# Depth is an important driver of nearshore benthic fish communities in the Salish Sea

## Introduction Objective Paragraph:

This project aims to determine if abiotic variables can act as proxies for nearshore fish biodiversity and explores with through three objectives. First, we will determine how fish species richness, abundance, and biomass vary with four abiotic variables, tidal current speed, depth, percent rock cover, and benthic slope, using linear mixed effect models. Second, using the variables of primary importance identified in our first objective, we will explore how community composition varies with that variable using a non-metric multidimensional scaling plot (nMDS). Third, we will explore how the life history of the observed fish species differ with the variable of primary importance. For these analyses, individual fish lengths were used in a partial pooling mixed effect model analysis to provide predictions for all species, even those with limited data.

## Methods (figures only)

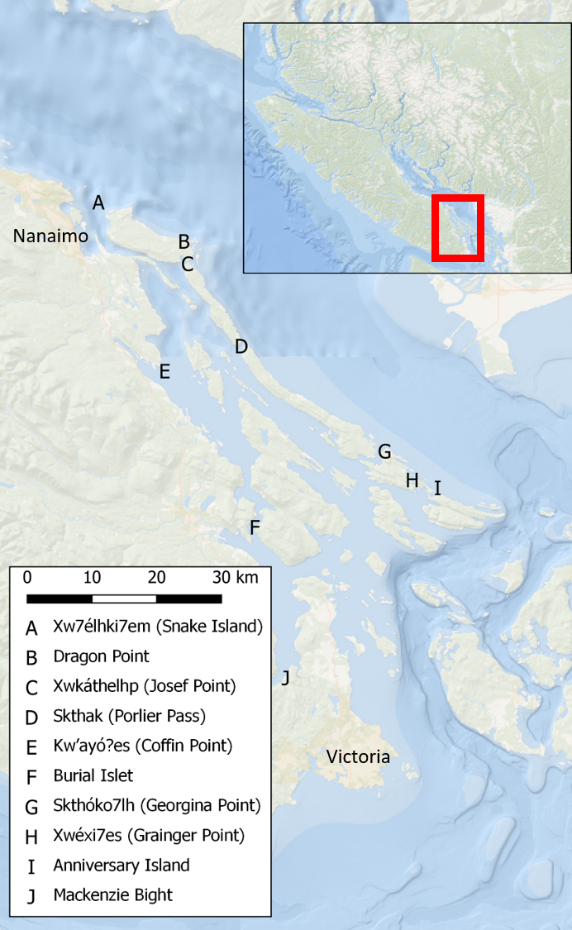


Figure 1: Map of survey sites within the Southern Gulf Islands BC Canada. High current sites are coloured red, low current sites are coloured blue. Current speed categories were defined by using the inflection point of all daily maximum current speeds at all sites. Hul’q’umin’um’ site names are used when they could be found in the literature.

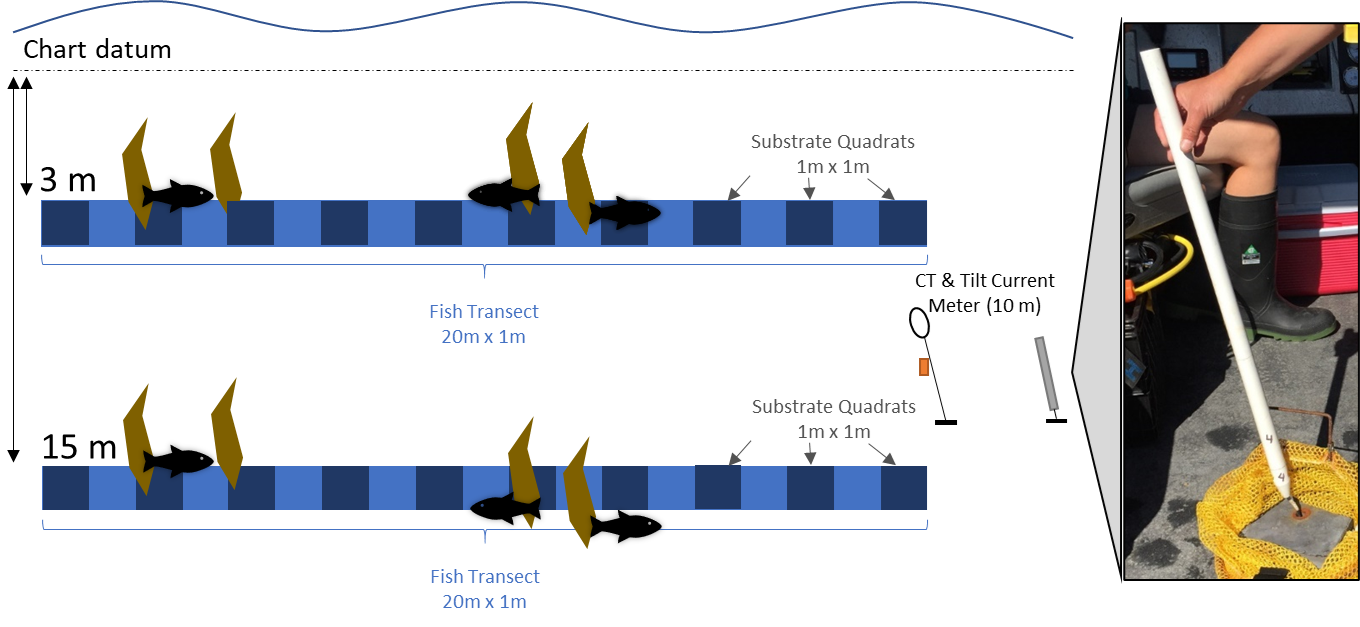


Figure 2: Schematic of fish and benthic data collection protocol. Fish and benthic characteristics were measured at 3 meter and 15 meter depth contours (below chart datum) at each of the 10 sites. Fish were counted and measured in a 1 meter width along the 20 meter long transect (light blue rectangle). Substrate characteristics were recorded in 1 m2 quadrats every 2 meters (10 quadrats per 20 meter long transect, dark blue squares). Sites were surveyed multiple times from October 2019 to March 2020 resulting in replicate transects at each depth. Current, temperature, and salinity data were continuously recorded at 10 meter depth from 16 December 2019 to 26 January 2020 using Tilt Current Meters from Lowell Instruments, LLC and conductivity and temperature loggers from Star Oddi.

## Results

*Abiotic data analysis*

Daily maximum tidal current speeds measured at 10 meter depths over the 41-day collection period (16 December 2019 to 26 January 2020) ranged from 1.81 cm/sec to 118.50 cm/sec over the 10 sites (Figure 3). The Tilt Current Meters can only record speeds up to 120 cm/sec but for them to reach this maximum speed they need to become completely horizontal, which is unlikely to occur since they are positively buoyant. We believe that current speeds at Skthak (Porlier Pass), Xwéxi7es (Grainger Point), and Burial Islet repeatedly exceeded this speed and therefore, the true current speeds are actually higher.

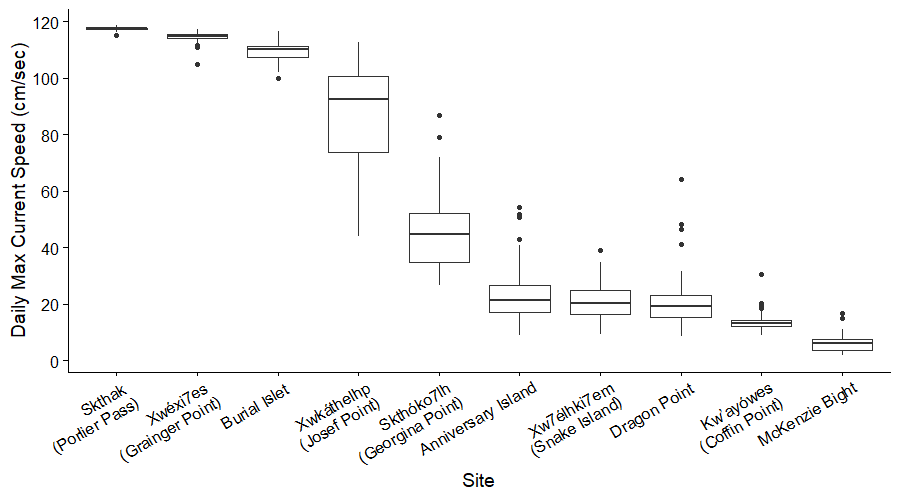


Figure 3: Daily maximum current speeds at each site presented as boxplots, indicating the median and quartiles with whiskers extending to 1.5 times the interquartile range.

Primary substrate type was similar over all sites and depths with rock substrates (bedrock, boulder, and cobble) comprising 89 - 97% of the transects. Gravel, sand, silt, mud, and shell hash substrates comprised the remaining 3-11% of transect primary substrate types.

*Fish species richness, abundance, and biomass analyses*

Across all sites and depths a total of 1,653 fish from 25 species were observed, resulting in a biomass of 210.7 kg. Six species were only observed on 3 meter depth transects and seven species were only observed on 15 meter depth transects (Appendix T1).

A total of 69 transects were completed and the number of replicate transects at each site and depth were not consistent due to logistical limitations (e.g., poor weather, currents, and/or visibility, or personnel and/or boat availability). Individual transect species richness, abundance, and biomass are displayed in Figure 4.

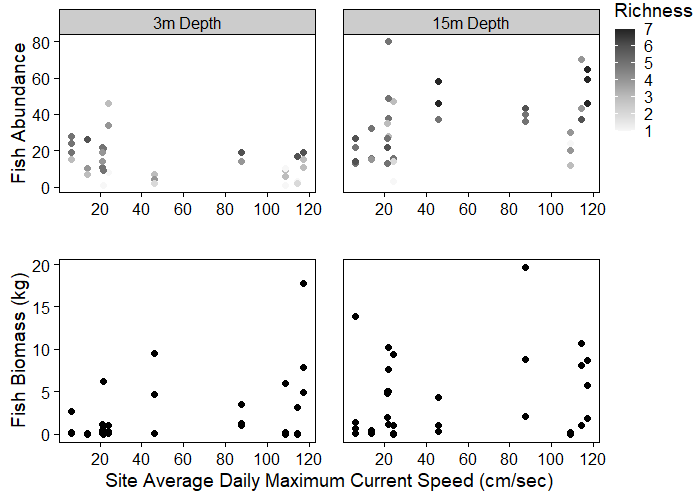


Figure 4: Individual transect fish abundance and biomass at each site average daily maximum current speed. Grey shaded circles in the abundance plot (top) represent the transect species richness (via shade) and abundance (via vertical position), black circles in the biomass plot (bottom) represent transect biomass. The number of replicate transects at each site and depth were inconsistent due to site sampling logistic limitations.

Fish abundance and biomass values for each transect do not necessarily exhibit a positive relationship since the species driving the abundance differences (*Rhinogobiops nicholsii, Artedius harringtoni* and *Jordania zonope)* have a maximum length of 15 cm or less*,* whereas the species driving the biomass differences can reach lengths up to 61 cm for *Hexagrammos decagrammus* or 152 cm for *Ophiodon elongatus*.



*Fish community results*

The fish community composition at the two depths were compared using non-metric multi-dimensional scaling (nMDS) plots (Figure 11). The transect depth communities do not overlap, but the moderate stress value (0.166) of the nMDS plot indicates the dissimilarities between replicate transects may not be well represented by the 2-dimensional plot. The analysis of similarity (ANOSIM) test results indicate there is no significant difference between depth communities (*p*-value = 0.001, *R* statistic = 0.082); an *R* statistic close to 0 indicates community similarity and a value close to 1 indicates community dissimilarity, with the *p*-value measuring how likely that result is over 999 permutations.

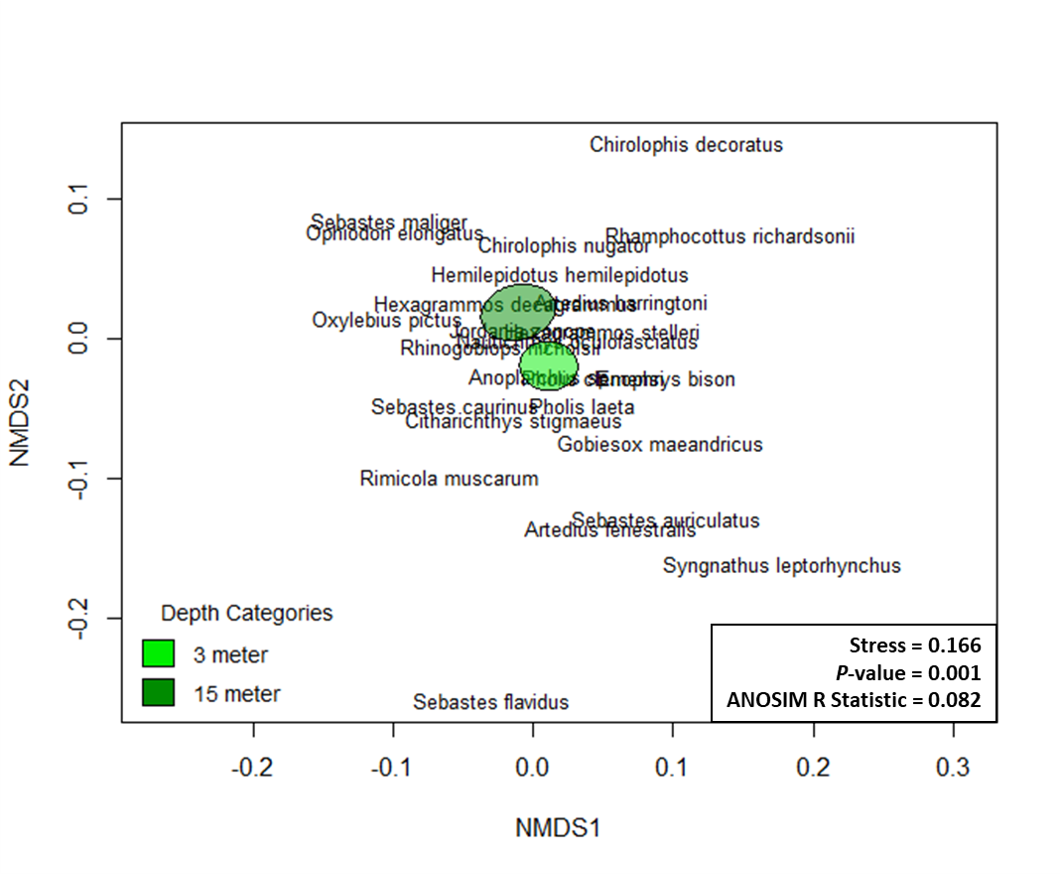
****

Figure 11: Non-metric multi-dimensional scaling (nMDS) plot of the Gower dissimilarity measure of fish community dissimilarities for current category or depth transects. Each symbol represents a replicate transect. The shape represents the transect depth (circle for 3 meter depth and triangle for 15 meter depth) and colour represents current category (blue for low current and red for high current).

*Fish life history analyses*