EELGRASS SURVEYS IN EAGLE HARBOR, WA, FOLLOWING CAPPING OF ADJACENT CONTAMINATED SEDIMENTS

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Between October 1993 and August 1995, the density of eelgrass (<u>Zostera marina</u> L.) in three beds within or near Eagle Harbor, WA, was recorded as counts of stalks within 0.1 m^2 quadrats. The surveys were conducted by the EPA Region 10 Dive Team and were designed to document any changes in eelgrass density following capping of nearby contaminated sediments, since it was unknown whether cap sediments might migrate and affect nearby beds. During the surveys, 30 quadrats were placed randomly in a 100 m by 20 m rectangle in the middle of each bed. In some quadrats two divers made counts. Shoot density differed: the Wyckoff bed (nearest the sediment cap) consistently had the least amount of eelgrass and the Murden Cove bed (to the north of Eagle Harbor) the most. Changes within beds appeared to be related to the natural cycle of winter reduction rather than the movement and subsequent deposition of cap materials. Variability among divers in counting stalks was a function of stalk density. The highest difference in counts ([high-low]/high) was 33% when the density was high and less than 14% (within 1 or 2 stalks) when density was low.

INTRODUCTION

The eelgrass, *Zostera marina* L., is an important constituent of intertidal and subtidal marine waters where its primary roles are stabilizing bottom sediments, providing substrate and cover for bottom organisms, and serving as a food source for many animals ranging from detritivores to waterfowl (Phillips, 1972).

Between October 1993 and July 1994, the density of *Zostera* in three beds within or near Eagle Harbor, WA, was recorded as counts of stalks from 0.1 m^2 quadrats randomly in each bed. In August 1995, only two of these beds were resurveyed. Each survey was conducted by the EPA Region 10 Dive Team and designed to document any changes in mean eelgrass density in the beds following the capping of nearby contaminated sediments, since it was not known whether or to what extent the cap materials might migrate and influence nearby beds. The purposes of the surveys were to determine baseline conditions for any future monitoring of eelgrass beds and whether significant quantities of sediment drifted into Eagle Harbor eelgrass beds during the period of cap placement (between mid-September 1993 and March 1994).

METHODS

The study area was located in Eagle Harbor and Murden Cove, two embayments on the east side of Bainbridge Island, which is on the west side of Puget Sound. Three eelgrass beds were chosen (Fig. 1); the first (Wyckoff), inside Eagle Harbor near the former Wyckoff facility, oriented roughly west to east; the second, inside Eagle Harbor near Wing Point (Wing), oriented northwest to southeast; and the third, about 1 mile north of Eagle Harbor inside Murden Cove (Murden), oriented northwest to southeast. The Wyckoff bed was expected to potentially receive the greatest impact from migrating cap sediments, with the Wing bed and Murden bed serving as reference areas within and outside Eagle Harbor, respectively.

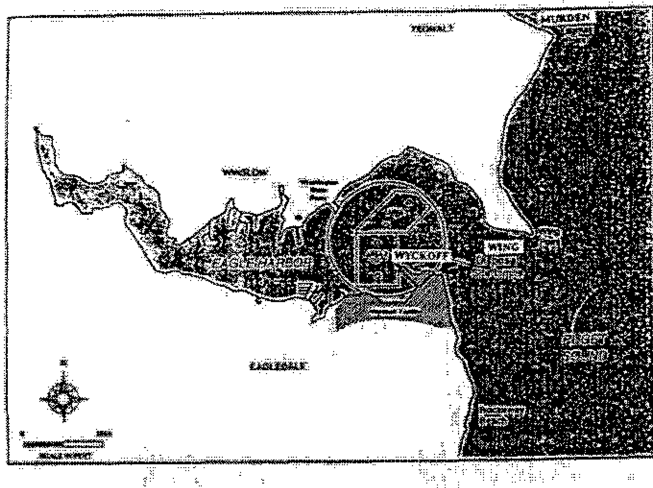

Figure 1. Approximate locations of the Wyckoff, Wing Point, and Murden Cove eelgrass beds in Eagle Harbor, WA.

Eelgrass shoot density was measured in each bed on four separate occasions (October 13 to November 4, 1993; March 18 to 22, 1994; July 13 to 14, 1994; and, August 9, 1995). During the first survey, a 100 m line was laid down somewhat parallel to shore through the approximate middle of each bed and the ends were marked by rebar rods. Locations of the ends of the transects were recorded using visual rangemarkers. General bearings of the transects were recorded using rangemarkers or compass headings. At a randomly selected meter along the first ten meters of the transect, a second line 10 m in length, was placed perpendicularly, first on one side of the transect, then the other. This 20 m subtransect line was divided into 60 segments of 1/3 m per segment.

Three of the sixty segments were sampled at random. Divers placed a 32 by 32 cm (0.1 m^2) quadrat on these three segments and counted the number of eelgrass shoots present. This was repeated at 10 m increments from the initial placement of the 10 m line, until 30 quadrats had been placed and the eelgrass shoots counted (Fig. 2). One diver counted eelgrass in the first 15 quadrats and the second diver counted shoots in the remaining 15. To account for variability in counting among divers, eelgrass shoots in approximately three randomly chosen quadrats were counted by both divers. For some of the surveys, the location of the edge of the bed relative to the subtransect line was recorded to the nearest meter. When the distance to the edge exceeded 10 m it was either estimated or recorded as 10+ m. This was particularly important in the Murden Cove surveys because that bed was approximately 22 to 25 m wide, and some quadrats fell outside the bed in the 1994 and 1995 surveys.

Reoccupation of the rebar stakes and placement of the 100 m transect line was hampered at times by wind and currents moving the deployment vessel relative to the desired path, or by poor visibility which limited the use of some distant rangemarkers. During the study, water depth over the beds typically ranged from 5 to 15 ft and water visibilities ranged from <1 to 20+ ft. The location of the transect line relative to the original stakes was noted for each survey. The general procedure was to relocate one set of stakes and then deploy the transect line using a combination of compass bearings, isopleths, and rangemarkers.

Data were evaluated by comparing plots of means and 95th percentiles to look for trends or patterns (95th percentiles that do not overlap indicate means that are likely to differ significantly). Adjustments were made to the Murden Cove data collected in 1994, by omitting counts of zero from quadrats located outside the boundaries of the bed. In some surveys, only one set of stakes was relocated. Therefore, the data from each bed were partitioned into western and eastern portions (15 quadrats in a 20 m x 50 m area for each partition) to evaluate the half of each bed that was relocated successfully somewhat independently of the half that may not have been. This partitioning was also used to evaluate a diver-suspected decline in eelgrass density observed in the eastern part of the Wyckoff bed and the erosion of the deepwater edge of the Murden bed.

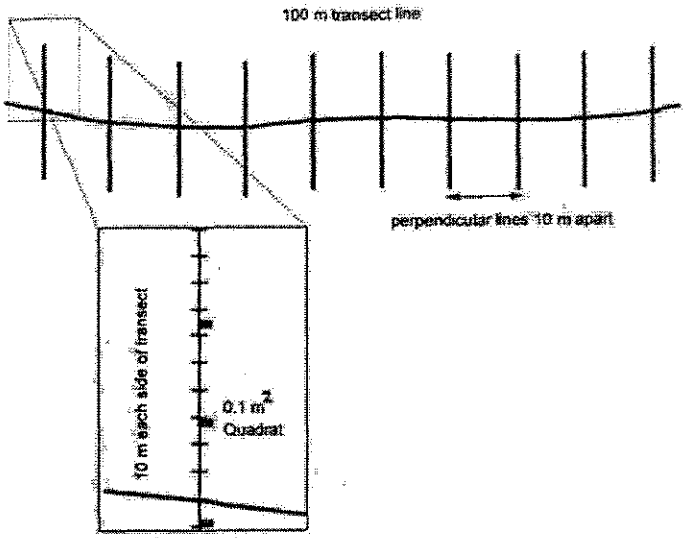

Figure 2. Sampling design for stalk counts. 100 m transect line, with perpendicular lines (each 20 m long, spaced every 10 m). First line crosses the transect at a random point between 0 and 9 m. Three quadrats (0.1 m^2) were censused on each 20 m line.

RESULTS

Based on an evaluation of the means and 95th percentiles of the shoot densities as shown in Figure 3, several patterns appear. First, the three beds differed initially in terms of shoot density; the Wyckoff bed had the least amount of eelgrass and the Murden Cove bed the most. Second, the variability in estimating the mean density appeared to be relatively consistent, even though the 95th percentiles increased somewhat with mean density. Third, relative to the fall densities, the late winter/early spring (March 1994) densities appear to have decreased at both of the Eagle Harbor sites with "recovery" in summer to densities at least matching the previous fall. However, the depression in density at Wing Point in March 1994 may be overestimated due to misalignment of the southeast end of the transect line somewhat offshore into what divers characterized as a less dense portion of the bed.

Except for the Wyckoff bed in July 1994, one end of each bed was always relocated. Just prior to July 1994, a building used as a range mark for the Wyckoff bed was removed so neither end was located. This transect then had to be placed by dead reckoning using a compass and depth sounder. At Wing Point, although the transect line was laid down from the northwest stakes on a known compass bearing, the southeast stakes were never relocated. At Murden Cove, the transect was laid down from the southeast stakes to the northwest and the northwest stakes were usually within about 6 m of the end of the transect. Data from the Murden bed (as shown in Fig. 3) were adjusted to remove counts of zero from outside the bed for 2, 5, and 10 quadrats, respectively, in March 1994, July 1994, and August 1995. Width measurements from March 1994 to August 1995 of the Murden bed show a decline of up to 10 m on the eastern end. Bottom erosion appeared to be the cause of the reduction in width.

Although some differences in stalk density appeared between the east and west halves of the portions of the beds, none appeared significant with the exception of the Wing bed in July 1994 (Fig. 3B). However, both the east and west portions of the beds in Eagle Harbor showed the same overall pattern of a winter decrease in eelgrass density followed by a summer increase, usually to at least the previous levels. In contrast, the western half of the Murden bed did not show an overall pattern of winter decline.

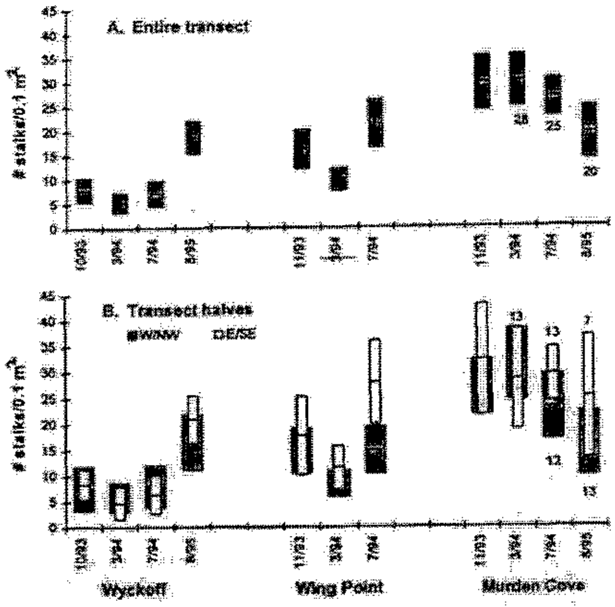

Figure 3. Stalk densities (mean + 95th CI) in each eelgrass bed: A. Along the entire transect; B. Comparing western and eastern halves (N=30 for A, N=15 for B, except as indicated for the Murden Cove bed).

Overall, replicate counts were made on 25 quadrats (of 270 total), in which stalk density ranged from 0 to 65. Variability among divers in counting stalks was a function of stalk density. The highest difference in counts ([high low]/high) was 33% when the replicate counts were 34 and 51 stalks. When stalk counts were less than or approximately equal to 32 (which occurred in 86% of the quadrats), differences were less than 14% and usually within 1 or 2 stalks.

DISCUSSION AND CONCLUSIONS

Based on the initial dataset comparing fall 1993 and late winter/early spring 1994 densities, it appeared that beds in Eagle Harbor (Wyckoff and Wing beds) were in decline. Dr. Ron Thom, an eelgrass expert at the Battelle Marine Sciences Laboratory in Sequim, WA, was consulted for his opinion on the interim results. He suggested (pers. comm.) that both the Wyckoff and Wing beds could receive sediments transported from the cap and pointed out an additional bed to the southeast of Wyckoff that might receive sediments transported in the eddy that forms in this area.

After evaluating the results from the next surveys (summer 1994), it was clear that there were no large (*e.g.*, >50%) declines in eelgrass density at any of the beds during the first nine months of the study period. While changes did occur, they were generally not significant (except March 1994 at the Wing bed, Fig. 3) and appear to be related to the natural cycle of winter reduction (except the northwest portion of the Murden bed transect; Fig. 3B). There is no suggestion of a decline in any of the beds when comparing the 1994 with the 1995 densities; indeed densities in the Wyckoff and Wing beds increased and appeared to be very similar in 1995 (Fig. 3A). Even if initial differences in density in the two beds in Eagle Harbor were influenced by drifting cap materials, no effect was discernible in 1995. Indeed, during all surveys, divers did not note any partial burial of eelgrass as they had when diving on a shoal in Eagle Harbor where eelgrass was covered during the capping process (the shoal extends north from the Wyckoff facility in the vicinity of the pier shown in Fig. 1).

There was not much difference between the east vs. west portions of the beds in Eagle Harbor except the Wing bed in July 1994 (Fig. 3B). In this instance, the southeast end was not relocated. It is possible that the greater density in the southeast half of the bed was due to location of the end of the transect line further inshore than the original transect. In this part of the Wing bed, divers noted that densities appeared greater inshore than offshore. The pattern of decline in winter and recovery in summer was consistent for both portions of the Eagle Harbor beds (Wyckoff and Wing, Fig. 3), suggesting that similar processes were acting on the beds and that any cap related effects were insufficient to disrupt what is interpreted here as a natural pattern.

The inability to reoccupy original transects may have affected the comparability of some of the data. Nonetheless, all transects were placed within the beds in approximately the same location so we are confident that the resulting data represent means and variability of eelgrass density in these locales. At Murden Cove, because this bed was so narrow, some counts fell outside the bed. To compensate, we removed these zero counts from the dataset. It was not necessary to adjust the data from the other two wider beds.

The error associated with having different divers count the number of eelgrass stalks in each 0.1 m^2 quadrat was relatively low (usually <14% difference between counts) when the densities were <32 stalks/quadrat. Since most (86%) of the quadrats were of this density range (0 to 32 stalks), the variability associated with counting was high (14% to 33% difference) only for a limited number of quadrats.

ACKNOWLEDGMENTS

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LITERATURE CITED

Phillips, R. C. 1972. Ecological life history of Zostera marina L. (eelgrass) in Puget Sound, Washington. Ph.D. thesis. University of Washington, Seattle, WA.