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THE ESTABLISHMENT OF *SPARTINA* IN THE TAMAR ESTUARY, TASMANIA

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(with five text-figures)

ABSTRACT

Spartina anglica was introduced into the Tamar Estuary, Tasmania, in 1947. Initially spread was slow but subsequently rapid. It is capable of colonizing all rock types and sediments available in the estuary but fine sediments provide the most and basalt the least suitable substrate. It colonises all available slopes (1^{o}-28^{o}).

As a result of the introduction, mud banks become stabilized and the navigable channel thereby safeguarded. The spread of *Spartina* has, however, adversely affected some beaches and private jetties. (Ed.).

INTRODUCTION

The grass *Spartina* was introduced to the Tamar Estuary in 1947 in a limited area of the inter-tidal mud flats at Windermere (see figure 1). By the summer of 1971/72 the *Spartina* had spread so rapidly that many acres of mud flats had been or were in the process of being colonized along the 18 mile (29 km) stretch of the estuary from Dilston and Dog Point at the upstream end to East Arm and Ruffins Bay downstream. The aim of this study is to examine in detail the spread and present distribution of *Spartina* relating these to geological and sedimentological variations, degree of slope of the surface of the intertidal zone and position relative to high and low water marks. The overall effect on the estuary will finally be considered.

THE TAMAR ESTUARY

The 38 mile (61 km) long Tamar Estuary extending from Launceston to Low Head is the major navigable waterway on the north coast of Tasmania. Its present form was determined by a rise in sea level which drowned the pre-existing river valley. The Tamar is characterized by having a very winding course which varies markedly in width from about 1,000 feet (305 m) at Batman Bridge to several miles/kms where there are extensive bays and "arms". There is one major navigable channel, with banks of fine sediment on either side except where the estuary is constricted. In the bays and "arms" the mud banks cover many acres. The estuary experiences a diurnal tidal regime as defined by the British Admiralty, but with clearly defined semi-diurnal components giving an approximately six hour flood tide and seven hour ebb. At Launceston the tidal range on spring tides is up to 14 feet (4.28 m) and on neaps down to 9 feet (2.75 m); at the mouth of the Tamar it is up to 8 feet (2.45 m) on springs and down to 6 feet (1.83 m) on neaps.

Prior to the introduction of *Spartina* the intertidal areas of the estuary were almost completely bare of vegetation. Only the alga *Enteromorpha* was present extensively. In the innermost parts of the bays and "arms" near high water mark limited areas of salt marsh had developed covered with *Salicornia australis* as the main primary colonizer and with the back of the marsh dominated by *Phragmites*, *Juncus* and *Gahnia*.

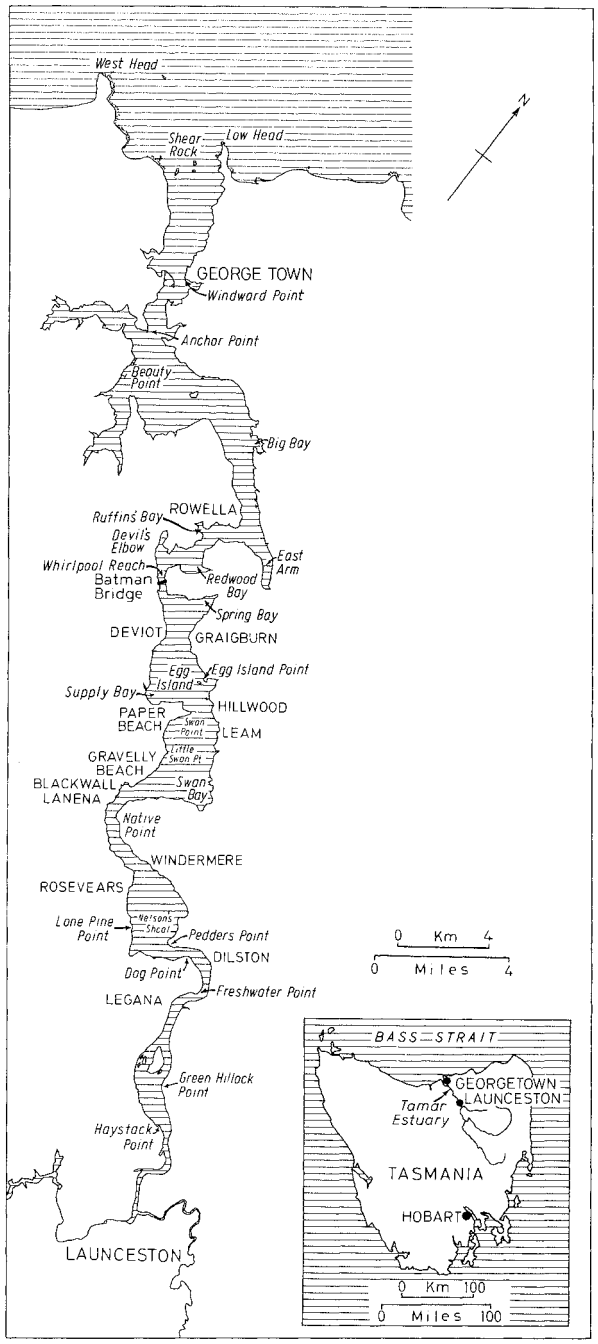


FIG. 1. - Locality Map.

INTRODUCTION OF *SPARTINA*

In 1947 the Department of Agriculture at Launceston planted *Spartina* on the mud banks at Windermere on behalf of the Port of Launceston Authority. The aim of this was to stabilize the banks. It was thought that the navigation channel off Rosevears and opposite Windermere could be safeguarded from considerable siltation if *Spartina* colonized the extensive shoals on the eastern side, which were subject to severe erosion during the combination of flood tide and north-west wind. After the initial plantings in 1947 a few more were made around them during the next three years. In 1955 a further acre (4,047 m^2) was planted with a 6 to 8 feet (1.83 - 2.45 m) interval between the plants and by 1962 these had spread and merged to give a continuous cover. During the early 1960's *Spartina* appeared rapidly in many places. Seeding was proved by the Department of Agriculture who measured a 15% germination rate, but the spread was probably due also to the distribution by the tidal streams of broken fragments which rooted easily.

The Department of Agriculture obtained the original *Spartina* plants from the Waite Agriculture Research Institute of the University of Adelaide and it is probable that these were derived from plants sent to South Australia from England. The British Nature Conservancy's Coastal Research Station has records of *Spartina townsendii* being despatched from East Anglia and Dorset to various individuals in south-eastern Australia although not specifically to the Waite Institute. It is very probable therefore that the species introduced was *Spartina townsendii* although whether it was the fertile hybrid or infertile hybrid is purely a matter for conjecture. It may be argued that the slow growth and lack of rapid spreading in the late 1940's and early 1950's indicated that the initial introduction was of the infertile hybrid and that either the

TABLE 1

AERIAL SURVEYS OF THE TAMAR ESTUARY

Date	Aerial Survey	Area of Estuary Covered	Remarks
27. 3.52	Project 1259 Scale 1:23,760	Dog Pt./Dilston-Deviot/Egg Is. except east shore Swan Bay - Leam	Almost H.W. conditions but with small areas of salt marsh exposed.
31. 1.56	1349 1:35,640(x2)	Launceston - Swan Pt./Egg Is.	Shores and mud banks clearly exposed.
24. 3.61	1301 1:35,640(x2)	Rosevears/Windermere - Tamar mouth	Mud banks close to shores exposed.
22. 1.63	1002 1:51,480	Rosevears/Windermere - Rowella/ East Arm	Mud banks very close to shores exposed.
2. 3.68	1696 1:31,680	Tamar Is. - Supply Bay/Hillwood except west shore Rosevears - Blackwall	Shores and adjacent mud banks clearly exposed.
6. 3.69	0017 1:9,504	Dilston and Freshwater Pt.	Almost H.W. conditions, but salt marsh exposed.
6. 3.69	0063 1:6,336	Lanena	" "
6. 3.69	0065 1:6,336	Blackwall	" "
6. 3.69	0066 1:6,336	Gravelly Beach	" "
6. 3.69	0067 1:6,336	Paper Beach	" "
6. 3.69	0018 1:6,336	Whirlpool Reach	" "
15.12.69	F115 1:31,680	Whirlpool Reach - Ruffins Bay/ Redwood Bay	Shores and mud banks well exposed.
16.12.69	F113 1:31,680	Tamar Is. - Paper Beach/Egg Is. except west shore at Blackwall	" "
5. 2.70	F102 1:11,088	Lanena	Shores and adjacent mud banks exposed.
16. 4.70	F177(colour) 1:15,840	Spring Bay - Ruffins Bay	Shores and adjacent mud banks well exposed.

1955 plantings were of the fertile hybrid or the infertile hybrid developed into the fertile hybrid during the late 1950's, when the rapid spread began to take place. The seeding proved in the early 1960's indicates that the dominant species then was the fertile hybrid, renamed in 1968 *Spartina anglica* (Hubbard).

SPREAD OF *SPARTINA* AS SHOWN BY AERIAL SURVEYS

Between 1947 and 1970 a series of vertical aerial surveys of parts of the Tamar Estuary was made on behalf of the Lands and Surveys Department and provides a record of the spread of *Spartina*. Table 1 gives the dates, project numbers, scales and areas of the surveys and notes on the tidal conditions. All the surveys were made during the summer months between December and March and records of seven summers are provided.

For *Spartina* to be recognisable from black and white air photographs within the range of scales listed a dense growth either in closely spaced clumps or in a continuous sward is necessary. It should be noted therefore that the following description is concerned only with such areas of dense growth and does not exclude the possible existence in addition of scattered clumps and isolated shoots.

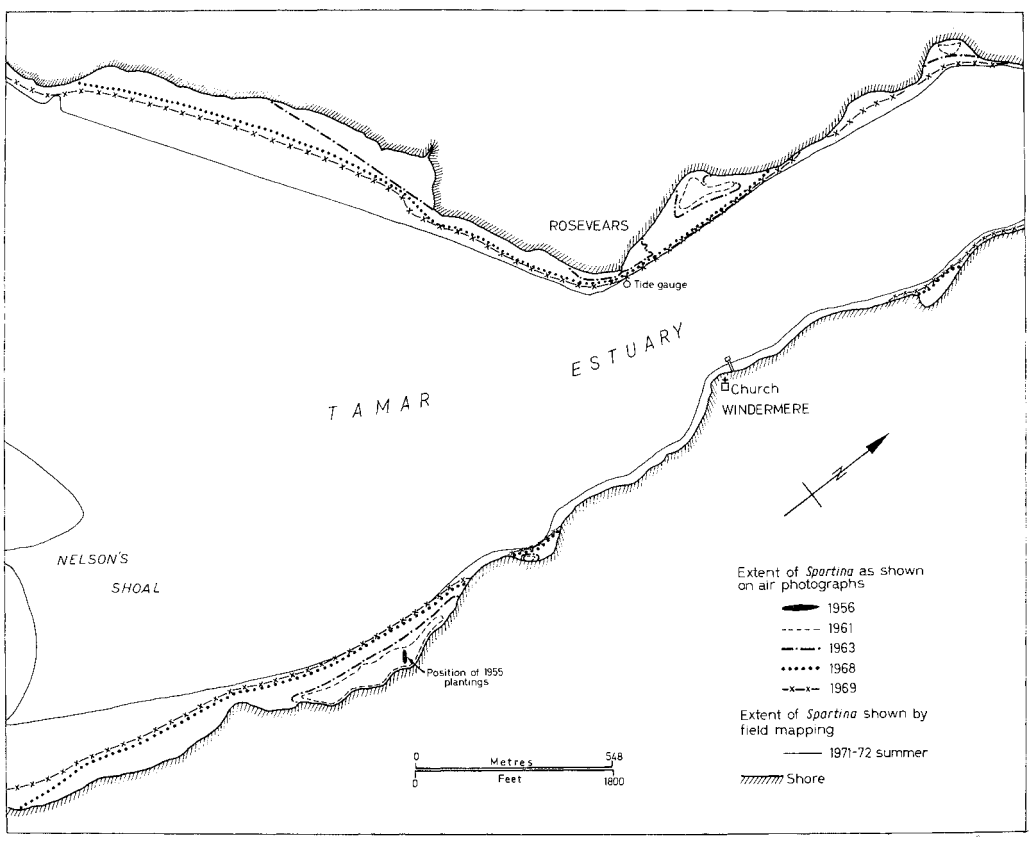


FIG. 2. - Extent of *Spartina*.

The survey of March 1952 fails to show the presence of any *Spartina* although presumably some of the plantings made between 1947 and 1950 at Windermere did survive. The following survey of January 1956 clearly reveals the acre planting at Windermere, made in 1955, but no other areas of growth are shown. The surveys from then onwards however reveal the rapid spread of *Spartina* throughout the whole central section of the estuary. Figure 2 is a plot of the spread in the Windermere and Rosevears areas.

By March 1961 the *Spartina* had spread from the acre (4,047 m^2) planting at Windermere to fill the central section of the embayment where it had been introduced and had appeared in an adjacent embayment. It had also become well established on the west shore of the estuary at Rosevears and Lanena, in sheltered embayments. By the time of the January 1963 survey, in addition to spreading around the previously established growths, it had appeared along further sections of the Rosevears shore and downstream from Native Point on the east shore. During the five years between this survey and that of March 1968 a considerable expansion occurred. By the latter date there was a continuous *Spartina* growth along much of the Windermere and Rosevears shores infilling the embayments and forming a narrow fringe around the small promontories. Upstream, the Legana shore and that around Pedders Point from Dilston almost to Windermere were continuously fringed with *Spartina*. Downstream, embayments between Native Point and Swan Bay and the shore at Gravelly Beach had been colonized.

From the six large scale aerial surveys carried out in March 1969 of limited parts of the Tamar Estuary the extension along the Dilston shore, the west shore between Lanena and Little Swan Point and around Swan Point can be traced. During the summer of 1969/70 four aerial surveys were carried out covering most of the central section of the estuary. They reveal an almost continuous fringe of *Spartina* on the east shore from Dilston to Swan Bay and on the west shore from Dog Point to around Swan Point, interrupted by only short sections where it was absent. In addition, on the east shore *Spartina* was starting to colonize the embayment upstream of Egg Island Point and Spring Bay. The rapid expansion of *Spartina* off Pedders Point on Nelson Shoal is particularly noteworthy at this time.

EXTENT OF *SPARTINA* DURING 1971/72 SUMMER

The distribution of *Spartina* was mapped in the field during the summer of 1971/72 and figure 3 shows the overall pattern. Maps showing the detailed distribution, plotted at a scale of 600 feet:1 inch (1:7,200) are held by the Port of Launceston Authority. For the purposes of field mapping, the *Spartina* was subdivided into areas of continuous sward, separate clumps and isolated shoots.

Not unexpectedly, the sections of shore where an almost continuous fringe of *Spartina* had been shown on the 1969/70 air photographs, by the summer of 1971/72 supported the major areas of continuous sward. The previously short bare sections within this had been colonized by separate clumps and clumps were also extending the continuous sward channelwards in many places. The expansion of *Spartina* on Nelson Shoal had continued at a rapid rate between 1969/70 and 1971/72 to give the most extensive area of continuous sward in the estuary, fringed with a zone of clumps channelwards. Downstream from Swan Point and Swan Bay *Spartina* had extended markedly. Areas of continuous sward were there limited to sheltered bays including that upstream from Egg Island Point and Spring Bay where *Spartina* had been noted in 1969/70. Separate clumps flanked these marshes, and together with isolated shoots formed an intermittent fringe as far downstream as Batman Bridge. Below this the clumps and shoots were found only in sheltered bays as far as Ruffins Bay on the west shore and East Arm on the east shore.

Viewing the distribution of *Spartina* in the summer of 1971/72 generally, two points are striking. Firstly, whereas *Spartina* had spread only 4 miles (6.44 km) upstream from its place of introduction at Windermere it extended downstream for 14

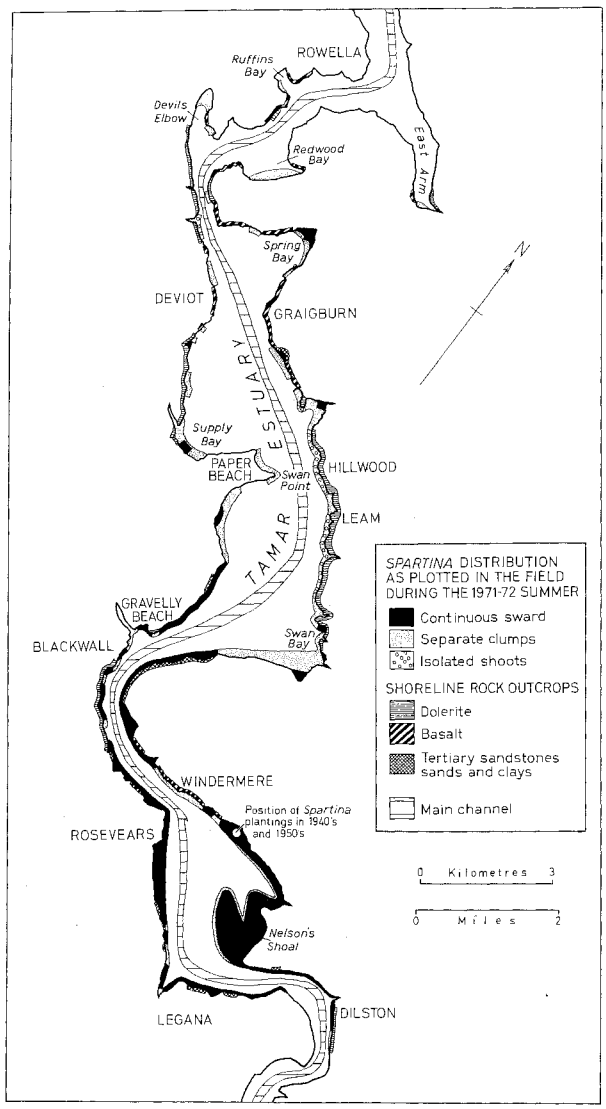


FIG. 3. - *Spartina* distribution and shoreline rock outcrops.

miles (22.54 km). This may be partly explained by the longer period of flow of the ebb tide than the flood, 7 hours as opposed to 6 hours, which will tend to produce a net transport of water, capable of carrying *Spartina* seeds and fragments, downstream. It will also be influenced, mainly indirectly, by salinity and table 2 gives details of measurements taken along the Tamar between September and December 1971.

The uppermost limit of *Spartina* in the Tamar, at Dilston, lay midway between Green Hillock Point and Lone Pine Point, where salinity is very low. Upstream from Dilston extensive areas of *Phragmites* flank both banks of the estuary in that part of the inter-tidal zone which downstream is colonized by *Spartina*. The *Phragmites* growing where low salinity gives way to fresh-water conditions appears to act as a barrier to the spread of *Spartina* upstream. Plantings of *Spartina* were made at an unknown date on the upstream side of Tamar Island, near Green Hillock Point, but these died. A limited, isolated area of plantings, also of unknown date were surviving in a stunted form during the 1971/72 summer at Kelso, near to the Bass Strait entrance to the Tamar. The higher energy conditions in this area are likely to mitigate against the extensive establishment and spread of *Spartina* there. However it seems probable that it will spread further downstream from the main area of colonisation in the central Tamar.

The second noteworthy point relating to the overall distribution pattern is an anomalous section at Windermere adjacent to the area where the original plantings were made, which in 1971/72 was still only colonized by isolated clumps of *Spartina*. Basalt outcrops along this shore as it also does at Hillwood and Deviot where there are gaps in the areas of more recent and sparser colonization.

RATE OF SPREAD OF *SPARTINA*

From the aerial photographs covering most of the central section of the Tamar

during one summer and from the field mapping in the 1971/72 summer the increasing extent of *Spartina* has been measured and details are given in table 3. The spread is plotted in graph form in figure 4.

TABLE 2

CHLORIDE IN G/LITRE

Location	Date			
	15.9.71	2.11.71	12.11.71	15.12.71
Haystack Point	0.0	0.0	0.0	0.0
Green Hillock Point	0.1	0.0	0.0	0.1
Lone Pine Point	3.6	3.8	1.4	4.2
Swan Point	5.4	7.1	3.2	7.3
Batman Bridge	9.7	9.3	9.1	11.4
Big Bay Point	12.1	12.9	12.7	14.3
Beauty Point	15.8	14.2	14.1	15.2
Anchor Point	15.4	15.6	13.9	15.1
Windmill Point	15.9	17.7	19.0	18.4
Shear Rock (Tamar Entrance)	19.0	19.3	19.3	19.3

(By courtesy of the Port of Launceston Authority)

GEOLOGY, SLOPE AND *SPARTINA* COLONIZATION

The section of the Tamar into which *Spartina* has spread is characterised geologically by parallel faulting and marked lithological variations within short distances. The basement rock is Jurassic dolerite, faulted in the late Mesozoic or early Tertiary to produce the Tamar Trough in which silts, sands, clays and gravels were deposited during the Tertiary. Fossil soils, bauxite and ferricrete developed at various levels within the sediments and vulcanism occurred at intervals producing basalt flows.

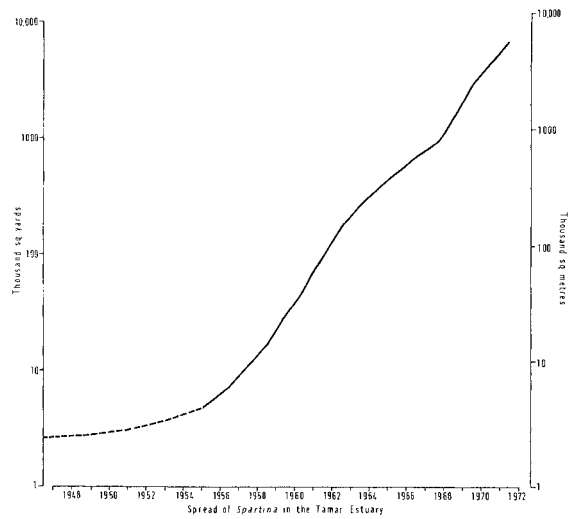


FIG. 4. - Rate of spread of *Spartina*.

Figure 3 shows the outcrops of the different rock groups along the shore where *Spartina* was present during the 1971/72 summer. The dolerite and basalt outcrops produce steep, irregular shores, with small promontories and embayments and angular boulders up to several feet in diameter. On the upstream outcrops of dolerite at Dilston, Lanena and Blackwall, where *Spartina* was present in March 1969, there was a continuous sward or isolated clumps by the 1971/72 summer. Along the dolerite shores downstream between Swan Bay and Egg Island and between Supply Bay and Whirlpool Reach, where no *Spartina* was visible on any of the aerial surveys, clumps and isolated shoots were extensively established by 1971/72. They were denser in sheltered embayments

and hollows where small amounts of mud had accumulated on top of the dolerite, but shoots were establishing in the lee of large boulders where only a thin veneer of mud was present. The sparsity of *Spartina* colonization along the basalt shores contrasts with that along the dolerite shores. Attention has already been drawn to the section at Windermere, adjacent to the area of initial introduction where only isolated clumps were present in 1971/72 and to the downstream outcrops at Hillwood and Deviot where there are gaps in the more recent and generally sparser colonization.

TABLE 3

SPREAD OF *SPARTINA*

Date	Area 1,000 sq. yds.	1,000 sq. metres	
March 1961	60	50.17	continuous sward and separate clumps
January 1963	180	150.50	" "
March 1968	c. 950*	794.30*	" "
Summer 1969/70	2,840	2,374.52	" "
Summer 1971/72	4,090	3,419.65	continuous sward
Summer 1971/72	2,380	1,989.92	separate clumps
Summer 1971/72	170	142.14	isolated shoots
Summer 1971/72	6,640	5,551.70	total

*Rosevears - Blackwall not included in survey, small allowance made in area calculation.

The Tertiary sandstones, sands and clays produce a smoother, more regular shore of lower gradient. Along the earlier colonized, upstream outcrops, *Spartina* by 1971/72, formed a continuous marsh and in the downstream more recently colonized areas over half these outcrops had isolated clumps and shoots growing on them. In places the *Spartina* roots were penetrating into the weathered rocks, especially the clays, and elsewhere the *Spartina* was rooted in overlying sediments.

Ferricrete outcrops along many parts of the shores of the Tamar in association with any of the other rock types. It characteristically forms extensive "pavements", which may be bare or only thinly veneered with fine sediments. *Spartina* is able to establish in small pockets of sediment and as it traps more sediment so it spreads over the "pavement". *Spartina*, in 1971/72, was found on ferricrete as a continuous sward, separate clumps or isolated shoots, the length of time since initial colonization apparently determining the form.

The most extensive accumulations of fine sediment overlying the rock outcrops are found upstream from Windermere and including Nelson Shoal, at Rosevears and between Gravelly Beach and Swan Point where they produce intertidal areas of very low gradient. In the first of these areas a very rapid rate of colonization has occurred since 1968 to give the largest continuous *Spartina* sward in the estuary.

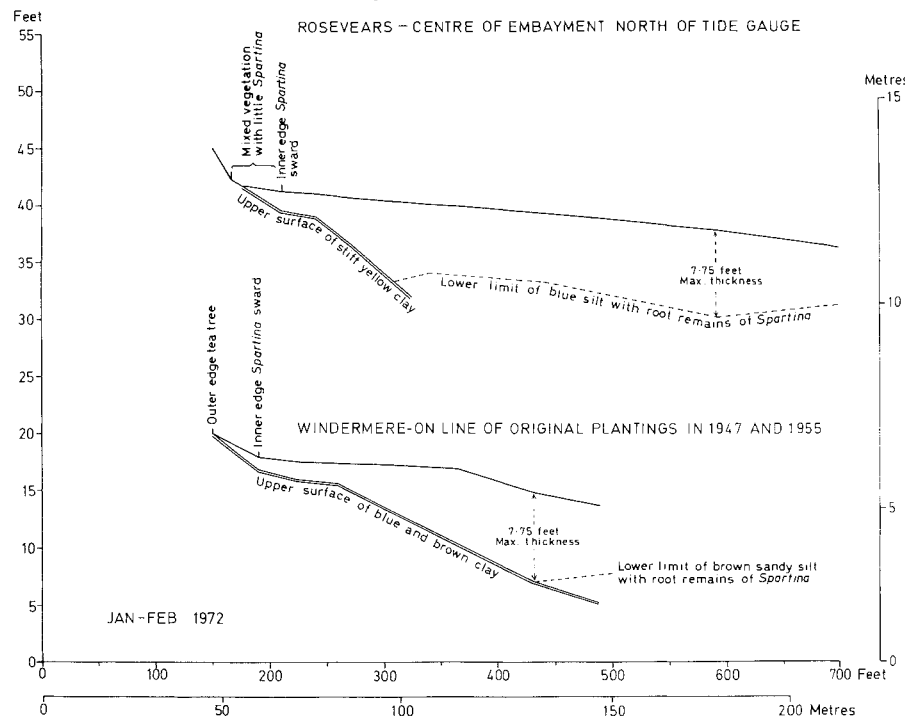
Measurements of the slope of the intertidal zone where *Spartina* is growing show that it is capable of colonizing slopes of up to 28° at least, and there are therefore probably none around the Tamar estuary unsuitable for it. Clumps and shoots were found on slopes ranging from 1° to 28° with an average of 5.6°. As *Spartina* begins to trap silt, so the slope begins to decrease. Slope measurements in the continuous *Spartina* swards show them to range between 1° and 14° with an average of 2.2°. The steeper slopes are found in the narrow belts of continuous sward, colonizing dolerite

outcrops as at Dilston, or found where the main channel lies close to the bank as around Crescent Shore and at Dilston. The lowest angle slopes are found in the broad mature swards as on Nelson Shoal and in many embayments.

RELATIONSHIP BETWEEN *SPARTINA* AND TIDAL INUNDATION

In the longest established *Spartina* marshes, it has extended down to approximately 4 feet (1.20 m) and up to approximately 10 feet (3.05 m) above George Town Chart Datum. The semi-diurnal components within the diurnal tidal regime produce the following sequence of tides: low low, low high, high low, high high, with successive high tides having only about half the vertical difference experienced by successive low tides. Only during the minimum neap tides does the high high tide fail to cover the uppermost part of the *Spartina* marsh diurnally, and during spring tides the high high and low high tides will submerge the whole marsh semi-diurnally. The lowest area of the *Spartina* is exposed semi-diurnally except during the minimum neap tides when the high low tide is above the lower limits of the grass.

Initial *Spartina* colonization takes place generally in the upper part of the intertidal zone, the shoots and clumps coalesce to give a continuous sward there first and its lower edge with a fringe of clumps and shoots then advances towards low water mark.



SECTION THROUGH THE *SPARTINA* SWARDS AT ROSEVEARS AND WINDERMERE

FIGURE 5.

SEDIMENTATION IN THE OLDEST *SPARTINA* MARSHES AT WINDERMERE AND ROSEVEARS

In order to investigate the sedimentation associated with the introduction of *Spartina* into the Tamar Estuary a series of bores were put down along transects at

right angles to the shore at Windermere and Rosevears. The transect at Windermere passed through the position of the acre (4,047 m^2) of plantings carried out in 1955, and that at Rosevears through the area where *Spartina* has been present since 1961 as shown on the aerial photographs. Figure 5 shows the results obtained from these bores.

At Windermere the top of the blue and brown clay which earlier must have formed the surface was easily located. Above this a brown sandy silt had accumulated in the continuous *Spartina* sward and root remains were found down to a maximum depth of 7.75 feet (2.35 m) at a distance of 243 feet (74.73 m) from the inner edge of the *Spartina*. Channelwards a greater depth of sedimentation was recorded above the clay surface but root remains of *Spartina* were found at increasingly shallow depths until at the outer margin of the sward they were found only to a depth of 6 feet (1.83 m).

At Rosevears the earlier surface was cut in a stiff yellow clay. Because this surface sloped relatively steeply, it was traced in the bores only to a distance of 100 feet (30.5 m) from the inner edge of the *Spartina* sward, where it was 7 feet (2.13 m) below the present marsh surface. The blue silt which had accumulated above this and continued channelwards contained root remains of *Spartina* down to a maximum depth of 5 feet (1.53 m) at Rosevears.

CONCLUSIONS

Despite the very slow growth of the early plantings of *Spartina* during the 1940's and mid 1950's, subsequently the introduction has proved highly successful. *Spartina anglica* is clearly well suited to ecological conditions in the Tamar, as is shown by its rapid increase in area by spreading from established colonies, seeding and growth of broken fragments. It is capable of colonizing the fine sediments and outcrops of dolerite, basalt, sandstones, sands, clays and ferricrete which at present form the shores and intertidal zone of the Tamar. The fine sediments however appear to provide the most favourable substrate and the basalts the least suitable. None of the range of slopes from 1^{o} to 28^{o} measured in the intertidal zone precludes colonization. The tidal regime provides a vertical range of about 6 feet (1.83 m) towards the upper part of the intertidal zone where frequency and duration of inundation and emergence are suitable for *Spartina* growth.

The initial aim in introducing *Spartina*, the stabilization of the mud banks and the safeguarding of the navigable channel in the Windermere and Rosevears area has undoubtedly been achieved. A similar effect has resulted in many other parts of the estuary. Not only have the banks been stabilized by the colonization of *Spartina* they have also been raised markedly in height as has been demonstrated at Windermere and Rosevears. They are therefore subject to less frequent and shorter periods of tidal inundation, and the tidal streams are more confined in the main channel.

However, the rapid spread of *Spartina*, generally indiscriminate of substrate and degree of slope within much of the intertidal zone has caused problems. A number of sand beaches with recreational facilities or potential have been at least partly invaded by *Spartina* and many private jetties have become useless as it has spread around them. Despite experimentation with a range of herbicides, which have proved a successful means of controlling *Spartina* in other parts of the world none had been successful up to 1972 in the particular range of ecological conditions found in the Tamar.

ACKNOWLEDGEMENTS

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