

# Restoration of Bull Kelp (*Nereocystis luetkeana*) in the Strait of Georgia

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## INTRODUCTION

Kelp forests play an important ecological role in coastal marine ecosystems by providing habitat for several marine species, and by contributing to primary production and carbon storage (Lamb et al., 2011; Pfister et al., 2017; Siddon et al., 2008). *Nereocystis luetkeana*, commonly known as bull kelp, is a species of kelp that grows and forms extensive forests in nearshore subtidal habitats on the Pacific coast (Schoch and Héloïse, 2004). Bull kelp is an annual species that completes its life cycle within a single growing season and reproduces in the same location from year to year (Dobkowski et al., 2019). Unfortunately, bull kelp has declined in the Strait of Georgia over the past several decades and is no longer found in

locations where previously abundant (Shaw, Heath, Tomlin, Timmer, and Schellenberg, 2018). Reasons for this decline are unclear because factors influencing bull kelp success, such as light, nutrients, and temperature, may never be entirely independent of each other (Dayton, 1985).

To combat this decline, the Mount Arrowsmith Biosphere Region Research Institute (MABRRI) has aimed to re-establish bull kelp beds within the Strait of Georgia by installing bull kelp enhancement plots; this is conducted using the methods established by Project Watershed for their bull kelp enhancement plots off Hornby Island. The purpose of the enhancement plots is

to deploy rope that is pre-seeded with bull kelp, allowing bull kelp to grow on the lines, ultimately dropping spores in the surrounding area, and regenerating self-sustaining kelp forests (Heath and Chambers, 2014). In March 2018, MABRRI installed enhancement plots at two sites: the first located within the United Nations Educational, Scientific, and Cultural Organization (UNESCO) designated Mount Arrowsmith Biosphere Region, off the coast of Winchelsea Islands, and the other located northwest of Dodd Narrows in the Northumberland Channel (Shaw et al., 2018). Additionally, in January 2019 MABRRI deployed new pre-seeded bull kelp lines at the same site locations for a second growing season. The work performed by MABRRI, as well as Project Watershed, is an important restoration initiative that aims to contribute to re-establishing bull kelp beds within the Strait of Georgia.

## **METHODS**

One new bull kelp line was deployed at each of the two previously established enhancement plot

sites, located off Winchelsea Islands and Dodd Narrows, British Columbia on January 13, 2019. Methods for deployment of new pre-seeded bull kelp lines were the same as the previous year, which closely followed the methods developed by Project Watershed (Heath and Chambers, 2014; Shaw et al., 2018). To deploy a new bull kelp line, spools of thin string that were pre-seeded with *N. luetkeana* were wrapped around a 30-meter long and 19-millimetre diameter polysteel floating rope that was attached to large concrete anchors on either side. The new kelp line for each site was aligned parallel to the old kelp line by deploying the new concrete anchors above the old concrete anchors, which were marked by buoys. Bull kelp lines at both sites were approximately 9 to 10 meters deep.

Following kelp line deployment and over the course of the growing season, May 26th to August 23rd, 2019, SCUBA divers monitored the growth of the bull kelp. Nylon cable ties were attached to each new bull kelp line in intervals of five meters and the individual plants growing at

each cable tie were measured for stipe length throughout the growing season. In addition, divers video surveyed the kelp by swimming along each kelp line with a GoPro™.

To monitor the potential influence of the enhancement plots on the surrounding biodiversity, fish and invertebrate species seen in the video surveys of the kelp lines were documented. In addition, during each dive, a one-meter squared quadrat was placed in three known semi-permanent locations at each site. Quadrat locations were established by placing bright yellow L-shaped cement blocks on the seafloor in three locations along each new line. The quadrat was placed in the same position at each of the six locations, three at each site, by wedging the bottom left-hand corner of the quadrat in the “L” of the yellow blocks. The quadrats were also video surveyed by GoPro™ and species of fish and invertebrates, as well as other species of kelp, were cataloged from the videos.

Water profiles were collected at each site location using a YSI Pro DSS sonde. A water profile was collected at each site in two locations: an inner site that was approximately 7 metres deep and an outer site that was approximately 16 metres deep. Inner sites were located near the bull kelp lines and outer sites were deeper and further away from the lines. Sonde measurements were taken at intervals of one meter until the seafloor was reached.

## **RESULTS**

### **Kelp growth**

Our visual surveys indicated a general increase in bull kelp biomass over the growing season at both sites. Most of the kelp at both sites were visible at the surface during low tide by the fifth site visit on August 10, 2019 (day 76). However, no kelp was present by the final dive on August 23, 2019 (day 89) at the enhancement plot off Winchelsea Islands while approximately half of the kelp appeared to be present at the surface at the Dodd Narrows site.

Over the course of the study, four of the six kelp measured at the enhancement plot off of the Winchelsea Islands were present up to day 76 (5th site visit) and grew an average of 0.7 cm/day, reaching a maximum average height of 99.8 cm. The remaining two kelp that were measured were only present up to day 55 (4th site visit) and grew an average of 0.7 cm/day, reaching a maximum average height of 86 cm. By the sixth survey, no kelp were observed on this line at this site.



Figure 1. SCUBA Diver measuring bull kelp at Dodd Narrows site (MABRRI, 2019).

At the Dodd Narrows enhancement plot, only four of the six bull kelp marked with cable ties to be measured were still attached to the line when the initial stipe lengths were measured. Of those

four kelp, two of them were still present during our final site visit; they grew an average of 9.8 cm/day and reached an average maximum height of 894.5 cm.

The bull kelp that was transplanted at each site in 2018 did see *sori* (spore) development, however there was greater *sori* development in 2019 at the Dodd Narrow site than in 2018. We are unable to compare for the Winchelsea Islands site due to grazers consuming the bull kelp and not allowing it to fully mature in 2019.

## Biodiversity

At the time of deployment when no kelp was present, no species of fish were observed during video and diver surveys of the kelp lines at the Winchelsea Island site. As bull kelp began to appear on the lines, juvenile rockfish (*Sebastes sp.*) were observed swimming around the kelp. Rockfish abundance continued to increase in numbers at this site with an increase in kelp biomass. Similarly, species of perch, pile perch (*Rhacochilus*

*vacca*) and shiner perch (*Cymatogaster aggregata*), increased in abundance with an increase in kelp biomass. Once the kelp had reached a mean height of approximately three meters, schools comprised of more than 50 individuals of Pacific herring (*Clupea pallasii*) were observed swimming around the kelp. Schools of herring also appeared more frequently as the kelp continued to grow. Kelp crabs (*Pugettia producta*) were periodically observed at low densities on the kelp at the Winchelsea Islands site throughout the season as well. At the Dodd Narrows site, no fish species were observed during the video and diver surveys at the time of the line deployment and when no kelp was present. However, as the kelp grew, more fish species were observed at the site. Although species of perch and herring were observed during diver and video surveys once kelp appeared. Overall, based on video surveys, fish biomass over time appeared to be less at this site in comparison to the Winchelsea Islands site.

Species observed within the quadrats, appeared to remain consistent throughout the course of this

study at both sites. Therefore, no apparent change in biodiversity was observed in the quadrat video surveys before and after kelp growth at either site. Common species of algae that were observed at the Dodd Narrow site were Turkish towel (*Chondracanthus exasperatus*) and sugar kelp (*Laminaria saccharina*). Common species of algae that were observed at the Winchelsea Islands site were rock weed (*Fucus vesiculosus*) and sea lettuce (*Ulva lactuca*). Common species of invertebrates observed at the Dodd Narrows site were Ochre sea stars (*Pisaster ochraceus*), leather sea stars (*Dermasterias imbricata*), and giant California sea cucumbers (*Parastichopus californicus*). Common species of invertebrates observed at the Winchelsea Islands site were purple sea urchin (*Strongylocentrotus purpuratus*), giant California sea cucumber, and frilled dog whelk (*Nucella lamellosa*). Common species of fish that were observed at the Winchelsea Islands site were black eyed goby (*Rhinogobiops nicholsii*). No fish species were observed in Dodd Narrows quadrats during video surveys.

## Temperature

In 2019, the sea surface temperature (SST) reached a maximum of 14.8°C and a minimum of 12.3°C across both the inner and outer sites at Winchelsea Islands throughout the summer months (Figure 1). The maximum difference in SST measurements between the inner and outer sites at Winchelsea on a given day was 0.2°C. The SST reached a maximum of 12.9°C and a minimum of 11.1°C across the inner and outer sites at Dodd Narrows (Figure 1). The maximum difference in SST measurements between the inner and outer sites at Dodd Narrows on a given day was 0.1°C.

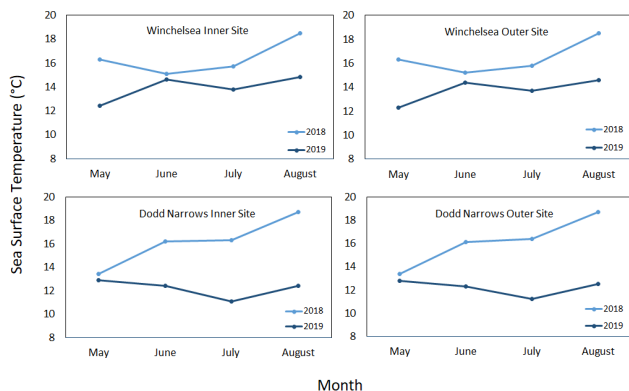


Figure 2. Sea surface temperatures (SST) (°C) of inner and outer sites at MABRRI's bull kelp enhancement plots located near the Winchelsea Islands and Dodd Narrows, British Columbia.

SST measurements were taken at a depth of 1m with a YSI Pro DSS sonde.

SSTs in 2019 were consistently lower every month at the inner and outer sites of both the Winchelsea Islands and Dodd Narrows sites when compared to the 2018 summer months (Figure 1). In 2018, SST had a maximum value of 18.5°C and a minimum of 15.2°C at the Winchelsea Islands site. At both the inner and outer sites at Dodd Narrows, SST reached a maximum of 18.7°C and a minimum of 13.4°C.

## Discussion

Overall, the 2019 growing season was successful; an abundance of bull kelp grew at both sites. In 2018, the bull kelp on the lines did not grow from seed, they were established via a transplant (Shaw et al., 2018). It is unclear why the bull kelp seeded lines did not grow in 2018, however it may have been a result of a much later planting than that of 2019 (March versus January), in combination with variations in factors affecting

bull kelp growth. Some considerations as to why there was greater success in bull kelp growth in 2019 versus 2018 could be the apparent variations in the sea surface temperature between the growing years. Sea surface temperatures in 2019 were consistently lower at both sites, which may have reduced thermal stress on the kelp and supported more successful growth. However, more years of data are required to confirm this hypothesis.

Through the video surveys of the kelp lines at both sites, the surrounding fish biodiversity near the enhancement plots appeared to have increased over time as the bull kelp increased in abundance and length. This suggests that the bull kelp at our sites were successful at providing habitat for organisms in the surrounding area. However, no apparent change in biodiversity was observed in the quadrat video surveys, suggesting that the kelp had no effect on surrounding local benthic invertebrates. Again, more years of data are required to draw more concrete conclusions.

Although during our final dive there were more bull kelp individuals being measured for stipe length at our site near Dodd Narrows, and those individuals had a higher growth rate over time, our video surveys indicated that there were more bull kelp individuals on the line at our site near Winchelsea Islands throughout the majority of the study. We recognize that our sample size of bull kelp individuals measured for stipe length was small and more individuals should be measured during the next growing season to better indicate those differences. This number was chosen due to the uncertainty of the bull kelp success rate using the pre-seeded line method and attaching the nylon cable ties before growth had begun.

The team at MABRRI will be deploying new lines for a third growing season in 2020. We will continue to monitor bull kelp growth over time and aim to quantify its effects on the surrounding areas. In addition, more years of data are needed to observe if the planted bull kelp is able to replenish itself. By collecting more data, this will also help us understand site effects and determine

the most suitable locations within the Strait of Georgia to implement these techniques and establish a more robust network of bull kelp enhancement plots. Long term efforts to support reestablishing bull kelp through enhancement plots will require further funding and support. Expanding upon our existing network of plots will further increase habitat availability for a variety of organisms, while contributing to a better understanding of the results of this study.

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