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Ecological effects of overwater structures on subtidal kelp, northern Puget Sound, Washington

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Ecological Impacts of Overwater Structures on Subtidal Kelp
Northern Puget Sound, Washington

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INTRODUCTION

Kelp (*Order Laminariales*) are a foundation species in the Puget Sound (Kain, 1989) providing many essential ecosystem services including buffering of wave energy, decreasing beach erosion, and serving as habitat, nursery, and foraging ground for a great number of species (Springer et al., 2007). In the Sound, only the two canopy-forming, floating kelp have been extensively researched, leaving a substantial lack of data on the 23 subtidal species found there (Mumford, 2007; Bartsch et al., 2008).

There are more than 9,000 overwater structures such as docks and piers in the Puget Sound (Rehr, 2014) that potentially impact kelp viability, principally through reductions in photosynthetically active radiation (PAR) caused by shading (Mumford, 2007). The Washington Department of Fish and Wildlife (WDFW) routinely encounters costly permit appeals for not adequately considering subtidal kelp when issuing Hydraulic Project Approval (HPA) permits for such structures (Sound Action, 2014).

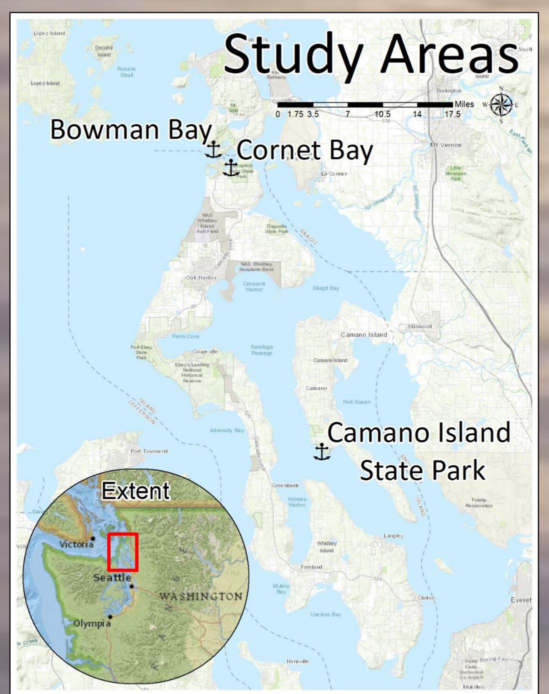
This research has developed a rapid subtidal kelp monitoring protocol for the Washington State Department of Natural Resources (WDNR) that will help expedite WDFW HPA permitting decisions, potentially reducing permit appeals. To determine how overwater structures affect productivity and distribution of subtidal kelp, pairs of dock and control sites were sampled once during the early summer, and once during the late summer of 2017. Statistical analysis revealed significantly less kelp coverage and biomass at docks than their paired controls, as well as significant differences in several related environmental conditions.

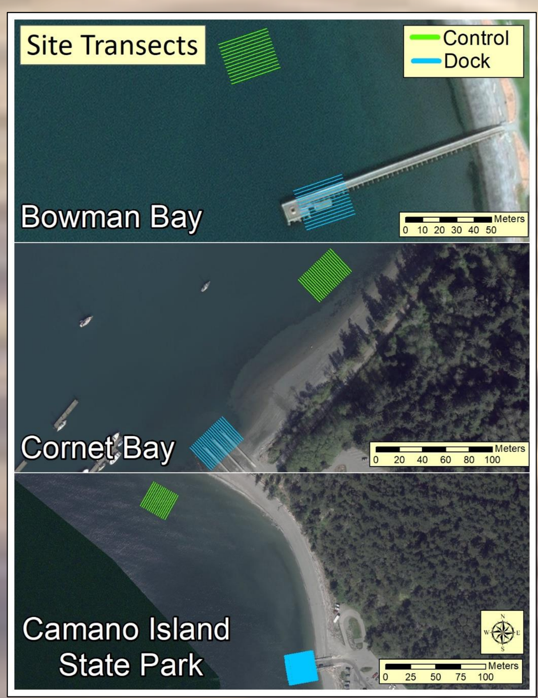
OBJECTIVES

1. To measure the density, distribution, and productivity of kelp beds at impact sites with overwater structures and paired control sites.
2. To measure potential environmental controls for subtidal kelp distributions at each site including light availability, depth, and substrate.
3. To determine differences in fish activity between the impact and control sites.

STUDY AREA

- Bowman Bay, Deception Pass State Park, Washington (BB).
- Cornet Bay, Deception Pass State Park, Washington (CB).
- Camano Island State Park Boat Launch, Washington (CI).
- Existing overwater structures in each area served as impact sites with control sites established nearby (within 200 meters) at equivalent depths ranging from 1.5 meters to 3.4 meters, MLLW.
- Two meter survey transects were created out to eight meters from each dock and were replicated in the controls.



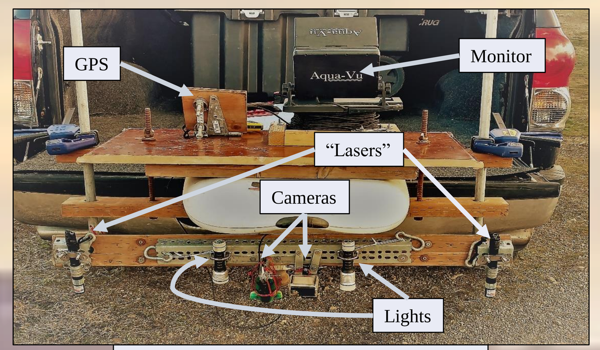


METHODS

VIDEO-GEOREFERENCED KELP SURVEY

- A floating research platform, with three meter depth adjustable survey array, was created featuring:
  - GPS and live feed camera monitor
  - Aqua-VU™ camera for live feed
  - GoPro™ camera for recording benthos
  - One spot and one flood light for illumination
  - Two lasers projecting parallel green beams at one meter apart for scaling imagery.
- The transects were followed on the GPS while it simultaneously recorded positions of the video.
- The GoPro™ camera recorded the seafloor and projected lasers for horizontal spatial reference.
- The depth of the survey array was manually adjusted.

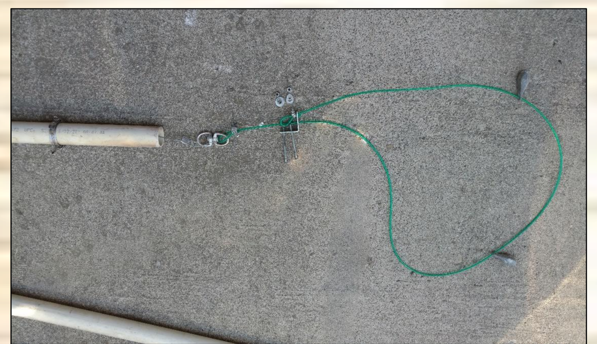
The floating research platform for video survey



Construction of research platform

BIOMASS SAMPLING

- To enable subtidal kelp biomass sampling from the boat, a "lasso sampler" was created with threaded PVC segments, weights, stoppers, a swivel, and coated wire calibrated to ¼ m^2.
- The sampler was lowered to the seafloor with the lasso open, encircling benthic species.
- After pulling all slack from the wire, the sample was lifted from the benthos. If no sample was present a second attempt was made.
- Thirty samples were collected from each site. Only kelp species were retained.
- Samples were bagged, labeled, placed on ice, and transferred to CWU's Aquatic Systems and Hydrology Lab for wet-weight measurements.
- Morphometric measurements recorded species, stipe count, and blade lengths and widths from five random samples at each site.
- Five samples were retained from each site to be dried for determining a dry-weight to wet-weight carbon content ratio.



Lasso biomass sampler's internal construction

SUBSTRATE SAMPLING

- A ¼ m^3 Petersen grab was dropped from the boat to collect substrate samples.
- Nine samples were collected at each control site: 3 at each end and 3 in the center of the transects.
- 15-18 samples were collected at each dock site in an array 2.5 meters and 5 meters from the dock.
- Substrate samples were bagged, labeled, and transported on ice to CWU's lab for analysis.
  - Substrate particle size analysis was conducted using standard sieves and a Ro-Tap™ sieve shaker.
  - Cobbles too large for particle size analysis were measured by mean medial axis.
  - Organic content of sediment was determined by organic loss on ignition by heating sub-samples to 550 °C.

Petersen grab used for substrate sampling

FISH ACTIVITY MONITORING

- Smithsonian's Squidpop Protocol (MarineGEO, 2016) was modified to be deployed from a boat for this research:
  - 15 mm circles of squid were attached to 0.6 meter garden stakes
  - A cork float kept the stakes erect in the water while their bases were tethered, at 0.6 m intervals, to a 15 m heavy chain
  - GoPro™ cameras were deployed along the chains to count fish and identify species.
- A Squidpop chain was deployed at every site.
- Bait loss was recorded as all-or-nothing at:
  - One hour after deployment
  - Twenty-four hours after deployment, when the Squidpop chains were retrieved.

Saltwater perch feeding on Squidpop

MEASURING LIGHT ATTENUATION

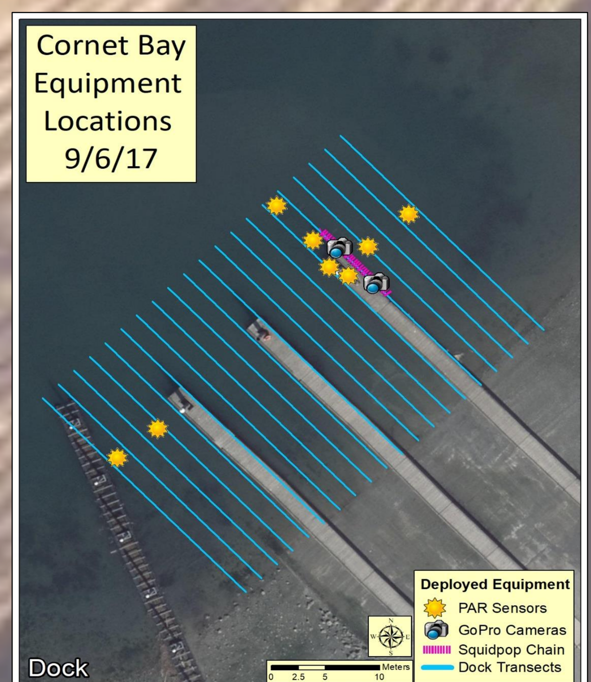
- Eight Odyssey™ submersible PAR sensors were deployed in an array 2.5 m and 7.5 m from each dock at depths ranging from above water surface to ½ m above seafloor.
- Three PAR sensors were deployed in each of the control sites at depths ranging from one cm below surface to ½ m above sea floor.
- Incoming solar radiation measurements were recorded every two minutes for a full tidal cycle and were summed to ten minute intervals.
- Tide levels were retrieved from the University of South Carolina's Biological Sciences Tide and Current Log website (Pentcheff, 2017).

PAR sensor for one centimeter from surface

PAR sensor for one meter from surface

Deployed Squidpops and benthic PAR sensor

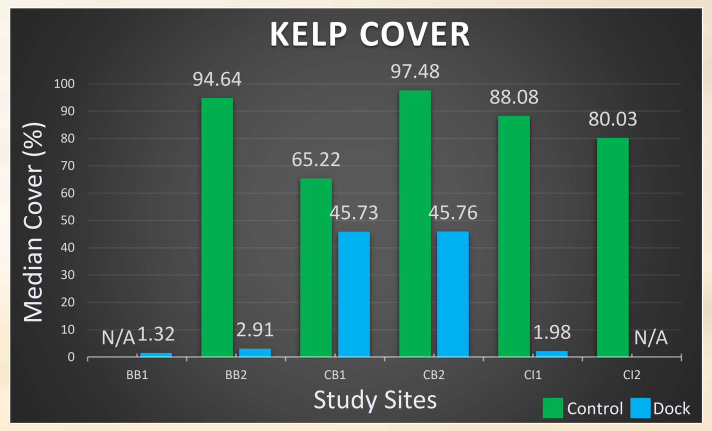
The Results section of this poster features maps of Cornet Bay as an illustrative example. Each site was set up, studied, and analyzed using equipment deployments at respective docks similar to the map below. Equipment was also similarly deployed in a central location at each paired control.



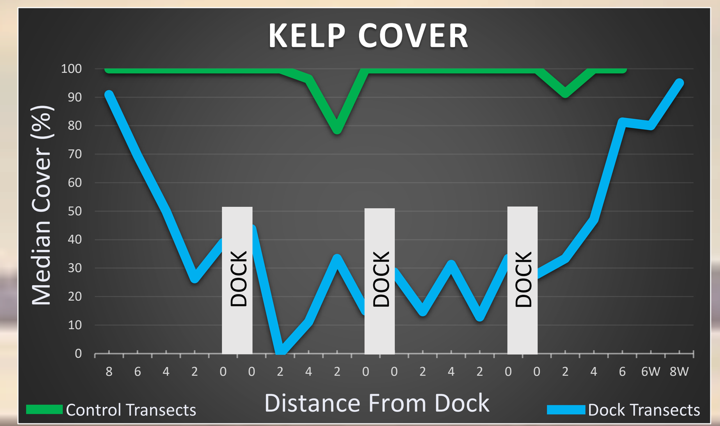
PRELIMINARY RESULTS

VIDEO-GEOREFERENCED KELP SURVEY ANALYSIS

- Using a python script, images were extracted from video at one second intervals and matched with GPS positions by timestamp. These images were viewed to encode 1 m kelp presence/absence grid cells along each transect.
- Dock transects were further analyzed by core (0-4 m from dock) and perimeter (6-8 m from dock).
- Kelp cover ranged from 1.32 % at Bowman Bay dock to 97.48 % at Cornet Bay control.

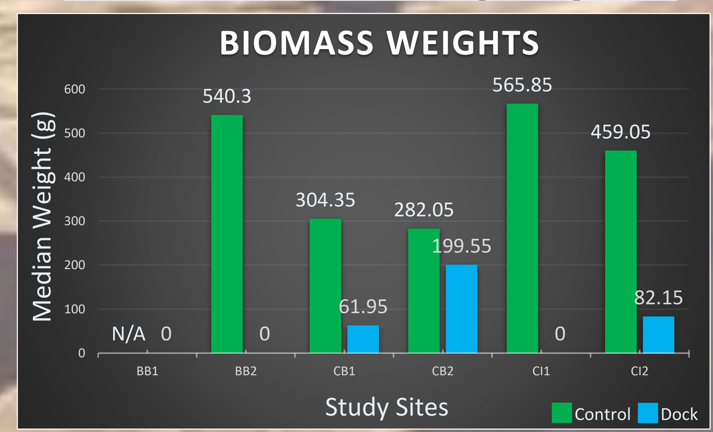


- Only dock data from the early summer visit to Bowman Bay was analyzed as no kelp was present in the control.
- The docks trapped large amounts of detritus as kelp was going into senescence during the late summer visit to Camano Island: making coverage mapping inaccurate.
- With the exception of the late summer visit to Camano Island, kelp cover was significantly less at docks than paired controls at all sites (Mann-Whitney U, $p < 0.05$).



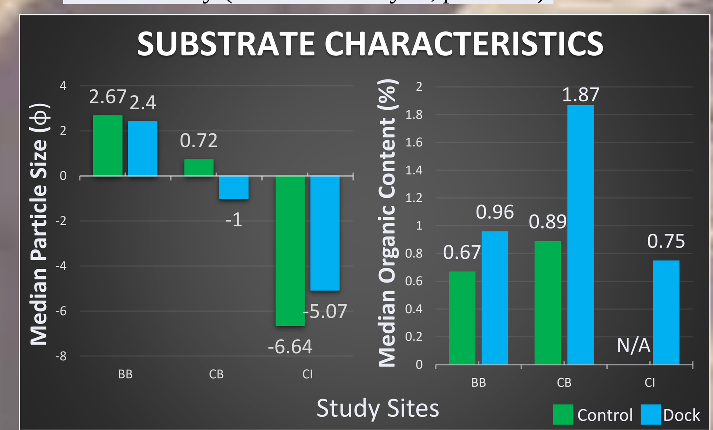
BIOMASS SAMPLING ANALYSIS

- Thirty biomass samples were collected along three transects at each control site and five transects at each dock site. Wet-weight means were calculated by transect.
- Large specimens of kelp were anchored to the floating docks at Cornet Bay and Camano Island.
- There was significantly less kelp biomass at docks than paired controls at all sites (Mann-Whitney U, $p < 0.05$).
- Core biomass weights were only significantly distinct from perimeter and control at Cornet Bay's late summer visit. (Kruskal-Wallis and mean ranks comparison, $p < 0.05$)



SUBSTRATE SAMPLING ANALYSIS

- Particle size was significantly larger at Cornet Bay dock but smaller at Camano Island and Bowman Bay dock than the respective controls (Mann-Whitney U, $p < 0.05$).
- Cornet Bay and Camano Island dock cores had significantly larger substrate particle size than the respective dock perimeters (Mann-Whitney U, $p < 0.05$).
- Sediment analysis only revealed significantly lower organic content in the control than at the dock at Bowman Bay (Mann-Whitney U, $p < 0.05$).

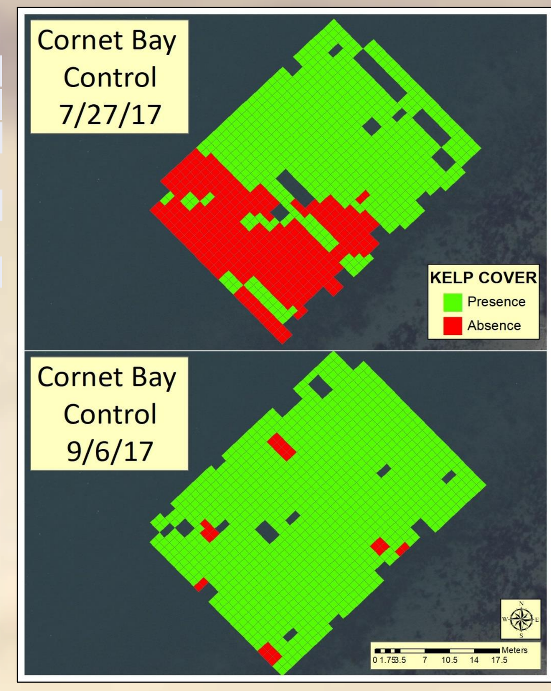


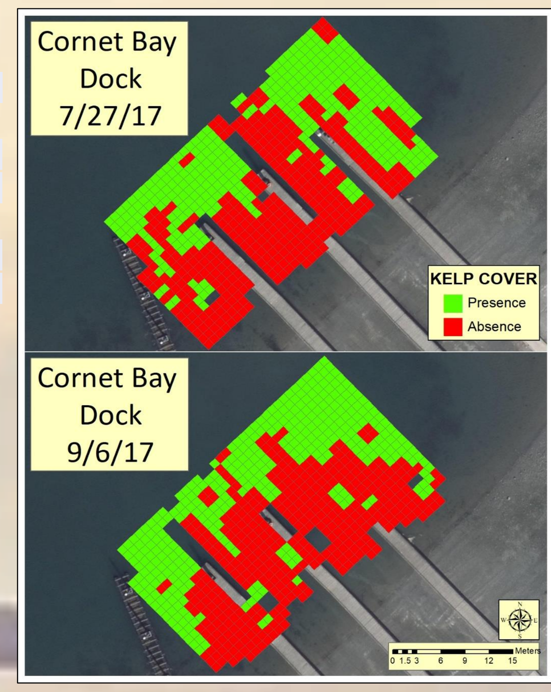
FISH ACTIVITY MONITORING ANALYSIS

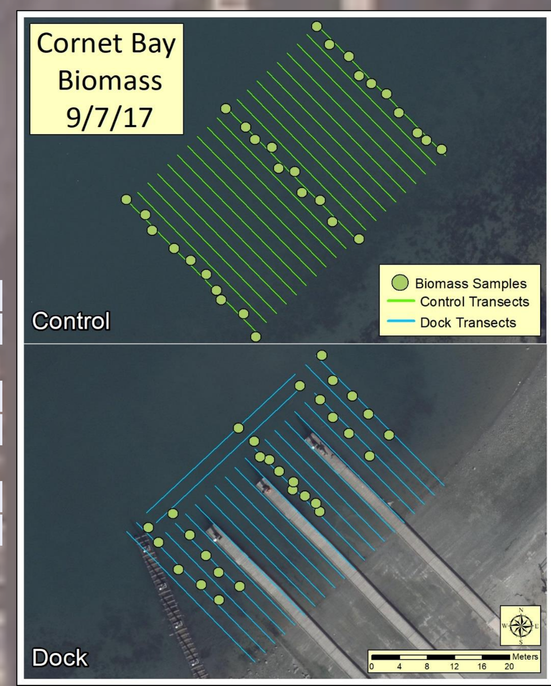
- Significantly more fish were present at two minute intervals at the docks (medians: 0-12) than at the controls (medians: 0-5) at all sites, with the exception of the early summer visit to Cornet Bay (Mann-Whitney U, $p < 0.05$).

LIGHT ATTENUATION ANALYSIS

- Bathymetry data was recorded March 15th and 16th, 2018, for correlation with PAR sensor readings and tide levels.
- Light extinction coefficients are being calculated.







CONCLUSIONS

Significant differences in subtidal kelp coverage across all sites and for both study visits suggest that docks are impacting subtidal kelp distribution in a negative way; as distances from docks increase, so does quantity of kelp.

Kelp coverage and biomass were significantly lower within the 25 foot buffer established under WAC 220-660 for minimum new construction dock distance from existing kelp beds than in paired controls at all sites.

Biomass sampling and morphometric measurements revealed significantly smaller and fewer kelp specimens at each dock than its paired control, suggesting that docks negatively impact kelp productivity in addition to kelp distribution. Nearly all kelp species identified by video survey and biomass sampling were sugar kelp (*Saccharina latissima*), with only a few bull kelp (*Nereocystis luetkeana*) blades and stipes present.

Substrate analysis suggests particle size and organic content has little effect on kelp presence as differences between docks and controls varied by site or were insignificant. The varied results of substrate particle size analysis in this study revealed that, in some instances, kelp were more abundant at control sites with finer grained substrate than at dock sites where the substrate is likely more suitable for kelp recruitment. This further suggests that the shading effects of docks have a negative effect on kelp that outweighs this known preference for coarser substrate. Furthermore, many large specimens of sugar kelp were also found anchored near the water surface to the unshaded portions of floating docks, but not in the more shaded substrates below.

The research platform developed for this project efficiently surveyed potential dock footprints and the 25 foot buffer in approximately 45 minutes. The lasso biomass sampler was effective when the transects were walked or the boat was double anchored. Two meter transects were sufficiently precise for survey, accommodating drift, tidal current, and GPS accuracy.

PROTOCOL RECOMMENDATIONS

- The lasso biomass sampler should be constructed out of a more rigid material like lightweight, metal conduit for biomass sampling by boat at depths greater than two meters.
- Green lasers were effective for scaling imagery but would be improved by using a higher wattage.
- Using a single camera for live feed and recording would improve minor discrepancies in live field of view versus recorded video.
- Standard Squidpop protocol would have been ineffective in this environment without supplementary video recording.
- A further experimental project might be conducted where temporary floating docks constructed with varied decking types, e.g. glass block, metal grating, etc., would be anchored above existing kelp beds to determine which decking material would have the least impact to light penetration and associated kelp productivity.

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Background image: "Dock at Sunset" by tvang83 from deviantart.com

Basemap imagery retrieved from ESRI.

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