



Padilla Bay

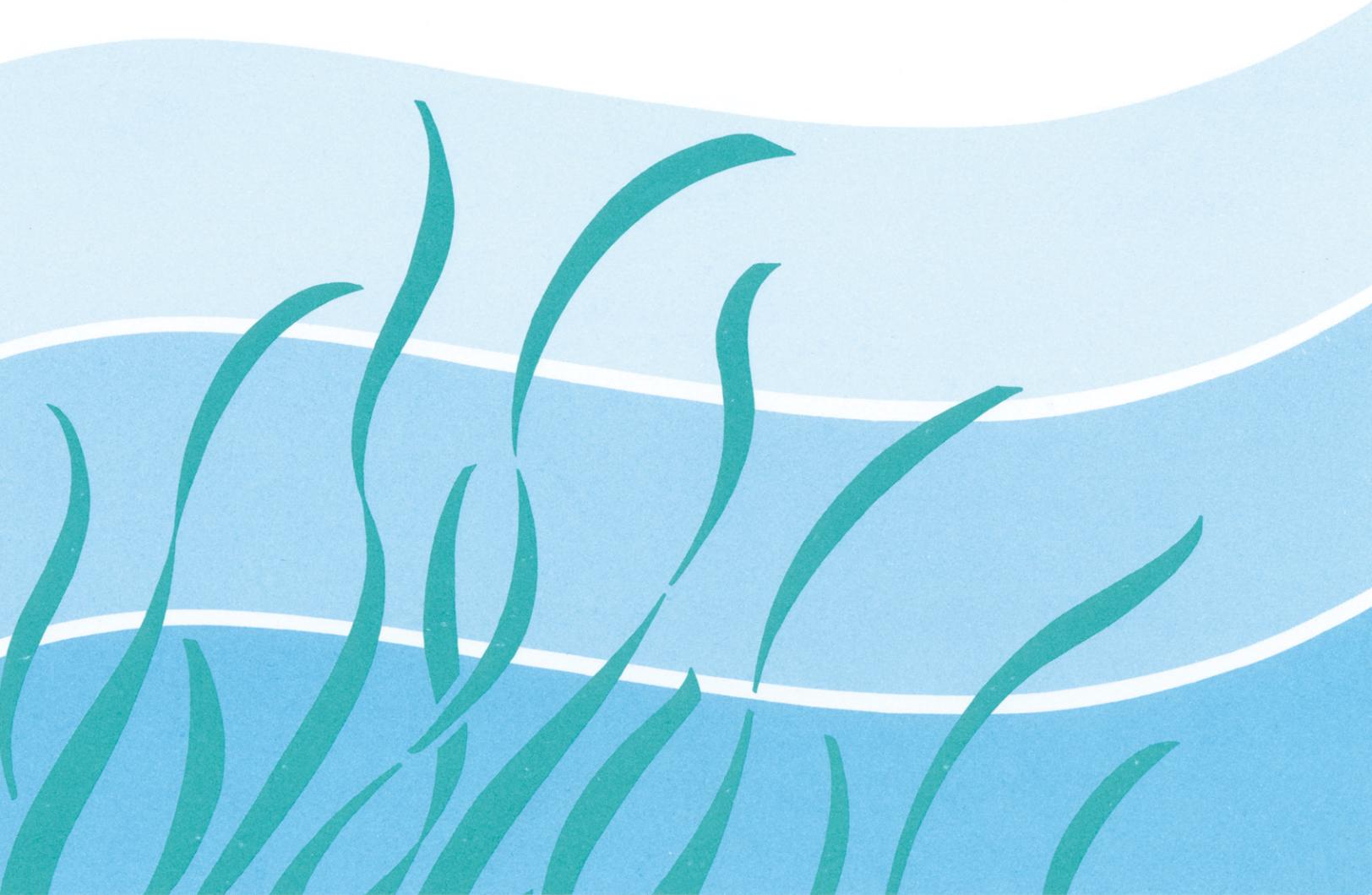
National Estuarine Research Reserve

Technical Report No. 3

**DISTRIBUTION OF *SPARTINA ALTERNIFLORA*
IN PADILLA BAY, WASHINGTON, IN 1991**

Sharon Riggs

February 1992



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Padilla Bay National Estuarine Research Reserve
10441 Bayview-Edison Road
Mount Vernon WA 98273-9668
(360)428-1558

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Padilla Bay National Estuarine Research Reserve
Shorelands and Coastal Zone Management Program
Washington State Department of Ecology

1043 Bayview-Edison Road
Mount Vernon, Washington 98273

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ABSTRACT

Riggs, S.R. 1992. Distribution of *Spartina alterniflora* in Padilla Bay, Washington, in 1991. Washington State Department of Ecology, Padilla Bay National Estuarine Research Reserve Technical Report No. 3, Mount Vernon, Washington. 63 pp.

The location and areal extent of *Spartina alterniflora* in Padilla Bay was determined in August and September of 1991. The field study used survey methods similar to those used by Wiggins and Binney in 1987. The area of *S. alterniflora* coverage is increasing in Padilla Bay but is distributed in the same general areas as it was in 1987. The number of stands increased from 12 (plus Dike Island) to 18 (plus Dike Island) and the area covered by nine of these stands increased at a rate of 100 m² per year. The lateral growth in three selected stands ranged from 1.1-1.7 m/yr. The total area of *S. alterniflora* in Padilla Bay in 1991 is 48,100 m². No evidence of flowers or seeds was found. *S. alterniflora* appears to be spreading only vegetatively in Padilla Bay at present. Native saltmarsh plant species bordering the stands also were recorded in this study.

INTRODUCTION

Spartina alterniflora (commonly known as cordgrass) is a species of interest in Washington state. Native to the east coast of North America, this plant has been purposefully and accidentally introduced to various west coast estuarine habitats. There is some controversy over whether it should be allowed to invade native habitats as it produces "massive habitat alteration, with ramifications for wildlife, fisheries, geology, native vegetation, and hydrology" (Mumford, 1991). *Spartina alterniflora* was added to the state noxious weed list (Class B) in 1989 in a number of Washington counties, including Skagit County. Class B noxious weeds are "those weeds not native to the state that are of limited distribution or are unrecorded in a region of the state and that pose a serious threat to that region" (WAC 16-750-003). This action indicates that steps are being taken to control the spread of *Spartina* species. What final action will be taken to control *Spartina*, if indeed it is controlled, is not yet known.

Padilla Bay is a shallow estuarine embayment in Skagit County, Washington, with extensive seagrass beds (*Zostera marina* and *Zostera japonica*) (Bulthuis, 1991). At extreme low tides most of the bay is exposed as mudflats and uncovered seagrass beds. *Spartina alterniflora* was introduced to Padilla Bay, Washington, between 1940 and 1946 by the Dike Island Gun Club to stabilize the long, narrow island that is part of the gun club (Parker and Aberle, 1979). In Willapa Bay *S. alterniflora* grows to within 1 m of MLLW (mean lower low water) (Sayce, 1988). Because large areas of Padilla Bay are shallower than +1m the potential spread of this species in Padilla Bay is quite extensive.

Since 1894 when *S. alterniflora* was introduced into Willapa Bay it has spread to cover more than 2,000 intertidal acres and is predicted to cover about 30,000 intertidal acres by the year 2030 (Mumford, 1991). Because of this rapid spread of *S. alterniflora* in Willapa Bay, state, federal and local agencies, and private corporations are working together to develop appropriate control strategies for this species in Willapa Bay.

The areal extent of *S. alterniflora* in Padilla Bay was estimated at 26,700 m² in 1987 by Wiggins and Binney who made detailed measurements of the small *S. alterniflora* stands and made a very general estimate of the Dike Island stand. In a broad-scale survey Bulthuis (1991) estimated *S. alterniflora* covered 80,000 m² in 1989. However, there have been no detailed surveys of the area of the small stands of *S. alterniflora* in Padilla Bay since the survey of Wiggins and Binney in 1987, the large Dike Island stand has never been measured in a field survey nor have the plants been examined for evidence of seed production since 1987. Therefore, the purpose of this study is to make a detailed survey of the areal extent of previously existing stands of *S. alterniflora*, to locate and measure any new stands, to check for flowers and/or seeds, and to obtain baseline measurements of *S. alterniflora* on Dike Island.

METHODS AND MATERIALS

Two plants were collected from the western tip of the Dike Island stand on 14 September 1991, brought back to the laboratory and identified to species as *Spartina alterniflora* using Hitchcock *et al.* (1969) and Sayce and Mumford (1991).

The location and area of all stands of *Spartina alterniflora* in Padilla Bay were measured in August and September, 1991. The small previously existing stands (Nos. 1-3, 5-7) of *S. alterniflora* in Padilla Bay were re-surveyed using the same methods and using the same numbering system as Wiggins and Binney (1987) (Fig. 1). Additional stands (Nos. 8 & 9) not measured or numbered in Wiggins and Binney (1987) were measured in this survey using the same methods.

Many of the stakes placed in Wiggins and Binney's (1987) study were very difficult to locate due to the height and density of *Spartina* in the stands. The transects were not placed in exactly the same locations as in the 1987 study, but were placed along the land/water interface as Wiggins and Binney had done, with the exception of Stand No. 4 and Stand Nos. 10-19 as described below.

Meter-long cedar 5cm x 5cm stakes were placed at the land/water interface on each side of the stand (unless otherwise noted) and a rope, marked in meter increments was placed between them. For the purpose of this study "land" was anything landward of the "edge" where native saltmarsh vegetation abruptly turned to mudflat or water. A compass bearing was taken on the rope transect and recorded. A declination of 21 degrees was used when taking the bearings and the bearing reported relative to true north. One person walked along the transect rope through the center of the stand. That person held one end of a measuring tape at meter increments along the transect rope while the other person walked the perimeter of the stand and recorded measurements (see Appendix 1). Some of the stakes left by Wiggins and Binney were located and those stand numbers were verified. All *S. alterniflora* plants on the perimeter were included in the measurements even though distribution of *S. alterniflora* along the perimeter, in some cases, was sparse.

This method was modified for Stand No. 4 as follows. This stand lies just east of the dike along the western side of Telegraph Slough (Fig. 1). There are small saltwater ponds along the slough side of the dike. The transect was laid along the eastern edge of these ponds. Most of the stand was east of the transect. The eastern edge of this *S. alterniflora* stand borders a large saltwater pond (see Fig. 5) maintained by a gun club. Therefore, the transect was not run at the land/water interface as for the other stands but along the eastern edge of the large saltwater pond.

Nine stands (Nos. 10-18) were measured on the northern side of Dike Island using similar methods. These stands were offshore so the transect could not be located at the land/water interface. Instead, the transect was placed at the widest point of each stand. A compass bearing (relative to true north with 21 degrees declination) was recorded for each transect.

On Dike Island a 100m transect rope was run between cedar stakes (1m x 5cm x 5cm) at the upper (northern) edge of the Dike Island southern *S. alterniflora* stand from

east to west. A compass bearing was recorded each time the rope was re-staked. A measurement was taken perpendicular to the transect from each stake every 100m the length of Dike Island. At each stake the measurement to the southern edge of the *S. alterniflora* (water side) was recorded.

In this study unmarked stakes were placed and left in Stand Nos. 1, 2, 5, 6, and 7. Stakes were not left in the remainder of the sites measured as all but Stand Nos. 1 and 2 are on private property.

Stand Nos. 5, 6, 7, and 8 were measured on 7 August 1991. Stand Nos. 1, 2, 3, 4, and 9 were measured on 8 August 1991. Stand No. 4 was re-measured on 23 August 91 at 5m intervals along the transect and compass readings were verified at Stand Nos. 1-4. Dike Island and Stand Nos. 10 - 18 were measured on 28 August 1991. The western shoreline of Big Indian Slough was examined for *S. alterniflora* by walking the entire length on 5 September 1991. The edge of Padilla Bay west of Stand No. 1 was examined similarly on 6 September 1991.

The area of each stand was estimated as the mean of three planimeter measurements of the perimeters of the maps included in this study.

Stake pairs from Wiggins and Binney (1987) were located in three stands (5, 6, and 7). Both the distance between the stakes and the distance along the stakes to the edges of the stands were measured.

RESULTS

Taxonomy

Two plants collected from the western tip of the Dike Island stand were identified as *Spartina alterniflora*. As there were no flowers or seeds the measurements and observations in Table 1 were used to identify the plants.

The measurements in this study would indicate the plants are either *S. townsendii* or *S. alterniflora*, but the leaf tips were strongly involute which would

Table 1. Comparison of *Spartina* plants collected in Padilla Bay to descriptions in Sayce and Mumford (1991) and Aberle (1990).

Species	Culm length (cm)	Leaf width (mm)	Length of ligules ^a (mm)
<i>S. alterniflora</i>	45-150	5-15	1.5
<i>S. patens</i>	15-80	0.5-2	--
<i>S. anglica</i>	30-130	6-15	20-30
<i>S. townsendii</i>	30-130	4-12	1-2
Plant 1 (Padilla Bay)	54.5	7.8	1.0-1.5
Plant 2 (Padilla Bay)	86.0	8.1	1.0-1.5

^a In these plants the ligules are hairs so the length of the hairs is measured as the length of the ligule.

indicate the species is *S. alterniflora*. Measurements in the present study rule out *S. patens* and *S. anglica* as possible species.

Maps & Area Comparisons

The total area of *Spartina alterniflora* in Padilla Bay is estimated to be 48,100 m² (Table 2). This includes 44,200 m² in one large stand on Dike Island (Table 2).

In addition to the seven stands Wiggins and Binney (1987) located along Telegraph Slough and the shoreline south of Dike Island, two new stands were found and measured. Figure 1 shows the location of all stands and Dike Island. Figures 2 - 20 are maps of each stand and Dike Island recording the location of transects and compass bearings (relative to true north) of transects (using 21 degrees declination). Table 2 compares estimated area of the *Spartina* stands in this study to the estimated area in Wiggins and Binney (1987).

There were areas of brown stubble that appeared to be dead *S. alterniflora* contained in some of the stands. The size of these areas is summarized in Table 3. Sparse *S. alterniflora* or native saltmarsh vegetation was growing in some of these areas of brown stubble. Table 3 also details those native species found.

Dominant vegetation bordering the stands was noted while in the field and is included in Appendix 2.

The western side of Big Indian Slough was examined from Bayview-Edison Road to Stand No. 7. No additional *S. alterniflora* stands were found. The edge west of Stand No. 1 was examined to the southern "Game Reserve" marker on the dredge spoil islands. No additional *S. alterniflora* stands were found. Appendix 3 includes a map and a general listing of the dominant vegetation along this edge.

Lateral Growth Along a Transect

Stand Nos. 5, 6, and 7 showed lateral growth of 1.1 - 1.7 m/yr (Table 4). Approximate locations of the 1987 transects in relation to the 1991 transects for these stands is included in Appendix 4.

Table 2.

Comparison of 1987 and 1991 areal estimates of *Spartina alterniflora* stands in Padilla Bay.

Stand No.	Wiggins & Binney (1987) area (m ²) planimeter	This study (1991) area(m ²) m ²	Change (+/-)
1	60	167	+107
2	250	272	+22
3	390	538	+148
4	1352	1270	-82
5	65	123	+58
6	50	81	+31
7	95	205	+110
8	--	41	+41
9	--	12	+12
Total Area (A)	2262	2709	+447
Five stands(1987)	2,400		
10 (1991)	--	99.6	
11 (1991)	--	9.9	
12 (1991)	--	159	
13 (1991)	--	184	
14 (1991)	--	112	
14a (1991)	--	15.6	
14b (1991)	--	6.3	
15 (1991)	--	81.6	
16 (1991)	--	29.2	
17 (1991)	--	185	
17a (1991)	--	20.0	
18 (1991)	--	277	
Subtotal	2,400	1,180	-1,220
Dike Island (south stand)	22,000	44,200	+22,200
Total Area (B)	24,400	45,400	+21,000
TOTAL AREA in Padilla Bay (A+B):	26,700	48,100	+21,400

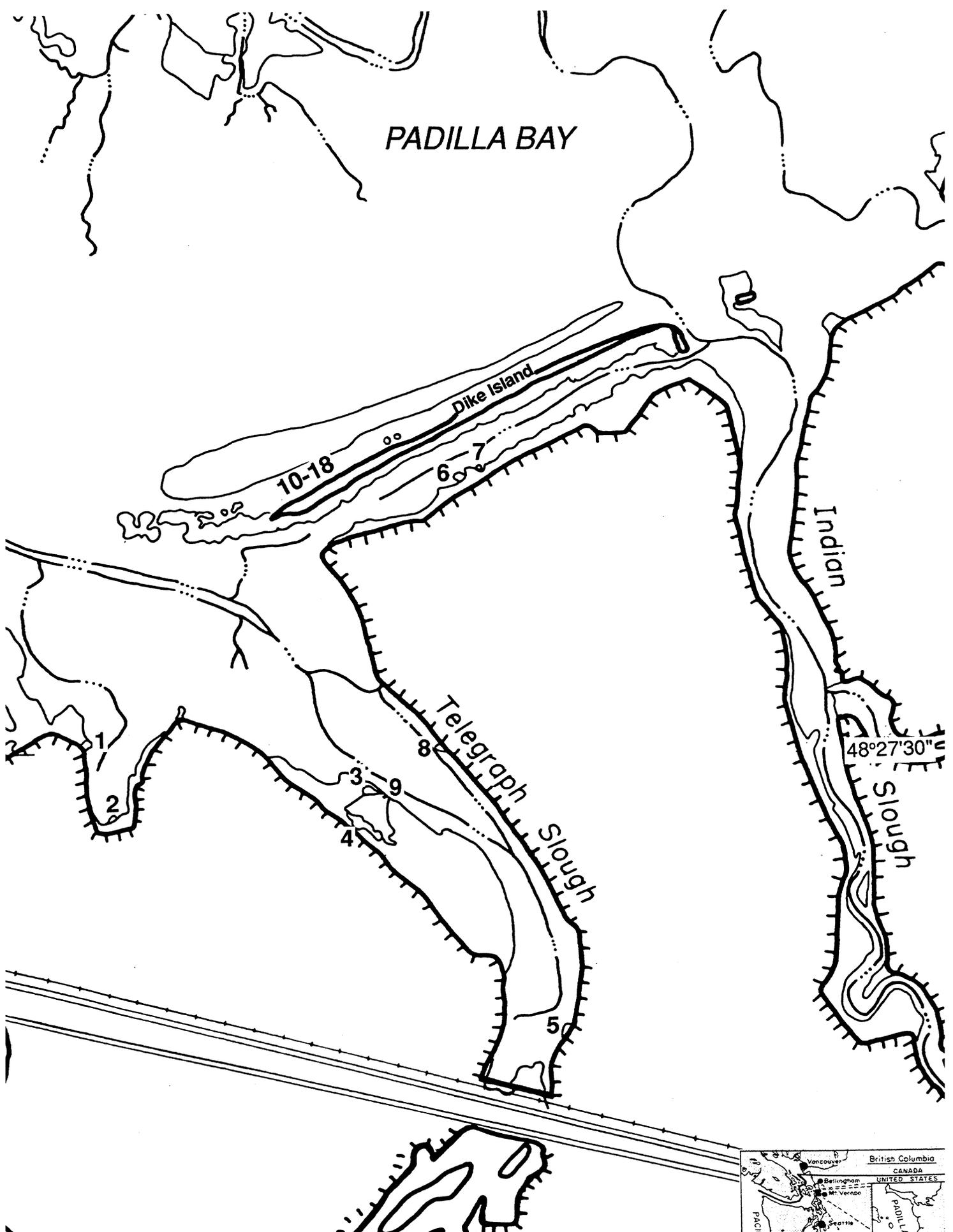
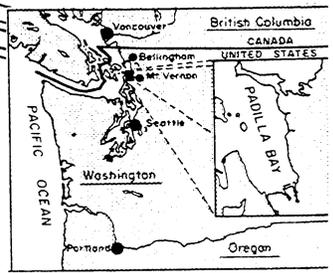


Figure 1: Locations of *Spartina alterniflora* stands in Padilla Bay, Washington. (Scale: 1:12,000)



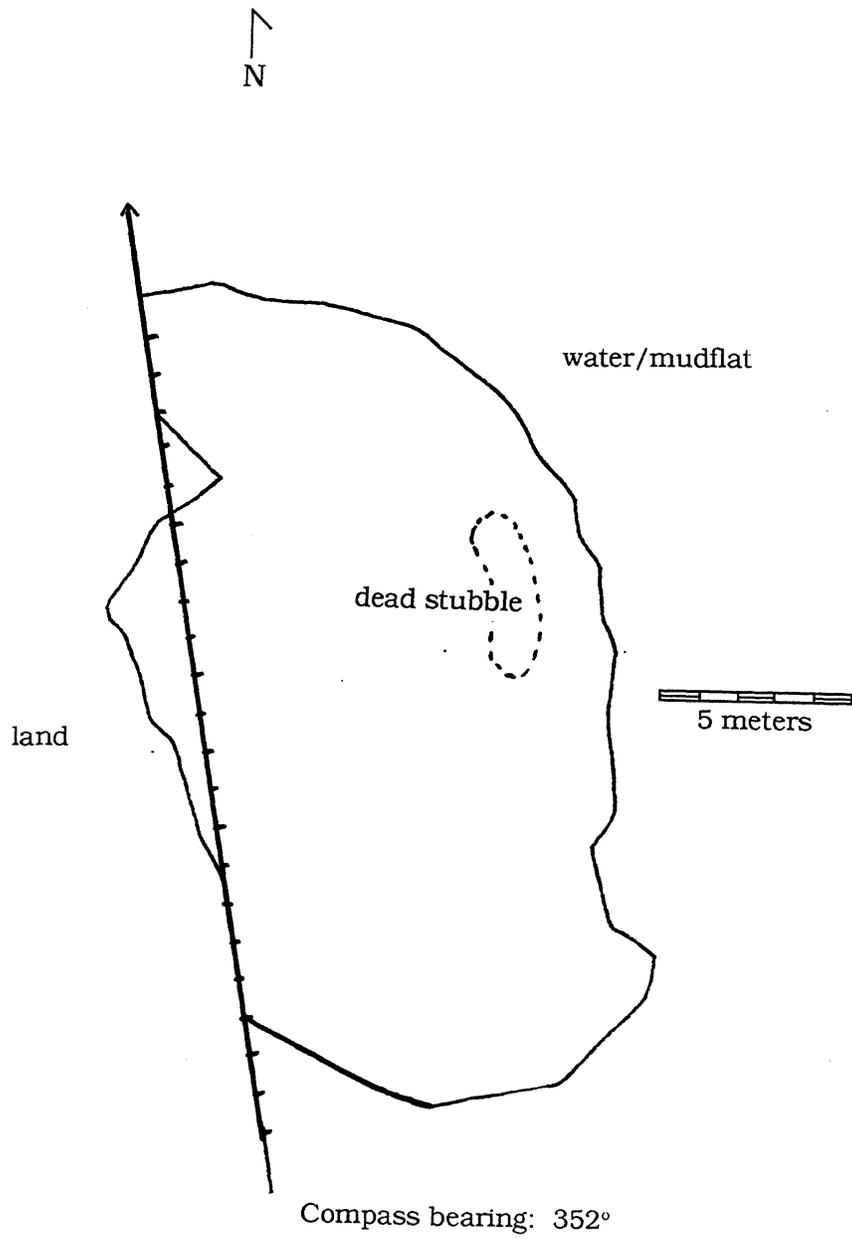


Figure 2. *Spartina alterniflora* in Padilla Bay. Stand No. 1.

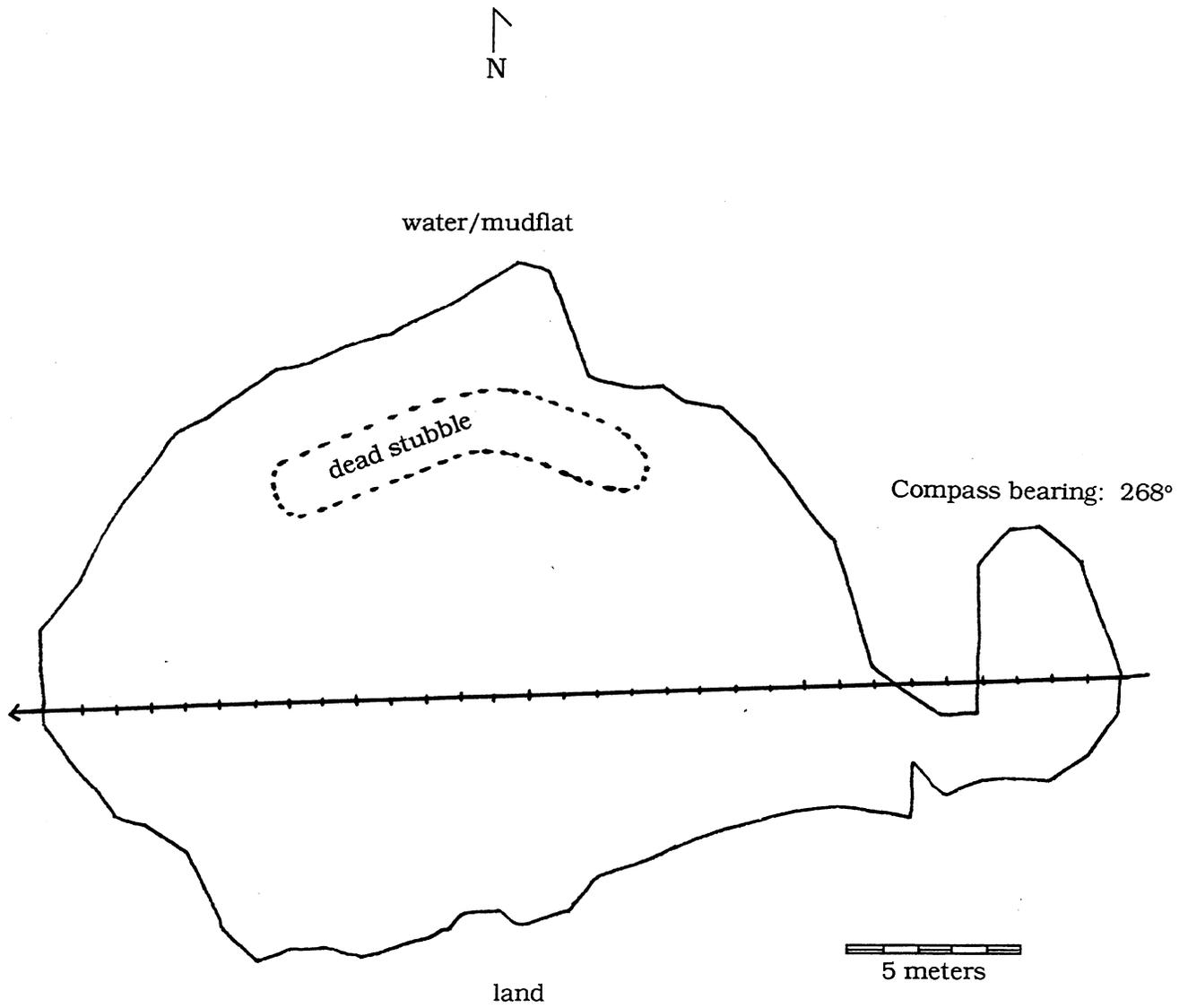


Figure 3. *Spartina alterniflora* in Padilla Bay. Stand No. 2.

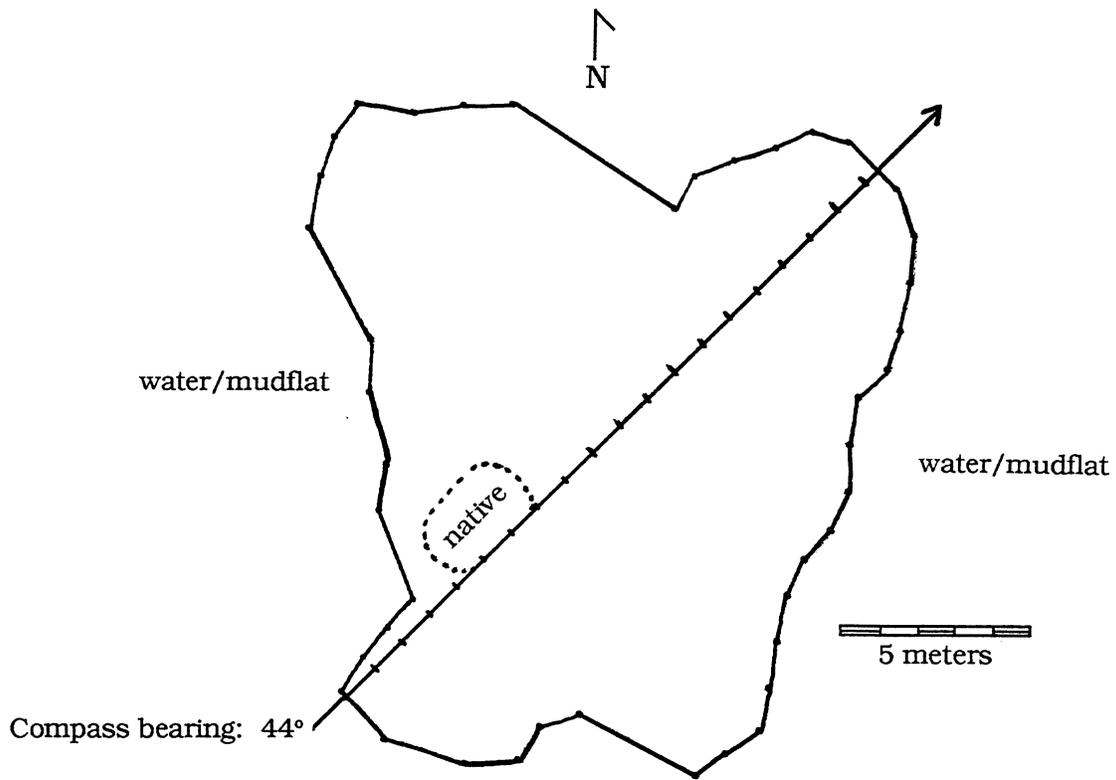


Figure 14: *Spartina alterniflora* in Padilla Bay, Stand No. 12.

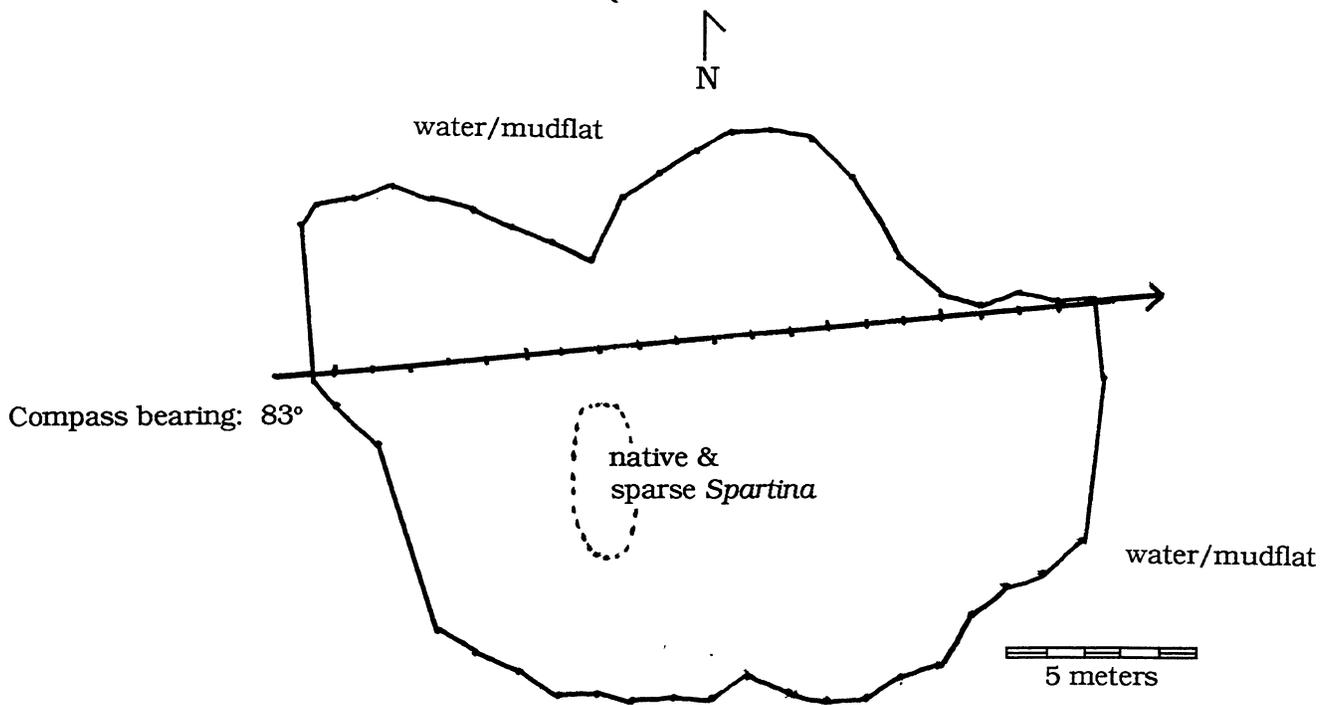


Figure 15: *Spartina alterniflora* in Padilla Bay, Stand No. 13.

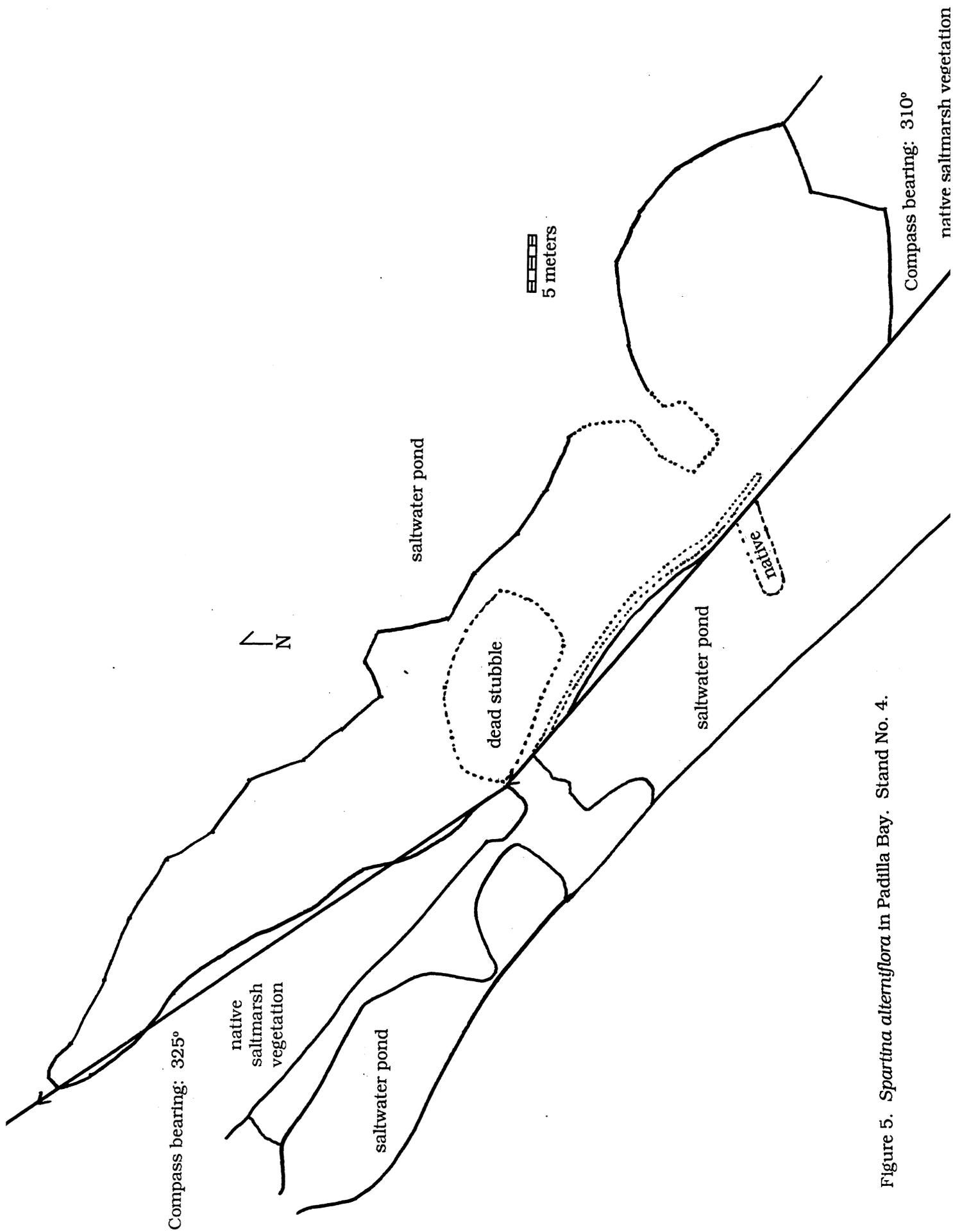


Figure 5. *Spartina alterniflora* in Padilla Bay. Stand No. 4.

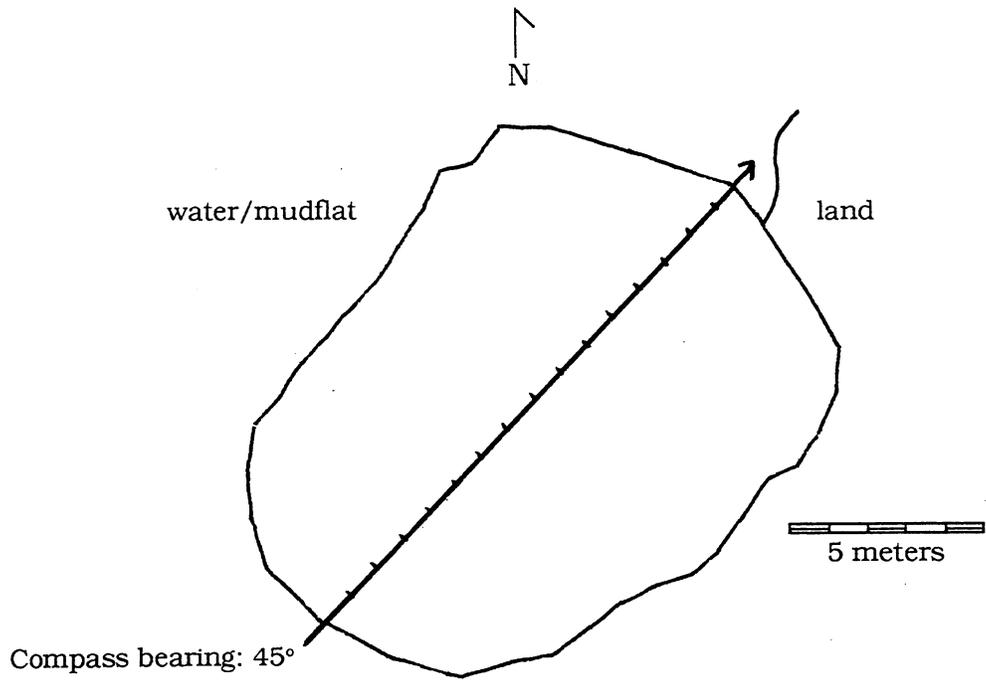


Figure 6. *Spartina alterniflora* in Padilla Bay. Stand No. 5.

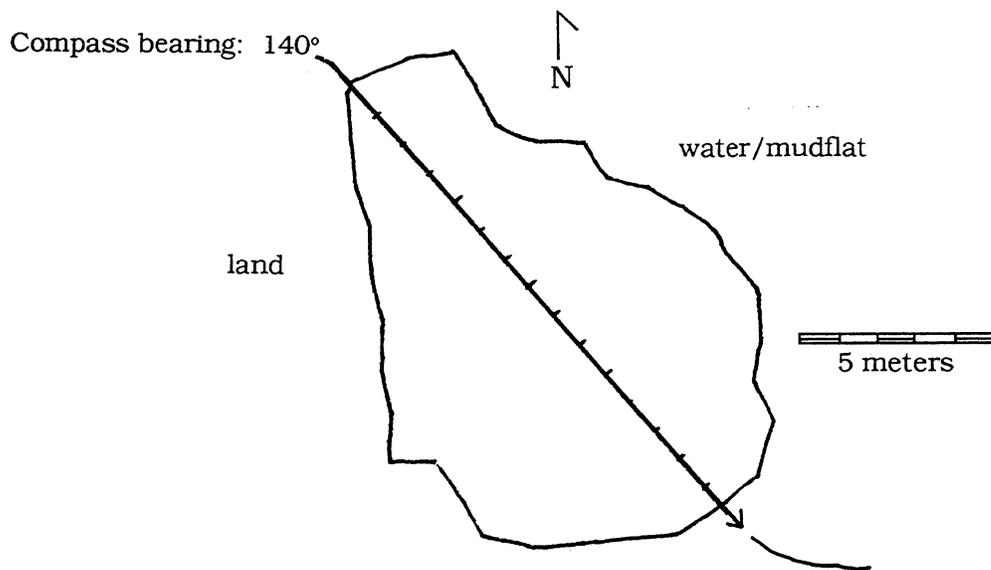


Figure 7. *Spartina alterniflora* in Padilla Bay. Stand No. 6

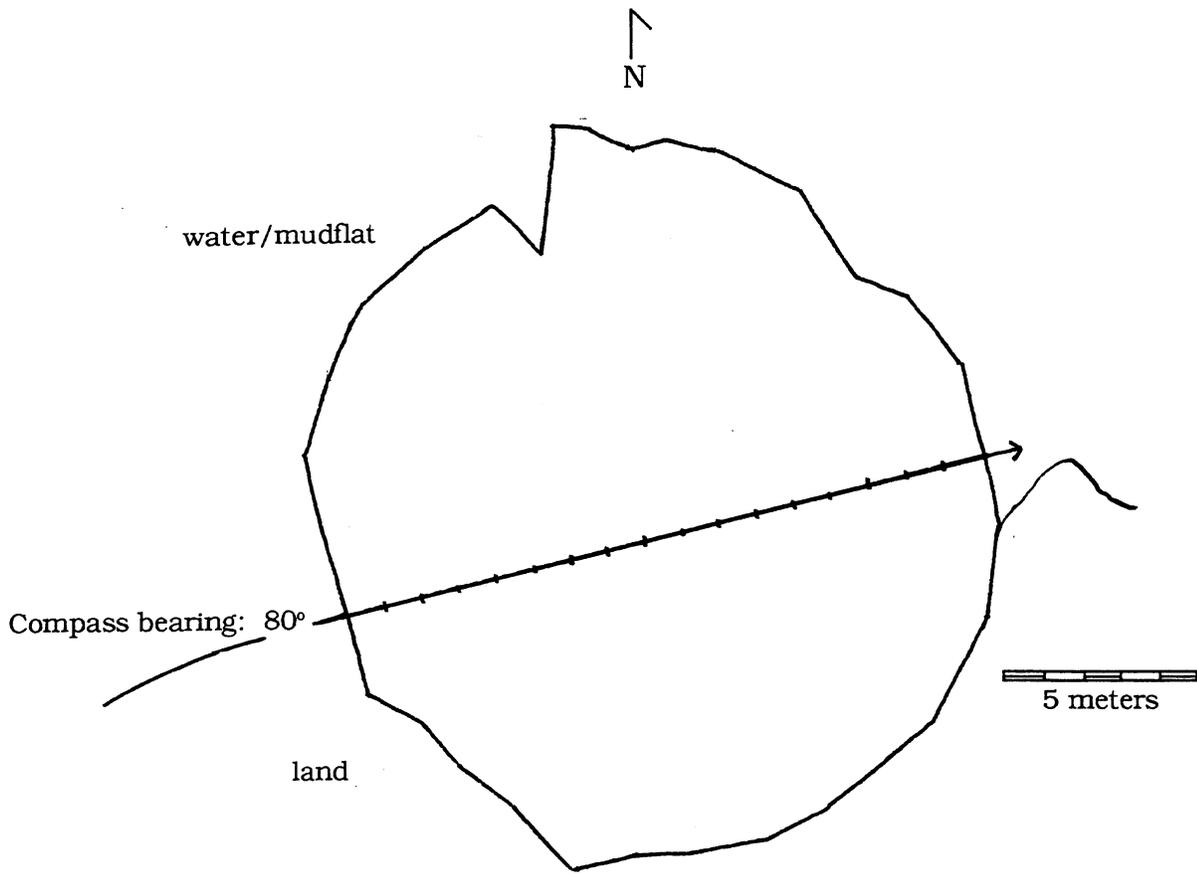


Figure 8. *Spartina alterniflora* in Padilla Bay. Stand No. 7

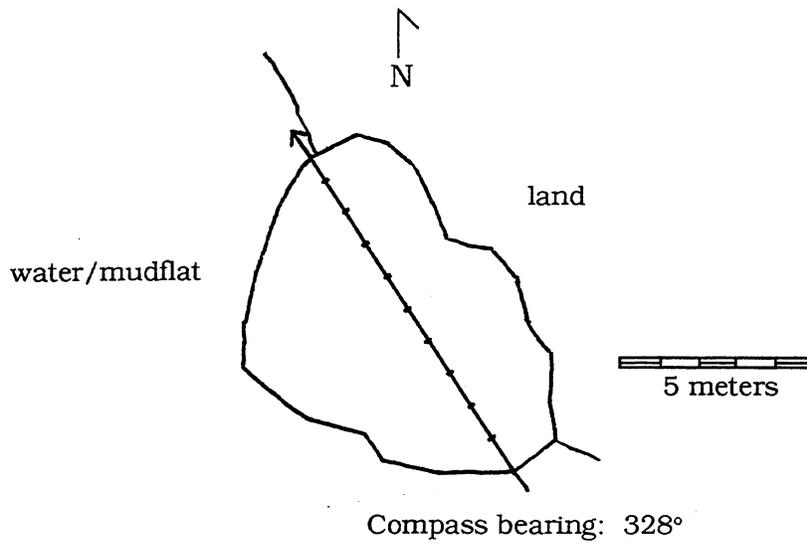


Figure 9. *Spartina alterniflora* in Padilla Bay. Stand No. 8.

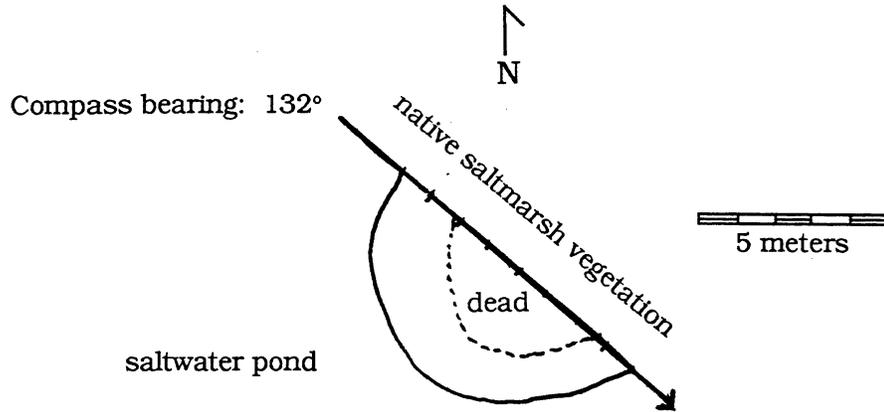


Figure 10. *Spartina alterniflora* in Padilla Bay. Stand No. 9.

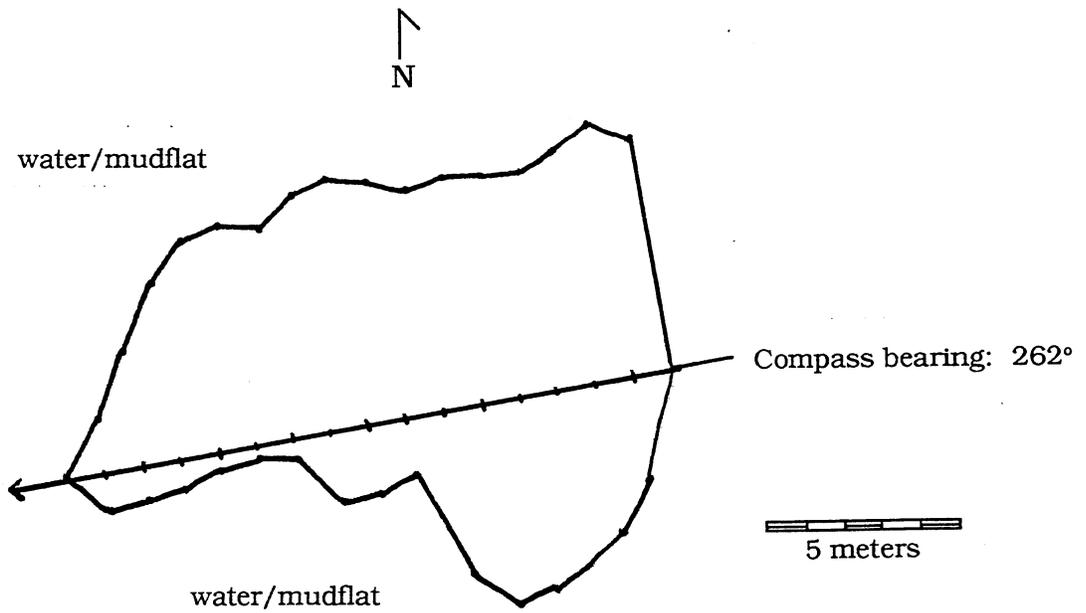


Figure 11: *Spartina alterniflora* in Padilla Bay, Stand No. 10.

Compass bearing: no bearing taken

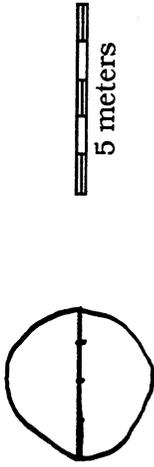


Figure 12: *Spartina alterniflora* in Padilla Bay, Stand No. 11.

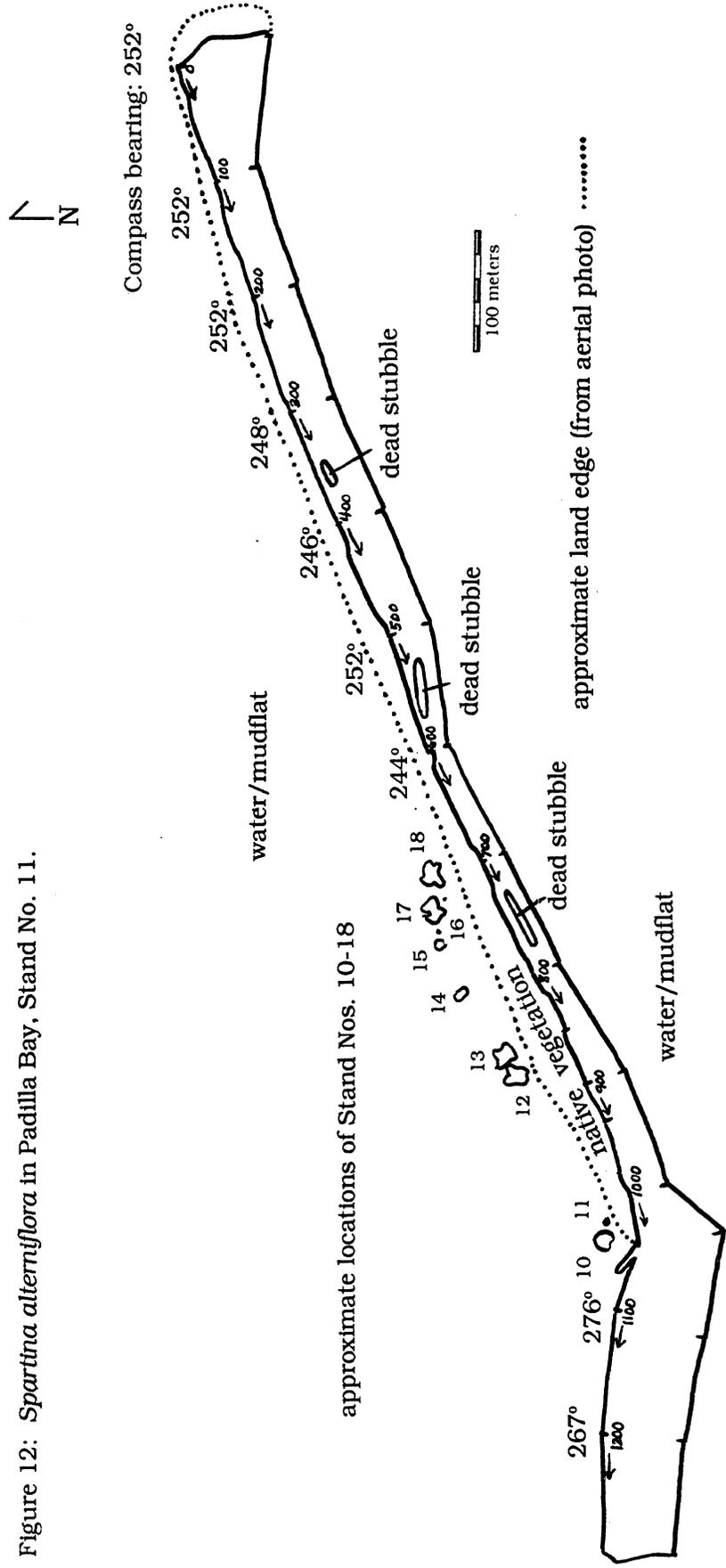


Figure 13: *Spartina alterniflora* in Padilla Bay, Dike Island (south).

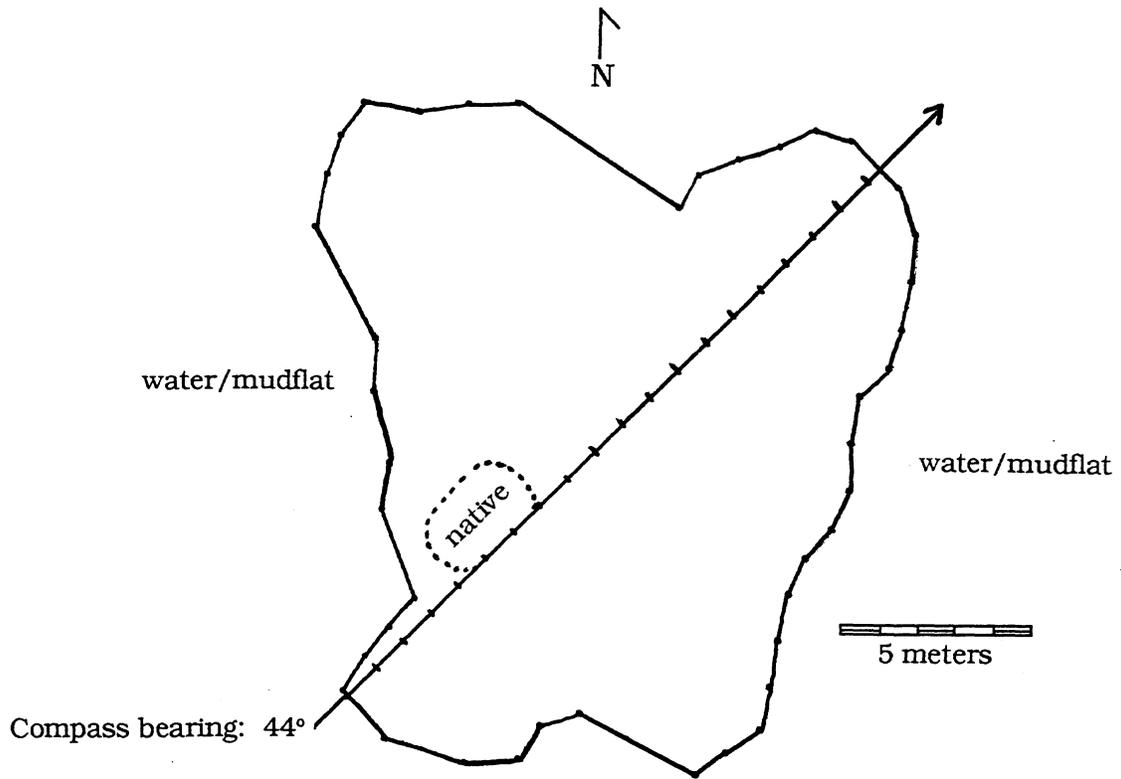


Figure 14: *Spartina alterniflora* in Padilla Bay, Stand No. 12.

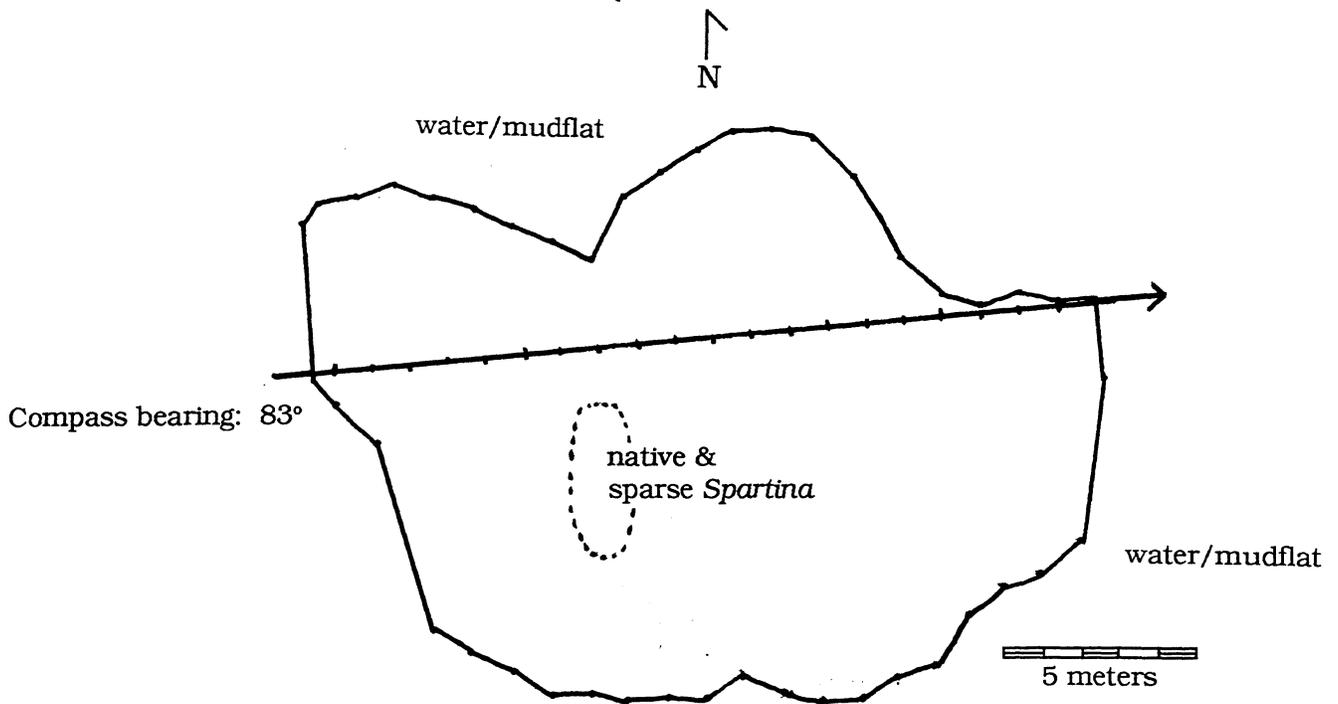


Figure 15: *Spartina alterniflora* in Padilla Bay, Stand No. 13.

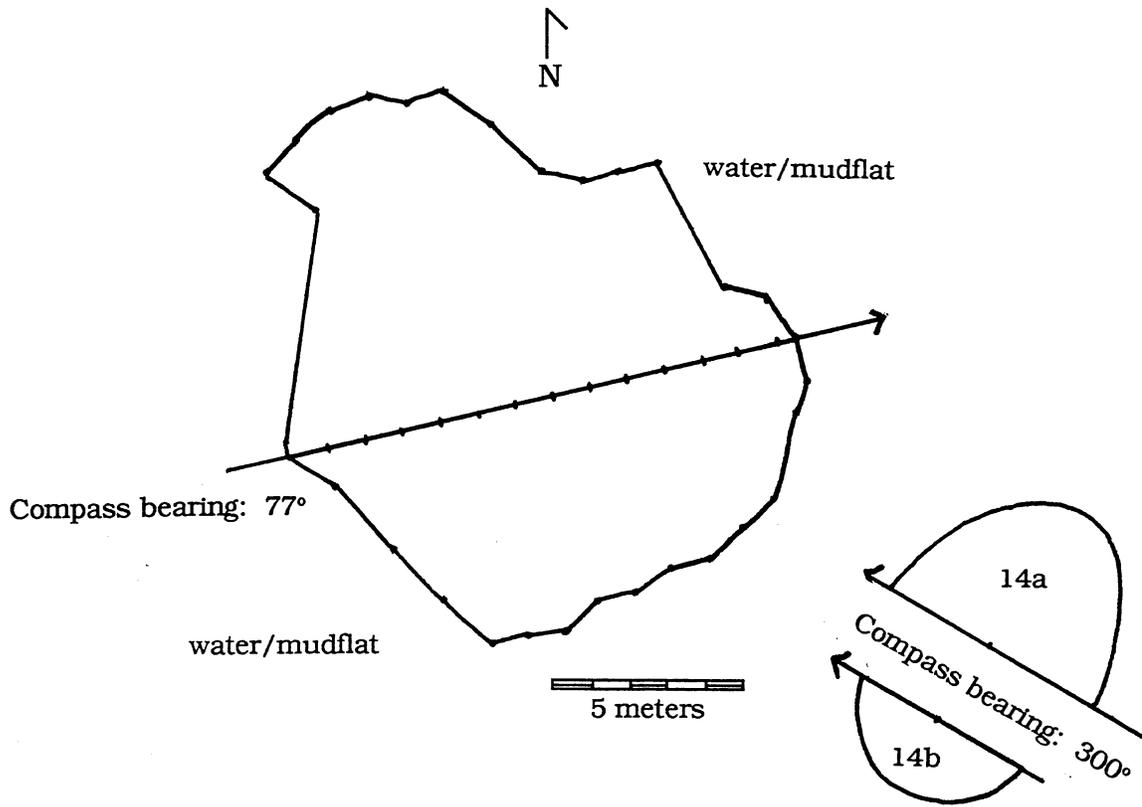


Figure 16: *Spartina alterniflora* in Padilla Bay, Stand Nos. 14, 14a, and 14b.

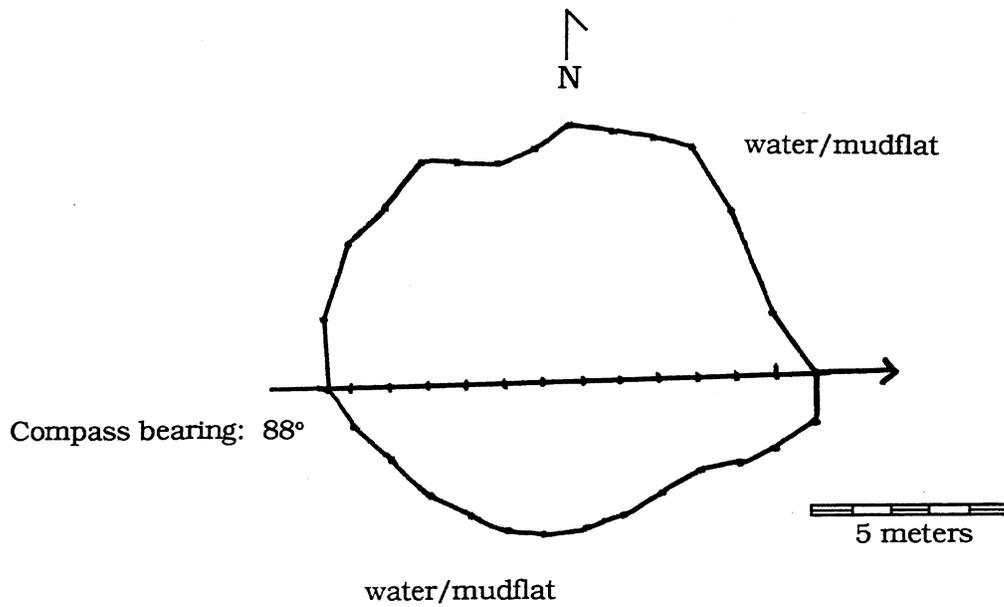


Figure 17: *Spartina alterniflora* in Padilla Bay, Stand No. 15.

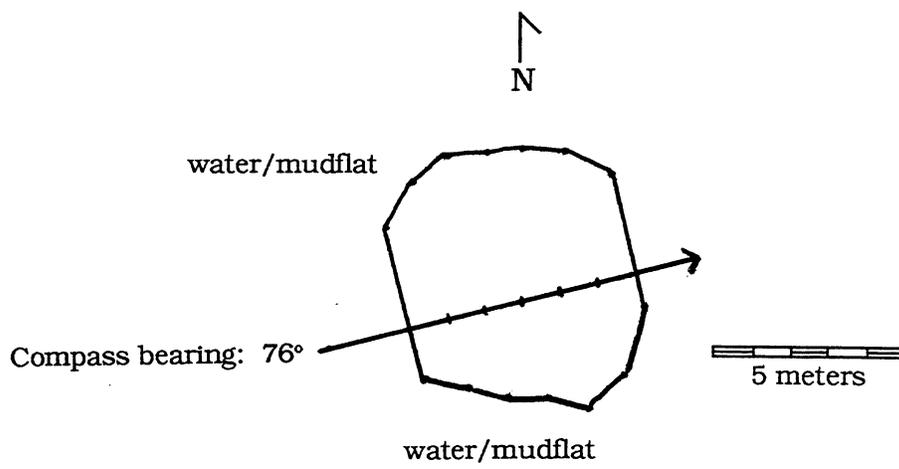


Figure 18: *Spartina alterniflora* in Padilla Bay, Stand No. 16.

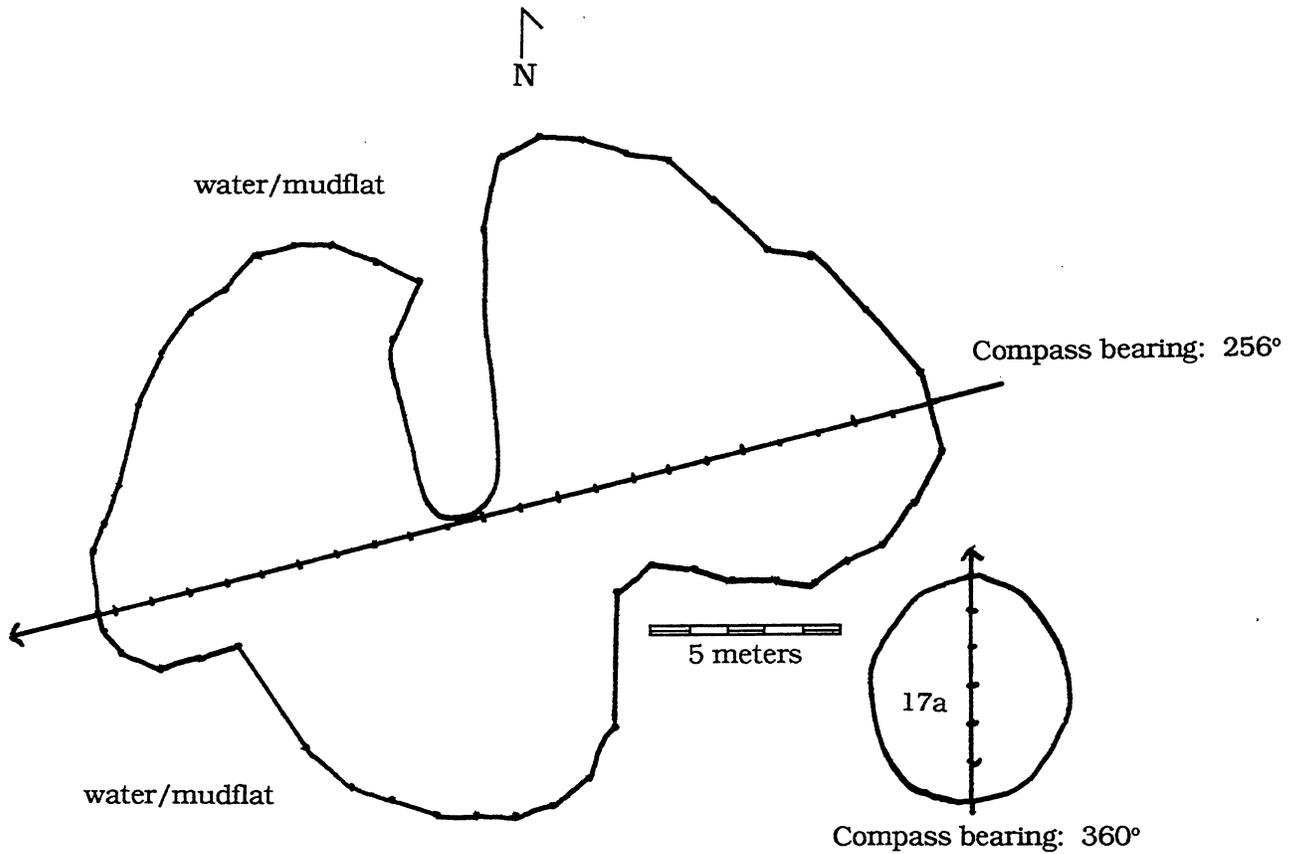


Figure 19: *Spartina alterniflora* in Padilla Bay, Stand Nos. 17 and 17a.

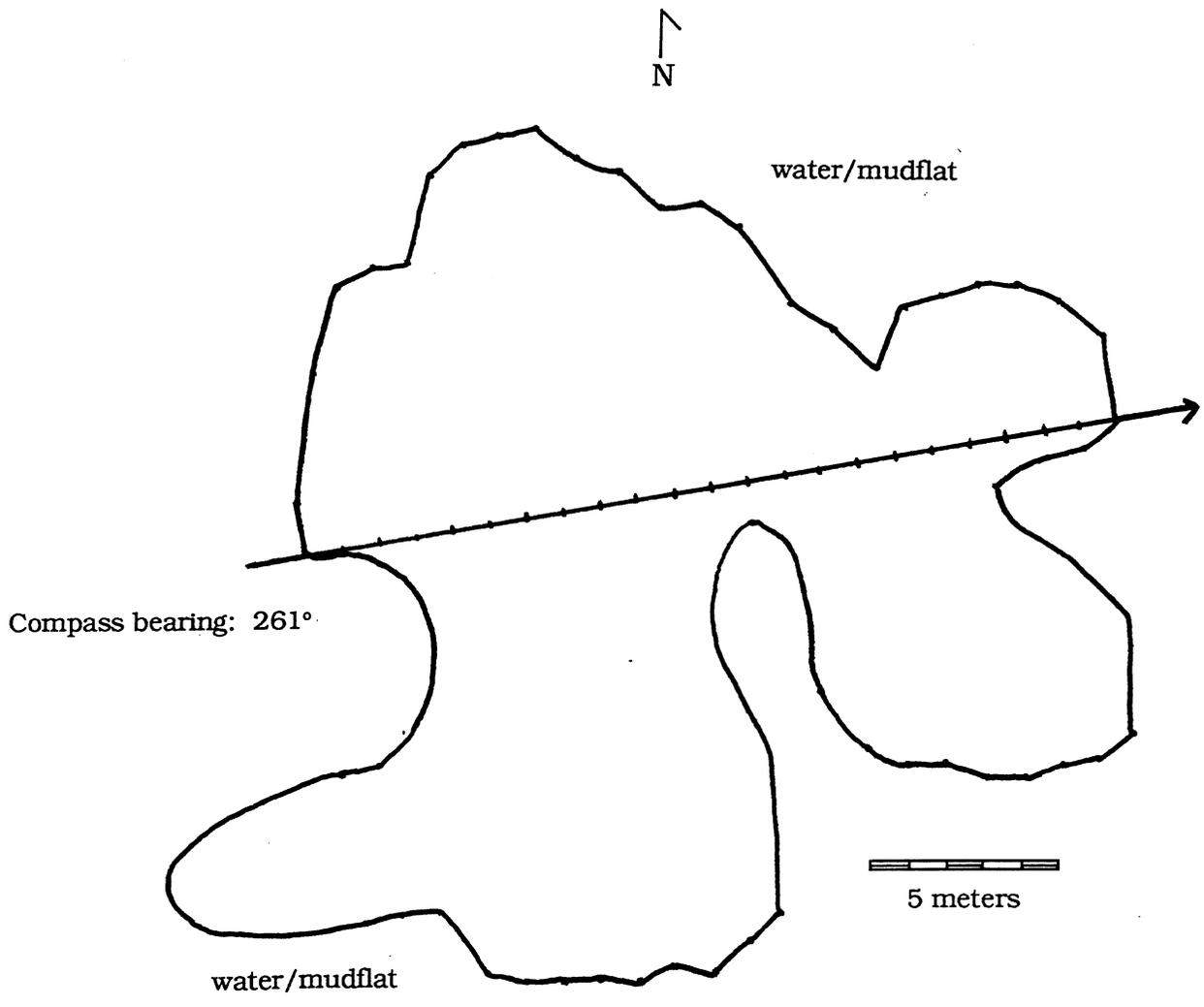


Figure 20: *Spartina alterniflora* in Padilla Bay, Stand No. 18.

Table 3. Approximate sizes of areas of brown stubble in *Spartina alterniflora* stands in Padilla Bay, Washington, 1991.

Stand No.	Approximate sizes of areas of brown stubble (meters)
1	1.5 x 4.0 m
2	2.0 x 11.0 m ¹
3	3.9 x 7.2 m
4	8.0 x 13.0 m ²
9	1.5 x 3.5 m
12	2.0 x 3.0 m ³
13	1.5 x 4.0 m ⁴

- 1 Sparse densities of *Salicornia virginica* and *Spergularia marina* were growing in this area of brown stubble.
- 2 Sparse densities of *S. alterniflora* were growing in this area of brown stubble.
- 3 *Spergularia marina* was growing in this patch.
- 4 Sparse *S. alterniflora* and some *Spergularia marina* were present in this area of brown stubble.

Table 4. Lateral growth (along a transect) of *S. alterniflora* in selected stands in Padilla Bay, Washington, 1987-1991

Stand No.	Transect length (m) 1987 ^a	Transect length (m) 1991 ^b	Lateral spread m/yr
5	9.3	16.0	1.7
6	13.1	17.4	1.1
7	11.2	17.5	1.6

- a The transect lengths were not recorded in Wiggins and Binney (1987) but the stakes placed by Wiggins and Binney in 1987 were located and a measurement between these stakes was taken on 22 September 1991.
- b These measurements were obtained in this study on 22 September 1991.

Flowers and Seeds

No flowers or seeds were observed in any of the *S. alterniflora* stands.

DISCUSSION

Spartina alterniflora stands in Padilla Bay have increased in number (from twelve stands plus the large Dike Island stand in 1987 to eighteen stands plus the large Dike Island stand in the present study and in area (from 26,700 m² in 1987 to 48,100 m² in 1991). It is doubtful that the area has almost doubled in the last four years because Wiggins and Binney (1987) did not measure the large Dike Island stand but only estimated areal coverage. A better indication of the rate of areal increase can be obtained from Table 2 by comparing Stands 1-9 which indicates areal spread for these nine stands as a little over 100 m² per year (447 m² over 4 years), ranging from +12 to +148 m² over 4 years with one stand apparently declining in size (-82 m over 4 years). Methods used to measure these stands were comparable, therefore the data is comparable.

Wiggins and Binney (1987) measured to the edge of sparse *Spartina* growth, which at times was approximately 15 cm from the outermost *Spartina* shoot (Wiggins, per. comm., 1991). This study measured to the outermost *Spartina* shoots so the areal estimates from this study may be somewhat higher than they would have been had the researcher been able to follow the exact sampling methods used by Wiggins and Binney (1987).

Since the method used to measure the large Dike Island stand was not recorded in Wiggins & Binney (1987) and personal communication with Jim Wiggins (1991) did not establish clearly how the measurement was taken, there is some question that the 1987 estimate accurately reflects the area of *S. alterniflora* on Dike Island at that time. Also, the scale on the map of Dike Island in the Wiggins and Binney (1987) report indicates the island is nearly 4,000 m long. The island is actually just over 1,300 m

long. This indicates that the scale on their map of Dike Island is probably in feet, not meters.

True north on the maps in this study differed from Wiggins and Binney (1987) by the following: Stand No. 1, 74 degrees; Stand No. 2, 44 degrees; Stand No. 3, 21 degrees; Stand No. 4, 25 degrees (north transect), 14 degrees (south transect); Stand No. 5, 23 degrees; Stand No. 6, 30 degrees; and Stand No. 7, 18 degrees. It is possible that Wiggins and Binney did not take declination into consideration when taking their compass bearings. Compass bearings for Stand Nos. 1-4 in this study were taken on two different days, with different compasses by two different people to verify true north on the maps in this study.

Wiggins & Binney (1987) mention seven major stands of *S. alterniflora* and "several small (1 m²) clumps" in Telegraph Slough. The two "new" stands found in Telegraph Slough in this study, one along the eastern side of Telegraph Slough (Stand No. 8) and one near Stand No. 3 (Stand No. 9), may actually be two of the "small clumps" Wiggins and Binney referred to in 1987.

Wiggins and Binney (1987) mention "five small stands on the north side of Dike Island" detected from aerial photographs. While in the field they did not do intensive measurements of these stands but did overall length and width measurements and estimated the total area covered by the five stands as approximately 2400 m². They also noted that only 25% of each stand consisted of live *S. alterniflora*. This may have been due in part to measuring the stands in May when the growth for that year was just beginning. Sayce (1988), in a study conducted May - October, found biomass lowest in May with biomass peaking at Leadbetter Point (Willapa Bay) in August and still on the increase in October at Jensen Spit (Long Island, Willapa Bay).

In the present study nine major stands of *S. alterniflora* were identified on the north side of Dike Island, the smallest of which was 3.5-4.0 meters in diameter and three other patches (two associated with Stand No. 14 and one with Stand No. 17).

Most of the stands had vigorous growth. The few areas of sparse growth within the stands are noted on the maps (Figs. 12-20).

In the present study, lateral growth in four years (along a transect) in three selected stands ranged from 1.1 - 1.7 m/yr. Sayce (1988) found the mean lateral growth in selected plots in Willapa Bay to be 0.5 m/yr. She also noted that "as their field work ended in mid-October, this may be an under-estimate of the total annual lateral growth."

As no flowering spikes or seeds were seen in any of the stands it can be assumed that the only form of spreading in Padilla Bay at this time is vegetative (i.e. by roots or by clumps breaking off and establishing at different sites). Sayce (1988) found that *S. alterniflora* flowers from early August through October in Willapa Bay with seed set in late October. As this study was performed throughout August and into late September flowers should have been visible if the plants were going to flower.

The effect *S. alterniflora* has on native saltmarsh plant communities in Padilla Bay has not been studied and is not clear. In some areas it appears to invade and outcompete native vegetation, yet the majority of the *S. alterniflora* growth extends onto mudflat with little or no previous macrovegetation. Also, in some of the brown stubble areas in the *S. alterniflora* stands, native vegetation is present. Whether the native vegetation will persist in these brown stubble areas is not known. It also is not clear what effect *S. alterniflora* has on the mudflat faunal communities or other wildlife (waterfowl, shorebirds, etc.) in Padilla Bay as no studies have been conducted on this to date.

Stand Nos. 1 and 2 are apparently on state-owned land. None of the *Spartina alterniflora* appears to be on Padilla Bay National Estuarine Research Reserve property.

At this point in time Padilla Bay National Estuarine Research Reserve has not decided whether to eliminate *S. alterniflora* from Padilla Bay or to allow it to persist.

Further studies might be in order to determine potential effects on flora and fauna and potential spread if *S. alterniflora* is allowed to persist.

In summary, *S. alterniflora* has increased in Padilla Bay in the past four years. New stands have developed in areas close to already existing stands. The potential for extensive spread of this species in Padilla Bay is great. Although the rate of spread at this time is not alarming, should the *S. alterniflora* start to flower and produce viable seed it is doubtful whether the spread of *S. alterniflora* in Padilla Bay could be contained. As it is not known at this time what triggers the flowering of this species in this area we do not know if it will ever flower in Padilla Bay, but because it has flowered and produced viable seed in Willapa Bay, the potential exists for the same to happen here, the result of which would be extensive habitat alteration.

ACKNOWLEDGEMENTS

A sincere thank you to all the staff members who assisted me in the field: Andy Freeman, Glen Alexander, Susan Wood, David Henry, and Cary Svoboda. I would also like to thank Robert Lindquist, Bob's Map Service, Bellingham, for his generous loan of a planimeter and Dr. Douglas Bulthuis and Dr. Ron Thom for their review and comments on this paper.

LITERATURE CITED

- Aberle, Barbara. 1990. The biology, control, and eradication of introduced *Spartina* (cordgrass) worldwide and recommendations for its control in Washington. Draft report. Washington State Department of Natural Resources.
- Bulthuis, Douglas A. 1991. Distribution of habitats and summer standing crop of seagrasses and macroalgae in Padilla Bay, Washington, 1989. Washington State Department of Ecology, Padilla Bay National Estuarine Research Reserve Technical Report No. 2, Mount Vernon, Washington.
- Hitchcock, C. Leo, Arthur Cronquist, and Marion Ownbey. 1969. Vascular plants of the Pacific Northwest, Part 1: Vascular Cryptogams, Gymnosperms, and Monocotyledons. University of Washington Press, Seattle, Washington.
- Mumford, Thomas F. Jr. 1991. About the *Spartina* workshop. In: *Spartina* Workshop Record, Seattle, Washington, November 14-15, 1990. (pp 1-2). Eds. Thomas F. Mumford Jr., Patricia Peyton, James R. Sayce, and Steve Harbell. Washington Sea Grant Program, University of Washington, Seattle.
- Parker, Richard C. and Barbara Aberle. 1979. A situation report on the *Spartina* infestation in northwest Washington. Unpublished report to the Washington State Department of Game, Mount Vernon.
- Sayce, Kathleen. 1988. Introduced cordgrass, *Spartina alterniflora* Loisel. in saltmarshes and tidelands of Willapa Bay, Washington. USFWS FWSI-87058 TS. 70 pp. Unpublished.
- Sayce, Kathleen and Thomas F. Mumford, Jr. 1991. Identifying the *Spartina* species. In *Spartina* Workshop Record, Seattle, Washington, November 14-15, 1990. (pp. 9-14). Eds. Thomas F. Mumford, Jr., Patricia Peyton, James R. Sayce, and Steve Harbell. Washington Sea Grant, University of Washington, Seattle, Washington.
- Wiggins, Jim and Elizabeth Binney. 1987. A baseline study of the distribution of *Spartina alterniflora* in Padilla Bay. Report to Washington Dept. Ecology, Padilla Bay National Estuarine Research Reserve. 28 pp. Padilla Bay National Estuarine Research Reserve Reprint Series No. 7, 1990.

APPENDIX 1

Data from measurements of individual
Spartina alterniflora stands

Stand No. 1 (Figs. 2 & 21)

Date Measured: 8 August 1991

Transect Compass Bearing: 352 degrees

Field Technicians: Susan Wood, Sharon Riggs

West of transect (s to n)		East of transect (s to n)	
0	0.0 meters	0	7.7 meters
1	0	1	9.2
2	0	2	10.5
3	0	3	10.7
4	0	4	9.8
5	0	5	9.6
6	0	6	9.6
7	0	7	10.3
8	0.4	8	10.3
9	0.5	9	10.4
10	0.6	10	10.6
11	1.2	11	10.8
12	1.4	12	10.7
13	1.6	13	10.8
14	2.0	14	10.5
15	1.1	15	10.5
16	0.5	16	10
17	0	17	8.0 (9.6 to transect)
18	0	18	8.3 (9.1 to transect)
19	0	19	8.1
20	0	20	7.1
21	0	21	4.9
22	0	22	2.0

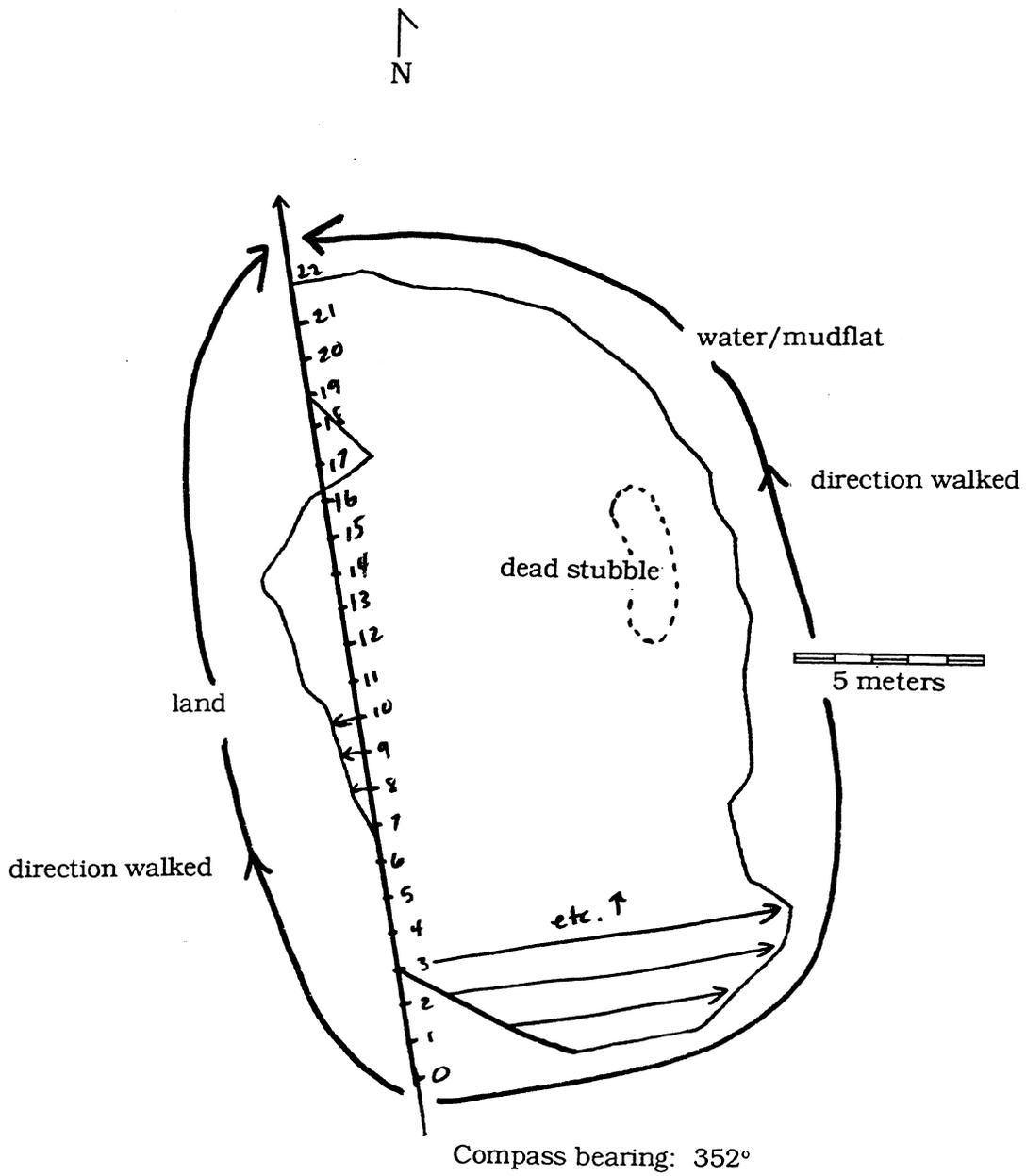


Figure 21: Method used to measure *Spartina alterniflora* Stand No. 1.

Stand No. 2 (Figs. 3 & 22)

Date Measured: 8 August 1991

Transect Compass Bearing: 268 degrees

Field Technicians: Susan Wood, Sharon Riggs

East to west		West to east	
0	0.0 meters	31	0.5 meters
1	3.4	30	1.7
2	4.2	29	3.0
3	4.3	28	3.5
4	3.2	27	4.1
5	0	26	6.6
6	0	25	7.5
7	0.4	24	7.2
8	4.2	23	7.1
9	5.5	22	7.4
10	6.9	21	7.3
11	8.1	20	7.0
12	8.4	19	6.4
13	8.7	18	6.3
14	8.7	17	6.6
15	9.2	16	6.3
16	12.4	15	5.3
17	12.6	14	5.0
18	12.1	13	4.5
19	11.5	12	4.2
20	11.0	11	4.0
21	10.5	10	3.8
22	10.3	9	3.5
23	9.9	8	3.5
24	9.6	7	3.6
25	9.05	6	2.4 - 3.8 live
26	8.4	5	1 - 3.2 live
27	7.95	4	0.8 - 2.9 live
28	6.8	3	2.7
29	5.15	2	2.9
30	3.5	1	2.3
31	2.3	0	.9

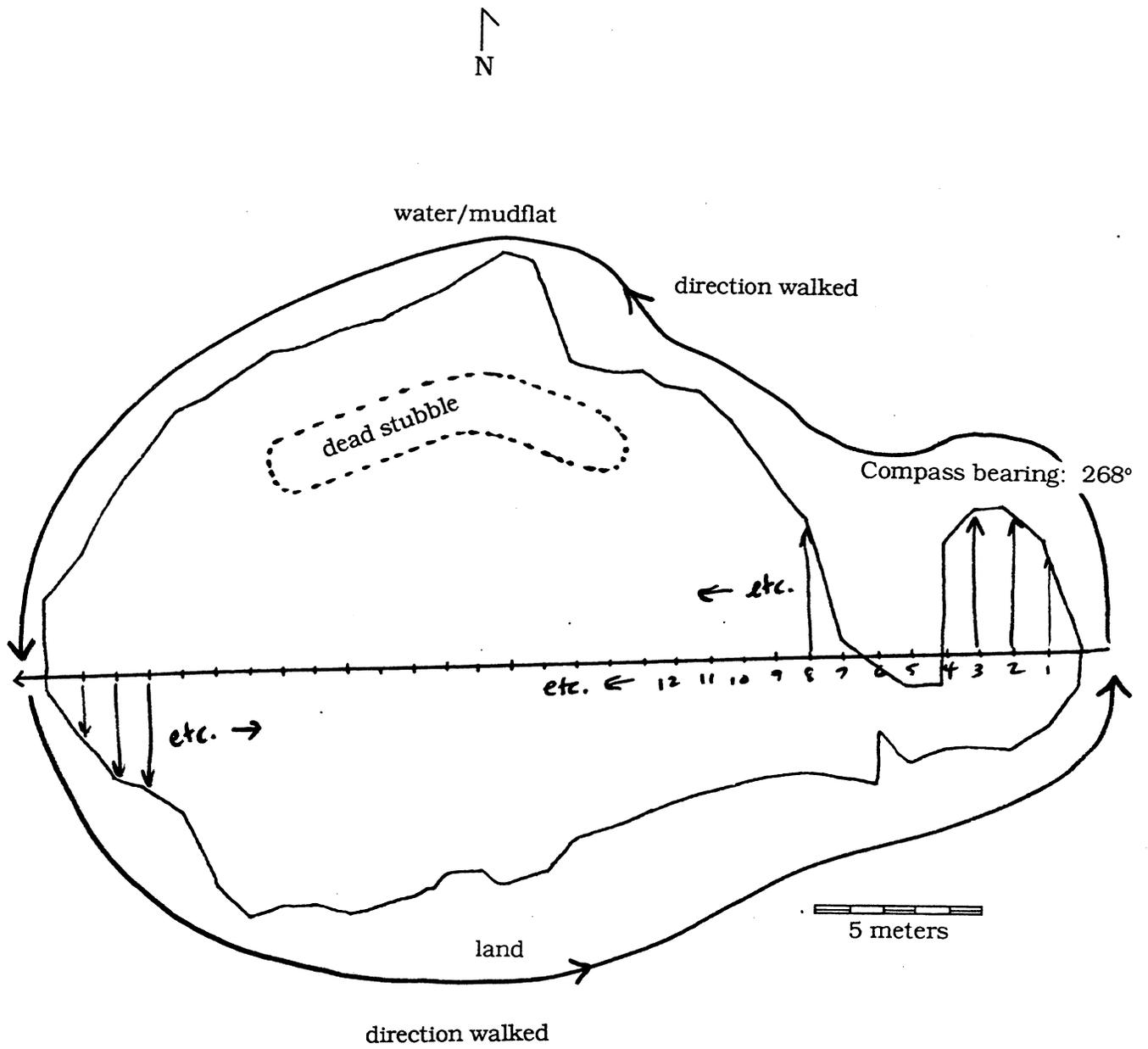


Figure 22: Method used to measure *Spartina alterniflora* Stand No. 2

Stand No. 3 (Figs. 4 & 23)

Date Measured: 8 August 1991

Field Technicians: Susan Wood, Sharon Riggs

First Transect Compass Bearing: 83 degrees

West to east

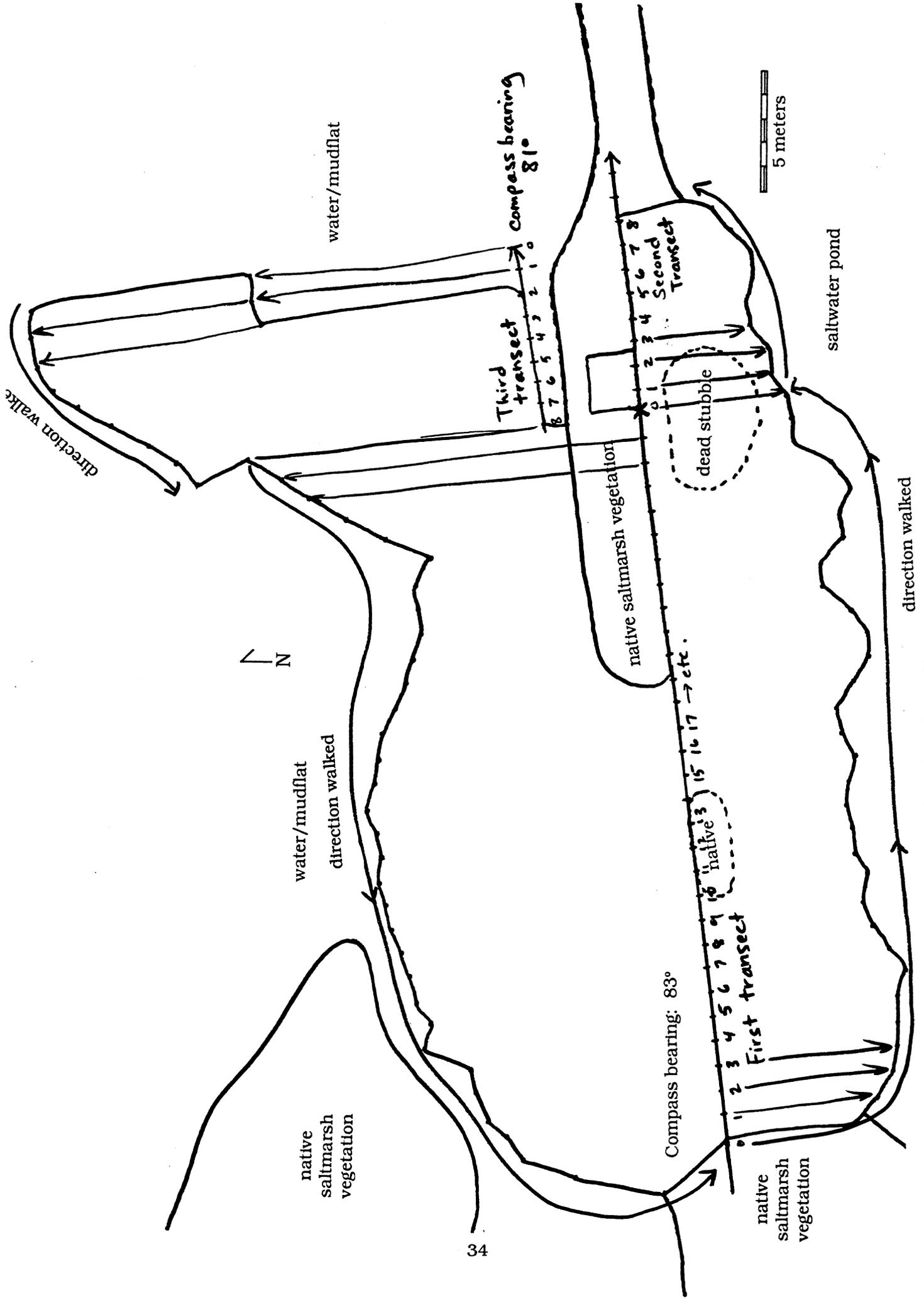
East to west

0	5 meters	30	16.2 meters (center dead)
1	6.3	29	14.9
2	6.9	28	13.8
3	7.1	27	12.4
4	7.2	26	10.9
5	7.5	25	9.1
6	7.8	24	9.8
7	7.4	23	9.9
8	6.8	22	9.9
9	6.6	21	10.3
10	6.8	20	10.6
11	6.5	19	11.2
12	6.5	18	11.9
13	6.4	17	12.1
14	6.5	16	12.4
15	6.9	15	12.7
16	6.5	14	12.5
17	6.4	13	12.45
18	7.3	12	12.6
19	8.0	11	12.5
20	8.0	10	12.4
21	7.5	9	12.1
22	6.5	8	11.9
23	6.5	7	11.7
24	7.5	6	11.3
25	7.5	5	11.6
26	8.0	4	9.9
27	7.5	3	9.8
28	6.0	2	9.5
29	6.0	1	8.7
30	5.9 (center dead)	0	8.1
		-1	6.1
		-2	2.7

Second Transect (all measurements to s. of transect)

Second Transect Compass Bearing: 83 degrees

0	5.9 meters
1	5.5
2	5.4
3	4.9
4	4.8
5	5.05
6	5.1
7	4.4
8	3.9



Third Transect Compass Bearing: 81 degrees (all measurements n. of transect)

West to east

0	9.4 meters
1	10
2	11
3	12.1
4	13.5
5	14.3
6	14.9 (8.9 from transect to grass)
7	7.9 (8.9 from transect to grass)
8	6.9 (8.9 from transect to grass)

Stand No. 4 (Figs. 5 & 24)

Date Measured: 23 August 1991

Field Technicians: Andy Freeman, Sharon Riggs

First Transect Compass Bearing: 310 degrees

South to north

0	16.5 meters	
5	20.5	
10	25	
15	25.6	
20	23.5	(<i>Salicornia</i> & <i>Atriplex</i> , 1-1.5m wide)
25	17.7	(<i>Salicornia</i> & <i>Atriplex</i> , 1-1.5m wide)
30	5.8 (0.6 m to rope)	(<i>Salicornia</i> & <i>Atriplex</i> , 1-1.5m wide)
35	16.5 (1.0m to rope)	(<i>Salicornia</i> & <i>Atriplex</i> , 1-1.5m wide)
40	15 (1.2 m to rope) (dead <i>Spartina</i> in center)	(<i>Salicornia</i> & <i>Atriplex</i> , 1-1.5m wide)
45	14.6 (1.4m to rope) (dead <i>Spartina</i> in center)	(<i>Salicornia</i> & <i>Atriplex</i> , 1-1.5m wide)
50	15 (1.0 m to rope)	(<i>Salicornia</i> & <i>Atriplex</i> , 1-1.5m wide)
55	14.1 (0.4m to rope)	(<i>Salicornia</i> & <i>Atriplex</i> , 1-1.5m wide)
60	18	(<i>Salicornia</i> & <i>Atriplex</i> , 1-1.5m wide)
63	17.2	(<i>Salicornia</i> & <i>Atriplex</i> , 1-1.5m wide)

Second Transect Compass Bearing: 325 degrees

South to north

0	17.2 meters
5	13 (+ 0.7 m west of rope)
10	12.8 (+0.6 m west of rope)
15	0.7 to rope, 12.5 total
20	0.5 to rope, 13.5 total
25	1.2 to rope, 11.6 total
30	1.5 to rope, 11.6 total
35	1.3 to rope, 9.2 total
40	5.9 (0.4 m west of rope)
45	2.8 (0.4 m west of rope)
48	2.0

Third Transect Compass Bearing: not recorded

South to north

0	2 meters
5	2.5
10	9
15	3
20	1.5 + 0.5 east (11 m wide)
25	2.5 (12 m wide)
30	3.5 (starts at 12, 13 m wide)
34.5	4

Fourth Transect Compass bearing: 41 degrees
Date Measured: 8 August 1991
Field Technicians: Susan Wood, Sharon Riggs
(One set of measurements taken across transect)

0	7.7 meters
1	7.9
2	7.9
3	7.7
4	7.9
5	7.3
6	6.7
7	6.6
8	6.5
9	9.8
10	11.2
11	11.1
12	10.0

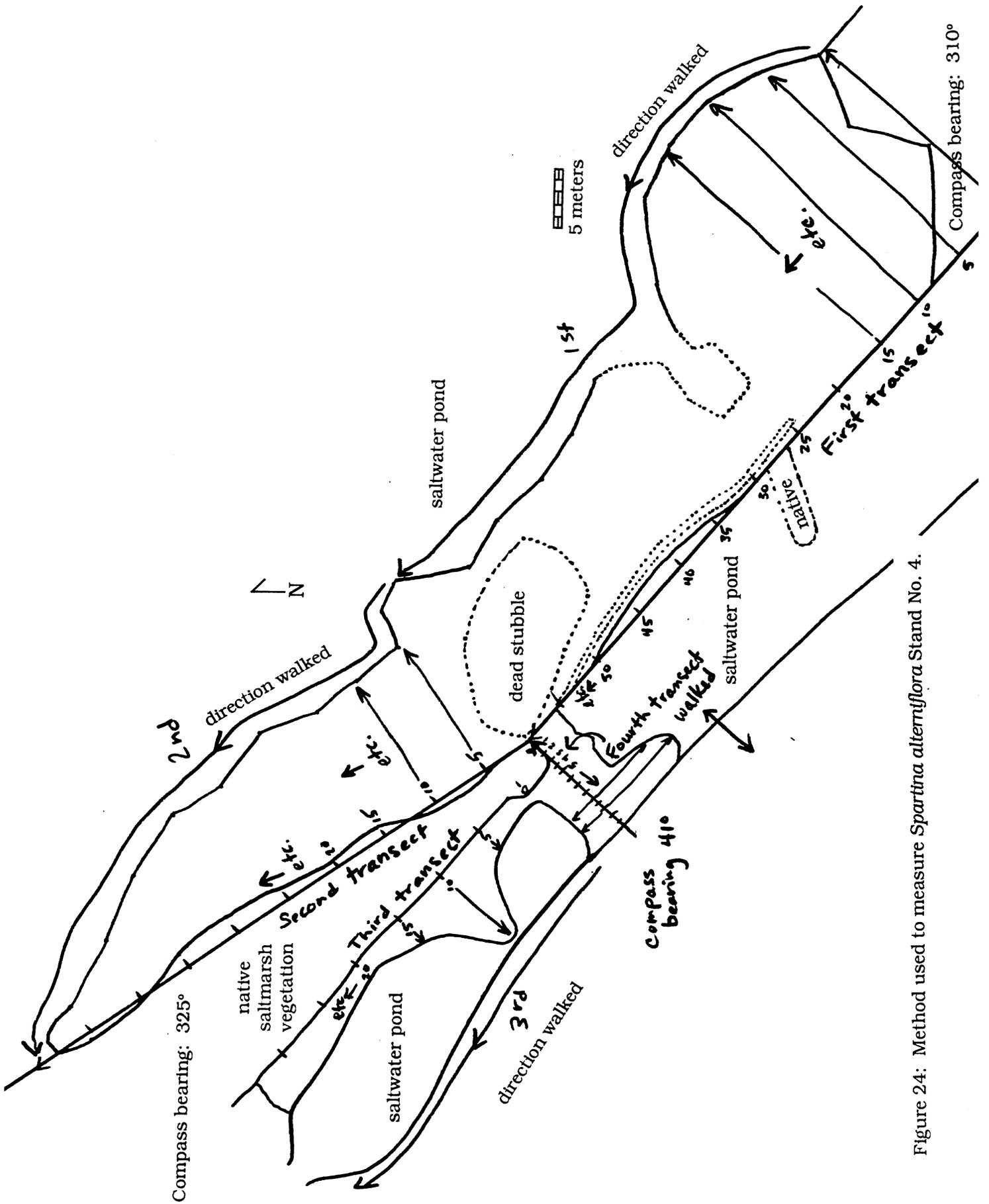


Figure 24: Method used to measure *Spartina alterniflora* Stand No. 4.

Stand No. 5 (Figs. 6 & 25)

Date Measured: 7 August 1991

Field Technicians: Andy Freeman, Sharon Riggs

Transect Compass Bearing: 45 degrees

North to south

1	4.8 meters
2	5.6
3	6.0
4	6.15
5	5.9
6	6
7	6.1
8	6.05
9	5.5
10	5.3
11	5.1
12	4.9
13	4.2
14	3.5
15	1.8
15.5	0.5

South to north

15.5	2.1 meters
15	3.2
14	4.1
13	4.8
12	4.9
11	5.1
10	5.1
9	5.1
8	5.2
7	5.4
6	5.6
5	5.9
4	5.5
3	5.5
2	4.5
1	2.1

Stand No. 6 (Figs. 7 & 26)

Date Measured: 7 August 1991

Field Technicians: Andy Freeman, Sharon Riggs

Transect Compass Bearing: 140 degrees

Northwest to southeast (land)

0	0.1 meters
1	0.7
2	1.7
3	2.1
4	2.9
5	3.4
6	4.5
7	5.0
8	5.6
9	4.9
10	5.0
11	5.2
12	4.6
13	3.2
14	1.8
14.6	0

Southeast to northwest (mud)

14.6	0.65 meters
14	2.3
13	2.5
12	2.9
11	3.7
10	3.8
9	4.0
8	3.7
7	3.5
6	2.9
5	3.0
4	2.4
3	2.1
2	2.3
1	2.3
0	0.5

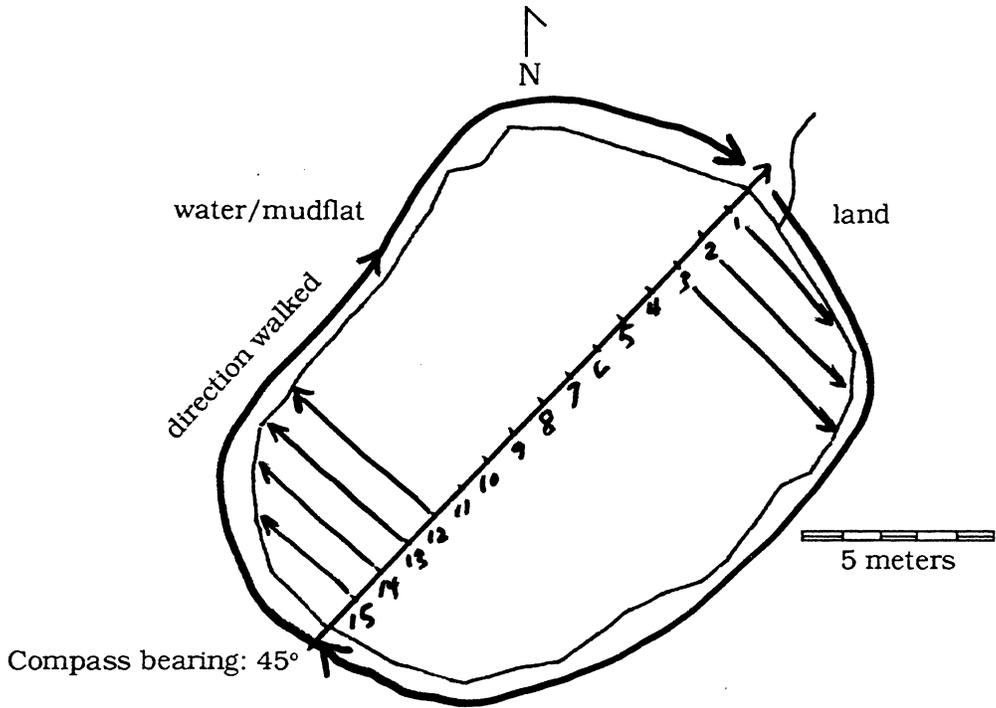


Figure 25: Method used to measure *Spartina alterniflora* Stand No. 5.

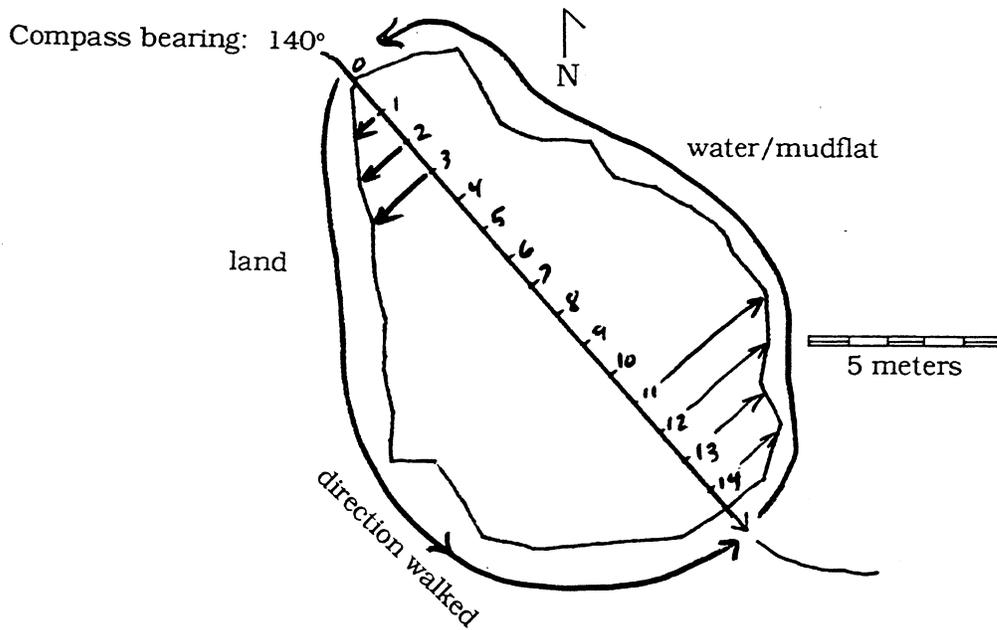


Figure 26: Method used to measure *Spartina alterniflora* Stand No. 6.

Stand No. 7 (Figs. 8 & 27)

Date Measured: 7 August 1991

Field Technicians: Andy Freeman, Sharon Riggs

Transect Compass Bearing: 80 degrees

West to east (land)		East to west (mud)	
0	2.2 meters	16.8	2.6 meters
1	3.2	16	4.6
2	4.9	15	5.1
3	6.0	14	7.8
4	7.8	13	8.7
5	7.8	12	9.4
6	8.0	11	9.8
7	8.05	10	10
8	8.05	9	10.6
9	8.3	8	11
10	8.1	7	7.8
11	7.8	6	9.4
12	7.4	5	9.1
13	6.8	4	8.7
14	6.35	3	8.1
15	5.2	2	7.6
16	4.2	1	6.2
16.8	1.7	0	4.3

Stand No. 8 (Figs. 9 & 28)

Date Measured: 7 August 1991

Field Technicians: Andy Freeman, Sharon Riggs

Transect Compass Bearing: 328 degrees

South to north (land)		North to south (mud)	
0	1.3 meters	9.5	0.3 meters
1	1.6	9	1.7
2	2.4	8	2.9
3	2.35	7	3.9
4	2.65	6	4.4
5	2.6	5	4.2
6	1.7	4	3.8
7	1.9	3	3
8	2.15	2	2.8
9	1.8	1	1.85
9.5	1.4	0	0.4

Stand No. 9 (Figs. 10 & 29)

Date Measured: 8 August 1991

Field Technicians: Susan Wood, Sharon Riggs

Transect Compass Bearing: 132 degrees

Transect length: 7.8m

Width of patch (half circle): 3.6m

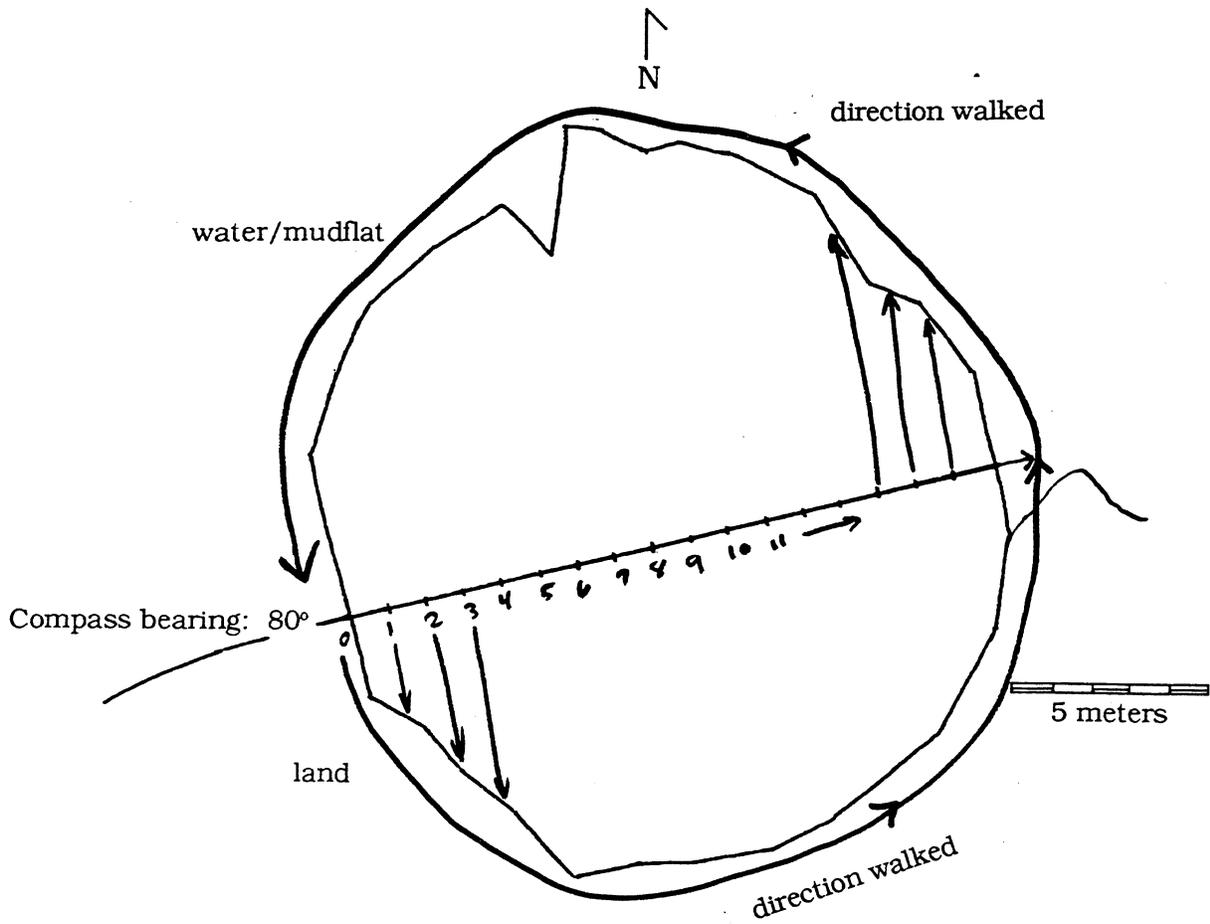


Figure 27: Method used to measure *Spartina alterniflora* Stand No. 7.

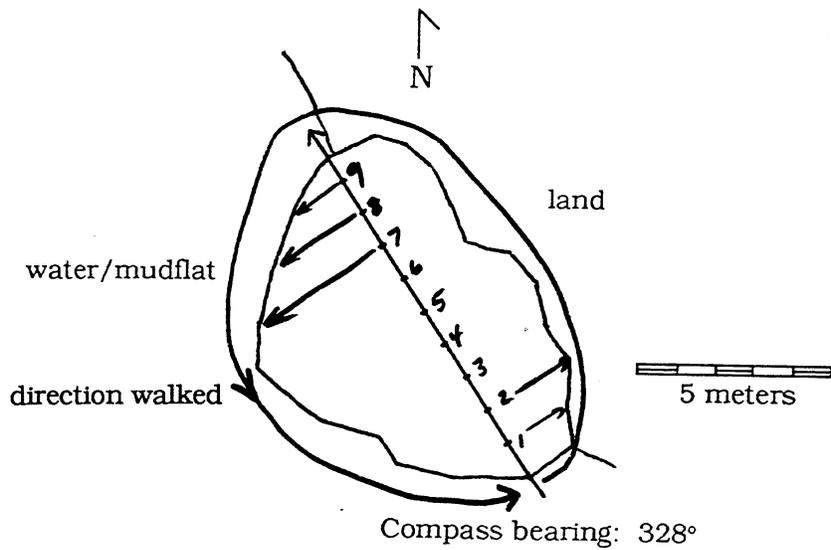


Figure 28: Method used to measure *Spartina alterniflora* Stand No. 8.

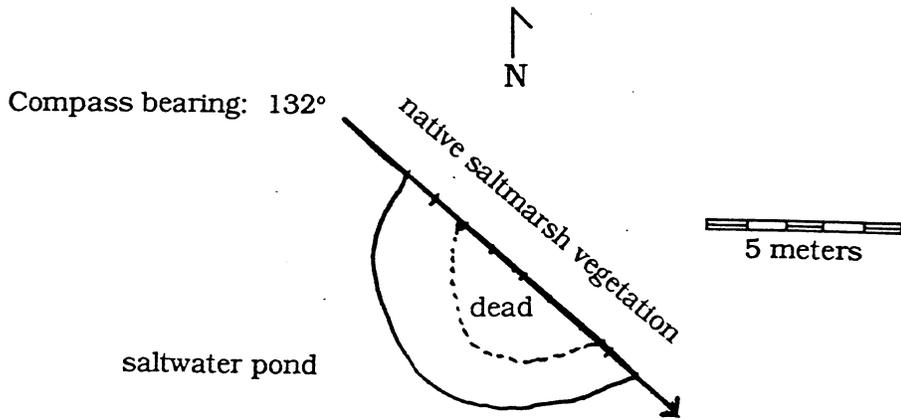


Figure 29: Method used to measure *Spartina alterniflora* Stand No. 9.

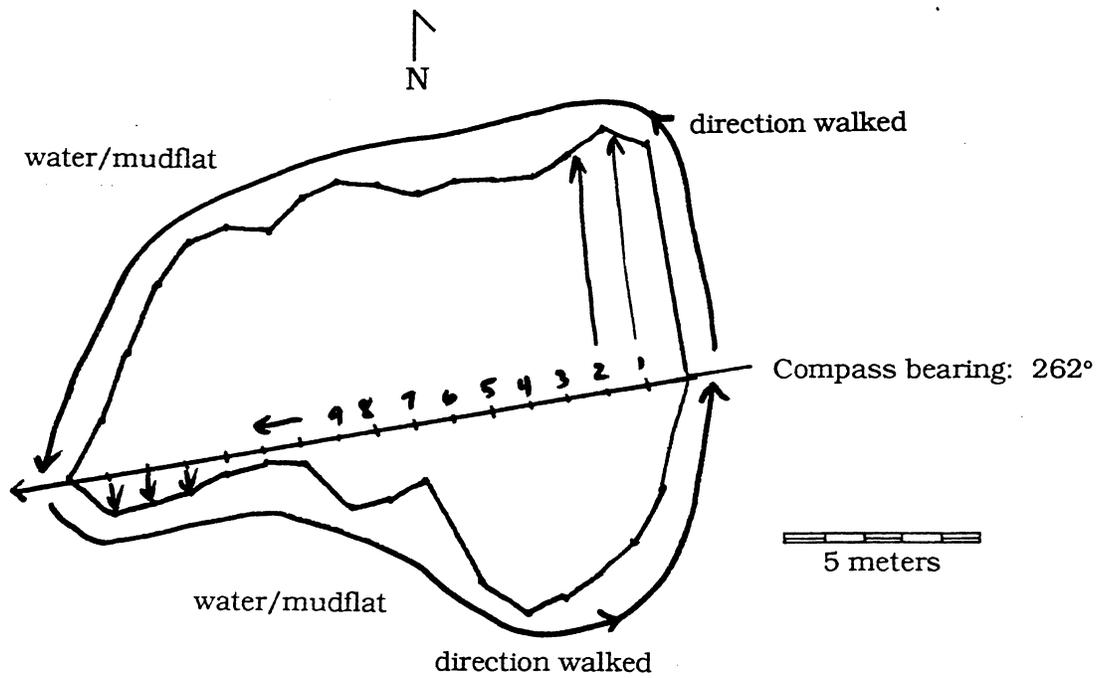


Figure 30: Method used to measure *Spartina alterniflora* Stand No. 10.

Stand No. 10 (Figs. 11 & 30)

Date Measured: 28 August 91

Field Technicians: Glen Alexander, Sharon Riggs

Transect Compass Bearing: 262 degrees

East to west

0	6.1
1	6.6
2	6.3
3	5.8
4	5.9
5	6.0
6	5.9
7	6.2
8	6.5
9	6.2
10	5.5
11	5.7
12	5.6
13	4.6
14	3.0
15	1.4
16	0

West to east

16	0
15	1.0
14	0.8
13	0.7
12	0.5
11	0.3
10	0.5
9	1.9
8	1.9
7	1.5
6	4.4
5	5.4
4	5.1
3	4.6
2	4.0
1	2.7
0	0

Stand No. 11 (Figs. 12 & 31)

Date Measured: 28 August 1991

Field Technicians: Glen Alexander, Sharon Riggs

Transect Compass Bearing: not taken

Diameter (circular patch): 3.7 - 3.9 m

Compass bearing: no bearing taken

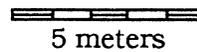
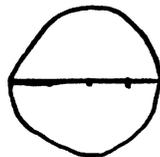


Figure 31: *Spartina alterniflora* in Padilla Bay, Stand No. 11.

Stand No. 12 (Figs. 14 & 32)

Date Measured: 28 August 1991

Field Technicians: Glen Alexander, Sharon Riggs

Transect Compass Bearing: 44 degrees

West to east

East to west

0	1.9 meters	19.5	1.1 meters
1	3.4	19	2.0
2	4.3	18	2.4
3	4.1	17	2.9
4	4.6 (Spergularia n.,2x3m)	16	3.3
5	7.9	15	3.0
6	8.1	14	8.0
7	8.1	13	8.7
8	7.6	12	9.6
9	6.8	11	10.7
10	6.2	10	10.6
11	5.9	9	10.1
12	5.8	8	9.4
13	5.4	7	6.2
14	4.6	6	5.3
15	3.9	5	3.6
16	3.8	4	2.9
17	3.4	3	0.65
18	2.6	2	0.5
19	1.8	1	0.4
19.5	0.6	0	0.2

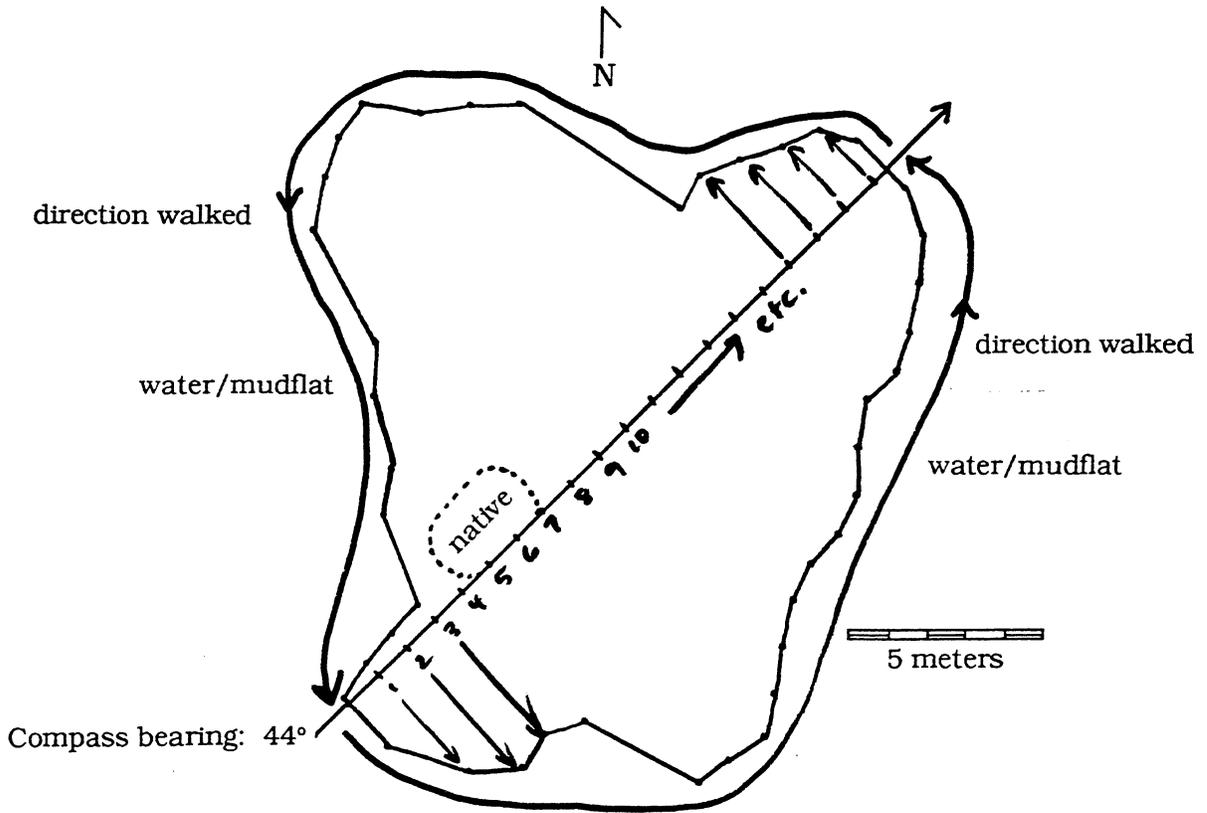


Figure 32: Method used to measure *Spartina alterniflora* Stand No. 12.

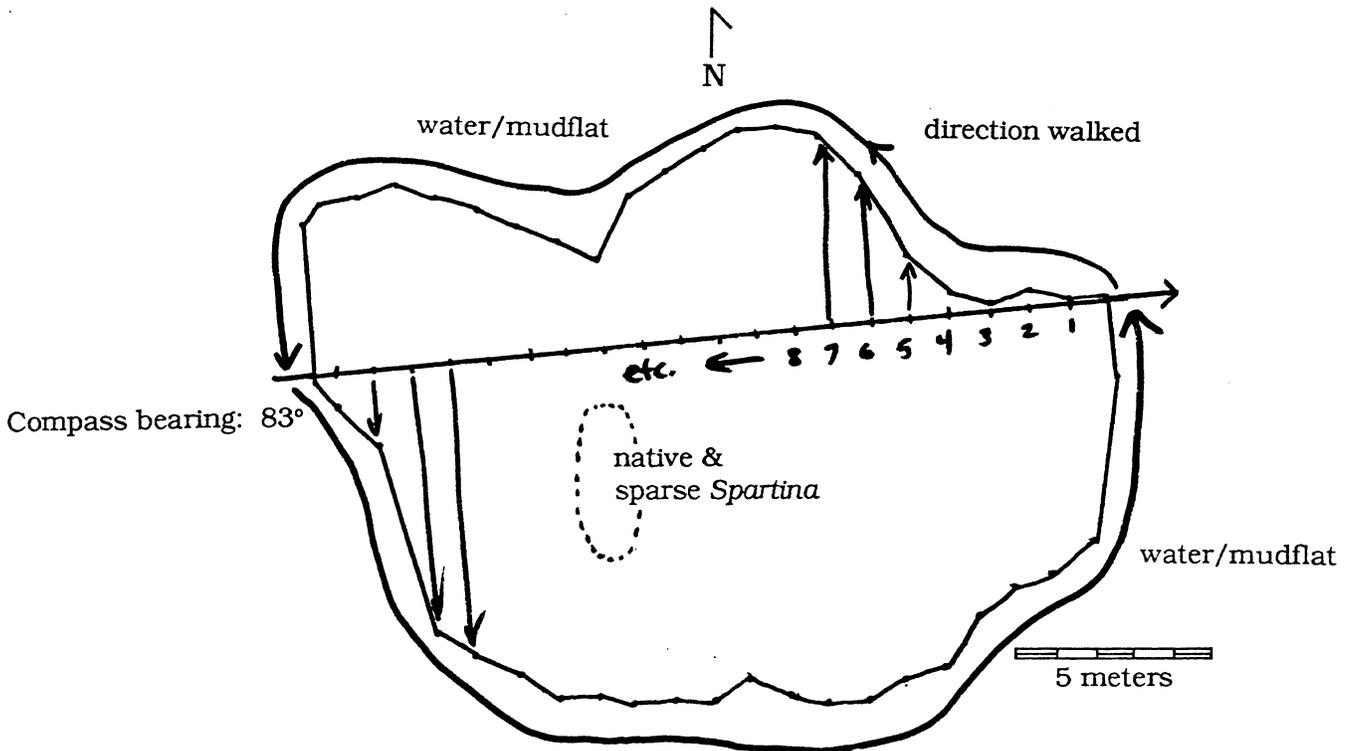


Figure 33: Method used to measure *Spartina alterniflora* Stand No. 13.

Stand No. 13 (Figs. 15 & 33)

Date Measured: 28 August 1991

Field Technicians: Glen Alexander, Sharon Riggs

Transect Compass Bearing: 83 degrees

East to west

0	0 meters
1	0.2
2	0
3	0.5
4	1.6
5	3.7
6	4.8
7	5.1
8	5.2
9	4.9
10	4.4
11	3.8
12	2.3
13	2.8
14	3.3
15	3.9
16	4.3
17	4.6
18	4.5
19	4.4
19.5	3.9

one meter more to east of transect

West to east

19.5	0.2 meters
19	0.8
18	2.0
17	7.0
16	7.6
15	8.2
14	9.0
13	9.0
12	9.2 (center sparse, <i>Spergularia</i>)
11	9.2
10	9.4
9	9.0
8	9.5
7	9.7
6	9.7
5	9.4
4	9.1
3	7.9
2	7.3
1	7.0
0	6.3

Stand No. 14 (Figs. 16 & 34)

Date Measured: 28 August 1991

Field Technicians: Glen Alexander, Sharon Riggs

Transect Compass Bearing: 77 degrees

East to west

0	not taken
1	1 meters
2	2.9
3	4.5
4	5.8
5	5.9
6	6.0
7	5.5
8	5.4
9	5.1
10	5.1
11	4.5
12	3.8
13	1.8
13.5	1.2

West to east

13.5	0 meters
14	1.1
13	1.7
12	5.3
11	5.3
10	5.3
9	5.7
8	7.2
7	8.4
6	8.3
5	8.6
4	8.5
3	8.0
2	7.4
0	6.2 (dips a meter west here)

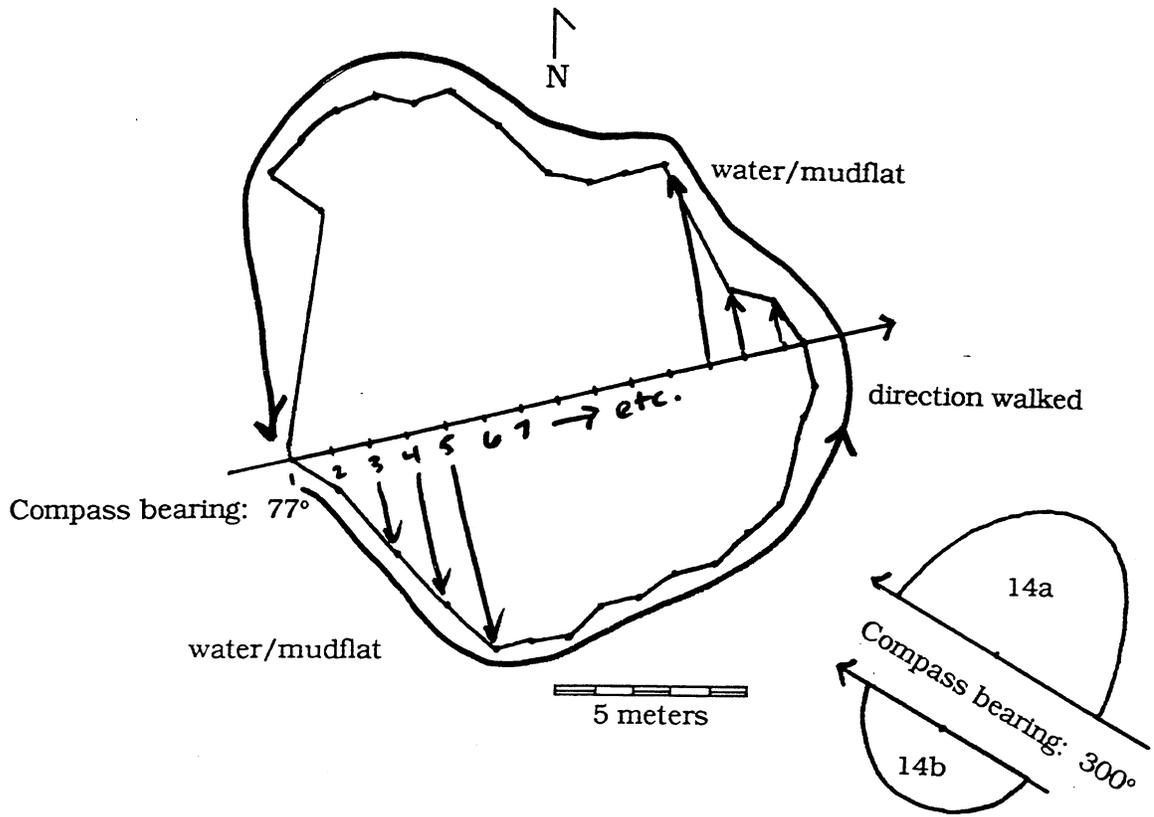


Figure 34: Method used to measure *Spartina alterniflora* Stand No. 14.

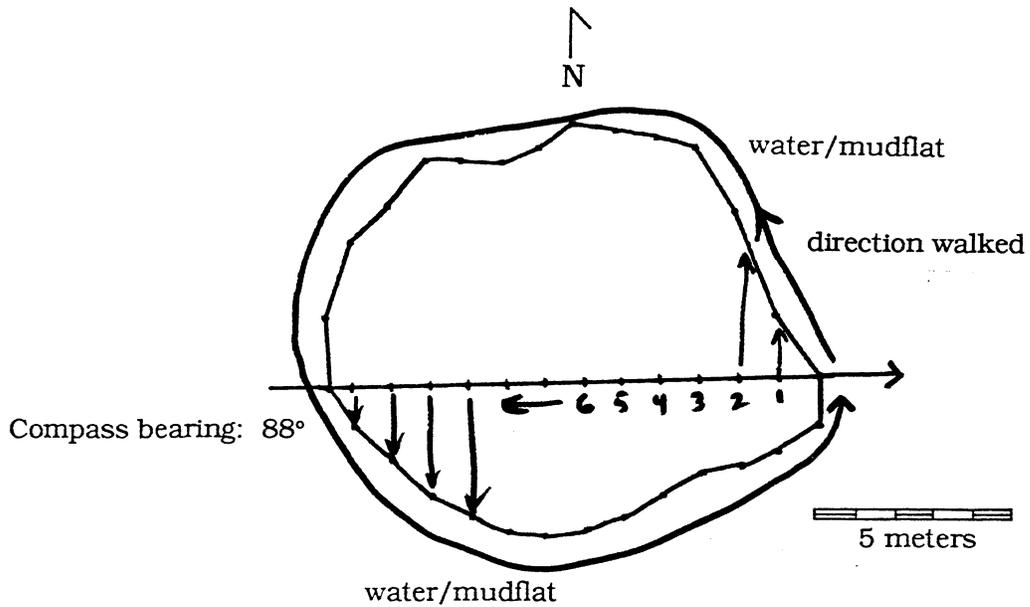


Figure 35: Method used to measure *Spartina alterniflora* Stand No. 15

14a

Date Measured: 28 August 1991
 Transect Compass Bearing: 300 degrees
 Length: 6.2m
 Width: 4.2m

14b

Date Measured: 28 August 1991
 Transect Compass Bearing: 300 degrees
 Length: 4.5m
 Width: 2.1m

Stand No. 15 (Figs. 17 & 35)

Date Measured: 28 August 1991
 Field Technicians: Glen Alexander, Sharon Riggs
 Transect Compass Bearing: 88 degrees

East to west		West to east	
0	0 meters	12.6	0 meters
1	1.6	12	1.0
2	4.4	11	1.8
3	6.0	10	2.8
4	6.2	9	3.4
5	6.5	8	3.8
6	6.6	7	4.0
7	6.1	6	3.9
8	5.7	5	3.6
9	5.8	4	3.0
10	5.8	3	2.5
11	4.6	2	2.4
12	3.7	1	1.9
12.6	1.8	0	1.4

Stand No. 16 (Figs. 18 & 36)

Date Measured: 28 August 1991
 Field Technicians: Glen Alexander, Sharon Riggs
 Transect Compass Bearing: 76 degrees

East to west		West to east	
0	2.7 meters	6	1.3 meters
1	3.6	5	1.7
2	3.9	4	2.3
3	4.0	3	2.5
4	4.2	2	3.0
5	3.7	1	2.4
6	2.7	0	0.8

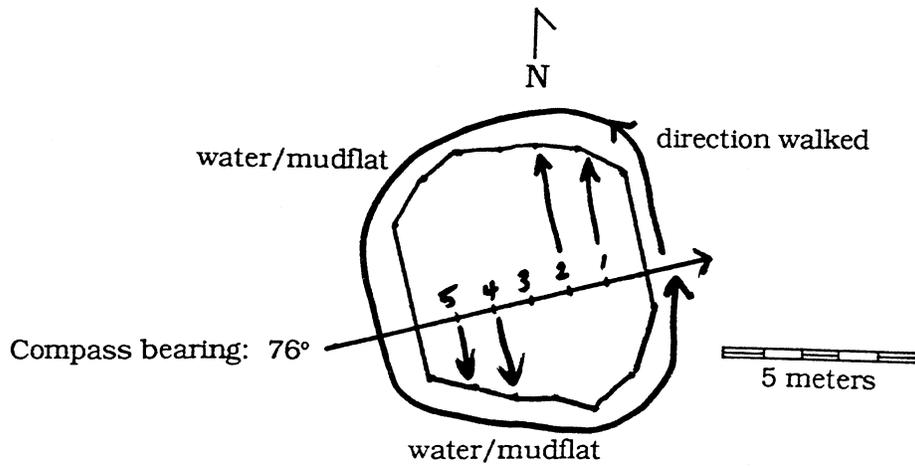


Figure 36: Method used to measure *Spartina alterniflora* Stand No. 16.

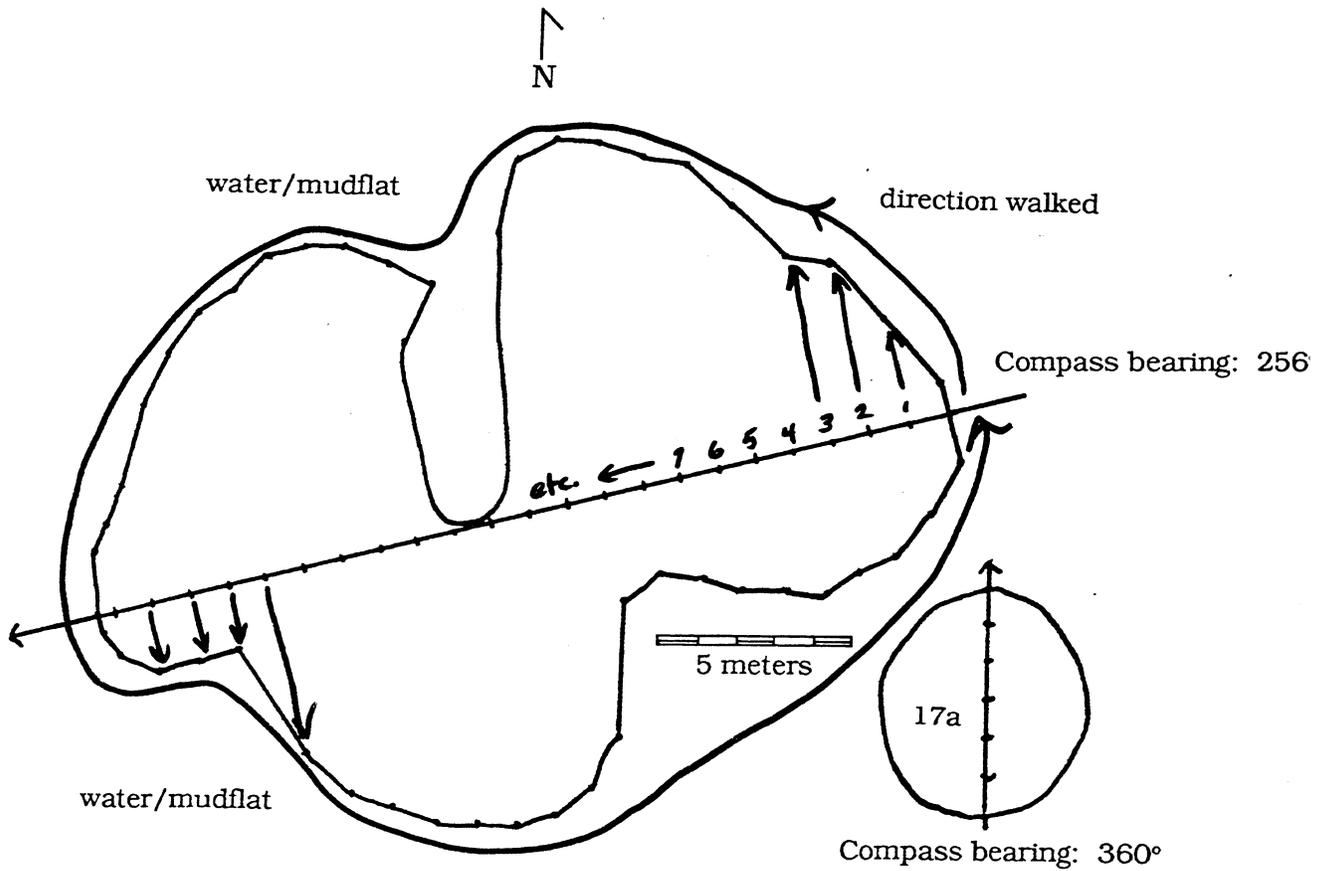


Figure 37: Method used to measure *Spartina alterniflora* Stand No. 17.

Stand No. 17 (Figs. 19 & 37)

Date Measured: 28 August 1991

Field Technicians: Glen Alexander, Sharon Riggs

Transect Compass Bearing: 256 degrees

East to west

West to east

0	0.7 meters	22.3	0.5 meters
1	2.7	22	1.2
2	4.4	21	1.8
3	4.9	20	1.8
4	6.5	19	1.7
5	7.7	18	4.8
6	8.2	17	6.1
7	8.9	16	6.7
8	9.2	15	7.3
9	8.9	14	7.6
10	7.2 (channel edge)	13	7.9
11	1.7 (channel)	12	7.8
12	6.3	11	7.4
13	7.0 (5m from transect to grass)	10	6.3
14	7.7	9	2.8
15	8.0	8	2.4
16	8.0	7	2.7
17	7.3	6	3.3
18	6.9	5	3.5
19	6.1	4	3.7
20	4.9	3	3.5
21	3.1	2	3.3
22	1.6	1	2.3
22.3	0	0	1.3

17a

Date of Measure: 28 August 1991

Transect Compass Bearing: 360 degrees

Circular patch

Transect length: 6 m

Width (perpendicular to transect): 5.2 m

Stand No. 18 (Figs. 20 & 38)

Date of Measure: 28 August 1991

Field Technicians: Glen Alexander, Sharon Riggs

Transect Compass Bearing: 261 degrees

West to east

0	2.2 meters
1	3.5
2	4.1
3	4.2
4	4.1
5	3.9 (sparse to #6)
6	2.5
7	3.6
8	4.5
9	6.8
10	7.6
11	7.7
12	8.9
13	9.4
14	9.9
15	9.9
16	9.7
17	9.1
18	7.4
19	7.4
20	7.1
21	4.8
22	1.5

East to west

22	9.9 meters (5.7m to transect)
21	9.9 (5.7m to transect)
20	10
19	11.8
18	12.3
17	12.4
16	12.5 (dead stubble n, 1x5m)
15	12.6
14	12.5
13	12.7
12	12.3
11	11.5
10	1.0
9	5.9
8	7.6
7	8.1
6	8.3
5	8.8
4	9.0
3	8.9
2	8.9
1	8.4
0	0

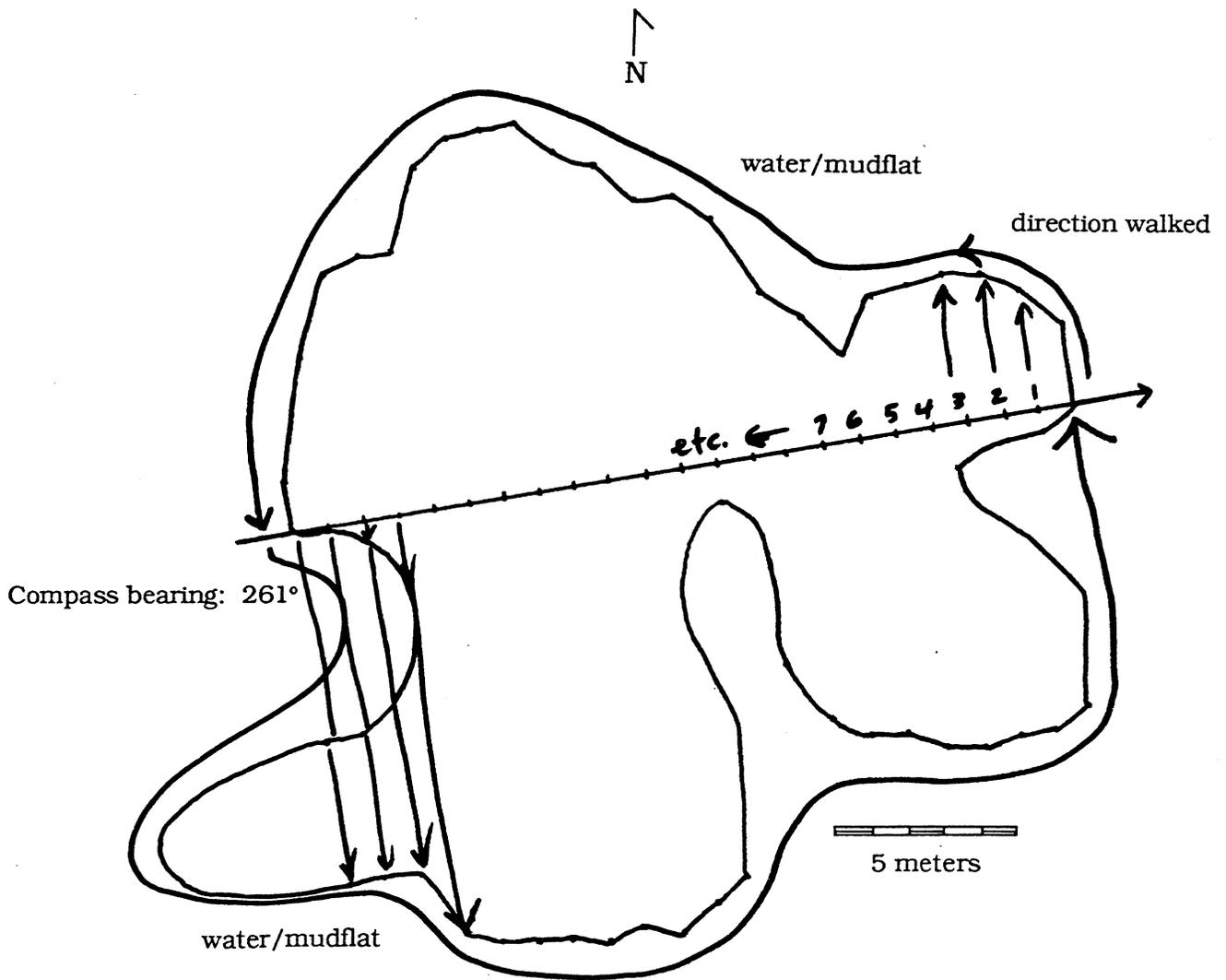


Figure 38: Method used to measure *Spartina alterniflora* Stand No. 18.

Dike Island (Figs. 13 & 39)

Date Measured: 28 August 1991

Field Technicians: Glen Alexander, Sharon Riggs

East to West(m)	Distance to Edge (m)	Transect Compass Bearing
0	79	252 degrees
100	35	252
200	37	252
300	39	248
400	39	246
500	32	252
600	19.2	244
700	19	246
800	21	245
900	31	244 to 33m 252 to 100 m
1000	19.8	258 to 41m 290 to 100m add "arm" to n. of transect 10 x 33 m
1100	79	276
1200	70	267
1276	57	172

Other Notes:

Between 0-100	1.5 x 10m & 2.0 x 45m <i>Spartina</i> north of transect
100-200	2.0 x 35m <i>Spartina</i> north
200-300	1.0 x 75m <i>Spartina</i> north
300-400	dead spot south of transect 25 x 10m
400-500	1 x 65m <i>Spartina</i> north
500-600	<i>Spartina</i> more spotty, dead stubble in center mixed with shoots
600-700	1.5 x 75m <i>Spartina</i> north, dead stubble 4.5m south
700-800	3 x 63m <i>Spartina</i> north, dead stubble 5 x 15m south
800-900	<i>Spartina</i> still spotty, dead stubble patches, <i>Salicornia</i> south of transect 4 x 33m
900-1000	3 x 18m <i>Spartina</i> north
1000-1100	mudflat north
1100-1200	mudflat north

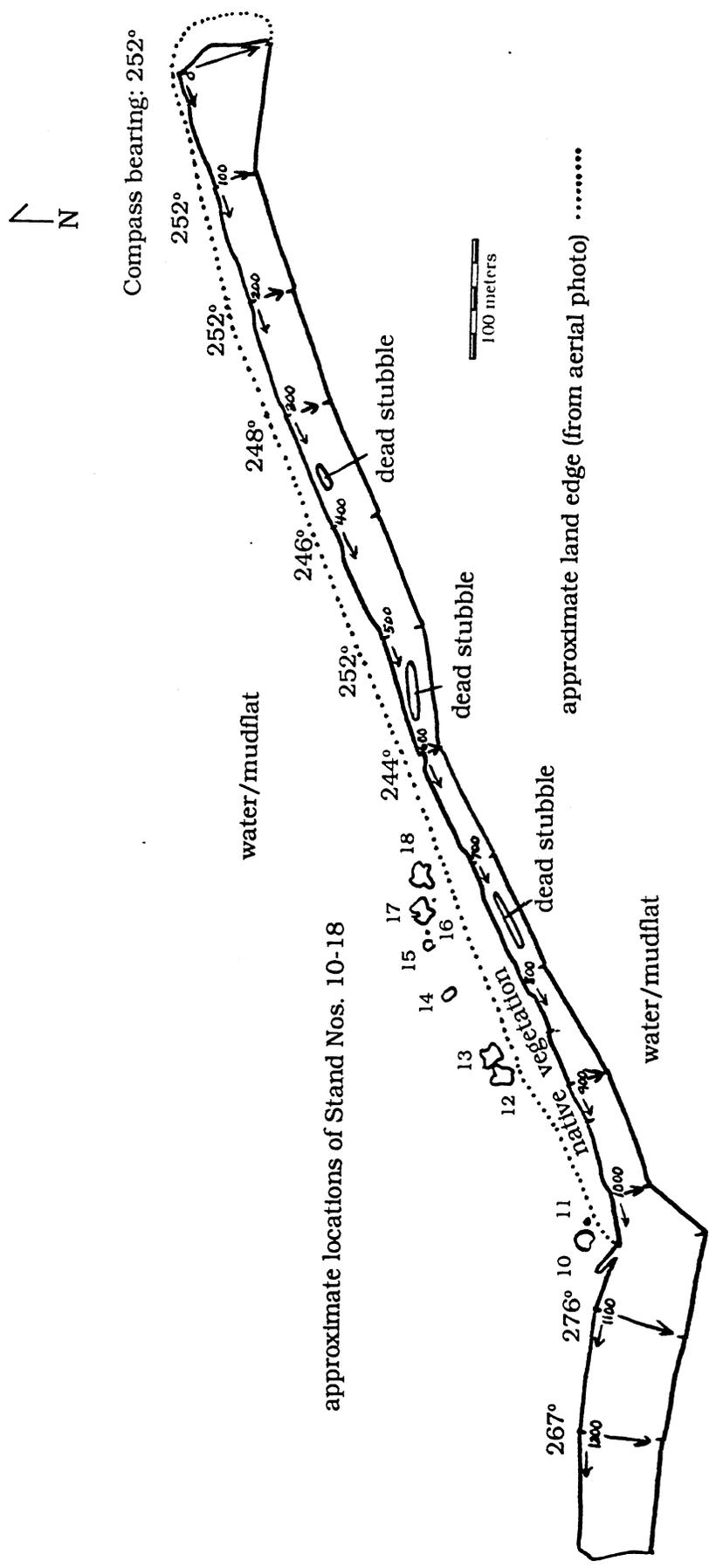


Figure 39: Method used to measure *Spartina alterniflora*, Dike Island (south side).

Appendix 2

Vegetation bordering *Spartina alterniflora* stands

Vegetation Bordering *Spartina alterniflora* Stands

Stand No. 1 (Fig. 2): The native vegetation bordering the stand is mainly *Distichlis spicata* (saltgrass) mixed with some *Salicornia virginica* (pickleweed). *Atriplex patula* (saltweed, orache) occurs a little higher, toward the dike.

Stand No. 2 (Fig. 3): To the east of this stand is a mixture of *D. spicata* and *S. virginica* with sparse *Spergularia marina* (saltmarsh sandspurry). South of the stand is largely *D. spicata* and *S. virginica* with some *A. patula*; *A. patula* occurring closer to the dike. There is also *Cuscuta salina* (saltmarsh dodder). Just off the southwest corner of the stand there is a patch of mixed *S. virginica* and *S. marina*.

Stand No. 3 (Fig. 4): The bordering vegetation is largely *D. spicata*. There was one small patch (approximately 1m x 2m) of native vegetation within this stand consisting of *A. patula*, *S. virginica* and *C. salina*. A higher area in the western central portion of the stand was largely *D. spicata* (10.9 m x 3.3 m). The southern edge of the stand borders on a saltwater pond that never empties.

Stand No. 4 (Fig. 5): The southern edge of the stand is bordered by *D. spicata* and *S. virginica*. A large "v" shaped wedge of *D. spicata*, *S. virginica* and *C. salina* (running north-south) bisects the northern end of the stand, with very sparse *S. alterniflora* overlapping into the edges. A narrow band (.5-1 m wide) of *S. virginica* and *A. patula* runs 35-40 m within the southwestern side of the stand. *D. spicata* and *S. virginica* grow along the dike side of the ponds, with *A. patula* present nearest to the dike. The entire northeastern edge of the stand borders on the same large saltwater pond as Stand Nos. 3 and 9.

Stand No. 5 (Fig. 6): Native vegetation bordering the southern edge of this stand includes *D. spicata* mixed with *S. virginica* and *S. marina*. There is also sparse *S. marina* on the mudflat here. Heading north around the landward edge, there is some *A. patula* mixed in as well. The northern edge is mostly *D. spicata* with

some *S. virginica* mixed in. A few *Triglochin maritimum* (seaside arrowgrass) plants were present on the northern edge as well.

Stand No. 6 (Fig. 7): The western side of this stand is bordered by *D. spicata* with *S. virginica* and *A. patula* present around the edges. The entire western edge of this stand is somewhat mixed with *A. patula*. The southern edge of the stand is bordered by *D. spicata* mixed with *S. virginica*.

Stand No. 7 (Fig. 8): The landward side of this stand was surrounded by mixed *D. spicata* and *S. virginica*. *A. patula* occurred closer to the bottom slope of the dike south of the stand.

Stand No. 8 (Fig. 9): This stand abuts the dike. There is a small triangle of *S. virginica* at the southern corner of the stand. *D. spicata* occurs north of the stand with some *S. virginica* in the mudflat. *A. patula* and *D. spicata* occur on the slope of the dike.

Stand No. 9 (Fig. 10): *D. spicata* and *S. virginica* form the northeastern border of this stand. The southwestern portion of the stand grows into the same saltwater pond as Stand Nos. 3 and 4.

Stand Nos. 10 - 18 (Figs. 11, 12, 14-20): These stands were all surrounded by mudflat and were approximately 4-5 meters from the land/water edge. There were no saltmarsh plants between the *Spartina* stands and the land/water edge.

Dike Island (Fig. 13): Native salt marsh vegetation occurred north of the large *S. alterniflora* stand on the southern side of the island. Native vegetation immediately north of the transect was noted every 100 m as follows:

0 m	<i>Salicornia virginica, Atriplex patula</i>
100 m	<i>S. virginica, A. patula</i>
200 m	<i>S. virginica, Distichlis spicata, A. patula</i>
300 m	<i>S. virginica, A. patula, Grindelia integrifolia</i> (gumweed), unidentified beach grass (higher)

400 m	<i>S. virginica</i> , <i>A. patula</i>
500 m	<i>S. virginica</i> , <i>A. patula</i>
600 m	<i>S. virginica</i> , <i>A. patula</i>
700 m	Mostly <i>S. virginica</i> with <i>Cuscuta salina</i> , sparse <i>A. patula</i>
800 m	<i>S. virginica</i> with <i>C. salina</i> , <i>A. patula</i>
900 m	Mixed <i>S. virginica</i> and <i>A. patula</i>
941 m	<i>S. virginica</i> , very sparse <i>A. patula</i>
941-1276m	The island ends at 941. A "peninsula" of <i>S. alterniflora</i> juts out at the western end of Dike Island. The "peninsula" is surrounded by mudflat and there are a number of very shallow "channels" draining the "peninsula". There was some <i>Zostera japonica</i> growth in some of these channels. There was sparse <i>Z. japonica</i> and very sparse <i>Z. marina</i> off the western edge of the "peninsula".

Appendix 3

Saltmarsh vegetation along the dikes west of Stand No. 1

These observations were made 6 September 1991 while walking the southwestern edge of Padilla Bay to look for *Spartina alterniflora* stands. Only the dominant or obvious vegetation was noted.

Edge A: *Distichlis spicata* (saltgrass), *Spergularia marina* (saltmarsh sandspurry), *Triglochin maritimum* (seaside arrowgrass), *Salicornia virginica* (pickleweed).

Edge B: Same as above but *Atriplex patula* (saltweed, orache) and *Grindelia integrifolia* (gumweed) occurred a little higher. There were about 21 rubber tires on the beach between B & C.

Edge C: *S. virginica* dominant, *D. spicata*, *S. marina* sparse along edge, *Fucus* sp. along edge (attached), *A. patula* higher.

Island D: *D. spicata*, *S. virginica*, *T. maritimum*.

Edge E: *D. spicata*, *S. virginica*, more *S. marina*. Lots of drift (*Zostera marina*, *Ulva* sp., *Enteromorpha* sp.) covering edge. *G. integrifolia* occurred higher.

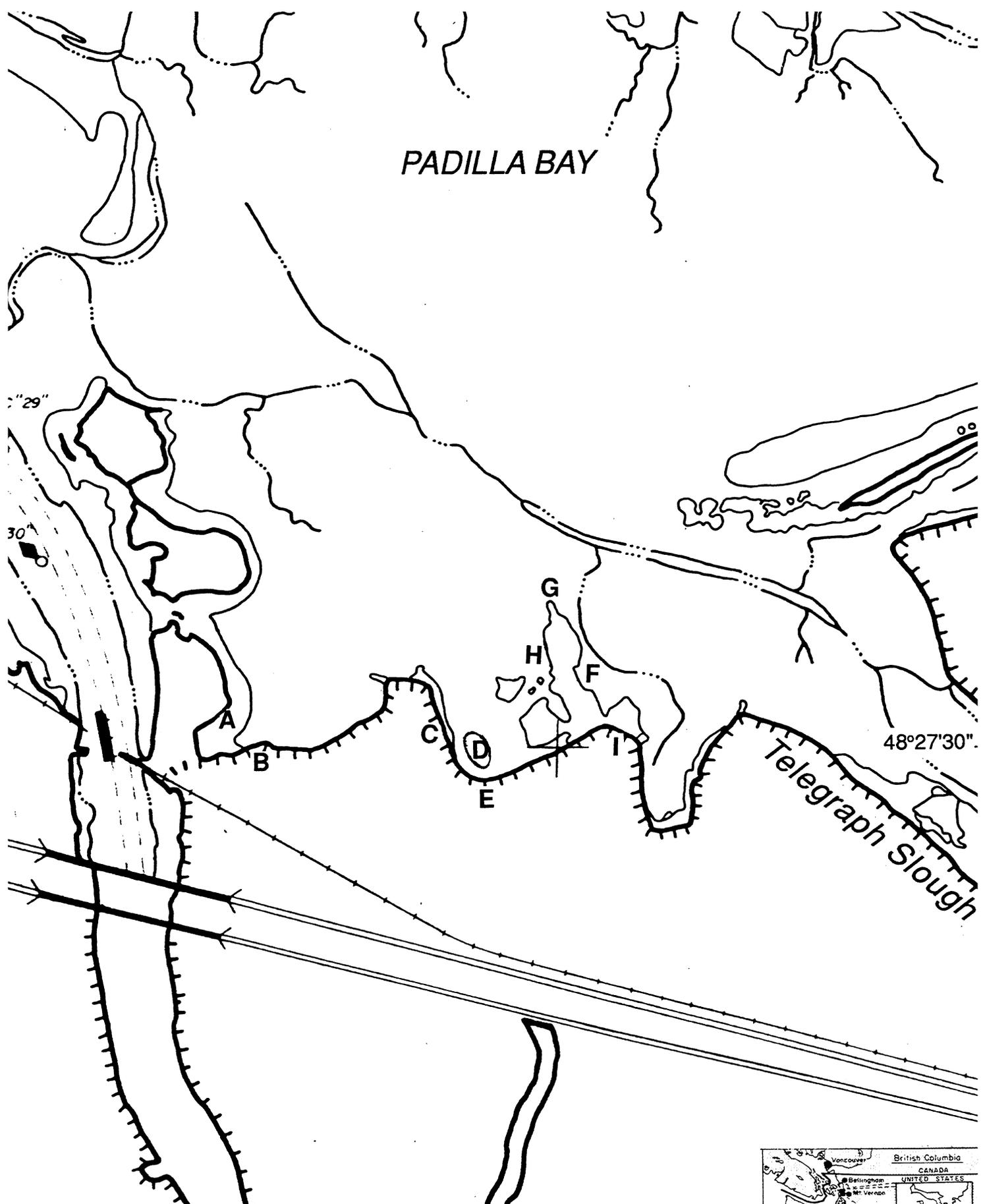
Edge F: The edge of this "peninsula" was 30-45 cm above mudflat. *D. spicata*, *S. virginica*, with sparse *A. patula* and scattered *T. maritimum*. Sparse *S. marina* along edge. One *G. integrifolia* plant.

Edge G: Basically, same as Edge F. *Z. marina* and *Z. japonica* drift on beach. *A. patula* around duck blinds.

Edge H: *D. spicata*, *S. virginica*, scattered *T. maritimum* and *S. marina*. One pocket of rushes (short, more like *Juncus effusus* in appearance than *Scirpus* sp.).

Edge I: Mixed *D. spicata* and *S. virginica* with *Cuscuta salina*. Some *A. patula*.

locations marked on map



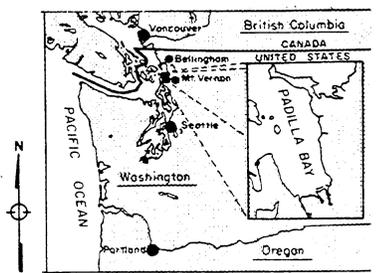
PADILLA BAY

Telegraph Slough

Figure 40: Salt marsh, southwestern Padilla Bay, Washington.
 Partial species listing at lettered sites. (Scale: 1:12,000)

60

2° 30' W



Appendix 4

Approximate locations of 1987 transects in relation to
1991 transects in three *Spartina* stands in
Padilla Bay, Washington

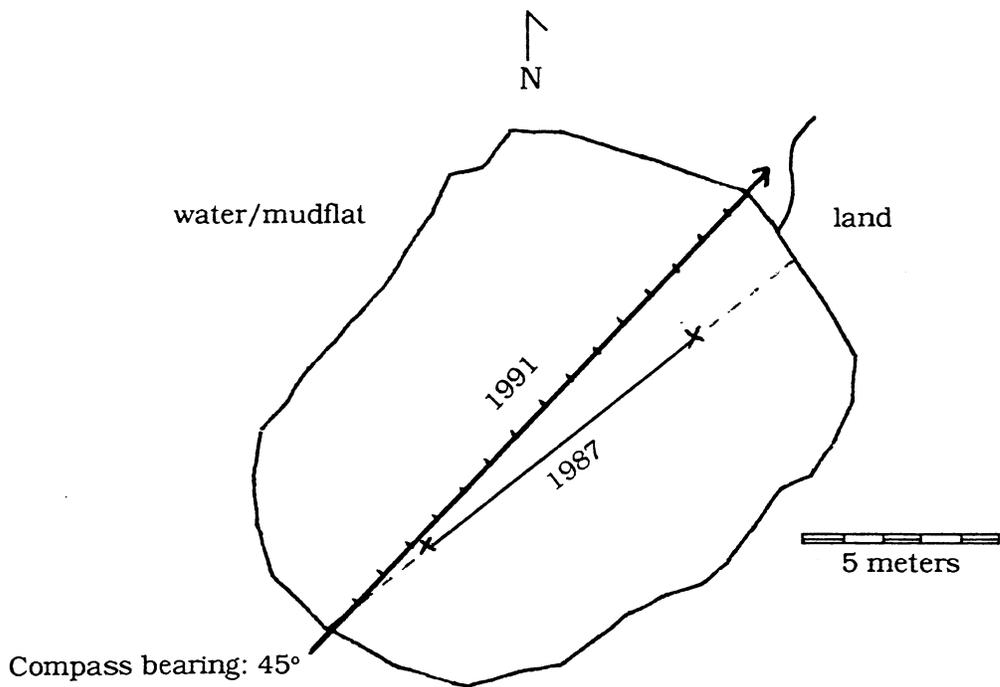


Figure 41: Approximate location of 1987 transect (Wiggins and Binney) as compared to 1991 transect. Growth along the 1987 transect from 1987-1991 is indicated by the dotted line. *Spartina alterniflora* Stand No. 5.

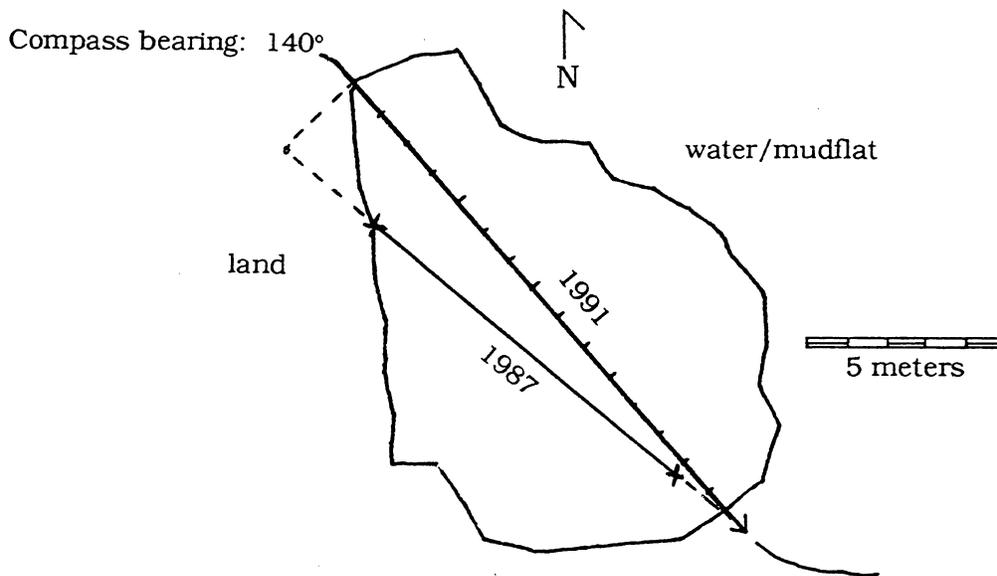


Figure 42: Approximate location of 1987 transect (Wiggins and Binney) as compared to 1991 transect. Growth along the 1987 transect from 1987-1991 is indicated by the dotted line. *Spartina alterniflora* Stand No. 6.

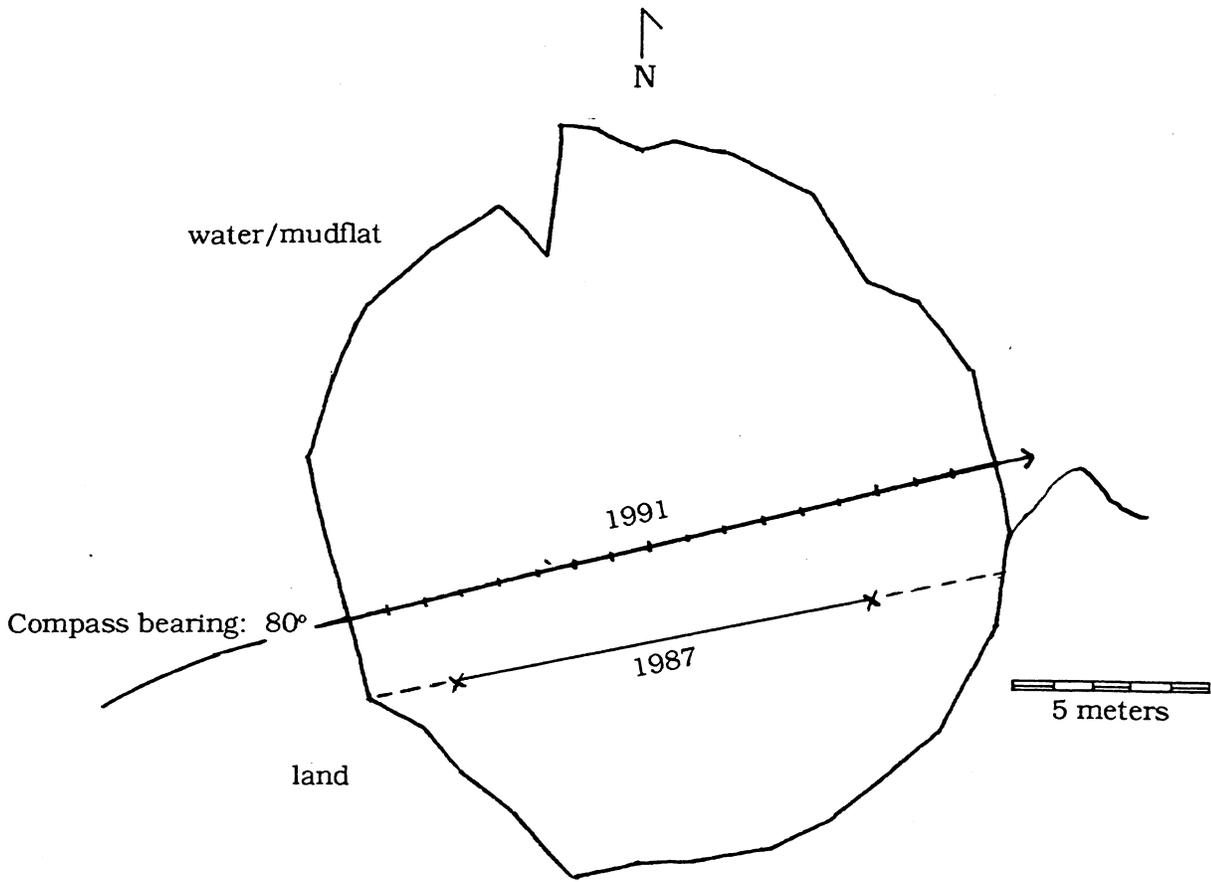


Figure 43: Approximate location of 1987 transect (Wiggins and Binney) as compared to 1991 transect. Growth along the 1987 transect from 1987-1991 is indicated by the dotted line. *Spartina alterniflora* Stand No. 7.

