

**OROVILLE FERC RELICENSING  
(PROJECT NO. 2100)**

**INTERIM REPORT  
SP-F3.2 Task 2  
SP-F21 Task 1**

**LITERATURE REVIEW OF LIFE HISTORY AND HABITAT  
REQUIREMENTS FOR FEATHER RIVER FISH SPECIES**

**REVIEW DRAFT**

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**JANUARY 2003**

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*DRAFT REPORT (SP-F3.2, Task 2; SP-F21, Task 1)*  
**LITERATURE REVIEW OF LIFE HISTORY AND HABITAT REQUIREMENTS FOR FEATHER RIVER  
FISH SPECIES**

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## **1.0 SUMMARY**

The objective of collecting and organizing information regarding lifestage characteristics and habitat requirements of fish species is to provide an information base intended to support other FERC Relicensing study plan tasks. This draft report is a “living document” intended to continue to grow and be refined as additional information becomes available from literature reviews, as well as from concurrent Feather River-specific studies conducted for FERC Relicensing.

The reporting format of a searchable and readily manipulatable matrix describing lifestage characteristics and habitat requirements is designed to facilitate the use of this information for comparisons between specific fish species and selected life history and habitat requirement elements. For example, comparing water temperature tolerances of selected predator and prey species may aid in determining whether potential temperature exclusion zones exist. The approach of building a searchable database of fish characteristics (Fish Matrix) was chosen over the more conventional approach of narrative descriptions of the fish characteristics for the purpose of providing a “tool” that would more efficiently support the use of this information in the other study plan tasks. The references that provide the information utilized to populate the Fish Matrix are “linked” by a reference manager software function, so that as the contents of the matrix are utilized in the development of the other study plan reports, the references are automatically updated and preserved. This function will improve document production efficiency and the integrity of the references sections of study plan reports. The specific functionality and benefits of the Fish Matrix are discussed in detail in section “4.0 Methodology.”

This deliverable satisfies the requirement to develop and describe fish lifestage characteristics and habitat requirements, as defined in several different study plans (SP-F3.1, SP-F3.2, SP-F5/7, SP-F10, SP-F15, and SP-F21). In order to ensure consistency of the treatment of the characterization of each fish species, and in order to avoid inefficiencies in the development of these similar deliverables, characterization of all fish species for which lifestage characteristics and habitat requirements are to be described are presented in this draft report. Twenty-four species of special regulatory status and management concern were characterized, with respect to as many as 94 elements for each species. This report was developed based upon the review of over 750 separate literature sources.

The current form of this deliverable is a separate Fish Matrix table for each fish species. After the completion of the additional literature review and the incorporation of edits submitted from the environmental work group review, the tables will be merged into one master Fish Matrix that will function as the searchable and manipulatable database to support the other study plans and reports.

## **2.0 PURPOSE**

The purpose of this report is to assemble and summarize information regarding fish species life history characteristics and habitat requirements (DWR 2002b). Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the Federal Energy Regulatory Commission

(FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife, and botanical resources in the vicinity of the project (Code of Federal Regulations 2001). The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operations. As subtasks of SP-F3.2 and SP-F21, both of these tasks fulfill a portion of the FERC application requirements by detailing the life history characteristics and habitat requirements of fish species of special regulatory status, native fish species, and sportfish species. In addition to fulfilling these requirements, information developed in this task may be utilized as the basis for evaluation of potential protection, mitigation and enhancement (PM&E) measures.

Several fish species considered under Task 2 of SP-F3.2 and Task 1 of SP-F21 are species of special regulatory status, meaning that they are species which are federally or state-listed threatened or endangered species under the Endangered Species Act (ESA), species which are candidates for listing under the ESA, or species which are California species of special concern. Species with special regulatory status considered under Task 2 of SP-F3.2 include splittail (*Pogonichthys macrolepidotus*), green sturgeon (*Acipenser medirostris*), and river lamprey (*Lamptera ayresi*), while species with special regulatory status considered under SP-F21 include steelhead (*Oncorhynchus mykiss*), spring-run Chinook salmon (*Oncorhynchus tshawytscha*), and fall-run Chinook salmon (*O. tshawytscha*). The regulatory status of each of these species is described below.

On February 08, 1999, Sacramento splittail was designated as Threatened under the ESA by the U.S. Fish and Wildlife Service (USFWS) (USFWS 1999). Splittail were listed as Threatened throughout their entire range, which includes the Feather River (USFWS 1999).

On June 12, 2001, the National Marine Fisheries Service (NMFS) received a petition from the Environmental Protection Information Center, Center for Biological Diversity, and Waterkeepers Northern California regarding the North American green sturgeon, in which the petitioners requested that NMFS list this species as either an endangered or threatened species under the ESA (Environmental Protection Information Center et al. 2001). On December 14, 2001, NMFS announced a 90-day finding that the petition presents substantial scientific and commercial information indicating that listing the North American green sturgeon may be warranted (NMFS 2001). While acceptance of the petition does not mean that listing is automatic, acceptance of the petition under the ESA requires that NMFS promptly commence a status review for the species concerned and make a finding as to whether the petitioned action is warranted within 12 months of the receipt date of the petition (NMFS 2002).

In June of 1995, River lamprey were designated as a California Species of Special Concern by the CDFG (DFG) (Moyle et al. 1995). "Species of Special Concern" (SSC) status applies to animals not listed under the federal Endangered Species Act or the California Endangered Species Act, but which nonetheless: 1) are declining at a rate that could result in listing; or 2) historically occurred in low numbers and known threats to their persistence currently exist (CDFG 2002). As described by the California Department of Fish and Game (CDFG), "*...this designation is intended to result in special consideration for these animals by the Department, land managers, consulting biologists, and others, and is intended to focus attention on the species to help avert the need for costly listing under federal and State endangered species laws*

and cumbersome recovery efforts that might ultimately be required. This designation also is intended to stimulate collection of additional information on the biology, distribution, and status of poorly known at-risk species, and focus research and management attention on them..." (CDFG 2002). SSC species are categorized into one of 4 classes: Class 1 - Endangered or Threatened; Class 2 - Special Concern; Class 3 - Watch List; and Class 4 - Secure. River lamprey are listed as Class 3 Watch List species, meaning that they occupy much of their native range, but were formerly more widespread or abundant within that range (Moyle et al. 1995).

On March 19, 1998, naturally spawned Central Valley steelhead (*O. mykiss*) were listed as threatened under the federal ESA by the NMFS (NMFS 1998). The Central Valley steelhead Evolutionarily Significant Unit (ESU) includes all naturally spawned populations of steelhead (and their progeny) in the Sacramento and San Joaquin Rivers and their tributaries, which includes the naturally spawned steelhead in the Feather River (NMFS 1998).

On September 19, 1999, naturally spawned Central Valley spring-run Chinook salmon (*O. tshawytscha*) were listed as threatened under the federal ESA by NMFS (NMFS 1999). The Central Valley spring-run Chinook salmon ESU includes all naturally spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries, which includes the naturally spawned spring-run Chinook salmon in the Feather River (NMFS 1999). In the same ruling, NMFS determined that naturally spawned Central Valley fall-run Chinook salmon (*O. tshawytscha*) were not warranted for listing under the federal ESA (NMFS 1999). However, the Central Valley fall-run Chinook salmon ESU was designated as a candidate for listing (NMFS 1999). The Central Valley fall-run Chinook salmon ESU includes all naturally spawned populations of fall-run chinook salmon in the Sacramento and San Joaquin River Basins and their tributaries, which includes naturally spawned fall-run Chinook salmon in the Feather River (NMFS 1999).

In addition to species with special regulatory status, information regarding the life history characteristics and habitat requirements of fish species of primary management concern (SP-F3.2) and predator and prey species of primary management concern (SP-F21) was also collected and compiled in the Fish Matrix. As described in SP-F3.2, non-salmonid fish of primary management concern include members of the *Centrarchidae* family including (bass and sunfish), striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), hardhead (*Mylopharodon conocephalus*), hitch (*Lavinia exilicauda*), Pacific lamprey (*Lamptera tridentata*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker (*Catostomus occidentalis*), tule perch (*Hysterocarpus traski*), and white sturgeon (*Acipenser transmontanus*) (DWR 2002b). As described in SP-F21, prey species of primary management concern in the Feather River are juvenile anadromous salmonids, including juvenile Chinook salmon (*O. tshawytscha*) and juvenile steelhead (*O. mykiss*), and predator species of primary management concern include Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass (*Morone saxatilis*). (DWR 2002a).

Operations of the Oroville Facilities can potentially affect, both directly and indirectly, the quality, quantity and distribution of fish habitat components in the Feather River. Developing a profile of the fish lifestage characteristics and habitat requirements establishes the basis for developing an understanding of the potential effects of Oroville facilities operations on these fish

resources. The purpose of this draft report is to provide an information base regarding lifestage characteristics and habitat requirements of the above named fish species which is intended to support other FERC Relicensing study plan tasks.

This interim report directly satisfies the requirement defined in Task 2 of SP-F3.2 and Task 1 of SP-F21 to compile and summarize information describing the life history characteristics and habitat requirements of fish species with special regulatory status and fish species of primary management concern (DWR 2002a; DWR 2002b). Information regarding fish species life history characteristics and habitat requirements was collected from a variety of sources, as described in "Background" and "Methodology". The information extracted from these sources was then integrated into the Fish Matrix, a searchable and readily manipulatable database of fish characteristics. The Fish Matrix is comprised of up to 94 separate elements or characteristics of fish lifestages and habitat requirements. These elements were identified by reviewing the lifestage and habitat characterization requirements in all of the fisheries study plans, and specifically represent literature review and reporting requirements in SP-F3.1, SP-F3.2, SP-F5/7, SP-F10, SP-F15, and SP-F21.

Although the information contained in this draft report will satisfy requirements in several plans, much of the required information will satisfy direct requirements of SP-F3.2 and SP-F21. SP-F3.2 was designed to support other tasks with SP-F3.2 and other FERC relicensing study plans. SP-F3.2 study plan requirements are satisfied by the Fish Matrix, including treatment of life history and habitat requirements for the non-salmonid species in the lower Feather River described above. SP-F3.2 was designed as a "clearing-house" for the development of the fish lifestage and habitat requirements, as well as for basic components of habitat mapping in order to ensure efficiency of development and to support the analysis conducted in SP-F3.1, SP-F5/7, SP-F15 and SP-F21. The habitat requirements by lifestage (i.e., the combinations and ranges of habitat characteristics suitable to a specific fish species) summarized in the Fish Matrix will be compared against habitat component distribution in order to determine fish habitat distribution by species (Task 4 of SP-F3.2).

As with SP-F3.2, SP-F3.1 was designed to support other tasks within SP-F3.1 and other FERC Relicensing study plans. Additionally, because the fish species of special regulatory status and primary management concern in the different geographic areas represented by SP-F3.1 and SP-F3.2 are the same, the requirements and reporting of the fish lifestage and habitat characteristics were combined to avoid duplication of effort and risks of inefficiencies and inconsistencies. Elements of SP-F3.1 that are addressed by the Fish Matrix include those elements that define the basic lifestage and habitat requirements for those fish resident in the Oroville reservoir and its upstream tributaries, the Thermalito complex and the Oroville wildlife area. As in SP-F3.2, SP-F3.1 was designed as a "clearing-house" for the development of the fish lifestage and habitat requirements, as well as for basic components of habitat mapping in order to ensure efficiency of development and to support the analysis of SP-F5/7, SP-F8, SP-F15 and SP-F21.

Some elements of the Fish Matrix are pertinent to fish species with specific life history traits or characteristics (such as anadromy or piscivory) and were included specifically to satisfy requirements of plans other than SP-F3.2. Elements of the Fish Matrix that address characterization of lifestage and habitat requirements for food, habitat and predator/prey species

relationships are represented to support components of the requirements in SP-F5/7 (Tasks 1 and 3) to aid in analyzing fish interactions. SP-F10 requirements for characterization of lifestage and habitat requirements are satisfied by the salmonid species represented in the Fish Matrix. Additional elements characterizing migration, holding and emigration lifestages were added to the Fish Matrix to satisfy the specific information and characterization requirements of anadromous salmonids (SP-F10, Tasks 1 – 4) and other anadromous fish (SP-F3.2, Tasks 3-5). SP-F15 requirements are supported by the Fish Matrix characterization of fish upstream migration, spawning and emigration lifestage and habitat requirements of salmonids and other species for consideration for fish passage assessment. Twelve additional elements were added at the end of the Fish Matrix regarding predation characteristics for piscivorous fish species to represent the requirements in SP-F21. Other elements, such as temperature tolerances and preferences at various lifestages of both predator and prey species, will also be utilized to support the analyses in SP-F21. The lifestage characteristics and habitat requirements documented in the Fish Matrix will also support the evaluation and development of potential protection, mitigation and enhancement (PM&E) measures.

### **3.0 BACKGROUND**

Because this deliverable is a compilation of the requirements for characterizing the life history and habitat requirements for all of the fisheries study plans, the geographic area represented by this deliverable is defined by the aggregation of all of the geographic scopes of the study plans. The resulting geographic scope represented by this deliverable is the upstream extent of the Oroville reservoir tributaries up to the first fish barrier, the Oroville reservoir and Thermalito complex, the Oroville Wildlife Area and the Feather River from the Thermalito Diversion Dam to the confluence with the Sacramento River.

Species of fish included in the Fish Matrix were identified in the study plans SP-F3.1, SP-F3.2, SP-F5/7, SP-F10, SP-F15, and SP-F21 and are species of special regulatory status or of primary management concern. Because the Fish Matrix is an aggregation of all of the elements necessary to characterize all of the lifestages and habitat requirements for all of the types of fish, not all of the elements in the matrix are applicable to all the fish. As an example, the migratory related elements represented are not applicable to the non-anadromous fish species. Similarly, not all of the fish species have the same amount of information available to characterize their requirements as the biology of some species is recognized as not thoroughly characterized, and therefore some of the fish species matrices are less fully populated than others. To the extent necessary to support the analyses of the study plans referenced above, the matrix will be supplemented with additional information. As described in Task 2 of SP-F3.2, local or regional studies or information regarding lifecycle timing, life history traits, and habitat requirements were reviewed and summarized as available and to the extent possible to specify Feather River specific information. In cases where no local information regarding life history exists, life history traits and habitat requirements from other geographic areas were utilized. As the results from Feather River studies become available from other FERC Relicensing study plans, the Feather River specific column of the matrix will become more fully populated.

#### 4.0 METHODOLOGY

The objective of this task was to conduct a literature review in order to assemble and summarize information regarding fish species life history characteristics and their habitat requirements (DWR 2002b). A literature review of the life history characteristics and habitat requirements was conducted for the following fish species, as specified in SP-F3.2 and SP-F21 (DWR 2002a; DWR 2002b):

- Sacramento splittail (*P. macrolepidotus*)
- green sturgeon (*A. medirostris*)
- white sturgeon (*A. transmontanus*)
- river lamprey (*L. ayresi*)
- Pacific lamprey (*L. tridentata*)
- Central Valley steelhead (*O. mykiss*)
- Central Valley spring-run and fall-run Chinook salmon (*O. tshawytscha*)
- members of the *Centrarchidae* family:
  - spotted bass (*Micropterus punctulatus*)
  - largemouth bass (*M. salmoides*)
  - smallmouth bass (*M. dolomieu*)
  - red-eye bass (*M. coosae*)
  - bluegill (*Lepomis macrochirus*)
  - green sunfish (*L. cyanellus*)
  - redear sunfish (*L. microlophus*)
  - black crappie (*Pomoxis nigromaculatus*)
  - white crappie (*P. annularis*)
- striped bass (*M. saxatilis*)
- American shad (*A. sapidissima*)
- hardhead (*M. conocephalus*)
- hitch (*L. exilicauda*)
- Sacramento pikeminnow (*P. grandis*)
- Sacramento sucker (*C. occidentalis*)
- tule perch (*H. traski*)

Specific information targeted to be summarized included:

- Specific life history periodicities (e.g., adult spawning, juvenile rearing and migration)
- General habitat requirements (e.g., warmwater or coldwater, lentic or lotic dwellers)
- Specific habitat requirements (e.g., water depth, water velocity, substrate composition)
- Community interactions (e.g., predators, prey and competitors for food and habitat)
- Habitat requirements of non-salmonids by species and lifestage (e.g. habitat types, water temperature, water depth, water velocity, substrate, etc.)
- Adult migration characteristics (e.g., timing, and water temperature and flow conditions)
- Spawning characteristics (e.g., habitat availability, timing, and factors affecting timing and success such as substrate conditions and water temperature)
- Early development (e.g., factors affecting incubation and survival during incubation)



- Juvenile rearing (e.g., water temperature, flow, substrate characteristics, refuges, shade, cover, food availability)
- Juvenile movements (e.g., timing, prevalent flow, water temperature and other abiotic conditions, predation, stranding)

In order to achieve the task objectives, a detailed list of elements and descriptions were developed for both general and, when available, for Feather River-specific information for each fish species. **Table 1** below is an example of the format and a description of the types of content for each element included in this report:

**Table 1. Fish matrix elements and element descriptors.**

Element	Element Descriptor
<b>General</b>	
common name (s)	English name (usually used by fishers and laypeople).
scientific name (s)	Latin name (referenced in scientific publications).
taxonomy (family)	Common name of the family to which they belong. Also indicate scientific family name.
depiction	Illustration, drawing or photograph.
range	Broad geographic distribution, specifying California distribution, as available.
native or introduced	If introduced, indicate timing, location, and methods.
ESA listing status	Following the categories according to California Code of Regulations and the Federal Register, indicate whether: SE = State-listed Endangered; ST =State-listed Threatened; FE = Federally listed Endangered; FT = Federally-listed Threatened; SCE = State Candidate (Endangered); SCT = State candidate (Threatened); FPE = Federally proposed (Endangered); FPT = Federally proposed (Threatened); FPD = Federally proposed (Delisting); the date of listing; or N = not listed.
species status	If native, whether: Extinct/extirpated; Threatened or Endangered; Special concern; Watch list; Stable or increasing. If introduced, whether: Extirpated (failed introduction); highly localized; Localized; Widespread and stable; Widespread and expanding.
economic or recreational value	Indicate whether target species sought for food or trophy. Whether desirable by recreational fishers, commercial fishers, or both.
warmwater or coldwater	Warmwater if suitable temperature range is similar to basses; coldwater if suitable temperature range is similar to salmonids.
pelagic or littoral	Environment: Pelagic - living far from shore; Littoral - living near the shore.
bottom or water column distribution	Environment: bottom (benthic) or along water column.
lentic or lotic	Environment: Lentic - pertaining to stagnant water, or lake-like; Lotic - moving water, or river-like.
<b>Adults</b>	
life span	Approximate maximum age obtained.
adult length	Indicate: Length at which they first reproduce; average length and maximum length the fish can attain.
adult weight	Indicate: Weight at which they first reproduce; average weight and maximum weight the fish can attain.
physical morphology	General shape of the fish: elongated, fusiform, laterally compressed, etc.
coloration	Indicate color, and color changes, if any, during reproduction phase.
other physical adult descriptors	Unique physical features for easy identification.

**Table 1. Fish matrix elements and element descriptors.**

<b>Element</b>	<b>Element Descriptor</b>
adult food base	Indicate primary diet components.
adult feeding habits	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder.
adult in-ocean residence time	For anadromous species, age when they migrate to the ocean and duration spent in the ocean before returning to freshwater to spawn.
adult habitat characteristics in-ocean	For anadromous species, description of the ocean habitat utilized: whether along major current systems, gyres, pelagic (beyond continental shelves) and neritic (above continental shelves) zones, etc.
<b>Adult upstream migration (immigration)</b>	
range of adult upstream migration timing	Time of year adults migrate upstream. If applicable, indicate for various runs.
peak adult upstream migration timing	Time of year most adults migrate upstream. If applicable, indicate for various runs.
adult upstream migration water temperature tolerance	Range of water temperatures allowing survival. Indicate stressful or lethal levels.
adult upstream migration water temperature preference	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.
<b>Adult holding (freshwater residence)</b>	
water temperature tolerance for holding adults	Range of water temperatures allowing survival. Indicate stressful or lethal levels.
water temperature preference for holding adults	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.
water depth range for holding adults	Reported range of observed (minimum and maximum) water depth utilization.
water depth preference for holding adults	Reported range of most frequently observed water depth utilization.
substrate preference for holding adults	If bottom dwellers, indicate substrate: mud, sand, gravel, boulders, aquatic plant beds, etc. If gravel, indicate range or average size of gravel.
water velocity range for holding adults	Reported range of observed (minimum and maximum) water velocity utilization.
water velocity preference for holding adults	Reported range of most frequently observed water velocity utilization.
other habitat characteristics for holding adults	General description of habitat (e.g. turbid or clear waters, lentic or lotic, presence of aquatic plant beds, debris, cover, etc.).
timing range for adult holding	Time of year (earliest-latest) and duration of stay from upstream migration to spawning.
timing peak for adult holding	Time of year when maximum number of adults are present before spawning.
<b>Spawning</b>	
fecundity	Average or range in the number of eggs females lay in a spawning season.
nest construction	Location and general description of nest -- substrates, aquatic plants, excavations, crevices, habitat types, etc.
nest size	Size and average dimensions of the nest.
spawning process	Indicate whether nest builder, broadcast spawner, or other.
spawning substrate size/characteristics	Range of substrates used during spawning (e.g. mud, sand, gravel, boulders, beds of aquatic plants). Indicate presence of plant/wood debris, crevices at spawning sites. If gravel, indicate range of average size.
preferred spawning substrate	Indicate preferred spawning substrate (e.g. mud, sand, gravel, boulders, plant bed, etc).

**Table 1. Fish matrix elements and element descriptors.**

<b>Element</b>	<b>Element Descriptor</b>
water temperature tolerance for spawning	Range of water temperatures allowing survival. Indicate stressful or lethal levels.
water temperature preference for spawning	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.
water velocity range for spawning	Minimum and maximum speed of water current the spawning fish can tolerate.
water velocity preference for spawning	Preferred water current (flow velocity) during spawning.
water depth range for spawning	Reported range of observed (minimum and maximum) water depth utilization.
water depth preference for spawning	Reported range of most frequently observed water depth utilization.
range for spawning timing	Earliest and latest time of season or year in which spawning occurs.
peak spawning timing	Time of year most fish start to spawn.
spawning frequency (iteroparous/semelparous)	Semelparous - producing all offspring at one time, such as in most salmon. Usually these fish die after reproduction. Iteroparous - producing offspring in successive, e.g., annual or seasonal batches, as is the case in most fishes.
<b>Incubation/early development</b>	
egg characteristics	Shape, size, color, in clusters or individuals, stickiness, and other physical attributes.
water temperature tolerance for incubation	Range of water temperatures allowing survival. Indicate stressful or lethal levels.
water temperature preference for incubation	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.
time required for incubation	Time duration from fertilization to hatching. Note: Indicate at which temperature range. Incubation time is temperature-dependent.
size of newly hatched larvae	Average size of newly hatched larvae.
time newly hatched larvae remain in gravel	Time of year of hatching, and duration between hatching and emergence from gravel.
other characteristics of larvae	Alevin -- early life history phase just after hatching (larva) when yolk-sac still present.
timing range for emergence	Time of year (earliest-latest) hatchlings (larvae and alevins) leave or emerge from the nesting/hatching (gravel) sites.
timing peak for emergence	Time of year most hatchlings emerge.
size at emergence from gravel	Average size of hatchlings at time of emergence.
<b>Juvenile rearing</b>	
general rearing habitat and strategies	General description of freshwater environment and rearing behavior.
water temperature tolerance for juvenile rearing	Range of water temperatures allowing survival. Indicate stressful or lethal levels.
water temperature preference for juvenile rearing	Range of suitable, preferred, or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.
water velocity ranges for rearing juveniles	Reported range of observed (minimum and maximum) water velocity utilization.
water velocities preferred by rearing juveniles	Reported range of most frequently observed water velocity utilization.
water depth range for juvenile rearing	Reported range of observed (minimum and maximum) water depth utilization.

**Table 1. Fish matrix elements and element descriptors.**

<b>Element</b>	<b>Element Descriptor</b>
water depth preference for juvenile rearing	Reported range of most frequently observed water depth utilization.
cover preferences for rearing juveniles	Type of cover for protection from predators used by rearing juveniles (e.g. crevices, submerged aquatic vegetation, overhanging vegetation, substrate cover, undercover bank, small woody debris, large woody debris).
food base of juveniles	Indicate primary diet components. Also indicate the diet changes, if any, as growth occurs.
feeding habits of rearing juveniles	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder. Also indicate change of feeding habits growth occurs.
predation of juveniles	Indicate which species prey on juveniles.
timing range for juvenile rearing	Range of time of year (months) during which rearing occurs.
timing peak for juvenile rearing	Time of year (months) during which most rearing occurs.
<b>Juvenile emigration</b>	
time spent in fresh water prior to emigrating	Duration (in years and/or months) from emergence to emigration to the ocean.
water temperature tolerances during emigration	Range of water temperatures allowing survival. Indicate stressful or lethal levels.
water temperature preferences during emigration	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.
emigration timing range	Time of year juveniles commence emigration and duration of emigration.
emigration timing peak	Time of year most juveniles are emigrating.
size range of juveniles during emigration	Minimum and maximum sizes (inches or mm) of emigrating juveniles. Indicate average size.
factors associated with emigration	Pulse flows, water temperature changes, turbidity levels, photoperiod, etc.
<b>Other potential factors</b>	
DO	Levels of dissolved oxygen in water expressed in mg/l tolerated by fish.
pH	Alkalinity/acidity of water (expressed in pH) that fish can tolerate.
turbidity	Indicate turbidity or state of water (e.g., clear water or presence of siltation or organic/inorganic matter in water) that fish can tolerate.
factors contributing to mortality	e.g. fishing/angling mortality, drastic habitat alterations, unfavorable climatic changes, etc.
<b>Predation-related characteristics</b>	
consumption rates by size	Rate of consumption of prey by predator size.
consumption rates by lifestage	Rate of consumption of prey by predator lifestage.
consumption rates by water temperature	Rate of consumption of prey by water temperature.
growth rate	Rate at which growth occurs.
community interactions (predators)	Known predators.
community interactions (prey)	Known prey.
community interactions (competitors)	Known competitors.

**Table 1. Fish matrix elements and element descriptors.**

<b>Element</b>	<b>Element Descriptor</b>
predator diet by size	Diet of fish by size classes.
predator diet by age group	Diet of fish by age group.
association of predators to physical facilities including habitat conditions created by operations	Habitat conditions created by operations that are conducive to predation (velocities, temperatures).
association of predators to physical facilities including instream flow obstructions/diversions	Instream flow obstructions and/or diversions associated with structures and facilities that are conducive to predation.
association of predators to physical facilities including unusual flow and/or water temperature patterns	Flow or water temperature associated with structures, or operations facilities that are conducive to predation.

The Fish Matrix was structured with the elements (listed above) on the vertical axis and the general information and Feather River-specific information, where available, as additional columns on the horizontal axis. For this draft report, each fish species matrix is a separate document. However, for the final report, the information from each matrix will be merged, such that the elements will be on the vertical axis and different fish species will occupy the horizontal axis. As described under "Purpose" and "Background", some elements were specifically designed for anadromous fish (adult holding, adult upstream migration, and juvenile emigration), while other elements were specifically designed for predatory species (predation-related characteristics). In cases where elements are not applicable for a fish species, such as adult upstream migration for a non-migratory fish, the matrix was populated with the "N/A" notation. Additionally, supplementary tables were provided for some elements of the matrix where available information was so extensive or detailed, it did not fit easily into the matrix (i.e., water depth and velocity preferences for Chinook salmon spawning).

In order to describe each element listed above for each fish species, a variety of literature was collected and reviewed. Material reviewed included technical reports from studies conducted by federal and state agencies, status reviews and listing petitions, consultant literature, and available peer-reviewed scientific literature. An extensive review of a wide range of literature was conducted. A representative sample of the types of materials reviewed is presented below. Reviewed materials included, but was not limited to, the following:

- California Fish and Game Bulletins (DFG)
- Estuarine Living Marine Resources Reports (NOAA)
- Water Projects Branch Reports (DFG)
- Fisheries Handbook of Engineering Requirements and Biological Criteria (USACE)
- Sacramento-San Joaquin Delta Native Fishes Recovery Plan (USFWS)
- IEP Technical Reports (DWR)
- Bonneville Power Administration Fish and Wildlife Technical Publications
- Columbia River Investigations Reports (Oregon Department of Fish and Wildlife)
- Pacific States Marine Fisheries Commission Reports
- Anadromous Fisheries Branch Administrative Reports (DFG)

- Biological Reports (USFWS)
- Status Reviews (NMFS and USFWS)
- Feather River Fish Studies Program Reports (DWR)
- Feather River Spawning Gravel Baseline Study (DWR)
- Biological Opinions (NMFS)
- IEP Newsletters (DWR)
- Federal Register
- Restoration Plans and Recovery Plans
- Transactions of the American Fisheries Society
- Canadian Journal of Fisheries and Aquatic Science
- North American Journal of Fisheries Management
- The Southwestern Naturalist
- Freshwater Biology
- Environmental Biology of Fishes
- Ecological Applications
- American Midland Naturalist
- The Progressive Fish-Culturist
- Fisheries
- Ecology
- Moyle, P. B. 2002. Inland Fishes of California. Berkeley: University of California Press.
- Theses and dissertations
- UC Davis research reports for DFG
- Listing petitions

As described in Task 2 of SP-F3.2, local or regional studies containing information regarding lifecycle timing, life history traits, and habitat requirements were reviewed and summarized as available and to the extent possible includes Feather River-specific information. In cases where no local information regarding life history exists, life history traits and habitat requirements from other geographic areas were utilized. In cases where very little life history information exists in the literature (such as green sturgeon), information was substituted from related species (such as white sturgeon).

There are several advantages in addition to those described above in "Summary" to utilizing the matrix format instead of lengthy narratives. One reason this format was chosen was because it allowed easy and concise representation of the many sources reviewed relating to life history characteristics and habitat requirements. The matrix format allowed ease of comparison of a single habitat requirement across species, and ease of manipulating cells for any desired comparison. Additionally, because of the concise nature of the informational entries and direct citations from the source authors, no interpretation of lengthy narrative is required. Utilizing the matrix format allowed representation of the diversity of research results and reports surrounding the element under review. It is important to review a range of studies when describing the relationship between an environmental factor, such as water temperature, and a biological characteristic. For example, water temperature thresholds resulting from experimental manipulations in the laboratory and field observations differ and, as a result, more than one type of source was utilized to populate the Fish Matrix. In order to avoid relying on a single water temperature recommendation, several water temperature recommendations were extracted from a

variety of sources for each fish species and lifestage. Generally, information from a variety of sources regarding any of the life history characteristics and habitat requirement elements in the Fish Matrix provided a more complete picture of how the element affects fish than information from only one source. As a result, when multiple sources provided information about the same topic, information from each source was documented. When information found in several independent sources was consistent, fewer sources were cited than when information found in several independent sources was widely disparate. In cases where information describing the same element from different sources was widely disparate, additional studies were reviewed in order to provide additional understanding of the relationship between the element under review and the life history characteristic or habitat requirement under investigation.

Several sources of information describing life history and habitat characteristics were utilized for the reasons described above. Therefore, within an element of the matrix, there may be conflicting information. For example, one citation may suggest that a fish species prefers to spawn under one set of velocity conditions, while another may suggest a range for the same species that does not include the velocities noted by the author of the first citation. One advantage to utilizing the matrix format was the ease with which it was possible to identify conflicting information. This was important because conflicting information could result either from a high level of natural variation within the species with respect to the element under review, or because relatively little is known about the relationship between the element under review and the biological characteristics of the species.

The Reference Manager, Professional Edition Version 10, software manufactured by ISI ResearchSoft was utilized to track and document source data. Because of the quantity of literature reviewed and the number of elements populated, it was important for the source data for each populated element to be accurately documented. Reference Manager was chosen because it is a database management and bibliographic building tool that utilizes object linking and embedding, which allows the authors to "link" the reference in the word processing program to the reference database while writing in the word processing application. Once citations have been linked to the Reference Manager database, bibliographies and in-text citations are automatically created and the format of either can be reformatted instantaneously. When new citations are added as additional information becomes available, Reference Manager will automatically renumber in-text citations and automatically re-configure the bibliographic citations. Another reason Reference Manager was chosen was because of the transportability of linked citations. If, for example, a related FERC relicensing study plan would like to turn the information in the Fish Matrix into a narrative report for select species, when text from the Fish Matrix is copied into a narrative form, the references will come with the text and are renumbered and reformatted automatically. Lastly, Reference Manager is a fully searchable matrix, and upon merging of the Fish Matrices for all the fish species, it will be possible to search for any cited reference by author, date, title, or subject.

## **5.0 RESULTS AND DISCUSSION**

See Appendix A, Matrix of Life History and Habitat Requirements for Feather River Fish Species.

## 6.0 CONCLUSIONS

The principle conclusions from the information represented in the Fish Matrix will be developed by the deliverables in the other study plans and tasks that the Fish Matrix was designed to support. Although the Fish Matrix will continue to evolve and be refined by additional information, it is already readily apparent that there is a wide range of the quality, quantity, consistency and availability of information between various fish species. In the cases where the cited information disagrees or does not coincide, the interpretation and use of the information should be tempered and evaluated on the basis of the credibility of the source and the applicability of the cited materials. The Fish Matrix is flexible and capable of fulfilling the literature review needs identified in Task 2 of SP-F3.2 and Task 1 of SP-F21, as well as associated plans that will draw upon this summary of life history characteristics and habitat requirements.

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