Lamprey Populations in California's Central Valley: Genetic analysis of an under-studied species complex

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INTRODUCTION

Lampreys, a group of jawless, eel-like fishes, are extant representatives of the first known vertebrates. At least six species of lamprey (*Entosphenus* spp. and *Lampetra* spp.) are native to California watersheds, including 3 anadromous species and one species endemic to California. Despite very different morphologies and life history strategies observed in their adult forms, one complication to lamprey population genetic research is the difficulty in determining an accurate species identification at the larval life stage. All lamprey species are listed as California Species of Special Concern; yet, little is known about interspecific and intraspecific genetic structure of populations throughout the state. This project utilizes genomic tools to help fill these knowledge gaps.

METHODS

In this pilot study, we applied restriction-site associated DNA sequencing (RADseq) to lamprey samples collected opportunistically through several ongoing salmon surveys. Our dataset captures individuals from various species, life stages, and geographic locations throughout northern California. Over 90% of samples were taken from larval individuals, and approximately half of all samples were not identified at the species level. We used principal component analysis and ADMIXTURE to investigate patterns of genomic differentiation.

RESULTS + CONCLUSIONS

Analysis of 480 individuals at variable SNPs (single nucleotide polymorphisms) throughout the genome showed high levels of genetic differentiation between two native anadromous species, Pacific lamprey (*Entosphenus tridentatus*) and [Western] river lamprey *(Lampetra ayresii)*. Each of these anadromous species co-occurs with at least one moderately genetically differentiated resident "brook" lamprey species. Geographically distant populations of anadromous lamprey showed very little genetic structure, which supports the hypothesis that anadromous lamprey do not exhibit natal homing behavior during their spawning migration. Multiple divergent lamprey species occur sympatrically in many sampling locations, including the Pit River, Sacramento River, American River, and Yolo Bypass. This co-occurrence of species demonstrates the high species diversity present and highlights the important of accurate species identification, which will likely require a genetic assay.

Species Name	Common Name	Anadromous	Predatory	Approximate Species Range
Entoshpenus tridentatus *	Pacific lamprey	✓	✓	Japan to Alaska to San Luis Obispo Creek, CA
Entosphenus similis	Klamath river lamprey	✓	✓	Klamath River
Entosphenus lethophagus	Pit-Klamath brook lamprey			Pit River, Upper Klamath River, Goose Lake Basin
Lampetra ayresii *	[Western] river lamprey	✓	✓	Alaska to Sacramento-San Joaquin Basin, CA
Lampetra richardsoni *	Western brook lamprey			Alaska to Sacramento-San Joaquin Basin, CA
Lampetra hubsii * *	Kern brook lamprey			San Joaquin, Kings, Kaweah, Merced Rivers, CA

* *endemic to California*
† *included in ESA petition to list as endangered in 2003*

California is home to a diverse group of genetically divergent lamprey species, all with high ecological value.
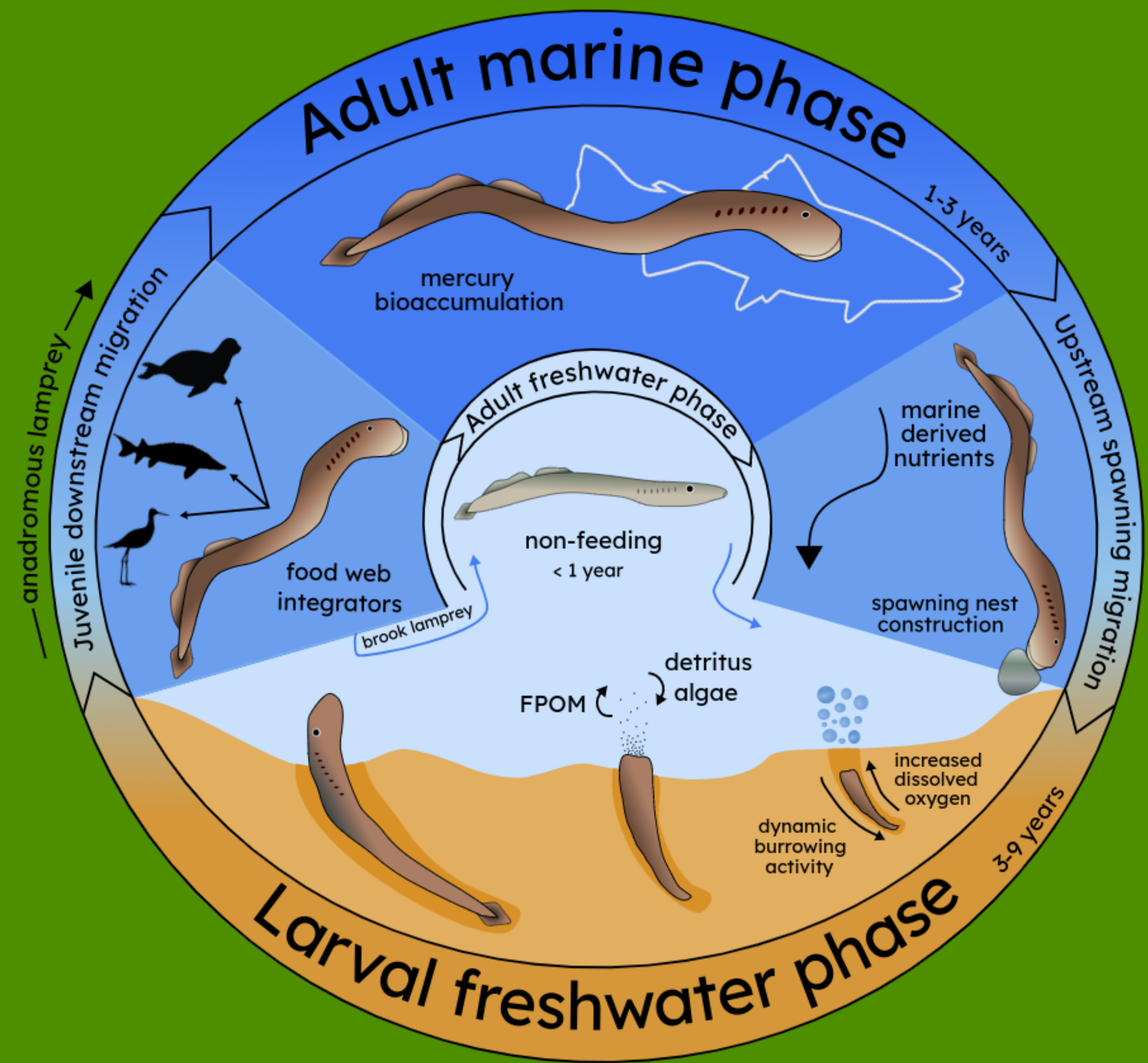
Lamprey ecosystem contributions
- Benthic filter-feeding larval lamprey support food web resilience by **cycling nutrients**
- Larval burrowing **maintains sediment** conditions and **increases oxygen** availability
- Juvenile and adult lamprey are a **rich prey item** for birds, mammals, and other fishes
- Lamprey are an **indicator species** for environmental contaminants at all life stages
- Construction of spawning nests **improve streambed habitat** quality
- **Marine derived nutrients** are carried upstream during spawning migration