



**University  
of Victoria**

Graduate Studies

Notice of the Final Oral Examination  
for the Degree of Doctor of Philosophy

of

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**“Nearshore Restoration Associated with Large Dam Removal and  
Implications for Ecosystem Recovery and Conservation of Northeast  
Pacific Fish: Lessons Learned from the Elwha Dam Removal”**

Department of Biology

Thursday, April 13, 2017  
10:00 A.M.  
David Turpin Building  
Room A137

Supervisory Committee:

Dr. Francis Juanes, Department of Biology, University of Victoria (Supervisor)  
Dr. Rana El-Sabaawi, Department of Biology, UVic (Member)  
Dr. Verena Tunnicliffe, Department of Biology, UVic (Member)  
Dr. Eric Higgs, Department of Environmental Studies, UVic (Outside Member)

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Dr. Karen Lynn Matthews Martin, Department of Biology, Pepperdine University

Chair of Oral Examination:

Dr. Tim Anderson, Department of Curriculum and Instruction, UVic

## **Abstract**

This dissertation addresses the relationship between large-scale dam removal and the nearshore ecosystem function for fish. The work is based on almost a decade's worth of collaborative field work in the nearshore of the largest dam removal in the world recently completed on the Elwha River. The data analyzed span seven years prior to, during, and thru the first year of dam removals (January 2008 to November 2015). As of September 2015, approximately 2.6 million m<sup>3</sup> of sediment material increased the area of the Elwha to over 150 ha. Long term study of fish communities in the estuary reveals fish response to dam removal, and indicate likely interactions in the nearshore between hatchery and wild fish, including chum salmon critical to watershed recovery. Continued hatchery releases may therefore further challenge chum salmon recovery and this interaction should be considered when planning for future watershed recovery. Community analysis revealed that while species richness and taxonomic diversity do not appear to have a significant response to dam removal, functional diversity in the nearshore does respond significantly to dam removal. Three main shifts in the nearshore: large scale and rapid creation of estuary habitats; delivery of large amounts of sediment to the delta/estuary in a short period of time, and; a shift in original habitats from tidally influenced to non-tidally influenced habitats resulted in changes in estuary function. Changes in functional diversity occur disproportionately in the new sites, which are also more unstable, and so less resilient functional communities. Functional diversity in the original estuary sites appears to be more resilient than in the newly created sites due to the large-scale environmental disruption that, ironically, created the new sites. However, the functional diversity at the original sites may be defined in part by management activities, including hatcheries that could mute/mask/inhibit other community responses. Further, functional diversity at the newly formed nearshore areas is predicted to stabilize as the habitats are vegetated and mature. Principal components analysis of Elwha fish community over the course of this study reveals that the fish communities of the Elwha are predictably grouped, indicating that dam removal has not resulted in observable disruptions in fish community assemblages.

And finally, nearshore habitats are critical for many forage fish species, and an emerging topic for large-scale dam removals. Forage fish spawning response to dam removal appears to be complex and may be related to multiple factors including high interannual variability in physical habitat conditions, geographic factors and complex life histories of forage fish. Habitat suitability for forage fish spawning should increase as restored ecosystem processes and newly created habitats mature and stabilize, indicating that time is an important factor in nearshore restoration for forage fish spawning. It is therefore important to implement long-term monitoring and incorporate nearshore ecosystem function for multiple life history stages of forage fish into large-scale dam removal restoration and management planning.