Pacific and River Lamprey

The following summarizes BDCP species-level goals and objectives for Pacific and River lamprey. These goals and objectives are currently being refined in accordance with a three tiered framework that includes landscape, natural community, and species- level goals and objectives. While the focus here is at the species level, actions taken to achieve landscape and natural community-level goals and objectives will benefit Pacific lamprey and are important components of the overall conservation strategy.

The species-level goals and objectives described below were developed in accordance with the Logic Chain approach. The Logic Chain approach explicitly incorporates consideration of broader, global goals and objectives (as provided by the resource agencies agencies) and focuses on select stressors that have been identified in species conceptual models and the literature as affecting species abundance. A summary of Pacific lamprey biology and factors influencing their growth, reproduction, survival, and migration is provided in Attachment A.

Species-Specific Goals and Objectives

Species-level goals and objectives for Pacific and River lamprey are intended to complement the natural community-level objectives by outlining the specific biological response conditions that are important for their rearing and migration success in the Delta. The following table lists BDCP species-level goals and objectives for Pacific and River lamprey in the context of global agency goals and objectives and key stressors that BDCP will address.

The plan seeks to achieve the broad goals of suitable larval rearing habitat in the Plan Area and increased scientific understanding of Pacific and River lamprey. Three specific, species-level objectives are provided that focus on improving larval rearing habitat quality, migratory survival; and scientific understanding of Pacific lamprey within the Plan Area.

1

Species:	**Pacific and River lamprey**	
Global Goals / Objectives: *Note: These are **not** BDCP goals and objectives. BDCP will contribute to meeting these, but will not in-and-of-itself achieve them.*	GG1: Manage estuary to improve habitat GG2: Restore/sustain Pacific and River lamprey populations throughout historic range	GO1: Implement actions known to benefit Pacific and River lamprey, minimize threats, and improve scientific understanding
Stressors addressed by BDCP:	Habitat loss/modification Altered flows Passage impediments/barriers Water quality Stranding	
BDCP Species Goal:	1. Suitable and productive larval rearing habitat for Pacific and River lamprey within the Plan Area. 2. Increase scientific understanding of Pacific and River lamprey.	
BDCP Larval Habitat Objective:	Protect and enhance existing tidal mudflat and channel margins with habitat characteristics necessary to support larval settlement and development. PHABSIM analysis on the Columbia River identified (see Close et al. 2003): • Silt, sand or organic (≥30 mm depth) substrates; • Water velocity of 0-19 cm/s. Avoiding sudden changes in water levels is also an important attribute to reduce stranding	
BDCP Juvenile Survival Objective:	Reduce entrainment risk of juvenile Pacific and River lamprey at project diversions.	
BDCP Science-Based Knowledge Objective:	Support regional lamprey monitoring and research programs with specific emphasis on factors directly related to the Plan Area.	

2
3

Rationale for Species-specific Goals and Objectives

While there is limited data on either Pacific or River lamprey, the following focuses primarily on Pacific lamprey with the assumption that goals and objectives for Pacific lamprey would also be applicable to river lamprey.

Distribution data indicate that Pacific and River lamprey ammocoetes are present in much of the Delta year round (see Attachment B). Ammocoetes remain in freshwater rearing habitats for 5-7 years where they bury into silt and mud and feed on algae, organic material, and microorganisms. Protection and enhancement of suitable larval rearing habitats within the Plan Area is expected to benefit productivity.

Using Jacobs' electivity index Close et al. (2003) developed habitat suitability index values for Pacific lamprey larvae in the Columbia River basin for use in Physical Habitat Simulation System (PHABSIM). Close et al. (2003) found that larval Pacific lamprey prefer habitats with soft sediments and low water velocities. Similar analysis of Pacific lamprey habitat preference could be used to identify and target areas for larval habitat conservation and enhancement within the Plan Area.

An additional consideration for larval habitat which was not identified by Close et al is stranding risk. Fluctuations in reservoir and stream water levels, irrigation diversions, and stream dewatering can strand ammocoetes in the substrate (FWS 2009). A single event can have a significant effect on a local lamprey population (FWS 2009, Luzier et al. 2009).

Downstream movement of juvenile lampreys (macropthalmia) happen year round (Luzier et al. 2009). Due to poor swimming ability movement is probably driven by flow conditions and velocities (Moursund 2009). Juvenile travel time is related to water particle travel time, increases in freshet flows will likely reduce lamprey travel time (Nez Perce et al. 2008). Downstream migrating macropthalmia are often impinged on diversion and intake screens resulting in death (FWS 2009).

Current hydrodynamic conditions are associated with passage delays and straying result in increased exposure to stressors and threats of stronger swimming species (e.g. salmonids) (Sommer et al. 2005, DWR 2005, Hanson et al. 2008; check cite). Estimating downstream migration success of lamprey is difficult. As a surrogate we recommend an objective to reduce entrainment of juvenile lamprey. This objective could be considered an indicator of higher level goals and objectives, such as providing more natural Delta hydrodynamics (ECSY1). Alternatively, information obtained from monitoring programs (outlined below) may provide a more direct means of evaluating juvenile migratory success.

There are no monitoring programs that target Pacific lamprey in the Delta and those that catch Pacific lamprey do not catch them regularly enough to establish trends through time. In addition, Pacific lamprey are inconspicuous, often overlooked, and ammocoetes can be difficult to distinguish from ammocoetes of the co-occurring river lamprey (H. Webb, pers. comm).

Contributing financial and/or technical resources toward implementing regional monitoring programs (e.g., The Pacific lamprey Conservation Initiative) focused on Pacific lamprey is expected to expand the

scientific understanding of Pacific lamprey and contribute to identifying measures necessary to maintain a self-sustaining population. Data obtained through cooperation in a regional program could be used to assess population trends, refine knowledge of stressors on key lifestages, and compliment future adaptive management actions. Relevancy of these data for use in the BDCP will be improved if contributions can be linked to conditions in the Plan Area.

Overview of Pacific and River lamprey BDCP Conservation Strategy

The general approach to achieving the plan goals and objective for Pacific and River lamprey will be to protect and improve the quality, quantity and availability of larval rearing habitats. This will be accomplished by implementing conservation actions on landscape, natural community and species levels; each informed by the specific habitat requirements for lamprey.

The plan will also include measures to provide bypass flows and other water operations criteria that will increase juvenile outmigration success.

Expansion of the scientific knowledge base of Pacific and River lamprey in the Plan Area is expected to provide valuable information to future adaptive management and facilitate achieving BDCP goals and objectives for lamprey.

Literature Cited

Close, David, Kimmo Aronsuu, Aaron Jackson, T. Robinson, Jennifer Bayer, James Seelye, Sang-Seon Yun, Alexander Scott, Weiming Li, Christian Torgersen, ''Pacific Lamprey Research and Restoration Project'', Project No. 1994-02600, 115 electronic pages, (BPA Report DOE/BP-00005455-6)

Attachment A – Species Account Summary for Pacific Lamprey

The Pacific lamprey is not a state or federally listed rare, threatened or endangered species. Pacific lamprey occur in both the lower Sacramento and San Joaquin Rivers (Moyle 2002) and many of their tributaries including the Stanislaus, Tuolumne, Merced, and King Rivers (Brown and Moyle 1993, 69 FR 77158.

Pacific lamprey are anadromous, beginning their migration into freshwater towards upstream spawning areas primarily between early March and late June (Moyle 2002). Most upstream migration occurs at night and occurs in pulses. Spawning habitat requirements are thought to be similar to those of salmonids.

Eggs hatch into ammocoetes, spend a short time in the nest, and then drift downstream to suitable areas in sand or mud (Moyle 2002). Ammocoetes remain in freshwater for approximately 5 to 7 years, where they bury into silt and mud and feed on algae, organic material, and microorganisms. Ammocoetes change locations during this stage.

Ammocoetes begin metamorphosis into macropthalmia (juveniles) when they reach 14-16 cm total length (TL). Individuals develop external features (eyes, oral disc, and color changes) and experience internal and physiological changes that prepare them for their predatory life stage in the ocean (McPhail and Lindsey 1970). Downstream migration begins upon completion of this metamorphosis, generally coinciding with high flow events in winter and spring (Moyle 2002).

Individuals outmigrating from Sacramento and San Joaquin River watersheds pass through the Plan Area during winter and spring on their way to the Pacific Ocean. Emigrating adults pass through the Plan Area on their way upstream towards spawning grounds primarily between March and June, although upstream movements in January and February have also been observed (Moyle 2002). It is unknown to what extent Pacific lamprey use the Plan Are for purposes other than a migration corridor.

The larval form of Pacific lamprey (ammocoetes) is commonly found throughout all of the BDCP regions, although no abundance estimates exist from Bay-Delta sampling programs. Population trends are unknown in California, although anecdotal evidence indicates that populations have been in decline (Moyle 2002, 69 FR 77158).

Stressors within the BDCP Plan Area anticipated to affect Pacific lamprey include; entrainment, habitat loss and modification, altered flows, climate change, food availability and disease.

Attachment B – Spatial/Temporal Distribution of Lamprey's in the Plan Area

Life Stage	July	August	September	October	November	December	January	February	March	April	May	June
Subregion: Yolo Bypass												
Eggs/Embryo												
Ammocoetes	●	●	●	●	●	●	●	●	●	●	●	●
Macropthalmia							●	●	●	●	●	
Adults/ Ocean Preator												
Adult/ Spawning	●	●							●	●	●	●

Life Stage	July	August	September	October	November	December	January	February	March	April	May	June
Subregion: Suisun Bay												
Eggs/Embryo												
Ammocoetes												
Macropthalmia							●	●	●	●	●	
Adults/ Ocean Preator												
Adult/ Spawning	●	●							●	●	●	●

Subregion: Cache Slough												
Eggs/Embryo												
Ammocoetes	●	●	●	●	●	●	●	●	●	●	●	●
Macropthalmia							●	●	●	●	●	
Adults/ Ocean Preator												
Adult/Spawning	●	●							●	●	●	●

Subregion: Suisun Marsh												
Eggs/Embryo												
Ammocoetes												
Macropthalmia							●	●	●	●	●	
Adults/ Ocean Preator												
Adult/Spawning	●	●							●	●	●	●

Subregion: North Delta												
Eggs/Embryo												
Ammocoetes	●	●	●	●	●	●	●	●	●	●	●	●
Macropthalmia							●	●	●	●	●	
Adults/ Ocean Preator												
Adult/ Spawning	●	●							●	●	●	●

Subregion: East Delta												
Eggs/Embryo												
Ammocoetes	●	●	●	●	●	●	●	●	●	●	●	●
Macropthalmia							●	●	●	●	●	
Adults/ Ocean Preator												
Adult/ Spawning	●	●							●	●	●	●

Subregion: Western Delta												
Eggs/Embryo												
Ammocoetes	●	●	●	●	●	●	●	●	●	●	●	●
Macropthalmia							●	●	●	●	●	
Adults/ Ocean Predator												
Adult/ Spawning	●	●							●	●	●	●

Subregion: South Delta												
Eggs/Embryo												
Ammocoetes	●	●	●	●	●	●	●	●	●	●	●	●
Macropthalmia							●	●	●	●	●	
Adults/Ocean Preator												
Adult/ Spawning	●	●							●	●	●	●

Key:	Abundant	Rare	Note: The size of the dots portrays the relative abundance of life stages in subregion in the month. The color coding for each life stage within each subregion indicates the overall abundance of the life stage relative to other subregions.
	Moderate	Not Present	