University of Victoria | Graduate Studies

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

of

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# "The Role of Fisheries Closures in Population Assessments and Management of Marine Benthic Invertebrates: A Dungeness Crab Case Study"

Department of Geography

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10:00 A.M.
Clearihue Building
Room B007

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Dr. David Duffus, Department of Geography, UVic (Member)
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## Abstract

Fishing for marine invertebrates is increasing globally, yet many fisheries are not managed sustainably which can have deleterious implications for populations and ecosystems. Effective management of invertebrate populations is imperative to ensure fished populations remain productive, fisheries sustainable, and marine ecosystems healthy and resilient so marine invertebrates can continue to be an important component of global marine fisheries in future years. Beyond providing direct benefits to exploited populations, effective spatial closures with unfished invertebrate populations can also serve as scientific reference sites with an important role in fisheries management. Comparing exploited and unfished populations can be useful for evaluating impacts of fisheries management measures, and the extent of shifted baselines. The new perspective garnered from unfished populations is important when defining stock status.

Dungeness crab in the Burrard Inlet system (southern Strait of Georgia, British Columbia) was the focal species of this research. This species is a heavily fished, low mobility benthic predator that responds well to spatial protection. There are two fisheries closures (Vancouver Harbour and English Bay) in Burrard Inlet where crab harvesting is not permitted by all sectors (commercial, recreational, First Nations). From 2009-13, biannual surveys were conducted in closed and fished areas throughout the inlet in the spring before the commercial fishery opened (mid-June) and during the fall near the end of fishing seasons (end of November). Crab biological data were collected from living crabs caught in standardized trap gear. Crab biological metrics that were examined included: trap Catch Per Unit Effort (CPUE; an index of abundance), size of various crab classes (total crabs, males, old males, legal males, sublegal males, females), injuries, shell condition (soft), discard ratios, sex ratio, proportion of old males, and sublegal males near the minimum size limit. Crabs in closed areas were tagged to provide information about movements from closed to fished areas. Time series of biological data for legal males collected since the early 1990s in one closed and one fished area were analyzed. Remotely Operated Vehicle (ROV) video imagery was used to estimate crab density and describe benthic habitats. Field measures of handling injuries were obtained from commercial vessels. Trap soak experiments were conducted to quantify injuries inflicted to crabs while captured in traps soaking on the sea floor. Crab shell condition data collected from the commercial fleet were analyzed.

Vancouver Harbour was found to be an effective closure whereas English Bay is not. Abundance and size of large males (the target of the fishery) were higher and stable between seasons in the harbour compared to other areas where these measures were consistently lower and decreased post fishery. Vancouver Harbour likely represents an effective closure because it is sufficiently large to retain adult crabs, has less edge habitat, and better enforcement. Advice regarding how to determine the degree of effectiveness of benthic invertebrate closures is provided.

The unfished crab population in the effective closure, Vancouver Harbour, was used as a reference against which to compare characteristics of the exploited population to evaluate impacts of the main management measures: the minimum size limit, non-retention of females and soft crabs, and a seasonal soft shell closure. The exploited population exhibited lower abundance of large, old males, smaller males, removals of, and injuries to, the biggest sublegal males, and higher rates of non-lethal

injuries and mortality to all crab classes. In contrast, positive consequences of the management measures include sublegal male and female abundances, and female size not being affected by the fishery. Moreover, sublegal males were injured the least and had low injury-related mortality. The exploited crab population never recovered after the seasonal closure to the abundance achieved in the permanent closure. Management options for fisheries managers to help minimize fishery-related impacts to harvested crab populations are presented.

Notable differences between exploited and unfished Dungeness crab populations are highlighted which provide important context to the shifting baseline syndrome and a new perspective regarding the definition of stock status. The unfished crab population, considered a proxy for invertebrate populations in general, provided:

· insights into population dynamics not influenced by fishing pressure,
· insights into population dynamics influenced by fishing pressure and context around the magnitude of changes that have occurred,
· a means whereby biological and/or environmental influences can be separated from fishery impacts,
· the foundation for challenging the accepted definition of ‘healthy’ populations as currently used in the precautionary approach framework and ecosystem-based fisheries management. Unfished invertebrate populations should be formally incorporated into fisheries management by redefining the Healthy Zone to include two population states, exploited and unfished.