Attempts to Restore Eelgrass (*Zostera marina*) in Port Moody Inlet, British Columbia

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Introduction

Eelgrass (*Zostera marina*) is a native species of seagrass that forms extensive ecologically important meadows at the low tide and subtidal regions of the north Pacific coast. About 200 species of invertebrates, 75 species of fish and 80 species of birds utilize this habitat (Philips 1984). Ecological functions of eelgrass meadows include a nursery and shelter for young fish, recycler of nutrients generated by the breakdown of eelgrass plants and ocean-borne nutrients, and stabilizer of sediments. Loss of eelgrass habitat significantly reduces the abundance, biomass, species richness and life history diversity of fish (Hughes et al. 2002).

The ecological and economic value of eelgrass habitat has led to many attempts to transplant shoots to new areas as mitigation for losses elsewhere. The success of a transplant depends on features of the transplant site and the transplant methodology. Short et al (2002) reviewed the possible features of the transplant site that can directly influence the survival of transplanted eelgrass. The features that negatively affected success included poor site selection, insufficient light and poor water quality, smothering by macroalgae, and bioturbation by crabs and clams. In British Columbia, transplant success defined as a net increase in eelgrass cover, was only slightly more than 50% (Wright 2005).

Early reports by the Burrard Inlet Environmental Action Program indicated the presence of eelgrass in Port Moody Inlet in the 1970s, and longtime residents remember seeing eelgrass along the north shore at this time. Eelgrass disappeared for unknown reasons

Our objective in this study was to restore eelgrass to the inlet. Our goal was to transplant test plots, monitor the success and compare changes in bird and fish fauna inside and outside the transplant site.

Methods

The transplant methods we employed were similar to those described by Davis and Short (1997) and successfully used in the region (Wright 2005). We enlisted the expert advice of Cynthia Durance from Precision Identification on transplant methods and arranged a site visit with Nikki Wright and Sara Verstegen from the Seachange Marine Conservation Society. We experimented with donor sites and transplant methods as follows:

First transplant attempt – Rocky Point

Between 1300 and 1500 h during low tide on 23 March 2007, approximately 500 eelgrass rhizomes and above ground shoots were dug by hand from a beach along the eastern shore of Deltaport in Delta. The eelgrass shoots were taken from the upper edge of the bed at about the 1m tide height. Four workers removed plants above the tide line by hand. The straightened hand was pushed into the substrate, feeling along the rhizome for about 20 cm. Each rhizome was removed and placed into a bucket filled with seawater collected at the site. The rhizomes were transported in buckets by truck to the site in Port Moody Inlet. On 24 March 2007, volunteers inserted rhizomes through 5/8" iron washers. A twist tie was twisted around the washer and the eelgrass stem. Each eelgrass stem with washer was placed into a tote of seawater and taken to the planting site by boat. At about 1200 h three SCUBA divers planted the rhizomes from floating laundry baskets into an approximately 75 X 75 m patch between 0-1m tide height about 100 m north of the end of the Rocky Point Pier and immediately west of the nearest set of pilings. Visibility during the dives was close to zero and the planting was done by touch.

Figure 1. Eelgrass rhizomes were dug from the donor site and placed in buckets of water for transport to Port Moody Inlet

Second transplant attempt – Rocky Point

Between 0900 and 1030 h during low tide on 27 August 2007, approximately 500 eelgrass rhizomes and above ground shoots were dug by hand from the same beach as the first transplant attempt along the eastern shore of Deltaport in Delta. Five workers removed the plants by hand. The straightened hand was pushed into the substrate, feeling along the rhizome for about 20 cm. Each rhizome was removed and placed into a bucket filled with seawater collected at the site. In this case, rhizomes were in about 20 cm of water when removed whereas the SCUBA planting used plants that were out of the water. The removal of plants covered in water was probably less destructive to the rhizome than removal of plants from the exposed beach. The rhizomes were transported in buckets by truck to the site in Port Moody Inlet. On 28 August 2007, volunteers followed the same method as the first attempt to prepare plants for planting. At about 1100 h, eight volunteers planted 50 groups of ten plants each immediately northwest of the first planting and at the same tide height near the Rocky Point Pier and northeast of the nearest set of pilings. Each volunteer stepped back about 1 m and repeated a planting until all 500 eelgrass stems were planted in 50 locations. The coordinates of the planting were: Southeast corner: 49.17.003N, 122.51.017W; Northeast corner: 49.17.008N; 122.51.021W; Northwest corner: 49.17.004N, 122.51.028W; Southwest corner: 19.17.001N, 122.51.021W.

Third transplant attempt – Rocky Point

A third attempted planting was made on 3-4 May 2008. Between 0930 and 1130 h during low tide approximately 1140 eelgrass rhizomes and above ground shoots were collected by seven harvesters at the same location using the same methods as in August 2007. The shoots were stored overnight in ocean water in laundry baskets suspended from the Ioco Boat Club dock. In this case, two rhizomes were inserted in a washer forming a cluster, and tied into place. Eelgrass clusters were planted by 16 volunteers on 4 May in three side-by-side rows. In the first planting, 10 people stood about 1 m apart forming a line parallel to the tide line where they planted ten clusters. They then stepped back about 1 m and repeated the planting for a total of 400 eelgrass plants. End point coordinates for the first planting were 49 17.05N; 122 51.035W and 49 17.056N; 122 51.039W. They then formed a line on the next stretch of beach to conduct a second planting using the same methods as the first except that 12 people planted eelgrass for a total of 480 eelgrass plants. End point coordinates for the second planting were 49 17.056N; 122 51.039W and 49 17.048N; 122 51.031W. The third planting was on the next adjacent stretch of beach and followed the same methods as the first except that 13 people planted a single row of eelgrass clusters for a total of 260 eelgrass plants. End point coordinates for the third planting were 49 17.048N; 122 51.031W and 49 17.067N; 122 51.053W.

Fourth transplant attempt – Mossom Creek

On 23 May 2009, about 1000 shoots were removed from Bedwell Bay by eight harvesters using the same technique as in Delta. The rhizomes were placed in laundry baskets of water covered by a tarp and suspended overnight off a wharf at the Ioco Boat Club. The following morning, the eelgrass plants were threaded through washers and planted in three rows near the zero tide line at the mouth of Mossom Creek. A team of thirteen volunteers accomplished this work. On 24 June 2009, 282 clusters were counted during the low tide. Some clusters in deep water might have been overlooked. Dungeness and hermit crabs, and shiner sea perch were present in the eelgrass. During very low tides, we enlisted volunteers to keep Canada Geese (*Branta canadensis*) from the meadow to reduce the chance of uprooting of the plants.

Fifth transplant attempt – Mossom Creek

On 30 April 2010, 1000 plants were harvested subtidally from Bedwell Bay by four SCUBA divers. The rhizomes were attached in clusters of three to four plants to washers by a team on shore before storing them overnight off the dock of the Ioco Boat Club in the same manner as previously described. On May 1 the stems were planted by SCUBA divers at the 5-foot tide in two plots. The east plot was a triangle with coordinates: N49$_0$ 17' 45.34" W122$_0$ 52' 00.47" to N49$_0$ 17' 45.40" W122$_0$ 51' 59.30". It was planted with approximately 180 clusters. The west plot was planted with approximately 20 clusters at -3 to -5 ft relative to zero chart datum. Shape of the plot approximates a trapezoid with coordinates: N49$_0$ 17' 48.18" W122$_0$ 52' 11.01" to 49$_0$17' 47.97" W122$_0$ 52' 10.81".

Figure 2. The Bedwell Bay eelgrass bed donor site was located on the northern shore of Bedwell Bay.

Bird and mammal census

All birds and marine mammals that were present on the mudflat, water and logs were counted through binoculars from the Rocky Point Pier and the shore. Counts began on 26 August 2007 at 0840 h a few hours prior to the first hand planting and continued about once per month.

Between 1985-2000, a log was kept of all birds seen in Sidney Lagoon in the Gulf Islands. The 100 ha eelgrass meadow and mudflat is about the area of the intertidal area in Port Moody. The species seen and their abundance in the lagoon on Sidney Island provide a comparison of the species and abundance of birds we might expect in Port Moody once the eelgrass is restored.

Beach Seines

On 4 May 2008, a beach seine was pulled toward shore three times through the water immediately adjacent to the third planting row of eelgrass (49 17.090N; 122 51.079W). The beach seine (4m x 1m) was attached to a pole on either end, a lead line on the bottom and a float line along the top edge. Two people waded to about 1m water depth and pulled the net ashore while keeping the lead line on the bottom and the float-line on the water surface. The net was opened at the water's edge and all fish were removed and placed into separate buckets for each seine. Fish were removed from the buckets, counted and the total length was measured on a fish ruler before being released into the water.

Seven beach seines were pulled behind a skiff on a beam trawl on 23 June 2008 at 1615h. Each trawl traveled about 50 m. The net was pulled into the skiff and all the animals were emptied into buckets of water.

Results

First planting

On 28 August 2007 (c. 5 mos. after the transplant), no shoots were visible and many washers were found on the surface of the mud during a low tide search. The first planting was considered unsuccessful.

Second planting

On 26 April 2008 (c. 8 mos. after the transplant) 25 of the original 50 plantings was counted from a skiff above the eelgrass plants. The leaves were bright green and several stems were present in each cluster. By July (c. 11 mos), the plants were growing and epiphytes were attaching to the stems. However, a few days later most plants were gone and only a few rhizomes were present. Footprints of Canada Geese were seen in the mud in the planting site.

Third planting

The third planting of eelgrass stems collected from Bedwell Bay looked healthy on 16 August 2008 (c. 3.5 mos. after the transplant). We inspected some plants using an underwater video camera on 15 October 2008 (c. 5 mos) and located 10-15 clusters of plants. On 24 May 2009 (c.1 year after the transplant) we found about a dozen healthy looking plants growing in the substrate.

Fourth planting

The fourth planting of about 1000 plants on 23 May 2009 was healthy on 24 June 2009 when we tallied 282 clusters of bright green plants with epiphytes adhering to the leaves. A school of shiner sea perch (*Cymatogaster aggregata*) was seen in the eelgrass and hermit crabs clung to the leaves. Sandlance (*Ammodytes hexapterus*) were buried in the sand. There was no sign of any plants in the autumn of 2009.

Fifth planting

The fifth planting on 1 May 2010 was healthy on 24 June 2010 when a reconnaissance SCUBA dive indicated 93 and 15 clusters in the east and west plots, respectively. During this inspection three

clusters of eelgrass were observed outside the plot. It was assumed that these clusters originated from a previous transplant attempt, presumably 23 May 2009 (c. 13 mos). A reconnaissance dive using snorkel on 30 August 2011 revealed no plants although visibility was poor.

The lagoon on Sidney Island has an eelgrass bed about the size we expect would occur in Port Moody Inlet. Forty-five species occurred regularly at Sidney between 1985-2000 (Table 1). The maximum number counted of any species during that period was generally quite small – only the Western Sandpiper exceeded 1000 individuals. A few species such as Heermann's Gull, California Gull and Long-tailed Duck are unlikely to be present in the same abundance in Port Moody because Sidney is more strongly influenced by the local marine conditions they prefer, than Port Moody. The opposite is true for Ring-billed Gull. It prefers the estuarine conditions of Port Moody over the marine conditions at Sidney. Thirteen species were fish-eaters likely drawn to the lagoon by the large numbers of small fish. Twenty-three species were invertebrate eaters that lived on the mudflat or in the eelgrass. The remaining nine species were herbivorous that ate eelgrass or saltmarsh plants.

Table 1. Maximum number present of annually occurring species in an eelgrass bed in Sidney Lagoon in spring and summer, 1985-2000.

Max no. present	No. of species	Species
1-10	14	Common Loon, Pigeon Guillemot, Northern Shoveller, White-winged Scoter, Red-breasted Merganser, Hooded Merganser, Ring-billed Gull, Caspian Tern, Killdeer, Greater Yellowlegs, Spotted Sandpiper, Pectoral Sandpiper, Osprey, Belted Kingfisher
11-100	20	Horned Grebe, Red-necked Grebe, Great Blue Heron, Double-crested Cormorant, Canada Goose, Northern Pintail, American Wigeon, Green-winged Teal, Surf Scoter, Black Scoter, Long-tailed Duck, Heermans Gull, Black-bellied Plover, Semipalmated Plover, Lesser Yellowlegs, Short-billed Dowitcher, Long-billed Dowitcher, Black Turnstone, Bairds Sandpiper, Semipalmated Sandpiper
101-1000	10	Brant, Mallard, Greater Scaup, Bufflehead, California Gull, Mew Gull, Glaucous-winged Gull, Dunlin, Sanderling, Least Sandpiper
1001-10,000	1	Western Sandpiper

Seasonal abundance of birds

The typical pattern of bird abundance in coastal bays around southern British Columbia is an autumn peak and a summer low, a pattern also reflected in Port Moody Inlet (Fig. 3).

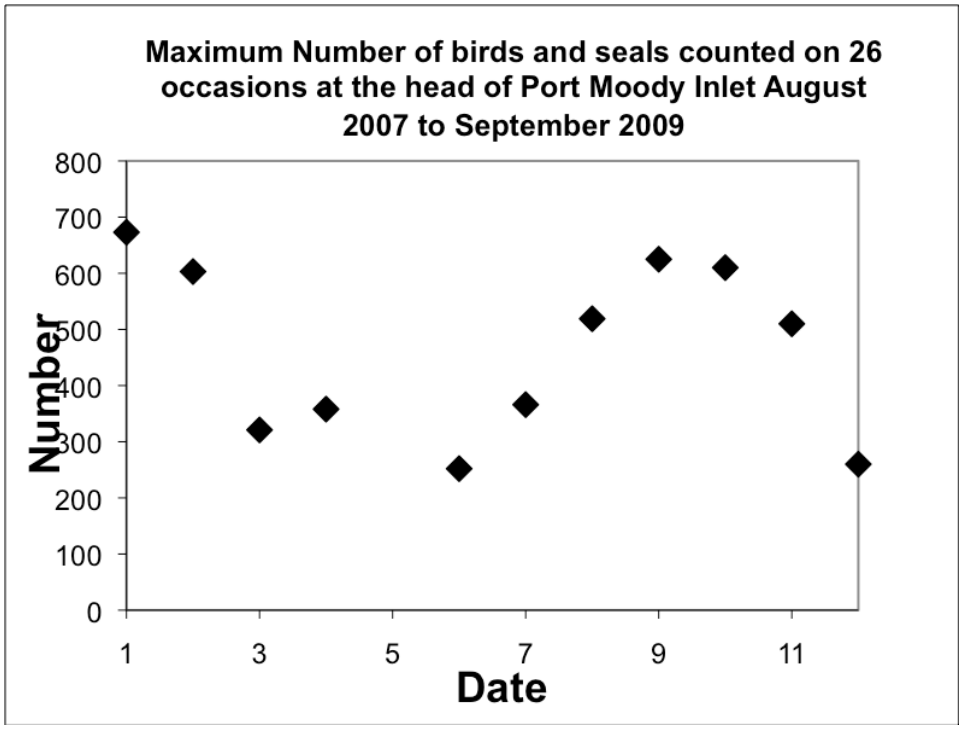

Figure 3. Maximum number of birds and seals counted at Port Moody Inlet. 1 = January, 12= December.

Species composition

Thirty-eight species of birds and two species of marine mammals were recorded in the inlet. The 10 most numerous species in descending order of abudance were Canada goose, glaucous-winged gull, green-winged teal, bufflehead, northwestern crow, mew gull, harbour seal, northern pintail, dunlin and Barrow's goldeneye (Table 2). The Canada geese in the inlet are descendents of a small flock introduced to the Fraser Valley from the Prairies and Central Canada in the 1970s by the provincial government and conservation groups. Tens of thosuands now reside in the valley. The goose grazes lawns in neighbouring Port Moody and rests on the water in the inlet. It breeds around the inlet in spring and summer. The geese had a significant impact on our transplant efforts by uprooting recently planted shoots near the boat ramp at Rocky Point and at Mossom Creek. Despite patrols to keep the geese away from the freshly planted stems, we lost much of our effort to these birds. The remaining 8 species of birds and the harbour seal are species typically associated with muddy bays and beaches in southern British Columbia. In addition to the species seen during the census, two western grebes and six spotted sandpipers were seen from a boat on separate occasions.

Table 2. Number of birds and mammals by species in Port Moody Inlet from August 2007 to September 2009 (n=26 counts).

Species identified	Total
American wigeon	61
Bald eagle	25
Barrow's goldeneye	128
Belted Kingfisher	11
Black Turnstone	76
Bufflehead	843
Canada goose	1571

California gull	27
Caspian tern	2
Common goldeneye	38
Common loon	4
Common merganser	24
Common raven	1
Double-crested cormorant	10
Dunlin	160
European starling	3
Great blue heron	31
Greater scaup	17
Glaucous-winged gull	1234
Green-winged teal	937
Horned grebe	22
Hooded merganser	9
Harbour seal	379
Killdeer	2
Long-billed dowitcher	20
Mallard	458
Mew gull	168
Northern pintail	365
Northern river otter	1
Northwestern crow	709
Osprey	6
Pelagic cormorant	13
Peregrine falcon	1
Ring-billed gull	5
Red-breasted merganser	34
Red-necked grebe	12
Red-throated loon	2
Thayers gull	3
Western sandpiper	10
White-fronted goose	1

Habitat comparison

The birds used the water, mudflat, pier, and logs boomed in the inlet near a sawmill. Port Moody Inlet is comparable in area to Sidney Lagoon in the Gulf Islands. Where the two sites differ is that Sidney Lagoon has a stronger marine influence being located close to the entrance to Juan de Fuca Strait and it has an extensive eelgrass bed. All species seen at Port Moody Inlet were also present in Sidney Lagoon. Gulls, waterfowl and shorebirds were the predominant avifauna at Sidney whereas gulls and waterfowl predominated the Inlet scene. Great blue herons and double-crested cormorants are far more numerous at Sidney that at Port Moody. Flocks of 10 to 40 herons and cormorants are commonplace in summer at Sidney compared to 1 to 5 at Port Moody, even though both species nest nearby at both sites. Western sandpipers flocks of 50 to 100 are often encountered at Sidney in summer compared to only a single sighting of 10 at Port Moody. Most notable was the abundance of brant at Sidney and complete absence at Port Moody. Flocks of 10 to 350 brant are seen annually in spring at Sidney. The reason for this difference is that brant eat eelgrass that is abundant at Sidney. Two ducks species present at Sidney but absent from Port Moody were the surf and white-winged scoter. Both scoters feed on invertebrates and are regularly seen nearby in Indian Arm, Vancouver Harbour and English Bay. It was surprising to find them absent from the inlet. Also present regularly at Sidney but missing from the inlet were many shorebirds. I saw no black-bellied plover, semipalmated plover, greater and lesser yellowlegs, short-billed dowticher, Baird's sandpiper, pectoral sandpiper, least sandpiper, and semipalmated sandpiper. They were seen regularly at Sidney.

Beach Seines

Trawls over the mudflat in Port Moody Inlet in June caught mostly shrimp and ctenophores (Table 3). Our plan was to sample adjacent to an restoring eelgrass meadow to measure change in species composition. However, we aborted this plan when the eelgrass failed to survive.

Table 3. Trawl location, species and number of individuals caught in 7 beam trawls between 1612-1720 h on 23 June 2008 in Port Moody Inlet.

Trawl	Lat	Long	Species	Number
1	49.1716	122.511	Shrimp	2
			Lumpenus sagitta	8
			Ctenophore	1000s
2	49.17217	122.5113	Moon jelly	1
			Ctenophore	1000s
			Aquoria	1
			Shrimps	1
			larval Lumpenus	1
3	49.1724	122.5108	Shrimps	2
			Ctenophore	300
4	49.172	122.5119	Ctenophore	1000s
			Aquoria	1
5	49.1722	122.5119	Aquoria	1
			Ctenophore	300
6	49.1708	122.511	nil	
7	49.1705	122.511	Aquoria	3
			Ctenophore	300
			Shrimps	2

Discussion

Our results showed that many plants appeared to be healthy and survived for several months in Port Moody Inlet. The sudden disappearance after what appeared to be successful transplants suggests the problem was not with the transplant method or the quality of the site. We do not know why the plants did not survive but it might have been uprooting by geese and/or crabs. There were Canada geese tracks around our first transplant location and we saw geese with eelgrass in their bills at the Mossom Creek transplant site. We also saw Dungeness crabs around eelgrass plants at Mossom Creek. Geese ate eelgrass on Roberts Bank and Sidney Island (RWB) and crabs are known to uproot eelgrass. Future efforts to transplant eelgrass in Port Moody should consider ways to prevent these species from reaching the plants until they have become sufficiently rooted.

The suite of bird species present and absent in Port Moody is an indication of the ecological quality of the site. Loss of eelgrass leads to lower abundance, biomass, species richness and life history diversity of fish (Hughes et al. 2002). Several bird species occurred in low numbers or were absent from the inlet likely because of the absence of eelgrass. The most striking example is the brant. The sea-going goose eats mostly eelgrass and occurs in the thousands along the south coast in late winter and early spring during its migration to the Arctic breeding grounds. It is not surprising that it is absent in the inlet where no eelgrass grows. A few great blue herons were present in the inlet on

most counts but the numbers pale in comparison to Sidney Island. The eelgrass bed on Sidney holds several million fish in spring and early summer that attract scores of herons (Butler 1997). The link between the presence of an eelgrass meadow and a suite of shorebird species regularly seen on Sidney but largely absent from the inlet is more tenuous than for the brant and heron. Nevertheless, it is a plausible hypothesis. None of the species eat eelgrass but all eat marine invertebrates on the mudflats adjacent to the eelgrass beds.

Our trawl on a single day did not reflect the abundance and diversity of fish caught in beach seines at five sites on nine days between May and August in Port Moody Inlet. Graham (2011) tallied 18 species of fish. The arrow goby, shiner sea perch and staghorn sculpin occurred in the hundred or thousands of individuals. Her results indicate that many small fish are present in the inlet. Fish fauna in southern BC eelgrass meadows are not similar (Robinson et al. 2010) and so it is not clear which species would be present if an eelgrass meadow were restored to Port Moody Inlet. However, it is well known that the absence of eelgrass reduces the abundance and diversity of species (Hughes et al 2002).

Recommendations

We have shown that transplanted eelgrass can survive many months in Port Moody Inlet. We also have made the case that the avifauna in Port Moody Inlet would increase with the presence of eelgrass meadows. We also showed that eelgrass will grow in the inlet if Canada geese are prevented from uprooting newly planted shoots. Therefore, we recommend that:

1. More eelgrass be transplanted from local donor beds;
2. Methods be investigated to reduce Canada goose grazing and Dungeness crabs uprooting of eelgrass shoots;
3. Species composition and change in fish and bird populations be periodically assessed as the eelgrass meadow becomes established;
4. The restoration of an eelgrass meadow in Port Moody Inlet be included in wider environmental vision that includes fish streams, forested edges, water quality and other environmental features.

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