# United States Department of the Interior

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In Reply Refer To:
AESO
02EAAZ00-2019-F-0214

March 04, 2019

Memorandum

To: Superintendents, Grand Canyon National Park and Glen Canyon National Recreational Area. Attention: Rob Billerbeck and Jenny Rebenack

From: Field Supervisor

Subject: Biological Opinion and Concurrence for the Glen Canyon National Recreation Area and Grand Canyon National Park Expanded Non-native Aquatic Species Management Plan

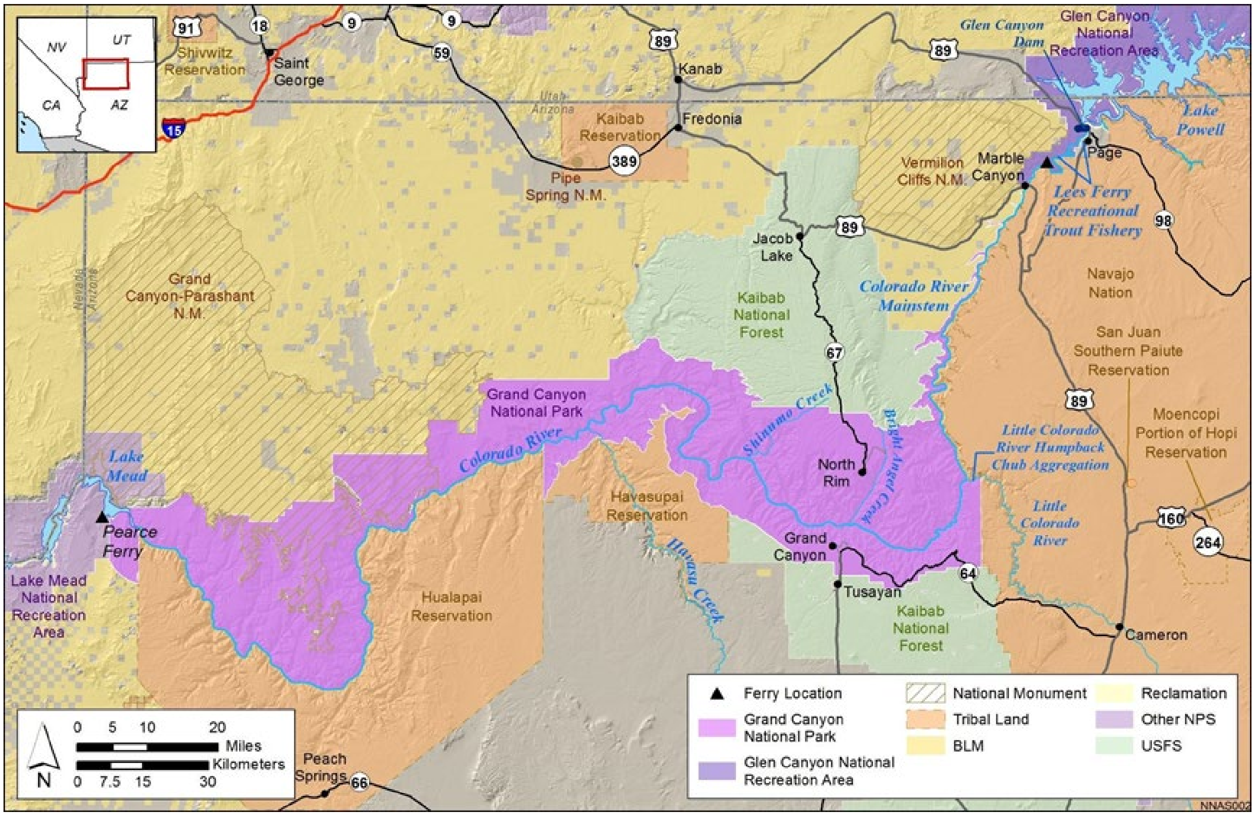
Thank you for your correspondence received November 28, 2018, requesting consultation with the U.S. Fish and Wildlife Service (Service) for the Expanded Non-native Aquatic Species Management Plan (NNAS), in compliance with section 7 of the Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. 1531 et seq.). The National Park Service (NPS) has requested formal and informal consultation regarding their proposed NNAS for management actions that will occur in Glen Canyon National Recreational Area (GCNRA) and Grand Canyon National Park (GCNP); Coconino County, Arizona. A full description of the action can be found in the NPS Environmental Assessment (EA), EA errata, and Biological Assessment (BA). The NPS proposes an adaptive management approach that includes tools to manage current and possible future detected, non-native aquatic species. The NNAS provides means of management that are to work in addition to, and in conjunction with, their existing Comprehensive Fish Management Plan (CFMP); and that importantly maintain NPS' Section 7(a)1 responsibilities under the ESA. Undesirable aquatic non-native species can pose threats to listed fish species in the action area, and therefore a plan to minimize these non-native species, and their possible impacts, is recovery minded. The Proposed Action provides additional tools to the CFMP that are expected to provide better short- and long-term control of non-native aquatic species with little risk to other resources. The tiered and adaptive approach of the Proposed Action identifies safeguards for adjusting or stopping actions, if unacceptable adverse impacts are observed, or are projected to occur.

The NPS has concluded that the proposed action "may affect, and is likely to adversely affect" the endangered humpback chub (*Gila cypha;* chub) and razorback sucker (*Xyrauchen texanus;*

sucker) and associated designated critical habitat. We agree with the determination and provide the following Biological Opinion (BO). The NPS has concluded the proposed action "may affect, but is not likely to adversely affect" the Mexican spotted owl (*Strix occidentalis lucida*), southwestern willow flycatcher (*Empidonax traillis extimus*), western yellow-billed cuckoo (*Coccyzus americanus*), Yuma Ridgway's (clapper) rail (*Rallus obsoletus*); nor will it prohibit recovery of the California condor (*Gymnogyps californianus*) and the 10(j) population that exists in the project footprint. We concur with your determinations and provide the rationale for our concurrence in Appendix A of this BO. In addition, NPS has made a "no effect" determination for Kanab ambersnail (*Oxyloma haydeni kanabensis*), Sentry milk-vetch (*Astragalus cremnophylax cremnophylax*), Brady's pincushion cactus (*Pediocactus bradyi*), and Fickeisen plains cactus (*Pediocactus peeblesianus fickeiseniae*). Concurrence with, "no effect" determinations is not required, and thus these species will not be addressed further in this document; however, the rationale for doing so is documented in the NPS BA.

This BO is based on information provided in the NPS EA, draft EA errata, BA, telephone conversations, meetings between staff, and other sources of information found in the administrative record supporting this BO. The full NPS EA can be found at the following link; http://parkplanning.nps.gov/Expanded_Nonnative
https://parkplanning.nps.gov/document.cfm?parkID=62&projectID=74515&documentID=90478
Literature cited in this BO is not a complete bibliography of all literature available on the species of concern. The before mentioned documents provided by NPS are collectively considered the BA for this proposed action, and this BO. A complete administrative record of this consultation is on file at this office.

Figure 1. General Project Area for the Expanded Non-Native Aquatic Species Management Plan



**CONSULTATION HISTORY**

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|---|---|
| October 23, 2017 | The NPS sought comment on alternatives considered in the Non-native Aquatic Species Environmental Assessment (EA) and began early consultation with the Service. |
| January 4, 2018 | Meeting between NPS and Service to discuss a process and timeline for consultation. |
| March 19 | Service receives outline of the BA for review. |
| May 29 | Service receives sections of the draft BA for input. Subsequent and intermittent phone calls took place between the NPS and Service. |
| October 4 | Service and NPS conference call to discuss conservation measures. |
| October 16 | Service and NPS conference call to further discuss YY-males and additional YY-males conservation measures. |
| October 25 | Service receives initial draft of the BA. |
| November 14 | Service and NPS conference call to discuss comments on the draft BA. |
| November 26 | Service and NPS conference call to discuss YY-male conservation measures. |
| November 27 | The NPS sent Service the final BA. |
| November 28 | Service receives final BA. |
| December 22 | Federal Government Furlough begins |
| January 25, 2019 | Federal Government Furlough ends |
| January 31, 2019 | Service and NPS conference call to discuss updated timeline and draft BO questions |
| February 11 | Draft BO sent to NPS |
| Date | Service receives comments on Draft BO |

# BIOLOGICAL OPINION

## DESCRIPTION OF THE PROPOSED ACTION

The purpose of the Proposed Action is to provide additional tools beyond what is available under the CFMP and the Bureau of Reclamation's (Reclamation) Long-term Experimental and Management Plan (LTEMP) to allow the NPS to prevent, control, minimize, or eradicate potentially harmful non-native aquatic species, and the risk associated with their presence or expansion, in the project area.

Future management actions may be needed due to an increase in green sunfish (*Lepomis cyanellus)* and brown trout (*Salmo trutta*) and potential expansion, or invasion, of other non-native aquatic species that threaten downstream native aquatic species, including listed species; such as humpback chub and razorback sucker. Non-native species have become an increasing threat due to changing conditions since completion of the CFMP and LTEMP. Existing measures identified in the CFMP and the LTEMP may be inadequate, in and of themselves, to address harmful non-native aquatic species.

Recent increases in the non-native green sunfish and brown trout in the Glen Canyon reach have prompted concerns about risks to humpback chub and razorback sucker in downstream areas (Runge et al. 2018; Ward 2015). Green sunfish and brown trout are not native to this location and had been observed in small numbers, but have recently been reproducing in larger numbers in this reach. Both species have high predation rates on native fish (Yard et al. 2011; Runge et al. 2018; Marsh and Langhorst 1988; Whiting et al. 2014; Ward 2015), raising concerns that large populations of these species in the Grand Canyon or the Glen Canyon reach could lead to large numbers of individuals migrating downstream where they could negatively impact the endangered humpback chub population. The Proposed Action identifies adaptive approaches to manage these threats as they appear over time.

The Proposed Action includes additional tools that could be used downstream of Glen Canyon Dam in GCNRA and in GCNP over the next 20 years. For the purposes of this Proposed Action, potentially harmful non-natives are defined as those fish, aquatic plants, or aquatic invertebrate species that are not native to the action area and that may pose a threat to native species (including federally or state listed or sensitive aquatic species). The list of potentially harmful non-natives includes; but is not limited to, brown trout, catfish species (Ictaluridae), bass and sunfish (Centrarchidae), striped bass (*Morone saxatilis*), cichlids (Cichlidae), perch and walleye (Percidae), new carp species (Cyprinidae), northern pike (*Esox lucius),* Asian clam (C*orbicula fluminea*), quagga mussel (*Dreissena bugensis*), didymo (*Didymosphenia geminata*), Eurasian watermilfoil (*Myriophyllum spicatum*), hydrilla (*Hydrilla verticillata*), and other non-native aquatic species detected in GCNRA or GCNP. Some of these species occur in Lake Powell and may enter the area through Glen Canyon Dam; however, there are other possible sources of non-native introduction including accidental tributary or river introductions.

The Proposed Action is expected to provide better short- and long-term control of non-native aquatic species with little risk to other resources. The tiered and adaptive approach of the Proposed Action identifies safeguards for adjusting or stopping actions if unacceptable or unanticipated adverse impacts are observed or projected to occur. Control actions that could be applied under the Proposed Action, and their respective tiers, triggers, off-ramps, and mitigation actions are presented in Table 2-1 of the EA and Table 1 of the BA. Tiers, triggers, and off-ramps are designed to balance the need to use the most effective methods necessary, while avoiding using deleterious methods unless necessary, by demonstrating lower Tiers being ineffective. Off-ramp parameters are defined by activities, but are generally defined in this document as criterion or environmental conditions that once met would result in a cessation of the associated activity that may be causing them, or that may exacerbate impacts beyond an acceptable or anticipated level. A full description of the action and associated Conservation Measures are included in the BA, are incorporated within this BO by reference, and are summarized below.

Control actions are separated into the following five categories:

- *Targeted harvest:* changing harvest rates to increase removal of non-native aquatic species.
- *Physical controls:* habitat modification or exclusion of specific areas less than 5 ac in size that are identified as source areas or non-native habitat areas for harmful non-native aquatic species.
- *Mechanical controls:* physical removal of non-native aquatic species from habitats.
- *Biological controls:* introduction of organisms to control populations of non-native aquatic species.
- *Chemical controls:* limited application of chemicals to control populations of non-native aquatic species.

*Targeted Harvest*

The NPS may organize incentivized harvest methods (H1) which may include a combination of guided fishing efforts with Tribal members and volunteers, tournaments, prize fish, restoration rewards for target fish harvested and removed, or similar tools in the Glen Canyon reach of Glen Canyon NRA. This method will initially focus on brown trout but may include other aquatic non-native species detected in the future. This activity is a Tier 1 method and can be used at any time and is triggered by non-native species presence. Should this method be found ineffective or have adverse impacts beyond what is anticipated, this action will cease. This action would occur in cooperation with Federal and Non-Federal partners. Targeted harvest is not planned in GCNP. See Table 1 and associated footnotes in BA for full description of this action.

*Physical Control*

Physical controls include methods such as; dewatering relatively small ponds and backwater areas by high-volume portable pumps for short time periods (no more than 2 weeks total, excluding refill time which may require an additional 7 days), placement of selective weirs to disrupt spawning or new invasions, placement of non-selective barriers to restrict access to tributaries, backwaters, and off-channel habitat areas, production of small scale temperature changes using a propane heater to adversely affect coldwater non-native fish, and dredging/placement of water control structures in small ponds or backwaters. See Table 1 and associated footnotes in BA for full description of this action. Should any of these methods be found ineffective or have adverse impacts beyond what is anticipated, this action will cease.

Dewatering of small ponds and backwaters (P1) may be used in Glen Canyon NRA including but not limited to, the 12-Mile Slough (upper slough only), and in small ponds and backwaters attached to the mainstem Colorado River and associated tributaries in GCNP. Additionally, placement of selective weirs (P2) and non-selective barriers (P3) will be used to restrict aquatic non-native access to tributaries, backwaters, and off channel habitats in Glen Canyon NRA and GCNP. Dewatering activities, selective weirs and non-selective barriers are a Tier 1 method and can be used at any time and is triggered by non-native species presence.

Production of small scale temperature increases to disadvantage cold water non-native fish (P5) may occur in tributaries to the Colorado River in GCNP. This activity is experimental, outside of the Tier schema, and may be triggered by detection of any cold water non-native aquatic fish.

Dredging may occur at the 12-Mile Sloughs in Glen Canyon NRA (P4). This dredging would be contained within, and between, the Upper and Lower Sloughs and would facilitate the complete initial draining of the upper slough, and any subsequent drainings needed, to remove a majority of the non-native fish (especially warmwater species). This activity would also include the installation of water control infrastructure in order to maintain the wetland and current wildlife habitat values. Dredging and associated activities is a Tier 4 activity and will only be used should activities in Tiers 1, 2, and 3 be ineffective. This would be a one-time event and as such would not have off-ramps to cessation of activity.

*Mechanical Control*

Mechanical control includes methods such as; mechanical removal by electrofishing (boat, barge, and backpack units) and trapping, mechanical disruption of early life stage habitats at spawning sites by high-pressure water flushing and mechanical gravel displacement, acoustic fish deterrent and guidance, and mechanical harvesting of non-native aquatic plants. Each of these activities have reach-specific guidance and may be contained in different Tier categories based on location, and in some cases based on high risk fish species. See Table 1 and associated footnotes in BA for full description of this action.

Mechanical removal methods include electrofishing and various trapping net mechanisms for the long-term control of aquatic non-native fish species. This method is anticipated to capture and remove fish with relocation of live fish, or beneficial use of dead fish when applicable, permitted, and possible. Mechanical removal (M2) is a Tier 3 activity in the GCNRA reach when targeting brown trout; and includes the following parameters for implementation;

> LTEMP triggers for mechanical removal of trout at the Little Colorado River (LCR) confluence have been exceeded and mechanical removal is being implemented there or has been proposed for the following year,
>
> AND
>
> Brown trout are a contributing proportion of the fish predators in the Little Colorado River reach (e.g., 6 adult brown trout h [>350 mm] caught in the current or previous year in the Juvenile Chub Monitoring [JCM] reach [River Mile {RM} 63.5-65.2]),
>
> AND
>
> Brown trout production in the Glen Canyon reach is an important contributor to the number of adults in the Little Colorado River reach (i.e., the number of adult brown trout in the Glen Canyon reach is > 5,000),
>
> OR
>
> LTEMP triggers for mechanical removal of trout in the Little Colorado River reach have not been met, but monitoring data and modeling indicate the number of adult brown trout is > 20,000 in the Glen Canyon reach, which modeling using moderate-risk parameters indicates that the population of adult brown trout would reach 47 in the JCM reach, the threshold above which mechanical removal at the Little Colorado River confluence would be ineffective in controlling further increases.
>
> If mechanical removal has ceased at the Little Colorado River confluence and if brown trout adults in the Glen Canyon reach have decreased to below 10,000 then mechanical removal would cease until the initiation trigger of > 20,000 is reached again.

Mechanical removal (M2) is a Tier 2 activity in GCNRA for all other species, to be implemented when Tier 1 methods are shown or projected to be ineffective and there is a threat of dispersal or increase. At the 12-Mile Sloughs and inside GCNP this is a Tier 1 action that is triggered by non-native presence. For all areas, this activity will cease if this control action is ineffective in removing or controlling a majority of non-native fish, adequate funding is not available, or long-term unacceptable adverse effects on native fish or other important resources are expected or observed.

Implementing mechanical disruption in early life stage habitats at spawning sites (M1) will include the use of high-pressure water flushing and mechanical displacement of gravel. This method is anticipated to displace eggs, larvae and young non-native fish from spawning and nursery locations. This is a Tier 2 activity with specific implementation parameters at different locations and by species. This method would be used to target brown trout spawning locations, within GCNRA, if the estimated number of brown trout adults (>350 mm long) in the Glen Canyon reach exceeds 5,000 and there is evidence that reproduction in Glen Canyon is contributing to the continued increase. If brown trout adults decrease to below 2,500, then mechanical disruption would cease. For all other areas and other aquatic non-native fish species, this activity would be triggered if Tier 1 actions are shown or projected to be ineffective and there is a threat of dispersal or increase. Should these methods be found ineffective or have adverse impacts beyond what is anticipated, this action will cease.

The use of acoustic fish deterrent and guidance activities (M3) are Tier 1 actions that may take place at any location in the action area; inside backwaters, off-channel ponds, and low velocity areas less than 5 acres in size. The trigger for this activity is presence of aquatic non-native fish species that may be deterred from target areas that are defined as future detection and management dictates. Should these methods be found ineffective or have adverse impacts beyond what is anticipated, this action will cease.

Mechanical harvesting of aquatic non-native plant species (M4) may occur at any off-channel location, including tributaries inside the action area and will include areas that are less than 5 acres in size. This method is a Tier 1 activity that is triggered by presence of non-native aquatic plant species, and will cease should this method be ineffective or be found to have adverse impacts beyond what is anticipated. Additional regrading of gravel may be necessary in areas once treatment is complete.

*Biological Control*

The introduction of non-native fish into the action area may occur in an attempt to use new technologies that focus on the long-term management of undesirable fish populations. One such experimental technology is the creation of male populations in which sex chromosomes are modified through hormonal adjustments and brood stock management. This results in male fish that can reproduce but their resulting offspring are males only. Population models based on this technology indicate that by drastically skewing the population towards males, there could be a decrease in the overall population. For salmonid species, in the first generation male fish have a YY sex chromosomal makeup, rather than the typical XY. Second generation male fish are normal XY males. In other species, the overall concept of hormonally adjusted sex chromosomes and male population skewing is the same, but may result in the characteristics of sex chromosomal makeup being species specific (i.e. ZW/ZZ forced to WW). Currently, this technique is in the experimental phase, but has shown some success with brook trout. Should YY-male brown trout broodstocks, or broodstocks of other non-native fish species become available, this technology may be used inside the action area as part of this current management plan.

This method (B1) will be used cautiously and incorporates safeguards that will avoid or mitigate possible effects to listed and sensitive species as much as possible; included in the Conservation Measures section below. Currently, no brood stock is available for this action; however, development of brood stock for brown trout and walleye is underway and could be available in the next 5 years, possibly sooner. Green sunfish is being evaluated as a possible species for brood stock, however, there may be biological barriers to that development. As noted in Conservation Measure (CM)-13, NPS will first conduct a pilot of brown trout YY-male introduction on a limited basis (2-5 years) in GCNP if a comparable study has not yet been successfully completed by another agency elsewhere. This NPS pilot would occur in Bright Angel Creek or a similar tributary. All YY-males would be PIT tagged in the pilot study to determine migration and survival rates. If a pilot is attempted and successful or other project locations (not part of this proposed plan) show positive results, and after communication and agreement with the Service, NPS may consider introducing YY-male brown trout in the Glen Canyon reach with up to 5,000 adult fish per year (or comparable numbers of juveniles). The

NPS would communicate with the Service if the NPS plans to introduce YY-males of species other than brown trout, or if locations other than Glen Canyon reach, or stocking numbers other than those specified in the EA were being contemplated. Also, if prior to the availability of brood stock for YY-male brown trout, new modeling or studies become available for brown trout YY males that suggest potentially different mortality/survivorship or migration values or other significant parameters, then NPS would reassess and communicate or consult with the Service as needed. Species and site-specific parameters will be implemented as part of this experimental approach. YY-male brown trout may be stocked into the Glen Canyon reach under the following environmental conditions:

- Experimental evidence and modeling indicate the action may be effective and brown trout adults (>350 mm long) are present in the reach.
- Annual stocking would be initially limited to a maximum of 5,000 adult YY-male brown trout, or an equivalent number of juveniles (estimated to be 10,000 based on assumed juvenile survival rates).
- This number represents a conservative level of risk to humpback chub if survival, movement, and predation rates are at high-risk levels.
- If wild brown trout adults in the Glen Canyon reach are not observed during monitoring for 3 years, then YY-male introduction may cease.

Should other brood stocks using similar methods become available and these species are present in the Glen Canyon reach or into tributaries to the Colorado River in GCNP, then NPS may introduce these broodstocks in a similar manner (including use of Conservation Measures) in coordination with the Service. This experimental action may take place if experimental evidence and modeling indicate that action may be effective, and target non-native fish are present in the area that may pose a medium to very high risk to humpback chub and razorback sucker. See Conservation Measures for full action.

*Chemical Control*

Chemical control actions includes methods such as; overwhelming ecosystem-cycling capabilities (C1; ammonia, oxygen, carbon dioxide, pH, etc.) and application of registered piscicides for control to target non-native fish (C2, C3, C4). Each of these activities have reach specific guidance and may be contained in different Tier categories based on location, and in some cases based on risk level of the fish species. Activities associated with this action are contained in the Conservation Measures section below; which outlines important application and safety methods that are provided to control, avoid, and minimize possible negative effects to the ecosystem, non-target species, and listed species such as humpback chub and razorback suckers, etc. See Table 1 and associated footnotes in BA for full description of this action.

Overwhelming ecosystem-cycling capabilities may be effective at removing non-native aquatic fish species. This action may occur in small backwaters or off-channel areas in GCNRA, in the upper pool of the 12-Mile Slough, or in the action area within the GCNP as a Tier 3 action (i.e. Tier 1 and 2 is ineffective and threat of dispersal or increase of non-native populations). This activity will cease if this control action is ineffective in removing or controlling a majority of non-native fish, adequate funding is not available, or long-term unacceptable adverse effects on native fish or other important resources are expected or observed. NPS will take actions to remove and relocate a majority of the non-target native species where feasible prior to a treatment.

Application of registered piscicides within the action area will fall under a variety of Tiers based on non-native species threat, stage of invasion or establishment, or location. Activities in the GCNRA reach and the -12 Mile Slough fall under Tier 3 (either C2 rapid response application for new invasions of medium to very high risk or C1 experimental use of natural substances to overwhelm ecosystem-cycling capabilities in the -12 mile upper slough, backwaters, or off-channel areas, and low velocity areas <5 acres) and Tier 4 (application focused on high and very high-risk species (C3) in the -12 mile sloughs, backwaters, or off-channel areas, and low velocity areas <5 acres) actions; each being triggered by all previous activities in lower Tiers being ineffective. In other parts of GCNRA, actions C1, C2 or C3 may be used per the constraints specified in Table 1 and associated footnotes in BA.

In GCNP, application of registered piscicides will occur as Tier 2 activities in the tributaries for the purposes of tributary renovation (C4); when action of Tier 1 or control actions of the CFMP are shown or projected to be ineffective. Tributary renovation will occur in tributaries with natural barriers only. Use of registered piscicides will also occur in backwaters, off-channel ponds, and low velocity areas <5 acres in GCNP for the purposes of rapid response. Rapid response application (C2) is a Tier 3 action for any new harmful non-native aquatic species rated medium to very high risk. Lastly, application of registered piscicides may be used as a Tier 4 action for long-term control of any high to very high-risk species (C3) in GCNP backwaters, off-channel ponds and low-velocity areas <5 acres only after lower tiers have been shown to be ineffective. These activities will cease should control action be shown to be ineffective in removing or controlling a majority of non-native fish, adequate funding is not available, or long-term unacceptable adverse effects on native fish or other important resources are expected or observed.

Management of high- to very high-risk aquatic plants or algae (C5) may require the application of herbicides and non-toxic dyes to backwaters, off-channel areas, and tributaries of the Colorado River inside the action area. This method is a Tier 1 activity and could be triggered by presence of plants and algae, in off-channel areas less than 5 acres or in low-velocity reaches of the tributaries. Also, a Tier 1 activity, mollusk repellents and non-toxic anti-fouling paints (C6) may be used on boats, equipment used in the river and NPS water intakes. Both sets of activities have associated conservation measures. These activities would cease if found that they are ineffective in controlling non-native plants or algae, are not inhibiting the attachment of invasive mussels, adequate funding is not available, or long-term unacceptable adverse effects on native fish or other important resources are observed.

*Conservation Measures*

Conservation measures that avoid or mitigate impacts to species that are likely to be adversely effected by these actions (humpback chub or razorback sucker) are listed in this section.

Conservation measures that are designed for species with a determination of "may affect, not likely to be adversely affected" are outlined in the Appendix A: Concurrence, section of this document. Other conservation measures that were provided in the BA for species with a "no effect" determination are not included in this document, but are provided in the BA and are therefore part of the administrative record and can be requested from NPS or the Service (AESO).

CM-1. Pre-Treatment Surveys to Avoid Impacts to Endangered Fish:
As necessary, surveys would be conducted in the immediate area of a control action for endangered fish prior to initiation of the action. If endangered fish are found, and unless otherwise specified, NPS will assess whether to continue with the action and will apply the appropriate conservation measures as outlined below. Measures in CM-5 and CM-6 would be used to minimize impacts from the survey itself.

CM-5. Mechanical Removal/Electrofishing Conservation Measures (M2):

- Electrofishing gear will be set to avoid injury to all fishes, including rainbow trout in Lees Ferry; the least-intensive electrofishing settings that effectively stuns and captures fish will be used in most cases. For example, during tributary electrofishing in Grand Canyon, a pulsed-DC at a frequency of 30-40 Hz (300-350 volts) has proven to be sufficient in minimizing mortality to both non-native trout and native fishes. However, if no native or non-target species are present in backwater or off-channel areas, settings may be altered to maximize the capture of target species.
- In tributaries where humpback chub have been released, electrofishing equipment use will be minimized in large-volume, deep pools where gear is less effective in capturing fish, and where humpback chub tend to congregate.
- In tributaries or small backwaters, during multiple-pass depletion electrofishing, native fish will be retained in holding areas between passes, or released in a manner that will minimize the likelihood of repeated electrofishing (i.e., away from the sampling areas).
- Non-target fish captured using electrofishing will be monitored in buckets, and gear settings would be adjusted if sufficient shock recovery is not observed.
- Crew members will be sufficiently trained in electrofishing techniques.

CM-6. General Fish Handling:

- Trammel net use will be minimized when possible, and will not be used if water temperatures exceed 20°C, in areas with known presence of ESA-listed fishes. Trammel nets would be checked every 2 hours or less.
- "General Guidelines for Handling Fish" published by the USGS-GCMRC to minimize injury to non-target fish would be followed during all field projects (Persons et al. 2013).
- During sampling efforts, all native fish will be processed first and handling time on captured listed fish will be minimized whenever possible
- If incidental mortality occurs, humpback chub and razorback sucker otoliths will be extracted and preserved (if feasible) in 100% ethanol, otherwise the entire fish will be preserved as described in Persons et al. (2013) and deposited into GCNP's museum.
- In areas with known presence of ESA-listed fishes, and subject to NPS regulations, no bait, or an artificial or natural substance that attracts fish by scent and/or flavor (i.e., live or dead minnows/small fish, fish eggs, roe, worms, or human food), would be used by

anglers participating in non-native fish control efforts. If angling is used in any mechanical removal efforts in GCNP, then barbless hooks would be used for trout removal activities in areas with known presence of listed fishes.

CM-7. Aquatic Invasive Species (AIS) Prevention Measures

- Standard quarantine/hatchery pathogen and disease testing and treatment procedures will be followed to prevent the transfer of AIS from one water to another during live transport of non-native fish species; currently only proposed for green sunfish removed from the 12-Mile Slough in GCNRA to Lake Powell.
- To prevent inadvertent movement of disease or parasitic organisms among aquatic sites, research and management activities shall conform to the Declining Amphibians Population Task Force Field Work Code of Practice (www.nrri.umn.edu/NPSProtocol/pdfs/Amphibians/Appendix%20B.pdf), with the exception that 10% bleach solution or 1% quaternary ammonia should be used to clean equipment rather than 70% ethanol. Abiding by this code will effectively limit the potential spread of pathogens via fish sampling equipment.

CM-11. Conservation Measures When Using Piscicides (Rotenone, Antimycin or Ecosystem Cycling Treatments, Action C1, C2, C3, C4):

- For Actions C1, C2, C3, and C4, if any humpback chub or razorback sucker are found during pre-treatment surveys or if there is reason to believe the treatment area is occupied and critical for spawning and rearing, NPS would communicate with the Service AESO prior to conducting these actions to determine whether to halt this action in this area or conduct salvage relocation.
- NPS would not implement Actions C1, C2, C3, or C4 in the same location for more than 5 consecutive years. If this action is not effective as a long-term solution when implemented over a 5-year period under the implementation of this Proposed Plan, NPS would pursue additional planning and compliance for any subsequent actions not included within this BA.
- Registered piscicide treatments (C2, C3, or C4):
    - NPS would seek state permits and follow state treatment plan requirements and guidelines. Additionally NPS would follow the NPS approval process and required pesticide use plan. Rotenone or antimycin would be applied in accordance with labels and the appropriate standard operating manuals (Finlayson et al. 2010; Moore et al. 2008). Formulations and application rates would be selected to minimize potential effects for birds and mammals and minimize toxicity to aquatic invertebrates. These would be used with standard neutralizing agents.
- Experimental treatments to overwhelm ecosystem cycling capabilities (C1)
    - Treatments with naturally occurring compounds (i.e., ammonia, carbon dioxide, pH alteration, or oxygen-level alteration treatments) could be used for research purposes and to control non-native invertebrate, amphibian, and fish species in targeted, small backwater or off-channel habitat areas (Ward et al. 2011; Ward 2015; Treanor et al. 2017).

- These would be limited to small backwater areas (< 5 ac) and would be performed under appropriate state experimental permits through ADEQ or other agencies as required.
- Chemical treatments under actions C1, C2, C3, C4 would include:
  - Standard pre-treatment monitoring and watershed assessment within five days prior of application to ensure the treatment area conditions are accurately characterized and representative. This may include: Secchi depth transparency; water temperature, dissolved oxygen, and pH depth profiles; collection of non-native and native fish for use in bioassays; water flow, water quality and soil samples.
  - Barrier construction (if necessary) that could include an impermeable barrier (turbidity curtain) and/or a temporary barrier net may be installed to minimize movement of piscicide from the treatment area into the river (turbidity curtain), and to contain and facilitate removal of dead fish (turbidity curtain and/or net).
  - Native species salvage and relocation prior to piscicide treatment using boat or backpack electrofishing or netting/trapping.
  - Pre-treatment bioassay of water quality conditions would be conducted (e.g., pH, alkalinity, water temperature, sunlight exposure) as needed for adjustments to treatments.
  - Proper storage, transfer and mixing and spill response procedures will be used.
  - Fish will be actively removed during and after the treatment and any remaining fish found at the site will be removed and disposed within 48 hr of treatment at a landfill, or left in place if few in number, small in size, or sunken to the bottom and inaccessible to avian and terrestrial scavengers.
  - Monitoring would include the use of sentinel fish throughout the treatment area, and immediately downstream of the treatment area.

CM-12. Conservation Measures for Incentivized Harvest (H1)

- NPS would make available educational information to anglers in the Glen Canyon reach in the form of signs or information for the identification of humpback chub and razorback sucker, and other native fish, and provide direction to anglers to return these species to the river.
- NPS would make available educational information to anglers in the Glen Canyon reach to discourage any potential non-native introductions.

CM-13. Conservation Measures for YY Male Introductions (B1)

- NPS will communicate with the Service prior to the first introduction of YY male non-native fish to determine if any new studies or modeling suggests that additional consultation is needed. Modeling for any species of YY male would be based on the spreadsheet model for brown trout YY males (Appendix B) and should include new or revised estimates for annual numbers to be stocked, survival/mortality rates, emigration rates, predation rates, and number of years to stock.
- NPS will work with the Service and the Grand Canyon Monitoring and Research Center (GCMRC) prior to implementation to ensure that introduction of YY males is not expected (based on the modeling and current conditions) to cause the Tier 1 or Tier 2 triggering conditions in the LTEMP BO to be reached due to the YY males introduced

(given the current status of humpback chub population, the estimated predator index in the LCR area, and the estimated number of introduced YY male migrants to reach the LCR). In addition, if the Tier 1 or Tier 2 trigger have already been reached in a given year or are modeled to be reached in the next year, regardless of the YY introductions, then NPS would not introduce YY males in that year.

- Prior to introducing YY male brown trout in the mainstem, a pilot study will be conducted, either by NPS, or a comparable project completed elsewhere by another agency under their own compliance may be substituted.
    - If NPS conducts the pilot study of brown trout YY male introduction, it will be done first on a limited basis for between 2-5 years in a GCNP tributary. Prior to the introduction, NPS will communicate and seek agreement from the Service on the specifics of the stocking level, locations and conditions. The stocking level maximum for a pilot study in GCNP would be 2,000 adult brown trout (or an equivalent number of juveniles adjusted for expected mortality) per year; however, the actual number could be lower based on communication with the Service about current conditions, and the population of brown trout in the action area at that time (e.g. 2017 population of adult brown trout in Bright Angel Creek >230 mm was 626; B. Healy pers. comm. 2018).
    - During the pilot study in GCNP, all brown trout YY males would be PIT tagged to more closely monitor migration and survival rates using existing studies in the tributary and the mainstem, and existing passive antenna arrays.
- Upon conclusion of a pilot study, NPS will communicate about the results with the Service and if there is agreement that this was an applicable and successful study, then NPS may consider a YY male brown trout introduction in the mainstem. NPS may then stock an annual maximum of 5,000 adult brown trout in the Glen Canyon reach (or an equivalent number of juveniles adjusted for expected mortality).
    - After the pilot study, NPS will PIT tag every introduced YY male for the first five years to monitor migration rates. After the first five years, NPS will PIT tag a proportion of the introduced cohort sufficient to continue monitoring migration rates. In addition, NPS will mark or tag all introduced YY males to assist with identification by agencies and anglers.
- YY male non-native fish stocking would be discontinued in a location or for a species if:
    - NPS determines through monitoring or in communication with the Service that the introduced YY male non-native fish are having a negative effect beyond what is estimated based on this consultation process on the humpback chub or razorback sucker populations; or
    - If the rates of survival and migration of YY male brown trout from the stocking location to the Little Colorado River reach are greater than what was modeled; or
    - If the reproductive success of the introduced YY males is determined to be too low to be effective.

Under these conditions, the NPS would cease introductions and would use mechanical removal or other available tools to remove the introduced YY male non-native fish to reduce and mitigate the threat.

- NPS would communicate and seek agreement with the Service prior to implementation for any new area where YY male brown trout are being considered for introduction.
- Tagging or marking of species other than brown trout would be consistent with the approach discussed above.
- To enhance the effectiveness of this method, NPS would utilize incentivized harvest, mechanical removal or other efforts in conjunction with the YY-introductions to reduce the population of wild brown trout.

CM-14. Conservation Measures for Other Control Actions not Covered Above (M1, M2, M3, M4, P1, P2, P3, P4, P5)

- Monitoring for unintended or unacceptable effects and tracking of non-target native or federally listed species encountered in any treatment areas.
- When applicable, prior to control treatment, boat electrofishing and/or barge or backpack electrofishing or netting/trapping will be used to survey and, as appropriate, salvage native species. Native species would be relocated live to another stretch of the same river/stream outside of the treatment area.
- For Action P5 specifically, temperatures would be heated over a period of approximately 8 hr using a propane heater powered by a generator. This would prevent causing temperature shock to the fish. Additionally, NPS would carefully monitor the main channel of the stream below the mixing point to ensure the temperature change is negligible after mixing. Continued monitoring and temperature adjustment would occur after the target temperature is reached.
- For Actions M1, M3, M4, P1, P3, P5 if any humpback chub or razorback sucker are found during pre-treatment surveys or if there is reason to believe the treatment area is occupied and critical for spawning and rearing, NPS would communicate with the Service prior to conducting these actions to determine whether to halt this action in this area. When practicable, NPS would avoid conducting actions in these areas during spawning season for humpback chub and razorback sucker.

CM-15. Conservation Measures for Mollusk Repellents and Herbicides (C5, C6)

- Aquatic application of herbicides (Action C5) would be applied according to label and would be subject to strict guidelines and controls to protect aquatic species and water quality, including the NPS required pesticide use plan and NPS approval processes in strict adherence with applicable regulations and guidelines. Aquatic applications will only occur in backwater and off-channel aquatic habitats and tributaries.
- Mollusk repellents that contain capsaicin will be used on boats and equipment in the river, or non-toxic anti-fouling paints that do not contain copper and are approved for use in Arizona will be used. All use of repellent and anti-fouling paint would be subject to NPS pesticide use plan and approval processes in strict adherence to applicable regulations and guidelines.

CM-16. Interagency Coordination:

- All sampling activities will be coordinated with AGFD (according to 43 CFR part 24) and the Service Arizona Fish and Wildlife Conservation Office and AESO, as well as the

USGS-GCMRC or other agencies performing fish monitoring or research within the project-area.
- Annual reports documenting implementation and monitoring conducted by the NPS will be provided to the Service, AGFD, Reclamation, USGS and other interested parties.
- Bi-monthly, or more frequently as needed, conference calls (or written status updates in lieu of a call) will continue to be held by the NPS Fisheries Program to update interested parties on ongoing or new NPS management activities under the Proposed Action.
- In the selection of an herbicide (Action C5), NPS will consider (1) the site location to be treated, (2) the non-native vegetation, and (3) the time of year and water temperatures. Herbicide selection will be communicated with the Service and Arizona for a NPDES prior to the initiation of the action.
- If the NPS planned to introduce YY males of species other than brown trout, or in locations other than Glen Canyon reach, or stocking numbers other than those specified in the Proposed Plan were being contemplated, the NPS would communicate and seek agreement with the Service prior to initiation of the action. Also, if prior to the availability of brood stock for YY male brown trout, new modeling or studies become available for brown trout YY males that suggest potentially different mortality/survivorship or migration values or other significant parameters, then NPS would reassess and communicate or consult with the Service as needed. If new information becomes available regarding non-native movement rates and/or predation rates, the model will be re-evaluated to ensure the anticipated impacts of this action on humpback chub or razorback suckers are not greater than anticipated in the current analyses.

## ACTION AREA

The action area is defined as all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment. The action area for this proposed action included is identical to the one identified in the CFMP and includes all waters from Glen Canyon Dam to Lake Mead National Recreation Area, including the Colorado River and its tributaries in GCNP, and the Glen Canyon reach (Glen Canyon Dam to the Paria River confluence) in GCNRA (see Figure 1; down to approximately RM 277). While there are likely to be continued cooperation of efforts between Lake Mead and GCNP staff that address native and non-native fish issues in the vicinity of their shared boundary, the scope of the Proposed Action is within the boundaries of the Glen Canyon NRA and GCNP as described in the BA and referenced in this BO. Further, staff from the Service, Reclamation, U.S. Geological Survey (USGS), and other NPS units, and contractors coordinate other fish management activities in the action area. Actions taken for humpback chub and razorback sucker by individuals other than NPS staff and NPS contractors, volunteers, or other individuals under NPS control are not covered by this BO. Those agencies and contractors have separate ESA and National Environmental Policy Act (NEPA) compliance and section 10(a)(1)(A) permits from the Service to address their activities. Those activities are included as part of the environmental baseline.

STATUS OF THE SPECIES AND CRITICAL HABITAT

*Humpback Chub*

The information in this section summarizes the rangewide status of humpback chub that are considered in this BO. Further information on the status of these species can be found in the administrative record for this project, documents on our web page (https://www.fws.gov/southwest/es/arizona/) under Document Library, Document by Species, and in other references cited below.

***Humpback chub and critical habitat***

The humpback chub, an endemic fish to the Colorado River Basin of the southwestern United States, was listed as endangered on March 11, 1967 (32 FR 4001) and the Service designated critical habitat in 1994 (Service 1994). It is native to the states of Wyoming, Colorado, Utah, and Arizona and there are six recognized populations that occur in mid- and low-elevation, canyon-confined, deep-water regions, including five in the upper basin and one in the lower basin (Lees Ferry is the demarcation line between upper and lower Colorado River basins). The upper basin populations occur in (1) the Colorado River in Cataract Canyon, Utah; (2) the Colorado River in Black Rocks, Colorado; (3) the Colorado River in Westwater Canyon, Utah; (4) the Green River in Desolation and Gray Canyons, Utah; and (5) the Yampa River in Yampa Canyon, Colorado. The only population in the lower basin occurs in the Colorado River in Marble Canyon, the Grand Canyon, and LCR. The numbers of individuals in upper basin populations have varied over time, with the three largest populations most recently supporting 404 and 1,315 adults in Black Rocks and Westwater Canyon in 2012, respectively, and 1,672 adults in Desolation/Gray canyons in 2015. The smallest populations are in Cataract Canyon with 468 adults in 2003 to 295 in 2005 and in Yampa Canyon of the DNM population with 320 adults in 2001 to 224 in 2003. Individuals have not been collected in the DNM population since 2004 and it is therefore considered functionally extirpated (Service 2017).

The lower basin population is found in Marble and Grand canyons, with individuals occupying about 400 km (249 mi) of the mainstem Colorado River from RM 30 to RM 280, as well as about 18 km (11 mi) of the lower LCR and about 6 km (3.7 mi) of lower Havasu Creek. The core population (i.e., LCR population) includes fish from the LCR and fish in an area of about 15 km (9.3 mi) of the mainstem around the LCR confluence that move into the LCR to spawn and mix with resident fish (Kaeding and Zimmerman 1983; Valdez and Ryel 1995; Douglas and Marsh 1996). The LCR population of chub, consists of an adult population (abundance for 2009–2012) of about 11,500–12,000 adults (Yackulic et al. 2014). Annual spawning in the LCR has not been quantified but could contain millions of fish larvae, with approximately 1% reaching the first year of life. Adult and juvenile chub are detected upstream up through the 30-mile reach.

Historically, the humpback chub occurred throughout much of the Colorado River and its larger tributaries from below the Grand Canyon upstream into Arizona, Utah, Colorado, and Wyoming (Service 2002). Historical range and abundance levels are unknown. In 1994, the Service estimated that historical range may have included 2,179 km (1,354 mi) of river (Service 1994), but estimates in 2002 and 2011 have been modified to include only canyon-bound reaches of this previously estimated area, estimating an historic range of approximately 756 km (~470 mi)

(Service 2002, 2011). Current resource conditions in both the upper and lower basin are fair to good, and are mostly adequate to support the species (Service 2018).

Surveys conducted in 2013, 2014, and 2015 suggest that translocated humpback chub have successfully spawned in Havasu Creek (NPS 2013). Humpback chub occupy approximately the lower 5.6 km (3.5 mi) of Havasu Creek, from the mouth to Beaver Falls, which is a barrier to upstream movement of fish. The most recent humpback chub population estimate in Havasu Creek was approximately 297 individuals as of May 2016; with progressively larger cohorts reported by year (NPS pers. comm. 2018). While reproduction and recruitment have been documented in Havasu Creek, the population has increased primarily as a result of continued translocations.

Sampling conducted between October 2013 and September 2014 in western Grand Canyon between Lava Falls (RM 180) and Pearce Ferry (RM 280) captured 144 juvenile humpback chub during sampling of the small-bodied fish community. In addition, 209 humpback chub larvae were collected during sampling of the larval fish community in randomly selected sites (Albrecht et al. 2014). Results were similar in larval and small-bodied fish sampling in 2015, when 285 juvenile and 67 age-0 humpback chub were captured during small-bodied and larval fish sampling, respectively, from throughout the study area (Kegerries et al. 2015). These results suggest that young humpback chub are using widespread nursery and rearing habitats between RM 180 and RM 280 in the western Grand Canyon. In the spring of 2017, evidence of reproduction and recruitment was documented at 30-mile. During this survey, over 90 young fish, of varying size classes were documented by the Service and GCMRC (K. Young pers. comm. 2018; Dodrill pers. comm. 2018).

The LCR aggregation of humpback chub underwent a significant decline in the mid- to late-1990s. This was followed by a period of relatively low, but stable abundance between 2000 and 2006, and by a period (2007–2014) of significantly increased abundance levels (Van Haverbeke et al. 2013). The post-2006 increase in humpback chub ≥150 mm and ≥200 mm was visible during both spring and fall seasons, but it was more apparent during spring months. Spring 2015 monitoring showed significant decrease in abundance of humpback chub ≥150 mm and ≥200 mm compared to the previous several years. The cause of this decline is unknown, but there is evidence from sampling in the mainstem during 2015 that many chub may have simply remained or emigrated into the mainstem during 2015 (i.e., the portion of the LCR aggregation of chub residing in the nearby mainstem was higher than usual).

Humpback chub have expanded in Western Grand Canyon, from near Havasu Creek (RM 158) downstream to below Surprise Canyon (>RM 249). Since 2014, humpback chub in Western Grand Canyon have exhibited annual recruitment and increased catch per unit effort (Van Haverbeke et al. 2017; Rogowski et al. 2018). This expansion has occurred within and outside of the two recognized aggregations (Havasu Creek and Pumpkin Spring) in this area.

In summary, annual abundance estimates suggest that sometime between the early 1990s and 2000, the abundance of humpback chub ≥150 mm underwent a decline in the LCR (Coggins et al. 2008). This decline was followed by a period of relatively low but stable abundance between 2000 and 2006 and then by a post-2006 period of significant increasing trend and has been relatively stable for about the last five years (Service 2017). A number of factors have been suggested as being responsible for the observed increases, including experimental water releases, trout removal, and drought-induced warming (Andersen 2009; Coggins and Walters 2009). In addition, translocations of juvenile humpback chub to Shinumo and Havasu Creeks have resulted in increased numbers of adult humpback chub captured in the mainstem aggregations (Persons et al. 2017). Translocations to tributaries have been shown to provide an adequate mechanism for rearing juvenile humpback chub that may later disperse to the Colorado River and augment aggregations (Spurgeon et al. 2015).

The humpback chub is a large, long-lived species. This member of the minnow family may attain a length of 20 inches, weigh 2 pounds or more, and live for 20 to 40 years (Andersen 2009). The humpback chub evolved in seasonally warm and turbid water and is highly adapted to the unpredictable hydrologic conditions. Adult humpback chub occupy swift, deep, canyon reaches, but also use eddies and sheltered shoreline habitat (Valdez and Clemmer 1982; Valdez and Ryel 1995; Andersen et al. 2010). Spawning occurs on the descending limb of the spring hydrograph at water temperatures typically between 16 and 22°C. Young require low-velocity shoreline habitats, including eddies and backwaters.

The main spawning area for the humpback chub within the Grand Canyon is the LCR, which provides warm temperatures suitable for spawning and shallow low-velocity pools for larvae (Gorman 1994). This healthy population provides substantial redundancy and representation for the species in the Lower Basin. The species spawns primarily in the lower 13.6 km (8.5 mi) of the LCR, but spawning likely occurs in other areas of the Colorado River as well (Valdez and Masslich 1999; Anderson et al. 2010). Spawning and development of young chub has been documented near 30-mile of the Colorado River through Grand Canyon; where multiple, small, size classes have been documented (Anderson et al. 2010; K. Young pers. comm. 2018; Dodrill pers. comm. 2018) or in other areas in the western Grand Canyon following the detection of larval humpback chub in recent years (Albrecht et al. 2014; Kegerries et al. 2015). Gorman and Stone (1999) found ripe adults aggregated in areas of complex habitat structure associated with clean gravel deposits among large boulders mixed with travertine masses in or near runs and eddies.

Young humpback chub use areas that provide physical cover and contain some velocity refuges, including shoreline talus, vegetation, and backwaters typically formed by eddy return current channels (AGFD 1996; Converse et al. 1998; Dodrill et al. 2015). Backwaters can have warmer water temperatures than other habitats, and native fish, including the humpback chub, are frequently observed in backwaters, leading to a common perception that this habitat is critical for juvenile native fish conservation. However, backwaters are rare and ephemeral habitats, so they contain only a small portion of the overall population. Dodrill et al. (2015) demonstrated the total abundance of juvenile humpback chub was much higher in talus than in backwater habitats, which could be a factor of availability of talus habitats versus backwaters. The Near Shore Ecology project concluded that backwaters are likely not important to the LCR chub aggregation because they are not a significant habitat component in that area (Pine et al. 2013).

As young humpback chub grow, they shift toward deeper and swifter offshore habitats. Valdez and Ryel (1995, 1997) found that young humpback chub remain along shallow shoreline habitats throughout their first summer, at low water velocities and depths less than 1 m (3.3 ft.). They shift as they grow larger and by fall and winter move into deeper habitat with higher water velocities and depths up to 1.5 m (4.9 ft.). Stone and Gorman (2006) found similar results in the LCR discovering that as humpback chub physically develop their behavior changes from diurnally active, vulnerable, nearshore-reliant, to nocturnally active, large-bodied adults, which primarily reside in deep mid-channel pools during the day and move inshore at night.

The humpback chub is primarily an insectivore, with larvae, juveniles, and adults all feeding on a variety of aquatic insect larvae and adults, including dipterans (primarily chironomids and simuliids), Thysanoptera (thrips), Hymenoptera (ants, wasps, bees), and amphipods (such as *Gammarus lacustris*) in the Colorado River population (Department 2001). Donner (2011) found that 65% of humpback chub production in the Grand Canyon was attributed to abundant food resources including chironomids and simuliids. Feeding by all life stages may occur throughout the water column as well as at the water surface and on the river bottom. Spurgeon et al. (2015) also found that humpback chub consumed native fish, and that they occupied a high trophic position in the food web in a Grand Canyon tributary, similar to rainbow trout.

Primary threats to the species include streamflow regulation and habitat modification (including cold water dam releases and habitat loss), competition with and predation by non-native fish species, parasitism, hybridization with other native *Gila*, and pesticides and pollutants (Service 1990, 2002). Upper basin habitat, including channel geomorphology and water temperature have not changed appreciably, but spring peak flow has been reduced, while summer and winter base flows have increased. Habitat in the Grand Canyon has been modified by the presence and operation of Glen Canyon Dam, including altered flow, temperature regimes, and sediment budget. Predation and competition by non-native fishes is likely the greatest threat to both upper basin and lower basin populations.

Recovery for the humpback chub is defined by the Service Humpback Chub Recovery Goals (Service 2002). The Recovery Goals consist of actions to improve habitat and minimize threats. The success of those actions is measured by the status and trend (i.e., the demographic criteria) of the population. The Service, the Glen Canyon Dam Adaptive Management Program (GCDAMP), and the Upper Colorado River Endangered Fish Recovery Program (UCRRP), are the programs that address conservation of all of the upper Colorado River basin populations of humpback chub, and each uses the underlying science in the Recovery Goals. A 5-Year Review conducted in 2011, relied on the information provided in the recovery goals and provides supplemental information on the species' distribution and status (Service 2011), with an additional 5-year review and recommendation for down listing to threatened in 2018 (Service 2018).

*Critical Habitat*

Critical habitat for humpback chub was designated in 1994 in seven reaches for a total of 610 km (379 mi) (Service 1994). There are 319 km (198 mi) of critical habitat in the upper basin (Colorado and Utah) and 291 km (181 mi) in the lower basin (Arizona). In Arizona, critical habitat includes 278 km (173 mi) of the Colorado River through Marble and Grand Canyons (Reach 7) from Nautiloid Canyon (RM 34) to Granite Park (RM 208), and the lower 13 km (8 mi) of the LCR (Reach 6). The entire Colorado River reach in Arizona and the bottom portion of the LCR are within the action area for this proposed action.

Critical habitat was designated for the four big river fishes (Colorado pikeminnow [*Ptychocheilus lucius*], humpback chub, bonytail chub [*Gila elegans*], and razorback sucker) concurrently in 1994, and the primary constituent elements (PCEs) were defined for the four species as a group (Service 1994). However, the PCEs vary somewhat for each species on the ground, particularly with regard to physical habitat, because each of the four species has different habitat preferences. The PCEs are:

- Water: Consists of water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminants, nutrients, turbidity, etc.) that is delivered in sufficient quantity to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species.

- Physical Habitat: This includes areas of the Colorado River system that are inhabited by fish or potentially habitable for use in spawning, nursery, feeding, or corridors between these areas. In addition to river channels, these areas include bottomlands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100-year floodplain, which when inundated provide spawning, nursery, feeding, and rearing habitats, or access to these habitats.

- Biological Environment: Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the humpback chub. Predation, although considered a normal component of this environment, is out of balance due to introduced fish species in some areas. This is also true of competition from non-native fish species.

The PCEs are all integrally related and must be considered together. For example, the quality and quantity of water affect the food base directly because changes in water chemistry, turbidity, temperature, and flow volume all affect the type and quantity of organisms that can occur in the habitat that are available for food. Likewise, river flows and the river hydrograph have a significant effect on the types of physical habitat available. Changes in flows and sediment loads caused by dams may have affected the quality of nearshore habitats utilized as nursery areas for young humpback chub. Increasingly the most significant PCE seems to be the biological environment, and in particular predation and competition, from non-native species. Even in systems like the Yampa River, where the water and physical PCEs are relatively unaltered, non-native species have had a devastating effect on the ability of that critical habitat unit to support conservation (Finney 2006; Fuller 2009). It is likely that the future conservation of humpback chub may depend on our ability to control non-native species, and manipulating the water and physical PCEs of critical habitat to disadvantage non-natives may play an important role.

***Razorback sucker and critical habitat***

The razorback sucker was listed as endangered in 1991 (Service 1991). The Razorback Sucker Recovery Plan was released in 1998 (Service 1998) and Recovery Goals were approved in 2002 (Service 2002). Critical habitat for the fish was designated in 1994 (Service 1994).

The species is endemic to large rivers of the Colorado River Basin from Wyoming to Mexico; however, the species range has been substantially reduced (Marsh et al. 2015). The razorback sucker was once abundant in the Colorado River and its major tributaries throughout the basin, occupying 3,500 miles of river in the United States and Mexico (Service 2002, 2018). Records from the late 1800s and early 1900s indicated the species was abundant in the lower Colorado and Gila River drainages (Kirsch 1889; Gilbert and Scofield 1898; Minckley 1983; Bestgen 1990). Within the Grand Canyon, it is likely that razorback suckers historically occurred throughout the Colorado River to Lake Mead (after Hoover Dam construction), with several documented captures in the mainstem (near Bright Angel and Shinumo Creeks), at the Little Colorado River inflow in 1989 and 1990, and from the Paria River mouth (in 1963 and 1978, as reported in NPS 2013). Until recently, the last razorback sucker collected from the Grand Canyon (RM 39.3) was caught in 1993, and the species was considered extirpated from the Grand Canyon. However, in the 2012 and 2013, adult razorback suckers were captured in western Grand Canyon (NPS 2013, GCMRC 2014). In addition, sampling of channel margin habitats has also documented razorback sucker larvae as far upstream as RM 173 (just upstream of Lava Falls) in 2014 (Albrecht et al. 2014) and 2015 (Kegerries et al. 2015), respectively, indicating that spawning is occurring in the mainstem river in the western Grand Canyon (Albrecht et al. 2014; Kegerries et al. 2015). This is the farthest upstream razorback sucker spawning has been documented in the Grand Canyon (Albrecht et al. 2014). The razorback sucker also occurs in the Green River, upper Colorado River, and San Juan River subbasins; the lower Colorado River between Lake Havasu and Davis Dam; Lake Mead and Lake Mohave; and tributaries of the Gila River subbasin (Service 2002; 2018) and Lake Powell (Francis et al. 2015).

Razorback suckers are actively stocked into occupied habitats in the upper and lower basins to prevent extirpation of the species from the wild. The stocking efforts rely on the captive broodstocks in the basins, and the capture of wild-born larvae from Lake Mead and Lake Mohave to provide sub-adult fish for stocking programs. Most populations in the upper Colorado River Basin are maintained by stocking, and in the lower basin, with the exception of Lake Mead, razorback sucker are also maintained through stocking, including populations in Lakes Mohave and Havasu (Marsh et al. 2015). Recruitment has been occurring since the 1970s, sustaining the small population remaining in Lake Mead (Albrecht et al. 2010, Service 2018, Mohn et al. 2015); rangewide, however, recruitment is rare or nonexistent in other populations (Marsh et al. 2015).

The razorback sucker is a large river sucker (Catostomidae) with adults reaching lengths up to 3.3 feet and weigh 11 to 13 pounds (Minckley 1973). Razorback suckers are long-lived, reaching the age of at least the mid-40s (McCarthy and Minckley 1987). Adult razorback suckers use most of the available riverine habitats, although there may be an avoidance of whitewater type habitats. Main channel habitats used tend to be low velocity ones such as pools, eddies, nearshore runs, and channels associated with sand or gravel bars (Bestgen 1990). Adjacent to the main channel, backwaters, oxbows, sloughs, and flooded bottomlands are also used by this species. From studies conducted in the upper basin, habitat selection by adult razorback suckers changes seasonally. They move into pools and slow eddies from November through April, runs and pools from July through October, runs and backwaters during May, and backwaters, eddies, and flooded gravel pits during June. In early spring, adults move into flooded bottomlands. They use relatively shallow water (approximately three feet) during spring and deeper water (five to six feet) during winter (McAda and Wydoski 1980; Tyus and Karp 1989; Osmundson and Kaeding 1989).

Much of the information on spawning behavior and habitat comes from fishes in reservoirs where observations can readily be made. They typically spawn over mixed cobble and gravel bars on or adjacent to riffles or in shallow shorelines in reservoirs in water 3 to10 feet deep (Minckley et al. 1991). Spawning takes place in the late winter to early summer depending upon local water temperatures. Suitable water temperatures for spawning, egg incubation, and growth range from 14 to 25°C (Service 2002, 2018b), with estimated optimal temperatures of 18°C for spawning, 19°C for egg incubation, and 20°C for growth (Valdez and Speas 2007). Hatching success is temperature dependent, with the potential for complete mortality occurring at temperatures less than 10°C (Service 2002, 2018b).

Habitat needs of larval and juvenile razorback sucker are reasonably well known. Young razorback suckers require nursery areas with quiet, warm, shallow water such as tributary mouths, backwaters, and inundated floodplains along rivers, and coves or shorelines in reservoirs (Service 2002, 2018b). During higher flows, flooded bottomland and tributary mouths may provide these types of habitats.

Razorback suckers are somewhat sedentary; however, considerable movement over a year has been noted in several studies (Service 1998). Spawning migrations have been observed or inferred in several locales (Jordan 1891; Minckley 1973; Osmundson and Kaeding 1989; Bestgen 1990; Tyus and Karp 1990).

Razorback sucker diet varies depending on life stage, habitat, and food availability. Larvae feed mostly on phytoplankton and small zooplankton and, in riverine environments, on midge larvae. Diet of adults taken from riverine habitats consisted chiefly of immature mayflies, caddisflies, and midges, along with algae, detritus, and inorganic material (Service 1998, 2018).

Since the arrival of Euro-Americans in the Southwest, the range and abundance of razorback sucker have been significantly decreased due to water manipulations, habitat degradation, and importation and invasion of non-native species. Construction of dams, reservoirs, and diversions destroyed, altered, and fragmented habitats needed by the sucker. Channel modifications reduced habitat diversity, and degradation of riparian and upland areas altered stream morphology and hydrology. Finally, invasion of these degraded habitats by a host of non-native predacious and competitive species has created a hostile environment for razorback sucker larvae and juveniles. Although the suckers can bring off large spawns each year and produce viable young, in many areas the larvae are largely eaten by non-native fish species (Minckley et al. 1991). The range-wide trend for the razorback sucker is a continued decrease in wild populations due to a lack of sufficient recruitment due to predation by non-native species on the eggs and larvae and the loss of old adults due to natural mortality.

The UCRRP has implemented considerable research, habitat management, non-native species removal, and stocking actions to benefit the razorback sucker in Colorado, Utah, and Wyoming. The San Juan Program works in the San Juan River in New Mexico and Utah. The Lower Colorado River Multi-Species Conservation Plan (LCR MSCP) is also engaged in research and stocking actions to benefit the razorback in the lower Colorado River of Arizona, California, and Nevada. The razorback sucker is also a covered species in the Bartlett-Horseshoe Habitat Conservation Plan (HCP) on the Verde River, and the Gila River Basin Conservation Program that focuses on impacts from the Central Arizona Project canal.

The 5-year status review for the razorback sucker was completed in 2012 (Service 2012) and the Service is currently in the process of completing an additional 5-year review (Service 2018). The majority of the most meaningful threats to the species, listed in the current recovery plan, have not been mitigated, as only nine of the 29 recovery factor criteria were met.

*Critical habitat*

As stated above, critical habitat was designated for the four big river fishes (Colorado pikeminnow, humpback chub, bonytail chub, and razorback sucker) concurrently in 1994, and the PCEs were defined for the four species as a group (Service 1994). However, the PCEs vary somewhat for each species on the ground, particularly with regard to physical habitat, because each of the four species has different habitat preferences. The biological support document (Maddux et al. 1993) discusses in depth how each designated reach met the PCEs. The PCEs for razorback sucker are:

- Water: This includes a quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminations, nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage.

- Physical habitat: This includes areas of the Colorado River system that are inhabited by razorback suckers or potentially habitable for use in spawning, nursery, feeding, rearing, or corridors between these areas. In addition to river channels, these areas also include bottomlands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100-year floodplain, which, when inundated, provide spawning, nursery, feeding, and rearing habitats.

- Biological environment: Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the razorback sucker. Predation, although considered a normal component of this environment, may be out of balance due to introduced fish species in some areas. This may also be true of competition, particularly from non-native fish species.

Critical habitat was designated in 15 river reaches in the historical range of the razorback sucker and includes portions of the Colorado, Duchesne, Green, Gunnison, San Juan, White, and Yampa rivers in the upper basin, and the Colorado, Gila, Salt, and Verde rivers in the lower basin (Service 1994).

*Previous Consultations for Humpback Chub and Razorback Sucker*

Section 7 consultations on humpback chub and razorback sucker have evaluated large-scale water-management activities. For the upper basin, UCRRP tracks the effects of such consultations on the species and provides conservation measures to offset the effects. Several consultations have occurred on the operations of Glen Canyon Dam, including one in 1995 that resulted in a jeopardy and adverse modification opinion. Subsequent consultations in 2008, 2009, and 2010 reached non-jeopardy/non adverse modification conclusions. The GCNP has consulted on their Comprehensive Fisheries Management Plan (NPS 2013), Exotic Plant Management Plan (2009), and Colorado River Management Plan (2006). Reclamation completed consultation on their *Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead* (2007) and Glen Canyon Dam Long-Term Experimental Management Plan (LTEMP 2016) which focuses on impacts of Dam operations. Specific to razorback sucker in the lower basin, the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) provides for incidental take and conservation of species under section 7(a)(2) and 10(a)(1)(B) for Federal and Non-Federal entities in regards to impacts of water delivery and power generation below Lake Mead. The Service's Wildlife and Sportfish Restoration Program completed a formal consultation on sportfish stocking actions in Lee's Ferry in 2018. Biological opinions on actions potentially affecting humpback chub in Arizona may be found at our website https://www.fws.gov/southwest/es/arizona/ in the Section 7 Biological Opinion page of the Document Library.

ENVIRONMENTAL BASELINE

The environmental baseline includes past and present impacts of all Federal, State, or private actions in the action area, the anticipated impacts of all proposed Federal actions in the action area that have undergone formal or early section 7 consultation, and the impact of State and private actions which are contemporaneous with the consultation process. The environmental baseline defines the current status of the species and its habitat in the action area to provide a platform to assess the effects of the action now under consultation.

**Status of the species and potential habitat within the action area**

*Humpback chub*

The Lower Colorado River Basin population of humpback chub is the largest of the six population centers of the humpback chub (Service 2011, 2018) and is found in the Colorado River and LCR (60 mi; 96.6 km) downstream Glen Canyon Dam, with detections of adult and recent spawning and recruitment of young humpback chub occurring 30 miles (48.28 km) downstream of Glen Canyon Dam and Lees Ferry. Within the Grand Canyon, this species is most abundant in the vicinity of the confluence of the Colorado River and LCR (Kaeding and

Zimmerman 1983; Douglas and Marsh 1996 Valdez and Ryel 1995). This population is specifically referred to as the LCR aggregation of humpback chub and includes those fish residing in the LCR and in the mainstem within approximately 15km (9.3 mi) of the LCR mouth. In addition, some of the eight other areas (aggregation areas) where humpback chub are, or have been, regularly collected within the action area. These aggregation areas include the mainstem at 30 Mile, Lava Chuar-Hance, Bright Angel Creek inflow, Shinumo Creek inflow, Stephen Aisle, Middle Granite Gorge, Havasu Creek inflow, and Pumpkin Spring (Valdez and Ryel 1995; Ackerman 2008; Persons et al. 2017). In addition, since 2009, translocations of humpback chub have occurred to introduce juvenile fish into Shinumo and Havasu Creeks, with the goal of establishing additional spawning populations within the Grand Canyon (NPS 2013b) and stocking adults into Bright Angel in 2018. Surveys conducted in 2013, 2014, and 2015 suggest that translocated humpback chub have successfully spawned in Havasu Creek (NPS 2013b). Humpback chub occupy approximately the lower 5.6 km (3.5 mi) of Havasu Creek, from the mouth to Beaver Falls, which is a barrier to upstream movement of fish. Translocations have led to an additional reproducing population in Havasu Creek in Grand Canyon (Service 2017), and they are expanding into western Grand Canyon (Van Haverbeke et al. 2017; Rogowski et al. 2017, 2018). Humpback chub have also been released into Bright Angel Creek, in May of 2018, which followed successful reduction of invasive salmonids in the creek (Healy et al. 2018). An additional adult humpback chub that was initially tagged in the Colorado River was detected on a remote PIT tag antenna in Bright Angel Creek, indicating occasional use of tributaries by adult fish. Approximately 120 humpback chub were reintroduced during the 2018 stocking; however, the current status of chub in Bright Angel is unknown. Annual spawning has been documented in the LCR with young of year moving into the mainstem Colorado River. Sub-adult abundance is stable overall and is not expected to drop below a three-year running average of 1,500 fish during the spring LCR population estimates; in addition the adult population has been stable for the past 5 years, indicating a self-sustaining and possibly growing population (Service 2018).

Sampling conducted between October 2013 and September 2014 in western Grand Canyon between Lava Falls (RM 180) and Pearce Ferry (RM 280) captured 144 juvenile humpback chub during sampling of the small-bodied fish community. In addition, 209 humpback chub larvae were collected during sampling of the larval fish community in randomly selected sites (Albrecht et al. 2014). Results were similar in larval and small-bodied fish sampling in 2015, when 285 juvenile and 67 age-0 humpback chub were captured during small-bodied and larval fish sampling, respectively, from throughout the study area (Kegerries et al. 2015). These results suggest that young humpback chub are using widespread nursery and rearing habitats between RM 180 and RM 280 in the western Grand Canyon.

The LCR aggregation of humpback chub is measured with closed and open population models. Closed models estimate the annual spring and the annual fall abundance of various size classes of chub within the Little Colorado River (Van Haverbeke et al. 2013, 2017). As such, the closed models do not account for chub that are not residing in the LCR during any particular year (i.e., there is always a portion of the LCR aggregation that is residing in the nearby mainstem each year). Initial closed mark-recapture population efforts in the Little Colorado River were conducted in the early 1990s (Douglas and Marsh 1996), after which there was a hiatus until they were resumed again in 2000 (Van Haverbeke et al. 2013, 2017). Results from both of these studies indicate that sometime in the mid- to late-1990s, humpback chub underwent a significant decline in the LCR. This was followed by a period of relatively low, but stable abundance between 2000 and 2006, and by a period (2007–2014) of significantly increased abundance levels (Van Haverbeke et al. 2013). The post-2006 increase in humpback chub ≥150 mm and ≥200 mm was visible during both spring and fall seasons, but it was more apparent during spring months. Spring 2015 monitoring showed significant decrease in abundance of humpback chub ≥150 mm and ≥200 mm compared to the previous several years. The cause of this decline is unknown, but there is evidence from sampling in the mainstem during 2015 that many chub may have simply remained or emigrated into the mainstem during 2015 (i.e., the portion of the Little Colorado River aggregation of chub residing in the nearby mainstem was higher than usual).

In summary, population estimates indicate that the number of adult humpback chub in Grand Canyon has been increasing since 2000 or 2001 and has been relatively stable for about the last five years. A number of factors have been suggested as being responsible for the observed increases, including experimental water releases, trout removal, and drought-induced warming (Andersen 2009, Coggins and Walters 2009). In addition, translocations of juvenile humpback chub to Shinumo and Havasu creeks have resulted in increased numbers of adult humpback chub captured in the mainstem aggregations (Persons et al. 2017). Translocations to tributaries have been shown to provide an adequate mechanism for rearing juvenile humpback chub that may later disperse to the Colorado River and augment aggregations (Spurgeon et al. 2015).

*Critical habitat*

Critical habitat for humpback chub in the action area includes a portion of Critical Habitat Reach 6, the LCR, and portions of Critical Habitat Reach 7, the Colorado River in Marble and Grand canyons. Reach 6 consists of the lowermost 8 mi (13 km) of the LCR to its mouth with the Colorado River. Reach 7, consists of a 173-mile (278-km) reach of the Colorado River in Marble and Grand Canyon from Nautiloid Canyon (RM 34) to Granite Park (RM 208).

The current condition of critical habitat in the LCR (Reach 6) is probably similar to historical conditions in many ways. All of the PCEs are provided for in this reach of humpback chub critical habitat, and this segment supports the majority of the Grand Canyon population, the largest of the humpback chub populations.

Critical habitat in Reach 7, in Marble and Grand Canyons, has been altered significantly from historical conditions, primarily due to the construction and operation of Glen Canyon Dam and the presence of non-native aquatic species (Service 2011). The flow of the Colorado River in Marble and Grand canyons has been modified by Glen Canyon Dam since 1964, and the dam and its operation is the primary factor in the function of PCEs in this reach. However, humpback chub use a variety of riverine habitats, with adults found in canyon areas with fast current, deep pools, and boulder habitat, and at least some of the PCEs are functional as demonstrated by the persistence of mainstem aggregations of humpback chub. Reach 7 serves an important role in support of the Grand Canyon population although the relationship with the LCR and the overall importance of habitats in the mainstem to recovery is not well known. This is because most of the humpback chub population occurs in the Little Colorado inflow aggregation, which uses the LCR to a large degree.

Dam discharge and river flow regimes can both destroy and build shoreline rearing habitat, thus affecting juvenile chub survival (Converse et al. 1998). Fluctuating flows can destabilize backwater habitats and may negatively impact aquatic macroinvertebrate production (Kennedy et al. 2016). However, dam releases, such as High Flow Experiments (HFEs), can create shallow backwater habitats associated with sandbars and are thought to provide rearing habitat for native fish, because they may be warmer than the mainstem river water temperature during the summer months due to solar radiation (Behn et al. 2010; Dodrill et al. 2015). Although HFE water releases from Glen Canyon Dam between 2000 and 2008 may have improved some habitat characteristics (e.g., backwaters) for humpback chub, the limited availability of suitable warm water temperatures in the mainstem may have constrained the potential for positive population responses (Kennedy and Ralston 2011). Additional factors affecting the PCEs of critical habitat are discussed below.

The PCEs, as described in the Status of the Species section, are: Water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminants, nutrients, turbidity) that is delivered to a specific location in accordance with a hydrologic regime required for the particular life stage for each species; Physical Habitat, areas for use in spawning, nursery, feeding, and movement corridors between these areas; and Biological Environment, food supply, predation, and competition. In summary, the conditions of the PCEs in Reach 7 are:

- The physical PCE for spawning is present within critical habitat Reach 7. During the early 1990s, nine aggregations of humpback chub were described in Grand Canyon (Valdez and Ryel 1995). These comprised the aggregations at 30-Mile, LCR, Lava-Hance, Bright Angel, Shinumo, Stephen’s Aisle, Middle Granite Gorge, Havasu, and Pumpkin Spring. Critical habitat has supported additional small aggregations, ranging from 5-98 adult humpback chub per aggregation. Population estimation was not provided for some of the aggregations because of too few recaptured fish (Valdez and Ryel 1995). This trend of low catch in aggregations outside of the LCR aggregation continued during 2002-2006, although the pattern was reported as low relative abundance (catch per unit effort, CPUE) rather than absolute abundance (Ackerman 2008). Since 2010, annual sampling of the aggregations has again resumed. Major findings have been that relative abundances of adult humpback chub in the aggregations have increased since sampling events during the earlier time periods (Persons et al. 2017). Additionally, a group of adult chub likely consisting of between 300-600 individuals has been found near RM-34 in Marble Canyon (Van Haverbeke 2016, pers. comm.), and there appears to have been a dramatic increase in abundances of humpback chub in western Grand Canyon (Havasu Creek and below), with multiple size classes being represented (Van Haverbeke et al. 2017). For example, while the number of adults estimated at the Pumpkin Springs aggregation (~RM 213) was only 5 adult fish during the early 1990s, 69 humpback chub were captured in this aggregation during a single day in 2016; 31 of these being adults. Finally, translocations of humpback chub into Shinumo and Havasu creeks have significantly augmented those respective mainstem aggregations.

- Nursery habitat for juvenile humpback chub may be limited by fluctuating flows that alternately flood and dewater mainstem near shore habitats important to early life stages of humpback chub and by the loss of sediment-formed habitats. Feeding areas are available to all life stages, especially for adult fish as indicated by condition factor of adult fish in the mainstem compared to those in the LCR (Hoffnagle et al. 2006), although feeding areas in the mainstem may be limiting for juvenile humpback chub due to the effect of fluctuations on nearshore habitats (AGFD 1996). There is evidence of expansion of this population of humpback chub, spawning, survival and growth, upstream near 30-Mile spring (Young Pers. comm. 2018; Dodrill, Pers. comm. 2018).

- Movement corridors appear to be adequate based on movements of humpback chub throughout the system (Valdez and Ryel 1995; Paukert et al. 2006).

- Food supply is a function of nutrient supply, productivity, and availability to each life stage of the humpback chub. River regulation by Glen Canyon dam decreases turbidity in the tail waters (the water immediately downstream of a dam) and permits increased algae growth on bottom substrates (Angradi and Kubly 1994; Shannon et al. 1994), leading to an increased expansion of macroinvertebrate populations in the tail water reach of Glen Canyon Dam (Blinn et al. 1993; Stevens et al. 1997). Algae biomass and production decrease downstream as water clarity decreases (Carothers and Brown 1991; Stevens et al. 1997). This drives a downstream decrease in aquatic invertebrate biomass (e.g., midges, snails, and aquatic worms) (Carothers and Brown 1991; Stevens et al. 1997; Kennedy and Gloss 2005; Rosi-Marshall et al. 2010). Cold water temperatures and daily fluctuations in discharge associated with hydropower production are likely responsible for the low diversity and abundance of aquatic insects downstream of the Paria River (Stevens et al. 1997; Kennedy et al. 2016).

- Non-native fish species that prey on and compete with humpback chub affect the PCEs of the biological environment aspect of critical habitat. Catfish (channel catfish and black bullhead), trout (rainbow and brown trout), and common carp are well established in the action area and will continue to function as predators or competitors of humpback chub. Minckley (1991) hypothesized that non-native fish predation and competition may be the single most important threat to native fishes in Grand Canyon (Valdez and Ryel 1995; Marsh and Douglas 1997; Coggins 2008; Yard et al. 2008). From 2012 to 2018 green sunfish were detected in a slough in the Lees Ferry reach of Glen Canyon and brown trout appear to be fluctuating in this reach as well. Partner agencies treated the slough with various piscicides and/or chemicals annually from 2015-2018 to remove the green sunfish, but it is likely invasions of non-native, predatory fish will continue. Currently, there is evidence that population of brown trout in Lees Ferry is present and fluctuating.

**Factors affecting species environment and critical habitat within the action area**

Primary factors affecting humpback chub and critical habitat within the action area include habitat alterations associated with dams and reservoirs that have modified water temperature, and the introduction, and expansion, of non-native fishes (Service 2011), which act as competitors and/or predators of the humpback chub (Andersen 2009; Yard et al. 2011; Kennedy et al. 2013).

- Temperatures, particularly in the upper reaches of the action area, even in warmer years, are not optimal for humpback chub spawning and growth. The cold water temperatures in most places of the main channel are below the temperature needed for spawning, egg incubation, and growth of the humpback chub. Survival of humpback chub young in the mainstem near the LCR is thought to be low because of cold mainstem water temperatures (Clarkson and Childs 2000; Robinson and Childs 2001), which may limit hatching success, reduce larval survival and larval and juvenile growth, reduce swimming ability, and increase predation vulnerability (Ward and Bonar 2003; Ward 2011). Water temperatures in the mainstem Colorado River have generally been warmer over the last decade, and warming over the summer increases downstream, due to solar radiation. These warmer water temperatures in the mainstem over the last decade may be providing some temporary benefit and contributing to the improving status of the humpback chub (Reclamation 2011). For example, maximum daily temperatures exceeded 68°F in the lower river (RM 180–RM 280), and daily average temperature was 64°F below the action area in early July (Kegerries et al. 2015). The evidence of recruitment at the 30-mile aggregation possibly due, in part, to the presence of warm springs. Adult chub captured near RM 35, and small size classes of chub found at 30-mile suggests recruitment and possibly an expansion of the 30-mile aggregation.

- Non-native fishes including wild rainbow and brown trout piscivory has been studied in the Lower Colorado River basin, including impacts to humpback chub young. Rainbow trout in the Grand Canyon exhibit slower growth in months when turbidity is high for example with inputs from the Paria and Little Colorado rivers (Yard et al. 2015); smaller rainbow trout are likely due to reduced foraging success (Sweka and Hartman, 2001; Ward et al. 2018). Ward et al. (2018) demonstrated that hatchery reared rainbow trout consumed between 22-47% fewer young chub than wild-born counterparts and that the successful catch of larval chub decreased as turbidity increased under captive research conditions. However, although consumption was lower, the attempt of rainbow trout to forage was still existent, resulting in trout chasing young chub. Although chasing does not always result in a successful catch, it has the potential to result in energy expenditures of larval humpback chub that would not happen unless they were being chased, which could lead to reduced fitness and survival. Additionally, hatchery reared rainbow trout become more efficient over time in this study (Ward 2018). Ingestion of humpback chub eggs by trout has not been studied, but it cannot be ruled out. Yard et al. (2011) documented rainbow and brown trout consume native fish disproportionally to their availability in the Colorado River, in areas where humpback chub aggregations exists. They estimated that a range of 1,232-1,826 humpback chub were consumed each year by wild rainbow trout near the LCR confluence, between 2003 and 2004. Under specific environmental conditions (such as temperature and density of fish) and an increase of rainbow trout abundance from 800 to 1,750 (roughly 46% increase) could lead to a 23% decline in annual survival of humpback chub probability (Yackulic et al. 2018). The Arizona Department of Game and Fish has stocked, and have plans for future stocking of hatchery reared rainbow trout, for which there is likely to be a low level of harassment and predation of humpback chub.

- The incidence of piscivory by brown trout has been found to be much higher than for

> rainbow trout in the Grand Canyon (Yard et al. 2011; Whiting et al. 2014), but rainbow trout are much more abundant in the Colorado River, and thus may impact native fish at a similar magnitude or greater (Yard et al. 2011). However, over the past few years the wild population of brown trout in Lees Ferry has increased. Predation by channel catfish, black bullhead, and green sunfish are also thought to impact humpback chub in the Grand Canyon, particularly if warmer water conditions occur (NPS 2013). Because of their size, adult humpback chub are less likely to be preyed on by trout; however, emergent fry, young-of-year (YOY), and juvenile humpback chub are susceptible to predation in the LCR and mainstem Colorado River (Yard et al. 2011). There is evidence of density dependent movement of rainbow trout and a negative relationship of number of rainbow trout and survival and growth of juvenile humpback chub (Yackulic et al. 2018).

In addition, the Colorado River includes non-native fish parasites, such as the Asian tapeworm and anchor worm, which may infect some humpback chub and affect survival (Clarkson et al. 1997; Andersen 2009). Recent studies also indicated that toxic mercury (Hg) and selenium (Se) concentrations in native fish were elevated in the Grand Canyon (Walters et al. 2015). While humpback chub were not tested in the study, elevated levels of Hg in the food web, and in particular, primary prey items, including blackfly larvae (Simuliidae), may result in negative impacts to humpback chub (Walters et al. 2015).

The lower Colorado River, including the action area, has been subject to the effects of Federal, State, and private activities for over 120 years. The greatest changes have come in the last 80 years, with the construction of large dams. Impacts of these human activities along the river have had profound effects on the river, associated riparian and floodplain areas, and the aquatic fauna. The Colorado River below Glen Canyon Dam releases water for a multitude of human uses but primarily for hydropower generation and water delivery. A number of monitoring and research efforts are underway in and throughout the action area as a result of the NPS including their CFMP; and LTEMP, managed by Reclamation, and other biological, cultural, and recreational programs that work in concert to provide management and balance of shared resources. Other meaningful actions are outlined, in previous and ongoing consultation for the Lower Colorado River Basin population of humpback chub including LTEMP (2016), and CFMP (2014). All of these actions take into account their complex impacts to humpback chub and focus on conservation to the species to such a level that it does not jeopardize the species existence. Additional protections and impacts come from actions outlined in the body of documents referred to as the Law of the River, including the Grand Canyon Protection Act. Consideration of native fishes will continue to be a priority and will continue during the life of the proposed action.

**Razorback sucker and critical habitat**

**Status of the species and critical habitat within the action area**

Within the Grand Canyon, it is likely that razorback sucker historically occurred throughout the Colorado River to Lake Mead (after Hoover Dam construction), with several documented captures in the mainstem (near Bright Angel and Shinumo Creeks), at the LCR inflow in 1989 and 1990, and from the Paria River mouth (in 1963 and 1978, as reported in NPS 2013). Until recently, the last razorback sucker collected from the Grand Canyon (RM 39.3) was caught in 1993, and the species was considered extirpated from the Grand Canyon.

Recent efforts to better understand the use of the western Grand Canyon by razorback sucker has revealed that the species is present, but likely rare, in Grand Canyon. Adult razorback suckers have recently been captured from the western Grand Canyon. Four fish that were sonic-tagged in Lake Mead in 2010 and 2011 were detected in the spring and summer of 2012 in GCNP up to Quartermaster Canyon (RM 260) (NPS 2013). An additional untagged adult razorback sucker was captured in GCNP near Spencer Creek (RM 246) in October 2012 (NPS 2013), and another adult was captured in late 2013 (GCMRC 2014). Sampling of channel margin habitats has also documented 462 and 81 razorback sucker larvae as far upstream as RM 173 (just upstream of Lava Falls) in 2014 (Albrecht et al. 2014) and 2015 (Kegerries et al. 2015), respectively, indicating that spawning is occurring in the mainstem river in the western Grand Canyon (Albrecht et al. 2014, Kegerries et al. 2015). Recent captures of larval razorback sucker in western Grand Canyon found the highest density of larvae in isolated pools and backwaters, which comprised less than roughly 2% and 9%, respectively, of all habitat sampled (Albrecht et al. 2014; Kegerries et al. 2015). Larval razorback sucker may drift along the shoreline adjacent to the main channel until settling into warmer, shallow backwaters, or floodplain wetlands (Valdez et al. 2012). This is the farthest upstream razorback sucker spawning has been documented in the Grand Canyon (Albrecht et al. 2014). Unfortunately, small-bodied fish sampling designed to detect juvenile razorback sucker in western Grand Canyon has failed to detect any older larval or juvenile fish. The capture of YOY suckers indicates that there is the potential for razorback sucker spawning in lower Grand Canyon and in-river recruitment (Albrecht et al. 2014). However, based on the presence of larger, older sucker species (i.e., flannelmouth suckers [*Catostomus latipinnis*]) and the lack of predatory non-native fish species in the lower river, it is possible that razorback suckers could (or do) recruit into the action area. There is also evidence that at the Colorado River inflow to Lake Mead, where six razorback suckers, seven razorback sucker x flannelmouth sucker hybrids, and 251 flannelmouth suckers were captured in 2014, hybridization is occurring between razorbacks and flannelmouth suckers. Although the extent and effect of this hybridization on razorback suckers in the lower Grand Canyon is unknown, it may be that with so many flannelmouth and so few razorback sucker adults apparently present (based on capture data), hybridization between the two species is common.

Tagged adult razorback suckers have also been located as far upstream as RM 184.4 near Lava Falls, and along with the collection of larvae, these indicate that the species utilizes the Colorado River above the Lake Mead inflow area more than previously thought (Albrecht et al. 2014). In 2015, submersible ultrasonic receivers (SURs), devices used to detect sonic-tagged razorback suckers, were installed upstream of Lava Falls, to an area below Bright Angel Creek. No detections of razorback sucker were recorded above Lava Falls through September 2015; however, the continued collection of larval fish upstream of Lava Falls indicates spawning is occurring in at least one unknown location in the mainstem or tributaries (Kegerries et al. 2015).

In summary, razorback sucker are located within the project area, from the Colorado River inflow of Lake Mead upstream, as far as an area above Lava Falls in Grand Canyon. The upstream distribution of adult razorback sucker is unknown, but they have been found upstream of Lava Falls. These occurrences since 2013 of adult and larval razorback sucker in Lake Mead and the lower Grand Canyon downstream of RM 180 indicate that the connectivity of the lake to the riverine reaches may be important to maintenance of razorback sucker in the action area.

*Critical habitat*

Critical habitat within the action area includes the Colorado River and its 100-year floodplain from the confluence of the Paria River downstream to Hoover Dam (a distance of about 500 mi), including Lake Mead to full pool elevation (Service 1994). Therefore, the entire Colorado River within the action area is razorback sucker critical habitat.

In the riverine portion of the reach (Paria River to Separation Canyon), the PCEs for water, physical habitat, and biological environment have been altered by creation of Glen Canyon Dam as described earlier for the humpback chub. The suitability of the physical habitat conditions for razorback sucker in this reach were likely significantly less even before closure of the dam as razorback suckers are generally not found in whitewater habitats that are home to humpback chub (Bestgen 1990).

Recent warming river temperatures due to lower Lake Powell elevations, attributed to drought and consumptive water use, may have resulted in more suitable habitat in the western Grand Canyon for razorback suckers. In 2015, river temperatures were within the acceptable range needed for razorback sucker spawning and successful hatching, particularly farther downstream (Kegerries et al. 2015). In addition, fish community composition in the lower river below Diamond Creek has changed dramatically from one dominated by non-native species, to native species (Kegerries et al. 2015). However, the cause of the change in fish community composition is unknown. The drop in non-native predator abundance, combined with periodically warmer water temperatures, may have allowed for the expansion of razorback sucker into the western Grand Canyon. Additional research and monitoring are needed to better understand the management implications of these habitat changes for recovery of razorback sucker in Grand Canyon (Albrecht et al. 2014).

**Factors affecting species environment and critical habitat within the action area**

The historical decline of the razorback sucker and its critical habitat in the Grand Canyon has been attributed primarily to habitat modification due to dam construction (including cold water dam releases, habitat loss, and migration impediments), streamflow regulation, and predation by non-native fish species, which have resulted in a lack of recruitment (Service 2002b, 2018b, Gloss and Coggins 2005).

- Similar to the humpback chub, cold hypolimnetic releases from Glen Canyon Dam have likely contributed to reproductive failure in razorback sucker (Gloss and Coggins 2005). Flow regulation has decreased the magnitude of spring peak runoff, which is closely linked to reproduction of the razorback sucker. The loss or drastic reduction in peak flows, along with channelization or disconnection of floodplain nursery habitats with the main channel (as a result of loss of peak flows), have resulted in the reduction of reproduction and recruitment as it likely occurred historically (Service 2002b, 2018). The flow regimes necessary to maintain razorback sucker populations in the action area, including flows that provide adequate spawning cues and spawning and nursery habitat, are presumably present as some razorback suckers have been detected in western Grand Canyon and there is evidence of spawning (Albrecht et al. 2014). However, the low numbers of adults detected and lack of recruitment indicate that habitat may not be adequate for suckers to maintain themselves within the action area at this time.

- Competition with and predation by non-native fishes have also been identified as important factors in the decline of the razorback sucker (Minckley et al. 1991, Service 2002b, 2018). The reduced sediment supply and resulting clear water due to dam operations also is thought to favor sight-feeding non-native predators, over razorback sucker and other native fish that evolved in highly turbid conditions (Gloss and Coggins 2005). Studies on the impacts of wild rainbow and brown trout on razorback sucker have not occurred, however, we anticipate that impacts to razorback suckers if present would be similar to humpback chub. Non-native fish attempting to forage may result in harassment and consumption of razorback suckers. Ingestion of razorback sucker eggs and young may occur at locations where detections have occurred. Yard et al. (2011) documented rainbow trout consume native fish disproportionally to their availability in the Colorado River. The Arizona Department of Game and Fish have stocked, and have plans for future stocking of hatchery reared rainbow trout, for with there is likely to be a low level of harassment and predation of humpback chub. The incidence of piscivory by brown trout has been found to be much higher than for rainbow trout in the Grand Canyon (Yard et al. 2011; Whiting et al. 2014). Predation by channel catfish and black bullhead are also thought to impact humpback chub in the Grand Canyon, particularly if warmer water conditions occur (NPS 2013). Because of their size, adult razorback suckers are less likely to be preyed on by trout; however, emergent fry, YOY, and juvenile razorback sucker are susceptible to predation (Yard et al. 2011). Detections of small bodied, young razorback suckers in the lower portion of the action area without evidence of recruitment to adult age in this location may be caused by non-native aquatic species predation.

- Similar to impacts on humpback chub, elevated Hg and Se described by Walters et al. (2015) may be another factor that affects razorback sucker in the Colorado River. While razorback suckers were not tested, other native suckers with similar diets were found to have high levels of Hg and Se in the Grand Canyon (Walters et al. 2015).

## EFFECTS OF THE ACTION

Effects of the action refer to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated and interdependent with that action that will be added to the environmental baseline. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. Indirect effects are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur.

### Humpback chub and critical habitat

Many of the treatment actions and associated monitoring in the proposed action have potential to have direct impacts to individuals or habitat or by directly and indirectly influencing the abundance and distribution of non-native fish. The majority of negative effects to individual humpback chub are anticipated to be short-term; however, the proposed action is designed to have long-term net population-level benefits for chub through reductions in non-native species which prey on, compete with, and alter habitat of humpback chub.

*Targeted Harvest*

Incentivized harvest actions (H1) are limited to the Glen Canyon reach where humpback chub historically occurred, but are not currently present. As a result, there is a low probability for anglers to incidentally capture chub in the Glen Canyon reach. NPS would employ CM-12, which is specific to incentivized harvest and includes documenting any new reports of incidental capture, returning any incidental captures to the water immediately, and providing education. Therefore, the anticipated effects of incentivized harvest on humpback chub are insignificant and discountable.

*Physical Control*

Dewatering of small ponds and backwaters (P1) by portable pumps could have direct effects on humpback chub. This action involves dewatering small non-native breeding and nursery areas by using high-volume pumps for up to two weeks total, and would require first capturing all fish possible by mechanical methods. Should complete desiccation of the area not be possible, then remaining water may be treated with chemical methods. This would result in the removal of any eggs, larvae, or fish remaining in the treatment area. As specified in CM-1 and CM-14, pretreatment surveys will be conducted to relocate any native or endangered species. Additionally, if small fish were missed in the pretreatment surveys, they would likely be caught in the filter screens, or be in the small remaining pools after the pump-out, and could be relocated if still alive. Though there is a low likelihood of harming individual chub during the pump-out process (stranding in water or captured in screens) the possibility is not completely eliminated. Therefore, dewatering of small ponds and backwaters may harm individual humpback chub by stranding, desiccating, or killing with chemicals should chub be present in the treatment area, and therefore may have adverse effects to chub.

The installation of temporary selective weirs (P2) and longer-term non-selective barriers (P3) may have short-term negative effects humpback chub movement and incidental handling. However, long-term impacts are anticipated to be beneficial in that fewer non-native fish will be present in the action area. Impacts from temporary selective weirs will be minimized by CM-6, which dictates the use the “General Guidelines for Handling Fish” (Persons et al. 2013) to minimize injury to non-target fish. Non-selective barriers could potentially affect this species by impeding movement; however, the locations in which this would be used is limited to small backwaters or in tributaries. Implementation of CM-1 and CM-14 will result in pre-treatment surveys and relocation of humpback chub and other non-target species, incidentally captured. The NPS will contact the Service prior to treatment if the area is believed to be occupied and critical for spawning and rearing of chub. These barriers could be in place for a period of time, so there is the potential for some individual humpback chub to be affected by these barriers but a low chance of incidental take. Though CM-1 and CM14 minimizes the potential to affect chub it is still possible that these activities may create a barrier to movement, therefore, they may have adverse effects to humpback chub.

Small scale temperature change (P5) using a propane heater, would only occur in headwaters of tributary streams such as Bright Angel Creek or smaller areas. An initial small-scale experiment would be conducted prior to implementing this at a larger scale; raising temperatures of water from approximately 15°C to at least 22°C, which may be a critical threshold for YOY brown trout. A target of as high as 29°C, a lethal threshold for adult brown trout (>350 mm total length), would be the maximum attempted temperature target. Initial experiments would target heating a 1,500 ft (457 m) stream segment for up to 6 weeks. Should this small-scale experiment prove successful at eliminating trout (without harming native fishes and aquatic invertebrates), and if heating a larger volume of water is deemed feasible, it could be expanded to treat larger areas and tributaries. Temperature ranges for humpback chub spawning, incubation, and growth are 16°C-22°C and 16°C-27°C, 16°C-22°C, respectively (Valdez and Speas 2007). Temperatures above 35°C are lethal to humpback chub. With (1) CM-1 and CM-14, pre-treatment surveys, relocation of native species, and further discussion with the Service if the treatment area is believed to be occupied and critical for spawning and rearing; (2) because temperature increases likely having beneficial effects to humpback chub; and (3) the temperature range staying under the lethal temperatures for humpback chub, we don't anticipate that this is likely to have a large adversely affect humpback chub. Therefore, the effects of this activity are anticipated to be discountable and insignificant.

Dredging in the 12-Mile Slough (P4) is highly unlikely to affect humpback chub because they have not been documented in the sloughs and currently are not known to occur that far upstream (Service 2017). Pre-treatment surveys would be conducted before the actions per CM-1 and CM-14, and should humpback chub be detected, NPS will contact the Service to discuss options and seek agreement to implement this action. With the implementation of CM-1 and CM-14, we do not anticipate any adverse effects to humpback chub by dredging the 12-Mile Slough area.

*Mechanical Control*

Any monitoring or removal methods that result in incidental capture and handling of humpback chub could result in harm and increased mortality; CM-6 minimizes, but does not eliminate the chances of this with specific fish handling guidelines. Therefore, there is potential for each of the mechanical removal actions to affect chub. Though there would be a net benefit to the species by removing non-native fish and decreasing their overall number over time. Handling humpback chub that are incidentally captured could result in limited incidental take in the form of harassment and harm (including possible mortality). The result of incidentally handling chub as part of the mechanical removal will likely vary from minor (no physical injury and low stress response) to significant (physical injury or high stress levels that may result in immediate or delayed mortality) depending on the physical fitness of the fish, abiotic environmental conditions, and how the actions are implemented. As described in the proposed action; biological surveys, monitoring and non-native removal in the Colorado River and tributaries in the action area is subject to tagging and handling protocols that are designed to reduce the risk of high stress or physical injury to individual fish that are captured and handled (Person et al. 2013). These apply to all project elements and some may have additional restrictions not included in those protocols that are part of the CFMP BO or conditions in NPS' section 10(a)(1)(A) permits, which outlines purposeful take not included in this BO.

Mechanical removal using electrofishing and other trapping methods (M2), could be used in any locations within the project area as a method of control to target non-native species. Electrofishing could be used as a monitoring and survey method throughout the project area, so during use of this method NPS personnel could reasonably encounter humpback chub, particularly around the LCR area. This action could potentially lead to some incidental capture and take of individuals in the form of harassment and harm (including mortality). The extent of effects on captured fish rely on sampling gear, size and age class of fish, physical condition of the fish, and environmental conditions under which the fish is captured. Little data exists on the effects of electrofishing on chub; however, occasional mortality has occurred in Grand Canyon due to monitoring. Ruppert and Muth (2011) tested electrofishing and concluded that electrofishing does not affect short-term growth or survival of juvenile humpback chub. However, there is extensive information on capture and handling stress of fish that can be generalized to chub and all methods result in some level of stress to the captured animal, and the results of that stress can vary from species to species and within different lineages of the same species (Cone and Krueger 1988, Hunt 2008). The standard guidelines in fisheries management (Nickum 1988, Schreck and Moyle 1990, Murphy and Willis 1996, and Bonar et al. 2015) were designed around this knowledge to incorporate guidelines that minimize the potential for injury and mortality during survey and monitoring activities. NPS will follow conservation measures CM-5 and CM-6, which include electrofishing and fish handling procedures to minimize incidental harm to natives; however, even with these conservation measures in place it does not completely eliminate the possibility of harming humpback chub. Therefore, the effects from this activity may have an incidental adverse effect on humpback chub.

Passive and active sampling gears, such as nets, will be used as part of this action. Passive nets are those that are set, left, and checked periodically; such as, trammel nets, hoop nets, and minnow traps. Active nets are those that require crews to move them through the water; such as, seines and dip nets. The NPS will use standard methods in the use of these methods which are outlined in the CFMP BO and associated standard practices in fisheries management (Nickum 1988, Schreck and Moyle 1990, Murphy and Willis 1996, Person et al. 2013, and Bonar et al. 2015). Trammel nets can capture larger fish effectively when used properly; however, there is always a level of stress involved that can be fatal in some more sensitive species (Hunt 2008, Hunt et al. 2012, Paukertet al. 2005). Fish can end up injured or dead from the physical trauma or exhaustion while in these nets, especially when set in flowing water such as the Colorado River. Individuals can also be killed if left in these nets too long, and the combined stress of time in the net plus the handling can cause delayed mortality. Current limitations on use of trammel nets based on temperature and time between checking for captured fish are designed to reduce the potential impact on fish captured in the nets. Traps such as hoop nets and minnow traps are less likely to result in physical trauma as the capture is passive and the fish either swim into these traps randomly or are baited into them. Some fish may be captured together with a predatory fish or a larger fish that may begin eating smaller fish within the trap, resulting in mortality of the smaller fish or size classes. Similarly, seines pulled up onto shore may have bunched material that can harm individuals. With small fish, the act of picking them up out of the seine can cause injury if not done with care. Damage to the mucus coating on a fish's skin can be avoided by having wet hands before handling fish. More active methods of capture include dip nets, hand captures, angling, and seines. These methods are less likely to result in injury or death from being left too long attached to the gear. The act of field crews moving through the water with nets or other equipment also has a risk to eggs or larvae if activities are conducted during the spawning and nursery period for a species. Removing fish from various sampling gear, holding, handling, and release can also result in injury and mortality from physical trauma, secondary infections, and stress (Cho et al. 2011; Francis-Floyd 2009; Harper and Wolf 2009; Portz et al. 2006; Sharpe et al. 1998). Therefore, the effects from netting and handling of fish may have an adverse effect on humpback chub.

Mechanical disruption of early life stage habitat (M1) by use of high-pressure water flushing and mechanical displacement of gravel is a geographically isolated and targeted method. This method is anticipated to displace eggs, larvae and young fish from spawning and nursery locations where non-natives are present. Areas with humpback chub early life stage habitats will not be targeted and therefore, this activity should have a low potential for deleterious effects to humpback chub given that NPS would use CM-14 which includes pre-treatment surveys, relocation of natives, and further discussion with the Service if the treatment area is believed to be occupied by humpback chub and critical for spawning and rearing. Should this method be used in areas where eggs, larvae, of spawning humpback chub are present, this is a risk of disturbing spawning behavior, and killing eggs and larvae. Additionally, this action includes an off-ramp for if potential long-term unacceptable adverse effects on native fish are expected to occur. The limited spatial extent, off-ramp, and CM-14 minimize the potential of adverse effects, but does not completely eliminate the potential for overlap between invasive species early life stage habitat and humpback chub spawning and rearing habitat. Therefore, the effects from mechanical disruption may have an adverse effect on humpback chub individuals.

Activities focusing on acoustic fish deterrent and guidance (M3) are designed to repel fish from target areas and guide them elsewhere. This tool would be deployed to repel non-native fish from suitable breeding habitat, such as warmwater natives from warm backwater habitats where they could reproduce. Acoustic fish deterrents are intended to be non-lethal tools and any incidental mortality of fish should be very low (USACE 2013). These fish deterrents are likely to be non-selective and may also repel humpback chub and prevent their use of target areas; however, the use of sonic guidance would be limited to small backwaters or ponds < 5 ac, many of which are outside of areas occupied by chub. These devices may also require some limited disturbance at the shoreline for installation of generators or solar panels to power the devices. Pre-treatment surveys and relocation would be conducted for humpback chub under CM-1 and CM14 and if chub are present further discussion with the Service would occur to discuss occupancy and if the area is critical for spawning and rearing. These devices could be in place for an extended period of time, so there is the potential for some individual humpback chub to be affected by these barriers by harassment of chub out of the area, but a low chance of incidental take in the form of harm or mortality. The NPS minimizes the potential of take of chub by implementing CM-1 and CM-14; however, there is still the possibility for this activity to affect humpback chub by creating an area of harassment and a barrier to movement, therefore, it may have adverse effects.

Mechanical harvesting of non-native aquatic plants and algae (M4) could be used in small backwater locations (<5ac) and tributaries. Removal of vegetation would include hand removal, rakes, hooks, hand tools, boat rakes, vacuums, underwater weed cutters, nets, shade coverings, covering mats, dyes, or other physical tools for removal. Where feasible, water drawdown and drying may be considered with refilling occurring once the target species are controlled. It is possible for this action to potentially harm, including mortality, individual humpback chub through the physical removal process or water drawdown. Additionally, individual chub may become entrapped in equipment, but most will likely be harassed out of treatment areas if present. With the implementation of CM-14, which includes pre-treatment surveys and further discussion with the Service if the treatment area is believed to be occupied and critical for spawning and rearing, the potential to harm humpback chub should be minimized. Additionally, per CM-14, NPS will avoid conducting actions during spawning season when practicable. However, even with the implementation of CM-14, a drop in oxygen levels or harm to humpback chub during the removal process may occur, therefore this activity may have adverse effects on humpback chub.

*Biological Control*

Introduction of YY-male brown trout into Glen Canyon (B1) is likely to effect humpback chub downstream starting at RM 30 and down past the confluence of the Colorado and Little Colorado rivers. The analyses in the EA indicated that if the brown trout YY-male stocked fish in Glen Canyon reach have mortality/survivorship, migration and reproduction rates within the bounds of what has been analyzed in the EA, then this tool will reduce the population of predatory non-native brown trout and have a net benefit to the humpback chub population in the long-term, by reducing or eliminating the brown trout population. Wild brown trout live for an average of 5 years with some individuals living in excess of 10 years (NPS 2015), so this effect could occur over a period of years until the YY-males begin to reduce the brown trout population. This analysis was considered over an approximately 10-15 year timeline (anticipating the duration of this action is 20 years). Some stocked YY-male brown trout may migrate and come into contact with individual chub and could lead to incidental take of individuals through competition or predation. However, the expected net effect would be beneficial to humpback chub through the overall reduction in the brown trout population in the long-term. Also, NPS would use the conservation measures for YY-males introductions (CM-13) including PIT tagging or marking introduced YY-males to monitor migration rates, and conditions under which the action would be stopped. The analysis of the estimated level of take in the form of harm (mortality) of humpback chub by brown trout YY-males is found in Appendix B. The effects from this action may have an adverse effect on humpback chub.

The movement and dispersal of various trout species on big rivers has been studied and we use this information in our analysis of estimated out-migration rates for the proposed brown trout stocking. Downstream movement may vary by habitat type (lentic versus lotic systems) and by strain (Moring 1993). Ninety-five percent of the catchable triploid rainbow trout stocked in the Middle Fork of the Boise River, Idaho, was located within 3 km (1.9 mi) of the stocking point (High and Meyer 2009). Similar results of movement for catchable trout were reported in Idaho's upper Salmon River, where more than 90% of the reported recaptures were within 3.2 km (2 mi) of the stocking site (Bjornn and Mallet 1964), and in the Portneuf

River, where 66% of tagged catchable trout were captured within a few hundred meters of the stocking location (Heimer et al. 1985). Catchable rainbow trout stocked in a tail water fishery moved an average of only 1.4 km (0.9 mi) in July and 3.8 km (2.4 mi) in September within 24 hours after stocking (Bettinger and Bettoli 2002). This lack of dispersal concurs with other studies, where, in general, catchable trout disperse no more than about 1 km (0.62 mi) (Helfrich and Kendall 1982). Some stocked brown trout are expected to move away from stocking locations in a similar manner as these examples. Their behavior in streams shows a combination of long range movements and restricted movements in any given population. Individual fish will also show signs of switching these behaviors (Skurdal et al. 1989). Furthermore, these behavior combinations are presumably adaptive when conditions are often unpredictable and changeable. These movements demonstrate the possibility of trout moving into areas where humpback chub are persisting and spawning, and potentially resulting in disruption of chub spawning behavior or predation on small, larval humpback chub. Predation by brown trout at the LCR confluence has been identified as an additional mortality source affecting chub survival, reproduction, and recruitment (Valdez and Ryel 1995; Marsh and Douglas 1997; Yard et al. 2011; Yackulic 2018). Brown trout are opportunistic feeders and their primary food items depend in part on the life history stage as well as the habitat being used, but includes measurable piscivory (Bachman et al. 1984; Sublette et al. 1990; Valdez and Ryel 1995; Marsh and Douglas 1997; Yard et al. 2011; Yackulic 2018). Sweetser et al. (2002) found brown trout to be the most piscivorous of three trout species (brown, rainbow, and brook [*Salvelinus fontinalis*]) they examined in the LCR in Arizona. Bryan et al. (2000) noted that trout can adversely affect native fish populations through aggressive displacement through interference competition, using resources more quickly and efficiently through exploitative completion, increasing stress hormones, or by opportunistic piscivory.

We evaluate impacts that wild brown trout have on the Grand Canyon population of humpback chub, which is driven by density and movement of trout in the action area (Yackulic 2018). Stocked brown trout movement out of Lees Ferry has not been studied. As conservation measures are employed, managers will be able to detect density dependent movement of stocked brown trout, similar to what has been documented for wild rainbow trout in the Lees Ferry reach. Reduction in trout abundance in the Lees Ferry reach may reduce downstream dispersal into reaches where humpback chub are located (Avery et al. 2015; Yard et al. 2015; Yackulic et al. 2018). Brown trout numbers are currently relatively low but will initially increase with augmented by the proposed action. Another example of density dependent impacts to the Grand Canyon population of humpback chub showed a strong negative relationship between density of brown trout and survival of chub; meaning the higher the density of trout, the lower the numbers of juvenile humpback chub (Yackulic et al. 2018).

The proposed action is to stock 5,000 tagged YY-male brown trout annually into the Glen Canyon reach or into a tributary as a pre-experiment of this method. This number of stocked YY-male brown trout is a large proportion of the overall estimated number of wild brown trout in the Glen Canyon reach. By design, this method relies on swamping the number of wild brown trout by stocking YY-males as a means of skewing the sex ratios of the population.

It is anticipated that predation of humpback chub by stocked YY-male brown trout may result in a moderate to high level of harm in the short-term, but may reduce or eliminate the harm from wild brown trout in the long-term. Individual humpback chub will experience mortality due to predation of small humpback chub by stocked YY-male brown trout. Impacts to humpback chub are expected to be minor at the stocking site since very few humpback chub persist in the Lees Ferry portion of the river. However, the stocked trout will disperse in the river, increasing the likelihood of competition and predation. We know little about the differences of outmigration rates, or predation rates, of stocked brown trout compared to their wild-born counterparts from Glen Canyon Dam to either the 30-Mile Spring area or down to the confluence with the LCR, therefore we use estimates of movement of the wild rainbow trout from Lees Ferry to areas occupied by humpback chub downstream. Given the wild trout information, we anticipate that some stocked brown trout will move out of the Glen Canyon area either upstream or downstream toward the 30-Mile Spring and LCR confluence area. A model developed by the GCMRC and Service to evaluate the impact of stocking rainbow trout on humpback chub was modified to estimate how stocking YY-male brown trout in the Glen Canyon reach might contribute to mortality of juvenile humpback chub in the LCR reach of the Colorado River (Appendix B). Annual stocking would be limited initially to a maximum of 5,000 adult YY-male brown trout, or an equivalent number of juveniles (estimated to be 10,000 based on assumed juvenile survival rates). This number represents a conservative level of risk to humpback chub if brown trout survival, movement, and predation rates are at high-risk levels. Survival of introduced YY-males would be expected to be lower than that, but the modeling considered a range of survival levels. Modeling indicated that annual stocking of 5,000 adult YY-male brown trout into the Glen Canyon reach for a 10-year period could result in average annual consumption over a 20-year period of 13, 113, and 1,915 juvenile humpback chub under low-, moderate-, and high-risk scenarios, respectively (see Appendix B). Estimated YOY humpback chub production in the Little Colorado River ranges from approximately 5,000 to 45,000 per year (Yackulic 2018), with larval fish being even higher, perhaps as high as millions with only 1% of these surviving the first year (Service 2018). Based on these estimates, stocked brown trout could consume up to 76% of a year's production in some low humpback chub production years and up to 8% of the YOY humpback chub could be consumed in high production years. All efforts will be made to use this technique in years of high productivity for humpback chub and to avoid years when the chub population is below an acceptable threshold. For example, NPS will implement CM 13 which in part ensures that introduction of YY-males is not expected to cause the Tier 1 or Tier 2 trigger conditions in the LTEMP BO to be reached, and if the Tier 1 or Tier 2 trigger have already been reached in a given year or are modeled to be reached in the next year then NPS would not introduce YY-males in that year. Because the tiered triggers of LTEMP are in part based on low humpback chub population estimates and also on the ratio of predatory non-native fish to chub, NPS will avoid stocking when the impacts of the taking are higher, resulting in the predation of 76% of the year's production an unlikely scenario. As part of this action we anticipate a high end estimate of 36 YY male brown trout may accumulate in the LCR reach in any one year, through stocking and movement out of the Glen Canyon Reach. Monitoring efforts (both passive and active) will attempt to document movement and quantify the number of stocked brown trout that move downstream. Brown trout that move downstream may reach areas where humpback spawn in the mainstem or tributaries, resulting in larval humpback chub co-occurring where stocked trout may have dispersed. Nevertheless, given the limited overlap of the two species, we expect the overall impact to the humpback chub per year to be low in the long-term. Monitoring and conservation measures are in place to evaluate the numbers of stocked trout that leave the Glen Canyon area and reach the LCR confluence and to cease the action if immigration rates are higher than anticipated. Although loss of larval humpback chub is expected, the adult population of humpback chub currently has a population estimate of 12,000 adults and is expected to persist during the life of this project.

Harassment of spawning humpback chub adults by stocked brown trout and some direct predation on small (larval and young of year), and perhaps eggs, of humpback chub is anticipated. Disruption in foraging may also occur, should brown trout harass adults. Additional take in the form of harassment of all life stages of humpback chub, by stocked brown trout, is also expected to occur. This harassment may be in the form of non-lethal harassment of humpback chub by brown trout to such an extent that behavioral modification of avoiding trout might reduce individual humpback chub to shelter, forage, or breed, and could result in decreased fitness of individuals.

Piscivory has been documented by wild brown trout in the Lower Colorado River basin, and in particular for piscivory impacts to humpback chub young (Yard et al. 2011). Although consumption of YOY may be lower with naïve stocked trout, the need to forage will still existent, resulting in trout chasing young chub. Even if chasing does not result in a successful capture, it has the potential to result in energy expenditures of larval humpback chub, which could lead to reduced fitness and survival. Additionally, Ward (2018) found hatchery reared rainbow trout become more efficient at catching prey over time in this study (Ward 2018). Ingestion of humpback chub eggs by trout has not been studied, but it cannot be ruled out as a form of take. Given Yard et al.'s (2011) documented work on trout's disproportionate consumption of native fish in relation to the areas where humpback chub aggregations exists, piscivory is expected to continue with the proposed action.

Because the current population estimate of adult humpback chub is relatively high and stable, this population will likely be able to withstand this experimental action. Additionally, a resilient population of adult humpback chub relies on a larger number of larvae for a population's resiliency and stability. This amount of larval loss should be overcome by compensatory mortality on a system with its current carrying capacity sustaining an adult population of such a large size, as relatively high juvenile mortality is expected for this long-lived fish (Pine et al. 2013). Although predation of small sized humpback chub is anticipated to occur as a result of this stocking, it is not anticipated that it will result in a population level impact, and conservation measures are in place to cease stocking at an early stage if it appears that impacts of the action are greater than anticipated. The conservation measures in the proposed action are designed to protect humpback chub resiliency and support continued efforts towards species conservation and recovery. The Lower Colorado River Basin population of humpback chub is estimated to be abundant (around 12,000 adult individuals) and self-sustaining (Service 2018). Because the current population of adult chub is high and stable, and because the proposed action outlines measures to cease stocking once a conservative number of stocked brown trout have moved into areas where humpback chub are detected, the population level impacts to this humpback chub population is not expected to result in permanent long-term population losses. If the assumed stocking rate was sufficient for successfully eliminating wild brown trout from the Glen Canyon reach over a 20-year period, the long-term benefits to humpback chub population may outweigh the expected relative short-term adverse effects of the annual losses of juveniles to predation. This control action is considered experimental and updated scientific information, results of field studies, and any other new information regarding effectiveness and negative or unintended impacts of stocking YY-male fish would be reviewed prior to implementation. Additional planning and compliance assessments would be considered if there were significant new information regarding potential impacts.

*Chemical Control*

Chemical control includes methods such as; overwhelming ecosystem-cycling capabilities (C1; ammonia, oxygen, carbon dioxide, pH, etc.); application of registered piscicides for control of high- and very high-risk non-native species (C2 and C3); and application of registered piscicides for tributary renovation. Each of these activities have reach specific guidance and have Conservation Measures which outline important application and safety methods that are provided to control, avoid, and minimize possible negative effects to the ecosystem, non-target species, and listed species such as humpback chub.

Chemical treatment actions could affect humpback chub individuals and could adversely affect this species and result in low numbers of incidental take. Chemical treatment is only expected in very limited areas in any given year (limited to use in tributary segments with natural barriers, and backwaters and off-channel ponds < 5 ac in size). NPS would not implement overlapping chemical treatment actions in the same location for more than 5 consecutive years. These actions would be a net long-term benefit to humpback populations, as they would reduce populations of non-native species that could compete or predate on humpback chub. A number of conservation measures would be employed in CM-11 to ensure that the chances of effects or incidental take would be minimized. These include pre-treatment surveys and relocation of any humpback chub found in the treatment area, as well as a number of steps to ensure the effect of the chemical treatment is contained in the intended treatment area and neutralized afterwards, if appropriate. However, rotenone, antimycin, or the experimental use of carbon dioxide, oxygen-level alteration, pH alteration or ammonia could have various direct and indirect effects on humpback chub in the treatment area. Direct effects could be from direct exposure to any individual fish to the chemicals in the treatment area, which could be lethal to the fish, or exposure from any spills, though measures in CM-11 should minimize the impacts.

Indirect effects could come from temporary loss of food base in the treatment area. For application of registered piscicides studies have shown that piscicide treatments in streams using rotenone or antimycin had large short-term effects on benthic invertebrate communities but that these communities recovered over time; within one year for antimycin and up to three years for rotenone (Finlayson et al. 2010; Hamilton et al. 2009). Results from rotenone treatments and whole lake experiments indicate that most invertebrate populations will recover after exposure to piscicide concentrations of rotenone (Blakely et al. 2005, Havens 1980). An experiment conducted with a paired set of four wetlands (treated and untreated) found that exposure to rotenone at 300 ppb primarily resulted in only short-term decreases in the abundances of most zooplankton taxa. No significant response was detected in the benthic invertebrate community and most zooplankton taxa recovered seven months after the exposure to rotenone (Melaas et al. 2001). Vinson et al. (2010) reviewed published laboratory toxicity tests and twenty-two field studies that examined the effects of rotenone on invertebrate communities in lakes, rivers, and streams. They found that zooplankton abundances recovered to pretreatment abundances between one month to three years and that species assemblages can recover within six months of a piscicide treatment. They also found that benthic invertebrate communities in lakes demonstrated similar recovery patterns with recovery times ranging between six months to one year. Application of registered piscides could have adverse effects to humpback chub through harm (including mortality) and short-term reductions in food availability.

Effects from experimental use of carbon dioxide, oxygen manipulation, pH alteration or ammonia addition, should be of similar or shorter duration in effects (compared to rotenone/antimycin) to the benthic invertebrate communities (D. Ward pers. comm. 2018). Therefore, these experimental treatments could have adverse effects to humpback chub through harm (including mortality) and short-term reductions in food availability. However, the effects to food base are expected to be less in duration and extent than piscicide treatments.

Application of registered herbicides and non-toxic dyes to backwaters and off-channel areas would be expected, with the use of conservation measures in CM-15, to have no-effects to humpback chub. Herbicide formulations include inerts, surfactants, and adjuvants, which would be released to water bodies in aquatic applications and particular herbicide formulations and their associated surfactants may vary in their toxicity (Folmar et al. 1979). Those with appropriately low levels of toxicity would be selected through the NPS pesticide approval process and in discussion with the Service for the particular species and treatment area. Neither the active herbicide nor these additives would be expected to have effects on non-target organisms or water quality when used as directed by the manufacturer, and with strict adherence to applicable regulations and guidelines. Treatment of non-native vegetation can lead to a short-term drop in oxygen levels as the vegetation decays (Evans 2008), however some studies have also shown a long-term improvement in dissolved oxygen levels from the removal of non-native aquatic vegetation (Perna and Burrows 2005). This treatment would occur in small backwater areas (<5 acres) or tributaries so any effects would be localized to those areas with a small amount of downstream drift. Under CM-1, pre-treatment surveys would be conducted to assess potential for effects to non-target species, and native species would be relocated or the treatment might be avoided in the specific area or during a specific time period if there was reason to be believe it could effect humpback chub. This action would be expected to provide long-term benefits by removing non-native aquatic vegetation and contributing to the recovery of listed species and conservation of native species and habitats. Though decaying vegetation may result in a drop in oxygen levels, these effects to humpback chub are insignificant and discountable.

Application of mollusk repellents (C6) and non-toxic anti-fouling paints (C5) on boats, equipment used in the river, and NPS water intakes, will be carefully considered by NPS and NPS will ensure that they have also been approved by the state of Arizona. Current repellent treatments include the use of hot pepper capsaicin in a wax-based application. Approved anti-fouling paints for boat and equipment surfaces that do not utilize copper derivatives, which are toxic to aquatic organisms, or other toxic additives will be considered as new options are developed. All use of repellent and anti-fouling paint would be subject to NPS approval processes in strict adherence to applicable regulations and guidelines. This action is expected to have no effects to humpback chub based on the use of non-toxic repellents as outlined in CM-15.

*Humpback chub critical habitat*

In our analysis of the effects of the action on critical habitat, we consider whether or not a proposed action would result in the destruction or adverse modification of critical habitat. In doing so, we must determine if the proposed action would result in effects that appreciably diminish the value of critical habitat for the recovery of a listed species. To determine this, we analyze whether the proposed action would adversely modify any of the PCEs that were the basis for determining the habitat to be critical. To determine if an action results in adverse modification of critical habitat, we considered the current condition of all designated critical habitat units for this species, to determine the overall ability of all designated critical habitat to support recovery. Further, the functional role of critical habitat in recovery must also be considered as it represents the best available scientific information as to the recovery needs of the species.

Below, we describe the primary constituent elements or "PCEs" for humpback chub critical habitat that we are evaluating and then briefly describe the "effects" to these PCEs within Reach 6 (Little Colorado River) and Reach 7 (Colorado River from Marble through Grand Canyon) from implementation of this action.

***Water Quality/Quantity PCE:*** This PCE calls for water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminants, nutrients, turbidity, etc.) that is delivered in sufficient quantity to a specific location in accordance with a hydrologic regime that is required for each of the life stages of humpback chub. Impacts to this PCE will be short term and minimal. We anticipate that none of the actions will affect water quality, with the exception of chemical treatments for non-native fish and plant removal. However, such treatments will be small in scale and fleeting in time.

***Physical Area PCE:*** This PCE includes the physical areas of the Colorado River system that are inhabited by humpback chub or potentially habitable for use in spawning, nursery, feeding, or corridors between these areas. In addition to the main river channel, this includes bottomlands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100-year floodplain, which when inundated provide spawning, nursery, feeding, and rearing habitats, or access to these habitats. We do not anticipate any physical alternation of habitat in areas where humpback chub are present.

***Biological Environment PCE:*** This PCE includes important elements of the biological environment, food supply, predation, and competition. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition (i.e., for food and/or habitat resources) are considered normal components of this environment; but, are likely not at "natural" levels due to the presence of introduced, non-native fish (e.g., brown and rainbow trout) within the action area. Chemical treatments of water may temporarily decrease food supply in small areas, however, we do not think this level of impact will be biologically meaningful to humpback chub, nor will it measurable diminish this PCE.

The introduction of non-native fish species that prey on, and compete with, humpback chub affect one of the PCEs of the biological environment aspect of critical habitat. Non-native fish predation and competition is an important threat to native fishes in Grand Canyon (Minckley 1991, Valdez and Ryel 1995, Marsh and Douglas 1997, Coggins 2008, Yard et al. 2008, Yackulic et al. 2018) including humpback chub. Stocking of non-native brown trout inherently impacts this PCE as outlined under critical habitat for humpback chub. Under the factors listed for the biological environment, areas with no, or low, numbers of non-native fish are preferred. The addition of non-native species, which will prey on and compete with humpback chub, impacts this PCE by definition, consistent with the analysis provided above. However, impacts to all PCEs must be considered collectively when analyzing adverse modification, and impacts to critical habitat.

We do not have evidence that stocking of brown trout will impact any other PCE except for temporarily stocking additional non-native fish that may prey on and compete with humpback chub for food and other resources. One example of this is that stocking of brown trout is not anticipated to impact water quality or quantity. The proposed action is also not likely to significantly alter food resources or the non-natives' fish assemblage presently occurring in the area. However, given the size of the action area, the number of trout proposed to be stocked over the 20-year period, their ability to reproduce, the anticipated estimated level of movement of stocked brown trout into designated critical habitat, and current non-native fish assemblage that is present in the area, we anticipate that proposed stocking of brown trout will not appreciably diminish the conservation value of critical habitat for humpback chub under current environmental conditions.

Additionally, should movement of stocked brown trout be higher than anticipated, monitoring is in place to document this occurrence, and the stocking action will cease, ensuring no unintended impacts or additional impacts to the conservation value of the critical habitat. Finally, other ongoing conservation measures, and a robust research and monitoring plan associated with LTEMP, CFMP, and other efforts are in place, to ensure the conservation of the humpback chub and other native fishes. The proposed action is not expected to further diminish the conservation contribution of critical habitat to the recovery of the humpback chub, because the majority of the PCEs will remain unchanged from baseline, and the current critical habitat in the action area is maintaining a stable population of humpback chub.

**Razorback sucker and critical habitat**

Many of the treatment actions and associated monitoring in the proposed action have potential to have direct impacts to individuals or habitat or by directly and indirectly influencing the abundance and distribution of non-native fish. The majority of negative effects to individual razorback suckers are anticipated to be short-term; however, the proposed action is designed to have long-term net population-level benefits for the razorback suckers through reductions in non-native species which prey upon, compete with, and alter habitat of suckers. Impacts of the proposed action are anticipated to be similar to humpback chub since there is documentation of razorback suckers being present within the action area. Currently razorback suckers have been primarily found in the Colorado River mainstem in western Grand Canyon (Kegerries et al.

2015), so actions in that area have a higher chance of effecting razorback sucker individuals, however they have the potential for continued expansion throughout the project area and so this section considers the potential, though lower probability, for actions to effect razorback sucker individuals in Marble Canyon or Glen Canyon reach or in the confluence areas of tributaries. We anticipate the level of take of razorback suckers to be less than humpback chub because there are far fewer razorback suckers, to such an extent that we do not have reliable population estimates for these fish within the action area.

*Targeted Harvest*

Incentivized harvest actions (H1) are limited to the Glen Canyon reach where razorback suckers likely historically occurred, but are not currently present. As a result, there is a low probability for anglers to incidentally capture razorback sucker in the Glen Canyon reach. The NPS would employ CM-12, which is specific to incentivized harvest and includes documenting any new reports of incidental capture, returning any incidental captures immediately to the water, and providing education. Therefore, the anticipated effects of incentivized harvest on razorback sucker are insignificant and discountable.

*Physical Control*

Dewatering of small ponds and backwaters (P1) by portable pumps could have direct effects to razorback sucker if present. This action involves dewatering small non-native breeding and nursery areas by using high-volume pumps for less than two weeks, and would require first capturing all fish possible by mechanical methods. Should complete desiccation of the area not be possible, then remaining water may be treated with chemical methods outlined in the action. This would result in the removal of any eggs, larvae, or fish remaining in the treatment area. As specified in CM-1 and CM-14, pretreatment surveys will be conducted to relocate any native or endangered species. Additionally, if small fish were missed in the pretreatment surveys, they would likely be caught in the filter screens, or be in the small remaining pools after the pump out, and could be relocated if still alive. Though there is a low likelihood of harming individuals during the pump out process (stranding in water or captured in screens) the possibility is not completely eliminated. Therefore, dewatering of small ponds and backwaters may harm individual razorback sucker by stranding, desiccating, or killing with chemicals should they be present in the treatment area.

The installation of temporary selective weirs (P2) and longer-term non-selective barriers (P3) may have short-term negative effects razorback sucker movement and incidental handling. However, long-term impacts are anticipated to be beneficial in that fewer non-native fish will be present in the action area. Impacts from temporary selective weirs will be minimized by CM-6, which dictates the use the "General Guidelines for Handling Fish" (Persons et al 2013) to minimize injury to non-target fish. Non-selective barriers could potentially affect this species by impeding movement; however, the locations this would be used is limited to small backwaters or in tributaries. Implementation of CM-1 and CM-14 will result in pre-treatment surveys and relocation of razorback sucker and other non-target species, incidentally captured. The NPS will contact the Service prior to treatment if the area is believed to be occupied and critical for spawning and rearing. These barriers could be in place for a period of time, so there is the potential for some individual razorback sucker to be affected by these barriers but a low chance of incidental take. Though CM-1 and CM14 minimizes the potential to affect razorback sucker it is still possible that these activities may affect suckers by creating a barrier to movement, therefore, they may have adverse effects.

Small scale temperature change (P5) using a propane heater, would only occur in headwaters of tributary streams such as Bright Angel Creek or smaller. An initial small-scale experiment would be conducted prior to implementing this at a larger scale; raising temperatures of water from approximately 15°C to at least 22°C, which may be a critical threshold for YOY brown trout. A target of as high as 29°C, a lethal threshold for adult brown trout (>350 mm total length), would be the maximum attempted temperature target. Initial experiments would target heating a 1,500 ft (457 m) stream segment for up to 6 weeks. Should this small-scale experiment prove successful at eliminating trout (without harming native fishes and aquatic invertebrates), and if heating a larger volume of water is deemed feasible, it could be expanded to treat larger tributaries. Optimal temperature ranges for razorback sucker spawning, incubation, and growth are 14-22°C, 14-25°C, 18-24°C, respectively (Valdez and Speas 2007). This temperature range could be beneficial (in the 22-25°C range to slightly adverse (in the >25-29°C range) in its effects to razorback sucker (Valdez and Speas 2007) while being detrimental to cold water non-natives. With (1) CM-1 and CM-14, pre-treatment surveys, relocation of native species, and further discussion with the Service if the treatment area is believed to be occupied and critical for spawning and rearing; (2) because temperature increases likely having beneficial effects to sucker; and (3) the temperature range staying under the lethal temperatures for razorback sucker, we don't anticipate that this is likely to adversely effects. Therefore, the effects of this activity are anticipated to be discountable and insignificant.

Dredging in the 12-Mile Slough (P4) is highly unlikely to affect razorback sucker because they have not been documented in the sloughs and currently are not known to occur that far upstream (Service 2017). Pre-treatment surveys would be conducted before the actions per CM-1 and CM-14, and should suckers be detected, NPS will contact the Service to discuss options and seek agreement to implement this action. With the implementation of CM-1 and CM-14, we do not anticipate any adverse effects to razorback suckers by dredging the 12-Mile Slough area.

*Mechanical Control*

Any monitoring or removal methods that result in incidental capture and handling of razorback suckers could result in harm and increased mortality; CM-6 minimizes, but does not eliminate the chances of this with specific fish handling guidelines. Therefore, there is potential for each of the mechanical removal actions to affect suckers. Though there would be a net benefit to the species by removing non-native fish and decreasing their overall number over time. Handling suckers that are incidentally captured could result in limited incidental take in the form of harassment and harm (including possible mortality). The result of incidentally handling razorback suckers as part of the mechanical removal will likely vary from minor (no physical injury and low stress response) to significant (physical injury or high stress levels that may result in immediate or delayed mortality) depending on the physical fitness of the fish, abiotic environmental conditions, and how the actions are implemented. As described in the proposed action; biological surveys, monitoring and non-native removal in the Colorado River and tributaries in the action area is subject to tagging and handling protocols that are designed to reduce the risk of high stress or physical injury to individual fish that are captured and handled (Person et al. 2013). These apply to all project elements and some may have additional restrictions not included in those protocols that are part of the CFMP BO or conditions in NPS' section 10(a)(1)(A) permits, which outlines purposeful take not included in this BO.

Mechanical removal using electrofishing and other trapping methods (M2), could be used in any locations within the project area as a method of control to target non-native species. Electrofishing could be used as a monitoring and survey method throughout the project area, so during use of this method NPS personnel could encounter razorback suckers. This action could potentially lead to some incidental capture and take of individuals in the form of harassment and harm (including mortality). The extent of effects on captured fish rely on sampling gear, size and age class of fish, physical condition of the fish, and environmental conditions under which the fish is captured. Little data exists on the effects of electrofishing on razorback suckers. However, there is extensive information on capture and handling stress of fish that can be generalized to sucker and all methods result in some level of stress to the captured animal, and the results of that stress can vary from species to species and within different lineages of the same species (Cone and Krueger 1988, Hunt 2008). The standard guidelines in books on fisheries management (Nickum 1988, Schreck and Moyle 1990, Murphy and Willis 1996, and Bonar et al. 2015) were designed around this knowledge to incorporate guidelines that minimize the potential for injury and mortality during survey and monitoring activities. The NPS will follow conservation measures CM-5 and CM-6, which include electrofishing and fish handling procedures to minimize incidental harm to natives; however, even with these conservation measures in place it does not completely eliminate the possibility of harming suckers. Therefore, the effects from this activity may have an incidental adverse effect on razorback sucker.

Passive and active gears, such as nets, will be used as part of this action. Passive nets are those that are set, left, and checked periodically; such as, trammel nets, hoop nets, and minnow traps. Active nets are those that require crews to move them through the water; such as, seines and dip nets. The NPS will use standard methods in the use of these methods which are outlined in the CFMP BO and associated standard practices in fisheries management (Nickum 1988, Schreck and Moyle 1990, Murphy and Willis 1996, Person et al. 2013, and Bonar et al. 2015). Trammel nets can capture larger fish effectively when used properly; however, there is always a level of stress involved that can be fatal in some more sensitive species (Hunt 2008, Hunt et al. 2012, Paukertet al. 2005). Fish can end up injured or dead from the physical trauma or exhaustion while in these nets, especially when set in flowing water such as the Colorado River. Individuals can also be killed if left in these nets too long, and the combined stress of time in the net plus the handling can cause delayed mortality. Current limitations on use of trammel nets based on temperature and time between checking for captured fish are designed to reduce the potential impact on fish captured in the nets. Traps such as hoop nets and minnow traps are less likely to result in physical trauma as the capture is passive and the fish either swim into these traps randomly or are baited into them. Some razorback suckers may be captured together with a predatory fish or a larger fish that may begin eating smaller fish within the trap, resulting in mortality of the smaller fish or size classes. Similarly, seines pulled up onto shore may have bunched material that can harm individuals. With small fish, the act of picking them up out of the seine can cause injury if not done with care. Damage to the mucus coating on a fish's skin can be avoided by having wet hands before handling fish. More active methods of capture include dip nets, hand captures, angling, and seines. These methods are less likely to result in injury or death from being left too long attached to the gear. The act of field crews moving through the water with nets or other equipment also has a risk to eggs or larvae if activities are conducted during the spawning and nursery period for a species. Removing fish from various sampling gear, holding, handling, and release can also result in injury and mortality from physical trauma, secondary infections, and stress (Cho et al. 2011, Francis-Floyd 2009, Harper and Wolf 2009, Portz et al. 2006, Sharpe et al. 1998). Therefore, the effects from netting and handling of fish may have an adverse effect on razorback sucker.

Mechanical disruption of early life stage habitat (M1) by use of high-pressure water flushing and mechanical displacement of gravel is a geographically isolated and targeted method. This method is anticipated to displace eggs, larvae and young fish from spawning and nursery locations where non-natives are present. Areas with razorback sucker early life stage habitats will not be targeted and therefore, this activity should have a low potential for effects to suckers given that NPS would use CM-14 which includes pre-treatment surveys, relocation of natives, and further discussion with the Service if the treatment area is believed to be occupied by razorback sucker or critical for spawning and rearing. Should this method be used in areas where eggs, larvae, or spawning razorback suckers are present, this is a risk of disturbing spawning behavior, and killing eggs and larvae. Additionally, this action includes an off-ramp for if potential long-term unacceptable adverse effects on native fish are expected to occur. The limited spatial extent, off-ramp, and CM-14 minimize the potential of adverse effects, but does not completely eliminate the potential for overlap between invasive species early life stage habitat and sucker spawning and rearing habitat. Therefore, the effects from mechanical disruption may have an adverse effect on razorback sucker individuals.

Activities focusing on acoustic fish deterrent and guidance (M3) are designed to repel fish from target areas and guide them elsewhere. This tool would be deployed to repel non-native fish from suitable breeding habitat, such as warmwater natives from warm backwater habitats where they could reproduce. Acoustic fish deterrents are intended to be non-lethal tools and any incidental mortality of fish should be very low (USACE 2013). These fish deterrents are likely to be non-selective and may also repel razorback sucker and prevent their use of target areas; however, the use of sonic guidance would be limited to small backwaters or ponds < 5 ac, many of which are outside of areas occupied by razorback sucker. These devices may also require some limited disturbance at the shoreline for installation of generators or solar panels to power the devices. Pre-treatment surveys and relocation would be conducted for humpback chub under CM-1 and CM14 and if chub are present further discussion with the Service would occur to discuss occupancy and if the area is critical for spawning and rearing. These devices could be in place for an extended period of time, so there is the potential for some individual razorback sucker to be affected by these barriers by harassment of razorback suckers out of the area, but a low chance of incidental take in the form of harm or mortality. The NPS minimizes the potential of take of sucker by implementing CM-1 and CM-14; however, there is still the possibility for this activity to creating an area of harassment and a barrier to movement, therefore, it may have adverse effects to razorback sucker.

Mechanical harvesting of non-native aquatic plants and algae (M4) could be used in small backwater locations (<5ac) and tributaries. Removal of vegetation would include hand removal, rakes, hooks, hand tools, boat rakes, vacuums, underwater weed cutters, nets, shade coverings, covering mats, dyes, or other physical tools for removal. Where feasible, water drawdown and drying may be considered with refilling occurring once the target species are controlled. It is possible for this action to potentially harm, including mortality, individual razorback sucker through the physical removal process or water drawdown. Additionally, individual suckers may become entrapped in equipment, but most will likely be harassed out of treatment areas if present. With the implementation of CM-14, which includes pre-treatment surveys and further discussion with the Service if the treatment area is believed to be occupied and critical for spawning and rearing the potential to harm razorback sucker should be minimized. Additionally, per CM-14, NPS will avoid conducting actions during spawning season when practicable. However, even with the implementation of CM-14 a drop in oxygen levels or harm to sucker during the removal process may occur, therefore this activity may have adverse effects on razorback sucker.

*Biological Control*

Introduction of YY-male brown trout into Glen Canyon (B1) is likely to effect razorback sucker downstream, should these trout move a lengthy amount into areas occupied by suckers. The analyses in the EA indicated that if the brown trout YY-male stocked fish in Glen Canyon reach have mortality/survivorship, migration and reproduction rates within the bounds of what has been analyzed in the EA, then this tool will reduce the population of predatory non-native brown trout and have a net benefit to razorback sucker in the long-term, by reducing or eliminating the brown trout population. Wild brown trout live for an average of 5 years with some individuals living in excess of 10 years (NPS 2015), so this effect could occur over a period of years until the YY-males begin to reduce the brown trout population. This analysis was considered over an approximately 10-15 year timeline (anticipating the duration of this action is 20 years). However, some stocked YY-male brown trout may migrate and come into contact with individual razorback sucker and could lead to incidental take of individuals through competition or predation. However, the net effect would be expected to be beneficial to sucker through the overall reduction in the brown trout population. Also, NPS would use the conservation measures for YY-males introductions (CM-13) including PIT tagging or marking introduced YY-males to monitor migration rates, and conditions under which the action would be stopped. The effects from this action may have an adverse effect on razorback sucker.

Various trout species movement and dispersal on big rivers has been studied and we use this information in our analysis of estimated out-migration rates for the proposed stocking. Some stocked brown trout are expected to move away from areas in which they are stocked and into areas where razorback suckers may be present. Brown trout behavior in streams shows a combination of long range movements and restricted movements in any given population (Skrdal et al. 1989). Individual fish will also show signs of switching these behaviors. Furthermore, these behavior combinations are presumably adaptive when conditions are often unpredictable and changeable. These movements demonstrate the possibility of trout moving into areas where razorback suckers are present and spawning, and potentially resulting in disruption of razorback sucker spawning behavior or predation on small, larval razorback sucker. Predation by brown trout at the LCR confluence has been identified as an additional mortality source affecting native fish survival, reproduction, and recruitment (Valdez and Ryel 1995, Marsh and Douglas 1997, Yard et al. 2011, Yackulic 2018).

We evaluate impacts that brown trout have on razorback sucker in the Grand Canyon, which is driven by density and movement of rainbow trout in the action area (Yackulic 2018). Stocked brown trout movement out of Lees Ferry has not been studied. As conservation measures are employed, managers will be able to detect density dependent movement of stocked brown trout, similar to what has been documented for wild brown trout in the Lees Ferry reach. Reduction in trout abundance in the Lees Ferry reach may reduce downstream dispersal into reaches where razorback suckers may be present (Avery et al. 2015, Yard et al. 2015, Yackulic et al. 2018). Brown trout numbers are currently relatively low but will initially increase with augmented by the proposed action.

It is anticipated that predation of razorback sucker by stocked YY-male brown trout may result in a moderate to high level of harm in the short-term, but may reduce or eliminate the harm from wild brown trout in the long-term. Individual razorback sucker will experience mortality due to predation by stocked YY-male brown trout. Impacts to suckers are expected to be minor at the stocking site since very few razorback suckers have been recently documented in upper portion of the river. However, the stocked trout will disperse in the river, increasing the likelihood of competition and predation the farther downstream they move. We know little about the differences of outmigration rates, or predation rates, of stocked brown trout compared to their wild-born counterparts from Lees Ferry. For humpback chub, we were able to estimate the level of expected predation by brown trout; however, we do not have population analyses for razorback sucker, and therefore cannot give an estimate of take. Razorback suckers that are detected in the action area are most likely at the upper end of the Lake Mead population, that move up into Grand Canyon, and few in number. Consistent with the humpback chub analyses of this action we anticipate that a high end estimate of 36 stocked YY male brown trout will accumulate in the LCR reach, with the number declining farther downstream. It is not known how many trout move out of the Glen Canyon Reach but low movement rates measured at the LCR reach coupled with mortality of stocked fish limit the number present in any one year or reach.

Harassment of spawning razorback sucker adults by stocked brown trout and some direct predation on small (larval and young of year), and perhaps eggs, of razorback sucker is anticipated. Disruption in foraging may also occur, should brown trout harass adults. Additional take in the form of harassment of all life stages of razorback sucker, by stocked brown trout, is also expected to occur. This harassment may be in the form of non-lethal harassment of razorback sucker by brown trout to such an extent that behavioral modification of avoiding brown trout might reduce individual razorback sucker's ability to shelter, forage, or breed, and could result in decreased fitness of individuals.

Piscivory has been documented by wild brown trout in the Lower Colorado River basin. Although consumption of YOY may be lower with naïve stocked trout, the need to forage will still existent, resulting in trout chasing young razorback sucker. Even if chasing does not result in a successful capture, it has the potential to result in energy expenditures of larval suckers, which could lead to reduced fitness and survival. Additionally, Ward (2018) found hatchery reared rainbow trout become more efficient at catching prey over time in this study (Ward 2018). Ingestion of razorback sucker eggs by trout has not been studied, but it cannot be ruled out as a potential form of take. Given Yard et al.'s (2011) documented work on rainbow trout's disproportionate consumption of native fish, piscivory is expected to continue with the proposed action.

The current population estimate of razorback suckers in the action area is not possible, likely because numbers are so low. Additionally, a resilient population of adult razorback sucker relies on a larger number of larvae for population's resiliency and stability, which may be present in Lake Mead, but is not currently thought to exist upstream in the Grand Canyon. Although predation of small sized razorback sucker is anticipated to occur as a result of this stocking, it is not anticipated that it will result in a population level impact to the Lake Mead population, and conservation measures are in place to cease stocking at an early stage if it appears that impacts of the action are greater than anticipated. The conservation measures in the proposed action are designed to promote razorback sucker resiliency and support continued efforts towards species conservation and recovery. This control action is considered experimental and updated scientific information, results of field studies, and any other new information regarding effectiveness and negative or unintended impacts of stocking YY-male fish would be reviewed prior to implementation. Additional planning and compliance assessments would be considered if there were new information regarding potential impacts.

*Chemical Control*

Chemical control includes methods such as; overwhelming ecosystem-cycling capabilities (C1; ammonia, oxygen, carbon dioxide, pH, etc.); application of registered piscicides for control of high- and very high-risk non-native species (C2 and C3); and application of registered piscicides for tributary renovation.. Each of these activities have reach specific guidance and have Conservation Measures which outline important application and safety methods that are provided to control, avoid, and minimize possible negative effects to the ecosystem, non-target species, and listed species such as razorback sucker.

Chemical treatment actions could affect razorback sucker individuals and could adversely affect this species and result in low numbers of incidental take. Chemical treatment is only expected in very limited areas in any given year (limited to use in tributary segments with natural barriers, and backwaters and off-channel ponds < 5 ac in size). NPS would not implement overlapping chemical treatment actions in the same location for more than 5 consecutive years. These actions would be a net long-term benefit to razorback sucker as they would reduce populations of non-native species that could compete or predate on razorback sucker. A number of conservation measures would be employed in CM-11 to ensure that the chances of effects or incidental take would be minimized. These include pre-treatment surveys and relocation of any razorback sucker found in the treatment area, as well as a number of steps to ensure the effect of the chemical treatment is contained in the intended treatment area and neutralized afterwards, if appropriate. However, rotenone, antimycin, or the experimental use of carbon dioxide, oxygen-level alteration, pH alteration or ammonia could have various direct and indirect effects on razorback sucker in the treatment area. Direct effects could be from direct exposure to any individual fish to the chemicals in the treatment area, which could be lethal to the fish, or exposure from any spills, though measures in CM-11 should minimize the chances of that.

Indirect effects could come from temporary loss of food base in the treatment area. For application of registered piscicides studies have shown that piscicide treatments in streams using rotenone or antimycin had large short-term effects on benthic invertebrate communities but that these communities recovered over time; within one year for antimycin and up to three years for rotenone (Finlayson et al. 2010, Hamilton et al. 2009). Results from rotenone treatments and whole lake experiments indicate that most invertebrate populations will recover after exposure to piscicide concentrations of rotenone (Blakely et al. 2005, Havens 1980). Application of registered piscides could have adverse effects to razorback sucker through harm (including mortality) and short-term reductions in food availability.

Effects from experimental use of carbon dioxide, oxygen manipulation, pH alteration or ammonia addition, should be of similar or shorter duration in effects (compared to rotenone/antimycin) to the benthic invertebrate communities (D. Ward pers. comm. 2018). Therefore, these experimental treatments could have adverse effects to razorback sucker through harm (including mortality) and short-term reductions in food availability. However, the effects to food base are expected to be less in duration and extent than piscicide treatments.

Application of registered herbicides and non-toxic dyes to backwaters and off-channel areas would be expected, with the use of conservation measures in CM-15, to have no-effects to razorback sucker. Herbicide formulations include inerts, surfactants, and adjuvants, which would be released to water bodies in aquatic applications and particular herbicide formulations and their associated surfactants may vary in their toxicity (Folmar et al. 1979). Those with appropriately low levels of toxicity would be selected through the NPS pesticide approval process and in discussion with the Service for the particular species and treatment area. Neither the active herbicide nor these additives would be expected to have effects on non-target organisms or water quality when used as directed by the manufacturer, and with strict adherence to applicable regulations and guidelines. Treatment of non-native vegetation can lead to a short-term drop in oxygen levels as the vegetation decays (Evans 2008), however some studies have also shown a long-term improvement in dissolved oxygen levels from the removal of non-native aquatic vegetation (Perna and Burrows 2005). This treatment would occur in small backwater areas (<5 acres) or tributaries so any effects would be localized to those areas with a small amount of downstream drift. Under CM-1, pre-treatment surveys would be conducted to assess potential for effects to non-target species, and native species would be either be relocated or the treatment might be avoided in the specific area or during a specific time period if there was reason to be believe it could effect razorback sucker. This action would be expected to provide long-term benefits by removing non-native aquatic vegetation and contributing to the recovery of listed species and conservation of native species and habitats. Though decaying vegetation may result in a drop in oxygen levels, these effects to razorback sucker are insignificant and discountable.

Application of mollusk repellents (C6) and non-toxic anti-fouling paints (C5) on boats, equipment used in the river, and NPS water intakes, will be carefully considered by NPS and NPS will ensure that they have also been approved by the state of Arizona. Current repellent treatments include the use of hot pepper capsaicin in a wax-based application. Approved anti-fouling paints for boat and equipment surfaces that do not utilize copper derivatives, which are toxic to aquatic organisms, or other toxic additives will be considered as new options are developed. All use of repellent and anti-fouling paint would be subject to NPS approval processes in strict adherence to applicable regulations and guidelines. This action is expected to have no effects to razorback sucker based on the use of non-toxic repellents as outlined in CM-15.

*Razorback sucker critical habitat*

In our analysis of the effects of the action on critical habitat, we consider whether or not a proposed action would result in the destruction or adverse modification of critical habitat. In doing so, we must determine if the proposed action would result in effects that appreciably diminish the value of critical habitat for the recovery of a listed species. To determine this, we analyze whether the proposed action would adversely modify any of the PCEs that were the basis for determining the habitat to be critical. To determine if an action results in adverse modification of critical habitat, we considered the current condition of all designated critical habitat units for this species, to determine the overall ability of all designated critical habitat to support recovery. Further, the functional role of critical habitat in recovery must also be considered as it represents the best available scientific information as to the recovery needs of the species.

Below, we describe the primary constituent elements or “PCEs” for razorback sucker critical habitat that we are evaluating and then briefly describe the “effects” to these PCEs within the action area.

***Water Quality/Quantity PCE:*** This PCE calls for water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminants, nutrients, turbidity, etc.) that is delivered in sufficient quantity to a specific location in accordance with a hydrologic regime that is required for each of the life stages of humpback chub. Impacts to this PCE will be short term and minimal. We anticipate that none of the actions will effect water quality, with the exception of chemical treatments for non-native fish and plant removal. However, such treatments will be small in scale and fleeting in time.

***Physical Area PCE:*** This PCE includes the physical areas of the Colorado River system that are inhabited by humpback chub or potentially habitable for use in spawning, nursery, feeding, or corridors between these areas. In addition to the main river channel, this includes bottomlands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100-year floodplain, which when inundated provide spawning, nursery, feeding, and rearing habitats, or access to these habitats. We do not anticipate any physical alternation of habitat in areas where razorback sucker are present.

***Biological Environment PCE:*** This PCE includes important elements of the biological environment, food supply, predation, and competition. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition (i.e., for food and/or habitat resources) are considered normal components of this environment; but, are likely not at “natural” levels due to the presence of introduced, non-native fish (e.g., brown and rainbow trout) within the action area. Chemical treatments of water may temporarily decrease food supply in small areas, however, we do not think this level of impact will be biologically meaningful to razorback sucker, nor will it measurable diminish this PCE.

The introduction of non-native fish species that prey on and compete with razorback sucker affect one of the PCEs of the biological environment aspect of critical habitat. Non-native fish predation and competition is an important threat to native fishes in Grand Canyon (Minckley 1991, Valdez and Ryel 1995, Marsh and Douglas 1997, Coggins 2008, Yard et al. 2008, Yackulic et al. 2018). Stocking of non-native brown trout inherently impacts this PCE as outlined under critical habitat for razorback sucker. Under the factors listed for the biological environment, areas with no, or low numbers of non-native fish are preferred. The addition of non-native species, which will prey on and compete with razorback sucker, impacts this PCE by definition, consistent with the analysis provided above. However, impacts to all PCEs must be considered collectively when analyzing adverse modification, and impacts to critical habitat.

We do not have evidence that stocking of brown trout will impact any other PCE except for putting additional non-native fish that may prey on and compete with razorback sucker for resources. One example of this is that stocking of brown trout is not anticipated to impact water quality or quantity. The proposed action is also not likely to significantly alter food resources or the non-natives' fish assemblage presently occurring in the area. However, given the size of the action area, the number of trout proposed to be stocked over the 20-year period, their ability to reproduce, the anticipated estimated level of movement of stocked brown trout into designated critical habitat, and current non-native fish assemblage that is present in the area, we anticipate that proposed stocking of brown trout will not appreciably diminish the conservation value of critical habitat for razorback sucker under current environmental conditions.

Additionally, should movement of stocked brown trout be higher than anticipated, monitoring is in place to document this occurrence, and the stocking action will cease, ensuring no unintended impacts or additional impacts to the conservation value of the critical habitat. Finally, other ongoing conservation measures, and a robust research and monitoring plan associated with LTEMP, CFMP, and other efforts are in place, to ensure the conservation of the razorback sucker and other native fishes. The proposed action is not expected to further diminish the conservation contribution of critical habitat to the recovery of the razorback sucker because the majority of the PCEs will remain unchanged from baseline, and the current critical habitat in the action area is maintaining small numbers of razorback suckers.

## CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this BO. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

This portion of the river is managed by NPS, Reclamation, and Tribal partners, requiring Federal permits or authorization, which would be subject to Section 7 consultation. Below is a summary of future non-federal activities that are reasonably likely to occur within the action area that directly and indirectly affect species/critical habitat addressed in this assessment. These are added to the environmental baseline (discussed above).

Uranium mining peaked in the 1980s in the Grand Canyon region, but there is now a renewed interest due to increases in uranium prices. Increased uranium mining (on state and private lands) could increase the amount of uranium, arsenic, and other trace elements in local surface water and groundwater flowing into the Colorado River (Alpine 2010). Uranium, other radionuclides, and metals associated with uranium mines can affect the survival, growth, and reproduction of aquatic biota. Aquatic biota and habitats most likely to be affected during mine development and operation are those associated with small, ephemeral, or intermittent drainages. Impacts on aquatic biota and habitats from the accidental release of regulated or hazardous materials into ephemeral drainages would be localized and small, especially if a rapid response to a release is undertaken. However, the potential for such an event is extremely low. For these reasons, the impacts from uranium mining on aquatic biota in the Colorado River or its major tributaries would be localized and may not reduce the viability of affected resources. It is anticipated that any impacts on wildlife from uranium mining would be localized and should not affect the viability of affected resources, especially with the use of best management practices to control mine discharges and proper mine reclamation.

As the population in the Colorado River basin states grows and expands, municipal, industrial, and agricultural water demand continues to increase. A Reclamation study in 2012 showed that the demand for Colorado River basin water may exceed demand before 2060 (Reclamation 2012), which may result in lower Lake Powell levels and changes in flow, sediment, and water temperature regimes in Grand Canyon. Meeting increasing water needs will likely lead to lower reservoir levels in Lake Powell, which may already be affected by increased evaporation associated with higher air temperatures. The decreasing elevation of Lake Powell can lead to warmer water discharges from Glen Canyon Dam and increased water temperatures downstream into Glen and Grand Canyons. This could increase the likelihood of establishment of more warmwater non-native predators and have several other effects described below. This includes fish parasites such as the Asian tapeworm, anchor worm, and non-native crayfish. Increased zooplankton due to climate change may increase abundance of cyclopoid copepods. All cyclopoid copepod species appear to be susceptible to infection by, and therefore serve as intermediate hosts for, the Asian tapeworm (Marcogliese and Esch 1989). Crayfish can prey on fish eggs and larvae and can diminish the abundance and structure of aquatic vegetation such as filamentous algae through grazing (Service 2011). Higher temperatures in the Colorado River Basin have resulted in less precipitation falling and being stored as snow at high elevations in the Upper Basin (the main source of runoff to the river), increased evaporative losses, and a shift in the timing of peak spring snowmelt (and high streamflow) to earlier in the year (NAS 2007; Christensen et al. 2004; Jacobs 2011). These effects in turn have exacerbated competition among users (farmers, energy producers, urban dwellers), as well as effects on ecological systems, during a time when due to a rapidly rising population water demand has never been higher (Garfin et al. 2014). The combination of decreasing supply and increasing demand will present a challenge in meeting the water delivery commitments outlined in the Colorado River Compact of

1922 (apportioning water between the Upper and Lower Basins) and the United States–Mexico Treaty of 1944 (which guarantees an annual flow of at least 1.5 million ac-ft to Mexico). In 2007, DOI adopted interim guidelines (Reclamation 2007) to specify modifications to the apportionments to the Lower Basin states in the event of water shortage conditions. An additional Drought Contingency Plan is being finalized to address falling water elevations of Lake Mead and the result of such a plan could result in additional modifications to the overall system.

Local development projects, such as proposed in the town of Tusayan, Arizona, could impact humpback chub habitat by withdrawing water from the same aquifer that is the basis for streamflow in Havasu Creek, however the true extent of water withdrawals and their effects on Havasu Creek baseflow are unknown. In future years, the adaptive management framework for humpback chub translocations to Havasu Creek will allow for changes in management strategies in the case that streamflows are reduced to a point that the project is not viable, which is unlikely. Population and industrial growth, coupled with climate change, will act in concert to increase water demand in the region (Schindler 2001) and lower flows downstream of Glen Canyon Dam. This could stress existing riparian and wetland vegetation, leading to plant community alterations that would affect both wildlife habitats and the wildlife prey base. Climate change would not affect all wildlife species uniformly. Some species would experience distribution contractions and likely shrinking populations while other species would increase in suitable areas and thus possibly experience increases in population numbers. Generally, the warmer the current range is for a species, the greater the projected distributional increase (or lower the projected loss) will be for that species due to climate change (van Riper et al. 2014). Increased climate warming may increase the spread and establishment of some non-native aquatic species into this geographic area.

Urban runoff, industrial releases, and municipal discharges are considered some of the leading nonpoint sources of contaminants to surface waters (USEPA 2004). Areas of intensive agriculture can have an adverse effect on the water quality as a result of the salinity, nutrients, pesticides, selenium, and other trace elements that are common constituents in agricultural runoff. For example, elevated selenium found in aquatic organisms in Colorado River in Grand Canyon is thought to be partly due to agricultural runoff from areas with soils containing selenium (Walters et al. 2015). It is unclear how contamination due to agricultural and urban discharge may change into the future.

The Navajo Nation has proposed a 420-ac development project, known as the Grand Canyon Escalade, on the Grand Canyon's eastern rim on the western edge of the Navajo reservation at the confluence of the Little Colorado and Colorado rivers. The development would include a 1.4-mi-long, eight-person tramway (gondola) to transport visitors 3,200 ft from the rim to the canyon floor. Analysis for this project has not been conducted, so impacts have not been fully determined; however, the construction and operation of the Escalade project could result in adverse impacts on natural and cultural resources in the areas of the LCR confluence, wilderness, visual resources, and resources of importance to multiple Tribes. The LCR contains critical spawning habitat for humpback chub. The Grand Canyon Escalade Project and its associated facilities near the confluence of the LCR could cause both a localized loss of wildlife habitat and source of wildlife disturbance due to human presence.

The incremental effects of the proposed action on the listed species addressed in this biological assessment are not expected to contribute significantly to cumulative impacts along the Colorado River corridor or within the basin at large. The larger cumulative effects to humpback chub and razorback sucker expected to occur are from increased municipal and agricultural demand coupled with climate change resulting in less, and warmer, water and the related effects. This proposed action in expected to have net positive effects to humpback chub and razorback sucker from controlling non-native species, and is not expected to add any net negative cumulative impacts for these species.

**CONCLUSION**

After reviewing the current status of the humpback chub and razorback sucker, the environmental baseline for the action area, the effects of the action, and the cumulative effects, it is our opinion that the NPS NNAS plan is not likely to jeopardize the continued existence of humpback chub and razorback sucker, nor result in adverse modification of associated critical habitat. A number of individual humpback chub and razorback sucker, of all life stages, will be displaced or preyed on by introduced YY-male fish. Additionally, harassment of adults or harm of young chub by stocked YY-male fish species could occur. Additional handling and harm may come from all other removal actions, but the impacts of this taking are anticipated to be minimal. Fish community structure disruption is not anticipated to result in population level impacts to the humpback chub or razorback sucker in this area for the overall Proposed Action. Individual humpback chub and razorback sucker will be taken but not to such an estimated level that long-term population level impacts will result. Taking of humpback chub and razorback sucker will be a small number compared to the current estimated stable population's level.

## INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined (50 CFR 17.3) to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. "Harass" is defined (50 CFR 17.3) as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. "Incidental take" is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. 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 to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the Action Agencies so that they become binding conditions of any grant or permit issued, as appropriate, for the exemption in section 7(a)(2) to apply. The Action Agencies have a continuing duty to regulate the activity covered by this incidental take statement. If the Action Agency (1) fails to assume and implement the terms and conditions or (2) fails to require any applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(a)(2) may lapse. In order to monitor the impact of incidental take, the Action Agencies must report the progress of the action and its impact on the species to the Service (AESO) as specified in the incidental take statement. [50 CFR §402.14(i) (3)].

## AMOUNT OR EXTENT OF TAKE

*Targeted Harvest*

Incentivized harvest actions are limited to the Glen Canyon reach where humpback chub and razorback sucker are not currently present. As a result, there is a low probability for anglers to incidentally capture chub or sucker and the anticipated effects of incentivized harvest on humpback chub are insignificant and discountable. As such we do not provide an estimate of incidental take for this activity.

*Physical Control*

Physical controls include methods such as; dewatering relatively small ponds and backwater areas by high-volume portable pumps for short time periods, placement of selective weirs to disrupt spawning or new invasions, placement of non-selective barriers to restrict access to tributaries, backwaters, and off-channel habitat areas, produce small scale temperature changes using a propane heater to adversely affect coldwater non-native fish, and dredging of one identified small pond at RM-12 in GCNRA. Despite the provisions for safe capture, transport, holding, and release of humpback chub and razorback sucker from the treatment areas, there is always a risk of mortality when handling fish in these situations. Incidental take from monitoring, handling and salvage efforts is addressed below. Further, if present, it is unlikely that all humpback chub and razorback sucker will be removed by the salvage operation, and any individuals remaining in the treatment area will die due to the effects of entrapment in pumps and areas that are dewatered, or by restricting movement by weirs. Incidental take of humpback chub and razorback sucker is reasonably certain to occur as a result of the proposed physical control methods in the action area. Incidental take will result in the form of harm if fish die, and harassment should fish be restricted from areas which they were using for feeding, breeding, or sheltering.

The Service anticipates incidental take of humpback chub and razorback sucker will be difficult to detect for the following reasons: detection of a dead or impaired individual fish is unlikely as bodies disappear quickly as they are carried downstream, sink to the creek bottom, or are eaten by birds and mammals, and quantifying a minimal amount of interference in movement is difficult. Although we cannot estimate the number of individual fish that will be incidentally taken during these actions we anticipate the number of humpback chub and razorback sucker taken in such a way will be minimal because NPS will employ conservation measures that will oftentimes avoid areas that are occupied by chub or suckers. Incidental take during salvage, or as a result of the physical control activity itself should not rise above the level of take of mechanical removal and handling as specified below. Meaning that should the percentage or number of take be exceeded from handling or from the mechanical treatment separately, then take will have been exceeded. . The following incidental take is anticipated to be no more than (annually):

- Humpback chub
    - Individuals from 31-100 mm = 5% of total number captured
    - Individuals from 101-200mm = 1% of total number captured
    - Individuals over 201 mm = no more than 5 individuals regardless of total number captured

- Razorback sucker
    - Individuals less than 20 mm = 5% of total number captured
    - Individuals 31-100 mm = 5% of total number captured
    - Individuals from 101-300 mm = 1% of total number captured
    - Individuals over 300 mm = no more than 2 individuals regardless of total number captured

*Mechanical Control*

Incidental take of humpback chub and razorback sucker will occur as a result of mechanical control which include fish capture and handling action taken under this action. This take will be in the form of harassment from capture and handling individuals incidentally taken while pursuing other species and in the event of injury or mortality of individuals as a result of any capture or handling event.

Based on results of past survey and monitoring efforts for humpback chub and razorback sucker by NPS, we anticipate future incidental take will be consistent with levels seen in past years, even with increased capture and handling of these fish. The anticipated level of take is dependent on size on the individuals captured, and thought to be relatively low. Incidental take during Mechanical control activities, or as a result of the physical control activity itself should not rise above the level of take of physical control and handling as specified above. Meaning that should the percentage or number of take be exceeded from handling during mechanical control separately, then take will have been exceeded. The following incidental take is anticipated to be no more than (annually):

- Humpback chub
    - Individuals from 31-100 mm = 5% of total number captured
    - Individuals from 101-200mm = 1% of total number captured
    - Individuals over 201 mm = no more than 5 individuals regardless of total number captured

- Razorback sucker
  - Individuals less than 20 mm = 5% of total number captured
  - Individuals 31-100 mm = 5% of total number captured
  - Individuals from 101-300 mm = 1% of total number captured
  - Individuals over 300 mm = no more than 2 individuals regardless of total number captured

*Biological Control*

We anticipate the stocking of YY-male non-native fish is reasonably certain to result in incidental take of humpback chub and razorback sucker in the Lower Colorado River Basin population. This incidental take is expected to be in the form of harm (including direct fatality) and harassment resulting from the effects of the proposed action on chub. In particular we focus on the stocking of YY-male brown trout as part of the proposed action and will later address other possible species where this technique may be applied in the future. Incidental take is anticipated to occur from the brown trout consuming eggs, larvae and sub-adult humpback chub and razorback sucker. The NPS modified a model that GCMRC developed in coordination with the service to estimate the loss of humpback chub as a result of trout stocking. Estimates of emigration and predation were based on studies of wild rainbow and brown trout in the action area and were provided by modifications of Yard et al. (2015) and Korman et al. (2012 and 2015) formulas. Modifications to this estimate also included up to date data on brown trout and humpback chub numbers provided by GCMRC and the Department. For a full description of the justification and estimation of predation please see Appendix B of this document.

Although it is possible that stocked brown trout might behave differently than the wild-born brown trout population, we anticipated that environmental conditions tied to the geographic location and density of the current fish population also plays a crucial factor in all trout behavior in the action area. As such, we accept that there is uncertainty in the possible outcome of this stocking, and will work with NPS to reevaluate models and environmental conditions prior to stocking. We estimate take in the form of harm and/or harassment by predation of larval humpback chub to range from 13, 113, and 1,915 juvenile humpback chub will be consumed by brown trout per year (see Appendix B) under low-, moderate-, and high-risk scenarios. We are currently unable to offer a similar estimate for razorback suckers in particular.

Currently, we do not have a meaningful easily monitored way to estimate take in the form of harassment of larval humpback chub and razorback sucker as a result of brown trout attempting to forage on YOY in cold water or other sub-optimal conditions. Resulting take or harassment may include energy expenditure on young humpback chub that may impact their fitness and survival. Harassment of adult humpback chub and razorback is also possible because brown trout can be aggressive and territorial while foraging. If harassment in this form happens it may result in competition and a reduction in the ability of adult humpback chub to shelter, forage, or reproduce. The Service anticipates incidental take of humpback chub and razorback sucker may be difficult to monitor over the timeframe of this action, for the following reason(s): 1) humpback chub or razorback sucker that have been consumed by brown trout cannot always be detected; 2) early detection of effects to larval humpback chub or razorback that may lead to decreased survival or fitness is not feasible; 3) detection of harassment of adults and loss of opportunities to forage, shelter or breed are limited; 4) the status of the species is changing over time through immigration, emigration, and natural loss; and, 5) the species occur within almost 300 miles (483 km) of river including the action area in extremely remote locations, so individual humpback chub and razorback sucker are difficult to locate.

Because of the challenges of quantifying direct incidental take, the uses of surrogate measures have been adopted to determine when take has been exceeded for both humpback chub and razorback sucker. From previous work we have estimates of trout movement and presence in this area, as well as the resulting predation rate by the number of brown trout for native species in the area of the LCR confluence. For example, Yard et al. (2001) estimated that over a 3 month period, the consumption rate of humpback chub by brown trout ranged from approximately 6.8 to 25.5 humpback chub per brown trout. Since long-term monitoring of predation by brown trout is not feasible, we adopt brown trout detection estimates as a surrogate. The numbers of brown trout are a reasonable surrogate to determine the incidental take on the endangered fish given this demonstrated causal link between number of brown trout and take, through predation, of endangered species. We have estimated the level of anticipated incidental take based on a humpback chub population viability assessment used by GCMRC to evaluate the effects of LTEMP, estimates of trout movement and predation in Appendix B of this document, and the works of the GCMRC and its cooperators (Korman et al. 2012, Avery et al. 2015, Korman et al. 2015, Yard et al. 2015, Young et al. 2015, Ward 2018 in press, Yackulic, 2018). If it is estimated that YY-male brown trout stocking has contributed to the action triggers of LTEMP (Tier 1 or 2) being met then incidental take will have been exceeded. Additionally, if $\geq$ 36 individual stocked brown trout (less than 1% of annual stocking) are estimated to be in the LCR reach, measured by brown trout detected outside of the stocking reach from any stocking event, or by annual total then incidental take will have been exceeded. This number of brown trout comes from back calculating what the emigration rate of brown trout would be if the high-risk scenario of stocking were to be met, resulting in 1,915 juvenile humpback chub consumed by brown trout per year. Information gathered by the conservation measures will ensure that monitoring results are sufficient to determine when anticipated take of humpback chub and razorback sucker is exceeded.

Stocking of other non-native species, should broodstock of this technique become available, may result in similar take of humpback chub and razorback sucker. However, we are unable to provide meaningful modeling of take because we do not know; the species to be stocked, the level of piscivory of stocked species, the rate or density of stocking, location, nor the environmental conditions at stocking. As such, we offer the NPS and Service will collaborate to provide the needed models prior to stocking of any other non-native fish within the action area. Should these models indicate that take has exceed the uppermost range of humpback chub consumption set by the risk scenarios from above, 1,915 humpback chub consumed annually, then take will be exceeded. Since quantifying this form of take is difficult we offer a surrogate measure above for brown trout, which will be modified for the different non-native species to be stocked. Estimates of piscivory level, rate of emigration, level of humpback chub consumption (not to exceed 1,915 humpback chub), and back calculation to non-native fish presence or emigration rate will be used as a surrogate similar to brown trout.

*Chemical Control*

Chemical Control include methods such as; overwhelming ecosystem-cycling capabilities (ammonia, oxygen, carbon dioxide, pH, etc.) and application of registered piscicides for control of high and very high risk non-native species. Despite the provisions for safe capture, transport, holding, and release of humpback chub and razorback sucker from the treatment areas, there is always a risk of mortality when handling fish in these situations. Incidental take from monitoring, handling and salvage efforts is addressed above. Further, if present, it is unlikely that all humpback chub and razorback sucker will be removed by the salvage operation, and any individuals remaining in the treatment area will die due to the effects of chemical treatments. Incidental take of humpback chub and razorback sucker is reasonably certain to occur as a result of the proposed chemical treatment applications in the action area. Incidental take will result as fish die from contact with the piscicide or otherwise altered water chemistries.

The Service anticipates incidental take of humpback chub and razorback sucker from exposure to chemical treatments will be difficult to detect for the following reasons: finding a dead or impaired individual fish is unlikely as fish that are exposed to rotenone typically disappear quickly as they are carried downstream, sink to the creek bottom, or are eaten by birds and mammals. Although we cannot estimate the number of individual fish that will be incidentally taken during treatment, based on experience from past rotenone treatments, the number of humpback chub and razorback sucker killed by rotenone is likely to be low after salvage of fish. Incidental take during salvage, or as a result of the chemical treatment itself should not rise above the level of take of mechanical removal and handling as specified above. Meaning that should the percentage or number of take be exceeded from handling or from the chemical treatment separately, then take will have been exceeded.

Management of high to very high risk aquatic plants or algae that require the application of herbicides and non-toxic dyes to backwaters, off-channel areas, and low velocity tributaries to the Colorado River inside the action area are not anticipated to result in take by harm.

**EFFECT OF THE TAKE**

In this BO, the Service determines that this level of anticipated take is not likely to result in jeopardy to these species or destruction or adverse modification of critical habitats. We reach this conclusion because the anticipated take of individual humpback chub and razorback sucker is low relative to the size of the overall population. The purpose of the all activities in this proposed action, including the stocking of YY-male fish, is to manage and decrease non-native populations that adversely impact humpback chub and razorback suckers. Although some activities may result in incidental take and impacts to these species in the short-term, we anticipate there will be an overall positive effect at the population level long-term because of the reduction in non-native species populations and the corresponding reduced predation and competition effects to the native species. Additionally, although by definition one of the PCEs are impacted by definition in that it adds non-native fish to critical habitat; we anticipate that so few stocked YY-male fish will be added that it will have limited impact to critical habitat and not to the level that all PCEs will be impacted. In other words it will not decrease the conditions of critical habitat to such an extent that it no longer has a conservation benefit to the species.

## REASONABLE AND PRUDENT MEASURES AND TERMS AND CONDITIONS

We determine that the proposed action incorporates sufficient conservation measures to monitor and minimize the effects of incidental take of humpback chub and razorback sucker. Take is estimated to be relatively low when compared to population estimates of adult humpback chub and razorback sucker and each action will cease prior to the need of severe intervention to protect humpback chub or razorback sucker population level impacts. Long-term positive impacts to native species, including humpback chub and razorback suckers, are anticipated by incorporating these activities to combat non-native species known for their detrimental impacts in the action area. The NPS is taking a pro-active approach to managing deleterious non-native species, and seek to move toward their fulfillment of their 7(a)(1) responsibilities for humpback chub and razorback sucker under this proposed action. All reasonable measures to minimize take have been incorporated into the project description. Thus, no additional reasonable and prudent measures are included in this incidental take statement. Annual monitoring reports will be submitted to this office.

*Disposition of Dead or Injured Listed Species*

Upon locating a dead, injured, or sick listed species initial notification must be made to the Service's Law Enforcement Office, 2450 W. Broadway Rd, Suite 113, Mesa, Arizona, 85202, telephone: 480/967-7900) within three working days of its finding. Written notification must be made within five calendar days and include the date, time, and location of the animal, a photograph if possible, and any other pertinent information. The notification shall be sent to the Law Enforcement Office with a copy to this office (AESO). Care must be taken in handling sick or injured animals to ensure effective treatment and care and in handling dead specimens to preserve the biological material in the best possible state.

## CONSERVATION RECOMMENDATIONS

Section 7(a) (1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The following recommendations are;

1) Continued collaboration and work with researchers to create more robust non-native fish population estimates.
2) Should resources be available, collaborate with management partners to examine the relationship of non-native fish coming through Glen Canyon Dam and resulting survival and establishment of these species.
3) Further explore, and track, non-native species in relationship to changing temperatures of water releases from Glen Canyon Dam and Lake Mead.

## REINITIATION NOTICE

This concludes formal consultation on the action outlined in the Project Description of this Opinion. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, actions will cease pending reinitiation.

In keeping with our trust responsibilities to American Indian Tribes, we encourage you to continue to coordinate with the Bureau of Indian Affairs in the implementation of this consultation and, by copy of this biological opinion, are notifying the Hopi Tribe, Hualapai Tribe, Kaibab Band of Paiute Indians, Navajo Nation, Shivwits Band of Paiute Indians, Southern Paiute Consortium, Pueblo of Zuni, and Bureau of Indian Affairs of its completion.  We also encourage you to coordinate this project with the Arizona Game and Fish Department.

We appreciate NPS' addressing our collective responsibilities under 7(a)(1) and this plan that identifies and minimizes effects to listed species from this project. Please refer to the consultation number 02EAAZ00-2019-F-0214 in future correspondence concerning this project. If you have questions or need information regarding this Opinion, please call Jessica Gwinn or myself at (602) 242-0210 or email jessica_gwinn@fws.gov.

cc (electronic):
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Tribal Secretary, Havasupai Tribe, Supai, AZ
Director, Hopi Cultural Preservation Office, Kykotsmovi, AZ
Director, Cultural Resources, Kaibab Band of Paiute Indians, Fredonia, AZ
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## APPPENDIX A – CONCURRENCES

This appendix contains our concurrences with your "may affect, not likely to adversely affect" determinations for the threatened Mexican spotted owl (*Strix occidentalis lucida*) and critical habitat), endangered southwestern willow flycatcher (*Empidonax traillii extimus*), endangered California condor (*Gymnogyps californianus*), threatened western yellow-billed cuckoo (*Coccyzus americanus americanus*), and the endangered Yuma Ridgway's rail (*Rallus obsoletus yumanensis*).

<u>Mexican spotted owl</u>

We concur with your determination that the proposed action may affect, but is not likely to adversely affect the threatened Mexican spotted owl, nor adversely modify critical habitat. We base this concurrence on the following:

- Helicopters will remain at least 1,200 ft from, or at least 1,200 ft above ground level of, any designated Mexican spotted owl protected activity center (PAC). Therefore, use of the helicopters will result in insignificant noise effects to owls occupying habitat beneath the fly routes. No helicopter flights associated with this plan will occur in GCNRA. Primary access to GCNRA locations would be by motor boat. Therefore, the effects would be insignificant and discountable from these activities.

- Additional noise-related effects would be temporary, lasting for the duration of the activity (the hours of equipment operation), and would not occur within 0.25 mile of any known occupied habitat. In addition (and as stated in CM-4) NPS will also use sound dampening measures to reduce the potential for noise disturbance. Based on the limited size, duration, and location of anticipated noise, we think that effects to Mexican spotted owls from additional project-related noise will be insignificant and discountable.

- Actions C1, C2, C3 and C4 involve the use of chemical treatments, including; rotenone, antimycin, potassium permanganate (to neutralize rotenone and antimycin) ammonia, oxygen-level alteration, carbon dioxide or pH altering chemicals, for short durations. Exposure to piscicides from these actions is unlikely given the diet of Mexican spotted owl is primarily made up of small, terrestrial mammals; so owls would not be consuming aquatic species killed by this method. Treatments will be outside of PACs and therefore greatly limits the chance that owls could potentially ingest water in a piscicide treatment area. Additionally, research on toxicity of rotenone to birds indicates that acute toxicity is not possible from field application of rotenone to the prescribed chemical concentration needed to achieve a fish kill. CM-11 measures require formulations and application rates to minimize effects to birds, mammals and invertebrates. Chemical spills could present a risk of greater exposure but standard spill prevention, monitoring, reporting and cleanup procedures would be employed as stated in CM-11. Oxygen-level alteration, carbon-dioxide and pH would be very limited in spatial extent to the immediate treatment area, be short in duration, would be unlikely to cause toxicity to birds through direct or indirect exposure. Chemical treatment is only expected in very limited areas in any given year (limited to use in tributary segments with natural barriers, and backwaters and off-channel ponds < 5 ac in size). Because it is not likely that owls will be in the vicinity of chemical treatments, the birds do not eat aquatic organisms, and chemical concentrations will be below levels that are toxic to birds, possible impacts of this action are be insignificant and discountable.

- The FWS designated critical habitat for the Mexican spotted owl in 2004 (69 FR 53182, USFWS 2004). Critical habitat for Mexican spotted owl in GCNP includes PACs (30,285 acres) and recovery mixed conifer areas on the North Rim (27,079 acres), totaling 57,364 acres; however, critical habitat does not exist within the action area along the Colorado River corridor. The proposed action does not include any activities that would affect the primary constituent elements of critical habitat; therefore, there will be no effect critical habitat.

The NPS designed conservation measures that avoid and mitigate effects to Mexican spotted owls, pertinent excerpts of these Conservations Measures include:

CM-3

- Prior to the start of project activities for the year, GCNP's Wildlife Department will be contacted for any new information related to Mexican spotted owls near the project area. Sensitive species maps will be updated annually with any new information to ensure consistency with the above measures and will be referenced when annual work plans are developed.

- Camping will not occur within 0.25mi of PAC boundaries during the breeding season (March 1 – August 31), until surveys can be done to locate nests. Such situations will be coordinated with the GCNP's Wildlife Department.

- Crews will not exceed 12 people in Mexican spotted owl PACs or suspected occupied areas during the breeding season.

- To reduce noise impacts on sensitive wildlife and areas with natural or wilderness characteristics when flying to and from the work area, helicopters would maintain a minimum 2,000 ft altitude where possible, per FAA Advisory Circular 91-36D Visual Flight Rules (VFR) Flight Near Noise-Sensitive Areas.

- Pilots would minimize aircraft use along the rim and cliffs to the greatest extent possible. Helicopter pilots will be encouraged to use quieter maneuvers (ones that produce less noise), wherever possible, according to the Fly Neighborly training available at: https://go.usa.gov/xQPCW and https://www.rotor.org/operations/flyneighborly.aspx

- In order to minimize noise disturbance within Mexican spotted owl PAC, helicopters will stay at least 1,200 ft (366 m) away from PAC between March 1 and August 31. If non-breeding is inferred or confirmed during approved-protocol surveys in a Protected Activity Center during the breeding season, restrictions on noise disturbances should be relaxed depending on the nature and extent of the proposed disturbance.

- On a case-specific basis, NPS will assess the potential for noise disturbance to nesting owls. Breeding-season restrictions will be considered if noise levels are estimated to exceed 69 dBA (A-weighted noise level; approximately 80 dBA [owl-weighted noise level, Service 2012]) consistently (i.e., >twice/hour) or for an extended period of time (>1 hr) within 165 ft (50 m) of nesting sites (if known) or within entire Protected Activity Center if nesting sites are not known.

CM-4

- Where possible, pumps, heaters and generators that do not exceed 60 dBA, at 50 ft, will be selected, per the NPS Audio Disturbances rule (36 CFR 2.12).

- Where possible, boats that do not exceed 75 dBA, at shoreline, will be selected, per the NPS maximum boat noise rule (36 CFR 3.15). Pressure washers will also be selected for action M1 to conform to this noise rule.

- Where possible crews traveling through riparian areas to get to treatment sites will use established trails and campsites.

CM-11 (Abridged)

- Registered piscicide treatments (C2, C3, or C4):
    - NPS would seek state permits and follow state treatment plan requirements and guidelines. Additionally NPS would follow the NPS approval process and required pesticide use plan. Rotenone or antimycin would be applied in accordance with labels and the appropriate standard operating manuals (Finlayson et al. 2010c, Moore et al. 2008). Formulations and application rates would be selected to minimize potential effects for birds and mammals and minimize toxicity to aquatic invertebrates. These would be used with standard neutralizing agents.

Southwestern willow flycatcher

We concur with your determination that the proposed action may affect, but is not likely to adversely affect the endangered southwestern willow flycatcher. We base this concurrence on the following:

- Effects to southwestern willow flycatcher would be focused on the river/riparian habitat within the action area which constitute the species' potential, suitable and existing breeding areas. As with other bird species, the primary ways in which the proposed action could affect this species would be human-generated noise during the breeding season from humans, mechanical treatments, helicopters or from generators or pumps used for various control actions, potential direct effects from chemical treatments, indirect effects to prey from chemical or mechanical treatments. As stated in CM-4, there are a number of measures to mitigate sound for riparian birds, and as stated in CM-8 there would be periodic surveys for this species and avoidance of suitable breeding habitat during breeding season. No helicopter landing zones will be used in suitable habitat during breeding season unless a clearance survey in the past year has determined that it is unoccupied. If the area is occupied or NPS is unable to conduct clearance surveys, then either the action will not occur during the breeding season (May 1 – August 31) or NPS will communicate with USFWS Arizona Ecological Services Field Office (AESO) prior to the action to determine an appropriate buffer if there is still a reason to consider going forward in this location during that time. Therefore, these effects would be insignificant and discountable from these activities.

- Additional noise disturbance to southwestern willow flycatcher may result from any of the control actions, particularly those with appreciable noise generation. Noise-related effects would be temporary, lasting for the duration of the activity (the hours of equipment operation), and may result in flushing but would be unlikely to result in nest abandonment or changes in significant behavioral activity or important life requirements such as nesting, roosting, foraging, rearing, and movement activities and habitat. As stated in CM-4, there are a number of measures to mitigate sound for birds. These effects would also be insignificant and discountable.

- Southwestern willow flycatchers are unlikely to be directly affected by most control treatments because actions will be primarily water-based, however some activities may occur near the banks in temporary, un-vegetated, backwaters that may be available depending on river water level/GCD discharge, but sampling could affect some shoreline vegetation (trampling) and cause some noise disturbance. Therefore, CM-8 prescribes periodic surveys for this species and avoidance of suitable breeding habitat during breeding season. Therefore, these effects would be insignificant and discountable from these activities.

- Actions C1, C2, C3 and C4 involve the use of chemical treatments, including; rotenone, antimycin, potassium permanganate (to neutralize rotenone and antimycin) ammonia, oxygen-level alteration, carbon dioxide or pH altering chemicals, for short durations. Southwestern willow flycatchers could potentially consume insects or ingest water exposed to rotenone, however, research on toxicity of rotenone to birds indicates that acute toxicity was not possible from field application of rotenone to achieve a fish kill. CM-11 measures require formulations and application rates to minimize effects to birds, mammals and invertebrates. Chemical spills could present a risk of greater exposure but standard spill prevention, monitoring, reporting and cleanup procedures would be employed as stated in CM-11. Oxygen-level alteration, carbon-dioxide and pH would be very limited in spatial extent to the immediate treatment area, be short in duration, would be unlikely to cause toxicity to birds through direct or indirect exposure. Chemical treatment is only expected in very limited areas in any given year (limited to use in tributary segments with natural barriers, and backwaters and off-channel ponds < 5 ac in size). Any effects would be insignificant and discountable.

Conservation measures that are designed to avoid and mitigate potential harm to southwestern willow flycatcher are outlined in CM-3, CM-4, and CM-8, and pertinent excerpts of these Conservations Measures include;

CM-3

- Sensitive species maps will be updated annually with any new information to ensure consistency with the above measures and will be referenced when annual work plans are developed.

- To reduce noise impacts on sensitive wildlife and areas with natural or wilderness characteristics when flying to and from the work area, helicopters would maintain a minimum 2,000 ft altitude where possible, per FAA Advisory Circular 91-36D Visual Flight Rules (VFR) Flight Near Noise-Sensitive Areas.

- Pilots would minimize aircraft use along the rim and cliffs to the greatest extent possible. Helicopter pilots will be encouraged to use quieter maneuvers (ones that produce less noise), wherever possible, according to the Fly Neighborly training available at: https://go.usa.gov/xQPCW and https://www.rotor.org/operations/flyneighborly.aspx

- No helicopter landing zones will be used in suitable breeding habitat for southwest willow flycatcher during breeding seasons.

CM-4

- Where possible, pumps, heaters and generators that do not exceed 60 dBA, at 50 feet, will be selected, per the NPS Audio Disturbances rule (36 CFR 2.12).

- Where possible, boats that do not exceed 75 dBA, at shoreline, will be selected, per the NPS maximum boat noise rule (36 CFR 3.15). Pressure washers will also be selected for action M1 to conform to this noise rule.

- Where possible crews traveling through riparian areas to get to treatment sites will use established trails and campsites.

CM-8

- Surveys of southwestern willow flycatchers through the project area will be conducted periodically (typically every 2 years) as budget allows or in accordance with the Service's 2016 LTEMP Biological Opinion (Service 2016c).

- To ensure that staff have the most current information on flycatchers prior to the start of any management activities under the Proposed Action, the GCNP's wildlife department would be contacted for suitable breeding habitat maps and any new occurrence near the project area.

- Southwestern willow flycatcher location, survey maps, and suitable breeding habitat maps will be updated following any new information to ensure consistency with the above measures and will be referenced when annual work plans are developed.

- Suitable southwestern willow flycatcher breeding habitat, as defined in the Southwestern Willow Flycatcher Recovery Plan (Service 2002a), will be avoided for activities which may cause disturbance including Actions M1 (if using pressure sprayer), P1, P5, C1, C2, C3, C4, and C5 (if using noise generating equipment) during the breeding season (May 1-

August 31). If there is a need to move forward with any of these actions in suitable breeding habitat during breeding season, then clearance surveys for southwestern willow flycatcher will be conducted during breeding season in the immediate action area to determine if it is occupied or unoccupied prior to the action. NPS will conduct clearance surveys as close to the start of the action as possible, preferably within 1-2 days. If the area is occupied or NPS is unable to conduct clearance surveys, then either the action will not occur during the breeding season or NPS will communicate with the Service AESO prior to the action to determine an appropriate buffer if there is still a reason to consider going forward in this location during that time.

- No helicopter landing zones for this Proposed Action will be used in suitable breeding habitat for southwest willow flycatcher during the breeding season unless a clearance survey in the past year has determined it is unoccupied. If the area is occupied or NPS is unable to conduct clearance surveys, then either the action will not occur during the breeding season or NPS will communicate with AESO prior to the action to determine an appropriate buffer if there is still a reason to consider going forward in this location during that time.

- No camping or sustained activities would occur by fisheries crews for this proposed action, except at already established campsites, in suitable breeding habitat within the breeding season (May 1 – August 31) and travel through these areas will be minimized during this season.

- Habitat modification of riparian areas in this species' suitable breeding habitat would not occur as part of management activities under the Proposed Action.

CM-11

<u>California condor</u>

We concur with your determination that the proposed action may affect, but is not likely to adversely affect the endangered California condor. We base this concurrence on the following:

- The proposed action includes activities that may attract California condors and result in potential contact with humans. Condors are naturally curious and it is not uncommon for them to be seen frequenting areas of high human activity. The noise and activity associated with management activities has the potential to attract condors to project sites and can increase the potential for interaction between condors and humans. Fisheries crews would generally consist of small groups of up to 4-8 people. Conservation Measures (implemented under past consultations) to educate work crews of condor concerns and to cease activities if condors are present would reduce potential disturbance from management activities to the birds. To date, condors have not been observed near NPS fisheries projects. While California condor nesting and roosting habitat is generally limited to cliffs and caves in the inner canyon, a pair of condors has successfully nested multiple times within Marble Canyon. The activities of the proposed action will take place along the mainstem Colorado River and in tributaries within GCNP and in GCNRA below the Glen Canyon Dam, near the Marble Canyon nest site. Crews may also need to travel through these areas to get to a project site, however, crews will use established trails and therefore will not contribute measureable disturbance to condors when compared to current conditions. Conservation Measure (CM) 4 includes a number of measures to mitigate sound in general for birds; therefore, these effects would be insignificant and discountable.

- Activities under the Proposed Action have the potential to affect California condors through noise disturbance associated with activity in the vicinity of known condor locations in side canyons as well as helicopter flights carrying live fish, staff, and project equipment. Actions M2, M3, B1, P1, P2, P4, P5, C1, C2, C3, C4 and C5 may require helicopter use. There is potential for direct noise disturbance to condors, however, Conservation Measures to minimize the potential for noise disturbance to condors during the breeding season are listed above as CM-3. These measures are currently implemented at GCNP and have previously been included in other Biological Opinions for the park (Service 2000, 2009c, 2009d, 2012b) and include offsets for helicopter flight paths from known condor nesting and roosting areas to avoid disturbance. There is some, but very low, potential risk of helicopter collisions with condors, though a collision or even a 'near miss' has never occurred in GCNP and are highly unlikely; therefore, these effects would be insignificant and discountable.

- Additional noise disturbance to California condors may result from any of the control actions, particularly those with appreciable noise generation. Noise-related effects would be unlikely, and if occurring they would be temporary, lasting for the duration of the activity (the hours of equipment operation), and would be unlikely to result in nest abandonment or changes in significant behavioral activity or important life requirements such as nesting, roosting, foraging, rearing, and movement activities. As stated in CM-4, there are a number of measures to mitigate sound for birds. These effects would also be insignificant and discountable.

- Actions C1, C2, C3 and C4 involve the use of chemical treatments, including; rotenone, antimycin, potassium permanganate (to neutralize rotenone and antimycin) ammonia, oxygen-level alteration, carbon dioxide or pH altering chemicals, for short durations. Exposure to piscicides from these actions is unlikely given the diet of Mexican spotted owl is primarily made up of small, terrestrial mammals; so birds would not be consuming aquatic species killed by this method. Treatments will be outside of PACs and therefore greatly limits the chance that owls could potentially ingest water in a piscicide treatment area. Additionally, research on toxicity of rotenone to birds indicates that acute toxicity is not possible from field application of rotenone to the prescribed chemical concentration needed to achieve a fish kill. CM-11 measures require formulations and application rates to minimize effects to birds, mammals and invertebrates. Chemical spills could present a risk of greater exposure but standard spill prevention, monitoring, reporting and cleanup procedures would be employed as stated in CM-11. Oxygen-level alteration, carbon-dioxide and pH would be very limited in spatial extent to the immediate treatment area, be short in duration, would be unlikely to cause toxicity to birds through direct or indirect exposure. Chemical treatment is only expected in very limited areas in any given year (limited to use in tributary segments with natural barriers, and backwaters and off-channel ponds < 5 ac in size). Because it is not likely that owls will be in the vicinity of chemical treatments, the birds do not eat aquatic organisms, and chemical concentrations will be below levels that are toxic to birds, possible impacts of this action are be insignificant and discountable.

Conservation measures that are designed to avoid and mitigate potential harm to California condors are outlined in CM-3 and CM-4, and pertinent excerpts of these Conservations Measures include;

CM-3

- Prior to the start of project activities for the year, GCNP's Wildlife Department will be contacted for any new information related to California condors near the project area. Sensitive species maps will be updated annually with any new information to ensure consistency with the above measures and will be referenced when annual work plans are developed.

- Any crew access necessary within 0.25 mi of an active condor nest site during the breeding season will be limited to established roads and trails. If access off designated roads or trails or camping is necessary during the breeding season, only activities that occur greater than 0.25 mi from any known or suspected nest area may be conducted. Such situations will be coordinated with GCNP's Wildlife Department.

- Planned projects involving mechanized equipment will not occur within 0.5 mi of active condor nesting sites during the breeding season (February 1 – September 30).

- To reduce noise impacts on sensitive wildlife and areas with natural or wilderness characteristics when flying to and from the work area, helicopters would maintain a minimum 2,000 ft altitude where possible, per FAA Advisory Circular 91-36D Visual Flight Rules (VFR) Flight Near Noise-Sensitive Areas.

- Flights would occur prior to 10 am whenever possible because condors are less active in the morning hours.

- Pilots would minimize aircraft use along the rim and cliffs to the greatest extent possible. Helicopter pilots will be encouraged to use quieter maneuvers (ones that produce less noise), wherever possible, according to the Fly Neighborly training available at: https://go.usa.gov/xQPCW and https://www.rotor.org/operations/flyneighborly.aspx

- Aircraft associated with this project would stay at least 1 mi (1.6 km) away from active condor nest locations and vicinities except when human safety would be compromised. The active nesting season is February 1 – September 30. These dates may be modified based on the most current information regarding condor nesting activities (roosting, fledging, etc.) and coordination with GCNP's Wildlife Program Manager, Section 7 Coordinator, and the Service.

- Helicopters will stay at least 1,200 ft (366 m) away from condors in the air, or on the ground or cliffs unless safety concerns override this restriction.

- If airborne condors approach aircraft, aircraft will give up airspace to the extent possible, as long as this action does not jeopardize safety.

CM-4

- Where possible, pumps, heaters and generators that do not exceed 60 dBA, at 50 feet, will be selected, per the NPS Audio Disturbances rule (36 CFR 2.12).

- Where possible, boats that do not exceed 75 dBA, at shoreline, will be selected, per the NPS maximum boat noise rule (36 CFR 3.15). Pressure washers will also be selected for action M1 to conform to this noise rule.

- Where possible crews traveling through riparian areas to get to treatment sites will use established trails and campsites.

<u>Western yellow-billed cuckoo</u>

We concur with your determination that the proposed action may affect, but is not likely to adversely affect the threatened western yellow-billed cuckoo. We base this concurrence on the following:

- Effects to yellow-billed cuckoo would be focused on the river/riparian habitat within the action area which constitute the species' potential, suitable and existing breeding areas. As with other bird species, the primary ways in which the proposed action could affect this species would be human-generated noise during the breeding season from humans, mechanical treatments, helicopters or from generators or pumps used for various control actions, potential direct effects from chemical treatments, indirect effects to prey from chemical or mechanical treatments. As stated in CM-4, there are a number of measures to mitigate sound for riparian birds, and as stated in CM-8 there would be periodic surveys for this species and avoidance of suitable breeding habitat during breeding season. No helicopter landing zones will be used in suitable habitat during breeding season unless a clearance survey in the past year has determined that it is unoccupied. If the area is occupied or NPS is unable to conduct clearance surveys, then either the action will not occur during the breeding season or NPS will communicate with USFWS Arizona Ecological Services Field Office (AESO) prior to the action to determine an appropriate buffer if there is still a reason to consider going forward in this location during that time. Therefore, these effects would be insignificant and discountable from these activities.

- Additional noise disturbance to yellow-billed cuckoo may result from any of the control actions, particularly those with appreciable noise generation. Noise-related effects would be temporary, lasting for the duration of the activity (the hours of equipment operation), and may result in flushing but would be unlikely to result in nest abandonment or changes in significant behavioral activity or important life requirements such as nesting, roosting, foraging, rearing, and movement activities and habitat. As stated in CM-4, there are a number of measures to mitigate sound for birds. These effects would also be insignificant and discountable.

- Yellow-billed cuckoos are unlikely to be directly affected by most control treatments because actions will be primarily water-based, however some activities may occur near the banks in temporary, un-vegetated, backwaters that may be available depending on river water level/GCD discharge, but sampling could affect some shoreline vegetation (trampling) and cause some noise disturbance. Therefore, CM-8 prescribes periodic surveys for this species and avoidance of suitable breeding habitat during breeding season. Therefore, these effects would be insignificant and discountable from these activities.

- Actions C1, C2, C3 and C4 involve the use of chemical treatments, including; rotenone, antimycin, potassium permanganate (to neutralize rotenone and antimycin) ammonia, oxygen-level alteration, carbon dioxide or pH altering chemicals, for short durations. Southwestern willow flycatchers could potentially consume insects or ingest water exposed to rotenone, however, research on toxicity of rotenone to birds indicates that acute toxicity was not possible from field application of rotenone to achieve a fish kill. CM-11 measures require formulations and application rates to minimize effects to birds, mammals and invertebrates. Chemical spills could present a risk of greater exposure but standard spill prevention, monitoring, reporting and cleanup procedures would be employed as stated in CM-11. Oxygen-level alteration, carbon-dioxide and pH would be very limited in spatial extent to the immediate treatment area, be short in duration, would be unlikely to cause toxicity to birds through direct or indirect exposure. Chemical treatment is only expected in very limited areas in any given year (limited to use in tributary segments with natural barriers, and backwaters and off-channel ponds < 5 ac in size). Any effects would be insignificant and discountable.

Conservation measures that are designed to avoid and mitigate potential harm to western yellow-billed cuckoos are outlined in CM-3 and CM-4, and pertinent excerpts of these Conservations Measures include;

CM-3

- Sensitive species maps will be updated annually with any new information to ensure consistency with the above measures and will be referenced when annual work plans are developed.

- To reduce noise impacts on sensitive wildlife and areas with natural or wilderness characteristics when flying to and from the work area, helicopters would maintain a minimum 2,000 ft altitude where possible, per FAA Advisory Circular 91-36D Visual Flight Rules (VFR) Flight Near Noise-Sensitive Areas.

- Pilots would minimize aircraft use along the rim and cliffs to the greatest extent possible. Helicopter pilots will be encouraged to use quieter maneuvers (ones that produce less noise), wherever possible, according to the Fly Neighborly training available at: https://go.usa.gov/xQPCW and https://www.rotor.org/operations/flyneighborly.asp

- No helicopter landing zones will be used in suitable breeding habitat for western yellow-billed cuckoo during their breeding season.

CM-4

- Where possible, pumps, heaters and generators that do not exceed 60 dBA, at 50 feet, will be selected, per the NPS Audio Disturbances rule (36 CFR 2.12).

- Where possible, boats that do not exceed 75 dBA, at shoreline, will be selected, per the NPS maximum boat noise rule (36 CFR 3.15). Pressure washers will also be selected for action M1 to conform to this noise rule.

- Where possible crews traveling through riparian areas to get to treatment sites will use established trails and campsites.

CM-10

- As funding allows, GCNP would conduct surveys through the project area for the western yellow-billed cuckoo, typically every 3 years. Such surveys may be combined with surveys for other breeding birds and/or southwestern willow flycatchers.

- To ensure that staff have the most current information on cuckoos prior to the start of any management activities under the Proposed Action, GCNP's wildlife department would be contacted for suitable breeding habitat maps and any new occurrence near the project area.

- Western yellow-billed cuckoo locations, survey maps, and suitable breeding habitat maps will be updated following any new information to ensure consistency with the above measures and will be referenced when annual work plans are developed.

- Suitable western yellow-billed cuckoo breeding habitat will be avoided for activities which may cause disturbance including Actions M1 (if using pressure sprayer), P1, P5, C1, C2, C3, C4, and C5 (if using noise generating equipment) during the breeding season (May 15 – September 15. If there is a need to move forward with any of these actions in suitable breeding habitat during breeding season, then clearance surveys for the cuckoo will be conducted during breeding season in the immediate action area to determine if it is occupied or unoccupied prior to the action. NPS will conduct clearance surveys as close to the start of the action as possible, preferably within 1-2 days. If the area is occupied or NPS is unable to conduct clearance surveys, then either the action will not occur during the breeding season or NPS will communicate with the Service AESO prior to the action to determine an appropriate buffer if there is still a reason to consider going forward in this location during that time.

- No helicopter landing zones for this proposed action will be used in suitable breeding habitat for cuckoos during the breeding season (May 15 – September 15) unless a clearance survey in the past year has determined it is unoccupied. If the area is occupied or NPS is unable to conduct clearance surveys, then either the action will not occur during the breeding season or NPS will communicate with the Service AESO prior to the action to determine an appropriate buffer if there is still a reason to consider going forward in this location during that time.

- No camping or sustained activities would occur by fisheries crews for this proposed action, except at already established campsites, in suitable breeding habitat within the breeding season (May 15 – September 15) and travel through these areas will be minimized during this season.

- Habitat modification of riparian areas in this species' suitable breeding habitat would not occur as part of management activities under the Proposed Action.

Yuma Ridgway's rail

We concur with your determination that the proposed action may affect, but is not likely to adversely affect the endangered Yuma Ridgway's rail. We base this concurrence on the following:

- Effects to the Yuma Ridgway's rail would be focused on the river/riparian habitat within the action area which constitute the species' potential, suitable and existing breeding areas. Marsh habitat is very limited in the action area and rails have only been detected a couple of times. As with other bird species, the primary ways in which the proposed action could affect this species would be human-generated noise during the breeding season from humans, mechanical treatments, helicopters or from generators or pumps used for various control actions, potential direct effects from chemical treatments, indirect effects to prey from chemical or mechanical treatments. As stated in CM-4, there are a number of measures to mitigate sound for riparian birds, and as stated in CM-8 there would be periodic surveys for this species and avoidance of suitable breeding habitat during breeding season. No helicopter landing zones will be used in suitable habitat during breeding season unless a clearance survey in the past year has determined that it is unoccupied. If the area is occupied or NPS is unable to conduct clearance surveys, then either the action will not occur during the breeding season or NPS will communicate with USFWS Arizona Ecological Services Field Office (AESO) prior to the action to determine an appropriate buffer if there is still a reason to consider going forward in this location during that time. Therefore, these effects would be insignificant and discountable from these activities.

- Additional noise disturbance to rails, if present, and may result from any of the control actions, particularly those with appreciable noise generation. Noise-related effects would be temporary, lasting for the duration of the activity (the hours of equipment operation), and may result in flushing but would be unlikely to result in nest abandonment or changes in significant behavioral activity or important life requirements such as nesting, roosting, foraging, rearing, and movement activities and habitat. As stated in CM-4, there are a number of measures to mitigate sound for birds. These effects would also be insignificant and discountable.

- Yuma Ridgway's rails are unlikely to be directly affected by most control treatments because rails are unlikely to be in the action area, and actions will be primarily water-based, however some activities may occur near the banks in temporary, un-vegetated, backwaters that may be available depending on river water level/GCD discharge, but sampling could effect some shoreline vegetation (trampling) and cause some noise disturbance. Therefore, CM-8 prescribes periodic surveys for this species and avoidance of suitable breeding habitat during breeding season. Therefore, these effects would be insignificant and discountable from these activities.

- Actions C1, C2, C3 and C4 involve the use of chemical treatments, including; rotenone, antimycin, potassium permanganate (to neutralize rotenone and antimycin) ammonia, oxygen-level alteration, carbon dioxide or pH altering chemicals, for short durations. Research on toxicity of rotenone to birds indicates that acute toxicity was not possible from field application of rotenone to achieve a fish kill. CM-11 measures require formulations and application rates to minimize effects to birds, mammals and invertebrates. Chemical spills could present a risk of greater exposure but standard spill prevention, monitoring, reporting and cleanup procedures would be employed as stated in CM-11. Oxygen-level alteration, carbon-dioxide and pH would be very limited in spatial extent to the immediate treatment area, be short in duration, would be unlikely to cause toxicity to birds through direct or indirect exposure. Chemical treatment is only expected in very limited areas in any given year (limited to use in tributary segments with natural barriers, and backwaters and off-channel ponds < 5 ac in size). Any effects would be insignificant and discountable.

- Some control actions could remove a source of food for the rail. Non-native crayfish, which currently make up a large portion of the food base for this species, could be targeted for control in certain areas under the proposed action. However chemical treatment is only expected in very limited areas in any given year (limited to use in tributary segments with natural barriers, and backwaters and off-channel ponds < 5 ac in size). Mechanical removal efforts would also be limited in space and time, especially if targeting non-native crayfish. Also, the removal of non-native fish from certain areas could result in increased abundance of native amphibians and aquatic invertebrates, thereby potentially boosting these food sources for this species, which is what they used to depend on more in the past (LCR MSCP 2008). Therefore, indirect effects to birds from food sources would be insignificant and discountable.

Conservation measures that are designed to avoid and mitigate potential harm to Yuma Ridgway's rails are outlined in CM-3 CM-4, and CM-9, and pertinent excerpts of these Conservations Measures include;

CM-3

- Sensitive species maps will be updated annually with any new information to ensure consistency with the above measures and will be referenced when annual work plans are developed.

- To reduce noise impacts on sensitive wildlife and areas with natural or wilderness characteristics when flying to and from the work area, helicopters would maintain a minimum 2,000 ft altitude where possible, per FAA Advisory Circular 91-36D Visual Flight Rules (VFR) Flight Near Noise-Sensitive Areas.

- Pilots would minimize aircraft use along the rim and cliffs to the greatest extent possible. Helicopter pilots will be encouraged to use quieter maneuvers (ones that produce less noise), wherever possible, according to the Fly Neighborly training available at: https://go.usa.gov/xQPCW and https://www.rotor.org/operations/flyneighborly.aspx

- No helicopter landing zones will be used in suitable breeding habitat for Yuma Ridgway's (Yuma Clapper) rail during their breeding season.

CM-4

- Where possible, pumps, heaters and generators that do not exceed 60 dBA, at 50 feet, will be selected, per the NPS Audio Disturbances rule (36 CFR 2.12).

- Where possible, boats that do not exceed 75 dBA, at shoreline, will be selected, per the NPS maximum boat noise rule (36 CFR 3.15). Pressure washers will also be selected for action M1 to conform to this noise rule.

- Where possible crews traveling through riparian areas to get to treatment sites will use established trails and campsites.

CM-9

- Surveys of Ridgway's rail through the project area will be conducted periodically (typically every 3 years) as budget allows or in accordance with the LTEMP biological opinion.

- To ensure that staff have the most current information on Ridgway's rail prior to the start of any management activities under the Proposed Action, the park's wildlife department would be contacted for suitable breeding habitat maps any new occurrence near the project area.

- Ridgway rail locations, survey maps, and suitable breeding habitat will be updated following any new information to ensure consistency with the above measures and will be referenced when annual work plans are developed.

- Suitable breeding habitat will be avoided for activities which may cause disturbance including Actions M1 (if using pressure sprayer), P1, P5, C1, C2, C3, C4 and C5 (if using noise generating equipment) during the breeding season (March 1-July 1). If there is a need to move forward with any of these actions in suitable breeding habitat during breeding season, then clearance surveys for the rail will be conducted during breeding season in the immediate action area to determine if it is occupied or unoccupied prior to the action. NPS will conduct clearance surveys as close to the start of the action as possible, preferably within 1-2 days. If the area is occupied, then either the action will not occur during the breeding season or NPS will communicate with the Service prior to the action if there is still a reason to consider moving forward in this location and during that time.

- No helicopter landing zones for this proposed action will be used in suitable breeding habitat for Ridgway rail during the breeding season (March 1-July 1) unless a clearance survey in the past year has determined it is unoccupied. If the area is occupied or NPS is unable to conduct clearance surveys, then either the action will not occur during the breeding season or NPS will communicate with the Service AESO prior to the action to determine an appropriate buffer if there is still a reason to consider going forward in this location during that time.

- No camping or sustained activities would occur by fisheries crews for this proposed action, except at already established campsites, in suitable breeding habitat within the breeding season (May 1 – August 31) and travel through these areas will be minimized during this season especially in dense riparian vegetation where cattails and/or bulrush are present.

- Habitat modification of riparian areas in this species' suitable breeding habitat would not occur as part of management activities under the Proposed Action.

## APPENDIX B: DESCRIPTION OF ESTIMATED BROWN TROUT MOVEMENT AND PREDATION OF HUMPBACK CHUB

To estimate anticipated consumption of humpback chub by stocked yy-male brown trout we modified a model that was developed for stocking rainbow trout into Lees Ferry. This model was developed in cooperation with the U.S. Geological Survey, Grand Canyon Monitoring and Research Center, and modified by NPS. For the modeling, it was assumed that 5,000 adult YY-male brown trout would be stocked into the Glen Canyon reach during each of the first 10 years of a 20-year period (Table 3). The estimated range of input values for 3-month brown trout survival rate, 3-month rate of brown trout movement from the Glen Canyon reach to the Little Colorado River reach, and number of humpback chub eaten by an individual brown trout over a 3-month period were used to estimate effects under low-, moderate-, and high-risk scenarios (Table 3).

In the previous model it was assumed the 3-month per capita predation rate of humpback chub by a rainbow trout was estimated to range from approximately 0.4 to 1.5 humpback chub per rainbow trout, with a median value of about 0.8 humpback chub per rainbow trout. Using an assumption that brown trout are approximately 17 times more piscivorous on humpback chub than a rainbow trout (Yard et al. 2011), it was estimated that the 3-month per capita predation rate of humpback chub by a brown trout could range from approximately 6.8 to 25.5 humpback chub per brown trout, with a median value of about 13.6 humpback chub per brown trout (Table 3). The model assumed a quarterly (three-month) time step and was run over five years. In each time step, the model keeps track of the number of brown trout in the Lees Ferry reach, $N_t^{RBT,LF}$, the number of brown trout in the 30-mile aggregation, $N_t^{RBT,30}$, the number of brown trout in the Little Colorado River (LCR) aggregation, $N_t^{RBT,LCR}$, the cumulative number of juvenile humpback chub eaten in the 30-mile aggregation, $N_t^{HBC,30}$, and the cumulative number of juvenile humpback chub eaten in the LCR aggregation, $N_t^{HBC,LCR}$. In the first time step (i.e., at t=0), all of these values are set equal to zero except $N_t^{RBT,LF}$, which is determined by the number of stocked YY-male brown trout. In subsequent time steps, values are updated according to the following equations:

$$
\begin{aligned}
N_{t+1}^{RBT,LF} &= N_t^{RBT,LF}(1-\phi_{30}-\phi_{LCR})\varphi \\
N_{t+1}^{RBT,30} &= (N_t^{RBT,LF}\phi_{30}+N_t^{RBT,30})\varphi \\
N_{t+1}^{RBT,LCR} &= (N_t^{RBT,LF}\phi_{LCR}+N_t^{RBT,LCR})\varphi \\
N_{t+1}^{HBC,30} &= N_t^{HBC,30}+N_t^{RBT,30}\rho_{30} \\
N_{t+1}^{HBC,LCR} &= N_t^{HBC,LCR}+N_t^{RBT,LCR}\rho_{LCR}
\end{aligned}
$$

Where $\phi_{30}$ is the three-month movement rate of brown trout from Lees Ferry to 30-mile, $\phi_{LCR}$ is the three-month movement rate of brown trout from Lees Ferry to the LCR aggregation, $\varphi$ is the three-month survival rate of stocked brown trout, $\rho_{30}$ is the number of juvenile chub eaten per rainbow trout in the 30-mile aggregation, and $\rho_{LCR}$ is the number of juvenile chub eaten per brown trout in the LCR aggregation. Take at either 30-mile or the LCR aggregation was given by $N_8^{HBC,30}$ and $N_8^{HBC,LCR}$ respectively. Interestingly, we found that take at 30-mile was generally lower even though the expected number of brown trout there was greater because there are many fewer juvenile humpback chub at 30-mile (i.e., even though $\phi_{30} > \phi_{LCR}$, $\rho_{LCR} \gg \rho_{30}$). We considered low- and high-end values for each parameter when calculating to give a range of possible outcomes; however, high end values were used for the immigration rate, the intermediate value was used for predation, and the low end value was used for immigration rate in the final reporting in this Biological Opinion in order to analyze the most impactful scenario to make a determination of take and jeopardy, which is necessary to the section 7 consultation. For more information, on parameters and associated derivation and application of this model to brown trout, see the Table 1 below.

**Table 1. Calculations used for YY male Brown trout Distribution Model. Parameters for spreadsheet model**

| Stocked | Starting estimates and citation | Value for calculation |
|---|---|---|
| 3-month survival ($\varphi$) | Korman 2016 (~0.55 annual time scale – 0.85 on 3-month time scale) | We used 0.05 on an annual time scale (0.48 on a 3-month scale) as likely high end value (0.02 is plausible, but potentially too low as many of the studies being cited were not dealing with movement out of the study reach. Did not use higher end estimate based on naturally reproducing trout in the system, as we agree with Department's general argument that survival will be lower for stocked fish.) |
| 3-month movement to LCR ($\phi_{LCR}$) | Emigration rate (Korman 2015) | Emigration rate (Korman 2015) |
| 3-month per capita effect of brown trout on juvenile chub at LCR ($\rho_{LCR}$) | Modification to Yard 2011 assuming juvenile chub densities are ~ 4x higher now. | Modification to Yard 2011 assuming chub densities are ~ 4x higher now. |
| 3-month movement to 30 mile ($\phi_{30}$) | Emigration rate (mean estimate from Korman 2015) | Emigration rate (Mean estimated from Korman 2015) |
| 3-month per capita effect of brown trout on juvenile chub at 30-mile ($\rho_{30}$) | (rate modified from LCR, based on ratio of chub abundance at 30-mile to LCR – see below) | Multiply $\rho_{LCR}$ by ratio of chub abundance at 30-mile to LCR. |
| Ratio of Chub abundance at 30-mile to LCR | Expert Opinion explanation to the right. | Expert opinion. Calculated relative catch rates for two aggregations and relative spatial extents, and used to estimate ratio of abundances between aggregations. |

Table 2. Summary of Quantities used in calculation.

| | |
|---|---|
| Brown trout stocked | User inputs. 5,000 stocked YY male brown trout. |
| Brown trout at Lees Ferry | Updates BNT remaining at Lees Ferry after each quarter based on survival and movement rates. |
| Brown trout at LCR | Updates BNT that move to and survive at LCR after each quarter based on survival and movement rates. |

| | |
|---|---|
| Brown trout stocked | User inputs. 5,000 stocked YY male brown trout. |
| LCR chub eaten | Running sum of chub in the LCR calculated to have been consumed by stocked brown trout. Rounded number in larger font to the left (closer to parameters) is the total consumed over 2 years. |
| Brown trout at 30-miles | Updates brown trout that move to and survive at 30-mile after each quarter based on survival and movement rates. |
| 30-mile chub eaten | Running sum of chub at 30-mile aggregation calculated to have been consumed by stocked brown. Rounded number in larger font to the left (closer to parameters) is the total consumed over 2 years. |
| Total chub eaten per year | Sum of total chub consumed at 30-mile and LCR. |

Table 3. Modified model including inputs for three risk level assessments.

| Parameter | Low-Risk | Moderate-Risk | High-Risk |
|---|---|---|---|
| Number of YY-male brown trout stocked[a] | 5,000 | 5,000 | 5,000 |
| 3-month brown trout survival rate | 0.38 | 0.62[b] | 0.85 |
| 3-month proportion of stocked brown trout moving from Glen Canyon reach to Little Colorado River reach[c] | 0.0008 | 0.0008 | 0.0008 |
| 3-month effect on humpback chub at Little Colorado River[d] | 6.8 | 13.6 | 25.5 |
| | | | |
| | | | |

[a] Number of YY-male brown trout stocked annually during initial 10 year period; same for all risk levels.

[b] Moderate-risk value calculated as midpoint of low- and high-risk parameter values

[c] Four times the estimated movement rate to reaches IVa and IVb (Korman et al. 2016) to represent number of brown trout within the entire Little Colorado River reach. The reaches monitored by Korman et al. (2016) represent about 28% of the entire Little Colorado River reach.

[d] Number of humpback chub eaten by an individual brown trout during a 3-month period. Calculated by multiplying low, median, and high per capita predation estimates for rainbow trout by a factor of 17.

The modeled estimates of the annual number of YY-male brown trout in the Glen Canyon and Little Colorado River reaches and humpback chub eaten by stocked YY trout in the Little Colorado River reach during the 20-year period under the various risk scenarios are presented. Modeling indicated that annual stocking of 5,000 adult YY-male brown trout into the Glen Canyon reach for a 10-year period could result in average annual consumption over a 20-year period of 13, 113, and 1,915 juvenile humpback chub for low-, moderate-, and high-risk scenarios, respectively. The model estimated that stocked YY-male brown trout could consume fewer than 30 juvenile humpback chub in any given year under the low-risk scenario and up to 225 juvenile humpback chub under the medium-risk scenario. Under the high-risk scenario, approximately 40-3,800 juvenile humpback chub were estimated to be consumed annually during the 20-year period by YY-male brown trout stocked in the Glen Canyon reach and emigrating to the Little Colorado River confluence.

Estimated YOY humpback chub production in the Little Colorado River ranges from approximately 5,000 to 45,000 per year (Yackulic 2018b). Thus, it is estimated that stocked brown trout could consume 8-76% of the annual humpback chub production in a given year under the high-risk assumptions, 1-5% under the medium-risk assumptions, and 0 to 1% of humpback chub production under the low-risk assumptions.