Critical Uncertainties for Lamprey in the Columbia River Basin: Update and Revision

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In April, 2005, the Columbia River Basin (CRB) Lamprey Technical Workgroup (Workgroup) produced a document to describe critical uncertainties for lampreys in the CRB, establish research and monitoring needs, and prioritize them. The document was produced for fishery managers in the CRB and was intended to guide lamprey conservation, management, research, and funding decisions.

At their October, 2010, meeting, the Workgroup decided that the Critical Uncertainties document needed to be revised. The Workgroup thought that the revision should be simpler, more concise and straightforward, and contain tables of RME items and Implementable Actions (IA) for major problem areas. The Workgroup used a pallid sturgeon recovery document, published by the USFWS, as a guide for its revision. The Workgroup identified six major problem areas that directly impede success of lamprey in the CRB or for which our understanding is so limited that the development and implementation of actions to facilitate lamprey restoration is impeded.

To make substantial progress towards restoration of lamprey in the CRB, progress should occur within all areas. The Workgroup will probably have to discuss prioritization of certain actions that should be addressed now, but should also be aware that work is needed in many areas to increase our knowledge base. There should also be discussions of monitoring programs and adaptive management as this revision proceeds.

The major problem areas identified by the LTWG are:

- Passage
- Habitat
- Abundance and Distribution
- Population Structure
- Biology and Ecology
- Population Dynamics and Life-Cycle Modeling

What follows are brief summaries of the problem areas, largely derived from the original Critical Uncertainties document, and associated tables outlining specific needs or action items.

Passage

Anadromous lampreys actively migrate from estuarine and marine waters to freshwater spawning areas as adults. Upon metamorphosis, juveniles participate in both active and passive emigration from freshwater rearing areas. In the CRB, lampreys may migrate hundreds of kilometers through both mainstem and tributary habitats. Consequently, they encounter a variety of obstacles to passage that could negatively affect their short and long-term survival. Extensive research has indicated that large hydropower dams delay and obstruct adult passage. These facilities may also delay, obstruct, injure, or kill juveniles. Smaller barriers also can block

passage by lamprey, including irrigation diversions, culverts, tide gates and other structures. When an obstacle is identified, its effects on all life stages should be considered. The priority of subsequent actions should reflect the relative impacts of the structure on each life stage.

Ongoing work to improve passage through placement of passage structures, modifying specific problem areas, etc., should continue. Experimental efforts to mitigate for poor passage, such as translocation programs, should also continue and should be evaluated. In addition to these actions currently being implemented, we need to increase our knowledge regarding lamprey migration, navigation, and passage needs, and our ability to accurately and precisely evaluate passage. These action and information needs form the foundation of the strategies and actions required to address lamprey passage.

Table 1. Strategies and activities recommended for addressing lamprey passage problems.

Strategy	Activity	Activity type
Attain timely and efficient passage of adult lamprey at mainstem dams and tributary structures.		
	Identify potential obstacles to adult passage (e.g., loss of recruitment upstream from a potential obstacle, observation of lamprey aggregations or mortalities at potential obstacles during migration periods, etc.). Includes predation caused or exacerbated by passage obstacles.	RME
	Assess passage efficiency, direct mortality, and/or other metrics that relate to loss of fitness (i.e., stresses or injuries that reduce ability to reproduce).	RME
	Determine the specific structures or operations that delay, obstruct, or kill migrating adult lamprey.	RME
	Develop aids to passage (e.g., modify structures or operations, provide lamprey-specific fishways or bypasses, etc.).	IA
	Monitor lamprey passage to evaluate aids to passage and to identify any new passage problems that might occur.	RME
	Identify and evaluate factors that motivate migration of adult lamprey.	RME
	Identify passage metrics and develop standards for those metrics. Develop quantifiable objectives from these standards.	RME
	Determine fate of adult lamprey that are unaccounted for based on dam counts or results from specific studies.	RME
	Continue implementing translocation to help mitigate for losses due to inadequate passage facilities.	IA
	Monitor and evaluate the effect of translocation on lamprey abundance and distribution.	RME
	Improve the tagging and marking technology used to evaluate lamprey passage.	RME
	Evaluate energetics of adult lamprey during migration and the relationship between energetics and passage.	RME
	Identify cues used by adult lamprey to navigate during upstream migration.	RME
Attain timely and efficient passage of juvenile lamprey at mainstem dams and tributary structures.		

	Identify potential obstacles to juvenile passage (e.g., direct mortality on screens and other potential obstacles, inneffective screens at diversions, etc.). Includes predation caused or exacerbated by passage obstacles.	RME
	Assess passage efficiency, direct mortality, and/or other metrics that relate to loss of fitness (i.e., stresses or injuries that reduce ability to survive throughout migration and early-ocean periods).	RME
	Determine the specific structures or operations that delay, obstruct, or kill migrating juvenile lamprey.	RME
	Develop aids to passage (e.g., modify structures or operations, provide lamprey-specific fishways or bypasses, etc.)	IA
	Monitor lamprey passage to evaluate aids to passage and to identify any new passage problems that might occur.	RME
	Identify passage metrics and develop standards for those metrics. Develop quantifiable objectives from these standards.	RME
	Improve the tagging and marking technology used to evaluate lamprey passage.	RME
	Evaluate energetics of juvenile lamprey during migration and the relationship between energetics and passage.	RME

Habitat

Documenting potential factors limiting the growth of lamprey populations will be critical to continuing conservation efforts. In particular, knowledge of habitat availability and quality as limiting factors will identify problem areas that can be targeted for mitigation or corrective actions. Documenting the habitat preferences and habitat availability for all life stages of anadromous and resident lampreys seems prerequisite to conservation and restoration efforts.

Table 2. Strategies and activities recommended for addressing lamprey habitat problems

PROBLEM	**STRATEGY**	**ACTIVITY**	**Activity Type**
HABITAT			
	Restore, improve, and/or protect spawning habitat		
		Restore and improve instream flows	IA
		Restore and/or protect spawning substrate	IA
		Improve and protect water quality in spawning habitats	IA
		Sedimentation	
		Identify and protect key spawning areas.	IA
		Implement habitat restoration actions	
		Integrate lamprey needs into salmonid restoration efforts.	
		Evaluate and map spawning habitat extent.	RME
	Restore, improve, and/or protect larval rearing		

	areas		
		Restore and improve instream flows	IA
		Improve and protect water quality in rearing areas	IA
		Protect sediment retention and sediment quality in optimal rearing habitats.	IA
		Evaluate and map key rearing habitat extent.	RME
		Detrital input/organic component	
		Implement habitat restoration actions	IA
		Integrate lamprey needs into salmonid restoration efforts.	IA
		Contaminants	
	Restore, improve, and/or protect migration areas		
		Restore and improve instream flows	IA
		Identify critical habitat needs for both migrating juveniles and adults.	
		Implement habitat restoration actions	IA
		Integrate lamprey needs into salmonid restoration efforts.	IA
	Restore, improve, and/or protect estuary and near-shore areas		
	Identify incidence and extent of mainstem spawning and rearing.		

Distribution and Abundance

Pacific lampreys were once widely distributed in the CRB according to historic collection records. Although the largest number of observations has occurred in the lower Columbia Basin including the Willamette River, adults also occurred upriver into Columbia River head waters in Canada, and up the Snake River to Shoshone Falls. The current distribution is severely reduced from the historic pattern and anadromous lamprey have been lost from all areas that are blocked by impassible barriers. These barriers include the Willamette River sub-basin dams, and other high-elevation dams such as the Pelton/Round Butte complex (Deschutes), Dworshak (Clearwater), Hells Canyon complex (Snake), and Chief Joseph/Grand Coulee (Columbia). Other smaller barriers that may pass salmonids also can block passage by lamprey, including small water diversion dams, culverts, tide gates and other structures.

Count data at Columbia and Snake River dams provide one of the few time series of Pacific lamprey abundance. However, count data can only serve as a relative index of adult population size because most adult lamprey pass at night when counting is not conducted, and numerous routes are available for lamprey to pass dams without being detected. Nevertheless, counts indicate order-of-magnitude reductions in the number of Pacific lampreys that return to the

interior CRB. For example, annual counts at Bonneville Dam averaged about 110,000 from 1950-69, and peaked at over 350,000, but have exceeded 100,000 only twice in the last decade and have been below 20,000 in most recent years. Declines are most dramatic for interior populations such as in the upper Snake River, where counts at Lower Granite Dam have ranged from 282 to a low of 12 over the last decade.

Table 3. Strategies and activities recommended for addressing lamprey abundance and distribution problems.

PROBLEM	STRATEGY	ACTIVITY	Activity Type
ABUNDANCE AND DISTRIBUTION			
	Abundance		
		Develop methods to differentiate among species at all life stages (field-based)	
		Develop standardized sampling protocols and conduct systematic basin-wide surveys to assess adult and juvenile abundance and distribution	
		Review historic databases to better understand historic distributions and abundance	
		Define, improve, and continue historic distribution and abundance indices (e.g., dam counts, tribal harvest records, smolt trap collections, etc)	
		Coordinate information exchange with existing and future projects not targeting lamprey specifically	
		Translocation	IA
		Propagation	
	Distribution		

Population Structure

Understanding population delineation and structure is important for management and conservation of anadromous lampreys. This information will be important for developing the scope of restoration and conservation programs. Some preliminary genetic analyses have been done for Pacific lamprey with equivocal results. More work is needed to adequately assess the population structure of Pacific lampreys. Because protein electrophoresis and existing genetic markers developed primarily for salmonids have proven ineffective for lampreys, genetic markers and potentially other methods specific to lamprey must be developed. After these tools are developed they need to be applied to better understand homing, population delineation, and population structure.

For resident populations of lampreys, current thought is that they are highly structured due to their relatively non-migratory life history. Given this assumption, gaining information on population delineation will have little benefit in guiding near-term management actions. Because there is some potential for populations to mix in the lower reaches of watersheds, work may be

needed to identify the potential for population structure at different scales. Some preliminary genetic analysis has been attempted with resident species with limited success. More work is needed.

Table 4. Strategies and activities recommended for addressing lamprey population structure problems.

PROBLEM	STRATEGY	ACTIVITY	Activity Type
POPULATION STRUCTURE			
	Document presence or absence of population structure		
Old		Develop new genetic markers to supplement existing libraries for lamprey (e.g., microsatellites, single nucleotide polymorphisms, etc.)	
Old		Build and maintain lamprey tissue collections from the CRB and neighboring basins. Conduct CRB-wide sampling program to obtain material for genetic analysis.	
Old		Investigate other methods to delineate populations	
Old		Implement tagging studies or programs (e.g., PIT tags) to determine if anadromous lamprey in the CRB represent a panmictic population (completely mixed) and to supplement data from genetics studies	
New		Continue to develop and refine genetic tools and methods as needed	
New		Analyze the genetics of anadromous and resident lamprey populations (e.g., existence of genetically distinct population structure, rate of gene flow, population/sub-population characteristics, etc.)	

Biology and Ecology

Identifying the biological and ecological characteristics of lampreys in the CRB is critically important for guiding work in many of the other problem areas. Although still limited, efforts

have increased in recent years to supplement our knowledge about the life-history of Pacific lamprey. More work is need to increase our understanding of the biology, ecology, and life history of all lampreys in the CRB.

Table 5. Strategies and activities recommended for addressing lamprey biology and ecology problems.

PROBLEM	STRATEGY	ACTIVITY	Activity Type
BIOLOGY AND ECOLOGY			
		Understand the biology of anadromous lamprey (e.g., reproduction, feeding)	
		Understand the ecological function of anadromous lamprey (e.g., predator/prey relationships, linkages to other aquatic and terrestrial organisms)	
		Develop methodology for gender identification in the field and laboratory (e.g., identify spawning sex ratios, sex related behavioral characteristics)	
		Develop aging techniques	
		Assess life history characteristics of freshwater and ocean-phase anadromous lamprey (e.g., age, growth, timing of metamorphosis, movement, basin-specific comparisons)	
		Life-Stage mortality rates	
		Migration motivation/cues (pheromones, etc.)	
		Physiological and behavioral responses to a bunch of stuff	
		Investigate disease and parasitism	
		Biology/ecology of over-wintering adults	
		Effects of ocean conditions	
		Effects of ocean conditions	

Population Dynamics and Life-Cycle Modeling

Current knowledge of lamprey population dynamics (e.g., recruitment and mortality rates) is limited, yet is necessary to fully understand temporal and spatial variations in density and abundance of lamprey populations. Population dynamics can be used to predict the effects of conservation strategies.

Table 6. Strategies and activities recommended for addressing lamprey population dynamics and life-cycle modeling.

PROBLEM	STRATEGY	ACTIVITY	Activity Type

POPULATION DYNAMICS AND LIFE-CYCLE MODELING			
Old		Estimate demographic rate parameters capable of changing the size of populations such as birth, death, immigration, and emigration rates	
Old		Build life tables	
Old		Develop a predictive model to assess the rate of increase/decrease of lamprey populations in the CRB including abiotic and biotic factors	