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The Benthic Biotopes of South West Arm, Port Hacking, N.S.W., 1975

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THE BENTHIC BIOTOPES OF SOUTH WEST ARM, PORT HACKING, N.S.W., 1975

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Abstract

The distribution in South West Arm of the main substrate types and of the benthic macroflora and fauna was determined from a diving survey in 1975 along 76 subtidal transects. The slope between the intertidal zone and the central basin included some exposed bedrock, otherwise varying from sandy-silt around the central basin to well-sorted fine sand on the entrance sill and the mouth of South West Arm Creek. The surface sediments of the central basin were largely unconsolidated, forming a gelatinous mud. The biomass and diversity of the macrobenthos was greatest between the intertidal zone and 5 m below datum; the macrobenthos was relatively less diverse on slopes deeper than 5 m, and no organisms were apparent in the mud of the central basin. Seagrasses covered about 12% of the total area, with *Posidonia australis* being the dominant species. Macroalgae were present between the intertidal zone and about 6 m. Live benthic macrofauna were found down to about 12 m, while a wide variety of fish was noted on most transects.

INTRODUCTION

The Port Hacking Project (CSIRO 1976) was initiated as part of a general study of estuarine processes, including the development of a carbon budget. Much of the research effort was concentrated in South West Arm, a drowned river valley lying within the Royal National Park at about 37°05'S, 151°06'W (Fig. 1). South West Arm is about 1 km^2 in area, with a central basin up to 20 m deep and with a shallow entrance sill. There is a shallow sandflat at the mouth of South West Arm Creek and several small beaches along the sides, which otherwise slope steeply from eucalyptus forest on Hawkesbury Sandstone. The bottom is an apparently homogeneous area of unconsolidated mud.

The benthic ecology of estuarine habitats in New South Wales is known in general terms from publications by Dakin (1960), Hutchings and Recher (1974), Weate and Hutchings (1977), Hutchings *et al.* (1978) and others. Information on the benthos of Port Hacking is largely restricted to the intertidal fauna and flora (Collins 1921; Dakin 1960; CSIRO 1967). Some information on the seagrasses is provided in CSIRO (1976), and on the subtidal macrobenthos by Rainer (1979), while Colquhoun-Kerr (1977) has estimated the contribution of oysters and mussels to benthic production.

A survey of the benthic biotopes in South West Arm was made during March 1975 to provide a basic framework for a more detailed investigation of macrobenthic production for input to the carbon model. The survey was to determine the areas of major sediment types and of seagrasses, and to investigate whether there were any major differences within South West Arm in the distribution of the larger benthic animals and plants. A preliminary report of the biotope survey was given in CSIRO (1976).

METHODS

Seventy-six transects were laid down around the shoreline and across the sill of South West Arm at approximately 100 m intervals, using weighted lines 100 m long. The transects were laid approximately normal to the shoreline, and extended from about mean high water to a maximum depth of 17.8 m below datum. Distances from the shoreline were marked at 1 m intervals; depths at the offshore end of each transect were measured by shotline; depths along each transect were measured by calibrated diver's depth gauges. Depths were adjusted to datum using tidal curves obtained each day from a tide gauge at the mouth of South West Arm.

Written notes on depth, distance along the transect line, substrate type and the macroflora and fauna were made by SCUBA divers while swimming along each transect. The resulting profiles of sediment type and seagrass cover at different depths (Figs 4-21) were used to determine the approximate area of major sediment types in South West Arm, and the area covered by seagrasses. Nineteen transects were sampled on 10-11 March 1975 before underwater visibility was reduced to near-zero by freshwater runoff from a prolonged rainstorm. These transects were repeated when the survey was finally carried out during 20-27 March 1975, which also provided a basis for observing the effect of freshwater runoff on the nearsurface fauna and flora.

RESULTS

Substrate types

The intertidal regions of South West Arm vary from rock walls and ledges to gently sloping sand or muddy sand beaches. Subtidally the sides slope fairly steeply to a central basin varying in depth from 4.6 m below datum near the head of South West Arm (transect 30) to over 17.8 m towards the sill (transect 69). The sides of the basin are usually clearly demarcated from the central area by a sharp increase in slope and by having relatively firm sediments, and extend down as far as 16.0 m below datum (transect 69). The slope of the sides may be 10° or more, and the sediments range from sandy silt near the central basin to fine well-sorted sand on the entrance sill and in the creek mouth. Considerable surface detritus may be present, particularly in the denser seagrass beds. The sides are broken in places by series of rocky ledges and overhangs at various depths between 15.3 m (transect 60) and the surface. The ledges are often covered by a few centimetres of silty sediment, while the faces usually have a narrow band of calcareous material deposited below them. The sediments of the central basin are very fine, forming a gelatinous mud.

The distribution of major sediment types in South West Arm (Fig. 2) indicates that deposit substrates occupy by far the greatest area, with exposed bedrock occupying approximately 3.5% of the total (Table 1). The unconsolidated silts of the central area occupy just over half of the total area, while predominantly sandy sediments of the slope occupy most of the remaining area.

Plants

On hard surfaces the most conspicuous species were brown algae. *Hormosira banksii* was abundant in the lower mid-littoral, *Ecklonia radiata* occurred occasionally between low water and about 2 m below datum, while *Sargassum* sp. and *Macrocystis pyrifera* were found down to 5 m below low water. Vertical faces below low water were covered with a variety of small red and brown algae, including *Padina* sp., encrusting and branched corallines, and many small mat-forming species. No algae were found under overhangs or below 10 m depth.

Deposit substrates were dominated by the three seagrasses *Zostera capricorni*, *Posidonia australis* and

Table 1. Areas and relative proportions of major substrate types in South West Arm.

Substrate	Area	
	Actual (ha)	Proportion (%) of total
Unconsolidated silt	46.3	52.6
Sand	30.2	34.3
Shell	8.4	9.5
Bedrock	3.1	3.5
Total	88.0	100.0

Table 2. Areas and relative proportions of seagrass species in South West Arm.

Seagrass	Area	
	Actual (ha)	Proportion (%) of total
Zostera capricorni	3.6	34
Posidonia australis	6.1	58
Halophila ovalis	0.8	8
Total	10.6	100

Halophila ovalis (Fig. 3, Table 2) and by the sheet-forming green alga *Ulva lactuca*. *Zostera capricorni* occurred around low water level, occasionally down to 2 m depth; it was abundant on the sea flats at the head of South West Arm, but was also found in the more sheltered areas along the sides of South West Arm. *Posidonia australis* usually occurred below *Z. capricorni*, usually down to 2-3 m depth but occasionally occurring as deep as 5 m; its abundance was greatest at the mouth of South West Arm, although it was present on most transects along the sides of South West Arm. The smaller *H. ovalis* occurred in patches in most shallow areas in South West Arm, usually below *P. australis* at depths of 2.0-5.8 m, but occasionally occurring near low water.

Kirkman (personal communication) has found *H. decipiens* in South West Arm, growing below *P. australis*. Although *H. decipiens* was not recorded in this survey, references to *H. ovalis* in deeper water in this report may include some *H. decipiens*.

Ulva lactuca was often abundant along the sides of South West Arm, occcurring from the lower intertidal to down as far as 7.5 m, commonly down to 3-5 m below low water. Below this depth it was present only in small fragments, probably representing material carried down from shallower water; above this depth it often covered completely the underlying sediment or seagrass. Other algae present on soft substrates included *Sargassum* sp., occurring occasionally between 0-6 m, *Caulerpa* sp., found between 5-8 m, and a number of small filamentous or finely-branched red algae between 6-8 m. No algae were found on deposit substrates below 8 m.

Animals

Intertidal hard substrates were dominated by the Sydney rock oyster *Saccostrea commercialis*. Between low water and 2 m depth, rock surfaces were often completely covered by the hairy mussel *Trichomya hirsuta*. A wide variety of animals was found on vertical faces, with at least a dozen species of sponges, many species of hydroids, the cup coral *Culicia* sp. and the colonial coral *Plesiastrea* sp., sabellid and serpulid polychaetes, sometimes extensive sheets of the acorn barnacle *Balanus* sp., erect and encrusting bryozoans, and at least seven species of solitary and compound ascidians. The fauna under overhangs was similar, while in water below 10 m the overall richness was reduced, and faces at about 15 m depth had only one or two species present (usually including *Balanus* sp.). The fauna was generally restricted where there was any amount of silt present, when the dominant species were massive or branching forms of sponge and the sessile ascidian *Pyura stolonifera*. The blue mussel *Mytilus edulis* was often found intermixed with the deepest members of *Trichomya hirsuta*.

The macrofauna of deposit substrates was largely infaunal, with the main epifaunal organisms being asteroid starfish (*Patiriella* sp., *Astropecten polyacanthus* and *Coscinasterias calamaria*) and the occasional large sponge, mud oyster (*Ostrea* sp.), scallop (*Pecten* sp.) and sea tulip (*Pyura pachydermatina*). Infaunal species particularly in evidence from the abundance of surface burrows included the bivalve *Theora fragilis*, the polychaetes *Australonereis ehlersi*, *Chaetopterus variopedatus*, *Spiochaetopterus* sp. and *Arenicola* sp., the ghost shrimp *Callianassa arenosa* and the heart urchin *Echinocardium cordatum*. Both *Australonereis ehlersi* and *Arenicola* sp. were most abundant in the sand flat near the mouth of South West Arm Creek, while *Theora fragilis* and *Echinocardium cordatum* were commonest in the deeper silty sediments around the central basin. *Theora fragilis* was abundant in slightly finer sediment than *E. cordatum*, and tended to be found at slightly greater depths.

Schooling and individual fish were observed on most transects (Table 3), as well as the occasional cuttlefish (*Sepia liliana*, *Sepiola* sp.). The records made were inadequate to determine if the distribution of the various species differed around South West Arm.

The shallow water fauna may be affected by changes in salinity associated with periods of heavy rainfall. During the first attempt to survey South West Arm on 10-11 March 1975 there was sufficient freshwater input from the Hacking River and from South West Arm Creek to create a strong interface between resident and overlying reduced-salinity water at about 2 m depth. The residual effect of the freshwater input was seen on a number of shallow rock faces, where sponges and colonial ascidians that had been present during the initial survey of the first 18 transects were present only as disintegrating remnants.

The fauna of the deeper areas is apparently strongly affected by the periodic deoxygenation of the bottom and near-bottom water noted in South West Arm (CSIRO 1976). Many of the rocky faces below 10 m had no live macrofaunal cover, although the rock surface was completely covered by dead specimens of *Balanus* sp. At the time of the survey a pool of deoxygenated water was present below about 17 m. No trace of live macrofauna was found below this depth, which was delineated by the absence of the usual covering of the sulphur-reducing bacterium *Desulphovibrio* sp. except on projecting twigs or branches sticking out of the silt. Patches of *Desulphovibrio* sp. were present on the surface of the mud between 16.6-16.9 m, and completely covered the surface of the mud from this point to the edge of the slope. Abundant dead *Theora fragilis* (> 100 m^{-2}) were present above about 14.3-14.4 m (transects 66, 69), while dead *Echinocardium cordatum* were present on the surface of the sediment at about 13.2-13.4 m. At this depth most *T. fragilis* were alive, in their usual subsurface position, and apparently siphoning actively. Above 12.3 m, both living and dead *E. cordatum* were present on the surface of the sediment, while a number of burrowing specimens were also noted.

Table 3. Fishes recorded in the 1975 South West Arm biotope survey.

torpedo ray	*Hypnarche subnigra*
stingray	*Urolophus testaceus*
fortesque	*Centropogon australis*
flathead	*Platycephalus* sp.
perchlet	*Velambassis jacksoniensis*
trumpeter	*Pelates quadrilineatus*
old wife	*Enoplosus armatus*
yellow tail	*Trachurus declivis*
trevally	*Caranx georgianus*
silver biddy	*Gerres ovatus*
bream	*Acanthopagrus australis*
snapper	*Pagrosomus auratus*
butter fish	*Sciaena antarctica*
goat fish	*Upeneus* sp.
magpie morwong	*Cheilodactylus gibbosus*
mado	*Atypichthys strigatus*
butter bream	*Monodactylus argenteus*
blackfish	*Girella tricuspidata*
stripey	*Micracanthus strigatus*
mullet	*Mugil cephalus*
blennies	*Dasson lupus*, etc.
gobies	*Arenigobius bifrenatus*
	Bathygobius kreffti
	Favonigobius exquisitus
	F. lateralis
flounder	? *Rhombosolea tapirina*
sole	*Pardachirus hedleyi*
leather jackets	*Brachyleuteres jacksoniensis*
	Meuschenia trachylepis
	Monacanthus chinensis
	Paramonacanthus oblongus otisensis
toado	*Torquigener hamiltoni*
porcupine fish	*Dicotylichthys myersi*

DISCUSSION

The present assessment of the topography, substrate characteristics and benthic organisms, while largely qualitative, indicates some general features of benthic diversity and production in South West Arm. Fresh-water input is negligible at most times of the year, and the flora and fauna of the intertidal and shallow subtidal areas are usually diverse. In deeper water, particularly in the central basin, the combined effects of low light intensity, fine sediments and periodic deoxygenation of the overlying waters (CSIRO 1976) are to reduce diversity substantially.

The abundance of the macroflora, particularly seagrasses, is greatest in the shallow water areas of South West Arm, and it is likely that benthic primary production is greatest in these areas also. Similarly, the biomass of the macrofauna is greater on the sides of South West Arm than in the central basin, and it is also likely that the greatest secondary production occurs on the sides rather than in the central area. The pattern of secondary production in deeper water is likely to be highly variable, with periods of high production associated with the settlement and growth of opportunistic species alternating with short periods of little or no production at times when the overlying water is anoxic.

The survey was made shortly after a period of reduced salinities and when the bottom water had become anoxic. Such catastrophic events are a common occurrence in South West Arm and will result in considerable mortality among stenohaline species in the near-surface waters and among sessile macrobenthic species in and around the central basin. The density of the macrofauna is low in the central basin, but may be considerably higher in the more compacted sediments around the central basin. The reduction in diversity of the macrofauna below 10 m is in accordance with other observations that deoxygenation of the bottom water occurred below 10 m (Scott 1978). Together, the central basin and the slopes below 10 m comprise more than half the total area of South West Arm, and would contain a significant proportion of the total benthic biomass. While the severity of mortality from catastrophic events will vary at different times, they may provide a mechanism for the rapid release of substantial amounts of carbon from the macrobenthos, and should be an important consideration in the development of a carbon model of ecosystems such as South West Arm.

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The diving and transect-laying operations of the biotope survey would not have been possible without the participation of many people. The following, members of CSIRO Division of Fisheries and Oceanography except where noted otherwise, are gratefully thanked for their assistance: Ms A. Bothwell, N. Bulleid, S. Crane, W. Fitzgerald, F. Griffiths, H. Higgins, H. Kirkman, Dr R. Parker, C. Purday, R. Rose, B. Scott, P. Straw (NSW State Fisheries), D. Tranter, Ms V. Wadley and Dr P. Young. I also thank R. McRae and M. Paul for technical assistance.

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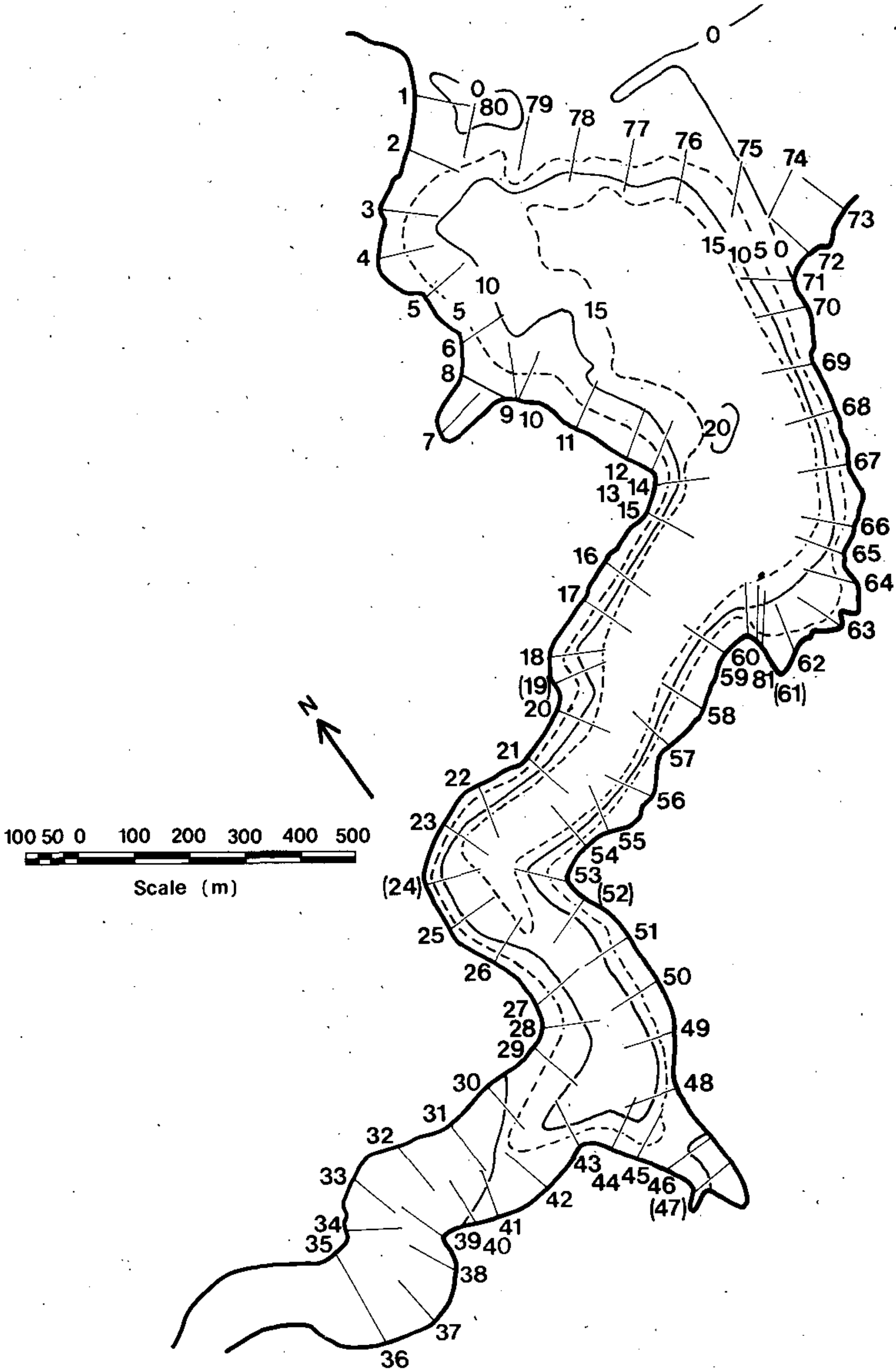

Figure 1. Bathymetry of South West Arm and location of transects 1-81. Depth contours are at 5 m intervals from chart datum; transect numbers in parentheses indicate transects for which no data were available.

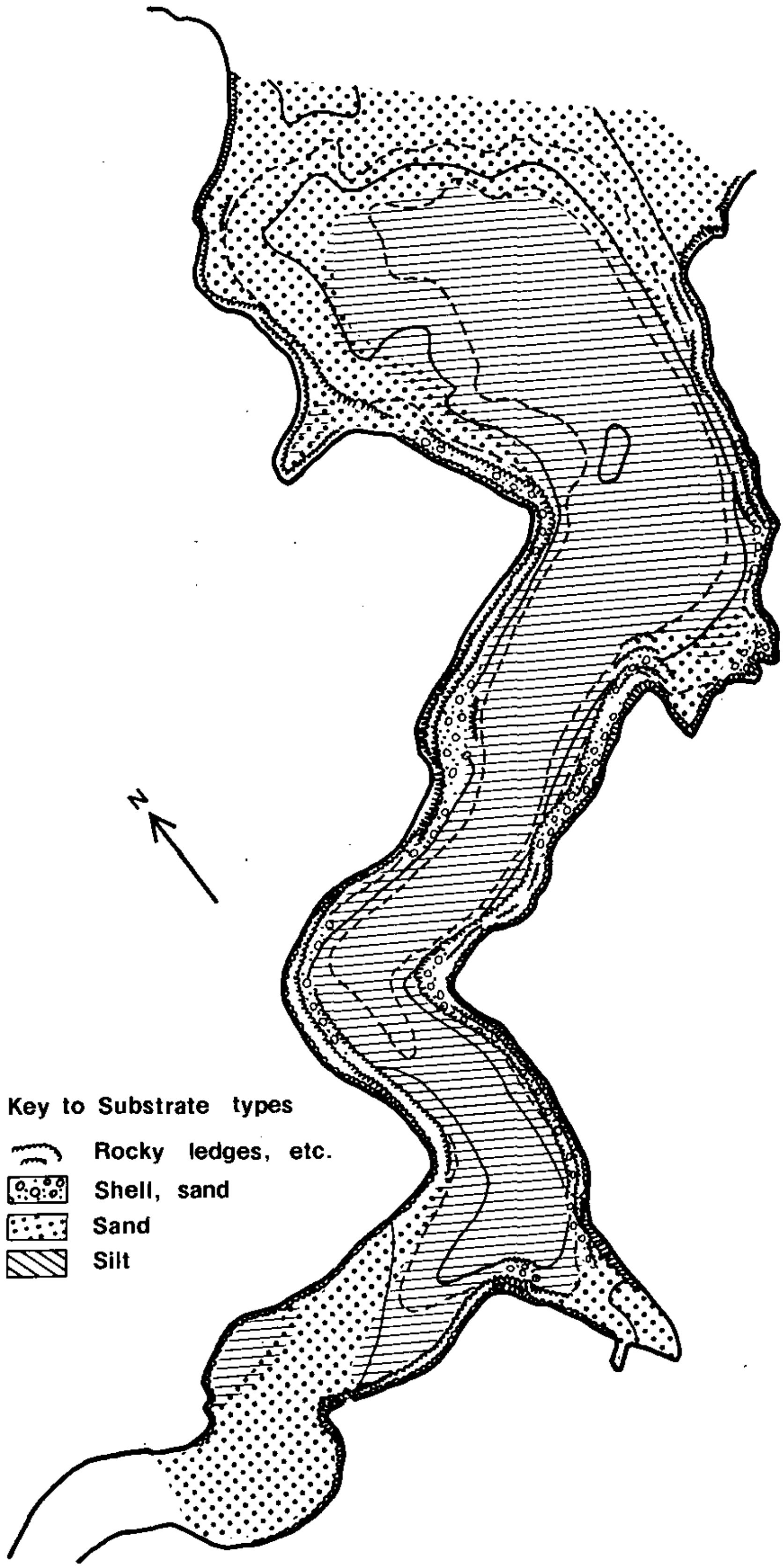

Figure 2. Main substratum types at South West Arm, determined from the transects of Fig. 1. Depth contours are those of Fig. 1.

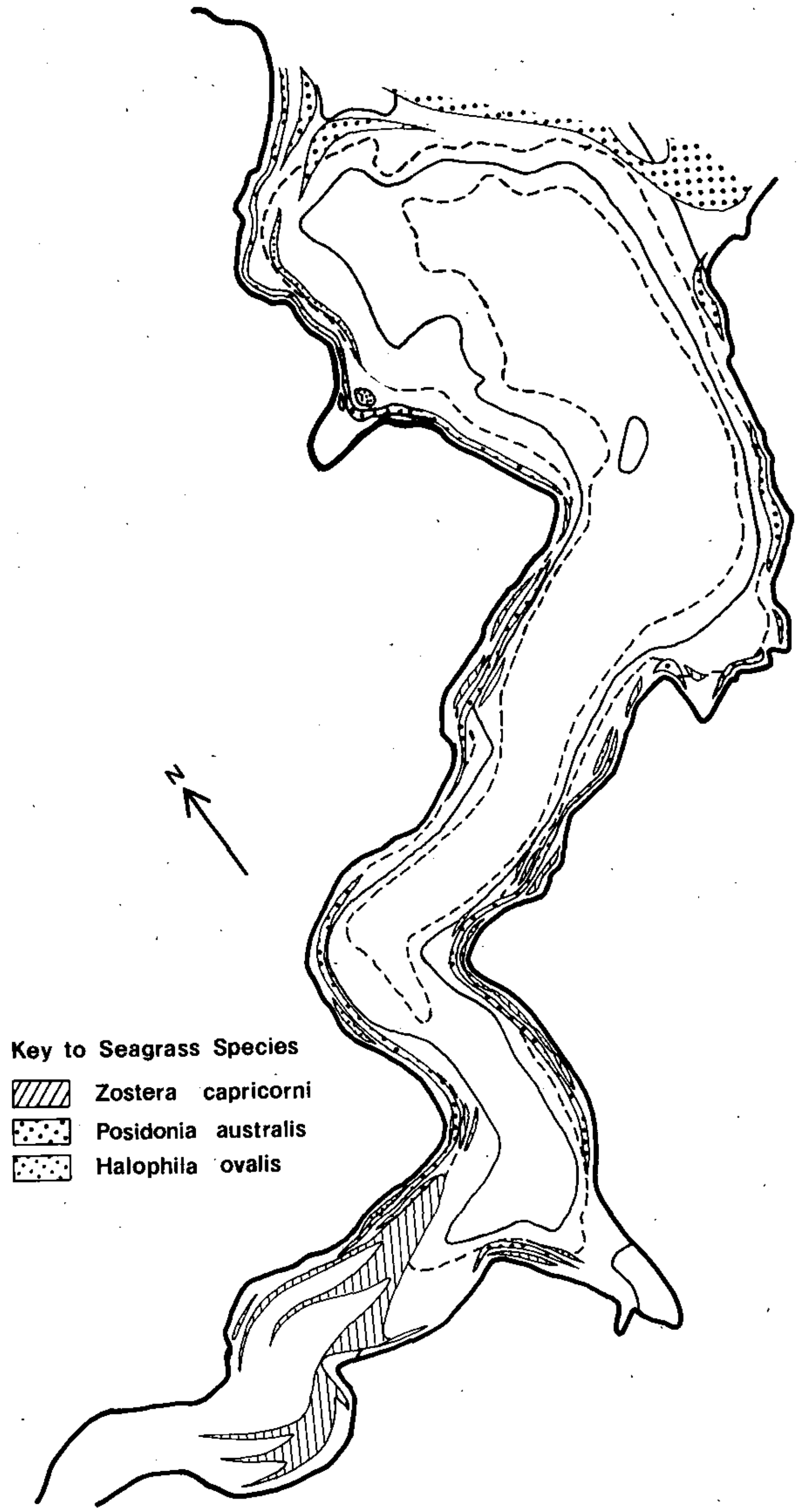

Figure 3. Distribution of seagrass species in South West Arm. Depth contours are those of Fig. 1.

Figure 3a. Key to Figures 4-22: substratum types and seagrass species.

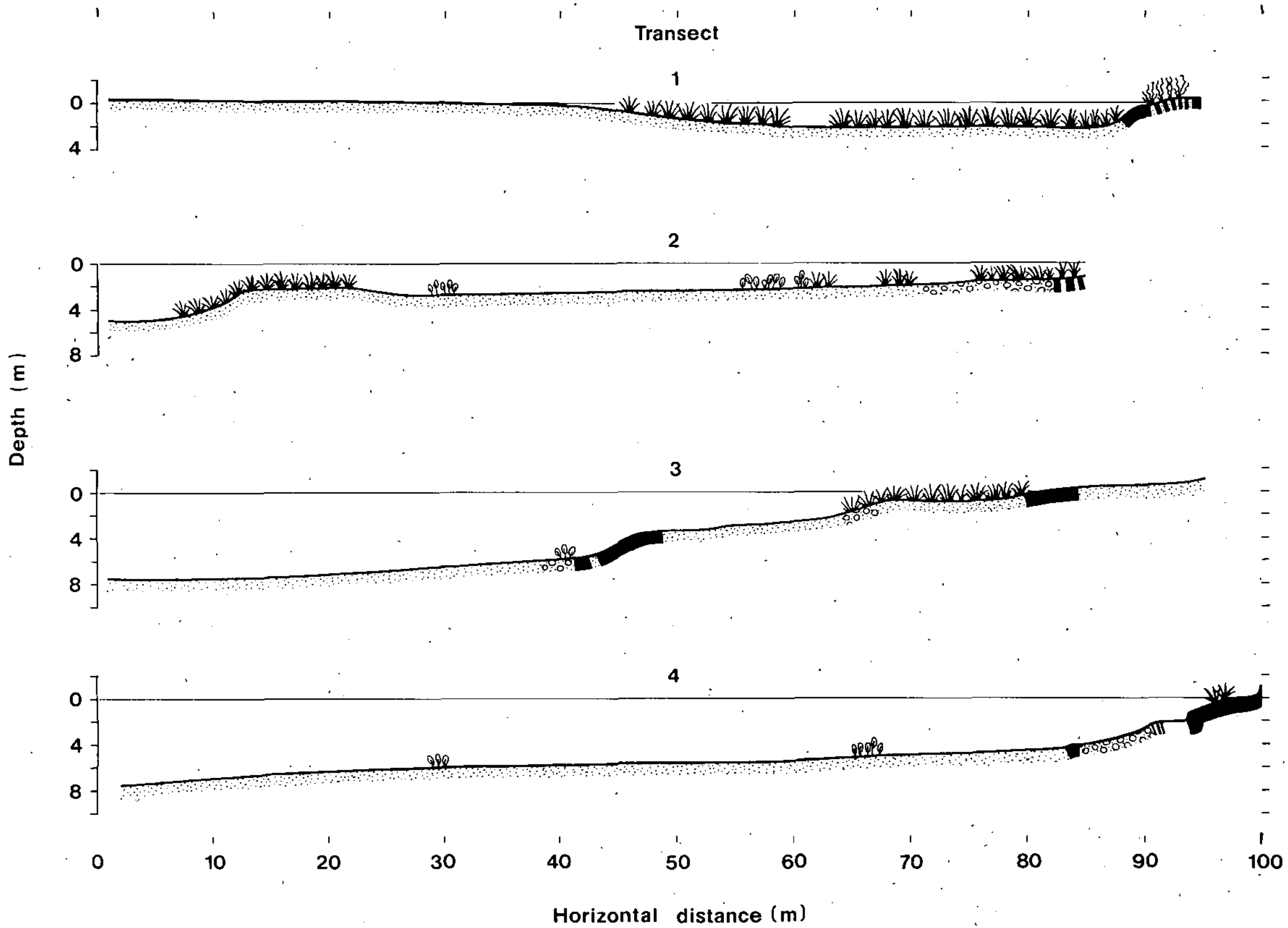

Figure 4. Depth profile, substratum type and seagrass species. Transects 1-4.

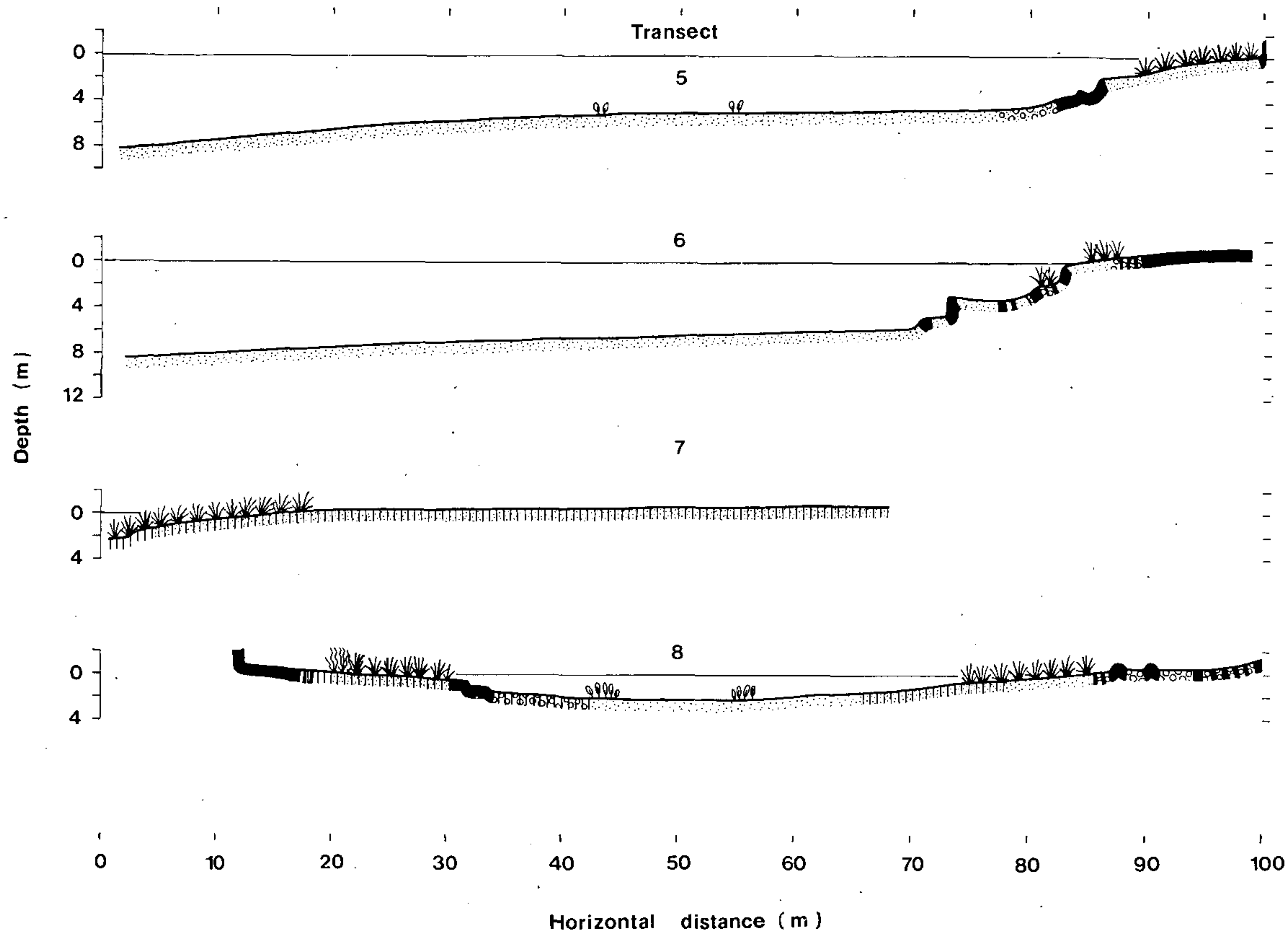

Figure 5. Depth profile, substratum type and seagrass species. Transects 5-8.

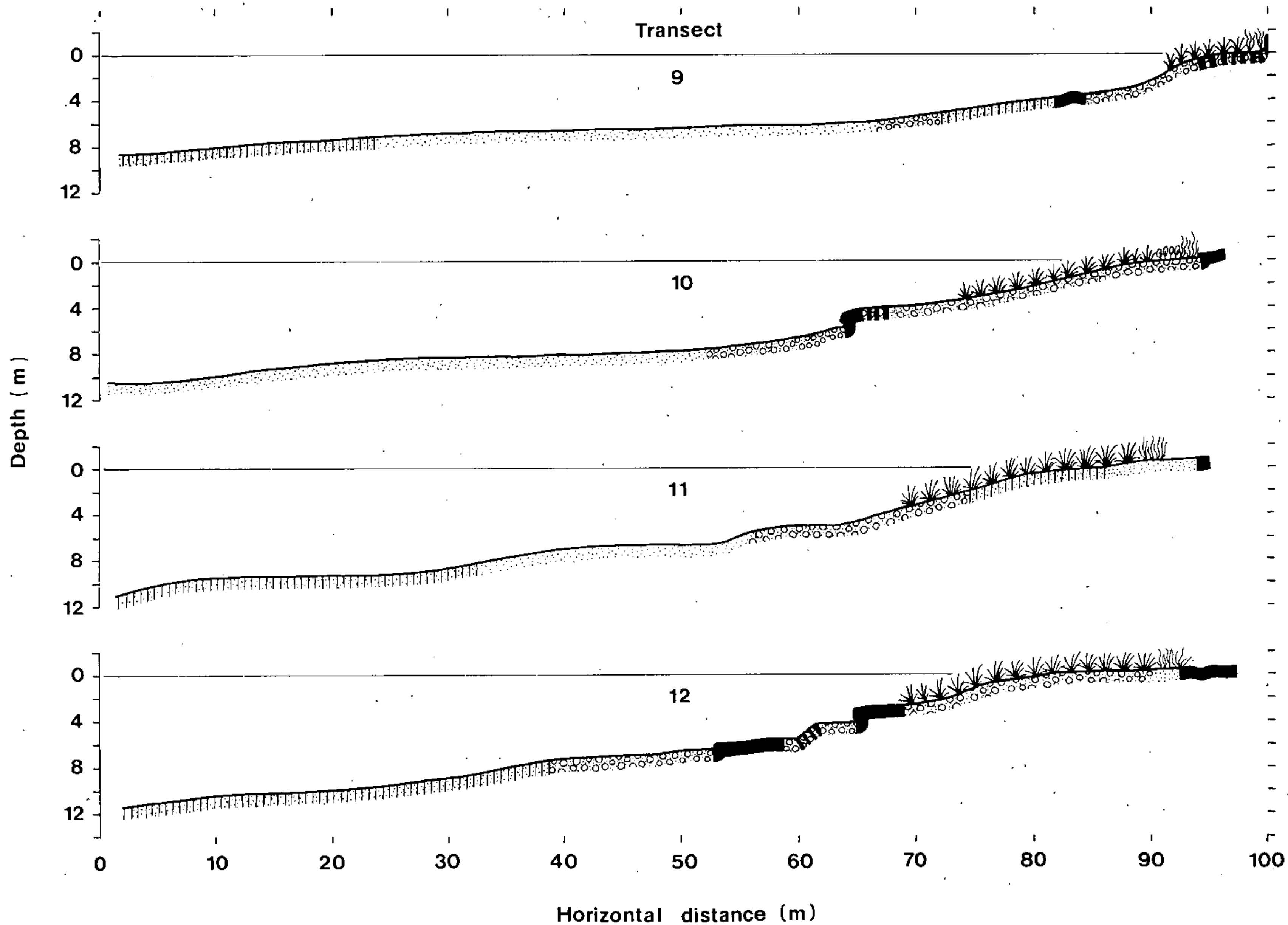

Figure 6. Depth profile, substratum type and seagrass species.
Transects 9-12.

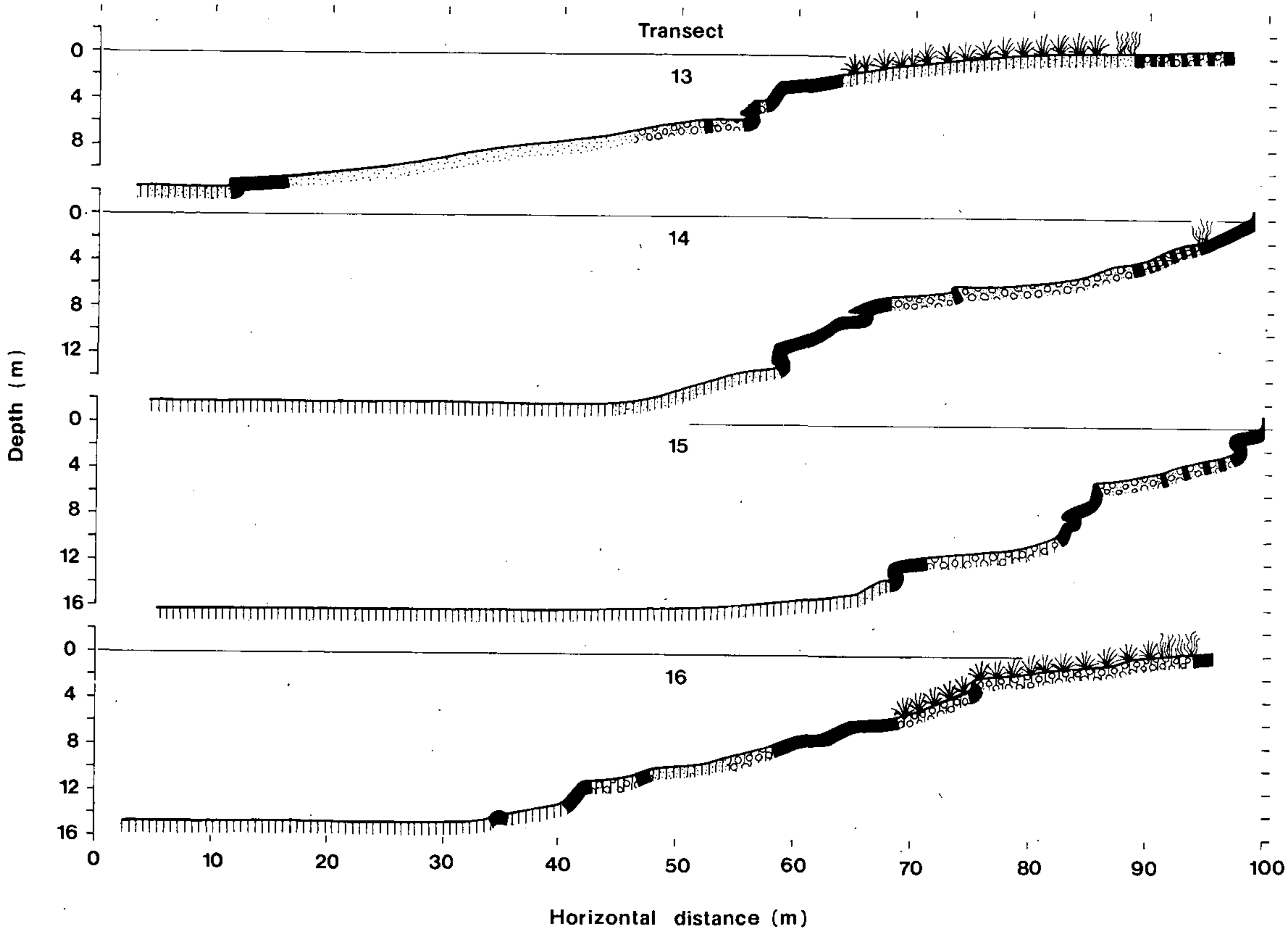

Figure 7. Depth profile, substratum type and seagrass species.
Transects 13-16.

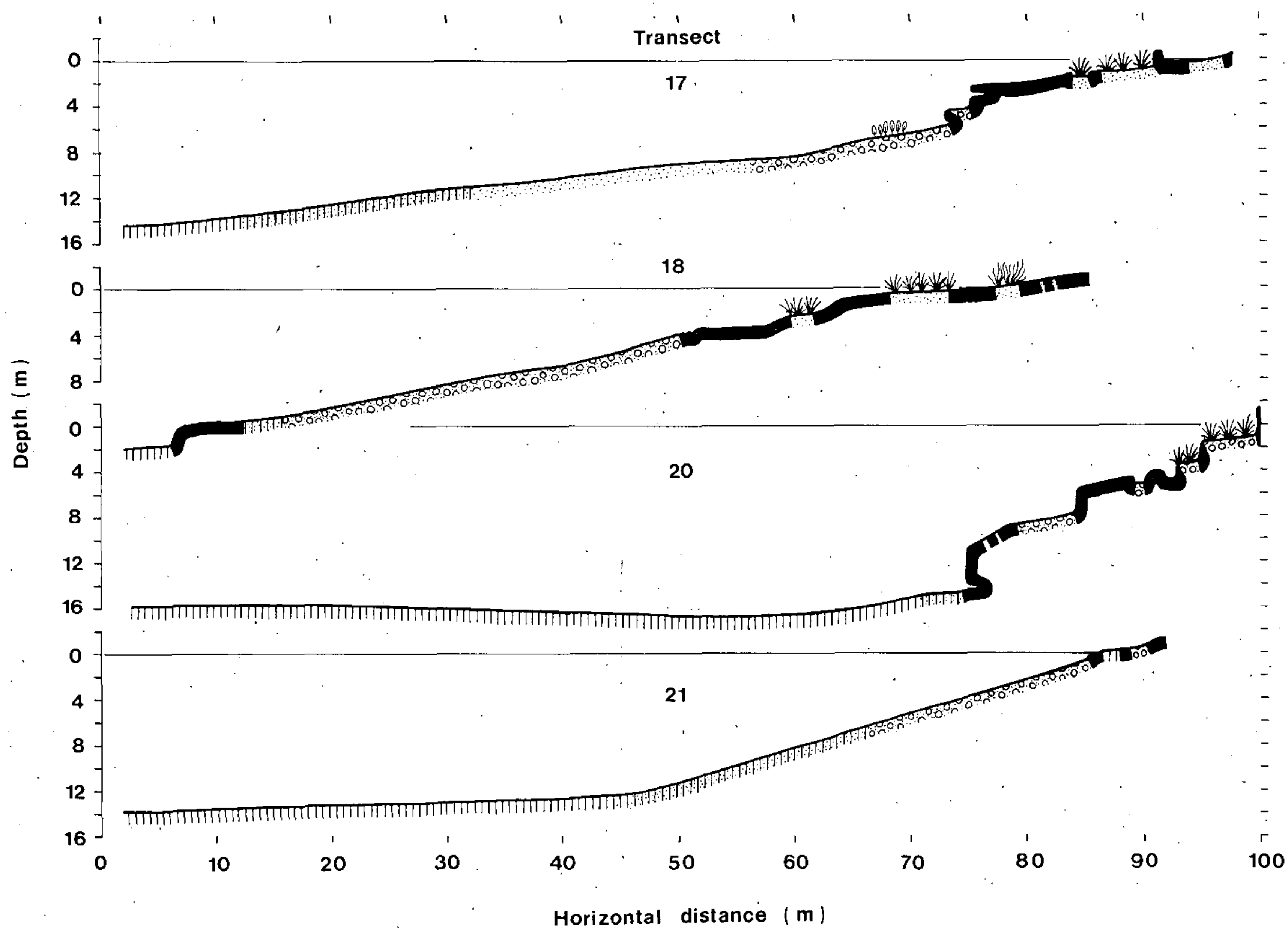

Figure 8. Depth profile, substratum type and seagrass species. Transects 17,18,20,21.

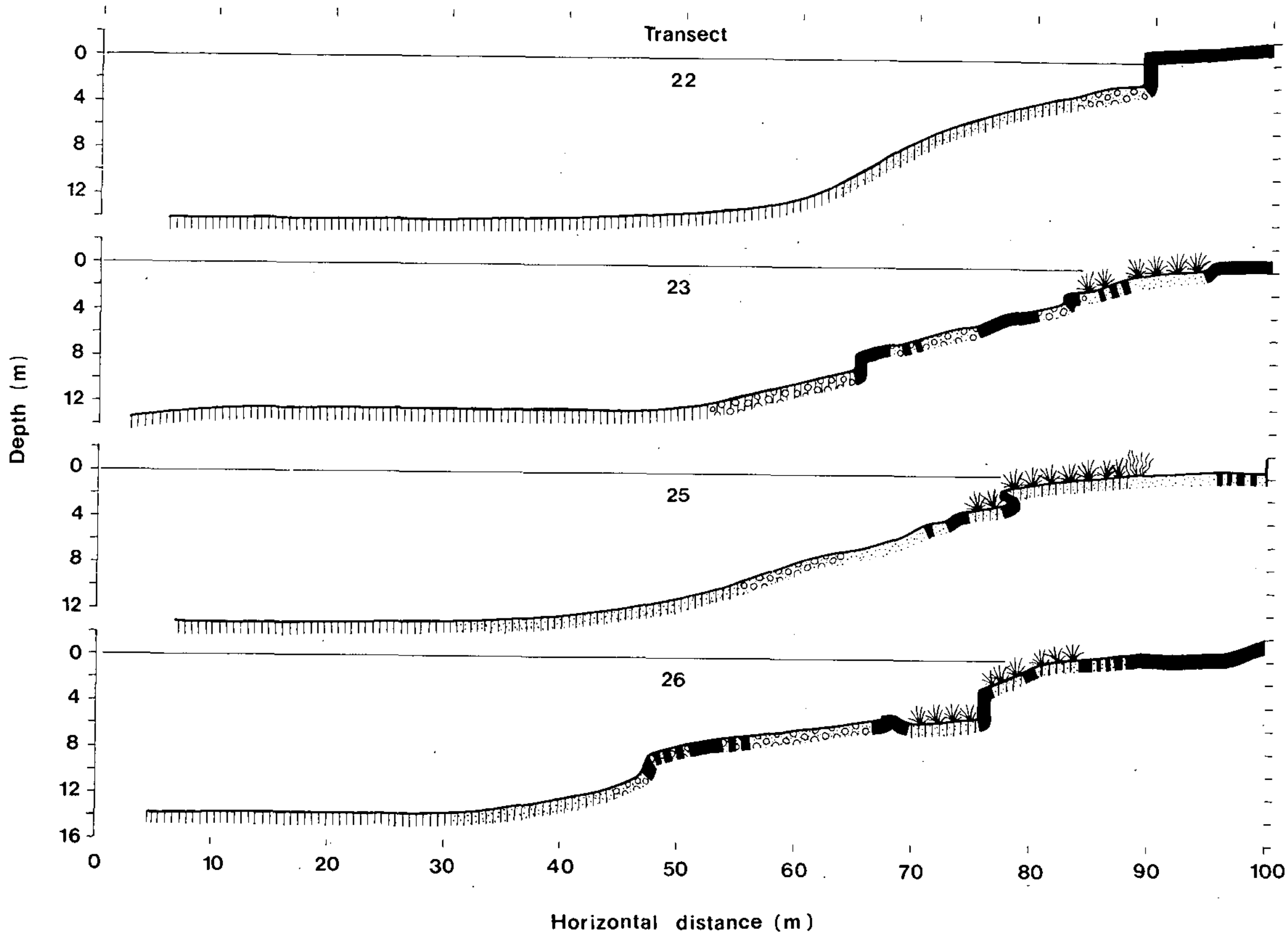

Figure 9. Depth profile, substratum type and seagrass species.
Transects 22,23,25,26.

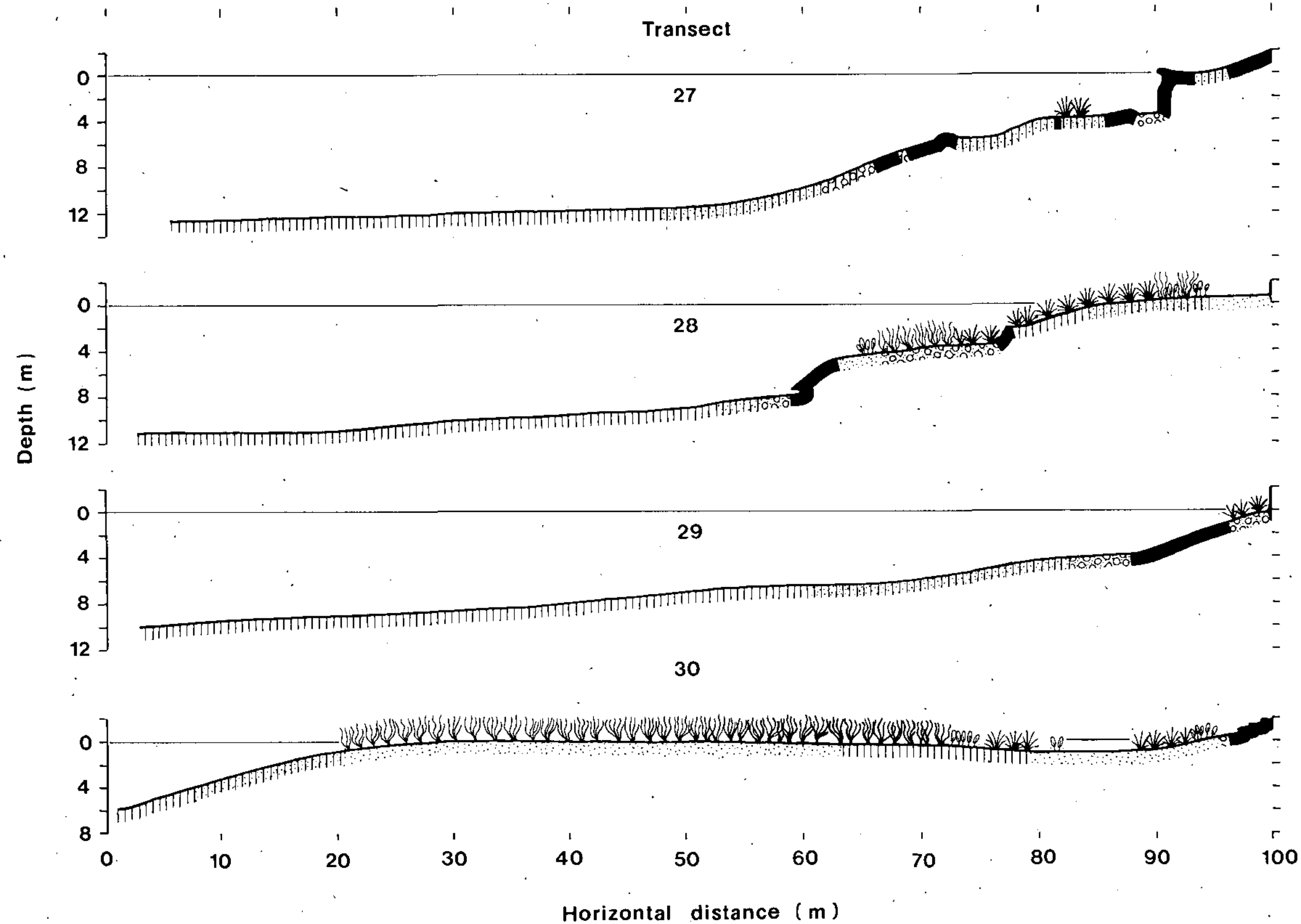

Figure 10. Depth profile, substratum type and seagrass species. Transects 27-30.

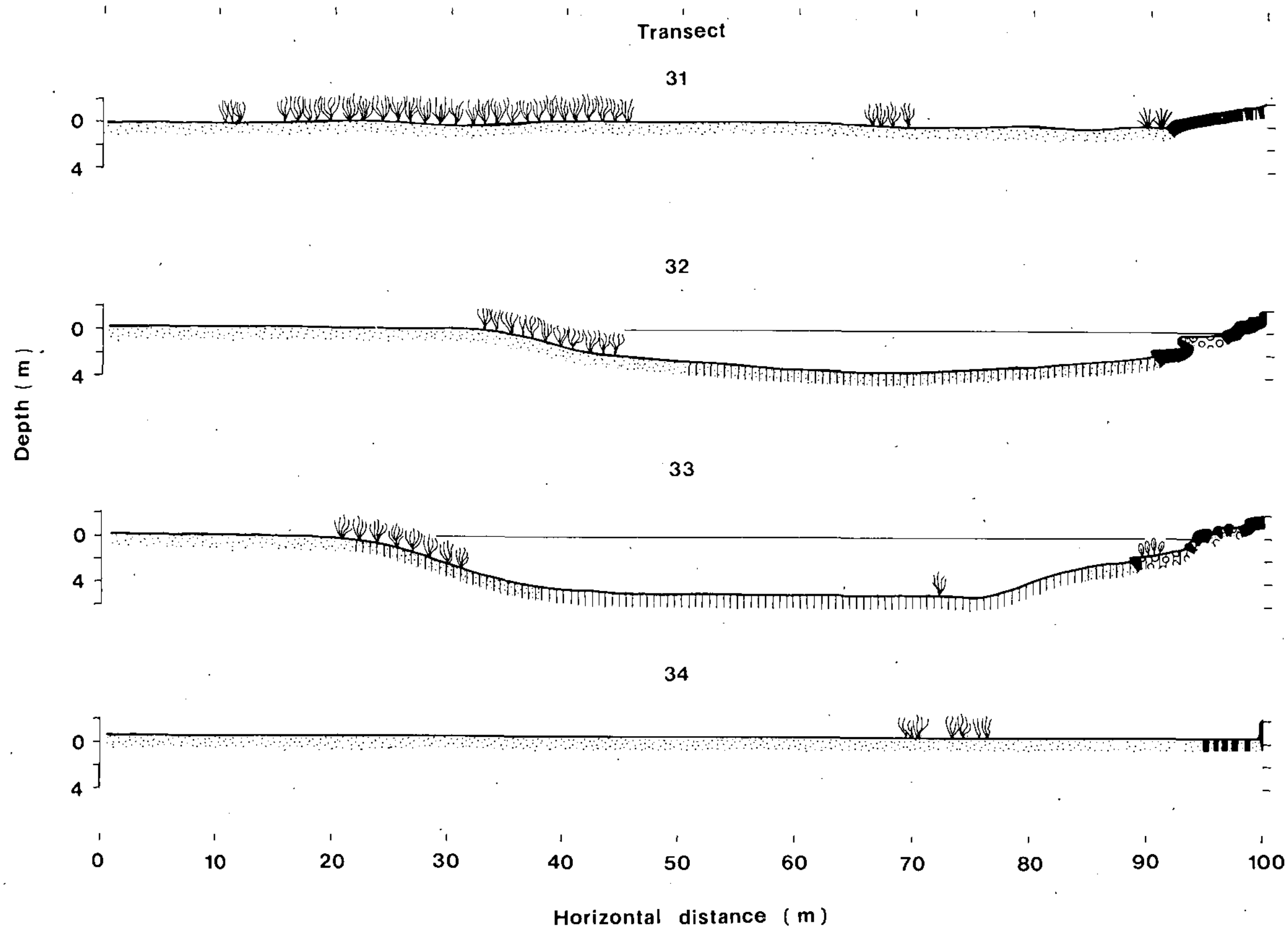

Figure 11. Depth profile, substratum type and seagrass species.
Transects 31-34.

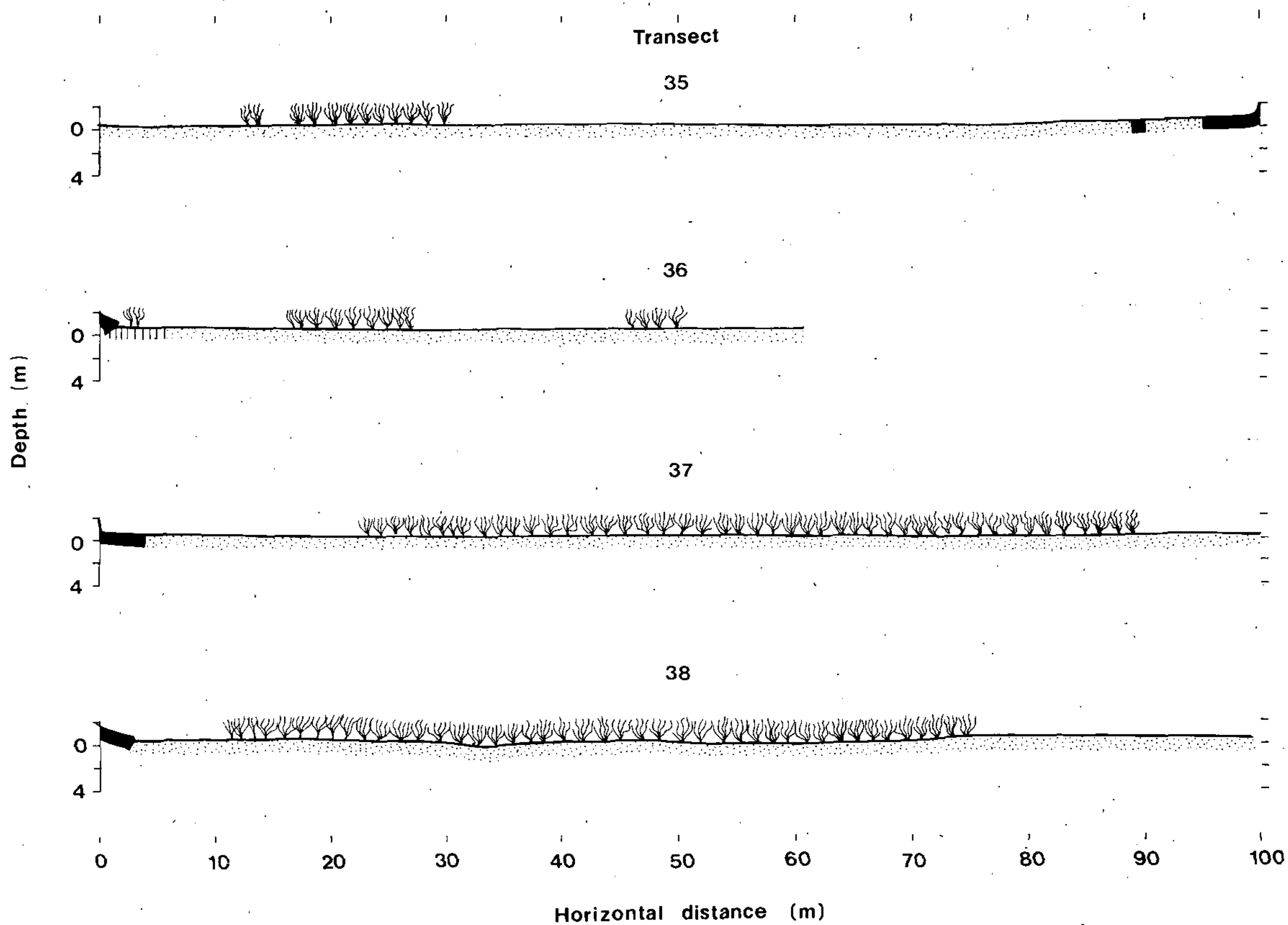

Figure 12. Depth profile, substratum type and seagrass species. Transects 35-38.

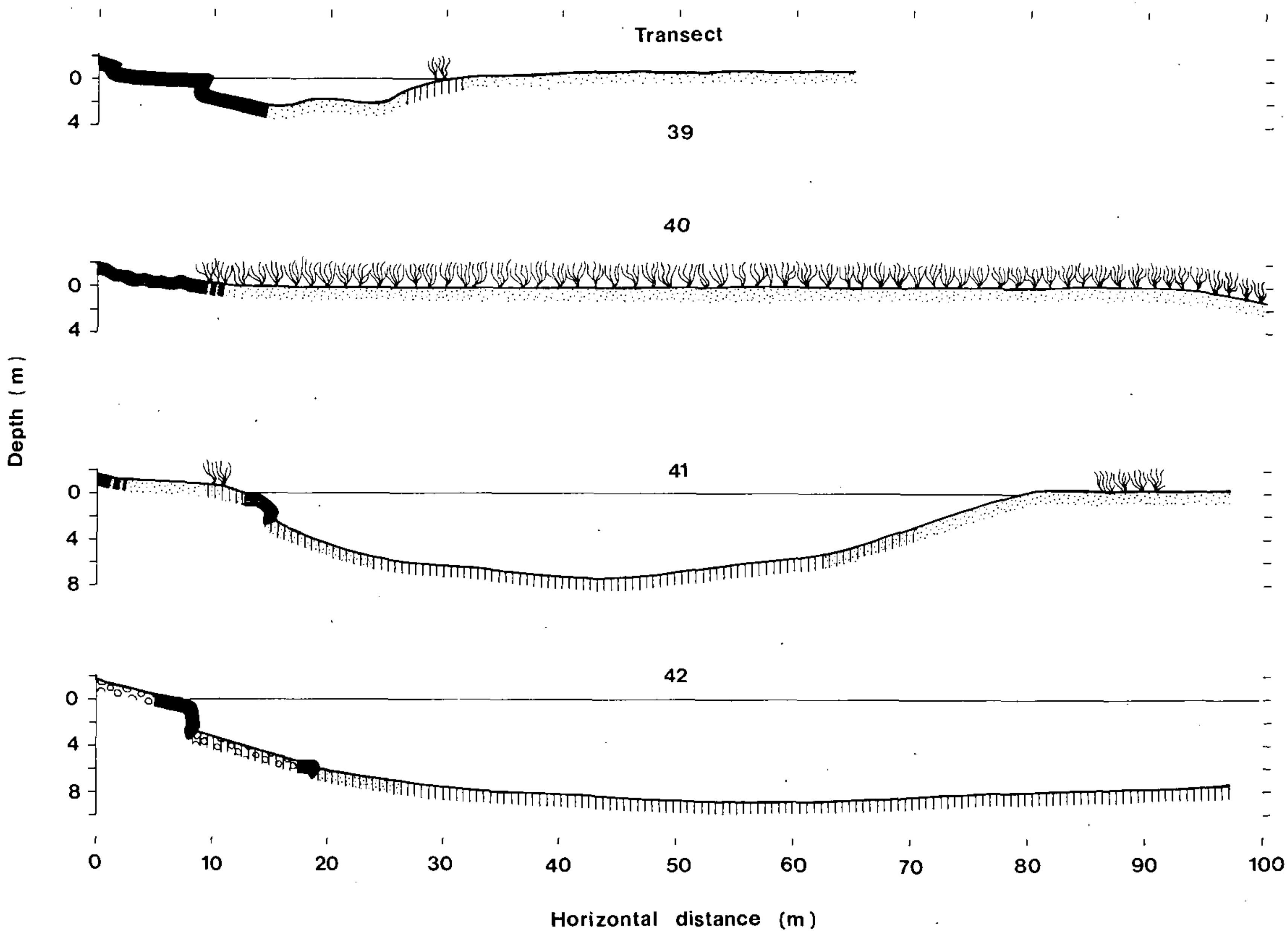

Figure 13. Depth profile, substratum type and seagrass species.
Transects 39-42.

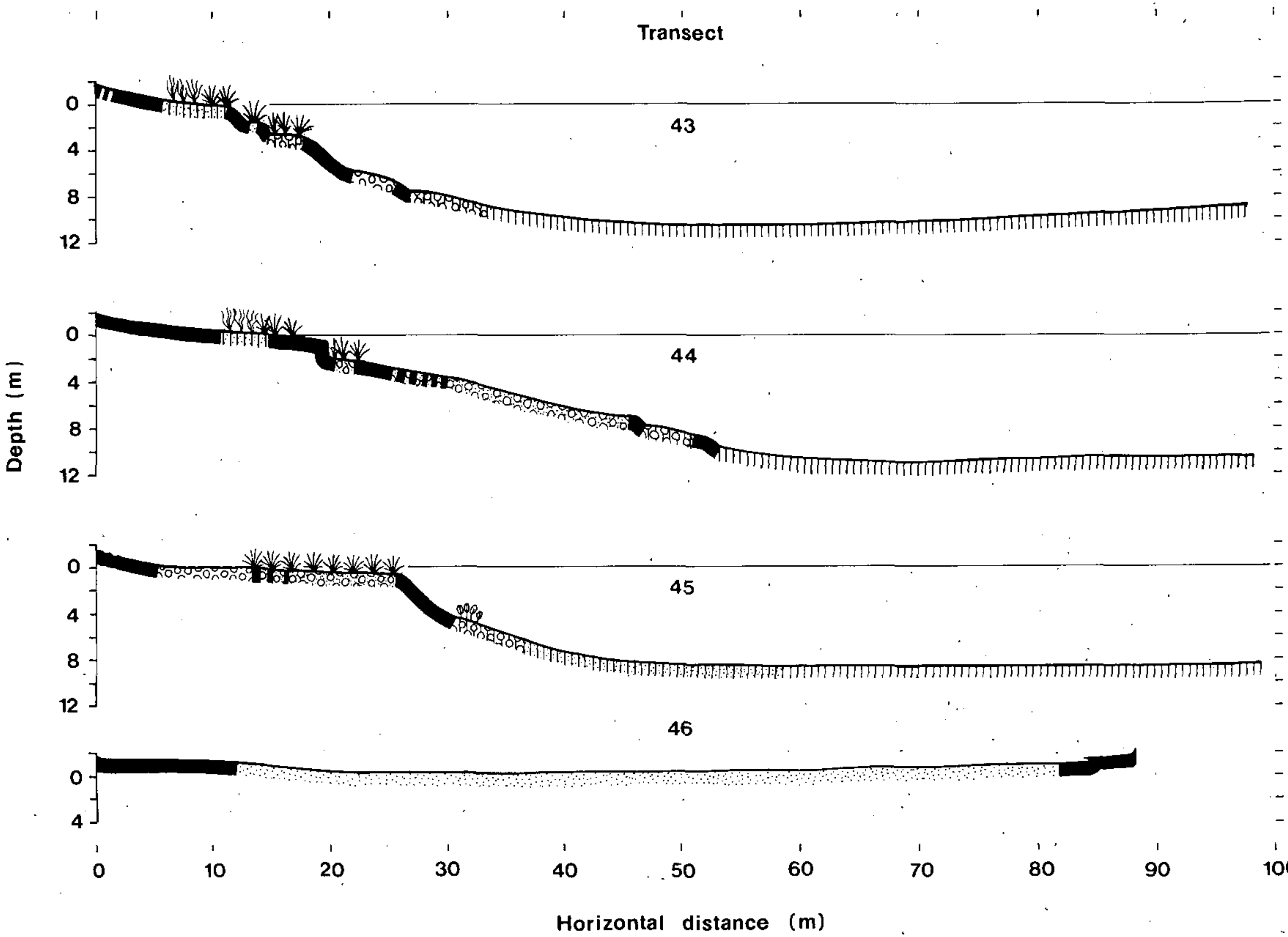

Figure 14. Depth profile, substratum type and seagrass species.
Transects 43-46.

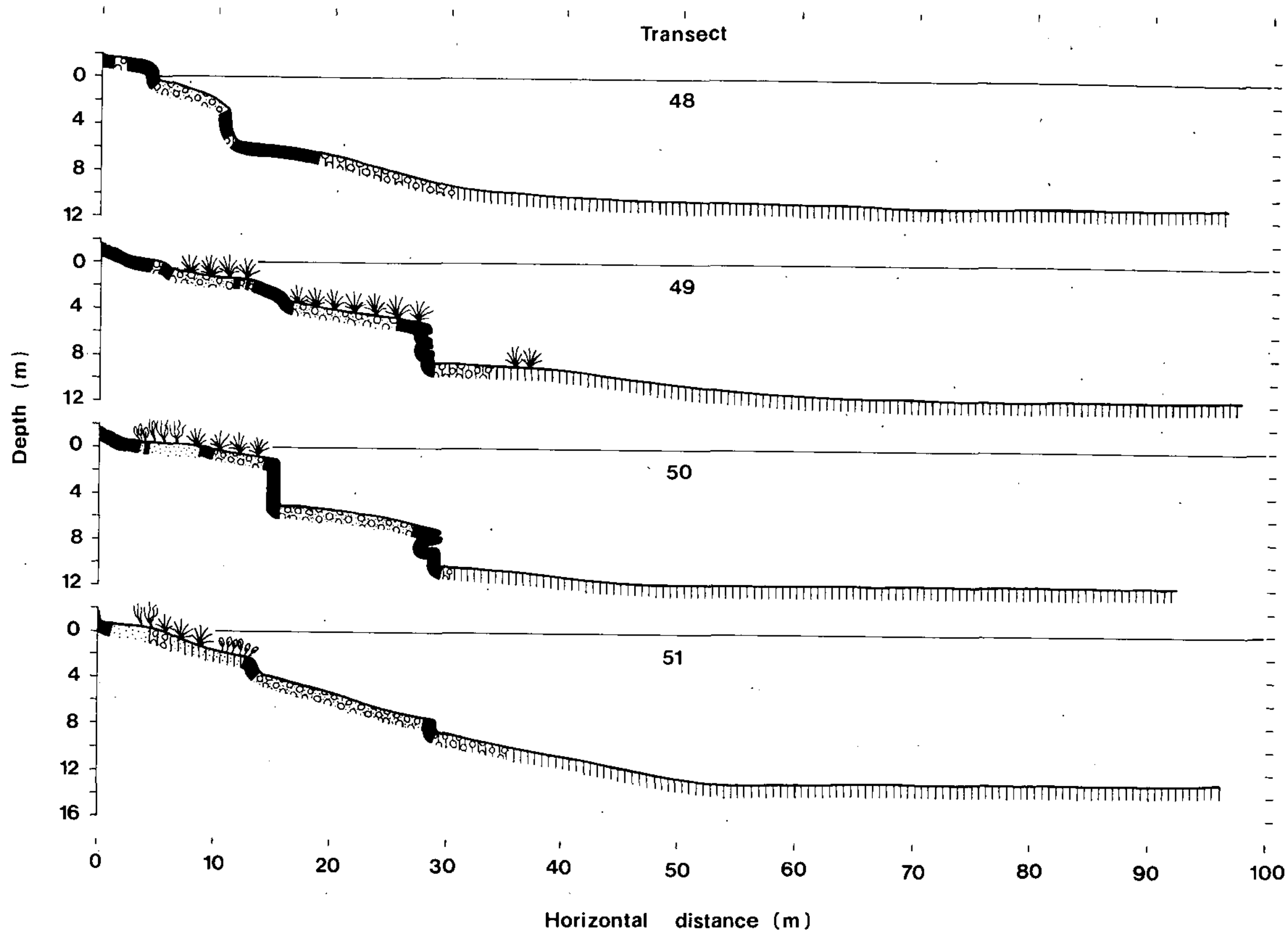

Figure 15. Depth profile, substratum type and seagrass species.
Transects 48-51.

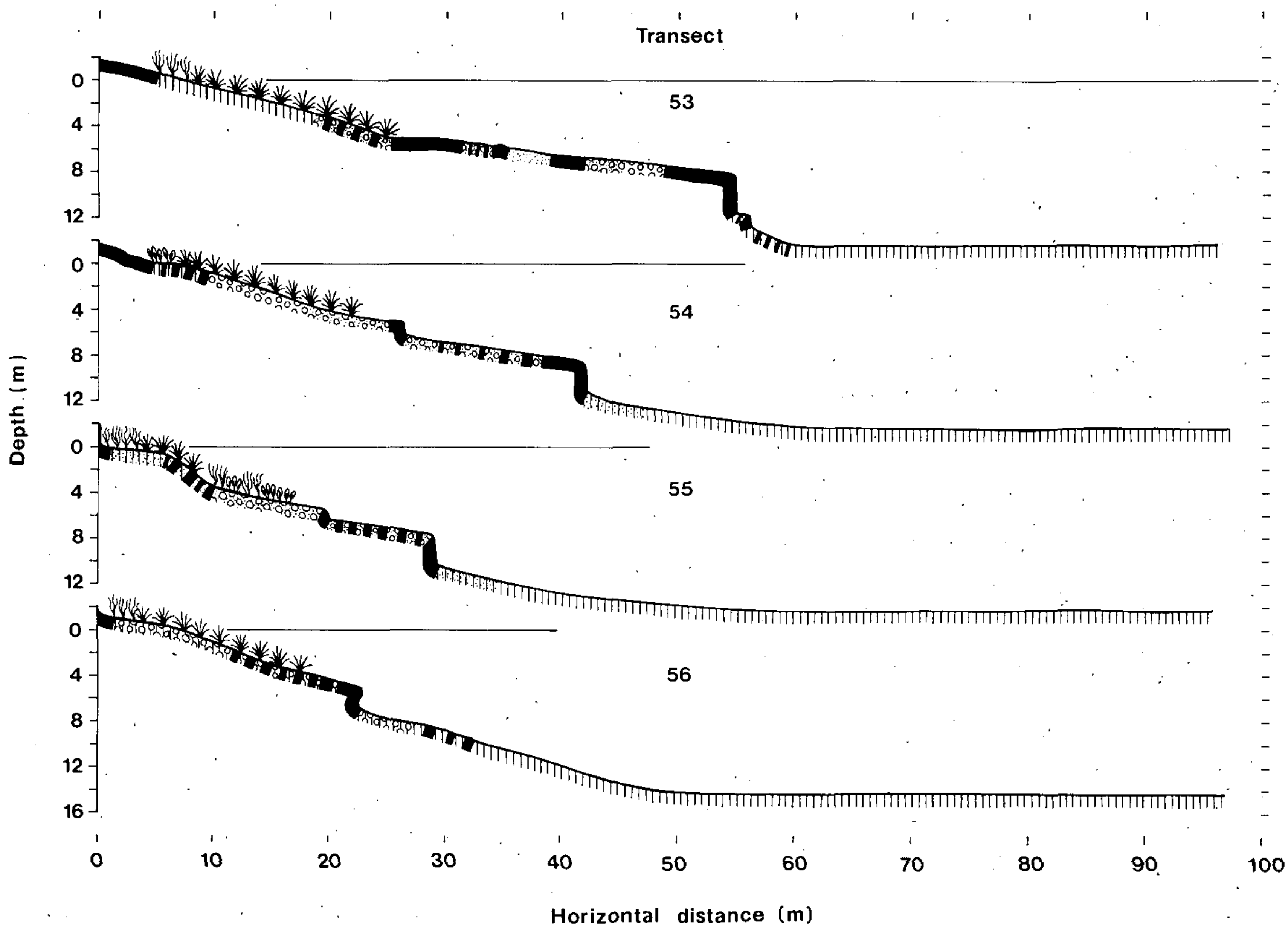

Figure 16. Depth profile, substratum type and seagrass species. Transects 53-56.

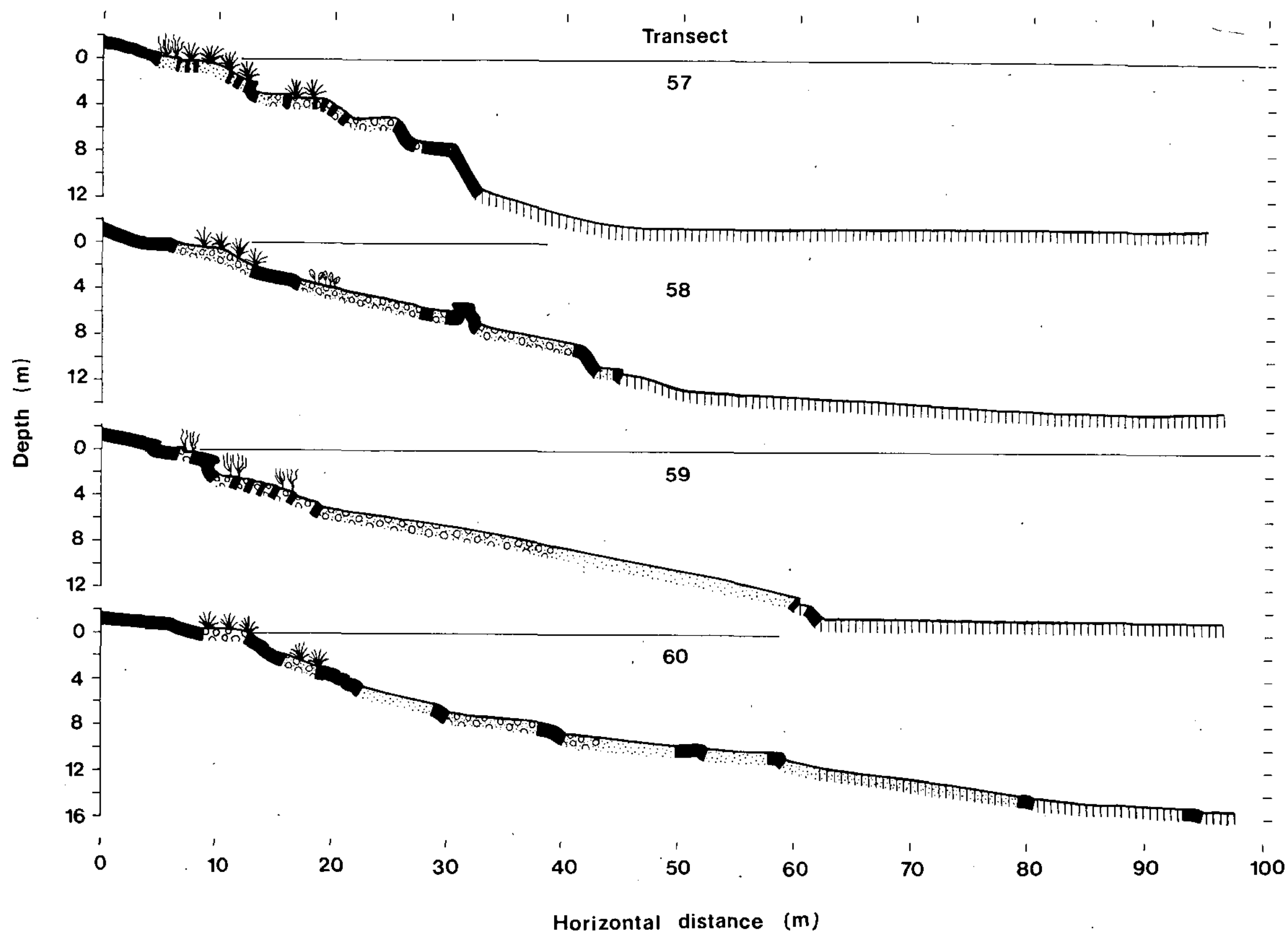

Figure 17. Depth profile, substratum type and seagrass species.
Transects 57-60.

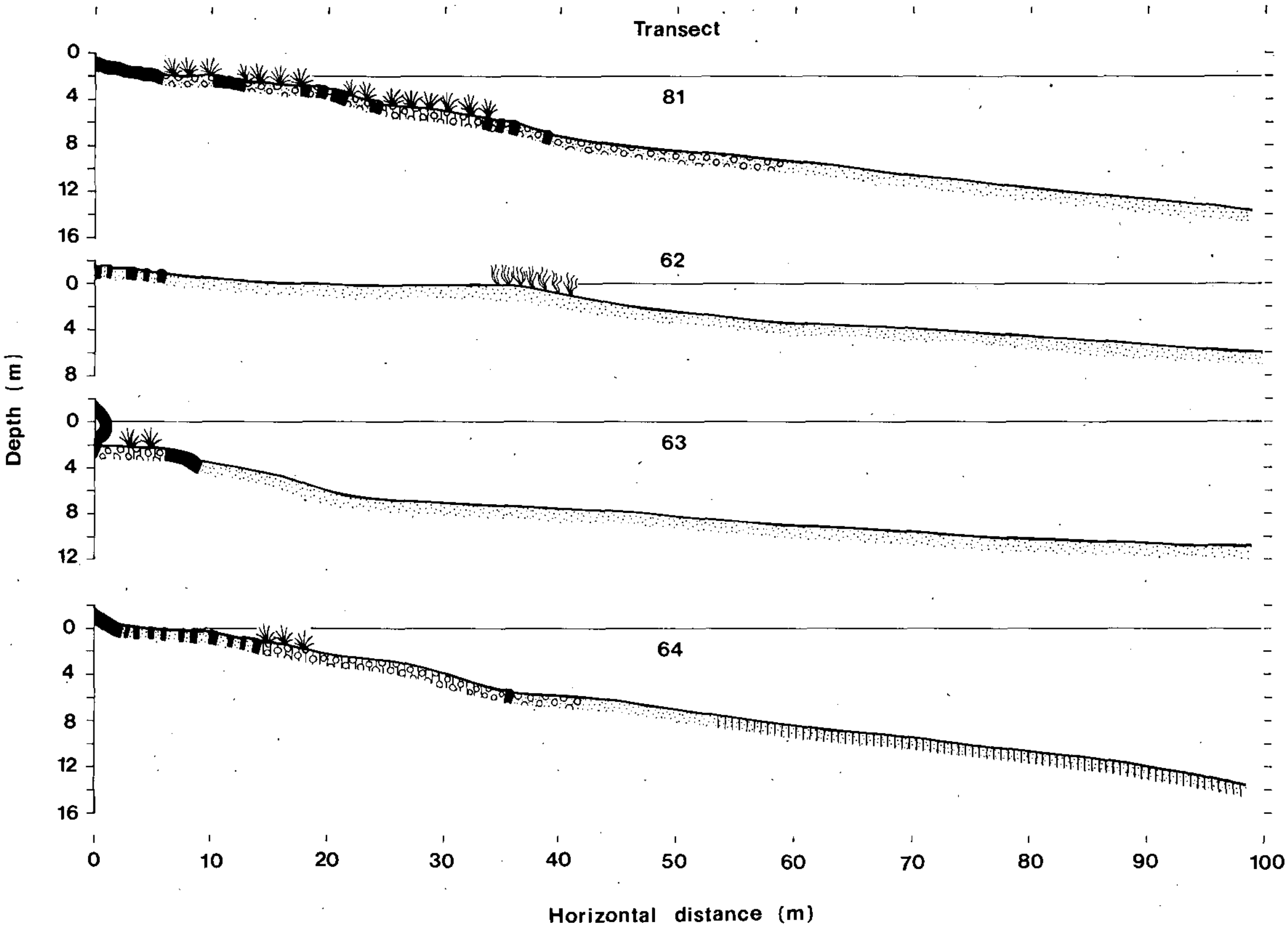

Figure 18. Depth profile, substratum type and seagrass species. Transects 81, 62-64.

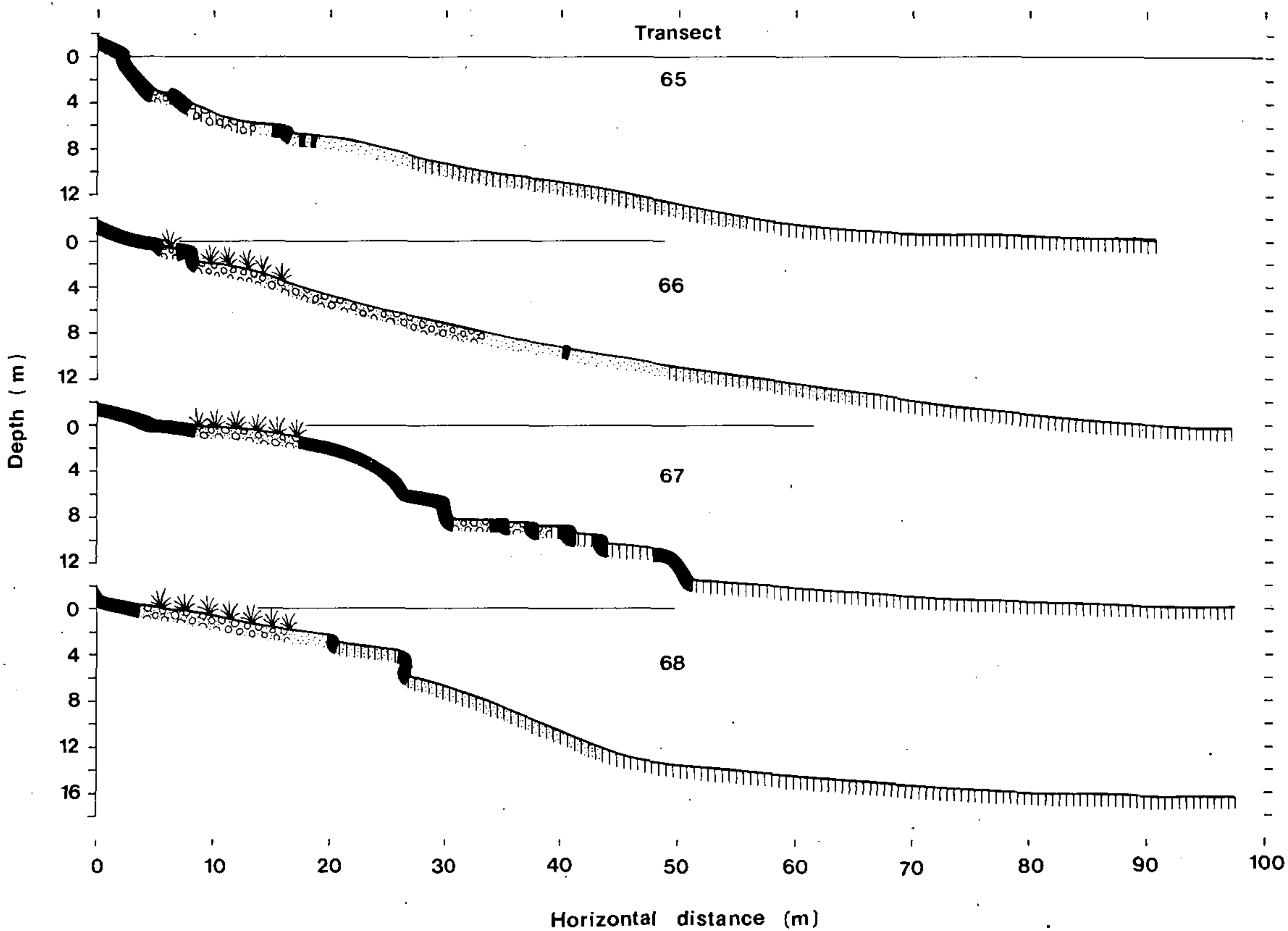

Figure 19. Depth profile, substratum type and seagrass species.
Transects 65-68.

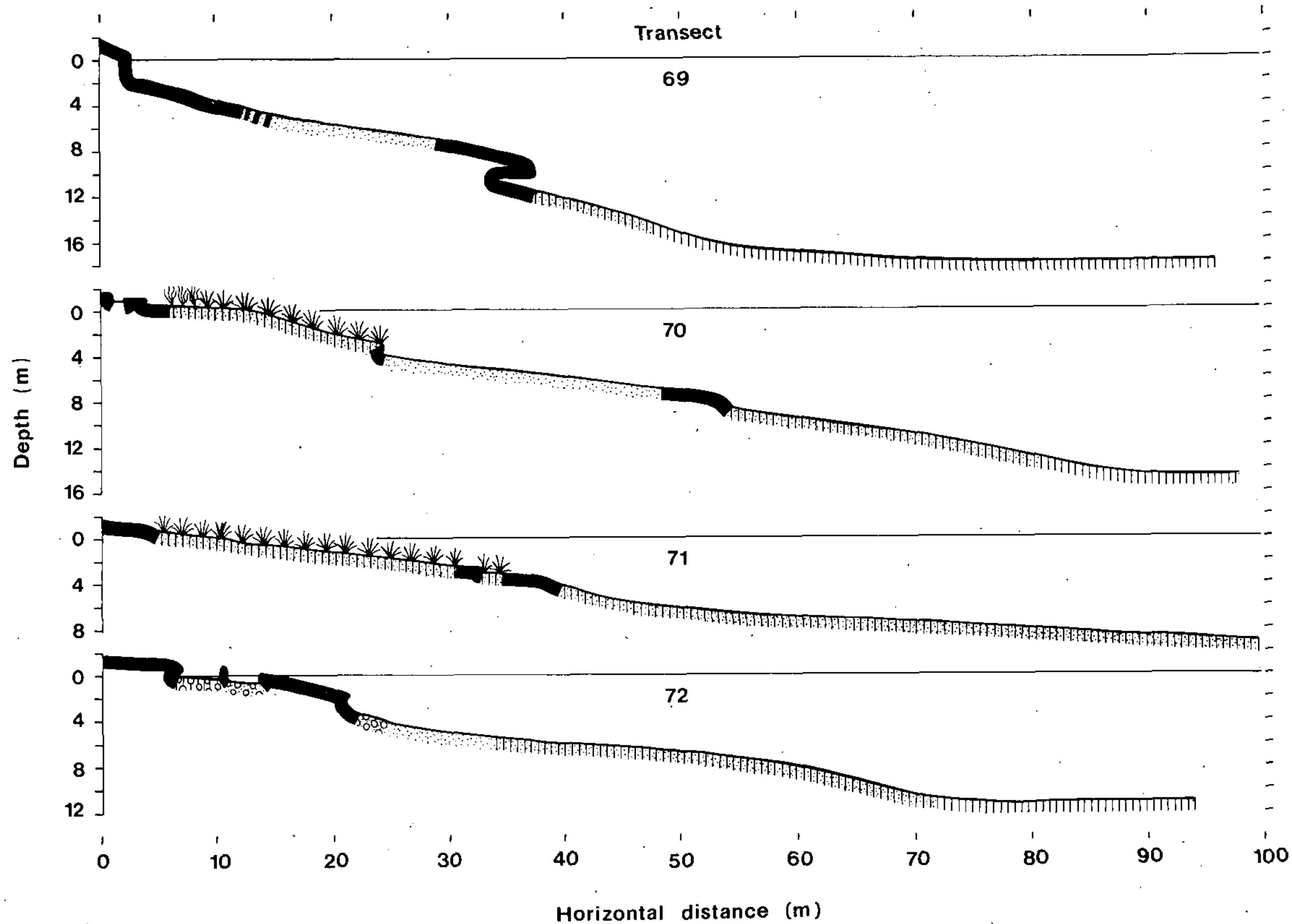

Figure 20. Depth profile, substratum type and seagrass species.
Transects 69-72.

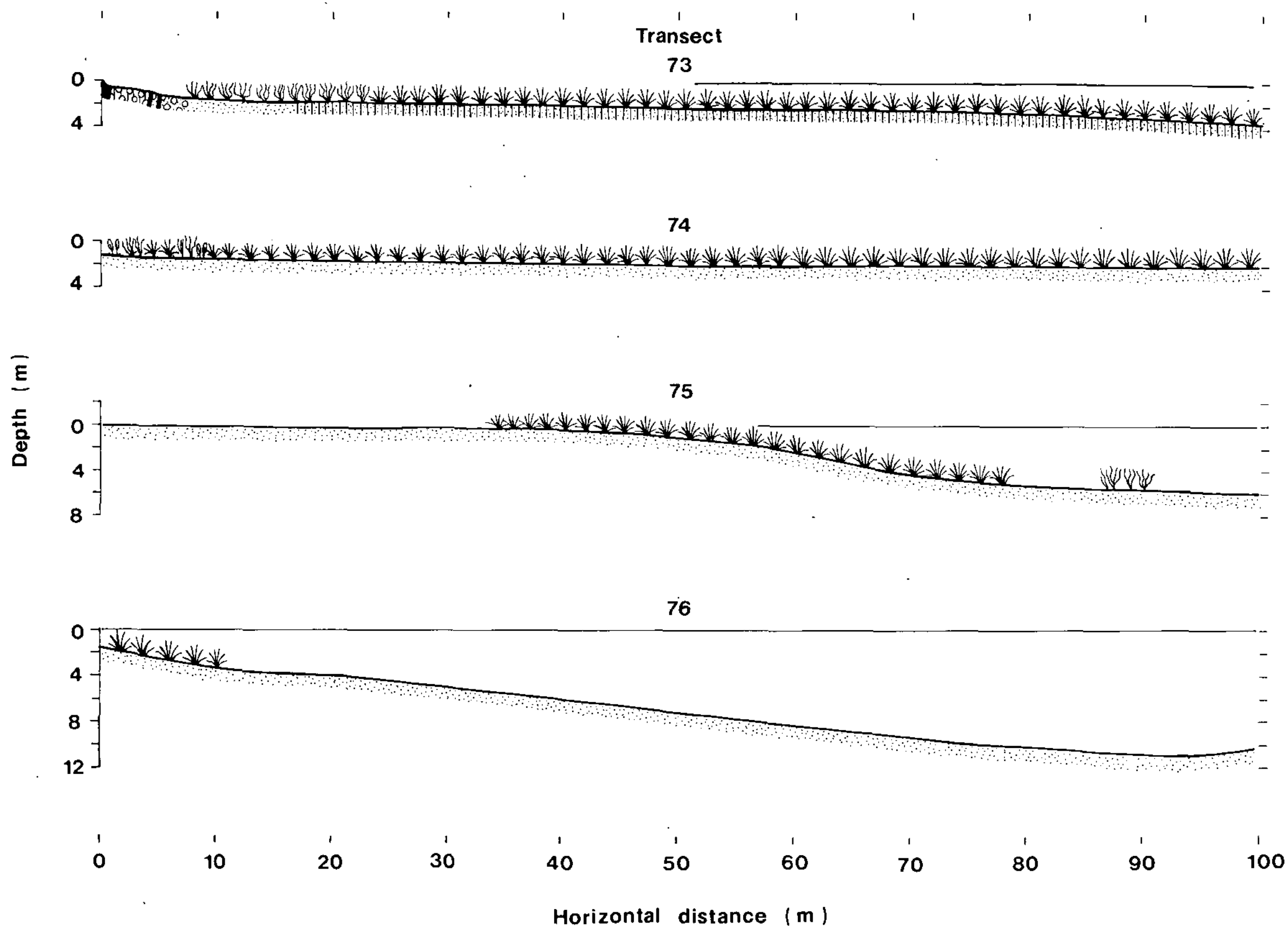

Figure 21. Depth profile, substratum type and seagrass species.
Transects 73-76.

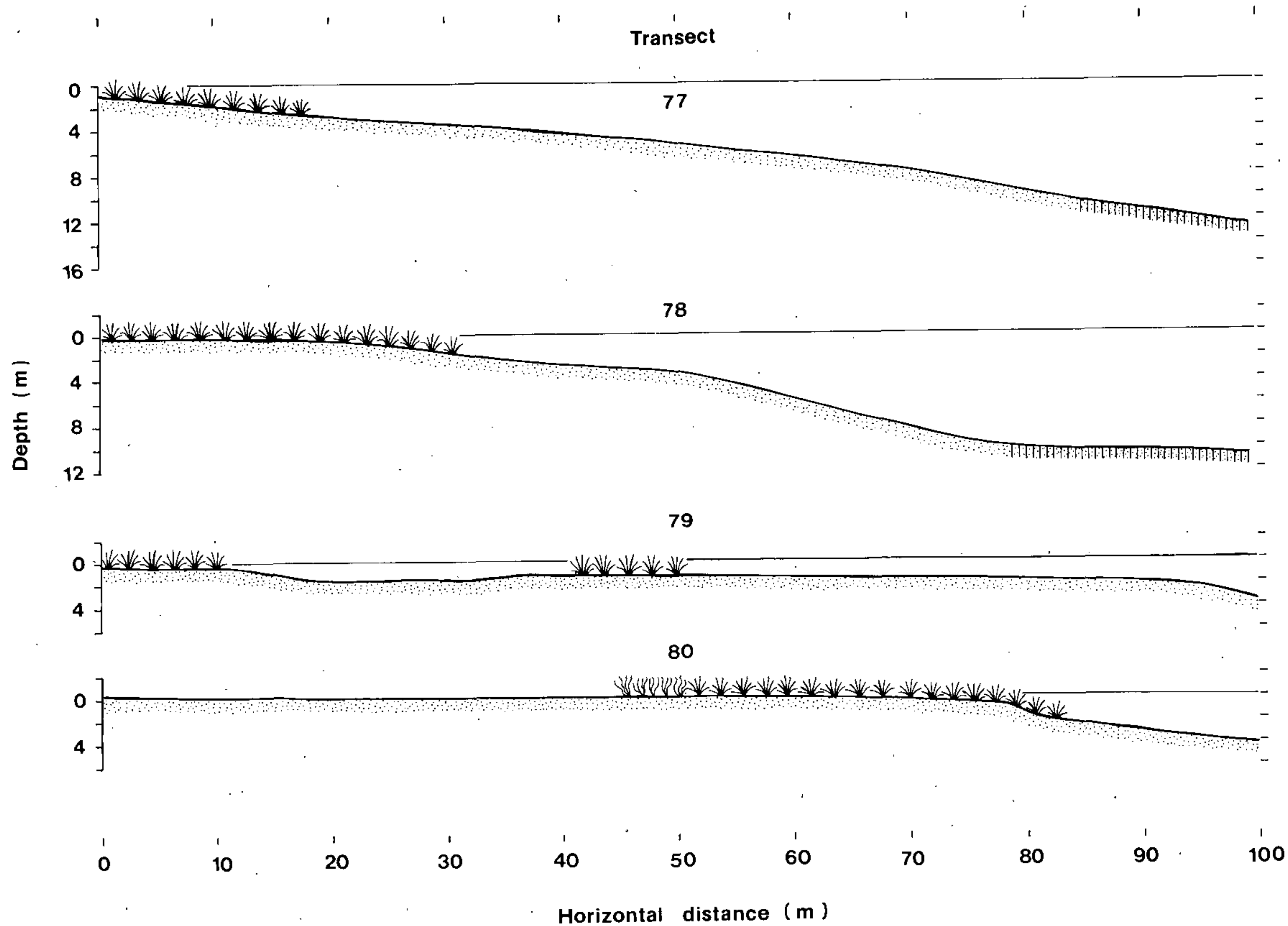

Figure 22. Depth profile, substratum type and seagrass species. Transects 77-80.

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