PACIFIC SALMON FOUNDATION

EELGRASS RESTORATION PRACTITIONERS' HANDBOOK

A PRACTICAL GUIDE TO NATIVE EELGRASS RESTORATION IN THE SALISH SEA AND WEST COAST VANCOUVER ISLAND

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2026


Illustration:Delaney Cox of Drawing it Out

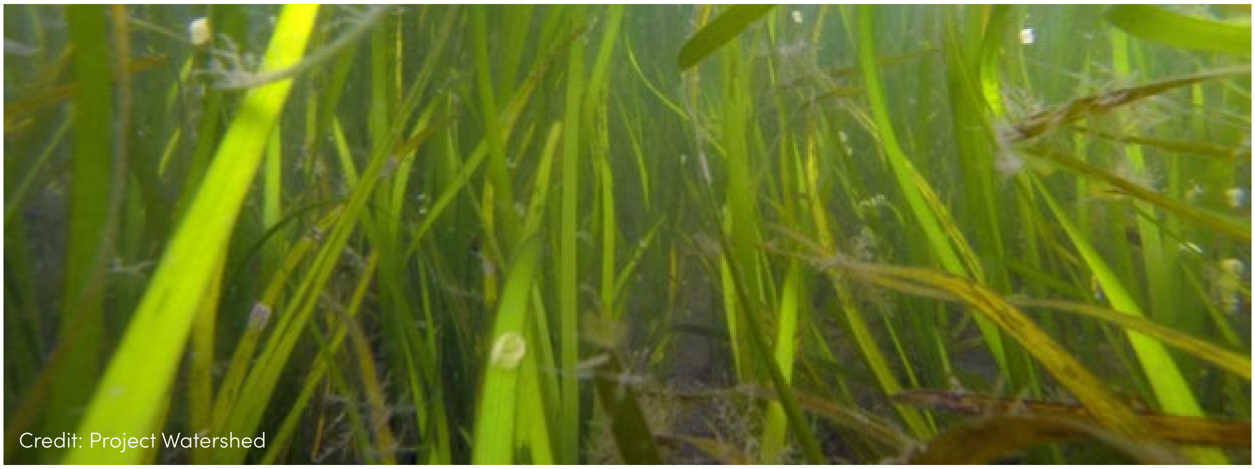
PREFACE

Estuaries and nearshore ecosystems provide vital support to juvenile and adult Pacific salmon, as well as the larger food web they depend upon. There is increasing interest in protecting and restoring the interconnected nearshore habitats of kelp, tidal marshes, and eelgrass habitats within these critical salmon systems.

However, the success of nearshore recovery projects is hampered by a number of factors: a paucity of open-access information about nearshore habitat restoration and monitoring methodologies, a lack of knowledge about priority areas and suitable site selections for restoration, and a need for knowledge based approaches to conservation strategies under worsening climate change scenarios.

With funding from Fisheries and Oceans Canada's Aquatic Ecosystem Restoration Fund (AERF), the Pacific Salmon Foundation has created a Restoration Resource Hub of open-access informative resources and decision-support tools. The purpose is to guide adaptive nearshore habitat restoration and monitoring approaches to kelp, tidal marsh, and eelgrass habitats.

This Eelgrass Restoration Practitioners' Handbook is one of the components of this Hub. Other documents can be found through this link.


Credit: Project Watershed

Cover photo credit: Jamie Smith, Coastal Photography Studio

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Credit: Greenways Land Trust

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The authors of this Eelgrass Restoration Practitioners' Handbook are deeply grateful to the Indigenous Peoples who have cared for the lands and waters of the Salish Sea and the west coast of Vancouver Island for millennia. They include the First Nations of the Coast Salish, Nuu-chah-nulth, and Kwakwakaw'akw areas.

Many people have contributed to the creation of this document. They include First Nations work crews and hundreds of community volunteers surrounding the Salish Sea and the west coast of Vancouver Island, the participants of the Eelgrass Symposium in the fall of 2024, some of whom offered their thoughts and time for individual interviews, and the dedicated staff of the Pacific Salmon Foundation, whose support is immeasurable.

Credit: C. Doucet

ABOUT THE AUTHORS

Credit: Volunter with the Cowichan Estuary Nature Centre

NIKKI WRIGHT

In 1998, Trish Farrell and I were sitting in Rob Russell's office at the Pacific Biological Station in Nanaimo. Rob was the Habitat Biologist for the South Coast of Vancouver Island for Fisheries and Oceans Canada. He was also our last resort.

For some time, I had been researching the possibility of restoring native eelgrass in areas where it had been damaged or destroyed near Victoria, BC. I was tired of hearing about "sustainable yields" and how much we could get from the ocean during conferences over the years. I thought it was time to find a way to give back.

Everyone had told us it could not be done. Rob gave us hope by directing us to Cynthia Durance, and, by the way, "Had we considered wetland restoration as well?"

Loaded with resource books and Cynthia's contact information, we set course. Over 28 years later, we have not paused on our path forward.

I came to this adventure with a multiplicity of experiences with native plants as a landscaper in northern California for 15 years, an academic background in marine biology, experience as a scientific diver, as a community organizer, and as an educator. I arrived in BC in 1970 from the San Francisco/Berkeley area, returned to the US in 1977, and then returned to Vancouver Island for good in 1993.

Cynthia and I began a long working relationship in 1998, and therein lies the beginning of this eelgrass evolutionary tale. Also in 1998, Trish and a small group of marine conservationists (mostly SCUBA divers) started a not-for-profit organization, SeaChange Marine Conservation Society, within the W̱SÁNEĆ Territory to conserve and restore marine ecosystems in BC. Since its inception, we have completed over 60 eelgrass restoration projects and have taught eelgrass ecology to thousands. We honour the many individuals and groups who have helped make eelgrass a household term. Because of Rob, Cynthia, and a cast of thousands, restoration and protection of this emerald plant is possible.

Credit: Len Gilday

Credit: Sasha Howey

CYNTHIA DURANCE, R.P. BIO.

After moving to Vancouver in 1981, I joined Dr. P.G. Harrison’s soft-bottom ecology lab at the University of British Columbia (UBC). He had grant funding to conduct field and lab studies of eelgrass (*Zostera marina* and *Z. japonica*). The following year, the Port retained our lab to monitor changes in the eelgrass communities at Roberts Bank and research various transplant methods. I was actively involved in the design and implementation of this research for the following eight years, during which time I became intrigued by, and passionate about, eelgrass conservation and restoration.

After leaving UBC, I continued to study eelgrass and developed a method for successful transplantation. I have remained in contact with many eelgrass colleagues and continue to attend international seagrass conferences to share what I have learned and to learn from others. Forty years later, I’m still learning new things about this complex species.

Since 1994, I’ve completed over 150 transplants as compensation, mitigation projects, and for habitat banking through my company, Precision Identification. I met Nikki in 1998 and began assisting her with developing Eelgrass Restoration Practitioners' Handbooks to be implemented in community-led eelgrass restoration and enhancement projects.

I am truly fortunate to have been able to follow my passion, turning it into a career, replete with travel to interesting places and encounters with yet more interesting people.

Credit: Ann-Marie Norris

ANGELA SPOONER

Between 2023 and 2026, I was the Pacific Region senior coastal habitat restoration biologist on the Operations Coordination and Technical Support team of the Pacific Salmon Strategy Initiative of the Restoration Centre of Expertise in DFO. I provided coastal habitat restoration subject matter expertise and piloted buoy and burlap bag eelgrass restoration by seeding methods with multiple coastal First Nations.

I am now returning to my own business of Sylvan Island Environmental Consulting, started in 2013, where I developed significant experience in eelgrass and saltmarsh restoration and monitoring, and Blue Carbon Sequestration. I have authored several reports on eelgrass restoration and coastal assessments and authored/co-authored research on Blue Carbon Accumulation in eelgrass beds. My DFO published technical bulletins, "Eelgrass Restoration Using Buoy Deployed Seeding (BuDS)" and "Eelgrass Restoration Using the Burlap Bag Seeding (BBS) Method" are the first works of their kind in BC.

In my capacity with DFO, I provided insight and advice on salmon habitat restoration on the Pacific Salmon Foundation’s Greening the Salish Sea Project.

I work, live and play in Cumberland, part of the unceded traditional territory of the K’omoks First Nation. I am grateful to see the changes around me brought to fruition by meaningful restoration efforts by so many people and groups and to have contributed to these projects in any way.


Credit: Natalie Mahara DFO

ANURADHA RAO

Anuradha Rao is a Registered Professional Biologist, writer and facilitator with a focus on coastal and marine ecosystems. She has worked on research, conservation, mapping, planning, policy, restoration and stewardship projects across Canada and in 12 other countries. She is the author of the book *One Earth: People of Color Protecting Our Planet* (Orca, 2020) and has authored or co-authored more than 60 other technical and popular works. She currently works as Senior Environmental Specialist-Marine Ecosystems on staff with Tsleil-Waututh Nation.

A child of Indian immigrants, Anuradha's worldview and approach to science are heavily influenced by teachings from her own culture and from Indigenous knowledge holders. These teachings and the principles of ecology have shown her that everything and everyone is connected, and that we must remember this in our actions and interactions. Anu finds her happy place when she walks off a beach and snorkels among the creatures of the sea.


Credit: Justin Bland

JAMIE SMITH

Owner of Coastal Photography Studio (www.coastphotostudio.com) on Vancouver Island, Jamie has dedicated over 20 years to capturing the beauty and fragility of the natural world. With more than 18+ years of underwater experience, he specializes in documenting marine ecosystems and the environmental challenges they face. His work has contributed to major productions for BBC, National Geographic, and Netflix, bringing global attention to conservation issues.

Operating a fully equipped professional dive boat with advanced underwater and aerial camera systems, Jamie has the tools and expertise to film in some of the planet's most remote and challenging environments. From fragile eelgrass meadows to cold-water habitats, his imagery highlights the delicate balance of ecosystems while exposing the pressures they endure. Jamie has combined his passion for visual storytelling with his camera lens. Jamie strives to tell compelling stories that inspire awareness and action, using visual storytelling as a force for environmental advocacy and change.


Credit: Jamie Smith Coastal Photography Studio

ABOUT THIS EELGRASS RESTORATION PRACTITIONERS' HANDBOOK

This Handbook is designed to support planning and implementation of native eelgrass restoration (*Zostera marina L.*) by First Nations and stewardship organizations in coastal areas of the Salish Sea and the west coast of Vancouver Island (WCVI). It supplements other eelgrass-related documents: the Eelgrass State of Knowledge Report (Eriksson & Clowater-Eriksson, 2026), which describes the ecology, distribution, pressures, and conservation recommendations and strategies for native eelgrass, and the Mapping and Monitoring Practitioners' Handbook (Durance & Wright, 2026), a field guide to mapping and monitoring intertidal and subtidal eelgrass habitats in BC.

For this Handbook, the Table of Contents will give you an overview of the necessary steps required to complete an eelgrass restoration project successfully. Chapters 1-3 provide background for understanding eelgrass ecology, selecting restoration sites, and collaborating with communities to make it all happen. If the particular subtidal area to be restored is already selected, go directly to Chapters 4 and 5 ('Successful Restoration by Transplanting Vegetative Shoots' and 'Successful Restoration by Seeding'). The Appendices contain important background knowledge, tools, and field data sheets to assist in a successful eelgrass restoration project, including a short guide to assist in the field (Appendix L).

You will notice icons indicating important information throughout this Handbook:

A sidebar with this image of eelgrass indicates more detailed information can be found within the Eelgrass State of Knowledge Report.

This map icon indicates reference to the Eelgrass Mapping and Monitoring Practitioners' Handbook.

A star indicates a suggestion or "tip" related to the text beside it.

This raised hand indicates Frequently Asked Questions found at the end of each Chapter.

Bold words are defined in a Glossary at the end of the Handbook.

This play button icon indicates a link to a helpful video. As part of this handbook, a video demonstrating community based restoration is available for reference.

Links to the sections in the video demonstrating key steps can be found next to the relevant text.

CHAPTER 1: WHAT DO WE NEED TO KNOW BEFORE RESTORING EELGRASS?

1.1 BRIEF HISTORY OF EELGRASS RESTORATION IN BRITISH COLUMBIA

Methods to restore eelgrass habitats were first developed in Northern Europe and on the Atlantic coast of the United States (US), where wasting disease combined with densely populated shorelines had resulted in huge eelgrass habitat losses and a subsequent decline of fisheries. In the US, these recovery efforts began in the 1940s.

In Canada, the Department of Fisheries and Oceans Canada (DFO) established a No Net Loss (NNL) policy in 1986. The policy was designed to protect fish habitats and ensure that any harmful alteration, disruption, or destruction of fish habitat was offset, meaning that the net impact on fish habitat from a project should be no greater than what existed before the project started. This led DFO in the Pacific Region to experiment with eelgrass transplanting methods that had been successful on the Atlantic coast. Unfortunately, the Atlantic methods did not translate well to the Pacific coast, and resulted in numerous transplant failures, which led DFO to place a moratorium on eelgrass transplanting as a **habitat offsetting** option. As a result, projects impacting eelgrass habitats needed to compensate in other ways, such as building rock reefs. The primary reason for failure was that none of the methods used at the time anchored the shoots, and they washed away by tidal currents.

Eventually, success was achieved. A lab at the University of British Columbia received a Natural Sciences and Engineering Research Council of Canada (NSERC) grant to undertake an experimental small-scale eelgrass transplant at Roberts Bank, near Vancouver, BC. The project demonstrated that eelgrass transplants could be successful by using **rebar** to anchor them. The rebar method was later modified by using **ungalvanized steel washers** for anchors, as the rebar was expensive and difficult to use. This modified method also included planting in clusters of eelgrass shoots and being mindful that **ecotypes** were placed at the proper depth.

DFO granted permission to use this method for a large-scale (5420 m^2) transplant in Nanaimo in 1994, which was very successful. Since that time, it has been successfully used at over 200 locations throughout BC.

1.2 ENHANCEMENT AND RESTORATION

Following the successful Nanaimo transplant, eelgrass transplanting has been undertaken as compensation for lost or damaged eelgrass habitats. Over the last three decades, native eelgrass enhancement and restoration projects for conservation goals (i.e., not for offsetting or **mitigation** purposes, e.g., expanding or creating fish habitat) implemented by First Nations and community stewardship organizations have also become increasingly accepted and approved by DFO.

Marine underwater plant restoration strategies are very different from those used for terrestrial restoration. If there is not a clear understanding of the requirements to maintain healthy eelgrass plants, collectively we might be harming rather than improving critical marine systems. This Handbook serves as a practical tool to increase the likelihood of successful transplants. While we acknowledge that there are no guarantees with restoration, particularly in a time of increasing coastal population and climate change, the methods described here come from a foundation of experience and have been adopted by practitioners around BC and beyond.

The focus in this Handbook is on tried and tested subtidal eelgrass transplant methods (Chapter 4), because suitable intertidal habitat is limited and challenging to work in within BC. Other pitfalls associated with attempting transplanting in intertidal areas are the short working window during low tides, which can be stressful for work crews, and transplants are prone to grazing by Canada geese and exposure to heat or freezing if too high in elevation. On the other hand, subtidal transplants can be effectively executed by certified WorkSafe BC (WCB) **SCUBA** divers. We also discuss seeding methods (Chapter 5) as an alternative or an add-on to transplanting as it provides a less resource intensive strategy and potentially has genetic diversity benefits.

Fortunately, since 1994, methodologies for transplanting *Zostera marina* have improved. With expert advice, training, and collaboration with Indigenous communities, collectively we can continue this trend and support other eelgrass restoration efforts in British Columbia and beyond.

One reality persists: Significant areas of critical salmonid habitat in the Strait of Georgia are disappearing or being degraded by human activities and climate change. Rising sea surface temperatures, summer droughts, and more intense winter storms, combined with impacts from mining, forestry, agricultural activities, coastal development, and recreational activities, are taking a real toll on eelgrass habitats. This in turn negatively impacts over 80 per cent of commercially important fish and shellfish species, including all species of salmon, and millions of shorebirds that use eelgrass beds for foraging.

Experiment, take risks,
Learn from both successes and failures,
Stay curious, and
Network with other practitioners

Credit: Jamie Smith Coastal Photography Studio

1.3 IMPORTANT ECOLOGICAL CHARACTERISTICS

Being familiar with how eelgrass grows and reproduces is fundamental to determining a restoration strategy and achieving a successful outcome. Additionally, there are ecological conditions, ecotypes, non-native species, and various stressors to be mindful of.

a. Eelgrass reproduction

Eelgrass grows differently from any land plant. A leaf is short-lived. When it starts to die, it breaks off the stem, and new roots are produced where the leaf broke off. The roots grow longer, reaching the sediment where the stem is pulled in. In the southern Salish Sea, research has shown that one shoot may produce up to 10 branches in a year. This is vegetative reproduction. A few other related seagrasses share this way of growing, where the shoots travel through the substrate, producing more shoots as they move. The section of stem that is pulled into the sediment changes to become **rhizome** (Figure 1.1). The new shoot and rhizome continue growing away from the 'parent' shoot. Studies in the Salish Sea with the ecotype *Z. marina* ecotype *phillipsii* found that a shoot typically travels 0.5 metre per year in this way.

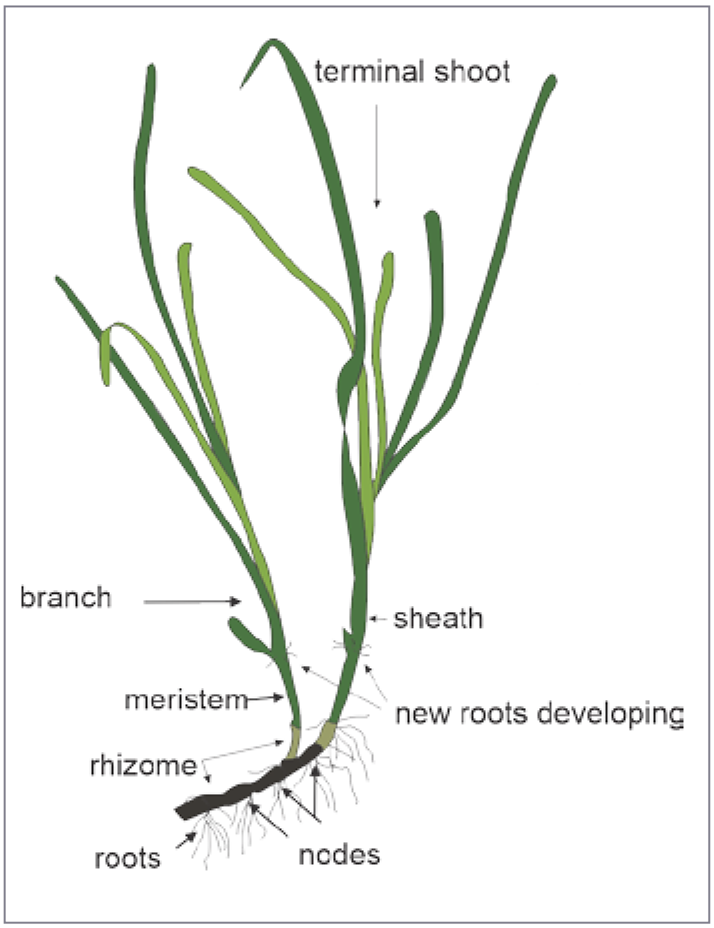


Figure 1.1 Diagram of plant parts of *Zostera marina*.
Credit: Cynthia Durance

Eelgrass reproduction in BC is primarily vegetative, with seedling survival usually between 3 to 4 per cent. This is contrary to the Atlantic coast, where there are many annual populations that recruit from seeds every year. The tidal range, and subsequently tidal currents, in many areas of the Atlantic are low relative to BC. For example, in Chesapeake Bay, extending from Maryland to the District of Columbia, where much of the eelgrass research originates, the tidal range varies between 0.9 and 0.3 metres, whereas tidal ranges in the Salish Sea and WCVI typically range between 4 and 5 metres, which causes much greater currents. This may partially explain why seedling survival is greater, and transplants using unanchored shoots are more successful on the Atlantic coast of North America than on the Pacific coast.

Sexual reproduction through seeding begins in spring and continues throughout the summer. The environmental factors that cause a vegetative shoot to become sexually reproductive are not clearly understood. The percentage of shoots that flower varies between locations and years from 0 to 100 per cent. The **morphology** of a vegetative shoot changes as it develops into a flowering shoot. The stem becomes round in cross-section and elongates, developing side branches with flowering **spathes**, and the flowers release pollen that drifts on the tide to pollinate other flowers (Figure 1.2). Once the seeds are mature, the entire shoot breaks away from the rhizome and is carried away by the tide.

Information about restoration methods by seeding can be found in Chapter 5.

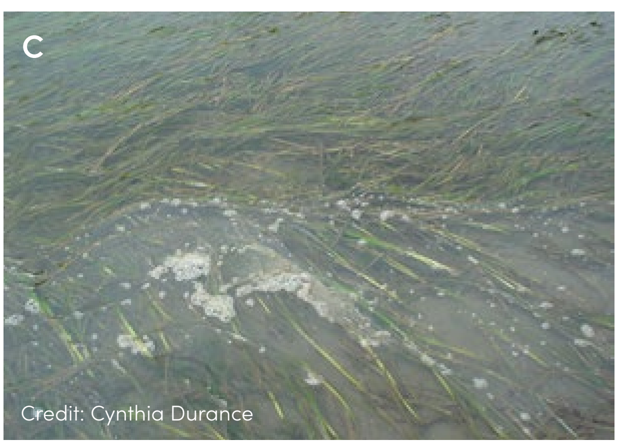


Figure 1.2 Eelgrass flowering shoots (A) with a practitioner showing the rounded stem, (B) in the water column, and (C) releasing thread like pollen which appears as floating brown foam.

b. Ecotypes

Ecotypes are variants of a species with distinct characteristics adapted to local or regional environmental conditions.

Backman (1991) researched the ecotypes of *Z. marina* in California, Oregon, Washington, and Alaska, and named four distinct ecotypes. Three of the four, *Z. marina* ecotype *typica*, *Z. marina* ecotype *phillipsii*, and *Z. marina* ecotype *latifolia*, are common throughout BC. The fourth, *Z. marina* ecotype *izembekensis*, which was only encountered in Alaska in Backman's study, matches some populations in BC from Port Renfrew northwards, and it often lives with one of the other ecotypes.

Generally, the length of eelgrass shoots increases with depth, and often the density decreases. *Z. marina* ecotype *typica*, the shortest ecotype, flourishes in the intertidal. *Z. marina* ecotype *phillipsii*, the most common ecotype in BC, can extend from the shallow subtidal to deeper waters. *Z. marina* ecotype *latifolia*, the largest ecotype is limited to the subtidal zone (Table 1.1). Since an eelgrass meadow most often contains several ecotypes, it may be useful to review the schematic diagram below illustrating a meadow comprised of three ecotypes (Figure 1.3).

Differences important to note in the field: The ecotype *Z. marina* ecotype *typica* is often completely exposed, lying flat on the substrate during low tide.

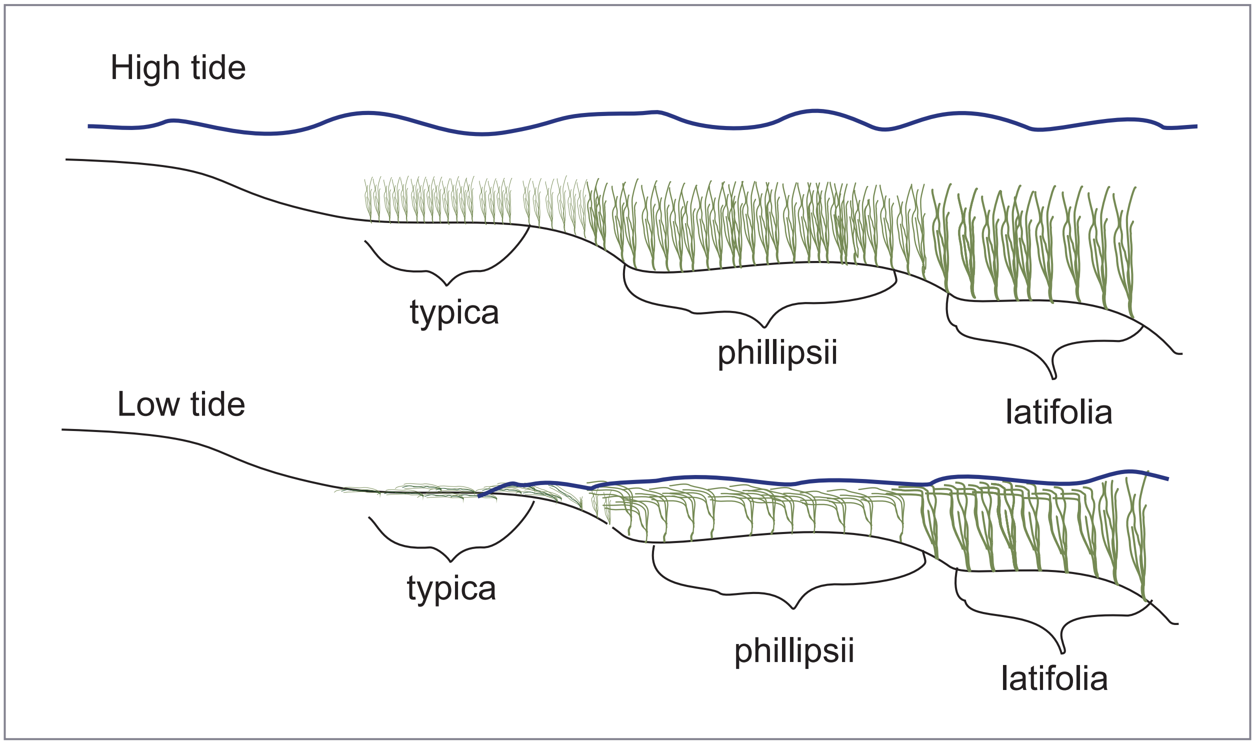


Figure 1.3 Three eelgrass ecotypes most commonly present in BC at high and low tide.
Credit: Cynthia Durance

Eelgrass transplant projects are most successful when an ecotype most suited to the transplant site is harvested from an eelgrass bed growing at a similar depth.

Table 1.1 The habitat and **morphological** attributes associated with the four ecotypes of *Zostera marina* common in British Columbia (adapted from Backman, 1991).

Ecotype	Mature shoot length (cm)	Leaf width (mm)	Typical depth range CD (m)**	Seasonal variation in size	Current tolerance
typica	<30	2 to 5	Primarily intertidal	Small variation	Low
phillipsii	40 to 210	4 to 9	Intertidal to 4	Large, plant length reduced in winter	Moderate
latifolia	100 to 300	12 to 20	0.5 to 10	Minimal variation	Strongest
izembekensis	40 to 106	2 to 5	0 to 3*	Large, plant length reduced in winter	Moderate

* based on few observations in B.C. ** Canadian chart datum (CD) is measured relative to lowest normal tide. 0 metres is the lowest normal tide, datum measurements are the depth below 0, therefore they don't require a – sign. Tides that are lower than the lowest normal tide are negative. The US chart datum differs because it is based on the Mean Lower Low Water (MLLW).

★ Since the length of the shoots increases with depth, donor stock needs to be harvested from a depth similar to the depth range within the transplant site. Thus, it may be necessary to harvest from the donor site at several depths, keeping stock separate to plant at comparable depths in the transplant area.

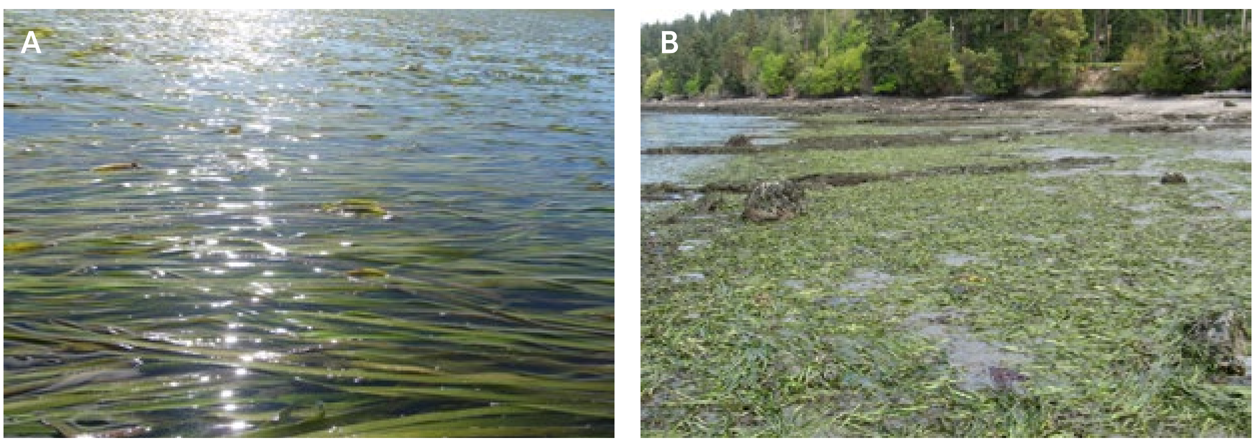


Figure 1.4 *Z. marina* ecotype *latifolia* during low tide (A), and *Z. marina* ecotype *phillipsii* can be exposed during very low tides (B). Credit: Cynthia Durance (A) Leanna Boyer (B)

c. Zostera japonica: history, ecology and identification

It is important to note that there are two species of eelgrass in British Columbia: the native species *Zostera marina* and an introduced species *Zostera japonica* (Figure 1.5). *Z. japonica* was thought to have been accidentally introduced with oyster spat brought from Japan to aquaculture sites in Washington State (Harrison, 1976), however, there have been several recent reports of *Z. japonica* in Alaska, which suggests it may have arrived naturally.

Figure 1.5 *Z. japonica* at low tide in Parksville.
Credit: Michele Deakin

Z. marina ecotype *typica* is often misidentified as *Z. japonica*. The easiest way to determine the species is by examining the sheath and/or roots: *Z. marina*: Each shoot grows from the end of a **rhizome**, not from nodes on the rhizome; the **sheath** tears when leaves are separated (Figure 1.6). Other morphological and characteristic differences are compared in Table 1.2, 1.3, and Figure 1.7.

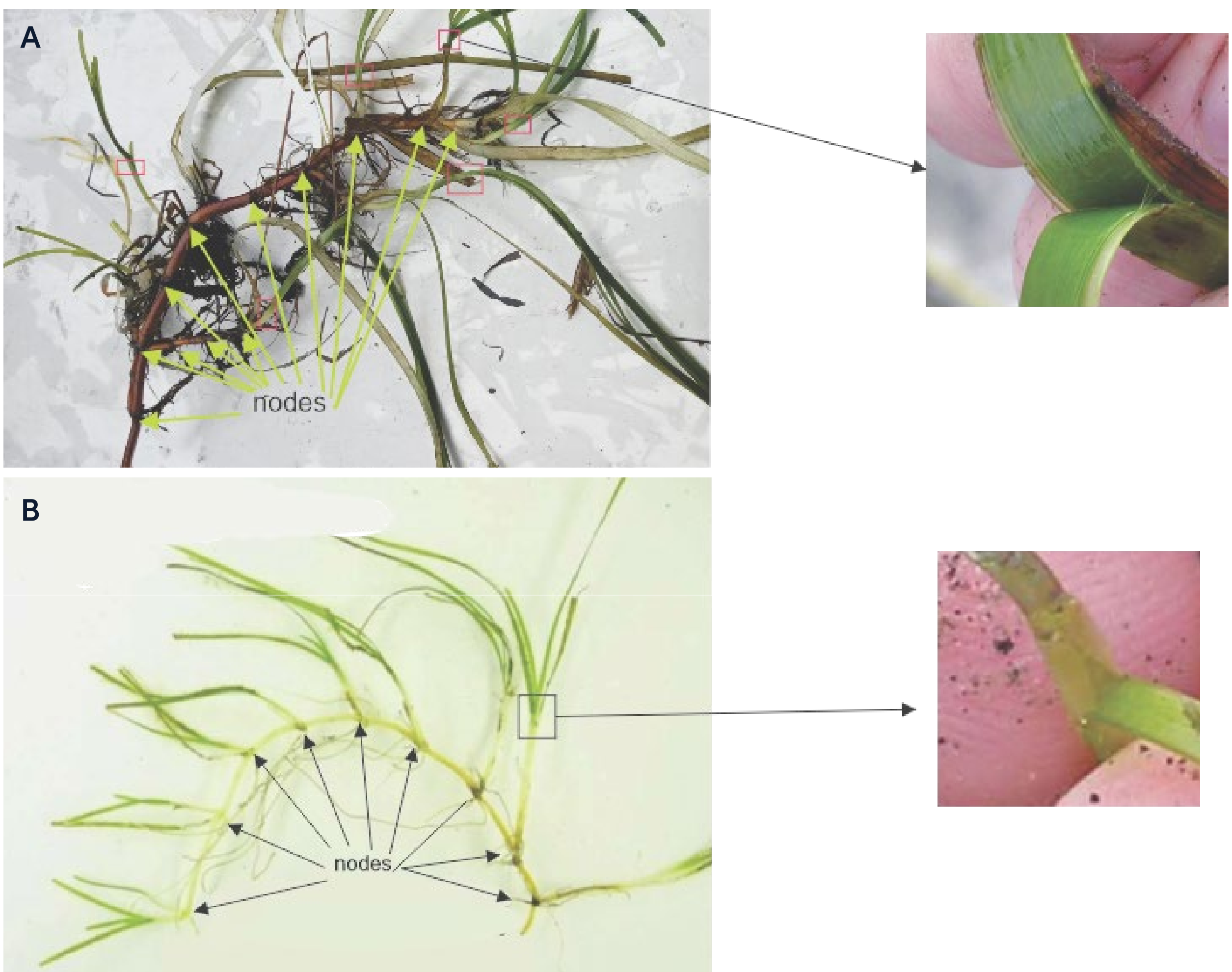


Figure 1.6 *Z. marina* rhizome and sheath (A), *Z. japonica* rhizome and sheath (B). Credit: Cynthia Durance

Table 1.2 Morphological comparisons between *Z. marina* and *Z. japonica.*

Plant part	*Z. marina*	*Z. japonica*
Roots at each node	5 -20	4
Leaf tip	Rounded	Slightly notched
# leaf veins	5 – 11	3
Sheath	Entire, tubular	Split to base, 2 overlapping flaps
Leaf width	1.5 – 20 mm	1 – 2 mm
Leaf length	10 – 300 cm	5 – 30 cm
Seeds	Ridged with short tips	Smooth, tips about ¾ length of base

Table 1.3 Characteristics differentiating *Z. marina* and *Z. japonica.*

Z. marina	*Z. japonica*
Perennial	An annual or short-lived perennial (recruits from seed every year)
Z. marina ecotype *typica* can tolerate short periods of exposure	Tolerates exposure during low tides because of its small size
Z. japonica is considered an exotic in BC and not a threat to *Z. marina*	Slower growth rate than *Z. marina*
Z. marina ecotype *typica* and *Z. japonica* intermix on mudflats (e.g. Tofino)	Size resembles *Z. marina* ecotype *typica*

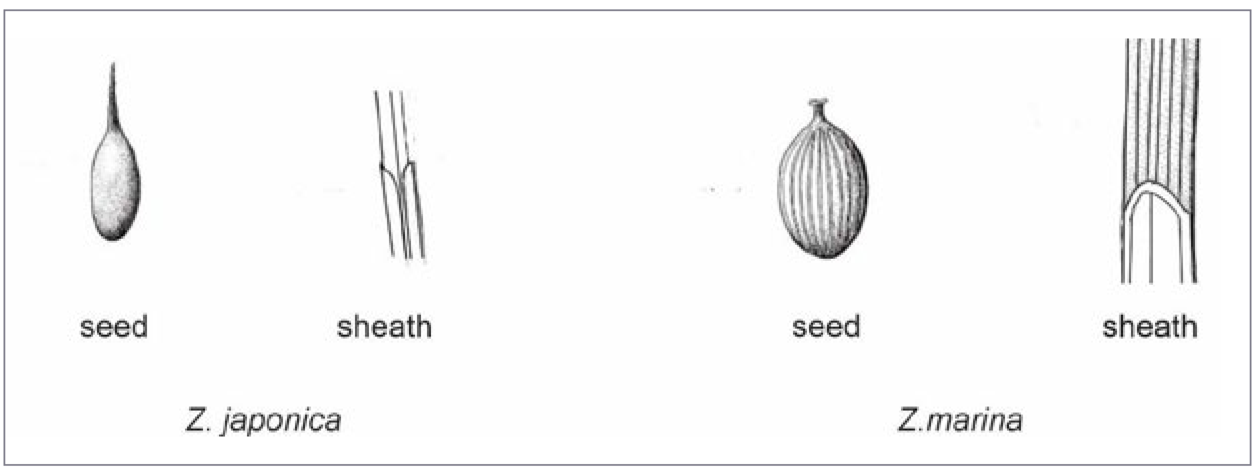


Figure 1.7 Comparison between the seeds and sheaths of *Z. marina* and *Z. japonica.* Credit: Cynthia Durance

Figure 1.8 *Z. japonica* adjacent to *Z. marina*.
Credit: Nikki Wright

Dense populations of *Z. japonica* **accrete** fine sediment and have been responsible for converting sandflats to mudflats, changing the species composition of **infauna** as a result. The Canadian Wildlife Service (CWS) has reported this conversion caused a decline of foraging habitat for Western Sandpipers in the intertidal zone at Roberts Bank. On a positive note, the dense *Z. japonica* shoots ponded water during low tides, enabling *Z. marina* to expand further up the flats (Figure 1.8).

Z. japonica has value to fisheries during higher tides when it is submerged, providing cover and foraging opportunities for juvenile salmonids. Unlike *Z. marina*, *Z. japonica* is an annual. Sometimes, however, it is a short-lived perennial. Typically, it dies back completely in winter and regenerates from seed the following spring. Some shoots may persist through the winter; however, these will die the following summer.

1.4 SOME IMPORTANT STRESSORS TO WATCH FOR[1]

Disease

Wasting disease, caused by the pathogen *Labyrinthula zosterae*, decimated eelgrass beds along eastern North America and northern Europe in the 1930s. Many species dependent on eelgrass for habitat and food sources faced dramatic population declines. Fish species, including cod and flounder, which spawn and shelter in eelgrass beds, experienced severe reductions in their numbers. Shellfish, which depend on eelgrass for protection and food, also experienced declines. Studies in the Pacific Northwest have discovered that the pathogen is present in most eelgrass beds. Increasing sea surface temperatures may be increasing its presence. If wasting disease is observed in the majority of eelgrass shoots (Figure 1.9), ***it is important not to choose the site as a donor bed, and to rinse all equipment after contact to avoid spreading the disease to other areas***. Note that similar dark lesions can also be caused by poor water quality, nutrient deficiencies, environmental stress, grazers, and other diseases.

Figure 1.9 Wasting disease on eelgrass presents as dark lesions. Credit: F. Short

1. Additional detailed descriptions of stressors and impacts on eelgrass habitats can be found in Appendix B.

Grazers

In the Strait of Georgia, green urchins (*Strongylocentrotus droebachiensis*) and Canada geese (*Branta Canadensis*) (Figure 1.10) have been observed consuming significant amounts of eelgrass and seriously impacting the local eelgrass populations.

Figure 1.10 Canada geese grazing on eelgrass in Parksville. Credit: Michele Deakin

Invasive European green crabs

European green crab (*Carcinus maenas*) (Figure 1.11) numbers are increasing within the Salish Sea and the west coast of Vancouver Island. They disturb the rhizomes in their search for prey within soft sediments where eelgrass meadows are present.
For more information see:
https://www.invasivespeciescentre.ca/european-green-crab/

Figure 1.11 Adult European green crab.
Credit: Patty Menning DFO

Sediment sulphides

High sediment sulphide concentrations, most often present in long-term marine log storage sites, may inhibit eelgrass growth and survival. However, if the water quality is good, eelgrass can survive by using oxygen in the water.

Overgrowth of epiphytes

Epiphyte growth on eelgrass may act as a sunscreen by protecting leaves from being 'sunburnt' during low tide (Figure 1.12). Sunburn injuries can sometimes kill the leaves, depending on their severity. The epiphytes are part of many invertebrate food webs within eelgrass habitats. However, there have been many cases on the East Coast where epiphyte load resulting from nutrient enrichment from fertilizer run-off (nitrification) has damaged or destroyed eelgrass habitats.

Figure 1.12 Epiphytes on eelgrass blades.
Credit: Cynthia Durance

Excess nutrients

Eutrophication can lead to very dense algal growth, smothering and killing eelgrass. Evidence of severe eutrophication has been seen in the Gulf Islands by the author N. Wright in an estuary that previously had been mapped for subtidal eelgrass. Over a short time, perhaps because of run-off from a new business enterprise in the watershed, an abundance of algae was present in the estuary, which prevented the mappers in a boat from seeing eelgrass plants through the water column to accurately monitor changes in eelgrass productivity in the bay.

A number of chemical and physical factors can also impact eelgrass. These are summarized in Table B.1 in Appendix B, which summarizes the sensitivity of eelgrass to different levels of severity of these stressors (Moreno-Marin et al., 2018).

FREQUENTLY ASKED QUESTIONS:

1. Is *Z. japonica* considered an invasive species in BC?

No, *Z. japonica* is considered an exotic or introduced species in British Columbia, and not an invasive plant because it does not displace the native species, *Z. marina*.

2. What is the difference between eelgrass and surfgrass (*Phyllospadix spp.*)?

Surfgrass only grows on solid surfaces in areas with exposure to high wave energy; eelgrass needs softer sediments and less wave energy. The leaves of surfgrass are roundish and rubbery, unlike eelgrass that has flat leaves that are not rubbery. See Figures 1.13 and 1.14.

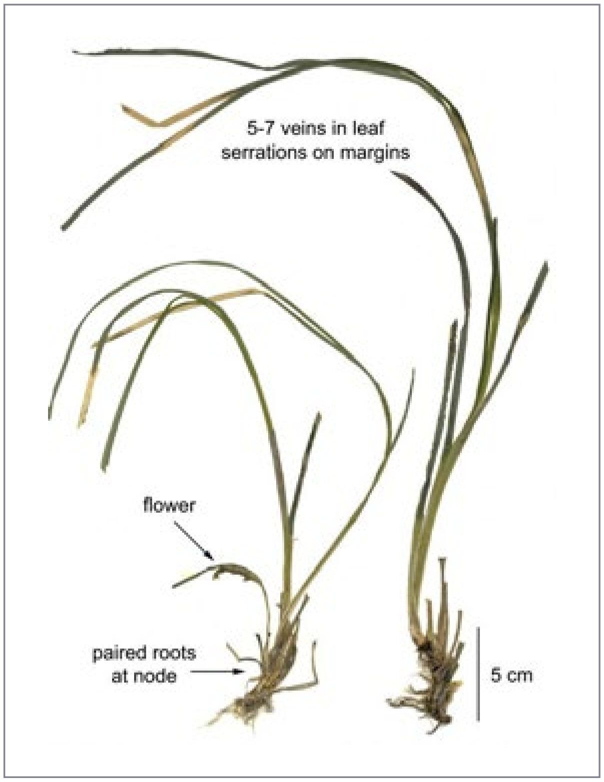


Figure 1.13 Surfgrass plant parts.
Credit: https://alchetron.com/Phyllospadix

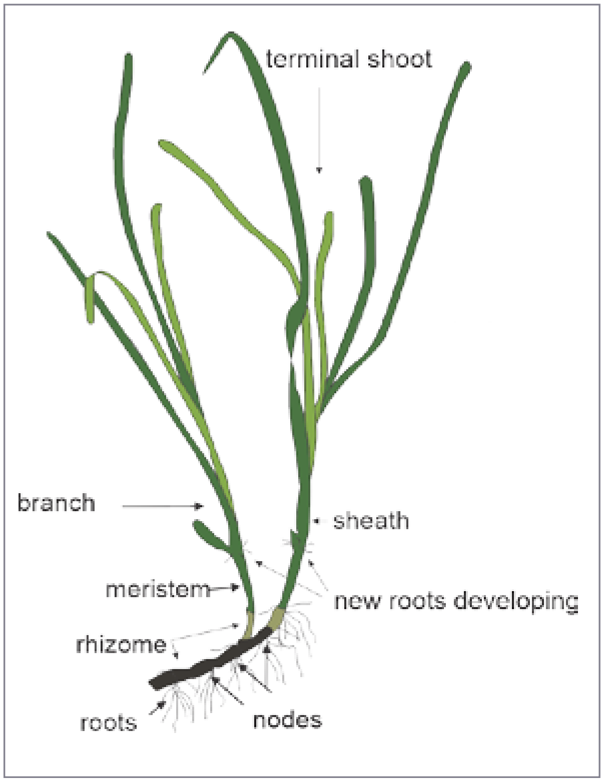


Figure 1.14 Eelgrass plant parts. Credit: Cynthia Durance

CHAPTER 2:
HOW DO WE BEGIN? RESPECTFUL APPROACH TO FIRST NATIONS

Contributed by Anuradha Rao (R.P. Bio. with Tsleil-Waututh Nation), edited by Jordon Labbe (Wei Wai Kum Guardian)

When intending to carry out work on a site, it is important to first connect with the First Nation(s) whose territory it lies within. This chapter provides advice for a respectful approach.

2.1 DO THE HOMEWORK

- If you know in which First Nations' Territory you may be working, read about the Nation(s) in their own words, and follow their social media. If the community is hosting public events, you may significantly benefit by attending those events and listening to the hosts. Be mindful of the intent of the conversations.
- In some cases, not in all cases, because there is diversity among different Nations, you can find a wealth of published material online, including Action Plans outlining the priorities that guide the work being undertaken by the Nation(s). Approach the authority Figure/Department Head of the relevant department to seek clarification and/or have a conversation where protocols can be articulated that may not be written or publicly accessible.
- It is advisable to seek out the Nation(s) before the project grant is written to discover what work takes priority as well as the Nation(s)' level of interest in the proposed project.

2.2 PREPARE

- Different protocols are followed by different Nations. It is important for positive, sustaining relationships to be willing to learn from them.
- Indigenous knowledge is science and is equivalent to Western science; one does not take priority over the other. Being open to Indigenous priorities based on Indigenous science should be at the foundation of the restoration work. Broadly speaking, Indigenous knowledge centers thinking of the system holistically, rather than focusing on treating parts of the system as independent, and this is in tandem with Western science.
- Acknowledge and know, more than a Land Acknowledgment; that stewardship work did not begin with Western scientists, but that First Nations have been stewards of the land and waters since time immemorial.
- First Nations' representatives' time and work costs real money, and their time is already stretched very far. They cannot be expected to be involved in someone else's project for free. Develop your ideas in a way that fits within each First Nation's articulated priorities. Be prepared to present your ideas to First Nations with an open mind and open heart, and come with a budget that would help cover their administrative and personnel costs, and minimize their administrative burdens.
- It won't always be possible for a Nation(s) to participate in a project for various reasons, but it does not always mean a closed door. At times, there may be consent to move forward with an agreement.
- Be prepared beforehand to share the results of the work with First Nations, both in plain-language terms and in raw data formats. This may need to be adapted for the individual Nation(s). Be open to edits of qualitative analysis based on Indigenous Knowledge. Be aware that Nations' relevant departments may have different capacities for technical information.
- Do not share First Nations' information without their explicit permission. Familiarize yourself with the Ownership, Control, Access and Possession (OCAP) Principles, which guide the collection, protection, use and sharing of First Nations' data.

2.3 MAKING THE APPROACH

- Find out if the Nation(s) have an established referrals process. Each referral procedure is distinct, and each Nation has varying levels of capacity. Sometimes that referral process comes with an administrative fee to help cover their costs. If there is no published referral process, a phone call is recommended, along with a follow-up email. Don't be discouraged significantly if there is radio-silence, as your inquiry may not have reached the intended person.
- Allow time to find out what the referral process is, and who to contact. If it is possible to find that information before the project grant is written, it makes it easier.
- If possible, make yourselves known, who you are as people, as an organization, the kind of things that you work on. Be clear about your intentions and find a way of communicating those intentions in a way that is individualistic and authentic for the Nations. Take the time to build trust through listening to the priorities and needs of the community.
- Contribute what you can; if you know what the needs are, the budget can be prepared to include administrative costs, training if desired, and honoraria for time spent giving historical and cultural context.
- Foster the idea of training the Nation's members if there are capacity building opportunities with the project.

> "As a non-Indigenous person who works with Indigenous peoples, I would suggest that if your group is very inexperienced about First Nations, and if you do not know the history of the area, there are a lot of resources you can access to educate yourself and improve your own awareness and sensitivity to First Nations, even before launching a project and before approaching a First Nation. Any project will require individuals working together in a cross-cultural situation, with various power dynamics, within an ongoing colonial system. The project idea may be really great, but the non-Indigenous individuals involved with it need to do advance work on themselves to contribute to the development of positive relationships."
>
> - Anuradha Rao, Senior Environmental Specialist-Marine Ecosystems on staff with Tsleil-Waututh Nation.

Credit: A. Spooner

University of Victoria Indigenous student volunteer collecting reproductive shoots at Juus Ḵáahlii, Haida Gwaii

CHAPTER 3: RESTORATION IS ABOUT COMMUNITY

If a restoration site(s) has not been determined, this Chapter offers a process for determining locations illustrated by the diagram below (Figure 3.1). The model was successfully implemented in four regions of the Salish Sea from 2017-2022.[2] Each step is explained below, from choosing an appropriate restoration site with community input to preparing for a restoration event.

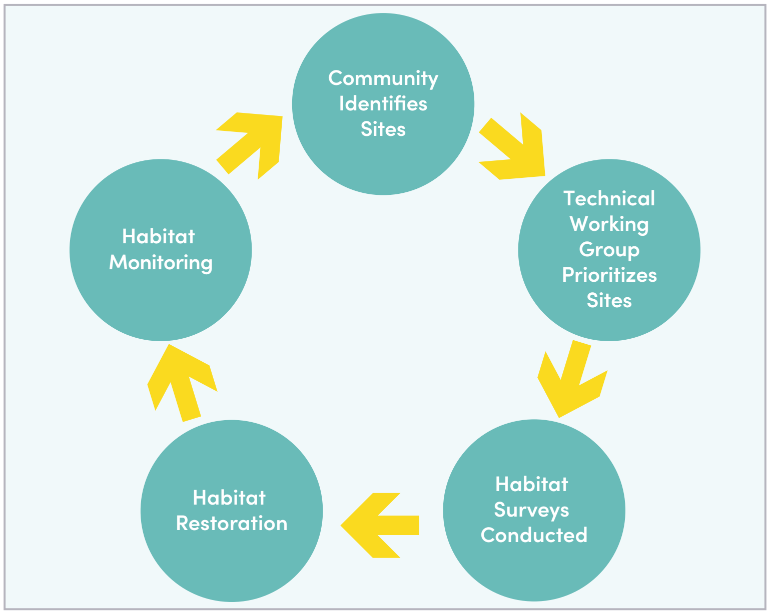


Figure 3.1 Schematic of community-based restoration plan.
Credit: Nikki Wright

3.1 ORGANIZE COMMUNITY GATHERINGS TO IDENTIFY SITES

One of the best methods for determining where eelgrass habitat might successfully expand or be restored is by conversing with locals familiar with the history of an area. Groups of people with knowledge of nearshore sites include members of the nearest First Nations Community, long-time residents, fishers, shellfish harvesters, workers in industries such as logging, boat construction, and survey companies, marine conservationists, and recreationists who know the local waters and may know the changes over time that have occurred. The memory of a coastal community is long.

Figure 3.2 Community members sharing their knowledge. Credit: SeaChange

Figure 3.3 Map of potential restoration sites.
Credit: SeaChange

2. SeaChange Marine Conservation Society supported by DFO's five year Coastal Restoration Fund program.

If there is time, budget, and organizational capacity, a community gathering can be called to request help with identifying possible restoration sites. Small groups around tables with either paper or digital maps and a note taker to record comments related to each site can be the first portal to community engagement in restoration efforts. Time to organize and hold a meeting could be included in the proposed project budget (see Appendix C for suggested budget items).

From this group, a smaller number of volunteers might offer their skills to form an Advisory Technical Committee. The Technical Committee can apply their collective knowledge to assess suitable sites using the history, environmental conditions, and physical attributes (see Appendix E for a list of criteria) to further narrow down potential sites ahead of undertaking full habitat surveys. The Technical Committee would also meet two to three times during the project to review data collected during a Habitat Survey of a site(s) suggested by the Community Group. If an Eelgrass Habitat Suitability Map is available for the areas of concern, it will contain data related to existing and potential eelgrass habitats, which would be useful for determining site suitability.

This video clip demonstrates habitat surveys

3.2 COMPLETE HABITAT SURVEYS

Habitat Surveys are detailed assessments undertaken on location to develop an understanding of whether the site(s) have a high likelihood of success, and ensure there are no unforeseen 'deal breaker' conditions. We recommend habitat surveys be done after the Technical Committee has determined possible sites based on criteria listed in Appendix E and if/when all necessary equipment is available (boat, WCB certified divers, cameras, crew). A list of survey equipment is in Appendix C, and Habitat Survey forms can be found in Appendix D. Once the survey is completed and the field data is evaluated by the surveyors and the Advisory Technical Committee, a clear course of action can be determined for restoration. For example, in an area where eelgrass was impacted by shading of a derelict barge, it can be determined that the restoration strategy would be to: 1. remove the barge with community support, 2. accelerate the growth of eelgrass in the formerly shaded area by transplanting the bare site with eelgrass shoots, and 3. monitoring the transplant site for up to five years or until the area has the same shoot density as the eelgrass habitat adjacent to the transplant.


Credit: SeaChange

3.3 EVALUATE THE HABITAT SITE SURVEY DATA

(see Appendix E for a description of the attributes listed below, and Appendix F for the metrics to use for measuring these attributes).

After a location(s) and restoration/enhancement goals are determined, the next step is evaluating specific criteria collected from research, community conversations, and field observations (Figure 3.4). To assist in making this assessment, use Appendix G, which is a Site Assessment Checklist for rating potential restoration sites. The values for each number assigned to an attribute range from 0 to 2. A 0 rating is a "No go"; 1: a "Maybe" and 2: a "Yes."

Physical Attributes

- Wave exposure
- Water quality
- Light quality
- Substrate charateristics
- Presence of woody debris
- Sensitivity to sea level rise

Biological Attributes

- Habitat connectivity
- Biodiversity
- Proximity to natural eelgrass beds
- Presence of algae
- Presence of disease/invasive spp. (i.e.European green crab)

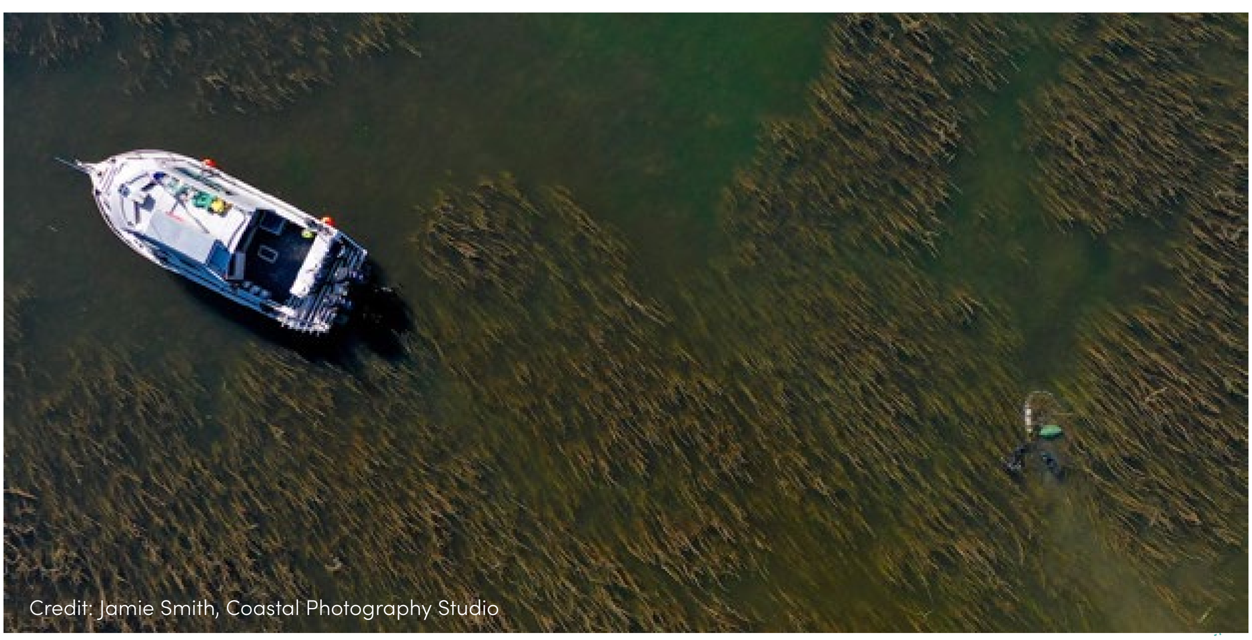
Cultural/Social Attributes

- Cultural use/value to local First Nations
- Level of community engagement
- Backshore use
- Level of recreational use (i.e. boat anchoring)

Figure 3.4 Attributes to include in Habitat Surveys. Credit: Thetis Island Technical Advisory Committee members

If funding allows, it is highly recommended that a test plot of up to 1,000 shoots be installed and monitored at six month intervals. If the plot increases in size and density, a second transplant can be added to the first to increase the density and size of the first transplant.

Monitoring should continue at six and twelve month intervals for five years. If funding is limited, community volunteers might be able to continue the monitoring schedule with visual observations of the transplant from the surface of the water in kayaks or canoes.



Credit: Jamie Smith, Coastal Photography Studio

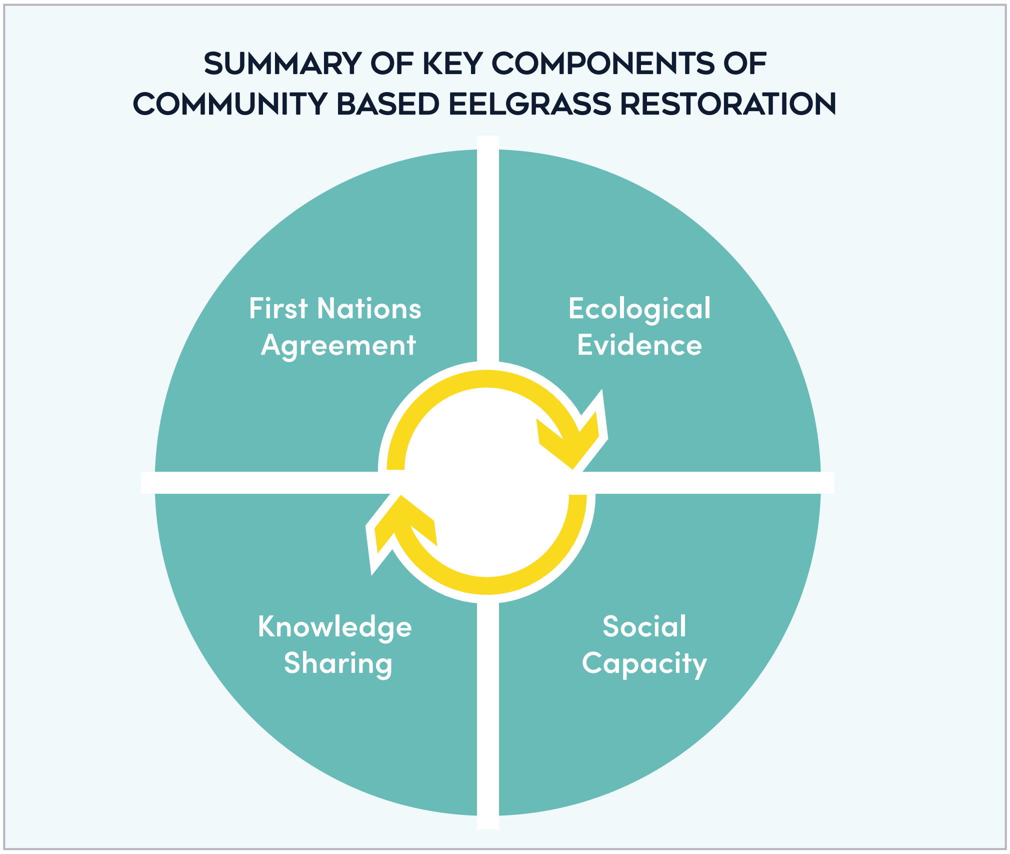


Figure 3.5 Restoration based on First Nations' advisement, field evidence, community will and research.

This video about the importance of estuaries to salmon could be useful to include in a Community Forum

3.4 SET UP THE RESTORATION EVENT

Effective communication is a crucial first step for a successful community restoration event. Public presentations, in addition to announcements through social and print media, disseminate the rationale for caring about eelgrass habitats. A community forum can include First Nations' members and stewardship organizations who could share their knowledge and experience, and lead field trips in the estuary or bay of local concern.

★ It is important to highlight the reasons why volunteer community members are asked to participate in the restoration process. Participating in transplant work increases awareness of the ecological and cultural values of eelgrass and the role interconnected nearshore habitats play for local and global health. With this understanding, community members are more likely to develop a conservation ethic, reducing the need for restoration efforts in the future.

The following is a list of points to consider while preparing for the restoration event:

- ☑ An outdoor space is needed for a staging area to prepare eelgrass for transplanting, such as a park or parking lot near a boat launch or marina. A permit may be required by the local municipality or regional district to reserve such a site, so consult with the appropriate agency several weeks before the event. Proof of insurance coverage for volunteers will be necessary to proceed with the approval.
- ☑ Restoration work can take more than one day to complete, depending upon the number of eelgrass shoots to be transplanted and the number of volunteers or paid shore crew available.
- ☑ The work site should be located a safe distance from a boat launch to avoid traffic leading to or away from the launch, but close enough to the water for convenient transport of eelgrass plants and saltwater collection.
- ☑ Overhead tent canopies are helpful so that volunteers or work crew members are protected from exposure to sun, snow, or rain. Ensure the overhanging material is secure from gusty winds. Chairs and tubs can be arranged in small groupings for efficiency and comfort (see Chapter 4 and Appendix C: Equipment Lists).
- ☑ A work shift schedule is the easiest way to ensure volunteers do not burn out. Work crews also need regular breaks. Two-hour shifts are suggested if there is volunteer capacity to complete the transplant. Many volunteers return after their first shift to help complete the work.
- ☑ A sign-in table can serve as a welcoming site for arriving volunteers, as well as a central site for refreshments and information. Water and snack bars help keep volunteers and staff comfortable. Sign-up sheets should include full names and space for emergency contact phone numbers. A first aid kit and bathroom (or porta-potty) facility are required for the safety and comfort of all participants.
- ☑ Metal washers, which serve as anchors for eelgrass shoots so they do not drift away during strong winds or turbulent water caused by boat wash, need to be prepared with 4" paper twist ties, preferably before the restoration event. The instructions for preparing them are described in Chapter 4. If washers are prepared on site, the method can be shown to the volunteers at the work station.

While the volunteers are preparing the shoots, the divers prepare the transplant site for planting and conduct a second harvest, having done a first harvest before the work crew or volunteers arrived on site. Once the second harvest is completed there should be enough prepared shoots ready to plant from the first harvest.

★ It is important to coordinate the rate of harvest with that of processing and planting. It is best if the shoots that are harvested are planted within 24 hours.

FREQUENTLY ASKED QUESTIONS:

1. What should I consider as expenses for a community meeting?

Costs for room rental, honoraria for First Nations presenters and/or gifts (such as blankets), hot/cold beverages, snacks, printing of large paper maps, markers, pens, large poster sized paper for notes, sticky note pads, and printing of posters and brochures.

2. How often would a Technical Committee need to meet?

A meeting schedule can be decided amongst the Technical Committee members. It may be dependent on how many survey sites are reviewed and the complexity of the sites (e.g. seasonal recreational uses at or near the site).

3. How can I demonstrate appreciation to volunteers or the work crew?

Showing appreciation begins with the welcoming table at the restoration event and with the designated greeter, who can ensure each volunteer or work crew member is acknowledged and informed of the requirements to complete the work. It is important to make sure each participant is physically comfortable at the work station. When they complete their shift, they would be acknowledged for their labour, informed of the next steps for restoration and monitoring, and how information about the progress of the work will be communicated.

Credit: Rebecca Benjamin-Carey

CHAPTER 4: SUCCESSFUL RESTORATION BY TRANSPLANTING VEGETATIVE SHOOTS

This chapter outlines the process for eelgrass restoration by transplantation step-by-step with tips from decades of experience. The method uses the 'SAFE technique' (Safely Anchored with Fe) (Durance & Kyte, 2011), which has been used successfully for the last forty years in British Columbia, Puget Sound in Washington State, and in the United Kingdom.

In addition to the text, we provide videos to support the process.

4.1 SET UP OF WORK STATIONS

The work stations where participants will attach anchors to shoots should be organized in a manner that maximizes processing efficiency and is comfortable for the community volunteers or work crew. Safe and convenient access to the work site should be a factor in the selection of the restoration site.

The work station (Figure 4.1) should be in close proximity to saltwater so that the water in the totes containing harvested eelgrass shoots can be refreshed easily and regularly throughout the day. The water should be kept cold and clean for the health of the eelgrass shoots. An on-site gas-powered generator with an attached pump and hose can make the transfer of seawater to the containers easier than transferring water regularly with buckets by hand.

Figure 4.1 Work station near Cowichan Bay boat launch (A), and Pacheedaht First Nation work crew set up ready to go (B).

A commonly used setup for efficient processing of the eelgrass shoots is shown in Figure 4.2. This work station setup is designed for a crew of four people and can be duplicated to accommodate additional volunteers and work crew members.

Chairs 1-4 are positioned so that the volunteers/work crew can share a container of 100 anchors (ungalvanized steel washers with paper twist-ties attached). Those sitting in chairs 1 and 2 pick up individual shoots out of tote A and check to see whether the rhizome has three nodes and extends about 10 cm from the sheath. If the rhizome is longer than 10 cm, the excess can be broken off for ease of planting. If the rhizome is shorter the shoot needs to be placed in a separate discard bucket of saltwater. An anchor is then attached to the shoot with enough pressure to keep the shoot in place, but not enough to damage the rhizome. The tied shoot is then placed in the laundry basket in the middle of the group (C).

The crew in chairs 3 and 4 pick up eelgrass shoots from tote B, attach a washer, then place the tied shoot in the laundry basket in tote C. Avoid draping the shoots over the rim of the basket as the leaves of the shoots must be kept moist.

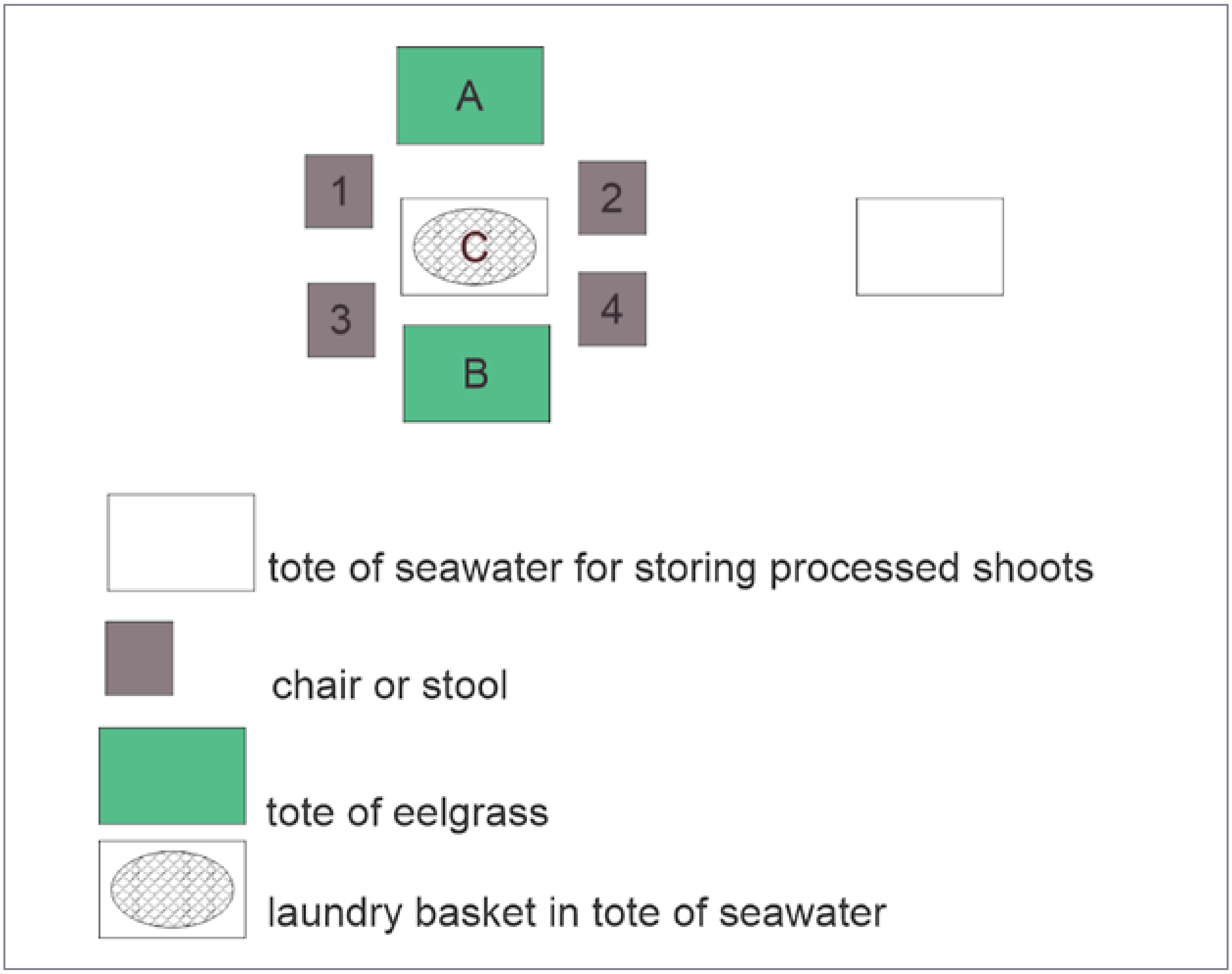


Figure 4.2 Set up of the work station. Credit: C. Durance

★ It is advisable to assign a Monitor to ensure quality control of tying of shoots to washers, as eelgrass shoot rquire proper attachment to their anchors for successful transplanting.

This video clip demonstrates eelgrass harvesting

4.2 HARVESTING EELGRASS SHOOTS BY DIVERS

Work Safe BC certified SCUBA divers[3] (Figure 4.3) harvest eelgrass shoots before the work crew or volunteers arrive at the work station. The shoots must be harvested from a continuous eelgrass bed with a minimum density of 24 shoots/m^2. The divers tease individual shoots out of the sediment without breaking the rhizome too short (10 cm or three nodes/rhizome). The ease of removal depends on the sediment. If a diver has trouble removing shoots they should move to another part of the bed and try again as the sediment may be looser.

Divers fill a harvest mesh bag with eelgrass shoots, then swim to the dive boat where the harvest bags are emptied into a tote of fresh seawater. These transplant shoots need to be submerged in seawater at all times, except when they are being attached to washers.

Figure 4.3 The Pacheedaht commercial dive crew.

It is often easier to harvest shoots when the tide is slack or flooding. The divers should harvest throughout the bed, at the pre-determined depth, and never harvest more than 10 per cent of the shoots in the harvest site.

3. Divers must be certified with Work Safe BC if they are receiving payments for their labour; the certification also insures qualified and safe SCUBA divers.

This short video demonstrates this process of preparing the washers

4.3 PREPARE ANCHORS

For efficiency, it is recommended anchors be prepared before the restoration event. Anchor preparation requires paper twist ties[4] 10 cm length, and containers of plain steel (ungalvanized) 1.6 cm metal washers[5], see Appendix C for an equipment list and potential suppliers. The twist tie is folded exactly in half, and placed over the washer with the two ends meeting in the middle opening of the washer. The two ends are twisted once and spread apart. This facilitates processing. The twist-tie must be tightly tied to the washer (Figure 4.4).

Figure 4.4 Examples of prepared metal washers with twist ties attached. Note that it is important to use paper-wrapped twist ties, which will fully disintegrate, and not plastic-wrapped ones, which would leave behind non-biodegradable debris. Credit: SeaChange

The tied washers are then placed in containers (plant pots or a similar size – 100 washers/container). This makes it easier to estimate the total number of shoots prepped and transplanted.

4. 10 cm paper covered twist ties are available from most packing and shipping companies.
5. Preparing the anchors (washers with twist-ties) and cutting the jute in advance can double the number of shoots processed in one day.

This video demonstrates selecting harvested shoots for washer attachment

4.4 ATTACH EELGRASS SHOOTS TO ANCHORS

Choose a shoot from the container of harvested shoots with at least three nodes on the rhizome and ~7 cm length (about the width of your fist).

- Thread the rhizome through the top of the anchor where the paper tie is twisted until you can see a slight difference in the colour of the rhizome – from white to a slight green.
- Twist the paper tie around the shoot gently but with enough tension that when the shoot is lifted the anchor does not slip.
- Place the tied shoot in a laundry basket inside a tote filled with clean seawater (tote C in Figure 4.2).

4.5 ORGANIZE EELGRASS SHOOTS FOR DIVERS

The diagram below (Figure 4.5) illustrates the method for threading anchored eelgrass shoots onto jute or twine so that it is easy for divers to place and plant groups of ten shoots a metre apart along a transect line or measuring tape.

Why 100 shoots/basket?

The number of 100 tied shoots in each basket is important as it is the way divers and the Project Manager can track the total number of shoots that are transplanted. If the shoots are tied into groups of 10 into a "jute necklace", the divers do not have to count the shoots under water where the visibility might be low.

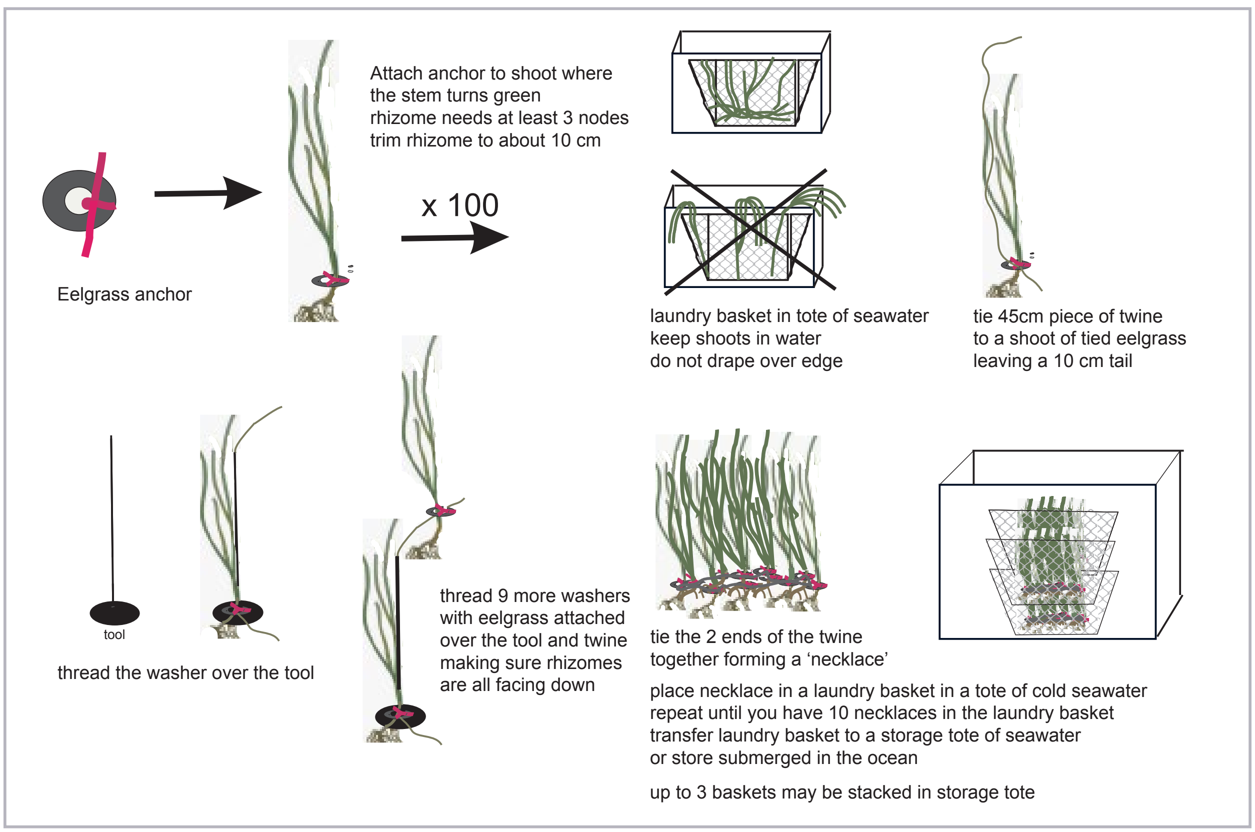


Figure 4.5 Illustration of tying jute necklaces. Credit: Cynthia Durance

This video clip reviews instructions for preparing eelgrass shoots for transplanting

4.6 PROCEDURE FOR TYING EELGRASS NECKLACES

The method for organizing eelgrass shoots for planting is stringing ten anchored shoots onto a 30 cm piece of jute and tying the end to the first threaded shoot, to make an "eelgrass necklace" of ten shoots (Figure 4.6). After ten necklaces are placed into the laundry basket, another empty laundry basket is placed in a tote filled with clean seawater. The basket of necklaces is immediately placed in the shallow nearshore, or into a saltwater filled tote with a lid on the shore.

Figure 4.6 Ten eelgrass shoots strung onto jute to make a necklace. Credit: SeaChange

The following steps describe "eelgrass necklacing":

1. One or two people at the work station areas are designated as necklace weavers. They measure and cut 10 pieces of jute or twine in 30 cm lengths. These can be cut in advance. After 100 shoots are tied with metal washers, one person can count out ten anchored shoots and pass them to another to string together to make a necklace.
2. Threading eelgrass shoots with anchors attached onto the jute can be very tedious, as the jute has a tendency to fray. A tool similar to the one shown below (Figure 4.7) facilitates the threading and cuts the 'necklacing' time in half. The one pictured below was made from a BBQ meat skewer.
3. One metal washer with eelgrass shoot attached is tied to the end of the 30 cm jute, leaving 10 cm (4") tail. The other end of the jute is notched onto the threading tool and aligned with the tool so nine other shoots can be threaded on the jute. The jute is then un-notched from the threading tool and both ends are tied, resulting in 10 anchored shoots on a jute necklace which is immediately placed in a laundry basket inside a seawater filled tub.

Figure 4.7 Threading tool made with a BBQ skewer. A notch at the end helps with threading.
Credit: Cynthia Durance

4. The washers need to be threaded so that all the rhizomes are facing the same direction, up or down.
5. Once the basket within the tote of clean seawater contains ten necklaces (100 shoots total), it can be transported to the underwater pick-up site (Figure 4.8). Baskets of tied shoots may be stacked to a maximum of three during transport. It is important to keep close watch on the tides, as baskets can either be carried away by rising tides, or exposed to the sun and air, causing stress for the shoots.

If the work station is not close to the shore, the baskets can be placed in tubs with lids, making sure the water temperature in the tub is kept cool until pick up.

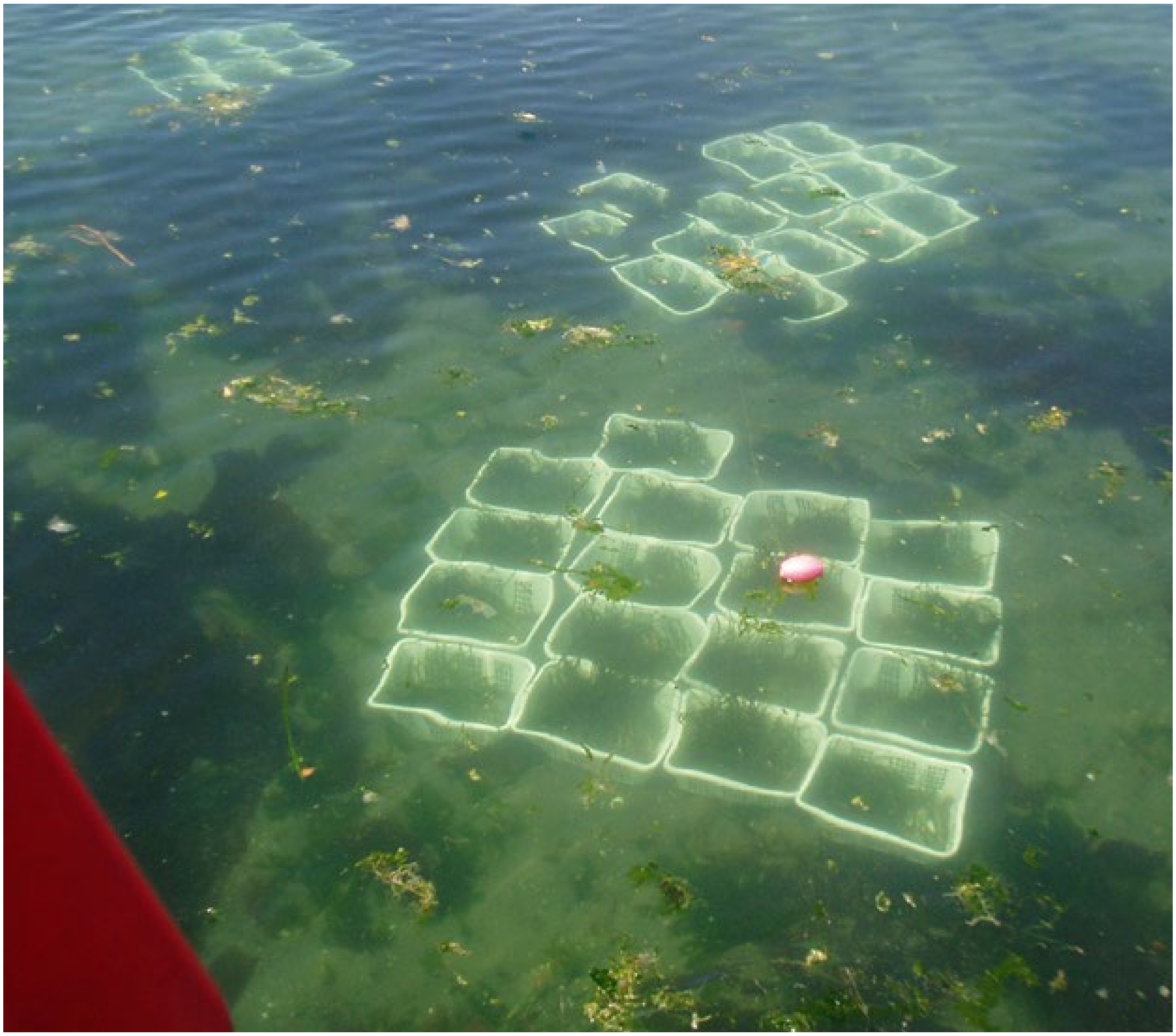


Figure 4.8 Submerged baskets of prepared eelgrass. Credit: SeaChange

This video clip reviews instructions for eelgrass placement and eelgrass transplanting

4.7 EELGRASS TRANSPLANTING

Divers plant 10 shoots per square metre along a transect line using a measuring tape.

The video clip above demonstrates setting a transect line between two endpoints. Some projects may include marking a transplant plot. Instructions for doing this are included in Appendix J.

The design pattern of transplanted shoots makes it easier to monitor over time, as the transplant has a specific shape and size that is recorded in a sketch map immediately after the transplant work is completed. The map drawing is referred to in order to note changes in the number of surviving shoots and their distribution. It is very advantageous to video the site before and after the transplant, and during each monitoring event to compare change over time of the site.

All measuring tapes are removed after the transplant work is completed (Figure 4.9). No stationery object is left behind to demarcate the site as debris and sediment accumulated around a permanently placed marker can damage the transplant. GPS coordinates of the borders of the transplant area are recorded on the boat. This is done by the diver using a marker float attached to a lead weight with durable string. The floats are released after the weights are positioned at the end points of the transplant area and surface, where a boat crew member will then record the GPS coordinates of each marker, so that the location of the transplant site can be easily found for future monitoring (see Appendix K for instructions on how to make marker floats).

If there is a boat large enough to transport the transplant work crew or volunteers, a visit to the restoration site is valuable. With an underwater camera with a viewing screen on the deck, or, if the water is clear, sighting the new plant installation over the side of the boat can be rewarding and informative for the whole team.

Figure 4.9 Transplanted shoots in groups of 10 spaced 1 metre apart. Credit: Coastal Photography Studio

4.8 MEASURING SUCCESS

How do we know a restoration project is a success? A project is considered successful if the restored habitat is equal to or greater than a healthy reference bed in eelgrass productivity (shoot density and **biomass**), ecological habitat functions (**macrofaunal** species richness and abundance as evidence of nursery function), and biogeochemical functions such as water quality modulation. (Beheshti et al., 2022). In BC, eelgrass productivity (shoot density and biomass) and area coverage have been the main criteria for measuring success (Durance, 2001).

It is advisable to monitor the transplant(s) six and 12 months after installation (Figures 4.10 and 4.11). Six months after the planting will indicate if winter storms are adversely affecting the shoots, as well as give evidence if other activities (i.e., boat anchoring, disturbance by crabs or shellfish harvesting) are disturbing the newly installed plot. Then, if the bed is disturbed or destroyed after 12 months, there is some understanding as to the causes. After a year, monitoring should be done on an annual basis, within two calendar weeks of the 12-month monitoring schedule.

Monitoring method (Please refer to the Eelgrass Mapping and Monitoring Practitioners' Handbook for greater detail of monitoring methods)

1. Density

The eelgrass is transplanted at a rate of one cluster (or patch) of 10 shoots per square metre. It usually takes two to three years for them to multiply enough to coalesce. Therefore, the success of the transplant can be monitored before that time by counting the number of shoots per patch. If resources allow, count the number of shoots per patch in 40 per cent of the total number of patches present. Once the patches have started to coalesce, a 1 square metre quadrat should be used to estimate the number of shoots per square metre. Thirty replicates (number of samples) should be done if the area is large enough.

This video clip reviews instructions for eelgrass monitoring

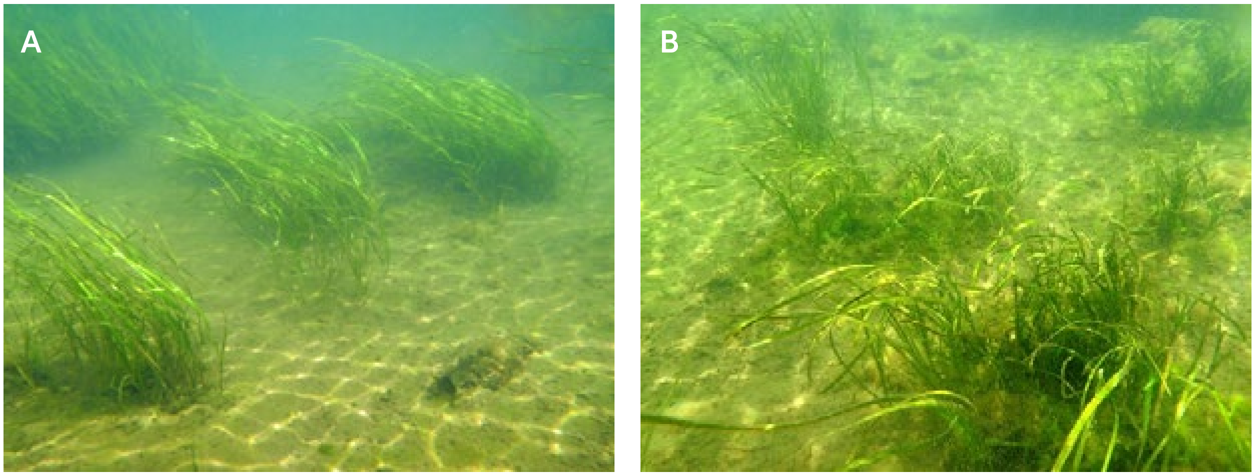


Figure 4.10 Eelgrass transplants spaced at 10 shoots/m^2 at the time of planting (A), and an eelgrass patch expansion after one year (B). Credit: SeaChange

2. Area

The area where eelgrass plants survived is measured with a measuring tape and recorded to compare with the original size of the transplant to determine if more or less of the eelgrass survived. For example, if an area of 100 m^2 was planted, did the eelgrass survive throughout that area, or less? Refer to the sketch maps drawn right after the transplant occurred. The map should include information such as GPS coordinates of the transplant site, date, tide height, and time. Draw another sketch map in the same notebook containing the original map to record changes over time. A monitoring data form can be found in Appendix D.

3. Reference bed

It is optional to monitor a reference bed (natural eelgrass bed near the transplant site) to compare density, distribution, and productivity of the transplanted bed. It is best to use a quadrat[6] to measure density, shoot width, and length of the reference bed shoots in 30 samples to compare these measurements to the transplant. It is also helpful to note the **infauna** and fish populations in the reference bed during each monitoring event.

Shoot density changes with the seasons in both reference and transplant sites. **HOBO®** data loggers can be used to record temperature and **salinity** changes over time at the transplant site and can add valuable information to explain seasonal and other changes in densities and distribution within a transplant and reference site. Count the number of shoots rooted in at least 20 quadrats at a depth similar to the transplant site.

4. Productivity

Eelgrass **productivity** refers to the rate at which the plants convert sunlight energy into organic plant material (biomass) through photosynthesis.

Leaf Area Index (LAI) indices are often used to estimate the productivity of eelgrass and the amount of habitat available for colonization by **epifauna** (Durance, 2002). The LAI is calculated according to the following formula:

LAI = **mean** shoot length x **mean** shoot width x **mean** density of shoots/m^2

LAI is potentially more sensitive to environmental stress than a parameter such as leaf width since it integrates both density and area (Neckles, 1994).


Credit: Sean Smyrichinsky

6. Quadrats are instruments used to quantify shoot density within a specified area. For eelgrass, densities are typically assessed using a 0.25 metre squared quadrat Refer to the Mapping and Monitoring Practitioners' Handbook for more details.

4.9 POSSIBLE CAUSES FOR TRANSPLANT FAILURES

There are many reasons an eelgrass transplant may fail, some of which are out of our control. These include major storms coinciding with low tides, new channels developing on tidal flats, or benches created to support an eelgrass transplant at an incorrect depth or gradient.

Eelgrass can grow in substrate that contains a large amount of wood waste or woody debris, such as from floating logs, but the transplant site needs to be located in very calm waters, such as harbours, lagoons, or sheltered bays. Consider maximum water velocity during spring tidal cycles before transplanting, as mobile logs and debris can scour the seabed and destroy plants.

Seaweed, either live or its detritus, can smother eelgrass. Many species of seaweeds die back in winter; therefore, potential transplant sites should be surveyed during late spring or summer to observe the amount of seaweed, such as sea lettuce (*Ulva spp.*), that may prevent sunlight from reaching the eelgrass shoots during the most active growing season.

Any hard substrate, including cobble and shells, has the potential to be colonized by seaweeds that could shade and/or smother eelgrass, such as Japanese wireweed, *Sargassum muticum* (Figure 4.12). Breakwaters and reefs often support dense kelp that may smother adjacent eelgrass.

Quality control throughout the transplant process is essential to its success. Shoots must be kept submerged in cold seawater, have long enough rhizomes with three nodes to support the shoot, the washers must be tied correctly, and the anchored shoots should not be buried too deeply, but deep enough that the washers are covered and well situated in the sediment.

A checklist of potential causes for transplant failure can be found in Appendix H.

Figure 4.11 Diver monitoring eelgrass transplant.
Credit: Coastal Photography Studio

Figure 4.12 *Sargassum muticum* (Japanese wireweed) attached to rock near eelgrass.
Credit: SeaChange

FREQUENTLY ASKED QUESTIONS:

1. Is it best to transplant intertidally or sub-tidally? What are the advantages/disadvantages of each?

The majority of eelgrass habitat in BC is subtidal, so it is likely your transplant site will be too. Subtidal transplants are the most likely to succeed, as **desiccation** (drying) from exposure to the sun during the hot summer months, or exposure to freezing temperatures during the winter, will increase the likelihood of failure. Canada geese are likely to graze upon exposed eelgrass shoots at low tide.

However, you might want to restore a portion of an intertidal bed that has been damaged (e.g., damage caused by log storage or the grounding of a barge). If the transplant area is surrounded by healthy intertidal eelgrass your project should be successful. It is critical that the donor plants are from a location of the same depth, or **bathymetry**, as those in the selected transplant site, as the eelgrass shoot height and width are adapted to depth. Refer to Ecotypes, Chapter 1.

2. How do we determine the most suitable transplant site to ensure success?

Please see Chapter 3 for the criteria for selecting a transplant site.

3. When is the best time to restore eelgrass?

Any time of the year in most locations is suitable, but it may be best to implement restoration when volunteers or a work crew are available, and weather conditions are favorable for them at the work station.

4. What would be the typical budget items for an eelgrass transplant project?

Please see Appendix C for a list of the budget items needed to complete a transplant project.

5. What about an alternative for the steel washers?

It has been discovered that the ungalvanized steel washers used for transplants have a positive impact on sediment quality, especially in former log boom areas high in hydrogen sulphides (HS_2) from decomposing wood waste, which causes the sediment to become low in oxygen. Anaerobic (low oxygen) sediments limit the infauna that can live there (e.g. clams). Iron (Fe) or rust from the corroding metal washers combines, or chelates, with hydrogen sulphides in the sediment. Field observations have shown that over time, the black anaerobic sediment around the anchors becomes brown, indicating that the sediment is no longer anaerobic.

6. Is the donor bed negatively impacted by harvesting?

If harvesting is done carefully, without creating empty spaces between shoots, there are no negative impacts. Eelgrass has compensatory growth; removing a shoot stimulates the plant to produce a new shoot. The bed will recover at approximately 0.5 m/yr. Please view the video clip on harvesting.

7. How do I find out how others are succeeding (or not) with eelgrass transplanting?

You can contact groups directly. Information can also be found in the Eelgrass State of Knowledge Report, the Community Salmon Restoration Atlas, and the 2024 Eelgrass Symposium Report, which lists the Symposium attendees and their work in the Salish Sea and WCVI, as well as other coastal areas of BC.

8. Is there a way to connect with others who are restoring eelgrass?

A network is presently forming (2026) named the 'Seagrass Collective'. A group of seagrass researchers, First Nations, and conservation groups and practitioners are beginning conversations across the 49th parallel to compare notes on our collective work. Most meetings will be virtual. For more information contact seagrass@hakai.org.

CHAPTER 5: SUCCESSFUL RESTORATION BY SEEDING

Eelgrass produces seeds. In nature, germination rates are low (3-4%), and are only somewhat higher in restoration seeding projects, meaning initial restoration rates can also be quite low. In eelgrass restoration, these low germination rates are offset by the low-cost and low-tech benefits, making seeding projects especially well-suited to community groups and schools.

5.1 SEEDING METHODS

There are several seeding methods that have been trialed globally (Figure 5.1 and Table 5.1). Some require no seed storage, such as Buoy Deployed Seeding (BuDS) and Burlap Bag Seeding (BBS). Other methods, such as hand broadcasting or injected seeds require more equipment and space for over winter seed separation and storage. Note, BBS can also be done with seed separation and winter storage.

Figure 5.1 Different eelgrass restoration seeding methods. Top two images credit: A. Spooner

Bottom left credit: https://depts.washington.edu/fhl/tidebites/Vol94/index.html
Bottom right credit: https://www.makewaterfamous.com/news/seagrass-seeds-restoring-thames-underwater-meadows

Table 5.1 Comparison of eelgrass seeding methods with transplant methods.

Method	Advantages	Disadvantages
BuDS / BBS	▸ Added genetic diversity ▸ Low cost ▸ No disturbance to donor bed ▸ Low tech and easy ▸ Compatible with community engagement	▸ Time sensitive ▸ Not effective in higher energy sites ▸ Challenges with intertidal sites ▸ Monitoring can be challenging ▸ Difficult to do large area restoration
Hand broadcast /injected seeds	▸ Added genetic diversity ▸ Moderate cost ▸ No disturbance to donor bed ▸ Low tech and relatively easy ▸ Compatible with community engagement	▸ Time sensitive ▸ Facilities needed for overwinter seed treatment and storage ▸ Not effective in higher energy sites ▸ Monitoring sites can be challenging ▸ Difficult to do large area restoration
Transplant	▸ Effective in higher energy sites ▸ Intertidal restoration possible ▸ Compatible with community engagement ▸ Large area restoration possible	▸ Donor sites may be difficult to find ▸ Projects are higher cost ▸ Slower to prepare/plant ▸ Divers needed ▸ Lower genetic diversity

Transplant methods have proven to be successful for over eight decades of restoration work and research, but with a relatively high cost and remaining uncertainty about the compounding conditions for successful restoration (Ward & Beheshti, 2023). There is value in advancing other restoration techniques, including eelgrass seeding. Seeding is a method that can add genetic diversity to restoration projects compared to transplanting shoots from a single donor site. This advantage can also have a positive effect on plant fitness and resilience, possibly an added advantage for resilience and adaptability against climate change impacts (Kendrick et al., 2012). Reproductive shoot collection for seeds has the advantages of leaving the donor eelgrass bed intact as the plant rhizomes are undisturbed, and of being very low-cost and low-tech.

Buoy Deployed Seeding (BuDS) and Burlap Bag Seeding (BBS) methods are described here as the least complex and costly methods. Seeding by BuDS or BBS is recommended as a value-added method in traditional transplanting projects or can be a restoration method on its own. If there are cultural or archaeological concerns, seeding methods can be a lower disturbance alternative to transplanting.

5.2 SEEDING SITE SELECTION

Site selection makes the difference between a successful eelgrass restoration project and one that isn't. All eelgrass transplant site selection conditions, such as **bathymetry**, sediment type and water quality measurements described in Chapter 3, apply to eelgrass seeding projects. Unlike transplanting, there is more tolerance to not match conditions between seed donor beds and seed restoration sites because seedlings can adapt to the conditions as they grow (Smith et al., 2022). Specific to seeding projects, there are some general recommended best practices for donor and restoration site selection to consider when collecting seeds for a restoration project. If large numbers of lugworm casts (Figure 5.2) or European green crabs are present, reconsider your site selection as these species voraciously eat eelgrass seeds. Trial projects suggest combining eelgrass seeding methods with a transplant project is most beneficial (Figure 5.3). If seeding independently of a transplant project, seed where eelgrass is nearby to be sure conditions are suitable for germination and establishment. Survey the project site when selected to map out plot size(s) and shape(s), including mapping any existing eelgrass patches (Figure 5.4) (see the Eelgrass Mapping and Monitoring Practitioners' Handbook for mapping methods). Make notes of species present, density of worm casts, eelgrass density and health, etc.

★ **Can seeding be done intertidally and subtidally?**

Yes, but pilot projects have only been in 0 metre to 2 metre **chart datum** depth. Concerns are human and predator disturbance intertidally, and light penetration limitations if very subtidal.

Figure 5.2 Dense lugworm castings (poop). Credit: C. Durance

Table 5.2 Recommended best practices for site selection and project success in BuDS/BBS eelgrass seeding restoration.

Recommended Best Practice	Comment
Harvest reproductive shoots from several different donor beds to optimize germination and maximize any site-specific adaptive advantages (Figure 5.3).	Consider harvesting seeds from both sheltered beds and those that are exposed to waves and currents (Smith et al., 2022). Avoid beds further away than a reproductive shoot would naturally travel. Some sheltered sites may see minimal transport, whereas others, the eelgrass may travel further.
Stay within the same ocean circulation and **ecozone** area when selecting donor bed(s).	The distance is dependent on processes affecting currents (i.e., tides, freshwater inputs, dominant wave and wind generated currents) at the site and is therefore highly site specific.
Avoid the transfer of other vegetation and invertebrates from the donor bed to the restoration site.	Avoid site-to-site **bio-contamination.**
Reproductive shoot collection rate should be <50% of the donor bed's reproductive shoot density.	Collection rate maintains the innate viability of the donor bed.

Figure 5.3 Seeding BuDS sets overlaying eelgrass transplant site where seedlings will germinate on the bare sediment between planted eelgrass bundles, Juus Ḵáahlii, Haida Gwaii. Credit: A. Spooner

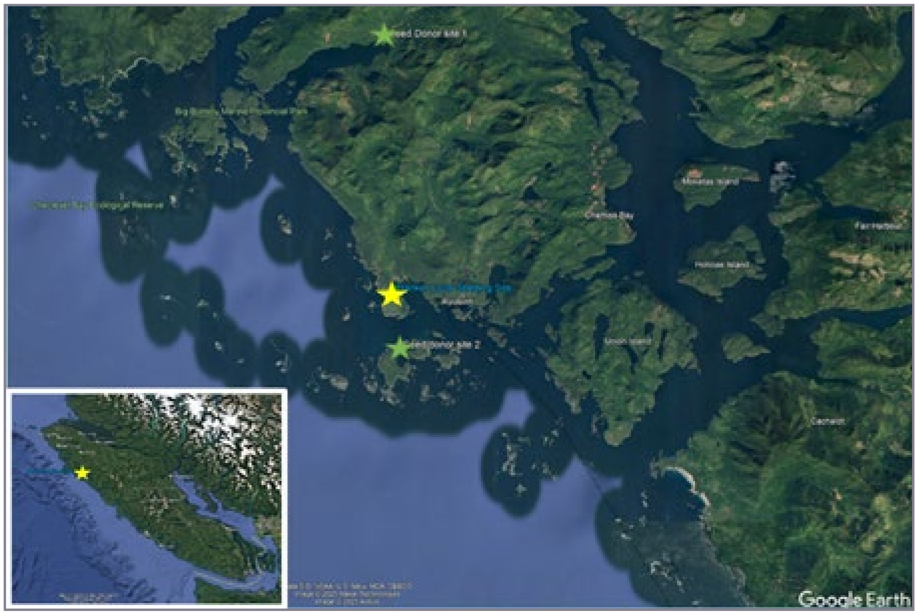


Figure 5.4 Example of BuDS seeding restoration project site (yellow) showing two reproductive shoot donor sites (green) Ka:'yu:'k't'h'/Che:k'tles7et'h' First Nations, Kyuquot.
Credit: Google Earth

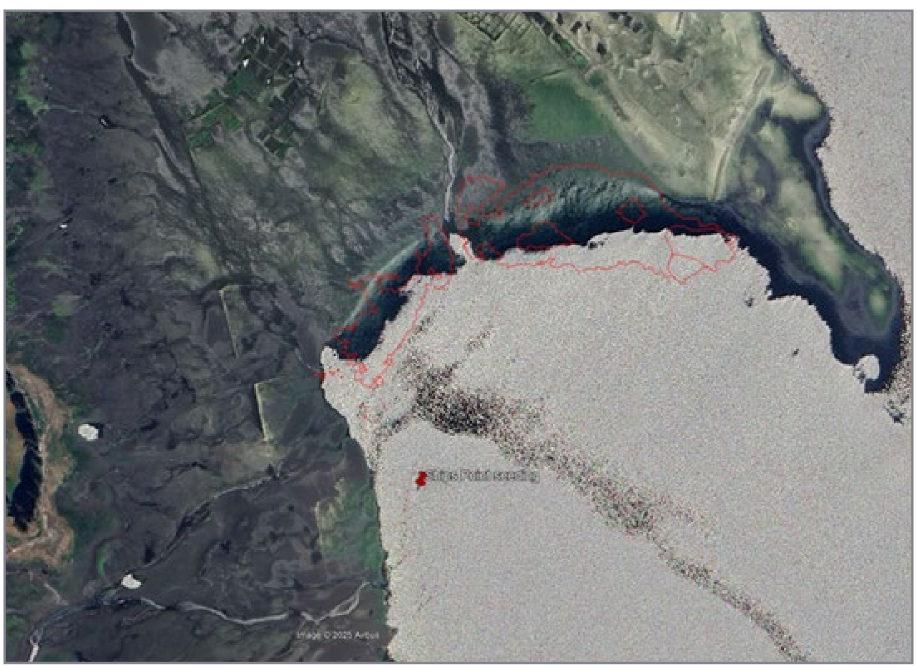


Figure 5.5 BuDS Seeding site (red pin) with eelgrass beds (red outline) nearby (<100m), Ships Point Vancouver Island (bed data provided by Comox Valley Project Watershed Society).

5.3 SEEDING EQUIPMENT AND METHODS

The following summarizes the BuDS and BBS seeding equipment and methods used by DFO's Restoration Centre of Expertise, Coastal Habitat Restoration Biologist's 2023-2026 eelgrass seeding pilot work in British Columbia (Spooner, 2025; Spooner, 2026). Equipment needed to build BuDS and/or BBS is listed in Table 5.3. Practitioners should feel free to adapt equipment and methods to best suit their project and location.

This video clip demonstrates BuDS methods

Which is better, the BuDS or BBS method?

Selection between BuDS or BBS methods will vary depending on site characteristics and scale of project. You might use both!

Construction of BuDS sets or BBS

Table 5.3 Equipment required for small and large BBS and BuDS set deployment.

Equipment per one BuDS Set	Equipment for multi-Large BBS	Equipment for multi-Small BBS
▸ 20-m floating line* ▸ 2x large floats* ▸ 2x quick clip snaps ▸ 1x half cinder block or drilled rocks** ▸ 1x nylon mesh produce bags or poly mesh shellfish bags ▸ Twine/wire	▸ Landscape staples (steel) ▸ Loose weave burlap bags (35.5cm x 66cm) ▸ Rolls hardware cloth cut into rectangles (1/4" mesh) ▸ Twine ▸ Local sediment or play sand ▸ Shovel/trowels ▸ Sorting trays ▸ Anchor for site marking ▸ Line for site marking ▸ Floats for site marking	▸ 15 m, 9.5 mm sisal/hemp line ▸ Loose weave burlap bags with drawstring (10 cm x 15 cm) ▸ Large rocks for line end anchors ▸ Pliable wire ▸ Sorting trays ▸ Anchor for site marking ▸ Line for site marking ▸ Floats for site marking

* New equipment is not necessary. Consider using clean, used floats and line, purchased or beachcombed.

** A diamond bit can be used to drill holes through rocks rather than purchasing cement blocks.

To build a Buoy Deployed Seeding (BuDS) set, an anchor is attached to a floating line with 1-2 large floats at the end of the line (Figure 5.6). These sets should be placed out ahead of seed collection time. Ensure the plots' lines and buoys are not a navigational hazard during your site selection. Buoys should be brightly coloured, visible on the surface and labelled 'research' with contact information. The visibility of the buoys in popular areas may make the site at risk of vandalism or disturbance. Sharing the intent of the project through community notices may help as well as recruiting local 'eyes on' from neighbours. If concerned, consider either burlap bag method as there are no visible markers to attract attention. The BuDS set anchor can be half cement blocks or rocks with a hole drilled through them (Figure 5.7).

Figure 5.6 One BuDS set (anchor, line and floats) ready for later attachment of net bag of reproductive shoots Hankin Cove, Kyuquot. Credit: A. Spooner

★ **Drilled rocks and recycled floats and line can also be used!**

Figure 5.7 Using a diamond bit and drill, locally collected 2-5 cm sized rocks were used as an anchor instead of cement blocks in Juus K̲áahlii, Haida Gwaii. Credit: A. Spooner

The collected reproductive shoots are placed into nylon mesh produce bags or poly mesh seafood bags tied closed with a quick snap attached to each end (Figure 5.8). Mesh spacing should have a gap size of 2-9 mm so seeds disperse through the gaps but reproductive shoots stay in the bag. At the time of seeding, the prepared net bags will simply be clipped to the buoy lines at the water surface (Figure 5.9). The length of line should be at a minimum, equal to the maximum tide range during the months the sets are deployed. Example: if the anchor is in 0.5 m water at a zero tide, and the greatest tide range is 2.5 m, then the length of rope from the anchor to float should be at least 3 m (Remember, tide math is fun!). A line that is longer than the minimum will allow more drift in a radius around the anchor and a potentially broader area of seed dispersal. A shorter line may have a smaller area of seed dispersal, but it may also mean the buoys and bag are submerged at high tides making gear retrieval challenging later in the season.

The approximate cost is $200 per 10 BuDS sets — note this does not include the reproductive shoot collection equipment and effort. Equipment can be found at hardware stores, pet stores, fishing shops, online, and at your local beach.

Figure 5.8 A mesh produce bag with quick clips attached full of reproductive shoots ready for deployment to a BuDS set on site. Credit: A. Spooner

Figure 5.9 A BuDS setup showing the net bag of reproductive shoots clipped to the floating line at the buoy end. Credit: A. Spooner

Minimal equipment is needed to build Burlap Bag Seeding (BBS) sets. Note, groups can choose either burlap bag size or do both. All equipment is meant to rot and rust away, leaving no waste. With small BBS, the reproductive spathes can either be placed in the small burlap bags the same day or mature reproductive shoots can be kept in wet tanks/tables and seeds collected after they release (40 days), then seeds are placed in the small burlap bags.

To build large BBS, burlap bags are prepared by inserting a piece of hardware mesh cloth (Figure 5.10), which will prevent the bags from rolling up due to wave action. The total amount of reproductive shoots collected is divided among the number of bags (weigh or estimate) in the project. Full-length reproductive shoots are placed in a prepared bag, and a shovelful of sediment is added. The bag is tied shut with a piece of twine, kept horizontal and stored in totes of seawater for deployment. This method is more suitable for protected, low-energy sites. The approximate cost for 10 large BBS, including the staples for securing bags to sediment, is $115 — note this does not include reproductive shoot collection equipment and effort. Equipment can be found at hardware stores and online.

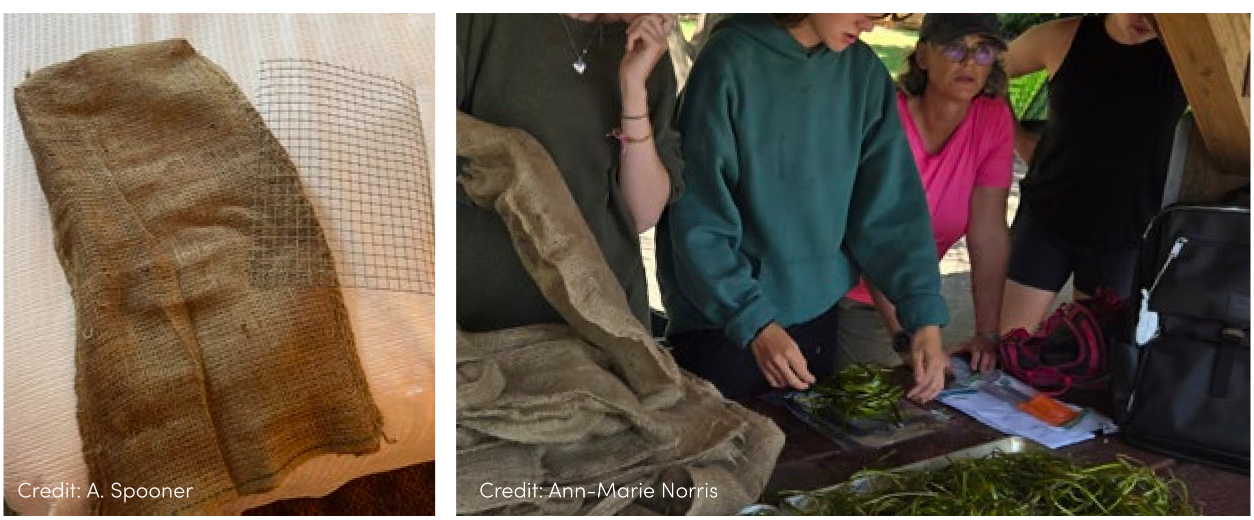


Figure 5.10 Large burlap bags and a square of hardware cloth to be inserted, weighed reproductive shoots to go into prepared large burlap bags, Tsleil-Waututh Nation, Whey-ah-Wichen (Cates Park).

To build small BBS (Figure 5.11), pre-soak 9.5mm (3/8") sisal/hemp line(s) so it is negatively buoyant. Attach a large rock to each end as anchors. Separate all seed spathes with formed seeds from the reproductive shoots. The total amount of spathes is divided into the number of bags (3-5 spathes each). Add a small amount of local sediment or play sand to each bag, no more than half full. Lay the line out onshore and, using wire, attach the prepared small burlap bags along its length. This method is better suited to sites with moderate current. The approximate cost for 30 m lines with 36 small burlap bags is $75 — note this does not include reproductive shoot collection equipment and effort. Equipment can be found at hardware stores and online.

Figure 5.11 Small burlap bags before filling, separated seed spathes (A), and filled burlap bags attached to pre-soaked sisal/hemp line (B).

5.4 DEPLOYMENT AND REPRODUCTIVE SHOOT COLLECTION FOR BUDS AND BBS

BuDS or BBS restoration sites can be set up in any configuration desired – several small plots or a single large one. The spacing, layout, or number of BuDS/BBS sets in a plot will vary depending on site characteristics such as slope and bathymetry, as well as project goals and budget. The shape may be linear, rectangular, or irregular. Examples of different shapes and scales of BuDS plot layouts are shown in Figure 5.12.

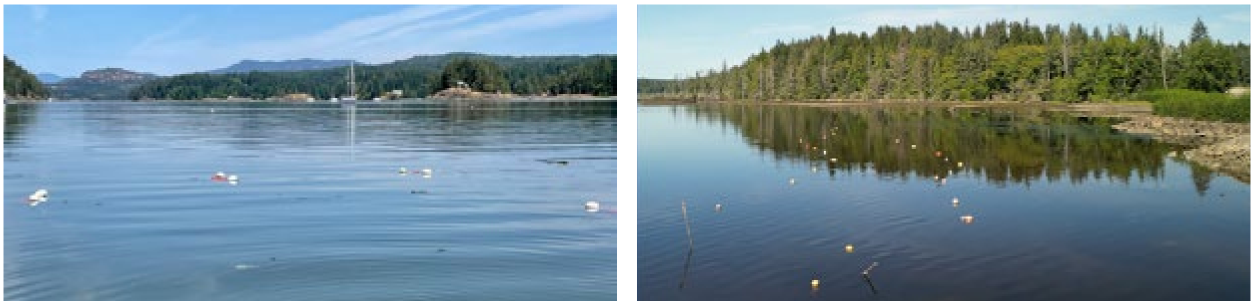


Figure 5.12 Layout, scale and numbers of BuDS sets will vary with each site: Gowlland Harbour, Quadra Island (left) and Juus K̲áahlii, Haida Gwaii (right). Credit: A. Spooner

For seed restoration projects there are four Stages as seen in the timeline below (Figure 5.13):

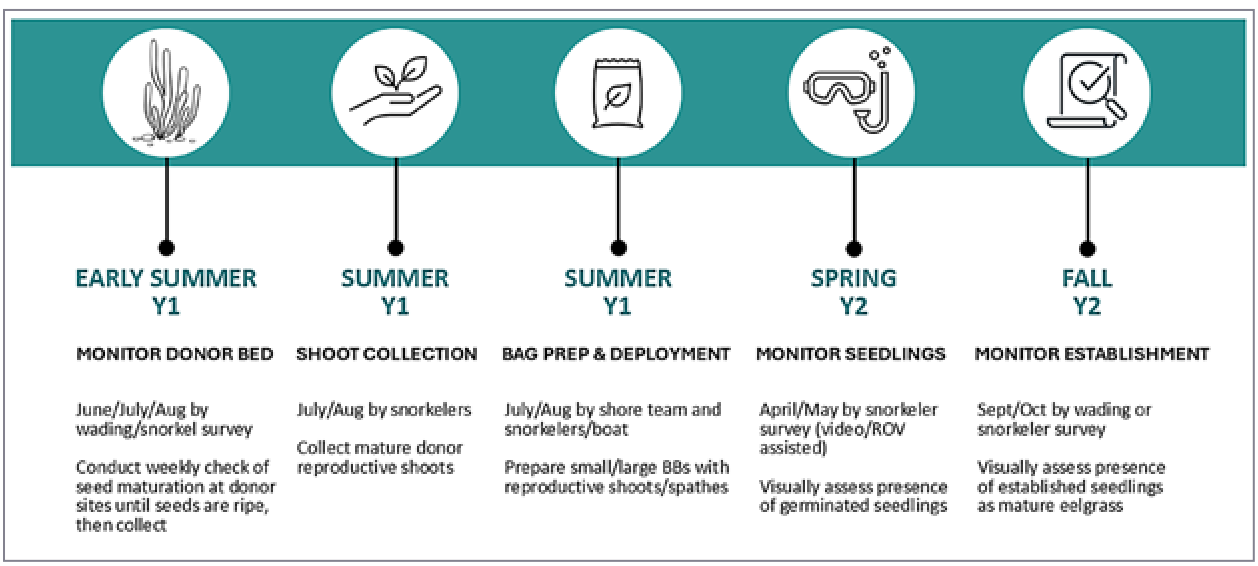


Figure 5.13 Project Stages 1-4 of eelgrass seeding restoration using the BuDS and BBS. For BBS, there is no Stage 1. Diagram credit: Laura Weatherly

Walking on the sediment during Stages 1 and 2 is fine, or a boat, standup paddleboard, or kayak can be used. From Stage 3 on, do not walk on sediment for a year. The collection team must have experience or instruction on how to recognize the reproductive shoots from vegetative shoots (Figure 5.14), and be instructed to snap the stem off by hand near the substrate without disturbing or uprooting the rhizomes in the donor bed (Figure 5.15). Equipment needed to collect donor reproductive shoots from donor beds is listed in Table 5.4.

Figure 5.14 Reproductive shoots (circled) are lighter colour, finer, with a round stem and taller compared to the more broad, green, vegetative leaves. Credit: A. Spooner

Figure 5.15 University of Victoria Indigenous student snorkeler carefully snapping the reproductive shoot stem near substrate, Juus K̲áahlii, Haida Gwaii. Credit: A. Spooner

Stage 1: BuDS deployment

BuDS sets only: The plot sets should be set up in advance of seed collection. The timing of this step is at your convenience, but it should be completed before the seeds are mature in the summer. It is okay to walk on sediment in this stage.

Stage 2: Seed assessment

BuDS and BBS: Conduct weekly assessment of reproductive shoot seed readiness. It is best to start shoot collection in the first 1 to 2 weeks of the 4-week period of seed release (June/July) – harvest when more than half of the spathes on each reproductive shoot have mature seeds in stage 4 or 5 (Figure 5.16). Early monitoring of the donor bed is critical as timing can vary by location and differ year to year, even at the same locations.

★ Walking on sediment after Stage 2, when seeds start to disperse can affect germination success.

Stage 3: Collection/deploy

For all methods:

Do not disturb the sediment until one year after deployment.

Harvest when more than half of the spathes of a reproductive shoot have stage 4 or 5 seeds. Using the equipment in Table 5.4, collect reproductive shoots by snorkelers, prepare the reproductive shoot net bags and/or BBS, then deploy bags. Ensure all bags are kept moist in cool seawater and deploy within 48 hours from harvest.

BuDS: The prepared net bags are attached to the floats at the surface in each plot.

★ Reproductive shoots are kept viable in totes with seawater and need to be deployed within 48 hrs.

Large BBS: The prepared large burlap bags are laid onto the sediment and secured with four landscaping staples (Figure 5.17). This work is done at the same time as the seed shoot collection and can be done at low tide with snorkelers. Seed collection occurs when more than half of the spathes on each reproductive shoot is ripe using the equipment in Table 5.3. Collect any marking buoys the day of, there is no other material to retrieve at the end of Stage 3 with this method, as all materials are bio-degradable.

Small BBS: The pre-soaked rope with prepared small burlap bags is placed out parallel to the shoreline at the restoration site, with the anchors at each end (Figure 5.17). This work is done at the same time as the seed shoot collection and can be done at low tide, with snorkelers or by boat/kayak/standup paddleboard. Seed collection occurs when more than half of the spathes on each reproductive shoot are mature using the equipment in Table 5.4. Collect any marking buoys the day of, there is no other material to retrieve at end of Stage 3 with this method as all materials are bio-degradable.

Table 5.4 Equipment required for donor reproductive shoot collection for BuDS and BBS methods.

Equipment for Donor Reproductive Shoot Collection
▸ Coolers, totes and buckets
▸ USB rechargeable aerators (pet store grade)
▸ Weigh scale*
▸ Mesh laundry bags (to collect shoots)
▸ Ziplock bags
▸ Sinking 0.5-m quadrat (PVC tube home build)*
▸ Permits as required
▸ Stand up paddleboard, kayak or other low profile boat as needed
▸ Snorkel team

* optional

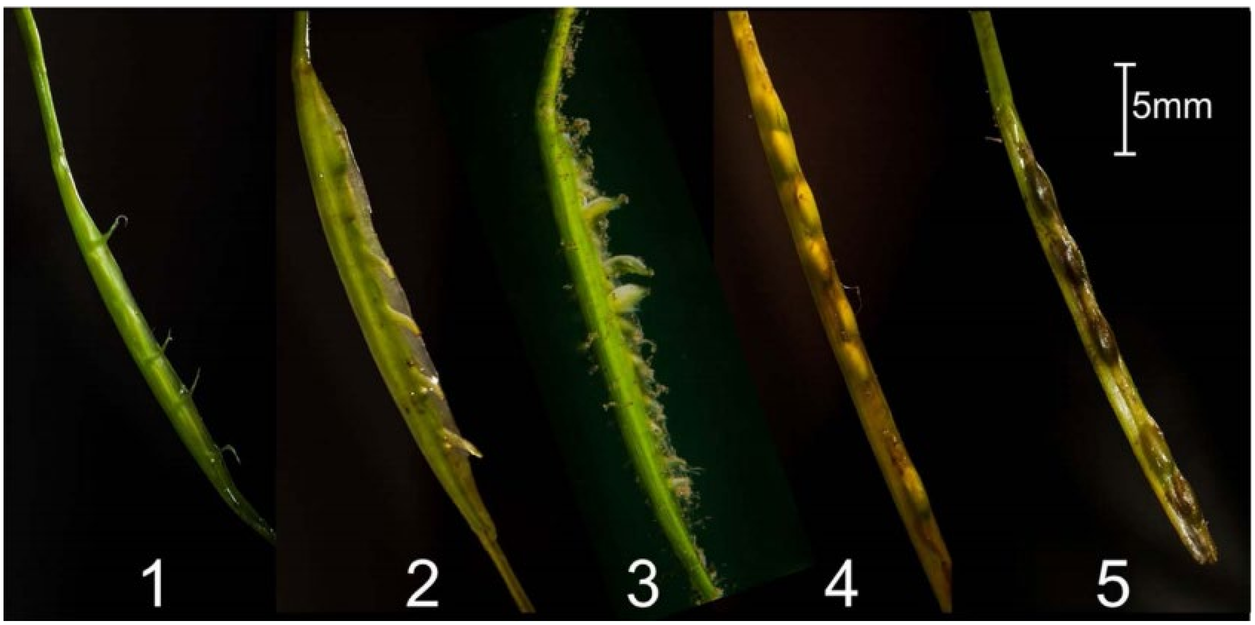


Figure 5.16 Developmental stages of eelgrass seeds (above) (Pickerell et al., 2006). Collect reproductive shoots when spathe's seeds are at stage 4 (left). Some spathes at end of shoots may be in stage 5.

Figure 5.17 Large BB pinned with 10 cm landscape staples to sediment (left) and portion of line with small BBS (right), Tsleil-Waututh Nation, səlilwət (Burrard Inlet). Credit: Natalie Mahara

Stage 4: Monitor seedlings/establishment

BuDS and BBS: Project monitoring.

See Section 4.8: Measuring Success

For both BuDS and BBS, there are two Stage 4 time points for monitoring in the year after seeding deployments (Stages 1-3) (Figure 5.13).

First monitoring timing: Early the following spring, in April/May, survey the site for very small seedlings (approx. 1-10 cm length) (Figure 5.18). This should be done by swimming during a higher tide period to avoid walking on the site and damaging seedlings. By June, it may be difficult to differentiate between a seedling and any sparse pre-existing eelgrass present.

Detailed monitoring by counting individual seedlings in the first spring can be a challenge due to the small size of seedlings and site conditions. If the quantitative count is not reliable due to site challenges, project success can be measured by recording "few (1-5)", "some (5-20)", "many (21-50)", "lots (50 -100)" and, "numerous (>100)" within a defined area.

Second monitoring timing: survey again in the fall or the following spring to determine whether the new seedlings established into eelgrass plants (Figure 5.19). It is much harder to distinguish established new plants from pre-existing or transplanted bundles of eelgrass. One way is if there is no lateral expansion growth between the plant and surrounding eelgrass stems, the stem is an established seedling. Presence of lateral growth stems can be tested with a plastic knife, gently 'cutting' through the sediment around the stem. Generally, establishment rates are much lower than seedling germination rates. At this stage, it is safe to walk/wade on the project area to conduct survey counts, or swim surveys may be repeated as done in the spring.

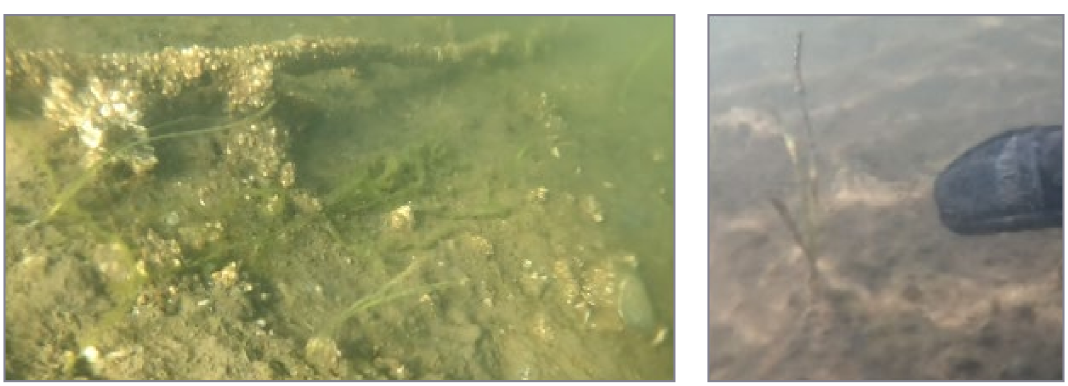


Figure 5.18 New seedlings video screenshot from May 2025 monitoring survey by Pacheedaht First Nations Fisheries Team commercial divers and DFO biologist; gloved finger for scale on right. Gordon River, Port Renfrew. Credit: A. Spooner

Figure 5.19 Screenshot from Nov 2025 monitoring survey video showing established seedlings (left) near transplanted eelgrass (right) by Pacheedaht First Nations Fisheries Team commercial divers, Pacheedaht First Nation, Gordon River, Port Renfrew. Credit: Richard Jones

Analysis of underwater video footage is also an option for enumerating seedlings and established plants i.e., from digital cameras, GoPro or small underwater remote-controlled vessels (ROVs). Ongoing annual monitoring can determine the long-term success of the project.

Credit: A. Spooner

CHAPTER 6:
HOW CAN WE PROTECT EELGRASS?

Several methods for protecting existing and transplanted eelgrass habitats have been used in the Salish Sea over the last decade. See Chapter Five in the Eelgrass State of Knowledge for more information on these methods. This chapter describes how these conservation tools can be implemented.

Some of the strategies described below are highlighted in this video by Bob Turner as he describes conservation actions taken in Deep Bay, Bowen Island

6.1 EDUCATION

✓ **GOALS:** Increase awareness of the connectivity amongst tidal marsh, eelgrass, and kelp habitats; recruit volunteers for transplant projects; and nurture a conservation ethic towards nearshore ecosystems.

If a public presentation is scheduled before the transplant event, include information about the ecological and cultural importance of eelgrass and its connectivity to nearshore ecosystems (how salmon, for example, benefit from proximity to tidal marshes and kelp forests for ecological connectivity and protection throughout their growth cycle) (Figure 6.1).

A map of the location of local eelgrass meadows posted on a wall in the room where the public presentation is held can elicit robust conversations and lead to discovering local knowledge of potential restoration sites, or areas that need increased protection.

Figure 6.1 Eelgrass display, Cortes Island.
Credit: Friends of Cortes Island

Tsleil-Waututh students plant eelgrass to restore marine life and reconnect with cultural practices

A presentation by a local Knowledge Keeper or stewardship group, eelgrass brochures and displays with images and tips on how to protect eelgrass are useful.
Link to an Eelgrass Fact Sheet: https://gibsons.ca/sustainability/eelgrass-mapping/

https://projectwatershed.ca/2020/03/07/lower-watershed-resources/

https://seagrassconservation.org/

At the eelgrass transplant event, provide a sign-up table to welcome and orient volunteers. At this table, there can be informative eelgrass fact sheets and brochures. https://islandstrust.bc.ca/document/protecting-eelgrass-brochure/


Credit: Ann Eriksson

6.2 SIGNAGE TO INCREASE AWARENESS AND PREVENT DAMAGE

✓ **GOAL:** To prevent boats anchoring or mooring in eelgrass meadows (Figure 6.2).

Most boaters want to do the right thing and protect important habitat. Simply raising awareness of sensitive eelgrass habitats with signs that demarcate locations of nearby eelgrass habitats for boaters and other recreationists with suggestions of what they can do to avoid damage (Figure 6.3) can go a long way.

Below are tips to create and install eelgrass signage at marinas, near docks, and nearshore recreational sites:

1. If a recently produced map of eelgrass habitat locations is available for your area, you may want to include it on the sign so that boaters and other recreationists are able to see areas to avoid anchoring or kayaking at low tide.
2. A designer can modify the text and graphics with a legend, and prepare the files for printing according to the printer's specifications.
3. In some instances, you may want to ask for permission from the person (for example, the wharfingers of a marina) responsible for each potential signage location.
4. If this is part of a funded project, make sure you have up to date quotes for materials and supplies, such as posts and hardware, to create an accurate budget.
5. In some areas, it is necessary to seek permission from First Nations in whose Territory the signage is planned to be posted, as some sites with little development (i.e., not near a marina or popular recreational area) are known to be middens or former village sites.
6. Signs can be attached to info boards, dock railings, and walls of buildings on private property with permission.

Figure 6.2 Boat propeller in eelgrass bed.
Credit: Friends of Semiahmoo Bay

Figure 6.3 Eelgrass signage. Credit: SeaChange

6.3 LOW IMPACT BOAT MOORINGS

✓ GOAL: Minimize eelgrass damage by anchor scouring in areas where boats are attached to mooring blocks within or in close proximity to eelgrass habitats.

Adding a mid-line float modification to a mooring can prevent scouring of the benthic habitat (Figure 6.4). A more detailed description of these mooring systems and a diagram for installation can be found at: https://resilientcoasts.ca/resource/protecting-eelgrass-when-boating/

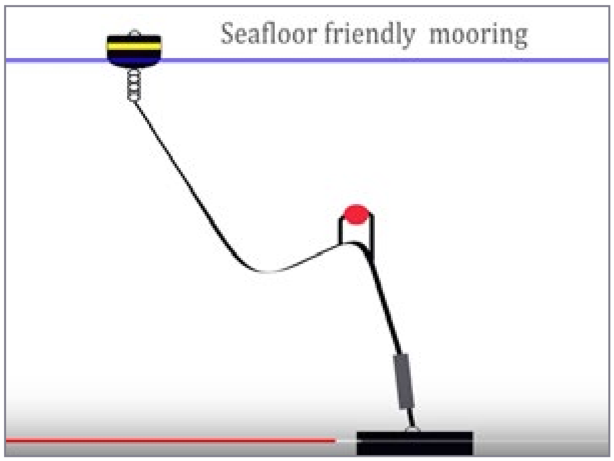


Figure 6.4 Low impact mooring systems.
Credit: Jamie Smith, Coastal Photography Studio

Credit: Crystal Norman

6.4 VOLUNTARY NO ANCHOR ZONES

✓ **GOAL:** Encourage boaters to anchor or find moorage outside eelgrass habitats by demarcating locations of nearshore eelgrass beds in protected bays and harbours with marked buoys.

To protect sensitive eelgrass beds, voluntary no-anchor buoys can be installed (Figure 6.5). These buoys typically consist of a float and mooring system designed to minimize contact with the seafloor. The mooring line is constructed from rope, with an additional mid-line float to ensure the rope remains suspended and does not drag along the seabed.

When installing markers, divers locate the outer edge of the eelgrass bed. The buoy system is then deployed approximately 5–10 metres away from the edge to avoid disturbance.

Voluntary no anchor zones can be established in areas that avoid shipping lanes within the Strait of Georgia and WCVI. These buoys can be seen in Cowichan Bay, Oak Bay, Mannion Bay, and Gibsons Harbour in Howe Sound.

The concept of voluntary eelgrass protection zones originated in Port Townsend, Washington, where there is 98 per cent compliance, protecting 52 acres of eelgrass for decades. The components required to install this mooring system can be found in Appendix I.

A transboundary collaboration with the Friends of San Juan Islands has created public information and educational materials downloadable from https://www.nwstraits.org/our-work/voluntary-no-anchor-zones/

Examples in BC can be found in these links:

https://bowenislandconservancy.org/stories/eelgrass/

https://nwstraits.org/sites/default/files/2025-11/nwsc_vnazoneoverview.pdf

Figure 6.5 Voluntary No Anchor Zone buoy.
Credit: Bob Turner

6.5 COMMUNITY EELGRASS MAPPING

✓ **GOAL:** Locate existing intertidal eelgrass habitats, monitor them over time and encourage their protection (Figure 6.6).

Refer to the Eelgrass Mapping and Monitoring Practitioners' Handbook for methods for surveying eelgrass beds.

A cost effective and accurate method for mapping eelgrass, which lends well to community groups, is conducting surveys using free divers. Free divers (divers who submerge by breath holding without air tanks) accurately locate the boundaries of underwater eelgrass beds and inform kayakers on the water's surface above the eelgrass bed (Figure 6.7). GPS marks are recorded to create accurate maps of eelgrass locations sometimes missed during boat surveys.

This short video illustrates the use of free divers to locate and map underwater eelgrass beds off of Mayne Island

Figure 6.6 Volunteer eelgrass mappers.
Credit: SeaChange

Figure 6.7 Free divers mapping eelgrass
Credit: Jillian Lynn-Lawson

Credit: Jamie Smith, Coastal Photography Studio

6.6 ORGANIZING DEBRIS CLEAN-UPS

✓ **GOAL:** Remove debris from shores and shallow underwater areas to decrease debris and associated pollution from impacting eelgrass beds and the life living within them, and where possible, expand areas for eelgrass restoration.

Shoreline clean-ups are less expensive, but require low tides, volunteers, and cooperation from local governments to assist with debris removal from the site. Budgets usually include supplies needed for debris pick up and recording of debris content, gloves, bags and refreshments for volunteers.

Larger beach debris clean-ups have been organized by such organizations as Rugged Coast Research Society https://www.ruggedcoastresearchsociety.com/, Coastal Restoration Society https://www.coastrestore.com/partners, and SeaChange Marine Conservation Society https://www.seachangesociety.com.

A list of Indigenous, government, and not for profit partners are included on each web site listed above.

Underwater debris removals are more costly, time consuming, and require large equipment, such as a barge with a crane for lifting large derelict boats from the seafloor (Figures 6.8, 6.9, 6.10). An example of items to include in a large debris removal project budget is included in Appendix C.

Figure 6.8 Diver removing fishing net from Sechelt Inlet. Credit: SeaChange

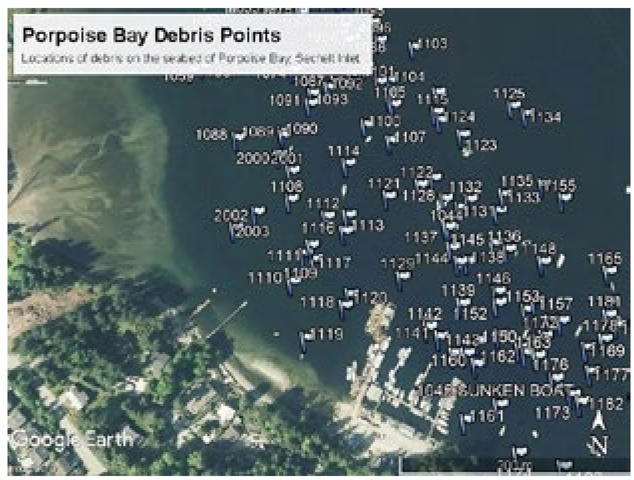


Figure 6.9 Debris map of Sechelt Inlet. Credit: SeaChange

Figure 6.10 Debris removed from Genoa Bay near Cowichan Bay. Credit: SeaChange

6.7 PARTICIPATE IN LOCAL GOVERNMENT POLICY MAKING

✓ **GOAL:** Co-create policies to protect eelgrass and nearshore habitats with local and regional governments.

Local eelgrass maps presented to local municipalities and the public effectively highlight eelgrass habitat values and opportunities for their protection (Figure 6.11). For example, maps of local eelgrass beds were presented to the community of Oak Bay in 2016 by a local conservation organization. The Mayor and members of the Oak Bay Council participated. An Oak Bay Mapping Report with a set of recommendations informed the Oak Bay Official Community Plan.

Figure 6.11 Eelgrass presentation to the Trustees of the Island Trust Conservancy. Credit: SeaChange

6.8 PARTICIPATE IN EELGRASS RESTORATION PROJECTS

✓ **GOAL:** Recover lost or damaged eelgrass habitats by engaging in local coastal community eelgrass restoration events.

As concern for conservation of marine nearshore habitats increases, expanding opportunities arise for coastal communities to be directly engaged in recovery efforts (Figure 6.12). Find out about volunteer opportunities through websites, such as the Stewardship Centre for BC: https://stewardshipcentrebc.ca/members/connect/, and local newspapers and posters.

Figure 6.12 Community eelgrass restoration event.
Credit: SeaChange

6.9 JOIN AN EELGRASS NETWORK

✓ **GOAL:** Collaborate with other individuals, communities, institutions and organizations locally, regionally, nationally, and internationally to increase the conservation of thriving eelgrass systems.

In 2001, the Seagrass Conservation Working Group (SCWG) formed as a consortium of government agencies — First Nations, Fisheries & Oceans Canada, Environment Canada, the BC Ministry of the Environment, scientists, and 21 stewardship groups: https://seagrassconservation.org/

The SCWG collaborated on projects to conserve and protect native seagrass in British Columbia. Since then, networks have evolved both in BC and internationally. You are welcomed to join the newly forming Seagrass Collective: seagrass@hakai.org.

Credit: Marcello Ogata

FINAL WORD

The principle authors of this Handbook consider it a privilege to work together. We acknowledge each of our contributions towards increasing community awareness about eelgrass value, conservation, and restoration throughout BC. We have enjoyed preparing this manual for you with our 70 years of combined experience and hope you will find it useful.

Restoring eelgrass and witnessing the life that quickly moves into a newly planted site is such a rewarding experience. We hope you will be a part of that wonder.

Please feel free to contact us if you have any questions via email to discuss or to arrange a phone call.

Nikki Wright: nikki@seachangelife.org

Cynthia Durance: precid@shaw.ca

Credit: Ryan Miller

REFERENCES

Barsh, R. (2003). The importance of human intervention in the evolution of Puget Sound ecosystems. Abstract presented at the 2003 Georgia Basin/Puget Sound Research Conference, Vancouver, BC.

Backman, T.W.H. (1991). Genotypic and Phenotypic variability of *Zostera marina* on the West coast of North America. *Canadian Journal of Botany, 69*(6): 1361-1371. https://doi.org/10.1139/b91-176

Beheshti, K. M., Williams, S. L., Boyer, K. E., Endris, C., Clemons, A., Grimes, T., Wasson, K., & Hughes, B. B. (2022). Rapid enhancement of multiple ecosystem services following the restoration of a coastal foundation species. *Ecological Applications, 32*(1), 1–21. https://doi.org/10.1002/eap.2466

Cullis-Suzuki, S. (2007). *Tending the meadows of the sea: Traditional Kwakwaka'wakw harvesting of Ts'áts'ayem (Zostera marina L.; Zosteraceae).* [Unpublished master's thesis]. University of Victoria.

Cullis-Suzuki, S., Wyllie-Echeverria, S., Dick, K. A., Sewid-Smith, M. D., Recalma-Clutesi, O. K., & Turner, N. J. (2015). Tending the meadows of the sea: A disturbance experiment based on traditional indigenous harvesting of Zostera marina L. (Zosteraceae) the southern region of Canada's west coast. *Aquatic Botany, 127*, 26–34. https://doi.org/10.1016/j.aquabot.2015.07.001

Daniels, L. (2001). Recorded interview with W.P. Suttles and R.L. Barsh, July 23, 2001. Samish Nation Archives, Anacortes, WA.

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

Durance, C. (2002). Methods for mapping and monitoring eelgrass habitats in British Columbia. Funded by the Canadian Wildlife Service, Environment Canada, p. 5.

Durance, C. & Kyte, M. (2011). Eelgrass (*Zostera marina*) restoration trajectories. Presented at Pacific Estuarine Research Society Conference. Astoria, Oregon. March 3-5.

Durance, C., & Wright, N. (2026). Handbook for the mapping and monitoring of eelgrass in the Salish Sea and British Columbia. Pacific Salmon Foundation. https://doi.org/10.48689/dfc1044f-66fa-4346-9710-95c140907526

Eriksson, A., & Clowater-Eriksson, C. (2026). Eelgrass state of knowledge for the Salish Sea and West Coast Vancouver Island Region. Pacific Salmon Foundation. https://doi.org/10.48689/0c-1544be-69e4-4542-a35d-81096677331e

Harrison, P.G. (1976). *Zostera japonica* Archers. & Graeb. In British Columbia, Canada. *Sepsis, 9*:359-360.

Kendrick, G. A., Waycott, M., Carruthers, T. J. B., Cambridge, M. L., Hovey, R., Krauss, S. L., Lavery, P. S., Les, D. H., Lowe, R. J., Vidal, O. M. I., Ooi, J. L. S., Orth, R. J., Rivers, D. O., Ruiz-Montoya, L., Sinclair, E. A., Statton, J., Van Dijk, J. K., & Verduin, J. J. (2012). The central role of dispersal in the maintenance and persistence of seagrass populations. *BioScience 62*(1), 56–65. https://doi.org/10.1525/bio.2012.62.1.10

Moreno-Marin, F., Brun, F.G., & Pedersen, M.F. (2018). Additive response to multiple environmental stressors in the seagrass *Zostera marina L. Limnology and Oceanography, 63*(4) pp. 1528-1544. https://doi.org/10.1002/lno.10789

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

Pickerell, C., Schott, S., & Wylie-Echeverria, S. (2006). Buoy-deployed seeding: A new low-cost technique for restoration of submerged aquatic vegetation from seed. ERDC (pp.1-10). TN SAV-06-2.

Smith, T. M., Sherman, C. D. H., Cumming, E. E., York, P. H., & Jarvis, J. C. (2022). Size matters: variations in seagrass seed size at local scales affects seed performance. *Hydrobiologia, 849*(10). https://doi.org/10.1007/s10750-022-04873-1

Spooner, A. (2025). Eelgrass Restoration Using Buoy Deployed Seeding (BuDS). Salmon Habitat Restoration Center of Expertise, Technical Bulletin V2. https://publications.gc.ca/collections/collection_2025/mpo-dfo/Fs23-760-2025-eng.pdf

Spooner, A. (2026). Eelgrass Restoration Using the Burlap Bag Seeding (BBS) Method. Salmon Habitat Restoration Center of Expertise Technical Bulletin.

Thom, R.M., Borde, A.B., Williams, G.D. , Southard, J.A., Blanton, S.L., & Woodruff, D.L. (2001). Effects of multiple stressors on eelgrass restoration projects. Proceedings of Puget Sound Conference.

Thom, R.M., Borde, A.B., Blanton, S.L., Woodruff, D.L., & Williams, G.D. (2001). The influence of climate variation and change on structure and processes in nearshore vegetated communities of Puget Sound and other northwest estuaries. Proceedings of the 2001 Puget Sound Research Conference. Olympia, Washington: Puget Sound Water Quality Action Team. PNNL-SA-34977.

Thom, R., Southard, M., & Borde, A. (2014). Climate-linked mechanisms driving spatial and temporal variation in eelgrass (*Zostera marina L.*) growth and assemblage structure in Pacific Northwest estuaries, USA. *Journal of Coastal Research, (68)*:1-11. https://doi.org/10.2112/SI68-001.1

Turner, N. (1995). *Royal British Columbia Museum Handbook: Food Plants of Coastal First Peoples.* University of British Columbia Press.

Turner, N. (2001). *Coastal Peoples and Marine Plants on the Northwest Coast.* School of Environmental Studies, University of Victoria. https://docslib.org/doc/9472406/coastal-peoples-and-marine-plants-on-the-northwest-coast-nancy-j-turner-school-of-environmental-studies-university-of-victoria

Turner, N. (1995). Food Plants of Coastal First Peoples. Vancouver, UBC Press: 53-4.

Uu-a-thluk (Nuu-chah-nulth Tribal Council Fisheries Department). (2010). *ts'aay'imts Eelgrass: "Candy of the Sea": Nuu-chah-nulth Traditional Foods Toolkit*. Nuu-chah-nulth Tribal Council.

Ward, M., & Beheshti, K. (2023). Lessons learned from over thirty years of eelgrass restoration on the US West Coast. *Ecosphere, 14*(8). https://doi.org/10.1002/ecs2.4642

Wyllie-Echeverria, S., Arzel, P., & Cox, P. A. (2002). Seagrass Conservation: Lessons from ethnobotany. *Pacific Conservation Biology, 5*: 329-335.

GLOSSARY OF TERMS

Accrete	To grow by accumulation.
Anthropogenic	Modified by human activities.
Bathymetry	The science of mapping the contours of the ocean floor or lake bed.
Beggiatoa	A genus of colorless, filamentous, and gliding bacteria known for oxidizing sulphide to elemental sulfur, often found in sulfur-rich aquatic environments like deep-sea vents, marine sediments, and polluted water.
Bio-contamination	The presence of harmful biological materials, such as bacteria, viruses, fungi that could adversely affect other organisms, surfaces, air, or water.
Biotope	An area of uniform environmental conditions.
Biomass	Total mass of living organisms in a given area or ecosystem at a specific time.
Chart datum	Canadian chart datum is measured relative to lowest normal tide: Zero metres is the lowest normal tide. Datum measurements refer to the depth below 0 metres, therefore they don't require a negative sign.
Desiccation	To dry up.
Ecotype	Variants of a species with distinct characteristics adapted to local or regional environmental conditions.
Ecozone	A broad geographic area in which there are distinctive climate patterns, ocean conditions, types of landscapes and species of plants and animals.
Epifauna	An animal living on the outside of another substrate (e.g. seafloor) in a non-parasitic relationship.
Epiphyte	A plant growing on the outside of another plant in a non-parasitic relationship.
Eutrophication	The process of nutrient enrichment in aquatic ecosystems—primarily by nitrogen and phosphorus that stimulates excessive growth of algae and plants, leading to degraded water quality, low dissolved oxygen (hypoxia), and ecological disruption.
Fetch	Uninterrupted, straight-line distance over which wind blows across a body of water without significant change in direction, a factor in determining wave size, height, and energy.
Geomorphology	The study of land forms, the process whereby they are formed, and the materials of which they consist.
Geo-reference	A navigational and positioning system with which the three-dimensional geodetic (scientific understanding of the shape of the earth) and velocity of a user at a point on the earth can be determined in real time.
Habitat off-setting	Actions taken by a proponent to counterbalance the residual effects to fish and fish habitat that are caused by their project after avoidance and mitigation measures have been applied.
HOBO unit	A small, battery-powered data logger used for measuring water temperature and salinity at set schedules.

Hydrogen sulphide (H_2S)	A toxic byproduct of anaerobic organic matter decomposition by bacteria, often accumulating in oxygen-depleted (anoxic) conditions.
Infauna	Aquatic animals that live within the ocean floor, rather than on its surface (e.g. clams).
Knot	One nautical mile per hour, used to measure speed. A nautical mile is slightly more than a standard mile: 1 nautical mile = 1.15 miles = 1.85 kilometers.
Litmus paper	Papers that measures the acidity or alkalinity (pH) of solutions by changing color. Red litmus turns blue in bases (pH >7); blue litmus turns red in acids (pH < 7).
Mean	The arithmetic average of observations in a data set.
Macrofaunal	Marine invertebrates visible to the eye, such as isopods (sea slaters), amphipods (crustaceans), small snails, worms, and bivalves (clams, oysters, cockles, mussels, and scallops).
Mitigation	The lessening or minimizing of the adverse impacts of a harmful event.
Morphology	The form and structure of living organisms.
PSU	Practical Salinity Units (PSU) are a measure of seawater salinity, essentially equivalent to parts per thousand (ppt), where 1 PSU equals 1 ppt (1 gram of salt per kilogram of seawater).
Productivity	The rate at which organic matter accumulates over a given area in a period of time.
Rebar	Short bars of ridged metal, usually made of steel.
Rhizome	Fleshy, underground stem of an eelgrass plant that grows horizontally through the sediment of the seafloor.
Salinity	Level of salt in a sample of water, measured either with a CTD Probes or portable hand-held devices, such as a HOBO unit. The CTD probe is the primary method used by scientific and governmental agencies, such as DFO: a CTD probe measures electrical conductivity, temperature, and pressure (depth). Portable devices are less expensive and measure electrical conductivity and convert it to a salinity reading, typically in parts per thousand (ppt).
SCUBA	Self Contained Underwater Breathing Apparatus used by underwater divers.
Sheath	A tubular covering such as part of a grass leaf surrounding the stem.
Spathe	A bract or leaf-like sheath that wraps around or subtends a flower cluster, specifically an inflorescence called a spadix.
Turbidity	A measure of water quality, or the degree to which water is opaque due to suspended silt or other sediments.
Ungalvanized metal washer	A flat metal ring (for eelgrass restoration: steel) that does not have a protective zinc coating applied to its surface, which accelerates the decomposition of the washer In the sediment.

APPENDIX A: FIRST NATIONS' USES OF EELGRASS IN BC*

For thousands of years Indigenous Peoples have valued native eelgrass, evident in their language, cultural traditions and oral histories (Cullis-Suzuki, 2007, 2015; Uu-a-thluk, 2010; Turner, 1995, 2001). The cultural uses of native eelgrass are deeply significant to coastal communities in BC. These habitats were and remain critical for salmon and shellfish harvesting and other practices for First Nations. Reef net fishing was the dominant harvesting gear used to fish adult migrating sockeye salmon as they travelled inshore to feed in nearshore eelgrass meadows by the Coast Salish in the island archipelago of the San Juan and Gulf Islands as far south as Bellingham Bay (Daniels, 2001).

The first run of sockeye would arrive in June. After the salmon were harvested, they were processed near reef-net sites by removing their heads, tails and backbones. The refuse was returned immediately to the beach and bay. The fish were then smoked and dried over beach fires fueled with local wood. Afterwards, the salmon remains, charcoal, and ash were deposited into the eelgrass meadows and shoals from which the sockeye had been removed. Thus, a reef net harvest recycled nutrients from the sea and the surrounding forest and concentrated them at approximately 40 sites in the San Juan and Gulf Island archipelagos (Barsch, 2003).

Nutrient feeding of reef-net grounds fed the next generation of sockeye on the remains of their parents. Each operation site sustained its own supplies of sockeye by recycling the remains into salmon prey, feeding the emerging salmon fry and crustaceans that fed on the carcasses. These "fertilized" eelgrass meadows then attracted the next generation of fish to the site. Sound stewardship of the harvesting sites was recognized by making the local households responsible for the site well known and popular through feasts and the sharing of access to the fishing sites with other households. The greater the care for the fish and habitat, the greater the prestige (Barsch, 2003).

Native eelgrass plants were used for feasting, cooking, basket making; the Salish, Nuu-chah-nulth, Kwakwaka'wakw, and Haida ate crisp sweet rhizomes and leaf bases of the eelgrass blades. The WSANEC placed the rhizomes in steaming pits to flavor deer, seal and porpoise meat. The Songhees formed thin cakes and dried them for winter food (Turner, 1995).

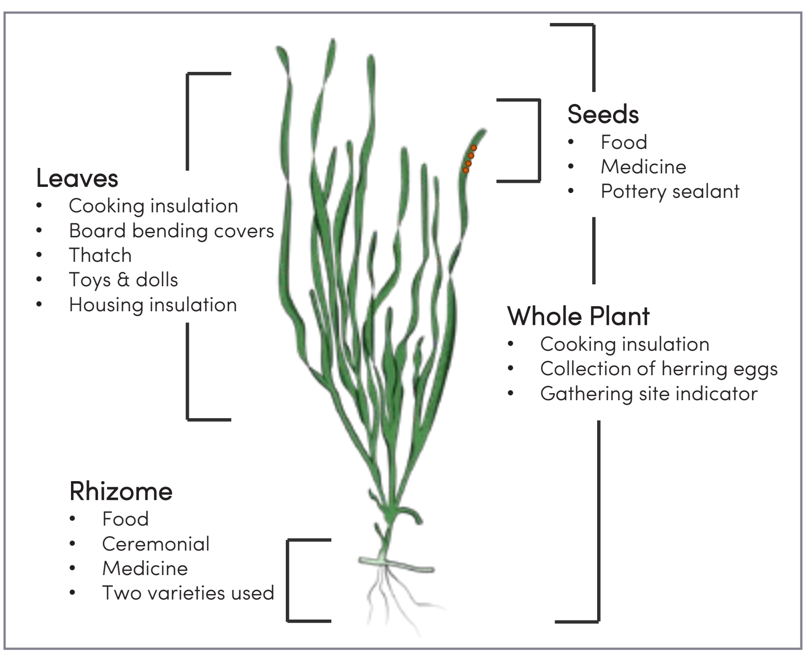


Figure A.1 Some uses of eelgrass plant by Indigenous communities. Adapted from Wyllie-Echeverria et al., (2000). Credit: Nicole Christiansen

*What is included in this appendix is a selection of examples, and not comprehensive of all First Nations' relationships with eelgrass in BC.

APPENDIX B: IMPACTS AND STRESSORS ON EELGRASS

1. The productivity of eelgrass at a certain location varies between years. The physical factors that interact to cause these variations include:

- **Water temperature** — optimal temperature for net productivity in the Pacific Northwest is between 12 and 17 °C (Thom et al., 2001).
- **Pacific Decadal Oscillation Index (PDO)** — temperature and climate anomalies occurring between May and July.
- **Pacific North American Index (PNA)** — pressure anomalies occurring between May and July causing a direct and inverse influence on productivity that has been shown to affect salmon, crabs, clams, zooplankton, and eelgrass.
- **Timing of daytime low tides** — low tides affect light available for photosynthesis.
- **El Niño events** — Eelgrass productivity usually increases following an El Niño winter.

2. Assessment of the impacts of various pressures on eelgrass habitat

'Intolerance' is the susceptibility of a habitat, community, or species (i.e., the components of a biotope, or area of uniform environmental conditions that supports eelgrass habitats) to damage, or cause death due to an external factor. Intolerance must be assessed relative to change in a specific factor.

'Recoverability' is the ability of a habitat, community, or species (i.e., the components of a biotope) to return to a state close to that which existed before the activity or event caused change.

'Sensitivity' is dependent on the intolerance of a species or habitat to damage from an external factor and the time taken for its subsequent recovery. For example, a very sensitive species or habitat is one that is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) and is expected to recover over a very long period of time, i.e. >10 or up to 25 years ('low'; recoverability). Intolerance and hence sensitivity must be assessed relative to change in a specific factor.

'Evidence' High Assessment has been derived from sources that specifically deal with sensitivity and recoverability of a species or biotope to a particular factor. Experimental work has been done investigating the effects of such a factor.

Credit: SeaChange Marine Conservation Society

Table B.1 Pressures and impacts on eelgrass habitats.

Criteria	Intolerance	Recoverability	Sensitivity	Evidence/ confidence
Physical pressures				
Sediment loss	High	Very low	Very high	Moderate
Smothering	High	Very low	Very high	Moderate
Increased suspended sediment	Intermediate	Moderate	Moderate	Moderate
Desiccation	Intermediate	High	Low	Moderate
Increase in temperature	Tolerant	Irrelevant	Not sensitive	Moderate
Increased **turbidity**	High	Very low	Very high	Moderate
Increase in wave exposure	High	Very low	Very high	Low
Physical disturbance	Intermediate	Moderate	Moderate	Moderate
Displacement	High	Low	High	Low
Chemical pressures				
Synthetic compounds	Intermediate	Moderate	Moderate	High
Heavy metals	Low	Very high	Very low	Moderate
Hydrocarbons	Low	Very high	Very low	Moderate
Changes in nutrients	High	Very low	Very high	Moderate
Increased salinity	Low	Very high	Very low	Low

Red: High **Yellow: medium** **Green: low rating to risk**

Eelgrass sensitivity review can be found at https://www.marlin.ac.uk/species/detail/1282

APPENDIX C: BUDGETS FOR EQUIPMENT

Community-led transplant projects can range in size from 50 m^2 to 1.0 ha. The smaller transplants may be completed by community volunteers such as Rotary Clubs, Girl Guides, school groups, and streamkeepers.

All paid SCUBA divers must be WorkSafeBC certified:

https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-guidelines/guidelines-part-24

The larger projects require oversight by managers and biologists, and often require administration and overhead costs (see Table C.5).

Listed below are suggestions of budgets for habitat surveys, eelgrass transplants, monitoring, underwater debris removals and costs associated with projects executed by not-for-profit organizations. They are intended to serve as guides for project planning for projects at different scales.

Many of the required items listed below could be sourced from the community, with the exception of the metal washers and the budget for the dive team. The washers cost approximately $0.30 CAD each (2026 estimate). Dive teams charge between $3,000 and $5,000 per day. Usually, the dive crew has their own boat that they bill an extra $500 to $900 per day, depending on the size of the boat.

There are many commercial dive teams throughout BC. Finding a local team avoids travel expenses. A local dive shop or DiveSafe BC (info@divesafe.com) can help with finding local certified divers. The commercial dive crew is responsible for bringing all their certifications for the divers, dive gear, insurance papers, and safety equipment.

An inexperienced volunteer shore crew of four to six people can usually process about 800 to 1,000 shoots per day; the rate increases with experience. It is advisable to hire an experienced shore crew leader to provide quality control. At least one member of the dive crew should have experience harvesting and planting eelgrass.

A not-for-profit organization requires more human resources, such as a project manager, an experienced shore crew leader, and administrative support. There are also overhead expenses, such as office space, liability insurance for volunteers and staff (dive teams carry their own insurance) and storage costs.

Table C.1 lists the equipment and supplies needed for **Habitat Surveys**.

Table C.2 lists equipment recommended for land-based activities for **Eelgrass Transplants**.

Table C.3 lists equipment needed for water-based **Transplant and Monitoring**.

Table C.4 lists expenses required for an **Underwater Debris Removal** project.

Table C.5 lists expenses for a transplant project **Coordination Not-for-profit** organization.

* denotes that an equipment item is optional.

Suggested/sources of supplies for land based restoration activities are included at the bottom of Table C.2.

For remote communities, on-line delivery outlets may be the best option.

Table C.1 Supplies and equipment required for habitat surveys.

Item	Details
Dive boat with Work Safe BC certified divers with dive gear	Underwater surveys
Safety gear for all crew members	Safety protocols followed with all required equipment in place
Navigational charts	Navigation; orient site for fetch distance and site location
Supply of waterproof paper	Extra supply for the boat and dive crew
Binoculars for boat crew	Viewing of the nearshore
Underwater camera	Document underwater characteristics of the site
Clipboards for notetaking by boat crew	Detailed descriptions of observations
Secchi disk	Measures depth of light penetration
Hydrometer	Measures salinity, noting tide time and depth of measurement
Thermometer	Measures sea surface temperature
Waterproof copies of Habitat Survey Data Forms (Appendix D)	For use by divers
GPS units	Records location of survey site
Land camera	Records activities on water and backshore use
Tablet for notes*	Data forms can be uploaded and filled out digitally
Portable table	Sign up/welcoming station to track # of volunteers
Brochures or info sheets	Inform volunteers and on-lookers of rationale for transplant (see Education Chapter 5)
Clipboards with sign-up sheet	Emergency contact numbers; means to communicate for future events
First aid kit	Safety of crew and volunteers
Snacks/water	Keep energy up
Plastic or folding chairs — not folding camping chairs as they are too low to ground and not ergonomic for working	Eelgrass shoot preparation

Item	Details
Tent(s) awning or portable car port with anchor rope	Shelter large enough for the shore crew; protection from weather
Porta potty	If restrooms are not available
Laundry baskets	Two for every 150 shoots to be planted every day; white if possible, as they are easier to see underwater
Rubber tubs	Large enough to fit a laundry basket inside, 3 per workstation, +3 for storage of processed shoots, +2 for dive boat
Generator*, water pump, garden hose, and extension cord	Facilitates transport of fresh seawater to Eelgrass tubs
5 gallon buckets	For transport of seawater
Ungalvanized steel 5/8" (~1.59 cm) washers	Anchors for eelgrass shoots
Twist ties (paper)	To be attached to metal washer
1 gallon plant pots or similar sized container	Storage of tied washers: 100 per container
Jute or twine and barbecue skewer; rope for attaching collection bags to dock	30 cm for every 10 shots
Scissors	To cut jute/twine
Latex gloves* for volunteers/cloth or paper towels	Washers are usually coated in canola oil which can be difficult to clean off.
Waterproof aprons Gator waders*	Keeps shore crew dry while working For one person to transport eelgrass baskets to shallow water
Note pad with pencil	To record # shoots planted throughout the day

Table C.2 Suggested suppliers for transplant equipment for land-based activities.

Suggested supply sources	
Canadian Tire	Home Depot
Home Hardware	Rona
Save-On-Foods	Grange Canada
Safeway	BC Fasteners and Tools/K2 Fasteners
Real Canadian Superstore	Monk's
Shoppers Drug Mart	Staples
Cabela's	Mountain Equipment Company

Table C.3 Equipment list for eelgrass transplanting and monitoring.

Item	Details
Dive team and boat	Work Safe BC certified
Cameras	Fully charged (underwater cameras with extra batteries and charging cord)
Data sheets, clipboards, attached pencils	Habitat Survey/Monitoring forms in Appendix D
Tide tables	To calculate the depth of transplant
Harvest bags with clasps (nylon mesh preferable); 1/diver	For harvesting shoots
Water quality monitoring equipment with data sheet binder (optional- suggest using Community College students if capacity low)	For Habitat Survey forms in Appendix D
4-6 surface marker floats with attached rope and weights	For instructions for making marker buoys, see Appendix K
iPad or tablet*	For uploading data and consulting and consulting previous data when at the site
HOBO(s)[7] and computer*	Fully charged for deployment and downloading data
2-4 25 and 50 metre measuring tapes	Measurement and setting transect for transplant site
Laundry baskets with rope attached on the sides for lifting	Transport of anchored eelgrass shoots
Rope to hang laundry baskets off the dock	Laundry baskets of prepared eelgrass can be hung from a dock as well as placed in the shallow nearshore, dependent on boat access and foot/ boat traffic
Small sledge hammer	Placement of temporary copper or rebar posts
Small hand trowels (2)	For planting into coarse or compact sediment
1.2 metre copper pipes or rebar (4 pipes per site)	For temporarily marking end points of transplant

Credit: Anne Shaffer, Coastal Watershed Institute, All rights reserved

7. HOBO pendants are data loggers that record water temperature and salinity. Data can be downloaded onto a laptop at regular intervals.

Table C.4 Debris removal expenses.

Item	Details
Boat rental and fuel	Use of boat to transport crew and equipment
40 yard containers	For containing underwater debris delivered to shore
Rental of excavator	Removal of debris bags from boat into debris bins
Towed barge and crane	Pick up of debris from seabed for transport to boat deck
Supplies for underwater debris removal	Debris lift bags, rope and pulley replacements
Dumping and recycling fees	If transfer fees are not waived by municipality or regional district
Underwater camera	To document removal of debris
Boat moorage	Moorage of boat during project operations
Scuba equipment rental (3 divers)	Underwater communication, air and Scuba equipment allowance

Table C.5 Not-for-profit expenses.

Human Resources	Details
Project coordinator (manager)	Obtains funding; coordinates project
Operations manager	Coordinates logistics
First Nations	Covers time for meetings, administrative costs, sharing knowledge of Territory
Eelgrass biologist	Biologist guides decisions on suitable sites for transplants
Administrative assistant	Keeps track of budget expenditures and helps with reporting
Eelgrass shore crew (if not volunteers)	Labour for transplanting
WCB dive team: 3 divers	Labour for underwater surveys, transplanting and monitoring
Archaeology overview/archaeology monitoring	If archaeological concerns are raised by First Nations within Territory of potential transplant or signage and budget allows for expense
Employee mandatory benefits	Rates according to BC Employment Standards Act

Table C.5 Not-for-profit expenses (continued).

Equipment and Supplies	Details
Boat rental	Obtains funding; coordinates project
Rental of underwater cameras	Coordinates logistics
Boat fuel	Covers time for meetings, administrative costs, sharing knowledge of Territory
Boat moorage	Biologist guides decisions on suitable sites for transplants
Supplies for eelgrass restoration sites: see Tables above	Keeps track of budget expenditures and helps with reporting
Scuba equipment rental (3 divers)	Labour for transplanting
Porta potty	Labour for underwater surveys, transplanting and monitoring
Travel/Accommodations	**Details**
Travel costs for dive crew and project manager	Travel to and from work site if not local dive team
Accommodations	For the dive team (3 divers) during project operations
Other Expenses	**Details**
Liability insurance	Coverage for Board of Directors, staff and volunteers
Rent for meeting space	For Community and Technical Advisory meetings
Administrative overhead	Usually up to 10 per cent of the overall program funding amount
Rental of office space and utility costs	As part of overhead costs
Equipment storage/repairs	As part of overhead costs
Accounting expenses	As part of overhead costs
Web service/communications costs	As part of overhead costs
5 per cent GST	Applies to equipment, supplies, and tipping fees

APPENDIX D: FIELD DATA FORMS

Credit: Jamie Smith Coastal Photography Studio

HABITAT SURVEY DATA SHEET

Location: ______________________________

Survey date: (d/m/yr) ______________________ **Time:** ______________________

Dive team: (initials): ______________________________

GPS coordinates: (lat and long) ______________________ **N** ______________________**W**

Georeferenced photo #s: ______________________________

Notes from community meeting:

____

____

____

____

____

____

Detailed site assessment: (Factors to consider when deciding between potential transplant sites)

Water Quality

Temperature: (°C)[8] ______________________

Salinity: (ppt)[9] ______________________

Turbidity: (m)[10] ______________________

Light:[11] ______________________

Dissolved oxygen:[12] ______________________

Sediment Quality

Hydrogen sulphide level:[13] ______________________

Sedimentation rate:[14] ______________________

8. Thermometer at 1 m depth or HOBO unit reading
9. Hydrometer sample at 1 m depth or salinity meter
10. Secchi disc
11. HOBO unit placed ~1 m from seabed at level of eelgrass shoot tips
12. Dissolved oxygen meter
13. 10 cm length samples only if lab support available.
14. Collect 5 samples of shoot rhizomes and examine for vertical/horizontal growth patterns in native bed.

HABITAT SURVEY DATA SHEET

Biology

Species utilization of habitat: ____

____

____

Fetch: (km) ______ **Water depth:** (m) _______ **Native bed present:** (Y/N) _____ **Proximity to site:** (m) _______

Direction of wave exposure (aspect) ____

Sediment type: (sand/mud/mix/cobble) ____

Sediment quality: (consolidated/unconsolidated) ____

Backshore land use: (residential, commercial, natural) ____

____

____

Water activities observed: (# moorings/anchorages, # docks/recreational use) ______________________

____

____

Status of water lease known? (Y/N) _______ **List any known causes for damage:** ______________________

____

____

Cause of damage/destruction removed? (Y/N) _________

Notes and sketch map:

____

____

____

Adjacent area near potential restoration site: Georeferenced ground photo, preferably at low tide

a. **Uplands** — Photo or sketch map
   i. Estimated nearest permanent structure to Natural Boundary
   ii. Unstable bank present (bare or partially bare slope)

b. **Riparian** — Describe in words, photo or sketch map
   i. Tree cover
   ii. Shrub cover
   iii. Ground cover
   iv. Width
   v. Overhang of intertidal zone elevation of lowest overhanging branches (relative to HWL); this is an index of insect potential for fish

c. **Shore modification**
   i. Type
   ii. Restoration potential?
   iii. Permeability?

d. **Intertidal modification**
   i. Seawall in the intertidal zone?
   ii. Man-made structures?
   iii. Man-made modification?

e. **Intertidal sensitive habitats**
   i. Sand lance spawning potential?
   ii. Wetland?
   iii. *Sarcocornia* (previously *Saliconia*) — "Sea Asparagus"

f. **Subtidal**
   i. Eelgrass present? Suitable habitat?
   ii. Kelps present?


Credit: Rebecca Benjamin-Carey

EELGRASS TRANSPLANT MONITORING DATA SHEET

Location: ______________________________

Survey date: (d/m/yr) ____________________ **Time:** ____________________

Tide height: ____________________ **Dive team:** (initials): ____________________

GPS coordinates: (lat and long or UTM) ____________________ **N** ____________________**W**

Georeferenced photo #s: ______________________________

Site Characteristics

Depth distribution (m) of native bed:[15] shoreward ____________ seaward ____________

Depth distribution (m) of transplanted bed: shoreward ____________ seaward ____________

Sediment type[16] (sand/mud/mix/cobble) **native bed:** ______________________________

Sediment type (sand/mud/mix/cobble) **transplanted bed:** ______________________________

Sediment quality: (consolidated/unconsolidated) ______________________________

Photo taken of sediment (Y/N)? ____________

Qualitative Description

Form of native eelgrass bed if present: (channel/fringing/flat) ______________________________

Form of transplanted eelgrass bed: (channel/fringing/flat) ______________________________

Distribution of transplanted bed: (patchy/continuous) ______________________________

Quantitative Description

Average shoot density (#/.25 m^2) native bed: ______________________________

Number of shoots/m^2 within patches: ______________________________

Average Leaf Area Index (LAI)[17] **native bed:** ______________________________

Average Leaf Area Index (LAI) transplanted bed: ______________________________

Reproductive shoots: (#/m^2) within .25m quadrat in native bed: ______________________________

Reproductive shoots: (#/m^2) /1.0 m^2 quadrat in transplanted bed: ______________________________

Ecotype of native eelgrass: *(typica, phillipsii, latifolia, izembekensis)*[18] ______________________________

Ecotype of transplanted eelgrass: *(typica, phillipsii, latifolia, izembekensis)* ______________________________

Video footage of native and transplanted bed (Y/N): __________

Area extent native bed (m): ______________________________

Area extent transplanted bed (m): ______________________________

Distance between native bed and transplanted bed (m):______________________________

15. Weighted measurement tape from surface of water to seabed.
16. Photos to be taken of sediment sample collections; disturb seabed to check depth of sediment and measure in cm.
17. Leaf Area Index: Av. Shoot length x av. Shoot width x av. Shoot density.
18. *typica*: narrow leaf size; shoot width: 2-5mm; *phillipsii*: medium leaf size; shoot width: 4-15mm; *latifolia*: large leaf size; shoot width 12-20 mm.

Water Quality

Temperature: (°C)[19] ________________________________

Salinity: (ppt)[20] ________________________________

Turbidity: (m)[21] ________________________________

PSU:[22] ________________________________

Light:[23] ________________________________

Dissolved oxygen:[24] ________________________________

Biology

Species utilization of habitat:[25] ________________________________

____

____

Presence of invasive nearshore:[26] ________________________________

____

____

Presence of introduced species:[27] ________________________________

____

____

Presence of invasive disease:[28] ________________________________

____

____

Notes and sketch map:

____

____

19. Thermometer at 1 m depth or HOBO unit reading
20. Hydrometer sample at 1 m depth or salinity meter
21. Secchi disc
22 Use litmus test if conductivity metre not available
23. HOBO unit placed ~1 m from seabed at level of eelgrass shoot tips
24. Dissolved oxygen meter
25. Note species observed within natural and transplant beds if available; note degree pf bioturbation by crabs and/or shrimp/shellfish
26. Note potential for forage fish spawning on nearshore and species near kelp beds if present; include photos of nearshore.
27. European green crab (see ID sheet); *Sargassum japonica*; document with photos
28. Eelgrass shoots that may show evidence of *Labyrinthula zostera* (see ID sheet); document with photos.28 Note presence of epiphytic load on blades or algae mats on seabed; document with photos.

APPENDIX E: ATTRIBUTES FOR RESTORATION SITE SELECTION

The following tables detail the specific attributes to be considered for assessing transplant sites in the Salish Sea and the west coast of Vancouver Island. The method has been designed to be low-cost and requires minimal training. Stressors at the site, such as multiple anchored boats, can be noted during the habitat survey and evaluated using the Site Assessment Checklist in Appendix G.

Table E.1: Includes the parameters and methods to assess the history of the site.

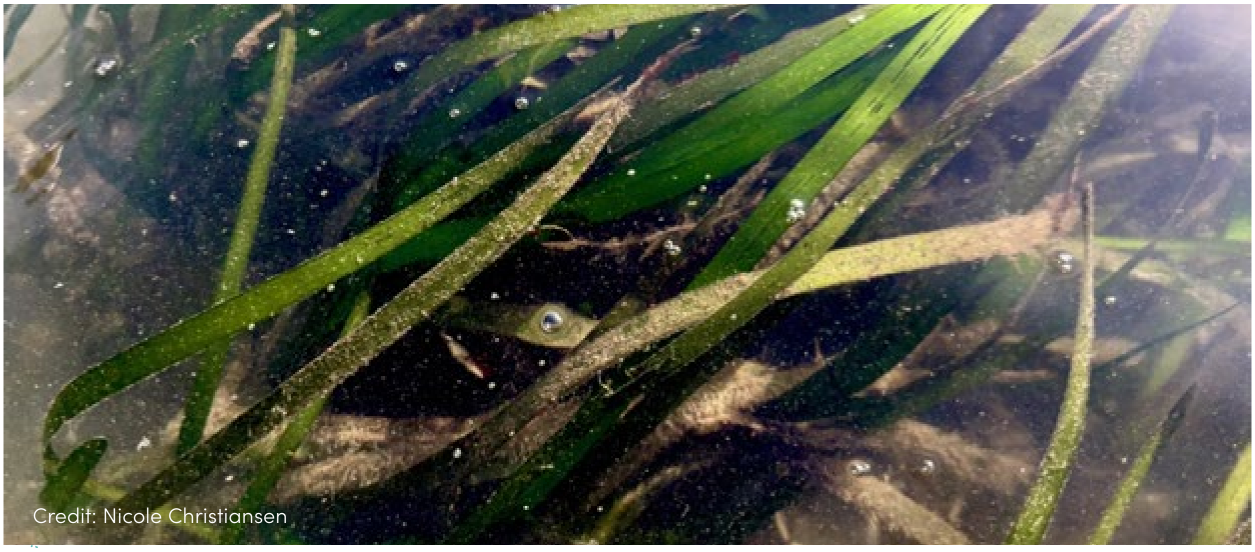
Table E.2: Includes a list of the environmental conditions to consider.

Table E.3: Includes an evaluation of the measurements of physical attributes.

★ A calm bay is suggested as a good candidate for a transplant during a Community Meeting, as a comment is made that it is a former log dump but the area has been unused for that purpose for many years. However, during a habitat boat survey the site is observed to be crowded with recreational boat anchorages during the summer months, thereby disqualifying the area as a good candidate for restoration unless actions are taken to protect the newly transplanted habitat from scouring by boat anchors.

Table E.1 Parameters to assess the site history.

Parameters	Range	Assessment Method
Reference site	Close to potential restoration site to non-existent (may not be present)	Maps of subtidal area including depth range
Donor site	100 m to non-existent if eelgrass absent but historically present	Maps, depth readings, boat surveys
Historical records/ maps	Accessible and accurate to none available	Government agencies
Local knowledge	Accessible and accurate to none available	Communications with community members



Credit: Nicole Christiansen

Table E.2 Parameters to assess the environmental conditions of a site.

Parameters	Range	Assessment Method
Availability of suitable ecotype	*Z. marina* ecotype *typica/phillipsii/latifolia/izembekensis*	Direct observations of plant and distribution range
Nearby land use	None to heavy use	Observations, local knowledge
Activities on the water	None to intense activities (e.g. boat anchoring area)	Observations, local knowledge
Protection status	None to marine protected area	Government agencies
Type of freshwater inputs	None to heavy flows (ex: heavy flow from stormwater discharges)	Observations Maps
Sensitivity to Sea Level Rise	Report: BC Parks Shoreline Sensitivity Model	BC Shoreline Sensitivity Model

Table E.3 Physical attributes to assess for a site (Thom et al., 2014).

Parameters	Range	Optimum
Salinity	Freshwater to 42 ppt	10 ppt
Sediment type	Firm sand to soft mud	Mixed sand and mud
Current velocity	Waves to stagnant water	Little wave action gentle currents to 3.5 knots
Light/depth	1.8 m above MLLW to –10 m	MLLW to – 4.4 m
Temperature	-6 °C to 40.5 °C	6 °C to 17 °C
pH	7.3 to 9.0	7.3 to 9.0
Nutrients		Moderate soil nutrients; low in water column

MLLW — mean low low water
ppt — parts per thousand


Credit: Jeff Skinner

APPENDIX F: METRICS FOR SITE ASSESSMENTS

Parameters	Metrics	Methods
Location of eelgrass bed	Coordinates	GPS, lat / long, or UTM, or marked on a map
Form of eelgrass bed	Observation	Descriptive: fringe, flat or channel; subtidal/ intertidal
Type of eelgrass bed	Observation	Descriptive – continuous or patchy – photos
Substrate type	Observation	Descriptive – sand, mud, gravel, cobble – photos
Tide height	Depth (m) from MLT tide mark	Calculate depth at time of monitoring to tide chart

Quantitative Descriptions	Metrics	Methods
Shoot density	# shoots per m^2	.25 m^2 quadrat if < 100 shoots/m^2; 25 cm x 25 cm if > 100 shoots/m^2
Reproductive shoots	Presence of flowering shoots	Note # flowering shoots/m^2 within quadrat
Zonation	Ecotypes according to elevation	Note ecotype monitored (*Z. marina* ecotype *typica*, *phillipsii*, *latifolia*, *izembekensis*)
Area extent	m^2	Measuring tape; measure distance between natural and transplant beds
Distribution	Degree of patchiness	Video, photos, notes
Leaf Area Index	Mathematical calculation	Calculate av. shoot length x av. shoot width x avg. shoot density

Site Characteristics		
Depth distribution	Metres from water surface	Weighted measurement tape from surface of water to seabed
Sediment characterization	Characterize sediment (sand, mud or mix)	Photos of sediment samples; disturb seabed to check depth of sediment
Hydrogen sulphide level	Collection of sediment samples	Only if lab is available for analysis; support from local college or university
Sedimentation rate	5 samples of shoot rhizomes	Examine 5 rhizomes for vertical/horizontal growth patterns

Water Quality		
Temperature	Degrees Celsius (°C)	Thermometer at 1 m depth or **HOBO unit**
Salinity	Parts per thousand (ppt)	Hydrometer sample at 1 m depth from surface or salinity meters
Turbidity	Metres	**Secchi disc**
Acidity/Alkalinity	pH measurements	pH probe and meter setup or **litmus paper**
DO	mg/l	Dissolved oxygen meters
Light	°C and 0 to 320,000 lux (0 to 30,000 lumens/ft^2)	HOBO units placed ~1 m from seabed (level of the eelgrass tips)


Credit: Jamie Smith Coastal Photography Studio

APPENDIX G: SITE ASSESSMENT CHECKLIST FOR RATING POTENTIAL RESTORATION SITES

Location: ____

Date: (d/m/yr) ____________________ **GPS coordinates:** (lat and long) ____________ **N** ___________**W**

Attribute for eelgrass restoration	Ranking category	Circle 1 ranking category for each attribute	Notes
Community: First Nations linkages. Yes or no only, not to be ranked.	Cultural sites such as Reserve Land, village, burial site, **midden** site, and/or clam garden present. *If Yes, refer to the appropriate department within the First Nations, in whose Territory the site is located.	Yes*/No	
	Unknown First Nations linkages; more site information needed.	Yes/No	
Community: Human capacity: Yes or no only, not to be ranked.	Group of willing and capable community volunteers.	Yes/No	
Eelgrass presence:	Healthy eelgrass habitat present that could be expanded or filled in.	2	
	Historical presence of eelgrass known or suspected with potential for restoration.	1	
	Presence of eelgrass with present unmitigated impacts; historical eelgrass known or suspected, but site has no potential for restoration.	0	
	Presence of eelgrass with present unmitigated impacts; historical eelgrass known or suspected, but site has no potential for restoration.	0	
Sediments:	Suitable sediment (sand or sand/mud).	2	
	Mixed sediment (sand/mud/cobble).	1	
	Unsuitable sediment (unconsolidated material: cobble, gravel, rock).	0	

Attribute for eelgrass restoration	Ranking category	Circle 1 ranking category for each attribute	Notes
Water quality parameters: (see Table E.3)	Restoration site is within optimum range for depth, temperature, **pH**, **salinity** and light.	2	
	One or more water quality parameters within range but not optimum.	1	
	One or more water quality parameters out of range for eelgrass survival.	0	
Presence of donor eelgrass bed:	Suitable donor bed present near site.	2	
	Donor bed within x km of site.	1	
	Donor bed further away from site will need to be used.	0	
Adaptability to sea level rise:	Medium sensitivity, medium resilience, medium levels of unconsolidated materials; good potential for restoration success.	2	
	Low sensitivity, steep shorelines with consolidated materials or high in one dataset; medium potential for restoration success.	1	
	High sensitivity both foreshore and backshore, low resilience, high levels of unconsolidated material; no potential for restoration success.	0	
Wave exposure:	Protected: wave **fetch** less than 10 km.	2	
	Semi-Protected: wave **fetch** between 10 and 50 km.	1	
	Semi-Exposed: wave **fetch** in the range of 50 km to 500 km.	0	

Attribute for eelgrass restoration	Ranking category	Circle 1 ranking category for each attribute	Notes
Current velocity:	Little wave action; gentle currents to 3.5 **knots**.	2	
	Some wave action to stagnant water.	1	
	High current velocity.	0	
Level of development:	Backshore protected; some development with minimum impacts.	2	
	Stable backshore with little or no impacts on nearshore.	1	
	Highly developed backshore with impacts; plans are in place for development that will affect nearshore.	0	
Dredging and filling:	No current or historical dredging or filling.	2	
	Past dredging or filling with no present impact on donor bed.	1	
	Present dredging and filling; planning in place for dredging and filling.	0	
Overwater structures:	Overwater structures absent.	2	
	Overwater structures present but constructed to maintain light availability to eelgrass habitat.	1	
	Overwater structures obstructing eelgrass growth.	0	
Presence/Absence of woody debris/ hydrogen sulphide level:	No woody debris in sediments (**H_2S** not a limiting factor)	2	
	Medium levels of woody debris in sediments (Medium levels of **H_2S** measured or suspected) with potential for reversal	1	
	Excessive wood waste in sediments (High levels of **H_2S** measured or likely) with no potential for reversal.	0	

Attribute for eelgrass restoration	Ranking category	Circle 1 ranking category	Notes
Evidence of eutrophication:	No evidence of **eutrophication**.	2	
	Macroalgae present, higher nitrate levels suspected but potential for reversal.	1	
	Observed hyper-abundance of algae suggesting high level of **eutrophication** and no potential for reversal.	0	
Presence of boat groundings and anchorages:	No boats grounded or anchored in eelgrass area; fixed conservation moorings.	2	
	Anchorages or fixed moorings with impact in eelgrass bed but potential for reversal at this time.	1	
	Multiple anchorages and/or moorings present and actively fragmenting existing eelgrass habitats.	0	
Level of boat traffic:	No boat traffic or no evidence of impacts.	2	
	Boat traffic with impacts but potential for reversal at this time.	1	
	Steady boat or ferry traffic impacting eelgrass habitat.	0	
Presence of invasive species:	No invasive species detected	2	
	Wasting disease or green crabs present. Site requires monitoring; restoration not recommended.	0	
Other: marine debris: (indicate details in notes)	Small amounts of debris easily cleaned up or no debris at depth where eelgrass present or could grow.	2	
	Medium to small sizes and amounts of debris requiring moderate effort to clean up in potential or actual eelgrass habitat.	1	
	Derelict boats and large amount of debris requiring extensive effort and expense to clean up before restoration can begin.	0	

APPENDIX H: POSSIBLE CAUSES FOR TRANSPLANT FAILURE CHECKLIST

Quality control

- [ ] Eelgrass leaves dried out or damaged between harvesting and planting; washers were improperly tied to the shoots, or washers were planted too deep in the sediment.

Water quality issues

- [ ] Excessive presence of hydrogen sulphide (H_2S0 in sediment (presence of excessive ***Beggiatoa***)).
- [ ] Poor water quality from outputs from backshore activities (e.g. upland dairy farm, winery, stormwater outputs, stream/river outflows, long term development activities).
- [ ] Site has an excessive amount of algae growth during summer months from high nutrient concentrations, blocking sunlight, or smothering shoots and causing low dissolved oxygen.
- [ ] Too high or too low water circulation at site.

Sediment issues

- [ ] Sediment too coarse for shoots to establish, or too loose to stabilize.
- [ ] Excessive woody debris above or in the sediment.
- [ ] Increased water runoff from streams, rivers or glacial meltwater smothers shoots or washes plants away.

Bathymetry

- [ ] Eelgrass planted too shallow (e.g., presence of Canada geese caused predation of plants or shoots exposed during daylight hours with warm or freezing temperatures).
- [ ] Eelgrass shoots planted on an unstable slope.

Predation

- [ ] Eelgrass shoots planted in an area with an abundance of juvenile crabs or presence of European green crabs.
- [ ] High population of geese, swans dabbling ducks in area disturbing eelgrass during low tides.

Light availability

- [ ] Overhead structure (e.g., boat, barge, houseboat) moored over transplant for an extended time.
- [ ] Boat anchoring over transplant site.
- [ ] Transplant site is receiving debris swept in by predominant winds (southeasterly in the Salish Sea; southwesterlies on the West Coast Vancouver Island) during winter months.
- [ ] Seaweeds (e.g., kelp) on adjacent rock outcroppings or reefs blocking light at transplant site.
- [ ] Angle of sunlight in spring and summer months too low over site (e.g., mountain over-shadowing transplants).

Climate changes

- [ ] Excessively high winds during winter storms rips shoots from the sediment or causes damage from debris movement.
- [ ] Plants planted too high in the tidal zones so that they are exposed to excessively low or high temperatures during low tide periods.
- [ ] Coastal squeeze does not allow eelgrass shoots to grow shorewards (i.e., sediment changes from fine to coarse; seawalls obstruct expansion).
- [ ] Increasing sea surface temperatures slows eelgrass productivity and expansion.
- [ ] Extreme changes can negatively impact growth.

APPENDIX I: EQUIPMENT LIST FOR VOLUNTARY NO-ANCHOR ZONE BUOYS

To protect sensitive eelgrass beds, voluntary no-anchor buoys can be installed. These buoys typically consist of a float and mooring system designed to minimize contact with the seafloor.

The mooring line should be constructed from rope, with an additional mid-line float to ensure the rope remains suspended and does not drag along the bottom.

When installing markers, divers should locate the outer edge of the eelgrass bed. The buoy system should then be deployed approximately 5–10 metres away from the edge to avoid disturbance.

MOORING SYSTEM COMPONENTS:

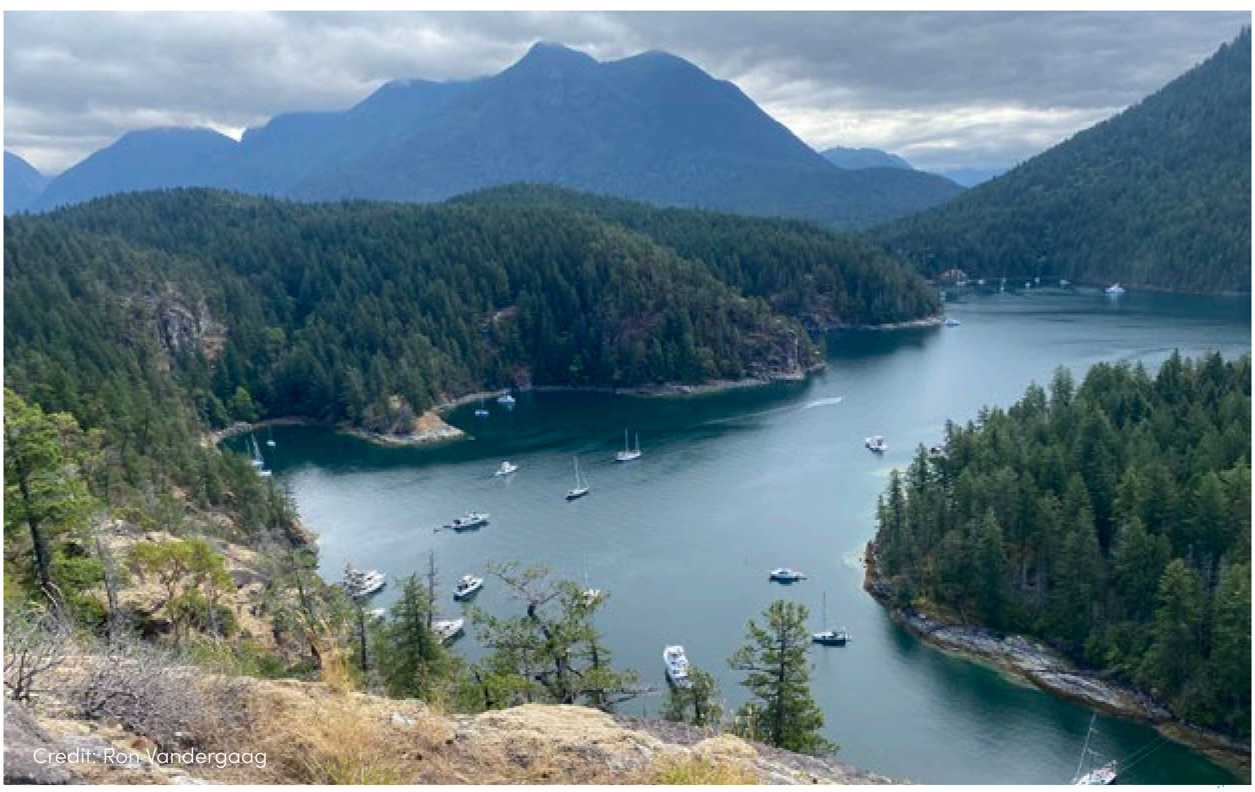
- **Anchor/weight:** Approximately 250 lbs. (113 kg), sufficient to hold the flotation system in place. The anchor does not need to be oversized since the system is intended as an informational marker, not a boat mooring.
- **Hardware:** Anchor → shackle → swivel (to prevent line twisting in tidal currents) → shackle.
- **Rope:** Approximately 1-inch (2.54 cm) double-braided rope leading upward.
- **Line float:** Positioned on the rope to prevent it from contacting the seabed at low tide.
- **Surface buoy:** Attached at the surface with a shackle. This serves as the visible informational marker.

Each buoy must be set at the appropriate depth to allow for tidal changes so the buoy remains upright and visible without being submerged or pulled under during high tide.

For more information, refer to:

https://www.jeffersonmrc.org/projects/voluntary-no-anchor-zones/

https://nwstraits.org/our-work/anchor-out-eelgrass

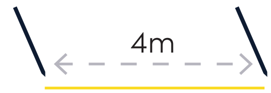


Credit: Ron Vandergaag

APPENDIX J: MARKING A TRANSPLANT PLOT

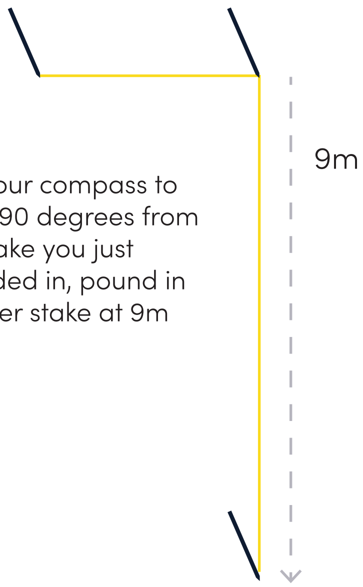
1

Pound in a large stake, then run a measuring tape 4m, and pound in another stake, take a compass bearing along the m tape



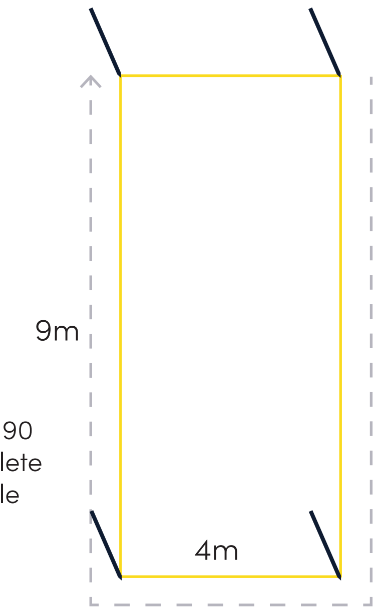
2

Use your compass to head 90 degrees from the stake you just pounded in, pound in another stake at 9m



3

Continue turning 90 degrees to complete a 9 x 4m rectangle



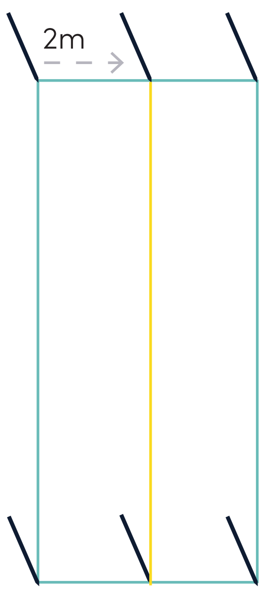
4

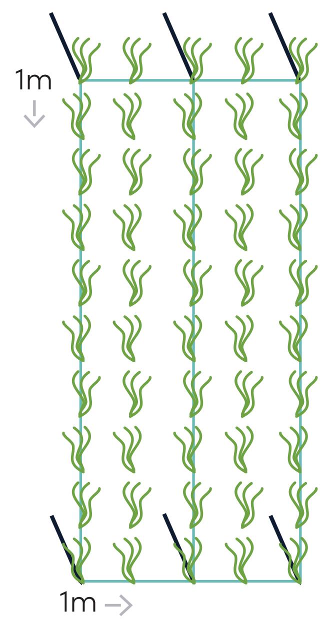
Measure 2m from a corner stake and pound in the next stake.

Attach a second m tape to the stake and swim parallel to a side.

When you reach the opposite side of the plot, check that you are 2m away from the corner stake and add another stake.

Pull tape taught and attach to the stake.



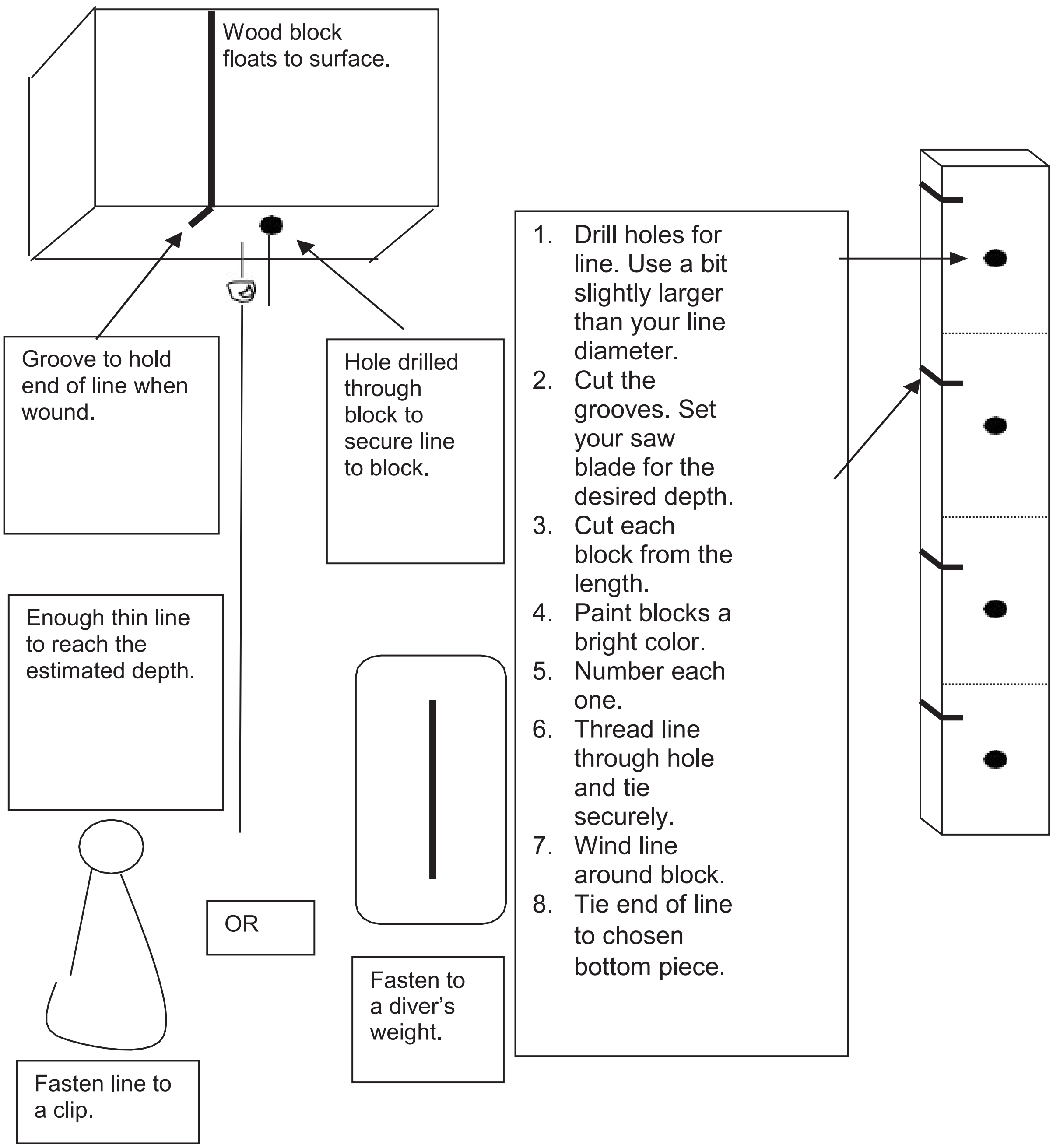


5

Plant a necklace at 1m intervals along the second tape and perpendicular at 1m intervals using the perimeter tape to guide you.

The laundry basket can be used to measure the distance between perpendicular plantings.

APPENDIX K: INSTRUCTIONS FOR MAKING MARKER BUOYS

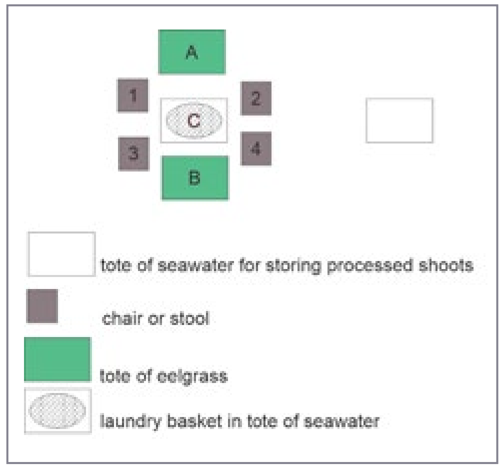


APPENDIX L: EELGRASS RESTORATION FIELD REFERENCE GUIDE

This video illustrates the procedures of an Eelgrass Restoration Event

This Field Guide provides key procedures to ensure a successful Eelgrass Restoration Event. Refer to Chapter 4 in the Restoration Handbook for more details of each step.

Step 1: **Prepare metal washers** before the event, if possible, by tying 4" paper twist ties to the number of ungalvanized steel washers required for the transplant and placing them in groups of 100 in small containers: Make sure the twist is in the middle of the washer.



Step 2: **Arrange work station** as shown on the right. Fill totes with clean seawater. **Assign a Monitor to oversee the preparation of the eelgrass shoots.**

Step 3: **Attach shoots to metal washers**

Transfer harvested shoots from the divers to the saltwater filled totes. Demonstrate to the work crew/volunteers how to select shoots with rhizomes with three nodes and lengths of ~7-10 cm (about the size of the width of your fist). Extra rhizome is trimmed. Shoots are then attached to the washers, with the rhizome placed in the middle of the washer where the twist tie can be gently attached on the part of the shoot that changes from white to pale green. Shoots should be securely attached, but not so tight the tissue of the plant is damaged — two or three twists should do it.

Step 4: **Prepare shoots for divers**

1. Consider designating one person at each work station to be a 'necklace weaver'. They measure and cut 10 pieces of jute or twine in 30 cm lengths. These can be cut in advance.
2. One anchored shoot is tied to the jute or twine, leaving a 10 cm tail. Nine more anchored shoots are threaded through the long end of the twine with a simple tool, then tied to the short tail. Make sure all washers are facing the same direction, up or down. If you would like to see making a necklace in action, see the video starting at 5:30.
3. Place ten necklaces into a laundry basket and immediately transport each basket to shallow water or seawater filled tote. When divers are ready to plant, pass the baskets of processed shoots to them. Keep track of how many baskets they take and also how many they bring back. Tell them whether most of the last harvest could be used, or whether they need to modify their harvesting techniques to get useable shoots.
4. Make sure volunteers/shore crew are comfortable, taking breaks as needed, and appreciated.
5. If possible, have the volunteers or shore crew view either the video footage of the transplant or visit the site by boat if the water visibility allows viewing of the transplant plot.

REMINDERS TO DIVE TEAM

Dive supervisor

- Check dive certificates are up to date, and all equipment, including compasses are on the boat.
- Make sure required equipment is on board, including:
  - **Large totes** — for storing eelgrass
  - **GPS unit** — to locate and record harvest and transplant sites
  - **Large mesh bags** — for collecting eelgrass
  - **Marker buoys** — at least four
  - **Metre tapes**
  - **Stakes** — at least six
  - **Underwater camera** — to document the site, before and after transplant

First eelgrass harvest

Dive supervisor: Review harvesting techniques with divers, including requirements for rhizome collection: (7-10 cm, 3 nodes); avoid flowering shoots (pale, branched, round stems).

- Determine the correct depth for harvesting, record GPS point where divers enter the water.
- Divers return to the boat when their harvest bag is full. Shoots are immediately emptied into a tote of seawater and checked if the rhizomes are long enough. Harvest bag is then returned to the diver to continue harvesting with feedback regarding shoot quality.

Lay out transects for planning following the first harvest

- Identify transplant area, select location to start at edge of area; release marker buoys to the surface at end points so that GPS coordinates are recorded on the boat. It helps to have floats with weights to mark corners; this makes it easier to monitor the transplant site.
- Lay out perimeter of area to plant and at least one additional transect for divers to navigate along.

Subsequent harvests

- Follow instructions above **BUT** do not harvest in same area twice, move about 10 metres away.

Transplanting

- Collect processed shoots from the location positioned by the shore crew. If transplant site is close, baskets can be stacked 3 high on boat deck. If the transplant site is more than a few minutes away, store baskets in totes of seawater.
- Once the divers start planting, visibility will be extremely poor. Stagger divers starting points to minimize suspended sediment.
- Plant a necklace at each metre mark, dig a hole with hand, shell, or trowel large enough to bury washers about 5 cm deep, place a necklace in hole and cover with sediment you removed to dig hole. Make sure washers are on top of rhizome and all leaf blades are positioned upward.
- Periodically, have divers return to planted areas to make sure the necklaces are properly planted.
- Remove stakes, metre tapes, and floats once area has been planted.

Credit: Tsleil-Waututh Nation

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