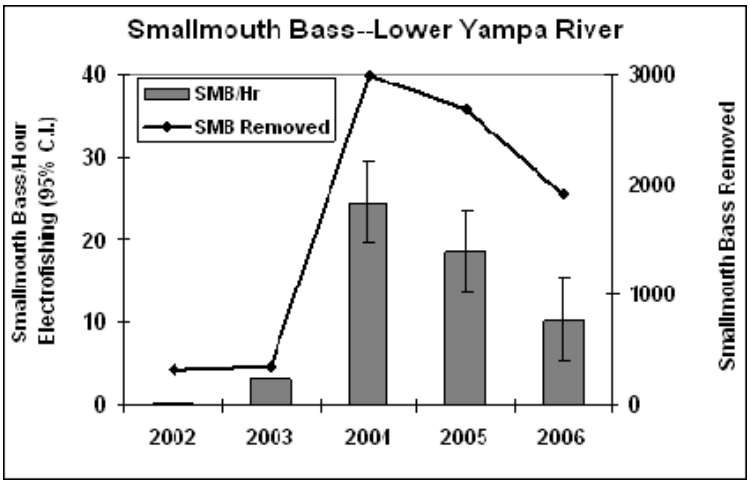


Figure A-2. Electrofishing catch rate and total smallmouth bass removed from the lower Yampa River. Data from Fuller, M.H, and B. Haines. 2007. Lower Yampa River Channel Catfish and Smallmouth Bass Control Program, Colorado, 2001-2006. Synthesis Report.

In the middle Yampa River (Figure A-3), 410 to 660 northern pike were removed in 2004 and 2005, and the population declined from 974 to 650 between 2004 and 2006. Although up to 1,852 smallmouth bass were removed in 2005, the numbers remained between 406 and 894 with no apparent sign of a decline. Channel catfish are found in small numbers in the middle Yampa River and are removed as bycatch to other removal efforts.

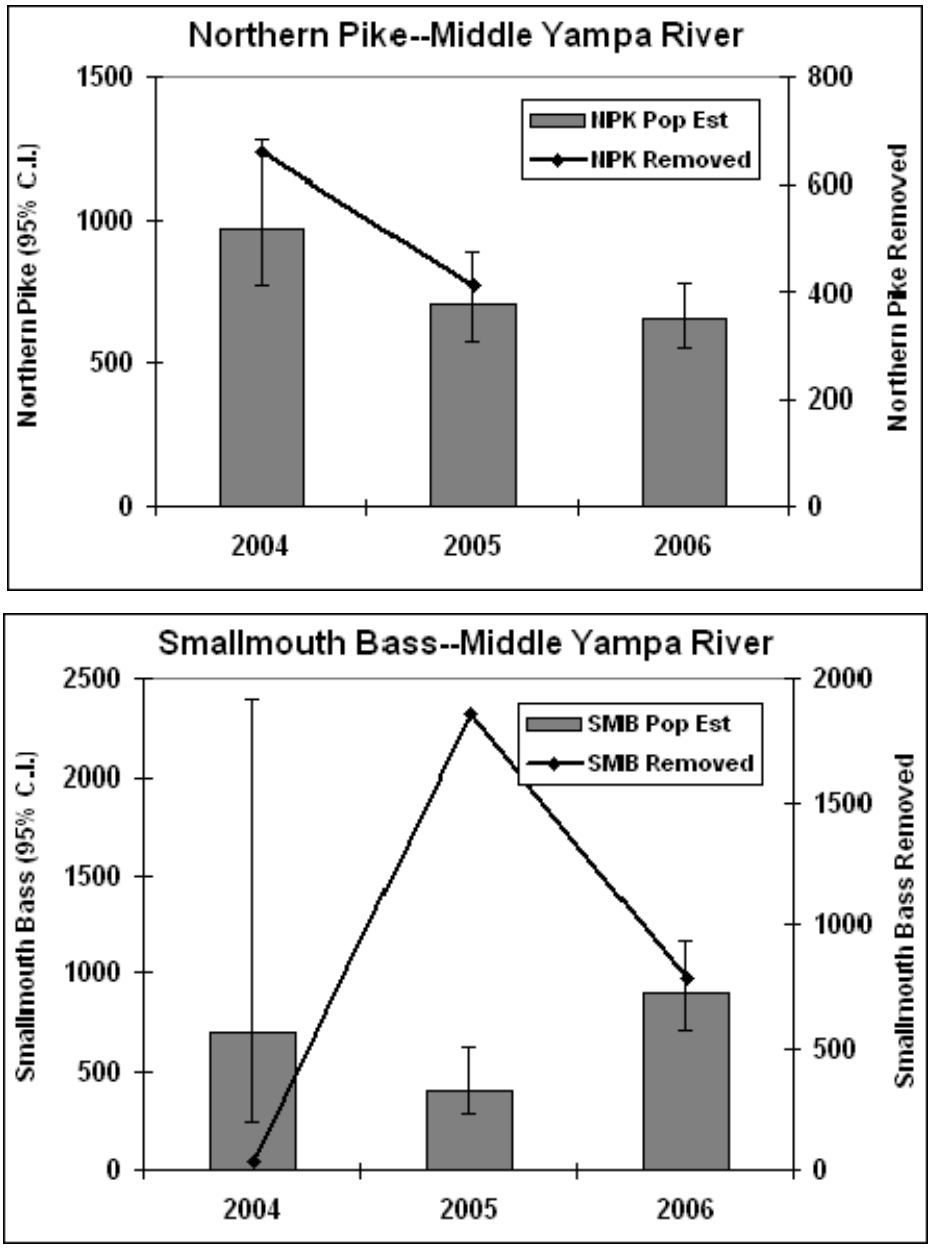


Figure A-3. Mark-recapture population estimates and total number of fish removed from the middle Yampa River for northern pike (top) and smallmouth bass (bottom). Data from Martin, L.M. 2005. Middle Yampa River northern pike removal and evaluation. FY 2005 Annual Report Project Number: 98a.

In the upper Yampa River (Figure A-4), 452 to 1,002 northern pike were removed from 2004 to 2006 with a significant reduction from 1,755 to 717 between the first and last years. About 320 smallmouth bass were captured but not removed in 2004 and 34 and 68 in 2005 and 2006; nevertheless, a significant decline occurred that reduced population estimates from 1,469 in 2004 to numbers too small to estimate in 2005 and 2006. Channel catfish are not found in the upper Yampa River.

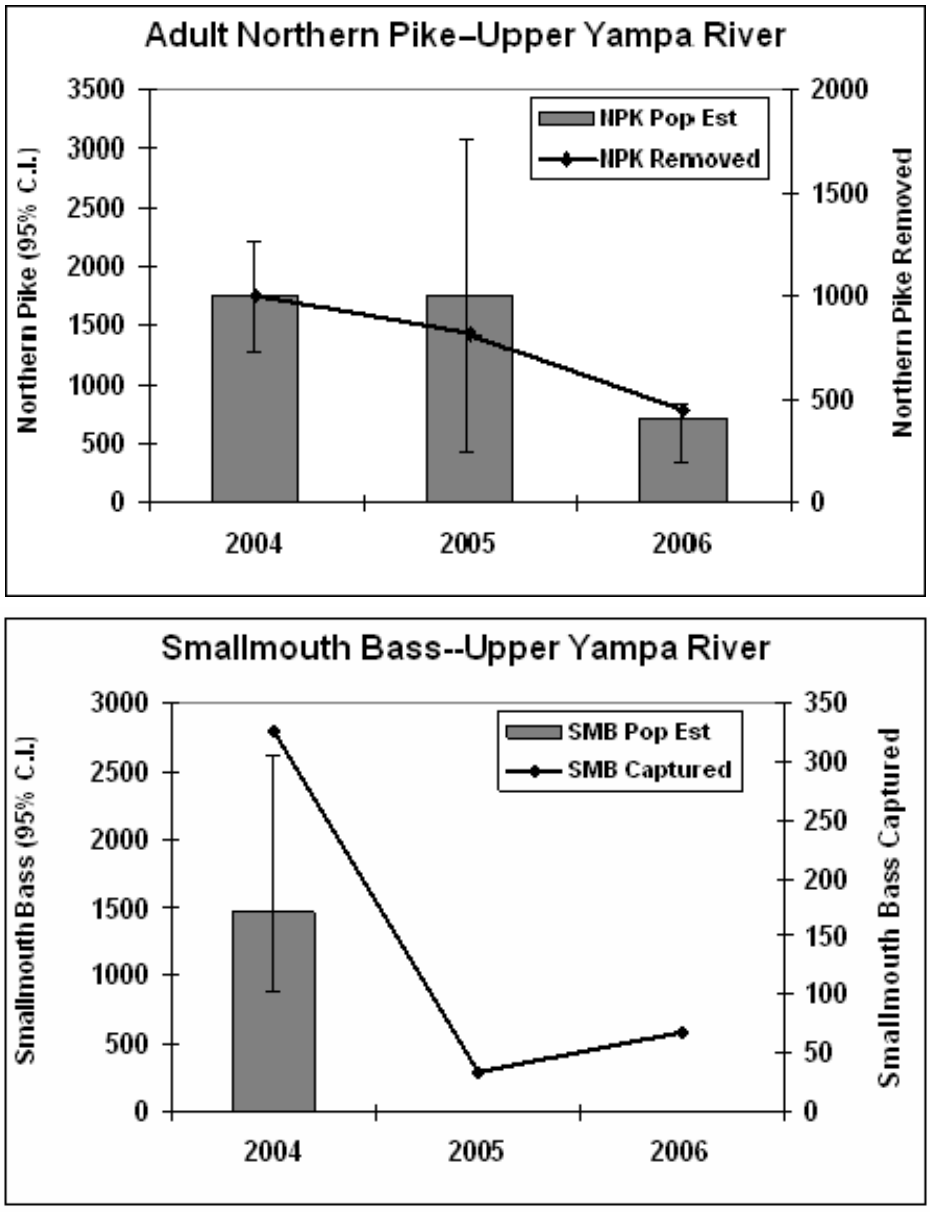


Figure A-4. Mark-recapture population estimates and total number removed for northern pike (top) and mark-recapture estimates and total number captured for smallmouth bass (bottom) in the upper Yampa River. Data from Finney, S.T., and B. Haines. 2007. Northern Pike Removal, Smallmouth Bass Monitoring, and Native Fish Monitoring in the Hayden to Craig Reach, Yampa River, 2004-2006. Synthesis Report, Project No. 98b.