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United States Department of the Interior

FISH AND WILDLIFE SERVICE

Mountain-Prairie Region

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TAKE PRIDE IN AMERICA

DEC 1992

Memorandum

To: Regional Director, Bureau of Reclamation, Upper Colorado Regional Office, Salt Lake City, Utah

From: Regional Director, Region 6
U.S. Fish and Wildlife Service
Denver, Colorado

Subject: Errata to Final Biological Opinion for the Operation of Flaming Gorge Dam (November 25, 1992)

Please make the following correction. Page 30, line 5, change the sentence which reads:

> "For example, if 1,600 cfs is selected as the target flow, then flows as measured at Jensen will remain between 1,350-1,800 cfs; or if a target of 1,300 cfs is selected, then flows will remain between 1,100-1,625 cfs."

to read as follows:

> "For example, if 1,600 cfs is selected as the target flow, then flows as measured at Jensen will remain between 1,200-1,800 cfs; or if a target of 1,300 cfs is selected, then flows will remain between 1,137.5-1,462.5 cfs."

/S/ [illegible] L. [illegible] Jr.

cc: Director, FWS, Washington, D.C.
Assistant Director, FWE, Washington, D.C.
Western Area Power Administration, Salt Lake City, UT
Regional Solicitor, Denver, CO
Field Supervisor, FWE, Salt Lake City, UT

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Memorandum

To: Regional Director, Bureau of Reclamation, Upper Colorado Regional Office, Salt Lake City, Utah

From: Regional Director, Region 6
U.S. Fish and Wildlife Service
Denver, Colorado

Subject: Final Biological Opinion for the Operation of Flaming Gorge Dam

This memorandum transmits the Fish and Wildlife Service's final biological opinion (attachment) on the operation of Flaming Gorge Dam.

Your active participation in recovery and protection of endangered fish is greatly appreciated. If you have any questions concerning aspects of this biological opinion, feel free to contact Jim Lutey, Fish and Wildlife Enhancement, at (303) 236-8186.

Attachment

cc: Director, FWS, Washington, D.C.
Assistant Director, FWE, Washington, D.C.
Western Area Power Administration, Salt Lake City, UT
Regional Solicitor, Denver, CO
Field Supervisor, FWE, Salt Lake City, UT

U.S. FISH AND WILDLIFE SERVICE
FINAL
BIOLOGICAL OPINION
ON THE
OPERATION OF
FLAMING GORGE DAM

NOVEMBER 25, 1992

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INTRODUCTION AND BACKGROUND

[redacted] (Western Power) became a party to this consultation, with Reclamation remaining the lead agency.

Coincident with issuance of the Biological Opinion for the Strawberry Aqueduct and Collection System (Strawberry System) dated February 27, 1980 (subsequently amended on August 31, 1990), Section 7 consultation began on the continued operation of Flaming Gorge Dam. The Strawberry System biological opinion determined that depletions in the amount of 108,000 acre-feet from the Duchesne and Green Rivers would be "likely to jeopardize the continued existence of the Colorado squawfish and humpback chub." The 1978 amendments to the Endangered Species Act (Act) allowed for development of a reasonable and prudent alternative if a jeopardy opinion was issued. The reasonable and prudent alternative for the Strawberry System was that Flaming Gorge Dam and reservoir would compensate for those depletions and would be operated for the benefit of endangered fish.

Jeopardy opinions also were issued for the Upalco, Jensen, and Uinta projects of the Central Utah Project during the late 1970's and early 1980's. The reasonable and prudent alternative for each of these jeopardy opinions was reoperation of Flaming Gorge Dam to provide flows required for endangered fish. In addition, the Service stated that it would further evaluate and recommend flows needed by the endangered fish in a biological opinion for the continued operation of Flaming Gorge Dam. Biological opinions issued for the Narrows Project (March 25, 1992) and the Price-San Rafael Salinity Control Project (February 4, 1992) also are linked to this opinion. As stated in the Narrows Project Opinion "Acceptance and implementation of the reasonable and prudent alternative in that [Flaming Gorge] biological opinion will constitute progress under the Recovery Program to offset the impacts of the Narrows Project . . . . In the event that the reasonable and prudent alternative in the Flaming Gorge final draft biological opinion is not accepted or implemented by the time construction . . . of the Narrows Project begins, additional measures may be required to offset the effects of this depletion." Similar language is contained in the Price-San Rafael Salinity Control Project biological opinion.

After completion of the Strawberry System opinion, the Service and Reclamation determined that insufficient data existed on flow requirements of endangered Colorado River fish and that a biological opinion on the continued operation of Flaming Gorge Dam should not be issued until further studies were conducted. From 1980-1991 there was a series of agreements between the Service and Reclamation delaying the issuance of a biological opinion until studies were completed and enough scientific data collected to recommend specific flows. Flows within the operational criteria for Flaming Gorge Dam, without special considerations for the Colorado River fish, were evaluated from 1979-1984. This was followed by an interim flow agreement which constrained summer flows to benefit the fish; these constrained flows were studied from 1985-1991.

This biological opinion is being issued by the Service consistent with the provisions of the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin (Recovery Program) (U.S. Fish and Wildlife Service 1987). The Recovery Program was formally endorsed by the Secretary of the Interior (on behalf of the Service and Reclamation); the Governors of Colorado, Utah, and Wyoming; and the Administrator of Western Power in January 1988. The purpose of the Recovery Program is to recover the endangered fish while allowing water development to proceed in the Upper Colorado River Basin consistent with the Act. The Recovery Program contains five principal elements or strategies for recovering the endangered fish in the Upper Basin: habitat management (provision of instream flow); habitat development and maintenance; stocking of native fish; nonnatives fish and sport fishing; and research, monitoring, and data management. Refining the operation of Flaming Gorge Dam is identified as one of the principal habitat management strategies for recovering the endangered fish in the Green River. The following excerpts from the Recovery Program are pertinent to the Section 7 consultation on Flaming Gorge:

> "The water resource development projects constructed in the Upper Basin by Reclamation may have significantly and adversely affected the river system's rare fish species. In addition to the mechanism described in the preceding sections, there are ways to support essential habitat areas through the refined operation of these reservoirs to reduce or eliminate those adverse impacts and contribute to recovery in a manner consistent with all applicable laws." (page 4-8)
>
> "Reclamation and the Service will make every effort to complete Section 7 consultation on the operation of Flaming Gorge Dam during 1989. The parties will develop a release schedule that treats conservation of the endangered fish species as a firm constraint on release patterns from Flaming Gorge. Upon completion of consultation, Reclamation will adopt alternatives or recommendations jointly developed with the Service." (page 4-10).

Accordingly, refining the operation of Flaming Gorge to benefit the endangered fish and completion of the biological opinion has been given a high priority under the Recovery Program. Since 1985, Reclamation has operated Flaming Gorge to provide flows in the Green River that enhance survival and growth of young Colorado squawfish. In addition, numerous studies were funded through the Recovery Program to better understand the effects of Flaming Gorge Dam on the endangered fish and their habitat. These studies provided information that was critical in the formulation of this biological opinion.

In accordance with Section 7 of the Act (16 U.S.C. 1536) and its regulations (50 CFR 402 et seq.), we transmit the Service's biological opinion for the continued operation of Flaming Gorge Dam on federally listed endangered species.

The bald eagle (Haliaeetus leucocephalus), peregrine falcon (Falco peregrinus), and Ute ladies'-tresses orchid (Spiranthes diluvialis) also are addressed in this biological opinion.

BIOLOGICAL OPINION

Based upon the best scientific and commercial information currently available, it is the Service's biological opinion that the continued operation of Flaming Gorge Dam, as described below, is likely to jeopardize the continued existence of the endangered Colorado squawfish (Ptychocheilus lucius), humpback chub (Gila cypha), bonytail chub (Gila elegans), and razorback sucker (Xyrauchen texanus) by appreciably reducing the likelihood of both the survival and recovery of these species in the wild by further reducing their numbers, reproduction, or distribution.

Elements of a reasonable and prudent alternative, that in the opinion of the Service, will avoid the likelihood of jeopardy to the endangered Colorado River fish are based, in part, on the reoperation of Flaming Gorge Dam and include:

1. Refinement of the operation of Flaming Gorge Dam so that flow and temperature regimes of the Green River will more closely resemble historic conditions.

2. Conduct a 5-year research program including implementation of winter and spring research flows beginning in 1992 to allow for potential refinement of flows for these seasons. This research program will be based on the Five-Year Flaming Gorge Flow Recommendations Investigations which are being conducted by the Recovery Program (Appendix B). The program provides for annual meetings to refine seasonal flows based on research findings and water year forecast. Except for specific research flows during the 5-year research program, year-round flows in the Green River will resemble a natural hydrograph described under element 1 of the reasonable and prudent alternative.

3. Determination of the feasibility and effects of releasing warmer water during the late spring/summer period and investigation of the feasibility of retrofitting river bypass tubes to include power generation thereby facilitating higher spring releases.

4. Legal protection of Green River flows from Flaming Gorge Dam to Lake Powell.

5. Initiation of discussions with the Service after the conclusion of the 5-year research program to examine further refinement of flows for the endangered Colorado River fish.

The Service believes implementation of the reasonable and prudent alternative will preclude jeopardy to the endangered fish from the continued operation of Flaming Gorge Dam. Furthermore, it is the Service's biological opinion that

. the current and proposed operation of Flaming Gorge Dam is not likely to affect the continued existence of the bald eagle, peregrine falcon, or Ute ladies'-tresses orchid.

DESCRIPTION OF FLAMING GORGE OPERATION

BACKGROUND

Flaming Gorge Dam, located on the Green River in northeastern Utah, lies approximately 410 river miles upstream from the confluence of the Colorado and Green Rivers. The reservoir extends north into Wyoming with its upper terminus near the town of Green River, Wyoming. At capacity, the reservoir has 42,000 surface acres, is 91 miles long, and has a live storage capacity of 3.75 million acre-feet. Flaming Gorge Dam was authorized by the Colorado River Storage Project Act of 1956, 43 U.S.C. 620. The operation of the Colorado River Basin projects, which includes Flaming Gorge, was further described in the Colorado River Basin Project Act of 1968, 43 U.S.C 1502, which states:

> "This program is declared to be for the purpose, among others, of regulating the flow of the Colorado River; controlling floods; improving navigation; providing for the storage and delivery of the waters of the Colorado River for reclamation of lands, including supplemental water supplies, and for municipal, industrial, and other beneficial purposes; improving water quality; providing for basic public outdoor recreation facilities; improving conditions for fish and wildlife, and the generation and sale of electrical power as an incident of the foregoing purposes."

Construction of the dam and powerplant began in 1956 and was completed in 1964. Filling of the reservoir began in November 1962 and continued through 1966. Full operation of the facility began in 1967. Reservoir releases through the powerplant range from 800 to 4,700 cubic feet per second (cfs). Maximum powerplant releases are constrained by generator output and reservoir elevation; while minimum releases are constrained by an agreement with the Utah Division of Wildlife Resources which provides for a minimum flow of 800 cfs to maintain the tailwater trout fishery. Additionally, the dam has the capacity to release up to 4,000 cfs through two river outlets (jet tubes) and an additional 28,800 cfs through the spillway.

OPERATION

Existing and proposed future operational criteria for Flaming Gorge Dam and reservoir provide for a full reservoir while maximizing power revenue and avoiding the use of the jet tubes and/or spillway. Depending on snowpack and monthly forecasting, an appropriate winter drawdown to avoid spills results in minimum reservoir storage of approximately 800,000 acre-feet at 6,020 feet in elevation which usually occurs in March. Attempts are made to refill the reservoir during spring runoff, and maximum levels usually occur in July. Releases during the remainder of the year are patterned to meet energy demands. Peak electrical power demand occurs during summer (July through

September) and winter (December through February). During these periods water releases from Flaming Gorge Dam fluctuate within the operational constraints of the powerplant (800-4,700 cfs). Flaming Gorge Reservoir results in an estimated annual depletion of 78,300 acre-feet due to evaporation.

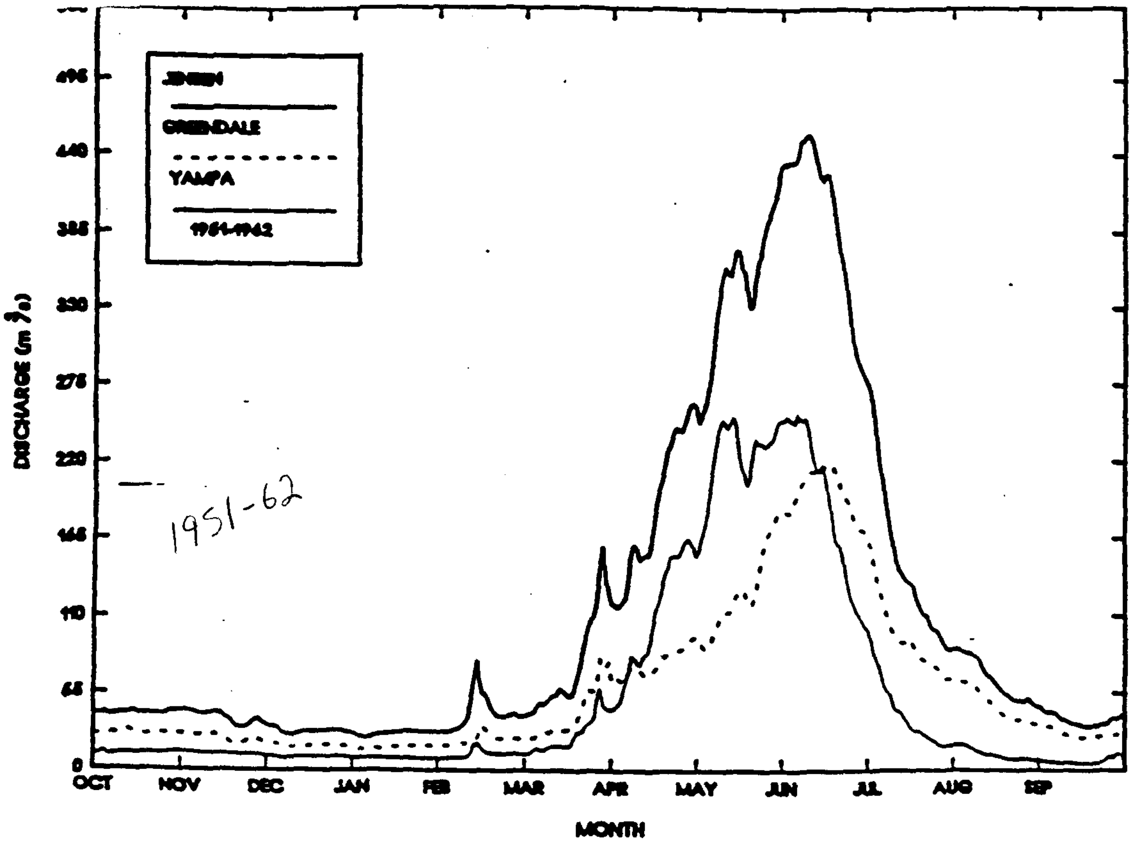
The mean annual flow of the Green River, near Jensen, Utah, is almost the same now as prior to the construction of Flaming Gorge Dam, but the flows and temperatures are significantly changed from historic patterns. In general, spring peak flows are much lower, while late summer and winter flows are higher, than historic averages. Minor peaks in discharge occur in summer and winter corresponding to peak power demands, while base flows are generally elevated during the remainder of the year to accommodate winter reservoir drawdown and minimum flow agreements.

Flaming Gorge operations are within the general framework of the above criteria, but vary year to year based on hydrologic conditions. Historical and post-Flaming Gorge flows differ significantly (Figure 1). Historically, flows in the river increased with the onset of snowmelt in March, peaked in June, and remained high through July. The mean annual spring peak for the historic period, measured at Greendale, was about 7,800 cfs. Following spring runoff, flows declined to less than 1,000 cfs for the remainder of the year. Variations of this pattern occurred during wet and dry historic periods.

Reservoir filling occurred from 1963-1966 with the first full year of operation beginning in 1967. In 1979, Reclamation began releasing water through the multilevel outlet structure which provided warmer water for fish. Operations changed in 1985, when the Service and Reclamation signed an "agreement" for protection of critical endangered fish nursery habitats downstream of Jensen, Utah, and for other special releases associated with study objectives contained in the interagency agreement (6-AA-40-04070).

BASIS FOR OPINION

The endangered Colorado squawfish, humpback chub, bonytail chub, and razorback sucker inhabit the Green River. Occupied habitat currently extends from the confluence with the Colorado River at river mile zero (0) upstream to near the Willow Creek confluence (Swallow Canyon) at river mile 383.5. The main stem Green River and its tributary, the Yampa, contain the largest populations of Colorado squawfish and razorback sucker known to exist in natural riverine habitats. Humpback chub have a limited, discontinuous distribution in canyon-bound habitats and persist in small numbers in Desolation and Whirlpool Canyons. The bonytail chub is extremely rare throughout the Upper Colorado River Basin.



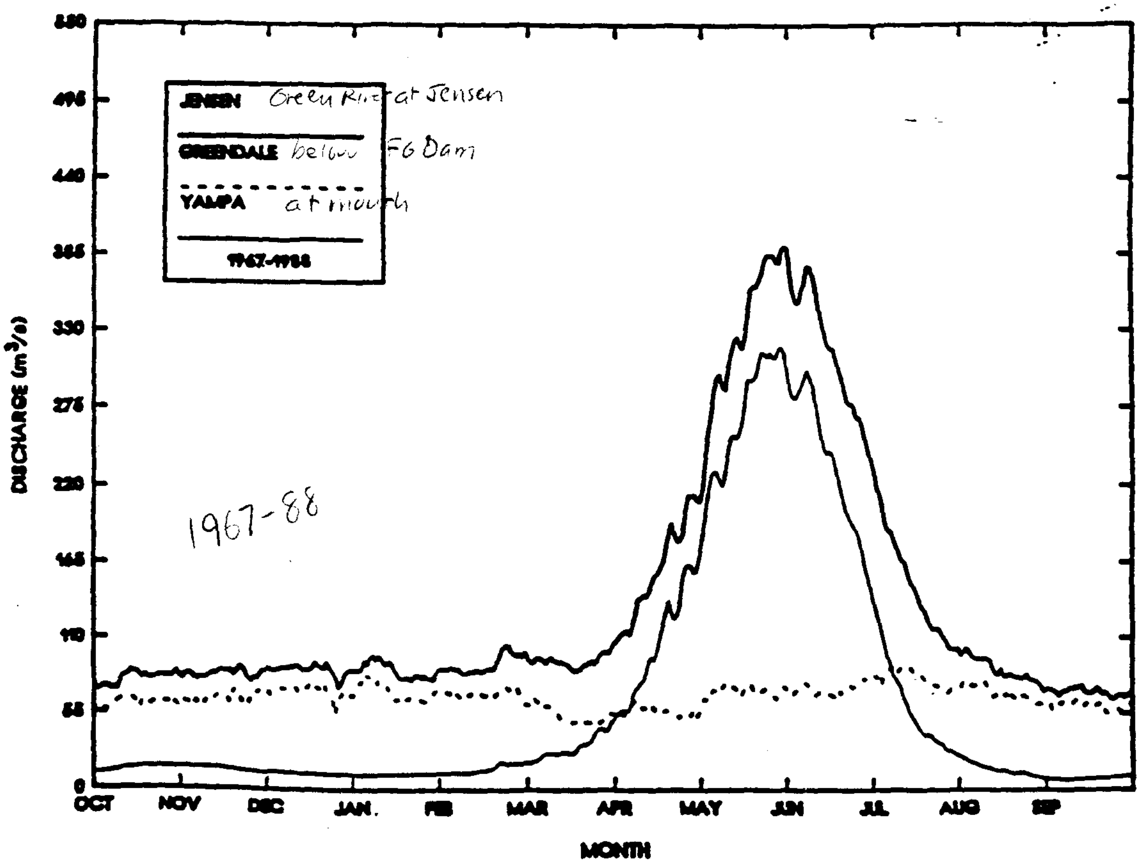


Figure 1. Average annual hydrograph for the Green and Yampa rivers. Upper figure for 1951-62; lower figure for 1967-88. USGS flow records: Jensen=Green River at Jensen, Utah; Greendale=Green River below Flaming Gorge Dam; Yampa=Yampa River at mouth. (After Tyus and Karp 1991)

Figure 2, taken from Tyus and Karp (July 1991), shows the conceptual relationships between a natural hydrograph and the timing of life history requirements for the Colorado squawfish, humpback chub, and razorback sucker. It is this natural hydrograph with a large spring peak; a gradual descending limb into early summer; and low, stable flows through the summer, fall, and winter that the Service believes creates the best habitat conditions for rare and endangered fish in the Green River Basin. This flow pattern maintains long-term stability and geomorphology of the channel, prepares spawning areas, and forms nursery habitats.

DEVELOPMENT AND EXTENT OF PERTINENT SCIENTIFIC DATA BASE

The Act of 1973 (P.L. 93-205) charged all Federal Agencies to consider the needs of species listed as threatened and endangered. The Act also mandated all Federal Agencies to consult with the Service to ensure that their actions were not likely to jeopardize listed species. Early consultations revealed the need for scientific information on the endangered species. In 1979, the collection of life history data to expand the scant data base that existed for the rare and endangered fish of the Upper Colorado River Basin began with formation of the Colorado River Fisheries Project. In 1982 Reclamation and the Service continued studies on endangered fish under the Colorado River Fishery Monitoring Program. These studies were to examine the effects of flows from Flaming Gorge Dam primarily on Colorado squawfish. In 1985 the Service and Reclamation agreed to an interagency Flaming Gorge Studies program that began in 1986 and ended in 1990. That program evaluated habitat requirements and streamflow needs of the rare fish and provided flow recommendations in a final report dated July 1991 (Tyus and Karp 1991).

Just prior to implementing the Recovery Program in 1988, a multiagency Flaming Gorge Section 7 Consultation Team was formed to evaluate biological information and ongoing studies prior to issuance of the biological opinion. The final products formulated under the direction of this team were the consolidated hydrology and biology reports. The Final Consolidated Hydrology Report (Smith and Green 1991) provided hydrologic information on the past and current operation of Flaming Gorge Dam and discussed models which could be used to predict changes in sediment transport, temperature, and channel morphology resulting from recommended operational changes included in this opinion. The final consolidated biological report titled Habitat Use and Streamflow Needs of Rare and Endangered Fishes in the Green River, Utah (Tyus and Karp 1991) merged the results of numerous studies done by a variety of government and private researchers. Together, these consolidated reports form the basis for the Service's recommended refinement of the existing operation of Flaming Gorge Dam to improve downstream conditions for rare and endangered fish in the Green River.

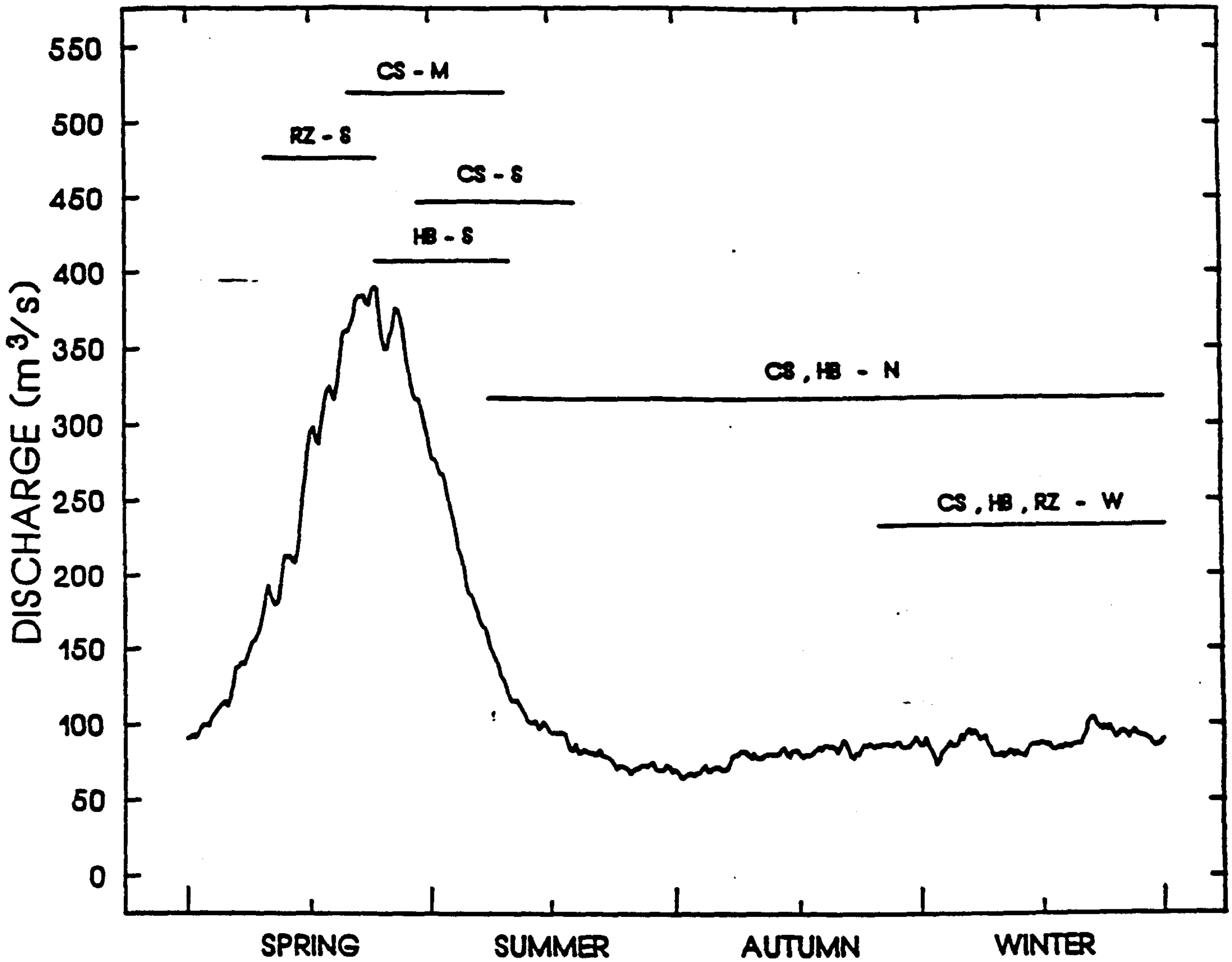


Figure 2. Conceptual relation between Green River annual distribution hydrograph (USGS records; Jensen, Utah) and timing of some life history events of Colorado squawfish, razorback sucker, and humpback chub. CS=Colorado squawfish, HB=humpback chub, RZ=razorback sucker, M=migration, s=spawning, N=nursery, W=winter. (After Tyus and Karp 1991)

GREEN AND YAMPA RIVER COMPLEX

The Service considers the Yampa and Green Rivers as a system that is essential to the survival and recovery of the endangered fish, primarily because of their biologic and hydrologic interrelationships. The Green River above its confluence with the Yampa River has been altered (hydrograph, temperature, sediment transport, fish habitat, and stream species composition) by construction and operation of Flaming Gorge Dam. Yampa River flows, however, remain predominately unregulated and follow a more natural hydrograph.

Relative to the Green River, the Yampa River has higher spring and summer water temperatures, and its input of sediment promotes the creation and maintenance of backwater nursery habitats for Colorado squawfish in the Green River. Operation of Flaming Gorge Dam has altered the magnitude, duration, and timing of the spring peak and has increased base flows in the Green River. This had negative impacts on the nursery habitat for Colorado squawfish and razorback sucker.

Sediment and stream channel morphology in the Green River are maintained somewhat by spring runoff from the Yampa River (Tyus and Karp 1989). Sediment import into the Green River from the Yampa River contributes to the system's present sediment quasi-equilibrium (Lyons 1989). This sediment is important in creating backwaters and other important habitats for endangered fish.

The Green and Yampa Rivers also are interrelated biologically. Colorado squawfish migrate from the Green River to spawn in the Yampa River; the larvae are then transported back to Green River nursery habitats. Movement of adult endangered fish, between the Green and Yampa Rivers, was well documented by Tyus (1990), Tyus and Haines (1991), and others.

ENDANGERED FISH

The importance of the Green River to rare and endangered fish was established by the Recovery Program and recognized by many biologists as noted in the recovery plans for each of the species. The Green River and its tributaries were listed as the highest priority for recovery of Colorado squawfish in the Colorado River Basin in the recently revised Colorado Squawfish Recovery Plan (U.S. Fish and Wildlife Service 1991). The Green River in Desolation and Gray Canyons and in Dinosaur National Monument (Dinosaur) is considered extremely important in the recovery of humpback chub in the Humpback Chub Recovery Plan (U.S. Fish and Wildlife Service 1990a). The Bonytail Chub Recovery Plan (U.S. Fish and Wildlife Service 1990b) indicates that one of the last known riverine concentrations of bonytail chub was in the Green River within Dinosaur. In addition, the Green River supports the largest known population of razorback sucker in their natural riverine habitat (Lanigan and Tyus 1989).

The Recovery Program placed a high priority on habitat management in the Green and Yampa Rivers through protection of instream flows. Because of the importance of providing legal protection for instream flows, the Service considers, within the Section 7 process, the legal protection of flows essential to offsetting project impacts.

The consolidated biology report (Tyus and Karp 1991) summarizes the distribution, abundance, and habitat use for the endangered fish. Much of the species biological information discussed below was extracted from that report.

COLORADO SQUAWFISH

General Status

Historically, Colorado squawfish occurred in mainstream habitats of the Colorado River system. The species was found in the Colorado River from the Utah-Arizona border to the Sea of Cortez in Mexico, and the Salt and Gila Rivers of the lower Colorado River Basin. However, all lower basin populations are considered extirpated (Minckley 1973). In the Upper Colorado River Basin, Colorado squawfish occurred in the Colorado, Green, Yampa, White, Dolores, Gunnison, San Juan, Uncompahgre, and Animas Rivers and in many smaller tributaries. Although still occurring in much of its former upper basin range, most areas contain only remnants of their former number and few reproducing populations exist.

All life history phases of the Colorado squawfish are considered in this biological opinion and include migration, spawning, and larval recruitment to the adult life stage. These phases are closely related with specific flow events and habitat requirements. The recovery goals for Colorado squawfish established through the Recovery Program are to "maintain and protect self-sustaining populations and natural habitat."

Adults

Adult Colorado squawfish are widely distributed in the Yampa and Green Rivers, and the fish is considered more abundant in the Green River than any other location (Holden and Stalnaker 1975; Tyus et al. 1982a and 1982b; Behnke and Benson 1983; Tyus, in press). In the mainstream Green River, adults are most prevalent in upper (i.e., near Ouray, Utah) and lower (i.e., near Labyrinth Canyon) sections (Tyus et al. 1987).

During the winter months, adult Colorado squawfish occupy a variety of low velocity habitats including slow runs, slackwaters, eddies, and backwaters (ephemeral along-shore embayments) (Valdez and Masslich 1989; Wick and Hawkins 1989). Colorado squawfish select certain river reaches in the Green and upper Yampa Rivers and generally remain active in these areas all winter (Valdez and Masslich 1989; Wick and Hawkins 1989). The fish presumably use ice as cover and some local movements are probably made to avoid floating ice jams (Valdez and Masslich 1989).

Flow fluctuations in the winter may affect fish use of preferred winter habitats. Movement patterns of radio-tagged fish suggested that such fluctuations result in greater movement of Colorado squawfish than in more stable conditions (Valdez and Masslich 1989; Wick and Hawkins 1989). Valdez and Masslich (1989) believed that a rapid change in river stage altered locations of squawfish preferred microhabitats resulting in greater fish movement. Increased movement was hypothesized as resulting in increased energy expenditure and decreased body condition. Decreases in body condition during winter may affect ova development, number, and size.

In spring and early summer, adult Colorado squawfish are most often located in seasonally inundated shoreline habitats, including backwaters or bottomlands (Tyus 1990). Radio-tracking data indicated use of shoreline backwater habitat in the 1981 low-flow year and use of flooded bottomlands during the 1983 high-flow year (Tyus and Karp 1989). During the 2 high-flow years, 1983 and 1984, adult Colorado squawfish also used flooded shorelines (Tyus et al. 1987). From late April to May in 1985 and 1987, at flows of 8,000-10,000 cfs, they used the inundated portions of Old Charley Wash. Wick et al. (1983) noted that in 1982 (an average-flow year) that adult Colorado squawfish used backwater and eddy habitats as runoff flows increased from early may through mid-June. In May, backwater habitat use occurred in backed-up tributary mouths and diked-off side channels. Adult squawfish moved to main channel habitats as the river level dropped.

Adult Colorado squawfish occupy a variety of habitats in mid-to-late summer but are most common in eddies, pools, runs, and shoreline backwaters over sand and silt substrates (Tyus et al. 1984 and 1987). Visual observations of fish in shallow water suggests that adults use sheltered microhabitats behind boulders, flooded vegetation, or other cover. During the summer, radio-tagged fish were most often located in deeper shoreline habitats where movements suggested heavy use of the eddy-run interface (Tyus et al. 1987).

Capture of introduced northern pike, Esox lucius, and channel catfish, Ictalurus punctatus, in habitats shared by adult Colorado squawfish (Wick et al. 1985; Tyus and Beard 1990) suggests a potential for competition and/or predation during times of resource limitation. Although Pimentel et al. (1985) found that Colorado squawfish did not prefer channel catfish as prey, observations of channel catfish lodged in throats of adult Colorado squawfish (McAda 1983; Pimentel et al. 1985; Wick et al. 1985) indicate that these introduced fish are eaten by Colorado squawfish, and some may cause mortality. However, little is known concerning conditions that either favor or impede nonnative fish. McAda and Kaeding (1989) found that during years of low annual runoff, numbers of nonnative fish increased; yet in years of moderately high runoff, their relative abundance decreased. Predacious fish of concern include channel catfish, northern pike, and walleye, Stizostedion vitreum.

Migration

The initiation of spawning migration is an important component of the reproductive cycle of the Colorado squawfish. Based on radio-tracking data (Wick et al. 1983; Tyus and McAda 1984; Tyus 1990), fish in the Green and Yampa Rivers initiated spawning migrations around the summer solstice; Green River fish initiated migrations about June 21 (range: May 23-July 22) and Yampa River fish migrated about June 15 (range: May 26-July 13). These movements included downstream migrations in the Yampa and White Rivers and upstream and downstream migrations in the Green River (Tyus et al. 1987; Tyus 1990).

Flows and water temperatures were highly variable during Colorado squawfish spawning migrations, and migrations were initiated earlier in low-water years (e.g., 1981) and later in higher water years (e.g., 1983). The earlier the spring peak flow occurred, the longer the interval before migration began (Tyus 1990). Initiation of spring migration occurred about 28 days after peak flow in the Yampa and Green Rivers (Tyus and Karp 1989). Migration was associated with water temperatures of at least 9 °C (average 14 °C).

Homing behavior in Colorado squawfish is suggested by long-distance movement patterns and repeated recaptures of the same fish on spawning grounds in subsequent years (Wick et al. 1983; Tyus 1985 and 1990). Fish use of more than one spawning area was not detected (Tyus 1990), supporting the idea of spawning fidelity in Colorado squawfish. Colorado squawfish spawning areas thus should be protected as unique habitats that are essential to the conservation of the species.

The migrations and homing behavior of Colorado squawfish mandates protection of known migration routes. Migrations of Colorado squawfish are vulnerable to stream blockage (Tyus 1984) as evidenced by the recent loss of 50 miles of occupied habitat in the White River due to blockage (Martinez 1986) at Kenny Reservoir. Lack of access to spawning grounds was implicated in the decline of Colorado squawfish (Joseph et al. 1977; Tyus 1984).

Spawning

Males generally mature at age 5 or 6 and females at age 6 or 7 (Hamman 1981b; Vanicek and Kramer 1969; Seethaler 1979). Most mature fish in the Green and Yampa Rivers migrate in spring to two locations identified as spawning areas. These include riffle and pool habitats in Yampa Canyon on the lower Yampa River and Gray Canyon on the Green River (Tyus and Karp 1989; Tyus 1990).

The annual spawning period (as indicated by the presence of migrating radio-tagged fish on spawning grounds, collections of ripe fish, or calculated dates of larval emergence in spawning reaches) lasts about 4 to 5 weeks. An optimum spawning period also was calculated by averaging the dates in which radio-tagged fish and ripe fish were present in the spawning reach and back-calculated dates of egg deposition. The length of the estimated optimal spawning period (about 26 days) was similar in both spawning areas for all years. Spawning generally occurred earlier in low-water years (1981, 1987, and 1988) and later in high-flow years (1983 and 1984). Discharge was

72°f - 77°f

variable between years during the optimum spawning period, but average temperatures ranged from about 22-25 °C (Tyus 1990). Others reported a peak in spawning after temperatures reach 20 °C (Haynes et al. 1984; Hamman 1982a; Holden and Stalnaker 1975; Tyus and McAda 1984). Spawning, both in the hatchery and in the wild, generally occurs from July-August but may extend into early August depending on flows and temperature.

Vanicek and Kramer (1969) first suggested that discharge and temperature influenced spawning in Colorado squawfish. Data from 1981 to 1988 indicated that spawning occurred during the period of declining flows following spring peak runoff and increasing temperatures (Tyus 1990). This generally occurred about 26 days (range: 17-33 days) following migration. Peak discharge preceding spawn, and mean minimum temperatures during spawn were highly correlated with the spawning period, ostensibly because discharge, temperature, and the spawning period are correlated. Spawning of Colorado squawfish is considered a result of complex environmental and biological influences and is not triggered by a single flow or temperature event (Tyus 1990). As an example, flow spikes from rainstorms during spring runoff may also influence ovulation and spawning in Colorado squawfish, as recently hypothesized by Nesler et al. (1988). Radio-tracking data suggest that all adult Colorado squawfish do not spawn each year, and male and female fish may require different stimuli for gonadal maturation (Tyus 1990), some of which appear to be flow related.

Breeding adults were most ofteh concentrated in river reaches containing deep pools, eddies, and submerged cobble/boulder bars. Radio-tagged fish moved from pools or eddies to presumably spawn on bars and then returned to the former habitat (Tyus et al. 1987), behavior similar to that of spawning northern squawfish (Beamesderfer and Congleton 1981). Turbid riverine conditions precluded direct observations of egg deposition; yet, cobbles removed from the substrate during this time of year are clean of sediment and algae (Archer and Tyus 1984; U.S. Fish and Wildlife Service, unpublished data). There is substantial field and laboratory data showing that Colorado squawfish and other squawfish species require cleaned cobble surfaces for successful egg adhesion (Burns 1966; Patten and Rodman 1969; Hamman 1981b). Hamman (1981b) also noted hatching of Colorado squawfish larvae from cobble surfaces. The need for cleaned cobble and boulder substrates is supported by spawning of Colorado squawfish following peak flows and peak sediment transport (Tyus and Karp 1989). Spring scouring, a gradual decrease in summer flow, and a concomitant decrease in sediment load aid in preventing siltation of cobble bars. Thus, magnitude, timing, and duration of spring flows are considered potential limiting factors for successful reproduction by Colorado squawfish.

Temperature also affects egg development and hatching. In the laboratory, egg mortality was 100 percent in a controlled test at 13 °C. At 16-18 °C, development of the egg is slightly retarded, but hatching success and survival of larvae were higher. At 20-26 °C, development and survival through the larval stage were up to 59 percent (Hamman 1981b).

68 - 80°f

Larvae and Postlarvae

Colorado squawfish eggs hatch in 4-5 days at 20-21 °C. Sac-fry emerge from cobble bars and drift downstream with declining flows (Tyus et al. 1982b; Haynes et al. 1984; Tyus and Haines 1991) to concentrate in shallow backwater habitats in the Green River (Tyus et al. 1982b and 1987). Newly emerged Colorado squawfish fry drift to the mouth of the Yampa River from the midpoint of the spawning grounds, river mile 16.5-18.2, in about 6 days after hatching (Tyus and Haines 1991). Nesler et al. (1988) also noted rapid downstream transport of larvae (3-15 days) following hatching. From 1979 to 1988, peaks in abundance of young Colorado squawfish occurred in the Green River about 100 miles downstream of the Yampa River spawning reach (Tyus et al. 1982b and 1987; Tyus and Haines 1991). Young fish presumably use river transport for dispersal from upstream spawning grounds to downstream nursery habitats (Tyus and McAda 1984; Tyus 1986; Nesler et al. 1988; Tyus and Haines 1991; Paulin et al., in prep.). Gradually decreasing flows following spring runoff create productive nursery habitats which persist with summer-winter base flow conditions. Availability (quality and quantity) of these habitats in the Green River is considered essential for successful recruitment of the species.

Flow, river temperature, availability of backwater habitat, and predator abundance contribute to mortality of drifting larvae. Berry (1988) noted that larval Colorado squawfish acclimated to about 22 °C are adversely affected by cold water of 10 °C and 15 °C. Young Colorado squawfish are routinely collected in isolated pools in the Green River system (U.S. Fish and Wildlife Service, unpublished data). These pools form when decreasing flows strand bodies of water from the main channel. Natural fluctuations in river level are usually slow enough to make this a gradual process and thereby allow entrapped fish to escape. Abrupt fluctuations in river level, as is characteristic of the Green River and other regulated systems, could increase mortality of small fish by cutting off escape routes and thereby increasing potential for competitive interactions and exposure to terrestrial predation. Herons (Ardeidae), raccoons (*Procyon lotor*), garter snakes (*Thamnophis* spp.), and other animals were observed feeding on fish trapped in isolated pools (Erman and Leidy 1975; U.S. Fish and Wildlife Service, unpublished data).

Age-0 Colorado squawfish are most abundant in shoreline backwaters when water temperatures are the same or greater than the main river channel. Mark-recapture studies indicated a diel movement of postlarval (age-0 and age-1) fish between backwaters and the mainstream river in April, October, and November (Tyus 1991).

Postlarval squawfish appear adaptable to changing conditions. During the winters of 1985-1986, 1987-1988, and 1988-1989, a significant overwintering mortality of age-0 Colorado squawfish was not detected (Tyus and Haines 1991). In addition, low flows in 1988 did not reduce standing crops (7.7 fish/100 m^2 seined) or growth of young Colorado squawfish. Total length of the fish in October 1988 (41.3 and 45.0 mm, upper and lower Green River, respectively) was similar to other years of best growth (Tyus and Haines 1991). Additionally, high spring catches of age-0 fish (6.5-28.9 fish/100 m^2 seined) showed good overwinter survival in some years. Laboratory studies (Thompson 1989) found that all age-0 Colorado squawfish survived simulated winter conditions when fed, and only smaller individuals with low lipid content died when starved 210 days at 3-4 °C. Thompson found that age-0 fish actively foraged in laboratory and field conditions, and it is assumed that healthy young survived the winters under 1985-1989 flow conditions (Tyus and Haines 1991).

Late summer and autumn are critical periods for growth and survival of young Colorado squawfish, and historical flows in the Green River system at this time are predictably low. Juvenile temperature tests showed that preferred temperatures ranged from 21.9-27.6 °C. The most preferred temperature for juveniles and adults was estimated at 24.6 °C. Temperatures near 24 °C also are best for optimal development and growth of young (Miller et al. 1982b). Tyus et al. (1987) noted that abundance and growth of young Colorado squawfish in the Green River were negatively correlated with high, cooler late summer and autumn flows. During the late summer and autumn, catch and growth were highest in average flow years of 1979 and 1980 and lowest in abnormally high flow years of 1983 and 1984 (Tyus et al. 1987). In 1983 and 1984, unusually high releases from Flaming Gorge Dam in the late summer and autumn inundated backwater nursery areas, and survivorship of young Colorado squawfish was low. These relationships suggest that flows promoting growth and survival of small Colorado squawfish vary with time of year and that both reproduction and survival are highest in years when hydrographs more closely approximated natural flow conditions. This presumably relates to the availability of nursery backwater habitat in autumn (Tyus and Haines 1991).

A summer flow range of about 1,100-1,800 cfs maximized the number of backwaters in the upper Green River basin on aerial photography and videography (Pucherelli and Clark 1989). These authors also noted that flows above 1,800 cfs reduced numbers of backwaters at Island Park and Jensen during their study. High spring flows may be needed to maximize backwater formation, and gradually decreasing flows may be required to produce good nursery habitats (Pucherelli and Clark 1989).

Effects of competition and predation by introduced fish on growth and survival of young Colorado squawfish have yet to be adequately assessed, but the common use of backwater habitats and foods by young Colorado squawfish and small introduced fish species (e.g., channel catfish; green sunfish, *Lepomis cyanellus*; red shiner, *Notropis lutrensis* (Jacobi and Jacobi 1982; McAda and Tyus 1984; Muth et al., in prep.)) suggests a potential for negative interactions. Karp and Tyus (1990b) suggested that growth and survival of young Colorado squawfish may be adversely affected by the aggressive behavior of introduced green sunfish, red shiner, and fathead minnow, *Pimephales promelas*. This may be most acute when increases or decreases in river level reduces the availability of quality backwater habitat.

There is some indication that abundance of nonnative fish may be adversely affected by periods of high flow (Haynes and Muth 1984; Minckley and Meffe 1987; T. Nesler, written communication). Still, the hypothesis that native Colorado River fish exhibit greater tolerance to extreme flooding was not adequately tested. In the Green River, abundance of Colorado squawfish and red shiner in backwaters was lowest in years of high summer flows (Haines and Tyus 1990).

Backwater nursery habitats were influenced by inundation and resuspension of organic material from shorelines during increased flows and ultimately influenced backwater nursery habitats. This energy source was important for standing crops of fish food organisms (Grabowski and Hiebert 1989). Backwaters in the Ouray area, where young Colorado squawfish were most abundant, were richer in food than upstream areas studied. Reduced water-level fluctuations in that area resulted in more stable backwater habitats and possibly reduced the export of nutrients and food (Grabowski and Hiebert 1989).

Juveniles

Colorado squawfish reach about 74 mm total length by age-2; their greatest growth occurs during their third and fourth years just prior to attaining maturity. Little is known about the habitat requirements of juveniles, but they were captured in a variety of shoreline habitats including backwaters and flooded bottomlands. Juvenile Colorado squawfish may be more numerous in the lower Green River (Tyus et al. 1987) because of the downstream drift of larvae. If so, a long-distance upstream movement by juveniles is needed to repopulate upstream areas. Because only large-sized fish are found in the upper Yampa River and the highest concentration of juveniles occur in the lower Green River, upstream movements probably occur during the late juvenile or early adult stages (Tyus 1986 and 1990; Tyus et al. 1987). These movements require unrestricted access, which is considered essential to the species.

HUMPBACK CHUB

General Status

Humpback chub originally inhabited the main stem Colorado River from what is now Lake Mead to the canyon areas of the Green and Yampa River basins. They were considered less common than other endemic fish of the region but occur in fairly large numbers where reproducing populations exist. The greatest concentrations of humpback chub occur in the Grand Canyon portion of the Colorado and Little Colorado Rivers and Westwater/Blackrocks region of the Colorado River. Smaller populations and incidental catches are reported from Yampa River; Desolation, Gray, and Whirlpool Canyons of the Green River; and Cataract Canyon of the Colorado River. The recovery goals for humpback chub established through the Recovery Program are to "maintain or establish and protect five self-sustaining populations, natural habitat, and two refugia."

Adults

Humpback chub occur in several canyon-bound sections of the Green River basin, including the lower portion of the Little Snake and Yampa Rivers and Whirlpool, Desolation, and Gray Canyons of the Green River (Holden 1978; Tyus et al. 1982a, 1982b, and 1987; Karp and Tyus 1990a; M. Moretti and E. Wick, pers. comm.). Surveys conducted prior to and after closure of Flaming Gorge Dam indicated that all three forms of Colorado River chubs were locally common in the Green River. This includes bonytail and roundtail chubs in upper Green River above Ouray, Utah. Humpback chubs occurred in Desolation and Gray Canyons and in the Flaming Gorge basin of the upper Green River (Smith 1960;

Holden 1978; Vanicek 1967; Seethaler et al. 1979). Although intensive netting and electrofishing efforts in the Green River mainstream by Service and Utah Division of Wildlife Resources biologists yielded over 500 chubs (Miller et al. 1982c; Tyus et al. 1987; M. Moretti, pers. comm.), status of humpback chub in that system is not well understood, due in part to confusion with specific identification of some fish (Tyus et al. 1987; Rosenfeld and Wilkinson 1989; M. Moretti, pers. comm.).

More intensive studies are needed to further evaluate the systematics of Colorado River chubs and to determine their habitat needs in the Green River basin. The morphological variation that occurs in some areas of sympatry may be induced by recent habitat change (Valdez and Clemmer 1982). If preferred spawning conditions and/or habitats are unavailable for one or more species, spawning might occur during other times and/or places that promote hybridization. Thus, the presence of intermediate forms in altered systems (e.g., Green River and Colorado River) and the paucity of such forms in some unaltered rivers (e.g., Yampa River and Little Colorado River) suggests that natural riverine environments are important for recovery of the humpback chub. The following paragraphs summarize information on habitat use of humpback chub in Dinosaur, particularly Yampa Canyon (Tyus and Minckley 1988; Tyus and Karp 1989; Karp and Tyus 1990a) because little of this information is available for the mainstream Green River basin.

During spring and early summer, humpback chub in the Green River basin are most prevalent in high-gradient, whitewater reaches dominated by rocky runs, riffles, and rapids. Adult fish are most often collected in seasonally flooded shoreline eddies that are downstream of large boulders and upstream of rapids. Juveniles appear more common in smaller eddies in rocky shoreline runs. Humpback chub remain rare in Dinosaur, and only 133 juvenile and adult fish were captured during spring sampling efforts from 1986-1989 (Karp and Tyus 1990a). Feeding habits of humpback chub are relatively unknown in the Green River basin, but stomachs of a few fish contained hymenopterans and plant debris. Humpback chub also feed on Mormon crickets and presumably other foods at various levels within the water column (Karp and Tyus 1990a).

Although fall and winter habitat requirements of humpback chub are not well known, some observations in Dinosaur suggest that the fish remain in pools and eddies of impounded water and rapids in low flow conditions (Karp and Tyus 1990a). Minimum flows are thus required to maintain such habitats from midsummer through late winter, but specific flow levels for the Green River are not determined.

Spawning

Humpback chub generally spawn between temperatures of 16-20 °C but may also spawn in temperatures as low as 11.5 °C (Valdez and Clemmer 1982) and as high as 20.5 °C (Kaeding and Zimmerman 1983). Eggs are adhesive, but little is known about preferred substrate for egg deposition. Hatchery success diminishes as temperatures vary from their optimum of 20 °C (Hamman 1982a; Marsh 1985). The eggs generally hatch in 5-7 days at 19-20 °C (Hamman 1982a).

In Dinosaur, humpback chub spawn in spring and early summer following highest spring flows at river temperatures about 20 °C (Karp and Tyus 1990a). This included May and June in low (e.g., 1987 and 1989) and average (e.g., 1988) flow years but extended into July during the 1986 high-flow year. Ripe fish are predominantly captured in shoreline eddy habitats in the upper 30 miles of Yampa Canyon, and there is some indication that these fish remain in or near specific eddies for extended periods and return to the same eddy during the spawning season in different years (Karp and Tyus 1990a). It is unknown where humpback chubs deposit eggs, but the use of shoreline eddies that are associated with boulder/sand substrates is considered important to the breeding requirements of humpback chub in Dinosaur. Availability of shoreline eddy habitat is greatest with spring flooding and decreases thereafter with decreasing summer flows; these habitats are formed and maintained by spring runoff. Loss or reduction of spring runoff could reduce availability of spawning habitat and consequently adversely affect humpback chub reproduction. Habitat alternation also may promote hybridization with other species (Valdez and Clemmer 1982). Flow reductions (absence of spring peak) and decreased temperatures were implicated as factors curtailing successful spawn and increasing competition in the Colorado River (Kaeding and Zimmerman 1983).

Larval and Juvenile

Larval and young-of-year humpback chub are generally found in low velocity microhabitats associated with backwaters and eddies. Fish grow from 7.5-10.5 cm during their first year of life, and by age-2 many are 200 mm (8 inches). Males begin reaching sexual maturity at age-2 and females at age-3. Once humpback chubs reach sexual maturity growth slows considerably.

BONYTAIL CHUB

Status and Distribution

Historically, the bonytail chub occurred throughout the Colorado River main stem and its major tributaries, including the Gila and Salt Rivers in the lower basin and the Green, Yampa, White, Gunnison, and San Juan Rivers in the upper basin. Recent collections indicate the fish is extremely rare and is extirpated from much of its former range, although individual fish are still occasionally collected from the upper and lower basins. Supplemental stocking from hatchery fish and maintaining stocks in hatcheries may be necessary to preclude this species from becoming extinct. The recovery goal for bonytail chub (U.S. Fish and Wildlife Service 1990b) is to "prevent immediate extinction."

Adults

Habitat requirements of the bonytail chub in the Green River basin are little known. Fish collections in Echo Park (Dinosaur) before and after closure of Flaming Gorge Dam indicated that the species was present in moderate numbers at the confluence of Yampa and Green Rivers (Vanicek 1967). But, more recent investigations in that area yielded few captures. Holden and Stalnaker (1975) reported the capture of 36 bonytail chubs in Yampa (lower 10 miles) and upper Green Rivers from 1968 to 1970. Holden and Crist (1981) collected one bonytail chub in the lower Yampa River in 1979, and Service biologists captured one suspected juvenile in 1987. Preliminary results of a radio-tracking study of adult bonytail chub introduced into the upper Green River in 1988 and 1989 indicate that the fish exhibit crepuscular movements and are somewhat quiescent during the day and night (S. Cranney, Utah Division of Wildlife Resources, pers. comm.).

Spawning

Bonytail chub spawning locations are unknown. Vanicek and Kramer (1969) believed spawning occurred in the Green River between mid-June and early July when water temperatures were near 18 °C. Similar to humpback chub, the optimum temperature for hatching success was reported at 20-21 °C (Hamman 1982c and 1985). Hatching success decreased considerably when temperatures varied ±10°C. When temperatures are near optimum (20-21 °C) hatching occurs in 4-7 days (Hamman 1982c).

Larval and Juvenile

Little data exist on larval and juvenile bonytail chub in the wild because of their extreme rarity. Vanicek and Kramer (1969) reported mean total lengths of 55, 100, and 158 mm for age-1 through age-3 bonytail chub from the Green River. Still, like most larval fish, it is presumed that their survival and growth are dependent on low velocity habitats.

Bonytail chub drastically declined in the Echo Park area, presumably due to flow and temperature changes resulting from closure of Flaming Gorge Dam. A similar pattern was noted in the Colorado River downstream from Glen Canyon Dam (Utah State Department of Fish and Game 1964 and 1969). Although the preimpoundment poisoning of riverine habitat in the upper Green River in 1962 contributed to the decline of the bonytail chub in that system, fish collections in Dinosaur before and after the poisoning (Binns et al. 1963; Vanicek and Kramer 1969; Vanicek et al. 1970) suggested that the downstream extent of the poison was not the only factor in the dramatic decline of the species from the Echo Park area. Decreased temperatures and changing flow patterns caused by the construction and operation of Flaming Gorge Dam permanently altered the physical environment, and bonytail chub habitats may have been lost. Thus, Flaming Gorge Dam operations also could affect the future of bonytail chub reintroductions and recovery efforts in the Green River system.

RAZORBACK SUCKER

General Status

Historically, razorback suckers were abundant throughout the Colorado River Basin, primarily in the main stem and the major tributaries from Wyoming to Mexico. At present, the largest concentrations occur in the Green River in the upper basin and Lake Mohave in the lower basin. Fish in reproductive condition also were captured in the Yampa, Colorado, and San Juan Rivers, which suggests the importance of these river systems. Although reproduction in the wild was documented, larvae were seldom captured and may not survive past 20 mm in size. The lack of recruitment places this species in a precarious situation. Because of its recent listing, there is no formal recovery goal for the razorback sucker. However, the immediate goal is to prevent their extinction in the wild.

Adults

In the Upper Colorado River Basin, adult razorback suckers were captured predominantly from the upper Green River (Mile 176-345) and in the lower 13 miles of the Yampa River (Azevedo 1962; Vanicek et al. 1970; Holden and Stalnaker 1975; Seethaler et al. 1979; McAda and Wydoski 1980; Miller et al. 1982a; Tyus et al. 1982b; Tyus 1987; Tyus and Karp 1990). Catch-effort estimates suggest that adult razorback suckers are rarer than other native suckers and the endangered Colorado squawfish.

Radio-tagged razorback suckers overwintered in the Jensen, Island Park, and Echo Park reaches of Green River (McAda and Wydoski 1980; Valdez and Masslich 1989). In winter, razorback suckers used slow runs, slackwaters, eddies, and backwaters in the Green River, where local movements increased with flow fluctuation (Valdez and Masslich 1989).

Razorback suckers in breeding condition were captured primarily on several cobble/gravel/sand bars in the lower Yampa and upper Green Rivers (including Echo Park and the reach from Ashley Creek to near the lower boundary of Dinosaur) but also were collected in flooded shorelines, bottomlands, and tributary mouths (including Old Charley Wash, lower Ashley Creek and Duchesne River, and Stewart Lake Drain (Tyus and Karp 1990)). From 1987 to 1989 (low and moderate water years), most ripe fish (98 percent) were collected in riffle areas, but during the high water of 1986, 30 percent of all ripe or tuberculate razorback suckers were captured in flooded river bottoms of Old Charley Wash and Stewart Lake Drain. Twelve ripe adults were observed in Old Charley Wash in late May-early June 1986 at flows of about 19,000-20,000 cfs (Tyus and Karp 1990).

Migration

Razorback suckers exhibited both local and long-distance spring and summer movements (Tyus 1987; Tyus and Karp 1990). Two spawning migrations were detected with fish movement between lower Yampa and upper Green Rivers and movement between upper Green River and Ouray area (Old Charley Wash and lower Duchesne River (Tyus and Karp 1990)).

Spawning

Spawning of razorback suckers occurred during ascending and highest spring peak flows, as indicated by capture of ripe fish (Tyus and Karp 1989 and 1990). Ripe fish were captured in main channel habitats at water temperatures of about 14-15 °C (Tyus 1987; Tyus and Karp 1990). However, temperatures averaged 19.6 °C (range 17.5-21 °C) in flooded areas (Old Charley Wash and Stewart Lake Drain) in spring 1986 when ripe razorback suckers were present. Main channel temperatures were colder (mean 15.6 °C, range 15-16.5 °C) at this time, which suggests that razorback suckers may seek warmer habitats in the spring. Bulkley and Pimentel (1983) reported that razorback suckers preferred temperatures of about 22-25 °C and avoided temperatures of 8-15 °C. Razorback sucker eggs taken in the Green River experienced poor hatching at 11 °C due to fungus, but hatching was successful (80 percent or more) when incubated at 20 °C (U.S. Fish and Wildlife Service, unpublished data). Marsh (1985) noted optimal hatch in razorback sucker larvae incubated at 20 °C, but historic water temperatures in the upper Green River at Jensen did not average 20 °C until June-July (Smith and Green 1991). Thus, required spawning and incubation temperatures of razorback sucker are not well understood and continue to be studied.

Larval and Juvenile

The capture and artificial spawning of ripe razorback suckers in the lower Yampa and upper Green Rivers (Severson et al. 1990) and the tentative identification of larvae in upper Green River seine collections (R.T. Muth and D. Snyder, pers. comm.) suggests that razorback suckers reproduce successfully, but there is little recruitment there or elsewhere in the Colorado River Basin (Holden 1978; McAda and Wydoski 1980; Minckley 1983; Tyus 1987; Marsh and Minckley 1989; Tyus and Karp 1990). The existing standing crops of razorback sucker in the Green River are presumably old fish (Minckley et al., in prep.) that were spawned in the mid-1960's.

The apparent lack of widespread recruitment in razorback sucker was attributed to habitat alteration, such as lower water temperatures (Marsh 1985) and predation by introduced common carp (*Cyprinus carpio*), green sunfish, channel catfish, flathead catfish (*Pylodictus olivaris*), and other nonnative fish (Minckley 1983; Brooks et al. 1985; Tyus 1987; Marsh and Langhorst 1988; Marsh and Minckley 1989). Predation by nonnative fish is believed a serious threat to the survival and recovery efforts of razorback sucker. The absence of young fish in the Green River basin population also may be linked with the reduced availability of inundated shorelines due to curtailment of spring flooding. Naturally inundated lowlands, such as Old Charley Wash and the Stewart Lake area, that were readily accessible to razorback suckers in the spring are now less accessible due to blockage and low water levels following closure of Flaming Gorge Dam.

Habitat requirements of this species in riverine environments are not well known because of the scarcity of extant populations (Minckley 1983; Lanigan and Tyus 1989) and the absence of younger life history stages (McCarthy and Minckley 1987; Tyus 1987). Adult razorback suckers in the Green River basin are old individuals (Tyus 1987; Minckley et al., in prep.) and the low number of reproducing razorback suckers is considered limiting (Lanigan and Tyus 1989; Tyus and Karp 1990). Nonnative fish, high spring flows, warming river temperatures, and inundated shorelines and bottomlands all appear as factors that influence successful reproduction and recruitment in razorback sucker.

EFFECTS OF THE ACTION

Operation of Flaming Gorge Dam, since it began filling in November 1962, altered downstream flow, temperature, and channel morphology in the Green River due to reregulation of flows and annual depletions of 78,300 acre-feet due to evaporation. Above the confluence with the Yampa River, spring peaks were virtually eliminated and baseline flows increased during summer and winter in response to needs for water storage, spill prevention, and peak electricity. The river in this reach is sediment-poor and the channel is degrading (Lyons 1989). Spring flows of the Yampa River greatly influence the Green River hydrograph, changing an almost flat hydrograph into a more natural one. Although a spring and early summer peak is maintained to some degree by runoff from the Yampa River Basin and other tributaries, the river channel is aggrading below the Duchesne River confluence (Andrews 1986). Late summer and winter flows, normally low and stable within the framework of a natural hydrograph, fluctuate considerably in response to highest peaking power demand in July, August, and September and December, January, and February, respectively. Flaming Gorge releases can fluctuate daily from 800-4,700 cfs with ramp rates as high as 500 cfs per minute based on power production needs.

The most dramatic effects to the hydrograph occur directly below the dam and downstream to the confluence with the Yampa River. Below the Yampa River confluence, the effects of fluctuating releases from Flaming Gorge Dam are somewhat reduced due to attenuation over the 100-mile distance as well as being ameliorated by the Yampa River flow which remains largely uncontrolled. Further downstream at Green River, Utah, the effects of fluctuating releases can still be seen but are diminished further by tributary inflow, agricultural return flows, and attenuation. The Consolidated Hydrology Report (Smith and Green 1991) contains additional operational information.

There are other endangered species that use the Green River. Bald eagles currently use the river corridor for wintering. One pair successfully nested along the Green River in 1991. Peregrine falcons were discovered along the Green River during the 1980's. Presently there are two peregrine falcon eyries and possibly one other. Most observations were downstream of the areas significantly impacted by Flaming Gorge operation. To protect peregrine falcon eyries, exact locations will not be presented herein. The bald eagle and peregrine falcon became established along the Green River under current operation criteria and neither the present operation nor the proposed refined operation will likely affect their presence (Steve Cranney, Utah Division of Wildlife Resources, pers. comm.). The Ute ladies'-tresses orchid, a threatened species, occurs in the Browns Park area and is not expected to be affected by the change in operation of Flaming Gorge Dam.

[redacted] More detail on the effects of operations on these fish and their various life history stages is contained within their respective life history sections contained in this biological opinion.

ENVIRONMENTAL BASELINE

The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area; the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation; and the impact of State or private actions which are contemporaneous with the consultation in process.

Past Federal, State, and private actions which resulted in depletions in the Green River are presented in Table 1 and Appendix A. To place this information in perspective, the total potential (water already allocated although not all may be used in any given year) depletions accumulate to approximately 1,572,552 acre-feet annually, at or above Green River, Utah. Comparing this to the Green River flow at Green River, Utah, which averaged around 4,648,000 acre-feet over the past century, the depletions (real and potential) represent approximately 32 percent of the flow of the Green River. The total depletion for the entire Green River system is approximately 1,583,960 acre-feet.

The 32-percent depletion of the Green River affects endangered fish in two ways. First, any depletion above Flaming Gorge Dam decreases the amount of water which can be regulated for endangered fish (i.e., historic spring peaks may not be attainable). Secondly, any depletion below Flaming Gorge Dam is a net loss of water available for endangered fish. Other impacts of Flaming Gorge Dam and current operation include changes in the temperature regime; the magnitude, timing, and duration of the spring peak; and the amount of daily fluctuation occurring in the Green River. Late spring and summer temperatures in the Green River were moderated as a result of releases from the reservoir. Summer-winter flows were generally higher than those observed historically. With the exception of very wet years, the magnitude of the spring peak seldom approaches historic levels.

Table 1. Summary of water depletions in the Green River Basin.

RIVER/AREA	DEPLETION (Acre-feet)
Green River above Flaming Gorge	372,331
Upper Green River in Utah	145,089
Yampa River	129,841
Little Snake River	48,800
Duchesne River	542,118
White River	131,456
Lower Green River	125,325
San Rafael River	89,000
TOTAL	**1,583,960**

CUMULATIVE EFFECTS

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation. There are no known future State or private actions, that would not require a Federal action, anticipated to occur within the action area. This is primarily because the Green River flows through very little private or State land within the action area.

CONSIDERATIONS IN DEVELOPING A REASONABLE AND PRUDENT ALTERNATIVE

The Act requires the Service to work with other Federal Agencies in developing a reasonable and prudent alternative to the project under consultation if there is a determination that the project is likely to jeopardize the continued existence of listed species. As defined by 50 CFR 402, Final Rule, Federal Register, June 3, 1986, an alternative is deemed reasonable and prudent only if:

1. It can be implemented by the lead Federal Agency (Reclamation) in a manner consistent with the intended purpose of the project.

2. The Service believes it would avoid the likelihood of jeopardizing the continued existence of listed species.

3. It can be formulated so that it can be implemented by the lead Federal Agency consistent within the scope of its legal authority and jurisdiction.

4. It is economically and technically feasible.

The reasonable and prudent alternative developed to avoid the likelihood of jeopardizing the continued existence of endangered fish in the Green River meets the aforementioned criteria. The June 1991 Flaming Gorge Consolidated Hydrology Report by Smith and Green and the July 1991 Habitat Use and Streamflow Needs of Rare and Endangered Fishes in the Green River Utah by Tyus and Karp provide the basis for development of the reasonable and prudent alternative.

The Green River below Flaming Gorge Dam represents one of the most important riverine habitats left for rare and endangered fish in the Upper Colorado River Basin, and, as such, is necessary for the continued existence and recovery of these species.

Decline and endangerment of the Colorado River fish is due, in part, to human-induced habitat changes. Closure and operation of Flaming Gorge eliminated most of the native fish in 80 miles of the upper Green River from Flaming Gorge Dam down to Dinosaur (Baxter and Simon 1970; Vanicek et al. 1970). Present operation of Flaming Gorge Dam through this reach does not provide desirable flow and temperature conditions for endangered fish. Existing stocks of some species of endangered fish are maintained in the Yampa River because of the more acceptable flow and temperature regimens (Tyus and Karp 1989). Reproduction of Colorado squawfish in the lower Green River continues because of ameliorating effects of tributary flows, increased distance from Flaming Gorge Dam, and past cooperative efforts by Reclamation in providing flows beneficial to maintenance of the rare fish. However, bonytail chub (which are near extirpation from the Upper Colorado River Basin) and razorback suckers (which have had virtually no recruitment) have continued to decline since the closure of Flaming Gorge Dam.

Many factors influence the habitat needs of endangered and other native fish in the Green River, including time of year, life history stage, and habitat use of sympatric species. Flow, temperature, and other parameters associated with natural spring runoff influence the reproductive activities of Colorado squawfish, humpback chub, and razorback suckers. Maintenance of low, stable flows in late summer and early autumn is conducive to successful recruitment in Colorado squawfish. High spring flows are believed to benefit all native fish. However, the timing of high releases is critical. The abnormally high summer releases of 1983 and 1984 from Flaming Gorge Dam resulted in the almost total loss of two year classes. Low, stable winter flows through ice breakup are probably important to overwinter survival of young and adults of native species, and very high winter flows may adversely affect endangered fish and could provide an undesirable winter refugium for some introduced fish. Alteration of historic flow regimens directly affected razorback sucker recruitment in the Green River basin as its continued survival in the wild is imperiled. Humpback chub are rare in Whirlpool Canyon of the upper Green River and their status and habitat needs in Desolation and Gray Canyons remain relatively unknown.

Operation of Flaming Gorge Dam can be refined to lessen adverse impacts and to aid in the survival and recovery of the endangered Colorado River fish. Acceptable flows and temperatures will require two major changes: (1) higher spring releases and (2) lower, more stable warm flows during the summer and autumn.

Colorado Squawfish

The presence of adult Colorado squawfish in inundated shorelines and lowlands during spring runoff indicates that such behavior, and associated feeding, may offset the large energy expenditure required for migration and spawning. Thus, natural flooding of lowlands in the spring and the consequent increased availability of food and resting habitat appear important in the physiological readiness of adult Colorado squawfish. Migration signals the onset of the reproductive cycle in Colorado squawfish, and we consider migration cues (e.g., high spring flows, increasing river temperatures, and possible chemical inputs from flooded land) important to the maintenance of successful reproduction. Migration routes must be protected and barriers discouraged. The duration, magnitude, and timing of spring runoff also affect preparation of substrate for spawning and formation of eddy and pool habitats used by staging fish. High spring flows mobilize and deliver nutrients and sediments downstream and aid in the formation of nursery areas. Additional studies are required to refine this relationship.

Humpback Chub

Humpback chub predominantly use high-gradient, rocky, canyon habitats, and availability of such habitat may be adversely affected by the present alteration of spring runoff in the Green River. Spawning of humpback chub occurs shortly after highest spring discharge at river temperatures of about 20 °C in the Yampa River, and presumably in the Green River as well. Reduced spring runoff promotes growth of the introduced salt cedar, Tamarix spp., resulting in bank stabilization and increased availability of spawning habitat for introduced fish. Relationships between magnitude and duration of spring runoff should be further evaluated with a consideration of availability of shoreline eddy habitat, bank stabilization due to exotic vegetation, overgrowth, and abundance of nonnative and other potential competitor and predator fish.

68°F

Razorback Sucker

Spawning of razorback suckers occurs with increasing flows associated with highest spring runoff. Curtailment of spring runoff in the mainstream Green River may be associated with loss of recruitment to the juvenile stage. Overbank flooding during spring runoff is considered beneficial to adults and may be important for dispersal and rearing of young. Flaming Gorge releases should promote spring flooding of historic flooded lowlands. Influence of spring flows on razorback sucker spawn in the Green River should be more fully evaluated.

Bonytail Chub

Because so few bonytail chub were collected in the wild, their spring behavior and requirements are unknown. It is hypothesized that if the habitat and life history requirements of squawfish, humpback chub, and razorback suckers are met, then the remaining bonytail chub will benefit.

Summer

Colorado Squawfish

Gradually decreasing flows and sediment transport regimens and warming river temperatures in early and midsummer are necessary for successful spawning, hatching, and downstream transport of drifting larvae. The gradual decline of summer flows following spring scouring maintains natural sediment transport equilibria, prevents siltation of spawning substrate, aids downstream drift of larvae, and creates productive nursery areas.

Humpback Chub

Rapidly declining summer flows adversely affects spawning and nursery habitats by concentrating fish in suboptimal habitats and increasing the potential for disease, competition, predation, and hybridization. Gradually declining flows following peak spring runoff are desired. Year-round low flows aid growth of channel catfish, a potential competitor and predator of humpback chub.

Bonytail Chub

Because so few bonytail chub were collected in the wild, their summer behavior and requirements are unknown. It is hypothesized that if the habitat and life history requirements of squawfish and humpback chub are met, then the remaining bonytail chub will benefit.

Razorback Sucker

Recruitment failure of razorback suckers presumably occurs in late spring and early summer. This failure was linked elsewhere with predation by introduced fish (including common carp and channel catfish) and may be associated with loss of flooded bottomlands and lowered river temperatures. Lower flows may favor proliferation of potential predators.

Autumn and Winter

Colorado Squawfish

Low flows in late summer and autumn are correlated with availability of nursery habitat, young fish abundance, and growth. Backwater habitat (quantity and quality) in the upper Green River should be maximized through regulating Flaming Gorge releases. Reregulation should, however, consider tributary inflows provided by the Yampa River. Unusually high flows in the late summer and autumn reduce availability of nursery habitat for young Colorado squawfish. Stable winter flows reduce ice scouring of shoreline habitats used by overwintering adults and young, and stable winter base flows may reduce stress to the fish.

Humpback Chub

Habitat use and flow needs of the humpback chub during autumn and winter are not well understood. Observations during low-flow periods noted that *Gila* species were constrained to pools in dewatered rapids and other impounded waters. Conditions favoring reproduction and growth of channel catfish should be identified and avoided because of possible negative interactions between these species.

Bonytail Chub

Because so few bonytail chub were collected in the wild, their autumn/winter behavior and requirements are unknown. It is hypothesized that if the habitat and life history requirements of squawfish and humpback chub are met, then the remaining bonytail chub will benefit.

Razorback Sucker

Fluctuating winter flows with icy conditions may stress overwintering adults, and low, stable flows near historic levels are recommended.

REASONABLE AND PRUDENT ALTERNATIVE

1. Refinement of the operation of Flaming Gorge Dam so that flow and temperature regimes of the Green River will more closely resemble historic conditions.

   Typically, to produce a natural hydrograph and temperature regime, releases from Flaming Gorge Dam must be high in the spring, as warm as possible in early summer, and low and stable throughout the remainder of the year. However, because it is not possible to duplicate the exact flows which existed historically, the Service's recommendations are directed toward maximizing habitat as larval endangered fish enter the drift and to the fullest extent possible based on the biology of the species and upon the scientific data currently available. Releases needed to produce a natural hydrograph are discussed below in more detail with regard to timing, magnitude, and duration. Reclamation and Western Power will monitor releases from Flaming Gorge and flows at Jensen and on the Yampa River to ensure compliance with this opinion.

   Reclamation and Western Power will convene coordination meetings with the Service in April and October of each year to review past operations and discuss operation for the upcoming period. These meetings also will be used to examine research flow requests for the upcoming field seasons. Reclamation will prepare, for Fish and Wildlife Enhancement, an annual document detailing compliance with all elements of this reasonable and prudent alternative and detailing releases from Flaming Gorge Dam and flows at the Jensen, Utah, gage and from the Yampa River. Reclamation and Western Power will integrate these flows into their annual operating plans to further ensure that this element of the reasonable and prudent alternative is satisfied. The Jensen gage was chosen as a point of measurement because the flows from Flaming Gorge Dam and the Yampa River are attenuated at this point and endangered fish also are found at this location.

Spring

Releases from Flaming Gorge Dam will be patterned after spring flows of the Yampa River. Flaming Gorge releases will be gradually increased beginning between April 1 and May 15 of each year so peak Flaming Gorge releases will match peak runoff from the Yampa River, both in timing and duration, and thereby approximate historic average peak flows at Jensen, Utah. A high release from Flaming Gorge Dam must be provided annually to obtain a target peak flow between 13,000 and 18,000 cfs at Jensen, Utah, sustained for approximately 1 to 6 weeks beginning between May 15 and June 1. To achieve this flow, a release of 4,000-4,700 cfs will be required for the 1 to 6 weeks. The duration of these peak releases will depend on the water year with longer release periods in wet years and shorter release periods in dry years. A determination of whether it is a wet, average, or dry year will be made by the Service and Reclamation during the April coordination meeting.

We recognize conditions will vary each year depending on water conditions. However, as a guideline, to achieve a gradual increase in peak flows at Jensen, Utah, between April 1 and May 15 of each year, releases from Flaming Gorge should be gradual (i.e., no more than 400 cfs per day) and should reach at least 2,000 cfs during May. Then a peak flow release of 4,000-4,700 cfs would be made beginning between May 15 and June 1 for 1 to 6 weeks. Likewise, the postpeak decline should gradually be stepped down (i.e., a rate of not more than 400 cfs per day) and be synchronized with the drop in spring runoff in the Yampa River. If Reclamation and Western Power so chose, releases may fluctuate during the ascending and descending arms of the spring hydrograph. However, flows must attenuate by Jenson, Utah, and follow the hydrograph described above. When natural flow (>9,000 cfs) from the Yampa River is unavailable for an extended spring peak, then a brief peak with releases remaining at 4,000-4,700 cfs for only 1 week is acceptable from Flaming Gorge Dam as long as it coincides with the highest flows from the Yampa River. During normal water years, the entire spring peak will occur for a period of about 6-8 weeks. If it becomes necessary to bypass water from Flaming Gorge Dam to alleviate problems with storage, then the bypass should occur during or prior to the spring peak of the Yampa River, as has occurred occasionally in the past.

The peak spring flow as described above should stimulate spawning migration, prepare substrate for spawning, and prepare nursery areas for larval fish later in the year. Bottomlands in the Jensen and Ouray areas also would flood, thereby providing habitat and food for native fish.

Summer

Green River flows should continue decreasing, attaining a target flow of between 1,100-1,800 cfs at Jensen, Utah. Although historic summer and fall flows generally fell within this range, varying hydrologic conditions sometimes produced summer flows higher than these. It is the intent of the summer recommendation to optimize available nursery habitat shown to be necessary for larval Colorado squawfish. The date for achieving the target flow will be established based on the Yampa River hydrograph and using the following guidelines. During dry years, when the spring peak is abbreviated, larval squawfish should reach the nursery areas around June 20. During normal and wet years, the target flow should be achieved on or near July 10 and July 20, respectively. The dates presented herein are based on past spawning and larval drift data and are typical for dry, wet, and normal water years. The actual dates will be determined based primarily on the timing of runoff in the Yampa River. Also, if during the course of spring and/or summer annual monitoring more precise data becomes available, Reclamation and the Service will adjust the target date, ensuring that nursery habitats are maximized when larval endangered fish drift into the Green River. Based on hydrologic conditions and Reclamation's water release needs, a target flow for Jensen will be selected in the range of 1,100-1,800 cfs which will remain in effect through the summer period. Fluctuations will deviate no more than 25 percent around the established flow, while remaining within the 1,100-1,800 cfs range. For example, if 1,600 cfs is selected as the target flow, then flows as measured at Jensen will remain between ~~1,300-1,800~~ cfs; or if a target of 1,300 cfs is selected, then flows will remain between ~~1,100-1,625 cfs~~. These ranges are not daily means but are hourly values as measured at the U.S. Geological Survey gauge at Jensen, Utah.

A summer freshet originating from the Yampa River or any other tributary would not require a change in release from Flaming Gorge Dam to compensate for the additional flow. We assume that these were natural events historically and can probably be tolerated by the native species. Releases from Flaming Gorge beginning July 1 and continuing until November 1 should be of the warmest water available, approaching 15 °C (highest lake levels). By releasing the warmest water available during this period, water temperatures in the upper Green River should not differ more than 5 °C from the temperature in the Yampa River at Echo Park and should average near 22-25 °C in Gray Canyon from July 1 to August 15.

Autumn

Autumn flows are a continuation of the late summer flows described above. However, if the year was classified as wet during the April coordination meeting and a need to release excess water still exists, the target flow may be increased to within the range of 1,100-2,400 cfs. If water conditions dictate, the new target may be selected on or after September 15. The 25-percent fluctuation around the target flow remains in effect. Green River flows (measured at Jensen) at or below 2,400 cfs should be sustained until November 1 of each year. During average and dry years, the target flows selected for summer will remain in effect. Flows after November 1 are addressed in the winter period.

Winter

The goal for winter releases is to provide low, stable flows near historic levels. Winter flows should be stabilized once ice cover forms and remain so through normal spring breakup. The exception to this is when it becomes evident that higher winter releases are necessary to ensure meeting spring through autumn flows. Under ice conditions, fluctuating flows that promote ice breakup, jams, and shoreline scoring in the mainstream Green River are undesirable for adult fish. Under conditions when ice does not form or when specific research flows are not requested, flows may be operated within constraints of Reclamation's agreement with the State of Utah and the need to release water during wet years. If possible, fluctuations during this period should be moderated. The winter period also should be used to manage Flaming Gorge storage to ensure that flows needed for the following spring peak and summer low, stable period will be provided.

The Service realizes that emergency events may occur that impact Reclamation's ability to comply with this element of the reasonable and prudent alternative. Where emergency circumstances mandate the need to consult in an expedited manner because Reclamation or Western Power determine that they will not be able to conform to the reasonable and prudent alternative for an extended period, consultation may be conducted informally through alternative procedures that the Service determines to be consistent with the requirements of Section 7(a)-(d) of the Act. This provision applies to situations involving acts of God, disasters, casualties, national defense, and security emergencies. If emergency events exceed 20 hours during any month, Western Power will contact the Service to determine if reinitiation of Section 7 consultation is necessary and to examine ways of maintaining flows for the endangered fish. If after informal consultation, a formal consultation is deemed necessary, it shall be initiated as soon as practical after the emergency is under control. Reclamation and Western Power will submit information on the nature of the emergency action(s), the justification for the expedited consultation, and the impacts to endangered or threatened species and their habitats. The Service will evaluate such information and issue a biological opinion including the information and recommendations given during the emergency consultation. Western Power will report all short-term emergency events that result in a deviation in the reasonable and prudent alternative on a quarterly basis.

2. Conduct a 5-year research program including implementation of winter and spring research flows beginning in 1992 to allow for potential refinement of flows for these seasons. This research program will be based on the Five-Year Flaming Gorge Flow Recommendations Investigation which was approved by the Recovery Program (Appendix B). The program provides for annual meetings to refine seasonal flows based on research findings and water year forecast. Except for specific research flows during the 5-year research program, year-round flows in the Green River will resemble a natural hydrograph described under element 1 of the reasonable and prudent alternative.

   Research needed to further evaluate the winter/spring flows, flow needs and effects in the lower Green River, and research flows for the summer and autumn periods will be established during an annual coordination meeting between Reclamation, Western Power, and the Service in early April after determination of the water year forecast. The Standardized Data Collection Program with supportive studies for the Green River is in place and will be able to monitor fish response to yearly flow patterns (contained in the Five-Year Flaming Gorge Flow Recommendations Investigation, Appendix B). Research beginning in 1992 will focus on the winter and spring seasons. Winter research flows will be established so that various conditions ranging from base loading to full peaking power operations can be further evaluated. This will include at least 1 year of stable winter releases at or below 2,000 cfs and 1 year with a spring peak of approximately 18,000 cfs measured at Jensen gage. If hydrologic conditions do not provide a 18,000-cfs spring peak, then jet tube bypass will be utilized. Spring research flows will examine various spring peaks altering the current established spring flow in both magnitude and duration. Fish access to off-channel habitats during years with high spring peaks will need improvement and should be provided concurrent with the research flows. In years where specific research flows are not established, winter and spring flows will be those outlined in element 1 of the reasonable and prudent alternative.

Part of the 5-year research plan will be to evaluate the year-round seasonal flow recommendation throughout the entire Green River. At the conclusion of the 5-year research period, flow recommendations will be extended from the dam to Lake Powell.

3. Determine the feasibility and effects of releasing warmer water during the late spring/summer period and investigate the feasibility of retrofitting river bypass tubes to include power generation, thereby facilitating higher spring releases.

   The change in water temperatures as a result of impoundments is believed to be one of the causes for the decline in rare and endangered fish throughout the Colorado River Basin. Water temperature was shown to influence spawning migrations, spawning, egg viability, larval survival, feeding, and growth of endangered fish. Providing warmer water during critical life history periods could further benefit the affected fish. Reclamation will complete these examinations during the 5-year research program. If technologies exist or future technologies become available which make these alternatives feasible, then Reclamation should enter into discussions with the Service concerning implementation.

4. Legal protection of Green River flows from Flaming Gorge Dam to Lake Powell.

   Protection of flows for the endangered fish is a major element of the Recovery Program (U.S. Fish and Wildlife Service 1987). Section 4.1.3 of the Recovery Program states that "the success of this recovery program is contingent upon the provision of water rights for instream flows that satisfy the requirement of the Endangered Species Act." Specifically, the Recovery Program contains commitments from the States of Colorado and Utah to work with the Secretary of the Interior to legally protect the instream flows necessary for recovery of the endangered fish. Legal protection of flows also is identified as a requirement for delisting in the Colorado squawfish and humpback chub recovery plans (U.S. Fish and Wildlife Service 1991; U.S. Fish and Wildlife Service 1990a). Additionally, releases from Flaming Gorge are the reasonable and prudent alternative/conservation measure identified to offset the actual or potential depletion impacts associated with the Strawberry System; the Jensen, Uintah, the Upalco Units of the Central Utah Project; the Price-San Rafael Salinity Control Project; and the Narrows Project, as described in the biological opinions for these projects. Consequently, development of a legal mechanism to ensure that the releases from Flaming Gorge Dam are delivered to and available for use by the endangered fish in occupied habitat from Swallow Canyon, near Browns Park National Wildlife Refuge, downstream to Lake Powell, is necessary to satisfy all of these needs. Inflows from the Yampa River, White River, and other major tributaries contribute significantly to the flows of the Green River, especially during the spring. Ultimately, tributary inflows necessary to satisfy the flow requirements of the endangered fish in the Green River also will need to be legally protected. Protection of tributary flows will be pursued through the Recovery Program and not as a requirement of this biological opinion.

The Service believes that the legal protection of releases from Flaming Gorge to benefit the endangered fish in the Green River can best be accomplished by working through the Recovery Program. Within the Recovery Program, a Water Acquisition Committee was formed to coordinate and facilitate acquisition and legal protection of water and water rights necessary to recover the endangered fish in the Upper Colorado River Basin. Many of the parties who are instrumental to or have an interest in legal protection of instream flows in the Green River are represented on this committee, including Reclamation; the Service; Western Power; the States of Utah, Colorado, and Wyoming; the environmental community; and private water-user groups. Reclamation, as the lead Federal Agency for carrying out the reasonable and prudent alternative in this biological opinion, will work through the Water Acquisition Committee to develop and/or implement a legal mechanism to protect releases from Flaming Gorge. In addition, the Northern Ute Tribe will be invited to participate in the process because of its unique status and interest in water in the Green River basin.

The Service believes that the initial focus should be on providing for legal protection of flows in the Green River from Flaming Gorge Dam to the confluence of the Duchesne River for the July through October period, because there has been general acceptance of the Service's flow recommendations for this section of the Green River for this time period. Furthermore, the Service believes that development of a legal mechanism to protect releases from Flaming Gorge Dam to the confluence of the Duchesne River for July through October should be completed within 2 years following finalization of this biological opinion. If this is not accomplished, the Service may request reinitiation of Section 7 consultation for units of the Central Utah Project described above and other projects which rely upon Flaming Gorge to offset their depletion impacts.

The Service recognizes that there is uncertainty about the flow requirements of the fish during the spring and winter periods in the upper Green River. In addition, the flow requirements in the lower Green River have not been precisely quantified. It is anticipated that the 5-year research program identified in this reasonable and prudent alternative will address these uncertainties and provide a basis for identifying more precisely the quantities of water that require legal protection. Upon completion of the 5-year research program, Reclamation will work within the Recovery Program to develop a mechanism to provide for legal protection of flows for other seasons and other sections of the Green River. If legal protection is not accomplished, reinitiation of Section 7 consultation will be required.

5. Initiate discussions with the Service after the conclusion of the 5-year research program to examine further refinement of flows for the endangered Colorado River fish.

   Flows were established year-round based on the best scientific and commercial data currently available. Yet questions remain pertaining to the winter and spring periods. Current data indicate the need for a spring peak, although the nature of the peak (magnitude versus duration) may still need refinement. Historically, winter flows were low and stable in the Green River. Questions regarding the effects on the endangered fish of deviating from low and stable winter flows need to be addressed. Therefore, further research is imperative for these periods to ensure that the flows required to preserve and recover the endangered fish will eventually be in place.

Formal Section 7 consultation must be reinitiated if:

a. the amount or extent of taking specified in the incidental take statement is exceeded;

b. new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;

c. the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or

d. a new species is listed or critical habitat designated that may be affected by the identified action.

Although the Yampa River flow regime is used to cue releases from Flaming Gorge Dam, this opinion does not prejudge future development in the Yampa River. Any such development will require Section 7 consultation in compliance with the Act.

CONSERVATION RECOMMENDATIONS

In order to avoid adverse effects of long-term operation of Flaming Gorge Dam on the rare and endangered fish, the Service makes the following recommendations.

1. Reclamation should examine methods for opening fish access to backwaters and flooded bottomlands during high releases. Salt cedar establishment reduced fish access to habitats off the main channel. The methods may include salt cedar removal or opening channels through the salt cedar and obtain any necessary flowage easements.

2. Changes in tributary and main channel flow patterns contributed to the accumulation of heavy metals and other contaminants in historic bottomland areas. As use of these areas increases through operational changes, these areas will require some cleanup effort. Reclamation should continue its active role in cleaning up these habitats.

INCIDENTAL TAKE

Section 9 of the Act prohibits any taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct) of listed species without a special exemption. Harm is further defined to include significant habitat modification or degradation that results in death or injury to endangered fish and wildlife by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered taking with the bounds of the Act provided that such taking is in compliance with the incidental take statement.

With protective provisions included in the reasonable and prudent alternative contained herein, the Service does not anticipate that the proposed operation of Flaming Gorge Dam will result in any incidental take of Colorado squawfish, humpback chub, bonytail chub, razorback suckers, bald eagles, peregrine falcons, or Utah ladies'-tresses. Accordingly, no incidental take is authorized. Should any take occur, Reclamation must reinitiate formal consultation with the Service and provide detailed circumstances surrounding the take.

The incidental take statement provided in this opinion satisfies the requirements of the Act. This statement does not constitute an authorization for take of listed migratory birds under the Migratory Bird Treaty Act, the Bald and Golden Eagle Protection Act, or any other Federal statute.

CONCLUSION

This concludes the biological opinion on the impacts of operation of Flaming Gorge Dam. The Service determined that current operation of Flaming Gorge Dam is likely to jeopardize the continued existence of the endangered fish in the Green River; however, a reasonable and prudent alternative which offsets jeopardy to the endangered fish was identified as a result of this consultation.

The reasonable and prudent alternative includes:

1. refinement of the operation of Flaming Gorge Dam so that flow and temperature regimes of the Green River will more closely resemble natural conditions;

2. conduction of a 5-year research program including implementation of winter and spring research flows beginning in 1992 to allow for potential refinement of flows for these seasons. This research program will be based on the Five-Year Flaming Gorge Flow Recommendations Investigations which was approved by the Recovery Program (Appendix B). The program provides for annual meetings to refine seasonal flows based on research findings and water year forecast. Except for specific research flows during the 5-year research program, year-round flows in the Green River will resemble a natural hydrograph described under element 1 of the reasonable and prudent alternative;

3. determination of the feasibility and effects of releasing warmer water during the late spring/summer period and investigation of the feasibility of retrofitting river bypass tubes to include power generation, thereby facilitating higher spring releases;

4. legal protection of Green River flows from Flaming Gorge Dam to Lake Powell; and

5. initiation of discussions with the Service after the conclusion of the 5-year research program to examine further refinement of flows for the endangered Colorado River fish.

Thank you for your cooperation in the formulation of this opinion and your interest in conserving endangered species.

REFERENCES

Andrews, E.D. 1986. Downstream effects of Flaming Gorge Reservoir on the Green River, Colorado, and Utah. Geological Society of America Bulletin 97:1012-1023.

Archer, D.L., and H.M. Tyus. 1984. Colorado squawfish spawning study, Yampa River. U.S. Fish and Wildlife Service, Salt Lake City, Utah. 32 pp.

Azevedo, R.L. 1962. Dinosaur National Monument-Green River fish collections. Fishery management report. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 41 pp.

Baxter, G.T., and J.R. Simon. 1970. Wyoming Fishes. Wyoming Game and Fish Department, Cheyenne. 168 pp.

Beamesderfer, R.C., and J.L. Congleton. 1981. Spawning behavior, habitat selection and early life history of northern squawfish with inferences to Colorado squawfish. Pages 47-127 in Colorado River Fishery Project, Part 3, Final Report. U.S. Fish and Wildlife Service and Bureau of Reclamation, Salt Lake City, Utah.

Behnke, R.J., and D.E. Benson. 1983. Endangered and threatened fishes of the upper Colorado River basin. Cooperative Extension Service, Colorado State University, Fort Collins. Bulletin 503A. 38 pp.

Berry, C.R., Jr. 1988. Effects of cold shock on Colorado squawfish larvae. Southwestern Naturalist 33:193-197.

Binns, N.A., F. Eiserman, F.W. Jackson, A.F. Regenthal, and R. Stone. 1963. The planning, operation, and analysis of the Green River rehabilitation project. Utah State Department of Fish and Game and Wyoming Game Fish Department, Salt Lake City and Cheyenne. 83 pp.

Brooks, J.E., P.C. Marsh, and W.L. Minckley. 1985. Reintroduction and monitoring of razorback sucker in the lower Colorado River basin. Proceedings Western Division, American Fisheries Society 65:203.

Bulkley, R.V., and R. Pimentel. 1983. Temperature preference and avoidance by adult razorback suckers. Transactions of the American Fisheries Society 112:601-607.

Burns, J.W. 1966. Sacramento squawfish. Pages 525-527 in A. Calhoun, ed. Inland Fisheries Management. State of California, Department of Fish and Game.

Erman, D.C., and G.R. Leidy. 1975. Downstream movements of rainbow trout fry in a tributary of Sagehen Creek, under permanent and intermittent flow. Transactions of the American Fisheries Society 104:467-473.

Grabowski, S.J., and S.D. Hiebert. 1989. Some aspects of trophic interactions in selected backwaters and the main channel of the Green River, Utah. 1987-1988. Final Report. Bureau of Reclamation, Denver, Colorado.

Haines, G.B., and H.M. Tyus. 1990. Fish associations and environmental variables in age-0 Colorado squawfish habitats, Green River, Utah. Journal of Freshwater Ecology 5:427-436.

Hamman, R.L. 1981a. Hybridization of three species of chub in a hatchery. Progressive Fish Culturist 43:140-141.

Hamman, R.L. 1981b. Spawning and culture of Colorado squawfish in raceways. Progressive Fish Culturist 43:173-177.

Hamman, R.L. 1982a. Culture of endangered Colorado River Fishes, sections I-V. In W. Miller et al., eds. Colorado River Fishery Project, Part 3, Final Report. U.S. Bureau of Reclamation, Salt Lake City, Utah.

Hamman, R.L. 1982b. Report number 3, Culture of endangered Colorado River fishes: Section IV; Spawning and culture of humpback chub. U.S. Fish and Wildlife Service, Willow Beach National Fish Hatchery, Boulder City, Nevada. 10 pp.

Hamman, R.L. 1982c. Report number 3, Culture of endangered Colorado River fishes: Section V; Induced spawning and culture of bonytail chub. U.S. Fish and Wildlife Service, Willow Beach National Fish Hatchery, Boulder City, Nevada. 8 pp.

Hamman, R.L. 1985. Induced spawning and culture of hatchery reared bonytail. Progressive Fish Culturist 47:239-241.

Haynes, C.M., and R.T. Muth. 1984. Identification of habitat requirements and limiting factors for Colorado squawfish and humpback chubs. Colorado Division of Wildlife, Job Progress Report, Federal Aid Project, SE-3, Work Plan 2, Job 1, Denver. 21 pp.

Haynes, C.M., T.A. Lytle, E.J. Wick, and R.T. Muth. 1984. Larval Colorado squawfish (Ptychocheilus lucius Girard) in the upper Colorado River basin, Colorado, 1979-1981. Southwestern Naturalist 29:21-33.

Holden, P.B. 1978. A study of the habitat use and movement of the rare fishes in the Green River, Utah. Transactions of the Bonneville Chapter, American Fisheries Society 1978:64-90.

Holden, P.B., and C.B. Stalnaker. 1975. Distribution of fishes in the Dolores and Yampa River systems of the Upper Colorado Basin. Southwestern Naturalist 19:403-412.

Grabowski, S.J., and S.D. Hiebert. 1989. Some aspects of trophic interactions in selected backwaters and the main channel of the Green River, Utah. 1987-1988. Final Report. Bureau of Reclamation, Denver, Colorado.

Haines, G.B., and H.M. Tyus. 1990. Fish associations and environmental variables in age-0 Colorado squawfish habitats, Green River, Utah. Journal of Freshwater Ecology 5:427-436.

Hamman, R.L. 1981a. Hybridization of three species of chub in a hatchery. Progressive Fish Culturist 43:140-141.

Hamman, R.L. 1981b. Spawning and culture of Colorado squawfish in raceways. Progressive Fish Culturist 43:173-177.

Hamman, R.L. 1982a. Culture of endangered Colorado River Fishes, sections I-V. In W. Miller et al., eds. Colorado River Fishery Project, Part 3, Final Report. U.S. Bureau of Reclamation, Salt Lake City, Utah.

Hamman, R.L. 1982b. Report number 3, Culture of endangered Colorado River fishes: Section IV; Spawning and culture of humpback chub. U.S. Fish and Wildlife Service, Willow Beach National Fish Hatchery, Boulder City, Nevada. 10 pp.

Hamman, R.L. 1982c. Report number 3, Culture of endangered Colorado River fishes: Section V; Induced spawning and culture of bonytail chub. U.S. Fish and Wildlife Service, Willow Beach National Fish Hatchery, Boulder City, Nevada. 8 pp.

Hamman, R.L. 1985. Induced spawning and culture of hatchery reared bonytail. Progressive Fish Culturist 47:239-241.

Haynes, C.M., and R.T. Muth. 1984. Identification of habitat requirements and limiting factors for Colorado squawfish and humpback chubs. Colorado Division of Wildlife, Job Progress Report, Federal Aid Project, SE-3, Work Plan 2, Job 1, Denver. 21 pp.

Haynes, C.M., T.A. Lytle, E.J. Wick, and R.T. Muth. 1984. Larval Colorado squawfish (*Ptychocheilus lucius* Girard) in the upper Colorado River basin, Colorado, 1979-1981. Southwestern Naturalist 29:21-33.

Holden, P.B. 1978. A study of the habitat use and movement of the rare fishes in the Green River, Utah. Transactions of the Bonneville Chapter, American Fisheries Society 1978:64-90.

Holden, P.B., and C.B. Stalnaker. 1975. Distribution of fishes in the Dolores and Yampa River systems of the Upper Colorado Basin. Southwestern Naturalist 19:403-412.

Holden, P.B., and L. Crist. 1981. Documentation of changes in the macroinvertebrate and fish populations in the Green River due to inlet modification of Flaming Gorge Dam. Contract No. 0-07-40-S1357, Water and Power Resources Service, U.S. Fish and Wildlife Service, Salt Lake City, Utah.

Jacobi, G., and M. Jacobi. 1982. Fish stomach content analysis. Pages 285-324 in Colorado River Fishery Project, Part 3, Final Report. U.S. Fish and Wildlife Service and Bureau of Reclamation, Salt Lake City, Utah.

Joseph, T.W., J.A. Sinning, R.J. Behnke, and P.B. Holden. 1977. An evaluation of the status, life history, and habitat requirements of endangered and threatened fishes of the upper Colorado River system. U.S. Fish and Wildlife Service, Office of Biological Services, Fort Collins, Colorado. 183 pp.

Kaeding, L.R., and M.A. Zimmerman. 1983. Life history of the humpback chub in the Little Colorado and Colorado rivers of the Grand Canyon. Transactions of the American Fisheries Society 112:577-594.

Karp, C.A., and H.M. Tyus. 1990a. Humpback chub (Gila cypha) in the Yampa and Green Rivers, Dinosaur National Monument, with observations on roundtail chub (G. robusta) and other sympatric fishes. Great Basin Naturalist 50:257-264.

Karp, C.A., and H.M. Tyus. 1990b. Behavioral interactions between young Colorado squawfish and six fish species. Copeia 1990:25-34.

Lanigan, S.H., and H.M. Tyus. 1989. Population size and status of razorback sucker in the Green River basin, Utah and Colorado. North American Journal of Fisheries Management 9:68-73.

Lyons, J. 1989. Green River channel characteristics below Flaming Gorge. U.S. Department of the Interior, Bureau of Reclamation, Earth Sciences Division, Surface Water Branch, Sedimentation Section, Denver, Colorado. February 1989 Draft.

Marsh, P.C. 1985. Effect of incubation temperature on survival of embryos of native Colorado River fishes. Southwestern Naturalist 30:129-140.

Marsh, P.C., and D.R. Langhorst. 1988. Feeding and fate of wild larval razorback sucker. Environmental Biology of Fishes 21:59-67.

Marsh, P.C., and W.L. Minckley. 1989. Observations on recruitment and ecology of razorback sucker: lower Colorado River, Arizona-California-Nevada. Great Basin Naturalist 49:71-78.

Martinez, P.J. 1986. White River Taylor Draw Project. Pre- and Post-impoundment Fish Community Investigations. Final Report. Colorado Division of Wildlife. 121 pp.

McAda, C.W. 1983. Colorado squawfish, Ptychocheilus lucius (Cyprinidae), with a channel catfish, Ictalurus punctatus (Ictaluridae), lodged in its throat. Southwestern Naturalist 28:119-120.

McAda, C.W., and L.R. Kaeding. 1989. Relationship between maximum-annual river discharge and the relative abundance of age-0 Colorado squawfish and other fishes in the upper Colorado River. U.S. Fish and Wildlife Service, Grand Junction, Colorado. 25 pp.

McAda, C.W., and H.M. Tyus. 1984. Resource overlap of Age-0 Colorado squawfish with other fish species in the Green River, 1980. Proceedings of the Bonneville Chapter, American Fisheries Society 1984:44-54.

McAda, C.W., and R.S. Wydoski. 1980. The razorback sucker, Xyrauchen texanus, in the Upper Colorado River Basin, 1974-76. U.S. Fish and Wildlife Service Technical Paper 99. 15 pp.

McCarthy, M.S., and W.L. Minckley. 1987. Age estimation for razorback sucker from Lake Mohave, Arizona, and Nevada. Journal of Arizona-Nevada Academy Sciences 21:87-97.

Miller, W.H., D.L. Archer, H.M. Tyus, and R.M. McNatt. 1982a. Yampa River fishes study, Final Report. U.S. Fish Wildlife Service and National Park Service Cooperative Agreement 14-16-0006-81-931 (1A), Salt Lake City, Utah. 107 pp.

Miller, W.H., ~~D.L. Archer~~, H.M. Tyus, and K.C. Harper. 1982b. White River fishes study, Final Report. U.S. Fish and Wildlife Service, Salt Lake City, Utah. 58 pp.

Miller, W.H., J.J. Valentine, D.L. Archer, H.M. Tyus, R.A. Valdez, and L.R. Kaeding. 1982c. Colorado River Fishery Project Final Report Summary. U.S. Fish and Wildlife Service, Salt Lake City, Utah. 42 pp.

Minckley, W.L. 1973. Fishes of Arizona. Arizona Game and Fish Department. Phoenix. 293 pp.

Minckley, W.L. 1983. Status of the razorback sucker, Xyrauchen texanus (Abbott), in the lower Colorado River Basin. Southwestern Naturalist 28:165-187.

Minckley, W.L., and G.K. Meffe. 1987. Differential selection by flooding in stream fish communities of the arid American southwest. Pages 93-104 in W.J. Matthews and D.C. Heins, eds. Community and Evolutionary Ecology of North American Stream Fishes. University of Oklahoma Press, Norman.

Minckley, W.L., D.S. Schultz, and H.M. Tyus. In preparation. Age Determination in Colorado Squawfish and Razorback Sucker.

Muth, R., C.A. Karp, and H.M. Tyus. In preparation. Diet of young Colorado squawfish and other fishes in backwaters, Green River, Utah.

Nesler, T.P., R.T. Muth, and A.F. Wasowicz. 1988. Evidence for baseline flow spikes as spawning cues for Colorado squawfish in the Yampa River, Colorado. American Fisheries Society Symposium 5:68-79.

Patten, B.G., and D.T. Rodman. 1969. Reproductive behavior of northern squawfish (Ptychocheilus oregonensis). Transactions of the American Fisheries Society 98:108-111.

Paulin, K.M., G.B. Haines, H.M. Tyus, and C.M. Williams. In preparation. Response of young Colorado squawfish to water flow and light intensity. Environmental Biology of Fishes.

Pimentel, R., R.V. Bulkley, and H.M. Tyus. 1985. Choking of Colorado squawfish, Ptychocheilus lucius (Cyprinidae), on channel catfish, Ictalurus punctatus (Ictaluridae), as a cause of mortality. Southwestern Naturalist 30:154-158.

Pucherelli, M.J., and R.C. Clark. 1989. Comprehensive Report (1986-1988) on the Effects of Green River Flows on Backwater Habitat Availability as Determined by Remote Sensing Techniques. U.S Bureau of Reclamation, Engineering and Research Center, Denver, Colorado.

Rosenfeld, M.J., and J.A. Wilkinson. 1989. Biochemical genetics of the Colorado River Gila complex (Pisces: Cyprinidae). Southwestern Naturalist 34:232-244.

Seethaler, K.H., C.W. McAda, and R.S. Wydoski. 1979. Endangered and threatened fish in the Yampa and Green rivers of Dinosaur National Monument. Proceedings of the first conference on scientific research in the national parks. Vol. 1. National Park Service Transactions and Proceeding Series (5):605-612.

Severson, S.H., C.A. Karp, H.M. Tyus, and G.B. Haines. 1990. Rearing of razorback suckers at Ouray, Utah. Proceedings of the Bonneville Chapter, American Fisheries Society. In press.

Smith, G.R. 1960. Annotated list of fishes of the Flaming Gorge Reservoir Basin, 1959. Pages 163-168 in A.M. Woodbury, ed. Ecological studies of the flora and fauna of Flaming Gorge Reservoir basin, Utah and Wyoming. Anthropological Papers 48, University of Utah Press, Salt Lake City.

Smith, G.R., and R.G. Green. 1991. Flaming Gorge consolidated hydrology report. U.S. Fish and Wildlife Service, Division of Water Resources, Denver, Colorado.

Thompson, J.M. 1989. The role of size, condition, and lipid content in the overwinter survival of age-0 Colorado squawfish. M.S. Thesis, Colorado State University, Fort Collins. 82 pp.

Tyus, H.M. 1984. Loss of stream passage as a factor in the decline of the endangered Colorado squawfish. Pages 138-144 in Issues and technology in the management of impacted Western Wildlife. Proceedings of a National Symposium. Thorne Ecological Institute Technical Publication 14. Boulder, Colorado.

Tyus, H.M. 1985. Homing behavior noted for Colorado squawfish. Copeia 1985:213-215.

Tyus, H.M. 1986. Life strategies in the evolution of the Colorado squawfish (Ptychocheilus lucius). Great Basin Naturalist 46:656-661.

Tyus, H.M. 1987. Distribution, reproduction, and habitat use of the razorback sucker in the Green River, Utah, 1979-1986. Transactions of the American Fisheries Society 116:111-116.

Tyus, H.M. 1990. Potamodromy and reproduction of Colorado squawfish in the Green River Basin, Colorado and Utah. Transactions of the American Fisheries Society 119:1035-1047.

Tyus, H.M. 1991. Movements and habitat use of young Colorado squawfish in the Green River, Utah. Journal of Freshwater Ecology 6:43-51.

Tyus, H.M. In press. Ecology and management of Colorado squawfish, Ptychocheilus lucius. In Minckley, W.L., and J.E. Deacon, eds. Battle against extinction: native fish management in the American West. University of Arizona Press, Tucson.

Tyus, H.M., and J. Beard. 1990. Esox lucius (Esocidae) and Stizostedion vitreum (percidae) in the Green River basin, Colorado and Utah. Great Basin Naturalist 50:33-39.

Tyus, H.M., and G.B. Haines. 1991. Distribution, habitat use, and growth of age-0 Colorado squawfish in the Green River basin, Colorado and Utah. Transactions of the America Fisheries Society 120:79-89.

Tyus, H.M., and C.A. Karp. 1989. Habitat use and streamflow needs of rare and endangered fishes, Yampa River, Colorado. U.S. Fish and Wildlife Service, Biological Report 89(14). 27 pp.

Tyus, H.M., and C.A. Karp. 1990. Spawning and movements of razorback sucker, Xyrauchen texanus, in the Green River basin of Colorado and Utah. Southwestern Naturalist 35:427-433.

Tyus, H.M., and C.A. Karp. 1991. Habitat use and streamflow needs of rare and endangered fishes, Green River, Utah. U.S. Fish and Wildlife Service, Flaming Gorge Studies Program, Vernal, Utah. 54 pp.

Tyus, H.M., and C.W. McAda. 1984. Migration, movements, and habitat preferences of Colorado squawfish, Ptychocheilus lucius, in the Green, White, and Yampa Rivers, Colorado and Utah. Southwestern Naturalist 29:289-299.

Tyus, H.M., and W.L. Minckley. 1988. Migrating Mormon crickets, Anabrus simplex (Orthoptera: Tettigoniidae), as food for stream fishes. Great Basin Naturalist 48:25-30.

Tyus, H.M., B.D. Burdick, R.A. Valdez, C.M. Haynes, T.A. Lytle, and C.R. Berry. 1982a. Fishes of the Upper Colorado River Basin: Distribution, abundance and status. Pages 12-70 in W.H. Miller, H.M. Tyus, and C.A. Carlson, eds. Fishes of the Upper Colorado River System: Present and future. American Fisheries Society, Bethesda, Maryland. 131 pp.

Tyus, H.M., C.W. McAda, and B.D. Burdick. 1982b. Green River Fishery Investigations: 1979-1981. Pages 1-99 in Colorado River Fishery Project, Part 2, Final Report. U.S. Fish and Wildlife Service and Bureau of Reclamation, Salt Lake City, Utah.

Tyus, H M., B.D. Burdick, and C.W. McAda. 1984. Use of radiotelemetry for obtaining habitat preference data on Colorado squawfish. North American Journal of Fisheries Management 4:177-180.

Tyus, H.M., R.L. Jones, and L.M. Trinca. 1987. Green River rare and endangered fish studies, 1982-1985. Final Report. Colorado River Fishes Monitoring Project, U.S. Fish and Wildlife Service, Vernal, Utah. 117 pp.

U.S. Fish and Wildlife Service. 1987. Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. U.S. Fish and Wildlife Service, Denver, Colorado. 82 pp.

U.S. Fish and Wildlife Service. 1990a. Humpback Chub Recovery Plan. U.S. Fish and Wildlife Service, Denver, Colorado. 43 pp.

U.S. Fish and Wildlife Service. 1990b. Bonytail Chub Recovery Plan. U.S. Fish and Wildlife Service, Denver, Colorado. 35 pp.

U.S. Fish and Wildlife Service. 1991. Colorado Squawfish Recovery Plan. U.S. Fish and Wildlife Service, Denver, Colorado. 56 pp.

Utah State Department of Fish and Game. 1964. Reservoir fisheries investigation: Glen Canyon unit, Upper Colorado River Storage Project. Annual Progress Report 1. Utah State Department of Fish and Game, Salt Lake City. 30 pp.

Utah State Department of Fish and Game. 1969. Glen Canyon reservoir postimpoundment investigation. Annual Progress Report 6. Utah State Department of Fish and Game, Salt Lake City. 16 pp.

Valdez, R.A., and G.H. Clemmer. 1982. Life history and prospects for recovery of the humpback chub and bonytail chub. Pages 109-119 in W.H. Miller, H.M. Tyus, and C.A. Carlson, eds. Fishes of the Upper Colorado River system: Present and Future. American Fisheries Society, Bethesda, Maryland.

Valdez, R.A., and W. Masslich. 1989. Winter habitat study of endangered fish-Green River. Wintertime movement and habitat of adult Colorado squawfish and razorback suckers. BIO/WEST, Inc., Logan, Utah. 184 pp.

Vanicek, C.D. 1967. Ecological studies of native Green River fishes below Flaming Gorge Dam, 1964-1966. Ph.D. Thesis, Utah State University, Logan. 125 pp.

Vanicek, C.D., and R.H. Kramer. 1969. Life history of the Colorado squawfish, Ptychocheilus lucius, and the Colorado chub, Gila robusta, in the Green River in Dinosaur National Monument 1964-1966. Transactions of the American Fisheries Society 98:193-208.

Vanicek, C.D., R.H. Kramer, and D.R. Franklin. 1970. Distribution of Green River fishes in Utah and Colorado following closure of Flaming Gorge Dam. Southwestern Naturalist 14:297-315.

Wick, E.J., and J.A. Hawkins. 1989. Colorado squawfish winter habitat study, Yampa River, Colorado, 1986-1988. Contribution 43, Larval Fish Laboratory, Colorado State University, Fort Collins. 96 pp.

Wick, E.J., D.L. Stoneburner, and J.A. Hawkins. 1983. Observations on the ecology of the Colorado squawfish (Ptychocheilus lucius) in the Yampa River. Report Number 83-7, Colorado Water Resources Field Support Laboratory. National Park Service, Fort Collins. 55 pp.

Wick, E.J., J.A. Hawkins, and C.A. Carlson. 1985. Colorado squawfish and humpback chub population and habitat monitoring, 1983-1984. Colorado Division of Wildlife, Denver. 48 pp.

APPENDIX A

GREEN RIVER ENVIRONMENTAL BASELINE

Green River Above Flaming Gorge Reservoir	Depletion Amount Acre-Feet	
Agriculture above Fontenelle Reservoir	167,000	
Agricultural Use above Green River Wyoming	20,000	
Fish and Wildlife use at Seedskadee Refuge	6,000	
Jim Bridger Power Plant and other Thermal use	34,000	
Minerals below Fontenelle Reservoir	34,000	
M & I uses below Fontenelle Reservoir	4,000	
Naughton Thermal Plant	7,000	
Agricultural use above Greendale, Wyoming	71,000	
Layman Project Agricultural use	10,000	
Other Minerals above Greendale	6,000	
Kemmerer Mine Modification	107	*[1]
Belina Mine Complex	5	*
Trail Mountain Mine	110	*
Wilberg Mine	69	*
Gorden Creek Mine # 2	75	*
Chirch and Dwight Company	1,250	*
Enron Oil and Gas	30	*
Chevron	8	*
Pac. Enter. Oil	2	*
South Haystack Mine	95.8	*
Chevron Phosphate	10,200	*
Black Butte Mine	72	*
Coastal Oil and Gas	4	*
Texaco	4	*
Soda Unit Natural Gas	102	*
Bridger/Teton Forest Plan	3	*
PG&E Fontenelle Gas	61	*
Amaco Moax Arch	82	*
High Gross Creek	6	*
Fremont Lake	1,000	*
Big Piney/La Barge Coordinated Activity Plan	45	*
TOTAL	372,331	

Upper Green River in Utah			
Agriculture between Greendale and Jensen		48,000	
Jensen Unit		15,000	*
Vernal Unit		15,000	
Moon Lake Power		22,089	*
Leland Bench	Indian Use	45,000	*
TOTAL		145,089	

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[1] * Denotes Project With Completed Biological Opinion

GREEN RIVER ENVIRONMENTAL BASELINE

Yampa River

	Depletion Amount Acre-Feet
Yampa River Historic Agriculture	79,928
Municipal and Commercial use	1,067
Hayden Power Plant	5,300
Craig Power Plant # 1 & 2	5,600
Craig Power Plant # 3	6,400 *
Private Actions	5,900 *
Reservoir Evaporation	8,845
Yampa River Minerals	3,000
Stagecoach Reservoir	12,800 *
Seneca II Mine	4 *
Eckman Park Mine & Amendment	152 *
Edna Mine	28 *
Colowyo Coal Company and Expansion	130 *
Apex #2 Mine	3 *
Lake Catamount Ski Area	24 *
Indian Partnership	2 *
Steamboat Springs Pipeline	27 *
City of Craig	600 *
Hann's Peak	31 *
TOTAL	129,841

Little Snake River

Little Snake Historic Agriculture Wyoming	14,000
Cheyenne Stage I	8,000
Cheyenne Stage II	15,800 *
Little Snake Historic Agriculture Colorado	11,000
TOTAL	48,800

Duchesne River

	Indian Use	
Bonneville CUP		
Strawberry Aqueduct		143,000 *
Uinta Basin	10,000	22,000 *
Agricultural use above Randlette	114,852	325,000
Uinta Indian Irrigation Project		28,200 *
Indian Use	18,500	*
Ute Indian Agriculture	4,000	4,000
Miscellaneous use above Randlett		8,000
Upalco Project	1,400	11,900 *
Coors Duchesne Oil Company		1 *
Colorado Interstate Uinta Pipeline		17 *
TOTALS	148,752	542,118

GREEN RIVER ENVIRONMENTAL BASELINE

White River

	Indian Use	Depletion Amount Acre-Feet	
Colorado Agriculture		38,000	
Colorado Municipal and Industrial		2,000	
Kenny Reservoir		5,467	*
Utah Agriculture	4,000	4,000	
Wolf Ridge Nocolite Mine #1 & 2		219	*
Andrikopolous Water Disposal		2	*
Meeker area Mines		34	*
Trapper Mine		123	*
Colo DOW Rio Blanco Reservoir		200	*
White River Dam	26,796	80,500	*
Conslo Preference Right		400	*
James Creek		400	*
Chapman Riobold		35	*
James Miller		30	*
Miller Creek Ranch		46	*
TOTALS	30,796	131,456	

White River to Green River Utah

	Indian Use		
Utah Agricultural use	11,447	66,000	
Miscellaneous use above Green River		7,000	
Price River exports		12,000	
Price River Mines		43	*
Emery Power plant # 3		3,850	*
Trail Mountain Mine expansion		72	*
Paraho Ute Project		4,344	*
Cottonwood Creek Utah		2,041	*
Price River Mine Complex		43	*
Rock Creek		120	*
Narrows		4,500	*
Price-San Rafael			
Cypress Creek			

...presented herein. The bald eagle became established along the Green River under current operation criteria and neither the present operation nor the proposed refined operation will likely affect their presence (Steve Cranney, Utah Division of Wildlife Resources, pers. comm.). The Ute ladies'-tresses orchid, a threatened species, occurs in the Browns Park area and is not expected to be affected by the change in operation of Flaming Gorge Dam.

[redacted] More detail on the effects of operations on these fish and their various life history stages is contained within their respective life history sections contained in this biological opinion.

GREEN RIVER ENVIRONMENTAL BASELINE

Green River Below Green River Utah

San Rafael River	Depletion Amount Acre-Feet
Hunter Power Plant	18,000
Hunting Power Plant	7,000
Emery County Project	1,000
San Rafael Agriculture	61,000
San Rafael Minerals	2,000
TOTAL	89,000

Total Green River Depletions	1,583,960
Total Green River Depletions Consulted Upon	470,220