
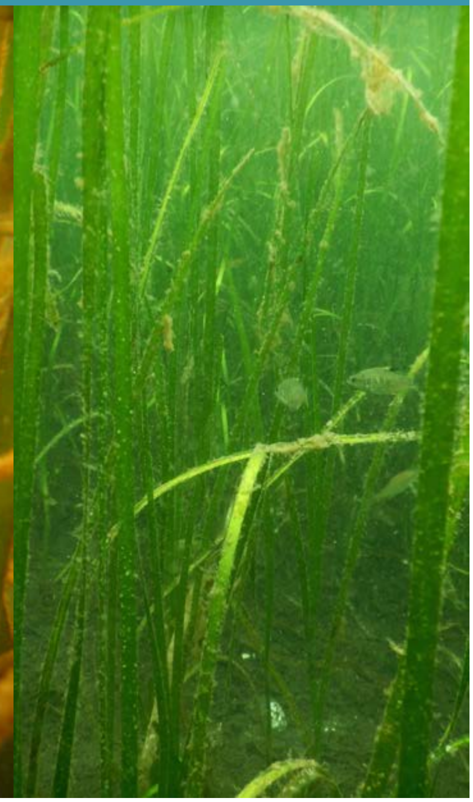

Oak Bay Eelgrass Inventory

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Executive Summary

The importance of seagrass to nearshore health and ecology is comparable to tropical coral reefs, but its decline is more drastic. In British Columbia, the major species of seagrass is *Zostera marina*, commonly known as eelgrass, which grows in estuaries and quiet bays. Four percent of the province's coast is suitable for eelgrass growth, making it vital to protect existing meadows. Eelgrass meadows serve as nurseries for young salmon emerging from streams and rivers. As well, rockfish, crabs, starfish and a myriad of other invertebrate and fish species spend part of their lifecycle in eelgrass. Great Blue Heron and Brant geese depend on eelgrass meadows for foraging. The District of Oak Bay Environmental Advisory Committee requested SeaChange Marine Conservation Society to survey existing eelgrass habitats along the coastline of the municipality. In late August of 2014, SeaChange initiated the survey with a Grant-in-Aid from the District of Oak Bay and leveraged funding from the Pacific Salmon Foundation.

Oak Bay supports a healthy population of eelgrass meadows. Seventy-eight percent of the eelgrass is continuous meadows and 22% is patchy habitat. In some areas the plant grows to over 9m below the low tide line. The maximum depth to which eelgrass can grow depends upon the clarity of the water. The average depth in the Salish Sea is approximately 0m to -7m. The depth of eelgrass growth in the waters surrounding Oak Bay, then, may indicate good water quality.

Eelgrass habitat surrounding the Oak Bay marina is most impacted where moorings scour the bottom and prevent growth. There may be opportunities for community participation in restoring a small site in this area to encourage growth in suitable substrate.

It is recommended that educational outreach addresses issues such as boat anchoring in eelgrass beds and scouring by boat anchors and the input of detergents, chemical and microplastics into the marine waters through stormwater outlets.

This report summarizes work done between 2014 and 2015 to map eelgrass beds in Oak Bay. The Study Area is delineated in Appendix A (**see Study Area Map 1, pg. 24**). The methodology is described under Appendix B. A set of recommendations is included in this report to support land use decisions and policy that may protect and enhance eelgrass meadows and the diversity of associated species within the Oak Bay municipality.

1.0. Introduction

1.1. A Case for Conservation of Seagrasses

Seagrasses are rooted aquatic plants that grow in estuaries and along low wave energy shorelines throughout the world. They have important influences on biogeochemical cycling, sediment stability, and food web support (McGlathery et al. 2007; Orth et al., 2006). Seagrasses can form extensive meadows supporting high biodiversity. The global species diversity of seagrasses is low (~60 species). Across the globe, however, seagrass meadows cover about 177,000 square kilometers of coastal waters – larger than the combined area of the Maritime Provinces (Short et al, 2007).

Land use developments within watersheds have led to a loss of estuarine and nearshore marine habitats in British Columbia - the receiving waters of land based activities. Agricultural and forestry practices, dredging for commercial and residential development and stormwater pollution have contributed to the loss of estuarine habitat, including eelgrass (Durance 2002). The pressure to modify natural marine features and habitat for the development of commercial facilities and residential units within coastal areas is intensifying as population increases along the coast. It is possible for local governments to meet both shoreline development and ecological resiliency goals and has been demonstrated using soft armoring techniques at a cost savings of 30-70% compared to hard shoreline armoring (Lamont et al. 2014).

Coupled with the expected effects of climate change it is critical to conserve and protect the resiliency of nearshore habitats like eelgrass. Mapping the location and extent of eelgrass meadows are important steps towards conservation and establishing a baseline for monitoring health over time.

1.2. Ecology and Biodiversity

Two species of eelgrass occur in British Columbia—the more productive, native species, *Zostera marina,* and the introduced *Zostera japonica,* or Japanese eelgrass (pictured right: the smaller *Z. japonica* mixes with *Z. marina*). Both species are vascular plants that grow in relatively shallow and protected marine areas, but *Z. japonica* typically grows higher in the intertidal zone than *Z. marina*. The two species are not considered competitive for the

Photo credit: Alison Prentice

same space. The eelgrass inventory reported here, focuses on the native species (although no *Z. japonica* was observed in the study area).

The complex and intricate food webs of an eelgrass meadow provide food and shelter for numerous fish and invertebrates. The productivity of native seagrasses rivals the world's richest farmlands and tropical rainforests. From an unstructured muddy/sandy bottom grows a myriad pattern of leaves that supply nutrients to salmonids and other fish, shellfish, waterfowl and about 124 species of invertebrates.

The plants offer surface area for over 350 species of macroalgae (large algae plants) and 91 species of epiphytic microalgae (small algae living on the surface of the eelgrass blades) – the basis of the food web for juvenile salmon in marine waters (Phillips 1984). Often referred to as "salmon highways", nearshore marine environments containing eelgrass beds are home to over 80% of commercially important fish and shellfish species, including all species of salmon, at some point in their life histories (Durance 2002).

Photo credit: Tavish Campbell

1.3. Ecosystem Services

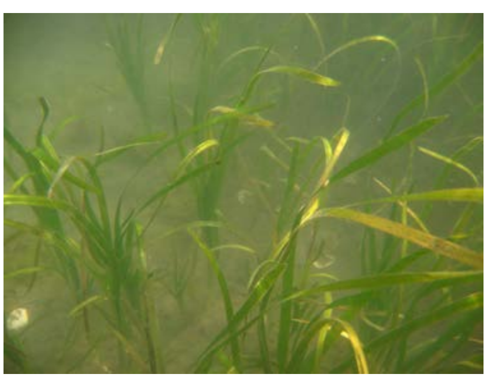


Photo credit: Jamie Smith

Ecosystem services are the benefits provided by the land, air, water and subsurface materials of the earth. Eelgrass habitats within the lower reaches of the Salish Sea provide carbon sequestration and storage, habitat refugia and nursery and nutrient cycling benefits to an approximated natural capital cost of $80,929 per hectare per year (Molnar et al. 2012).

Another ecosystem service eelgrass habitats provide is shoreline stability. Established eelgrass beds reduce currents, leading to increased sediment and organic detritus deposition (Durance 2002). Seventy-eight percent of the eelgrass beds surrounding Oak Bay are continuous, providing a buffer for incoming wave energy.

The more eelgrass beds are fragmented by physical structures (e.g. boats, wharves, docks and overwater play structures), the less they serve as erosion buffers. Where shorelines are constrained by development or structures to prevent erosion (e.g. rip rap, sea walls), natural coastal features will be squeezed out. Maintaining shoreline infrastructure and development will require increasingly expensive engineering measures (Mumford 2007). Pre-emptive planning for these changing conditions is necessary to protect settlement areas and shore features recognized for their natural and ecosystem services.

1.4. Blue Carbon

Eelgrass meadows capture and store large amounts of carbon like terrestrial forests, but at much more efficient rates - up to ninety times the uptake provided by equivalent areas of forest. This “Blue Carbon” is stored in sediments where it is stable for thousands of years. In B.C., roughly 400 km^2 of salt marsh and seagrass meadows sequester as much carbon as B.C.’s portion of the boreal forest, and the equivalent of the emissions of some 200,000 passenger cars (Campbell 2010).

When eelgrass beds are restored, the rate of carbon sequestration appears to be rapid over the first few years and up to 40 years following restoration. The natural transport of eelgrass by currents and wave action to deeper waters in estuaries and the coastal ocean may further sequester more carbon (Thom et al. 2011).

As ocean waters warm as a result of climate change (up to 5 C° during the spring), greater flowering as well as faster growth of eelgrass shoots has been observed. Both of these changes result in greater biomass, or living matter. Like marshes, much of the eelgrass biomass is under the substrate, indicating that a warming environment may result in greater carbon accumulation rates (Thom et al. 2011).

2.0. Eelgrass Habitat Characteristics

Eelgrass meadows are found in most of the world’s coastal temperate regions except at extremely high latitudes. Physical and chemical factors affecting *Zostera marina* include temperature, light availability, elevation, substratum, wave action, salinity and pH. Worldwide, the plants survive under a wide range of water temperatures, from 0° to greater than 30°C. The optimum temperature for growth lies between 10° - 20° C in most areas (Phillips 1984). Eelgrass grows best within the Salish Sea in salinity ranges of 20 ppt - 32 ppt. It can tolerate periods of freshwater inundation on a seasonal or daily basis (Durance 2002). Eelgrass prefers calm bays with sandy and/or muddy bottoms but is also found in higher current areas and coarser substrates with a mix of sand or mud.

Of all the above factors, light availability and elevation may be the most crucial. Light availability seems to be the primary factor limiting depth, distribution, density, and productivity of eelgrass meadows within their salinity and temperature ranges. In the Pacific region eelgrass grows from the intertidal zone to -10m (below zero, chart datum). The lowest depth range for eelgrass in the Salish Sea is typically between -5 and -7m. Although subtidal (below zero chart datum) eelgrass is more common than intertidal, there is anecdotal evidence that intertidal eelgrass is in decline.

3.0. Human Impacts

Photo credit: Friends of Semihamoo Bay

Human impacts on eelgrass and other seagrasses include:

• Dredging and filling associated with marina construction, which is one of the primary reasons for loss of eelgrass beds (Levings and Thom 1994)
• Turbidity, smothering and anoxia (lack of oxygen) from woody debris generated by forestry activities such as log dumps and log booms (Phillips 1984, BC/Washington Marine Science Panel 1994)
• Pollution, which is of particular concern in sheltered areas with poor water circulation. This includes:
    - Eutrophication (excessive nutrient enrichment) in streams that provide needed freshwater and sediment input to eelgrass beds. This can result in reduced oxygen input for the beds (BC /Washington Science Panel 1994)
    - Chemical pollution and road runoff which can affect sediment health (BC /Washington Science Panel 1994)

- Toxins such as heavy metals which can be taken up by eelgrass and have cascading effects through the food web (Lyngby and Brix 1989)
- Oil pollution, especially in late summer or winter when it can be retained and enter into the intertidal zone by mats of drifting eelgrass blades. In spring this oil pollution can affect eelgrass seed production and viability (Beak Consultants 1975)

• Shading, physical damage and disruption of water movement by overwater structures such as docks (Fisheries and Oceans Canada 2003)
• Effects of boating, including damage by propellers, anchoring and bottom dragging by chains and poorly-affixed moorings

Climate change can be expected to change the extent and densities of eelgrass habitats. One of the expected effects of climate change is landward movement of nearshore habitats as sea level rises (Nicholls et al. 2007). Shoreline alterations that remove nearshore habitats will impede this landward movement. Erosion and resulting sedimentation is an expected result of sea level rise. Depending on the extent and rate of sedimentation this could either create eelgrass habitat or smother the beds. Erosion and scouring of the nearshore are exacerbated by shoreline developments such as seawalls and other hard structures. Wave energy strikes these structures and reflect back onto the beach, accelerating the transport of sand and small gravel into the water and exposing coarser sediment, unsuitable substrate for vegetation such as eelgrass.

Conservation of continuous eelgrass beds and the integrity of adjacent habitats will both protect the beds themselves over time and limit the overall effects of climate change.

4.0. Methodology

Photo:SeaChange research boat with towed underwater camera

A standardized methodology was used for mapping eelgrass in Oak Bay which has been utilized province-wide since 2002 (Appendix E, pg. 33). The eelgrass inventory for this project entailed determining the extent (area) of *Z. marina* with an underwater towed camera, GPS and a motorized boat. The edges of the eelgrass bed were determined by running transects perpendicular and parallel to shore. Characteristics of the habitats were recorded along these transects. To geographically delineate the eelgrass beds a Trimble Pathfinder ProXR GPS was used which achieves an average horizontal precision of +/- 0.691 metres.

4.1. Habitat Attributes

The following characteristics were recorded during the survey:

Distribution

The distribution of eelgrass within the bed is described for this inventory as either patchy or continuous. Patchy beds are those that contain isolated groups or patches of plants. Beds that are not patchy are classified as continuous; a bed that contains bare patches surrounded by eelgrass is classified as continuous (Appendix E, pg. 34). The boundary of a bed is determined by a shoot density of less than 1 shoot per square meter.

Form

There are two basic forms of eelgrass beds in the Pacific Northwest: fringing beds that occur as relatively narrow bands usually on gentle slopes, and more expansive beds that cover large areas such as tidal flats known as “flat” beds (Durance 2002). Inter-annual variation within a bed is not well known, but appears to be less than ten percent (Dowty et al. 2005). Fringing beds are generally linear. Flat beds are areas of large eelgrass beds in embayments that extend deeper than fringing and more linear beds found along shorelines (Dowty et al. 2005).

Sediment Types

When possible, field observers rated the primary, secondary and tertiary occurrence of substrate types: sand, mud, pebble and cobble. A subtidal environment dominated by cobble might indicate a habitat more suitable for large kelps, which would shade any eelgrass shoots growing between the cobble during the summer months. A predominately sandy muddy bottom would support continuous eelgrass meadows in most cases, unless other factors are present, such as exposure to strong waves or the interruption of habitat by boat mooring buoys. In some cases substrate characteristics change with increasing depth (e.g. cobble to sand or mud to cobble).

Percent of Cover

Percent cover was estimated in broad categories to increase accuracy of observation (<25%, 26-75%, >75%). The coverage of an eelgrass meadow reflects both the substrate and the flow of water through it. A calm environment with a sandy mud substrate generally supports a dense, continuous eelgrass bed with virtually 100%

cover. The cover of eelgrass in areas subjected to strong currents is typically patchy. Areas with heterogeneous substrate (mixture of fine and coarse) also tend to be patchy (Durance 2002). The percent of cover data collected from this inventory is based on subjective approximations as observed through the lens of an underwater camera. The approximate percent of cover offers important information on the density and productivity of a bed.

Tidal Fluctuations

It was important to note whether the tide was running or slack at the time of the inventory. Eelgrass shoots will tend to bend towards the substrate during running tides; the accuracy of percent of cover is then very approximate.

Presence of Other Vegetation

Other types of algae were documented as broad or tuft. Broad algae, such as kelps, sea lettuce and *Laminaria saccharina* can blanket the ocean floor and make it difficult to characterize substrate. These plants can also shade eelgrass in mixed substrates as they anchor to hard surfaces. The presence of kelps, predominately large brown kelps, was noted.

Presence of other vegetation can also explain a decrease in eelgrass density or increase in patchiness. Tuft algae, such as brown and red algae do not shade eelgrass; they indicate presence of hard surfaces for attachment.

Visibility

Visibility of eelgrass is a subjective observation and is rated low, medium and high. In some instances, visibility could impact the accuracy of the observations, namely characterization of substrate. For example, Gambier Island often had low visibility. This can be caused by winds, sediment flows from the lower reaches of watersheds, inputs from nearby streams and tidal/current movements. Observations during low tide periods make for the best visibility.

Comments

Other details were recorded at each waypoint or for each eelgrass bed as applicable, including photograph number; potential threats to eelgrass in the area; backshore characteristics including shoreline developments; observations of Canada geese, which are a threat to eelgrass, and other wildlife; whether the site is suitable but eelgrass was not observed; and whether the site has potential for restoration.

4.2. Survey Limitations

The average horizontal precision for the GPS unit used for the 2014 and 2015 eelgrass inventories was +/- 0.691 metres.

Percent of cover of eelgrass shoots is difficult to assess accurately with an underwater camera but was deemed important to characterize. Areas of particular interest, such as those impacted by shoreline modifications and those with potential for restoration can be further refined from surveys by SCUBA divers.

5.0. Inventory Findings

The shoreline between Gonzales Beach and Willows Beach (**Map 1**)was surveyed by following a 0 to -3m depth contour. This is the depth at which most eelgrass grows. Surveyors noted that the main portion of Gonzales Beach (West of Oak Bay border) is devoid of eelgrass but other seaweeds were observed that appeared to be floating. Further investigation would be required to find out why there was an absence of eelgrass habitat outside the Oak Bay boundary.

The eelgrass meadows surrounding Oak Bay make up 174,604 square metres of nearshore habitat for fish, birds, mammals and invertebrates. Seventy-eight percent of the eelgrass is continuous and 22% is patchy. The dominance of continuous eelgrass indicates that the underwater marine environment of Oak Bay supports a healthy population of eelgrass. These findings are based on the absence of historical data, therefore, the extent of habitat loss due to nearshore construction and other impacts is unknown.

5.1. Gonzales Beach

A small portion of Gonzales Beach that is within the Oak Bay municipal border was surveyed on August 29, 2014 (**see Map 2, pg. 25**). Four polygons were mapped in a cove bound by rocky outcroppings on the eastern shore. All polygons were continuous and fringing and had a primary percent cover of 1-25%. The beds were shallow and flanked by rocky outcroppings. The depth range for each polygon is as follows: Polygon 1 [+0.2m to -3.2m]; Polygon 2 [+0.3m to -0.7m]; Polygon 3 [-0.8m to -2.1m]; Polygon 4 [-0.6m to -4.0m]. There is a mooring buoy placed in Polygon 2.

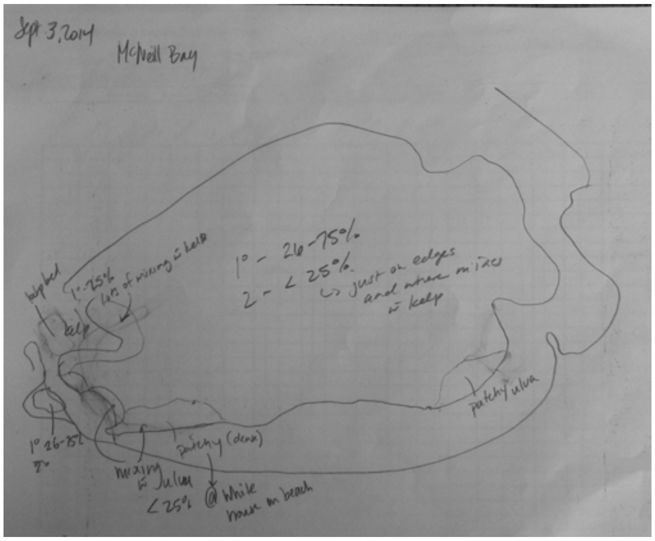
5.2. Trafalgar Park

The eelgrass bed located in the cove adjacent to (West) Trafalgar Park was surveyed on August 29, 2014. This bed was continuous and flat with a primary percent cover of 26-75%, with the exception of a small patchy area on the East side of the cove. The minimum depth of the bed was -1.2m and therefore did not extend into the intertidal zone. The maximum depth was between -6.5m and -7.8m, an indication of good water quality.

5.3. McNeill Bay

McNeill Bay was surveyed on September 3rd and 4th 2014. Overall McNeill Bay supported a healthy continuous and flat eelgrass bed with primary cover being 26-

75%. 1-25% cover was observed where mixing with other algae species occurred. Some bare patches in the bed were observed with no obvious cause.



The field drawing to the left (North is down) illustrates where the rocky substrate was located on the East side and supported kelp growth (rocky) and where mixing of eelgrass occurred. Shoreward areas on the East and West were patchy due to mixing with sea lettuce. It was difficult to ascertain with the underwater camera whether the sea lettuce was attached or drifting.

The average minimum depth of the eelgrass was 0m (at chart datum), therefore the bed did not extend into the intertidal zone. The maximum depth of eelgrass ranged from -5.5m to -9.6m, an indication of good water quality.

Photo credit: Sharon Jeffery

A large school of forage fish (small fish upon which other marine life depend) was observed along with yellow egg masses deposited by the hooded nudibranch (pictured on the left).

5.4. Golf Course

On a small sandy beach in front of the golf course was a small, dense, continuous bed grew from -0.1m on the shallow edge to -2.4m on the deep edge. The primary percent cover was 26-75% and the substrate was sand. Bottom kelp intermingled with the eelgrass.

5.5. Oak Bay Marina

The eelgrass bed between the Oak Bay Marina and Mary Tod Island was surveyed on May 18th and 19th, 2015 (see **Map 3, pg. 26**). The continuous portion of the bed had a primary percent cover of 1-25% and a secondary cover of 26-75%. The patchy portions had 1-25% cover. The substrate was mud or a mud/sand combination, typical of estuarine habitat at the foot of a stream, in this case Bowker Creek.

The average maximum depth of eelgrass facing the marina was -6.0m. The average minimum depth of eelgrass facing Bowker Creek was -1.9m. The eelgrass bed facing Mary Tod Island extended into the intertidal zone and terminated where algae species grew on rocky substrate.

The patchy portions flanking the bed, facing Mary Tod and Bowker Creek, had a significant amount of mixing with bottom kelp (most likely *Laminaria spp.*). Although only the mud/sand substrate was visible, the kelp would have been attached cobble or rock. The patchy part of the bed facing the marina was intermingled with moored boats.

5.6. Mary Tod Island East

Photo shows the area between Mary Tod Island and Oak Bay proper

Eelgrass growing on the North and East side of Mary Tod Island was surveyed on May 19th and July 3rd. It extended East to Emily Islet and North towards Willows Beach. The continuous portion of the bed had a primary percent cover of 1-25% and a secondary cover of 26-75% and a sandy substrate. Eelgrass mixed with bottom kelp throughout most of the bed. The circled area in **Map 3, Inset 1** shows where bed terminated despite the continuance of suitable substrate (sand/mud) and depth (-2.5 to -4.8m) for eelgrass growth. The maximum depth of the Eastern edge of the bed ranged from -5.5m to -7.6m.

The Southern edge of the bed between Mary Tod Island and Emily Islet grew at a maximum depth of -3.8m to -5.5m. The shallower depth of this eelgrass could be explained by exposure from southerly storms and high currents (which were experienced during the survey). The eelgrass that extended towards the shores of Mary Tod Island and Emily Islet terminated at rocky substrate.

A school of tube snouts (example pictured on the right) was observed during the July 3rd survey. Several crab trap floats were also observed in the bed.

5.7. Willows Beach

The Willows Beach eelgrass meadow was surveyed on July 3rd and September 11th, 2015 (**Map 3**). The bed was a continuous and flat bed with a primary percent cover of 1-25% and secondary cover of 26-75%. Sea lettuce (*Ulva sp.*) was seen throughout the bed and increased on the southern half where the eelgrass was sparser. The southern part of the bed tapers off with a maximum depth of -1.4m at the tip and -5.4m at the widest point. From the widest point toward the northern end, the bed narrowed again with a maximum depth range of -4.5m to -1.9m. The northern tip of the bed also had several bare patches (although it was still considered continuous). The minimum depth of the bed was between -0.6m and +0.3m; however, most of the bed did not extend into the intertidal zone.

5.8. Cattle Point

A fringing eelgrass bed growing around the tip of Cattle Point was surveyed on September 11, 2015 (**Map 3**). The bed had patchy and continuous portions with a primary percent cover of 1-25%. East of the boat ramp the eelgrass was noticeably sparser (5-10% cover) and large schools of forage fish and perch were observed. The maximum depth ranged from -5.4m to -7.2m, an indication of good water quality.

6.0. Opportunities for Eelgrass Restoration

Map 3, Inset 1 illustrates a circled area where eelgrass restoration could be considered. As described in the inventory observations, the substrate at this location was mud/sand, suitable substrate for eelgrass, yet it ceased to grow between -2.5m and -4.8m. However, it is not recommended that restoration be initiated where there is unrestricted boat moorage or active dredging.

6.1. History of Eelgrass Restoration

In the Pacific Northwest, the history of success for *Z. marina* transplanting projects was dismal prior to 1985. Initially transplant techniques were developed and successful on the Atlantic coast. However, these techniques were not well suited to the Pacific north coast environment and eelgrass. Many of the early transplants were conducted without a thorough understanding of eelgrass physiology and ecology; the donor stock was not always well suited to the area where they were transplanted, and the biophysical conditions of the transplant sites were not always appropriate for the species (Durance 2001).

Since 1985, knowledge and experience from adaptive management practices have resulted in a higher success rate for focused mitigation and enhancement projects along the Pacific coast (Thom et al. 2001). Factors that led to a higher success rate include the correct selection of physical attributes for the restoration area, including elevation, substrate composition and light and current regime. The selection of the most suitable ecotype or genotype increased the likelihood for success and rate of production. The criteria for success included shoot density and area re-vegetated (Durance 2001).

6.2. Criteria for Successful Restoration

In British Columbia, the criterion for transplant success is based upon the mean shoot density being equal or greater than the area of adjacent natural beds and the area coverage. Projects are thus considered successful if the habitat that was created provided habitat equal in eelgrass productivity (shoot density) to that which it was designed to replace (Durance 2001).

Site selection with the appropriate biophysical characteristics (salinity, sediment type, current velocity, light/depth, temperature, and pH), using suitable plant donor stock (ecotype), using an appropriate transplanting technique and handling the donor plants with care are necessary for successful transplants. Several restoration transplants have occurred in Maple Bay, Cowichan estuary, Saanich Inlet, Pender Island the Sunshine Coast and other areas. Most of the locations have been impacted by historical log storage practices. The majority of these transplants are considered successful based on monitoring of shoot densities and area coverage post-transplant. Monitoring of each site continues for a minimum of 5 years. The restoration work is carried out by an experienced SCUBA dive team in partnership with local community coordinators.

7.0. Recommendations

Globally, eelgrass has been used as an indicator of water quality (Neckles 1994). Often, a bed will decrease or increase in width and length dependent on light availability. The lower depth distribution of eelgrass is related to overall water clarity. Water quality, including water clarity, is affected by land practices and water uses. If, for example, a large scale development occurs on shore near an eelgrass bed, the bed may decrease in size because the water quality in the nearshore is consistently compromised by the increased pollution load, known as non-point source pollution, frequently delivered by the storm water system. When the amount of light reaching the plants is limited by shading from increased sediment or plankton blooms associated with increased nutrients from land activities, eelgrass meadows adapt to the poor light availability through dieback, decreases in density or width and migration to shallower depths.

The population of Oak Bay is approximately 18,000 people (2011 Census). However, non-point source pollution inputs affecting the municipal shoreline include Bowker Creek watershed boundaries (including Victoria and Saanich) and Hobbs Creek watershed boundaries (including Saanich). Although, stormwater collection systems for the District of Oak Bay consist almost entirely of piped systems, CRD's 2014 Stormwater Monitoring Report cited 9 stormwater discharges along the coastline that were rated high for public health concern. Pollutants include high fecal coliform counts, polycyclic aromatic hydrocarbons (PAH's) and heavy metals. "Discharge 307 is near the Oak Bay marina and had PAH concentrations that were 12 times higher than the marine guideline for protection of aquatic life. This discharge was also rated high in 2010, but due to elevated mercury and lead (Capital Regional District 2014; p. 19)." Improving stormwater quality would be an important step in protecting and conserving marine habitats.

The District of Oak Bay has a number of policies and bylaws that benefit eelgrass: the prohibition of private docks, regulation of pesticide use and designated Shoreline Development Permit Areas. The Bowker Creek Urban Watershed Renewal Initiative and the Provincial Riparian Area Regulation also benefit eelgrass by improving vegetative buffer zones along creeks and reducing sediment from entering the bays surrounding Oak Bay. These provisions reflect the high value Oak Bay residents place on the health of the natural environment, as indicated by responses to the Official Community Plan community survey. "In general, Oak Bay residents want to live as harmoniously as possible within the natural world that encompasses Oak Bay and nurture and enjoy desirable plants and animals of the built environment" (District of Oak Bay 2014; p. 45).

Only a small portion of the marine shores in Oak Bay is protected; none are within the eelgrass inventory study area. The Oak Bay Islands Ecological Reserve protects eelgrass communities within its boundaries of Trial Island and Discovery Islands. Rockfish Conservation Areas confer some protection. Sound decisions by Oak Bay Council and an educated public are necessary to protect the functions of the nearshore for all who benefit from their healthy ecology.

A set of recommendations is listed below to contribute to the conservation work of the District of Oak Bay.

7.1. Education

- Educate boaters, coastal residents and visitors about the presence and importance of eelgrass beds.
- Encourage signage at boat ramps reminding boaters to avoid eelgrass beds in shallow water.
- Oak Bay's storm sewer system includes direct outfalls to creeks and the ocean, and combined storm/sanitary sewers. Increase public awareness about the importance of reducing household use of detergents, chemicals and microplastics that flow directly onto marine nearshores through sewer and storm water systems.
- Develop a long-term public outreach nearshore marine education strategies that include new shoreline property owners.
- Promote Green Shores for Homes, a program designed to reduce the impact of residential development on shoreline ecosystems, and help waterfront homeowners restore natural shorelines (Green Shores for Homes).

7.2. Regulatory and Enforcement

- Limit the impact of boating and marina related activities with adverse marine impacts by adopting policies that employ protective measures (Clean Marine BC: Eco-certification Program).
- Create protected marine zones and encourage encourage creation of "No anchoring/mooring" zones where eelgrass grows and in suitable eelgrass areas (based on substrate, depth and observed presence of eelgrass); encourage boat moorings to areas too deep for eelgrass growth.
- Establish marked navigation channels for boat safety and protection of eelgrass. See collaborative initiative in Cowichan Bay (Cowichan Valley Regional District 2012).
- Maintain a coastal riparian zone that will enable inland shift of eelgrass beds.
- Create and implement appropriate setbacks for built structures from the nearshore, considering predicted sea level rise (AECOM 2015).
- Require removal of illegal shoreline modifications; require restoration or removal of aged derelict structures and boats.

7.3. Opportunities for collaboration with other agencies

- Regularly monitor sensitive or vulnerable shorelines and keep monitoring data readily accessible to the public.
- Promote management strategies to mitigate impacts from nearshore activities such as oyster and clam harvesting, boating, anchoring in meadows and near-shore development requiring dredging.
- Promote restoration of natural hydrology (streams and creeks) when opportunities arise.
- Promote restoration of eelgrass habitats where possible.

8.0. References

AECOM. 2015. Coastal Sea Level Rise Risk Assessment. Capital Regional District, Victoria. https://www.crd.bc.ca/docs/default-source/climate-action-pdf/coastal-sea-level-rise-risk-assessment-report.pdf?sfvrsn=0 (accessed 28 January 2016).

BC/Washington Marine Science Panel. 1994. The shared marine waters of British Columbia and Washington: a scientific assessment of current status and future trends in resource abundance and environmental quality in the Strait of Juan de Fuca, Strait of Georgia and Puget Sound of BC State of Washington. Report to the British Columbia / Washington Environmental Cooperation Council by the British Columbia / Washington Marine Science Panel, 169 pp.

Beak Consultants. 1975. Biology oil impact literature review final report 1975. Baseline Study Program, North Puget Sound, Dept. of Ecology, Olympia Washington.

Bostrom C., Bonsdorff E. 2000. Zoobenthic community establishment and habitat complexity – the importance of seagrassshoot density, morphology and physical disturbance for faunal recruitment. Marine Ecology Progress Series 205:123-138.

Campbell, C. 2010. Blue Carbon Report. Sierra Club BC. http://sierraclub.bc.ca/wp-content/uploads/2015/08/Blue-Carbon-British-Columbia-Report.pdf. Pg. 1. (accessed 23 February 2016)

Capitol Regional District. 2014. 2014 Core area stormwater quality report. https://www.crd.bc.ca/about/document-library/Documents/annual-reports/environmental-protection/integrated-watershed-management. Pg. 19. (accessed 23 February 2016)

Cowichan Valley Regional District. 2012. Cowichan Bay VORR and Navigational Channel. http://www.cvrd.bc.ca/index.aspx?nid=1372 (accessed 24 February 2016).

Clean Marine BC. Eco-certification Program. http://georgiastrait.org/work/cleanmarinebc/marinas/certification/ (accessed 29 January 2016).

District of Oak Bay. 2014. District of Oak Bay Official Community Plan. https://www.oakbay.ca/municipal-hall/plans-reports/official-community-plan. Pg. 45. (accessed February 11 2016)

Dowty, P.B. Reeves, H. Berry, S. Wyllie-Echeverria, T. Mumford, A. Sewell, P. and Wright R. 2005. Puget Sound submerged vegetation monitoring project: 2003-2004monitoring report. Nearshore Habitat Program, Aquatic Resources Division, Washington State Department of Natural Resources, Olympia, Washington

Duarte, C.M. 2000. Marine biodiversity and ecosystem services; an elusive link. Journal of Experimental Marine Biology and Ecology. 250:117-131.

Durance, C. 2001. A review and assessment of eelgrass transplant projects in British Columbia. Document prepared for Fisheries and Oceans, South Coast Area. 37.

Durance, C. 2002. Methods for mapping and monitoring eelgrass habitats in British Columbia. Funded by the Canadian Wildlife Service, Environment Canada.

Fisheries and Oceans Canada et al. 2003. Coastal shore stewardship: a guide for planners, builders and developers on Canada's Pacific Coast. The Stewardship Series. http://www.stewardshipcentrebc.ca/portfolio/coastal-shore-stewardship/ (accessed 28 January 2016)

Fourqurean, J. W., Duarte, C.M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M.A., Apostolaki, E.T., Kendrick, G.A., Krause-Jensen, D., McGlathery, K.J., Serrano, O. 2012. Seagrass ecosystems as a globally significant carbon stock. Nature GeoScience. 5:505-509.

Green Shores for Homes: a project of the Stewardship Centre for B.C. http://stewardshipcentrebc.ca/Green_shores/green-shores-for-homes/ (accessed 4 February 2016)

Lamont, G. Readshaw, J., Robinson, C., St-Germain, P. 2014. Greening to enhance resilience, An evaluation of approaches for adaptation to sea level rise; guide prepared by SNC Lavalin Inc. for the Stewardship Centre for B.C. and submitted to Climate Change Impacts and Adaptation Division, Natural Resources Canada (AP040), 46p.

Levings, C.D. and Thom, R.M. 1994. Habitat changes in Georgia basin: implications for resource management and restoration in: Proceedings of the BC/Washington Symposium on the Marine Environment. January 13th -14th, 1994. R.C.H. Wilson, R.J. Beamish, F. Aitkens, j. Bell, eds. Can. Tech. Pep. Fish. Aqua. Sci. 1948: 330-349.

Lyngby, J.E. & Brix, H. 1989. Heavy metals in eelgrass (Zostera marina) during growth and decomposition. In: Hydrobiologist 176/177:189-196. Belgium.

McGlathery, K.J., J. Sundback, and I.C. Anderson. 2007. Eutrophication in shallow marine bays and lagoons; the role of plants in the coastal filter. Marine Ecology Progress Series 348:1-18.

Molnar, M. 2015. Sound investment: measuring the return on Howe Sound's ecosystem assets. David Suzuki Foundation, Vancouver.

Molnar, M., Kocian, M and Batker, D. Nearshore natural capital valuation. 2012. David Suzuki Foundation. p. 12.

Mumford, T.F. Jr. 2007. Kelp and eelgrass in Puget Sound. Prepared in support of the Puget Sound Nearshore Partnership. Washington Department of Natural Resources Aquatic Resources Division. Technical Report 2007-05.

Neckles, H.A. (ed.) 1994. Indicator development. Seagrass monitoring and research in the Gulf of Mexico. U.S.E.P.A.

Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, S. Ragoonaden and C.D. Woodroffe. 2007. Coastal systems and low-lying areas. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on

Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK: 315-356.

Orth, R.J., Carruthers T. J. B., Dennison, W.C., Duarte, C.M., Fourqurean, J.W., Heck Jr., K.L., Hughes, A.R., Kendrick, G. A., Kenworthy, W.J., Olyarnik, S., Short, F.T., Waycott, M., and Williams, S. L. 2006. A global crisis for seagrass ecosystems. BioScience vol. 56 no. 12: 987-996.

Orth, R. J, Heck, Jr. K. L, and J. van Monterans. 1984. Faunal communities in sea grass beds: A review of the influence of plant structure and prey characteristics on predator-prey relationships. Estuaries 7: 339-350.

Phillips, R.C. 1984. The ecology of eelgrass meadows in the Pacific northwest: A community 37 profile. SCH. Nat. and Mathematical Sciences, Seattle Pacific University. Fish and Wildlife Service, U.S. Dept. of the Interior.

Short, F., Carruthers T., Dennison W., Waycott M. 2007. Global seagrass distribution and diversity: A bioregional model CA Department of Natural Resources, University of New Hampshire, Jackson Estuarine Laboratory, Durham, NH 03824, USA

Thom, R., Borde, A.B., Williams, G.D., Southard, J.A., Blanto, S.L. & Woodruff, D.L. 2001. Effects of multiple stressors on eelgrass restoration projects: Proceedings of Puget Sound/Georgia Strait Conference. p.5.

Thom, R., Diefenderfer, M., Vavrinec, J., Borde, A. 2011. Restoring resiliency: Case studies for Pacific Northwest estuarine eelgrass (*Zostera marina L.*) ecosystems.

Thompson, R.E. 1994. Physical oceanography of the Strait of Georgia-Puget Sound-Juan de Fuca system. Symposium on the Marine Environment, Institute of Ocean Sciences, Sidney, B.C. p.36

Appendix A: Maps