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BIOLOGICAL ASSESSMENT OF BEACH/HABITAT-BUILDING FLOW(S) FROM GLEN CANYON DAM IN 1999

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Prepared 10 September 1998

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INTRODUCTION

This biological assessment was prepared in compliance with Section 7 of the Endangered Species Act of 1973, as amended. The Bureau of Reclamation (Reclamation) may conduct one or more beach/habitat-building flows (BHBF) from Glen Canyon Dam between January and July of 1999 as a management activity, if Lake Powell inflow and stage criteria, as well as downstream resource criteria, are met. Both flow criteria and resource criteria have been established by the Technical Work Group for such event(s) (see Attachments).

Six species identified as threatened or endangered are addressed in this assessment: Kanab ambersnail (Oxyloma haydeni kanabensis), razorback sucker (Xyrauchen texanus), humpback chub (Gila cypha), bald eagle (Haliaeetus leucocephalus), peregrine falcon (Falco peregrinus), and southwestern willow flycatcher (Empidonax traillii extimus). This list of species is based on discussions with the Fish and Wildlife Service (Service) and previous consultations. Impacts of the test flow on endangered species may result from: physical displacement, injury, or death; loss or alteration of habitat; reduction in food availability; or alteration of interactions with other species (Bureau of Reclamation 1995). This biological assessment summarizes the distribution and abundance, life requisites, and potential impacts of the test flow on these species and their habitats.

Background

Glen Canyon Dam is located in north-central Arizona in Coconino County one mile west of Page, Arizona (Fig. 1). Glen Canyon Dam regulates the Colorado River's flow through lower Glen Canyon and all of Grand Canyon, and is managed in accordance with the Colorado River Compact and the Colorado River Storage Project Act (1956).

Flooding was characteristic of the pre-dam Colorado River, and sediment and other Colorado River ecosystem resources may benefit from occasional flows above powerplant capacity (Grand Canyon Monitoring and Research Center 1997). However, dam operations have virtually eliminated this dynamic natural ecological process. Flow regulation in the Colorado River corridor has resulted in erosion and depletion of lateral sand deposits, particularly in narrow reaches of the river, has contributed to the loss of 4 of 8 (50%) of the native fish species, and has produced other changes in the river ecosystem. These impacts focused public and scientific attention on the need for modified operation of Glen Canyon Dam, resulting in a recently completed Environmental Impact Statement (GCD-EIS, Bureau of Reclamation 1995) and subsequent Secretary's Record of Decision (1996). Although a program of reduced daily flow fluctuation (Interim Operations) was implemented in 1991 to conserve a mass balance of tributary-derived sand, occasional high flows are required to restore high elevation sand deposits and characteristic aquatic habitats, such as backwaters. Backwaters are used as rearing habitats by young native fish. Occasional high flows are widely considered to be a primary tool, but not a panacea for ecosystem restoration in this system (Stanford et al. 1996, Poff et al. 1997, Schmidt et al. 1998).

Adaptive management of the Colorado River ecosystem includes a program of planned flooding. The Grand Canyon Protection Act of 1992 (P.L. 102-575) requires the Secretary of the Interior to operate Glen Canyon Dam "...in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established, including, but not limited to natural and cultural resources and visitor use" [Section 1802(a)]. In concert, the ROD directs that dam operations be conducted under the modified low fluctuating flow alternative (MLFF) or the Preferred Alternative of the GCDEIS, in order to preserve a mass balance of sand, and therefore fisheries habitats, in the main channel. The MLFF has a minimum release of 5,000 cubic feet per second (cfs) between 7:00 p.m. and 7:00 a.m. (at night), and 8,000 cfs as a minimum release from 7:00 a.m. to 7:00 p.m. (day time flows). The maximum release is 25,000 cfs, with a maximum daily flow range of 5,000 cfs, 6,000 cfs or 8,000 cfs, depending on the monthly release volume (during low, medium or high volume months, respectively). Ramping rates under the Preferred Alternative are 4,000 cfs/hr up and 1,500 cfs/hr down. Dam and reservoir management may involve exceptions to these criteria: exceptional flows occurred in 1997 due to high reservoir inflow forecasts, and ROD ramping rates were exceeded in 1998.

The GCDEIS and ROD include a provision for BHBFs. In the GCDEIS, such flows were to be considered in low reservoir storage years, thus avoiding the need to bypass the power generators, while rejuvenating sand bars and fisheries habitats; however, this provision was altered in the ROD so that BHBFs are to occur in high reservoir storage years using releases in excess of powerplant capacity required for dam safety purposes. However, neither document discussed hydrologic or resource condition criteria that should be considered to initiate a BHBF.

The Adaptive Management Work Group (AMWG) recently recommended hydrologic criteria for triggering a BHBF (Reclamation memorandum 17 January 1998). These criteria include: (1) January 1 target storage content of 21.5 MAF; (2) July 31 target storage content of 23.8 MAF; (3.1) if January-July monthly releases cannot be maintained at relatively uniform levels; (3.2) if January monthly releases cannot be constrained to 1.2 MAF; (4a) if January-July inflow to Lake Powell exceeds 13 MAF (about 140% of normal); and (4b) any time an increasing forecast requires a powerplant monthly release greater than 1.5 MAF or use of the 0.5 MAF storage buffer. Reclamation analyses indicate that the frequency of BHBFs will be 1 year out of 6. In years when purposeful BHBFs occur, Reclamation predicts that 30% would occur in January, 30% would occur in March, and 40% would occur in May or June. Similar criteria were developed by the Technical Work Group (TWG) for biological resources in 1998.

The 1996 test flow provided experimental evidence that high flows can be used to achieve some sediment management objectives (Grand Canyon Monitoring and Research Center 1997). However, numerous research projects concluded that the week-long 45,000 cfs BHBF in 1996 was too long in duration, but of insufficient stage to rejuvenate return current channel backwaters, or sufficiently scour riparian vegetation. Therefore, shorter duration BHBF(s) in 1999 may be from 45,000 cfs to >60,000 cfs, and may be used to test assumptions about the use and efficacy of high flows to reinvigorate ecosystem geomorphology, biological and cultural (archeological and traditional land use) resources, and ecosystem processes, while mitigating downstream sediment transport. Data collected during test flow(s) will validate existing hypotheses regarding flow effects on sediment, natural and cultural resource management. Both 45,000 cfs and ≥60,000 cfs flows are considered in this document.

DESCRIPTION OF THE TEST FLOW(S)

Hydrograph(s)

The BHBF(s) will begin whenever flow and resource criteria permit, from 1 January through 31

July 1999. The BHBF hydrograph(s) consist of: (1) a 3-day constant flow at current release levels prior to the BHBF for photodocumentation of pre-exising resource conditions; (2) discharge increased at an up-ramping rate of 4,000 cfs/hr until a flow of 45,000 cfs or more is achieved; (3) an essentially constant flow of ≥45,000 cfs for 2-4 days, with flow changes less than +/- 1000 cfs per day, followed by (4) a decrease in discharge to the same constant flow level as that used prior to the BHBF with down-ramping criteria of (a) a down-ramping rate of 1,500 cfs/hr between peak flows and 35,000 cfs, (b) a down-ramping rate of 1,000 cfs/hr between 35,000 cfs and 20,000 cfs, and (c) a down-ramping rate of 500 cfs/hr between 20,000 cfs and the constant flow level used for the pre-BHBF assessment (if the constant pre-BHBF flow is <20,000 cfs); and (5) a 3-day constant flow following the BHBF at the same flow used in (1) above, for photodocumentation of post-BHBF resource conditions. The duration of the BHBF will be determined by the TWG. The staggered down-ramp will more closely mimic the descending hydrograph of a natural flood. ROD flows will resume on the fourth day following the BHBF.

The Timing of BHBF(s)

The timing of BHBF(s) will determined through consultation with the TWG, using the flow-triggering criteria recently developed by the AMWG (Attachment A). These BHBF flow-triggering criteria are based on inflow predictions in high inflow years, and will provide less than one month of prior notification for high flows. While on-going monitoring should, in most cases, be adequate to assess single high flow effects, little if any opportunity will be realized for monitoring of more than one BHBF, and little opportunity for research will occur.

Biological and socio-economic/cultural resource criteria may also influence the decision to conduct BHBF(s) in 1999, and these criteria have been developed by the GCMRC and the TWG (Attachment B). Considerations which led to the timing of the March/April planned flood in 1996 included having flows that took place: 1) prior to native fish (especially humpback chub) spawning, or larval dispersal; 2) after the peak of rainbow trout spawning at Lees Ferry; 3) several weeks after the peak concentrations of wintering bald eagle and waterfowl 4) prior to the Neotropical bird and waterfowl breeding seasons; 5) during a month in which high flows occurred in the pre-dam era; 6) prior to the peak release of non-native saltcedar (Tamarix ramosissima) seeds in late April and May, to allow riparian soils time to desiccate after the test flow, thereby reducing saltcedar germination; and 7) prior to the recreational river rafting season to reduce recreation and safety impacts (Patten et al. in press). These resource criteria were considered for planning the 1996 BHBF, which had little detrimental impact on the affected resources. However, other resources, as well as seasonal changes in the relative importance of the above resources, may alter recommendations regarding the conduct, timing and duration of BHBFs. The rigorous resource criteria produced by the GCMRC evaluates the impacts of BHBF(s) of 45,000 cfs (but not higher flows) at various times of the year on Colorado River ecosystem resources.

KANAB AMBERSNAIL SPECIES ACCOUNT

Distribution and Abundance

Kanab ambersnail (KAS; Succineidae: *Oxyloma haydeni kanabensis* Pilsbry 1948), is a federally endangered landsnail that was proposed for emergency listing (U.S. Fish and Wildlife Service 1991a, 1991b) and officially listed in 1992 (U.S. Fish and Wildlife Service 1992). Fossil Oxyloma shells have been recovered from sediments in Grand Gulch (lower San Juan River) that date to 9,200 years ago (Kerns 1993). Living KAS were first collected by J.H. Ferriss in 1909 near Kanab, Utah in seep vegetation (Ferriss 1910, Pilsbry and Ferriss 1911, Pilsbry 1948). This genus has a broad distribution (North America, Europe and South Africa), but the taxonomy has been based on internal and shell morphology, and is being revisited through molecular genetic techniques. Extant populations of KAS are presently known to occur at two southwestern springs: one at Three Lakes, near Kanab Utah, and the other at Vaseys Paradise, a spring at Colorado River Mile 31.5R, in Grand Canyon, Arizona (Spamer and Bogan 1993a, 1993b). Two populations formerly occurred in the Kanab area, but one population was extirpated by desiccation of its habitat. The remaining Utah population at Three Lakes occurs at several, small spring-fed ponds on cattail (Typha sp.; Clarke 1991). The Three Lakes site is privately-owned and the land owner is commercially developing the property.

KAS were first collected at Vaseys Paradise in 1991 (Blinn et al. 1992, Spamer and Bogan 1993), and an interagency team lead by Reclamation examined KAS ecology there from 1995 through 1997 (Kanab Ambersnail Interagency Work Group 1997a). Vaseys Paradise is a popular water source and attraction site for Colorado River rafters; however access is limited by the dense cover of poison ivy (Toxicodendron rydbergii) and the nearly vertical terrain (Stevens et al. 1997b). Within Grand Canyon, KAS is apparently restricted to Vaseys Paradise: no KAS have been detected at more than 100 other Grand Canyon springs surveyed from 1991 through 1997. Rematched historic photographs of Vaseys Paradise (e.g. Turner and Karpiscak 1980:58-59) reveal that vegetative cover has increased greatly at lower stage elevations since completion of Glen Canyon Dam, and that flow regulation by the dam has increased primary KAS habitat area at Vaseys Paradise by more than 40%. All vegetation below the approximate 90,000 cfs stage was scoured by annual pre-dam floods in normal years.

Stevens et al. (1997b) defined primary KAS habitat at Vaseys Paradise as that dominated by crimson monkeyflower (Mimulus cardinalis), non-native watercress (Nasturtium officinale), sedge (Carex aquatilis) and smartweed (Polygonum amphibium). Secondary, or marginal, habitat has been defined as patches of other riparian vegetation that are not dominated by these species and are not used extensively by KAS. Land surveys from 1995 through 1997 revealed rapid changes in vegetation cover over the growing season, with 11.2% to 16.1% of the estimated total primary habitat occurring below the 45,000 cfs stage in 1995, and 7.0-12.0% of the estimated total primary habitat occurring downslope from the 45,000 cfs stage from 20 April 1996 through 3 October 1997. The total estimated area of primary habitat was 905.7 m^2 (0.22 acres), equivalent to the area of secondary habitat, and the total vegetated area was 1811.4 m^2 (0.44 acres) in June, 1995. Photogrammetric analyses indicate that the upper primary habitat area in November 1997 had decreased to approximately 720 m^2 (L.E. Stevens, personal communication).

The total estimated Vaseys Paradise KAS population rose from 18,476 snails in March 1995 to as many as 103,653 snails in September, 1995 as reproduction took place in middle to late summer (Stevens et al. 1997b). The proportion of the total estimated KAS population occurring below the 45,000 cfs stage was 3.3% in March, 11.3% in June, and 16.4% in September in 1995. Three years of population data indicate that the KAS population sustains a 40%-80% reduction through over-wintering mortality (Kanab Ambersnail Interagency Work Group 1997b).

The KAS population and habitat lying downslope from the 45,000 cfs stage was scoured in the BHBF in 1996 (Kanab Ambersnail Interagency Work Group 1997a). Habitat recovery was delayed in 1996 and 1997 because of high flows (20,000 to 28,000 cfs) that resulted from high reservoir forecasts and large summer monsoon floods on the Paria River, particularly in 1997. Recovery of habitat continued during the high flows of 1998 (Stevens, personal observation). Analyses of oblique photographs taken in November of 1994-1997 indicate that no major changes have occurred in the vegetation cover lying upslope from the 70,000 cfs stage (Kanab Ambershail Interagency Work Group 1997). In October 1997, 101.22 m^2 (12% of the estimated total primary habitat at Vaseys Paradise existed downslope from the 45,000 cfs stage. October 1997 population data indicate that an estimated 2187 KAS exist downslope from the 45,000 cfs stage, 6.4% of the estimated total KAS existing at Vaseys Paradise (Kanab Ambersnail Interagency Work Group 1997b). Also, these data indicate that recovery of the Vaseys Paradise KAS habitat and population to pre-1996 BHBF conditions has required more than 2 full years.

Life Requisites

KAS occurs on little-disturbed, saturated soil and associated wetland vegetation at Three Lakes, near Kanab, Utah (Stevens, pers. commun.), where cattail and sedges are the predominant macrophytes. In contrast, Vaseys Paradise is a fast-flowing, cool, dolomitic-type spring, with abundant wetland and phreatophyte vegetation, especially native crimson monkeyflower, sedge, smartweed, and poison ivy, and non-native watercress. Monkeyflower, sedge, smartweed and watercress are persistent aquatic wetland or hydrophytes (Kearney and Peebles 1960), and KAS is virtually completely restricted to those species at Vaseys Paradise (Stevens et al. 1997b, Kanab Ambersnail Interagency Work Group 1997a,b). KAS were rare to absent on other plant species and bare substrata.

Introduction of watercress at Vaseys Paradise provided KAS with an alternate host plant. KAS densities are generally higher on watercress than on the native host plants during the growing season (Kanab Ambersnail Interagency Work Group 1997b). Although watercress is an annual species, its life cycle at Vaseys Paradise is unpredictable. In part, this irregularity is due to the unithermal warm flows of the spring (ca. 16°C), which keep the microenvironment warm enough to prevent freezing during moderately cold winter months. Also, warm winters, such as 1995-1996, do not freeze watercress back, while cold winters (e.g. 1990) freeze and kill the plants. Warm spring flow and warm winters decouple the watercress life cycle from climate, and limit predictability of habitat conditions.

Demographic analyses based on size class distribution indicate that KAS is essentially an annual species, with much of the population maturing and reproducing in mid-summer (July and August), and most snails over-wintering as small size classes (Kanab Ambersnail Interagency Work Group 1997b). Loose, gelatinous egg masses were observed on the undersides of moist to wet live stems, on the roots of water-cress, and on dead or decadent stems of crimson monkey-flower in mid-summer of all years of study. No data on egg development or emergence success are presently available. In warm winters, such as that of 1995-96, KAS may emerge from dormancy early, and produce a double generation within one year (Kanab Ambersnail Interagency Work Group 1997a).

KAS at Vaseys Paradise are parasitized by the trematode flatworm, Leucochloridium cyanocittae, with 1.0% to 9.5% of the mature snails expressing sporocysts in mid-summer from 1995 through 1997 (Stevens et al. 1997b, Kanab Ambersnail Interagency Work Group 1997 a,b). Potential vertebrate predators of KAS at Vaseys Paradise include deer mice (Peromyscus crinitus and P. maniculatus), as well as rainbow trout (Oncorhynchus mykiss) in the stream mouth), resident common raven (Corvus corax) and canyon wren (Catherpes mexicanus), summer breeding Says and black phoebe (Sayornis sayi and S. nigricans), and winter resident American dipper (Cinclus mexicanus).

Impacts of High Flow(s)

In its 21 December 1994, Final Biological Opinion (BO) the Service evaluated impacts to KAS from the operation of Glen Canyon Dam according to operating and other criteria of the Preferred

Alternative in the GCD-EIS. The Service determined implementation of the Preferred Alternative would not jeopardize the continued existence of the KAS. This opinion also supported the concept of BHBF flows as part of the Preferred Alternative. The 1994 B.O. indicated that incidental take of KAS resulting from scour of more than 10% of the occupied habitat at Vaseys Paradise requires re-consultation. The 1996 B.O. recognized the importance of BHBFs for ecosystem management, but included as Reasonable and Prudent Measures (RPMs) mitigation of impacts by moving snails in the flood zone to higher locations immediately prior to the BHBF. Stevens et al. (1997b, Kanab Ambersnail Interagency Work Group 1997a) predicted the 1996 BHBF would result in a KAS habitat loss of 16.1%, and KAS population losses of 11.4% to 16.4%, without mitigation through translocation. A total of 1,275 KAS were transferred upslope of the 45,000 cfs stage in the week preceeding the 1996 BHBF, reducing the estimated number of KAS lost by 40% (Kanab Ambersnail Interagency Work Group 1997a). Before another habitat-building flow, Reclamation will enter into informal consultation with the Service to evaluate prior test flow studies, the establishment or discovery of a second population of Kanab ambersnail in Arizona, and reinitiate formal consultation with the Service if incidental take will exceed the 10 percent as established in the 1996 B.O. Also, the 1996 B.O. indicated that the impacts of all flows above ROD levels (25,000 cfs) should be evaluated prior to, within one month after, and 6 months after exceptional high flows.

In October 1997 the Service followed the 1996 B.O. recommendations regarding consultation and mitigation on a proposed November 1997 Habitat Maintenance Flow (HMF). HMFs are annual or biennial flows of variable duration at near-powerplant-maximum discharge (33,200 cfs) that may rejuvenate riverine habitats. The Service agreed with Reclamation's Finding of No Significant Impact (FONSI), allowing the HMF to proceed provided that monitoring was conducted immediately before, within one month after, and 6 months after the HMF. The November 1996 HMF lasted 2 days, and inundated 29.79 m^2 of existing habitat (3.5% of the estimated existing total primary habitat at Vaseys Paradise), scouring 4.3 m^2 of habitat (0.5% of the estimated total primary habitat). That HMF eliminated no more than an estimated 181 KAS, which was 1.4% of the estimated KAS population existing downslope from the approximate 70,000 cfs stage, and 0.5% of the estimated total KAS population at Vaseys Paradise (Kanab Ambersnail Interagency Work Group 1997b).

Natural winter mortality may reduce the KAS population by nearly an order of magnitude: the lowest KAS populations observed from 1995 through 1997 occurred during emergence in March, indicating winter mortality rates of 43.5% to 84.7%. March floods may result in a lower total take of KAS because there are fewer total KAS prior to reproduction, but the proportional take is probably approximately equivalent in any month from January through July. Additional factors to consider regarding differences in take between months are (1) that a BHBF when watercress is abundant and in the middle of its growth phase may result in increased proportional take, and (2) a BHBF from mid-May through July is likely to result in take of reproductively active snails, potentially affecting annual reproductive output. Therefore, although BHBF's later in the growing season may take an equal proportion of KAS, later high flows may exert relatively greater impacts on KAS reproduction.

If the estimated total primary habitat upslope from the approximate 70,000 cfs stage in March 1999 is 416.3 m^2 (77.2% of that mapped in 1994 by Stevens et al. 1997b), approximately _____ m^2 (____%) of the estimated total habitat will be lost due to inundation or scour during a BHBF, which exceeds the level of habitat take by ___%. However, a total of _____m^2 of the habitat lying below the 45,000 cfs stage in the July 1998 survey consisted of mixed vegetation patches dominated by horsetail (Equisetum spp.), reed (Phragmites australis) and other species. These patches are little used by KAS, and are extremely resistant to scour, having persisted through the 1996 BHBF and the high flows of 1997 and 1998. If this portion of the habitat is excluded from the calculation of primary KAS habitat, only _____m^2 (_____%) of the estimated total primary habitat will be at risk during a 1998 BHBF. For reference, the 1996 BHBF removed 119.4 m2 of habitat and would have eliminated an estimated 2,126 KAS had not 1275 KAS been moved to higher stage elevations.

If the above habitat assumptions are accurate, and if KAS densities are equivalent across stage elevation (as suggested by the Kanab Ambersnail Interagency Work Group, 1997b), and if winter mortality is negligible or proportional among stage zones, as many as an estimated _____KAS (_____% of the estimated total population of _______KAS) may be lost during a 1999 BHBF of 45,000 cfs. Additional stage-to-discharge modeling is required to determine the impacts of flows >45,000 cfs on the KAS habitat and population at Vaseys Paradise.

The Arizona Game and Fish Department and the National Park Service are in the process of introducing Vaseys Paradise KAS to three remote inner canyon springs in Grand Canyon. Such an introduction may resolve the Service's 1996 B.O. requirement that at least one additional population of KAS be discovered or established in Arizona prior to conduct of another BHBF of 45,000 cfs. However, a 1998 B.O. on these secondary KAS population establishment efforts indictates that the involved parties need to determine what constitutes successful establishment (FWS 1998).

Conclusions

The introduction of non-native watercress and the construction of Glen Canyon Dam has increased primary KAS habitat area at Vaseys Paradise by more than 40%, and has undoubtedly substantially increased the snail population. The KAS population at Vaseys Paradise survived and recovered from innumerable flows equal to or higher than BHBFs in the pre-dam era. After the initial >2-yr period of development of the new, post-dam vegetation, the KAS population survived seven flows of ≥45,000 cfs during the post-dam era (i.e., 1965, 1980, 1983-1986, and 1996). Although incremental take from repeated high flows is a concern, the >2 yr recovery period for KAS habitat at Vaseys Paradise documented by the Kanab Ambersnail Interagency Work Group (1997b) indicates that the KAS population has existed in a state of recovery from flows of ≥45,000 cfs for at least 16 of the past 35 years (≥45% of post-dam time). Therefore, the KAS habitat lying in the BHBF flood zone has often re-developed following large flows, and flows of 45,000 cfs are unlikely to affect the long-term integrity of the KAS population. Effects of flows >45,000 cfs are not presently predictable because no stage-to-discharge relationship exists at Vaseys Paradise above the 45,000 cfs stage.

Reclamation concludes that: 1) the Vaseys Paradise KAS population appears to be relatively large and self-sustaining; 2) more than 40% of the present primary KAS habitat at Vaseys Paradise lies below the pre-dam 10-year flood stage of 125,000 cfs and is new, post-dam habitat; 3) the KAS population has survived numerous larger floods both before and after dam construction; 4) the estimated loss KAS habitat (______to_______%) may contain an estimated ____% of the total VP KAS population, which would be lost during 1999 BHBF(s) of 45,000 cfs; and 5) the vegetation and the KAS population will re-colonize the scoured area in >2 yr. Given the four FWS B.O.'s that exist on KAS at Vaseys Paradise, additional stage-to-discharge and habitat area information is required before conduct of BHBF(s) >45,000 cfs.

The 1996 B.O. incidental take statement allowed for mitigation of take through relocation of KAS to a position within the habitat above the 45,000 cfs stage. Moving of snails may be the best long-term management strategy, as it is efficient, inexpensive, and continues to be the most obvious means of mitigating BHBF impacts. Despite concerns about detrimental effects on moved KAS resulting from disturbance due to handling and the potential for increased competition, the Kanab Ambersnail Interagency Workgroup (1997a) reported few if any negative impacts of the 1996 BHBF related to translocation within the habitat.

HUMPBACK CHUB SPECIES ACCOUNT

Distribution and Abundance

The endangered humpback chub (HBC; Cyprinidae: *Gila cypha*) is an endemic fish species in the Colorado River basin (Valdez and Ryel 1997). The HBC was taxonomically described by Miller (1946), and was listed as an endangered species in 1968. Stream alteration, including flow modification, diversion for irrigation, channelization, and the introduction of non-native fish species, have been suggested as responsible for declining populations of HBC throughout the Colorado River basin (Valdez 1995). Five HBC populations remain in canyon-bound reaches of the upper Colorado River basin: Black Rocks (upper Colorado River), Westwater Canyon (upper Colorado River), Cataract Canyon, Desolation/Gray canyons (Green River) and in the Yampa River (Valdez and Williams 1993, Valdez and Ryel 1997).

The Grand Canyon supports the only successfully reproducing HBC population in the lower Colorado River basin (Kaeding and Zimmerman 1983, Valdez 1995, Valdez and Ryel 1997). Valdez (1995) identified nine distinct aggregations in the mainstream Colorado River downstream from Glen Canyon Dam, including: 30-Mile, the Little Colorado River (LCR) confluence area, Lava/Chuar to Hance Rapids, Bright Angel Creek mouth, Shinumo Creek mouth, Stephens Aisle, Middle Granite Gorge, Havasu Creek mouth and Pumpkin Spring. From 3000 to 3500 adult HBC occupy the mainstream Colorado River, and these are largely concentrated within $\pm$ 4.2 miles of the mouth of the Little Colorado River (Mile 61), the largest sub-population. The mainstream HBC in the LCR aggregation use the LCR for spawning, while other HBC appear to be resident in the LCR. The distribution of HBC in the mainstream has not changed over the past two decades (Valdez and Ryel 1997); however, HBC density may have declined in the LCR during the past decade (Douglas and Marsh 1996).

Habitat use by HBC varied between age classes and by time of day. Young HBC in the Colorado River mainstream commonly use return current channels and other backwater habitats (Maddux et al., 1987, Arizona Game and Fish Department 1996, Valdez and Ryel 1997); however, HBC use of backwater habitats in Grand Canyon has been compromised by fluctuating flows and cold-stenothermic releases which reduce warming and create unstable conditions. In addition, backwater habitat area has been reduced and backwaters have aggraded through siltation under Interim Operations in Grand Canyon (McGuinn-Robbins 1997).

Young-of-year and subadult HBC in the Colorado River mainstream often use irregular shorelines as habitat, and adult HBC often occur in or near eddies (Valdez 1995, Valdez and Ryel 1997). Adult radio-tagged HBC demonstrated a consistent pattern of greater near-surface activity during the spawning season and at night, and day-night differences decreased during turbid flows (Valdez

1995, Valdez 1997).

Life Requisites

The life history and ecology of HBC in Grand Canyon has been intensively studied (Suttkus and Clemmer 1977, Kaeding and Zimmerman 1983, Carothers and Minckley 1981, Maddux et al., 1987, Gorman 1994, Valdez 1995, Douglas and Marsh 1996, Valdez and Ryel 1997). A key issue is the lack of recruitment to the adult population, which is reflected by low survivorship of young fish (Valdez, 1995). Individual adult HBC demonstrate high microsite fidelity (Valdez 1995), but young HBC may drift for relatively long distances (Tuegel 1995). Mainstream Colorado River HBC in Grand Canyon spawn primarily in the lower nine miles of the LCR from March through May. Adult fish initially stage for spawning runs in large eddies in February and March, and make spawning runs that average 17 days into the LCR from March through May, as LCR flows decrease, warm and clear (Valdez 1995). Spawning runs of up to 25 miles have been reported for this species. After spawning, many adult chub apparently return to specific microsites in the mainstream. Young HBC remain in the LCR, or move into the mainstream where mortality due to thermal stress (Lupher and Clarkson 1993) and predators (Valdez 1995) appears to be extremely high. During the summer the young HBC that survive in the mainstream tend to occupy low-velocity, vegetated shoreline habitats; however, low winter survivorship virtually eliminates the young-of-the-year HBC in the mainstream. Therefore, few if any HBC spawned during the previous year are present in the mainstream in the following spring.

Limited breeding of HBC occurs among other sub-populations in the Colorado River. Valdez (1995) documented limited spawning success at 30-Mile Spring in upper Marble Canyon, and rare young HBC have been documented at Kanab Creek; however, these sightings are rare compared with the reproductive success of those HBC that spawn in the LCR.

Dietary analyses reveal HBC to be opportunistic feeders, selectively feeding on aquatic and terrestrial invertebrates (Valdez 1995, Valdez and Ryel 1997). HBC diet changes over the course of the year in response to food availability and turbidity-related decreases in benthic standing biomass over distance downstream from Glen Canyon Dam (Stevens et al 1997, Valdez and Ryel 1997). Non-native Gammarus lacustris occasionally comprise a large proportion of HBC diet, especially after high mainstream flow events (Valdez 1995, Valdez and Ryel 1997) and Gammarus selectively feeds on epiphytes (i.e., diatoms) associated with Cladophora glomerata, the dominant alga in the upper reaches where clearwater conditions often prevail (Shannon et al. 1994).

Impacts of BHBF(s)

High flows, such as the 1996 BHBF, had little detectable effect on the movement patterns or distribution of adult HBC, and the 1996 BHBF did not appear to serve as a spawning cue (Valdez 1997). The increased drift associated with that BHBF resulted in an increase in Gammarus in HBC gut contents, an effect which is not surprising given the opportunistic foraging behavior of this species (e.g., Tyus and Minckley 1988). Given that this species evolved under the highly variable flow regimes that characterized the pre-dam Colorado River, it is unlikely that short-duration BHBF flows of 45,000 cfs could be demonstrated to affect subadult or mature HBC.

In contrast, high mainstream flows may affect younger HBC. High flow impacts are likely to most pronounced from May through July, as larval and young HBC emerge from the LCR and occupy mainstream near-shore and backwater habitats. Although a 2-4 day 45,000 cfs BHBF may briefly create additional pool area at the mouth of the LCR, that effect is unlikely to substantially benefit drifting HBC, which would subsequently be flushed into the mainstream. Flows of 45,000 overtop existing bars in the LCR area, and subject shoreline and backwater habitats to cold temperatures and high velocity flows. Thus, high flows stress and displace young HBC in those habitats. Therefore, even brief BHBFs from May through July may negatively affect HBC recruitment throughout the mainstream.

The Reasonable and Prudent alternatives of the 1994 B.O. include BHBF's, however, the Service determined some HBC may be taken during high flow events. Their discussion of incidental take considered testing and studies to determine impacts of flows on young humpback. One goal of a BHBF is the redistribution of channel-stored sediment to rejuvenate margin and current return channel nursery habitats for young life stages of HBC along the mainstream. This hypothesis will continue to be tested through possible 1999 BHBF(s).

The 1996 B.O. indicated that little impact on mature HBC was anticipated, and this conclusion was supported by data collected in association with that event (Valdez 1997). The 1996 BHBF did not serve as a spawning cue for movement into the mouth of the Little Colorado River. High flows did result in substantial additional drift, and radio-tagged HBC shifted location to the low velocity portions of eddies. Although some scour of the benthos occurred, rejuvenation of return current channels and other mainstream backwater habitats was brief and persisted only for about 6 months. Therefore, there was little additional recruitment habitat for young HBC by the late summer in 1996. In conclusion, the 1996 BHBF had little effect on HBC, and apparently did not adversely affect them.

The Service's B.O. on Reclamation's 1997 HMF expressed concern regarding the high levels of winter mortality sustained by Grand Canyon HBC. That B.O. permitted Reclamation to proceed with the flow event, but stipulated that Reclamation initiate a study of the causes of HBC winter mortality, and support the recovery process.

Conclusions

A 45,000 cfs BHBF in 1999 is not likely to adversely affect subadult or adult HBC during any month between January and July, because HBC appear to be well-adapted to high flow events. However, the timing of high flow events may affect larval and young HBC, depending on the spawning peak in any given year. High flows from January through March are unlikely to affect young HBC because high winter mortality results in low to non-existent populations of young fish during that period. High flows that occur during the spawning and drift phase of the HBC life history cycle in the LCR may reduce annual survivorship and recruitment in the mainstream, and may flush refugial backwater habitats along the mainstream. BHBF's from May through July may negatively affect the HBC population. The 1995 through 1997 years appeared to be rather normal recruitment years (Tuegel 1995, Grand Canyon Monitoring and Research Center 1997), and the cold spring conditions in 1998appeared to have depressed spawning acitivity (Hoffnagle, personal communication). The extent of HBC spawning in 1999 will not be determined until at least May.

If BHBF(s) are conducted in 1999, Reclamation may consider middle winter to early spring BHBF's are preferable to late spring or summer high flow events for HBC. Reclamation may continue to support the Service's recommendations regarding research and recovery efforts on this species, including analyses of winter mortality and establishment of a self-sustaining second population. If the AMWG proposes a May through July BHBF, Reclamation may recommend analysis of HBC mortality in relation to ponding and predator responses at the LCR mouth, stress and displacement from mainstream shoreline and backwater habitats, and drift in the mainstream.

RAZORBACK SUCKER SPECIES ACCOUNT

Distribution and Abundance

Razorback sucker (RBS; Catostomidae: *Xyrauchen texanus*) is a widely distributed, endemic, warm water Colorado River fish. RBS formerly occurred throughout the Colorado River, but has declined since 1930 with the regulation of the Colorado River (Dill 1944, Minckley 1991). The decline of RBS has been attributed to thermal regime changes, altered spawning habitat and introduction of non-native fish species, which have cumulatively resulted in wide-scale recruitment failure (Bestgen 1990, Minckley 1991). This species was listed as an endangered species by the U.S. Fish and Wildlife Service in 1991 (U.S. Fish and Wildlife Service 1991).

The largest RBS population in the Lower Colorado River Basin exists in Lake Mohave, where it was estimated to be approximately 60,000 fish in 1989 (Marsh and Minckley 1989). Other, smaller lower basin RBS populations occur in Lake Mead, downstream from Hoover Dam, and in Senator Wash Reservoir. In the Upper Colorado River Basin, RBS occur regularly in the upper Green and lower Yampa rivers, and individual RBS have been collected at rare intervals in the Colorado River near Grand Junction, Colorado, and in the major tributary arms of Lake Powell. RBS are long-lived (20 to 50 yr), but most wild-caught RBS are old individuals, and recruitment failure may lead to the rapid demise of this species (McCarthy and Minckley 1987, Minckley 1991). Experimental releases in the Upper Basin, and attempts to propagate RBS in Lower Basin reservoirs are encouraging, but the mainstream Colorado River populations continue to decline.

RBS are extremely rare in Grand Canyon. Recent observations include those of Carothers and Minckley (1981) who reported four RBS from the Paria River in 1978-1979; Maddux et al. (1988) reported one blind female RBS at Upper Bass (Colorado River Mile 107.5) in 1984; and Minckley (1991) reported records of 5 additional RBS captured in the lower Little Colorado River from 1989-1990. Putative hybrids between flannelmouth sucker (Catostomus latipinnis) and RBS have been reported from the Little Colorado River (Suttkus and Clemmer 1979, Carothers and Minckley 1981, Minckley 1991). RBS have not been observed since 1991 in this system.

Life Requisites

RBS are generally associated with calm river reaches, particularly man-made lakes (Tyus 1987); however, river spawning typically occurs in riffle habitats over gravel and cobble substrata (Mueller 1989). Larval RBS drift downstream from the spawning habitat, and concentrate in warm, low-velocity areas (e.g. flooded bottoms). These areas also support post-larval RBS, and channel and mid-stream river habitats floored by fine-grained alluvium are important to subsequent RBS life stages (Minckley 1983, Tyus and Karp 1989, Minckley 1991). Springtime concentrations of adult RBS have been noted in side-channels, off-channel impoundments, and in tributaries (Bestgen 1990, Minckley 1991).
22 to 25°C (Bulkley and Pimentel 1983); however, RBS occur in widely varying temperatures. RBS habitats in the Upper Colorado River Basin are ice-covered during winter, while the temperatures of mainstream habitats in the Lower Colorado River exceed 90°F (Dill 1944).

RBS diet varies by age class and habitat type, but few data are available on the diet of larval and juvenile RBS (Bestgen 1990). Larval RBS are known to feed on phytoplankton and zooplankton, and (in fluvial habitats) on chironomid larvae. Adult RBS in lentic habitats feed on benthic and planktonic algae and macroinvertebrates, while adult RBS in rivers feed primarily on benthic algae and invertebrates.

RBS spawn earlier in the season than do most other native, warm water Colorado River fish (Minckley 1973, 1991). Lake Mohave RBS spawn from November into May, with the peak of spawning activity between January and March when water temperatures were stable (50 to 54°F) or rising from 50 to 59°F (Bozek et al., 1984). In riverine situations in the Upper Basin, RBS begin spawning on the rising limb of the spring (April-May) hydrograph, and spawn for an extended period through the spring runoff. Although it occurred throughout the day, spawning activity is most intense at dusk.

RBS are susceptible to parasitic bacteria, protozoa and copepods. Minckley (1983) and others have reported a high incidence of blindness in one or both eyes; however the reasons for this condition are not clear (Bestgen 1990).

Impacts of BHBF(s) and Conclusions

The 1996 BHBF had no detectable effect on the remaining RBS population in the Colorado River in Grand Canyon. The remaining RBS are mature or senile fish, which survived comparable or higher mainstream flows in 1965, 1973, 1980, and 1983-1986, and possibly those of the late pre-dam era. These older fish are capable of finding suitable refugia, and the lack of recruitment of this species indicates that no young razorback sucker are likely to be in the system or at risk during any 1999 BHBF's. Because RBS spawn somewhat earlier than HBC, earlier (February-April) BHBF's may stimulate some additional RBS spawning activity; however, the rarity of this species precludes testing of such hypotheses.

BALD EAGLE SPECIES ACCOUNT

Distribution and Abundance

The bald eagle (Accipitridae: *Haliaeetus leucocephalus*) has suffered population declines from habitat loss, mortality from shooting and poisoning, and reduced reproductive success from ingestion of contaminants (U.S. Fish and Wildlife Service 1983), and was recognized as a threatened and declining species in 1967. This species occurs throughout North America from Alaska to northern Mexico, and commonly breeds in the northern portion of its range (Stahlmaster 1987). Although bald eagles face numerous threats throughout the 48 states, they have recovered from dramatic population declines over the past several decades. Consequently, the U.S. Fish and Wildlife Service downlisted the bald eagle from endangered to threatened status (U.S. Fish and Wildlife Service 1995).

Wintering bald eagles were first observed to congregate in Grand Canyon in the early 1980's and the winter population there increased dramatically after 1985 (Brown et al., 1989, Brown and Stevens 1991, Brown and Stevens 1992). The wintering bald eagle population has been monitored since 1988, and it occurs primarily throughout the upper half of the Grand Canyon (in Marble Canyon) and on both Lakes Powell and Mead. Density of the Grand Canyon bald eagles during the winter peak (in late February and early March) ranged from 13 to 24 birds between Glen Canyon Dam and the LCR confluence from 1993 to 1995 (Sogge et al., 1995). A concentration of wintering bald eagles occurs in late February at the mouth of Nankoweap Creek, where bald eagles forage on spawning rainbow trout (Brown et al., 1989, Brown 1993). Bald eagle density there ranged from 6 in 1987 to 26 in 1990, and 18 bald eagles occurred at Nankoweap Creek in 1995 (Sogge et al., 1995). Eagle density was correlated with trout density in the lower 0.5 km of Nankoweap Creek, and trout density was correlated with tributary stream water temperature (Leibfried and Montgomery 1993). Apparent territorial behavior, but no breeding activity, has been detected in Grand Canyon.

Life Requisites

Bald eagles are opportunistic feeders, preying on fish, waterfowl, rabbit and road-killed game (Stahlmaster 1987). Wintering bald eagles frequent rivers, reservoirs and lakes, including western reservoirs (Detrich 1987), and their distribution is dependent on prey availability, perch suitability, weather and human disturbance intensity (Ohmart and Sell 1980, Brown and Stevens 1997). Their wintering range extends from northern Mexico throughout the western United States.

At Nankoweap Creek in Grand Canyon, wintering bald eagles preferentially capture rainbow trout in the shallow creek, rather than in the mainstream where foraging success is low (Brown 1993, Sogge et al., 1995). Bald eagles at Nankoweap Creek prefer roosting and feeding areas that are relatively free of vegetation. The eagle population there consists of all age classes, with considerable piracy and other interactions between individuals (Brown and Leibfried 1990, Brown and Stevens 1991). The ease and relative safety of foraging in Nankoweap Creek affords wintering bald eagles at Nankoweap Creek the opportunity to accumulate energy reserves needed for their long, northward migration flights and initiation of nesting.

Bald eagle distribution in Glen and Grand canyons appears to be negatively related to human disturbance (Brown and Stevens 1997). Although bald eagles are widely known as opportunistic foragers, they are rare in the Glen Canyon and uppermost Grand Canyon reaches. This is surprising given that those reaches contain the most abundant aquatic foodbase and trout populations (Stevens et al. 1997c). Those reaches support the highest intensity of recreation and other human uses, and Brown and Stevens (1991) reported that bald eagles in Grand Canyon are extremely sensitive to human disturbance, often abandoning their foraging sites when human came within 0.5 km. For these reasons, Brown and Stevens (1997) concluded that human disturbance is responsible for the general rarity of bald eagles in the upper reaches.

Impacts of BHBF(s) and Conclusions

Wintering and migrant bald eagles have largely left the Grand Canyon region by late March (Stevens et al. 1997b). The few remaining eagles in April forage opportunistically and may continue to catch trout in the mainstream. The rainbow trout conclude their spawning run in Nankoweap Creek in April as water temperatures warm (Leibfried and Mongomery 1993), and remaining bald eagles no longer have access to that food source. Short-duration BHBF's in January through March may have slight negative effect on bald eagle foraging at Nankoweap Creek, if the trout spawn is robust. BHBFs from late March through July will have no negative effect on the bald eagle population in the Colorado River in Grand Canyon because this migratory species is unlikely to be present.

PEREGRINE FALCON SPECIES ACCOUNT

Distribution and Abundance

The peregrine falcon (Falconidae: *Falco peregrinus anatum*) is a federally listed endangered raptor, which declined dramatically as a result of the biological concentration of pesticide residues in prey species, and resulting eggshell thinning (U.S. Fish and Wildlife Service 1984). The population in the Rocky Mountain/ Southwest region declined from 180 pairs prior to 1975 to 55 pairs in 1983, largely as a result of DDT/DDE thinning of eggshells (U.S. Fish and Wildlife 1984).

The Grand Canyon peregrine population was thought to be low in the mid-1970's (Ellis and Monson 1989), but apparently increased dramatically in the 1980's, following recovery efforts by the U.S. Fish and Wildlife Service (1984; Glinski 1993). At present, the Grand Canyon supports the largest breeding population of peregrine falcons on a single land management unit in the coterminous United States (Brown et al. 1991a, 1992). Surveys for nesting peregrine falcons in 1988 and 1989 revealed 28 and 58 pairs, in 15% and 24% of the park, respectively. Habitat-based estimation of the potential number of peregrine falcons in Grand Canyon suggested that as many as 96 pair existed in Grand Canyon in 1989.

Life Requisites

Peregrine falcons feed on more than 40 species of birds and several small mammals (Porter and White 1973, Stevens et al. 1998). Hunting areas included marshes or narrow tongues of streamside vegetation, and peregrine falcons may forage up to 17 mi from nest sites. Peregrine falcon diet at nest sites in national parks in southern Utah included small and medium-sized birds, especially including white-throated swifts, large shorebirds and Clark's nutcracker (Burnham 1987).

In Grand Canyon, peregrine falcons feed on waterfowl, swifts, swallows and bats (Brown 1991a, Stevens et al. 1998), many of which feed on invertebrate species (especially Diptera) that emerge out of the Colorado River (Stevens et al. 1997c). Therefore, dam operations that influence aquatic macro-invertebrate populations exert, at most, only indirect impacts on peregrine falcons.

Peregrine falcons breed up to 3,130 m elevation, typically on ledges on steep cliff faces (U.S. Fish and Wildlife Service 1984). The mean distance between nest sites along the South Rim of Grand Canyon varied from 3.5 to 5.0 linear miles, with minimum distances of 1.8 linear miles (Brown 1991a, 1992). The breeding season in Grand Canyon extends from February to July.

The primary reason for the national decline of the peregrine falcon population has been eggshell thinning from DDE and other environmental contaminants, which are biologically concentrated through the food chain (U.S. Fish and Wildlife Service 1984). DDE sources to peregrine falcons are derived from their prey, many of which are migratory insectivores. Burnham (1987) reported that swifts, shorebirds, and other migratory insectivores contained 5.8 ppm DDE (wet weight), while mean DDE levels in granivorous migrants, such as grosbeaks and mourning doves, was only 0.14 ppm DDE. Peregrine eggshells from southern Utah parks from 1985 to 1987 were 21% thinner than those from the pre-DDE era, indicating poor viability of eggs (Burnham 1987). Brown (1991b) reported that peregrine falcon eggshells from the Grand Canyon in 1988 were 11.4% to 12.7% thinner than pre-DDE controls.

In addition to pesticide concentrations, competition with other raptors has been considered as a possible cause of peregrine falcon population declines; however, Porter and White (1973) examined peregrine and prairie falcon interactions and concluded that competition was not important.

Impacts of BHBF(s)

Most wintering waterfowl on which peregrine falcons feed will have migrated from Grand Canyon by late March; however, mallard and late migrating gadwall and American widgeon are still likely to be common (Stevens et al. 1997a, 1998). Springtime food sources (swifts, swallows and bats) should be present in large numbers at that time of year (Stevens et al. 1998), and are only indirectly influenced by dam operations. Therefore, peregrine falcons will not lack food resources during the proposed high release. BHBF's at any time of the year will have no effect on peregrine falcons in the Colorado River downstream from Glen Canyon Dam.

SOUTHWESTERN WILLOW FLYCATCHER SPECIES ACCOUNT

Distribution and Abundance

The southwestern willow flycatcher (SWWF; Tyrannidae: Empidonax trailii extimus) is a Neotropical migrant. Overall, the willow flycatcher species has a broad breeding range, extending from Nova Scotia to British Columbia and south to Baja California. The SWWF is an obligate riparian insectivore (Hunter et al., 1987), preferring habitat near open water (Gorski 1969; Sogge 1995). The historic breeding range of the SWWF includes Arizona, New Mexico, southern California, and southern portions of Nevada, Utah, and perhaps southwestern Colorado, and extends east into western Texas (U.S. Fish and Wildlife Service 1993). It probably winters from Mexico to Panama, with historical accounts from Colombia (Phillips 1948). The SWWF is distinguished from other subspecies by distribution, morphology and color, nesting ecology, but not by song dialect (Phillips 1948, Aldrich 1953, King 1955, Sogge 1995).

The regional SWWF population has declined over the past 50 years, corresponding with loss and modification of riparian habitats (Phillips 1948). Southwestern riparian ecosystems support a rich avian fauna (Johnson and Haight 1987) and habitat changes have resulted in reduction or extirpation of many avian species (Hunter et al., 1987). Modification and fragmentation of these systems through development and livestock grazing have precipitated devastating changes to SWWF populations. Destruction of native willow/cottonwood vegetation has provided opportunity for invasion by non-native plant species, notably saltcedar. Habitat fragmentation and modification has been beneficial to some southwestern avian species, especially cowbirds (Molothrus spp.), which parasitize SWWF nests, contributing to the precipitous population declines of SWWF (Brown 1994, Johnson and Sogge 1995, Sogge et al. 1995). SWWF habitat loss in Central and South America has also undoubtedly contributed to recent SWWF population declines, although little information is available.

The SWWF has been extirpated from much of its range (Hunter et al. 1987). Population reduction since 1950 was so dramatic that it was proposed (U.S. Fish and Wildlife Service 1992) and listed, with critical habitat, under the Endangered Species Act, on July 23, 1993 (U.S. Fish and Wildlife Service 1993). The SWWF is more rare than most other currently listed avian species (Unitt 1987). An estimated 300-500 breeding pairs remain in the United States, including 115 pairs in California and approximately 100 pairs in New Mexico (U.S. Fish and Wildlife Service 1993). Limited information exists for Colorado, Utah, Nevada, and Texas. It has been given special protection status by the Game and Fish Departments in Arizona, New Mexico and California.

Arizona has experienced the sharpest decline in SWWF numbers. SWWF formerly bred throughout the state at high and low elevations. For example, a 1931 breeding record exists from the south rim of the Grand Canyon (Brown et al., 1984), indicating that this taxon bred at high elevations, even at the northern edge of its range. By 1987, the State population was estimated at less than 25 pairs (Unitt 1987; U.S. Fish and Wildlife Service 1993), but much habitat was not surveyed. At least 52 territories or active nests were reported during extensive surveys in 1993 in Arizona (Muiznieks et al. 1994), and at least 62 active nests were located during a more thorough inventory in 1994 (Sferra et al. 1995). In Arizona, there were approximately 113 SWWF pairs in 1996 (Sferra et al. 1997).

From 1974 through 1996 the Grand Canyon population was detected between Colorado River miles 47 and 71 (Unitt 1987, Sogge et al. 1995, 1997). In its recent proposal the Service included the Colorado River from River Mile 39 to River Mile 71.5 as critical habitat U.S. Fish and Wildlife Service 1993), and stipulated in a subsequent final rule that defines such habitat as that "within 100 meters of the edge of areas with surface water during the May to September breeding season and within 100 meters of areas where such surface water no longer exists owing to habitat degradation but may be recovered with habitat rehabilitation" (U.S. Fish and Wildlife Service 1997). The boundary of this area in Grand Canyon includes the main Colorado River channel and associated side channels, backwaters, pools and marshes.

SWWF were common in Glen Canyon and the lower San Juan River prior to impoundment by Glen Canyon Dam (Woodbury and Russell 1945, Behle and Higgins 1959). This area was inundated by Lake Powell and no singing male SWWF were detected in a 1991 survey below Glen Canyon dam, although weather may have been a factor (Brown 1991a). SWWF were rather commonly reported along the pre-dam Colorado River at Lees Ferry, with records at Lees Ferry in 1909, 1933, 1935, and 1961, and near Lava Canyon in 1931 and near the Little Colorado River confluence in 1953 (reviewed by Sogge et al. 1997); however, the pre-dam distribution of SWWF in Marble Canyon and through Grand Canyon is poorly known. Carothers and Sharber (1976) reported only one pair of SWWF in Grand Canyon in the early 1970's surveys. Brown (1988) noted a brief population increase in the Grand Canyon from two in 1982, to a maximum of 11 (two in Cardenas Marsh), with a subsequent decline to seven in 1987. Brown (1991a) detected two pairs in 1991, with nests located at River Mile 50.7 and at River Mile 71.1 (Cardenas Marsh). Surveys in 1992 detected seven SWWF, three unpaired males and two breeding pairs in Cardenas Marsh (Sogge et al. 1995a). A total of five SWWF were detected in Grand Canyon in 1995: three territorial but non-breeding males and one breeding pair that fledged a single young (Sogge et al. 1995a). The unpaired male SWWF established territories between Colorado River miles 50.5 and 65.3, and the breeding pair nested at mile 50.5. In 1996 Sogge et al (1997) reported three singing SWWF, but only one successfully breeding pair along the Colorado River in upper Grand Canyon. The single pair apparently fledged two young. In 1997, the single nest in upper Grand Canyon was parasitized by brown-headed cowbirds and failed. A single SWWF nest near mile 265 in 1997 produced two young (Grand Canyon Monitoring and Research Center 1997). In both 1997 and 1998 SWWF failed to nest successfully in upper Grand Canyon because of cowbird brood parasitism (M. Sogge, U.S. Geological Survey Biological Resources Division, personal communication). The single nesting pair of SWWF at Mile 50.5L in upper Grand Canyon failed to produce young successfully in 1998 (N. Brown, personal communication). Other 1996-1997 reports of SWWF breeding in the lower Colorado River basin have stimulated additional research there.

The Service's 1996 B.O. on the BHBF defined several measures to mitigate impacts on the SWWF in Grand Canyon. Stevens et al. (1996) studied habitat changes at four historic SWWF nest sites in Grand Canyon. Fluvial marshes associated with these sites were dominated by common reed, horsetail and cattail. SWWF research activities associated with that BHBF included verifying stage-to-discharge relations, quantifying flow depth and velocity at nest sites, and determining nest site and foraging habitat structure, litter/understory characteristics, and nesting success.

The 1996 BHBF impacts on Grand Canyon SWWF habitat were reported by Stevens et al. (1996). Nest stand vegetation impacts were nominal: two stands were slightly scoured, and three sites sustained a slight reduction in ground cover and/or branch abundance at <0.6 m above the ground; however, no reduction in branch abundance or alteration of stand composition occurred, and the BHBF did not inundate the bases of any historic nest trees. Impacts on marsh foraging habitats were more severe, with decreases in area of 1% to >72%. Two of four SWWF sites regained vegetated area during the summer of 1996, while two other marshes sustained slight additional losses in cover through the 1996 growing season. The 50.05L marsh has not recovered appreciably since the 1996 BHBF (Stevens personal communication).

Life Requisites

SWWF arrive in the Grand Canyon area in mid-May, but may be confused with another subspecies, the more common E.t. brewsteri, which migrates through to more northern breeding grounds (Aldrich 1951; Unitt 1987). E.t. brewsteri sings during migration, making sub-specific distinctions difficult until mid-June (Brown 1991b). Males arrive earlier than females and establish territories. The characteristic territorial song is a "fitz-bew," most frequently heard in the morning before 10 AM (Tibbitts et al., 1994).

SWWF are highly territorial. Nest building begins in May after breeding territories are established. The nest is placed in a fork or horizontal branch 1-5 meters above ground (Tibbetts et al. 1994). A clutch of three or four eggs is laid from late May through July (Unitt 1987), but in Grand Canyon two or three eggs (usually three) are usually laid (Sogge 1995). Breeding extends through July and singing ceases at the end of the breeding season.

After a 12-14 day incubation, nestlings spend 12 or 13 days in the nest before fledging (Brown 1988; Tibbetts et al., 1994). The breeding season (eggs or young in nest) in Grand Canyon extends from early June to mid-July, but may extend into August. One clutch is typical, however re-nesting has been known to occur if the initial nest is destroyed or parasitized (Brown 1988). Riparian modification, destruction and fragmentation provided new foraging habitat for brown-headed cowbirds (Molothrus ater) and populations of brown-headed cowbirds continue to expand (Hanka 1985, Harris 1991). Brood parasitism is currently the greatest threat to SWWF and probably many other Neotropical migrants as well (Bohning-Gaese et al., 1993; Sogge et al., 1995). Over half the nests in Brown's study (1988) contained brown-headed cowbird eggs. Cowbirds may remove prey eggs, their eggs hatch earlier, and the larger nestlings are more competitive in the nest. Cowbirds fledged from Sierra Nevada SWWF nests while SWWF nestlings died shortly after hatching (Flett and Sanders 1987). Brown-headed cowbirds occur extensively around mule corrals on the rim of the canyon and travel down to the Colorado River.

SWWF may remove cowbird eggs or, more commonly, abandon the nest if the parasite's eggs are deposited. The second nesting attempt is energetically expensive, requiring a new nest to be built (Sogge 1995), although Brown (1988) noted that a SWWF pair covered a cowbird egg with fresh nesting material and laid a new clutch. The second nest, already at a temporal disadvantage, is often parasitized as well. Cowbird parasitism could be largely responsible for the absence of SWWF in otherwise suitable habitat in the Grand Canyon (Unitt 1987). Bronzed cowbirds (Molothrus aenus) have recently been reported colonizing the Grand Canyon and represent another threat (Sogge 1995).

The SWWF in Grand Canyon occupy sites with average vegetation canopy height and density

(Brown and Trossett 1989). SWWF commonly breed and forage in dense, often multistoried, riparian vegetation near surface water or moist soil (Whitmore 1977, Sferra et al., 1995), along low gradient streams (Sogge 1995). Nesting in the Grand Canyon typically occurs in non-native Tamarix approximately 4-7 m tall (13-23 feet), with a dense volume of foliage 0-4 m from the ground (Tibbetts et al., 1994). SWWF commonly and preferentially nest in saltcedar in upper Grand Canyon (Brown 1988), and nested in saltcedar in Glen Canyon before completion of the Glen Canyon Dam (Behle and Higgins 1959). Although habitat is not limiting in Grand Canyon (Brown and Trossett 1989), required patch size is not known. The 1997 nesting record from lower Grand Canyon demonstrates that this species can colonize new habitat; however, that habitat is influenced by Lower Basin Lake Mead management and is not within the purview of this Biological Assessment.

Proximity to water is necessary and is correlated with food supplies. Little is known of SWWF food preferences but it is probably a generalist feeder. It typically flycatches (sallys) from conspicuous perches, but also hovers and gleans insects from foliage (Stevens personal communication). SWWF also forage on sandbars, backwaters, and at the waters edge in the Grand Canyon (Tibbetts et al., 1994).

SWWF return to wintering grounds in August and September (Brown 1991b), but neither migration routes nor wintering areas are well known. Birds sing and perhaps defend foraging territories in Central America during winter, and winter movement may be tied to water availability (Gorski 1969). Threats to SWWF on the wintering grounds are poorly documented, but habitat losses in Latin America may be a major factor in the decline of this species.

Impacts of BHBF(s)

BHBF's that are conducted before May will have no substantial direct effect on the SWWF population along the Colorado River in Glen, Marble and upper Grand canyons because the birds do not establish territories until that time. BHBF's of 45,000 cfs during the breeding season are also unlikely to inundate SWWF nests because SWWF nest several meters up in tamarisk trees that stand at or above the 45,000 cfs stage. In upper Grand Canyon, SWWF generally nest in saltcedar trees and nest trees typically lie at or above the 45,000 cfs stage. The saltcedar stands in which SWWF nest are unlikely to sustain direct damage from BHBF(s): Stevens and Waring (1988) demonstrated that saltcedar is exceptionally tolerant of flooding in the Grand Canyon, persisting through many weeks of inundation. The saltcedar trees in which the SWWF presently nest survived the >92,600 cfs flows of 1983 as well as the 1996 BHBF (Stevens et al. 1996), and are therefore unlikely to be scoured by one or more brief, 45,000 cfs BHBF's in 1999.

The wetlands and low-lying areas near SWWF nesting habitats and in which they occasionally forage, are likely to continue to be affected by BHBF's. Impacts to associated wetlands ranged from 1% to >72% from the 1996 BHBF, and impacts on those sites persisted through the 1996 growing season (Stevens et al. 1996). Although those habitats were strongly affected by the 1996 flood, actual impacts on SWWF food resources remain undocumented. It is unlikely that the 1996 BHBF affected SWWF foraging, but impacts are impossible to document with so few birds to study. SWWF forage on adult, terrestrial (non-aquatic) flying invertebrates, populations which are unlikely to be affected by a brief BHBF, and which are likely to recover promptly after the event. Stevens (1985) reported that riparian invertebrate populations increased rapidly following a flow comparable to a BHBF in 1980 (U.S. Bureau of Reclamation 1990).

The habitat and population in lower Grand Canyon is influenced by Lower Colorado River basin management of Lake Mead, and is not part of this Reclamation Office's purview. Even if that section of the river corridor is considered, present data indicate no impacts of a BHBF on SWWF habitat there. Results of Hualapai Indian Tribal analyses on riparian resources in lower Grand Canyon indicate that the impacts of the 1996 BHBF extended no farther than Mile 255 (Christensen 1997). This point lies approximately 10 miles upstream from recently reported SWWF nesting areas on upper Lake Mead. Therefore, this, and the shorter duration of the proposed 1998 BHBF, suggest that a planned high flow should have no effect on potential SWWF habitat in lower Grand Canyon.

In conclusion, BHBF(s) in 1999 may continue to affect a component of the foraging habitat of SWWF, and flows >45,000 cfs will have an unknown impact on nest trees. High flows are likely to continue to reduce marsh areas associated with nest site stands, but the impacts on SWWF foraging success are unlikely to be nominal or undetectable.

OVERALL BHBF CONSIDERATIONS IN FY1999

The potential for conducting high flow(s) in 1999 may be influenced by numerous issues, some of which are potentially controversial. Several of the more prominent issues are listed below.

1. Several scientific issues were left unresolved by the 1996 BHBF, particularly including: the rate of bar building under low sediment availability (upstream from the LCR) and high sediment (downstream from the LCR) conditions; and velocities in and around eddies, particularly near return current channels. These elements, and the question of whether subsequent 45,000 cfs flows with different sediment availability repeat the 1996 event may justify the need to evaluate additional 45,000 cfs flows.

2. A primary issue surrounds uncertainty in stage-to-discharge relationships for flows in excess of 45,000 cfs at any of the terrestrial endangered species sites, including Vaseys Paradise and the four southwestern willow flycatcher populations. Stage-to-discharge relationships allow prediction of flow impacts, and not having a stage-to-discharge relationship may require a large amount of uncertainty. Also, although the NPS has apparently inventoried cultural resources up to the pre-dam 10-yr flood line, precise prediction of high flow impacts are not possible without stage-to-discharge relationships.

3. In its Biological Opinions and memoranda of 1996, 1997, and 1998, the FWS has stated that intentionally released high flows which inundate $\geq$ 10% of the Kanab ambersnail (KAS) habitat at Vaseys Paradise are to be avoided until at least one additional population is discovered or established in Arizona. The NPS and AGFD have launched an attempt to establish three KAS populations in Grand Canyon, but the terms of successful establishment have yet to be defined. As of July 1998, the KAS habitat lying downslope from the 45,000 cfs stage amounted to approximately 5% of the overall habitat at Vaseys Paradise, not having recovered from high flows in 1996-1998. Thus, Kanab ambersnail habitat may not preclude a 45,000 cfs BHBF, but is likely to preclude a flow of 60,000-70,000 cfs, which would inundate approximately 20% of the habitat.

4. Resource triggering criteria may warrant against higher flows during tamarisk seed release period (late April-early June), during peak whitewater recreation time (mid-May through August), or for other reasons.

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